Prospector's Guide

Department of Mines, Sydney, N.S.W.

PROSPECTOR'S GUIDE

NEW SOUTH WALES

ISSUED BY DIRECTION OF

MINISTER FOR MINES

Ninth Edition

Registered at the G.P.O., Sydney, for transmission by post as a book

SYDNEY:
V. C. N. BLIGHT, GOVERNMENT PRINTER

1966

G7943—1 K 5378 [$1.25]

Foreword

The development of our mineral resources is essential to our economic welfare and way of life. Much of the development of these mineral resources, however, can be attributed initially to the energy and enterprise of individual prospectors. With the needs of individual prospectors and small mine operators in mind, therefore, it has been the practice of the New South Wales Department of Mines, for many years now, to publish a "Prospector's Guide", containing concise but comprehensive geological, mineral and prospecting information.

In this edition, the information contained in previous issues of the "Guide" has been revised and amended and new sections have been added where necessary. It is hoped therefore that this handbook will continue to help stimulate prospecting activities in the State, and serve as a useful, practical, and valuable aid in the search for, and development of, our mineral wealth.

T. L. LEWIS,
Minister for Mines.

Introduction

The production of the "Prospector's Guide" resulted originally from the wide demand for information concerning the location, identification and prospecting of mineral deposits in New South Wales. This information has been compiled by officers of the Department of Mines who over the years have gained a wide range of knowledge of the mineral deposits and the mining industry of the State; and the "Guide" is one of the many mediums which the Department of Mines employs in passing on this knowledge to prospectors and those interested in the search for minerals.

Revision and reprinting of the "Guide" periodically has ensured that the information presented is up-to-date and in step with advances and improvements in the mining industry. In the previous edition information on petroleum and natural gases, safety practices in oil drilling, the use of explosives and electricity, etc., was added. In this edition, this policy has been continued with the addition or amendment of a wide range of information relating to the occupation of Crown and private lands, authorities to enter and to prospect, leases, exploration licenses, the Mines Inspection Act, controls on minerals and metals, and the list of available publications and maps.

It is hoped, therefore, that the information contained in this book will form the basis for much successful prospecting and that readers will not hesitate to contact the Department should any further assistance be required.

M. H. SLATER,
Under Secretary.

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CHAPTER I

INTRODUCTION TO GENERAL GEOLOGY

The Rock Groups

The rocks making up the earth's surface are divided into igneous, sedimentary and metamorphic groups.

The *igneous* rocks have risen from deep below the crust of the earth in a molten state and crystallized into solid masses. The coarse-grained rocks such as granite and diorite have solidified at great depths, but may now appear at the surface as a result of the erosion of the overlying material, while the fine-grained types such as basalt and felsite have solidified at or near the surface. There are all gradations between these two types.

The *sedimentary* strata are bedded rocks that have been laid down in sheets through the action of water and wind. The greatest quantity of stratified rocks has been deposited in seas, oceans and lakes. Sandstone, shale, mudstone, chert, coal and limestone are all sedimentary rocks. Some rock types classified as sedimentary may have a chemical or organic origin ; for example, limestones formed from coral reefs.

The *metamorphic* rocks are formed by the alteration of both igneous and sedimentary rocks. They have changed from their original state either by great pressure or by proximity to igneous intrusions. The degree of alteration varies. Slates, quartzites, schists, phyllites and gneisses are all metamorphic rocks. The areas of metamorphic rocks in New South Wales contain many of the important metallic mineral deposits.

Notes on Some Common Rock Types

(a) *Igneous.*

Granite is a crystalline rock, commonly coarse-grained, consisting mostly of the minerals quartz and felspar (white or pink) which give it a predominantly light colour. It contains lesser amounts of mica (muscovite or biotite), amphiboles (e.g., hornblende) and pyroxenes (e.g. augite) which are mostly dark minerals. By decrease of quartz, granite passes through *granodiorite* into *syenite*. *Aplite* is a fine-grained variety of granite consisting essentially of quartz and felspar. *Pegmatite* is a variety of granite, usually in dyke or vein form, of coarse texture with large quartz, felspar and mica crystals or masses, and often containing accessory minerals of economic value.

Porphyry is an igneous rock which has relatively large crystals (e.g., of quartz or felspar), called phenocrysts, set in a finer-grained or glassy groundmass. *Felsite* may be regarded as a finely crystalline variety of porphyry, with few or no phenocrysts, the individual minerals being difficult to distinguish by the unaided eye.

Diorite is a granite-type rock, usually darker in colour than granite, and composed essentially of hornblende and plagioclase felspar, with lesser biotite and augite. *Andesite* is a fine-grained volcanic rock made up of plagioclase felspar with biotite, hornblende and pyroxenes. *Basalt* is a dark volcanic rock, usually fine-grained, composed chiefly of pyroxene and plagioclase felspar. In the field, the term basalt is usually applied only to lava flows, the corresponding rock of minor intrusions being called *dolerite.*

(b) *Sedimentary.*

Shale is a laminated or banded sedimentary rock in which the constituents are commonly of the clay grade. It consists of more or less consolidated muds. The terms claystone and mudstone are used for similar varieties which are massive and non-laminated. Slightly coarser rocks, for example those which in addition contain fine quartz particles, may be called siltstones, and are intermediate between shale and sandstone.

Sandstone is a consolidated rock composed of sand grains (e.g., quartz grains) cemented together. The grain size is such that the individual grains may be seen with the unaided eye, and with increasing coarseness sandstones grade into grits and conglomerates. *Conglomerate* is a consolidated gravel or "pudding stone", essentially made up of worn and rounded pebbles of other rocks cemented together by finer material.

Tuff is a cemented or consolidated accumulation of volcanic ash or dust. If the fragments are large and angular the resulting rock may be termed a *breccia.*

Limestone is a rock consisting essentially of calcite (calcium carbonate). It may be massive or may be shaly or sandy when containing impurities. If it contains much of the double carbonate of lime and magnesia, it is usually termed magnesian limestone or dolomite.

(c) *Metamorphic.*

Slate is a compact, fine-grained rock formed from shale, mudstone or volcanic ash ,and having the property of easy fissility (splitting into plates) along planes which are not necessarily those of the original bedding.

Schist is a crystalline rock that can be readily split or cleaved because of a foliated or parallel structure, generally secondary and caused by shearing and recrystallisation under pressure. *Phyllite* is a lustrous schistose rock containing much mica, and is intermediate between slate and mica-schist.

Gneiss is a layered crystalline rock with a more or less well-developed cleavage but without the fissility of schist. Some gneisses are banded or metamorphosed igneous rocks, others may be altered and recrystallised sediments.

Quartzite is a metamorphosed quartz sandstone, and is generally harder, more firmly cemented and less porous than sandstone.

Serpentine rock is a greenish, metamorphosed rock composed chiefly or wholly of the mineral serpentine, which is a hydrous magnesium silicate.

Some of the types of mineral deposits which may be associated with one or more of the rock types described above may be judged from the mineral descriptions in Chapters II and III.

The Results of Earth Movement.

From time to time, large forces within the earth result in major earth movements. These movements cause two types of structures:—

(1) *Folds,* are merely bends in stratified rocks, and they can assume many forms. A fold which is convex upwards (arched) is an anticline and one which is convex downwards (like a trough) is a syncline.

(2) *Fractures* (also known as fissures or joints) are breaks or cracks in the rock, while *faults* are fractures along which there has been a slipping movement between the rocks on either side. Faults may be complex and form a compound fault or shear zone between the two masses made up of numerous small faults and fractures. Faults and fractures act as channels for mineralizing solutions. On the other hand, if such structures are formed later than an ore-deposit they may disrupt and offset the continuity of the lode.

Ore Deposits.

An ore is a rock from which minerals of economic use may be extracted profitably. Ore deposits are most conveniently considered under two headings: (a) Sedimentary deposits, (b) Lode deposits.

(*a*) *Sedimentary Deposits.*

1. *Recent Alluvial Deposits.*—Due to the influence of chemical and mechanical breakdown, the rocks exposed at the surface of the earth are undergoing continual decomposition. The materials thus freed are carried by stream, wind and wave action and deposited

where the velocity, and hence the carrying power, of currents has decreased. The deposits are concentrated into fractions according to the specific gravity or weight per volume of the material. In this manner, appreciable amounts of ore minerals are eroded from their parent materials and concentrated into payable "placer" deposits usually in the lower layers of alluvium and, more commonly, in the coarse gravels and pebbly drift.

Minerals concentrated in this way include gold, tin, magnetite, chromite, zircon, platinum and wolfram.

The newest alluvial deposits thus formed are termed "recent alluvials". In some instances the small drainage channels have been completely filled, and the ore covered by accumulations of sediment, while in other instances, the deposits occupy the beds of existing rivers.

2. *Deep Leads* are alluvial deposits which have been formed in the usual manner but in a past geological age, so that the ore concentrate is at a greater depth and may even be sealed under a later layer of basalt. It is important to remember that they were formed in many cases long before the present drainage systems were evolved, and, therefore, may cut across the hills and valleys of to-day.

3. *Beach Sand Deposits* are concentrated along beaches by currents and wave action. The concentrates formed in this way in New South Wales, are mainly zircon, ilmenite, rutile and monazite but garnet, tinstone, gold and platinum may also be present.

4. *Other Sedimentary Deposits* include coal, oil, shale, limestone, building stone, clay, slate, etc., all of which are formed by sedimentary depositions.

(*b*) *Lode Deposits.*

Lode deposits are best considered in the following groups:—

1. Lodes or veins.
2. Saddle reefs and deposits parallel to bedding.
3. Replacement deposits.
4. Contact deposits.
5. Pipes.
6. Pegmatites.

1. *Lodes or Veins* are tabular or sheet-like masses of minerals occupying or following a fracture or a set of fractures in the enclosing rock. They have been formed later than the country rock and the fractures either by filling of the open spaces or by partial or complete replacement of the adjoining rock, or, most commonly, by both of these

processes combined. The forms of the deposits are mainly dependent on the primary fractures, and are characterised by frequent pinching and bulging between sharply defined walls. They often persist for considerable distances both in length and depth.

2. *Saddle Reefs and Deposits Parallel to the Bedding* are formed by mineralizing solutions which, instead of following tensional fractures, consolidate in weak layers of bedded strata. In the case of saddle reefs these weak layers are at the crests or troughs of folds. Some of the valuable metal deposits of New South Wales are of this type.

3. *Replacement Deposits* have been formed by the removal or alteration of the original constituents of rocks by mineral-bearing solutions and the deposition of new minerals by a process of substitution and replacement. The forms of the ore-bodies are more or less irregular with gradually fading limits, and the textures and structures of the original rocks are often preserved.

Silver, lead, zinc, tin, copper and iron deposits are often formed in this manner.

4. *Contact Deposits* are formed at or near the margin of igneous rocks intruded into strata favourable to the deposition of ore minerals. Limestones and shales are particularly favourable, but the deposits may even be formed at contacts with older igneous rocks. Sometimes the form of the deposit follows more or less closely the boundary between the intrusion and the older rock, while in other instances where they are actually due to chemical replacement of one particular rock, such as limestone, their shape is determined by the area over which the intrusion happened to come near or into contact with the limestone. Silver, lead, copper, iron and gold have all been found in contact deposits in New South Wales.

5. *"Pipes"* are cylindrical siliceous intrusions or replacements which have been formed as offshoots of larger igneous masses and form very irregular deposits of ore minerals. They usually form near the contact of siliceous granite and other rocks such as basic granite or sediments. The most common ores in this type of deposit are molybdenite, bismuth, tin, gold and copper.

6. *Pegmatites* are portions of granite magmas which segregate and occur as dykes, stringers and veins intruded mainly around the borders of granite masses. They frequently have a concentration of valuable minerals which occur only in accessory amounts in the main body of the igneous rocks, while the growth of crystals of large size makes exploitation profitable.

Economic deposits of such minerals as tin, uranium, felspar, quartz, mica, beryl and gemstones are formed in this manner.

Secondary Enrichment of Ore Deposits.

Ore bodies, like other rocks, undergo weathering and decomposition at their outcrops.

Downward percolating groundwater causes a chemical process of solution and deposition which results in a leaching and enrichment of certain zones of the ore body.

The top zone is the weathered upper part of the deposit known as the *gossan*. This consists principally of hydrated oxides of iron and has resulted from the oxidation and removal of the sulphur as well as the copper, etc.

Next is a leached zone from which the ore has been removed and deposited in the following, the oxidized zone, which is limited by the mean level of the water-table. Near the level of the water-table an enriched sulphide zone is often formed which grades into the primary ore body.

By this chemical concentration, workable deposits may result from low-grade ore bodies, but it must be realised that such deposits may not be payable once the primary ore is reached.

Geological Time Scale.

Geological time is divided into thirteen periods on the basis of breaks in geological history. All rocks are assigned on fossil and other evidence to the period in which they were formed and geological maps show the rocks formed in each period or part of each period.

TABLE OF GEOLOGICAL TIME.

Era	Period	Age in Millions of Years	Chief Rocks Occurring in New South Wales.	Igneous Rocks	Economic Significance
Cainozoic Era	Recent	0- 1	Alluvium	....	Sand, clay, gravel, gold, tin and gemstones.
	Pleistocene ..	1- 2			
	Tertiary......	2- 65	Lavas, deep leads and alluvium of eastern half of the State.	Basaltic and acidic lava flows.	....
Mesozoic Era	Cretaceous	65- 105	Desert sandstone of the north-west portion of the State.	....	Gold-bearing leads, artesian intake beds.
	Jurassic	105- 145	The Clarence-Tweed Coal Field and the sandstones and shales of the Dubbo-Narrabri region.	....	Minor coal production, artesian intake beds.
	Triassic	145- 195	Sandstone, shales and conglomerates overlying the Main Coal Basin.	....	Brick and tile clays, moulding sands and building stone, minor coal production.
Palaeozoic Era	Permian	195- 225	Sandstones, shales, conglomerates and coal of the Main Coal Basin (Nowra to Gunnedah).	Mainly acid igneous rocks, both intrusive and extrusive—granite, diorite, porphyry, andesite, rhyolite.	Major coal production, brick and tile clays.
	Carboniferous	225- 275	Shales, sandstones, limestones and lavas of the north-eastern quarter of the State.		All the metalliferous lodes and reefs occur in rocks of these ages.
	Devonian	275- 310	Quartzites, slates, shales, conglomerates and limestones of eastern and central western portions of the State.		
	Silurian	310- 335	Slates, sandstones, cherts, limestones, tuffs, andesites, etc., of the eastern and central portions of the State.		
	Ordovician ..	335- 390	Slates, tuffs, quartzites and some limestones of the south-eastern quarter of the State.		
	Cambrian ..	390- 500	No rocks of this age have been proved to exist in New South Wales.		
	Pre-Cambrian	500-3000	Quartzites, schists and gneisses of the Barrier Ranges.		

CHAPTER II

NOTES ON ECONOMIC MINERALS

Metallic Minerals

ALUMINIUM.

Aluminium is the most abundant metal in the crust of the earth and occurs in such common minerals as clay and felspar and many other rock-forming silicates. These silicates are not used commercially for the production of metallic aluminium owing to the high cost involved.

Under certain conditions of weathering in sub-tropical areas, clays and rocks rich in aluminium silicates break down to yield bauxite, which consists essentially of hydrated oxide of aluminium together with some iron oxide and a little silica present as impurities. Bauxite is an earthy-looking substance, cream to reddish-brown in colour, and lacks the plasticity of an ordinary clay. It often has a pisolitic or concretionary structure, but it cannot be identified without chemical tests. It is a low-priced substance, and occurs in great abundance in many parts of the world. Deposits are of no commercial importance unless they are large and situated in localities where mining and transport costs are low. It is the chief ore used for the production of aluminium, but it is also used as a flux in steel making, for the manufacture of certain types of cement, and when fused in an electric furnace, it yields a crude form of aluminium oxide which is crushed and sold as an abrasive known as "alundum" or "aloxite".

Large deposits of bauxite, mainly of low grade, are known in the Inverell-Emmaville and the Wingello-Sutton Forest areas.

ANTIMONY.

Antimony occurs chiefly in the form of the sulphide, stibnite, and the oxide, cervantite, which are the only important ores of the metal. Other less important, antimony-bearing minerals are native antimony, and the complex sulphides of lead and antimony, copper and antimony and silver and antimony, which are usually to be regarded as sources of lead, copper and silver rather than of antimony.

Stibnite is a soft lustrous silvery-white mineral which tarnishes rapidly in air to a lead-grey colour. It can be scratched easily with a knife and is fusible in the flame of a candle. Cervantite is a dirty white to yellow earthy-looking mineral formed by the weathering of stibnite.

Stibnite generally occurs in well-formed crystals, e.g., in veins of quartz, often traversing altered sedimentary rocks at or near their contact with a mass of granite. It may also occur in tiny particles scattered through more or less altered rocks.

The price of antimony ore fluctuates widely, but the ore is generally readily saleable, provided the grade is high. Buyers will not accept ores containing less than 35 per cent. of antimony and ores of lower grade must be either hand picked or concentrated mechanically in order to raise the grade to above this figure.

Antimony is used chiefly in the form of alloys with lead and sometimes tin, in the form of antimonial lead used extensively for plates for storage batteries, in type metals and bearing metals, and compounds of antimony are used in medicine, pigments, safety match manufacture, and in the processing of rubber, the colour of red rubber goods being obtained by the addition of antimony sulphide.

Scheelite occurs in some localities in association with antimony ores and some antimony ores are so rich in gold that they are worked for their gold content rather than for antimony. The separation of gold from antimony is a difficult metallurgical problem.

Antimony is sometimes obtained as a by-product of the refining of ores of other metals such as lead or copper in which it is often present in small quantities. A considerable amount is won in the form of antimonial lead during the refining of lead from Broken Hill.

The chief antimony mining districts in N.S.W. are the Hillgrove, Point Lookout, Upper Nambucca River, Drake, Aberfoyle River, and Ilford districts. Production has been on only a small scale for many years.

ARSENIC.

The principal source of arsenic is the mineral mispickel, also known as arsenical pyrites or "white iron", which is a sulphide of iron and arsenic. Although it is a common mineral, it is seldom mined for its arsenic content alone, and much of the arsenic of commerce is obtained as a by-product from arsenic-bearing gold ores. It is a hard, tin-white mineral, which can only just be scratched with the point of a knife, and when struck with a hammer or heated strongly, it gives a characteristic garlic-like smell. It is often associated with iron pyrites or pyrrhotite, and usually occurs embedded in quartz veins or scattered through altered rocks in close proximity to masses of granite. Other arsenic-bearing minerals are realgar and orpiment, the brightly coloured sulphides of arsenic, native arsenic and scorodite, a green form of hydrated iron arsenate derived from the weathering of arsenical pyrites.

The chief use of arsenic is for the manufacture of poisons for the killing of weeds and insect pests in agriculture and horticulture, and it is used extensively in sheep dips and cattle dips. Arsenic is also used in glass manufacture, and as a hardening agent in certain lead and copper alloys.

Arsenic ores are low in price and can seldom be worked at a profit unless they contain other metals to enhance their value. They often contain gold or silver in payable quantities and any discovery of arsenical minerals should be investigated for their possible presence. An assay is necessary to determine the presence of gold or silver in arsenical ore.

Most of the arsenic produced commercially in N.S.W. has been obtained from the Ottery Mine at Tent Hill, the Valla Mine near Urunga and from the Rockvale deposits situated south-east of Armidale.

BERYLLIUM.

The only mineral which is of any commercial value as a source of beryllium is beryl, which usually occurs in the form of hexagonal prismatic crystals which are sometimes of enormous size. Beryl crystals up to several tons in weight have been discovered in some part of the world, including Broken Hill. It sometimes occurs in massive or non-crystallised form. It is usually pale-green to yellowish in colour, but may be white, brown or colourless and typically has a glassy lustre and often looks very much like quartz, from which it can be distinguished only with great difficulty by means of chemical tests or by optical tests which are beyond the capabilities of the average prospector.

Nearly all the beryl of commerce is obtained from dykes of pegmatite, but its occurrence within the dykes is very erratic. It is seldom that any deposit yields sufficient beryl to enable it to be worked for its beryl content alone, and most of the beryl is recovered as a by-product of the winning of the felspar or mica content of the pegmatite dykes. Beryl also occurs in gneisses and schists, but seldom in workable quantities.

The metal beryllium obtained from beryl is now widely used in industry, chiefly in the form of various alloys with copper, which possess the hardness, strength and springiness of steel, but which are rust-proof and non-magnetic. The metal is also used in atomic energy plants.

The whole of the beryl produced commercially in New South Wales has been obtained from pegmatite dykes in the Broken Hill district, but a little beryl, some of it of gem quality, has been found in the Torrington and Emmaville districts.

BISMUTH.

The principal ore of bismuth is the native metal but the sulphide, bismuthinite, the carbonate, bismutite and the oxide, bismite are also of some importance as a source of bismuth. The telluride of bismuth, tetradymite, is of fairly common occurrence, but is seldom found in sufficient quantities to be of any commercial value.

Native bismuth has a bright metallic lustre with a definite pink tinge. It is brittle and fairly soft, can be cut readily with a knife and melts easily when heated in a flame. The sulphide somewhat resembles stibnite, the better-known sulphide of antimony, but is rather darker in colour and does not occur in large crystals. It is soft enough to be scratched with the fingernail and also fuses at a low temperature. The carbonate and oxide are dirty white or buff coloured, earthy-looking minerals formed by the weathering of native bismuth or the sulphide, and it is difficult to recognise either of them without chemical tests.

Most deposits of bismuth occur in "pipes" of quartz developed in granites near the junction of the granite mass and the surrounding sedimentary rocks. The "pipes" are irregular in form and twist and turn in an unpredictable manner at a depth. The bismuth is commonly associated with molybdenite, and sometimes with tin or wolfram in the pipes. Bismuth also occurs in regular veins of quartz and sometimes as impregnations in granite.

The chief use of bismuth is for the manufacture of compounds for medicinal use, the well-known carbonate being widely used for digestive disorders. In metallic form, bismuth is used chiefly as an ingredient in a number of "fusible alloys", some of which will melt at a temperature of less than the boiling point of water.

Bismuth has been obtained from many localities in New South Wales, but the mines at Kingsgate near Glen Innes, and Whipstick near Pambula, have been the chief producers. A little has also been won from the Tenterfield, Torrington, Deepwater, Duckmaloi and Murrumbateman districts. Some bismuth occurs in the Cobar copper-gold ores and in silver-lead-zinc deposits at Broken Hill.

CADMIUM.

There are no commercial ores of cadmium. The mineral greenockite, cadmium sulphide, occurs very sparingly in ores of zinc, and the whole of the world's supply of cadmium is obtained as a by-product of the refining of zinc. A quantity of cadmium is thus obtained from the Broken Hill silver-lead-zinc ores. Cadmium is used as a plating metal, chiefly to protect iron and steel from rust and corrosion. It is also used in various alloys, chiefly with copper and some of its compounds are used as pigments.

CHROMIUM.

The only important ore of chromium is the mineral chromite, which is an oxide of iron and chromium. When pure, this mineral contains 68 per cent. of chromic oxide and 32 per cent. of iron oxide, but it usually contains also magnesia, alumina and rather more than 32 per cent. of iron oxide, so that the ores as worked contain considerably less chromic oxide than the figure given. Ores containing over 50 per cent. are considered as high grade and material containing as little as 40 per cent. is saleable. It is a heavy, dense dark-brown to black mineral which can only just be scratched with a knife, and is found in serpentine or other ultra-basic rock in which it generally occurs in the form of lenses or irregular masses.

Alluvial chromite may be found in areas where ultra-basic rocks are undergoing decomposition and releasing their chromite under the action of weathering.

Apart from its use as a source of the metal chromium, which is used in making alloy steels and as a plating metal, chromite is used for making refractory bricks for furnace linings and as the source of chromium chemicals.

Although not a high-priced commodity, the search for deposits of chromite in serpentine areas is worthwhile, as resources of this mineral are not large and any reasonably high-grade material found could be sold readily.

Chromite has been won commercially from the Barraba, Gordonbrook, Nundle, Gundagai and Wallendbeen districts, but the production has always been on a small scale and no large deposits of high-grade ore have yet been discovered in this State.

COBALT.

Few of the cobalt-bearing minerals can be recognised by their appearance, excepting the pink "bloom" referred to below, and chemical tests are necessary for their identification. The most important of the cobalt minerals are smaltite, the arsenide of cobalt, cobaltite, the sulph-arsenide, asbolite, a cobaltiferous oxide of manganese, and erythrite or cobalt bloom, the hydrated arsenate of cobalt. Smaltite and cobaltite are hard white minerals with metallic lustre which look rather like arsenical pyrites. Cobaltite has a faintly reddish tinge which distinguishes it from smaltite. Both minerals, on long exposure to moist air, decompose and yield a pink earthy incrustation of the mineral erythrite. The presence of a bright pink coating on the weathered surface of a hard white metallic-looking mineral is a sure sign of the presence of cobalt Asbolite is a dark-brown to black earthy substance and cannot be identified by inspection. It consists essentially of impure manganese oxide containing from 1 to 2 per cent. up to about 30 per cent. of cobalt oxide. The presence of the cobalt is sometimes indicated by a slight bluish tint on the otherwise black manganese oxide, but the presence of a considerable amount of cobalt is not always to be seen in this manner.

Smaltite or cobaltite may occur in veins of quartz either alone or with other minerals of economic importance such as silver, copper, uranium, lead or zinc, and in many cases cobalt is a by-product of the mining or refining of these other metals. Asbolite may occur in nodular masses or pockets in decomposing basic igneous rocks.

Formerly, the chief use of cobalt was for the production of blue coloured glass and porcelain, and for making driers for paint, but it is now widely used in metallurgy. It is used in the production of special heat-resisting alloys, hard-facing alloys and magnet steels and for electro-plating. The new heat-resisting alloys are used for the blades of the rotors in jet aircraft and this use has resulted in a great increase in the demand for cobalt in recent years and a corresponding increase in price. Cobalt is also required as a trace element in fertilising soils deficient in that element.

A small amount of smaltite has been mined in the Torrington district, and several small lenses of cobaltiferous ore were won from Carcoar in the late '80s. Asbolite occurs sparingly at Port Macquarie and Bungonia, but it is low-grade material and has not been worked commercially. At present the chief source of cobalt in Australia is that recovered in Tasmania during the electrolytic refining of zinc concentrates from Broken Hill.

COPPER.

The copper-bearing minerals vary greatly in appearance, but many of them have a conspicuously bright colour. The commonest and most important, are copper pyrites, a sulphide of copper and iron, and azurite and malachite, both of which are basic carbonates of copper. Other minerals of less importance as ores are bornite, another sulphide of copper and iron, copper glance, a sulphide of copper, and cuprite, an oxide of copper. Copper pyrites is of a deep brassy-yellow colour rather darker than the commoner iron pyrites and often shows an iridescent tarnish, when it is known as "peacock copper ore". It is much softer than iron pyrites and can be scratched easily with a knife whilst iron pyrites can be scratched only with great difficulty. Azurite and malachite, the two carbonates of copper, are blue and green respectively. They are sometimes well crystallised, but more often are earthy in appearance and often are present as mere stains on a rock to which they impart bright-blue or green colouring. The other copper minerals are difficult to recognise by inspection alone.

All copper minerals are dissolved by nitric acid, and yield a green solution. If a knife blade or other object of iron or steel is dipped into an acid solution containing copper, it becomes coated with a film of metallic copper, whilst the addition of ammonia to the solution causes it to change to a deep-blue colour.

Gold is sometimes present in copper ore, which should always be sent for assay for gold as its presence cannot be determined without an assay.

High-grade ores only will pay to send to smelting works for treatment as freight and smelting charges are high. Ores containing less than about 10 per cent. of copper should be concentrated before sale to reject worthless material and thus reduce freight and smelting charges.

Copper ores occur in veins or lenses either cutting across or deposited along the cleavage planes of slates, schists or sedimentary rocks, as replacements along crush zones in sediments, as contact deposits at the junction of igneous and sedimentary rocks and as segregations in igneous rocks.

Copper is one of the most important of the common metals. Its biggest single use is for the production of wire for use in the electrical industry for which purpose its high electrical conductivity renders it particularly suitable. It is also used for making boilers and piping for water and steam, and was formerly used for kitchen utensils on a large scale, but its use for this purpose has now been largely replaced by aluminium. Alloyed with zinc to form brass it has many uses, as in making pipe fittings, parts for motor cars, refrigerators and radios, door and window fittings and for ornamental purposes. In war-time, the consumption of brass for cartridge cases constitutes one of the biggest uses of copper. When alloyed with tin, copper forms bronze which has many uses including bearing metals, castings for marine use and coinage.

Compounds of copper, particularly the sulphate ("blue stone") are used in electro-plating and as a fungicide for orchard and agricultural use.

By far the most important district for copper production in New South Wales has been the Cobar-Nymagee-Tottenham district, with the mines at Cobar as the biggest individual producers. Numerous mines have been worked along the slopes of the Main Dividing Range almost from the Queensland to the Victorian borders of the State. Amongst some of the more important mines in this area have been those at Drake, Burraga and Captain's Flat.

GOLD.

The identification of gold and methods of prospecting for it are described in detail in Chapter VI. It may be mentioned here, however, that nearly all gold occurs in the free or native state and is generally easy to recognise from its typical golden colour and metallic lustre. It occurs in alluvial form resulting from the disintegration of various gold-bearing reefs, lodes, veins and impregnations, and is concentrated by running water in stream beds and by wave action on beaches.

Native gold usually contains a certain amount of silver. The proportion is normally small but it may be so high as to cause the gold to assume a very pale colour. Gold is soft, malleable and ductile and is insoluble in any single acid, although it is dissolved slowly by a mixture of nitric and hydrochloric acids. Both iron pyrites and copper pyrites, which sometimes look like gold, are brittle and are readily soluble in hot nitric acid. Partly decomposed biotite mica often has a golden sheen and is mistaken for gold, but it is readily distinguished from its low specific gravity, being "lively" when shaken up with water in a prospecting dish, whereas gold, owing to its great weight, sinks rapidly to the bottom of the dish.

Gold is extremely widely distributed in nature and there are few rocks or soils which do not contain a trace of it, but it is only in places where it has been concentrated into a definite deposit that it is of any commercial value.

The principal types of deposit are as follows:—

(1) Detrital or alluvial deposits—See Chapter VI.

(2) Lodes or veins of gold-bearing quartz occupying fissures or joints in rocks.

(3) Veins or reefs lying between bedding planes of altered sedimentary rocks. If folded or contorted these become "saddle reefs".

(4) Replacement deposits usually formed by selective replacement of some particular bed in a series of sediments by sulphide minerals which may carry gold.

(5) Contact deposits formed at the contact of igneous intrusions.

(6) Impregnations of gold in the form of tiny particles scattered through rocks.

(7) Irregular "pipes" in siliceous granite.

Apart from its uses in coinage and jewellery, gold has several minor but important applications. It is used in dentistry and in certain scientific apparatus on account of its resistance to corrosion and non-tarnishing properties, and is used as a coating metal both for its decorative and protective qualities. Compounds of gold find some application in pharmacy and photography.

It is not possible in a short note to list more than a few of the more important occurrences of gold in New South Wales. Amongst the alluvial fields, those in the Bathurst-Orange, Parkes-Forbes-Wellington, Araluen-Braidwood, Gulgong, Grenfell, Adelong, Kiandra, Temora and Uralla districts may be mentioned, whilst some of the more important lodes have been worked at Hill End, Lucknow, Lyndhurst, Cobar, Mount Boppy, Yalwal, Pambula and West Wyalong

See also Chapters I and III for further information on occurrences of gold.

IRON.

The principal ores of iron are the oxides, hematite and magnetite, the hydrated oxide, limonite, and the carbonate, siderite. When pure, hematite contains 70 per cent. of iron and magnetite 72 per cent., limonite about 60 per cent. and siderite 40 per cent. The ores as mined contain less iron than the above, owing to the presence of more or less of the earthy impurities such as quartz and clayey matter. As mined, the better grades of ore contain from about 50 per cent. to 65 per cent. of iron. The exact content of iron is of less importance than freedom from objectionable impurities such as sulphur and phosphorus, which must not exceed a trace if the ore is to be used for making high-grade steel. Under certain circumstances, a higher phosphorus content is allowable, as for the manufacture of high-phosphorus pig iron.

Hematite is usually dark steel-grey in colour but may have a red colour. It is usually hard and heavy but may be soft and earthy, but when scratched it always yields a red powder.

Magnetite is hard, heavy and black in colour and the powdered mineral is also black. It is readily attracted to an ordinary magnet, and specimens of some varieties, known as "lode stone" behave like magnets and will attract small pieces of iron or steel.

Limonite is usually a rusty-brown in colour, although its colour varies from yellow to chocolate-brown. When crushed, the colour is always lighter than the mineral in solid form.

Siderite (also known as chalybite) is very variable in appearance and chemical tests may be necessary for its recognition.

There is little demand for iron ores for iron and steel from New South Wales as the Steelworks at Newcastle and Port Kembla draw practically all their supplies of ore from the high-grade deposits in South Australia and the north-west coast of Western Australia.

Whilst deposits of ironstone of a grade suitable for smelting occur, most of them are of no interest, as unless a deposit contains several million tons of high-grade material and is situated in an easily accessible locality where mining and freight costs are low, it is of no commercial value. It must be remembered that iron ores are low in price and high freight and mining costs cannot be met.

All of the principal deposits of iron ore in New South Wales have been investigated, and whilst it is recognised that in the aggregate several millions of tons are available, none of them offer attractive conditions for commercial working as they are so small or so badly situated that the attendant costs of winning and freighting are relatively high.

There is a small demand for high-grade magnetite for use in heavy-medium coal washing plants which have been established to clean certain high-ash coals. This market is relatively new and no indication of its ultimate importance can be given, but a few thousand tons a year will probably be required. Iron oxide, used for gas purification and cement manufacture, is also produced from N.S.W. deposits.

A small amount of ironstone is ground for use as paint pigment—see under "Pigments" in section on Non-Metallic Minerals.

LEAD.

The chief sources of lead are the minerals galena and cerussite. Galena, sulphide of lead, contains, when pure, 86 per cent. of lead and is by far the most important of the lead-bearing minerals. It often occurs in fairly large crystals, which exhibit perfect cubic cleavage but may also be found in fine grained massive forms. It is silvery-white with a bright metallic lustre when freshly broken, but soon tarnishes to a dull lead-grey. It is soft enough to be scratched with a knife, and melts readily. On heating it gives fumes of sulphur and is easily reduced to metallic lead. Like all the lead-bearing minerals it is conspicuously heavy. Cerussite, the carbonate of lead, is formed by the oxidation of galena. It is a glassy-looking brittle mineral which is generally white or colourless, but it may occur in an earthy form. It is fairly soft and heavy, but is difficult to recognise without chemical tests.

Other lead-bearing minerals are pyromorphite (chlorophosphate of lead), anglesite (the sulphate), wulfenite (molybdate of lead), stolzite (tungstate of lead) and minium (red oxide of lead).

Lead ores are of interest to prospectors and small-scale mining syndicates, owing to the ease with which high-grade concentrates may be obtained either by hand-picking or mechanical concentration and, in times of high lead prices, even very small veins of lead ore are profitable to work provided the ore produced is free from harmful impurities. Lead ores or concentrates containing 20 per cent. or more of lead are readily saleable, but penalties are incurred for the presence of over 1 per cent of arsenic or a mere trace of bismuth.

Lead ores often contain minerals of other metals. More or less silver is invariably present whilst zinc blende, copper pyrites, iron pyrites and arsenical pyrites are often present. Such mixed ores are difficult for the ordinary small-scale operator to treat, but they provide by far the greater proportion of the lead won throughout the world. The subject of these ores is dealt with in some detail under "Silver" and "Zinc".

Ores of lead occur either in distinct veins or lenses or as replacement of beds of sedimentary rocks.

Lead is a metal which is very widely used in industry. Amongst its most important uses are: lead plates for car and lighting batteries, as a sheathing for electric and telephone cables, as sheet lead for building purposes and the construction of acid-proof ware. Its high specific gravity renders it highly suitable for such purposes as making balance weights, ballast for boats and for bullets and shot. It alloys with the other soft metals and is widely used in alloys such as type metals, bearing metals, solders and pewter. Compounds of lead form useful paint pigments, the basic carbonate known as "white lead" and the red oxide called "red lead" being the ones most used. Lead compounds are poisonous and utilised in the manufacture of agricultural insecticides, lead arsenate being widely used for pest control on growing crops. Compounds of lead find wide use in the glass, rubber and chemical industries.

Lead ores have been mined at a very large number of localities in New South Wales. The chief ones are mentioned under the heading "Silver".

MANGANESE.

Although manganese is a constituent of many minerals and occurs sparingly in nearly all rocks, it is only the oxides which are of any commercial value as a source of this metal. The principal oxides are pyrolusite, psilomelane and manganite, whilst the varieties known as wad, braunite, hausmanite and polianite are of less importance. When pure, the oxides contain approximately 60 per cent. of manganese but the oxygen ratio varies from one mineral to another. Usually water, iron and silica are present and reduce the content of manganese. Typically all the manganese oxides are black, but may be dark steel-grey or somewhat brown in tint. They vary from a soft sooty form to hard and flinty in texture and are seldom to be found in pure form. Several different manganese minerals may be found in a single lump of ore. Besides the oxides, the carbonate rhodocrosite and the silicate, rhodonite are of fairly common occurrence, but are of no commercial value as a source of manganese.

All of the commercially-worked deposits of manganese oxide are the result of the weathering of manganese-bearing rocks and minerals and are essentially surface deposits. Some of them have been deposited in the form of more or less flat bedded sediments or as residual sheets, whilst others, as in the case of most of those worked in New South Wales are the result of the weathering of veins of rhodonite associated with intrusions of granite into sedimentary rocks. The best material in these veins occurs quite close to the surface and at a depth the black oxide can be seen to be forming from the worthless pink silicate. The depth of weathering is not great and useful material is seldom found as deep as 50 feet below the surface.

The chief uses of manganese are in the iron and steel industry where it is used partly as an addition to the metal to neutralise the bad effect of sulphur present either in the ore or the coke used for smelting, or to form a definite alloy with the steel, manganese steels being hard and wear-resisting. Much of the manganese used by the iron and steel industry is used in the form of manganiferous iron ores containing from 5 per cent. to 20 per cent. of manganese, but a large part is supplied in the form of artificially prepared ferro-manganese.

A large amount of high-grade manganese oxide is used in the manufacture of dry batteries in which the oxygen content of the mineral acts as a depolariser, combining with the hydrogen evolved. For this purpose the content of oxygen should be as high as possible and buyers usually demand a minimum of 75 per cent. manganese dioxide. Smaller amounts of manganese are used in the glass, ceramic, paint and chemical industries.

Ores of manganese, chiefly in the form of small deposits are widely distributed throughout New South Wales, the most important ones worked have been in the Tamworth-Walcha, Barraba, Grenfell and Parkes districts.

MERCURY.

The only important ore of mercury is cinnabar, a dark-red, heavy, semi-transparent mineral which when scratched yields a vermillion coloured powder. It occurs in veins, usually in the form of small crystals or grains scattered through the gangue or may occur in the form of disseminations in quartzite or granite. Other sulphide minerals such as iron pyrites, copper pyrites and marcasite are sometimes present, and bituminous material is also present in some deposits. Although cinnabar is a soft mineral, it is chemically fairly stable and it is sometimes found in alluvial deposits.

Mercury is used in the recovery of gold and silver from their ores by the amalgamation process, and is used in the electrical industry chiefly in switches and mercury vapour lamps. It is widely used in thermometers and scientific instruments and is important in dentistry. Compounds of mercury are used in explosives and the chemical industry.

The principal deposits of cinnabar in New South Wales have been those in the Pulganbar and Yulgilbar district on the upper reaches of the Clarence River, but small quantities have been reported from Bingara, Orange, Broken Hill and the Cudgegong River. Production of mercury has always been on a very small scale in the State and none has been produced for many years on a commercial scale. Although the price of mercury fluctuates widely, any deposit containing a reasonable quantity of 1 per cent. ore would be attractive.

MOLYBDENUM.

The most important source of molybdenum is the mineral molybdenite, sulphide of molybdenum. This mineral is easily recognisable as it occurs in the form of scales or flakes, often of considerable size, which have a strong resemblance to pieces of lead foil. It has a bright metallic lustre and is almost white when first mined, but soon tarnishes to a dull lead-grey. It can be split into thin flexible leaves which are soft and will mark paper. It resembles graphite in general appearance, but the latter mineral is darker in colour and flakes of graphite lack the flexibility of molybdenite. It is not conspicuously heavy, and its comparatively light weight combined with its showy appearance makes it very easy to over-estimate the richness of its ores. Molybdite, also known as molybdic ochre, is a brilliant yellow earthy-looking hydrated molybdate of iron formed by the weathering of molybdenite. Other molybdenum minerals are powellite, calcium molybdate and wulfenite, molybdate of lead, which are of no importance as sources of molybdenum.

Molybdenite occurs in "pipes" or veins of quartz in granite masses near their junction with sedimentary rocks, in pegmatite, aplite or granite veins or dykes, as segregations in granite, in contact deposits at the junction of granite or porphyry with limestone, claystone or other sedimentary rock or as a minor constituent of sulphide ore bodies. Bismuth is a common associate of molybdenite in the "pipe" deposits, some of which produce ore of high grade. The contact type of deposit usually contains calcite, wollastonite, actinolite, garnet and quartz with the molybdenite scattered through the mass in an irregular manner in the form of small flakes. The grade of such ore is usually low.

Molybdenite ores are not saleable in their crude state; buyers require concentrates containing a minimum of 85 per cent. of molybdenum sulphide. In the case of coarse grained ores concentration may sometimes be effected by hand picking, but ores are generally concentrated by the flotation process, as molybdenite is one of the most readily floatable minerals.

The chief use of molybdenum is in the production of alloy steels and it is also used as an addition to certain types of cast iron. Compounds of molybdenum are used in analytical chemistry and also in the dyeing industry. Molybdenum is used as a trace element in fertilisers added to soils deficient in the metal.

The largest proportion of the molybdenite produced in New South Wales has been obtained from Kingsgate near Glen Innes and Whipstick near Pambula. Numbers of small mines have been worked in the New England district, chiefly in the vicinity of Tenterfield and Deepwater, and the large contact deposits near Yetholme in the Bathurst district have been opened up but abandoned as unpayable.

MONAZITE.

See under "Thorium", also "Zircon-Rutile-Ilmenite".

NICKEL.

The nickel-bearing minerals are, in general, difficult to recognise by their appearance and no deposits of commercial importance have yet been discovered in New South Wales. The most important of the nickel-bearing minerals are the sulphides and the arsenides, but the bright green silicate of nickel and magnesium known as garnierite is an important source of nickel in New Caledonia. The sulphides and arsenides all have a metallic lustre, and are not readily identified by appearance alone. The sulphides, millerite and pentlandite, both look like iron pyrites although their crystal form is different. The arsenide, nicolite or kupfernickel, has a peculiar reddish-bronze colour and chloanthite, another arsenide, is white in colour and resembles arsenical pyrites in general appearance. Much of the world's supply of nickel is obtained from nickel-bearing pyrrhotite which is essentially a sulphide of iron. These primary nickel minerals, on weathering give rise to the so-called "nickel blooms" which are apple-green earthy incrustations of nickel carbonate, sulphate or arsenate, and it is the appearance of these green stains, which are of an entirely different appearance from the familiar copper stains, which leads to the discovery of nickel-bearing ore bodies.

Nickel often occurs with cobalt and specimens of nickel-bearing minerals have been recorded from Broken Hill, Bingara, Captain's Flat, Junee, Kempsey, Moruya, Murrumbateman, Oberon, Tarago, Tumbarumba and Windeyer.

Nickel is used chiefly in the manufacture of alloy steels and as a plating metal, and is also used for coinage.

Ores of nickel are difficult to treat for the recovery of the metal and are not readily saleable through ordinary channels, but a large deposit of ore of a reasonably high grade would be of commercial interest.

PLATINUM AND THE PLATINOID METALS.

The elements platinum, palladium, rhodium, iridium, osmium and ruthenium are referred to as platinoid metals. They are all hard and heavy and are white in colour, and occur in nature chiefly in the form of the two alloys native platinum and osmiridium. Native platinum consists mainly of platinum with a little of the other platinoid metals and often some iron, copper and sometimes gold. It is silver-white in colour, fairly hard and malleable, has a specific gravity of about 19 and melts only at a white heat. Osmiridium is an alloy of osmium and iridium, and is white in colour, has a very high specific gravity and is hard and brittle. It has a very high melting point and is even more difficult to fuse than is platinum.

The chief sources of platinum and osmiridium are alluvial deposits in which both metals occur chiefly in the form of small irregular grains although small nuggets are occasionally found. The alluvial deposits are associated with ultra-basic rocks such as serpentine and such rocks were the original source of the metals. Platinoid metals also occur in traces in certain sulphide ores, particularly the copper-nickel ores of Sudbury, Ontario, which is an important source of supply.

Platinum and the other platinoid metals are used in the electrical industry and for jewellery, and also in the chemical industry and in scientific instruments. Their good electrical conductivity, strength and resistance to chemical corrosion make them useful for a wide range of industrial applications. They are also used in finely divided form as catalysts in the chemical industry.

The only commercial production in New South Wales in the past has been from the Fifield district and the beach sands of the North Coast, although both platinum and osmiridium have been found in alluvial gold from many parts of the State. A little platinum has been produced during the course of gold dredging operations on the Macquarie River at Wellington. Platinum has been recorded as occurring in association with copper at Little Darling Creek and Mulga Springs near Broken Hill and at Red Hill in the same district.

RADIO-ACTIVE MINERALS.

See under "Thorium" and "Uranium".

RUTILE.

See under "Zircon-Rutile-Ilmenite".

SILVER (See also under "Lead" and "Zinc").

Silver occurs in nature in metallic forms as native silver and also alloyed with gold. There are many silver-bearing minerals, the principal ores being the sulphides, arsenides and antimonides and the halides of the metal. A very large proportion of the silver produced throughout the world is obtained from argentiferous galena in which it is present in microscopic particles of silver sulphide or in solid solution in the galena. The mineral fahlore or tetrahedrite, a sulphide of copper and antimony, also often contains a considerable amount of silver. The silver sulphides, arsenides and antimonides are sometimes primary, but may occur in the form of secondary enrichments near the surface of an ore body. The iodide, chloride, bromide and chloro-bromide of silver are secondary minerals formed during the weathering of silver-bearing ores, and much of the native silver so far won has also been of secondary origin.

Native silver possesses the usual properties of metallic silver. It is white in colour, fairly soft and malleable, and usually occurs either in flat platy or wiry form and is normally tarnished black so that the white colour is not seen unless the metal is scratched. The sulphides, arsenides and antimonides are grey and have a metallic lustre, which soon becomes dull owing to tarnishing. The chief of these minerals are:—argentite, sulphide of silver, proustite, sulph-arsenide of silver, pyrargyrite, sulph-antimonide of silver and dyscrasite, antimonide of silver. There are also a large number of complex sulphides containing silver, lead, antimony and copper. The halides of silver are iodyrite, the iodide, cerargyrite, the chloride, bromyrite, the bromide, and embolite the chloro-bromide. These are waxy-looking minerals which are usually yellow, green to pale-brown when freshly broken, but which darken on exposure to light. They are fairly soft and are sectile and feel somewhat like horn when being cut by a knife and are sometimes called "horn silver".

The silver minerals are often found concentrated in rich patches in the upper weathered portions of argentiferous lead ore bodies, and when first worked such bodies are regarded as of value chiefly for their silver content. With increased depth, the silver minerals become scarcer and when unaltered sulphides of lead are encountered the silver value is generally so low that the ore is regarded as a lead ore, the value of the latter metal being of more importance than the silver present. These sulphide ore bodies often contain a considerable amount of zinc present as sphalerite, the sulphide, and are then referred to as silver-lead-zinc ores. They may occur as vein fillings or more commonly as replacements in closely folded sedimentary rocks.

The recovery of silver from its ores presents many difficulties and is more complex than the extraction of almost any of the commoner metals. In the rich secondary deposits, large masses of the minerals may sometimes be separated by hand picking, but mechanical concentration, smelting, amalgamation and cyanidation processes are all used. In the case of the complex sulphide ores, the usual method of treatment is crushing followed by selective flotation to produce separate concentrates of lead and zinc followed by smelting operations which produce a silver-lead bullion from the lead concentrate and metallic zinc from the zinc concentrate.

The chief uses of metallic silver are for coinage, jewellery and plate and a very large proportion of all the silver produced is used in the form of compounds of silver in photography. Silver in its pure form is referred to as "fine silver". It is too soft and weak for use in coinage and for most jewellery purposes, and a small amount of copper is generally alloyed with silver to harden and strengthen it for such uses. The alloy most commonly used for jewellery contains 92.5 per cent. of silver and 7.5 cent. of copper and is known as "sterling silver". The proportion of silver present in alloys used for coinage differs in various countries but is generally lower than that used for jewellery. Silver compounds are used in medicine and the chemical industry and an important use is in the silvering of mirrors.

The chief silver producing centre in New South Wales is Broken Hill, where large bodies of silver-lead-zinc ores are being mined. Other mines have operated at Captain's Flat, Yerranderie, Howell, Rivertree, Drake, Cobar, Sunny Corner, Leadville, Condobolin, Moruya, Boro Creek, Pye's Creek, Peelwood, Marulan and Glen Innes.

TANTALUM AND COLUMBIUM.

These two metals are found chiefly in the minerals tantalite and columbite, the former being essentially a tantalate of iron and the latter a columbate of iron. Tantalite invariably contains some columbium and columbite contains some tantalum, the two minerals being the end members of a series of minerals which contain all possible proportions of the two metals. Both minerals are hard, heavy, black in colour and look rather like wolfram, although their cleavage is less perfect than that of the latter mineral. Neither mineral can be identified with any certainty from its appearance and their identification is difficult even by means of chemical tests.

Both minerals occur in pegmatite dykes, but they are not common and even in productive deposits their distribution is very irregular.

Tantalum and columbium (also known as niobium) are used chiefly for the production of hard alloy steels, and carbides of both metals are prepared for use as tips for cutting tools. Both metals are strong, hard and very resistant to chemical attack and are used in chemical and electrical apparatus where such properties are desired. Tantalum sheet and wire is used in surgery for the repair of shattered bones and tissues as the metal may be left embedded in the body indefinitely without ill effects owing to its high resistance to corrosion.

The only known occurrences of these two minerals in New South Wales are in the Barrier Ranges in the Broken Hill district.

THORIUM.

The only commercial source of thorium is the mineral monazite which is essentially a phosphate of the cerium metals but which generally contains some thorium as an impurity. The thorium content varies from under 1 per cent. to over 10 per cent. Monazite is a yellow to brown semi-transparent mineral with a resinous to glassy lustre. It occurs in the form of crystals and grains scattered as a minor constituent through certain granites and also in quartz veins traversing granite or sedimentary rocks near the margin of a granite mass. When it occurs in quartz it sometimes is found in the form of crystals up to several inches in length. Most of the monazite of commerce is obtained from alluvial deposits as a by-product of the winning of tin or gold or as a constituent of heavy beach sand concentrates. It is fairly strongly radio-active but the degree of radio-activity depends chiefly on the thorium content. It is worked for its cerium content as well as its thorium. The cerium is used in special alloys chiefly as a de-oxidising agent and in the production of sparking "flints" for cigarette and gas lighters. The oxide of cerium is used in making certain types of glass, chiefly for optical appliances.

Thorium was formerly used extensively in the manufacture of gas mantles owing to the fact that when thorium oxide is heated by a flame it emits an intense white light. The present interest in thorium lies chiefly in its radio-activity and the possibility of its use as a source of atomic energy. Although it, like uranium, undergoes radio-active decay and theoretically should be useful, present activities in atomic energy research are centred on uranium and there is little demand for thorium. Monazite is, however, readily saleable chiefly for use as a source of cerium.

A small amount of monazite has been obtained in New South Wales in tin concentrates from the New England district and from the zircon-rutile-ilmenite sands from the beaches on the North Coast. It is very widespread in its occurrence and traces of it are to be found in most rocks and alluvial materials. Monazite occurs in pegmatitic lodes in the Broken Hill and New England districts.

TIN.

The only important source of tin is the mineral cassiterite or tin-stone. Stannite, a sulphide of tin, copper and iron, is one of the few other tin-bearing minerals, but is of little value as an ore of tin. Cassiterite varies greatly in appearance. Its colour varies from white, through shades of grey, yellow, reddish-brown to black. It is hard and very heavy and when freshly broken often has a glassy lustre. A constant characteristic is that when crushed, even the dark varieties always yield a light coloured powder, and this property serves to distinguish it from the common oxides of iron which give a black, dark brown or dark red powder.

Tourmaline, which is often mistaken for cassiterite, is much lighter in weight, often forms radiating needle-like crystals and a thin splinter of it is fusible in the flame of a blowpipe, whereas cassiterite is infusible. An easy method of identifying cassiterite is to place a little of the crushed mineral on a piece of zinc or clean galvanised iron and to cover it with a few drops of hydrochloric acid, when the mineral will become coated with a film of grey metallic tin. This simple test is particularly useful for the identification of cassiterite in fine-grained sands.

Cassiterite occurs in veins or lodes of quartz, as impregnations in granite or sedimentary rocks near a granite mass, in pegmatite dykes, in "pipes" in granite and in irregular networks of small veins called "stockworks". In all cases granite is regarded as being the ultimate source of tin. Wolfram is often associated with tin, and less common associates are molybdenum, bismuth and arsenical and iron pyrites. Cassiterite is almost indestructible under the action of the weather, and passes unchanged into alluvial deposits on the decay of the lodes and surrounding rocks. A very large proportion of the world's supply of tin is obtained from alluvial sources.

The chief uses of tin are in the production of tinplate and alloys such as solders, bearing metals, pewter, type metal and bronze. Tin oxide is used as a polishing powder under the name of "putty powder" and is also used as an opacifier in vitreous enamels, and compounds of tin are used as mordants in the dyeing and textile industries.

The chief producing centres in New South Wales have been in the New England district, where both alluvial and lode deposits have been worked. From a point a little to the north of Tamworth, tin bearing rocks occur, with breaks, over a belt of country about 30 miles wide extending northwards to the Queensland border where it joins the tin-mining districts around Stanthorpe. Within this area lie Bendemeer, Inverell, Emmaville, Tingha, Torrington, Deepwater, Oban, Pheasant's Creek and Wilson's Downfall, all of which have been centres of tin production. Tin ore is being produced in the central to south-west part of the State at Tallebung and Ardlethan, and other deposits in this belt are known at Gibsonvale-Kikoira, Conapaira, Erigolia, Buddigower and Holbrook. Tin mines were once worked at Euriowie in the Barrier Ranges. Traces of fine grained tinstone occur in the heavy beach sands of the North Coast but are of no commercial importance.

TITANIUM.

See under "Zircon-Rutile-Ilmenite".

TUNGSTEN.

Wolframite, tungstate of iron and manganese, and scheelite, tungstate of calcium, are the two chief sources of tungsten. Ferberite, tungstate of iron, and hubnerite, tungstate of manganese, may be regarded as special varieties of wolframite. Stolzite, tungstate of lead, does not occur in sufficient quantity to be regarded as an ore of tungsten. Wolframite is a very heavy, hard black mineral, which has perfect cleavage and breaks readily into flat flakes which have a bright lustre. It can just be scratched with the point of a knife and yields a brownish red powder when crushed. The bladed character of any large crystals is easily recognised.

Scheelite is typically white to buff in colour but may be colourless. It is relatively soft and can be scratched readily with a knife. It has a peculiar greasy or resinous lustre which distinguishes it from quartz, calcite or barytes which it otherwise resembles in appearance. Like wolframite it is also conspicuously heavy. Under the action of short-wave ultra-violet light it fluoresces strongly and "black lamps" of a suitable type are useful in the search for scheelite. See also Chapter VI for notes on "Prospecting for Scheelite with Ultra-Violet Light".

Wolframite occurs chiefly in quartz veins associated with granite and sometimes in lodes with sulphide minerals. It also occurs in pegmatite dykes and quartz "pipes" and sometimes in finely divided disseminations through rocks. It is often associated with tin.

Scheelite occurs in a similar manner to wolframite, but also occurs in contact deposits in metamorphosed limestone. These contact deposits are sometimes of large size but are generally low in grade. Both wolframite and scheelite may be found in alluvial deposits, but such deposits are of less importance than reefs or lodes as a source of tungsten.

Tungsten is used in the steel and electrical industries chiefly. The chief use in the steel industry is as an ingredient of hard "high speed" tool steels which contain up to about 30 per cent. of tungsten. It is also used for making tungsten carbide, an extremely hard substance used for the cutting tips of tools, including drill bits. In pure metallic form, tungsten is used as filaments in electric lamps, as electrodes in vacuum tubes, as targets in X-ray tubes and for contact points in switches and current breakers such as the "make and break" points in motor cars.

From the above uses it will be seen that tungsten is a valuable metal and its price is therefore high. The demand for the ores, however, is variable and price fluctuations are rapid and wide. The ores are always sold as concentrates and the price is based on the content of tungstic acid present. Concentrates containing less than 65 per cent. are difficult to dispose of and penalties are imposed for the presence of impurities such as traces of arsenic, sulphur, copper and phosphorus. The separation of impurities from tungsten ores often presents great difficulties.

The chief production of tungsten ores in New South Wales has been from Torrington and Hillgrove, wolframite having been obtained from the former locality and scheelite at the latter. Scheelite has also been worked at Nundle, Barraba, Frogmore, Rye Park and Walang. Small amounts of wolfram, often associated with tin, have been won from many other localities including Albury, Holbrook, Taleeban, and Tallebung, but the production as yet has not been important.

URANIUM.

Uranium is a metal which normally undergoes a slow form of disintegration, liberating a large amount of energy in the process, passing through a number of stages, and finally changing to the inactive end-products, lead and helium. This disintegration is very slow and the liberation of energy is normally at such a low rate that it is not practicable to harness it commercially; but it is now possible to speed up the process and to control the rate so that the vast amount of energy locked in the atoms may be used either destructively, as in the atomic bomb, or constructively, as for the generation of electric power.

Uranium is not found in metallic form in nature, but occurs in certain minerals which when found in sufficient concentrations, constitute the ores of this metal. Quite a large number of uranium-bearing minerals are known, but many of them contain such a low content of the metal, or are combined with other metals in such a form as to make its extraction very difficult, that they are of little interest as a commercial source of the metal.

The bulk of the uranium of commerce is obtained from the primary mineral uraninite (of which pitchblende is a variety), or from carnotite, tyuyamunite, autunite and torbernite which are secondary minerals derived from the alteration of other minerals.

Information on the identification and radio-metric assaying of uranium ores will be found in Chapter VI.

Description of the Principal Minerals of Uranium

Uraninite (*Pitchblende*).—Uraninite is the most important of all the uranium minerals and is composed chiefly of the oxide of the metal.

The name pitchblende is commonly used for varieties of uraninite occurring with sulphides and arsenides. Uraninite or pitchblende is a heavy, hard, black mineral with a pitch-like to metallic lustre and is opaque. In general appearance it is not unlike tourmaline, cassiterite, wolfram or tantalite, for any one of which it might easily be mistaken on casual inspection. There are no simple tests which can be applied for the rapid determination of this mineral. Any hard, heavy, black mineral occurring in a lode formation or in a vein of pegmatite should be investigated, particularly if its weathered surfaces are coated with a bright yellow or orange powdery deposit of some decomposition product. Such coatings of secondary material are the only features of uraninite which are sufficiently characteristic to attract the attention of prospectors. Traces of uraninite have been found in New South Wales at Carcoar, Whipstick and Broken Hill, and some pitchblende may occur at Blackfellow's Dam near Bobadah.

Davidite.—An Australian source of uranium is the mineral davidite, occurring at Radium Hill in South Australia, 20 miles from the New South Wales border and in rocks similar to some of those present in the Broken Hill field. Davidite is a complex titanium-iron mineral containing uranium oxide. It is black in colour, hard and glassy to sub-metallic, and when crushed is attracted by a powerful hand-magnet. Davidite is also present in the Cloncurry–Mt. Isa district of Queensland, and has recently been found in the Thackaringa area of the Broken Hill district.

Carnotite and Tyuyamunite.—These are bright, yellow earthy or waxy-looking minerals which occur in the form of a powder or as small scales. Carnotite is a vanadate of uranium and potassium, and tyuyamunite is a vanadate of uranium and lime. They occur either as coatings on primary uranium minerals or scattered through porous rocks associated with other uranium minerals. At Radium Hill and in the Broken Hill district, carnotite occurs as yellow coatings on davidite.

Autunite and Torbernite.—These two minerals are sometimes called "uranium micas", from their occurrence in platy or micaceous form. The former is a bright lemon yellow in colour and the latter is a distinctive emerald green. Both minerals are quite soft and may be pulverised with the fingers. Autunite is a phosphate of uranium and lime and torbernite is a phosphate of uranium and copper. Both minerals occur as alteration products from primary uranium minerals, and they often are found together in the one deposit. They form tiny scales and crystals on cracks or joints in rocks but may occur in the form of larger masses or veins, or scattered throughout a rock mass. Both minerals occur, for example, at Mount Painter in South Australia, and at Rum Jungle in the Northern Territory. In N.S.W. torbernite and autunite have been found in the New England, Broken Hill, Carcoar, Bobadah and Pambula districts. Autunite fluoresces under the ultra-violet lamp, as described in Chapter VI under the heading "Identification of Radio-Active Minerals".

Uranium Ochres.—These are field names for secondary uranium-bearing substances which consist of uranium oxides usually combined with other elements such as calcium, phosphorus, barium, lead and thorium. Uranium ochres occur in the oxidised zone of lodes which carry uraninite at depth, and they may be associated with gossan or ironstone. For example, a bright yellow powdery ochre may be present, resembling carnotite but differing from the latter in being fluorescent. Uranium ochres are known to occur in the New England district, and probably near Bobadah.

Mode of Occurrence of Uranium Minerals.

Uranium is not a rare element. In the rocks of the Earth's crust, it is nearly 1,000 times more abundant than gold, 100 times more abundant than silver, and about as abundant as tin. But it is a very dispersed element, and not nearly so prone to form large economic concentrations as some other metals such as lead, silver, gold and copper. Moreover, many of the uranium minerals are chemically unstable, and the solubility of uranium salts leads to migration in solution, which may be followed by fixation in some favourable environment well removed from the primary source.

Uranium can occur in a wide variety of environments, and in New South Wales has been shown to exist in a range of rock ages from Precambrian to Permian.

Based on known occurrences in the State, the following generalisations may be some guide to uranium prospectors:—

1. Uranium deposits are commonly associated with such structural features as faults, shears and brecciated zones. Secondary minerals (e.g., torbernite) may be found on bedding and cleavage planes in sedimentary rocks and on joints in granitic rocks. Therefore, these features are favourable points of search, particularly where they occur in rock types and with minerals as described below.

2. Uranium may occur in almost any type of rock. Granites and associated acid igneous rocks may be favourable; in particular, the margins, roofs and contacts of granite masses, and pegmatite, aplite and greisen dykes. Also in granitised rocks and in sedimentary belts not far removed from granite masses.

   In areas of sedimentary rocks, the more favourable types include schists and slates.

3. In known mineral fields, all old mines, prospects, dumps and gossans should be examined; but in such areas the search should not be restricted merely to old workings. The most common or significant metallic mineral associates are cobalt, copper, iron, silver-lead-zinc, tin, tungsten, molybdenum and bismuth.

   Associated nonmetallic or gangue minerals of special interest are quartz (particularly blue, glassy or smoky varieties), felspar (particularly reddened felspars), fluorite (particularly of dark purple colour), biotite, zircon, chlorite, beryl, rutile and iron or iron-titanium minerals (ilmenite, hematite, magnetite, etc.).

The secondary alteration products, often of bright and striking colours (yellow, green, orange, red) may be a good guide to the prospector. They are formed by the weathering of the primary minerals, at the surface or in the zone of oxidation, and may occur as incrustations on the surface of rocks or minerals, as deposits in cracks or joints, or scattered evenly through porous rocks. The presence of small amounts of these secondary minerals does not necessarily mean that large deposits of the primary minerals exist nearby, for the original minerals may have been very sparsely scattered through the rocks, and the secondary minerals may have been concentrated in the position found by the agency of circulating ground water. The process of formation of the secondary minerals consists firstly of the breaking down of the primary minerals by acid constituents dissolved in the underground water and the leaching out of all or part of the uranium by the water. The solution may travel for some considerable distance before depositing the uranium as a secondary mineral owing to chemical precipitation or evaporation of the water.

In a few rare instances, radio-active material in solution may be carried into swamps or lakes and may then be deposited in carbonaceous muds. Such muds, on consolidation, give rise to deposits of radio-active peat or lignite, examples of which are known in Sweden, Madagascar and U.S.A.

Some of the rarer primary minerals of uranium which are found particularly in pegmatite dykes have not been described in this article because they are usually sparse in distribution and not normally in sufficient concentration to be of commercial importance. However, any heavy or dark-coloured minerals occurring in pegmatite should be examined for possible uranium content.

Uranium Distribution in New South Wales.

The main uranium-bearing mineral fields in New South Wales are the Broken Hill and New England districts, in the far-western and north-eastern portions of the State respectively. In addition, uranium mineralisation of some significance occurs at Carcoar and near Condobolin in the central west. Uranium minerals are known as Whipstick (near Pambula) on the far South Coast, and at Gordonbrook on the far North Coast.

Broken Hill.—It was natural that, as far as New South Wales was concerned, attention should focus early on the Broken Hill mineral field, for the geological age and general rock and mineral environment of the Barrier Ranges which surround Broken Hill was known to be the same as for Radium Hill and other South Australian occurrences at no great distance across the border.

The great silver-lead-zinc ore-bodies of the main line of lode at Broken Hill contain only minute traces of uraninite. Elsewhere in the district, there are about eight widely separated localities where radioactivity occurs and definite uranium minerals (mostly secondary) have been determined. There are other areas where radioactivity is present but where definite uranium minerals have not yet been isolated, or where thorium-bearing minerals such as monazite are the chief cause of radioactivity. In one instance, at Copper Blow, the uranium mineralisation is associated with that of copper and iron; in several other cases (e.g., Great Western and Hen-and-Chickens Mines), the association is with silver-lead-zinc and iron; while some deposits are in localities devoid of any previous mining and unassociated with other economic minerals (e.g., Mundi Mundi and Eldee Creek areas).

One of the most interesting occurrences is a davidite belt in the Thackaringa area west of Broken Hill. It is perhaps a hopeful sign for future prospecting that this particular zone was not discovered until 1955, yet it is only several hundred yards from the main Broken Hill-Adelaide road. Davidite is the ore mineral at Radium Hill, and the rock and mineral associates at Thackaringa strongly resemble those of Radium Hill.

All of these Broken Hill occurrences mentioned above occur within Pre-Cambrian rocks. Moreover, with one possible exception, they are confined to the older or Archaean group of rocks known as the Willyama Complex. The exception (at Corona) is a minor showing of rutherfordine in dolomite of the Torrowangee Series, which are Upper Pre-Cambrian beds. In all cases in the Broken Hill field, there is some association between uranium mineralisation and structural features such as shear zones, faults and jointing.

New England.—In the New England district, secondary uranium minerals such as torbernite and autunite have been found in a number of localities, either in lodes within granite or at the contact of granite with sedimentary rocks which the granite has intruded. Several types of granite are recognised in the New England district, but the uranium mineralisation is associated especially with a coarse-grained biotite granite (often called the "tin" granite) and in particular with late- and post-magmatic phases such as pegmatitic, greisen, quartz-topaz and chloritic lodes.

In the Torrington-Emmaville-Gulf area, the association in such lodes is with tin and tungsten minerals. Other minerals which may be present are those of beryllium, bismuth, molybdenum, cobalt, iron, arsenic and copper, together with biotite, quartz, chlorite, tourmaline, monazite and fluorite. The age of the granitic intrusions is regarded as Permian. Localities in this area where uranium minerals occur include Garth's lode, Heiser's lode, Nine-Mile workings, Fielders Hill, Blatherarm, Smith's Mica lode, Fords Hill, Silent Grove and The Gulf.

Torbernite occurs similarly in granite country at Gilgai near Inverell and at Watson's Creek (Giants Den) near Bendemeer. At Silver Valley near Inverell, some uranium mineralisation has been noted in a silver-lead-zinc lode. At Gordonbrook on the Upper Clarence River, north of Grafton, torbernite is found in sediments near a granite intrusion, in a neighbourhood where copper, cobalt and mercury minerals also occur. Some radio-activity has been noted in the molybdenite-bearing area of Wunglebung near Tenterfield.

Condobolin-Nymagee District.—Pearce's uranium prospect at Blackfellow's Dam, 54 miles north-west of Condobolin, was discovered only in 1954. The secondary uranium minerals are autunite and torbernite and probably curite (lead uranate), and some pitchblende may also be present. Associated minerals are those of zinc, lead, iron, manganese and copper, together with quartz, chlorite and dark purple fluorite. The lode is in a fissure within granite, which intrudes Silurian sediments.

Carcoar.—Half a mile south of Carcoar township, uranium minerals occur with those of cobalt, molybdenum and copper. Torbernite and autunite are found on the dumps, and some uraninite is found with primary cobalt and molybdenum sulphides. The lodes were worked for cobalt in the 1890's. The mineralisation takes the form of lenses in shear zones within slates and andesites, near a contact with diorite and not far from a large area of granite.

Other Areas.—Radioactivity is also known from the molybdenum-bismuth deposits at Whipstick, near Pambula, and has been reported from the Nymagee, Buddigower, Oberon, Burrinjuck and Toongi areas.

ZINC.

The most important of the zinc minerals is sphalerite, known also as zinc blende and "Black Jack", which is sulphide of zinc. Other minerals of less importance are smithsonite or calamine, the carbonate, zincite, the oxide and the silicates, willemite and hemimorphite. The whole of the zinc production of New South Wales is obtained from sphalerite. When pure, this mineral contains 67 per cent. of zinc and is colourless, yellow, yellowish brown, or green and is clear and glassy or resinous in appearance. It usually contains, however, more or less iron and manganese and these varieties are dark-brown to black in colour and almost opaque. It has a brilliant lustre when freshly broken but becomes dull on long exposure to the air. It is fairly soft and brittle, has good cleavage and the darker varieties look something like galena. It may be distinguished from galena by moistening it with a few drops of hydrochloric acid when it gives the peculiar rotten-egg odour of sulphuretted hydrogen.

It occurs in lodes and veins in a manner similar to galena. Most of the zinc produced in New South Wales has been obtained from bodies of ore containing galena, and zinc is almost to be regarded as a by-product of silver-lead mining.

The chief use of zinc is for galvanising iron or steel when it acts as an efficient rust-proofing coating. It is also used in the form of sheets in the building and manufacturing industries, and zinc shavings and dust are used to precipitate gold in plants using the cyanide process for the extraction of gold from its ores. It is also used in the process of de-silverising lead in lead refineries. Sheet zinc and zinc rods are used extensively in making electric batteries, the container of dry cells always being a canister of zinc. It is used also in many alloys, being an essential constituent of brass which contains about 30-40 per cent. of zinc alloyed with copper. A big range of zinc alloys are also made for use in die-casting. Zinc oxide and sulphide are used as paint pigments, and zinc chloride is used as a preservative for timber.

The chief output of zinc in New South Wales has been from the silver-lead-zinc mines at Broken Hill and Captain's Flat, and zinc ores, almost free from lead or other metals, have been mined at Drake and near Cootamundra. Zinc has also been produced from mixed ores at Leadville, Sunny Corner and a number of other less important localities.

ZIRCON-RUTILE-ILMENITE.

On many beaches along the coast of New South Wales, deposits of heavy grey or black sands are to be found overlying the ordinary sea sand. Layers of similar dark sand varying from a fraction of an inch up to several feet in thickness may also occur beneath the surface of the beach.

Inland from the present beaches in certain areas, raised beaches and terraces some 10 to 15 feet above the level of the present beaches also contain layers of black sand as do some of the sand dunes. In some of these areas the layers of heavy black sands have been cemented into a firm black rock by means of carbonaceous matter. Gold was found in one of these deposits at McAuley's Lead near the mouth of the Richmond River in 1895, and was worked for a short time, but the operations were abandoned as unpayable.

The deposits are the result of the natural concentration by wave action of the small amounts of heavy minerals contained in the ordinary sea sands, and the amount of concentration is greatest where old beaches have been cut into and re-concentrated. The concentration takes place chiefly during cyclonic storms, where gale-force south-east winds cause a heavy pounding of waves. The deposits are often found towards the northern end of the beaches, as wave action during the storms is more intense there than at the southern end where some shelter from the south-easterly winds is given by the southern headlands.

In size, the deposits range from less than 1 inch to as much as 6 feet in thickness, from about 5 to 100 yards in width and up to a mile or even more in length.

The material in the naturally concentrated black sand consists of a mixture of zircon, rutile and ilmenite with a little monazite and traces of tin, gold, platinum and osmiridium may also be present, but the chief interest in the sand lies in its rutile and zircon content. The average sand concentrate contains from 40 to 60 per cent. of zircon, 30 to 40 per cent. of rutile, 20 to 25 per cent. of ilmenite and about 0.5 per cent. of monazite. The content of tin, gold, platinum and osmiridium is generally negligible, although during storms, small patches of surface concentrates giving rich assay values may be formed, but they are too small to be of economic importance.

The most important of the deposits occur along the North Coast of New South Wales from Coff's Harbour to the Southern part of the Queensland coastline, and the greatest production has been obtained from beaches between Byron Bay and Tweed Heads. Smaller deposits occur along the coast from Coff's Harbour to Lake Illawarra and there are few beaches which do not contain a little black sand.

During periods of fine weather, the black sand concentrates become mixed with the ordinary sea sand on the beaches, but the material is still workable even when this occurs, as sand containing as little as 2 per cent. of heavy mineral is regarded as of economic value if it is available in large quantities and can be mined at low cost.

The deposits situated at the back of the present day beaches have been formed in a manner similar to those on the beaches and represent the position of a former strand line.

Rutile, the most important of the minerals, has been produced in Australia since about 1933 and its price has fluctuated widely. Its principal use until recently was as a flux coating for electric welding electrodes and for the manufacture of titanium tetra-chloride and other titanium chemicals. Recently, however, plants have been erected in U.S.A. and Europe for the manufacture of titanium and these call for large quantities of rutile for production of this metal. Metallic titanium is about as strong as steel but is as light as aluminium and it also has good heat-resisting and corrosion-resisting properties. It should find a large and increasing use in aeroplane construction.

Zircon is used as an opacifier in vitreous enamels and as an ingredient in certain glasses and also in heat-resisting porcelains and refractory blocks for furnace linings. A small quantity is used for making ferro-zirconium for the steel industry, whilst metallic zirconium has a large number of small-scale uses. Zirconium may also be a desirable metal as a constructional material in atomic energy plants.

Ilmenite, when pure, is used as a raw material for the manufacture of titanium pigments, but the presence of chromium in the ilmenite from the beach sand renders it unfit for that purpose and it is dumped as waste.

Monazite is a phosphate of cerium metals and contains also about 6 per cent. of thorium oxide. It was formerly used as a source of thorium for the manufacture of gas mantles but is now used chiefly for its cerium content. Cerium finds a limited use in the manufacture of the sparking "flints" for gas and cigarette lighters, some is used in special glasses. A small amount of cerium is used as an ingredient in alloys with other metals and cerium compounds are used to improve the light of carbon arc lamps. There is some interest in monazite as a source of thorium for use in atomic energy projects but there is as yet no large-scale demand for it for this purpose.

Most of the minerals produced from the black sands are exported, only a small proportion being used locally.

The total value of the minerals produced annually from the beaches now ranks third largest in New South Wales, being exceeded only by coal and silver-lead-zinc.

Further information dealing with the methods of prospecting, mining and treatment of these minerals will be found under the heading "Zircon-Rutile-Ilmenite—Prospecting, Mining and Treatment" in Chapter VI.

Non-metallic Minerals.

This group of minerals includes all those which lack metallic lustre and are mined for use because of some physical property possessed by them and which for the most part are used in industry without any preparation other than purification, where necessary, and grinding to the size required. It also includes a number of earthy substances which strictly speaking are not minerals but which are best considered under this heading. A few minerals such as bauxite and magnesite are used for the production of metals and as non-metallic minerals, but if their principal use is as non-metallics they have been included in this section.

ALUNITE.

Alunite is a sulphate of potassium and aluminium which is used as a source of alum and potassium salts. It occurs as a fairly hard white, grey or pink waxy-looking substance formed by the alteration of rhyolite or trachyte. It is a difficult mineral to identify without the aid of chemical analysis. It occurs also in soft earthy form scattered through certain clays. The only known deposit which has been worked in New South Wales is at Bulahdelah.

ASBESTOS.

A number of fibrous heat-resistant minerals of varying composition are called asbestos. The name includes chrysotile, a fibrous form of serpentine, and the amphibole minerals, tremolite, crocidolite and amosite. In general, chrysotile is stronger than the other varieties and is the only one used as spinning fibre, but some crocidolite is spun into asbestos yarn and some is used in the building industry. As a rough test for the quality of asbestos a small piece should be torn off the mass and twisted into a thread by rolling with the fingers. This thread should be flexible and strong, capable of being bent sharply and should be able to stand a considerable pull without breaking. The inferior grades of asbestos split into weak, harsh and brittle fibres which often crumble to a powder when rubbed with the fingers.

Chrysotile yields a soft silky fibre when teased and may be spun and woven into cloth. It is pale yellow to pale green in colour and has a peculiar silky sheen.

Tremolite and amosite are white to grey in colour and lack the strength and sheen of chrysotile, while crocidolite is dark blue to purple in colour.

The length of asbestos fibre varies from less than one-eighth of an inch to several inches and fibre length and quality governs the price paid.

Chrysotile asbestos occurs only in serpentine and is present as "cross fibre" in veins and "slip fibre" along joints and planes of schistosity. Tremolite and amosite occur chiefly amongst highly altered schistose rocks and crocidolite occurs as veins in certain ferruginous sedimentary rocks.

The biggest single outlet for asbestos is in the manufacture of asbestos-cement building products. Other important uses are for brake linings, heat-resisting gaskets, asbestos millboard and packings, boiler and steam pipe coverings, insulation for electric wires and spinning and weaving into fire-proof asbestos cloth. A small amount is used for filtering acid liquors which would corrode the ordinary filter cloths made from cotton, linen, jute or wool.

Chrysotile asbestos has been mined at Barraba and Baryulgil and low grade amphibole asbestos at Gundagai and Lewis Ponds.

BARYTES.

This mineral consists of barium sulphate. It is a heavy mineral which is colourless or white when pure, but is often stained brown by iron oxide. It is relatively soft and is easily scratched by a knife. It has good cleavage when well crystallised and the freshly broken mineral has a bright lustre. It is often fine grained or massive, in which form the cleavage and lustre are not seen. The unsually high specific gravity as compared to other common non-metallic minerals such as quartz or calcite, at once arrests attention.

It occurs in veins or lodes, often with iron pyrites and galena which greatly detract from its value. It may also occur in the form of residual nodules resulting from the decomposition of barium-containing clays, sandstones or limestones or in the form of a cement in certain sandstones.

Barytes is used as a source of barium and its compounds, but its chief use is as a paint pigment and as an inert filler in the linoleum, rubber and plastics industries. A large quantity of barytes is used in the preparation of heavy muds used in oil-well drilling to prevent "blow-outs" or the escape of high-pressure gas should it be encountered in drilling.

Barium compounds are used in the preparation of lithopone, a chemically precipitated mixture of zinc sulphide and barium sulphate. Barium peroxide and nitrate have some uses in explosives and fire-works, barium carbonate is used as a rat poison and barium sulphide is used in the tanning industry for removing hair from hides.

Barytes is a low-priced mineral, and it is normally sold in three separate grades based on colour, first-grade being pure white in colour, second-grade being essentially white but slightly stained, and badly discoloured or heavily stained material is classed as third-grade. The chief demand is for first grade and second grade material, as third-grade barytes is in plentiful supply.

The principal deposits which have been worked in New South Wales are at Kempfield, Lue, Mandurama, Gurrunda, Braidwood, Cobargo, Captain's Flat and Bredbo.

BENTONITE.

See under "Clays".

BUILDING STONE.

The State of New South Wales is richly endowed with a great variety of building stones, the supply being greatly in excess of the demand. The search for building stone therefore offers little hope of profitable reward particularly as the cost of opening up any new quarry is too high for the resources of most prospectors.

The chief building stones are sandstone, granite and marble although syenite, dolerite, basalt, serpentine, slate and gneiss are also used, and any rock which possesses the desired properties may be utilised for building construction. The choice of stone depends on the particular purpose for which it is to be used, whether for interior or exterior use, whether it is required to support heavy loads and whether to be used rough-dressed, sawn or polished. Durability, strength, and appearance are important factors in assessing the suitability of a stone, whilst ease of working and cost are also important factors.

There is a limited demand for a good white marble suitable for statuary and for stones with rich or novel colouring. A really good red granite would be in some demand as would a coarse-grained dark coloured igneous rock which could be sold under the trade name of "black granite." It would be essential, however, that such stones be obtainable in large blocks, free from flaws or cracks.

CLAYS.

The hydrated silicates of aluminium which are derived from the decomposition of felspars and other aluminous silicates are termed clays. A number of distinct clay minerals are recognised and the variable properties of clays as they are found in nature are due largely to varying proportions of these clay minerals present. The chief of these clay minerals are kaolinite, illite and montmorillonite. Clays also contain impurities such as quartz in the form of fine sand and silt, iron oxides, felspar, organic matter and alkalies. For commercial purposes clays are generally classified according to their uses, the chief types being brick clays, tile and terra-cotta clays, stoneware clays, china clays or kaolins, ball clays, fire clays, filler clays, bleaching clays and bentonite.

In general, the suitability of a clay for any particular purpose cannot be established by analysis, a practical test on a small scale being necessary. In the case of clays for ceramic use, a firing test usually yields the required information, although the plasticity of the clay in the moist condition is also important.

In the case of filler clays, a light texture is essential and uniformity of colour and freedom from grit are desirable. For use in the rubber industry, manganese and iron oxides must be low. Most high-grade kaolin or china clay is also useful as a filler clay.

The bleaching clays are those which have the property of removing colour from oils and which absorb grease readily. The chief of the bleaching clays is the variety known as "Fuller's Earth".

Bentonite is a grey, greenish or buff coloured waxy-looking clay which absorbs water readily and swells greatly into a jelly-like mass when wet. It has good bleaching properties and high plasticity. Its chief use is as a bonding agent for use in moulding sands. and it is used in drilling-muds. No true bentonite is known in New South Wales but certain highly plastic clays from Trida have been marketed under the trade name of "Australian Bentonite". The discovery of a deposit of high-grade bentonite would be of commercial interest.

There is an abundance of low-grade clay suitable for making bricks, tiles, stoneware pipes, fire bricks and the cheaper grades of pottery ware and such clays are low in price. The search for such material offers little hope of reward for a prospector.

Supplies of good quality white burning pottery clays and white filler clays are limited and there is a ready sale for these clays. A good quality pottery clay should be free from impurities such as iron oxide which would spoil the colour of the pottery, or fluxes which would result in warping or fusion on firing, and should possess a reasonable degree of plasticity.

White pottery clays have been worked at Clergate, Dunbible, Mudgee, Puggoon and in the Sydney district, whilst ball clays and filler clays have been obtained from Marrangaroo, Gulgong, Dalton, Bungonia, Oaklands and Tichborne.

CORUNDUM.

See under "Emery".

DIATOMITE.

This material is also called diatomaceous earth, tripolite, kieselguhr and infusorial earth. It consists of the siliceous skeletons of minute plants known as diatoms mixed with a varying proportion of clayey matter, silt and organic material deposited in the beds of lakes or the floor of the sea. It is white when pure but may be grey, buff or even black owing to the presence of impurities. It is very light in weight and extremely porous. All the deposits in New South Wales occur filling the beds of dried-up lakes associated with volcanic rocks.

Diatomite is used as a heat insulator, in the form of sawn blocks, moulded bricks or compounded into a paste with asbestos, magnesia and a binding agent for covering furnaces, boilers, steam pipes or hot water pipes. It is also used widely as an absorbing agent for chemicals and as a filter-aid for clarifying liquids and as a polishing abrasive for metals, glass, horn and plastics. Owing to its light weight, it now finds extensive use in light-weight concretes, cements and plasters for use in the building industry and is also used as a filler in paints, plastics and rubber.

The chief deposits of diatomite in New South Wales are near Coonabarabran, Barraba, Cooma, Orange and Lismore.

DOLOMITE.

See "Limestone".

EMERY.

This is a black impure form of corundum, the naturally occurring oxide of aluminium. It is fine grained and generally contains a considerable amount of iron oxide in the form of magnetite. When pure, corundum forms the gemstones ruby (red) and sapphire (blue, green or yellow). It occurs chiefly as segregations in basalt or other igneous rocks.

Formerly, emery was widely used as an abrasive in the form of a powder, or bonded and made up into wheels and sharpening stones, but its use for this purpose has been almost entirely supplanted by the harder synthetic abrasives carborundum and alundum, and there is now practically no market for natural emery.

Small quantities of emery in the past were obtained from Crookwell, Quirindi, Cooma and the Tweed River.

FELSPAR.

A number of silicates of aluminium with potash, soda and lime form the group of minerals known as the felspars which are essential constituents of most igneous rocks. Commercially, the name is restricted almost entirely to potash felspar of the variety known as perthite and to albite or soda felspar, the potash felspar being the most important. The felspars are hard minerals which vary in colour from white, through shades of cream, grey, buff, pink to red. They have a glassy to resinous lustre and break with good cleavage in two directions.

Most of the felspar of commerce is obtained from large masses of relatively clean mineral occurring in pegmatite dykes, and in places practically the whole of a dyke may consist of felspar with only a small amount of quartz and mica present.

The names Cornish Stone and China Stone are given to rocks consisting of an intimate mixture of felspar and quartz, with or without a small amount of mica.

The chief use of felspar is as an ingredient in glass manufacture. It is also used in making porcelain, pottery glazes and ferro-enamels and sold in ground form for use in making scouring soaps and powders for kitchen use. For use in the glass and ceramic industries it is essential that the iron content should be low, preferably well under 0.5 per cent., but the presence of a small amount of quartz is harmless. When used for scouring compounds, it is essential that quartz be absent owing to its hardness rendering it liable to scratch glass.

Most of the felspar mined in New South Wales has been obtained from large pegmatite dykes in the Broken Hill district, but felspar has also been produced in the Bathurst, Mudgee and Nambucca districts and soda felspar has been mined at Wog Mountain near Bombala.

FERTILISERS.

See under "Phosphates".

FLUORSPAR.

This mineral, also called fluorite, consists of calcium fluoride. It is a glassy-looking mineral which may be colourless, white, purple, green or yellow in colour, possesses perfect cleavage and is soft enough to be scratched with a knife. It is found in many places as a constituent of the gangue of tin or lead lodes, but deposits containing sufficient mineral to be worked for their content of fluorspar are rare.

The chief uses are as a flux in the iron and steel industry and in the manufacture of hydro-fluoric acid and fluorides. Small amounts of high grade fluorspar are used in the manufacture of glass, pottery glazes and ferro-enamels, and some perfectly clear fluorspar is used in making lenses for microscopes and other scientific instruments. Owing to scarcity of local supplies of fluorspar, substitutes have largely taken its place as a flux in the steel industry, but there is a ready market for any fluorspar available.

Fluorspar has been worked at Carboona, The Gulf, Woolgarlo, Taemas and near Broken Hill.

GEMSTONES.

Diamond.—Diamond is a crystalline form of carbon and is found typically in the form of octahedral crystals or as water worn fragments. It is the hardest substance known and will scratch any other mineral. Diamonds have a particularly brilliant lustre, and their colour varies from clear and colourless, through shades of grey, yellow, brown to black and opaque. Only the clear varieties of diamond are used as gems, but there is a ready market for off-coloured flawed or opaque stones for industrial use.

Diamonds occur in breccias in volcanic necks, but most of those actually worked are obtained from alluvial gravels, having been liberated from their original source by weathering away of the parent rock.

Industrial diamonds, sometimes called "boart" are used as abrasives, either in the form of powder or as tips for various cutting tools. The black opaque variety known as carbonado is used chiefly for the diamond drilling of rocks.

Diamonds have been recorded from many localities in New South Wales, but the principal deposits have been at Cope's Creek, Bingara, Cudgegong River and Mittagong. A few small diamonds have been found in the course of gold dredging operations on the Macquarie River near Wellington.

Sapphire.—Sapphire is the blue form of the mineral corundum, which is composed of oxide of aluminium. Yellow, green and parti-coloured sapphires are also known, but are not so highly prized as the blue variety. Red corundum is known as ruby, a stone which has the same chemical composition as sapphire, differing from it only in its colour. The sapphire miners use the word corundum to mean opaque sapphire of poor colour which is useless for gem purposes. Gem quality material should be of a pleasing colour and free from cracks and flaws. The cloudy and parti-coloured stones common in alluvial deposits along the Main Dividing Range of New South Wales are of little or no value.

Sapphires are found in the form of hexagonal crystals, usually in tapered shapes often called "pencil points". The mineral has a brilliant lustre and is very hard, being able to scratch all minerals except diamond.

Although sapphires are of common occurrence in New South Wales, the only deposit which has been worked commercially is the one in the Inverell district some seventeen miles east of the town.

Opal.—Opal is an amorphous form of silica containing a variable amount of combined water. It occurs in a great variety of forms and colours but is best described under two headings, *common opal* and *precious opal.* The former has a resinous to glassy lustre, may be clear or nearly opaque and varies in colour from colourless, white, yellow, green and brown to black. It is completely worthless. *Wood opal* consists of wood which has been replaced by opaline silica. Although sometimes used for making small ornaments it is valueless as gem material. Precious opal is of two principal types, white opal and black opal. Both types have the typical play of colour and fire of opal but the body colour of the former is milky white whilst in the latter the colours are displayed against a dark-coloured base. The black opal is the more highly prized variety as the colours are much more vivid than in the white. Names such as "harlequin", "pin-fire" and "flash" are used to describe the pattern of colours in precious opal. The colours are fiery red, orange, yellow, blue and green, in iridescent ever-changing hues, seen as the stone is turned in the light.

Opal occurs chiefly in thin veinlets and nodular masses in "opal dirt" a soft white clayey band in Cretaceous sandstones in New South Wales, Queensland and South Australia. It is often overlain by a hard band known to the miners as "steel band", and seams of worthless opal known as "potch" are common. Opal also occurs as fillings in steam holes in basalt and other volcanic rocks, but such material is seldom of gem quality.

The principal opal fields in New South Wales are at White Cliffs and Lightning Ridge and a small amount of opal has been won from basalt at Tintenbar.

In the north-western part of the State there is a big area of Cretaceous rocks similar to those at White Cliffs and Lightning Ridge and there is a strong probability that there are undiscovered deposits of opal within this area.

Other Gemstones.—Pebbles of topaz are common in the alluvial tin deposits of the New England district, and some of these have been cut for use as gems. Most of them are colourless but some are pale blue, the latter are more favoured for use as gems. The deep straw-coloured topaz which is the most highly-prized variety is not known in New South Wales.

Beryl in the form of pale green and pale blue crystals is found associated with lodes of tin and wolfram in the New England district, and in one locality beryl crystals of emerald-green colour have been won. Although gem quality beryl has been found, the quantity available has been too small for profitable working.

Zircons occur in abundance, chiefly yellow to brownish-red in colour, but they are of little value.

Garnets are abundant in areas of metamorphic rocks and are also to be found in river gravels. Although some are of gem quality, the value of garnets is so low that they are of little interest.

GRAPHITE.

This mineral is a soft, lustrous crystalline variety of carbon. It is also known as "plumbago" and "black-lead". It occurs chiefly in the form of flat flaky crystals which vary from submicroscopic size to large flakes ½ inch across and is found in veins, bedded deposits or disseminated through various rocks. The bedded deposits are usually formed as a result of the alteration of coal seams, and nearly all graphite is regarded as due to the alteration by metamorphism of other forms of carbonaceous material.

Graphite is sold under three trade classifications: crystalline, flake and amorphous, the crystalline grade being the most and the amorphous the least valuable.

As is well known, graphite is very soft and will mark paper and hence it is used in the manufacture of pencils. The most important uses for graphite are connected with foundry work. It is used in the manufacture of crucibles for melting metals and as a facing tor sand moulds where it imparts a smooth finish to the metal castings. Graphite is used fairly extensively as a lubricant, both in dry powdered form and in admixture with oils and greases. In the electrical industry it finds many uses owing to its electrical conductivity. It is utilised as a pigment in paint manufacture and has a very large number of minor uses in industry.

Graphite has been produced from Undercliffe Mountain, near the Queensland border, and from South Komungla in the Goulburn district, and occurs also at Winterbourne Station near Walcha.

GYPSUM.

This mineral consists of hydrated sulphate of lime. When pure it is colourless, but it is generally white, buff, or even reddish-brown owing to the presence of impurities. It may form large crystals which have good cleavage and look somewhat like mica, but the mineral is softer than mica and the leaves split off are not as springy as sheets of mica. Some forms of gypsum look like calcite, but may be distinguished from that mineral by the fact that it does not effervesce with acids.

The principal deposits of gypsum occur as beds at or near the surface where they have been formed by the evaporation of salt waters containing the mineral in solution. These beds may take the form of a loosely coherent rock called "rock gypsum", loose small crystals known as "seed gypsum" or contain a soft finely divided form of gypsum called gypsite or "flour gypsum".

Crystals of gypsum also occur embedded in surface clays and deposits of this type sometimes contain sufficient of the mineral to warrant commercial working.

Most deposits of gypsum contain some sand, clay, iron oxide, salt or limestone present as impurities and in many cases a washing process is necessary to produce gypsum of sufficient purity for commercial use.

The chief use of gypsum is for the manufacture of Plaster of Paris for which purpose the mineral should be as clean as possible. An important use is as a retarding agent in Portland cement, about 3 per cent. by weight being added to cement before sale. A small amount of gypsum is consumed as a flux in certain smelting operations, and a large amount of the soft powdery gypsite is used as a soil dressing in areas where the soils are excessively clayey, the use of gypsum greatly reducing the stickiness of the soil and permitting of cultivation to be carried out when the soils are wet.

Practically all the gypsum mined in New South Wales has been obtained from the western part of the State, chiefly from the Trida-Ivanhoe, Wentworth, Balranald and Bourke districts.

LIMESTONES (including Dolomite).

Limestone is a rock consisting essentially of calcium carbonate with impurities such as silica, magnesium carbonate and iron oxide. It is variable in colour, being white when pure but may be yellow, buff, grey or black. Sometimes it is soft and earthy but it may be hard and dense or have a crystalline structure. The crystalline forms of limestone are usually called marble if they are sufficiently hard to be cut and polished.

Nearly all limestone contains some magnesium carbonate, and if the amount exceeds about 5 per cent. the rock is called magnesian limestone. Dolomite is a variety containing, when pure, about 45 per cent. of magnesium carbonate but most commercial dolomites contain considerably less, generally from about 25 per cent. to 35 per cent. Dolomite may be distinguished from limestone generally by its slightly greater hardness, by a tendency to have a sugar-like appearance on a freshly broken surface and by the fact that it does not effervesce readily with cold hydrochloric acid.

Limestone is used extensively for making Portland cement and building lime. It is also used as a flux in smelting iron and most other metals and is an important ingredient in glass manufacture. The harder varieties of limestone are used as building stones and for road construction. Limestone in finely ground form is used as a sweetening agent for acid soils.

Dolomite finds its chief uses in the steel industry where it is used as a furnace lining. It is also used in the glass industry and is a useful fertilizer for use in soils which are deficient in lime and magnesia.

Limestone is widely distributed in New South Wales, and almost inexhaustible supplies are available. The more important deposits occur within the central and eastern divisions within easy reach of market.

Dolomite is much less abundant than limestone and the chief sources of supply are situated at Mount Knowles, Clandulla, Mount Fairy, and Cow Flat.

MAGNESITE.

This mineral consists of magnesium carbonate. It may occur in crystalline form but more often is found in a form which resembles porcelain in appearance. It is white in colour when pure but may be stained brown by iron oxide. Its weight is noticeable and it is considerably heavier than quartz or any of the commoner rocks. It is a hard mineral and normally can only just be scratched with a knife. It usually occurs in nodular masses or irregular veins in masses of decomposing serpentine or other basic igneous rocks, and small amounts are often associated with decomposing basalts.

Strict specifications regarding purity are laid down by buyers of magnesite who normally require a minimum of 85 per cent. of magnesium carbonate and will normally tolerate the presence of only a very little lime, silica and iron.

Magnesite is used chiefly for the manufacture of special types of fire-bricks and furnace linings for use in the steel industry. It is also used for making various magnesium chemicals and cements and metallic magnesium is prepared from calcined magnesite.

The chief deposits of magnesite in the State are at Fifield, Attunga, Thuddungra, Lake Cargellico and Piedmont near Barraba.

MICA.

Mica is a common constituent of igneous and metamorphic rocks in which it occurs in small flakes which are of no commercial value. There are two main varieties of mica, muscovite or white mica and biotite or black mica. The micas are all complex silicate minerals, characterised by their ability to split into thin flexible and elastic flakes. It is only when it occurs in large flakes that mica is of commercial value. Practically all of the mica of commerce is obtained from "books" in pegmatite dykes. Relatively little of the material obtained from any deposit is of sufficiently high grade to be sold as sheet mica and most of it is sold as scrap.

Mica is priced according to the size and quality of the sheets available and varies from a few pence per lb. for small sheets of washer size up to several pounds per lb. for large sheets of the best quality.

Mica is used widely as an insulating material in the electrical industry in applications where heat resistance is also required. Formers for heating elements, insulation for commutators, insulating strips and washers and bodies for spark plugs are made from mica. The transparency and heat resisting properties of mica make it suitable for use in windows in furnaces and heating stoves. Thin splittings of scrap mica may be bonded together with shellac or other binders to produce built-up sheets known as "micanite" which are useful for insulating purposes in places where high heat-resistance is not necessary.

Scrap mica is ground to powder and used as a filler in the paint, rubber, plastics and paper industries. It is used extensively overseas for its decorative appearance in plasters and wall-papers, but relatively little ground mica is used in Australia.

The only district which has produced mica of commercial quality in New South Wales has been the Broken Hill district, and production has been small and the quality of the mica has not been good.

OCHRES, OXIDES AND MINERAL PIGMENTS.

Many mineral earths are used as pigments, but the most important are the ochres, oxides and umbers. Ochre is essentially a fine clay, stained yellow or red with iron oxide and containing from about 5 per cent. to 10 per cent. of that substance. The value is dependent on the colour and staining power alone, and cannot be determined by chemical analysis. When the iron oxide content exceeds about 40 per cent. the material is referred to as "oxide". Sienna is an impure form of hydrated iron oxide containing some clayey matter and is of a warm brown colour. Umber is a mixture of hydrated iron and manganese oxides with some clayey matter and is of a particular coffee brown colour. Siennas and umbers are sometimes calcined to modify their colours and are then sold as "burnt sienna" and "burnt umber". Raddle is the name given to a bright red earthy form of iron oxide. Clays stained brown or black by organic matter are also used as pigments. A small amount of ironstone of suitable colour is used as a pigment but most ironstones are useiess.

The demand for the earth colours is not large and their use is restricted to the cheaper grades of paints. A small amount is used in colouring cement work and in the manufacture of linoleum. The bright yellow ochres are in greatest demand, as they are not easily imitated and their colours may be modified to orange, brown and red by calcining if desired. Besides colour, texture is important in a mineral pigment, which should be soft and fluffy when ground so that it presents no difficulty in mixing with oils to form paint.

The principal localities from which ochres and oxides have been obtained are Dubbo, Home Rule, Michelago and Sydney.

ORNAMENTAL STONES.

See under "Building Stones".

PERLITE.

Perlite is a rock of volcanic origin containing chemically bound water and perhaps gases and other liquids, which when suddenly heated to a suitable temperature undergoes great expansion owing to the volatilization of the gases and liquids. The degree of expansion varies depending on the inherent nature of the rock and furnace conditions.

Temperatures at which crushed perlite expands depend upon the amount of water present. Some, with a high moisture content, will expand at temperatures around 1,400 degrees F., whilst other types which are not as "lively" have to be heated to approximately 2,000 degrees F. before expansion occurs.

Perlites have a number of uses, among which are:—

1. In acoustical tiles, where it has high sound absorption, is incombustible, and reflects light.
2. As an aggregate for concrete which is lightweight, has a high strength/weight ratio, heat or cold insulating, fire resistant, not attacked by vermin or fungus, and can easily be sawed or nailed.
3. As perlite-gypsum plaster for fireproofing.
4. As loose-fill insulation.
5. As cement plaster, and a number of minor uses such as an additive to drilling mud, in cleansing and scouring powders and horticultural products.

In the Tweed-Richmond region of the State, perlites and rocks which are petrologically allied and expand on heating occur within acid volcanics of Tertiary age. They are associated in all known cases with rhyolite flows and occur both under, over, and interbedded with this rock type.

At the moment the Richmond-Tweed region is the only area where it is known that easily worked, good quality perlites occur in N.S.W. However, it is possible that other occurrences may exist closer to Sydney, and if this is so they would no doubt receive more attention because of cheaper rail freight.

PHOSPHATES.

All plants need phosphates and potash for their growth, and if soils are deficient in these substances the use of a fertiliser is necessary. Phosphate is usually supplied in the form of superphosphate prepared artifically from phosphate rock. The mineral apatite occurs sparingly in most igneous rocks and in a few places is available in sufficient quantity to serve as raw material for the manufacture of fertilisers. Apatite is composed of fluo-phosphate or chloro-phosphate of lime. It is a moderately hard crystalline mineral, which is difficult to recognise without chemical tests.

Phosphate rock consists chiefly of tricalcic phosphate and should contain at least 50 per cent. of this substance. It is buff-coloured to white and is opaque and generally somewhat earthy, but may be hard and banded. It is practically impossible to identify phosphate rock without the aid of chemical analysis.

No large-sized deposits of high-grade phosphate rock are known in New South Wales, but there are several small deposits of phosphatic material consisting largely of bones of small animals in caves at Wellington, Ashford and Molong, but none of these can compete commercially with the high-grade phosphate rocks obtainable in large quantity from Ocean Island and Nauru in the Pacific Islands. Besides its use in the manufacture of fertiliser, phosphate rock is used for the production of phosphorus and chemicals.

Discovery of significant deposits of phosphate rock would be of immense value to Australia, and the search for deposits is being stepped up.

Potash is not known to occur in any commercially workable form in New South Wales. It is a common constituent of a number of silicate minerals, but these are of no value as a commercial source of supply.

QUARTZ CRYSTALS.

Clear, transparent quartz has a number of uses. Formerly it was used extensively for making lenses, but its principal use is now in the electrical industry, where it is used for frequency controlling purposes in radio and telephone transmitters. To be of any value, crystals should be at least 3 inches long and at least 1 inch wide across the crystal faces. Perfectly formed crystals are not necessary, but at least two crystal faces should be present. If no crystal faces are present or if the material be in the form of water worn pebbles, pieces much larger than specified above are necessary, as a larger proportion is wasted in cutting. The quartz should be clear and free from flaws, cracks, bubbles and inclusions which can be detected by inspection. In addition the material should be free from twinning. Twinning cannot be detected by ordinary inspection; certain instruments are necessary to determine whether the quartz crystals are twinned or not, and material which appears to be high quality may prove to be worthless. Often only a portion of a crystal is of usable quality and, in such cases, payment is made only for the usable part.

Smoky quartz is acceptable provided it meets all the conditions described above, but milky or opaque quartz is quite useless.

Quartz suitable for use is rare and is priced at up to several pounds per lb., and great care should be exercised in mining and transporting the crystals, as damage in these operations may render them useless.

ROAD MATERIALS.

Various types of rocks and gravels are used for road building and in areas in which suitable rocks are scarce, the discovery of new deposits is desirable and may be profitable for their discoverers.

In most parts of New South Wales suitable material is available and the value of a deposit depends largely on ease of working and proximity to the place at which it is to be used. Igneous rocks such as basalt, dolerite and granite, metamorphic rocks such as quartzite and gneiss and some of the harder sandstones, cherts, limestones and slates are the principal roadstones. River gravels, lateritic ironstone and bauxite, and shed quartz ("hailstone") gravel, are used for surfacing roads for light traffic and are useful in that they need no crushing to prepare them for use.

The term "blue metal" is given to basaltic rocks and these are favoured as road stones in localities where they are available owing to their resistance to crushing. "White metal" is the term given to quartzites and hard sandstones. In general these are less satisfactory than blue metal.

SILICA.

There is much misunderstanding amongst prospectors over the meaning of the term "silica". Silica is silicon dioxide, which is the most abundant constituent of the crust of the Earth. The commonest form of silica is quartz, and any rock, sand or soil rich in quartz is therefore rich in silica. Various trades, however, have varying but restricted uses for the word "silica". Thus, "silica sand" refers to a quartz sand of high purity which might be used in manufacturing glass. "Silica rock" usually refers to a clean hard quartzite suitable for making silica firebricks, whilst the term "silica" often means a clean white quartz suitable for grinding into the "silica flour" used in making abrasive soaps. In any case, silica is an abundant substance and its value is quite low. Apart from its use as building sand, moulding sand and glass sand the demand for silica is not large.

SULPHUR.

Most of the sulphur used throughout the world is consumed in the form of sulphuric acid and other chemicals, which are made either from elemental sulphur, also called brimstone, or from sulphur dioxide gas made by roasting various sulphide minerals.

Sulphur is a yellow substance with a resinous transparent or translucent appearance. It is soft and has a low specific gravity. When heated, it darkens and melts readily then takes fire and burns with a blue flame giving off the characteristic choking fumes of sulphur dioxide.

Elemental sulphur is deposited around the craters of volcanoes, and formerly much of the world's supply was obtained from this source. Large deposits of sulphur occur in "domes" in sedimentary rocks associated with gypsum, salt and limestone, and such deposits now supply the most important part of the world's requirements at a much lower cost than sulphur obtainable from any other source.

Sulphur is formed in small quantities during the weathering of certain sulphide minerals but never in commercial deposits.

The roasting of sulphide minerals results in the evolution of sulphur dioxide which may be converted to sulphuric acid, and these sulphides provide the only commercial source of sulphur in Australia.

Iron pyrites is the only sulphide mineral which is ever mined solely for its sulphur content. When pure, it contains 53 per cent. of sulphur. Marcasite, a less profitable form of iron sulphide, contains the same quantity of sulphur as pyrites but the sulphur content of pyrrhotite, the magnetic form of pyrites, is lower. As pyrites contains only about 50 per cent. of sulphur its value is less than half that of elemental sulphur, and therefore only a large high-grade deposit situated not too far from transport can be regarded as commercially valuable. Some pyritic deposits contain gold, silver, lead, copper or other valuable minerals and the sulphur then may be regarded as a by-product of these.

Zinc blende, the sulphide of zinc, contains 33 per cent. of sulphur, and the roasting of zinc ores and concentrates provides a useful source of sulphur.

Copper pyrites contains about 35 per cent. of sulphur, and galena has 13 per cent., but the sulphur is seldom recovered during the smelting of these minerals.

The chief source of sulphur in New South Wales is iron pyrites, until recently produced as a by-product from the silver-lead-zinc-copper ore at Captain's Flat, and still produced from zinc concentrates from Broken Hill. Pyrites has been mined for its sulphur content from Leadville and Lewis Ponds.

TALC (including Soapstone and Pyrophyllite).

Talc consists of a hydrous silicate of magnesium. It is the softest of all minerals and can readily be scratched with the finger-nail. Its powder has a soft, smooth feel, hence the name "soapstone" is often applied to it. It crystallises in flakes which are sometimes large and resemble mica in appearance but the flakes, whilst being flexible, are weak and not elastic like mica. It often occurs in a massive or rock-like form when it is usually called steatite or soapstone, and this material is generally less pure than the flake variety.

Talc is a secondary mineral formed from the alteration of magnesia-rich rocks such as serpentines, peridotites and dolomites. It may occur as alteration zones in the country rock especially where heavy faulting or shearing has taken place or may occur in lenses or irregular masses in areas of contact metamorphism.

Most talc is used in ground form, and is used in toilet preparations and as a filler in the paper, rubber and paint industries. It has important uses in the manufacture of certain types of ceramic ware and in facings for foundry use. The electrical industry uses talc for making insulators, which may be pressed from ground talc mixtures or cut from solid blocks and then fired. Blocks for furnace construction are cut from massive soapstone.

Pyrophyllite, a hydrous silicate of aluminium, is similar to talc in many of its properties and may be used as a substitute for talc in many industries.

Most of the talc produced in New South Wales has been obtained from Wallendbeen and Cow Flat, whilst pyrophyllite has been mined at Cobargo and Pambula.

UNDERGROUND WATER.

Supplies of water are essential for most mining and prospecting work, and in areas where supplies of running water in streams are not available it may be necessary to utilise underground water. In general the country rocks around metalliferous areas do not yield large supplies of water and what water is available is often highly mineralised, so that the construction of surface storage dams is usually advisable if water requirements are large.

In most mines, once the "water level" has been reached, some water percolates into the workings and before such water is used for boilers or metallurgical treatment it should be analysed to determine its suitability for such use. The Department of Mines is able to arrange for the necessary tests to be carried out free of charge when the water is to be used for mining purposes.

In those parts of the State outside the metalliferous areas, it is frequently possible to obtain useful supplies of water by sinking wells or bores. No general information can be given here regarding the selection of sites for wells as each site presents an individual problem. Officers of the Geological Survey have made an extensive study of the occurrence of underground water in New South Wales and will discuss problems regarding it with those seeking advice.

VERMICULITE.

This mineral is an altered form of black mica which possesses the property of expanding enormously when heated. In the expanded form it is used extensively as a heat-insulating medium either in loose granular form or made up into blocks, slabs or sheets with a suitable binder. The colour of the heated mineral is often an attractive golden bronze and it has uses in decorative plasters and paints and has some use as a mineral filler. There are no known deposits of vermiculite in New South Wales.

Fuel Minerals.

Under this heading are considered coal, oil-shale and petroleum. Uranium and thorium may also be considered fuel minerals in the sense that they can be used in atom power plants as fuel, but they have been discussed under the heading "Metallic minerals".

COAL.

This is a black carbonaceous rock occurring interbedded with sandstones, shales and conglomerates. It has been formed by the alteration of vegetable matter which accumulated under special conditions in swamps and lakes in past geological ages and has been buried by later sediments. At least five types or ranks of coal are recognised as resulting from the alteration of the original vegetable remains.

Peat consists of largely unconsolidated and only partly decomposed vegetable matter. Usually roots, stems and leaves of plants are still readily seen in almost an unaltered state.

Lignite or Brown Coal consists of vegetable matter rather more altered than in the case of peat. It usually consists of more woody matter than does peat and is superior as a fuel, but its moisture content is high compared to bituminous coal and its heating quality is relatively low. In addition, it tends to break up on prolonged storage and is liable to spontaneous combustion.

Sub-Bituminous Coal is a dull black to satin or waxy-looking coal, which often shows a banded structure. It is one stage above lignite in the transformation of vegetable matter to coal.

Bituminous Coals.—Most coals belong to this variety. They are dense, black and brittle, and generally have alternating bands of bright and dull material. They ignite readily and burn with a yellow smoky flame, giving a strong tar-like odour when burning. They have a lower content of water than either lignite or sub-bituminous coal.

Anthracite is a jet black, hard brittle coal, often with a high lustre. It contains very little moisture or volatile combustible matter and ignites only with great difficulty. It is relatively smokeless and has a high heating value.

For commercial purposes, coals are divided into three main types: steaming coal, gas coal and coking coals. Steaming coals should have a high heating value, gas coals should have a maximum value of volatile constituents to give a high yield of gas when heated in a retort, and coking coals are those which yield a hard strong coke suitable for metallurgical use when heated in a coke oven.

Whilst these three classifications are convenient, it is possible for one coal to be suitable for all of these three purposes. A low sulphur and ash content is desirable in coals for all purposes.

The approximate boundaries of the coalfields of New South Wales are well known. The Main Coal Basin, extending from the Shoalhaven River in the south to Newcastle, Muswellbrook and Gunnedah in the north, and to Moss Vale, Lithgow, Kandos and Dubbo in the west is the most important one in Australia. It is a basin-shaped structure which, at its deepest part under Sydney is 3,000 feet deep, and it contains a number of rich and extensive seams. The Clarence-Moreton Basin and the Ashford field yield smaller reserves of coal, some of which is of good quality, whilst in the Riverina field, in the vicinity of Oaklands, a small basin contains a soft, low-quality coal.

The systematic prospecting for coal is a costly operation which, as a rule, can only be undertaken by interests with ample financial and technical resources.

Prospectors who discover a coal seam outcrop are advised to report the discovery to the Department of Mines. A sample may be forwarded for examination, but no analysis will be carried out unless the sample has been taken by or under the supervision of a Departmental Officer. Arrangements can be made for an Officer of the Department to visit and examine the occurrence and advise the discoverer as to what further work should be done to ascertain its economic value.

OIL SHALE.

This is a fine-grained greenish-black to brownish-black substance which should be regarded as a particular type of coal. It often has a peculiar sheen when freshly broken and looks very like vulcanite. It is tough and difficult to break, but can be cut by a knife. When heated on a thin edge it ignites readily and burns with a yellow sooty flame and yields a characteristic oily smell quite unlike the tar-like odour of burning coal. Oil shale contains no oil as such, but the organic material present decomposes when heated to a suitable temperature to yield vapours which can be condensed to an oil and which may be fractionally distilled to give motor spirit, kerosene and heavy oils.

The oil shales in New South Wales occur in association with coal mainly along the western margin of the Main Coal Basin. The most important area is in the Capertee-Wolgan district, in which Newnes and Glen Davis are situated, and in which oil shales have been worked intermittently since 1905. Other areas in which oil shales have been worked are Baerami-Whiddon Brook, Genowlan, Hartley Vale, Joadja, Katoomba and Kandos.

The mining and retorting of oil shales is a costly process and although the industry was once a flourishing one, competition of the cheaper flow oil from overseas makes it no longer attractive, so long as such imports are continuous.

PETROLEUM AND NATURAL GAS.

In New South Wales there is a complete absence of any surface indications of petroleum such as oil seepages, outcrops of bituminous rocks or oil sands, asphalt or wax deposits or emanations of "wet" (petroliferous) gas.

Petroleum and natural gas are usually found in favourable structures in sedimentary basins. In New South Wales the major sedimentary basins are the Great Artesian, Murray, Sydney and Clarence-Moreton Basins, and it is within these that the present active search for oil and gas is proceeding.

A few bores have been sunk upon structures within some of these basins in an attempt to locate commercial oil or gas supplies. In the Sydney Basin bores have been sunk at Penrith, Mulgoa, Dural, Kurrajong, Rossmore, Condell Park, Narrabeen, Singleton, Farley, Kulnura and Terrigal, and in the Clarence-Moreton Basin a bore was put down at Grafton. All the bores in the New South Wales portions of the Great Artesian and Murray Basins have been sunk for underground water only, and as yet no boring for oil has been undertaken.

As a result of these bores some inflammable gas flows have been found. Most of the gas encountered has been "dry", but "wet" gas was met in two bores near Farley.

The "dry" gas revealed in the various bores, including Grafton, Balmain, Mulgoa, Rossmore and several bores in the Artesian Basin in the north-west of the State, consists chiefly of methane, which has probably been derived from coal seams or beds of carbonaceous shales penetrated and cannot be taken as indicating the presence of petroleum. Some ethane has also been detected by analysis of gas from the Grafton Bore, and a trace of heavy oily material was found in a bore at Coonamble.

The iridescent films so often found in seepages of water or on shallow water in swamps, resemble oil films to the casual observer, but they are practically all due to oxidation of soluble iron compounds in the water. These films differ from a true oil film in being brittle and, if broken by stirring with a stick, fracture into sharp-edged pieces which do not run together again as do films of oil. They have no bearing on the possibility of the presence of oil in the vicinity.

Chapter III

THE DISTRIBUTION OF MINERAL DEPOSITS IN NEW SOUTH WALES

The results of years of experience and of studies of the rock formations associated with known mineral deposits make it possible to draw a fairly clear line of distinction between those areas which are likely to contain deposits of gold and other minerals and those which do not warrant further prospecting.

A glance at the mineral map at the back of this publication will show that, from the intending prospector's point of view, the State of New South Wales may be divided into seven areas, within which the characteristic geological formations and ore deposits are fairly well known.

These areas are:—

The Clarence Coal Basin, extending from Glenreagh to the Queensland border.

The Main Coal Basin, extending along the coast from Newcastle to Nowra and inland to Dubbo and Narrabri (tinted brown on the mineral map).

The North-eastern area between the Clarence and Main Coal Basins.

The South-eastern area.

The Central part of the State.

The Broken Hill-Tibooburra area.

The remainder of the State, including the Great Artesian Basin.

The Clarence Coal Basin.

This area is occupied to a large extent by sandstones and shales containing some coal seams. Small collieries have been opened to supply coal for local consumption. These are centred around Nimbin and the head of the Tweed River, and at Nymboida. Coal has been prospected at Moonem Range, near Coraki, at Glenreagh, Maclean and Coaldale. It is pointed out that the coal is inferior to that from the Main Coal Basin, and has only a limited local market.

The coastal beaches frequently contain a concentrate of heavy black sand, both on the surface after storms, and in layers beneath the surface. The concentrate is of very even size, and is composed mainly of zircon, ilmenite and rutile, with a little gold, platinum, tin and monazite, in a fine state of division.

The recovery of these beach minerals, particularly zircon and rutile, has become a very important industry. Although activity has been mainly confined to existing beaches, attention is now also directed to the possibility of other deposits in the sandy heath land and dunes, inland from the present-day beaches.

There are deposits of diatomaceous earth, which probably occupy a considerable area in the neighbourhood of Lismore, as evidence of their occurrence has been observed at several localities. They are overlain by a sheet of basalt. The distinguishing characteristic of the Wyrallah diatomaceous earth is the occurrence in it of hard and stony material of a greyish-white colour, and at the base of the deposit this passes into a band of common opal about 1 foot in thickness. The silica contents are shown by analysis to be over 96 per cent., but the value of much of the material has been destroyed by the loss of its porosity.

Several gold-bearing reefs occur in slates, slaty sandstones, and other strata in the ranges at Mullumbimby. Quartz-porphyry intrusions are found in the vicinity of the quartz reefs.

A deposit of white clay which has been formed by the weathering of a dyke occurs at Dunbible. A brick pit is established in shales at Coombell, near Casino.

There is a deposit of siliceous earth resulting from the decomposition of felsite at Bilambil.

Copper lodes are located in the Upper Clarence District, the most notable being the Cangai Copper Mine.

In the Gordonbrook-Fineflower area, deposits of chromite and magnetite occur, together with copper, mercury and uranium mineralisation.

A deposit of cinnabar is to be found at Horseshoe Bend, Clarence River, about 3½ miles south-east of Lionsville. It is described as a dyke 12 feet wide of felspathic rock, containing cinnabar distributed irregularly through it in spots and minute veins. The dyke intersects the granite of the district, and is considered likely to be permanent in depth.

Asbestos deposits are being worked at Baryulgil.

The Main Coal Basin.

To a large extent this area is occupied by sandstones, shales and conglomerates, and is practically devoid of economic deposits of metallic minerals. However, it is the most important coal-producing area in Australia. Coal seams outcrop on or near the surface close to the North-eastern, Southern and Western boundaries of the Basin. Important coal-producing centres include Newcastle, Cessnock, Singleton and Muswellbrook in the North, Bulli and Wollongong in the South, and Lithgow and Wallerawang in the West.

Oil shale deposits occur at Glen Davis, Baerami, Barigan, Hartley and Joadja. Of these, the most extensive are at Glen Davis and Baerami. Many smaller deposits occur throughout the State, but are relatively unimportant.

Along the Western Boundary of the Basin, large deposits of limestone occur in close proximity to coal. The juxtaposition of these two raw materials has resulted in the establishment of important cement works at Portland, Kandos, and Charbon.

In the vicinity of Moss Vale and Wingello there are several large deposite of bauxite.

Owing to the greater part of the State's population being concentrated in the Main Coal Basin, there has been a heavy demand for brick clays, road materials, sand, concrete aggregate, etc. These are adequately provided by the rocks in the vicinity of the larger cities, such as Sydney, Newcastle, Wollongong and Lithgow.

There are metalliferous deposits in close proximity to Lithgow. A little fossicking is done in the Solitary Creek and Cox's River near Rydal. Much prospecting has been carried out in the vicinity of Sunny Corner.

At Sunny Corner the country consists of claystones and sandstones, with dykes of hard felsite and felspar-porphyry. The felsites and felspar-porphyries are highly charged with small crystals of iron pyrites, copper pyrites, arsenical pyrites, galena, and zinc blende. There is no regular lode, but the deposits take the form of bunches of ore, which occur along the line of contact between the felsite and the sedimentary rocks, more particularly in the elbows formed by sudden changes in the direction of the dykes.

Mines have been extensively worked for lead and zinc and any future activity in the district would depend to a large extent on the successful re-opening of old mines.

Alluvial gold is obtainable by fossicking the creeks which form the tributaries to the upper reaches of the Turon River.

At Dubbo, in the extreme western portion of the Main Coal Basin, yellow ochre occurs in several localities close to the town.

The North-eastern Area between the Clarence and Main Coal Basins.

This is a most important area for many varieties of minerals. It includes the New England Plateau and the North Coast, with the exception of that part of the latter in the Clarence Basin.

Gold-bearing areas are scattered and relatively small. Goldfields such as Timbarra, Dalmorton, Coramba, Drake, Nundle, Niangala and Copeland are characterised, generally speaking, by a relatively large number of reefs which are narrow, but fairly permanent; that is, they maintain their identity at depth. The rich ore occurs within a few hundred feet of the surface, but payable shoots of ore are often widely disseminated.

In the Nowendoc-Barraba-Bingara serpentine belt, reef deposits, similar to those at Crow Mountain and Wood's Reef, may be expected. At Hillgrove the quartz reefs contain antimony in association with gold, and future development depends chiefly upon the result of metallurgical research into the treatment of such ores.

So far as alluvial gold is concerned much fossicking in and about old ground is in progress, but attention is being paid more and more to ground and hydraulic sluicing, particularly in the granitic areas, as at Uralla.

In addition to gold, deposits of other minerals occur, chiefly tin, wolfram, molybdenite, bismuth, silver-lead, copper, arsenic, antimony and uranium.

Bismuth, tin, molybdenite and wolfram deposits are commonly associated, and are confined mainly to areas where granitic rocks are developed extensively. The tin-wolfram deposits may occur within the granite or in the rocks intruded by them, but the bismuth-molybdenite deposits occur almost everywhere within the marginal portions of the granites themselves.

Most of the silver-lead, as also the arsenic deposits, occur either in granite or adjacent to granite contacts, and a number of mines which were originally worked from the surface for silver-lead yielded copper at depth.

Zircon and rutile occur in the beach sands along the coastal section, but the industry in this area has not yet reached the importance of that in the more northerly section of the coast.

ARMIDALE DISTRICT.

The most important mineral areas are Hillgrove and Uralla.

Hillgrove is not a poor man's field, and the gorge in which the main reefs are located has been thoroughly prospected and tested, so one cannot look for further new discoveries so far as gold is concerned in this part of the field. The old mines may contain payable stone, but it would require the expenditure of a considerable amount of capital to unwater them.

Scheelite is found in areas in which coarse-grained granitic rock occurs surrounding the sedimentary rocks, and in which are located the rich auriferous quartz reefs of the Baker's Creek mines. It occurs in lenticular patches in veins, and is, as a rule, associated with dyke formations, which traverse the country in all directions. The scheelite workings, following these lines, give the appearance of defined lodes extending for considerable distances. Within a radius of 4 miles from the township of Hillgrove, scheelite has been found in numerous localities, usually near the junction of the granite and slate formations.

Antimony occurs throughout the district. The mineral occurs so generally in the district that no particular locality is recommended. Old mines may be worthy of further attention when high prices for antimony are ruling. Good results are being obtained from a locality between Guyra and Hillgrove.

Silver-lead-zinc lodes occur at Hall's Peak. The country is extremely rugged and rough, and transport has militated against their development.

At Back Creek, about 40 miles easterly from Hillgrove, molybdenite occurs as nests and flakes in white quartz.

Molybdenite has been discovered at Booralong, about 29 miles from Armidale. The lodes in places are large and assay 2 per cent.; the mineral occurs in several places in the immediate vicinity of Booralong, and it is possible that these deposits and the adjacent country would warrant further exploitation.

Arsenic and silver deposits occur at Rockvale, 27 miles north-easterly from Armidale.

The auriferous areas of Uralla are of considerable extent. The deep leads and recent auriferous alluvials have yielded large returns, but operations at the present time are mostly confined to sluicing and fossicking old and abandoned ground. Nevertheless, some fairly good finds are made from time to time. In only a few instances is any work being done on the deep leads. During periods of light rainfall the fossickers are enabled to work the beds of the river and creeks, while the men engaged on sluicing areas have to await rain to complete their work.

At Sydney Flat, Mount Welsh, and other places near the Rocky River, sluicing claims have been worked with more or less success. A few reefs have been worked intermittently.

Fossicking ground for gold occurs at Puddledock, Tilbuster and Armidale Gully.

Manganese occurs at Gostwick, Kelly's Plains and Castle Doyle.

GLEN INNES DISTRICT.

This district includes important tin-producing centres, such as Emmaville, Torrington and Deepwater.

Around Glen Innes itself, the principal tin deposits occur at Backwater, near Guyra, Bald Nob, 15 miles east of Glen Innes; Mann River, and Skeleton Creek, a few miles east and Hogue's Creek, 13 miles to the north, near Dundee. All these deposits are alluvial, and are worked by individual miners.

Most of the deposits are easily worked. At Bald Nob and Hogue's Creek, where the tin is mostly obtained by "surfacing", difficulty is sometimes experienced in getting sufficient water for washing purposes. At the Mann River the wash-dirt is usually met at a depth varying from 8 to 20 feet, and the ground is mostly of a very wet nature.

Tin has been discovered near Pinkett, 26 miles east of Glen Innes. There is a fairly large area of country here which would probably pay the prospector if exploited.

A deposit of lode tin occurs at Lode Hill, near Backwater.

In the Emmaville district, shallow alluvial deposits have been worked for tin in no less than twenty-seven localities, with more or less successful results. With tin at high prices, this area should be capable of supporting a large number of men when water supplies are adequate.

Deep alluvial leads, some of which are capped by basalt, also occur. The richer portions of these leads appear to have been worked in the early days of Emmaville, but attempts to work the deep leads in recent years have not been marked by any great success.

Near Emmaville, tin-bearing lodes comprise (a) fissure veins, (b) joint veins, or those following joints in the granite or felspar porphyry; and (c) pipe veins. The veins are found most frequently in the granite, and they occur almost exclusively within a distance of about a mile and a half of the junction between granite and claystone.

At Torrington, tin occurs in veins in granite. They have been worked to shallow depths in several areas but operations on some of them have indicated that by continuing operations through low-grade areas, richer zones would be encountered at greater depths. One mine has reached a depth of 800 feet. There appear to be possibilities for further exploitation of the tin lodes of Torrington, Silent Grove and The Gulf when the price of tin is high.

Important deposits of molybdenite and bismuth occur at Kingsgate, 17 miles from Glen Innes. These minerals have also been discovered near Bald Nob and near Dundee. Molybdenite and bismuth (also wolfram) are found in quartz which occurs in the form of pipes. These pipes occur in granite in close proximity to its contact with the slate and claystones. The molybdenite usually occurs in solid masses in crystallised quartz.

A deposit also occurs at Glen Eden, near Hogue's Creek, 13 miles north of Glen Innes. About 5 miles north-east of Glen Eden, molybdenite and bismuth have been discovered. The molybdenite and bismuth occur in flakes in the granite, and also in small veins, but there does not appear to be any indication of these veins making into a defined pipe.

In the vicinity of Bow Creek, near Deepwater, molybdenite occurs in pipes in granite and has been worked in the Allies and Bow Creek mines. The Glen Innes district offers further opportunities for the development of mines to produce molybdenite when the market is attractive.

In many of the pipes which contain molybdenite and bismuth, crystals of clear quartz occur. This material, if free from flaws and inclusions, can be of considerable value to the electronic industries on account of its piezo-electric qualities.

Wolfram occurs in many places in the Deepwater, Emmaville, and the Torrington Divisions. The deposits at Deepwater are situated at the Ten-Mile, and are in association with tin, close to a contact of slate and felsite. The main deposits in the Torrington Division are situated at Bismuth, Tungsten, and Cow Flat. New finds are occasionally reported around Tungsten. These finds are generally in the nature of rich bungs which seem to give out after a few tons of mineral have been removed. Constant prospecting work is being carried out for bungs of this description. Torrington has been the largest wolfram producer in the State, and possesses immense dykes of low-grade ore which may be worthy of exploitation when the price of tungsten is high.

At The Gulf, 20 miles from Emmaville, wolfram and tin occur in granite near the contact with claystones. Attention has been chiefly directed to mining for wolfram, which occurs in "bunches", seldom exceeding 20 feet below the surface. Prospectors might direct their attention also to the search for tin-stone in this locality.

Wolfram, with a little tinstone, occurs at Hogue's Creek, near Dundee.

Silver lodes, with lead and zinc, have been opened up in several localities in the Emmaville and Deepwater Divisions, the principal workings being known as "Webb's" on Little Plant Creek, Webb's Consols, Mount Galena, and Wellingrove.

Uranium, thorium and beryllium minerals occur in the Emmaville-Torrington area.

Gold has been worked at Bear Hill, Kookabookra, Mitchell River and Backwater. At Glen Elgin gold occurs with tin in shallow alluvium. A dredge worked successfully on this deposit a few years ago.

Several hills in the vicinity of Emmaville are capped by deposits of bauxite.

INVERELL DISTRICT.

The main importance of this district to the Mining industry is the occurrence of tin at Tingha.

The alluvial deposits were first worked at Elsmore in 1872. In this locality tin-stone occurs as crystals disseminated through greisen, a crystalline granular rock consisting of quartz and mica. The tin-stone is not, as a rule, in sufficient quantity in the greisen to render the latter a payable ore, but the gradual decomposition of the exposed portions of the rock has set free the crystals of tin-stone, and these have been concentrated by the action of the rain on the hillsides into surface deposits. Deposits very similar to those at Elsmore were extensively worked at Newstead, about 4 miles further east, and, as the mining population spread out in their efforts to prospect the neighbouring country, tin-bearing alluvial deposits were found in the creeks and gullies at Stannifer, Tingha, Stanborough, and other places in the district. These deposits, being shallow, have been extensively worked. The alluvial flats along the creeks traversing granite country in this district are all tin-bearing, but they are of considerable depth, up to 20 feet or more, and require stripping. The greater portion of the bed and banks of Cope's Creek, with its branches, have been worked, or are now being worked, by dredges; also portions of Ponds Creek, Middle Creek, and other creeks in this district.

During recent years small parcels of tin have been obtained by treating surface material along the flats of Cope's Creek in the immediate vicinity of Tingha, further along the creek from Tingha and along South Branch. Fair results have also been obtained in the vicinity of Patridge's lode to the north of Tingha.

There are prospects of obtaining payable tin from shallow alluvial ground in places such as Ponds Creek, Joe's Gully, South's Gully, and Wetzler's Lead.

Leads up to 100 feet in depth which are either dry or carry only small quantities of water, such as Walmsley's and Beckett's are worth further prospecting, as also is the ground in the Oaks Lead area.

The future of the field may depend on the development of the deep leads from 100 to 200 feet in depth, in the neighbourhood of Topper's Mountain, the Oaks and Gilgai, but this work cannot be undertaken by men without financial backing owing to the cost involved in sinking deep shafts and dealing with large quantities of water.

A number of tin-lodes have been worked but, with a few exceptions, the shoots were of comparatively limited dimensions. The lodes worked were, however, rich near the surface. There are several large lodes which require capital for their development. Prospecting for lodes in this district may be worth the attention of experienced prospectors. Further attention might well be paid to the Belmore lode, the extension of the Brickwood lode, and to the vicinity of the Schuman's and Oaks Leads.

Following the discovery of the alluvial tin deposits of this district, diamonds were found from time to time by the miners, but it was not until some years later that they were won in quantity. In the neighbourhood of Copeton and Staggy Creek there are a number of isolated basalt-capped hills, and beneath the basalt are deposits of sands and gravels containing diamonds, stream-tin, and a little gold. They are portions of what was once a continuous basalt-capped lead, which followed approximately the present course of the Gwydir River, but the intervening portions have been removed by denudation, which has also deepened the existing river valley, leaving the isolated and elevated patches of gravel protected by their covering of basalt. The diamonds are accompanied by topaz, sapphire, zircon, tourmaline, etc., and the wash-dirt contains in addition up to 15 lb. of stream-tin per load.

At Howell, an important silver-lead lode occurs in granite country, and its outcrop has been traced for a considerable distance. The ore is rich in silver, and contains the following minerals—Galena, zinc-blende, copper-pyrites, mispickel, and stannite. There are two important mines, known as the Conrad and King Conrad, which have been recently re-opened by a large mining company.

Copper occurs within a narrow zone near Bundarra.

The tin found in the surface deposits at Elsmore is associated with wolfram, and also with carbonate of bismuth. The wolfram is derived from lodes which are known to intersect the greisen, and some of these are occasionally 18 inches or more in width.

Uranium minerals occur at Gilgai and at Silver Valley near Howell.

Bauxite deposits occur in a number of localities in the Inverell district.

TAMWORTH DISTRICT.

The Tamworth district adjoins the northern boundary of the Main Coal Basin and includes a number of mining centres which were notable in the past but have not been the subject of much recent mining activity.

On the southern end of the district is the Nundle-Hanging Rock Goldfield from which gold was won from shallow alluvium, reefs in slates, and beds of cemented gravel. Most gullies carried some alluvial gold but these have been almost worked out. The reefs proved rich in places but the gold shoots are usually short. The cemented gravels are extensive and up to 60 or 70 feet thick. In part they are covered by basalt. Rich patches of gold-bearing material occur in them, but for the most part they are low grade. Several attempts to work them by large-scale sluicing methods have been financially unsuccessful.

Small deposits of scheelite and antimony also occur near Nundle.

In the east of the Tamworth district are the towns of Walcha and Weabonga. In the neighbourhood of these towns gold-bearing reefs occur.

The Moonbi Ranges lie north of Tamworth and are composed to a large extent of granite. Molybdenite has been recorded from them in several localities but mine operations have been very limited.

Near Bendemeer, on the western flank of the granite of the Moonbi Ranges, alluvial tin occurs along the course of Watson's Creek. The tin-bearing section of the creek appears limited and is being worked by dredge at present. Lode tin has been recorded from the neighbourhood. Some uranium mineralisation occurs at Giant's Den, Watson's Creek.

Between Attunga and Bingara there is a large belt of serpentine trending N.N.W. With it is associated a large variety of minerals, including chromite, asbestos, magnesite, copper, gold and scheelite.

A large deposit of limestone between Attunga and Manilla is extensively quarried.

North of Barraba diatomaceous earth is found in association with the basalt capping that section of the Nandewar Range.

Gold has been worked in the past between Upper Bingara and Bingara, alluvial gold occurring in several of the tributaries of the Gwydir River.

Copper lodes are located near Upper Bingara.

Diamonds were worked successfully in gravels occurring partly beneath basalt cappings on some of the ridges west of the town of Bingara.

Perhaps one of the notable features of the Tamworth District with regard to mineral occurrences, is the widespread distribution of manganese. No deposit is very large but several are of commercial importance, producing manganese oxide, both of steel-making and battery grade. Manganese oxide occurs in lodes up to 10 feet wide in the sedimentary rocks surrounding the granites of the Moonbi Ranges. In most cases the payable sections of the lodes are short-lived vertically, changing to unsaleable siliceous material at depths usually less than 100 feet.

At present most activity on manganese lodes is taking place near Manilla and east of Walcha, near the edge of the New England Plateau, but the mineral has been worked or prospected at Barraba, Manilla, Watson's Creek, Kootingal, Danglemah, Walcha Road, Walcha, Niangala and Weabonga.

TENTERFIELD DISTRICT.

While some mining activity has taken place in the vicinity of Boonoo Boonoo, where both alluvial and reef gold have been won, the more important sections of the district, from a mining viewpoint, are Drake and Wilson's Downfall.

Extensive mining operations have been carried out in the vicinity of Drake. The country rock consists mostly of felsite, tuffs, breccias, and lava flows. The reefs are fairly well defined, generally possessing one good wall. Dykes in certain cases form walls to the reefs; in other cases reefs incline towards a large central dyke.

The old fields at Tooloom, Pretty Gully, McLeod's Creek, and other old diggings within this Division are intermittently worked. Pretty Gully diggings are fourteen miles by the shortest route from Drake. The depth of sinking is never more than 18 feet, but work is mostly in the nature of turning over old ground. A deposit of auriferous drift covered by basalt occupies a mountain range near the Clarence River. It extends along the northern side of Pretty Gully for about four miles. There are at least two drifts or old river beds beneath the basalt, and both of these appear to be auriferous. The sides of the range are very steep in places, and the gullies leading from them have been worked for alluvial gold and found to be rich though narrow. As no reefs are known to occur in the neighbourhood, it is very probable that this alluvial gold has been derived from the denudation of the old basalt-covered river beds at the top of the range. It may be said that there are evidences of the existence in this locality of several miles of basalt-covered gold-bearing drifts, which might well be worth prospecting.

There are possibilities for lode mining in the Drake area. Although the deposits of mineral are of low grade, it is possible that with more improved methods of treatment profitable results would be obtained. Various minerals of commercial value occur, viz., gold, silver, copper, lead, zinc, antimony, iron, arsenic, and limestone. The principal metal sought for is gold, and several mines have been worked profitably in the oxidised zones. This generally gives place to the sulphide zone at a depth of 80 feet from the surface, the principal metal in this zone being copper. The principal gold-producing mine was the Lady Jersey, 6 miles from Drake township. This locality is deserving of further search, as only a very small area was exploited by the original prospectors. A great quantity of gold has been obtained from Lunatic Reefs in the past. Small veins of metallic arsenic, carrying gold, occur at Lunatic, and not far from this spot molybdenite has been located. Some deposits of antimony have also been worked in the neighbourhood, and deposits of this mineral can be traced through the country to Pretty Gully. Most of the antimony contains gold. Ten miles north-west of Drake there are deposits of copper. In the same locality a deposit of zinc ore has been worked.

Low grade gold-bearing aplite dykes occur in granite country at Poverty Point, Timbarra.

Silver-lead lodes occur about 1½ miles south of Drake and at White Rock, Mount Carrington, and at Boorook, 12 miles north-west of Drake.

At Black Creek, near Tabulam, there is a deposit of iron ore and adjacent to it is a deposit of limestone of good quality.

WILSON'S DOWNFALL DISTRICT.

Tin is the main product of this area, and has been recovered mainly by dredging. The principal deposits so far have been found in Ruby Creek, Wylie Creek, Cemetery Creek, The Herding Yard, Stormer's Ridge, etc. Lode tin has also been located at the Sugar Loaf, a few miles from Wilson's Downfall. The lodes, however, have not been fully exploited.

Wolfram occurs in this Division at the Sugar Loaf and near the Tick Gate on the main road to Stanthorpe. A deposit also occurs in the vicinity of Ruby Creek. None of the deposits has been thoroughly worked so far.

Graphite has been found near Undercliffe.

Molybdenite occurs in many places in the Division, but none of the occurrences so far revealed appears to be very promising. Silver-lead-zinc ore is found at Rivertree. The ore bodies are contained in true fissures which traverse both slate and granite country indifferently. The lodes are characterised by well-defined walls, and they vary in width from several inches up to 2 feet, and occasionally as much as 4 feet. The lenses of ore are uncertain both in size and values, and large areas of barren gangue are often met with between them necessitating a considerable amount of dead work. The silver contents of the lodes vary from a few ounces up to 200 or 300 ounces per ton. These deposits suffer from the disadvantage of being situated in a very rough and remote district. This part of the field is one that requires the expenditure of a considerable amount of capital, and is apparently of not much interest to individual miners, as the ores are complex.

Some mining for wolfram and bismuth has taken place in the vicinity of Wunglebung, about 30 miles from Tenterfield. The occurrences are usually in the form of pipes. A number of pipes have been recorded, but no profitable development has yet eventuated. Some localities in this area are also known to be radio-active.

BELLINGEN DISTRICT.

This area extends from the New England Tableland at Point Lookout to the Coast, and from the Nambucca River to Woolgoolga and Dalmorton, the latter being close to the southern and western limits of the Clarence Coal Basin. The Bellingen district includes the old goldfield at Coramba, which was once the centre of important gold mines within the watershed of the Orara River. Reefs have been worked or prospected in numerous localities, and some good results have been obtained. In most cases workings have not been taken beyond water level. Gold has also been recorded from the neighbourhood of Tyringham and other localities near Dorrigo. Antimony and wolfram also occur near the latter locality.

Perhaps the most important mineral occurrences of the Bellingen District are those of antimony.

Deposits of antimony have been worked at Taylor's Arm and Burrapine and many other parts of the district. Large-scale operations are proposed for a low-grade deposit at Platypus Creek near Point Lookout. This deposit is in very rough country and the antimony deposits, which appear confined to a wide zone, may extend into neighbouring areas.

At Urunga, a deposit of auriferous arsenical pyrites occurs in the Valla Mine. The mine has been closed for some years but is said to contain reserves of gold-arsenic ores in the lower levels.

HASTINGS-MACLEAY DISTRICT.

This district includes the towns of Port Macquarie and Kempsey.

Port Macquarie is the principal centre in the State for the supply of iron oxide for gas purification. A number of deposits occurs as pockets in serpentine.

Within the town of Port Macquarie a deposit of cobalt has been worked during past years. The cobalt ore is found in serpentine, and in the clays which have resulted from its decomposition. The outcrop of serpentine, which crosses the Taree-Port Macquarie road, about 12 miles from the latter town, and which is for the most part covered by red clays and iron-stone pebbles, is commended to the notice of prospectors.

In this district there are a number of auriferous antimony lodes, which hitherto have not been profitably worked. Silver lodes have also been opened up.

A copper lode, which varies in width from 1 foot to 4 feet, has been worked at Yarras, 25 miles west from Wauchope. In this locality are a number of parallel quartz reefs, showing stains of copper. There are also gossan outcrops, some of which are certainly worth prospecting, and as this is virtually new country, chances of success by experienced prospectors are all the more likely.

Some 4 miles westerly from the copper lode, on the Forbes River, a reef has been found carrying fair bunches of molybdenite on the surface.

At Cowper, about 10 miles westerly from Yarras, a number of small quartz veins occur close to the serpentine, and some of them contain small but very rich shoots of gold ore. These veins may be found to repay attention by parties of men with limited means. Alluvial gold is also reported to have been won here.

Deposits of arsenical ore are situated on Frazer's Creek, about 7 miles by road west from Wauchope.

Tin, with a little gold, has been worked in a small way in an alluvial deposit at Carrai, 35 miles west of Kempsey, and at Gundle, 20 miles south-west of Kempsey, lode tin occurs.

Extensive limestone deposits occur at Yessabah, 10 miles west of Kempsey. A quarry has recently been opened for the supply of ground limestone for top dressing of dairy pastures.

GLOUCESTER-TAREE DISTRICT.

The principal mining centre in the district is Copeland, which is situated 10 miles by road westerly from Gloucester.

Alluvial gold has been won at Copeland (Back Creek), Rawdon Vale, Tucker's Creek, and the head of Craven Creek.

Old mines occur in a belt of country, 4 miles long, between Copeland and the Bowman River. This belt has been prospected for many years by local prospectors, and new arrivals are advised to confine their attention to the development of the present known reefs. The gold occurs in shoots, so that there is always the likelihood by continuing the abandoned shafts and tunnels of striking a rich patch. The most promising of these reefs are the Mountain Maid, the Homeward Bound, the Centennial, the Hidden Treasure, the Lady Belmore, the Mint, the Bank, and the Golden Spur.

Possible localities for the finding of new reefs occur at the Craven Plateau, Craven Creek, Tucker's Creek, Boranul, Berrico Creek, Whispering Gully, in addition to the rather inaccessible country in the western portion of the Gloucester district, where the Mount Royal Ranges (Barrington Tops) separate the Manning and Hunter Rivers. Near the head-waters of the Hunter Valley, and west of the divide, is Moonan Brook, where several small gold-bearing reefs occur.

The principal areas of interest to prospectors for gold, and which may be reached from Taree, are the Cells, Mummel and Cooplacurripa Rivers. Prospecting has also been carried on in recent years at Burrell Creek and Mount George.

Limestone occurs in the vicinity of Wingham and Taree.

South-eastern Area.

The South-eastern area includes a large number of well-known goldfields.

Alluvial deposits of many types, from shallow ground to deep leads, occur throughout the whole area. Basalt-capped leads occur particularly along the highlands and western slopes, from Gulgong to Kiandra. There is plenty of scope for prospectors interested in this type of deposit.

The ore deposits are related mainly to major belts of granite and porphyry, but some very important gold mines have been opened up adjacent to serpentine contacts, as at Gundagai. One great granite belt extends from the Victorian border between the headwaters of the Murray and Snowy Rivers, northwards through Tumbarumba, Adelong, Harden and Young. Gold occurs (and in the south-west tin also) at and adjacent to granite contacts with sedimentary rocks such as slate.

The granite and porphyry belt which forms much of the Main Dividing Range from a little south of Goulburn to the Victorian border, includes Braidwood-Araluen (gold), Captain's Flat (copper-lead-zinc mainly), and the gold, tin and molybdenite-bismuth deposits of the far South Coast. Between this belt and the coast, smaller granite outcrops occur and with these are associated small rich shoots of ore, commonly arsenical or pyritic, as at Bateman's Bay, Nelligen and Moruya.

The gold-bearing reefs of that wonderfully productive area which extends parallel to the western margin of the Main Coal Basin from Gulgong to a little south of Tuena (between 149th and 150th meridians of longitude) are large developed in slaty rocks and are mainly associated with porphyries as at Hargraves and Trunkey. Within this area also, rich calcite veins occur at the near serpentine contacts as at Lucknow and Rockley. Copper, silver-lead and iron occur on the central and western parts of this area, whilst the eastern margin is characterised by silver-lead, molybdenite and bismuth deposits.

CENTRAL TABLELANDS SECTION.

Bathurst District.—This district includes the sites of many of the early gold diggings and consequently has been well prospected with regard to the occurrence of alluvial gold, and to a lesser, but still great extent with regard to gold-bearing reefs.

The old goldfields within the District include Oberon, Rockley, Sofala, Trunkey, Tuena and Wattle Flat. Prospecting in these districts is unlikely to unearth important finds, but it is still possible to obtain small quantities of gold by fossicking the old workings. Some of the old reefs may pay to re-open when gold prices and costs are favourable. Basalt-covered leads carrying gold occur in several of the areas, and have not been worked out, but to date have not been worked profitably.

In addition to gold, which has been the most important mineral worked in these areas, perhaps the base metal mines containing lead-zinc and copper, near Tuena, are of most interest. Three mines, Peelwood, Mt. Costigan and Cordillera, have been worked in the past, and may be worthy of further development when high metal prices are ruling. Copper mines have been worked at Cow Flat near Rockley, and at Wiseman's Creek, near Oberon. Manganese occurs at Back Creek, near Rockley, and at Cow Flat, talc and dolomite are both being worked at present. Barytes occurs at Kempfield, near Trunkey.

The areas so far mentioned are the principal goldfields of the Bathurst district. However, gold occurs throughout the district, but not to the extent that it does within the areas mentioned, and further occurrences of payable gold are not unlikely outside of them. Near Mandurama a series of bedded rocks carry low gold values at a locality known as Junction Reefs. These have been extensively worked in the past, but there appear to be possibilities for further development. Burraga, one of the localities a little removed from the main centres of gold-mining, was the site of a very important mine in the past, the Lloyd Copper Mine. Another copper mine which has been idle for many years is at Blayney. The last activity to take place on this mine was the precipitation of copper from the mine water. Copper mines also occur in the vicinity of Cowra and Carcoar, the most extensively worked being the Milburn Creek Mine, near Mount McDonald. Iron ore occurs at Broula, near Cowra, and at Coombing Park, near Carcoar. In the latter locality small patches of cobalt ore have been worked. This material also contains traces of uranium minerals.

Mudgee District.—Like the Bathurst District, the Mudgee District contains many old goldfields which were of considerable importance in the past, but are now well prospected and almost worked out. These include Hargraves, Hill End, Windeyer, and Gulgong. Alluvial gold-bearing areas occur in all areas, but it is most likely that any future gold-mining in them will be mainly confined to reef-mining. Areas such as Hill End, Hargraves and Windeyer may be worthy of some attention. Gulgong produced most of its gold from deep leads, many of them basalt-covered and very wet. There are possibilities of further work on the leads, but extensive prospecting operations requiring heavy capital expenditure will be necessary. Until World War II, a dredge operated successfully on alluvial ground at Biraganbil. Around Mudgee itself there are a number of alluvial gold localities which might now be considered as fossicking ground only; they include Apple Tree Flat, Budgee Budgee, Crossroads, Log Paddock, Pipe-clay and Piambong. At Tucklan, near Dunedoo, gold occurs in small patches of alluvial wash derived from the weathering of conglomerate. There are several areas of such conglomerate in the district. The gold content is low, averaging about 2 dwts. per ton. They may offer some promise for future development when conditions are favourable, but would be unpayable at present.

At Leadville a large base metal ore-body occurs in the Mt. Stewart Mine. The mine originally produced lead and zinc, but in its later days it was worked primarily foı the production of massive iron pyrites used in the manufacture of sulphuric acid. It is understood that the known areas of pyrites are practically worked out, but that appreciable tonnages of zinc ore are still present in various sections of the mine.

Clays are worked in arcas between Mudgee and Ulan and at Puggoon, north of Gulgong.

Dolomite deposits occur in the Mount Knowles area.

Orange District.—The Orange District contains the site of the original discovery of payable gold in New South Wales at Ophir. This area, however, is not now attractive to prospectors. Other alluvial areas now well worked include Lewis Ponds, Emu Swamp, Forest Reefs, Slattery's Creek, Flyer's Creek and Wire Gully. Basalt-covered auriferous leads occur on hills above the Macquarie River, near Mullion, and at Forest Reefs. The town of Lucknow, 7 miles east of Orange, was the site of much past gold-mining activity. Rich gold ore occurs at the contact of andesite with serpentine. The occurrence of ore is sporadic and considerable prospecting is necessary to find the richer areas. A number of the old mines on the field failed to strike payable ore.

Gold-bearing lodes also occur at Cargo, but have received little attention since their discovery and early development.

An extensive deposit of iron ore occurs at Cadia, while copper lodes exist in the same area. Several copper lodes occur near Byng, Whitney Green, Carangara, Icely and Lewis Ponds. Some of these were originally worked in the eighteen fifties.

Marble occurs at Borenore, Caleula Creek and Waldegrave and limestone deposits are present in the Cudal-Cargo area.

Wellington District.—Gold has been worked in a number of localities within the district. Generally the alluvial areas have been confined to the Macquarie River and its tributaries upstream from the town. Basalt-covered leads occur in the vicinity of the Macquarie River, near Stuart Town. A dredge operated on the river for some years. A number of gold-bearing reefs occur near Stuart Town. These have mainly been worked to water level and then abandoned. Some may merit further attention.

An important gold mine operated at Bodangora some years ago. Large tonnages of ore were crushed and treated. The resultant sands were re-treated in fairly recent years.

Several copper mines have been worked in the District between Wellington and Molong. Large areas of limestone occur at Molong. Pockets of phosphatic rock are present therein at irregular intervals.

Yerranderie District.—The Village of Yerranderie is situated in the Wollondilly Watershed, about 84 miles from Sydney. A number of small galena lodes, very rich in silver, occur in the locality. Several mines have been opened and the deepest (Wollondilly) has been worked to a depth exceeding 1,400 feet on the underlay. The area may deserve further examination by companies, when high lead and silver prices are offering.

Barytes is being worked in the Burragorang Valley, near Jooriland. Gold has been recorded from the Kowmung River, but no payable occurrences are known.

Parts of the Burragorang Valley area are under water following completion of the Warragamba Dam.

SOUTHERN TABLELANDS SECTION.

Goulburn District.—Gold, copper, silver, lead, zinc, iron ore, clay, roofing slate, and limestone occur in the Goulburn District.

Gold in small quantities has been recorded from Manton's Reef, 7 miles from Bungonia, and Kangaroo Reef, 3 miles further south. Gold has also been found from time to time at Tirranna.

A gold-bearing reef has been discovered near Hanworth Post Office.

At Tolwong, on the Shoalhaven River, near Bungonia, mining for copper, silver, lead, and zinc was carried out by several companies. Rich veins of these minerals, as well as one of tin were discovered. The river gorges in this locality are precipitous, and searching for minerals here should not be undertaken single-handed. A similar mineral assemblage occurs in the Ettrema Gorge, north of Sassafras.

Copper has also been found at Touga Creek, 10 miles north of Nerriga, at Merilla, 8 miles from Breadalbane, and also between Breadalbane and Cullerin railwav stations.

Stream tin has been found in small quantities in Tin Gully, near Bungonia. The tin has been derived from narrow veins.

Iron ore occurs in several parts of this district, the most important being at Breadalbane, Tirranna and Mount Carrington.

On Boxer's Creek, about 6 miles from Goulburn, and at Inverary Park, there are large deposits of clay, some of which are suitable for pottery and refractory purposes.

Mineral pigments occur in several localities in this district, the most important being at Wingello, Yarra, and Carrington.

Large deposits of roofing slates occur in this Division. The principal work has been done by the Chatsbury and Argyle Companies at Tarlo River, 17 miles from Goulburn. Another good deposit is at Rix's Creek, between Goulburn and Bungonia.

Limestones occur in several parts of the district. At Marulan good quality limestone is quarried for cement manufacturers.

At Mount Fairy, near Bungendore, large deposits of limestone and dolomite occur, the latter being extensively worked for refractory use.

At Kingsdale, north of Goulburn, a limited deposit of limestone is worked for the production of quick-lime.

Crookwell-Yass District.—Gold-bearing gravels beneath basalt occur near Crookwell, but the gold content is generally low. Diamonds have been found in the gravels near Binda. A number of small but promising gold-bearing veins occur near Dalton.

Deposits of wolfram and scheelite have been worked at Frogmore, Reid's Flat and Rye Park. Operations have been intermittent owing to the instability of the price of tungsten. While high prices are maintained these mines offer possibility for successful operation. The Frogmore Mine has been worked very considerably to a depth of 500 feet.

Copper and lead-zinc lodes occur at Walla Walla, near Rye Park, and a large copper-lead-zinc lode has been worked at Kangiara, between Yass and Rye Park. There is an old copper mine at Frogmore, which has been idle for a great many years.

At Bevendale, 12 miles north-west of Dalton, tin has been found in alluvial deposits and lodes. A small pump dredge operated on one of the alluvial areas for some years. The area has not been extensively prospected for tin and may be worthy of further attention.

Young-Murrumburrah District.—The town of Young is situated on the old Lambing Flat gold diggings which have been well worked and there appears to be little chance of new areas of great value being found. Gold-bearing quartz reefs, which may pay further attention, occur at Bribbaree, 25 miles W.N.W. of Young. Other gold-bearing reefs occur in the vicinity of Murrumburrah and Demondrille.

There is a large deposit of magnesite between Thuddungra and Weedallion Siding. Chromite also occurs in the same locality and at Fontenoy, near Wallendbeen.

Extensive talc deposits are worked within 1 mile east of Wallendbeen.

Gundagai-Tumbarumba District.—This district includes a number of old alluvial goldfieids at Adelong, Batlow, Gundagai, Tumut and Tumbarumba. Many gold-bearing reefs have been worked throughout the district, the most important were those at Adelong. Gold-bearing basalt-covered leads occur on the high country around Laurel Hill and Tumbarumba.

Chromite has been worked at Gobarralong in the Gundagai area. Asbestos occurs at Jones' Creek. Both these minerals are associated with belts of serpentine.

Copper occurs at Lobb's Hole, near Yarrangobilly, and fluorspar has been worked at a mine at Carboona, near Jingellic.

Captain's Flat District.—This district possessed the large lead-zinc deposit, previously worked by Lake George Mines Ltd. The lode was an extensive one and can be traced on the surface for several thousand feet. It has been worked extensively and prospecting operations have been carried out beyond the main workings. Small copper lodes occur near the main lode, but appear to be of little economic value. The mine produced copper, gold and iron pyrites in addition to lead and zinc concentrates.

Several outcrops of gossan occur at Anembo and may be representative of lode material at depth.

Barytes has been worked in several localities between Captain's Flat and Braidwood.

A small amount of gold has been won from the alluvium of the Molonglo River, but the area is not recommended to prospectors.

Iron deposits occur in the Michelago area.

Cooma District.—The occurrences of alluvial gold in the Cooma district are widespread, and these have been extensively worked. The principal occurrences are along the upper reaches of streams heading in the Snowy Mountains. The greatest production of alluvial gold in the district is recorded from the Kiandra diggings, near the head of the Eucumbene River. The district does not appear to offer much inducement to alluvial prospectors under present conditions.

Several gold lodes have been worked in various parts of the district. At Bushy Hill, Cooma, gold occurs with pyrites in crushed and foliated quartz porphyry. The formation is extensive and may warrant further prospecting.

Copper lodes have been found in several parts of the Bombala area, but have not been worked to any extent. At Adaminaby, the Kyloe copper mine was formerly an important producer, but has been idle for many years.

Wolfram occurs at a locality 3 miles from Cooma and at Berridale. Tin and wolfram have been recorded from Bombala, and tin has also been prospected at Mount Pilot in the Snowy Mountains.

There is a deposit of diatomaceous earth about 1½ miles from Bunyan.

Wagga-Albury District.—A number of wolfram and tin lodes occur between Burrandana, Jingellic and Albury. Alluvial tin has been worked in the same area. The district appears worthy of further prospecting for these minerals. At Albury and Corowa, deep alluvial gold-bearing leads have been prospected. The gold-bearing gravels occur at depths exceeding 200 feet from the surface and are associated with heavy supplies of water. Attempts to work them in the past have not been financially successful.

Several gold-bearing reefs have been prospected or worked in a small way at Walbundrie, Stoney Park and Bungowanna.

SOUTH COAST SECTION.

Braidwood-Moruya District.—This district contains many gold diggings which were important in the early days of the discovery of gold. Alluvial gold deposits occur in the Braidwood, Mongarlowe, Araluen, Major's Creek and Bateman's Bay areas, and have received considerable attention. Many dredges have worked near Braidwood and Araluen. Most of the alluvial fields to-day are fossicking grounds only. High level gravels, with low-grade values, occur above the Shoalhaven Valley and at Nerriga.

Near Moruya there are important lodes of gold, silver, and arsenic in the vicinity of Donkey Hill and Candoin Creek. The Moruya Gold Mine worked successfully in this area until the outbreak of the War. A large low-grade pyritic gold lode occurs at Dargue's Reef, between Major's Creek and Braidwood.

A silver mine has been worked at Boro between Tarago and Braidwood.

Several small deposits of barytes have been worked between Major's Creek, Captain's Flat and Tarago.

Narooma District.—Extensive alluvial operations for gold took place in the past at Nerrigundah, but the deposits are practically exhausted. There are possibilities of payable reefs being found in the district at Nerrigundah, at the head of the Tuross River, near Tilba Tilba, and at Wagonga.

Turquoise has been found in small fissures in slate at Mummaga Creek near Bodalla.

Bega District.—Mineral deposits of this district discovered to date are of little importance. Alluvial gold has been worked in very limited areas, while small gold reefs have been recorded from several parts of the district.

Molybdenite and wolfram have been recorded from Cathcart and Tantawanglo and molybdenite occurs at Black Range. Barytes occurs in several parts of the district. Pyrophyllite has been worked recently at Cobargo.

Eden District.—Gold-bearing reefs and lodes have been extensively worked at Pambula, Wolumla, Yambulla, and to a lesser degree, Sugar-loaf Mountain near Nethercote.

Molybdenum and bismuth have been won from Whipstick and traces of uranium mineralisation occur in association with those metals.

Pyrophyllite is being won from Greig's Flat, near Pambula, and other deposits have been worked in past years at Back Creek. Soda felspar, with associated molybdenite, has been worked at Wog Mountain.

The Central Part of the State.

The Central district is the great copper province of New South Wales, but it is also noteworthy for other minerals, including gold, silver-lead, tin and wolfram.

A thick sheet of alluvium overlies a large part of the district, masking both alluvial and reef deposits. The shallow and deep alluvials of Peak Hill, Parkes, Forbes and Grenfell, are examples of types to be expected in the eastern part of the district. The Fifield area might also be mentioned. Here the Platina Lead (platinum and gold) was discovered in 1893, but it was not until 1917 that the North Lead was found, in spite of the fact that many men working the former must have frequently walked over the latter. A considerable area in the vicinity of the leads has paid when worked by puddling. Deposits similar to the above may be found.

In the eastern part of the Central area, gold usually occurs in quartz reefs within belts of slate trending north to north-westerly as at Parkes and Peak Hill-Tomingley.

In the western and northern parts of this area the prospector should note particularly that nearly all the important gold deposits have been found within belts of the older rocks, trending about N. 30 degrees W., in many places close to granite contacts. In these areas, also, heavy faulting has occurred, giving rise to zones of crush, in which the lodes occur. All such contacts and their extensions beneath the plain are well worth examination by prospectors. Attention, therefore, should be given to the older rocks rather than to the less altered and more gently dipping strata which are found overlying them. Two belts of old rocks are known, one of which includes Ardlethan, Wyalong, Weethalle, Nymagee, Canbelego, Cobar and Mt. Drysdale, and the other Tullamore, Tottenham, Hermidale and Byrock.

The history of the discovery and development of the ore bodies worked at these localities furnishes a guide to prospecting the region. The district offers considerable scope for reef prospecting by well-equipped parties. It should prove a good field for investigation by geophysical methods of prospecting of the extension of known crush zones beneath a cover of alluvium, although one cannot overlook the fact that, generally speaking, the most highly mineralised areas are likely to have been the most resistant to the processes of weathering and to have formed the higher points in the landscape.

It should be borne in mind also that much of the area has a rainfall of only 15 inches or less per annum, and that distances between settlements are considerable.

FORBES-PARKES DISTRICT.

This district includes the gold-mining centres of Forbes-Parkes, Peak Hill, Tomingley and Grenfell.

There are many alluvial leads which have been extensively worked in past years. The depth at which the wash was met with ranged to over 400 feet, the average being from 100 to 150 feet, but water is encountered at a comparatively shallow level. There is good reason for believing that the gold has been extracted only from the main channels, leaving the side or reef wash, as well as that from the junction of smaller tributaries, untouched. The difficulty of overcoming the water and the task of reaching the wash, however, places these leads beyond the reach of the prospector not possessing considerable financial means.

Important gold-bearing reefs and lodes have been worked at Parkes, Peak Hill, Tomingley, McPhail and Grenfell. The most recent production has been from a large low-grade zone of gold-bearing slates known as the London Line of lode at Parkes.

At Peak Hill and Tomingley, the large tailings dumps of the old mines have been cyanided in recent years.

The occurrence of copper ores in small quantities has been noted in numerous localities in this district, viz., Goobang Station, Gobondery, Goonumbla Hill, Limestone Reserve, Gunningbland Station, Little Mount Currumbla Station, Langford's Lease, Welcome Reef, Trundle, and Cumnock.

Manganese deposits have been worked about 3 miles west of Grenfell, the production from one of them being the largest from any individual manganese mine in the State.

TRUNDLE DISTRICT.

At Fifield, there are deposits of magnesite which have been worked on a large scale for many years. In the same locality there are alluvial leads containing platinum and gold. These have been extensively worked.

At Tottenham, there are several important copper lodes which have been worked to depths up to 400 feet. The ore contains up to 20 per cent. copper. The mines worthy of note are the Mount Royal, Bogan River, Caroline, Iron Duke, Ace and Underlay. With the shortage in Australia of copper, the mines may be worthy of attention. They are not propositions for small operators, as considerable capital would be required for prospecting, development and plant. Currently, there are some operations for the recovery of copper by precipitation from mine waters.

TEMORA DISTRICT.

This district covers a large area from Cootamundra to Narrandera and Wyalong to Junee.

Important mining centres include the old goldfields of Temora and Wyalong and the once important tin-producing centre of Ardlethan. The area contains numerous gold-bearing reefs and lodes of varying degrees of importance, those of West Wyalong being perhaps the richest. At Temora and Barmedman, alluvial leads received considerable attention in the past and the areas are not recommended for further alluvial prospecting. The whole district offers further opportunities for reef mining.

At Ardlethan, several tin-bearing pipes and lodes have been worked to a considerable extent, and nearby deep alluvial leads are now being worked. Shed tin has recently been discovered near Mirrool.

The alluvial tin deposits at Kikoira have been an important source of this mineral. The district between Kikoira and Ardlethan is worthy of further prospecting for tin.

Tin is found in association with wolfram at Conapaira, and wolfram occurs at Taleeban, near Weethalle.

About seven miles west of Cootamundra, a base metal lode containing lead, zinc and copper, has been worked in the past.

CONDOBOLIN-LAKE CARGELLIGO DISTRICT.

Gold and mineral-bearing lodes occur at distances of from $2\frac{1}{2}$ to 20 miles to the north-west and north-east of Condobolin. It may be said that there exist within a reasonable distance of Condobolin auriferous quartz reefs which may form a source of profitable employment if worked in a systematic and economical manner. A considerable proportion of the exploratory work hitherto performed upon them has been misdirected and has rendered the extraction of the ore unnecessarily costly.

At Melrose, about 30 miles northerly from Condobolin, copper was mined. The ores occur sparingly over a considerable area in this district, but so far only a limited amount of payable ore has been won.

At Blackfellow's Dam, between Condobolin and Nymagee, uranium minerals occur in a lode within granite in association with some copper, zinc and lead mineralisation.

Silver-lead ore has been worked at Potter's Mine, close to Condobolin, and at Mineral Hill, some 30 miles away.

At Mount Tallebung, alluvial and lode tin are being worked. Wolfram occurs in association with the tin in the lodes.

Close to Lake Cargelligo, several deposits of high-grade magnesite have been discovered in recent years. The area may be worthy of further search for supplies of this mineral.

COBAR DISTRICT.

This district extends from Bourke to Mount Hope and Nyngan to Wilcannia. The mineral-bearing section lies mainly between Bourke, Mount Hope, Hermidale and Cobar.

The Cobar district is famous for its production of copper, but in addition a considerable quantity of gold has been won, both from gold ores proper and gold-bearing sulphide ores worked principally for their copper content.

Considerable reserves of low-grade copper and gold ores exist in and near several of the old mines. Cobar Mines Pty. Ltd. is developing the C.S.A. mine 6 miles north of Cobar for the large scale production of copper concentrates.

At Nymagee, the Mouramba copper mine has produced a considerable amount of copper, but has been shut down for a number of years. Seventeen miles south-westerly from Nymagee are the Shuttleton-Crowl Creek workings, which have also produced a considerable quantity of copper. A few miles east of Shuttleton, copper has been found at the Old Wirlong workings, and gold at the Red Hill.

Near Hermidale, 30 miles east of Cobar, there are several copper mines which have not been in production for some years. Copper has also been worked to a large extent at Mount Hope in the extreme south of the district and at Girilambone 25 miles N.W. of Nyngan. Precipitation of copper from mine waters has been carried out at Mount Hope, Nymagee and Hermidale.

Twenty-five miles north of Cobar, at Mount Drysdale and Mount Billagoe, gold-bearing deposits occur as replacements of sedimentary rocks.

Generally speaking, the eastern part of the Division is more favourable than the west for the occurrence of metalliferous deposits. Particular mention might be made of the following localities: Gonella, Tindayrey, Dijou, Wilga Downs and Illewong.

The once famous Mount Boppy gold mine is situated at Canbelego, 3½ miles from Boppy Mountain railway station. There are several smaller mines and prospecting shafts in the vicinity of Canbelego.

The porphyry belt extending from Babego T.S., 10 miles north-east of Nymagee, southwards through Overflow Station and Bobadah, is worth prospecting. Gold is associated with silver, lead, copper and zinc in the main ore-body at Bobadah and a similar mineral assemblage has been found at other places along this belt.

Magnesite has been found in several localities close to Cobar, but occurrences of good grade material are very patchy.

The Cobar district has an arid climate, and is subject to severe droughts. Natural drainage channels are scarce, and these conditions make prospecting difficult. In many cases the rocks have a deep covering of loam and clay, lodes and ore deposits being thus made difficult to locate, the more easily discoverable ones have been found years ago. However, many localities offer scope for new discoveries similar to those already found in the district, but the work of searching for them should be undertaken only by men with experience and some capital. Alluvial deposits are rare in the Cobar district.

The Broken Hill-Tibooburra Area.

This area includes the whole of New South Wales west of the Darling and Paroo Rivers, and is centred around the City of Broken Hill. It also includes the old gold-mining areas of Milparinka and Tibooburra, and the White Cliffs opal field.

Broken Hill is situated in the far western portion of the State, being only 30 miles from the South Australian border.

The city is dependent on the mining industry. The principal mines extend almost in a direct line for a distance of fully 3 miles. Although various minerals are obtainable in the district, the mines along the main lode produce chiefly lead, zinc and silver.

Prospecting is constantly going on at either extension of the line of lode, and when metal prices are high a number of small mines are reopened.

The largest mine in the district outside the line of lode is the Pinnacles mine, about 10 miles south from Broken Hill. A great deal of prospecting has been carried out in the vicinity of this mine.

In the vicinity of Mount Robe, Mount Eldee, Thackaringa, and the Mayflower mine near Purnamoota, deposits of fluorspar have been opened up. Should the demand for this mineral increase notably, further deposits should be looked for in these localities.

North of Broken Hill, at Euriowie, Yanco Glen and Thomson's Siding, tin has been worked. The tin occurs here in veins of coarse pegmatite. Wolfram has also been recorded from the last two localities mentioned, but so far alluvial tin has not been recorded from the district except in minor amount from Euriowie.

Ores of platinum have been found associated with serpentine in parts of the Broken Hill district, principally in the Mount Darling Range, east of the city. So far no satisfactory metallurgical process has been evolved for the treatment of these ores.

Small deposits of copper ore have been prospected to the south of Broken Hill, but no activity in this direction has taken place of late years.

Although gold is a valuable by-product from the treatment of Broken Hill ores, no occurrence of free gold in veins or reefs in payable quantities has been recorded from the vicinity of the city.

Large bodies of sillimanite have been discovered near Thackaringa.

Extensive deposits of potash felspar of commercial value are being worked in the Egebeck area, south-west of Broken Hill, and felspar deposits occur in other parts of the field.

Uranium minerals are known to be present in a number of Broken Hill localities, e.g., Copper Blow, Thackaringa, Mundi Mundi, Brinkworth Well, Eldee Creek, Hen and Chickens, Great Western and Corona. The thorium-bearing mineral monazite also occurs in the district, both in pegmatitic formations and in alluvial creek deposits.

The lithium-bearing mineral amblygonite is obtained from the Trident mine at Euriowie.

Beryl deposits, chiefly in association with felspar in pegmatites, are present at Egebeck, Euriowie and near Broken Hill.

Milparinka and Tibooburra are situated in the north-western corner of the State, some 200 miles north of Broken Hill.

About 6 miles west of Milparinka are the Mount Browne diggings. These consist of a fringe of auriferous gravels dipping off the south end of a small slate range and disappearing under the plains. The alluvial deposits are now practically worked out, but there are many quartz reefs in the slate rocks on which little prospecting has been done.

At Warratta and New Bendigo, about 10 miles north of Milparinka, there are several reefs, some of which have been prospected, but with indifferent results.

A large area of alluvial deposits has been worked close to Tibooburra. There appear to be several parts of this locality in which little work has been done.

White Cliffs is 180 miles north-east of Broken Hill. This district is famous for its opal, having produced a considerable quantity of this gemstone in the past. The opal occurs in a white shale which outcrops close to the town. It is found on several levels down to about 40 feet in depth, and in vertical joint cracks in the shale. At present most of the easily workable ground has been thoroughly worked, and although there is no reason to believe that the surrounding country is not opal-bearing, it is too costly to prospect owing to a hard capping of quartzite known as "Grey Billy". Opal has been found in several parts of the district where the capping has been removed by the action of the weather, at Gemville, Barclay's Bunker, and other localities. It seems advisable to prospect for opal only in those places where some trace of the precious opal or "potch" has been found on the surface, as its occurrence is always sporadic, and does not appear to follow any set law.

At Wertago, in the western portion of this Division, about 20 miles east of Nuntherungie Station, several copper lodes occur. These lodes may be worth prospecting further, but the aridity of the climate and the long distance to rail considerably hamper any serious developments in this locality.

Copper lodes also occur on Grasmere Station, 30 to 40 miles south of the Wertago deposits. These have been worked by parties of miners with some success, during periods of high prices of copper. Alluvial gold has also been recorded from Grasmere.

Gypsum deposits occur in several areas west of the lower Darling near Wentworth, but owing to their isolated position, have not received much attention.

The Remainder of the State Including the Great Australian Basin

This area is generally represented by the southern portion of the Great Australian Basin, and the north-eastern portion of the Murray River Basin, separated by the great metalliferous provinces of the Central and Broken Hill-Tibooburra areas. Generally, the country is composed, to considerable depths, of unconsolidated sands, clays and gravels, underlain by sandstones and shales. It is practically devoid of any valuable deposits of metallic minerals. The Murray Basin, however, is important as a source of gypsum for plaster manufacture, cement making, and agricultural purposes. So far most attention has been paid to deposits close to the Broken Hill railway line in the Ivanhoe district where there are numerous deposits associated with the less elevated parts of the land surface. Other deposits occur in the Wentworth and Balranald district, and it is probable that the distribution of gypsum deposits is far more widespread than those so far recorded.

About 40 miles north of Walgett, ridges of sandstone extend from Lightning Ridge to Angledool Station. The sandstone country round Lightning Ridge has been considerably worked for opal. Opal has also been found at Grawin Tank, 30 miles W.S.W. of Lightning Ridge and it is possible that further finds will be made in the sandstone country throughout the district.

CHAPTER IV

OCCUPATION OF CROWN AND PRIVATE LANDS FOR PROSPECTING OR MINING

IT is essential that prospectors should take the necessary steps to acquire valid mining or prospecting titles to the areas on which they intend conducting operations.

The following brief outline of the provisions of the Mining Act, 1906, as amended, embraces only such portions as are considered to be of particular interest to the prospector.

Prospectors desiring fuller information should, if possible, obtain a Guide to the Mining Laws of New South Wales. Enquiries should be made from the Government Printer, or the Department of Mines, Sydney, regarding its availability.

Miner's Right.

1. A miner's right is no more than a document showing that the holder is entitled to enter upon certain classes of Crown land to search for gold and minerals and to take possession of such land under certain conditions.

It is not a title deed showing that he is the owner of the land, but is a document showing that he has a right to avail himself of the mining laws.

2. A miner's right may be obtained from all Mining Registrars at a cost of £1 ($2.00) for a term of twelve months or 10s. ($1.00) for a term of six months.

Term may be from six months to twenty years.

It may be renewed and may be transferred by endorsement but, in such case, the transfer must be registered at the office of issue. If a miner's right is lost or destroyed, a duplicate may be issued on payment of a fee of five shillings (50c).

3. A miner's right is required to be held by an applicant for an authority to prospect a tenement, a licence to prospect, and an authority to enter private land.

4. A miner's right may be held by a woman, an executor of a deceased estate and a corporation but NOT by a party or syndicate.

In the latter case each member of the party must hold one. A miner's right cannot be held by anyone under the age of 16 years.

PRIVILEGES CONFERRED BY A MINER'S RIGHT.

1. The holder of a miner's right may take possession of and occupy Crown lands, not exempted from occupation, mine thereon and retain any gold or minerals he finds. He may construct and use races, dams, roadways, etc., for mining purposes but, if the flow of any stream is affected, he must obtain a permit from the Water Conservation and Irrigation Commission to use the water.

2. He may, while following the occupation of a miner or prospector—

(*a*) graze upon Crown lands not exempted from occupation nor reserved for a temporary common not more than two horses and two cows for his subsistence and for the carrying on of prospecting or mining;

(*b*) procure for his *personal use only* any live or dead timber from any Crown land not exempted from occupation or in respect of which the Forestry Commission or Soil Conservation Service has not prohibited the cutting of timber.

3. He may also erect any building or machinery on the land so occupied and remove it at any time during such occupation.

Mining or Prospecting on Crown Land.

1. Generally speaking, Crown land is land that has not been—

(*a*) sold or contracted to be sold;

(*b*) leased under the Lands Act for purposes which are other than pastoral purposes;

(*c*) leased under Closer Settlement Act;

(*d*) acquired by purchase or resumption by the Crown under the Closer Settlement Acts; or

(*e*) leased under the Mining Act.

2. When there is any doubt as to whether land is Crown land or not, write to the Mines Department, Sydney, enclosing particulars of portion number, parish and county, or, if portion number is not available, a clear sketch showing location of the land.

CROWN LAND EXEMPTED FROM OCCUPATION UNDER MINER'S RIGHT.

This includes land—

(*a*) which has been reserved or dedicated for public purposes—for example, recreation reserves, parks, State forests and timber reserves, travelling stock and camping reserves and permanent commons:

Reserves for temporary commons or commonages and for mining purposes are open to occupation unless specifically exempted;

(*b*) left as a road, street or lane in any subdivision of Crown land, or retained for drainage;

(*c*) within any city, town or village outside a gold or mineral field;

(*d*) covered by tidal water and within 100 feet of high-water mark on the landward side;

(*e*) being the excepted surface of coal leases;

(*f*) held under an authority to prospect or subject of an application for a lease or an authority to prospect under the Mining Act;

(*g*) lawfully occupied as a yard, garden, cultivated field or orchard or upon which any building actually used or occupied or any artificial dam or reservoir is lawfully standing, and Crown lands held under a permissive occupancy for residence purposes only, except upon payment of compensation to be assessed by the Warden.

It is pointed out, however, that any Crown land can be specifically exempted from occupation under miner's right by notification in the *Government Gazette*.

MODE OF TAKING POSSESSION AND MARKING OUT.

A. Unsurveyed Land.

Any person intending to occupy or apply for any tenement, authority to prospect, licence to prospect, or lease (other than a lease of the nature specified in paragraph (i) hereunder or a lease exceeding 100 acres) of unsurveyed Crown land, or any part of a surveyed portion, must, either personally or by his authorised agent, take possession of the land by fixing firmly in the ground, at each angle thereof, a post not less than 3 inches in diameter, projecting above the surface not less than 3 feet; and by cutting trenches, each arm of which shall be not less than 3 feet in length and 6 inches in depth, placed so as to indicate the general direction of the boundary lines from the post, and commencing at a distance of not more than 2 feet therefrom. Where, owing to the nature of the ground, it is impracticable to cut trenches, mounds or rows of stones, not less than 3 feet in length and 6 inches in height, may be substituted. One of such posts shall be deemed the datum post, and the person taking possession must forthwith fix to such datum post a board or metal plate having legibly written thereon, or on a calico notice affixed thereto:—

Possession taken this day of , at o'clock in the noon, for the purpose of (here insert class of holding to be applied for e.g., "prospecting area", "gold-mining lease", "railway lease for mining purposes", etc.)

Area acres

x feet.

(If a surveyed portion, state Portion No.)

(Name of intending applicant or applicants.)

(i) *Areas Inaccessible from the Surface.*—Where, by reason of the land being under water, or from any other sufficient cause, possession cannot be taken in the manner indicated, the applicant must attach to his application a plan or sketch of the land applied for, and give such description as will lead to the ready identification thereof.

(ii) *Areas exceeding* 100 *acres.*—The intending applicant for an authority to prospect or a lease to mine on an area exceeding 100 acres must fix a post and cut trenches in the manner prescribed at any one angle of the said land. Such post shall be the datum post, and notice of possession as prescribed must be affixed thereto. The applicant must insert a description of the land in his application, or attach thereto a plan of such land.

B. Surveyed Land.

Any person intending to take possession of the whole of any surveyed portion of Crown land, or marking out the whole of any surveyed portion of private land must fix a post of the dimensions specified in the first paragraph hereof at any angle of the said land. Such post shall be deemed the datum post, and notice of possession as prescribed, or (in the case of private land) such notice as may be prescribed must be affixed to such datum post.

AUTHORITY TO PROSPECT AND CONSTRUCT RACES, ETC., ON CROWN LAND.

Any person desirous of prospecting a larger area than he is authorised to hold under the Regulations as a tenement, or an area exempted from occupation under miner's right, may apply to the Minister for authority to prospect on such area and/or occupy such land and to construct and use thereon races, dams, roads, etc., and to carry out such other mining purposes as may be authorised.

Possession must be taken in the prescribed manner and application lodged forthwith with the Warden's Clerk of the Division in which the area is situated, with a deposit at the rate of 6d. per acre (Minimum £2 ($4.00)).

An authority may be granted for an initial term of 12 months and may be renewed by the Minister while it is current, for further terms not exceeding 12 months on each occasion.

TENEMENTS.

An area of land lawfully occupied under a miner's right or business license is called a "Tenement".

Tenements are divided into classes:—

Class 1—prospecting areas

„ 2—claims

„ 3—water rights

„ 4—dams and reservoirs

„ 5—races

„ 6—machinery areas

„ 7—roads

„ 8—tramways

„ 9—tunnel sites.

All tenements, with the exception of class 1, must be registered. As registration expires on 31st December each year, application for renewal of registration must be made annually.

Not more than one tenement of any class can be held under one miner's right. An additional miner's right is required for each additional tenement of the same class. By virtue of one miner's right, a miner may hold nine tenements, one in each of the classes mentioned above.

The following tenements require survey:—

Reward claim—alluvial

Extended claim—alluvial

Sluicing claim

Reward claim—quartz

Ordinary quartz claim

Mineral reward claim (except opal reward claims)

Machinery area, business area, residence area on street within the boundaries of a town or village and area for tramway.

Application for survey should be made at time of applying for registration.

TABLE SHOWING MEASUREMENTS AND AREAS OF PROSPECTING AREAS AND CLAIMS.

Tenement.	Maximum Dimensions in feet.		Maximum Area.
	Length.	Width.	
			a. r. p.
Prospecting area, alluvial	600	600	8 1 2 (*d*)
	800	800	14 2 30 (*e*)
	1,200	1,200	33 0 9 (*f*)
	1,400	1,400	44 3 39 (*g*)
Prospecting area, quartz	480	400	4 1 25 (*d*)
	720	400	6 2 17 (*e*)
	960	400	8 3 10 (*h*)
Prospecting area, mineral—			
Opal or platinum	400	400	3 2 27 (*c*)
Coal or shale	1,867	1,867	80 0 0 (*c*)
Any other mineral	1,320	1,320	40 0 0 (*c*)
Reward claim, alluvial	300	300	2 0 10 (*d*)
	400	400	3 2 27 (*e*)
	600	600	8 1 2 (*f*)
	700	700	11 1 0 (*g*)
Reward claim, quartz	240	400	2 0 32 (*d*)
	360	400	3 1 0 (*e*)
	480	400	4 1 25 (*h*)
Reward claim, mineral—			
Opal or platinum	150	150	0 2 2
Other minerals	660	660	10 0 0
Block alluvial claim—gold and mineral claim for platinum—			
One miner	100	100	0 0 36
Two miners.........................	144	144	0 1 36
Three miners	185	185	0 3 5
Four miners	220	220	1 0 17
Five miners	260	260	1 2 8
Six miners	300	300	2 0 10
Mineral claim, opal	100	100	0 0 36 (*c*)
Any mineral other than opal and platinum	417·5	417·5	4 0 0 (*c*)
Quartz claim	60	400	0 2 8
Extended alluvial claim—			
One miner	590·3	147·6	2 0 0 (*a*)
Two miners.........................	933·5	233·4	5 0 0 (*a*)
Sluicing claim—			
Two miners.........................	722·8	180·8	3 0 0 (*a*)
Three miners	933·5	233·4	5 0 0 (*a*)
Dam site	808·4	269·5	5 0 0 (*b*)

NOTES.—

(*a*) Length must not exceed four times width.
(*b*) Length must not exceed three times width.
(*c*) Must be marked out in form of a square where practicable.

NOTES—*continued.*

(*d*) When area is between half a mile and one mile from nearest prospecting area or producing lease or tenement.

(*e*) When area is between one mile and three miles from nearest prospecting area or producing lease or tenement

(*f*) When area is between three and five miles from nearest prospecting area or producing lease or tenement.

(*g*) When area is five miles and upwards from nearest prospecting area or producing lease or tenement.

(*h*) When area is three miles and upwards from nearest prospecting area or producing lease or tenement.

LEASES OF CROWN LANDS—AREA, TERM AND DIMENSIONS.

(For definition of Crown lands—see page 96 hereof.)

Leases may be either ordinary gold-mining leases or mineral leases, special leases, dredging leases or mining purposes leases.

Ordinary leases may be for any area not exceeding the following:—

Gold—25 acres.

Opal-mining lease—½ acre.

Coal or shale—640 acres.

For any other mineral—80 acres.

Such areas shall, where practicable, be measured in the form of a parallelogram, the length of which shall not exceed three times the width, except where application is made for areas underlying roads, etc.

The term may be for any period not exceeding twenty years, but, subject to conditions, the lease may be renewed for further terms not exceeding twenty years. The application for renewal must be made in the last five years of the lease, or during the last year if the lease does not exceed five years.

Special leases and dredging leases are granted for minerals other than coal and shale under certain conditions. The maximum area for a dredging lease is one hundred acres.

Leases for purposes connected with mining (known as mining purposes leases) authorise the construction of dams, races, tramways, etc.

It should be noted that a dredging lease may be issued over Crown land, private land or over both Crown and private land. Mining purposes leases may also embrace both Crown and private land. Attention is drawn to page 107 in regard to the issue of leases of private land for mining purposes.

RENT.

The rent on dredging and ordinary mining leases, to mine for gold or minerals on Crown land, is five shillings (50c) per acre or part of an acre per annum. The rent on mining purposes leases and on special leases is fixed by the Governor.

ROYALTY.

A royalty on all gold and minerals won is payable to the Crown and reference should be made to page 107 regarding rates of such royalty.

LABOUR CONDITIONS.

Gold leases—not less than one man to ten acres or fraction of ten acres.

Opal leases—not less than one man to half an acre or fraction of half an acre.

	During 1st Year not less than—	After 1st Year not less than—
Mineral leases, other than coal or shale.	1 man to 20 acres or fraction of 20 acres	1 man to 10 acres or fraction of 10 acres
Coal or shale	2 men to 320 acres or fraction of 320 acres	4 men to 320 acres or fraction of 320 acres.

Dredging Leases: In the proportion of not less than seven men for one hundred acres.

Special Leases and Mining Purposes Leases: As the Governor may approve.

Mining or Prospecting on Private Lands.

"Private Lands", means lands other than Crown lands, but does not include lands within the boundaries of a town or village, unless the Governor declares them to be private lands by proclamation, or leases granted under Part III, Part IV or Part V of the Mining Act, 1906, as amended.

Except as set out hereunder, all private lands are open to mining for gold or any mineral.

(NOTE.—Part III, Mining Act, 1906, as amended, deals with leases of Crown land. Part IV deals with authorities to enter and leases of private lands. Part V deals with dredging leases of Crown or private land.)

EXEMPTED LANDS.

The following private lands are exempted from the operation of the Act, either wholly or subject to conditions:—

1. Lands upon which any person, at the time of application for authority to enter is entitled to prospect for gold or

minerals, or is lawfully carrying on or entitled to carry on mining operations, or is using or entitled to use the land for any mining purpose.

2. Except with the consent of the owner:—

   (a) within 50 yards on the surface of any land bona-fide in use as a garden or orchard in existence when the application for authority to enter was made;

   (b) within 200 yards on the surface of the principal residence of the owner or occupier provided the residence was in existence when the application for authority to enter was made;

   (c) any land whereon is any substantial building, bridge, dam, reservoir, well, or other valuable improvement. (The Minister decides whether any such improvement is substantial or valuable, and may define an area adjoining such improvement within which no mining operations shall be carried on.)

   (d) the surface of land under cultivation when the application for authority to enter was made.

A lease of land below the surface of the exempted land mentioned above may be granted at such depth as may be considered sufficient to prevent damage to the surface.

A lease may be granted of such portion of the surface of cultivated land as the Minister may deem necessary for giving access to the gold or minerals therein, subject to payment of compensation for any damage to the crop or improvements.

3. Lands which the Governor, by proclamation, exempts from the provisions of the Act.

LICENSE TO PROSPECT. (Immediate Entry.)

Any holder of a miner's right desiring to immediately prospect private land not exempted from the operation of the Act may make application to the Warden's Clerk for a license to prospect, which may be issued by the Warden or Warden's Clerk upon payment of a fee of £1 ($2.00). The license may be granted for any period not exceeding six months and entitles the holder:—

(a) to enter on any available private land in the mining division and to mark out an area in the manner and not exceeding that prescribed in the Act;

(b) to prospect for gold or for minerals other than coal or shale for a period not exceeding thirty days from the date of marking out;

(c) upon obtaining the consent of the Warden, to erect a temporary residence on the area marked out.

Forthwith after marking out an area the licensee must notify the Warden's Clerk who arranges for an inquiry by the Warden at which compensation for occupation and surface damage is assessed.

The licensee may apply during the term of his occupation under the license for an authority to enter and may continue in occupation of the area marked out and carry on prospecting operations pending the result of the inquiry in respect of the application for authority to enter.

Notice of abandonment is required to be served on the occupier of the land and the Warden's Clerk and a copy affixed to the datum post. The Warden may direct the licensee to fill in all shafts and excavations and to repair as far as practicable any surface damage.

AUTHORITY TO ENTER.

The holder of a miner's right may apply to the Warden for an authority to enter on private lands open to prospecting or mining. The application for authority to enter must be lodged with the Warden's Clerk of the Division in which the land applied for is situated.

A fee calculated at the rate of one pound ($2.00) for each 100 acres or part thereof comprised in the area applied for must be lodged with the application. In addition a deposit of ten pounds ($20.00) must be lodged. The deposit may, as directed by the Warden, be applied towards costs incurred by the owner or occupier of the land applied for in the event of the applicant not pursuing his application or may be applied towards any compensation assessed by the Warden in the event of an authority being granted in satisfaction of the application. Any surplus is refunded to the applicant.

Inquiry: Rent and Compensation.

Before issuing an authority to enter, the Warden holds an inquiry, of which due notice is given to the applicant, owner, and occupier, and fixes the rent and compensation to be paid by the applicant. The first payment of the rent must be paid within fourteen days of the date of execution of the authority by the Warden and before entry is made upon the land in pursuance of the authority. If the first payment is not made, or if any rent afterwards due is left unpaid for a period of one month, the Warden may cancel the authority. Similarly, compensation must be paid within the period fixed by the Warden. If the compensation is not paid, or if any compensation afterwards assessed and ordered to be paid is left unpaid for a period of one month, the warden may cancel the authority.

Duration and Extension of Authority.

An authority to enter may be granted for any period not exceeding twelve months; but may be extended on application to the Warden, while it is in force and where the application for the extension is made not later than one month before the expiry of the authority or any extension of the authority, for any further period if it appears to the Warden that further time is requisite to enable the holder to complete his prospecting operations. The whole period, original and extended, cannot exceed twenty-four months.

Duplicate of Authority to be Served on Owner.

The holder of an authority to enter must, within the period and as directed by the Warden give notice, in the prescribed form, of the grant of the authority and of every extension thereof to the owner and occupier at the time of the grant or extension, of the land defined in the authority.

However, where no part of the surface is applied for and there are ten or more persons each of whom is an owner or occupier of the land applied for, the holder, with the consent of the Warden, may in lieu of giving notice to the owner or occupier give notice by advertisement in a form directed by the Warden, published in a newspaper circulating in the district where the land is situated.

Extent of Area.

Every authority to enter must state the area and contain a definition of the land in respect of which it is granted. The area may be such as appears to the Warden suitable, having regard to the class of deposit to be searched for, but shall not exceed one thousand acres and the Warden shall, except where he considers it is impracticable or unnecessary to do so, cause the boundaries of the land in respect of which the authority is granted to be defined on the land. However the area which may be included in any one mining lease shall not exceed 25 acres for gold, half an acre for opal, or 80 acres for minerals other than gold, opal, coal and shale, and 640 acres for coal and shale.

Rights of Authority Holder.

When he has paid rent and compensation, and given notice of the grant of the authority to the owner and to the occupier, the holder of an authority to enter may construct such works, and conduct such operations on or under the area held by him as may be required for prospecting the same, and he may employ as many men as he may think fit in such prospecting operations ; but without the Warden's consent he cannot employ less than the minimum number prescribed. Upon obtaining permission of the Warden he may also erect temporary residences for the use of the persons employed in the prospecting operations, in such positions as the Warden may consider proper.

LEASES OF PRIVATE LAND.

Any holder of an authority to enter may, during the term thereof, apply for a mining lease of the area defined therein, or any part thereof, if he has first given notice of the grant of the authority to the owner and to the occupier, and paid rent and compensation.

The applicant must mark out the boundaries of the area to be applied for, if less than that held under the authority, and if the whole of the surface is not required he must also mark out the surface area. Boundaries must be marked by erecting posts and cutting trenches.

The application must be lodged with the Warden's Clerk of the Division in which the land is situated, and within seven days prior to lodging his application the applicant must serve upon, or forward by registered post to the owner and occupier (if any), a notice of his intention to lodge application for lease, and affix a copy of such notice to the datum post of the area applied for.

Rent, Royalty, Term, and Area.

The rent for mining leases of private lands is £2 ($4.00) per acre or part of an acre of the surface required only, together with rent at the rate of five shillings (50c.) per acre for the whole area, were coal and shale not reserved to the Crown is applied for, payable half-yearly in advance, the first half-year's rent to be lodged with the lease application, and all subsequent rent to be paid direct to the owner. Thus, if the applicant holds an authority to enter upon 25 acres, and he desires to obtain a lease of the whole area, but only requires 5 acres of the surface, he must deposit £5 ($10.00) with his application as the first half-year's rent for the surface right.

A royalty is payable on all gold and minerals won. (For rates see hereunder.) In respect of privately owned minerals, the royalty so paid is remitted to the owner of the minerals by the Department, less a small charge to cover cost of collection.

The term of a mining lease may not exceed twenty years, but subject to conditions the lease may be renewed for further terms not exceeding twenty years. Provided that the application for such renewal shall be made during the last five years of the term of the lease, or where the term of the lease does not exceed five years, during the last year of such term.

The area of a lease to mine for gold may not, under ordinary circumstances, exceed 25 acres, ½ acre for opal, 80 acres for any mineral other than gold, opal, coal and shale, and 640 acres for coal and shale.

Special mining leases of private lands may be granted for other than coal and shale mining whether or not the area or dimensions exceed those prescribed for ordinary leases. Before such a lease may be granted it is necessary to show that there are difficulties and costs, or other sufficient reasons, requiring that a special mining lease be granted.

Labour conditions for mining leases of private land are the same as those for leases of Crown Land. (See page 102.)

Leases of private land for purposes connected with mining (known as Leases of Private Lands for Mining Purposes) may also be granted. These leases authorise the construction of dams, races, tramways, etc. Dredging leases of private land may also be granted.

ROYALTY.

The Mining Act, 1906, as amended, provides for the payment of royalty on all mineral won from mining leases and appropriate clauses are inserted in all leases issued. In the case of gold and metallic minerals which *are reserved to the Crown,* a rate of one and one-half per centum of gross value is payable. In the case of a number of other minerals, royalty is payable at prescribed rates per ton of mineral won. These latter rates vary between a prescribed minimum of threepence and a prescribed maximum of two shillings (20c).

In the case of minerals which are *not reserved to the Crown,* a rate of one and three-quarters per centum in lieu of one and one-half per centum is payable in respect of all metallic minerals won. However, there are no variations in respect of those minerals on which royalty at tonnage rates is prescribed.

Petroleum Act, 1955, as amended.

The following brief commentary on the requirements of the Petroleum Act, 1955, as amended, is given for the information of those persons desirous of prospecting or mining for petroleum. Prior to 3rd January, 1956, provision was contained in the Mining Act, 1906, as amended, for the grant of titles to prospect or mine for petroleum, mineral oils and natural gas. It was found, however, that the provisions of that Act were inadequate and accordingly the Petroleum Act, 1955, was passed. All phases of prospecting or mining for petroleum are now vested in the new Act. Comprehensive Regulations have also been gazetted covering a wide range of matters of a technical and administrative nature. If further details, other than those given hereunder, are required, inquiry should be made to the Under Secretary for Mines, Sydney.

PROSPECTING AND MINING FOR PETROLEUM.

Under the Petroleum Act, 1955, as amended, three types of titles are provided for. These titles, details of which are given hereunder, may include any land within the State whether Crown or private or a combination of both, subject to certain exemptions. All applications for titles under this Act should be made direct to the Under Secretary for Mines, Sydney.

(1) *Petroleum Exploration Licence.*—This title is granted by the Minister for Mines. The maximum area which may be granted is 5,000 square miles and the minimum 1,000 square miles. The minimum area may, however, be varied by the Minister if, in view of special circumstances, he considers this desirable. An annual licence fee of 2s. (20c) per square mile or part of a square mile is payable. The initial term of the licence may not exceed two years but renewals for further terms not exceeding twelve months each may be granted. When application is being made for this type of licence, it must be accompanied by the first year's licence fee, a scale map of the area applied for and evidence of the technical qualifications of the applicant and of his advisers and his ability to conduct the operations authorised. These operations include carrying out surveys, etc., necessary to test for petroleum and scout drilling operations.

(2) *Petroleum Prospecting Licence.*—This title is also granted by the Minister for Mines, the maximum area which may be granted is 200 square miles and the minimum eight square miles. The minimum area may be varied for special reasons. The annual licence fee payable is £1 ($2.00) per square mile or part thereof. The initial term may not exceed four years but renewals for further terms not exceeding twelve months each may be granted. The first year's licence fee, a scale map of the area applied for and evidence of the technical qualifications of the applicant and of his technical advisers and his ability to conduct the operations authorised are required to be lodged with the application. The operations permitted under this title include the necessary surveys, etc., to test for petroleum and the sinking of deep test bores.

(3) *Petroleum Mining Lease.*—This title is granted by the Governor and, as its name implies, is required in order to carry out productive operations. The maximum area in this case is 100 square miles and the minimum four square miles. As in the previous cases, this minimum may be varied for special reasons if the Governor thinks fit. A lease fee of £10 ($20.00) per square mile or part hereof is payable as is also a royalty of 10 per cent. of the gross value at the well head of the crude oil, etc., won. The maximum term for which a lease may be granted is twenty years but provision is made for renewals of not more than twenty years each to be granted. Similar requirements to those set out in regard to licences are required to be lodged with the application.

General.—Upon the approval of an application for a licence or a lease under the Act, the applicant or the person nominated by him, is required to lodge with the Minister a bond with a surety approved by the Minister or other security, in cash or otherwise, in the sum of not less than £1,000 ($2,000.00) as a guarantee of compliance with the conditions of the licence or lease and of the Act.

Provision is made for the assessment and payment of compensation to the owner and occupier of land in respect of damage sustained by operations conducted by virtue of the title held under the Act.

No provision is made for "mining purposes" or "mining purposes leases" as understood by the Mining Act, 1906, as amended, but in addition to authorising the prospecting or recovery of petroleum, titles under the Petroleum Act, 1955, also convey the right to construct and maintain such works, buildings, plant, etc., as may be necessary for the efficient working of the land.

Exploration Licenses.

The Minister is empowered to grant an exploration license for a period of not more than one year in respect of gold or any mineral over areas of not less than 100 square miles and not more than 1,000 square miles. The license may be granted over Crown or private lands or over partly Crown lands and partly private lands. The land must not however be held under any lease, authority, license or other holding under other Parts of the Mining Act, 1906, nor be the subject of any prior application for such lease or authority. Further the land must not be the subject of bona fide operations being carried on by or with the concurrence of the owner at the time the application for the exploration license is made and the land must not be included in an existing exploration license held by any person other than the applicant. There is a prescribed form for making application for an exploration license which is posted or delivered to the Under Secretary for Mines.

The fee to be paid with the application is 2s. (20c.) for each square mile or part of a square mile (which is applied towards payment of the annual fee if the application is granted). Also required to be lodged is a map showing the boundaries of the land applied for and evidence of the applicant's financial standing and technical qualifications and his ability to comply with the provisions of the Act. Also to be lodged is a proposed scheme for the exploration of the land. The scheme must also contain particulars of the geological survey and other operations proposed to be carried out and the periods within which they will be carried out and the cost.

The applicant must within 28 days of being notified of the approval of the application lodge with the Minister a bond as prescribed with a surety approved by the Minister of a sum of not less than £1,000 ($2,000.00). There is provision in the Act for the granting of successive renewals of the license not exceeding six months. On each occasion, with the limitation that the initial term plus renewals shall not exceed twenty-four months. Surveys of private lands must be carried out so as not to interfere with the existing use of private lands to a greater extent than is necessary and the Act prescribes restrictions on the rights of holders of exploration licenses over certain land. Where a holder of a license determines or is required to carry out any surveys or prospecting operations on private lands he must first apply to the Warden to determine the amount of compensation payable unless agreement is come to between the holder of the license and the owner and/or occupier of the land.

Chapter V

ASSISTANCE TO PROSPECTORS AND MINERS

General.

The New South Wales Department of Mines gives assistance to prospectors and miners in many ways in order to further the development of the mineral resources of the State. This assistance may be in the form of technical advice and service or financial or practical aids. The three branches of the Department which are of importance in this respect are the Geological Survey including the Mining Museum, the Chemical Laboratory, and the Mines Inspection Branch.

The Geological Survey Office is situated on the second floor of Goldsborough House, Loftus Street, Sydney. Here, prospectors may discuss general and specific problems in geology and mining with qualified field geologists and geophysicists, or they may obtain a great deal of information about various past workings and deposits in all parts of the State from the Survey's records which go back over seventy-five years. Information is also supplied in reply to postal inquiries.

Officers of the survey spend a great deal of time in field work all over the State, and will make an inspection or a geological or geophysical survey of any deposits or workings which, in the opinion of the Department, may be of justifiable importance. This field service may indicate the probable extension of deposits, their value and possible methods of working.

The chief function of the Mines Inspection Branch is to supervise the safe working of mines, quarries and brickpits, but the branch also performs many other duties in policing mining regulations and assisting miners and prospectors with technical advice and practical help such as the renting of pumping and other equipment.

The head office of the branch is in Sydney, at the address shown above, but officers are also situated at Armidale, Broken Hill, Orange, Wagga Wagga, Newcastle, Wollongong and Lismore, and cover large areas of the State around these centres.

Inspection duties in the coalfields are carried out by Colliery Inspectors who are situated in the main coal mining centres.

The Mining Museum and Chemical Laboratory are close adjuncts of the Geological Survey and are situated in North George Street, Sydney. The examination and evaluation of ores constitutes one of the major activities of the Museum. A wide range of rock and mineral specimens is available for examination at the Museum.

At the Mining Museum many inquiries are also answered concerning the nature and values of ores, building stones, etc., the suitability of minerals as raw materials for industries, availability of minerals and mineral products, treatment processes, markets, consumers, and many other economic and industrial phases of mineralogy.

Contacts are maintained with a large number of industries to facilitate the correct answering of inquiries. These include ore buyers, rock milling companies, metallurgical and ceramic industries, foundries, chemical manufacturers, the paint trade, fertiliser manufacturers and many others. In addition, a large number of identifications and appraisals are carried out on samples tendered by callers who desire to know their nature, grade and value. If the material submitted is of commercial quality, the caller is directed to the appropriate dealer or consumer.

Prospector's specimen sets, containing a representative selection of ores and industrial minerals and the commoner rocks, are also available from the Mining Museum at a cost of 15s. ($1.50c) plus postage 2s. 6d. (25c). It should be realised, however, the provisions of these sets is dependent on the availability of suitable specimens, some of which are in short supply.

As well as partial and complete analyses of rocks minerals, the Chemical Laboratory has a wide range of work in the chemical field. This includes water and natural gas analyses, physical tests on coals, cokes, clays, etc., and tests on explosive materials.

For all correspondence to the Department, letters should be addressed to:—

The Under Secretary,
Department of Mines,
Box 48, G.P.O.,
Sydney.

Samples or inquiries for the Mining Museum should be sent to:—
The Curator,
Mining Museum,
George Street North,
Sydney.

Examination and Assaying of Ores and Preparation of Samples.

Samples of ores and minerals are accepted from prospectors, miners, and small mining syndicates, for examination and assay free of charge, provided they are taken from localities within the State of New South Wales. Samples which have been finely crushed, or metallurgical products, are not accepted, and coal samples are not accepted for assay unless the samples have been taken by an officer of the Department.

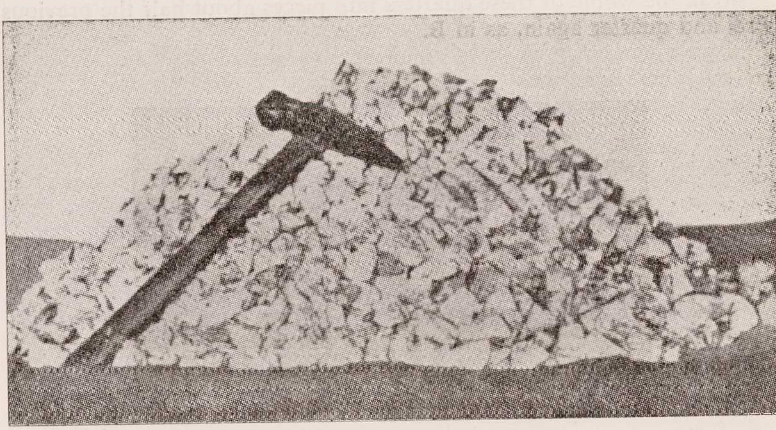
If it is merely desired that the substance found be classified, or is sent for general information only, the most typical specimen should be selected, but if an assay (that is a determination of the quantity of metal present) is expected, then the method indicated below should be followed.

Experience has shown that it is almost impossible to obtain a representative sample by picking up pieces of material from here and there, as the eye is a very unreliable judge of quality even when there are visible differences between the richer and poorer portions of a deposit.

The assays from carelessly taken samples have been responsible for much loss and disappointment in the past, thus the necessity for carrying out the sampling operation by the following method cannot be urged too strongly.

OPERATION A.

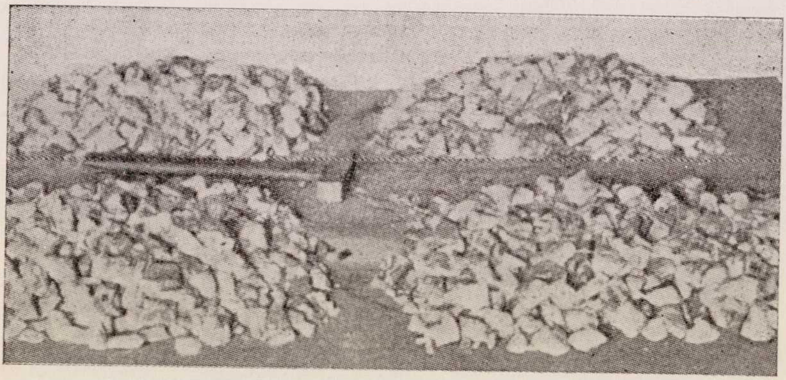
Break out the material uniformly across the whole width of the deposit, or of that portion you desire to test. It is of no use to take a pound from one place and an ounce from another. Never mind how big the heap is ; the larger the better.



A.—Ore as broken from the lode.

OPERATION B.

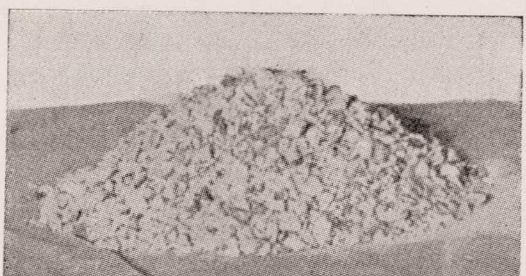
Break up the whole of the material to the size of walnuts or less. Mix it thoroughly with a shovel, taking care that the fine material is represented adequately. Shape it into a low heap; cut this across into quarters, and take out the whole of two alternate parts.



B.—The same after thorough mixing and quartering.

OPERATION C.

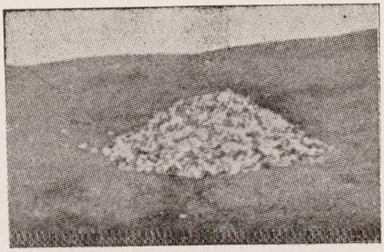
Break the whole of these quarters into pieces about half the previous size, and quarter again, as in B.



C.—A late stage in sampling.

OPERATION D.

Continue this process until what remains has been reduced to about the size of small peas. Mix this thoroughly, and take out about one pound of it to be sent to the Department. This is sufficient for assay purposes. It is advisable to send with the sample a small piece of **unbroken stone.**



D.—The final stage. 1 lb. of stone ready to be assayed.

Once taken, each sample should be wrapped separately and securely and forwarded to the Department by parcel post or rail, while a covering letter should also be sent giving full information as to locality, form of deposit, etc. When more than one sample is submitted, each should bear some distinguishing mark.

In addition to identifying the minerals present in the sample, the Department is prepared to advise as to the suitability of the material either as an ore or as raw material; an estimate of the value of the material and information concerning methods of working and treatment can be given, and details of possible markets supplied.

Experimental Treatment of Ores.

Applications will be received from bona fide mine operators for experimental ore treatment. Any such application approved by the Department will be submitted to the Chemical Engineering Department of Sydney University, which has undertaken to carry out experiments on a limited number of ore parcels each year.

Financial Aid to Prospectors.

Each financial year funds are voted by the New South Wales Parliament "for the purpose of assisting and encouraging prospecting and mining for gold and minerals, making loans for the purchase, transfer and installation of prospecting equipment, mining plant and machinery and payment of incidental costs and charges." The funds thus made available are utilised mainly under two broad headings, viz., (a) "Prospecting Aid" and (b) "Advances."

(a) PROSPECTING AID.

Prospecting aid is granted generally for sinking, driving, tunnelling, etc., at a specified rate per foot based on half the actual cost of the work to be performed. It is repayable only in the event of payable mineral being subsequently won from the site in respect of which aid was granted, or in the event of the prospector so improving in monetary position as a result of sales or other transactions in connection with the mine as to be able to refund such aid. It is essential that the prospector should hold a valid mining title over the area and all shafts, drives, cross-cuts or tunnels constructed must not be less than 6 feet by 3 feet clear of the timber. Prospecting operations must be carried out in accordance with the provisions of the Mines Inspection Act, 1901, as amended.

A form of application must be completed and in the event of aid being granted the prospectors are required to execute an agreement which contains the conditions abovementioned.

Before the application is finally considered the site is visited by a Departmental Inspector or Geologist who, in addition to furnishing a report on the application, will supply any practical advice that may be required. It is the practice to make progress payments from the total amount of aid granted following a report from a Departmental Geologist or an Inspector of Mines.

It should be noted that aid of this nature is granted for prospecting work only and not for development, wages, travelling expenses, ventilation or unwatering. Moreover, aid will not be granted for a site adjoining a payable mine; or within a ¼ mile of a payable mine if on the same line of reef, lode or lead. Similar embargoes apply to sites adjoining claims in respect of which aid or advances have already been granted. The Prospecting Board does not generally favour the granting of aid to sink from the surface as it is considered that the applicants should prove their bona fides by carrying out a certain amount of unassisted work.

(b) ADVANCES.

From time to time, cash advances are made for the purchase, transfer and/or installation of mining plant and machinery, construction of dams, roads, etc., for use in connection with mining, the carrying out of development work and for other miscellaneous purposes in connection with metalliferous mining in New South Wales. These advances are repayable on reasonable terms, usually by monthly or quarterly instalments or by a percentage of receipts from the sale of mineral won. They usually carry interest at current rates. As security for repayment of the advance, a lien is taken over any machinery and plant purchased with the advance, together with any other mining plant and equipment at the mine which is owned by the borrower. As in the case of prospecting aid, it is essential that the site should be covered by a valid mining title or titles and in most cases such title or titles are also included in the security. All security items must be otherwise unencumbered.

A form of application must be completed and a report is then furnished by a Departmental Inspector of Mines or Geologist.

Borrowers are allowed a reasonable time to commence repayments and meet interest due, but thereafter regular payments are expected in accordance with the terms of the advance.

Hire of Mechanical Equipment.

A quantity of mechanical equipment is available for hire at reasonable rentals to prospectors and small mine operators in the New England, Lismore, Orange, Broken Hill and Wagga Wagga districts. This equipment consists of portable compressor units complete with jackhammers and air legs, hoses, etc.; small air hoists and shaft pumping plant of various descriptions.

Tractor-mounted auger drilling units are also available for hire. One of these is located in the Armidale district and inquiries in regard to the unit should be addressed to the Inspector of Mines at Armidale. The other unit is located in the southern half of the State and hiring may be arranged through the Inspectors of Mines at either Orange or Wagga Wagga.

A proline drilling unit is also available for hire and is located in the Armidale district. Inquiries regarding the hire of this unit should be addressed to the Inspector of Mines, Armidale.

In addition to the above mechanical equipment, District Inspectors at Armidale, Broken Hill, Orange and Wagga Wagga are also equipped with geiger counters and scheelite detectors. The Inspector at Lismore is provided with a geiger counter. Samples suspected of containing scheelite or radio-active mineral should be submitted to the Inspector of Mines in the first instance.

CHAPTER VI

PROSPECTING METHODS

The information set out in this Chapter relates almost exclusively to gold prospecting. Nevertheless, the methods outlined are applicable to other minerals such as tin (alluvial) and tin, copper, silver, lead, zinc, tungsten, etc. (lodes or reefs). However, in recent years, high prices, world-wide shortages and the development of new processes have stimulated the demand for other minerals of economic importance. These factors have, to a large degree, been responsible for the development of new scientific and instrumental prospecting techniques. So far as the individual prospector is concerned, probably the most significant techniques developed have been those involving the use of the geiger counter (uranium) and the mineral lamp (scheelite). Information in respect of these and other instrumental prospecting aids will be found in this chapter.

Occurrence and Characteristic Properties of Gold.

The largest proportion by far of the gold won in New South Wales has been obtained from deposits of native or free gold. Gold occurs widely distributed throughout many different kinds of rocks in the form of lodes, veins, impregnations, and replacements of various types. The weathering away and breaking down of these form surface and alluvial deposits.

Gold is found usually as coarse and fine particles, irregular masses, strings, threads, thin plates and rounded masses, known as nuggets. In many ore-deposits containing such metallic minerals as iron and copper pyrites, galena and stibnite, native gold occurs in very fine particles closely associated with the sulphides.

Pure gold is seldom found in nature, silver being commonly alloyed with it. The proportion of silver present in natural alloys of gold and silver may amount to 26 per cent. Copper, iron, platinum, and other metals also have been found in gold.

The colour of gold when viewed in all lights and from any direction is a dull golden yellow. This distinct colour helps one to recognise it readily. The colour becomes paler in proportion to the amount of silver occurring in the gold. The presence of copper may cause the gold to have a bronze tint. It is very heavy, soft, tough, easily malleable and does not tarnish in air or when heated. No single strong acid attacks it.

When the particles of gold are very fine they easily float on water and are then termed "float gold." Sometimes it is coated with a film of some other mineral, commonly oxide of iron ("rusty gold") or black oxide of manganese ("black gold"). "Mustard gold" is very fine gold, sometimes with an earthy colour.

There are four minerals which inexperienced persons usually mistake for gold, mainly because of their colour. They are:—

(1) Iron pyrites, mundic or fool's gold (it has many other names), which has a pale brassy yellow colour.

(2) Copper pyrites which has a bright brassy yellow colour, often with a tarnish.

(3) Small flakes of golden coloured mica.

(4) Tarnished oxide of iron.

By using a few simple but decisive tests, gold can easily be distinguished from these minerals, a pocket magnifying glass being a help in this direction.

If a piece of mica is scratched with a needle-point it will be found to be very soft, and easily broken up into a flaky white powder. Mica is very light, and settles slowly in water. Gold is readily scratched with a needle, the mark made being the same colour as the gold itself.

To scratch copper pyrites a greater pressure is required, and the mark made is shiny, and shows a greenish black powder.

A needle will only scratch iron pyrites with very great difficulty.

Gold is easily cut, whereas copper pyrites crumbles beneath the blade of a knife, the powder made being greenish-black in colour.

Iron pyrites resists cutting, but the point of a very good steel knife will scratch it with great difficulty, the colour of the powder being greenish-black. Sparks will be emitted from it if a projecting edge of the iron pyrites is sharply struck with the back of a knife blade.

If a piece of iron pyrites and of copper pyrites be placed on an iron plate and struck with a hammer, both will be reduced to powder because they are brittle, but a piece of gold subjected to the same treatment simply flattens out without breaking, being both tough and malleable. This test alone serves to distinguish it from any mineral with which it is otherwise likely to be confused.

Both iron pyrites and copper pyrites contain sulphur, and if either is finely powdered and burnt or roasted in a fire on a thin piece of iron, sulphur fumes will be given off.

Tarnished oxide of iron sometimes exhibits a golden yellow colour, very similar in appearance to gold, but will always be found to be brittle if cut with a knife or hit with a hammer.

Any single acid such as nitric acid will attack iron pyrites and copper pyrites, but will not act on gold.

Description and Use of the Prospector's Dish.

Having learnt how to recognise gold, the intending prospector should become thoroughly acquainted with the use of the principal article of his equipment, the prospector's dish or pan.

DESCRIPTION.

A gold pan or prospector's dish is a shallow iron pan with sloping sides, stamped out of a single piece of sheet iron.

Most pans are provided with a riffle, which is a narrow groove stamped in the side of the pan about 1 inch from the lip, and extending half-way around the pan.

The riffle helps to retain gold when finishing off. In some pans the edge is turned over a wire to strengthen it. Newer types of dish have a rolled edge about an inch deep. It is advisable to bore a few holes in the lower curve of the roll, enabling water, which gets underneath, to drain out.

Some pans are plain; others are tinned to prevent rusting. A plain iron pan when new is greased. The grease must be burnt or rubbed off before use, and the pan kept clean and free from rust while in use. To prevent rusting, a pan is often smoked by holding it, bottom up, over a fire made of gum leaves.

An experienced operator can pan in nearly any sort of receptacle, a makeshift being a clean frying pan, a tin or enamel washing dish, and for finishing off a saucer is handy.

The pan is made in different sizes. The top diameter varies from 10 inches to 17½ inches, and the depth from 2½ to 3½ inches.

The favourite size is about 15 inches in diameter at the top, 9¾ inches in diameter at the bottom, and 3½ inches deep. This gives a sloping side about 4 inches long.

When filled to the brim with water this size holds 1½ gallons. A dish filled level with wash dirt weighs about 20 lb.; 112 of these dishes go to the load or cubic yard (about 1 ton).

Prospector's dishes may be obtained from the following Sydney firms:—

Briscoe & Co. Ltd., 383 Kent Street.
McPherson's Ltd., 51 Bathurst Street.
Nock & Kirby Ltd., 417-421 George Street.
S. Hoffnung & Co. Ltd., 153-157 Clarence Street.
W. S. Friend & Co. Ltd., 192 Clarence Street.

USE OF DISH-PANNING.

Wash dirt consists mainly of a large bulk of sand, clayey material and quartz gravel, together with a small proportion of heavy minerals and a few grains of gold. The heavy minerals are usually mainly magnetite and ilmenite, two black minerals which, together are referred to as "black sand". Magnetite is attracted by a magnet, but the ordinary magnet does not attract ilmenite.

Gold is approximately six times heavier than quartz gravel and three to four times heavier than "black sand." These differences in weight enable it to be separated from the rest of the wash-dirt. When clay-free wash-dirt is agitated in a prospecting dish, the minerals in the dirt are sorted according to their differences in weight (or relative specific gravities), the heavier sinking to the bottom and the lighter remaining on top. This operation is termed "panning."

A description of the use of the prospecting dish follows, but the intending prospector will find that the quickest way to become proficient is by watching experienced men and by having them give a few hints on the ground. Most experienced men are only too pleased to help the willing "new chum."

In panning, the dish is grasped with the hands, opposite each other, the fingers under the rolled edge and the thumbs pointing towards the riffle ends.

The dish should be filled about three-quarters full and immersed in water. There, while in a horizontal position, it is either rotated rapidly from side to side or the contents thoroughly mixed with the hands. Many men use a piece of wood or bent hoop-iron held in one hand to facilitate a thorough mixing.

With the prospecting dish under water, the wash-dirt is rubbed between the hands in order to break up and wash out any clayey material. This operation is repeated until all the clay is removed and the water remains clear. At the same time any large stones are washed and thrown out.

The wash-dirt is again covered with water and the contents of the dish thoroughly agitated with a swirling motion. This agitation assists the heavier minerals to sink and brings the coarser gravel to the top and sides of the dish. The dish is then tilted forward while the rotary movement is continued until the wash-dirt is about to pour over the lip. The water is allowed to drain off and the top layer of coarse gravel removed by drawing it forward and over the lip with the fingers. It is advisable not to remove too much the first time as flaky gold may be entangled with the gravel near the surface.

These operations are continued until the contents are reduced to a concentrate of about 1 to 1½ lb. in weight (about two cupfuls), consisting of a mixture of fine sand, "black sand," other heavy minerals and gold. Care should be taken to have sufficient water in the dish to keep the wash loose enough for the gold to sink through it.

As the prospector becomes more experienced he will use his fingers less and less for removing material from the dish. He will be able to do this by inclining the lip forward and allowing a gentle outflow of water to remove some of the wash-dirt.

The concentrate may now be still further reduced in size. A little water is dipped up, the contents of the dish agitated therein, the dish tilted forward, the material spread out up to the lip with a gentle side to side movement, and the water drained off.

With the dish tilted forward the material nearest the lip may be carefully brushed out with the thumb, or it may be removed by dipping a little water and allowing it to carry the material out as it recedes. A slight sideways and backward and forward movement should be kept up at the same time.

The concentrate is then settled in water again and the finer material removed. This action is repeated until only a few spoonfuls of concentrate remain. By keeping the main portion of the concentrate in the groove formed by the junction of the side and bottom of the dish most of the heavy minerals other than gold can also be removed by washing, but if fine gold is present great care should be taken to prevent the water lapping against the back of the dish.

It is advisable for the beginner to collect and store this concentrate in some receptacle which can be cleaned up at the end of the day or at some other convenient time. Final separation of the gold from the black sand is easy if the gold is coarse. This may be done by careful panning, repeating the procedure given in the previous paragraph, and using the side of the thumb to remove the black sand. Another method is, using very little water, to work the concentrate around the groove formed by the bottom and sides of the dish until the gold is arranged at one end of the concentrate. It may then be pushed out with the fingers into a suitable receptacle.

If the gold is fine, several other methods are used. The concentrate may be dried and magnetite, if present, removed with a magnet or magnetised knife blade. Fine material may sometimes be removed by gentle blowing. Another good method is to spread the dry concentrate out on paper and remove the unwanted portion with the aid of a feather, small brush or tweezers.

If it is found that the gold cannot be recovered by any of the above methods, mercury may be added to the concentrates in the dish, the sand removed, and the amalgam treated as described on page 160.

Estimation of Values.

Quantities of gold are weighed according to Troy measure, which is as follows:—

4 grains—1 carat.
24 grains—1 pennyweight (dwt.).
20 pennyweights—1 ounce (oz.).
12 ounces—1 pound (lb.).

Small amounts of gold may be approximately estimated as follows:—

Small pieces about the size of a pin's head weigh about 1-10th grain.

A mixture of flaky and fine gold which just covers the surface of a threepenny piece weighs approximately 9 grains.

An ordinary thimble filled with alluvial gold about the size of a grain of wheat weighs nearly 3 oz.

The prospector may form an approximate estimate of the value of wash-dirt by using the following table:—

Equivalents of grains of gold per dish in terms of one cubic yard, load or ton.

Grains per dish.	oz. per cubic yd.	dwt.	gr.	Grains per. dish.	oz. per cubic yd.	dwt.	gr.
½	0	2	8	7	1	12	6
1	0	4	16	8	1	17	8
2	0	9	8	9	2	2	0
3	0	14	0	10	2	6	16
4	0	18	16	11	2	11	8
5	1	3	8	12 (½ dwt.)	2	16	0
6	1	8	0				

Alluvial and Surface Deposits.

As mentioned on page 118, there are two principal types of gold deposits, reef and alluvial. Surface deposits are intermediate between these. A prospector usually gains experience with alluvial and surface deposits before attempting reef work.

SURFACE DEPOSITS.

When the gold contained in reefs, veins, and lodes is set free, it is spread out over the surface soil, where some of it may remain. The deposit thus formed consists of a mixture of angular pieces of quartz, country rock and gold, together with fragments of quartz containing gold (specimens). Such deposits are worked by stripping, the gold being recovered by sluicing or puddling. These operations may expose the reefs or veins which supply the gold.

In arid climates, as in the north-western part of New South Wales, where the absence of water and the low surface relief prevent the removal and later concentration of gold into leads, the gold may be found resting upon reefs and scattered over the surface in their immediate vicinity. In some places the removal of sand by wind effects concentration of the gold, coarse and fine gold being found together. The gold shows wear, due to the abrasive action of wind-blown sand.

Where this type of deposit is found, the gold may be recovered by dry-blowing (see article later herein).

ALLUVIAL DEPOSITS.

The greater proportion of the gold set free from the weathering of reefs is washed into the sands and gravels of adjoining water-courses to form alluvial deposits. In some places it may be carried by streams to intermingle with other minerals in "beach sands."

Broadly speaking, once it finds its way into streams, the coarser gold sinks rapidly to the bedrock, while the finer gold is swept on to be deposited further downstream where the grade of the stream beds is not so great and the rate of flow, in consequence, relatively gentle. Owing to local conditions and variations in the rate of flow there are, of course, exceptions to this general rule.

On its way downstream the gold may be held behind boulders or projecting rocks, or it may find its way into gutters, hollows, and cracks in the bedrock. The prospector will also observe that streams deposit sand and other materials on the 'inside" of curves. Rich deposits of alluvial gold are likely to be found at and near the bedrock in such places.

The nature and grade of the rock bottom play a big part in determining the amount of gold retained. Usually bottoms of pipeclay, decomposed clayey rocks and granite are favourable for retaining gold, but if the bottom is hard and smooth the gold is generally swept further on in the direction of flow of the stream. The same thing also occurs on the outside of bends where the current sweeps swiftly round. Bars of the bedrock which strike across the direction of flow of a stream act as natural riffles. It should be remembered that riffles not only provide a means of holding the gold, but that they cause momentary slacks in the rate of flow of the stream and allow the heavy mineral content, including gold, to fall out of the current. For this reason a concentration of gold is commonly found where it is least expected, namely, on the *downstream* side of a bar and particularly if the bars are widely spaced and dip upstream.

If the bars are closely spaced their direction of dip is not very material, since the tops of the bars check the rate of flow and the crevices between them form an efficient trap for the gold to fall into.

Narrow stream channels lead to a rapid rate of flow and absence of gold values. The swirling and grinding action in potholes also leads to poor values in many cases, so that what appears to be an ideal catchment for gold is frequently disappointing.

As time goes on, streams tend to flow more and more gently and to deposit silt and clay further from their mouths. Thus the gold-bearing sands and gravels become buried, mainly under deposits of clay and sand from which gold is absent, or present only in small quantity. Thus, though alluvial deposits may contain gold from grass roots to bedrock, in most places it does not pay to treat more than a few feet, at the most, of gravel and sand above the bedrock.

After the formation of an alluvial deposit as described above, the stream may have a varied geological history. It may be forced to change its course, thus destroying part of an older deposit and forming a new one.

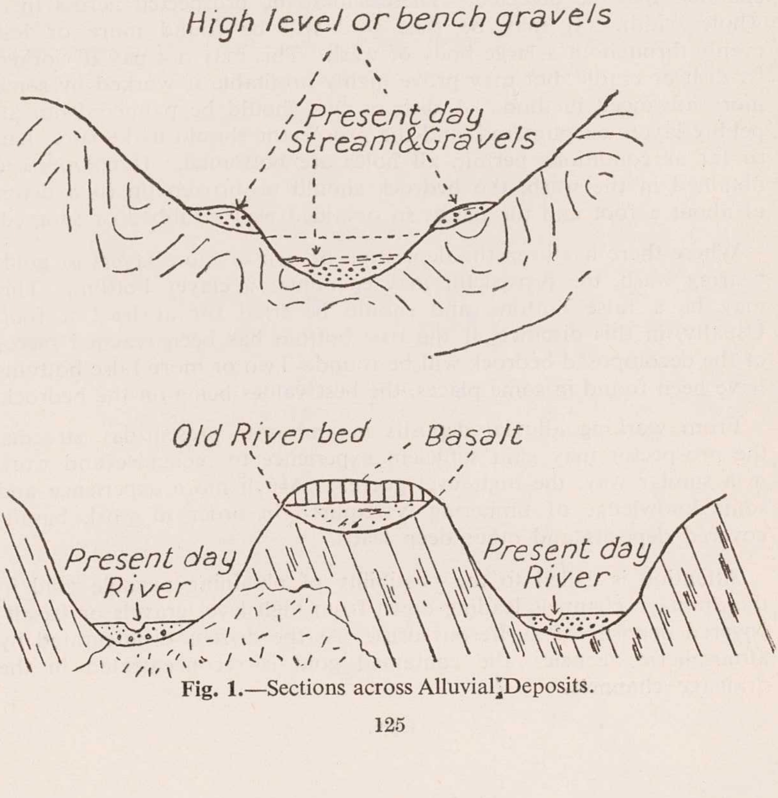


Fig. 1.—Sections across Alluvial Deposits.

It may cut down deeply below its old bed, leaving gravels on terraces many feet above the new stream bed. The stream may be destroyed altogether by its valley being filled with lava (usually basalt) and forming what is known as a basalt-covered deep lead. The majority of deep leads in New South Wales are covered, or partially covered, with basalt. (See Fig. 1.)

The older leads may be cut across by new streams forming still other alluvial deposits.

Alluvial Prospecting.

The description on the preceding pages of how alluvial deposits are formed should give the intending prospector a good general idea of where these deposits may be expected. Attention should first be paid to all watercourses. If the colours of gold are obtained, the prospector can proceed to test all likely places in the vicinity. Probably the best plan is to work upstream from a given point, testing the bed at all the likely places mentioned previously. The gravels exposed in the stream bank should all be tried and all flats should be tested by sinking holes to bedrock. In this way old stream channels may be detected. These should be prospected across their whole width. It may be that gold will be found more or less evenly throughout a large body of wash. This may not pay if worked by dish or cradle, but may prove highly profitable if worked by some more advanced method. A dish or two should be panned from all pebbly layers encountered, and the prospector should make sure that, so far as conditions permit, all holes are bottomed. If colours are obtained in the wash, the bedrock should be broken up to a depth of about a foot and the pieces so obtained well scrubbed or scraped.

Where there has been the deposition of two or more layers of gold-bearing wash, the prospector may encounter a clayey bottom. This may be a false bottom, and should be tried for at least a foot. Usually, in this distance, if the true bottom has been reached pieces of the decomposed bedrock will be found. Two or more false bottoms have been found in some places, the best values being on the bedrock.

From working alluvial deposits in and near present-day streams, the prospector may gain sufficient experience to recognise and work in a similar way, the high-level gravels. Much more experience and some knowledge of timbering is required in order to work basalt-covered deposits and other deep leads.

Attention is called to the possibility of obtaining payable gold in the drainage channels leading down from high level gravels or basalt-covered deposits of auriferous drift. As the drift is disintegrated by atmospheric agencies, the contained gold is reconcentrated in the drainage channels.

Small Scale Methods of Working Alluvial Deposits.

Only the more elementary methods of working alluvial ground, such as panning, cradling and small-scale sluicing, are dealt with in this booklet.

An experienced man can pan-off from seven to ten dishes per hour. If this rate could be maintained for a day of eight hours the quantity of dirt treated would be about half a load ($13\frac{1}{2}$ cubic feet) per day.

A larger quantity of wash-dirt may be treated by means of the cradle and trough. Two men can treat from two to four loads per day by this method, the quantity varying with the type of wash. Cradling requires about 80 gallons of water per cubic yard of wash-dirt. The water may be run into a reservoir and used again, but there is a large percentage of loss.

Where ample water is available, small-scale box sluicing or streaming methods may be adopted. By this means large deposits with a light over-burden may be worked.

The Gold-washing Cradle and Puddling Trough.

CONSTRUCTION OF CRADLE.

The cradle can be made with any available timber, such as old cases; the best job of course being obtained with dressed timber. Many different designs are in use in the field.

The diagrams, Figs. 2 and 3, show a standard type. Dimensions:—Length, 40 inches; width, 20 inches; head, 20 inches high; the sides in front of the hopper cut so as to slope down to the tail. Joints should be tight.

Hopper.—The hopper fits loosely into the top of the cradle, and is made of wood with a bottom of sheet iron in which holes varying from $\frac{1}{4}$ up to $\frac{1}{2}$ inch in diameter are closely punched. A make-shift can be made with the side of a kerosene tin, the holes being punched with the point of a pick, burr turned downwards. Supporting cleats are fitted so that when the cradle is in use the hopper is level.

A continuous discharge hopper can be made by having the front side open and extending the sides and the hopper bottom in a sloping position to discharge the oversize over the tail portion of the cradle, only the portion above the tray being punched with holes. A riffle should be placed across the hopper bottom at the discharge side of the last row of holes.

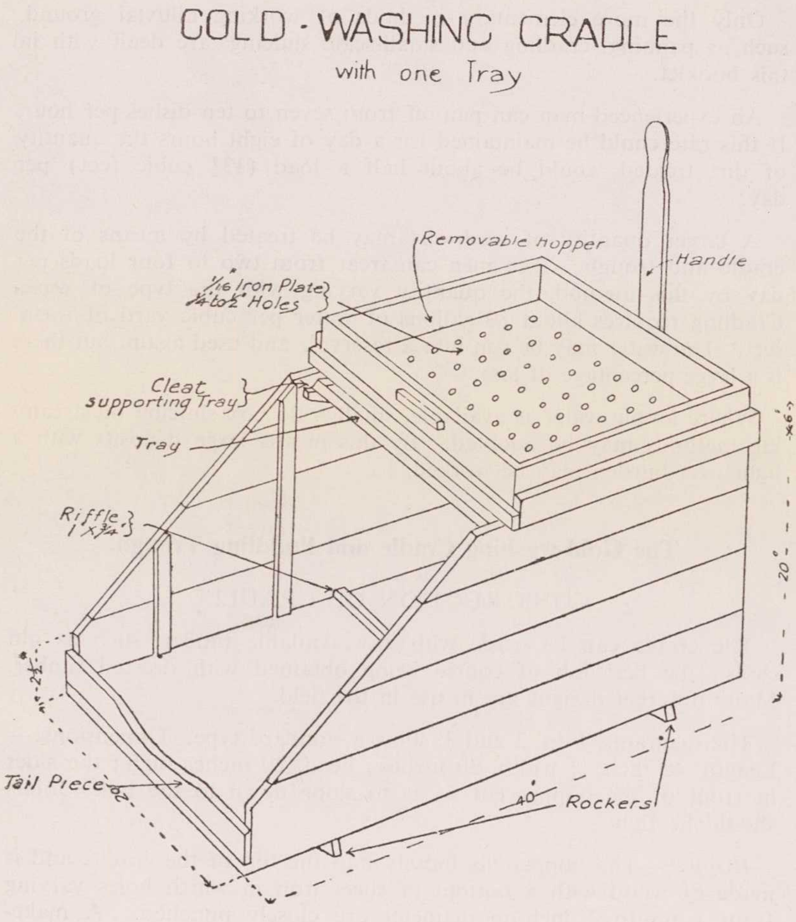


Fig. 2.

Tray.—The tray, apron or slide is below the hopper; it is removable and held in position by cleats. One, two or three trays may be used according to the fineness of the gold to be recovered.

The tray is generally made of wood, fitted at its lower end with a riffle of about $\frac{3}{4}$ inch high, the tray sloping towards the head of the cradle at about $1\frac{1}{2}$ inches to the foot.

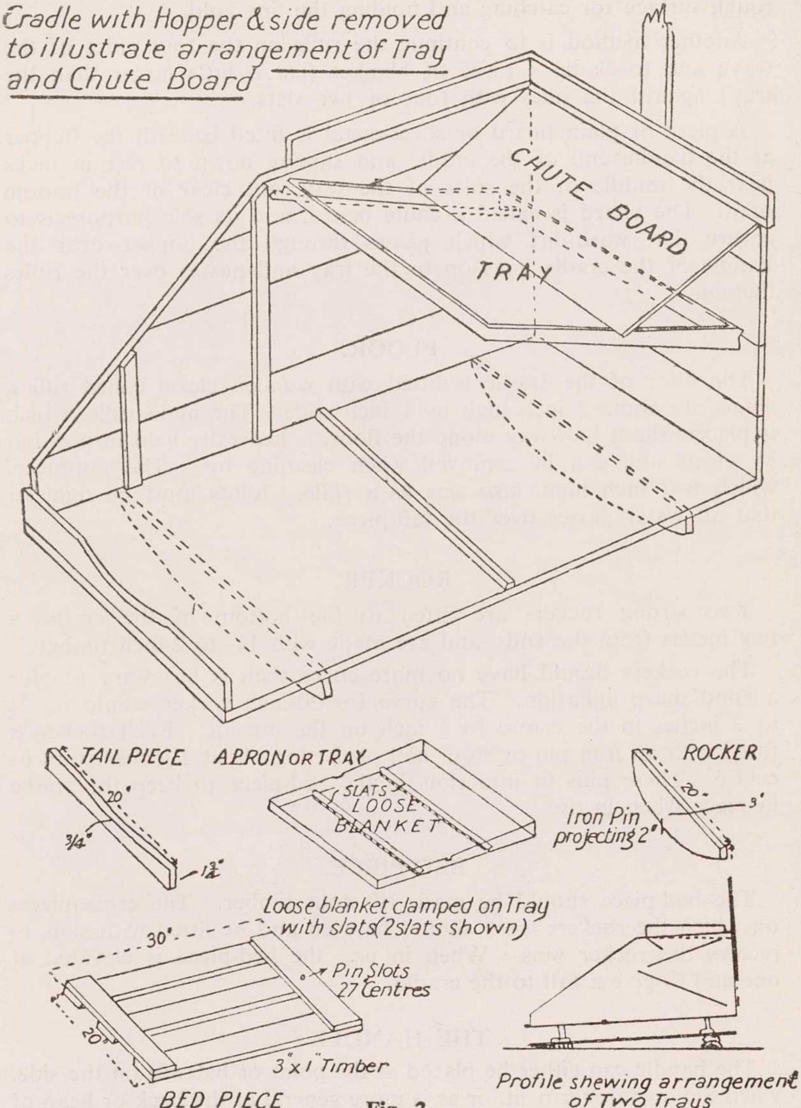


Fig. 3.

When two or three trays are used they are set at opposite angles, as shown diagrammatically in the profile sketch (Fig. 3). A tray of plain wood may be used, or various materials, such as canvas, bagging, coconut matting, corduroy or blankets, tacked upon it to offer a rough surface for catching and holding the fine gold.

Another method is to continue the riffle on the four sides of the tray; and to clamp a piece of blanket (cut a little larger than the tray) against the sides with four or five slats.

A piece of plain board or sheet-metal is fitted beneath the hopper at the handle end of the cradle and sloping down to rest in nicks near the middle of the sides of the tray, but clear of the bottom of it. The board is called a chute board, and its sole purpose is to ensure that wash-dirt which passes through the hopper near the handle of the cradle goes on to the tray and passes over the riffles thereon.

FLOOR.

The floor of the cradle is fitted with wooden cleats called riffles, which are about $\frac{3}{4}$ inch high by 1 inch wide. The main riffle, which is placed about half-way along the floor, is generally held in position by cleats and can be removed when cleaning up. The tail-piece, which is $\frac{3}{4}$ inch high, also acts as a riffle. Joints must be tight so that all water passes over the tail-piece.

ROCKER.

Two strong rockers are fitted to the bottom of the cradle a few inches from the ends, and are made with $1\frac{1}{2}$- to 2-inch timber.

The rockers should have no more curve than is necessary to give a good sharp agitation. The curve for 20-inch rocker would be $2\frac{1}{2}$ to 3 inches in the centre to $\frac{1}{2}$ inch on the outside. Each rocker is fitted with an iron pin or stout nail projecting about 2 inches from its centre. These pins fit into slots in the bed-piece to keep the cradle in place when in use.

BED-PIECE.

The bed-piece should be made of stout timber. The cross pieces on which the rockers work should be even and be fitted with slots to receive the rocker pins. When in use, the bed-piece is elevated at one end to give a fall to the cradle.

THE HANDLE.

The handle can either be placed at the point of balance on the side, when the operator can sit, or as is more general at the back or head of the cradle.

If the wash-dirt or gravel contains clay, this must be removed by puddling before cradling, the operation being performed in a pudding-box.

PUDDLING BOX OR TROUGH.

A puddling box can be of any shape, that resembling a water trough being the most convenient. A handy size is about 18 inches wide by 12 to 18 inches deep by 5 to 6 feet long. Ends are made of wood cut semi-circular in shape. Two long side pieces of timber may be fastened to the top edge of the trough and allowed to project beyond the ends to form four handles for transportation. Sheet iron is bent round and fastened to the ends and top side timbers. In one end, holes are bored and fitted with plugs. One hole should be a few inches above the bottom, the other about 6 inches below the top of the end piece. The top hole is for removal of slurry and the bottom for the removal of concentrates.

A hollow log, the ends of which have been made water-tight with boards nailed across and caulked with clay, makes a very serviceable puddling box. A large oil drum cut in half is useful for puddling small quantities of dirt.

OPERATION OF CRADLE AND TROUGH.

The operation of a cradle and trough is as follows. Clay-bearing wash-dirt is dumped into the puddling box, water is added and the material is puddled with a shovel or wooden paddle until the clay is broken up and in suspension; the top is then pulled out and the clay slurry run off. The operation is repeated until clay is removed. If water is plentiful, set the puddling box with a slight fall, divert water into the top end and the puddled clay will then overflow at the lower end.

To operate the cradle the bed-piece must be elevated to give fall from head to tail. This elevation must be found by experiment, and varies according to the type of wash-dirt being treated. For pebbly wash-dirt a fall of about one in twelve (*i.e.*, 3 inches with a 40-inch cradle) may be sufficient; if much fine sand is present a little more elevation may be needed, and if much sand is also present then still more elevation will be required.

A few pounds of clay-free wash-dirt is shovelled into the hopper, water is poured over it with a saucepan or bailer with one hand while the cradle is rocked with the other. The agitation spreads the material in the hopper, the finer material being washed through the holes. At intervals the hopper is lifted and the coarse material or oversize rejected. If fitted with a continuous discharge hopper, a certain amount of time and labour is saved. Examination of the oversize may disclose nuggets or quartz carrying gold. The finer material which is washed through the hopper falls on the tray. In passing over the tray, gold is retained on the rough surface of the blanket or behind the riffle. The tray deflects the material to the bed of the cradle, and it then passes along the floor and finally over the tail-piece. The wash-dirt must progress over the trays and bottom with an even transverse distribution and with sufficient water to be loose enough for the gold to sink through the bed of wash-dirt and be held behind a riffle. When using two or three trays, more care is required in adjusting the relative slopes of the trays.

CLEANING-UP.

When gold begins to appear near the tail-piece, or a certain pre-determined quantity of wash-dirt has been treated, the cradle is cleaned up. The feed is stopped and if the riffle on the floor is held by cleats, it is removed. A small quantity of clean water is then poured through the cradle, which is rocked at the same time. The hopper and chute board are then removed. After filling the prospecting dish with water, the tray is lifted out and held cornerways over the dish. All the material from behind the riffle and on the surface of the tray is washed into the dish. If the tray is fitted with a loose piece of blanket held with slats these are removed and the blanket carefully picked up and placed in the prospecting dish. It is then thoroughly washed to remove any fine gold adhering to the woolly surface. All material behind the tail-piece and fixed riffles is then collected and also placed in the prospecting dish. The concentrates thus collected are panned off and the gold recovered.

Sluice Boxes: Long-tom.

The small-scale sluicing plant consists of some arrangement of a puddling trough and sieve combined, which is mounted above a riffle board. This method, by breaking up the clay and removing coarse material, only requires a short riffle box to save the gold.

The sluice box requires more water to operate than a cradle, but has a greater capacity. Where an ample supply of water is available much manual labour may be saved by this means. A line of sluice boxes may be used, care being taken to provide ample fall for the disposal of tailings.

One type of sluice box is known as the "long-tom", and is suitable for treating gold-bearing wash where the water supply is not sufficient for ordinary sluice boxes to be used.

The long-tom consists of an open box 16 to 12 feet long (Fig. 4) with a perforated plate or screen S at the bottom, into which the gravel and running water are introduced by means of a flume or box-launder F. The material passing through the screen openings which are usually about $\frac{1}{2}$ inch in diameter, drops on to a set of riffles placed in another box R. The boxes are set on a slope varying from about 1:12, to 1.5 : 12. The amount of gravel which can be treated per day will vary with its nature, the water supply and the number of men employed to shovel into the tom and to fork out the large stones. It is stated that two men, one shovelling into the tom and the other working on it, can wash 6 cubic yards of ordinary gravel or 3 to 4 cubic yards of cemented gravel in ten hours. At times the tom is operated by four men, two shovelling in, one forking out stones, and one shovelling fine tailings away.

OPERATION OF LONG-TOM.

The gravel is shovelled into the tom or flume, where the fine material is washed through the screen and the larger rocks are forked out and discarded. The gold and heavy sands are caught behind the riffles. When the riffles become filled up, the material caught behind them is removed and cleaned up in a goldpan. Mercury is sometimes added to the riffle box to catch the fine gold. Figure 4 shows several common types of riffles and the method of placing them in boxes or sluices.

For long-tom operation, a good supply of running water is essential. The drops between the boxes serve to aid in breaking up lumps of clay and to free any gold particles locked up therein.

Another type of sluice box with which one man can sluice a couple of loads per day is constructed as follows:—

A box is made 6 or 7 feet long, about 10 inches wide and 8 inches deep, using inch timber. The bottom is covered with a blanket, on top of which is a false bottom. This is made from one or more boards 1 inch in thickness, and is bored with holes 1 inch in diameter, staggered and closely spaced. The board fits loosely in the box, and runs from head to tail. It is held in position at the tail end by two diagonal and converging cleats. Above the head end is a hopper, with $\frac{1}{4}$- or $\frac{1}{2}$-inch closely punched holes. The method of operation of this type of box is similar to that described above. In cleaning up the box, cease feeding wash-dirt and allow a stream of water to run through the box. Clean up the top trough by forking off large stones and search for coarse gold. The riffles are lifted out and the concentrates washed down and collected in a bucket or tin. If a blanket board is being used the blanket is similarly dealt with. Final concentration is effected with the prospecting dish.

Gold values in wash-dirt are expressed as "so much per load". A load is equal to 1 cubic yard, and weighs approximately 1 ton. Approximately forty-two petrol tins (of 4 gallons each) filled with wash-dirt are equal to "one load".

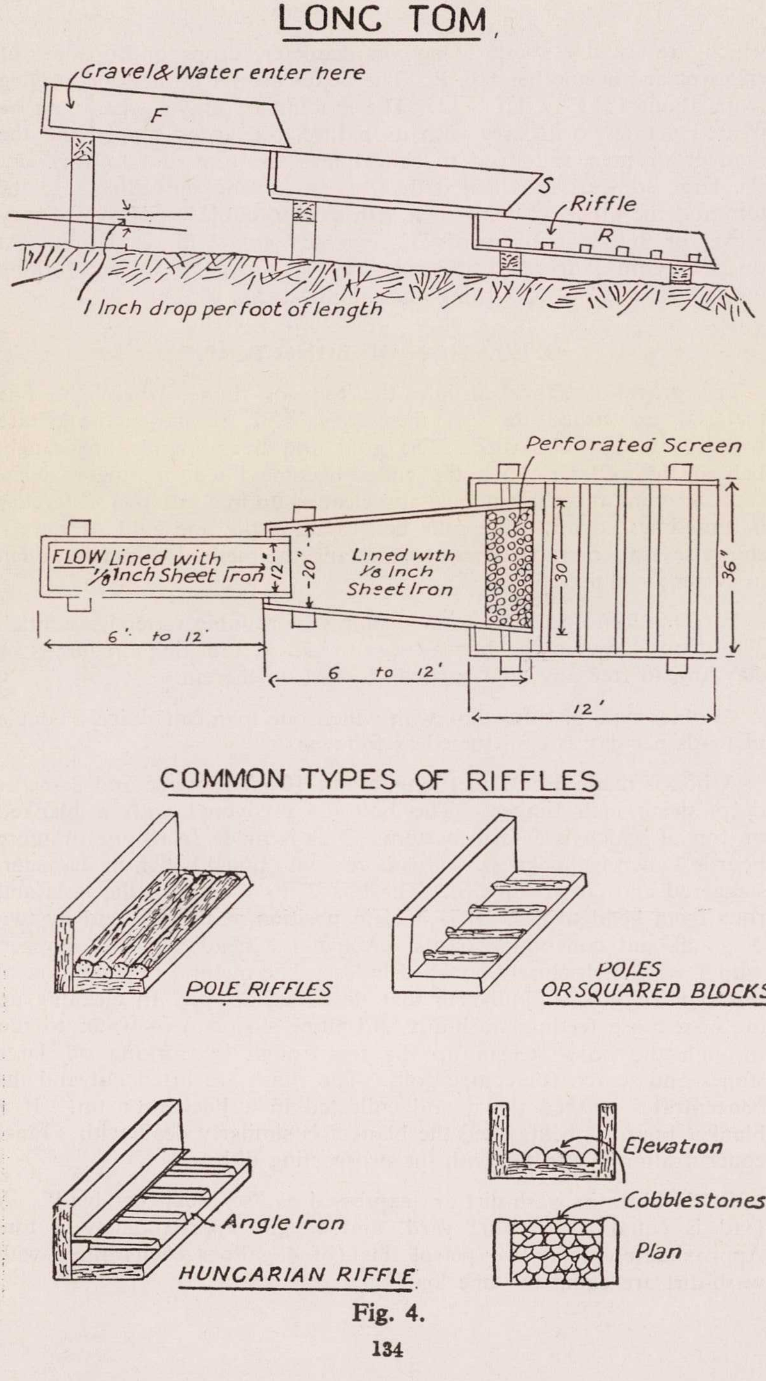
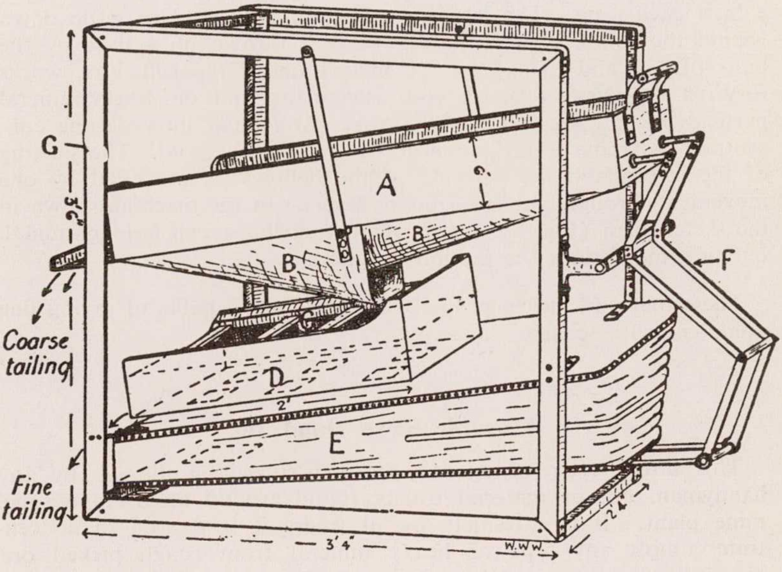

LONG TOM
Gravel & Water enter here
F
S
Riffle
R
1 Inch drop per foot of length
Perforated Screen
FLOW Lined with 1/8 Inch Sheet Iron
12"
20"
Lined with 1/8 Inch Sheet Iron
30"
36"
6' to 12'
6 to 12'
12'
COMMON TYPES OF RIFFLES
POLE RIFFLES
POLES OR SQUARED BLOCKS
Angle Iron
HUNGARIAN RIFFLE
Elevation
Cobblestones
Plan

Fig. 4.

Dry-blowing.

Where water is scarce, dry-blowing has to be resorted to. The simplest form of this method is the repeated pouring of the dry pulverised gold-bearing material from one pan to another, allowing the wind to blow away the lighter particles, thus gradually obtaining a concentrate containing the gold and other heavy materials, from which the gold is finally recovered by washing, only a limited amount of water being thus required.

Where alluvial ground has to be worked without water, dry-blowing machines are used. These vary in design, but the principle is the same. A light portable framework supports an inclined screen-plate of punched sheet-iron, on which the roughly pulverised dirt is shovelled. A rocking movement imparted to this screen causes the fine material to fall through the holes, the coarse stones and gravel passing off



A. Shaking screen. B. Metal chutes delivering onto C. C. Removable porous tray with riffles and bottom of hessian or toweling backed by metal gauze. D. Wind box. E. Bellows with clack valves opening into D and with trap below to facilitate removal of dust. F. Gearing which operates bellows while shaking screen is pushed to and fro. G. Angle-iron frame

Fig. 5—Dry Blower.

to waste over the end of the screen. The fine material falls on to an apron-plate, which directs it on to the upper portion of a riffle-box, set on the top side of an 18-inch or 20-inch bellows. The riffle-box, which is the gold-saving part of the appliance, is some 10 inches or 12 inches long by about 6 inches wide, or may have larger dimensions in these proportions, and has a bottom of sacking or similar material supported on fine wire screen. This box has two or three small riffle-bars across it and is fastened to, but removable from, the top of the bellows. The nozzle of the bellows is removed and the opening closed and a series of holes fitted with clacks or valves are made in the top of the bellows, under the riffle-box. The bellows is so set in the main frame that its top and the attached riffle-box are inclined at a suitable angle.

In operation, the dirt passing through the screen falls on the top end of the riffle-box, and the working of the bellows causes puffs of air to come through the permeable bottom under the dirt, lifting it a little each time. The heavy particles of gold tend to settle down behind the riffles, but the lighter waste is thrown up a little by the puffs of air, and helped by the inclination of the riffle-box, works forward and passes over the end, leaving the gold and heavy mineral particles behind the riffles in the box. At regular intervals the concentrate is removed and panned off to recover the gold. The shaking of the screen and the working of the bellows is controlled by one movement through suitable arms or levers. In the machine shown in the sketch plan (Fig. 5), the movement of the screen is longitudinal, but in some designs the motion is sideways.

These machines, when properly designed, are capable of saving fine gold, as well as coarse.

Movable Sieve Hand Jig.

This simple form of jig may be constructed on the job by any handyman, out of material usualy found around an average small mine plant. It is extremely useful where it is desired to concentrate almost any type of heavy mineral from rough picked ore, especially if the mineral grains are of a coarse nature. Typical uses could be on tin, scheelite (if of a coarse nature), wolfram, etc. Small parcels of picked ores crushed to about ¼-in. mesh can in a number of cases be cleaned up into saleable concentrates or otherwise reduced in bulk to lessen the necessity for heavy transport charges.

The jig consists of a tank or hutch about 5 ft. 6 in. x 2 ft. 6 in. x 2 ft. deep, internal measurement, standing at ground level, over which is hung from the lever gear a jigging box.

The jigging box is a rectangular box about 3 ft. 2 in. x 1 ft. 9 in. x 1 in. deep having a heavy screen cloth as a bottom. This is swung from the lever gear by strap-iron hangers in such a way that it may be plunged into the water-filled tank on operating the main lever.

The operation of jigging is as follows:—A charge of crushed and preferably roughly sized ore is loaded into the jig box and lowered into the water-filled "hutch" by pressing the main lever downwards. When the "feel" of the load is determined, the operator now gives the main lever a series of sharp plunges. This motion is transmitted by the connecting rod and top lever to the hanking straps which are slotted and bolted loosely to the right and left top lever. Thus a jigging or plunging motion is imparted to the jig box. By reason of this action, the ore on the tray is momentarily suspended in water and on settling at the end of the "stroke" assumes a stratification dependent to a large degree on its weight or relative density. After a few plunges, the operator will find most of his heavy mineral resting on the screen cloth, and the process is renewed by skimming off the top tail and adding more crude ore.

When the jig box becomes too weighted for efficient jigging, it should be "cleaned up", i.e., (1) as much "tail" as possible is removed and discarded; (2) a middling product may be removed if necessary for further treatment and in most cases re-crushing to liberate mineral particles; (3) all clean concentrates resting on screen cloth may be removed. The process is then repeated with fresh crude ore.

It will be realized that concentrates obtained by this process are greater in size than the actual screen cloth used in the jig, therefore a percentage of the material passes in the form of fines into the tank or "hutch". This material must be removed periodically and treated by other means such as in a steaming-down box or concentration table.

A suitable screen for the jig box consists of heavy duty screen cloth of about 10 or 12 mesh. If necessary it may be prevented from sagging from the weight of mineral by installing a grille support as shown in Figure 6, about 3 in. above the lower portion of the jig box. As sizing of material is important a second screen tray of ¼-inch heavy duty screen may be made to fit loosely on to slats or cleats about 6 in. above the main screen. The rough mineral is loaded on to this top screen and in effect sizes the load for concentration on the jig bed. Before jigging the material is plunged into the water several times and the oversize removed with the top tray.

The main points of interest in the use of this type of jig may be summarised thus:—

(1) Very little water required after tank has been filled.

(2) May be built on the job by a bush carpenter.

(3) Can produce high-class concentrates of many heavy minerals.

(4) Ideal for small tonnages of fairly rich ores.

(5) (a) Material required:—

1 inch planking for boxes, etc., 5 inch x 5 inch. Main lever and top levers. Small section strap-iron or iron hangers. Various bolts and nuts. Screen cloth 10 or 12 mesh. Screen cloth $\frac{1}{4}$ inch square opening. Small section round rods for screen support. Nails, etc.

(b) Tools required:—

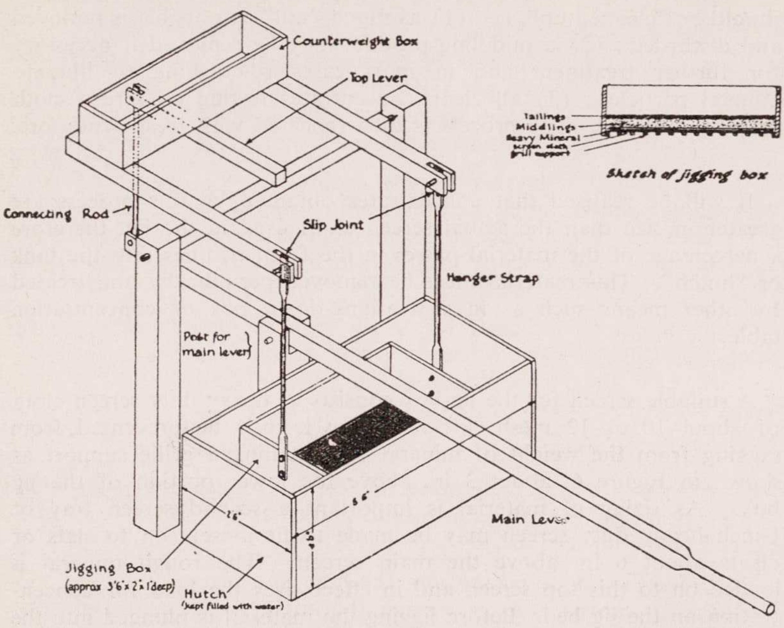
Simple carpenter's tools, small forge. Spanners to fit bolts.

(c) To operate:—

One man.

Small water supply for tank. Small fire shovel (domestic type).

Miner's shovel.



Sketch of jigging box

MOVABLE SIEVE HAND JIG Fig. 6.

Zircon, Rutile, Ilmenite—Prospecting, Mining and Treatment.

In prospecting for workable deposits of black sands, the areas are bored at close and regular intervals with an auger or a sludger when any black sand present is easily seen in the samples thus secured. The samples may be panned and the concentrates weighed to determine the amount of heavy minerals present. Small burrowing crabs often bring black sand to the surface and may indicate the presence of buried deposits.

Although it is not the purpose of this Guide to describe in detail how an engineer would estimate the value and quantity of heavy mineral in a beach deposit, the prospector should know how to set about determining if an area contains valuable minerals in sufficient quantities to make it worthwhile investigating further.

For a start, the beach or sand-bearing area should be examined for traces of black sand over an extensive stretch if possible. Samples should be gathered and panned off in a prospecting dish or shovel blade in order to determine if the sand contains heavy mineral. Should this be so, samples should be obtained and sent to the Mining Museum for positive identification. Unless the minerals contain appreciable percentages of rutile, zircon and ilmenite, they may not be of great economic importance. However, you will be advised by the Department on this score.

Should economic minerals be present, the next step would be to obtain a suitable auger drill and put down a few test bores in order to establish roughly if the mineral extends in depth and whether or not rich bands, etc., are present.

A suitable auger for this purpose is shown in Fig. 7. Apart from the auger head which may be fabricated in almost any small workshop by a competent tradesman, the remainder is composed of $\frac{1}{2}$ inch or $\frac{3}{4}$ inch water pipe in short lengths which may be added to the rod as the depth of hole increases.

If an auger is not available, shallow holes may be conveniently sunk to a depth of a few feet by using an old shovel with the blade cut down to form a width of about 6 inches and curved so as to form a scoop.

In normal sand, holes to a depth of 20 feet are easily sunk.

The prospector can determine the depth from which the samples are being taken by noting on the rod marks which indicate the length of rod below the surface.

Samples should be taken from the hole and placed on a flat sheet of iron or canvas. After mixing thoroughly, the sand should be formed in an even round heap and divided into four quarters. Reject three of these and reduce the remaining quarter in the same manner until a sample of 1 or 2 lb. only is left. This should then be placed in a small bag for further investigation.

Samples sent to the Department would normally be tested for percentage of heavy mineral in the sand and percentages of the various minerals contained in the total concentrate. Thus the *sand* from a bore could contain, say, 10% of *heavy* mineral which, in its turn, would be composed of, say:—

Rutile	25%
Zircon	30%
Ilmenite	40%
*Other minerals	5%
	100%

*Chromite, tin, monazite, etc.

The total amount of heavy mineral in a deposit is, of course, determined roughly by averaging a great number of evenly spaced bore holes for percentage mineral then estimating the total amount after determining the volume of sand in the deposit by multiplying the total area by average depth of the bore holes.

However, it is thought that the actual evaluation of a deposit is beyond the scope of an unskilled prospector and the soundest advice which can be given is first of all to merely determine the presence of economic minerals and, secondly, to seek skilled advice in order to determine the exact potential of any deposit discovered. The working and development of beach deposits for rutile and associated minerals is a question of considerable capital and technical know-how and the discoverer of a deposit is well advised to limit his work to the establishment of values and the securing of a lease to mine.

The mineral composition of the black sand concentrates may be determined by removing the ilmenite present with the aid of an electro-magnet and examining the remaining mixture of zircon and rutile with a microscope, estimating the proportions of each mineral present by counting the numbers of grains of each in a number of fields of view on the microscope slide.

The mining methods adopted for working the black sands are relatively simple. The ordinary sand overburden is first removed by a bulldozer or scoop to expose the richer black sand which is then loaded into trucks either by a mechanical excavator or by hand and transported to the treatment plant, or, in areas inland from the beaches, suction pump dredges may be used to mine material lying below

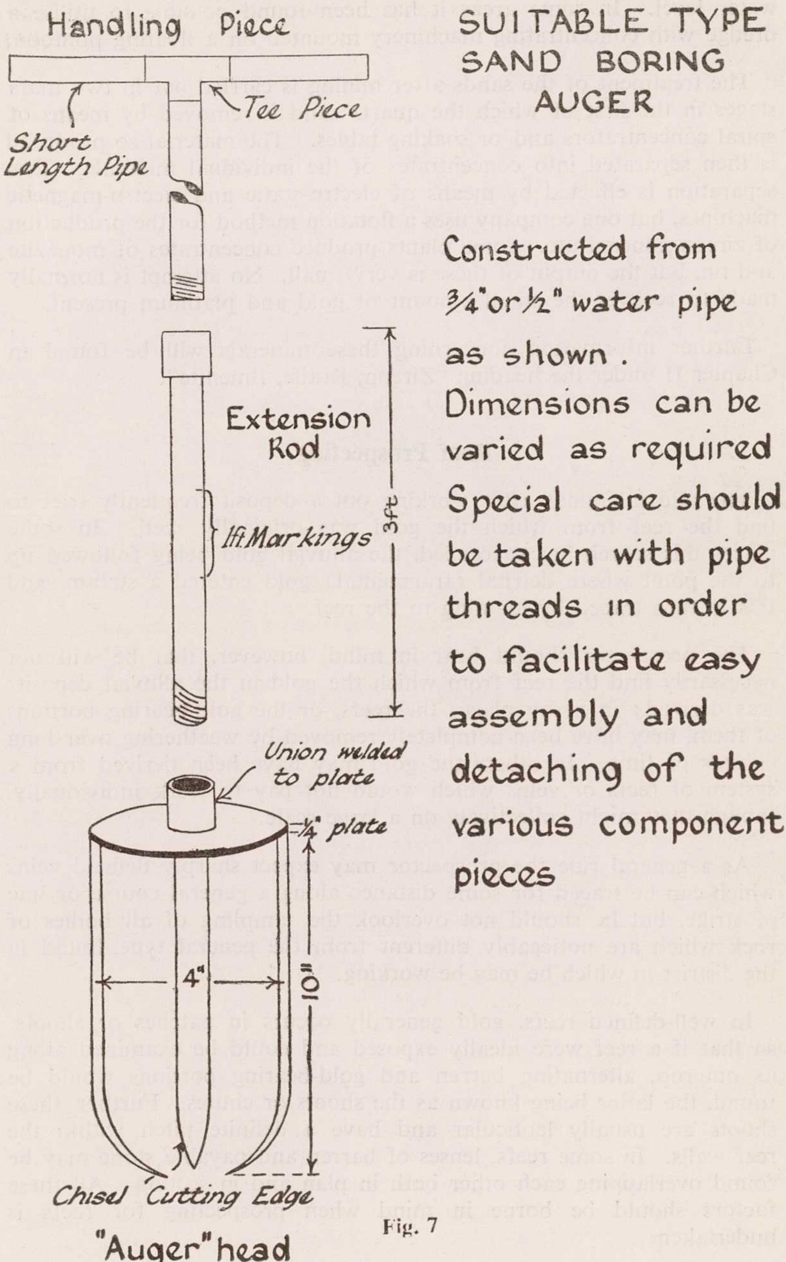

SUITABLE TYPE
SAND BORING
AUGER
Handling Piece
Tee Piece
Short Length Pipe
Constructed from ¾" or ½" water pipe as shown. Dimensions can be varied as required Special care should be taken with pipe threads in order to facilitate easy assembly and detaching of the various component pieces
Extension Rod
1ft Markings
3ft
Union welded to plate
¼" plate
4"
10"
Chisel Cutting Edge
"Auger" head

Fig. 7

water level. In some areas it has been found possible to utilise a dredge with concentrating machinery mounted on a floating pontoon.

The treatment of the sands after mining is carried out in two main stages in the first of which the quartz sand is removed by means of spiral concentrators and/or shaking tables. The material so produced is then separated into concentrates of the individual minerals. This separation is effected by means of electro-static and electro-magnetic machines, but one company uses a flotation method for the production of zircon concentrate. Some plants produce concentrates of monazite and tin, but the output of these is very small. No attempt is normally made to recover the small amount of gold and platinum present.

Further information concerning these minerals will be found in Chapter II under the heading "Zircon, Rutile, Ilmenite".

Reef Prospecting.

The alluvial miner after working out a deposit frequently tries to find the reef from which the gold was originally shed. In some places this search has succeeded, the alluvial gold being followed up to the point where detrital (fragmental) gold entered a stream, and this in turn traced by loaming to the reef.

The prospector should bear in mind, however, that he will not necessarily find the reef from which the gold in the alluvial deposits was derived; in many places the reefs, or the gold-bearing portions of them, may have been completely removed by weathering over long periods of time. In others the gold may have been derived from a system of reefs or veins which would not pay to work individually, though they might collectively on a large scale.

As a general rule the prospector may expect sharply defined veins which can be traced for some distance along a general course or line of strike, but he should not overlook the sampling of all bodies of rock which are noticeably different from the general type found in the district in which he may be working.

In well-defined reefs, gold generally occurs in patches or shoots, so that if a reef were ideally exposed and could be examined along its outcrop, alternating barren and gold-bearing portions would be found, the latter being known as the shoots or chutes. Further, these shoots are usually lenticular and have a definite pitch within the reef walls. In some reefs, lenses of barren and payable stone may be found overlapping each other both in plan and in section. All these factors should be borne in mind when prospecting for reefs is undertaken.

DEVELOPING AN ORE BODY

After locating the outcrop of an ore body which is auriferous or contains economic minerals, the prospector will be interested in proving its width, length, downward continuation and values.

Open Cutting

Unless the ore body is covered by a thick layer of overburden, considerable information can be obtained by making an open cut along its strike. Open cutting at the surface has often provided the means of obtaining a quantity of payable ore quickly, thus providing the prospector with ready cash to further develop his find.

Deep, narrow open cuts can become extremely dangerous to work in. Surface water also finds its way in, and after very heavy falls of rain the accumulation of water can retard the extraction of ore unless expensive pumping gear is installed.

The prospector will at some stage in his open-cut operations decide to put down a prospecting shaft to test the downward continuation of the ore.

Sinking a Prospecting Shaft

Selecting a Site

After having opened up the ore at the surface it will probably be found that some sections are richer than others. The richer sections are referred to as shoots or points of maximum flow. It is advisable to sink a prospecting shaft on the downward continuation of an enriched section, as by so doing, there is a better chance of defraying the cost of sinking, and perhaps making some profit.

Underlay and Vertical Prospecting Shafts

General

The following information on sinking a prospecting shaft is intended to help the prospector who has very little capital, but is prepared to work hard and use his initiative.

If the reef is dipping, a vertical shaft may be sunk to cut the ore at an estimated depth, but until it is proved that the ore extends to such depths, the sinking of a vertical shaft might be unnecessary. A shaft following the downward continuation of an ore body, with a dip, is known as an underlay shaft. Sinking an underlay shaft is preferable during the early stages of development, because the characteristics of the reef can be observed, and plans for further developmental work commenced at an early date.

Let us now consider the locality in which the work has to be performed, the nature of the ore and the country rock.

If the ore body is of a friable nature, and of some considerable width, the shaft will have to be timbered. Timbering will also be necessary if the reef is narrow and the country rock or walls are weak. If the ground is solid and stands well very little, if any, timber is required.

Provided the orebody is situated in forest lands the prospector can cut his own timber, subject to any limitations imposed by statutory authorities. In arid regions, where there is a scarcity of timber, an added financial burden is placed on the prospector if he has to purchase timber.

Cutting Timber

The method of timbering to be used must at first be decided on. There are two main systems from which spring many modifications:—

1. Box timbering.
2. Frame sets or Cornish studdle sets.

Box timbering is usually carried out with sawn timber, takes more time to cut, and may be beyond the reach of the prospector.

Frame sets can be cut from round timber and the lining split from trees in the forest.

Let us therefore consider the preparation of timber for use in frame sets.

Approval to cut timber must first be obtained from the owner, remembering that permission to cut timber on Crown lands must also be obtained from the appropriate authority.

Sets are cut from round timber, slabs or laths are split from suitable lengths (4 ft. to 6 ft.) of round timber.

The essential tools for cutting the timber are: 4½-lb. axe, adze, crosscut saw, maul and wedges, and a splitting knife and mallet.

Cutting round timber presents no difficulty. A straight tree of required diameter is felled and the bark stripped off before the trunk is cut into lengths.

A suitable tree from which slabs or laths can be split has to be selected. The tree must be straight, as free as possible from limbs and possess a free grain. Some idea of the nature of the grain can be obtained by taking a small chip out of the butt (avoiding unnecessary damage to the tree). After a selection has been made the tree is felled, stripped of bark and cut into the required lengths. If the bark is rolled off carefully into lengths it can be flattened and stacked. When dry the bark can be used for sheeting the outside of sheds, etc.

The round lengths of timber are now split into billets using the maul and wedges. With the splitting knife and mallet, slabs are split off what is known as the "quarter" or the "back" as shown in Figs. 1A and 1B.

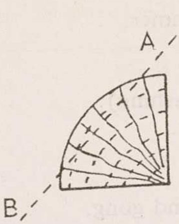


Fig. 1a. Billet of timber. Section AB—Splitting "off the back".

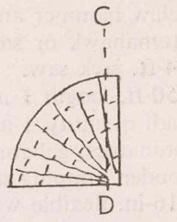


Fig. 1b. Billet of timber. Section CD.—Splitting "off the quarter."

It will be found that the timbers from various trees differ, some split more easily off the "back" while others split quite freely on the "quarter". An experienced splitter can cut 300 6 ft. x 6 in. x 2 in. slabs per day. Split slabs or laths are superior in strength to sawn timber and are less costly.

Size of Shaft

For prospecting purposes a shaft is kept as small as possible. The underlay affects the width. If a shaft is vertical it need be no more than 6 ft. x 3 ft. in the clear of timber, but an underlay shaft, say, with a dip of 45°, would need to be at least 6 ft. wide to give adequate standing room.

Small prospecting shafts should not be sunk to any great depth, as a depth of 60 ft. to 80 ft. is quite far enough for a prospector and his mate to sink. For greater depths the shaft will have to be larger and power used for hoisting and pumping, therefore this is outside the scope of the ordinary prospector.

Tools, etc., Required

Tools and equipment required are as follows:—

2 round-mouthed shovels.
6 miner's picks.
1 100 ft. of $\frac{3}{8}$ in. wire rope and safety hooks.
1 windlass and stand.
3 6-gallon iron buckets.
Small quantity of $\frac{5}{8}$ in. round M.S. bars (ladders).
Nails.
Jack hammer and compressor, if possible.
Quantity of $\frac{7}{8}$ in. drill steel (hand or machine).
1 6-lb. striking hammer.
1 3-lb. gimpy hammer.
4 8-in. gads.
1 small portable forge (optional).
1 anvil (optional).

1 claw hammer and 1 engineer's hammer.
1 tomahawk or small axe.
1 4-ft. jack saw.
1 50-ft. length ¾ in. manilla rope (lashing).
Small quantity ¼-in. round M.S. bars.
Detonators, gelignite and fuse.
Wooden tamping sticks.
3/16-in. flexible wire for signalling and gong.

SINKING THE SHAFT

Preparation

After the shaft has been sunk to approximately 8 ft. in depth provision is made for the disposal of mullock and the stacking of payable ore. Round timber is placed in the form of a "pigstye" around the shaft leaving sufficient room for the shaft timber to come up inside if required (see Fig. 2). The pigstye is commenced from a bearer, set in solid ground, a few feet below the surface.

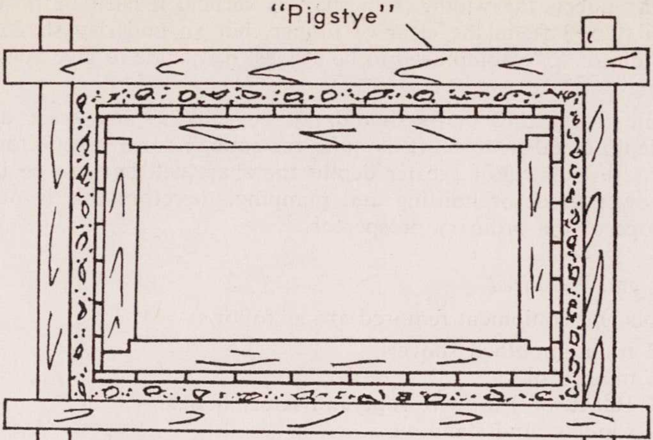


Fig. 2. Plan of shaft showing shaft timber being brought up through "pigstye".

The pigstye is built up to sufficient height to make a convenient tip for mullock in all directions and if payable ore is anticipated a suitable "ore paddock" or bin will have to be built. Where the shaft is on the side of a hill, provision is made for the ore on the downhill side as shown in Fig. 3.

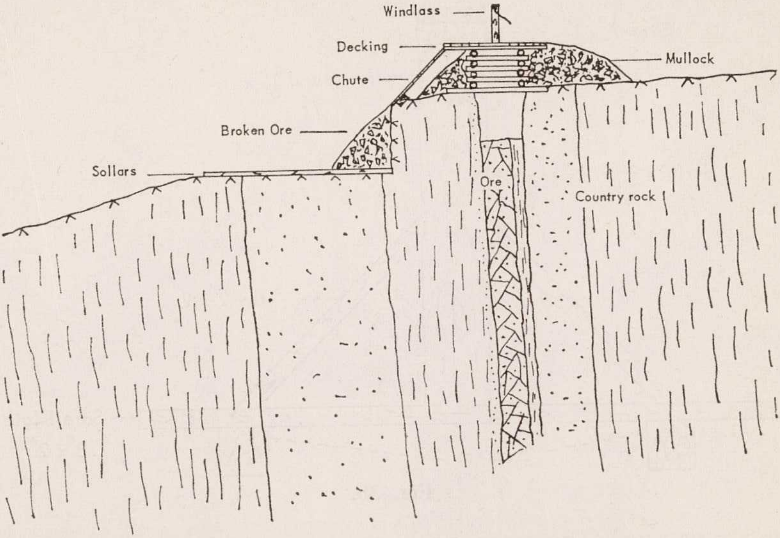


Fig. 3. Section of shaft prepared for further sinking or timbering.

CONSTRUCTION OF WINDLASS AND STAND

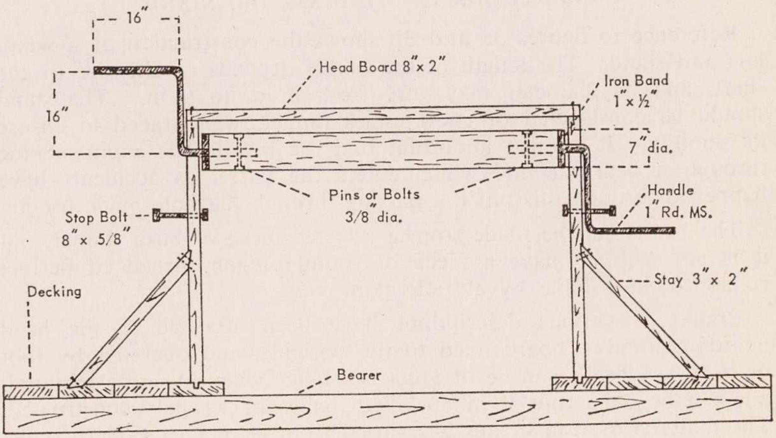


Fig. 3a.

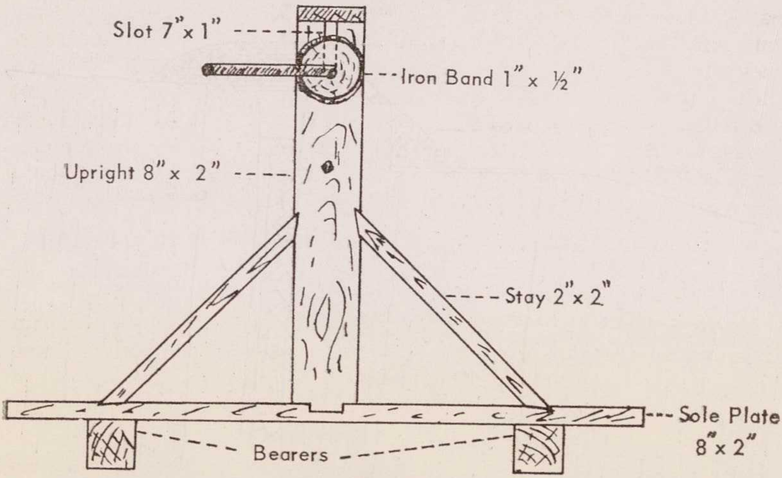


Fig. 3b.

It will be seen that on level ground the "pigstye" will have to be built up higher than would be the case on sloping ground. An ore bin can be built in place of the "paddock" if sufficient quantity of payable ore is won.

A windlass and rope are now installed on top of the "pigstye" with a suitable decking surrounding it to form what is known as the brace. Split slabs can be used for decking.

Construction of Windlass and Stand.

Reference to figures 3a and 3b shows the construction of a windlass and stand. The length of the barrel depends on the size of the shaft, and its diameter may vary from 6 in. to 9 in. The stand should be constructed of good sound timber, well braced to ensure its stability. It is most important that the handle has a pin passing through it near the end which enters the barrel as accidents have happened through this pin not passing through the hole made for it.

The barrel can be made from a selected piece of bush timber, but it is advisable to have a piece of sound oregon turned to perfect roundness in a lathe by a tradesman.

Brakes of various descriptions have been attached to the head board or another board fixed to the uprights, and operated by foot or hand. A brake can be of great assistance when lowering material, but can be dangerous if in unskilled hands, or wrongly constructed. The material used in brakes has varied from leather to modern brake lining, but it is considered that, unless housed within a thin steel band, these materials could be dangerous. Some prospectors have sufficient mechanical knowledge to make and operate a brake satisfactorily, but on the other hand the author has seen men lowering their mates down a shaft with a piece of leather strap wound around the barrel acting as a brake. The possibility of a brake snapping is always present unless it is properly designed and constructed, therefore, unless the services of an engineer are available, a brake should not be fitted.

SINKING.

General.

If the ground stands well sinking can proceed without timber but the sides and ends of the shaft must be inspected each day and loose material scaled off. Remember SAFETY FIRST, and that a piece of rock the size of a walnut, falling 60 ft., could kill a man. If there is any doubt it is wise to timber the ground in.

While sinking, the shaft must be kept as "square" as possible by checking the corners diagonally with a piece of cord, as shown in Fig. 4, and a vertical shaft must be kept plumb by suspending plumb bobs at the corners.

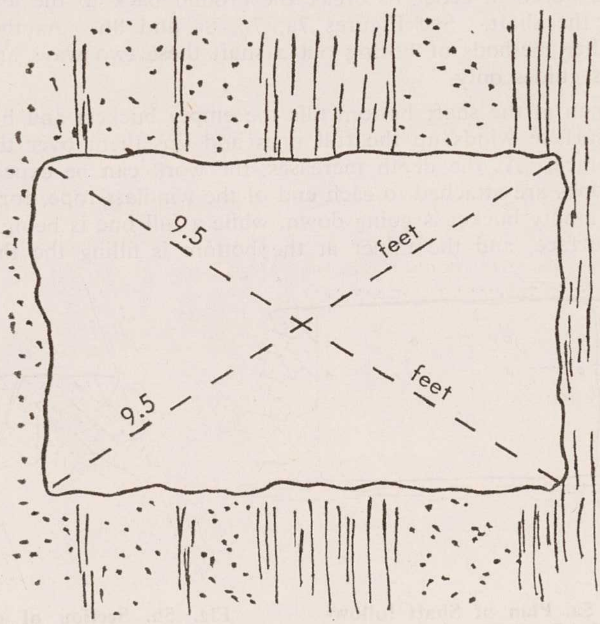


Fig. 4. Plan of vertical shaft showing method of checking shaft for squareness.

If timber has to be put in, the shaft will have to be sufficiently large to allow for the thickness of the frame sets and the lining.

Boring and Blasting.

Before blasting is commenced the prospector is advised to read Rule 2 of Section 55 of the Mines Inspection Act, and Chapter IX, Prospector's Guide, as both these references deal with the storage and use of explosives.

Boring a round of blast holes in a shaft bottom can be done in various ways, according to the dip of the strata and the nature of the ore. If a prospector wishes to economise on explosives he may bore and fire a cut first, and then, after having cleaned it out, complete boring the round. In this way it can be ascertained if the cut has "come out" satisfactorily.

If the shaft is following the ore body, it is usual to make the footwall one side of the shaft. If this is done the cut is bored in the ore finishing in close proximity to the footwall as shown in Figures 5a and 5b. The cut in a vertical shaft in country rock can be made by lifters in the opposite direction to the dip of the strata, as shown in Figures 6a and 6b. After the cut has formed an easement, other holes are bored in order to break the ground back to the ends and sides of the shaft. See Figures 7a, 7b, 8a and 8b. As there are many other methods of boring out a shaft these two ways are mentioned as guides only.

The man at the shaft bottom fills the empty buckets and his mate on the surface winds up the full ones and tips them over the edge of the brace. As the depth increases, the work can be expedited if safety hooks are attached to each end of the windlass rope, for in this way, an empty bucket is going down, while a full one is being hauled to the surface, and the miner at the bottom is filling the third.

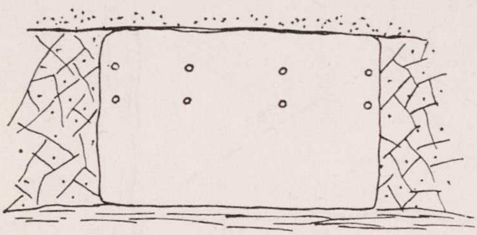


Fig. 5a. Plan of Shaft following the Ore body showing position of Cut Holes.

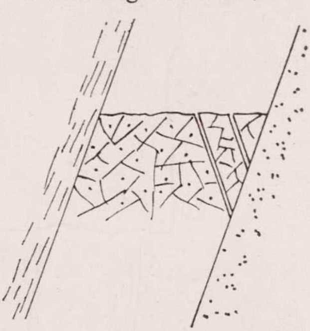


Fig. 5b. Section of cut holes in underlay shaft.

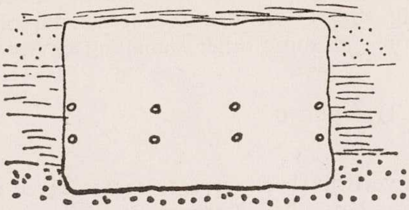


Fig. 6a. Plan of cut holes in vertical shaft.

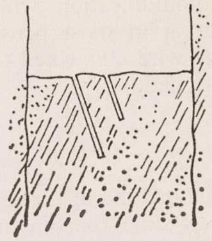


Fig. 6b. Section of cut holes in vertical shaft.

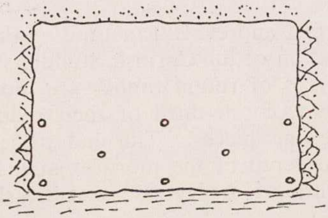


Fig. 7a. Plan of stope holes in underlay shaft.

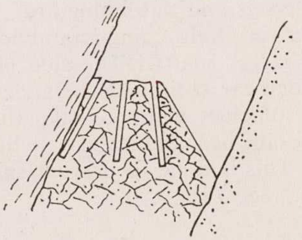


Fig. 7b. Section of stope holes in underlay shaft.

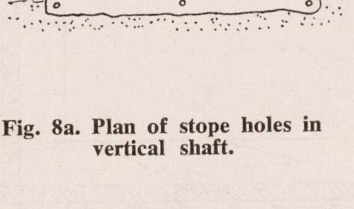


Fig. 8a. Plan of stope holes in vertical shaft.

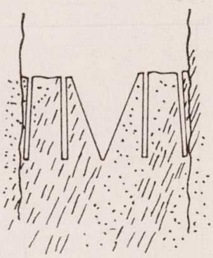


Fig. 8b. Section of stope holes in vertical shaft.

After a certain depth is reached, say, 20 ft. from the surface, it might be found desirable to put in timber. At about 6 ft. from the bottom, and in the sides of the shaft near the corners, hitches are cut into solid ground. These hitches are used to rent the bearers in and they must be sound as the section of timber above depends on them for support. See Figs. 9 and 10.

Communication with the man at the surface can be made by shouting in most prospecting shafts. If this is not satisfactory, a signal wire connected to a gong, or some other signalling device, will be needed.

TIMBERING

General

The method of timbering a vertical shaft varies to some degree from that of timbering an underlay shaft, the difference depending on the amount of underlay a shaft has.

Let us first consider a vertical or near-vertical shaft.

Vertical Shaft

Frame sets and slab lining are a fast and evident method of timbering a vertical shaft, being a modification of the Cornish Studdle system used in larger shafts. The side pieces of round timber are mortised out at or near their ends to a depth of one-third of their diameter, and to sufficient width to take the end pieces. The end pieces are checked out, near their ends, to the depth of the mortises in the side pieces. This is done to prevent splitting if heavy side pressure should develop. See Fig. 9.

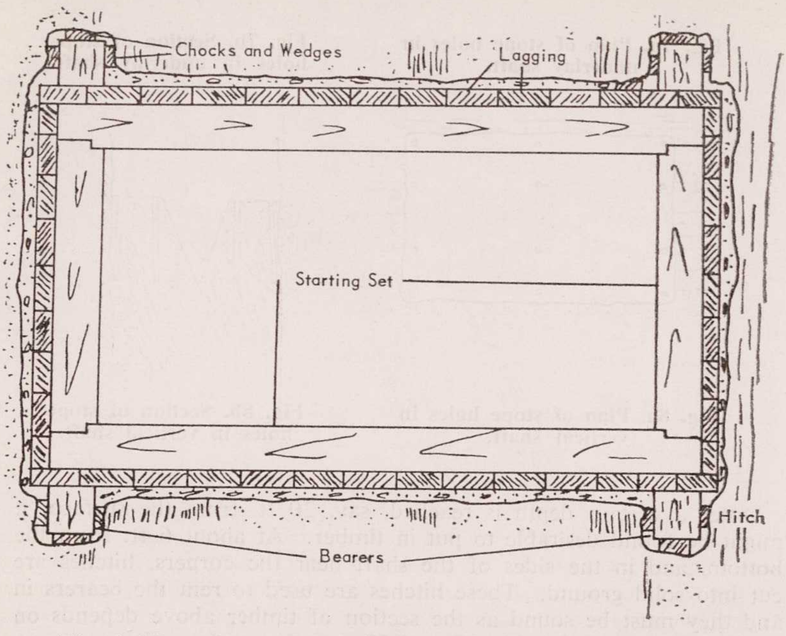


Fig. 9. Plan of vertical shaft showing bearers and starting set.

Studdles for supporting the sets above the starting set are cut from round timber, length being determined by the length of slab used for lagging. See Fig. 10.

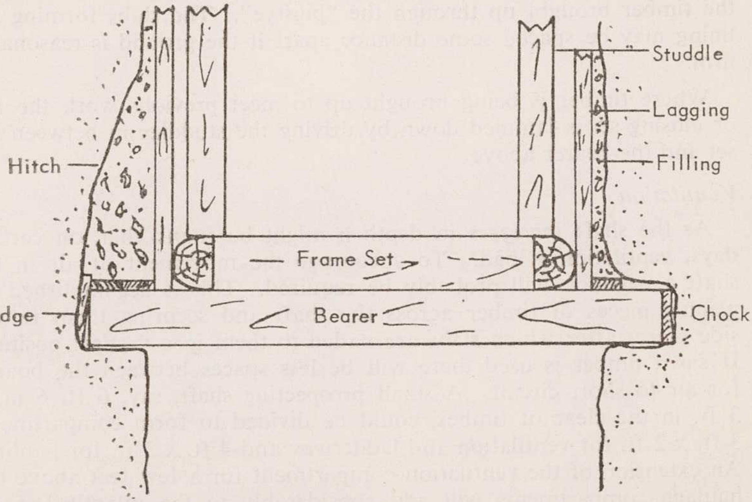


Fig. 10. Section of vertical shaft showing starting set and bearer.

To commence putting in the timber the bearers are placed in the hitches, levelled, squared and plumbed with the general layout of the "pigstye" on the surface. Where there are sets above, the bearers are made plumb with this timber. When the bearers are in their correct positions, they are wedged tightly in the hitches, as shown in Fig. 9, and a set of timber is now sent down. The side and end pieces are placed in position, resting on the bearers, the set is squared, plumbed and levelled before being tightly wedged into position.

Before the next set is sent down four corner studdles are nailed in position over the junction of the ends and side pieces. It will now be necessary to form a stage, by placing slabs over the starting set, from which the next set can be put in position.

With the studdles in position the next set can be rested on their upper ends and dealt with as in the case of the previous set. After the set has been securely wedged into position, the studdles are skew nailed or spiked to the underside at the intersection of the ends and sides.

After two sets have been put in it is advisable to place in position the slabs to form the lining. Some ground may have to be cut away to get the slabs in between the set and the rock, while in other places some packing is done. If a slab does not fit tight it must be packed against the set and all cavities filled with mullock. The position of the slabs in relation to the sets depends on whether the succeeding ones are to butt or lap them. After each succeeding set has been put in, the stage boards are moved up until the surface is reached and the timber brought up through the "pigstye". The slabs forming the lining may be spaced some distance apart if the ground is reasonably firm.

Where timber is being brought up to meet previous work the last or closing set is jammed down by driving the studdles in between the set and the bearer above.

Ventilation

As the shaft increases in depth it might be found that, on certain days, ventilation is bad. To encourage the movement of air in the shaft a partition will probably be required. This is accomplished by placing pieces of timber across the shaft and securing them to the side pieces after which slabs are nailed to them in a vertical position. If sawn timber is used there will be less spaces between the boards for air to short circuit. A small prospecting shaft, say, 6 ft. 6 in. x 3 ft. in the clear of timber, could be divided to form compartments 3 ft. x 2 ft. for ventilation and ladderway and 4 ft. x 3 ft. for hauling. An extension of the ventilation compartment for a few feet above the haulage compartments will add considerably to the quantity of air circulating. To obtain the maximum efficiency it is important that the ventilation compartment should be completely sealed off from the haulage compartment so that all the air circulating reaches the shaft bottom. If necessary, an exhaust blower can be attached to the ventilation compartment at the surface.

Bad ventilation affects the miner's ability to work and causes ill health so, in the long run, there is no gain in being niggardly about doing a little more work and spending a little more time.

Ladders

It will be necessary to have ladders down the shaft. These can be made from round or sawn timber, but a most satisfactory result is obtained by using 3 in. x 2 in. or 4 in. x 2 in. oregon or hardwood cheeks and $\frac{5}{8}$ in. round M.S. bars. 11/16 in. holes, 12 in. apart, are bored half-way through the cheeks to take the $\frac{5}{8}$ in. steel rungs. At intervals of 6 ft., and also near the ends, the holes are bored right through the cheeks and rungs in the form of long bolts are allowed to project sufficiently to take washers and nuts. These long rungs, with threads and nuts, ensure that the cheeks do not spread.

If no partition is used the ladders can be fixed to a corner of the shaft with a small landing at intervals. Where a partition is used, the ladders are fixed to the frame sets in such a manner that they present an angle with the side of the shaft and come to rest on a landing. At each landing the downward continuation of the ladders is on the opposite side of the shaft. The distance between landings must not exceed 30 ft.

Each ladder is hung from the preceding one with a ladder hook, after which it is fixed into position by ladder dogs. See Figs. 11a and 11b.

A chain ladder is of great assistance as it can be left hanging to the shaft bottom when blasting. A ladder should always be available when blasting, even though the miner is hauled away from the shaft bottom by the man on the windlass after lighting up. Fatal accidents have occurred through not taking this precaution.

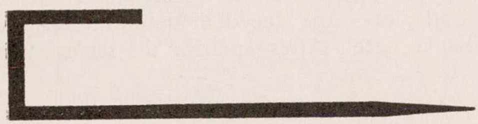


Fig. 11a. Ladder dog.

Fig. 11b. Ladder hook.

General Rule 43, Section 55 of the Mines Inspection Act, 1901, as amended, specifies the manner in which ladders are to be installed.

Underlay Shaft.

Where the dip of the lode is 60°, or greater, timbering is the same as for a vertical shaft, with the exception that the end pieces are placed at right angles to the footwall. However, if the dip is less than 60°, one of the side pieces may be dispensed with, depending of course, on the state of the footwall.

We will now consider a shaft being timbered with sets consisting of 2 ends and 1 side piece.

The side piece is mortised as for a vertical shaft, and the end pieces are checked at one end only. The end pieces are cut long enough to allow their ends to rest in hitches cut in the footwall, and near the corners of the shaft.

The side piece of the starting set is longer than in an ordinary set, so that it can rest in hitches cut in the ends of the shaft, and near the hanging wall. (See Figs. 12a and 12 b.)

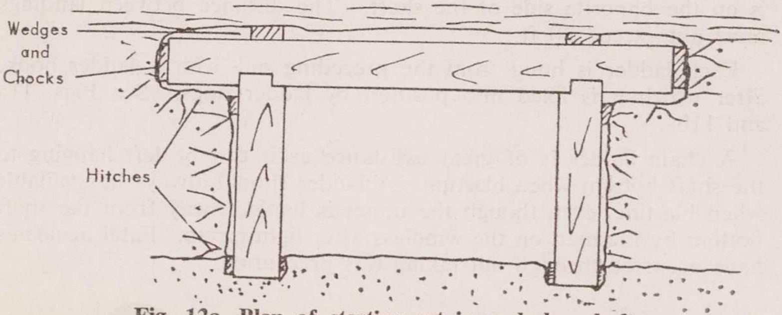


Fig. 12a. Plan of starting set in underlay shaft.

Timbering is commenced by cutting hitches in the footwall near the ends of the shaft, and two hitches in the ends near the hanging wall. The set is now sent down, and the side piece placed in its hitches and levelled. The end pieces are placed in their hitches and fitted to the mortises in the side piece. After squaring the set up, it is

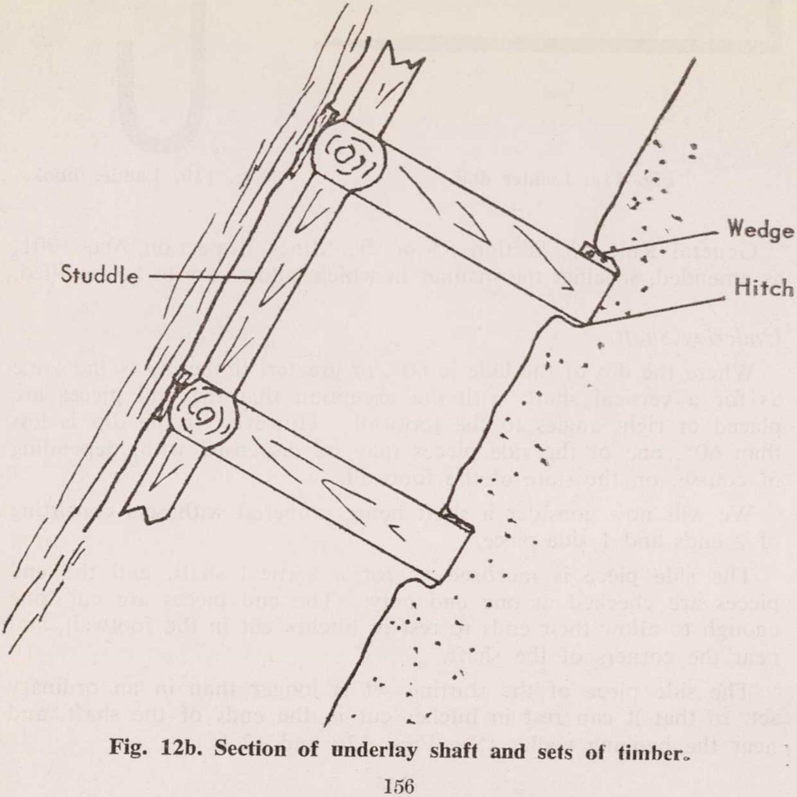


Fig. 12b. Section of underlay shaft and sets of timber.

wedged tightly into position, and spikes are driven through the end pieces into the side pieces.

Corner studdles are now placed at the intersection of the timbers, the upper ends being a guide as to where the next set of hitches will be cut.

The set above the starting set rests on the studdles, and in hitches in the footwall. After squaring up, it is wedged tightly at the corners (see Fig. 12a).

Slabs are secured behind the side and end pieces and the timber brought up to the surface, or the set above, as in a vertical shaft.

Hauling material from an underlay shaft is more difficult than from a vertical shaft. Guides for the bucket have to be fixed to timber placed against the footwall, and fastened to the end pieces. The guides consist of two pieces of round or sawn timber, of sufficient depth, and placed at the correct distance apart, to prevent the bucket catching on the timber or footwall. The thickness and position of the guides will depend on the diameter of the bucket used (See Fig. 13).

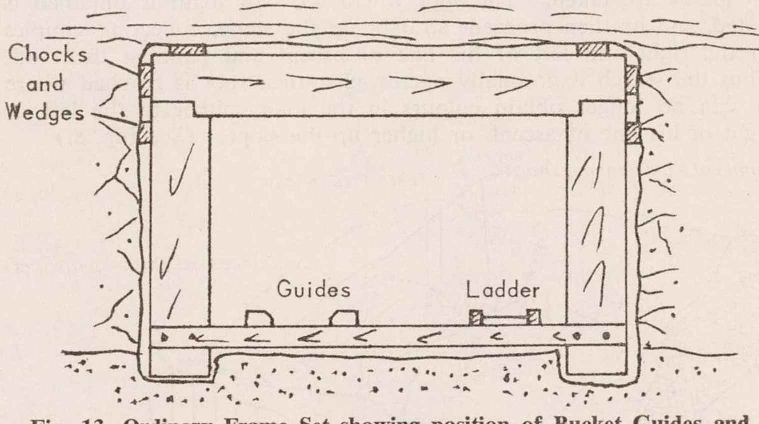


Fig. 13. Ordinary Frame Set showing position of Bucket Guides and Ladder.

Ladders.

The ladders are hooked together, near one end of the shaft, and dogged to the timbers carrying the guides.

CONCLUSION.

The above methods of sinking and timbering prospecting shafts can be modified in many different ways. More expensive machinery and timber can be used depending on the financial position of the prospector.

Above all, economy and safe working methods must be given first consideration before a prospector can hope to be successful. Many good "shows" have failed owing to wrong methods being applied by inexperienced persons in the first instance. Expert advice from the Geological Survey Branch and the Mines Inspection Branch of the Department of Mines can be obtained at any time. Advice from these Branches could perhaps save the prospector a lot of time, and money, and mean the different between success and failure.

LOAMING.

Prospecting for reefs by the systematic collecting of samples of surface soil (loam) and panning them off for "colours" of gold is known as loaming. Loaming requires patience and it must be done methodically. Many experienced reef prospectors carry a loam bag, numbered sample bags, a note-book, and a small prospecting dish.

A prospector may find colours of gold in a gully above which there are no obvious signs of a reef. He then sets out to discover it by loaming. First he works along the same general level as that at which he obtained colours, carefully noting the position from which all loams are taken. The spot where the best loam is obtained is noted, and he then proceeds straight up the slope, collecting samples to the right and left of his line of ascent and panning them off. Thus the search is gradually narrowed until a spot is reached where he can no longer obtain colours in the loam, either to the left or right of his line of ascent, or higher up the slope. (See Fig. 8.)

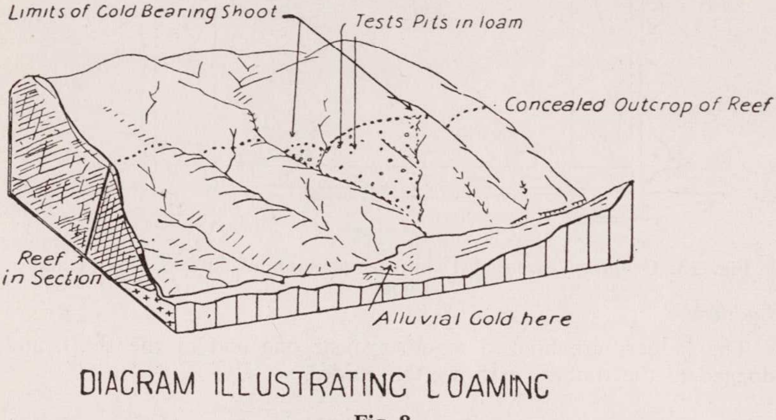


Fig. 8.

The prospector must then costean or trench the surface to bedrock to uncover the outcrop of the reef. If this is successful other trenches are dug to determine the continuity of the reef, its strike direction, and width. It is then tested by dollying or assaying.

Testing a Reef.

DOLLYING.

In order to test vein or reef material for its free gold content in the field, it must first be reduced to a powder. This operation is termed dollying. The fine powder is then washed in a prospecting dish in the usual way. If the stone contains pyrites or other sulphides the concentrate should be roasted until it ceases to give off a sulphurous odour. It should then be re-dollied and panned off.

A 12 inch or 12 pint mortar weighs about 40 lb. An old mercury bottle also makes a serviceable mortar. It is held between the feet, the pestle being a long iron bar. A serviceable dolly can be assembled by using a heavy flat piece of iron as an anvil, and an iron ring or bottomless box which stands on or over the anvil to prevent fragments flying when struck. Using a length of thick iron bar or a hammer-head as a pestle, a sample of quartz is pounded until fine enough to release the gold or mineral content. The work can be done more efficiently with the aid of sieves. The coarse material may be removed and returned to the dolly for further crushing.

A set of sieves for testing work can be made with woven wire screening of $\frac{1}{4}$, $\frac{1}{8}$ or $\frac{1}{20}$ inch mesh, about 6 inches square, and tacked on to wood frames.

Another type of dolly which can be erected by a handy man consists of a stump about 4 feet high, on top of which is set an iron plate to act as an anvil (an old stamp die is ideal if available). A removable wooden box is then made so it will stand on the stump with its base fitting closely around the iron plate. A round piece of hardwood 3 feet to 4 feet long forms the stamper, one end being squared and shod with wrought iron. The handle is made by boring a hole and driving a tapered wooden pin through, which is left projecting about 6 inches on either side. The stamper is hung with a short chain or rope from the end of a sapling, the spring of which holds it straight above and clear of the mortar box. The sapling is held securely by spiking the butt-end to a tree or stump about 2 feet from the ground. A stout fork supports the pole near the middle.

The dolly is operated by grasping the handles and bumping the stamper down into the mortar. The spring of the pole causes it to rebound, and an even swing can be maintained without much labour.

A similar dolly can be constructed at the ground level, the sapling from which the pestle is suspended being grasped in the hands and bumped down from waist level, instead of being pulled down by means of a rope.

Notes on the Treatment of Gold Ores.

USE OF MERCURY.

Mercury, or quicksilver, is used by the prospector for recovering fine gold. Only glass, earthenware or plain iron containers should be used. Mercury must be kept clean and free from oil and grease and from contact with oxides and metal, otherwise it becomes "sickened" or "floured". Fine clean gold is quickly dissolved by mercury when the two metals are brought into contact.

Where finely divided gold is present in a concentrate in association with a large amount of black sand, separation may be made as follows:—

The larger pieces of gold are picked out and the remaining material is placed in a black iron prospecting dish. Pure quicksilver is added and the contents thoroughly agitated until it is certain that the quicksilver has come in contact with all the gold present. The quicksilver unites with the gold, the resulting material being known as amalgam. The black sand has now to be removed from the amalgam. This is done by holding the dish at an angle under a small stream of water and allowing the sand to flow over the lip with the water, care being taken to retain the amalgam in the groove of the dish. With heavy sands it is usually necessary to assist this operation with the hand. The quicksilver should be present in sufficient amount to keep the resulting amalgam perfectly fluid. If the gold is dirty, greasy, or rusty, it will not amalgamate. When this occurs it may be cleaned with a caustic soda or weak cyanide solution. In some cases it may be necessary to grind the material with the solution, in a dolly pot. A piece of sodium or potassium cyanide about the size of a pea in

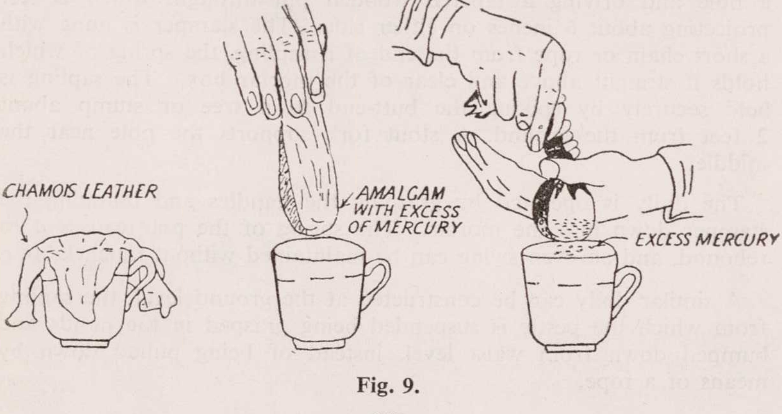


Fig. 9.

one gallon of water gives a solution that will clean most rusty or greasy gold. *It should be remembered that cyanide in all its forms is highly poisonous.*

Gold is recovered from amalgam as follows:—

A moist chamois leather is depressed into a cup and the amalgam poured in. (See Fig. 9.) Strong calico cloth can be used if chamois is not available and is preferable if large quantities of amalgam and mercury are to be treated owing to the ease with which it can be squeezed. The corners are then gathered up and the chamois twisted to form a neck. The twisting is continued until all the excess mercury has been squeezed through the chamois into the cup. This leaves a white pasty mass of mercury and gold, known as amalgam.

The mercury is separated from the amalgam by a distillation process called retorting, the amalgam being placed in an iron vessel and the mercury driven off by heating.

Retorting is not for the novice, and it is a good practice to have the amalgam treated by an experienced man with the proper equipment. Small quantities (up to an ounce in size) may, however, be safely treated as follows:—

Select a large well-rounded fresh potato, free from cracks, and cut it in halves. In one half-scoop out a hole large enough to hold the amalgam. Place the amalgam in the hole, join the halves and wire them tightly together. Place the potato in hot ashes until it is baked (for from half to three-quarters of an hour). A gold button will be found in the potato and the distilled mercury may be recovered by squeezing the potato to pulp.

Retorting mercury from amalgam by heating in a frying pan or shovel is a very dangerous operation as mercury fumes are colourless and exceedingly poisonous. It also results in losses of gold.

Practical Notes on Amalgamation.

Gold occurs in nature in particles, the size of which vary from tiny grains which can only be seen with a powerful lens to pieces which are easily visible to the naked eye. When these gold particles are free and large enough to be seen by the unaided eye, they are usually collected by crushing the ore in a battery or other suitable machine and passing the ground pulp over copper plates coated with quicksilver (mercury) which collects some of the gold. This process is known as plate or "outside" amalgamation.

Coarse gold, except in rare instances, alloys with mercury provided both have clean surfaces. The presence of oils, grease, carbon, soluble sulphates or minerals containing arsenic, lead, zinc, copper, antimony, some forms of pyrite or bismuth either singly or in combination has a harmful effect on amalgamation.

The ore should be chemically tested for the above minerals and compounds, and, if any of these are present, practical tests should be carried out before deciding to include amalgamation in the recovery process.

EXPERIMENTAL TESTS.

The experimental tests will indicate whether the ore is amenable to amalgamation or not, and if it is, the approximate recovery which may be expected, and the screen size through which the ore should be discharged. Unless it is intended to treat fairly high grade ore, it is not economical to amalgamate unless about 30 per cent. of the total gold particles remain on a 100 mesh screen.

If the tests prove that the ore will respond to amalgamation and the gold will pass through a 16 mesh screen, the next step is to dress the copper plates.

PREPARATION OF NEW PLATES.

A well-known and satisfactory method is to dress the plates as follows:—

Soft rolled copper plate $\frac{1}{8}$ to $\frac{1}{4}$ inch gauge should be used, with an area of about 2 square feet per ton of ore treated per twenty-four hours. The surface of the plate should be scoured with fine sand (or nitric acid solution—1 oz. acid to 1 pint of water) using a piece of bagging wrapped round a wooden block. After washing well with water, a solution of cyanide of potassium—$\frac{1}{2}$ oz. cyanide to 1 pint of water—should be applied with a woollen swab or soft brush and allowed to stand for twenty-four hours. The surface will turn a dark green.

A mixture of equal parts of fine sand and sal-ammoniac with a small quantity of mercury should be applied to the plate with a scrubbing brush until the plate will retain no more mercury. (New plates require about $\frac{1}{4}$ oz. mercury per square foot.) The plate is then allowed to stand for about an hour, and washed thoroughly with clean water.

A new plate will be made more efficient if gold or silver amalgam is rubbed into it at this stage, using a cloth wetted with a solution of sal-ammoniac—4oz. to 1 pint of water. The plate is then ready for use.

It should be remembered that a new copper plate will absorb $\frac{1}{4}$ oz. of gold per square foot. In the treatment of ore containing free gold and assaying over $\frac{3}{4}$ oz. per ton, it will take from two to three weeks for the plate to absorb $\frac{1}{4}$ oz. of gold per square foot.

If ore containing both coarse and fine gold is being treated (the coarse remaining on a 16 mesh screen) it is an advantage to add about 1 oz. of mercury per ton of ore to the battery box. This is known as a box or "inside" amalgamation. Coarse particles of gangue scour the amalgam on copper plates and considerable loss of amalgam is the result. When ores contain pyrites and other sulphide minerals, lime should be added to the ore as it is fed into the battery.

CARE OF PLATE.

It is essential that the amalgamated plate should be kept in a bright condition. If it becomes discoloured there will be considerable losses of gold. It may be necessary to keep swabbing new plates with a very weak cyanide solution while in use, until a good coating of gold is obtained Grease rapidly causes "sickening" of mercury and must not be allowed to come into contact with the plates.

ADJUSTMENT AND USE OF PLATE.

The plate should be mounted with a fall of from 1 to 2 inches per foot with a well or mercury trap 5 inches wide and 2 inches deep along the discharge edge of the plate. This collects any mercury dislodged by the scouring action of pulp mineral salts, etc.

The pulp—pulverised ore or concentrate—is passed over the plate in a gentle flow of water sufficient to prevent the deposition thereon of undesirable material. About 4 of water to 1 of ore by weight is a good working density. As the mercury collects, the gold hardens and from every two to four hours it is necessary to proceed as follows: Take a strip of hard rubber and, working from the bottom of the plate, rub all the loose mercury and amalgam to within 3 inches of the top of the plate, forming a small ridge of amalgam. This ridge should be preserved as long as possible. A small amount of mercury should then be placed on the plate and the whole swabbed over with the weak cyanide solution. Also add a few drops of mercury to the space between the ridge and the upper edge of the plate

CLEANING-UP.

At intervals it is necessary to clean up. These intervals must be determined by the operator, and will depend mainly upon the richness of the material treated. When the amalgam cannot be depressed with the ball of the finger, a clean-up is necessary. Cleaning up consists of softening the amalgam on the plate by rubbing in mercury with a cloth or brush and removing the amalgam by means of a strip of hard rubber. A thin coating of amalgam should always be allowed to remain on the plate, as this makes it more efficient in subsequent use. On no account should the plate be scraped with anything other than the rubber strip.

At times plates become coated with a thick hard layer of amalgam. This often happens when rich ore is being milled, and in order to save time, the plates are not lifted or cleaned each "clean up" day. The quickest way to remove this amalgam is to "strip" the plates. The plates are first lifted from the tables and placed on their edges on a low wooden bench which has a canvas cover over it. The flame from a blow lamp is now applied to the back of a plate, the heat being distributed as evenly as possible over the surface. Immediately the amalgam softens the plate is raised and dropped on its edge when it will be noted that a very large proportion of the amalgam has fallen off. A piece of rubber can now be used to remove any surplus amalgam. Great care must be taken so as not to overheat the plate. If properly carried out this method is far superior to some of the old ones such as heating the plate over charcoal or steaming.

An expert using a blow lamp can leave the plate "wet" with a thin film of amalgam over the surface and in excellent condition for immediate use.

After the amalgam has been removed, a new coating of mercury is applied to the plate and swabbed with a weak cyanide solution. The plate is then ready to be used again.

RECOVERY OF GOLD.

The amalgam which has been scraped off the plates is well kneaded under water in a prospecting dish and the sand, pyrites, and other impurities panned off. The amalgam is then ground in an iron mortar or dolly pot, warm water and mercury being poured in. The impurities which "float" to the surface should be skimmed off, or taken up with a sponge.

The remaining amalgam should be treated as described on page 160.

The various types of ores and their influences on amalgamation cover a very wide field. Consequently, only the barest outline of the process can be given in the space available. The Department will test and report on the amenability to amalgamation and other methods of treatment (of approved samples), and will furnish information free of charge on amalgamation and other methods of treatment.

Practical Notes on Corduroy Strake Concentration.

Gold-bearing minerals and coarse gold discharged from a battery or other type of fine crushing machine can be partially collected by means of corduroy strakes. Corduroy cloth is usually manufactured in 28-inch widths with furrows at right angles to the width of the cloth. The furrows are $\frac{3}{8}$ inch apart and $\frac{1}{8}$ inch deep.

The particles of coarse gold and heavy minerals are retained in the strakes, while the lighter particles are removed by an even and gentle stream of flowing water. The concentrate recovered by the strakes is usually batch amalgamated for the recovery of the gold. The difference between corduroy concentration and amalgamation is that the strakes produce a concentrate direct, from which by a secondary process of amalgamation some of the gold can be recovered, whereas amalgamated plates recover the gold direct from the battery discharge.

In certain cases corduroy concentration possesses considerable advantages over amalgamation. The main advantages are:—

(1) That prior to cyanidation the corduroy concentration will remove an appreciable proportion of the objectionable impurities the ore may contain.

(2) That heavy minerals which may be gold-bearing and are not amenable to amalgamation are recovered.

(3) That dissolved salts or other impurities in the water used for treatment do not affect the process.

(4) No skilled attention is required in the operation of strake concentration.

(5) The installation and running cost is substantially lower than in the amalgamation process.

The losses in corduroy concentration are mainly caused by small particles of gold in the form of thin laminae, flattened grains or scales which remain suspended in the flowing water used in treatment and thus do not come into contact with the corduroy cloth.

The actual slope, area, etc., of the strakes will, of course, vary with the grade and mineral content of the ore being treated. An ore ground to minus 20 mesh screen and containing from 10 per cent. to 15 per cent. of heavy minerals in a quartz gangue, can be efficiently concentrated on strakes having an area of 3 square feet per ton of ore treated per day, set at a slope of about $1\frac{1}{2}$ inches per linear foot. A pulp crushed to minus 10 mesh would require a steeper slope.

Experiments on each ore are necessary before details can be furnished as to actual grades to which the ore should be crushed, etc., but the following points should enable a fair recovery to be made from an average ore amenable to corduroy concentration.

The area of strake should be about 3 square feet for each ton of ore treated per day. The slope of the table carrying the cloth should be made adjustable, ranging from one to $2\frac{1}{2}$ inches per linear foot.

The corduroy should be placed on the table with the furrows at right angles to the pulp stream. The edges of the corduroy should be turned up about one inch against easily removed battens running lengthwise down each side of the table, thus forming a wide shallow channel through which the pulp flows.

The table supporting the corduroy can be made of wood or sheet iron. Any desired length and width of strake can be built. Excessive width should be avoided, however, when using wooden tables, because they have a decided tendency to warp after partial drying-out when the plant is not working.

Strake tables should be arranged in duplicate, in order to divert feed from one to the other during washing and cleaning-up periods. The pulp should be fed on to the strakes gently and evenly and not more than $\frac{3}{8}$ inch deep. Provision should be made for about eight parts of water to one of ore by weight for strake concentration. A narrow strip along which a man can walk should be provided between each set of strake tables. This is necessary, because the concentrates of many ores collect in small mounds on the cloth and it is necessary to push the concentrates towards the head of the strake at frequent intervals.

If the concentrates are free from minerals that interfere with amalgamation they should be transferred to an amalgamating barrel and rotated with a few steel balls, pebbles or rods for half to one hour. About half an ounce of pure mercury should then be added for each pound of concentrate in the barrel. The barrel should contain about three parts of water to one of ore by weight and the water should be made slightly alkaline with lime. The barrel and its contents should again be rotated for one to two hours, the mercury removed, cleaned and retorted in the usual way.

Should the concentrates contain minerals that cause difficulty in amalgamation, roasting will often prove an effective remedy. When the amount of concentrate recovered by the corduroy is small, it can be cheaply roasted and the gold extracted by barrel amalgamation as described above.

In the absence of a furnace, roasting can be satisfactorily accomplished by spreading the concentrate on a flat sheet $\frac{1}{4}$ to $\frac{1}{8}$ inch thick and in size about 6 ft. x 4 ft. The flat sheet should be raised about 2 feet above the ground by bricks or stone piers and a wood fire made beneath it. The temperature should be kept low for about half an hour, then raised until all fumes of sulphur, etc., are expelled. The concentrate should be allowed to cool. It is necessary to give the roasted concentrates one or two water washes to remove soluble sulphates before transferring to the amalgamation barrel.

The alternative to barrel amalgamation is to sell the concentrates direct to smelters. A decision in this matter is governed entirely by the quantity and nature of the concentrates.

Practical Notes on Cyanidation.

These notes are compiled for the use of those not thoroughly familiar with the operation of the cyanide process and who are desirous of working a small cyanide plant. The details of a suitable plant are shown in Figs. 10, 11 and 12.

Cyanidation can be applied successfully to the treatment of free-milling ores in which the gold occurs in very fine particles, or of tailings and concentrates resulting from amalgamation or concentration.

It is not economical to apply the cyanide process to the treatment of ores in which the gold occurs in a fairly coarse condition. Gold particles that remain on a 100 mesh screen should not be cyanided. Certain sulphides that commonly occur in gold ores limit the efficiency of the process. Copper-bearing gold ores present the most difficult problem in gold extraction by cyanidation and, if carbonate of copper is present, it may be impossible to treat the ore by the cyanide process.

When the average assay value of the ore or tailings has been definitely established, the nature of the impurities must be considered, followed by a study of the possibility of having to use impure water, which may or may not cause trouble in precipitation and increase cyanide consumption.

The next step in the process is to mill or grind the ore or sands to such a degree of fineness as to expose each particle of gold or silver to the action of the cyanide solution.

It is assumed that preliminary tests indicate that the ore contains sufficient free gold in a fine state of division to warrant treatment and that it is amenable to extraction by simple leaching. In treating ores or tailings containing too much slime to leach satisfactorily, centrifugal pump or air agitation should be used.

LEACHING TREATMENT.

Leaching is usually carried out in bitumen-treated circular galvanised iron tanks with a false bottom covered with a filter medium. A grid is first made on the bottom of the tank by laying sawn timber 3 in. x 1½ in. on edge and from 12 in. to 15 in. apart. A small inverted "V" should be cut underneath in the centre of these cross members in order to allow the solution to flow to the outlet pipe. On top of these, smaller strips of 1 in. in section are nailed transversely, leaving about one inch spaces between them. The top grid should have a diameter of about 3 inches less than the inside diameter of the leaching vat and be made in sections small enough to be handled by two men, because it has to be lifted out periodically for the purpose of cleaning out accumulated sand and slime that may work through the filter. On top of the grid is laid a circular mat of jute bagging sewn neatly together and on top of this another circular mat of jute or hessian that can be removed and cleaned without difficulty. A jute or fabric that is too fine in texture seriously retards the rate of percolation.

A thick hempen rope together with the edges of the filter cloth should be driven into the cavity between the sides of the tank and the top grid by means of a wooden caulking tool. This secures the filter cloth in close contact with the sides of the tank and ensures that very little slime or sand enters the false bottom of the vat. A flexible strip of wood should be used around the vat to support the rope caulking.

A pipe about 2 inches in diameter, to which a convenient valve is attached, is fitted in the bottom of the tank for drawing off the gold-bearing solution. A fitting to receive an independent 1 inch to 1½ inch pipe beneath the filter should be provided in case it is necessary to arrange for the cyanide solution to percolate upwards instead of downwards through the charge. The latter method is used to advantage when the product being cyanided contains a considerable quantity of slime. If the plant is built on a site with an appreciable fall, provision should be made for a central discharge in the bottom of the vat for the rapid disposal of the cyanided residues.

CHARGING THE VAT.

The sand should be placed in the vat as evenly as possible. If a mixture of sand and slime is being cyanided, about three shovelfuls of sand should be mixed with one shovelful of slime. Each seven or eight inches in depth should be levelled by means of a rake as it is charged into the vat. If it is practicable, it is an advantage to moisten the sand with a weak cyanide solution before feeding it into the vat. The vats can be charged to a depth ranging from one to three or more feet, according to the fineness and porosity of the sand. When a preliminary water wash or strong solution is applied, the charge will sink several inches.

If some parts of the charge are compressed more than others when the vat is being filled, the cyanide solution, when applied will follow the easiest path through the sand and form channels. Thus some parts of the charge will not make proper contact with the cyanide solution, and a satisfactory extraction of the gold may not be obtained.

Assuming that a depth of 3 feet of sand and slime will leach satisfactorily, the vat should be filled to this depth and the surface raked as level as possible. The sand should then be raked to a depth of 3 inches from the centre to the outside of the vat, thus raising the outside edge of the charge about 3 inches above the centre and preventing channelling down the sides of the vat.

CYANIDE SOLUTION.

A solution containing about 0.1 to 0.25 per cent. of 96 per cent. —100 per cent. sodium cyanide and sufficient lime to give an alkaline reaction is run on to the sands. The outlet at the bottom of the tank is, of course, closed while the solution is being applied. The displaced air is forced upwards and assists in aerating the charge. The air in its upward path through the charge may also cause channelling, which is detrimental to good leaching. This can be avoided by fixing a stand pipe about 2 inches in diameter against the side of the tank. The top of this pipe should be at approximately the same level as the top of the vat and the bottom should extend about 1 inch through the filter mat, which is well caulked around the pipe to prevent sand or slime filtering through the point. This acts as a vent for the imprisoned air that is forced down by the descending cyanide solutions.

Another remedy is to open the outlet valve slightly when the solution is being applied.

The cyanide solution is added until the level stands 2 or 3 inches above the top of the charge. The amount of solution required, varies from three-quarters to one and a half times the weight of ore. With most ores it is advisable to use a larger bulk rather than increase the strength of the cyanide solution.

It is not necessary to allow the solution to stand in contact with the charge. It should be allowed to drain off immediately and completely in order to aerate the charge as much as possible. If the solution drains off at the rate of 2 to 3 inches per hour it will be found satisfactory. The drawn-off solution is returned to the vat and this process is repeated until the gold has been dissolved. A very important factor in cyanidation is to keep the solution moving through the ore or tailing.

Some ores and tailings will yield a higher extraction if the surface of the charge is turned over with a shovel for about 6 inches in depth after the first and second cyanide solutions are drawn off. The leaching takes from about 16 to 30 hours, the period being governed by the character of the ore under treatment.

Leaching with the strong solution should be followed by a wash with a weak one for which purpose the effluent from the zinc boxes may be used. The volume of weak solution should be two or three times as great as that of the strong. Finally, the charge should be washed two or three times with water. The amount of water used in washing should not be more than one-eighth of the weight of ore being treated.

PRECIPITATION.

This is a phase of cyanide treatment that often causes trouble through neglecting clarification. If the solutions entering the precipitation unit contain any suspended matter, it will be deposited on the zinc shavings and difficulty in the precipitation of the gold will follow. A safe course is to pass the solution through a small vat with a filter bottom similar to that fitted in the leaching vat, which is covered with 10 or 12 inches of fairly coarse clean sand. The solution, of course, passes through this clarifier before entering the zinc boxes.

If the amount of solution to be treated is too small to warrant a filter tank the first two or three compartments of the zinc boxes can be filled with a filter cloth and sand utilised as a clarifier.

EXTRACTION OR ZINC BOX.

The extraction box is long and narrow and is usually made of wood. It is divided into from five to ten compartments, and fitted with baffles so arranged that the solution rises through the zinc in each compartment and descends through the narrow space between each partition and baffle. A quarter mesh screen made of iron or steel is fitted about 6 inches above the bottom of each compartment so as to allow space for the collection of the gold and silver sludge as it becomes detached from the zinc shavings.

DIAGRAMMATIC SKETCH SECTION OF A SIMPLE LEACHING PLANT

(The layout should be modified to suit local conditions)

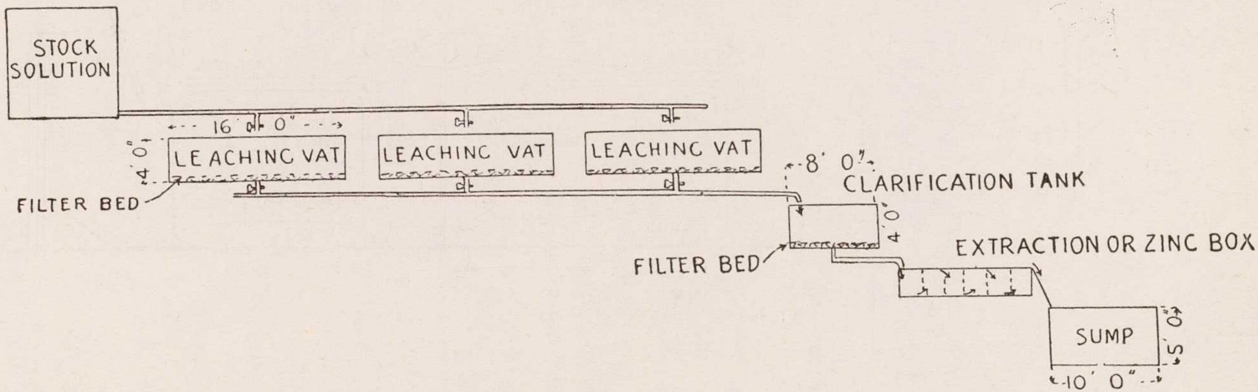


Fig. 10.

PERSPECTIVE SKETCH OF LAYOUT OF CYANIDE PLANT

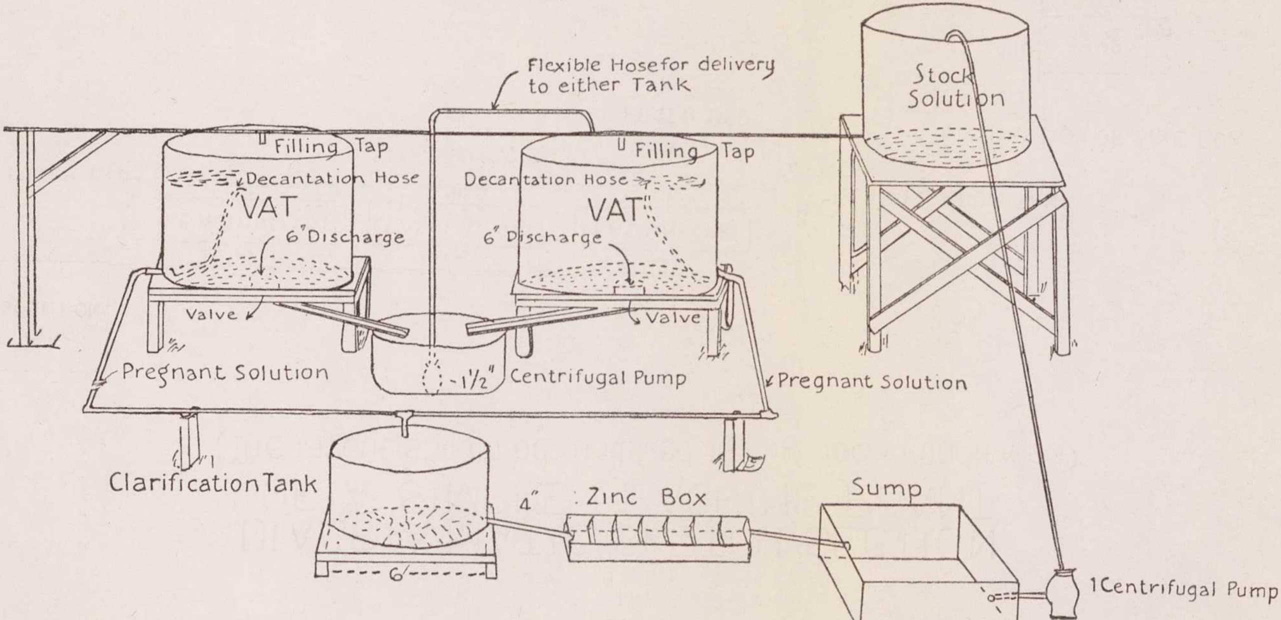


Fig. 11.

DIAGRAM
SHEWING SIMPLE METHOD OF PULP AGITATION

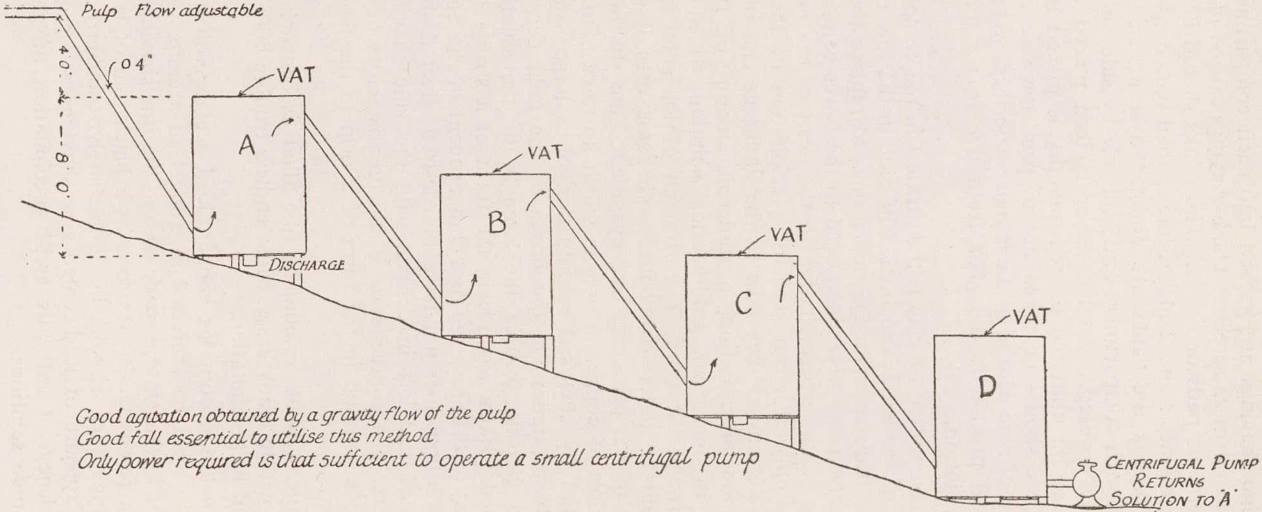


Fig. 12.

The zinc shavings are packed into each compartment and on top of the quarter mesh screen. These shavings can be placed in the box in the form of pads or hanks. The hanks should be made about 3 inches in diameter and 2 inches longer than the compartment. When charging a box the hanks are doubled over at each end the exact length of each compartment and laid side by side until the screen is completely covered. Another layer is then placed transversely on this and so on until the desired quantity is placed in the compartment. Care should be taken not to pack the zinc too tightly. A cubic foot of zinc packed in the manner described, weighs about 12 lb. and it will precipitate the gold from five to six tons of pregnant cyanide solution.

The consumption of zinc is the greatest in the compartments at the inlet end of the extraction box. The zinc in the lower compartments should be transferred to the upper ones to replace the zinc that has been dissolved and new zinc added to the lower compartments. This procedure confines precipitation to the head of the box and ensures a good supply of clean zinc for precipitation of the weaker gold-bearing solutions as they flow to the discharge end of the box. To ensure good precipitation, a sufficient amount of free cyanide is essential in the clear gold-bearing solution which should move freely through the box. The strength of the solution entering the box should be tested daily, and with some ores it should contain from 0.1 to 0.2 per cent. free cyanide. Zinc shavings often show the existence of copper in ores in which no trace of this metal could be detected by chemical examination of a large sample. If there is a white precipitate in the boxes or the gold deposit is hard or copper is causing trouble the strength of the solution should be investigated. Extra cyanide in the form of a strong solution should be allowed to drip into the first compartment of the box. If a strong cyanide solution does not have the desired effect it should be again strengthened and left in contact with the zinc shaving for two of three hours. If the precipitate is still unsatisfactory add a 5 per cent. caustic soda solution in the form of a drip to the first compartment of the box.

As a rule, a small amount of free alkali is beneficial. Too much, however, will in many cases, cause endless trouble both in the cyanide circuit and in precipitation.

If the solution contains copper, lead acetate will assist precipitation. Care must be exercised in using lead acetate. A 10 per cent. solution of lead acetate is made up and the zinc shavings are immersed in it for a few seconds. As soon as a black film of lead deposits on the shavings they should be immediately transferred to the zinc boxes. Exposure of lead-coated zinc shavings to air quickly impairs their efficiency. Lead salts assist precipitation of gold from very weak cyanide solutions.

As precipitation proceeds, bubbles of gas should be constantly rising to the surface of the solution. If many bubbles become attached to the zinc they should be removed regularly by gently moving the zinc. It is a good plan to attach two pieces of iron wire to the tray holding the zinc shavings, to enable it to be moved up and down sufficiently to disengage any accumulation of bubbles that form from time to time. A black or dark-coloured deposit on the zinc, which is easily removed, is an indication of good precipitation.

CLEAN-UP.

A wooden tub or half-cask, preferably lead-lined, should be on hand. Its size depends on the amount of zinc to be treated. A fine screen not larger than 30 mesh should be placed in the bottom of the tub. The zinc in the first compartment should be lifted up, allowed to drain, transferred to the tub and the loose gold and small pieces of zinc washed through the fire screen by means of a jet of clean water. Any gold precipitate adhering to the zinc should be removed by rubbing it gently with the fingers or with a brush containing short soft bristles. Care should be taken to avoid breaking the zinc into short lengths. The shavings in the first two or three compartments are treated in a similar way.

When the zinc on which gold has been deposited is removed from the precipitation box, some alum solution is added for the purpose of settling the gold slime. After settlement the clear liquid is siphoned off, the gold slime carefully scraped out of the box, and placed in a suitable dish. The coarse zinc which was washed in the tub should be returned to the compartment at the inlet end of the precipitation box. The zinc in each of the other compartments should be moved up towards the inlet end, fresh zinc being added to the compartments at the discharge end.

Also add a little more alum to the precipitate in the tub and when the gold sludge settles, siphon off the clear liquid. Collect the precipitate in the bottom of the tub and unite it with the precipitate in the dish. The precipitate will contain a high zinc content which can be treated by several methods for the recovery of the gold. Sulphuric acid treatment before fluxing is the most convenient method.

SULPHURIC ACID TREATMENT.

The amount of acid required, depends on the quantity of slime to be treated. A solution is made up by gradually adding about 6 lb. of sulphuric acid to 50 lb. of water (2 quarts of acid to 5 gallons of water). Sufficient of this mixture to dissolve all the zinc is gently poured on the precipitate in the tub and then well stirred with a wooden paddle. When all the zinc has been dissolved, the tub should be nearly filled with hot water and again well stirred. The contents of the tub should be allowed to settle and the liquid which contains most of the zinc can be siphoned off. The water washing (without acid) should be repeated four times in order to remove as completely as possible the soluble zinc contents of the gold-bearing sludge. After the final washing the gold-bearing slime should be collected and placed in an iron tray and gently heated until most of the moisture is removed. A little moisture in the precipitate prevents loss of gold by dusting. The acid treatment should be done in the open air, and naked lights should be kept away from the appliances in which acid treatment is being carried out. All fumes expelled in the process are highly poisonous and form an explosive mixture with air.

SMELTING.

The precipitate can be smelted either in plumbago or fire-clay crucibles. Usually, when very small amounts of precipitate are being smelted, fire-clay crucibles suffice. A pronounced disadvantage of fire-clay crucibles is that they tend to crack when subjected to rapid changes of temperature. On the other hand they are more inert to the action of slags than plumbago crucibles. All crucibles should be carefully annealed before use.

The pot should be placed in the fire and to prevent it from slipping down on the fire bars it should be supported by portion of a brick. The temperature should be gradually raised to redness. If the zinc has been completely removed by the acid treatment, the following charge should give a satisfactory smelt:—

Precipitate 50 parts.
Borax-Glass 30-40 parts.
Soda-Ash 10-15 parts.

If the cyanide product contained soluble lead or if lead acetate was used in the precipitation, from 5 to 10 parts manganese dioxide should be added to the above charge, and either a fire-clay crucible or a plumbago crucible with a fire-clay liner used in the smelting operation.

The charge should be well mixed, placed in small paper bags and transferred to the pot with the pair of tongs. The charge should be placed in the pot in small lots, otherwise the soda-ash will cause it to boil over.

When action ceases in the pot and the charge is calm, it can be poured into a suitable bullion mould. This mould is prepared to receive the molten charge by washing it out with a chalk paste and thoroughly drying it over a fire. The slag quickly sets, and it can be detached from the bullion by plunging the mould and its contents into a bucket of cold water.

It is obviously not within the scope of these notes to discuss in detail the complete working of even the simple leaching process. The main points, however, have been outlined.

The output from a mine or a large tailing dump is subject to almost daily physical and chemical changes and treatment requires continual modification to keep the extraction within certain limits.

The more complex ores or sands containing copper, etc., require testing before, during and after treatment. A high extraction may be obtained in laboratory tests on ores totally unsuited for treatment by the cyanide process when worked on a commercial scale; therefore, the interpretation of laboratory tests must be left to an operator with a wide experience in the cyanidation of the more complex types of ores and tailings.

The testing and making up of cyanide solutions are simple operations.

The amount of lime and cyanide present in the solution has the greatest influence on cyanide treatment. It is, therefore, important that the percentage of these compounds should be known.

CHEMICALS AND APPARATUS REQUIRED.

2 burettes and burette stand.
1 dozen beakers.
1 10 c.c. and 1 50 c.c. measure.
3 glass filter funnels.
Filter papers.
Balance and weights.
1 500 and 1 1,000 c.c. graduated flask.
3 oz. pure silver nitrate.
3 oz. oxalic acid.
2 oz. potassium iodide.
1 oz. phenolphthalein.
4 oz. pure alcohol.
4 gallons distilled water.
4 glass rods.
6 reagent bottles.

Note.—Wash all bottles inside and out with distilled water before using and use distilled water for preparing all reagents.

SILVER NITRATE.

Weigh 13.08 grams and transfer every particle to the 1,000 c.c. flask which has been previously washed out with distilled water. Half fill the flask and shake until all the silver nitrate crystals are dissolved. Fill the flask to the mark with distilled water. Pour into a bottle which has been washed out with distilled water. A dark or an ordinary bottle on which black paper has been pasted should be used as a container for the silver nitrate solution.

PHENOLPHTHALEIN SOLUTION.

Dissolve one gram in a little alcohol, make up to 100 c.c. with distilled water and transfer to a small bottle. Oxalic acid 2.25 grams are weighed out and dissolved in distilled water. Make up to 1,000 c.c. and transfer to a clean bottle.

POTASSIUM IODIDE.

Weigh 5 grams and dissolve in 50 c.c. of distilled water.

The strengths of the foregoing solutions have been made up as conveniently as possible. If 10 c.c. of the cyanide solution from the plant have been taken for the test, then each c.c. of the silver nitrate solution used, is equivalent to 0.1 per cent. of cyanide or 2¼ lb. of cyanide per ton of solution. Likewise, each cubic centimetre of oxalic acid solution is equivalent to 0.01 per cent. or ¼ lb. of lime per ton.

To test the solution seeping through the charge, a sample is taken at the outlet pipe and filtered. Take 10 c.c. of the filtered solution and place in a clean beaker. Add three drops of potassium iodide solution and then run in the silver nitrate solution, until a faint but permanent yellowish cloudiness suddenly appears. While the silver nitrate is being run in, the beaker should be slightly agitated. The number of c.c. of silver nitrate used from the burette should be read and noted. If the first drop of silver nitrate causes a permanent cloudiness, there is no free cyanide in the solution.

TEST FOR PROTECTIVE ALKALI.

This test is also carried out on the same sample taken for the free cyanide test.

After the volume of silver nitrate used has been read, a few drops more are run in, then two or three drops of the phenolphthalein solution are added. If the solution turns pink it is an indication that there is some free lime present. The oxalic acid should be run in slowly from a burette until the pink colour is just discharged, and the number of c.c. of oxalic acid used should be noted.

It should be observed that some cyanide solutions turn dark brown on adding silver nitrate. If this occurs add a teaspoonful of lead oxide to the solution and stir well, filter and test in the usual way.

EXAMPLE.

Calculate as follows:—

Silver nitrate required for cyanide test, say 1.6 cc.

Oxalic acid required for alkali test, say 1.4 cc.

The free cyanide in the solution is equivalent to $1.6 \times 0.1 = 0.16$ per cent. of free cyanide or 3.5 lb. cyanide per ton of solution.

Free lime in the solution is equivalent to $1.4 \times 0.01 = 0.014$ per cent. or 0.31 lb. lime per ton of solution.

If the solutions do not contain much cyanide or lime, 100 c.c. should be taken for the test. In this case 1 c.c. of silver nitrate is equivalent to 0.01 per cent. cyanide.

1 c.c. oxalic acid is equivalent to 0.001 per cent. lime.

The following are the most costly essentials in the erection of a cyanide plant:—

Stock solution tank.
Leaching or agitating vats.
Clarification tank.
Extraction box.
Sump for spent solutions.
Pump for returning spent solutions.
Pump for the necessary water supply.
Pump for agitation.
Pump for driving pumps or agitators.
Pipes, valves and the necessary connections.
Timber for plant erection.

The following data will be found useful:—

1 gallon of water weighs—10 lb.
224 gallons of water weigh—1 ton.
1 cubic foot of water weighs—62¼ lb.
1 cubic foot of water contains—6¼ gallons.
1 lb. equals—453.6 grams.
1 gram equals—15.4 grains.
1 litre equals—1¾ pints (approx.).
1 litre equals—1,000 c.c.
1 cubic centimetre of water (1 c.c.) weighs—1 gram.
1 cubic foot of water per minute is equivalent to 374 gallons per hour.
Reagents (cyanide and zinc shavings) would cost about 2s. per ton of sands treated.

The plant could be operated by one experienced man and a boy

Precipitation of Copper from Mine Water.

Copper is still attractively priced and attention has been directed to many old and previously abandoned mines in New South Wales, particularly in the Central Western Division of the State. While most of these old mines are virtually worked out as far as ore reserves are concerned, low-grade stope filling amenable to leaching *in situ* has provided a comparatively cheap, although necessarily limited, source of copper when mined by pumping and precipitation methods.

When copper sulphate in solution is passed over iron, the copper is precipitated and ferrous sulphate is formed. Decomposition of the copper solution is effected by chemical replacement, i.e., metallic iron replaces the copper in solution according to the formula:—

$$\underset{\text{copper sulphate}}{CuSo_4} + \underset{\text{iron}}{Fe} \longrightarrow \underset{\text{copper}}{Cu} + \underset{\text{ferrous sulphate}}{FeSO_4}$$

The finely divided copper thrown out of solution under operating conditions is known as copper cement, or copper precipitate, and is contaminated by iron oxide and other impurities.

Successful mining using this method is dependent upon several factors. Essential requirements are copper-bearing stope filling (mines containing little or no filling or broken ore should not be considered) in which there is sufficient sulphur to convert normally insoluble copper minerals into soluble copper sulphate, available and sufficient mine water or "make-up" water, suitable pumping equipment, precipitating vats, supplies of scrap iron, draining and drying areas, and a return water system. In some mines where the lack of sulphides has prevented the formation of sulphuric acid and the subsequent conversion of copper oxides and carbonates to sulphates, it has proved satisfactory and economical to add sulphuric acid to the return water. Surface pumps are sometimes treated as part of the leaching circuit.

As the solutions pumped contain copper and sulphuric acid, special precautions are necessary when choosing pumps and rising mains. Excellent results have been obtained by using stainless steel pump barrels and fittings, and rubber hose, plastic hose or fibro-cement rising mains and return water lines. Rubber lined pumps have been tried with success, and some mines were initially worked by winch and wooden baling tanks. Iron and mild steel pump barrels cannot be used, and brass pumps are only partially successful. Centrifugal or plunger-type pumps may be used, provided the latter are of the force-pump design with plunger rods independent of the rising main.

When old workings are leached for the first time it is often necessary to build up the copper content of the water by spraying recirculated or acid-enriched water over the old filling to assist the sulphating process, and during normal operations the return water is invariably sprayed or run over the filling.

Precipitation vats are usually concrete, but may be of bricks or close fitting and caulked timber frames, or occasionally wooden launders. The size and number of vats is determined by the quantity and quality of the water. For a system containing 25-40 lb. of copper per 1,000 gallons, pumping 600-800 gallons per hour, 3 vats, 4 ft. x 4 ft. x 12 ft., used in series are sufficient. Vats are fitted with slotted wooden platforms about 18 in. above the floor, and are provided with bottom doors to enable the precipitate to be scraped and washed on to a draining floor during "clean-up" operations. Water is short circuited to isolate the vat being cleaned. The precipitate is drained and dried before being bagged for shipment.

Scrap iron may be cast, wrought, hoop-iron, old pots, cans, rails, etc. Most operators prefer scrap from can manufacturing, which may or may not be de-tinned, and is bought in pressed bales direct from the factory or from scrap dealers. The scrap is placed loosely on the wooden platform of the vat, and during precipitation it is essential to shake off adhering copper, either by stirring at regular intervals or by agitation with compressed air.

The quality of the precipitate varies widely. Some miners obtain precipitates varying from 35 per cent. to 65 per cent. copper content while others consistently produce a relatively rich cement assaying about 70 per cent. copper. The variation depends on the type of scrap iron used, the build-up of ferrous sulphate in the constantly recirculated solution, and the amount of undissolved iron allowed to precipitate with the copper. The acidity of the water determines the amount of scrap iron used. Theoretically about 0.9 lb. of iron is replaced by 1 lb. of copper, and some is attacked by the sulphuric acid in solution. Consumption of scrap iron varies from 1 to $1\frac{1}{2}$ tons per ton of precipitate.

Examples of installations where this method has been or is being used are as follows:—

Mount Hope Mines, Mount Hope.—Leaching extraction methods have been in use more or less continuously for seven years, but operations are sometimes suspended for several months at a time to "spell" the mine. Water level is at 280 feet and plant comprises 10 h.p. diesel engine, pump jack with $\frac{3}{4}$ M.S. rods, 4 in. diam. x 12 in. stroke, stainless steel force pump of special design delivering 900 gallons per hour at 28 strokes per minute, 2 in. diam, reinforced 8, 6 and 4 ply rubber hose, rising main (heavy quality at bottom), four 3 ft. x 3 ft. x 10 ft. concrete vats and concrete draining floor. Water is returned to the open cut and stopes through 1 in. diameter hoses. Head assays are usually 35-45 lb. copper per 1,000 gallons, and return water 4 lb. per 1,000. Sulphuric acid is added to the return water, consumption being about 900 lb. acid per 1,000 lb. copper. Scrap consumption is about 1 ton per ton precipitate. Pumping eight hours per day for five days produces ¾ ton precipitate assaying 70 per cent. copper.

Budgery Mine, Hermidale.—Equipment and plant is somewhat similar to that in use at Mount Hope. Water level is at 270 feet and it is not necessary to add acid. Because of its small size, the mine is alternately leached and "spelled" for six-monthly periods.

Underlay Mine, Tottenham.—Lode dips at 43° and water level is at No. 1 level (about 120 feet vertical). Plant comprises 6 h.p. petrol engine, 110 v. generator and 3 h.p. "Mono" pump delivering 350 g.p.h. through 1½-in. diameter plastic hose. There are three 4 ft. x 4 ft. x 12 ft. vats and the usual draining floor. Head values are 20-35 lb. copper per 1,000 gallons and return water 5 lb. per 1,000 gallons. The mine is alternately mined and "spelled".

C.S.A. Mine, Cobar.—The workings and shaft of the Old C.S.A. were burnt out many years ago, but a few years ago the main shaft was retimbered as part of a mine valuation and exploration programme. Pumping conditions varied with reconditioning and retimbering, but the water level is now stabilised a few feet below the 560-ft. level. Three-stage pumping, using S.S. 2½-in. "Mono" pumps and 2½-in. diameter, 6-ply rubber rising mains is employed. The original installation of a gun-metal Pacific Beresford pump and 2-in. diameter copper rising main failed under the excessive acidity of the water. Two vats, each 3 ft. x 4 ft., were in use. During 1955, 6,316,000 gallons pumped produced 37 tons of precipitate assaying 37.4 per cent., equivalent to a recovery of 4.8 lb. copper per 1,000 gallons.

In addition to the mines detailed, leaching methods have been or are in use at the Caroline, Mt. Royal and Bogan River mines at Tottenham, and Eurow mine at Eugowra. The Girilambone, Cadia, Mountain Run, Queen Bee, Annandale, Burraga, Crowl Creek and Mouramba mines are also of interest.

Leaching vats using the above principles are also in operation at the Port Kembla plant of The Electrolytic Refining & Smelting Co. of Aust. Pty. Ltd.

Additional points to remember are:—

(1) Both heat and agitation are aids to precipitation.

(2) It is advisable to effectively "earth" all metallic pumping gear to avoid any possible action due to electric currents set up in the system either by strong electric leakage or chemical action.

The Flotation Process.

Prospectors and others interested in mining frequently ask for information on the flotation process for the treatment of gold and other ores. It is an efficient method of mineral separation by means of which the valuable minerals in a mass of finely ground ore can be made to float on a liquid. While its use may lead to the reopening of many mines closed down because of difficulties experienced in treating the ore, it is not a process that can be employed by the inexperienced or by prospectors operating in a small way, in view of the large initial outlay involved and the technical knowledge required.

The Divining Rod.

The origin of the divining rod is lost in antiquity. For 400 years, at least, popular ideas concerning the divining rod have remained practically the same.

At almost every step in the advance of science and philosophy, attempts have been made to explain the operation of the divining rod by the latest scientific theories. Geophysical methods of prospecting for various mineral substances have become prominent in recent years, and are confused by some people with divining. But geophyical prospecting is a properly controlled scientific method and has nothing in common with the divining rod. The diviner claims that some kind of special personal gift, such as a sympathetic affinity, a magnetic attraction or electrical current, exists between himself and an external object such as water or an ore deposit.

It is fruitless to discuss whether this view is correct or not; it is sufficient to judge by results. There is abundant historical evidence to show that the claims made for the divining rod have never been substantiated under supervised tests.

Officers of the Department of Mines in New South Wales have frequently been brought into touch with both men and women who claimed to be able to indicate the position of streams of underground water, leads and lodes, with the aid of the divining rod. So far as the Department is aware, however, no discovery of importance has been made by a diviner which could not have been made by simple methods of observation and inference.

For a number of years, also, the Water Conservation and Irrigation Commission of New South Wales has found that the percentage of success obtained by boring for water at sites selected with the use of the divining rod has always been less than in those instances in which bores have been put down without reference to diviners. This evidence is all the more convincing when it is remembered that many of the latter bores are sunk without consideration of topographical or geological features.

The divining rod must therefore be discounted as a reliable aid to prospecting.

Geophysical Prospecting.

Geophysical prospecting is the search for mineral deposits and geological structures by making physical measurements at the earth's surface. It does not rely on magic or any other supernatural procedure but on the interpretation of these measurements through the fundamental laws of physics. Geophysical prospecting methods are by no means infallible and do not supersede but merely supplement and assist the more conventional methods of prospecting. The interpretation of the results of a geophysical survey can be quite difficult as more than one set of subsurface conditions can give rise to practically identical surface effects.

In geophysical prospecting measurements are made either of natural physical fields or of artificial fields set up for the survey. Methods using natural fields include gravity, magnetic, self-potential, and radio-activity measurements while methods using artificial fields include electrical, electro-magnetic and seismic techniques.

In a gravity survey measurements are made of small variations in the earth's gravitational attraction produced by differences in the density of the underlying rocks. These surveys can be used to determine general geological structure or to locate any body much denser or lighter than the surrounding rocks. Dense massive ore bodies, light deposits such as lignite, and alluvial leads can be located by this method.

In the magnetic method local distortions in the earth's magnetic field are measured. These are caused almost entirely by the irregular distribution of magnetite and pyrrhotite in the rocks. Magnetic methods may be used directly to locate iron ores and other ores containing accessory magnetite or pyrrhotite, and indirectly to determine geological structure and to locate deposits associated with magnetic deposits, such as alluvial gold associated with black magnetic sands.

The self-potential method consists of measuring the naturally occurring electrical field which occurs around sulphide ore bodies undergoing active oxidation, near placer deposits of metallic minerals and near graphite deposits. An oxidising sulphide body acts somewhat like a battery and produces an electric potential field.

Radio-active minerals may be located directly by measuring the radioactivity emitted by them.

In the electric and electromagnetic methods electric currents are caused to flow in subsurface electrical conductors either by passing an electric current through the ground or by electromagnetic induction. These currents may be detected at the surface and the conductors located. Electrical surveys are useful for determination of general geological structure, for determining depth to bedrock under alluvium and so locating alluvial leads, for locating ground water and bedded sedimentary deposits. Electromagnetic methods may be used to locate sulphide ore bodies and groundwater.

In the seismic method, the shock waves set up by an explosion are studied to determine general geological structure or depth to bedrock under alluvium. The method can be used to locate alluvial leads.

The Geophysical Division of the Geological Survey will make an inspection and geophysical survey of any deposits or workings which in the opinion of the Department may be of justifiable importance. This service is given in order to further the development of the mineral resources of the State.

Prospecting for Scheelite with Ultra-violet Light.

Scheelite may be seen easily with the aid of short wave-length ultra-violet light, which causes the mineral to fluoresce strongly, and the so-called "black lamp" is a valuable aid in the search for the mineral.

In order to use ultra-violet light in the search for scheelite, it is not necessary to understand the theoretical aspect of the causes and nature of fluorescence, but it is necessary to utilise light of the correct wave-length and to use the correct type of lamp.

NATURE OF ULTRA-VIOLET LIGHT AND FLUORESCENCE.

Ultra-violet light occupies the part of the spectrum lying beyond the violet and having a wave-length of less than about 4,000 Angstrom units. Many substances, when radiated by ultra-violet light, will glow or fluoresce. In some cases, the fluorescence is due to the nature of the substance, but in many cases it is due to the presence of some trace of an impurity called a "phosphor", in the absence of which no fluorescence takes place. In some substances, the longer wave-lengths of ultra-violet light of about 3,000 to 4.000 Angstrom units cause fluorescence, whilst in other cases the shorter wave-lengths of about 2,500 Angstrom units are effective. Scheelite belongs to the type of substance which glows under the action of the shorter wave-lengths, the longer waves giving no fluorescence whatever. The fluorescent colour given by pure scheelite is pale blue, but this colour is modified and becomes distinctly yellow if molybdenum is present as an impurity in the mineral. The fluorescence is not bright enough to be seen in broad daylight, and it is necessary therefore to examine specimens in a darkened room or at night time.

The only practicable source of short wave-length ultra-violet light suitable for prospecting for scheelite is a cold-discharge low-pressure quartz tube powered either by batteries for field use or from electricity mains for use in the laboratory. It is necessary to use a quartz tube, as glass is opaque to short wave-length ultra-violet light. A special violet tinted filter is mounted in front of the tube to filter out the visible light. Ordinary glass is useless for these filters, as it would also stop the short wave-length light. The ordinary mains-powered "black lamp" is useless as it gives long wave-length ultra-violet light only.

Complete units consisting of a suitable lamp and filter, and a power supply comprising 6-volt battery, vibrator and transformer are available for field use. Costs of these instruments range from £22 10s. upwards. Home-made makeshift lamps are completely unsuitable for use in prospecting for scheelite.

USING THE LAMP.

Specimens suspected of containing scheelite should be washed or brushed free of dirt, and examined by placing them about six inches away from the lamp in a darkened room or after dark. Any scheelite present will shine with a bluish or white glow. Failure to see any glow in the light of the lamp means that no scheelite is present, but a glow does not necessarily indicate the presence of scheelite, as many other substances will shine with the aid of the lamp. If any fluorescent patches of minerals are to be seen they should be marked with a pencil or crayon and later tested to make sure that they really are scheelite.

Mine workings can be examined by passing the lamp over previously cleaned faces in shafts, drives and stopes. Tailing dumps can be prospected readily at night time, and it has been found in several cases that scheelite, whose presence was entirely unsuspected, has been discarded in mine tailings.

Rock faces and open cuts above ground may be prospected readily after dark, but if it is necessary to prospect in the daytime, the place must be darkened by draping a small proofed tent over the spot to be tested.

TESTING OF FLUORESCENT MINERALS.

Apart from scheelite, many other substances will fluoresce and it is necessary, therefore, to test a fluorescent mineral before deciding it is scheelite. A list of some of the commoner fluorescent minerals, together with the colour of the fluorescence is given below:

Name.	*Colour of fluorescence.*
Scheelite.	Bluish White (Yellowish if M_0 is present).
Powellite (Ca Molybdate).	Yellow.
Calcite.	White, bluish or pink.
Fluorspar.	Blue.
Zircon.	Yellow.
Wernerite.	Yellow.
Willemite.	Greenish yellow.
Zinc Sulphide.	Deep yellow (some specimens only).
Opal.	White to yellow.
Chalcedony.	Yellow (some specimens only).
Oils and Waxes.	Bluish to white.
Horny matter.	Bluish white.
Autunite.	Bright greenish yellow.

Of all the above substances, scheelite is by far the most valuable, and fortunately, whilst most of the others are energised by the presence of some impurity, the flourescence of scheelite appears to be an inherent property, and it always fluoresces, although the copper-bearing variety known as cupro-scheelite does not. Fortunately, cupro-scheelite is a very rare mineral and the presence of copper in it detracts greatly from its commercial value.

Scheelite may be identified readily by the following simple test:—

Grind a small amount (a piece as big as a grain of wheat is ample) to a powder, place in a test tube and boil with a little hydrochloric acid. A heavy yellow residue should be found after this operation, and if a small piece of metallic tin or zinc is now added and the boiling is continued, the contents of the test tube will turn a deep blue which will later change to a dirty dark green and finally dark brown. This is a positive test for tungsten and is given also by the mineral wolfram.

If test tubes and means of heating them are not available, the test may be carried out in a modified form by placing a drop of hydrochloric acid on the mineral and rubbing with a clean nail or the blade of a knife for about one minute, when a bluish grey stain should appear on the surface as a result of the action of the acid on the mineral and metallic iron together.

If there is any doubt as to the nature of any fluorescent mineral found with the aid of a black lamp, a specimen should be forwarded to the Department of Mines, where it will be examined and identified free of charge.

Identification of Radio-active Minerals.

Few of the minerals containing uranium are sufficiently distinctive for them to be determined by inspection alone, and the only simple test by which they may be suspected easily by prospectors in the field is by the means of a Geiger-Muller counter.

Apart from chemical methods these minerals may be detected by their radio-activity, which may be detected in several ways. All the minerals of uranium (and thorium) give off rays, some of which are of the same nature as X-rays. These rays are quite invisible but may be detected by the methods outlined below.

(a) *Electrical Methods.*—Some of the rays emitted from radio-active substances cause ionisation of gases surrounding them, and as this ionised gas becomes a conductor of electricity, this property may be made use of in the detection of radio-activity.

(i) *Electroscope.*—If a piece of radio-active substance is placed near the leaves of a charged gold-leaf electroscope, the ionisation of the air allows the charge to leak away and the leaves of the electroscope to come together more rapidly than otherwise. The increase in the discharge rate of the electroscope varies with the amount of radio-activity in the specimen and the test may, therefore, be made a quantitative one.

(ii) *Geiger-Muller Counter.*—The use of the electroscope has now been almost entirely replaced by the Geiger-Muller counter, an electronic instrument which gives instantaneous indications of the presence of radio-active substances, and if suitably calibrated, may be used to measure the degree of intensity of the radiation, and hence, the richness of the material being tested.

The basis of the Geiger counter is the Geiger tube which is affected by certain radiations or rays from radio-active substances. The rest of the instrument is simply a device, much like a radio set, to amplify and register the indications received by the counter tube, either as clicks in earphones or a loud-speaker, or by means of a meter. A few pulses or "clicks" will always be given by any particular instrument, for several reasons, in the absence of radio-activity, and this feature is known as the background count; but when the counter comes within the influence of radio-active substances, there is an immediate marked increase in the rate of "clicks".

The detection of radio-activity does not necessarily mean that uranium has been discovered, as thorium and a form of potassium are also radio-active; and further tests are necessary to distinguish between uranium and these other elements.

Portable Geiger counters suitable for prospecting are available for purchase and in some instances for hire. The prices of such instruments range from about £35 to over £100, and are in general in excess of £50 for those which incorporate a meter as well as an audible indicator.

(b) *Fluorescence.*—The mineral autunite and some of the uranium ochres show a yellow-green flourescence under the action of ultra-violet light. Portable types of ultra-violet lamps are available from several firms in Australia, ranging in price upwards of £20. Testing, of course, requires darkness, so that testing on the surface should be done at night or else under a cover of a cloth or other material which will exclude daylight.

All uranium-bearing minerals, if fused with borax, form a glass which fluoresces under the action of ultra-violet light and this property forms a useful test for the presence of uranium. In carrying out the test, a tiny fragment of the mineral is introduced into a borax bead on a loop on the end of a platinum wire and fused in a Bunsen or spirit lamp flame. On cooling the bead should be yellow to pale brown in colour. If the bead is dark in colour, it is an indication that too much mineral has been taken and another bead should be made. On placing the cooled bead near an ultra-violet lamp, a greenish yellow fluorescence indicates the presence of uranium. This is a useful and distinctive test which only requires a few minutes to carry out if the necessary apparatus is at hand.

(c) *Photography.*—Certain of the rays given off by the radio-active minerals will affect a photographic plate, and in making the test, a portion of the mineral is placed on a photographic plate which has first been wrapped in black paper to exclude light. The rays can penetrate paper with ease, and if the plate on development shows a darkening underneath the spot where the mineral rested, it is definite proof that the mineral is radio-active. The length of time required to produce a well-marked image varies from about one day to four weeks, depending on the richness of the specimen being tested. If a small metal object, such as a key, be placed between the specimen and the plate, a distinct image of the object should be seen on the plate after development and this greatly increases the certainty of the test by distinguishing the effects of the radio-active mineral from any accidental light-fogging due to careless handling of the plate prior to development.

(d) *Scintilloscopes and Scintillation Counters (Scintillometers).*—When rays from radio-active substances strike a screen coated with activated zinc sulphide, each produces a tiny flash of light, or scintillation. The scintilloscope is a small instrument whereby this phenomenon can be seen with a low power magnifying tube. Based on this principle, scintillation-type detectors have been developed commercially, known as scintillation counters or scintillometers, which can be used for prospecting or radiometric surveys on the ground or from an aeroplane. New areas of radio-activity have been discovered by airborne scintillometers (for example, at Croker's Well in South Australia).

In the scintillometer, the circuit is such as to convert the light flashes to pulses of electricity, which can then be amplified and detected, by ear or by meter, as in the Geiger counter.

The high cost of scintillometers (several hundreds of pounds), is a deterrent against their use by the average prospector; moreover, unless used by an experienced operator, their results are liable to errors in interpretation because of their sensitivity. For average field use, a Geiger counter suffices as a detector of radio-activity.

Radio-metric Assaying of Uranium Ores.

Owing to the tedious nature of most chemical methods of assaying ores of uranium and the consequent high cost of such assays, other methods have been devised for the evaluation of these ores. Methods based on the degree of radio-activity of an ore are found to be rapid, cheap and in most cases, sufficiently accurate for most prospecting operations.

From the fact that a piece of low grade uranium ore will cause a weak reaction on a Geiger counter whilst the response to a piece of high grade ore is much stronger, it might be thought that it would be a simple matter to relate the uranium content to the Geiger counter reading. There are several reasons, however, why this cannot be done, the three most important being:—

1. Uneven distribution of the radio-active minerals.
2. Possibility of lack of equilibrium in the minerals present.
3. The possible presence of thorium.

1. *Uneven Distribution.*—The response of a Geiger counter is proportional to the total radiation falling on the Geiger tube, and it is obvious that in the case of a lump of ore containing only a single piece of radio-active mineral, the response will be greatest if the radio-active mineral lies at or near the surface of the lump, rather than buried deeply in it or lying on the reverse side, for under these conditions much of the radiation would be absorbed by the stone itself. In order to guard against this source of error, the ore must be finely ground and thoroughly mixed before testing. To avoid errors due to different sized specimens of ores, the same quantity of ground material should be used for each test and should be placed in a standard sized container at a standard distance from the Geiger tube.

2. *Lack of Equilibrium.*—The total radio-activity of a piece of uranium ore is the sum total of the activity of all the decay products as well as that of the uranium present. As is well known, uranium undergoes a slow breaking down yielding a whole series of products of which the best-known one is radium, before ending up as lead. Each of the decay products is radio-active, and most of them are much more active than uranium itself, radium being something like 1,000,000 times more radio-active. In a sample of a primary uranium ore the greater part of the radio-activity is due to the presence of the radium and other decay products, but during the process of weathering these become separated from the uranium owing to their different solubilities, and the secondary uranium minerals deposited are deficient in radium, and the radium may be left behind in the rock with no uranium.

After a lapse of a long period of time, stated to be approximately 1,000,000 years, the uranium in the secondary minerals breaks down into its decay products and attains equilibrium with them again.

If the uranium is in complete equilibrium with its decay products, a measure of the radio-activity gives a definite measure of the amount of uranium in the ore, but if it is out of equilibrium the radio-activity, is not directly, proportional to the uranium content. It is a relatively simple matter to determine whether the uranium is in equilibrium or not and thus whether the radio-metric assay of the ore in question is reliable.

3. *Presence of Thorium.*—Thorium is strongly radio-active and an ore found to be radio-active may owe its radio-activity to the presence of thorium-bearing minerals and not uranium. If specific minerals can be seen, it may be possible to identify them either by their physical or chemical properties and thus ascertain the source of radio-activity. If uranium alone or thorium alone is present, the distinction between the two may be made with certainty by radio-metric means, but when both are present their detection presents difficulties and the accuracy of any radio-metric assay is greatly reduced.

Principles of Radio-metric Assaying.—Uranium and thorium together with their decay products omit three types of radiation, known as alpha, beta and gamma. The alpha rays consist of particles which have been identified as positively charged helium nuclei. Although they have high energy they travel only a short distance in air before colliding with molecules of oxygen or nitrogen and they are not detected by ordinary Geiger counters owing to their very short range.

Beta rays consist of electron streams, and they also have a short range being detectable in air at distances of up to about 2 inches and being absorbed almost entirely by a sheet of aluminium about $\frac{1}{8}$ inch thick or by $\frac{1}{32}$ inch thick copper. They may be detected by specially made Geiger tubes having thin glass walls or thin end windows of mica or aluminium foil. Such tubes also detect the gamma rays which are of an electro-magnetic character similar to X-rays. The gamma rays have a considerable range in air, being detectable at distances of up to about 25-30 feet from strong sources, but are almost entirely absorbed by about 1 foot thickness of rock or soil.

A measure of either the alpha, beta or gamma radiation gives an indication of the total quantity of uranium or thorium in any given specimen, and if the same quantity of ore be used in each test, the percentage in an ore can be calculated rapidly. No simple measurement of alpha radiation can be made by ordinary Geiger counters, but both beta and gamma counts may be made easily.

If both the beta and the gamma radiations are measured, it will be found that the beta/gamma ratio varies greatly according to whether the ore contains uranium or thorium, and also according to whether the uranium is in equilibrium with its decay products. These ratios cannot be stated exactly as they also depend on the design of the apparatus used for measurement of the radio-activity and must be determined experimentally, but they are sufficiently different from each other to be quite distinctive in each case. (As an example of the ratios to be expected, in the case of one particular instrument, the beta/gamma ratio for thorium proved to be 0.5, for uranium in full equilibrium about 4.) An unduly high proportion of gamma activity indicates the presence of thorium and/or radium, whilst a low gamma count indicates a lack of equilibrium.

Apparatus and Methods Used.—A simple field type Geiger counter such as is used for prospecting operations may be used for roughly determining the amount of uranium in an ore. Such a counter is sensitive to gamma radiation only, and no discrimination between uranium and thorium is possible with it, neither can the error due to lack of equilibrium in an ore be avoided. In using this type of counter, the ore is first ground to about 60 mesh and placed in a glass bottle or suitable cardboard box holding about 2-4 ounces of ore. The container should be completely filled for each test and the weight of ore should be known. The container is then placed at a standard distance from the tube of the Geiger counter and the counting rate noted. The reading obtained is compared with that obtained from a number of ores of known assay value, the comparison being made by means of a graph prepared from the count rates of the known ores. The count rate depends not only on the richness of the ore and the size of the sample, but on the general design and layout of the apparatus used, and the graph prepared for one instrument and set-up is not applicable to another. The results obtained by this method are useful as a guide to prospecting work but are only a very rough

Geiger counter using either a thin walled beta/gamma tube or the end window type is far more sensitive than one employing a gamma tube and is to be preferred for assay work. Properly designed and well constructed specimen holders are needed and metal absorbers for the beta radiation are used to discriminate between beta and gamma radiation. The assay procedure with such an instrument consists in filling the sample container with ground ore and recording the beta and gamma radiation. The absorber, which consists of a copper or brass tube in the case of the thin walled Geiger tube or a disc for the end window type, is then placed between the specimen holder and the Geiger tube and the radiation is again measured. The difference between the two readings gives the measure of the beta radiation, and the total reading less the beta reading is a measure of the gamma radiation. The background reading of the instrument is to be deducted in all cases. The beta and gamma readings enable the ratio beta/gamma to be calculated and these must be determined experimentally on known samples of uranium and thorium ores before discrimination of an unknown ore can be undertaken. To determine the percentage value of an ore, comparison must be made with a series of ores of known assay value and known equilibrium conditions. In plotting the radio-activity to form a graph for comparison, either the total beta and gamma may be plotted or twice the beta minus the gamma may be recorded. In any case, the determination should be based chiefly on the beta reading as such a large amount of the total gamma radiation is given by the radium content of the ore and an ore out of equilibrium is deficient in radium. By basing the calculation on the beta radiation, errors due to lack of equilibrium are minimised.

The above apparatus and method is simple and the time taken to complete an assay is only about 30 minutes, including the time taken to crush the sample. The results obtained may be expected to lie within about 25 per cent of the uranium oxide content of a sample as determined chemically. The method is applicable to ores containing down to as low as 0.05 per cent. of uranium oxide. With ores of lower grade than this figure, the variations of background counts are a source of serious error as their count rate is not sufficiently above the background to swamp the fluctuations which occur from moment to moment. This error could be overcome by shielding the apparatus with lead to reduce the background count, but this is hardly warranted in most cases as ores of less than the figure quoted are of no economic interest.

General Information.

It should be noted that the discoverer of any deposit in New South Wales is required to peg out and register a holding in accordance with the Mining Act, of New South Wales, as for other minerals.

Testing of Samples.—Owing to the difficulty of recognising the uranium minerals by inspection, coupled with the fact that there are few simple field tests for them, prospectors should forward any material suspected of containing them to the Department of Mines for examination and testing. Such tests are carried out free of charge, and samples should be addressed as follows:—

"The Under Secretary,
Department of Mines,
Sydney."

A letter of advice concerning the samples should be posted separately, and should give the approximate locality from which the samples were procured, the nature of the deposit, and should mention the fact that tests for radio-active minerals are desired. The sender's name and address should be placed on the outside of all packages to assist in identification.

CHAPTER VII

SAFETY AND HEALTH CONSIDERATIONS IN PROSPECTING

The prospector in the field, as well as the experienced miner underground should always bear in mind that, just as in other occupations, certain hazards exist, which might well cause accident or be detrimental to the health and safety of all persons in the vicinity.

The Mines Inspection Act makes provision for the control of health and safety in Mines and Quarries, and is administered throughout the State by the various Inspectors of Mines, who are stationed at Broken Hill, Armidale, Sydney, Newcastle, Orange, Wagga Wagga, Wollongong, and Lismore. Before going out in the field the inexperienced man might well contact the Inspector in his district for any help or advice he feels he might need. It is not necessary here to outline the main points of the Act, as copies and abstracts are readily obtainable at Mines Department Offices, but the following hints should be borne in mind by all persons engaged in mining or prospecting work.

Surface Prospecting.

Work of this nature is usually confined to shallow trenches or other diggings on the surface. Should explosives be necessary care should be taken to see that excessive amounts are not used, as flying rock is a very real source of danger. With some experience the prospector will soon be able to determine the exact amount to use in order to prevent flying rock, but at the same time break the ground sufficiently in order to obtain a good sample or remove the amount of ground necessary. Care should also be taken not to work under overhanging banks or loose ground and, where jointing or faulting in the rocks is evident, the possibility of a slide or a fall off a "greasy head" is always present. This is probably the most common type of FATAL accident to occur in lone prospecting work.

In alluvial ground, "runs" of loose gravel or sand are a source of danger and large boulders perched on a bank or in sand may come away without any warning. Consequently, always watch your "ground" for any signs of material coming away and keep well back from any banks that appear to be at all dangerous.

Underground.

If you are working in a tunnel or shaft underground, extra care needs to be taken and the following points should be considered:—

(1) **Falls of ground** due to old or rotten timber.

In this case do not touch or try to remove any old timber or interfere in any way with old filling behind the timber. Once a movement is started heavy falls of ground could result. Also, examine the "back" or roof before advancing into old workings, as a fall behind you could easily block the way out or injure you in a more direct manner. A small lump of rock falling from any height can easily cause serious injuries, so it is always recommended to wear a "hard hitter" or mine helmet. Many lives have been saved through wearing this protective headgear. (See later herein re protective clothing and equipment.)

(2) **Presence of Gases.**

Many old workings contain dangerous amounts of gases which can cause serious accident or death. Therefore, when entering old workings great care should be taken to observe if there is a current of air passing through the workings. A simple test is to observe movement of smoke from a cigarette or the flame of your mine lamp. If no movement of air is observed look out for signs of increased temperature, unpleasant smells, etc. If the flame of your lamp burns low and you have a tendency to feel a headache or other weakness, such as difficulty in breathing or aching limbs **do not continue** as this may point to the presence of carbon dioxide and the consequent lack of oxygen in the air might well cause suffocation and death. Another gas, but fairly rare in metal mines is carbon monoxide. Nevertheless, this gas can accumulate in the roof after explosives have been used, and should be considered.

Small animals, such as canaries or mice quickly react to this gas and are sometimes used to detect its presence, when more scientific instruments are not available.

Yet another dangerous gas which could be found in old sumps or winzes is hydrogen sulphide. This gas has the smell of rotten eggs and is very dangerous, being fatal in very small quantities. It should be looked for when pumping out old workings.

There are other gases and mixtures of gases more common to coal mines the most common of which, methane, is highly explosive when mixed with the correct quantities of air. A detailed knowledge of these gases and mixtures of gases is not within the scope of the prospector, and in any case it is advisable before embarking on the examination of extensive underground workings to seek the advice of an experienced mining man, or an Inspector of Mines. In any case do not take risks in badly ventilated workings.

(3) **Never enter a mine alone.**

This is a highly dangerous practice as a slight accident only may prevent you from getting out and in most cases you might not be discovered very easily. In any case, two or more persons each with a lamp, constitute a safety measure in case of emergency.

(4) **Breathing dust or fumes.**

Never breathe dust given off from drilling operations or fumes present as a result of the use of explosives. Both are injurious to health. Spray water around the collar of the hole when drilling if the drill is not provided with a "wet drilling" device. In mines containing lead ores extreme care should be taken not to absorb particles into the system. This especially applies to work being done in carbonate ore or ore likely to be nearer the surface. Always observe extreme cleanliness in regard to food and drink taken underground, and wash your hands before handling anything to be consumed.

(5) **Respect for explosives.**

Exercise extreme care in the use of explosives and do not mishandle them in any way. Respect for explosives is a safety motto which should always be observed. Incidentally, restrict the use of explosives to mining and do not use for fishing or other so-called sports.

(6) **Protective Clothing and Equipment.**

It is a well known fact that mining or prospecting is a hazardous occupation and the wise miner takes every precaution to prevent accidents. In this regard the use of protective clothing and equipment is an essential factor in good safety practice. The following items are listed as a guide and are recommended for the use of all following the mining or prospecting profession.

(a) *Safety Hats or Helmets.*

These are manufactured in various styles and of differing composition but in the main all follow the one principle. They are essential for protecting the head from falls of rocks and striking the head against roofs, walls and timbering. Many a life has been saved through their use and they are strongly recommended for underground and open cut mining.

(b) *Safety Goggles.*

These are also manufactured in various styles but again follow the main principle in protection for the eyes. They are especially recommended for spalling or knapping of rocks. Also where any grinding work is to be done in a workshop or factory. A man has two eyes—if one or both is lost, they cannot be replaced—so protect them.

(c) *Clothing.*

Tight fitting clothing is recommended where working among moving machinery. Loose fitting or flapping clothing can be easily caught up by belting, wheels or moving parts. Many an operator has lost his life through having his clothing caught in moving machinery, so the wise operator wears tight fitting clothing which cannot be caught in this manner.

(d) *Gloves.*

These are manufactured in various styles, but again the principle of protection of the hands and fingers is the same. A great proportion of accidents in the mining industry occur to hands and fingers. The use of protective gloves eliminates this hazard to a great extent and their use in all phases of the industry is highly recommended.

(e) *Boots.*

Safety boots are made with a protective cap inside the leather toe cap for the protection of feet and toes. Safety boots protect the feet and toes from falling objects, and are strongly recommended for all underground and open cut operations. In some States the use of safety boots underground is compulsory.

(f) *Safety Belts.*

In all operations where there is a danger from falling or slipping it is essential that an operator wears a safety belt. This is a leather or canvas belt to which is attached a thick hemp or wire rope which can be tied to a suitable anchor. When working near openings, such as winzes, shafts, open stopes, edges of quarries, etc., the use of such a device is essential to safe practice.

(g) *Shin Pads.*

In some operations underground the use of shin-pads on the legs is recommended for protecting the legs from falling stones, etc. These are especially recommended for work on grizzlies or shovelling on slopes or rills.

(h) *Respirators.*

When working in dusty or poorly ventilated conditions underground, the use of respirators is highly recommended.

This is a device which is strapped around the head, covering the mouth and nose and using a filtering medium to prevent the inhalation of dangerous dust or fumes.

As a matter of general health do not contaminate water or workings with any human excretion, and always check up on drinking water supply to see that it is pure and fresh. If in doubt, all drinking water should be boiled before use.

Too much stress cannot be placed on safety and health, so if you are in doubt as to the course to follow, seek the advice of someone who can tell you.

Such advice is always gladly given by field officers of the Department of Mines to would-be prospectors and small operators.

Résumé of Safety Practices — Oil Drilling.

1. Safety clothing to be worn where necessary, hard hats in particular.

2. Safety slide to be provided for derrick men.

3. Derrick men to be equipped with safety belt and life line.

4. Exposed moving parts of machinery to be provided with safety guards.

5. Usual precautions to be taken when explosives are being used.

6. Blow out preventors to have at least two controls, preferably all three of the following if drilling in high pressure formations.
   (*a*) At the accumulators (remote control).
   (*b*) On derrick floor.
   (*c*) Manual — at the well head.

7. Statutory requirements of N.S.W. Petroleum Act and Regulations are to be complied with.

8. Electrical wiring and installations on and within 100 feet radius of a drilling or testing well shall be installed, maintained and tested and certified as being in accordance with the S.A.A. Wiring Rules for electrical installations in inflammable and explosive surroundings (Class 1, Division 1, Location).

9. All electrical installations are to be effectively earthed (earth connections to oil or gas lines must not be used).

10. Steel derricks, masts, etc., are to be earthed with a maximum resistance to earth not exceeding 10 ohms. (for dissipation of static electricity).

11. Engines (internal combustion) to be provided with flame-spark arrestors.

12. When a well is testing or approaching possible petroliferous horizons no naked lights, smoking or motor vehicles (unless provided

with flame and/or spark arrestors) to be allowed within 100 feet of well head.

13. Gas flare lines must be to leeward and at least 100 feet in length from process units, tanks or any other important items of plant equipment.

14. Appropriate fire fighting equipment to be on site.

Extraneous Hazards Associated with the Detonation of Explosives by Electrical Means and Precautionary Measures to be Taken in Mines and Quarries in Order to Eliminate Premature Explosions

By extraneous hazards is meant those sources of electricity which are beyond the immediate control of the mine or quarry operator and which could cause an electric detonator to explode unexpectedly.

These may be summarised as follows:—

(*a*) Lightning discharges.
(*b*) Static accumulations.
(*c*) Radio and television high frequency transmission.
(*d*) Stray currents in the earth.
(*e*) Galvanic action in drill holes.
(*f*) Induction from transmission lines.

LIGHTNING

Of such magnitude are the electrical forces generated by nature that no precaution will avail against those forces when liberated in the form of lightning. There is only one safe way to act if the weather appears at all threatening, and that is to cease all shotfiring operations until the weather is clear again.

It has been definitely established that accumulations of static electricity occur when heavy clouds gather overhead. The discharge of these accumulations from cloud to earth, and vice versa, cause current of high values of electricity to flow in the ground over a wide area, and any adjacent conductors, such as a shotfiring circuit, will have current induced in them during the time of such discharges.

The formation of these ground currents does not necessarily depend on actual lightning strokes, but may occur in the ground itself as the result of one portion of the ground being more highly charged than another, and the consequent discharge between the two portions creates the electric current.

Some idea of the magnitude of the currents produced in the ground by lightning may be gained from an extract of an article (Reference No. 1) written in the U.S.A. which states:—

> " . . . Direct stroke currents measured in tall structures and transmission line towers average about 15,000 amperes, with a maximum of 160,000 amps.
>
> Lightning arrestor discharge currents have averaged about 1,500 amps at measuring locations, with a maximum of 35,000 amps, measured so far."

Thus, since it takes only approximately one-third of an ampere to cause a detonator to explode, it is fairly clear that any detonator in the path of a lightning discharge current will definitely explode.

STATIC ACCUMULATIONS.

In addition to the static charges created by storms, it is possible for static charges to accumulate from many other causes, for example, the friction against the air of large moving bodies, such as flywheels of crushing machines ; the rapid passing of a conveyor belt over a pulley ; the production of paper in paper machines, etc.

The phenomenon of sparks discharging from a moving vehicle via a dangling chain to the ground is quite familiar to all, and this again is simply the discharge of a static charge which has accumulated as the result of a combination of the friction between the rapidly moving parts of the vehicle and between the vehicle body and the air.

However, the static electrical energy developed by causes other than lightning is exceeding small, and no authoritative evidence can be given to suggest that sufficient current to explode an electric detonator can be produced by such causes (Reference No. 2), yet the evidence of the existence of static charges, however small, cannot be ignored entirely.

From experiments conducted in South Africa (Reference No. 3), it was found that when an electro-static charge is applied to one or to both the wires leading on to the detonator, or if an electro-static charge is applied to the metal shell of the detonator, a "spark over" takes place between the ignition element and the metal shell. This "spark over" sets off the detonator.

It is not a question of current passing through the ignition element as happens when the controlled power is applied to the detonator wires, but an electro-static charge from one mass to another as condenser action. The insulated conductors and the ignition element act as one plate and the cylindrical shell the other.

Thus, it is a simple matter to offer an explanation of what may occur during a storm.

During an electric storm, successive lightning charges from cloud to earth gradually raise the rock potential. The potential of the detonator and the insulated wires synchronise with the rock potential. A very sudden release occurs when a lightning discharge takes place, say, from a building to a nearby cloud, and the rock potential falls. The shell of the detonator, because of leakage, would keep to the rock potential, but the insulated conductors and the ignition element would momentarily be in a charged state.

A local discharge then takes place between the ignition element and the detonator shell.

By connecting one of the two detonator wires to the metal shell of the detonator, the metal shell and the wires become electrically bonded, and no gap exists for an electro-static charge to pass over in the form of a spark. The detonator thus becomes protected against electro-static charges.

"Protected" detonators were tested at the Rand Mines Laboratory with electro-static charges of about 500,000 volts. Not one exploded. When the protective connection was removed and the detonators retested, all exploded.

In another test at the mine an aerial was erected to which were attached 100 detonators, of which 50 were "Protected", and the remainder unprotected. During a severe lightning storm one flash of lightning, estimated to occur 1½ miles away, exploded 47 of the unprotected detonators, but none of the protected ones. The protection was then removed from the detonators and 48 out of 50 exploded by electro-static charge.

As far as eliminating the danger of electro-static charges, the above evidence seems fairly conclusive, yet there are limitations to the use of "protected" detonators of the simple type mentioned above.

Firstly, unless the detonator shell is insulated from the earth, no more than one shot can be fired at a time in damp conditions or where low water resistant explosives, such as A.N. are used, because the circuit would be "earthed" at each detonator.

By coupling the "earthed" wire at each detonator to the "un-earthed" wire of its neighbour, a series connection becomes a parallel connection if the detonator cases are not insulated from earth; and if the "earthed" wire of one detonator be connected to the "earthed" wire at the next detonator in a series circuit, then the second and subsequent detonators are short circuited and will not go off.

Therefore it is essential for multiple shotfiring for the outer shell of the detonator to be covered with some dielectric. With this arrangement the use of "Protected" detonators is to be recommended for shaft sinking and quarrying work.

RADIO AND TELEVISION TRANSMISSION.

Considerable experiment has been carried out to determine the possibility of exploding detonators by means of currents induced in shotfiring circuits by radio and television transmitting sources. The following extract from *National Safety News,* April, 1952, a United States publication (Reference No. 4), covers the practical aspects of the above hazard very effectively:—

"If you do blasting, keep radio away from blasting caps. Radio frequency energy from such sources as radio broadcasting stations, 2-way radios, television transmitters, FM stations, radar, shoran, micro wave relays and high powered amateur transmitters, can under certain conditions set off blasting caps without having any physical connection with the blasting circuit.

A case of premature detonation occurred on a seismic shooting boat equipped with a 50-watt transmitter operating on 1,602 kilocycles. Transmitting antenna was strung horizontally between two masts 25 feet above deck. Firing circuit was of such length that it was tuned nearly to resonance with the transmitter frequency. Steps taken to prevent a recurrence were the use of a vertical antenna, grounding of the transmitter, and prohibition of transmission while connected caps are on deck. This case, although the only one of its kind on record, prompted intensive study by manufacturers of blasting caps and radio equipment.

Tests with 15- to 50-watt 2-way mobile transmitters showed sufficient induced current within several feet of the antenna to constitute a hazard. In the vicinity of a 5,000-watt broadcasting station operating at 610 kilocycles, it was found that under certain conditions all common types of electric blasting caps could be detonated through absorption of radio energy in the blasting circuit. These conditions occurred when the leading wires were within 300 feet of the antenna towers, properly oriented, and sufficiently long.

In general the amount of radio frequency current induced in a circuit will vary directly with the power of the transmitter and inversely as the square of the distance from the source. Other factors which determine the amount of induced current in a blasting cap circuit are:—

Length of the Circuit—The critical lengths are (1) straight lengths equal to half the radio wave length of the transmitter (the half wave length in feet equals 500,000 divided by the frequency in kilocycles) or multiples thereof, having the cap in the centre, and (2) straight lengths equal to quarter the radio wave length, or an odd (3, 5, etc.) multiple thereof, with one end grounded and the cap near that end. These lengths are critical and any significant variation will make it unlikely that dangerous amounts of current can be induced in the circuit.

Orientation of Circuit—Maximum energy will be produced when the wires are parallel to the antenna of the transmitter. Current will be less in wires lying on the ground than in those suspended above ground.

Transmitter Frequency—Low frequency stations are a greater potential hazard than those using high frequencies because conditions for transfer of energy are more critical with higher frequencies.

Detonation will occur when the induced current approximates the amount required in a regular blasting circuit, 0.30—0.40 ampere, either AC or DC. A simple and positive test to determine whether the radio frequency hazard is present is to place a No. 47 radio pilot light in the blasting circuit in place of the blasting cap. If it glows at all use "Primacord" and regular cap and fuse.

Radio broadcasting stations with their relatively high outputs of energy and their locations in areas where blasting may occur constitute a major hazard. However, the increasing use of 2-way radio transmitters by mobile crews that do blasting is considered a greater potential hazard.

The Forest Service of the United States Department of Agriculture has issued the following instructions to their radio users and blasting crews:

(1) If electric caps are within 300 feet of any 2-way radio transmitter keep tightly enclosed in an all-metal can. Never open can when transmitter is in use.

(2) Never carry caps in a pickup or car equipped with 2-way radio, unless they are in an all-metal can. This can shall consist of a 24-gauge iron box.

(3) Do not use a radio transmitter within 300 feet of any electric blasting.

The State Industrial Commission of Oregon and several forests Departments have issued similar instructions.

Recent co-operative studies by Du Pont and several radio manufacturers have determined the following minimum distances for use of electric blasting caps near transmitting equipment:

Transmitter Power (watts)	Minimum Safe Distance (feet)
5— 25	100
25— 50	150
50— 100	220
100— 250	350
250— 500	450
500— 1,000	650
1,000— 2,500	1,000
2,500— 5,000	1,500
5,000— 10,000	2,200
10,000— 25,000	3,500
25,000— 50,000	5,000
50,000—100,000	7,000

This table is based solely on transmitter power. The distances provide a substantial factor of safety even for the worst possible conditions.

When electric caps are transported in vehicles equipped with mobile radio transmitters, they are considered safe from detonation by radio frequency energy if they are left in their 'as purchased' condition. Tests and theoretical considerations show that the methods of packaging the caps involve wire lengths and configurations that provide virtually ideal protection against induced current. The effective lengths of the folded or coiled wires are a matter of inches, whereas the radio half-wave lengths necessary for 'tuning' the caps to the radio circuits range from 2.3 feet (216 megacycles) to 924 feet (540 kilocycles).

When transporting caps in the field, if the original package as received from the manufacturer is altered, or if additional protection is desired, the following precautions should be taken:—

(1) Place the caps in a totally enclosed metal box lined with wood or sponge rubber. The metal provides a shield against radio frequency energy. The lining protects against shock and friction.

(2) If within the minimum safe distances given in the table, have the transmitting equipment turned off when caps are being put into or taken out of the box.

Du Pont, in their Blaster's Handbook, offers the following recommendations in connection with the use of electric blasting caps near radio transmitters:—

(1) If within the recommended safe distances, the blasting circuits should be laid out with a No. 47 radio pilot lamp inserted in place of the cap. This type of lamp lights to full brilliancy with 0.15 ampere, but electric blasting is not advised if any glow at all is observed. Rather 'Primacord' and regular cap and fuse should be used.

(2) Radio-frequency pickup in the blasting circuit can be minimized by avoiding one-half wave lengths or their multiples (the half wave length in feet equals 500,000 divided by frequency in kilocycles), laying wires on the ground but insulating them from it, and avoiding placement of caps in the centres of long, straight lengths of wire.

(3) Aboard ship, radio transmission should be prohibited, or prevented by suitable interlocking devices, while electric blasting caps are connected and in a hazardous location. Cap wires of 100 feet in length or longer should be used. The charge should be put overboard and allowed to drift away the full length of the wires before removing the manufacturer's shunt and connecting to the firing lines.

Although no experimental work has been done on them, it is obvious that shoran, radar, etc., present much the same hazards as radio. It is recommended that the precautions listed above also be followed in such cases."

STRAY CURRENTS IN THE EARTH.

The possibility of sufficient current being induced in a shotfiring circuit which is lying on the ground, or in a shothole, from stray currents in the ground which occur when the earth is used as the return path of an electric circuit, such as electric haulage system, or the return path of a single-phase high-voltage rural electrification system or from other stray currents, is exceedings remote if the circuit is well insulated. However, it is possible for hazardous voltages, i.e., greater than 0.2 volts, to be found between rails, pipes, bonds on rails, ventilating ducts and other conducting media and ground. Should the bare ends of the shotfiring circuit wires come in contact with these points, then the connected detonators could explode.

Insulation of all leading wires from the ground and separation of all detonator circuits from possible current conductors, and thorough insulation of all joints in the shotfiring circuits, are measures which can be taken to reduce the stray current hazard (Reference No. 5).

GALVANIC ACTION IN DRILL HOLES.

Where acidic or alkaline water may be encountered in drill holes, there is always the possibility of electrolytic action taking place between the metal of the detonator shell and the lead-in wires, and the subsequent galvanic cell created could cause sufficient current to flow through the detonator to explode it.

Effective insulation of the wires and joints can eliminate this potential hazard, together with the use of insulated detonators.

INDUCTION FROM TRANSMISSION LINES.

Under ordinary working conditions (wherein the inductive effect of an overhead conductor carrying current at commercial frequencies, i.e., 25, 40, 50 or 60 cycles, is mostly neutralised by the proximity of similar conductors carrying approximately the same current, but differing in time and space phase) there is little possibility of a hazard existing anywhere except within a few feet of the transmission line conductors.

Nevertheless, under faulty conditions, e.g., a lightning strike on the line, or a badly out of balance condition of the electrical load, it could happen that extraordinary frequencies of a very high value, comparable with those of radio frequencies, could be present, and coincidentally with a tuned resonant length of shotfiring circuit already coupled with detonators, sufficient current could be induced in the shotfiring circuit to cause the detonators to explode.

Again, the use of high frequency carrier waves for telephonic and control systems through the same conductors of a transmission line, may be employed, thus introducing the same potential hazard as a radio-frequency transmitter. Therefore, we consider that however improbable, the possibility does exist that the aforementioned coincidence *could* occur, so that it is wise to assume that the condition *will* occur, and the same precautions should be observed as for radio-frequency hazards.

In any case, there is always the chance of shotfiring circuit wires being flung over the live transmission line conductors during a blast with the consequent danger to people nearby.

To sum up, electric shotfiring should not be carried out within 300 feet of any transmission line carrying current at a potential above medium voltage.

CHAPTER VIII

OPERATING HINTS ON THE USE OF MECHANICAL EQUIPMENT AND ELECTRICITY IN MINES

Wire Ropes.

Flexible steel wire ropes used for haulage purposes require frequent cleaning and lubricating with a suitable rope compound. More frequent lubrication will be necessary when the rope is used under wet conditions.

The rope should be inspected regularly for evidence of broken wires, corrosion, wear, and perishing of the hemp core. A sample of the rope should be cut off the end at least once in every six months for testing by an approved authority.

Care should be taken to prevent kinking of the rope as this would impair its strength and lead to more rapid local wear when passed over sheaves.

A kinked rope should not be used.

The Mines Inspection Act requires the working load of a new rope, including the weight of the cage, bucket and rope itself, to be not greater than $\frac{1}{8}$ of the breaking strain of the rope when used for raising or lowering men, and $\frac{1}{6}$ of the breaking strain when used for handling materials only. No rope shall be used when the load is greater than $\frac{1}{5}$ of the breaking strain when men ride or 1/4.5 of the breaking strain when handling materials only.

Chains, Shackles, Rope Clips and Hooks.

Chains should be inspected for excessive wear, bent links and also locking of the links caused by overloading. Knotted chains should not be used.

Periodic heat treatment, necessary for wrought iron chain, is unnecessary and may be undesirable for steel chain. There is very little wrought iron chain in use these days but the use of higher tensile steel chain is becoming increasingly popular and heat treatment of such chain could be dangerous.

Shackles should not be used, where they are bent, strained, deformed or damaged. Shackle pins should be wired or otherwise locked to prevent them unscrewing.

Rope clips should be kept tight and the saddles should always be used on the main rope with the crown of each U-bolt pressing upon the less heavily loaded tail of the rope. Not less than three rope clips should be used on any rope anchorage.

Open hooks should not be used in any hoisting operation where men are working below.

Power Plants.

Care must be taken when installing internal combustion engines to see that the exhaust fumes will not be drawn into the mine workings by the ventilation system.

Never use an internal combustion engine in a shaft or underground workings. The gases from the exhaust of such an engine are highly poisonous.

Foundations must be firm and level, and provision made to prevent spillage of fuel or oil. Lubrication must be carried out in strict accordance with the maker's requirements and the correct type of fuel used. In the case of diesel engines, it is important not to allow the fuel tank to run empty, as it would then be necessary to bleed the fuel system right through to the injectors.

The radiator must be kept filled with rain water, and the fan belt kept properly adjusted. In cold weather, the radiator should be drained and left empty overnight, to guard against cracking of the cylinder heads or crank case by freezing of the water in the cooling system.

Pumping Plants.

May be operated by steam, compressed air, electricity or internal combustion engines.

The type of power used must be determined by the extent of pumping operation, and facilities available. Compressed air is convenient for use with a sump pump where a small quantity of water is to be pumped at irregular intervals, but is too costly for large scale pumping operations. Electricity is seldom available for small operators, but is ideal for large-scale operations using multi-stage centrifugal pumps. Steam pumps or diesel-operated deep-well pumps are suitable for unwatering existing shafts to depths of several hundred feet.

Pipe lines must be securely fastened in the shaft, and provisions made for removing sections of the pipe for replacement when necessary.

An efficient strainer should be attached to the end of the suction pipe to prevent abrasive material from entering the pump. Lubrication of pumps must be strictly in accordance with the makers' specifications, especially as regards the type of grease used.

Winches and Hoists.

May be driven by steam, compressed air, electricity or internal combustion engines.

Small operators generally find the air hoist or self-contained diesel engine and hoist most suitable for their requirements. It is essential that the capacity of the hoist should be considerably greater than the work required of it, and that the head sheave should be sufficiently large for the size of the rope.

The installation of the winch or hoist must be approved by the District Inspector of Mines, and the operator must be qualified under the Mines Inspection Act for the type of winch used and the nature of operations.

Compressor Plants.

The advice concerning power plants applies in the case of compressor units driven by internal combustion engines.

The air receiver must be tested annually by an authorised boiler tester, and the safety valve set by him at the safe working pressure.

In the case of any unusual noise, or overheating developing, the engine should be stopped immediately and the fault rectified before the engine is again put under load.

Rock Drills.

Should be lubricated with rock drill oil by means of a line oiler. Because of the effect of oil on the rubber lining of the hose, the oiler should be fitted as close to the machine as convenient, usually 10 feet, so that only a short section of hose will be affected.

When disconnecting the machine, the air spud, exhaust port and chuck should be plugged with cotton waste or rag. The air cleaner is provided for the protection of working parts, and should never be removed except for cleaning. A spare water tube should be kept on hand, as a faulty tube will result in lack of water feed to the drill, or fogging of the exhaust air.

When tightening or replacing side bolts, be careful to tighten them evenly. Uneven adjustment may cause damage to expensive working parts of the machine.

Drill Steel.

Careful attention must be paid to the shank of the steel. A worn shank will result in damage to the chuck of the machine and cupped or damaged end of the steel will cause serious damage to the hammer.

If tungsten carbide drills are used, care must be taken not to over-blunt them, as this will greatly reduce the life of the drill. A gauge should be obtained from the distributors and the drill frequently checked against it.

The Use of Electricity in Mines

This article is not meant to be a complete, or even summarised version of the application of electricity to mining, since the matter is too extensive to be covered fully in this book. However, for the information of the prospector in the field, certain safety precautions should be observed at all times when electricity is used for a prospecting or mining operation. These are:—

(1) No electricity may be used in or about a mine unless the installation conforms to the requirements of—

(*a*) the Wiring Rules of the Standards Association of Australia ; and

(*b*) Rule 56 of the Mines Inspection Act, 1901-1958 ; and

(*c*) the Seventh Schedule of the Coal Mines Regulation Act, 1912-1953, according to whether the prospecting is for coal and shale or for other minerals.

(2) Only competent persons properly qualified as electricians should be employed to install and maintain electrical equipment.

(3) Proper precautions should be taken to prevent damage to overhead electric mains during surface blasting operations.

(4) Should the overhead mains be within 100 ft. of an area in which blasting operations may be carried out, the local Electricity Authority should be contacted and their advice acted upon.

Advice on the use of electricity is always available from Inspectors of both Coal Mining and Metalliferous Mining Branches of the Mines Department to any prospector requiring technical information.

(5) Eternal vigilance is the price of safety with electricity. At the first sign of deterioration of cables or equipment, have the installation inspected and the defects corrected by a competent electrician.

Mines Inspection Act.

In many instances prospectors and small mine operators are unaware of their responsibilities under the Mines Inspection Act. The Act is mainly designed to protect owners, managers and employees and if followed carefully, should reduce accidents in all mining operations.

Copies of the Mines Inspection Act can be obtained from the Department of Mines, Sydney, or from the Government Printer, 390-422 Harris Street, Ultimo, Sydney.

It is recommended that all prospectors and mine operators should possess a copy of the above Act.

The following is a guide to the significant sections of the Act:—

Section 5—Nomination of Manager

Section 12—Engine Drivers' Certificates

Section 26—Restriction on employment

Section 41—Plans, returns, notices and abandonment

Section 42—Plans, returns, notices and abandonment

Section 42A—Plans, returns, notices and abandonment

Section 42B—Plans, returns, notices and abandonment

Section 43—Accident returns

Section 44—Notification of commencement, abandonment etc., of operations

Section 46—Testing of boilers and air receivers

Section 65—Publication of rules and abstract of the Act

Section 55—General Rules.

Under General Rules, the main points are as follows:—

General Rule 3—Change in shift

General Rule 4—Inspection at change of shift

General Rule 5—Manager to inspect

General Rule 6—Withdrawal of workmen

General Rule 7—Persons in charge of machinery

General Rule 17—Code of signals

General Rule 30—Testing of safety cage

General Rule 31—Testing of hoisting ropes

General Rule 52—Keeping of record books

General Rule 55—Dust prevention

General Rule 63—Notice of commencement to construct rises

General Rule 65—Allaying dust during blasting

General Rule 65A—Dust prevention in rock crushing plants and dredge

General Rule 67—Nomination of quarry manager

General Rule 67A—Appointment of shotfirer.

INSPECTION OF MINES.

Under Section 32 of the Act the Governor may appoint a Chief Inspector of Mines, a Senior Inspector of Mines and such other qualified persons as inspectors of mines, including electrical inspectors of mines and inspectors of mechanical engineering, as he may deem necessary.

Under Section 36 an Inspector may do all or any of the following things, namely:—

(*a*) make such inspection, examination, and inquiry as may be necessary to ascertain whether in respect of any mine the provisions of this Act relating to matters above or below ground are complied with ;

(*b*) at all times by day and night enter any mine and inspect the same and examine and inquire respecting the state and condition and ventilation of the mine or any part thereof, and the state and condition of the machinery, and the sufficiency of the special rules (if any) in force therein, and all matters and things connected with or relating to the safety of the persons employed in or about the mine or any mine contiguous thereto, or the care and treatment of the horses or other animals in the mine ;

(*c*) enter upon any private land in the performance of his duties ;

(*d*) exercise such other powers as may be necessary for carrying this Act into effect.

(i) The Minister may authorise any surveyor, engineer, electrician, medical practitioner, or other competent person to accompany an inspector above or below ground for the purpose of assisting him in making investigations or in carrying out his duties or the exercise of his powers under this Act

(ii) Every person who wilfully obstructs any inspector in the execution of his duty under this Act or any person so authorised to accompany him, and every owner or manager of a mine who refuses or neglects to furnish to the inspector or person so authorised to accompany him the means necessary for making any entry, inspection, examination, or inquiry under this Act in relation to such mine, shall be guilty of an offence against this Act.

Under Section 37 an inspector is given wide powers to have any matter or practice, not specifically mentioned in the Act, remedied within a certain time.

Inspectors of Mines are located throughout the State at Broken Hill, Orange, Wagga Wagga, Armidale, Lismore, Newcastle, Wollongong and Head Office, Sydney. They are available to advise on the provisions of the Mines Inspection Act and to advise on prospecting, mining and milling methods.

CHAPTER IX

EXPLOSIVES — STORAGE AND USE

An explosive is designed to break rock by suddenly generating a large amount of gas at high temperature and pressure. When the explosive "explodes" this sudden generation of gas produces a violent shock wave, for example, the shock wave from the small amount of explosive in a detonator will blow off several fingers. Remember that explosives are made to explode. Explosives are safe only if handled properly and carefully. Always store explosives in a proper, locked, magazine. Always keep detonators away from other explosives and under lock. Never hide explosives under ledges or rocks at the end of the day, they may be found by children with resulting accident for which the user would be responsible.

Explosives such as gelignite absorb moisture from the air and become wet; a watery solution will run out of the plugs. In this stage the explosive should not be used at it has become insensitive and may fail to explode or may burn in the hole. If explosive is stored in hot conditions or kept for too long nitroglycerine, an oily liquid, may run out of the plug. Nitroglycerine will first appear as an oily film on the wrapper of the explosive. Nitroglycerine is very dangerous and plugs having an oily film on the outside should never be used. Where possible use the explosives within a couple of months of buying them.

The storage of explosives is controlled by the Explosives Department; details of storage may be obtained from the Department, an Inspector of Mines or the local police. The use of explosives in Mines and Quarries is controlled by the Mines Inspection Act; the Department of Labour and Industry exercise control in building excavations.

When using explosives always remember that even a small charge can scatter rocks for a quarter of a mile. Never stand where the explosion can be seen as a small piece of fly rock can cause fatal injuries. Never overcharge a hole; it is safer to start off with less explosive than is needed and gradually increase the charge in following holes.

If using explosives to split wood it is important to realise that the wood will split along the cracks; many people have been killed by flying pieces of wood a quarter of a mile from the explosion.

Using Safety Fuse and Detonators.

N.B. Explosives (except gunpowder) need a detonator to explode them.

Tools required:—

Fuse cutter, detonator, crimper, wooden skewer, string, wooden tamping stick.

METHOD:

(1) Remove rock and water from the drill hole.

(2) Keep one plug out to make a primer. Place the remainder of the plugs down the drill hole. Do not force plugs down the hole, push gently with the wooden tamping rod.

(3) Cut the fuse at right angles with a special cutter or a sharp knife. The fuse must be long enough to come out of the hole ; never use a length of fuse shorter than 6 feet.

(4) Examine the inside of the detonator to see if there is any sawdust or foreign matter in the detonator. If there is, remove by turning the detonator upside down and gently tapping with the finger. If the foreign matter cannot be removed, do not use the detonator. (Many accidents have been caused by people picking at a detonator.)

(5) Gently slide the detonator on the cut end of fuse—do not twist—then hold the detonator lightly pressed on the fuse and crimp the open end of the detonator on to the fuse. Special crimping pliers are recommended.

(6) Open one end of the wrapping on the plug then make a hole in the exposed explosive with the skewer. Gently push the detonator in the hole, fold the paper around the fuse, wrap with string, then tie tightly.

(7) Carefully lower the "primer" down a vertical hole or gently push the primer along a horizontal hole with the tamping rod until it is in contact with the other plugs of explosive.

(8) If the hole is vertical pour sand down the hole to come about 8 inches above the primer, then press down hard with the tamping stick. Be careful not to damage the fuse. Then pour more sand down the hole and ram with the tamping stick, taking care not to damage the fuse.

If the hole is horizontal the easiest material to use for tamping is clay or clayey soil wrapped in paper to form plugs about the size of a plug of explosive. The first clay plug should be pushed in with the tamping stick, and the other clay plugs pushed in and then rammed. Take care to avoid damaging the fuse.

(9) When all people in the vicinity have been warned and are in a place of safety give a final warning and light the fuse. A fuse length of 6 feet or more allows at least 3 minutes to reach a place of safety—safety fuse burns at the rate of 2 feet a minute. To light safety fuse, crease the end with the thumbnail, with one hand hold the fuse and a match so that the head is in the crease made, with the other hand strike the side of a match box against the match head. When lighting a number of fuses use a fuse igniter, never try to light more than eight fuses.

(10) *Never* use a fuse shorter than 6 feet.

Never use safety fuse in sinking a shaft—one may be unable to climb out after lighting the fuse.

Never bull or chamber a hole using safety fuse, many people have been killed or injured doing this.

Never run after lighting the fuse, one may trip. Always walk away carefully; one has at least 3 minutes to reach a place of safety.

Always count the number of charges before lighting the fuses, then count the number of explosions. If the number of explosions is less than the number of charges do not return to the face for one hour.

There are special devices such as Multiple Fuse Lighters and Igniter Cord for special uses, such as lighting a number of "pop" shots in boulders.

Using Electric Detonators.

Tools required:—

Wooden skewer, wooden tamping rod, firing cable, exploder. A special circuit tester is desirable.

Electric detonators should be used for shaft sinking, for bulling holes and are recommended for these uses. If electric detonators are used fire all the charges at the same time or, by using special delay detonators having different delays the charges can be fired in a determined order, this leads to more efficient use of explosives and, if properly carried out, a reduction in vibration. It is most important to make sure that nobody can fire the charges while the operator is at the face so use a special exploder that can be locked and the shotfirer should always keep the key in his possession. Never carry detonators in the same box as torch batteries, never carry detonators around with the wires hanging loose. Many people have been killed or injured when the wires from an electric detonator have come in contact with a torch battery or electrical equipment because there are often stray currents in electrical equipment which are sufficient to set off an electric detonator.

When using electric detonators the following method is suggested:—

(1) Remove rock and water from the drill hole.

(2) With the skewer, make a hole in the middle of the end of a plug then gently push the plug in the hole with the detonator pointing towards the hole collar.

(3) Place the required number of plugs down the drill hole. Do not force plugs down the hole, gently push with the wooden tamping rod.

(4) If the hole is vertical pour sand down the hole to come about 8 inches above the last cartridge, then press down hard with the tamping stick. Be careful not to damage the wires. Then pour more sand down the hole and ram with the tamping stick, taking care not to damage the wires. If the hole is horizontal the easiest material for tamping is clay or clayey soil wrapped in paper to form plugs about the size of a plug of explosive. The first clay plug should be pushed in with the tamping stick and the other clay plugs pushed in and then rammed. Take care to avoid damaging the detonator wires.

(5) When all people in the vicinity have been warned and are in a place of safety, connect the wires from the detonator to the firing cable. If there is more than one detonator connect the wires in series, that is, so the current has to flow through each detonator. Test the circuit if you have a circuit tester, then connect the firing cable to the exploder and after giving a warning, fire the shot.

Misfires.

If a charge has misfired, that is, has failed to go off, do not return to the face for one hour if safety fuse has been used or fifteen minutes if electric detonators have been used. If you have a misfire seek the advice of a competent person to deal with the explosive.

Drilling near Old Holes.

Never start drilling a new hole in the bottom of a hole in which explosive has been fired, drill new holes at least 6 inches away.

Blasting Underground.

Obtain information on requirements from the Inspector of Mines.

Never return to the face until the fumes have dispersed. Fumes from explosives are poisonous. The amount of fumes can be reduced by using only explosive that is in good condition; wet explosive can produce large amounts of poisonous fumes. Fumes can be reduced by always tamping the charge with stemming material.

How much explosive should be used?

Using too much explosive is wasteful — explosives are expensive.

Using too much explosive is dangerous — rocks may fly up to half a mile. The amount of explosive will vary with the type of rock; cracked or jointed rock will require less explosive than solid rock. If you are blasting to a face — as in a small quarry — you will need less explosive per cubic yard of rock than if you are sinking a shaft or driving a tunnel. Try to get information from people who have blasted in similar rock. If you are in doubt, use less explosive than you think you will need, you can use more explosive in the next hole if necessary. Because of the great differences in the nature of rock it is not possible to recommend a quantity of explosive per cubic yard of rock broken but in quarrying operations one pound of explosives per 2 cubic yards is suggested, in tunnels and shafts two pounds of explosives per cubic yard is a rough guide to the amount required. Efficient use of explosives depends on proper burden and spacing of the holes in relation to the diameter of the hole.

Reference should also be made in regard to the use of explosives to the section contained in Chapter VII dealing with extraneous hazards associated with the detonation of explosives by electrical means.

CHAPTER X

DISPOSAL OF MINERALS

The method of disposal of any minerals won is a very important aspect of a mining operation, as the success of the venture as a whole may often depend on the selection of the most profitable outlet.

Except in the case of the richest ores, few can be disposed of profitably in their raw state. The value of an ore depends not only on the amount of mineral contained in it, but on other factors such as working costs, freight and handling charges, smelting costs and the presence or absence of certain undesirable impurities.

Most ores should be concentrated prior to sale in order to avoid needless expense in freight and smelting charges on worthless material, and in many cases buyers stipulate that the ore be concentrated up to a definite grade before sale. Hand-picking methods may be used to eliminate waste material and produce an acceptable grade in some copper, silver-lead, antimony, bismuth, tungsten, manganese and chromium ores, but some form of mechanical concentration is necessary for most others.

In many ores "penalties" are imposed by buyers if certain impurities are present, the price payable being reduced by an amount based on the quantity of impurity present, while the material may be rejected entirely if the amount exceeds a certain figure. It may be possible to remove some of the undesirable impurities during concentration of the ore in order to produce a grade of concentrate acceptable to buyers.

It is advisable to obtain from buyers full information about the required specification for any given ore before sending material for sale and a representative sample of the material for sale should be assayed to ensure that it will be acceptable. Failure to do this may result in the dispatch of material which is unsaleable, or for which the price payable will not meet the cost of mining, freight, and smelting.

Complex ores containing several different minerals are not valued at the sum total of all those present, and it is seldom possible to secure payment for each one. If possible such ores should be treated by a selective process in order to produce for sale a separate concentrate of each mineral present.

Controls on Minerals and Metals.

Export controls are maintained over certain minerals and metals These controls are enforced by the Customs (Prohibited Exports) Regulations as amended from time to time by Statutory Rules. In order to obtain permission to export, application should be made to the appropriate Commonwealth Department as listed in the various Schedules of the Regulations. The responsible Departments are as follows:—

Department of National Development—

Mineral sands in all forms (including concentrates) containing zircon, rutile or ilmenite; lithium ores and concentrates; beryllium ores and concentrates; manganese ores; iron ores, beneficiated iron ores and iron concentrates.

Department of Primary Industry—

Phosphate rock, phosphate and superphosphate and fertilizers containing phosphate or superphosphate.

Australian Atomic Energy Commission—

Beryllium, calcium, hafnium and lithium metals; minerals, raw and treated (including residues and tailings), containing more than 0.05 per centum of uranium or thorium, singly or together; thorium, uranium and zirconium metals.

Since 1st July, 1953, the Australian Atomic Energy Commission has acted on behalf of the Commonwealth Government in purchasing uranium ores and concentrates. Inquiries regarding grades of ores, prices payable, etc., should be addressed to the Australian Atomic Energy Commission, Box 41, Post Office, Coogee, N.S.W.

Further information may be obtained from the authorities mentioned above or from the Department of Mines, Sydney.

Export control on iron, steel and ferrous alloys, formerly exercised by the Department of Trade, was removed in August, 1962. Modifications of the conditions relating to the export of iron ore from Australia were announced by the Commonwealth Government in June, 1963. Under the policy introduced in 1960 approval to export from large deposits, other than from certain restricted areas, could be given within an overall limit of not more than 50 per cent. of proved reserves of direct shipping grade ore and at a rate which, in general, was not to exceed one million tons yer year from any one deposit. The export of the whole of any small deposit (i.e. less than two million tons) could be authorised without limit to the annual rate of export.

As from mid-1963 the export of the whole of any small deposit (now defined as one containing not more than five million tons) may be authorised without limit to the annual rate of export. From the larger unreserved deposits the proportion of the deposit which may be exported and the rate at which exports may take place will be determined on the merits of each particular case.

Alluvial gold and smelted bullion must be sold to the Reserve Bank of Australia or its agents, the trading banks or other registered gold buyers. The latter include the four establishments which produce refined gold, viz.: The Electrolytic Refining and Smelting Co. of Australia Pty. Ltd. (Port Kembla) ; The Royal Mint (Melbourne and Perth Branches), Matthey Garrett Pty. Ltd. and Engelhard Industries Pty. Ltd. The former treats gold ores, concentrates, mattes, etc., while the Royal Mint only treats gold in other forms such as bullion, retorted and alluvial gold. Messrs. Matthey Garrett Pty. Ltd. and Englehard Industries Pty. Ltd., treat all gold-bearing materials.

The Reserve Bank pays the producer the fixed price of gold less charges for transport, handling, refining, etc. The official buying price of gold has been £15 12s. 6d. per oz. fine and the official selling price (to recognised dealers only) has been £15 13s. 6d. per oz. fine since May, 1954. No gold is permitted to be exported outside Australia without the approval of the Reserve Bank, but the Gold Producers' Association Ltd., of 115 Egan Street (P.O. Box 147), Kalgoorlie, W.A., is authorised to sell gold on premium overseas markets. The profits are shared proportionately by the shareholders, and membership is open to all producers of gold at a nominal fee.

In November, 1954, the Commonwealth Parliament passed the Gold Mining Industry Assistance Act to assist the gold mining industry in Australia, Papua and New Guinea. The operation of the Act has been extended from time to time and the subsidy to producers will continue until 30th June, 1965. Under the Act, small producers whose annual output does not exceed 500 ounces receive a subsidy of £2 8s. 0d. (Aust.) per ounce irrespective of cost of production. Producers whose output exceeds 500 ounces may qualify as a "small" producer and in such instances the amount of subsidy allowable is reduced by one penny for each fine ounce in excess of 500 fine ounces produced. The subsidy payable to large producers varies according to the formula $\frac{3}{4}$ (cost per ounce minus £13 10s. 0d.) up to a maximum rate of £3 5s. 0d. per ounce subject to certain conditions being fulfilled. Premiums received by producers from the sale of gold overseas (see above) are offset against subsidy payments. Applications for subsidy should be forwarded to the Chief Finance Officer, Commonwealth Sub-Treasury, Treasury Gardens, Melbourne, Victoria.

Silver-lead ores are sold by the ton, prices varying with the metallic content. Lead ores containing bismuth are not acceptable and arsenic and other deleterious impurities are penalised.

Copper ore is sold by the ton. Gold and silver, which are common associates of copper in the ore are paid for, their cost of treatment being deducted in proportion to the amounts present.

Assistance is accorded to Australian copper producers by the Federal Parliament through the operation of the Copper Bounty Act and the Customs Tariff. Under the legislation effective from 1st January, 1961, for three years, assistance to the copper producers is by a combination of bounty payments and duty charges on imports. The operation of the Act has been extended for a further two years from its expiry on 31st December, 1963.

A minimum price of £305 (Aust.) is in effect guaranteed to Australian copper producers and *in addition* a bounty of up to £35 per ton is payable, on domestic sales of refined copper subject to a profit limitation of ten per cent. The bounty is reduced by £1 for every £1 rise above £305 in the locally fixed price.

Most of the other common metallic ores, such as those of tin, antimony, wolfram and molybdenum are sold on a unit basis less charges.

A unit is 1 per cent. or one hundredth part of a ton of pure metal or metallic compound, so that 1 ton of 1 per cent. ore contains one unit, or 20 tons of 1 per cent. ore contain 20 units; similarly 1 ton of 20 per cent. ore also contains 20 units.

By "percentage ore" is understood in most cases, the percentage of the metallic element present in the ore; for example, 10 per cent. antimony ore would be a stibnite (antimony sulphide) ore containing 10 per cent. of metallic antimony. Lead, copper, zinc, antimony, bismuth, tin and arsenic are all referred to in this manner. Tungsten, molybdenum, beryl and manganese are special cases. Tungsten ores, wolfram and scheelite, are referred to by their tungstic oxide content (WO_3) so that a 10 per cent. ore has a 10 per cent. tungstic oxide content. In the same manner molybdenum ores are referred to by their molybdenum sulphide (MoS_2) content, beryllium ores by their beryllium oxide (BeO) content, and manganese ores for battery manufacture by their manganese dioxide (MnO_2) content.

Manganese ores are bought mainly in three grades:—

1. Battery grade, assaying not less than 75 per cent. manganese dioxide, and with impurities limited to a certain content.

2. Metallurgical grade assaying not less than 40 per cent. manganese content, penalties being imposed for silica, iron and phosphorus contents beyond certain limits.

3. Industrial manganese ore, the grade depending on the use

Disposal of many minerals other than those mentioned above may be a matter for direct negotiation with consumers or ore buyers who specialise in a limited range of minerals for local consumption or export. Information on the prices and buyers of ores is frequently published in current mining periodicals and is also available on inquiry to the Department of Mines, Loftus Street, Sydney, or its district offices.

Mineral producers, especially those mining the less common non-ferrous metals, should bear in mind that the metal prices are subject to wide fluctuations and it is frequently impracticable for the ore buyers to assure them of long-term markets at fixed prices.

Directory of Ore Buying Firms.

METALLIC ORES.

General.

The following establishments are buyers of most metallic ores:—

The British Metal Corporation (Australia) Pty. Ltd., Kindersley House, Bligh and O'Connell Streets, Sydney. Telephone: 28 8135. Telegram, "Brimetacor", Sydney.

Derby & Co. (Australia) Pty. Ltd., M.L.C. Building, Victoria Cross, North Sydney. Telephone: 92 1161. Telegram, "Derphisyd", Sydney.

Frank Hambridge Pty. Ltd., 184 Henderson Road, Alexandria, N.S.W. Telephone: 51 7909. Telegram, "Hambrid", Sydney.

O. T. Lempriere & Co. Ltd., Bowden Street, Alexandria, N.S.W., Box 117, G.P.O., Sydney. Telephone: 69 1133. Telegram, "Lemprie", Sydney.

Metal Traders (Australasia) Pty. Ltd., 80A O'Riordan Street, Alexandria. Telephone: 67 0631. Telegram, "Serolatem", Sydney.

Jack Hilton (Metals) Pty. Ltd., 50 Young Street, Sydney. Telephone: 27 6973. Telegram, "Jakhiltore", Sydney.

Specific.

The following establishments buy only ores of a specific nature:—

Australian Atomic Energy Commission, 45 Beach Street, Coogee; Box 41, P.O., Coogee, N.S.W. Telephone: 665 1221. Telegram, "Atomcom", Sydney—Uranium, Monazite.

Broken Hill Associated Smelters Pty. Ltd., Works situated at Port Pirie, South Australia; Head Office, Box 1291K, G.P.O., Melbourne, Victoria. Telephone: 63 0491. Telegram, "Smelters", Melbourne—Silver-lead, etc.

The Broken Hill Proprietary Co. Ltd., Box 196, P.O., Newcastle, N.S.W. Telephone: Newcastle 61 0411. Telegram, "Hematite", Newcastle—Bauxite, chromite.

Electrolytic Refining & Smelting Co. of Australia Ltd., Box 42, P.O. Port Kembla, N.S.W. Telephone: Port Kembla 40251. Telegram, "Eratype", Port Kembla—Copper, gold, silver.

Matthey Garrett Pty. Ltd., 824 George Street, Sydney. Telephone: 211 3422. Gold, silver and other precious metals.

Sydney Smelting Co. Pty. Ltd., 39 Hunter Street, Sydney; Box 412, G.P.O., Sydney. Telephone: 28 5503. Telegram, "Tinsmelter", Sydney—Tin.

Union Carbide Australia Ltd., Consumer Products Division, Harcourt Parade, Rosebery; Box 11, P.O., Rosebery, N.S.W. Telephone: 6 7044. Telegram, "Eveready", Sydney—Manganese, battery grade.

NON-METALLIC MINERALS.

The following establishments are buyers of non-metallic minerals. The minerals particularly sought by each buyer are indicated, but producers should bear in mind that the requirements of buyers can vary considerably from time to time.

Austral Rock Milling Pty. Ltd., Gladstone Street, Newtown, N.S.W. Telephone: 51 5428—Limestone, quartz, sandstone.

Bell's Asbestos & Engineering (Australia) Ltd., 157 Canterbury Road, Bankstown, N.S.W. Telephone: 70 4374—Diatomite, kaolin.

The Broken Hill Proprietary Co. Ltd., 20 O'Connell Street, Sydney. Telephone: 2 0133—Fireclay, magnesite, foundry sand, quartzite, sandstone, serpentine.

Eclipse Milling & Trading Co. Pty. Ltd., 92 Cary-street, Marrickville, N.S.W. Telephone: 55 2648—Clay, pebbles.

Frank Hambridge Pty. Ltd. For address, etc., see "Metallic Ores"—Felspar, mica, rhodonite.

R. Fowler Ltd., Fitzroy Street, Marrickville, N.S.W. Telephone: 51 3275—Clays.

Minerals Pty. Ltd., 100 Euston Road, Alexandria, N.S.W. Telephone: 51 6058—Chlorite, clay, felspar, limestone, pyrophyllite, sand, sandstone, etc.

Newbolds General Refractories Ltd., Box 41, P.O., Mayfield, N.S.W. Telephones: Newcastle 68 2331 and Sydney 637 0571—Clays, diatomite, quartzite, sillimanite.

Non-Metallics Ltd., 74 Pitt Street, Sydney. Telephone: 28 4397—Clay, diatomite, limestone, pebbles, sand, talc, etc.

Proud Bros., 45 Beaconsfield Road, Alexandria, N.S.W. Telephone: 69 3150—Soapstone.

Quality Earths Pty. Ltd., Gordon Street, Rozelle. Telephone: 82 2410—Clays, limestone, pyrophyllite, talc, etc.

Western Fertilizers Pty. Ltd. (Associate company of Australian Window Glass Pty. Ltd. and Australian Glass Manufacturers Pty. Ltd.), Box 18, P.O., Waterloo, N.S.W. Telephone: 69 0455—Dolomite, felspar, limestone, magnesite.

Appendix I.

A GLOSSARY OF MINING TERMS.

Acid Rock: An igneous rock, usually light coloured, in which silica is the predominant constituent.

Adit: A nearly horizontal passage driven from the surface to the mine workings.

Air Shaft: A ventilation shaft of a mine.

Alloy: A compound of two or more metals.

Alluvial: That which is transported by running water.

Alluvial Gold: Gold found in association with water-worn sand and gravel.

Alluvium: Recent deposits of mud, sand and gravel resulting from water action.

Amalgamation: The process of extracting silver and gold from their ores by forming an amalgam with mercury.

Analysis: A determination of the individual constituents of a rock or ore.

Anticline: An up-fold or arch in strata.

Aquifer: Rocks or formations that are water-bearing.

Assay: Determination of one or more constituents of a rock or ore.

Auriferous: Containing gold.

Back: The roof of an underground cavity or stope.

Backs: That portion of a lode between a level, or a stope, and the surface or upper levels.

Barring-down: Removing, with a bar, loose rock from the sides and roof of mine workings.

Basalt: A dark-coloured lava (igneous rock).

Basic Rock: An igneous rock with low silica content, usually dark coloured.

Bathylith: A large crystalline mass of igneous rock.

Battery: A number of stamps for crushing and pulverising ores and rock.

Battery-Amalgamation: Amalgamation by means of placing mercury in the battery bore.

Bearers: Heavy timbers placed in a shaft to support the shaft timber sets.

Bearing: The direction indicated by a compass.

Bedrock: The rock on which alluvial or detrital matter rests.

Bench: The old bank of a river or lake.

Benching: A system of working in stages or steps in an open cut.

Bord: An underground passageway made in solid coal.

Bottom: Barren bedrock.

Box Timbering: Rectangular plan-frame lining a shaft.

Brace: The platform or landing at the mouth of a shaft.

Brattice: A curtain of cloth erected to control ventilation (coal mines).

Brush: To remove rock from the roof or floor of an opening to increase the height of working (coal mines).

Bull: To enlarge the bottom of a drilled hole to increase the explosive charge.

Cage: A frame, with one or more platforms used for hauling in a vertical shaft.

Cap: (1) The outcrop of a lode. (2) The horizontal piece of a mine timber set. (3) The blue halo of ignited fire damp.

Carat: A term used to distinguish the fineness of gold alloy, meaning one twenty-fourth. Fine gold is 24 carat.

It is also employed in weighing gems, one international metric carat equalling 200 milligrams.

Chute: A channel cut in rock or constructed of timber through which ore is passed from a higher to a lower level.

Clean Up: To collect periodically all the valuable product from an operation in a stamp mill, sluice box, etc.

Cleat: Parallel partings or cleavages crossing the bedding along which coal breaks most easily.

Collar: The horizontal timber around the mouth of a mine shaft.

Concentrate: Valuable minerals which have been separated from gangue.

Conglomerate: Cemented water worn pebbles.

Contact Deposit: A mineral deposit found between two unlike rocks, at least one usually being igneous.

Costean: A trench cut across the line of a lode.

Country Rock: Strata on each side of an ore deposit.

Cradle: A box on rockers for treating wash dirt for gold.

Cross-cut: A drive at right angles to the direction of the lode.

Crushing: Reducing the size of ore or rock by stamps and rolls.

Datum: Any fixed position.

Deep Leads: Alluvial deposits buried below a considerable thickness of soil or rock.

Detritus: Sedimentary material produced by erosion of rocks.

Dig: A layer of soft material along the wall of a vein. (Gouge, pug.)

Dip: The inclination of beds or veins, etc., from the horizontal, measured in a plane at right angles to the strike.

Dredging: Raising silt, loose sand, etc., in a scoop or by suction. Used for such minerals as alluvial gold and tin.

Drift: (1) A passage driven through country rock to intersect a seam or vein. (2) Loose sand which tends to flow.

Drive: A level along the course of a lode or reef.

Driving: Extending a drive.

Face: The end of a drive, or the wall in a surface excavation.

Fault: A fracture in a rock along which movement has taken place.

Feeder: A small vein joining a larger vein.

Fine Gold: Almost pure gold.

Firsts: The best ore picked from a mine.

Floaters: Loose fragments of rock, ore and reef in the soil.

Floor: The rock underlying a nearly horizontal deposit.

Flotation: Concentration of ore by inducing fine ore particles to float on the surface of a liquid while the gangue minerals sink.

Flour Gold: The finest of gold dust.

Fluccan: Crushed strata along a fault line.

Flume: A channel constructed on trestles to carry water.

Fold: An undulation or wave in stratified rocks.

Footwall: The wall that lies below an inclined vein or fault.

Free: Native or uncombined with other substances.

Gangue: The non-valuable minerals in an ore.

Girt: In square set timbering, a horizontal brace in the direction of the drift.

Glacial: Formed by ice action.

Glory Hole: A large open pit from which ore has been extracted.

Goaf: That part of a coal mine from which coal has been mined and the space more or less filled up.

Gossan: An iron oxide deposit resulting from the oxidation and leaching of a sulphide mineral body containing such minerals as pyrite.

Gouge: To mine only the richest portion of a mineral deposit; or to work a mine without plan or system. (*Also see* "Dig".)

Ground Sluice: A channel cut to carry a flow of water and act as a sluice box.

Gutter: The lowest portion of an alluvial deposit.

Hanging Wall: The wall that lies above an inclined fault or vein.

Head Frame: A structure over a shaft used for hoisting the cage.

Hoist: A winding engine used for raising and lowering the cage.

Hopper: A box with a perforated bottom forming part of a cradle, or a storage bin for ore in a mill or for a battery.

Horse: A mass of country rock lying within a vein or deposit.

Igneous: A rock formed by solidification from a molten state.

Impervious: Strata that will not permit penetration of a fluid.

Intrusion: The thrusting or penetrating of molten rock into or between other rock formations.

Jack Hammer: A hammer type of rock drill worked without a tripod.

Jig: An apparatus in which ore is concentrated on a screen or sieve in water by reciprocating motion of the screen or by the pulsion of water through the screen.

Joint: A parting in a rock along which there has been no visible movement parallel to the plane or surface.

Kerf: The undercut made to assist the breaking or mining of coal.

Knapping: The act of breaking stone. Improving the grade of ore by removing gangue and low grade material manually with a hammer.

Lagging: (1) Heavy planks or timbers used to support the roof of a mine, or for floors of working places, and for accumulation of rock or earth in a stope. (2) Timber over caps to prevent fragments of rock falling through.

Lead: Placer gravels on the surface.

Leader: A small vein leading to a large vein.

Leg: A prop of timber supporting the end of a stull or cap of a set of timber.

Lens: An ore body in the form of a convex lens.

Level: A drive in a mine.

Lode: Actually a fissure in country rock filled with mineral. In general use, a tabular deposit of valuable mineral between definite boundaries.

Matrix: The gangue. The rock containing a mineral or metallic ore.

Metamorphic Rock: A rock which has been altered by heat and/or pressure, changing the physical character and sometimes the mineral constitution.

Mullock: The accumulated waste or refuse rock about a mine.

Neck: A lava-filled conduit of an extinct volcano exposed by erosion.

Nugget: A water worn piece of native gold of some size.

Open Cut: A surface working open to daylight.

Ore: A rock from which economic minerals may be obtained profitably.

Ore at Grass: Ore stacked literally "on the grass" awaiting treatment, shipment, etc.

Ore Body: A solid and fairly continuous mass of ore which may include low grade and waste as well as pay ore but is separate in form and character from the country rock.

Ore Reserve: The tonnage of ore actually available for extraction, or in stock.

Ore-shoot: See "Shoot".

Outcrop: That part of a stratum which appears at the surface.

Overburden: The barren material overlying a mineral deposit.

Oxidised Zone: That part of a mineralised formation in which, due to the action of air and water, the original minerals have been changed, wholly or in part, into oxides. The depth to which this extends varies depending on local circumstances, but rarely exceeds 200 feet.

Paddock: Ore in "bins" or "stored" or stacked on the surface is said to be in the "paddock."

Pan: To wash earth, gravel, etc., in a pan in searching for heavy minerals such as gold.

Pass: An opening in a mine through which ore is delivered from a higher to a lower level.

Peg: To mark out a claim or lease.

Pegmatite: A coarse grained igneous rock usually having the same constituents as granite. May carry such minerals as mica, felspar, beryl, tin, tungsten, tantalum, uranium, etc.

Pillar: A solid block of ground ore left to support the roof or hanging wall of a mine.

Pinch: The narrowing of a vein or a deposit.

Pipe: A cylindrical siliceous intrusion formed as an offshoot from a larger igneous intrusion often containing such minerals as tin, copper, molybdenum, bismuth, tungsten, gold, etc.

Pitch: The dip or inclination of a vein or bed or the inclination of an ore body in the direction of its strike.

Plat: The floor of a level near its intersection with a shaft.

Pocket: A small body of ore; an enlargement of a lode or vein; an irregular cavity containing ore.

Primary Minerals: Those minerals that retain their original form and composition, as original sulphides.

Pug: See "Dig".

Replacement Deposit: A mineral deposit which has been formed by mineral solutions taking the place of some earlier, different substance.

Riffle: Cross bars in a cradle or sluice box to hold gold, tin or other heavy minerals.

Rise: A shaft excavated upwards from a mine level.

Run-of-Mine Ore: Average grade of ore produced from a mine.

Saddle Reef: A bedded vein that has the form of an anticline, and "inverted saddle" has the form of a syncline.

Sample: A portion of ore by which the quality of the deposit may be judged.

Sands: The coarser and heavier portions of the crushed ore.

Scree: See "Talus".

Secondary (Ore or Minerals): Resulting from alteration of primary minerals. Thus, original sulphides by oxidation change to sulphates, carbonates and oxides, and these by hydration become hydrous forms of the same.

Secondary Enrichment: An enrichment of a vein or ore-body by material of later origin, often derived from the oxidation of overlying ore masses, i.e., in the zone intermediate between the weathered outcrop and the unaltered sulphides.

Seconds: The second-class ore that requires dressing.

Sedimentary: Formed by a deposition of sediment such as mud, sand, gravel, etc., in water.

Set: The timber frame for supporting the sides of a shaft, etc.

Shaft: An excavation of limited area compared with its depth. It may be vertical or inclined.

Shearing: The deformation of rocks by one or more lateral movements generally resulting from pressure.

Sluicing: Washing earth through long races or boxes provided with riffles. Used mainly for heavy minerals such as gold and tin.

Shoot: The enriched section of the lode.

Sill: (1) An intrusive sheet of igneous rock forced between level or gently sloping beds. (2) A piece of wood laid across the floor or passage of a mine to support other timbers.

Skip: A large hoisting bucket used in the shaft, or a truck used for ore haulage.

Sollars: A temporary plank floor used for a smooth surface for shovelling.

Spall: To break ore. Pieces of ore broken are called spalls.

Specimen: Actually, a sample of anything. Applied to mining, it is often restricted to selected minerals.

Specific Gravity: The weight of a body (e.g., rock or mineral) divided by the weight of an equal volume of water.

Square Set: A set of timbers composed of cap, girt and post, which meet to form a solid 90 degree angle.

Stockwork: A mineral deposit, consisting of a system of small reticulating veins (forming a complicated network) traversing the country rock.

Stone: Ore sent to mill or treatment plant.

Stope: An excavation made as a result of extracting ore between two levels

Stope Fillings: Broken mullock used to fill stopes.

Stratum: (Pl. *Strata*). A bed or layer of sediment.

Strike: The direction or bearing of the dipping plane (a rock bed, fault or vein) on the horizontal. The strike is at right angles to the dip.

Stringer: A narrow vein or irregular filament of mineral traversing a rock mass of different material.

Stull: The top piece of a set of mine timbers.

Sulphide Zone: That part of a mineralised deposit in which the original minerals (often sulphides) have not been altered. Found below the oxidised zone.

Sump: A reservoir set at a low level to collect drainage, etc.

Syncline: A fold in strata in the form of an inverted arch.

Tailings: Those portions of washed ore that are regarded as being too poor to be treated further.

Talus: A heap of coarse rock waste at the foot of a cliff (also called scree).

Terrace: A level or nearly level plain generally narrow in comparison with its length from which the surface slopes upward on one side and downward on the other. Also high level river gravels.

Tribute: A portion of ore given to a miner for his labour. A tributer is one who works a mine or mineral deposit for a share of the product.

Tunnel: Strictly a passage open at both ends. Often this term is loosely used for adit, drift or drive.

Unit: One per cent., or one-hundredth part of a ton of pure metal or metallic compound. Thus 1 ton of 1 per cent. ore contains one unit, or 1 ton of 20 per cent. ore, for example, contains 20 units.

Vug, Vugh: A cavity in a rock usually lined with crystalline incrustations.

Wash: Any loose surface deposits of sand, gravel, boulders, etc.

Winze: An opening downwards from a level of a mine.

Appendix II.

TABLES OF WEIGHTS AND MEASURES, ETC.

LINEAR MEASURE.

12 inches	1 foot.
3 feet	1 yard.
6 feet	1 fathom.
5½ yards	1 rod, pole or perch.
4 rods	1 chain.
7·92 inches	1 link.
100 links 66 feet 22 yards	1 chain.
220 yards	1 furlong.
8 furlongs 1,760 yards 5,280 feet	1 mile.

SQUARE MEASURE.

144 square inches	1 square foot.
9 square feet	1 square yard.
30¼ square yards	1 square perch
40 square perches	1 rood.
4 roods 10 square chains 4,840 square yards	1 acre.
640 acres	1 square mile.

A square whose side is 70 yards is approximately an acre.

CUBIC MEASURE.

1,728 cubic inches	1 cubic foot.
27 cubic feet	1 cubic yard.
40 cubic feet	1 ton (shipping).
128 cubic feet	1 cord (wood).

LIQUID MEASURE.

4 gills	1 pint.
2 pints	1 quart.
4 quarts	1 gallon.

1 pint of water weighs 20 ounces.
1 gallon of water weighs 10 pounds.
1 cubic foot of water weighs 62½ pounds (1,000 oz.).
1 cubic foot of water equals 6¼ gallons.

AVOIRDUPOIS WEIGHT.

For all material other than precious metal and gemstones.

437½ grains	1 ounce (oz.).
16 ounces	1 pound (lb.).
28 pounds	1 quarter (qr.).
4 quarters	1 hundredweight (cwt.).
20 hundredweights	1 ton (2,240 lb.).
112 pounds	1 cwt.
2,240 pounds	1 ton (long ton).
2,000 pounds	1 ton (short ton).
2,204·62 pounds	1 metric ton.
1 metric ton	1,000 kilogrammes.

TROY WEIGHT.

By this weight gold, silver, platinum and gemstones, except diamonds, are weighed. Diamonds are weighed by carats of 200 milligrams each. The term carat applied to gold is a measure of purity and not weight. Pure gold is called 24 carat, and the number of carats in a gold alloy refers to the number of 24ths of gold present: thus 9 carat is 9/24 gold.

24 grains	1 pennyweight.
20 pennyweights	1 ounce = 480 grains.
12 ounces	1 pound = 5,760 grains.

The Avoirdupois pound exceeds Troy in the proportion of nearly 17 to 14, and the Troy ounce is greater than the Avoirdupois in the proportion of nearly 79 to 72.

SPECIFIC GRAVITIES OF SOME METALS AND MINERALS

METALS.

Aluminium	2·58	Iron	8·0	Platinum	21·5
Bismuth	9·8	Lead	11·3	Tin	7·2
Copper	8·9	Magnesium	1·75	Silver	10·5
Gold	19·3	Mercury	13·6	Zinc	7·0

MINERALS.

Barytes	4·5	Magnesite	3·1
Beryl	2·7	Magnetite	5·2
Cassiterite	6·8 to 7·1	Molybdenite	4·75
Chalcopyrite (Copper pyrites)	4·1 to 4·3	Monazite	4·9 to 5
Chromite	4·3 to 4·57	Pyrite	4·9 to 5·1
Cinnabar	8·0 to 8·2	Quartz	2·65
Coal	1·2 to 1·8	Rutile	4·2
Fluorspar	3·1	Scheelite	5·9 to 6·1
Galena	7·4 to 7·7	Stibnite	4·5
Gypsum	2·3	Talc	2·7 to 2·8
Haematite	4·9 to 5·3	Topaz	3·4 to 3·6
Ilmenite	4·5 to 5·0	Wolfram	7·2 to 7·5
Limestone	2·6 to 2·7	Zinc blende	3·9 to 4·1
		Zircon	4·7

WEIGHTS OF SOME SOLID MATERIALS.

Cast iron	450 lb. per cubic foot.
Concrete	140 lb. per cubic foot.
Lead	711 lb. per cubic foot.
Quartz	165 lb. per cubic foot.
Steel	490 lb. per cubic foot.
Wrought iron	485 lb. per cubic foot.

WEIGHT FACTORS OF SOME BROKEN MATERIALS.

Clay (packed)	28·0 cubic feet per ton.
Gravel (coarse)	23·0 cubic feet per ton.
Limestone (lump)	23·5 cubic feet per ton.
Quartz ore (little mineralized)	21·0 cubic feet per ton.
Sand (dry)	24·9 cubic feet per ton.

TIMBER MEASUREMENT.

One superficial (super) foot of sawn timber equals 12 inches by 12 inches by 1 inch or such other measurements as will give a total volume of 144 cubic inches.

ALLUVIAL DATA.

One box sluice-head is a body of water 1 inch by 12 inches.

One ground sluice-head is a body of water 3 inches by 12 inches.

A column of water 1 foot high exerts a pressure of 0·43 lb. per square inch at the base.

112 large prospecting dishes of alluvial material equals 1 cubic yard.

APPENDIX III.

Publications and Maps Issued by the Department of Mines, Sydney

(OBTAINABLE FROM THE GOVERNMENT PRINTER, HARRIS STREET, ULTIMO *or* MARKET STREET, SYDNEY (BOX 4050, G.P.O., SYDNEY) *or from* THE DEPARTMENT OF MINES, GOLDSBROUGH HOUSE, 11 LOFTUS STREET, SYDNEY (BOX 48, G.P.O., SYDNEY))

(THOSE MARKED * OUT OF PRINT, BUT COPIES MAY BE SEEN AT THE GEOLOGICAL SURVEY BRANCH, DEPARTMENT OF MINES, SYDNEY, *or at* VARIOUS PUBLIC, UNIVERSITY AND MINES DEPARTMENT LIBRARIES IN AUSTRALIA AND OVERSEAS)

GENERAL

The Mining Act, 1906, as amended; price 12s. ($1.20). This Act should be purchased in conjunction with the Mining Amendment Act, 1963; price 8s. (80c).

Mines Inspection Act and Regulations 1901-1958; price 14s. ($1.40). Acts and General Rules subsequent to 1958 can be purchased separately.

The Coal Mines Regulation Act, 1912-1953; price 10s. ($1.00). Acts, General Rules and Amendments subsequent to 1953 can be purchased separately.

Petroleum Act Regulations, 1955 (as amended); price 6s. (60c).

PROSPECTING GUIDE

Prospector's Guide, 9th Edition (1966); price ($1.25).

ANNUAL REPORTS

Annual Reports available for the following years: 1882, 1884, 1886-1901, 1907-1911, 1917, 1918, 1920-1925, 1928, 1929, 1932-1936, 1939-1954, 1957-1963. Prices range from 5s. (50c) to 16s. 6d. ($1.65).

GEOLOGICAL REPORTS, 1939-1945

(In one volume); price 15s. ($1.50).

TECHNICAL REPORTS

Vol. 1, for 1953; price £1 5s. ($2.50).

Vol. 2, for 1954; price 17s. 6d. ($1.75).

Vol. 3, for 1955; price £1 5s. 9d. ($2.58).

Vol. 4, for 1956; price £1 15s. ($3.50).

Vol. 5, for 1957; price £3 5s. ($6.50).

Vol. 6, for 1958; price £4. ($8.00).

Vol. 7, for 1959; price £3. ($6.00).

Vol. 8, for 1960; price £4 10s. ($9.00).

Note: The incorporation and publication of technical reports in one annual volume has been discontinued from 1960. Each report will be published as a separate booklet in future.

TECHNICAL REPORT REPRINTS

The Occurrence of Opal at Lightning Ridge, by J. W. Whiting and R. E. Relph; price 5s. (50c). (Extract from Technical Reports for 1958.)

Permian Sedimentation in the Sydney Basin, by F. W. Booker; price 10s. ($1.00). (Extract from Technical Reports for 1957.)

GEOLOGICAL SURVEY BRANCH PUBLICATIONS

(a) Reports

NO.

1. (*a*) Iron Ore Deposits, Fine Flower District, N.S.W., by D. W. Wynn (1962).

   (*b*) Magnetic and Gravity Survey of Iron Ore Deposits Fine Flower District, N.S.W., by D. M. Pegum (1962); price 6s. (60c).

2. (*a*) Iron Ore Deposits near Tarago, N.S.W., by D. W. Wynn (1962).

   (*b*) Magnetometer Survey of Iron Ore Deposits near Tarago, N.S.W., by D. M. Pegum (1962); price 4s. (40c).

3. (*a*) Iron Ore Deposits near Lionsville, N.S.W., by D. W. Wynn (1962).

   (*b*) Notes on the Mandurama Ironstone Occurrences, by D. W. Wynn (1962).

   (*c*) Ironstone Deposits near Lake Innes and Mingaletta, Port Macquarie District, N.S.W., by D. W. Wynn (1962).

   (*d*) Ironstone Occurrences North of Parkes, N.S.W., by D. W. Wynn (1962); price 2s. (20c).

4. (*a*) Trough Gully Copper Mine, Dungowan, near Tamworth, by R. E. Relph (1962).

NO.

(*b*) Magnetometer Survey of Trough Gully Copper Mine, Dungowan, near Tamworth, by D. M. Pegum (1962) ; price 5s. (50c).

5. Magnetometer Survey of Eurow Copper Lode, Eugowra, N.S.W., by D. M. Pegum (1962) ; price 3s. (30c).

6. Gravity Investigations at Captain's Flat, by G. S. Gibbons (1962) ; price 4s. (40c).

7. Coal Investigations in the Grafton District—Final Progress Report, by C. T. McElroy (1962) ; price 3s. (30c).

8. Variation in Cover Thickness Above the Great Northern Seam in Portion 153, Parish Awaba, County Northumberland, by A. B. Crouch (1962) ; price 2s. 6d. (25c).

9. (*a*) Kunderang Brook Limestone Deposits, by D. W. Wynn (1962).

(*b*) Limestone Deposit, Little Wombeyan Creek, by D. W. Wynn (1962) ; price 4s. (40c).

10. Extractive Industries, Gosford Shire, by G. Rose (1962) ; price 3s. (30c).

11. Geology of Cranky Rock and the Needles Proposed Dam Storage Areas, by C. L. Adamson and N. A. Trueman (1962) ; price 4s. 6d. (45c).

12. (*a*) The Green Scrub Basalt Deposit near Mountain Lagoon, by C. L. Adamson (1962).

(*b*) Geological Report on Sources of Igneous Rock in the Shire of Blacktown, by C. L. Adamson and D. S. Flack (1962).

(*c*) Report of Examination of Igneous Intrusions in the Liverpool-Campbelltown District, by D. S. Flack (1962).

(*d*) Geological Report on Far-western Stone Quarries "Bluemetal" Deposit at Byrock, by C. L. Adamson (1962) ; price 4s. (40c).

13. (*a*) Groundwater Survey of the Lower Shoalhaven River Flats, by R. J. Giffin (1962).

(*b*) Nymagee Town Water Supply, by R. J. Griffin (1962) ; price 2s. (20c).

NO.

14. (*a*) Notes on Two Manganese Deposits, Niangala District, N.S.W., by D. W. Wynn (1962).
    (*b*) Tin Occurrence at the Glen, Kingstown, by R. E. Relph (1962) ; price 3s. (30c).

15. (*a*) Slag Dumps at Sunny Corner, N.S.W., by D. W. Wynn (1962).
    (*b*) The Evening Star Gold Mine, Coramba, by L. McClatchie (1962) ; price 4s. (40c).

16. The Underground Water Resources of N.S.W., compiled by R. J. Griffin (1962) ; price 5s. (50c).

17. Quality Classification of Water by R. J. Griffin (1964); price 2s. (20c).

18. Geological Reports on Quarry Sites at Walcha, Pokolbin, Nowra and Warren by C. L. Adamson and G. A. Frenda; price 5s. or (50c).

19. Short Notes on various Building Stone Deposits in N.S.W. by C. L. Adamson, G. R. Wallis and G. A. Frenda (1964); price 5s. or (50c).

20. Town Water Supply: Evans Head, Iluka, Bowning, Tumbarumba, by R. J. Griffin, J. Ringis, P. McEwan (1964); price 5s. or (50c).

21. Coastal Water Supplies Nambucca, and Underground Water Wyong Shire by R. J. Griffin. Underground Water in the Cassilis-Merriwa Area by J. Ringis (1964); price 5s. or (50c).

22. Flooding at the Australian Golf Club by R. J. Griffin and Kogarah Golf Club Irrigation Water Supply by R. J. Griffin (1964); price 4s. or (40c).

(b) Mineral Industry Series

6. Beryllium. Compiled by E. O. Rayner (1958) ; price 2s. 6d. (25c).

18. Gemstones. Compiled by G. Rose (1960) ; price 4s. (40c).

21. Iron. Compiled by R. J. Griffin and D. W. Wynn (1959), revised by D. W. Wynn (1961) ; price 4s. 3d. (42c).

25. Manganese. Compiled by L. R. Hall (1959) ; price 4s. (40c).

(c) Mineral Resources Series

NO.

*1. Notes on Chromic Iron Ore, by J. E. Carne, F.G.S. (8vo Sydney, 1898).

*2. Notes on the Occurrence of Tungsten Ores in New South Wales, by J. E. Carne, F.G.S. (8vo Sydney, 1898).

*3. Notes on Gold Dredging, by J. B. Jaquet, A.R.S.M., F.G.S. (8vo Sydney, 1899).

*4. Notes on the Occurrence of Bismuth Ores in New South Wales, by J. A. Watt, M.A. (8vo Sydney, 1898).

*5. Report on the Wyalong Gold-field, by J. A. Watt, M.A. (8vo Sydney, 1899).

*6. The Copper Mining Industry and the Distribution of Copper Ores in New South Wales, by J. E. Carne, F.G.S. (8vo Sydney, 1899), *1st Edition ; *2nd Edition, 1908.

7. Mercury or Quicksilver in New South Wales, by J. E. Carne, F.G.S. (8vo Sydney, 1900), *1st Edition; 2nd Edition, 1913 ; price 2s. 6d. (25c).

*8. Report on Hillgrove Gold-field, by E. C. Andrews, B.A. (8vo Sydney, 1900).

*9. Report on Yalwal Gold-field, by E. C. Andrews, B.A. (8vo Sydney, 1901).

*10. Report on the Kiandra Lead, by E. C. Andrews, B.A. (8vo Sydney, 1901).

†11. Molybdenum, by E. C. Andrews, B.A. (8vo Sydney, 1906) ; price 2s. (20c).

*12. Report on Drake Gold and Copper Field, by E. C. Andrews, B.A. (8vo Sydney, 1908).

*13. The Forbes-Parkes Gold-field, by E. C. Andrews, B.A. (8vo Sydney, 1910).

*14. The Tin Mining Industry and the Distribution of Tin Ores In New South Wales, by J. E. Carne, F.G.S. (8vo Sydney, 1911).

*15. The Tungsten Mining Industry in New South Wales, by J. E. Carne, F.G.S. (8vo Sydney, 1912).

16. The Antimony Mining Industry and the Distribution of Antimony Ores in New South Wales, by J. E. Carne, F.G.S. (8vo Sydney, 1912) ; price 2s. (20c).

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† 2nd Edition forms Mineral Resources No. 24.

NO.

17. Report on the Cobar Copper and Gold-field, by E. C. Andrews, B.A. (8vo Sydney, 1913) ; price 5s. (50c) (no maps are available, price adjusted).

18. The Canbelego, Budgery, and Budgerygar Mines ; Part II of the Cobar Copper and Gold-field, by E. C. Andrews, B.A., F.G.S. (8vo Sydney, 1915) ; price 7s. 6d. (75c).

19. Geological Survey of the Cargo Gold-field, by E. C. Andrews, B.A., and M. Morrison (8vo Sydney, 1915) ; price 2s. (20c).

*20. Report upon the Ardlethan Tinfield, by J. R. Godfrey, B.A. (8vo Sydney, 1915).

*21. The Adelong Gold-field, by L. F. Harper, F.G.S. (8vo Sydney, 1916).

*22. Bibliography of Australian Mineralogy, by C. Anderson, M.A., B.Sc. (8vo Sydney, 1916).

*23. The Coke Industry of New South Wales, by L. F. Harper, F.G.S., and J. C. H. Mingaye, F.I.C., F.C.S. (8vo Sydney, 1916)

24. Molybdenum Industry in New South Wales, by E. C. Andrews, B.A., F.G.S. (8vo Sydney, 1916) ; price 10s. ($1.00).

*25. The Limestone Deposits of New South Wales, by J. E. Carne and L. J. Jones.

26. Felspar in New South Wales, 1917, by L. F. Harper ; price 1s. (10c).

*27. The Hill End-Tambaroora Goldfield, by L. F. Harper.

*28. Bibliography of the Economic Minerals of New South Wales, by O. Trickett.

*29. The Geology and Mineral Developments of the Ardlethan Tinfield, by L. F. Harper.

*30. The Lucknow Gold-field, by L. F. Harper.

*31. Notes on Petroleum and Natural Gas and the Possibilities of their Occurrence in New South Wales, by L. J. Jones, 1921.

32. Coal Resources of the Douglas Park Area, with Tabulated list of Bores (1924), by L. F. Harper ; price 1s. (10c).

33. Gypsum Deposits of New South Wales, by L. J. Jones (1925) ; price 2s. 6d. (25c).

*34. A Contribution to the Mineralogy of New South Wales, by Geo. Smith (8vo Sydney, 1926).

NO.

*35. The Yerranderie Silver-field, by L. F. Harper (8vo Sydney, 1930).

*36. West Darling District. A Geological Reconnaissance with special reference to the Resources of Sub-surface Water, by E. J. Kenny (8vo Sydney, 1934).

37. The Coal Resources of the Southern Portion of the Maitland-Cessnock-Greta Coal District (Northern Coalfield), by Leo J. Jones (1939) ; price 9s. (90c).

38. Part 1—The Gulgong Gold-field, Leo J. Jones. Part 2—Magnetic Prospecting of the Gulgong Deep Leads, J. M. Rayner ; price 9s. (90c).

39. Geology and Underground Water Resources of the East Darling District, C. St. J. Mulholland ; price 6s. (60c).

40. Geology of Coonabarabran-Gunnedah District by E. J. Kenny; price 12s. 6d. or ($1.25).

(d) Bulletins

NO.

*1. Tin, E. J. Kenny, 1922.

*2. Silver- Lead, Zinc, E. J. Kenny, 1923.

*3. Copper, E. J. Kenny, 1923.

4. Iron, L. F. Harper, 1923 ; price 1s. (10c).

5. Antimony, Arsenic, Bismuth, Molybdenum, Tungsten, by E. J. Kenny, 1924 ; price 3s. 6d. (35c).

6. Coal Resources of New South Wales, by Staff of the Geological Survey (1925) ; price 2s. 6d. (25c).

*7. Gold, by E. J. Kenny (1924).

8. Aluminium (Alunite and Bauxite), by L. F. Harper, F.G.S. (1924) ; price 1s. (10c).

9. Limestone, Dolomite, Lime and Hydraulic Cement, by L. J. Jones (1924) ; price 2s. 6d. (25c).

10. Silica, by L. F. Harper, F.G.S. (1924) ; price 1s. (10c).

11. Cadmium and Mercury or "Quicksilver", by E. J. Kenny, (1924) ; price 1s. (10c).

12. Coke, by L. F. Harper, with Notes on By-products, by H. P. White (1924) ; price 1s. 9d. (18c).

13. Chromium, Nickel, Cobalt, Zirconium, Thorium, and Cerium, by H. G. Raggatt, B.Sc. (1924) ; price 1s. (10c).

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NO.

*14. Asbestos, Emery, Fluospar, Fuller's Earth, Graphite, Phosphates, Talc, and Soapstone, by H. G. Raggatt, B.Sc. (1924).

*15. Diatomite, Siliceous Earths and Sands, by E. J. Kenny (1924).

16. Barytes, Ochres, and Oxides, by H. G. Raggatt, B.Sc. (1924) ; price 1s. (10c).

17. Reconnaissance Geological Survey, Ulladulla, 1-Mile Military Sheet and Southern Part of Tianjara 1-Mile Military Sheet, by C. T. McElroy and G. Rose (1962) ; price 25s. ($2.50).

18. Botany Basin, R. J. Griffin (1962) ; price £1 ($2.00).

(e) Memoirs

GEOLOGY

*1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S.

2. The Iron Ore Deposits of New South Wales, by J. B. Jaquet, A.R.S.M., F.G.S. (4to Sydney, 1901) ; price 10s. 6d. ($1.05).

*3. The Kerosene Shale Deposits of New South Wales, by J. E. Carne, F.G.S. (4to Sydney, 1903).

*4. Geology of the Hunter River Coal-field, by T. W. E. David, B.A., F.R.S. (4to Sydney, 1907).

*5. Geology of the Broken Hill Lode and Barrier Ranges Mineral Field, New South Wales, by J. B. Jaquet, A.R.S.M. (4to Sydney, 1894).

*6. Geology and Mineral Resources of the Western Coal-field, by J. E. Carne, F.G.S. (4to Sydney, 1908).

*7. Geological and Mineral Resources of the Southern Coal-field. Part I.—The South Coastal Portion, by L. F. Harper, F.G.S. (4to Sydney, 1915).

*8. The Geology of the Broken Hill District, by E. C. Andrews, B.A. (4to Sydney, 1922)—with Supplement and Portfolio of Maps.

9. The Geology of the Clarence-Moreton Basin, by C. T. McElroy (1963) ; price £5 ($10.00).

PALAEONTOLOGY

*1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by R. Etheridge, Jun. (4to Sydney, 1888).

NO.

*2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen (4to Sydney, 1888).

*3. Geological and Palaeontological Relations of the Coal and Plant-bearing Beds of Palaeozoic and Mesozoic Age in Eastern Australia and Tasmania; with Special Reference to the Fossil Flora, by Ottokar Feismantel (4to Sydney, 1890).

*4. The Fossil Fishes of the Hawkesbury Series at Gosford, by A. S. Woodward (4to Sydney, 1890).

*5. A Monograph of the Carboniferous and Permo-Carboniferous Invertebrata of New South Wales; Part 1, Coelanterata; Part 2, Echinodermata, etc., by R. Etheridge, Jun. (4to Sydney, 1891-2).

Vol. II, Pelecypoda, Pt. 1, The Palaeopectens, by R. Etheridge and W. S. Dun (4to Sydney, 1906); price 10s. ($1.00). Pt. 2, The Genus Eurydesma (4to Sydney, 1910); price 7s. 6d. (75c).

*6. Descriptions of the Palaeozoic Fossils of New South Wales, by the late L. G. de Koninck, translated by Professor T. W. E. David, Mrs. David and W. S. Dun (4to Sydney, 1898).

*7. The Mesozoic and Tertiary Insects of New South Wales, by R. Etheridge, Jun., and A. Sidney Olliff (4to Sydney, 1890).

*8. Contributions to a Catalogue of Works, Reports and Papers on the Anthropology and Geological History of the Australian Aborigines, Parts 1-3, by R. Etheridge, Jun. (4to Sydney, 1890-95).

*9. The Fossil Fishes of the Talbragar Beds (Jurassic), by A. S Woodward (4to Sydney, 1895).

10. The Fossil Fishes of the Hawkesbury Series at St. Peters, by A. S. Woodward (4to Sydney, 1908); price 2s. 6d. (25c).

11. A Monograph of the Cretaceous Invertebrate Fauna of New South Wales, by R. Etheridge, Jun. (4to Sydney, 1903); price 12s. 6d. ($1.25).

12. Mesozoic Floras of New South Wales, Part 1—Fossil plants, from Cockabutta Mountain and Talbragar, by A. B. Walkom, B.Sc. (4to Sydney, 1921); price 3s. 6d. (35c).

NO.

13. A Monograph of the Silurian and Devonian Corals of New South Wales, Part 1, The Genus Halysites, by R. Etheridge, Jun. (4to Sydney, 1904) ; price 10s. ($1.00). Part 2, The Genus Tryplasma, by R. Etheridge, Jun. (8vo Sydney, 1907) ; price 7s. 6d. (75c).

14. A Monograph of the Foraminifera of the Permo-Carboniferous Limestone of New South Wales, by F. Chapman and W. Howchin (8vo Sydney, 1906) ; price 7s. 6d. (75c).

ETHNOLOGY

*1. Aboriginal Carvings of Port Jackson and Broken Bay, by W. D. Campbell, L.S., F.G.S. (4to Sydney, 1899).

2. Part I—The Cylindro-conical and cornute stone implements of western New South Wales and their Significance ; Part II—The Warrigal, or "Dingo", introduced or indigenous? by R. Etheridge, Jun. (4to Sydney, 1916) ; price 7s. 6d. (75c).

3. The Dendroglyphs or "Carved Trees" of New South Wales, by R. Etheridge (4to Sydney) ; price 12s. 6d. ($1.25).

(f) Records

Records of the Geological Survey of New South Wales ; Vol. I to date (Vol. X, Part 2), 4 parts to each volume (8vo Sydney, 1889-1923). Prices vary from 1s. 6d. (15c) to 10s. ($1.00) per part. (Vol. I-IV, out of print.)

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2	..	..	..	1 6 (15c)
3	1 6 (15c)	1 6 (15c)	1 6 (15c)	..
4	..	..	1 6 (15c)	1 6 (15c)
5	..	1 6 (15c)	..	1 6 (15c)
6	..	..	..	1 6 (15c)
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9	7 6 (75c)	2 4 (23c)	2 6 (25c)	1 1 (11c)

GENERAL REFERENCE

*Mineral Resources of New South Wales, by E. F. Pittman, A.R.S.M. (8vo Sydney, 1901).

*Mineral Industry of New South Wales, by E. C. Andrews and Staff (8vo Sydney, 1928). Reprints of articles included in this publication available separately.)

†*The Coal Resources of New South Wales, by E. F. Pittman, A.R.S.M. (8vo Sydney, 1912).

MISCELLANEOUS REPORTS

Epitome of the Geology of New South Wales (1909), E. F. Pittman; (free).

*Problems of the Artesian Water Supply of Australia (1908), E. F. Pittman.

The Great Australian Artesian Basin and the source of its water (1914), E. F. Pittman; price 1s. 9d. (18c).

The Composition and Porosity of the Intake Beds of the Great Australian Artesian Basin (1915), E. F. Pittman; price 1s. 9d. (18c).

*Notes on the Geology of the Broken Hill District (1925), E. C. Andrews.

Coal Resources of the Newcastle-Maitland District (1926), L. J. Jones; price 1s. (10c).

Notes on the Utilisation of the Coal Resources of New South Wales (1927), J. M. Baddeley (free).

COALFIELDS BRANCH PUBLICATIONS

(a) Bulletins

*1. Erection of Barricades during Mine Fires or after explosions (1925). (Reprint of U.S. Bur. of Mines Miners' Circular No. 25.)

*2. Recent Accidents in and about Coal Mines which could have been avoided had "Safety First" principles been observed (1926).

*3. Organising and Conducting Safety Work in Mines (1927).

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†New Edition forms Bulletin No. 6; price 2s. 6d. (25c).

NO.

*5. Stone-dusting in Mines.

*6. "Don'ts" for Coal Miners, V. B. Collins (1928).

*7. Coal Dust—Its Inflammability and Treatment, R. P. Jack (1938).

*8. Prevention of Accidents from Falls of Roof and Sides, R. P. Jack (1938).

*9. Mine Roadway Dust. Some Practical Aspects of Sampling and Review of Proposals by the Royal Commission into the Safety and Health of Workers in Coal Mines, 1938-39, R. P. Jack (1940).

*10. Sampling and Analysis of Coal and Shale Mine Roadway Dust for Combustible Volatile Matter (with respect to requirements of the New South Wales Coal Mines Regulation Act, 1912-1941), H. A. J. Donegan (1944).

11. The Object of Earth Leakage Protection for Mines, by R. F. Doyle (1959) ; (free).

12. Organisation in Case of Disaster (1959) ; (free).

(b) Fuel Research Papers

1. The Variability of New South Wales Coals with respect to Ash Content, G. B. Howarth, M.Sc. (1939) ; price 6d. (5c).

2. The Crucible Swelling Test for Coal and its applicability to New South Wales Coals, W. J. Leslie, B.E., and J. F. L. Davies, B.E. (1939) ; price 6d. (5c).

(c) Reports

NO.

1. Nebo Colliery—Use of Arched Supports, by M. J. Muir (1962) ; price 10s. ($1.00).

2. Bellbird Colliery—Ignition of Inflammable Gases, by R. A. Menzies (1962) ; price 5s. (50c).

3. Liddell Colliery—Heating Underground Near Fan Drift, by N. E. Clark (1962) ; price 5s. (50c).

4. Wongawilli Colliery—Underground Ignition, by W. C. Anderson and M. J. Muir (1962) ; price 2s. (20c).

NO.

5. Bulli Colliery—Occurrences of Methane, by M. J. Muir (1962) ; price 2s. (20c).
6. Stockton Borehole Colliery—Breakage of left hand winding rope, by E. A. D. Buck (1963) ; price 12s. 6d. ($1.25).

MINES INSPECTION BRANCH PUBLICATIONS

(a) Bulletins

Quarry Blasting in Built-Up Areas, by A. G. Reid (extract from Technical Reports, Department of Mines, 1954) ; (free).

Some Aspects of Blasting in Built-Up Areas with Particular Reference to Ground Vibrations, by A. G. Reid (extract from Technical Reports of Department of Mines, 1957) ; (free).

Balmain Colliery Shafts—Eliminating the Gas and Filling the Shafts, by S. C. McDonald (extract from Technical Reports, Department of Mines, 1958) ; (free).

(b) Reports

NO.

1. The York Concentrator, by S. C. McDonald (1962) ; price 6s. (60c).
2. Blasting Investigation at Orange Blue Metal Quarry, by A. G. Reid (1962) ; price 4s. (40c).
3. An Investigation Into Problems Associated with Major Misfires, Especially in Limestone Quarry Blasting, by A. G. Reid (1962) ; price 5s. (50c).
4. Sand Stabilisation after Beach Sand Mining on the Far North Coast of New South Wales, by S. C. McDonald ; price 6s. (60c).

CHEMICAL LABORATORY PUBLICATIONS

(a) Reports

NO.

1. Ceramic Section—Selected Records, 1961, by R. A. Burg ; price 7s. 6d. (75c).
2. Fuel Section—Selected Records, 1961, by J. D. Thomas ; price 7s. 6d. (75c).
3. Rock, and Mineral Section—Selected Records, 1961, by J. H. Pyle ; price 5s. (50c).

NO.

4. Part 1—Water, Geochemistry, and X-ray Section, selected Records, 1961, by H. F. Conaghan; Part 2—Explosives Section, selected Records, 1961, by R. B. Welch.

5. Gas Analysis Section—Selected Records, 1961 and 1962, by A. C. Brigden.

11. Ceramic Section, Selected Records 1962 and 1963 by R. A. Burg; price 12s. 6d. or ($1.25).

GENERAL MAPS, LEASE MAPS, MINE PLANS, SECTIONS, ETC.

1. Mineral Map of New South Wales, 48 miles to 1 inch (1962); price 1s. (10c).

   This is a spot locality map showing notable mineral occurrences and in effect, mining fields, by various coloured symbols.

2. Numerous maps accompany Departmental Technical Reports, Annual Reports, Geological Memoirs, the Mineral Resources Series and other publications. Information concerning maps and reports for a specific mine or particular area can be obtained upon application.

3. Mining Surveys—Heliographs of plans of mining surveys of portions. Foolscap size; 1s. 6d. (15c) each; larger size 10d. (8c) per sq. ft.

4. Parish Maps—Information on lease holdings, prospecting areas, authorities to enter etc. (past and present) can be obtained from a set of parish maps which is kept plotted to date in the Charting Branch of this Department.

   Parish maps can be purchased from the *Lands Department,* Sydney. The maps, costing for the most part 5s. (50c), show mining leases held at the time of compilation and many of the past leased areas. Current information can be added from the abovementioned set of maps. If required this can be done by officers of this Department for a nominal fee.

5. Locality Maps:

   Broken Hill Mines—In two sheets (plain), scale 40 chains to an inch; price 10s. ($1.00) per sheet.

   Cobar—Scale 20 chains to an inch; 10s. ($1.00) per sheet.

Coal-fields Maps. (Scale: 40 chains to an inch)

Newcastle Coal-fields.—In 3 sheets (plain) ; price 10s. ($1.00) per sheet.

Maitland-Cessnock-Greta Coal-fields.—In 2 sheets (plain) ; price 15s. ($1.50) per sheet.

Lithgow Coal-fields.—In 4 sheets (plain) ; price 10s. ($1.00) per sheet.

Capertee-Rylstone Coal-field.—In 4 sheets (plain) ; price 10s. ($1.00) per sheet.

Southern Coal-fields.—In 4 sheets (plain) ; price 10s. ($1.00) per sheet.

Singleton Coal-fields.—In 1 sheet (plain) ; price 10s. ($1.00).

Burragorang Coal-fields.—In 1 sheet (plain) ; price 10s. ($1.00).

Geological Maps

(Additional to those covered by (2) above. Examples from publication list:—Memoir No. 9 (1963) with a 4 mile scale geological map of the Clarence-Moreton Basin ; Bulletin No. 17 (1962, with geological maps of the Ulladulla 1 mile and portion of the Tianjara 1 mile map area).

Geological Map of New South Wales (1962). Scale 1:1,000,000 ; price £2 ($4.00).

1:253,440 (4 mile) and the metric 1:250,000 Geological Map Series. (Maps are generally published with explanatory notes.

Canberra 1:250,000 (Published by the Bureau of Mineral Resources *without explanatory notes*), 2nd Edition 1963 ; price 7s. 6d. (75c).

Sydney 1:250,000, with explanatory notes, 3rd Edition.

Wollongong 1:250,000, with explanatory notes, by C. T. McElroy, 2nd Edition.

Enngonia 1:250,000.

Louth 1:250,000.

Wilcannia 1:250,000.

Barnato 1:250,000.

Newcastle 1:250,000, with explanatory notes, by B. A. Engel.

Mallacoota 1:253,440, with explanatory notes by L. R. Hall (Published by the N.S.W. Dept. of Mines), 1959. Geology of New South Wales portion only ; price 8s. 6d. (85c).

Narrandera 1:253,440, with explanatory notes by D. W. Wynn (Published by the N.S.W. Dept. of Mines), 1962 ; price 10s. ($1.00).

Jerilderie 1:253,440, with explanatory notes by L. R. Hall and J. W. Whiting (Published by the Bureau of Mineral Resources) 1957; price 7s. 6d. (75c).

Heliographs costing 5s. (50c) are available of the following 4 Mile maps:—

Euabalong (*Cargelligo*): See also Technical Report No. 5, 1957, for the geological report by R. J. Griffin on this 4 mile area.

Cobar 4 Mile Geological Map Nymagee 4 Mile Geological Map	—available as helios of the preliminary maps only.

NON-DEPARTMENTAL

Regional Maps, (Clarence, Oxley, Mitchell, New England, Monaro and southern Tablelands, Newcastle, Illawarra, Upper Hunter, Namoi, Macquarie, Murrumbidgee, etc.) were produced for the Premier's Department by the Geological Survey Branch of the Mines Department, for inclusion in Regional reports published about 1947, but now out of print. The maps, with explantory notes in the text, show geological systems and mineral deposits. Other maps showing topography, climate, land use, etc., are included with these reports.

The Regional Reports were fairly widely distributed and inquires could be made for them at Shire Headquarters and libraries in the cities and larger country towns.

North-eastern New South Wales. Geological Map of New England, 1:100,000 series (1.6 miles to 1 inch), compiled and published by the Department of Geology, University of New England, Armidale.

The price of the maps, each with marginal notes is 15s. ($1.50) per sheet payable to the Accountant at the University of New England.

Military (topographical) Maps. Military maps compiled by the Army Survey Corps are distributed by leading booksellers, e.g., H. E. C. Robinson and the Gregory Map Company in Sydney. The cost of the maps is 5s. (50c) per sheet.

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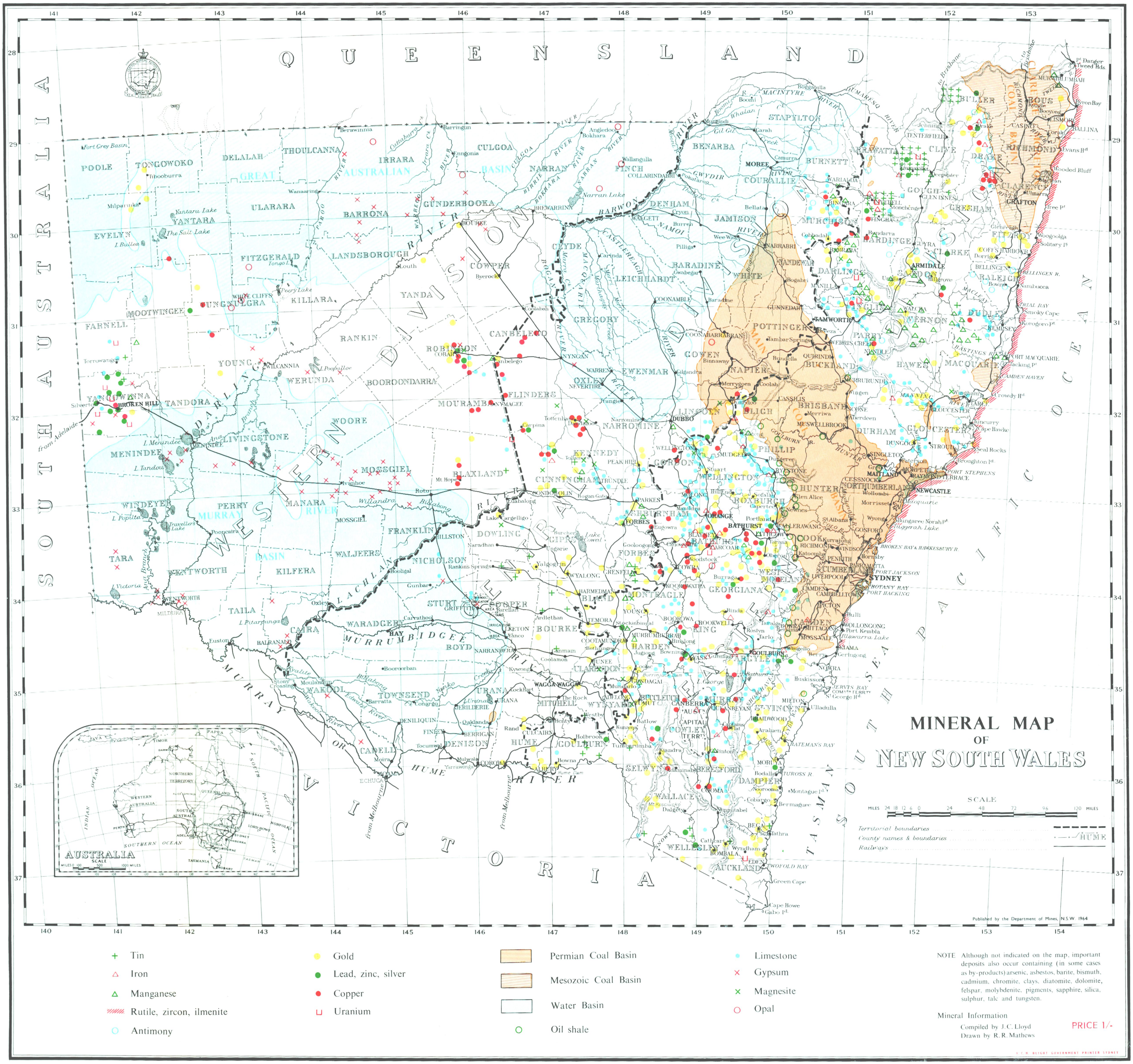

MINERAL MAP
OF
NEW SOUTH WALES
SCALE
MILES 24 18 12 6 0 24 48 72 96 120 MILES
Territorial boundaries
County names & boundaries
HUME
Railways
Published by the Department of Mines, N.S.W. 1964
QUEENSLAND
SOUTH AUSTRALIA
VICTORIA
SOUTH PACIFIC OCEAN
TASMAN SEA
WESTERN DIVISION
CENTRAL DIVISION
EASTERN DIVISION
GREAT AUSTRALIAN BASIN
MURRAY RIVER BASIN
SYDNEY
NEWCASTLE
BROKEN HILL
CANBERRA
AUSTRALIA
Tin
Iron
Manganese
Rutile, zircon, ilmenite
Antimony
Gold
Lead, zinc, silver
Copper
Uranium
Oil shale
Permian Coal Basin
Mesozoic Coal Basin
Water Basin
Limestone
Gypsum
Magnesite
Opal
NOTE Although not indicated on the map, important deposits also occur containing (in some cases as by-products) arsenic, asbestos, barite, bismuth, cadmium, chromite, clays, diatomite, dolomite, felspar, molybdenite, pigments, sapphire, silica, sulphur, talc and tungsten.
Mineral Information
Compiled by J.C. Lloyd
Drawn by R.R. Mathews
PRICE 1/-
V. C. N. BLIGHT GOVERNMENT PRINTER SYDNEY