

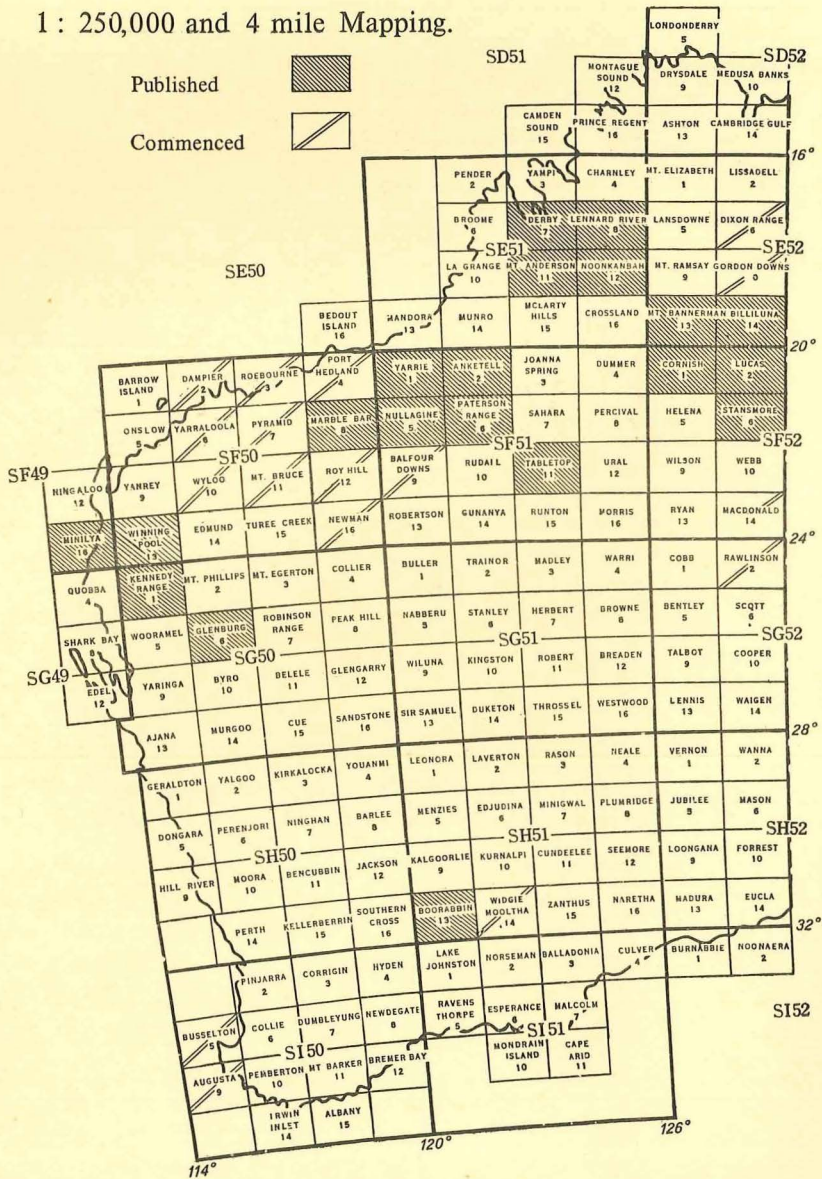


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GEOLOGICAL SERIES
EXPLANATORY NOTES

BOORABBIN, W.A.

Sheet SH/51-13

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GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

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Compiled by J. Sofoulis

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DEPARTMENT OF MINES, WESTERN AUSTRALIA

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GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

Director : J. H. LORD

Explanatory Notes on the Boorabbin Geological Sheet

Compiled by J. Sofoulis

INTRODUCTION

GENERAL INFORMATION

The Boorabbin Sheet is delimited by latitudes 31° and 32°S., and longitudes 120° and 121° 30'E. This area lies within the southern portion of the West Australian Precambrian Shield in the Coolgardie and Dundas Goldfields and covers about 6,000 square miles.

The railways, highways, telegraph lines and Goldfields Water Supply pipelines linking Perth to Kalgoorlie and Coolgardie to Norseman pass through the north-western and north-eastern quadrants of the area respectively. A few minor sidings and centres established along these routes (Bullabulling, Boorabbin, Woolgangie, No. 8 Pumping Station, Spargoville) are associated with the maintenance of these utilities and cater for the rail and road traffic.

Mining and pastoral activities are restricted to the north-eastern and eastern fringes and, except for a few isolated timber cutting camps in the central section, the remainder of the area is uninhabited. The township of Coolgardie forms the administrative centre for the area and is located at the junction of the two major routes, a few miles north of the north-eastern corner of the map area.

HISTORY OF INVESTIGATIONS

Early explorations into portions of the area were led by H. M. Lefroy in 1863, C. C. Hunt in 1864, J. Forrest in 1871, E. Giles in 1875, and D. Lindsay in 1891. These explorers were responsible for the general classification of the country's potentialities and named many topographic features in the region.

Following the gold discoveries in the Yilgarn field, several prospecting parties extended their activities eastward to investigate the quartz occurrences reported earlier by Hunt in a locality later named Hampton Plains. The eventual discovery of rich gold ore by Bayley and Ford in September 1892 in what is now the Coolgardie area precipitated the rush to these eastern fields. Further discoveries of major ore deposits in the metamorphic rocks of the Coolgardie and the adjacent Kalgoorlie districts firmly established the gold mining industry in this portion of the State, with the "Golden Mile" at Kalgoorlie subsequently becoming world famous as Australia's principal gold producing centre.

Since the early finds, the area has been subject to many geological investigations, the earliest general contributions being those by Woodward (1893), Goczel

(1894, 1896), Chewings (1896), Van Oldruitenborgh (1897), Maitland (1897a, 1900), and Blatchford (1897, 1899). Other systematic surveys on portions of the auriferous areas were subsequently carried out by Blatchford (1913), Honman (1914a, 1916), Clarke (1923), and Feldtmann (1922, 1925). The most comprehensive surveys carried out in recent years were those by McMath (1953) and Gray and Ward (1953). A part of this area was also reported on by Low (1960). Numerous other geological investigations concerning auriferous parts of the area were purely local examinations of individual leases or holdings. These and other general references are listed in the bibliography. The remainder of the area was known to be of a granitic nature and, until the current field work, had not been subject to any particular attention.

PRESENT INVESTIGATIONS

These notes are a result of field work carried out from April to October 1960 by departmental geologists J. Sofoulis (party leader) and W. Bock.

Vertical aerial photographs at a scale of 1:31,680 were provided for these investigations. The geological sheet is based on controlled one mile photomosaics supplied by the West Australian Lands Department. Where possible, geological boundaries were plotted by direct observation in the field. In areas of restricted outcrop, additional data were obtained from morphological features observed on the ground and on aerial photographs, and boundaries are approximate there.

Aeromagnetic maps prepared by the Geophysical Branch of the Bureau of Mineral Resources (scale 1 mile to an inch) were also available for the survey. Comparison with the geological sheet showed that higher magnetic values conform broadly to metamorphic rock distribution or to more prominent exposures surrounded by soil covered areas.

PHYSIOGRAPHY

GENERAL DESCRIPTION

The area forms part of the great inland plateau of Western Australia and lies within the Salt Lake or Salinaland physiographic division of Jutson (1950). It is characterised mainly by extensive old and new plateau developments and by broad shallow valleys containing salt lakes (see Fig. 1). Isolated granitic rocks and segments of metamorphic belts rise above the plateau levels and form the only elements of higher relief in the area.

The old plateau surfaces appear as flat to gently undulating sandplains that range in height from 1,000 feet to 1,500 feet above sea level but seldom show local relief greater than 200 feet. Sandplains are undissected in the western part of the sheet where they cover large areas. Elsewhere they occur only in the watersheds and form plateau remnants bounded locally by low escarpments.

New plateau surfaces occupy the lowland areas below the escarpments. These comprise eluvial granitic soil plains traversed by broad alluvial valleys. Such surfaces are generally of low relief but clusters of more resistant granitic hills may occur in the interfluvies and along valley flanks.

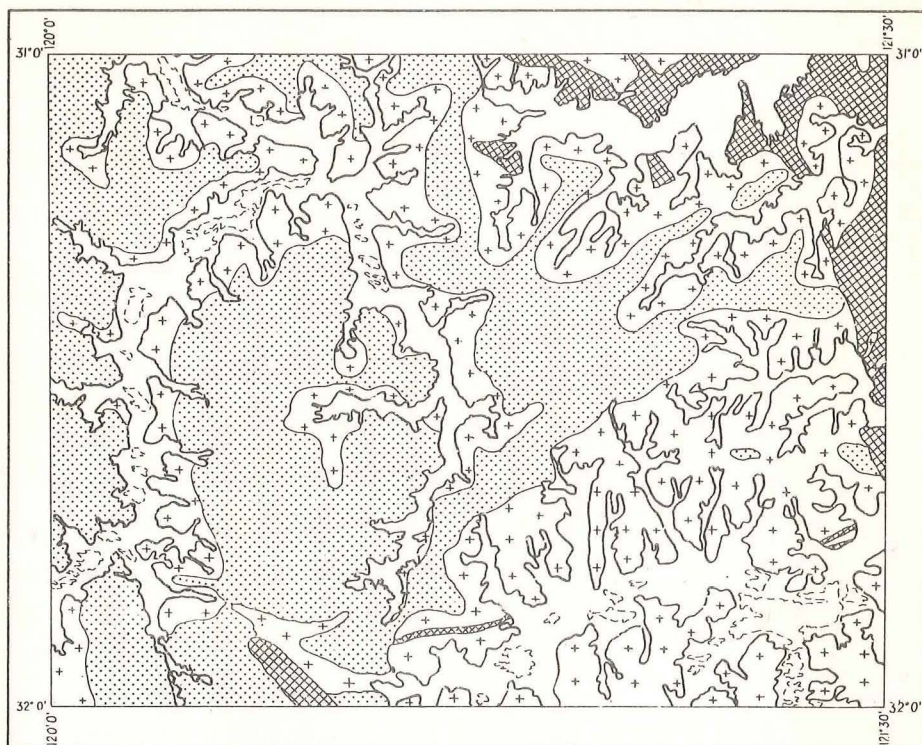
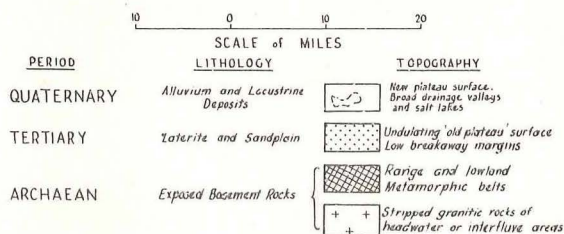


Fig. 1

MORPHOLOGICAL SKETCH MAP

BOORABBIN SHEET SH/51-13



The sandplains, eluvial and aliuvial soils of the old and new plateaux are separately discussed under Cainozoic.

DRAINAGE SYSTEMS

The dissection of the old plateau probably originated during a more active Tertiary cycle of erosion. The major drainages are now broad, dry, shallow alluvium-filled trunk valleys with valley floors ranging from 100 feet to 250 feet below the old plateau or sandplain level. These are joined by tributary valleys extending downslope from the sand or eluvial soil plains to form broad alluvial tracts commonly at right angles to the trunk valleys.

Incised channelling is generally lacking but some tributary valleys show faint or reasonably defined channels that are seldom incised to depths greater than

4 feet. These become ill-defined on entering the trunk valley or may terminate locally in a salt lake.

A watershed divides the area in a north-south arc and separates the system draining north-north-westwards in the western half of the area from the systems draining east-north-eastwards in the eastern half. The drainages of the western sector probably form part of the Avon-Swan River system draining to the Indian ocean. The others drain eastwards into major salt lakes (Lakes Dundas, Lefroy, and others) which are closed basins.

SALT LAKES

Salt lakes of the area are confined to the trunk valleys and form a local base level for drainage and erosion. Lake floors generally lie from 20 to 50 feet below the valley floors. The lakes appear as isolated features but may show connecting channels where closely associated. They range in size from small vegetated pans to larger, bare, saline clay flats, which exceed 20 square miles. Low gypsiferous and sandy banks are locally developed on some lake floors, particularly in the eastern sectors. Higher flour gypsum and sandy crescent-shaped dunes are general about the east and south-east lake margins.

Lake floors are frequently damp, with the saline ground water lying at the surface or within a few feet of the surface. Depending on rainfall, some lakes may retain water at a shallow depth for many months. Saline encrustations are general over dry lake floors.

Low escarpments developed along the west and north-west shores of lakes are mainly attributed to the scouring action of the prevailing west-north-west winds. This action and the transport of materials to the opposite shores has given preferred west-north-westerly lake elongations and has led to a migration of lakes in this direction.

STRATIGRAPHY

Table 1 summarizes the stratigraphy of the Boorabbin Sheet area. Names previously established are shown in inverted commas. The table is subject to modification as further information becomes available from mapping adjoining sheets.

ARCHAEAN

INTRODUCTION

The basement rocks of the area are essentially crystalline and comprise metamorphic and granitic rock complexes that form part of the West Australian Precambrian Shield. The metamorphic rocks occur as remnant belts preserved within the granitic terrains and are generally accepted as the older complex.

Age determinations, made on granite and lithium-bearing pegmatite materials from the area (Mungari, Bullabulling, Londonderry, Grosmont), are given in Wilson and others (1960) and are of 2,200 to 2,400 million years and 2,700 million years. These are in agreement with other age datings ascribed to similar complexes of the Yilgarnian and Pilbarian provinces and designated Archaean.

TABLE 1. — STRATIGRAPHY OF THE BOORABBIN SHEET

Era	Period	Classification	Rock Unit	Map Symbol	Remarks	Distribution and Topography	Economic Geology
CAINOZOIC	Quaternary	Aeolian Deposits		Unmapped	Gypseous and sandy lunette dunes, low banks, associated with salt lakes.	Low banks and dunes of lake margins and lake floors.	Gypsum, sand.
		Lake Deposits		Unmapped	Silts, clays, muds, grits, loams, gypsum and salt deposits of lake floors.	Lake floors and lake fillings.	Clays, salt.
		Transported Soils		Unmapped	Sands, grits, loams and debris of valley floors and drainage channels.	Flat to gently undulating. As surface accumulations along valley floors & drainage lines.	Sands, loams, grits, calcareous gravels, soaks, dam sites.
		Alluvium		Qa	Red sandy loam with nodular and earthy calcareous sub-soils.	Broad valley floors.	
		Eluvium		Qe	Mainly red sandy loams, locally with kaolinised and fresh granitic fragments and gritty soils. Calcareous sub-soils in lower valley sectors.	Upper valley slopes, interfluvies and flanking granite exposures.	
	Tertiary	Residual Sandplains		Ts	Red-yellow-brown loamy sands, lateritic gravels and pisolithic veneers.	Extensive flat to undulating upland plateau remnants. Stripped sandplain terrains, interfluvies of dissected areas, ridge and break-away crests and faces.	Sands, lateritic and calcareous gravels, magnesite, water.
		Duricrusts, Cements and kaolinisation		Unmapped	Ferruginous, siliceous, calcareous and magnesian duricrusts and surface cements above mottled pallid basement rocks.		
PROTEROZOIC	Proterozoic (Lower ?)	Basic Dykes	Dundas Dyke Suite	Pd	Quartz dolerite dykes, locally hypersthene-bearing, includes gabbro, norite, and pyroxenite differentiates.	Dykes rare, form an east-north-east trending suite cutting basement. Generally as discontinuous low hills or ridge features. Locally occupying valleys in metamorphic areas.	Road metal.
ARCHAEAN	Archaean (Younger)	Undifferentiated Granites and Gneisses		Agu Agn	External granites, generally gneissic in character. Would probably include younger granite emplacements. Agn - strongly gneissic.	Isolated hills or clusters, low outcrops in valleys, and in break-away faces. Underlies sand plain.	Road and ballast materials.
		Granites	Coolgardie Granite Bali Gneiss Horse Rocks Granite	Ag	Internal granites, as major granite bodies within metamorphic rock areas. Minor granitic pods also present. Lithium-bearing pegmatites (Ap) associated with these granites.	Isolated hills or clusters, low outcrops in valley or plain areas.	Water catchments, soaks, pegmatite minerals, road metal.
		Porphyries		Apo	Quartz-albite porphyries, as regionally concordant bodies, locally as minor intrusive dykes. Includes selective porphyritisation of country rocks. Possibly represents a pre-granite stage.	Restricted occurrence, generally as low outcrops associated with metasedimentary belts.	Gold. Water catchments.
					Period of granitisation, granite and porphyry emplacements, minor acid dyke intrusions and ore formation.		
	Archaean (Older)	Metasedimentary Rocks	"Whitestones"	Am	Undifferentiated, mainly of clastic origin. Includes assortment of pelitic schists (phyllites, mica, graphite, garnet, andalusite, schists, etc.) and siliceous rocks that include cherts, calc-silicates, sandstones, quartzites, greywackes and conglomerates. Thin "greenstone" members also present.	Broad belts or as thin bands associated with "greenstones". Locally as prominent strike ridges, generally as low lying soil covered belts.	Gold and other metallic minerals.
		Ultrabasic Rocks		Au Aud	Massive or schistose tremolite-actinolite, and serpentine rocks, local variations to talc, chlorite, anthophyllite, fuchsite, urolite, pyroxenite and carbonate forms. Aud — probably of dolomitic origin. Thin "whitestone" members also present.		Gold and other metallic minerals, marble, magnesite, talc, dolomite.
		Coarse-grained Amphibolites	"Greenstones"	Ac	Metamorphosed dolerites and gabbros, possibly recrystallised or hypabyssal phase of basic lava suite. (Also referred to as "Younger Greenstones" and "meta-gabbros"). Thin "whitestone" members also present.	Alternating succession of variable thicknesses. Locally as topographically prominent hilly belts. Valley sectors usually occupied by ultrabasics. Extensive soil covered flats.	
		Fine-grained Amphibolites & Basic Schists		Af	Metamorphosed basaltic lavas, pyroclastics, basic intrusives, & basic schists. Afl — Porphyritic basic lava. Thin "whitestone" members also present.		Gold and other metallic minerals.
		Undifferentiated Metamorphic Rocks		Acu Abu	Undifferentiated Coolgardie - Kalgoorlie Metamorphics. Undifferentiated Bremer Range Metamorphics.	Mainly soil covered, fragmentary veneers.	
	Coolgardie-Kalgoorlie Metamorphics "Yilgarn-Kalgoorlie System", Bremer Range Metamorphics						

Rocks of this age group are believed to form a primitive Archaean basement that is confined to the above West Australian provinces. The Precambrian of other Australian States is believed to be younger (Sofoulis, 1962).

Within this basement the metamorphic belts contain similar lithologic units. Their fundamental subdivisions into rocks of volcanic origin and of sedimentary origin have formed the general basis for the nomenclature appearing in past literature. These subdivisions have commonly been referred to as "greenstones" and "whitestones" respectively. The greenstones are generally believed to be the older phase. McMath (1953) has grouped the greenstone and whitestone units of the Coolgardie area in the Yilgarn-Kalgoorlie System.

In these notes, the metamorphic rocks of the Boorabbin sheet are referred to as the Bremer Range Metamorphics and the Coolgardie - Kalgoorlie Metamorphics. These are separated by vast expanses of granitic rocks and no detailed correlation from one to the other, or to other adjacent metamorphic belts, is here attempted.

BREMER RANGE METAMORPHICS

This name is tentatively proposed for the narrow north-west trending belt shown near the south-west corner of the geological sheet as undifferentiated metamorphic rocks. The belt represents an attenuated north-west extension of Honman's (1914b) "Bremer Range Country" and is flanked by granitic rocks.

Isolated exposures of rocks of volcanic origin occur as low hills within the belt. Other metasedimentary rocks and schists of various origins locally crop out in the alluviated ground or form patchy surface veneers of platy rubble. Elsewhere the belt is generally soil-covered and its limits have been interpreted mainly from soil patterns on air photographs.

COOLGARDIE-KALGOORLIE METAMORPHICS

A completely folded sequence of metamorphic rocks containing major and minor granite and porphyry bodies occurs as a widespread development in the north-east section of the Boorabbin Sheet area. Further developments extend southwards to the Larkinvile-Wannaway mining centres and there are also outliers at the Nepean and Prince of Wales localities.

Fundamental subdivision into more or less concordant belts consisting of either predominantly meta-igneous or predominantly metasedimentary members are recognised. These form a rapidly alternating succession, with individual bands frequently showing considerable facies and metamorphic variation across and along strike.

The subdivisions of the Coolgardie-Kalgoorlie Metamorphics are described below. Within the group, minor occurrences of one unit in another have been noted. They are separated on the geological sheet only where permitted by scale and continuity of outcrop. Soil-covered areas, or areas in which underlying metamorphic units cannot be reasonably inferred, are shown as undifferentiated.

The unit subdivisions as delineated on the geological sheet are as follows :

Fine-grained Amphibolites and Associated Basic Schists

The fine-grained amphibolites are mainly altered basic volcanic rocks. These appear as an assortment of hard, green to black rocks generally recrystallised into aggregates of shredded pale green amphibolite with plagioclase relics. They include schistose or massive, blocky, fine to coarse-grained amphibolites, some of which still retain their original porphyritic, agglomeratic, variolitic, amygdaloidal and pillow lava fabric. Many of the alignments of amygdules represent pillow margins, and their vesicles are commonly filled with quartz, calcite, or magma residues.

The prevalence of albitisation, and general association with chemically precipitated sediments (banded cherts, dolomitic rocks) is suggestive of a dominantly sub-marine extrusive volcanic suite of general spilitic character.

Fine to coarse-grained basic schists are associated with the altered volcanics. They are almost entirely composed of oriented fibrous masses of pale green tremolite-actinolite needles and are believed to be altered tuffs interbedded with thin bands of basic lavas and sediments. Other layered and laminated amphibolites are interpreted as metamorphosed dolomitic sediments.

Coarse-grained Amphibolites

These rocks are referred to in the literature as the "Younger Greenstones". They are usually dark green, medium to coarse-grained amphibolites, generally massive and blocky but may be schistose locally. Miles (1946) describes some rocks of this suite from the Tindal's locality (just north of this sheet) and suggests that they are hypabyssal rocks derived from the same basic magma as the volcanics of the area. Various authors have referred to similar rocks from adjacent areas as amphibolites, epidiorites, uralitised dolerites, quartz dolerites and meta-gabbros.

These coarse-grained amphibolites are frequently associated, and generally concordant, with the folded volcanic rocks. They are tentatively considered to be pre-metamorphic sills or laccoliths, intrusive into the volcanics and part of the same basic-igneous pile.

Ultrabasic Rocks

The ultrabasic belts include a range of grey, green to black, fine to coarse-grained, massive, blocky or schistose talc, tremolite-actinolite and serpentine rocks. Thin members of chlorite, anthophyllite, fuchsite, phlogopite, uralite, pyroxenite and carbonate schists also occur.

Many of the serpentinous rocks are believed to be altered pyroxenite and peridotite sills or flows. Some varieties contain fine vermiculite grains or small limonitic pseudomorphs after carbonate minerals. These minerals are generally decomposed or etched-out to give the rock a rusty-brown spotting or a characteristic pitting. Other ultrabasic rocks exhibit a network of fine, short sets of talc-tremolite-actinolite laminations, and are locally termed "spinifex rocks". Some

of the more massive blocky or foliated forms closely resemble the amphibolites of the preceding units and may represent further modifications or differentiates of the same basic-igneous magma.

McMath (1953) and Prider (1961) consider that some of the ultrabasic rocks are of dolomitic origin or have resulted from the metamorphism of rocks that have contained magnesia and silica. The presence of calc-silicate rocks, impure dolomites, limestones, marbles, and calcareous sandstones in some of the comparatively unmetamorphosed parts of ultrabasic belts suggests that many of the ultrabasic rocks are metamorphosed calcareous sediments.

Alteration or decomposition products, usually associated with the ultrabasic rocks, include vuggy opaline silica, magnesite, ankerite and calcite. These appear locally as surface crustings, coatings, or in pods, and as secondary veins developed along schistosity or joint partings. Thin cross-cutting talc shear zones are present but rare.

In general, the ultrabasic rocks of sedimentary origin that are associated with metavolcanic rocks appear to be the most favoured host rocks for gold in the Coolgardie District.

METASEDIMENTARY ROCKS

Rocks of sedimentary origin occur as facies variants or minor interbedded intercalations in the amphibolite and ultrabasic belts. These are dominantly of chemically precipitated sediments and include dolomitic rocks and jaspilitic cherts. Minor clastic and pyroclastic sediments are developed locally as discontinuous members.

Broader metasedimentary members appear as rapidly alternating successions of thin-bedded rocks that show considerable sedimentary and metamorphic variations across and along strike. They are dominantly clastic rocks and include phyllites, mica schist, graphite schist, garnet schist, andalusite schist, cherts, calc-silicates, sandstones, quartzites, greywackes and conglomerates.

The broader belts are often deeply weathered and large areas of the lateritic profile are still intact. The pelitic rocks usually contain secondary quartz segregations and veinlets along bedding or jointing planes and, where dissected, give rise to extensive surface veneers of angular quartz rubble. Other kaolinised rocks containing gritty quartz are believed to be arkoses and pelitic tuffs. The clastic sediments are generally devoid of mineralisation but may contain minor amounts of gold where associated with shearing and with acid igneous emplacements.

ACID-IGNEOUS ROCKS

The acid-igneous rocks include albite porphyries, granites, gneisses and minor acid-igneous dykes. The units distinguished on the Boorabbin Sheet area are as follows :

Porphyries

Major bodies of quartz-albite porphyry appear within the metamorphic rocks. They are regarded as intrusive sills that predate the folding. Minor

intrusive porphyries which post-date the folding also occur. The production of minor porphyrites as well as a selective albitisation of country rocks is attributed to metasomatism associated with porphyry intrusion. Some porphyrites and porphyries of the Kalgoorlie and Coolgardie areas have been reported on by Prider (1942) and by Gray and Ward (1953) respectively.

Porphyry development and selective albitisation of country rocks are particularly prominent about abandoned gold mining centres. A porphyry-gold association and a genetic relationship between porphyry and granite appears to exist (Sofoulis and Bock, 1962a).

GRANITIC ROCKS

These are the most widespread rocks of the Boorabbin Sheet area. They include granites, gneisses and minor associated acid dykes (quartz, aplite, and pegmatite). The granitic rocks are grouped on the compilation as "internal granites" or "external granites", depending on their mode of emplacement. Their mutual age relationship is not known.

The "internal granites" form separate masses and are emplaced within the metamorphic belts. These are believed to be the "mineralising granites".

Internal Granites : The major masses are the Coolgardie Granite, the Bali Granite and the Horse Rocks Granite. The last named mass appears in the same stratigraphic position as a granodiorite body defined by McMath (1953) as the Mungari Granite. Other granite masses of a generally similar character are also known in the Larkinvile-Widgiemooltha area.

In detail the internal granites show intrusive relationships and are, at regional scale, basically concordant and mainly confined to anticlinal parts of sedimentary units (whitestones).

Minor granites are developed in other parts of the metamorphic areas. McMath (1953) has referred to two of these masses as the East Gibraltar Granite and the South Grosmont Granite. Restricted granite pods are also known in the Londonderry district, at Hampton Location 59, and in the areas marginal to some of the larger granite masses. Some of the pods are porphyritic and contain albite phenocrysts, thus supporting the genetic relationship between granite and porphyry. The pods are believed to be local apophyses of the larger masses.

External Granites : Granitic rocks that occupy the remainder of the Boorabbin Sheet area outside the metamorphic belts are referred to as "external granites". On the geologic sheet these are grouped as undifferentiated granites and gneisses. In these areas, the external granites are dominantly gneissic, the common form being a grey, fine to coarse-grained, gneissic, biotite-microcline granite with chlorite and muscovite locally replacing the biotite.

The trunk drainages in the western part of the sheet area are believed to outline a major domal mass (see Fig. 2). Elsewhere, some of the recorded

foliation swirls and pronounced gneissic zones may represent independent granite bodies or margins of other masses.

Minor Acid Dykes

A network of thin quartz dykes, aplites, and pegmatites of various ages are associated with most of the granites and are particularly numerous in areas of gneissic-granite. They have not been mapped. The large pegmatite dykes of complex mineralisation (lithium-bearing pegmatites) are restricted to the basic and ultrabasic rocks and are marginal to the internal granites.

PROTEROZOIC

DUNDAS DYKE SUITE

East-north-east trending quartz dolerite dykes, vertical or dipping steeply southwards, cut the Archaean rocks in the Larkinville-Widgiemooltha area. These dykes carry hypersthene locally and include gabbro, norite and pyroxenite equivalents. A major dyke of the suite is distinguished in the southern part of the Boorabbin Sheet east of the Bremer Range Metamorphics. This dyke is traceable over a distance of 30 miles to the eastern sheet margin and would link with a major occurrence known along the north edge of Lake Cowan and described by Hooper (1959) as the Murdunna Gabbro.

The norite dyke known at Norseman and other similar east-north-east trending dykes cutting other parts of this and adjacent areas are believed to be part of the same suite and to form a major tectonic trend in the southern part of this Archaean block. The dykes have been grouped as the Dundas Dyke Suite (Sofoulis and Bock, 1962a) and their intrusion may be related to a Lower Proterozoic orogeny.

CAINOZOIC

The units classified as Cainozoic are mainly superficial deposits of continental origin. The older units originated in extensive peneplanation and deep weathering during the Tertiary Period. These units make up a lateritic profile and define an older erosion cycle. They include sandy or lateritic sandplains (or gravel plains) overlying lateritic duricrust and kaolinised bedrock. Other superficial and lacustrine deposits are related to present landscape evolution and development of drainage since Tertiary times.

The Cainozoic units include :

Lateritic Weathering Crusts

The weathering crusts form part of the "pan-Australian duricrust" of Woolnough (1927) developed during Tertiary times. Principal exposures occur along the sandplain margins where stripping has exposed pisolitic ironstone gravels, cements, and cavernous crusts above weathered granitic and metamorphic rocks. These can appear as massive ironstone cappings, pisolitic gravels, siliceous, magnesitic, and calcareous veneers or cements, which form duricrusts above pallid

kaolinised zones of variable depth. The weathering crusts are usually less than 5 feet thick but in some places attain a thickness up to 10 feet.

Sandplains

Residual sandplains of the old plateau are characterised by deep yellow to brown, sandy or gravelly (lateritic) soils. These are up to 50 feet thick and are mainly developed over granitic terrains. Some local transportation of material has occurred about the sandplain margins but in general the sandy and gravelly soils of the present plains are in situ and fixed by a characteristic vegetation of heath and low scrub.

Red sandy soils are as typical of the metamorphic rocks as the sandplains of granitic terrains. These red soils contain hematitic grains as a fine constituent and generally show a heavy surface veneer of hematitic pisolites. They are finer in texture and contain a higher clay content than the granitic sandplains and are similarly underlain by a lateritic layer.

Other types of sandplain occur in restricted forms along alluvial valley floors. These appear as surface accumulations of red or bleached-white sands transported by wind and water action. Red or bleached-yellow-white aeolian sands are also general about the east and south-east lake margins where they form dunes. These transported sands are unrelated to the lateritic profile and are comparatively recent in origin.

Eluvial Soils

Eluvial soils form part of the new plateau and the headwater and interfluvial areas below the stripped sandplains. They consist of broad areas of brown-red sandy loam on which lie surface veneers of granitic weathering products. These products include kaolinised to fresh granite, ferruginous and mottled fragments, calcareous nodules and local saline encrustations. Calcareous subsoils are extensively developed in the lower drainage sectors.

The eluvial areas contain groups, or isolated masses, of granite rocks locally fringed by run-off aprons or accumulations of gritty soils. Some of these gritty soils fill depressions in the granite surfaces and provide the sources of good shallow water (e.g. Gnarlbine Soaks, Yerdanie Well). The eluvial soils pass transitionally into the alluvial soils described below.

Alluvial Soils

Fine textured, red-brown, sandy loams, with a well defined powdery or nodular lime subsoil, occupy valley floors. The valley floors range from one half to two miles in width, but may broaden to four miles in the trunk valleys. The lime subsoil is extensively exposed in breakaway sections of the west and north-west lake margins where thicknesses of up to 30 feet can be observed. This calcareous zone is generally underlain by 1 to 4 feet of gritty ferruginous cement which may form lake shore platforms or low side benches (up to 10 feet above the lake floor) as cappings to pallid basement rocks.

Lacustrine Deposits

The saline encrustations, gypsiferous or sandy banks and lunettes associated with salt lakes have been noted under Physiography. The lake floors themselves generally contain up to 3 feet of saline alluvium overlying saline alunitic and kaolinitic clay and mud deposits of variable depth.

Boring outside the sheet area on part of the easterly draining system of the north-east sector revealed some four hundred feet of sedimentary fill of Upper Eocene or Lower Oligocene age (Balme and Churchill, 1959). In other instances, basement rocks are at subsurface or locally form low shore platforms, or crop out as lake islands.

STRUCTURE

PRECAMBRIAN

A structural map of the Boorabbin Sheet area is shown in Fig. 2. This is purely a tentative interpretation and is subject to alteration as further information becomes available from mapping adjoining sheets. Most of the structural information was obtained from the metamorphic belts of the north-east corner of the sheet area.

FOLDING

The metamorphic belts locally show intricate and strong isoclinal folding, some of which may be overturned. Some of the metamorphic belts mapped along the northern sheet margin may be repeated in the sequence by folding. The regional fold axes of the metamorphic belts as shown on the structure map (Fig. 2) are broadly oriented north-north-west but local arcuations occur. These arcuations reflect the foliation patterns of the granitic rocks and the trends of the flanking metamorphic belts. They are attributed to cross or echelon folding and possibly to faulting. In the metamorphic rocks of the Coolgardie region (includes part of this Sheet), the crossfold axes are oriented along north-east lines. McMath (1953) considers that major gold producing centres of this area are localised at such crossfold axes and that mineralisation has favoured the anticlinal crossfolds more than the synclinal crossfolds.

FOLIATION AND GNEISSIC BANDING

The regional schistosity in the metamorphic rocks is generally of north-north-west trend and conforms with the regional trend of the metamorphic belts. Those schistositities recorded in the metamorphic rocks adjacent to internal granite emplacements usually dip away from the granite. Amphibolites that show mineral alignments are believed to be of sedimentary origin and their banding is believed to reflect bedding.

Banding and mineral alignments in the internal granites generally conform to the domal shape of the mass itself. Some alignments are of flow origin while others, in peripheral areas, might be attributed to relic bedding.

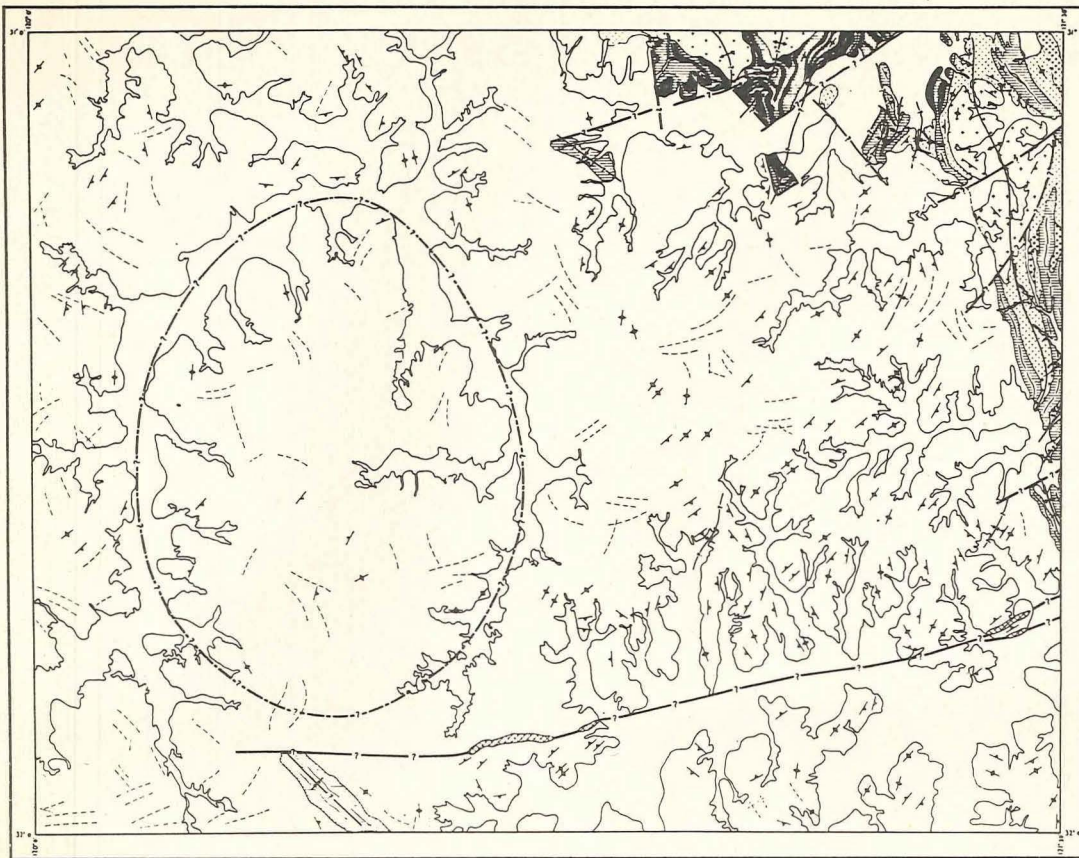
















FIG. 2.

STRUCTURAL SKETCH MAP BOORABBIN SHEET SH/51-13

10 0 10 20
SCALE OF MILES

REFERENCE

-  DOLERITE DYKE
-  INTERNAL GRANITE
-  PORPHYRY
-  UNDIFFERENTIATED GRANITE ROCKS
-  METASEDIMENTARY ROCKS
(WHITESTONES)
-  BASIC & ULTRABASIC ROCKS
(GREENSTONES)
-  TREND LINES
-  FOLIATION WITH DIP
-  VERTICAL FOLIATION
-  INFERRED FAULTS
-  INFERRED ANTICLINE
-  INFERRED SYNCLINE
-  SANDPLAIN LINEAMENT
-  SUGGESTED GRANITE DOME

The sheet dip of foliation in the external granites of the south-east part of the sheet is steep. The foliations strike north-east. They are deflected to a more pronounced northerly trend where adjacent to the metamorphic belts and thus form broad arcs. The pattern of dissection and outcrop shapes follow this regional trend. In detail, the structural observations show deviations and local swirls.

FAULTING

Major faults affecting the metamorphic and granitic areas are difficult to establish as they are not recognised on the ground. Strike faults in the metamorphics are believed to be general. Some abrupt terminations of metamorphic belts along particular lines and the presence of isolated and angular greenstone islands suggest a pattern of block faulting.

Some major faults proposed are indicated on the structural map. These follow a general north-east trend and, along the eastern sheet margin, appear to displace the metamorphic belts in a right handed pattern. This displacement could also be due to cross or echelon folding in the manner suggested by Campbell (1958). Complementary faults along north-west lines and a few faults mainly of northerly trend are also inferred. The basic dykes of east-north-east trend (Dundas Dyke Suite) are believed to be fault-fissure fillings.

CAINOZOIC

The Cainozoic units are not folded. Their nature and distribution locally serve to delineate geological boundaries or hidden structural features in the underlying basement.

SANDPLAIN LINEAMENTS

Lineaments on the sandplains overlying external granitic terrains appear in air photos as thin but prominent vegetation lines. They are particularly prominent in burnt sandplain country, where they are revealed as minor vegetated drainage features or as sub-parallel or radiating, vegetated lines.

The vegetation lineaments are active growths or regeneration of vegetation, overlying water supplied by drainage or by major partings (possibly faults or joints) in the underlying granitic rocks.

Below the southern margin of the sheet boundary (west of the Bremer Range Metamorphics), some sandplain lineaments are traceable as continuous lines to 20 miles long.

ECONOMIC GEOLOGY

INTRODUCTION

Gold has been the principal economic mineral recovered from the Boorabbin Sheet area. Other minerals of potential economic interest, pyrite, arsenopyrite, galena, blende, bismuth, and some copper ores, are associated with the gold ores,

but have not so far been found in sufficient quantity to be worked. Production of silver (as a constituent of the bullion) and scheelite has also been recorded. Microcline, petalite, beryl and other associated pegmatite minerals are mined currently in the Londonderry area.

Within the sheet limits, all of the metallic and pegmatitic minerals have been produced exclusively from the metamorphic rocks of the Coolgardie district. Traces of gold are reported from the Bremer Range Metamorphics but no production has been recorded.

Magnesite, clays and road-making and building materials have been mined sporadically in the Coolgardie area. Gypsum, salt, refractory minerals, asbestos, vermiculite, alunite and kaolinitic clays, sands, loams and lime gravels are known within the Boorabbin Sheet area. Either they do not meet industrial standards or they are too remote from the populated areas to be of any present economic significance.

Parts of the area are utilised for pastoral and forestry (mining timber) purposes. Future pastoral expansion would be dependent on the availability of suitable domestic and stock waters. The average rainfall of the region is low (10 to 12 inches per annum) and most available groundwaters are saline. Present water sources (mainly earth dams) are restricted to developed pastoral holdings. Granite catchments, rock dams and shallow soaks are known in some of the uninhabited areas. The Goldfields Water Supply pipelines follow the main highways and provide water where required en route.

GOLD

MINERALISATION

The metamorphic rocks form the potentially auriferous belts of the region. Some aspects of the gold distribution within the Coolgardie-Kalgoorlie Metamorphics are listed below. These have been deduced from the distribution of workings within the area investigated and from underground information given in the literature.

1. Gold mineralisation is generally restricted to the metamorphic rocks marginal to the internal granites and is comparatively absent in the metamorphic rocks adjacent to external granitic terrains.
2. Economic ore bodies are mainly associated with quartz in the form of reefs, veins, or lodes, and with albite porphyry intrusions.
3. The favourable structural locations are the complexly folded areas that show strong shearing, faulting and acid-igneous intrusions.
4. Mineralised shear or fault lines are common.
5. Anticlinal crossfold areas have been more favourable for gold mineralisation than the synclinal crossfold areas.

6. Ultrabasic rocks and particularly the ultrabasics of sedimentary origin that are associated with volcanic rocks are the most favoured host rocks for gold.

7. The intense metasomatic activity (carbonatisation) associated with the ore bodies of the "Golden Mile" at Kalgoorlie is not in evidence in this area.

These aspects suggest that the economic gold occurrences and their distribution within the Boorabbin Sheet area are related to the following controls :

1. Acid igneous activity (internal granite emplacements, quartz and albite porphyry dykes).
2. Lithology (ultrabasic rocks of sedimentary origin associated with volcanic rocks).
3. Structure (folding, shearing and faulting).

Alluvial gold won from the area has generally been associated with minor drainage lines or slopes adjacent to known areas of gold mineralisation.

MINING

Gold mining within the Boorabbin Sheet area is now at a standstill. Several of the old major producing mines are still held under existing leases but are no longer operative. General activities have been mainly restricted to week-end prospecting and the small gold productions which have been recorded in post-war years were derived principally from shallow gougings in and about old workings. The nearest active gold producer is Bayley's Mine at Coolgardie. This is the only surviving company-operated mine in the district. Battery facilities (10 stamp) and cyanidation plant for crushing and treating public ores are available at the State Battery at Coolgardie.

In the productive years, mining centres were established within the area at Bullabulling, Burbanks, Gibraltar, Gnarlbine, Hampton Plains, Logans, Larkinville, Londonderry and Wannaway. Reports on most of these mining groups are given in Gray and Ward (1953). Feldtmann (1922, 1925, 1935) has reported on Gibraltar and Larkinville centres. Other reports on local examinations of individual leases or holdings are listed in the bibliography.

Over most of the productive areas, mining was confined to depths of less than 200 feet or was terminated once the water table or bottom of the zone of oxidation was reached. Deeper workings in the area were located at Burbanks (800 feet vertical depth), Londonderry (800 feet v.d.), Tindals (600 feet v.d.), Nepean (600 feet v.d.), and Spargo's Rewards (450 feet v.d.).

Total gold production for the various mining centres of the area is given in Table 2. Production figures for leases within the area are available from the Mines Statistical Branch. Individual mine productions to December 1948 are already recorded in Geol. Surv. Bulletin 107 in the appropriate Mining Group reports (Gray and Ward, 1953). Production figures since this date are negligible but are available from the Mines Statistician.

TABLE 2. — TOTAL GOLD PRODUCTION OF AREA TO DECEMBER, 1961

<i>Mining Centre</i>	<i>Alluvial Fine ozs.</i>	<i>Dollied and specimen. Fine ozs.</i>	<i>Ore treated Long tons</i>	<i>Gold from treated ore. Fine ozs.</i>	<i>Silver Fine ozs.</i>
Bullabulling	5.21	15.98	3,533.82	1,843.08	—
Burbanks	69.95	874.53	437,563.46	315,599.84	521.12
Gibraltar	1.39	84.73	42,831.23	21,691.27	—
Gnarlbine	—	18.85	3,917.85	1,845.78	—
Hampton Plains *	4.19	618.39	294,339.96	154,865.35	29,872.36
Larkinville †	22.77	201.64	2,825.69	4,289.68	—
Logans ‡	6.88	140.04	108,733.16	27,863.88	—
Londonderry	16.68	173.70	38,347.02	24,918.72	22.77

* Portion only falls within Boorabbin Sheet.

† Site of "Golden Eagle" nugget find.

‡ Includes Spargoville.

OTHER MINERALS

PEGMATITE MINERALS

The principal pegmatite developments that occur within the region are at Londonderry, Grosmont, Ubini, Tantalite Hill, Gibraltar, Mt. Marion, Larkinville, and Spargoville. Reports on some of the main occurrences have been given by Wilson (1928), Förman (1937), Ellis (1944), Miles (1944), de la Hunty (1953) and Tomich (1956).

The minerals produced have included felspar (microcline and albite), lepidolite, beryl, columbite, petalite, amblygonite, spodumene, topaz and mica.

The only quarries still working are located at Londonderry, where approximately 2,000 tons of felspar is produced annually. Other pegmatitic minerals recovered from these quarries (beryl, columbite, lepidolite) are stock-piled and periodically a parcel is sold. Petalite in large tonnages is also available from the Londonderry quarry but is only mined when required.

The only available statistics of production of pegmatitic minerals, as recorded by the Mines Statistician for the Coolgardie District are as follows :

TABLE 3. — TOTAL PRODUCTION OF PEGMATITIC MINERALS TO DECEMBER 1961

<i>Mineral</i>	<i>Long Tons</i>	<i>Realised Value £A. as sold</i>
Felspar	62,098.80	207,130
Beryl	243.09	31,327
Tantalo-Columbite	8.55	14,118
Petalite	183.96	823

MAGNESITE

A total production of 2,789.37 tons of magnesite valued at £7,534 has been recorded from the Coolgardie district. This production has mainly been derived by scraping surface cements or by mining shallow magnesite pods associated with the ultrabasic belts (McMath, 1953).

SCHEELITE

Scheelite has been recovered from the area, mainly as a by-product to gold mining. To December 1959, the total production is recorded as 24.30 tons of concentrate valued at £8,479, this production coming principally from the Bayley's group of leases and Hampton Block 59 (Miles, 1944).

PRASE (Green Chalcedony)

Connolly (1960) reported upon the occurrence of this mineral in the Spargoville locality. A reputed production of 11 tons is believed to have been used for ornamental or specimen purposes.

HALLOYSITE

Recent geological investigations on this sheet (Sofoulis and Bock, 1962b) revealed a halloysite clay in a lake floor 26 miles north of Boorabbin. Similar clay occurrences could be expected in adjacent lakes of this vicinity, particularly where associated with metamorphic belts.

OTHER CLAYS

No production figures are recorded but a brickworks which once operated at Coolgardie utilised local materials. Other alunite and kaolinite clays, as well as spicular muds, all associated with some salt lakes of this region, are too remote to be of any present economic significance.

ROAD AND BUILDING MATERIALS

Numerous small quarries have been developed along the major highway and railway routes and have provided the sources of road surfacing and railway ballasting materials. Principal materials utilised have been the lateritic gravels of the stripped sandplains and the nodular lime gravels of alluvial drainage areas.

A rock quarry for supplying metal for highway surfacing and railway ballasting has been developed in the granitic rocks at Boorabbin. Some slaty rocks and pallid granitic materials have been used locally for paving and building purposes.

LAND USE

In addition to restricted mining activity, the area is utilised in part for pastoral (sheep) and forestry (mining and timber, fuel) purposes. The accompanying map would serve immediately as a basis for further developments in these pursuits, as well as provide a useful guide to future hydrological, pedological, ecological and allied land research studies.

PASTORAL

Pastoral activities are confined mainly to the areas underlain by metamorphic rocks. Properties adjacent to the sheet area are usually planned on the basis of 20 acres per sheep with the present holdings of Coolgardie District ranging up to 100,000 acres or more in size.

Lateritic sandplain soils west of the Coolgardie-Norseman road are of low inherent fertility and have not been utilised to any degree. The major trunk valleys containing the salt lake chains and the metamorphic terrains of the Bremer Range country may be of some pastoral use if watering points are available.

FORESTRY

Areas which have been cut for mining timber and fuel purposes are located in the metamorphic and granitic terrains, and principally in the trunk and tributary alluvial valleys. These areas have yielded good supplies of salmon gum, ribbon gum, grey gum, gimlet and boree. Blackbutt varieties, which have also been cut, are confined to the metamorphic terrains.

Old cutting areas were served by the network of woodlines shown on the map. All lines have since been removed but their paths are still recognisable and useful for purposes of navigation and access. Current wood cutting activities under licence are now confined to the alluvial valleys of the central portion of the area.

WATER SUPPLIES

Contour drains, rock walls and marginal dams have been constructed on or adjacent to some granite masses. These constitute valuable catchment areas which have in the past provided useful water for railway, woodline, pastoral and domestic purposes (Burra Rocks, Cave Hill, Woolgangie, Bullabulling). In the more remote areas, depressions in granitic rocks and their marginal gritty soils have provided catchments and shallow soaks that serve as good sources of potable water (Thursday Rock, Diamond Rock, Gnarlbine, etc.).

Stock waters for the pastoral industry are provided by a few scattered wells and bores but the main sources are from excavated dams located along drainage channels or alluvial floors. Small sidings, centres and pastoral properties established along the major routes are served by the Goldfields Water Supply pipelines. Some domestic waters are also provided from roof catchment.

Groundwater levels within the mining areas range from 50 feet to two hundred feet but the available waters are mostly saline. Ellis (1936) has reported on the domestic and battery water supplies of the Spargoville and Logan's Find localities. In the past, some useful supplies were provided by small catchments, dams and/or rock holes. Other bulk supplies were obtained from adjacent granite catchments or were carted from the nearest pipeline stand-pipe.

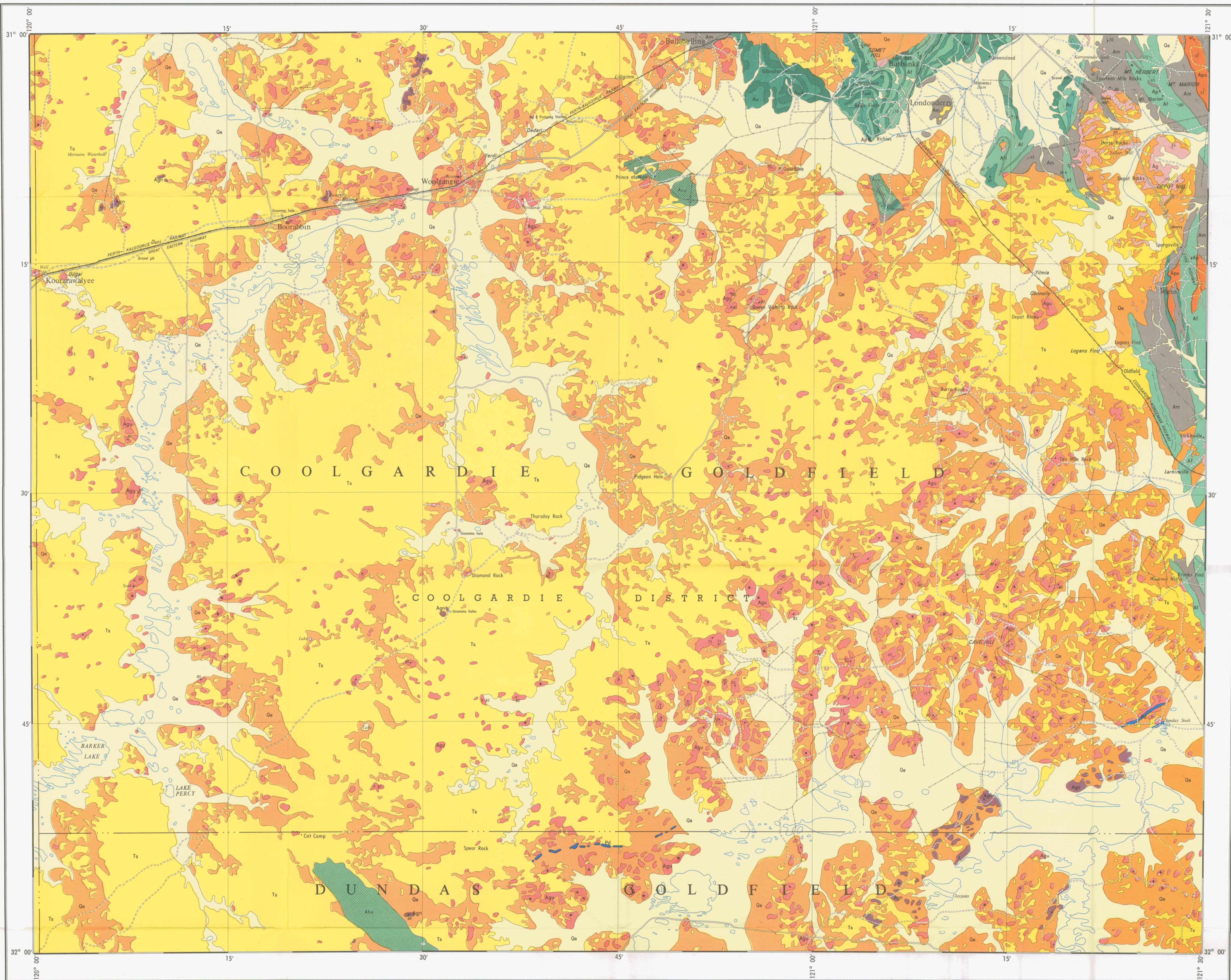
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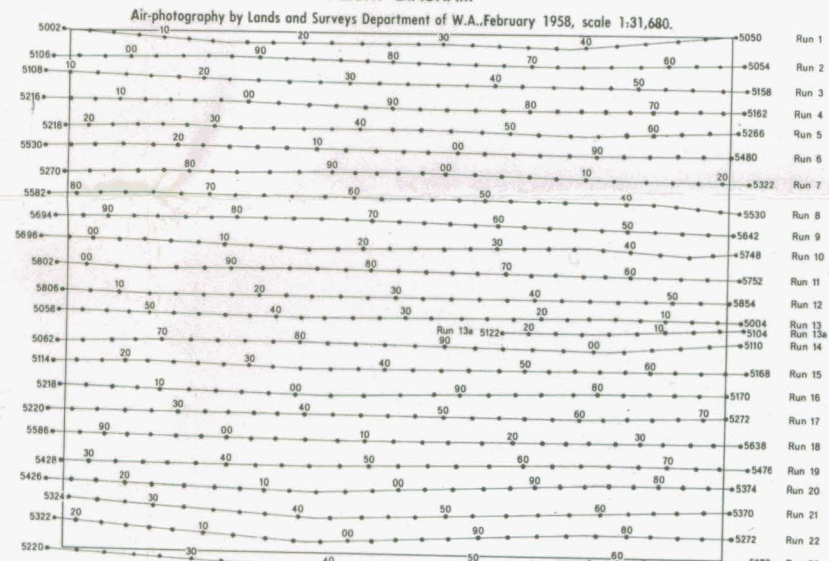
REFERENCE

- QUATERNARY**
- Qa Alluvium. Red sandy loam usually with a calcareous subsoil. Local sandy veneers.
 - Qe Granite Eluvium. Red heavy soils, gritty with granitic fragments. Calcareous subsoil in lower valley sectors.
 - Ts Residual Sandstones. Red, yellow and brown sandy lateritic soils. Ferruginous granitic veneers.
- PROTEROZOIC**
- Dundas Dyke Suite
 - Pd Basic Dykes. Quartz dykes, locally hypersthene-bearing. Includes gabros, norites and perovskite differentiates.
 - Agv Undifferentiated Granites and Gneisses. "General Granite". Generally granitic in character; would probably include younger granite emplacements.
 - Ag Granite. "General Granite". Major masses include Hare Rocks Granite, Bull Granite, Gungahlin Granite. Minor granite pods.
 - Ap Little Pegmatites.
 - Agp Porphyries. Porphyritic granites, generally in regions of concordance. Mostly in minor, extensive dikes. Also include zones of extensive peripheralization of country rocks.
- ARCHAEOZOIC**
- Am Metasediments. Thickly bedded, argillaceous, granitic, micaceous, and gneissic (schists) and siliceous rocks that range in texture from argillaceous to porphyritic. Includes Koorawalyce formation equivalents where present. This radiolite band.
 - Au Tremolite, Actinolite and Serpentine Rocks. Locally altered to talc, chlorite, and amphibolite. Perovskite and spineliferous. All believed to be mostly altered siliceous rocks. This development of talciferous schists and siliceous sediments.
 - Ad Metadiorites.
 - Ac Coarse Grained Amphibolites. Porphyritic, argillaceous, micaceous and gabbros. Commonly known as "Younger Greenstones".
 - Al Fine Grained Amphibolites. Metasedimentary, micaceous, and gabbros, perovskite, talc, amphibolite, argillaceous, and porphyritic textures, pillow structures. Includes this band of best siliceous, siliceous rocks and other altered sediments.
 - Alc Porphyritic Basic Lava.
 - Alu Undifferentiated Metamorphic Rocks. Mostly well crystallized. Lithology probably similar to above metamorphic groups.
 - Brm Undifferentiated Metamorphic Rocks. Mostly well crystallized. Lithology probably similar to above metamorphic groups.

SYMBOLS

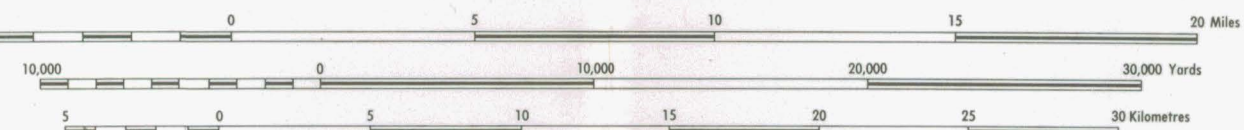
- Geological boundaries**
- Bedding
 - Strike and dip
 - Vertical
 - Foliation
 - Strike and dip
 - Vertical
 - Location
 - Direction and plunge
 - Cleavage
 - Strike and dip of schistosity
 - Vertical schistosity
 - Trend lines
- Geological features**
- Geological boundary
 - Highway
 - Formed road
 - Track
 - Railway with station
 - Telegraph line
 - Mining area
 - Landmark feature
 - Well
 - Soak
 - Lake
 - River or stream

FLIGHT DIAGRAM



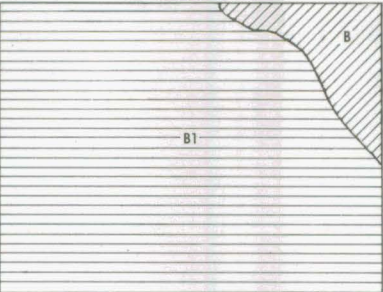
HON. A. T. GIBSON, M.L.C.
MINISTER FOR MINES
J. H. LLOYD GOVERNMENT GEOLOGIST

SCALE 1: 250,000



TRANSVERSE MERCATOR PROJECTION

RELIABILITY DIAGRAM



8 Detailed mapping
81 Traverses with air photo interpretation

DECLINATION DIAGRAM



Annual change is 02° easterly

BOORABBIN
SHEET SH 51-13

FIRST EDITION 1963
REPRINTED 1969



INDEX TO ADJOINING SHEETS

JACKSON SH 51-12	KALGOORLIE SH 51-9	KURNALLI SH 51-10
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HYDEN SH 51-4	LAKE JOHNSON SH 51-1	NOISEMAN SH 51-2

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Copies of this map may be obtained in Perth from the Geological Survey of Western Australia or the Bureau of Mineral Resources, Geology and Geophysics in Canberra, A.C.T.