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# REPORT ON MONARTO-SUMMERFIELD AREA

## SUMMARY.

The following conclusions can be drawn from the investigation of the broader features of the area.

(1) The area of low-grade schists has been developed by the metamorphism of arenaceous material which was originally deposited in a geosyncline. The east limb of the fold shows approximately 20,000 feet of sediments.

(2) The age of the rocks is not known, but the presence of grits and the ilmenitic rocks indicates the base of the Adelaide (Proterozoic) series.

(3) A compressional couple acting in an east-west direction produced major folding and small-scale faulting associated with it. There is no complex folding.

(4) Tertiary block-faulting (Kosiuskan period of Orogeny) produced an upthrust block of old rocks on the west side of the area, while Tertiary beds constitute the Murray Plains in the east.

(5) There are no important centres of mining and the prospects for future development are not convincing. The cost of exploration is not warranted by the nature of the mineralization.

# MONARTO - SUMMERFIELD AREA

## I. Location and Physiography.

The area covers 70 square miles of country, and is situated 10 miles west north west of Murray Bridge. The northern and southern boundaries are east-west lines just north of Summerfield and south of Monarto respectively. The Monarto-Sedan railway line approximates the eastern boundary, while the western side is bounded by a north-south line through the Preamimma mine. See Figure.

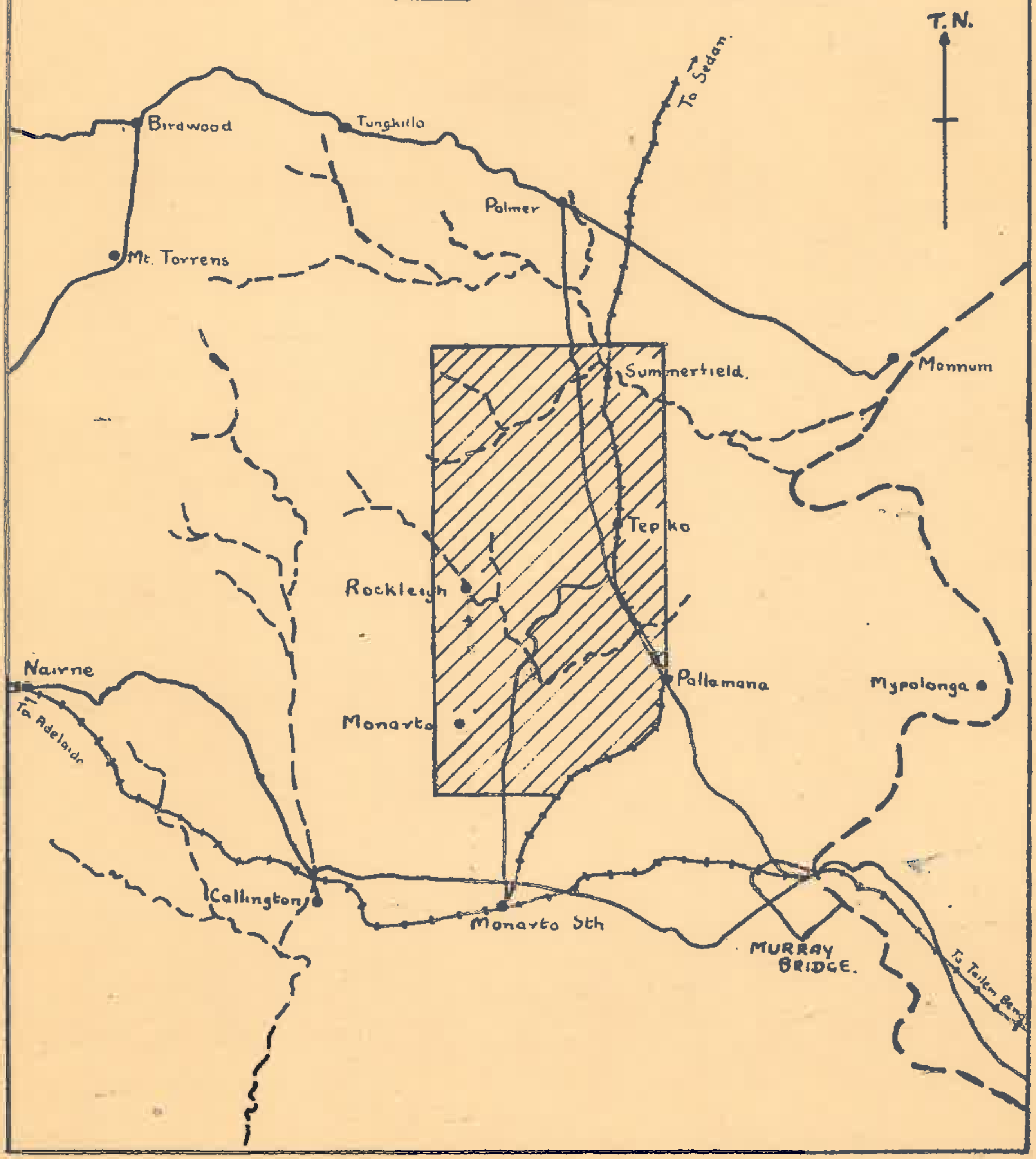
A major fault scarp, trending approximately parallel to the Murray Bridge - Palmer road, divides the area into two topographic sections. The Murray Plains, to the east of this line, change from a flat, featureless plain in the south, to gently undulating country near Summerfield. West of the scarp the hills rise steeply to an average elevation of 800 feet. The highest point of the area is in the extreme north-west corner, and this has an elevation of 1060 feet. The trend of the country is to a greater elevation in the range of hills east of the Bremer River.

There are three main creeks in the area; Gorge Creek, Salt Creek and Preamimma Creek. These flow in a west-east direction and are fed by numerous small tributaries from the higher hills in the west. This drainage pattern differs from the usual north-south network and represents small scale river capture by the creeks flowing towards the Murray River.

The Murray Plains are ideal agricultural land, but in the rugged hills, small mixed farms are found. Monarto, Tepko, Rockleigh, Summerfield and Pallamana are the towns in the area.

# LOCALITY MAP. OF MONARTO - SUMMERFIELD AREA.

SCALE 4 MILES TO THE INCH.



## II. Mapping Methods.

The base map for field work was prepared from aerial photographs by the slotted template method. My thanks are extended to Mr. Nye, of the photogrammetric section of the S.A. Mines Department, for his guidance in this project. The photographs consisted of two sets at different scales, and two base maps were prepared. The northern map has a scale of 1770 feet to the inch, while the southern map has 2800 feet to the inch.

The aerial photographs were used for location in the field. Observations and readings were marked and numbered on a tracing of the photographs. All relevant data were recorded in a field book. The localities were traced from the aerial photograph copy to the fact map. Numerous traverses were made across the area and the structural interpretation was filled in from the photographs.

## III. Lithology and Petrology

### Recent

Alluvium: Large areas of alluvium cover the deposits of Tertiary rocks in the Murray Basin. These extend to the fault scarp and the variable thickness cannot be measured. The central part of the Monarto Valley has a thin mantle of alluvium covering the older schists. In the basin of the Gorge Creek and its tributaries, there is a large area of loosely consolidated material, covered by alluvium. The age of the material mentioned will be discussed under "Economic Geology."

### Tertiary

Limestone.

Only one large area of massive white limestone has been found near Monarto. The material resembles kunkar in the field, but previous investigation has shown it to be fossiliferous. This represents the most western encroachment of the Tertiary seas.

### Proterozoic (Adelaide series)

Quartz-Biotite Schists.

The rocks included in this series constitute the major part of the area. Outcrops are abundant and the bedding can be traced easily. The rock occurs as bands, differing in texture. One band may be hard and compact, while the adjacent layer will have a sandy appearance and will crumble under pressure. The latter will weather easily, and topographically, the compact bands stand out along the strike, separated by detrital material which results from the sandy material. The resistant bands can be traced on the aerial photographs and they show the folding well.

Microscopic examination shows the rock to consist of quartz, biotite and plagioclase. The biotite shows slightly preferred orientation and this accounts for the weak schistose properties of the rock. Evidence of strain, due to folding, is shown in the quartz. Muscovite, Zircon and ilmenite are present in accessory amounts.

Considerable petrological variation can be seen in the rocks mapped within the belt of quartz-biotite schists. Detailed mapping on each band could not be carried out on all bands, but other rock types which occur are:-

(a) Light coloured ferruginous quartzite. A weathered product which has limonite present and all schistose properties obliterated.

(b) Flaggy biotite schists. This rock possesses a well-developed cleavage that is parallel to the bedding.

(c) Massive biotite rock. This is a local alteration produced by the contact metamorphism of pegmatites, dykes or hydrothermal quartz. It resembles a monomineralic rock.

(d) Sericitic quartzite.

A special band, low in the senes of schists, has been mapped in two or three places. By interpolation this band has been drawn on the final map to give some idea of the structure of the area. The rock is a light-coloured quartz-felspar mass with sheafs of grey-green amphibole, probably actinolite or anthophyllite. This has been designated on the maps as Actinolite schist and the boundaries and thickness of the band are hypothetical.

Calcareous Bands.

(a) Upper band.

Variation along the strike is the main feature of this band. A reasonable cross section has been taken in Mitchell Gully near Rockleigh. The basal beds show very little change in texture from the quartz-biotite schists but they have become more calcareous and large porphyroblasts of scapolite can be seen in a microscopic section.

Interbedded with the calcareous schists are quartzite bands. These beds show good drag folding in the outcrops.

Stratigraphically above these beds, there is a thin quartzite band and a band of amphibolite (see later). The top of the series is marked by regularly banded rocks of weathered appearance. The microcrystalline quartz ground mass appears homogeneous, and the strong banding is due to mafic minerals and their weathered products. Limonite, derived from pyrite, is common and unaltered magnetite is also present. Tremolite, staurolite, sericite and kaolin are all important minerals in the constitution of the rock. The bleached rocks of the southern extent of the band are deficient in pyrite but have abundant fresh magnetite. The banded nature is obvious throughout the whole deposit.

(b) Lower band.

These strata can be traced throughout the major folds by their topographic expression. The material does not outcrop, but appears as float in a well-defined barren strip of country. Geological evidence was obtained from quarries in the material, as this rock is valuable as road metal. The calcareous constituents, by solution and reprecipitation, act as a binding material.

These competent beds have intense areas of fracture and gypsum (as selenite) has been reprecipitated as thin veins.

Pronounced banding of the rocks is again an important feature. This micaceous rock is highly coloured due to iron stainings and has staurolite present. Silica is not as abundant as in the upper band. The second important member of this series is a dark grey compact rock without stratification or distinctive minerals. A microscopic section shows that quartz, plagioclase, tremolite, actinolite and diopside are plentiful, while magnetite, pyrite, and arseno-pyrite are important accessories. The mineralization is disseminated throughout the rock and can be seen on the quarry face. The limited extent of the rock and the nature of the mineral disseminations gives a possible igneous origin to this rock; the metamorphism of an intermittent basic flow.

Knotted Schist Band.

These rocks occur stratigraphically below the calcareous bands and separated from the lower band by quartz biotite schists. They exhibit fairly constant characteristics on the east limb of the syncline but show a marked increase in thickness in the southern part of the east limb.

Topographically, the bed is covered with a thin mantle of soil and very few outcrops are seen except in creek beds and road cuttings. Unlike the calcareous bands, this material is easily eroded and low-lying valleys result.

The rock is a fine-grained, high grade biotite schist with large knots of andalusite and staurolite. A crenulate biotite schist occurs with the knotted schists and has been mapped as such. A typical, complete cross-section has not been obtained in any area, so the presence of other rock types of the west limb cannot be confirmed.

This band is extremely favourable to the injection of pegmatites and quartz veins. Residual liquors from the crystallization of the Monarto granite have forced up along the bedding planes of the knotted schists and consolidated to form sills.

Near Rockleigh Post Office, a large area of quartz-biotite schists has been mapped as a lens-like formation within the knotted schists.

Monarto Granite

In the area between Monarto and Pallamana, flat rounded outcrops of granite are common. The northern boundary has been mapped as accurately as the outcrops permit, the contact being observed in two places. The southern boundary occurs several miles south of this area, and it has been mapped by R.K. Johns and J.M. Kruger.

An even, coarse-grained, light coloured rock, the microscopic section shows quartz, microcline, plagioclase and accessory biotite and muscovite. Microcline is the dominant felspar and in the area from which the specimen was taken, the composition of the rock is a granite. Petrographic studies in the abovementioned paper indicates a gradation between granite and adamellite in various parts of the area.

A good contact between the quartz-biotite schists and the granite can be seen in the Preamimma Creek and there is very little evidence of contact metamorphism. The boundaries of the granite tend to parallel the regional strike of the east limb of the fold, although directional tendencies due to mineral formation have not been noted in the granite. East of the granite boundary, rocks which may be described as felspathized arenites occur. These represent the quartz-biotite schists and other arenaceous rocks that have undergone metasomatic changes by the introduction of plagioclase (albite, oligoclase). These have been mapped in the zone of injection gneisses, but probably represent the gradation between the schists and the granite. The above evidence indicates the migmatic origin of the granite.

Injection Gneisses.

A belt of rocks that have undergone considerable metasomatic changes, occurs west of the fault scarp. Accompanying the metasomatic changes, injection of granitic material has taken place, and the resultant rocks are high grade biotite schists and gneisses. That is a general statement, as the variation within the belt produces a number of rock types. The felspathized arenite, as mentioned in the previous heading, and a compact light-green quartzite represent one end-member of a gradational series. Biotite-felspar gneisses represent the other end.

These rocks represent the product of metasomatic changes on the quartz-biotite schists. The most prolific change is felspathization; soda-rich plagioclase resulting.

In the area north of Gorge Creek, bands of almost completely granitized sediments occur between biotite schists. Their maximum width is 20 feet and they represent the southern extension of the Palmer granite. The granitized sediments follow the regional geology, viz. strike 340° dip 40-50° West.

Migmatites.

These rocks have been especially differentiated from the injection gneisses, by their more intense metamorphism. Stratigraphically, they are the oldest rocks of the area and extend east to the "Waterfalls" on Reedy Creek. In this region they are associated with tonalites and other granitic rocks.

Their contorted nature makes structural interpretation difficult, but the regional west dip of the gneissosity (bedding) is apparent. Tight folding and contortion produces areas of east dipping rocks.

Biotite gneisses have been formed by recrystallization and residual material has been intruded as aplite dykes and sills. The aplite contains microcline, oligoclase and quartz.

Grits.

Two outcrops of a white, compact grit occur in the Summerfield area. Consisting of kaolin and quartz, they represent the weathering of a felspathic grit. The two outcrops have comparable strike and dip and are the offset parts of a faulted band (see later). Traces of ilmenite were noted in the outcrops and it is possible that these beds may be associated with the Basal beds of the Adelaide series.

A similar gritty material occurs in a quarry near Mallee Hill Trig Point, but no correllation can be made.

Pegmatites, Quartz.

Outcrops of dykes and bedded veins have been found in many parts of the area and they have been plotted on the fact sheet. Their position on the final map is not warranted.

(a) Quartz. Hydrothermal, milky quartz occurs throughout areas of structural weakness, noticeably near the axis of folds and in the highly contorted area near the nose of the southern syncline. The material is usually barren, but may contain traces of copper and gold.

(b) Pegmatites

(1) Extending from the northern boundary of the Monarto granite, a series of pegmatites have been intruded along the bedding of the knotted schists, especially near the contacts with the more competent quartz-biotite schists. The sills are 2-3 feet wide and the outcrops vary in length from 10-100 feet. The main constituents are quartz, felspar, muscovite and tourmaline.

(2) A light pink, medium-grained pegmatite has been mapped in several places near the fault. It is a sill formation and is parallel to the fault. Microcline, plagioclase and quartz are the main constituents; an absence of mica is characteristic.

(3) Tourmaline is an important constituent of other pegmatites in the area. They are often associated with mineralization e.g. copper-arsenic at Preamimma mine.

Amphibolites.

Field mapping has revealed instances of dykes and sills, but frequently, plugs of this material, having no lateral extension, are found.

The dark-green rock has a schistose appearance, due to parallel alignment of the amphibole during recrystallization under pressure. The amphibole is a pleochroic bluish-green uralite and the abundance of quartz with this mineral indicates that the process of uralitization has been dominant.

Basic plagioclase is more abundant in the fine-grained schistose rock. A dense, compact, coarse-grained rock has been found interbedded with banded material in the upper calcareous band. The rock consists entirely of hornblende(uralite) quartz and apolite and may represent recrystallization of a basic flow. The structural control of these basic dykes and sills cannot be stated.

## IV. STRUCTURAL GEOLOGY.

### Faulting.

#### (a) Palaeozoic??

During the folding of the sediments, minor faulting took place on a dispersed scale. There are no regions of intense faulting. Near Summerfield, the grits have a strike of 340° but following along that direction, migmatites are found near the junction of Gorge Creek and Reedy Creek. The off-set extension of this band outcrops on the Palmer Road, so a fault, strike 250°, and movement north block west, is postulated.

Minor faults show off sets in an amphibolite sill (near wolfram mine) and in the calcareous bands. The latter is accompanied by quartz intrusion and silicification of the surrounding rocks. These faults, striking 250-255°, indicate that this will be a direction of maximum shear.

#### (b) Tertiary.

The older rocks in the western half of the area represent the most easterly block of the upthrust Mount Lofty Ranges. Formed during the Kosiuskan Period of Orogeny in late Tertiary periods, the block is bounded by a distinct strike fault, traversing the entire area. It has a strike of 340° and is almost vertical.

The distinct scarp is the main evidence of faulting. It rises as much as 300 feet above the plains in a short distance, but in other places, especially in the south, the scarp is not pronounced, but is represented by undulating country above the flat plain.

Along the approximate position of the fault (this alone can be mapped) the rocks have a complex fractured AND jointed nature; small faults being visible in hand specimens. Pegmatites and basic dykes are found near the fault, but the latter is not related to the faulting.

Hematite veins are common and these were formed by reprecipitation during the faulting, as they are themselves faulted. Recent alluvium, covering the whole of the Tertiary basin, has concealed any traced of the fault.

Folding.

East-west compression has produced the major folding of the area. The folding is not complex, except on the attenuated west limb of the southern syncline (Tester, 1950).

In the southern area, one main syncline has been developed, with several minor flexures near the nose of the fold. Near Monarto, both limbs of the fold are well developed. On the west limb, the beds strike ~~346~~ 347° and dip 60° EAST while on the east limb they strike 340° and dip 70° west. The west limb is carried to the west of this area by the axial trend of 338° and the east limb of this fold is the major development in the area. Special bands of knotted schists and calcareous material have outlined the structure.

The axis of the syncline has been deflected to a bearing of 30° in the area south-west of Rockleigh, and the fold eventually dies out south of the Mt. Torrens-Tepko road.

A second series of folds are formed east and north of Rockleigh. A broad anticline and narrow syncline are the essential features. Their axes trend 325° and 340° respectively and die out south-east of Rockleigh.

The possible manner in which the two series of folds are connected is not fully understood, as an expression of the latter folding cannot be seen in the calcareous bands or knotted schists. The second series of folds has none of the complex flexures in the nose of the fold as on the southern syncline.

Pitch.

The variation in pitch in the area is considerable. Many methods were available to measure pitch, but the depth of the beds at the nose of the fold was used where possible. Other methods included data from dragfolds, mineral elongation and extension joints.

South of the area, near Monarto, the pitch varies from 30° to 50° in a southerly direction (160°)

(a) near Rockleigh - pitch 30° in a direction 200° (change in axial trend)

(b) 25-30° in a direction 160°. This was measured on the syncline in the north near the Mt. Torrens - Tepko road.

(c) 15-25° in a direction 160°. This was measured near Gorge Creek.

The value of the pitch remains constant over a large area in the north so a reversal in pitch is not apparent, but just general flattening over the whole area.

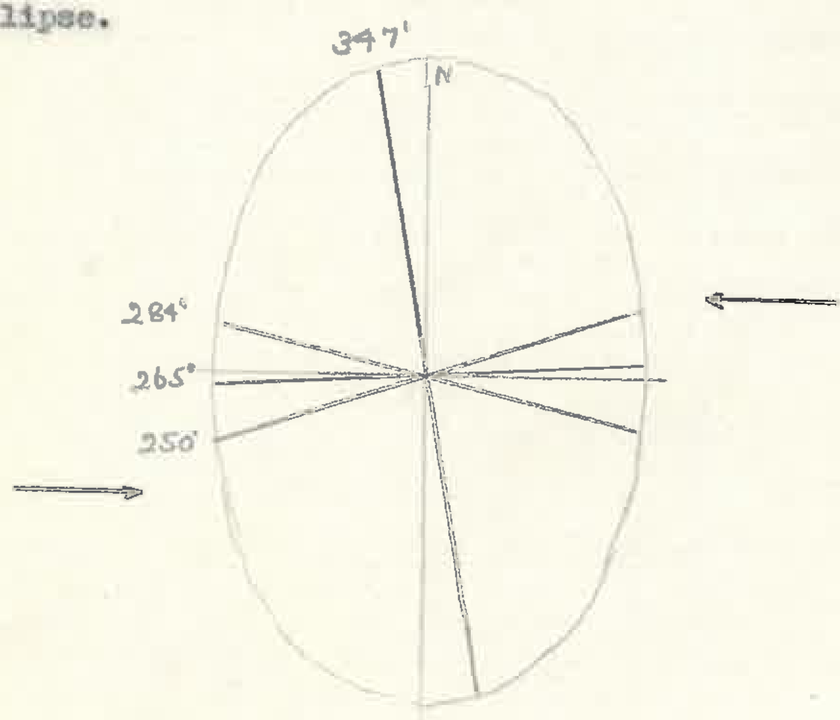
Jointing.

The most prominent joint directions are found to be 255°, 265° and 284°. Minor faults have a tendency to form in the direction 250-255° and this indicates the plane of maximum shear. The second plane of maximum shear has a strike of 284°.

The extension joints are represented by the set of joints striking 265°. They are predominantly north-dipping (70-80°) indicating the south pitch.

The axial plane cleavage which varies between 340° and 360° is not well developed except in isolated places. Along the west limb of the southern syncline it has a strike of 347° and dip 60° west. This well-developed area continues north of the nose of the syncline, and good examples of cleavage and bedding, perpendicular to each other, can be seen.

Relating these joint directions to the strain ellipse.



ECONOMIC GEOLOGY.

This region has never had extensive mining operations carried out except at the Preamimma mine. There are numerous small shafts and inclined shafts scattered around the hills. Copper, arsenic and gold have been the minerals most sought after, and a report of wolfram is the only other mineral occurrence. A brief statement on underground water is warranted because of its importance to the farmer.

(a) Wolfram.

This mineral was found in 1940 in Section 383, Hundred of Tungkillo. It was only a small find, and no records were kept, but information from local residents indicate that up to half a ton of wolfram was removed.

An underlay shaft (dipping 45° to west) was driven along pegmatite and quartz veins, but this is filled with water to within six feet of the top. The footwall and hanging wall are biotite-gneisses, and the region has undergone minor faulting associated with the folding. Lenses of ilmenite in barren quartz are abundant in the dump material. The material was hand-picked at the site of the shaft.

(b) Copper

(1) Preamimma mine - Copper-arsenic.

This mine is the largest in the area and is situated in Section 13, Hundred of Monarto.

The main shaft is 300 feet deep and is a vertical two-compartment one. There are two shafts north of this, one is 200 feet deep and the other 60 feet deep. A 60 foot prospecting shaft was sunk on the pegmatite outcrop.

The rocks are low-grade quartz-biotite schists, strike 347° and dip 60° East. The pegmatite and lode material have a similar strike but dip 80° West. The lode has a typical gossan capping, with malachite, azurite and yellow oxide of arsenic. Primary minerals are arsenopyrite and sulphides of copper.

(2) Copper-arsenic mine

Section 433. Hundred of Tungkillo.

The workings are large, but no reports are available. Two underlay and a main vertical shaft are unsupported, although debris has blocked the top of the underlay shafts. The rocks are flaggy biolite schists, jointed and cleaved into well-defined slabs. Quartz "blows" in test pit may indicate the cap of lode. A basic dyke occurs east of the main shaft and intersects the latter at depth.

Mineralization is the same as at the Preamimma mine. Boxwork structure in the oxidized zone shows remnants of pyrite and chalcopyrite being replaced by limonite. Regions of thin, laminar sheets indicate primary occurrence of mica and the presence of pegmatite with the lode material.

(3) Copper-gold mine

Section 116. Hundred of Mobilong.

Small developmental work was carried out on a bedded quartz lode and gossan capping. The wall rocks are high-grade gneisses and sediments of granitic composition. Traces of mineralization are rare.

(4) Copper mine

Section 490. Hundred of Tungkillo.

Traces of copper mineralization are found near two underlay shafts sunk in biotite schists. A tourmaline bearing coarse-grained granite is associated with the mineralisation.

(5) Copper mines near Rockleigh.

Sections 378, 382. Hundred of Monarto.

These mines, comprising a single shaft, were abandoned before developmental work was carried out. Malachite and azurite are found in a bedded quartz lode in the knotted schists and crenulate schists.

(c) Brown Coal.

Section 389. Hundred of Tungkillo.

A black semi-consolidated brown-coal or peat is found in the banks of Gorge Creek. The seams are horizontally bedded and the uppermost band is 4 feet below the surface. The thickest seam is 8" thick, but the number of seams is not certain. The lateral extent of the deposit is not known, but the seams could underlie the major part of the alluvium basin surrounding Gorge Creek and its tributaries.

Remains of branches, leaves and other vegetable material are found, while selenite and sulphur are present. No assay was made. The age of the deposit is uncertain, as the two alternative origins are:-

(a) Tertiary age: The material is an inlier, preserved by the block-faulting. The coal is comparable to the Middle Miocene deposits at Moorlands.

(b) Recent deposit. The formation took place under swampy conditions in an enclosed basin. The existing outlet of Gorge Creek was insufficient and areas of swamp lands formed beyond the barrier on the eastern side.

(d) Underground Water.

The Murray Plains are part of the Tertiary basin and boring has indicated several limestone aquifers which have a gentle dip to the east. The hills to the west of the plains supply the intake for these beds. The best quality water is found in the lower aquifers, but that of the upper beds is of good stock quality.

A number of bores have been sunk along the fault, indicating that the broken ground is a good locus for water. There are no other obvious correlations between structural control and the presence of water.

Specimens.

1. Quartz-biotite schist - near Preamimma mine.
2. Sandy variety of quartz-biotite schist - near Preamimma mine.
3. Sericitic quartzite - Mt. Torrens - Tepko Road - quarry.
4. Actinolite Schist - East of Church - Rockleigh.
5. Banded Biotite schist - Flag Gully.
6. Knotted schist - Mitchell Gully - 1 mile south east of Rockleigh.
7. Crenulate biotite schists - 100 yards east of Rockleigh.
8. Light blue calcareous band - quarry, Monarto - Palmer Road
9. Calcareous schist, base of upper band - Mitchell Gully.
10. Compact grey rock (igneous origin??) - quarry $\frac{3}{4}$ mile south east or Rockleigh
11. Light coloured pyritic banded material - Mitchell Gully
12. " " - quarry - Rockleigh
13. " " - quarry - Monarto-Palmer Road
14. " " - quarry - $3\frac{1}{2}$ miles east of Preamimma mine
15. Bleached rock - quarry - 3 miles east of Preamimma mine.
16. Purple fine banded material - calcareous band - Mitchell Gully.
17. Grits - Murray Bridge - Palmer road.
18. Monarto granite - Preamimma Creek
19. Migmatites - Reedy Creek
20. Aplite dyke - Reedy Creek
21. Biotite gneiss - $1\frac{1}{2}$ miles east of Tepko
22. Injection gneiss - intersection Salt Creek and Murray Bridge - Palmer Road.
23. Felspathized arenite - 1 mile south west of Pallamana
24. Garnet - ilmenite - hornblende gneiss - Salt Creek - $1\frac{3}{4}$ miles west of Pallamana.
25. Amphibolite - Copper-arsenic. Section 433, Hundred of Tungkillo.

26. Pegmatite - Intersection. Salt Creek- Murray Bridge - Palmer Road.

27. Thin tourmaline-bearing pegmatite - Section 490. Hundred of Tungkillo.

28. Silicified fault material - Quarry, Monarto - Palmer Road.

29. Hematite veins near Palmer Fault - quarry near Murray Bridge - Palmer Road.

30. Arsenopyrite, malachite - Preamimma mine.

31. Arsenopyrite, Malachite, Gossanous material - copper arsenic mine. Section 433. Hundred of Tungkillo.

32. Selenite - quarry - Monarto-Palmer Road.

33. Brown Coal - Gorge Creek.

Microscope Slides.

| | |
|---|---|
| Quartz-biotite schist | No. 91 |
| Amphibolite | Nos. 30, 78 |
| Pegmatite | No. 37 |
| Aplite | No. 84 |
| Monarto granite | No. 29 |
| Calcareous material | Nos. 15, 38, 63 |
| Banded material | Nos. 12, 26, 8. |