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GEOLOGICAL INVESTIGATIONS IN THE COBAR AREA, N.S.W. 1949

by

K.W.B. Iten and E.K. Carter

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CONTENTS

	Page.
SUMMARY	1
INTRODUCTION	3
SITUATION	4
PREVIOUS INVESTIGATIONS	4
MAP COMPILATION	4
GEOLOGY	5
GENERAL	5
STRATIGRAPHY	6
Canbelego Group	7
Cobar Group	8
Tuffaceous Sandstones and conglomerate.	8
Medium-coarse to fine-grained sandstones.	8
Fine-grained, quartzitic sandstones.	8
Slaty sandstones and sandy slates.	9
C.S.A. Group	9
Buckley Formation	9
Packham Formation	9
Scoot Quartzite	10
Weltie Group	10
Mallee Tank Group	11
Bee Quartzite	12
Rookery Limestone	13
PALAEONTOLOGY	13
AGE OF BEDS	14
STRUCTURE	17
The Rookery-Nurri Area	17
The areas covered by reconnaissance mapping	18
CHANGE IN FACIES	20
ECONOMIC GEOLOGY	21
ACKNOWLEDGEMENTS	23
REFERENCES	24

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LIST OF FIGURES AND PLATES.

Figure 1	:	Schematic representation of facies change in the Cobar Group.
Plate 1	:	Cobar District, N.S.W. Areas investigated by the Bureau of Mineral Resources, 1949 (map).
Plate 2	:	Geology of the Rookery-Nurri area, Cobar district, N.S.W.
Plate 3	:	Geological reconnaissance map of portion of the Cobar-Canbelego District, N.S.W.
Plate 4	:	Interpretation of the geology of portion of the Cobar-Canbelego District, N.S.W.
Plate 5	:	Sections from Plates 2 and 3, Cobar-Canbelego District, N.S.W.

S U M M A R Y.

The Cobar Mineral Province is in Central West N.S.W. The town of Cobar is 464 miles by rail west-north-west of Sydney. The district has a sub-arid climate with high summer temperatures.

This report is a detailed stratigraphical and structural study of an area of some 40 square miles south-east of Cobar (Rookery-Nurri area) together with a geological reconnaissance of an area of 500 square miles in the Cobar-Canbelego district.

The purpose of these investigations was the elucidation of the general geology and the problem of ore localisation in the Cobar-Nymagee-Canbelego metalliferous province.

The major results obtained are:-

1. The sediments occurring in the Cobar-Canbelego district were divided into Canbelego, Cobar, C.S.A., Weltie and Mallee Tank Groups. The unit names used by Andrews (1911, 1913) were generally adopted, but modifications in succession and further sub-divisions were made. Lithological and stratigraphical studies, confined to the Rookery-Nurri area, were concentrated on the Cobar, C.S.A., Weltie and Mallee Tank Groups which were sub-divided, where possible, into formations.

The Cobar beds were grouped in four lithological sub-divisions. They are, (commencing with the oldest): Tuffaceous sandstones and conglomerate; medium-coarse to fine-grained sandstones; fine-grained, quartzitic sandstones; slaty sandstones and sandy slates.

Within the C.S.A. Group three formations were distinguished; Buckley and Packham Formations and Scoot Quartzite. No attempt was made to sub-divide the Weltie Group. The Mallee Tank Group was sub-divided into the Bee Quartzite and the Rookery Limestone.

2. The stratigraphical succession of these groups, mainly based on structural observations is as follows (from youngest to oldest)-

Mallee Tank Group
Weltie Group
C.S.A. Group
Cobar Group
Canbelgo Group.

The Canbelego Group is older than the Cobar Group. The structure and the conformable passage, in several places between Cobar sandstones and C.S.A. Group, fix the position of the latter above the Cobar Group. The Weltie beds overlie the C.S.A. Group. The Mallee Tank Group is the youngest in the Cobar-Canbelego area. The actual position in the Rookery-Nurri area is due to infaulting.

3. The probable age of these groups has been determined as pre-Silurian for the Canbelego Group, Silurian for the Cobar, C.S.A. and Weltie Groups and Upper Silurian-Lower Devonian for the Mallee Tank Group. The evidence for their respective ages is, in the case of the Mallee Tank Group, given by a rich marine fauna of the Rookery Limestone. For the other groups structural features, including type of deformation and degree of folding, are related to the orogenies of the Ordovician-Devonian time which have affected Eastern Australia. It is considered that the Benambran orogeny (close of Ordovician period) deformed the Canbelego group while the Tabberabberan orogeny (Middle Devonian) was responsible for folding and faulting of the Cobar, C.S.A, Weltie and Mallee Tank Groups.

4. The structure of the Cobar-Nymagee anticline and its areas to the west and east was investigated in detail in the Rookery-Nurri area. This major anticline consists of a succession of minor anticlines and synclines. To the west there is an extensive development of C.S.A., beds. The eastern portion of the Rookery-Nurri area shows the infaulted Mallee Tank Group and, to the east of this, the Weltie Group. Lower C.S.A., sediments, observed on the eastern side of the Cobar-Nymagee anticline, prove the anticlinal structure and indicate the inferred fault between Cobar and C.S.A. Groups on the one hand, and the Mallee Tank Group on the other.

The Cobar-Nymagee anticline was traced to the north to Bee Mountain and south of the Rookery-Nurri area by regional mapping. To the east of this anticline the existence of a dome given the name of "Restdown Dome", was established. It consists mainly of Canbelego beds. The northern portion of the dome (that part lying in the area mapped) contains 4 anticlines and 3 synclines. To the north-east the "Meryula Basin" is occupied mainly by C.S.A. and Weltie sediments. The "Meryula Basin" is probably bordered to the east by a dome, of which the centre lies in the direction of Canbelego.

5. The absence of Cobar slates in the Rookery-Nurri area is explained by a change of facies between Cobar and the Rookery-Nurri areas. It is suggested that the conditions of sandy sedimentation which first prevailed in Silurian time in the area persisted in the southern part of the Silurian geosyncline, due to a domal rise built up by early orogenic movements of the Tabberabberan orogeny, while the sandy facies changed rapidly to a shaly facies in the vicinity of Cobar.

6. Surface occurrences which could have been taken as indicative of the presence of sulphides in the Rookery-Nurri area and elsewhere were examined, and it was concluded that they are not related to ore deposits. The conclusion was also reached that no large bodies of ore are likely to be found in the Rookery-Nurri area since the "discordance" which appears to have been the major ore channel in the Cobar field, is poorly developed here. This is probably due to the absence of slates. No structures regarded as being favourable to ore localisation were observed in the sandy slates of the Cobar group or the slates of the C.S.A. group.

INTRODUCTION.

Following work in the Cobar Mineral Province, consisting of both detailed mine investigations and reconnaissance mapping by members of the staff of the New South Wales Mines Department and of the Commonwealth Bureau of Mineral Resources, Geology and Geophysics in previous years, it was decided that field work should be continued during the 1949 field season. For this purpose a party of three Geologists, assisted by field hand and cook, set up camp in May on Mr. P.M. Madden's property, known as "The Rookery". The homestead is situated 3½ miles south-east of Mt. Nurri, and is 25 miles by road south-east of Cobar.

Work in the district was carried on until the middle of November. The Geologists in the party were:

H.J. Ward
K.W.B. Iten
E.K. Carter.

Mr. Ward was party leader until the end of July when he was transferred to other work. K.W.B. Iten then took charge of the mapping.

Results obtained by previous investigations in this district (Sullivan and others) led to the selection of an area of some 40 square miles for mapping in detail. This area will be described in this report as the Rookery-Nurri area. It is situated some 23 miles by road south-south-east of the township of Cobar, and can be reached either by following the main Cobar-Nymagee road, a distance of 15 miles to Brura Government Tank and taking from there the track which branches off to "The Rookery" homestead, or by the old Cobar-Nymagee road which passes through the deserted township of Illewong, then east of Mt.Nurri to "The Rookery" homestead.

The boundaries of the area mapped in detail (see plate 1) are as follows:-

The extreme northerly point lies half a mile north of Nurri Trig. Station. The eastern boundary passes two miles east of "The Rookery" homestead and the southern margin is 7 miles south of Nurri Trig. Station. To the west, the area extends to Buckley's Tank, 4 miles west of "The Rookery" homestead.

On completion of this detailed mapping, reconnaissance and regional mapping was carried out to the north, south and east of the area. The area covered by this work is shown in Plate 1. The boundary passes through Brura Tank, Bee Mountain, Nurri Trig. Station, Meryula Railway Siding, then along the Cobar-Nyngan railway line to a point 10 miles from Cobar. Continuing to the south-east the limit crosses the Canbelego-Nymagee road 9 miles south of Canbelego. An area of approximately 30 square miles to the east of this road was included in reconnaissance mapping.

The southern boundary is 13 miles north of Nymagee and leads from the Canbelego-Nymagee road to the main Cobar-Nymagee road, and thence back to Brura Tank. An area of almost 500 square miles was therefore covered by reconnaissance mapping.

SITUATION.

Cobar is situated 464 miles west-north-west of Sydney at the end of a branch line which joins the Sydney-Bourke railway line at Nyngan.

The flat to undulating country is broken only by a few low ranges of hills which trend, in general, a few degrees west of north. Permanent streams are absent and the only well defined drainage channels are erosion gullies. In the flatter parts, the water courses are ill-defined and heavily alluviated. The water supply depends largely on storms, the run off from which is stored in numerous earth tanks and dams. Natural water holes are rare. The average annual rainfall is 13.7 inches. Summer temperatures, and consequently evaporation, are high. The main pastoral industry is sheep grazing.

The vegetation consists of pines and a wide variety of eucalypts and acacias. The morphology and vegetation, as well as the influence of the semi-arid climate, have been fully described by Andrews (1911,1913) and Joklik (1948).

PREVIOUS INVESTIGATIONS:

The Cobar field was discovered in 1869 and mining began at Great Cobar in 1871. The first comprehensive reports were written by Andrews (1911, 1913). The sound foundations laid by his work provided a basis for all succeeding workers. Lloyd (1935-1938) carried out extensive reconnaissance work between Mt.Drysdale, Cobar, Nymagee and Mt. Hope, and between Girilambone, Canbelego and Nymagee.

Gray carried out surface and underground mapping between 1908 and 1920 and also again in 1944. His unpublished report (1945) has been available to the writers. Mulholland and Rayner of the Department of Mines, New South Wales, examined the Cobar field in 1945 and issued a report in 1947. Connolly (1946) carried out investigations on the Cobar Mines.

In 1945 the Commonwealth Bureau of Mineral Resources commenced a large exploration programme. The geological work was under the direction of C.J. Sullivan. Reports were written by Sullivan (1948-1949) dealing with the detailed structure of the Cobar mines and with ore finding prospects. Joklik (1948,1949) who worked in the area under Bureau direction, also contributed to the literature on the district.

This work was done in close association with Enterprise Exploration Co.,Pty.,Ltd., a subsidiary of Zinc Corporation Ltd. The geologists of this company (B.P.Thomson and R.E.Williams) mapped in detail the Cobar-Queen Bee mining field, while North Broken Hill Ltd., restricted its survey to the Nymagee-Shuttleton district.

Beside these geological investigations an extensive geophysical survey was carried out by the Geophysical Section of the Commonwealth Bureau of Mineral Resources and by Enterprise Exploration Co.Pty.Ltd.

MAP COMPILATION:

The maps accompanying this report are based on air-photo compilations and include the principal stratigraphic and structural features of the areas investigated by the 1949 field party.

Plate 1 shows the areas investigated during the 1949 field season.

The detailed mapping of the Rookery-Nurri area is presented in Plate 2.

The mapping was done on enlargements of 1 inch: 400 feet of air-photos taken originally on a scale of 4 inches to the mile. The field observations are entirely those of the 1949 field party.

Plate 3 contains the results of the reconnaissance and regional survey carried out in the areas surrounding the Rookery-Nurri area. Mapping was done in the field directly on to air-photos of a scale of 4 inches to the mile. The information obtained was traced on to a copy of a compilation of the photo runs, made by the slotted template method with known ground points as controls. The compilation was made by National Mapping Section, Department of Interior. The result was photographically reduced to map size (1 inch: 1 mile).

Plate 4 shows the interpretation of Plate 3 with regard to the distribution of the different stratigraphical groups and the major structure.

Finally Plate 5 represents cross and longitudinal sections of the Rookery-Nurri area and of portion of the Cobar-Canbelego district.

GEOLOGY.

GENERAL.

Andrews (1911, 1913) adopted the following classification for the sediments of the Cobar-Canbelego district.

		WEST (Cobar district)	EAST (Canbelego district)
DEVONIAN	Amphitheatre Series	Biddabirra Beds Alley Beds Water Tower Beds S.S.A. Beds	
	Weltie Series	... ...	Ballast Series.
SILURIAN	Mallee Tank Beds		
	Cobar Series	... ...	Canbelego Schist.

He gave a full description of the different rock types occurring within these "series" and discussed the conditions of sedimentation as well as the question of age. Structurally, he regarded the faulting within the Cobar series as being "en echelon" in nature and responsible, in part at least, for ore localisation.

This structural and stratigraphical concept was further developed by the investigations of Lloyd, Gray, Mulholland and Rayner.

In 1946, Conolly again stressed the importance of the contact between sandstones and slates of the Cobar series in the localisation of ore bodies. He considered that the sandstone-slate junction is arranged in steps. The contact bends from one echelon position to the next, and ore bodies occur, for the most part, in the vicinity of these bends.

Finally Sullivan (1948, 1949) developed a structural picture of the Cobar field again emphasizing the great importance of the sandstone-slate "discordance". According to the author, two periods of orogeny influenced the contact. The first period was responsible for the discordance between sandstone and slate and the second one deformed the contact, producing a series of bends in it and also giving rise to the lode shears. The main ore bodies occur, where shears project southward into the slates from the straight portions of the sheared contact.

Joklik (1948,1949) mapped the northern portion of the Rookery-Nurri area. He adopted the concept of Sullivan in full and his interpretation of the structure of the Rookery-Nurri area is based on structural hypotheses developed at Cobar.

The close relationship between ore occurrence and bends in the discordance contact (in many instances associated with pitch change) caused Sullivan to suggest that further ore bodies may be located west of the Nurri Range within the Rookery-Nurri area, where reconnaissance suggested both a bend in the discordance and a change in pitch.

To test this idea it was decided to map in detail an area of some 40 square miles south of Mt. Nurri to determine:

(a) the lithological and stratigraphical sequence of the sediments in the area.

(b) whether suitable ore-bearing structures occur and if these show any sign of mineralisation.

(c) the reason for absence of ore in the Rookery-Nurri area, if no ore prospects were found.

STRATIGRAPHY:

Lithological and stratigraphical studies were, in general, restricted to the Rookery-Nurri area, where a close investigation of the succession was carried out. The work within this area showed that Andrews' nomenclature (1911, 1913) for the different sequences could be adopted in general, but considerable alterations in their succession and order of age were made.

The term "group" has been used to replace Andrews' "series" to accord with the system of stratigraphical nomenclature recently adopted in Australia (Glaessner, Teichert, Thomas, Raggatt, 1948).

The marked scarcity of fossils in the Cobar-Nymagee district renders positive correlation between formations difficult. However, the present investigation indicates that the stratigraphical sequence postulated by Andrews (1911, 1913) should be modified as follows:-

LOWER DEVONIAN UPPER SILURIAN	Mallee Tank Group...	Rookery Limestone Bee Quartzite
SILURIAN	Weltie Group C.S.A. Group Cobar Group	Scoot Quartzite Packham Formation Buckley Formation
PRE-SILURIAN	Canbelego Group.	

The Canbelego Group was examined only in the course of reconnaissance mapping. It occupies a wide area but outcrops are poor. An accurate definition of the succession within the group would require a great amount of detailed mapping. The schists to which Andrews originally gave the name Canbelego lie on the margins of, or outside, the areas mapped.

Andrews' (1911) Water Tower, Alley and Biddabirra beds, which he regards as sub-divisions of the Amphitheatre series (together with the C.S.A. beds) have not been recognised in the areas with which the present investigation was concerned. They have therefore not been included in the foregoing table.

In the description and definition of groups and formations which follow, no attempt has been made to assign stratigraphical thicknesses as it is considered that due to the complexity of folding a reasonably accurate estimate cannot be made.

Joklik (1948) suggested a thickness of 30,000 feet for the slates and sandstones occurring in the Rookery-Nurri Area. This, in the writers' opinion, is excessive.

Canbelego Group.

Andrews (1913) established the sequence of Canbelego schists for sediments and metamorphics occurring in the vicinity of Canbelego. These consist of sandstones, quartzites, slates, phyllites and silky and quartz schists. The writers have adopted this definition but extend it to include some cherts observed two miles east-south-east of Stubb's Trig. Station.

The cherts are, in general, dark red to green in colour, but some grey-white varieties have been observed. Some are very impure. Other rocks, belonging to this group, which were recorded in the southern portion of the area covered by reconnaissance, are chiefly sandstones and their derivatives. The sandstones vary from grey-white to yellow-brown and are rather coarse-grained. Clay material forms a high proportion of some of the beds. These sandstones have been altered in places to quartz sericite and quartz mica schists, e.g., around Restdown Gold Mines and on the Canbelego-Nymagee road 1 mile south of Mt.Lewis. Subordinate rock types observed are slates, quartzites and mudstone.

In three places on or beyond the margin of our mapping, viz., on the Canbelego-Nymagee road, just south of Canbelego, 30 miles from Canbelego and on a high hill 2½ miles west of a point on the road 28 miles from Canbelego, dark chloritic schists were observed. These all occur in the proximity of igneous rocks and are, in part at least, products of thermo-dynamic metamorphism related to the intrusives. This is shown by the presence of well developed secondary tourmaline in a specimen examined microscopically (from the last mentioned locality).

Andrews regarded the Canbelego schists as contemporaneous with the rocks of the Cobar series. The greater degree of alteration was attributed to the local action of much greater stresses than those that acted generally in the district. The writers are of the opinion, however, that this higher degree of alteration is common to the whole group (though local intensifications do occur) and that these sediments are of a greater age than those of the Cobar Group. The alteration differs not only in degree but also in nature. The typical deformation of the Cobar sandstones is by fracture cleavage, but beds of somewhat comparable lithology in the Canbelego Group are also puckered and contorted. The cherts also display this deformation very well. It is therefore considered that the Canbelego rocks are probably Ordovician in age and that they have undergone at least one more period of orogeny than the Cobar sediments.

This is borne out by structural evidence of the succession. East of Stubb's Trig. Station the chert appears to underlie Cobar sandstone and conglomerate. Beneath the chert are sandstones with a variable degrees of argillaceous material.

Cobar Group.

The name Cobar "Series" was introduced by Andrews (1911) for a sequence of interbedded conglomerate, sandstones and slates. This important and widespread group forms most of the low ranges of hills which stand as residuals above the surrounding country.

In the Rookery-Kurri area, the Cobar Group consists mainly of a sequence of sandstones with a varying content of argillaceous and tuffaceous material and of conglomerate. The slates, well developed at Cobar, are absent in most other places. Four sub-divisions were distinguished, but, as many gradations exist within and between them, no attempt was made to map them as separate units. They are, commencing with the lowest:

Tuffaceous sandstone and conglomerates.

These are very coarse to medium-grained sandstones with an appreciable amount of tuffaceous material. While generally of yellow-brown to reddish-brown colour, some beds are grey to white in colour. Pebbles, ranging in size from less than ¼" to 4" occur throughout the sandstone. The density of distribution varies greatly, the mode of distribution apparently being lenticular. For the most part the pebbles are of quartzite, though some deformed sandstone and slate pebbles occur.

In a few places, e.g., south of Bee Mountain, around Stubb's Trig. Station, on Fairview Trig. Station and on Mt. Lewis (see Plate 3), the pebbles become predominant and form a definite conglomerate. The conglomerate is in places markedly silicified. The average size of the pebbles is approximately 3" in length, but pebbles exceeding 1 foot in length have been observed south of Bee Mountain and around Stubb's Trig.Station.

The pebbles are generally well rounded though plane faces are not uncommon. They are typically ovoid. On Fairview Trig. Station, however, they have been flattened and elsewhere a few attenuated sausage-like forms are encountered (see Andrews 1911 for further discussion). As mentioned by Andrews, the coarser conglomerate boulders may exhibit grotesquely distorted forms. This is undoubtedly due to the inability of the matrix to absorb the distorting forces. Pebbles are quite commonly sheared.

Medium-coarse to fine-grained sandstones.

These sandstones show a close relationship to the tuffaceous sandstones but they are free from tuffaceous material and pebbles are rare. The size of these few pebbles, in general does not exceed 2" in length. The colour varies from light grey to light brown. Grain size is variable but in most instances it is finer than that of tuffaceous sandstones. In places, the rock contains a considerable concentration of small limonite pseudomorphs and voids after pyrite cubes, which give it a spotted appearance.

Fine-grained quartzitic sandstones.

This sequence consists of fine-grained, light grey to mauve quartzitic sandstones. In many places, transitions to true massive quartzite have been observed but the extent of the quartzite is not great.

Slaty sandstones and sandy slates.

This highest division within the Cobar Group is composed of a sequence of interbedded sandy slates and slaty sandstones. The colour is generally dark brown. The grain-size is very fine. Slates and sandstones are, in some places, strongly silicified and composed of fine laminae.

In the lower part, the slaty sandstone is predominant, with interbedded sandy slates only in a few places, while in the upper part the sandy slates form the major portion.

It is believed that these beds represent the transitional facies between the Cobar Group and the C.S.A. Group within the Rookery-Nurri area. The sandstone-slate facies grades into the lowest formation of the C.S.A. Group, the Buckley Formation.

At Cobar itself the slates constitute a distinctive succession which has been mapped by others as a separate entity.

C.S.A. Group.

Andrews (1911) gave this name to the easternmost beds of his "Amphitheatre Series" and grouped in it a succession of quartzite, sandstones, cherty and ferruginous claystones and slates. The detailed mapping of the Rookery-Nurri area suggested that three well defined formations could be distinguished. These formations are mapped as separate units and are, in their order of age:

Scoot Quartzite
Packham Formation
Buckley Formation.

Buckley Formation.

This lowest formation of the C.S.A. Group contains interbedded sandy slates and slaty sandstones together with slates and mudstones.

An area approximately 2 miles north of Buckley's Tank, 2½ miles north-north-east of Packham Trig.Station and immediately south of the Brura Tank - "The Rookery" track was chosen as type locality (see Plates 2 and 3). Buckley, which is well known locally as the name of a tank and paddock, has been taken as the formation name in absence of other geographical names.

Sandy slates and slaty sandstones are closely related to the highest sub-division of the Cobar Group and it is suggested that these particular beds should be regarded as a transitional stage between the Cobar and C.S.A. Group. In the uppermost beds of the formation, the sandstone disappears completely. Slates and mudstones form the main part of the Buckley Formation. The junction between them is marked by passage beds in which slates and mudstones alternate. The pure mudstone is well bedded and of dark brown to yellow-brown colour, while the slates are red-brown to purple-brown.

The marked impregnation with limonite of some of the slate and mudstone calls for mention although it appears to be a superficial enrichment not related to ore occurrences.

Packham Formation.

The type locality of this formation is situated approximately 3 miles east-north-east of Packham Trig.Station or 2¼ miles east-north-east of Buckley's Tank. Well established names are rare within the Rookery-Nurri area and as members of this formation outcrop in the vicinity of Packham Trig. Station it was decided to use the name of Packham though the type locality lies elsewhere. The formation consists of a sequence of white and yellow argillaceous sandstones and yellow and brown cherty and ferruginous claystones. In the type area, the succession indicates that fine-grained white argillaceous sandstone underlies the yellow sandstone. This is not necessarily the case elsewhere.

Claystones, with cherty habit, such as those referred to by Andrews (1911), were observed only in association with the white sandstones.

The yellow argillaceous sandstones which form the greater part of the formation grade upwards into yellow claystone. The grain-size is very fine and the mica content varies. Some yellow and purple shales are also present.

Scoot Quartzite.

The type locality chosen for the youngest formation of the C.S.A. Group is situated outside the Rookery-Nurri area as its best development occurs in the line of hills whose highest point is Scoot Trig.Station. Scoot Trig. Station is about 9 miles south of Nurri Trig. Station (see Plate 3). This low ridge consists of quartzitic sandstone and quartzite which, without doubt, is of the same age as beds outcropping east and south-east of Buckley's Tank.

The sequence of the Scoot Formation starts with a fine-grained, yellow-brown sandstone in which occurs superficial enrichment of limonite comparable to the enrichment of limonite within the slates and mudstones of the Buckley Formation.

This bed is followed by a thin bed of medium-grained sandstone which in turn is overlain by massive quartzite. The quartzite forms the major part of the formation. The medium-grained sandstone is of yellow-brown to grey colour and is coarsely bedded. A bed of quartzitic sandstone appears as a transition between the sandstone and quartzite. The colour of these transition beds is mainly dark grey. Numerous quartz veinlets cut this massive sandstone.

The more sandy members of this formation are commonly lenticular, while the quartzite is very persistent.

Weltie Group.

This sequence occurs only to the east of the Cobar-Nymagee line of hills. The correct rank of the unit-- group or formation - is contoversial and is discussed at the end of the section . The name is adopted from Andrews (1911) for a succession of thinly interbedded sediments, the individual beds of which rarely exceed 2 feet in thickness. The beds are of chert, argillaceous, micaceous and quartzitic sandstones, claystones, mudstone and quartzite. There is some shale, but this is very subordinate. The sediments have offered little resistance to erosion and therefore have not produced any pronounced topographical features. Outcrops are consequently scanty and generally very discontinuous.

The sediments are typically fine-grained. Medium-grained quartzitic sandstone and quartzite show the coarsest grain size. These are grey to light brown. The sandstones grade into claystone with an increase in the content of argillaceous material (which has been commonly altered to sericite). Where present, mica flakes are small and white and lie in the bedding planes. The chert ranges from pure chert to sericite chert with as much as 30 per cent. sericite. The colours range from white and grey to red-brown and mottled green, grey and red, depending on the proportion of haematite and other impurities present. Under the microscope, no evidence of an organic origin was observed. The cherts are closely jointed at various angles to the bedding. These joints are frequently filled with secondary quartz. In sharp contrast to those of the Canbelego Group, the Weltie cherts are neither cleaved nor puckered.

At the surface the mudstone and fine-grained sandstone is commonly impregnated with iron oxide giving rise to "false gossans" similar to those found in the C.S.A. beds. One such outcrop has pellets of limonite giving an oolitic appearance to the rock.

The rocks assigned by the writers to the Weltie Group constitute only a portion of those which Andrews included under the same name. The remainder, comprising mainly argillaceous sandstones and claystones, are considered to be analogous to certain beds which occur to the west of the Cobar group sediments. These beds Andrews called C.S.A. and the writers have consequently mapped their counterparts to the east as such. The remaining sediments of Andrews' original Weltie beds - the cherts and their associates - thus cover a restricted stratigraphical range and possess a thickness of perhaps only a few hundred feet.

The question therefore arises whether the Weltie sequence forms a major independent unit within the Cobar district and can therefore be called a "group" or whether it merits only the status of "formation" within one of the other groups. Sullivan, in a map of the Cobar-Nymagee district (1949), included the Rookery Limestone and associates with the Weltie cherts under the name "Weltie". Joklik (1948, 1949) made the Weltie cherts a subdivision of the Mallee Tank sequence, which had the rank of a group. It is considered that in view of the difference in lithology between the Mallee Tank Group (as defined in this report) and the Weltie beds and the probable existence of a fault between the two there is little justification for their being grouped together.

A strong case may perhaps be made out for the assignment to the cherts of the status of a formation within the C.S.A.Group since it is apparent from mapping between Nurri range and the Canbelego-Nymagee road that the cherts overlie the C.S.A. sediments. However, owing to the infaulting of the Mallee Tank Group the C.S.A. and Weltie beds are not in contact within the area mapped in detail, hence an accurate knowledge of the succession has not been obtained and it has been decided not to disturb Andrews' ranking of the respective sequences despite the reduction in size of the Weltie Group.

A further point is that the Weltie cherts and associates do not occur to the west of the Nurri range, thus giving a point of distinction from the C.S.A. beds.

The Weltie cherts (Andrews, 1911) and Ballast cherts (Andrews, 1913) are probably identical.

Mallee Tank Group.

Andrews (1911) gave the name "Mallee Tank beds" to a sequence of conglomerate, sandstone, quartzite, breccia, claystone and limestone which he recorded from the vicinity of the Mallee Tank and Conqueror mines, 11 miles south-east of Cobar. He used this as his type locality although certain of the sediments appear to have been found only in the mine workings, and these were inaccessible even when he was engaged in his work in the area. He correlated the limestone from the Mallee Tank shaft with that occurring in the vicinity of, and north of, "The Rookery" homestead, and east of Mt. Nurri.

On the basis of our work in the Rookery-Nurri area the establishment of the two following formations is proposed:-

Rookery Limestone
Bee Quartzite.

The limestone is the younger formation.

As is invariably the case in this district, no natural sections exist, but the development of the major members of the group is greatest in the Rookery-Nurri area, and it appears to be the logical choice for the type locality of these formations. No conglomerates which could be assigned to the Mallee Tank Group occur in the area and, in the absence of information as to their stratigraphical relationship to the limestone and quartzite, no position in the sequence can be given to them.

__Bee Quartzite.__

The type locality of this basal quartzite is situated 1400 yards north-north-east of "The Rookery" homestead in the vicinity of the northern boundary fence of "The Rookery" property (see Plate 2).

The formation consists mainly of light-grey quartzite of cherty appearance. Angular inclusions of white and colourless quartz are often observed. The quartzite possesses a sub-conchoidal fracture and is commonly well-jointed. Bedding is not apparent. Most outcrops consist largely of rubble, the quartzite weathering into irregular rounded boulders and pebbles. The weathered product is, in some places, gritty; but, in many cases, the surface of the rock is tough and apparently unaltered. Iron-staining, in places, imparts a red colour to the rock. Towards the northern section of the Rookery-Nurri area, the quartzite appears to change gradually in character. It becomes more sandy and the white angular fragments of quartz become more predominant until, just east of Mt. Nurri, the rock becomes a true breccia with a sandy cement. Although the limited outcrops make it impossible to say with certainty that the northern most outcrops represent the same bed as that mapped farther to the south the gradual change in rock type suggests that such is the case. The total thickness of the bed probably does not exceed 20-30 feet.

Underlying this quartzite is a narrow bed of fine-grained, white, well-jointed sediment, which has been used as fireclay. This is followed by a very fine-grained, brown quartzite; by lenticular calcareous beds; and finally by thin beds of shale and claystone.

Occasional floaters of the cherty quartzites were seen on Kopje Station, to the east of the Canbelego-Nymagee road.

Andrews (1911, p.40) was of the opinion that the Bee Quartzite was not a true sedimentary bed but was due to "a fairly more recent redistribution of Mallee Tank rock material." Joklik (1948), on the other hand, considered it as a true sedimentary bed, and suggested that its origin was that of a volcanic "grey billy."

The quartzite bears a marked similarity to laterite of the pallid zone but its constant relation to the overlying limestone shows that it is a sedimentary bed. It may have undergone selective silicification after deposition but in the absence of evidence as to the cause of such silicification, the writers prefer to use the name "quartzite" rather than "grey billy".

Rookery Limestone.

Andrews (1911) created this term for the limestone occurring in the vicinity of "The Rookery" homestead. He included as associates of the limestone fireclays, calcareous claystones and quartzites. The quartzite is treated separately in this report and has been made a separate unit called the Bee Quartzite.

The limestone is dark grey to bluish-grey on freshly broken surfaces. Exposures are dull grey and rounded, with a "matte" surface. On these weathered surfaces abundant fossil remains may be seen in places though on freshly broken surfaces the fossils are not so obvious. The limestone occurs in massive and also in well-bedded bands. It is free from cleavage, although extensive recrystallization has taken place producing a tough rock with a hackly to flat conchoidal fracture. In places, e.g., in limestone pits 1½ miles north-north-west of "The Rookery" homestead, veins of white, coarsely crystalline calcite are quite prominent. These veins cut across the bedding and attain a width of 3". They appear to occupy joints and tension gashes. Elsewhere, however, the occurrence of white calcite is limited to replacements on fossils.

In addition to the limestone occurrence on and north of "The Rookery" area and in the Mallee Tank shaft, as reported by Andrews, there is an outcrop of limestone some two miles in length and from one to two hundred feet in width on the property of Mr. R. Elder - Kopje Station - about 5 miles north-east of Mt. Lewis and 16 miles south-south-east of Canbelego. Andrews called this "Restdown Limestone". There is no doubt that it is of the same age as the Rookery Limestone. In fact, the characters and field associations of the two are almost identical.

PALAEONTOLOGY:

Fossils are very rare in the Cobar district, so little palaeontological evidence of the age of the various groups is available.

On the eastern flank of the hill, 2½ miles to the west of the Field Camp, a tubular fossil was found in slates of Buckley Formation (C.S.A. Group). The fossil was of no value for determination of age.

Within the yellow, sandy claystone of the Packham Formation (C.S.A. Group), a single fossil was found south of the Rookery-Nurri area approximately 2 miles north-north-east of Victoria Tank and 200-300 yards south of the boundary fence between the parishes of The Rookery and Scott (see Plate 3). Dr.A.A.Opik, Bureau of Mineral Resources, Geology and Geophysics, examined the fossil and determined it as a large plate of a cystid of the Rhombifera. Such cystids with large plates, exhibiting an ornamentation of radiating ridges, are known from Upper Ordovician to the Devonian. Dr. Opik writes....."if an approximate answer is needed I shall compare the cystid plate from Cobar with Heliocrinites Fiscella (Badher) (Heliocrinus Fiscella B.) as described by F.R. Cowper Reed (1906) in "The Lower Paleozoic Fossils of the Northern Shan Slates, Burma", in Pal. Indica, N.S. Vol.11, Mem.No.13."

Only two rich fossil horizons are known in the area mapped. They are in the Rookery Limestone, which occurs on and north of "The Rookery", east of Mt. Nurri (see Plate 3) and on "Kopje" east of the Canbelego-Nymagee road (see Plate 3), and in a small outcrop of green and brown mudstone on the Canbelego-Nymagee road, at a distance of 28 miles from Canbelego (see Plate 3).

Andrews made an extensive collection of fossils from the Rookery Limestone. These were determined by W.S. Dunn and R. Etheridge (Andrews, 1911) who attributed to the limestone an

Upper Silurian age. Dr. A.A. Opik briefly examined specimens collected by the field party from an outcrop 1500 yards north of "The Rookery" homestead, just north of the boundary fence. Taking into account the re-assessment of the age of the Yeringian beds at Lilydale, Victoria, which, following work by Ripper, Hill, Jones, Gill and others (see Gill, 1942) have been assigned to the Lower Devonian, Dr. Opik considers that the age of the Rookery Limestone may have to be reconsidered. His fossil list is as follows:-

(1) Several undescribed Ostracods, among them two Beyrichid Genera. - Forms not yet recorded from the Silurian.

(2) Brachiopoda.

Gypidula sp.
Spirifer (Crispella ?) sp.
Spirifer (Eospirifer) sp.
Spirifer (Genus indet.) - No radiating ornamentation, regular concentric lines, bordered with spines. - Interior unknown. Long dental plates, no septum.
Atrypa sp.
Camarotoechia, one or two sp.
A Dalmanelloid (Rhipidamella ?)

(3) Trilobites: Proetides, a Scutellum (?), perhaps an Odontopleurid.

Gastropoda, Bryozoa, Corals, Lamellibranchiata, Crinoidal stem joints.

AGE: High in the Silurian, perhaps Lower Devonian.

Another rich fauna was collected from a small occurrence of green and brown, sandy mudstone on the Canbelego-Nymagee road (see Plate 3). Unfortunately, the relationship to the surrounding outcrops is not clear but it seems to the writers to be an outlier of Devonian Sediments.

A preliminary fossil determination was made by Dr. Opik, who writes: "This sandy mudstone contains Brachiopods, Ostracods, Bryozoans, Lammellibranchs. Among them a Panenka occurs which resembles some forms described from the Yeringian of Victoria. The Ostracods represent forms unknown in the Silurian of Australia. Among Brachiopods, Rhynchonellids and Arthoids are represented. Tentatively the age of the beds may be regarded as Lower Devonian (Yeringian)."

AGE OF BEDS:

The scarcity of fossils in the area investigated by the field party renders very difficult the determination of the age of the bulk of the sediments. Palaeontological data obtained in the area are sufficient to indicate the age of only the youngest formation - the Rookery Limestone (Mallee Tank Group). For an assignment of age to the other groups, structural and general considerations must be taken into account.

While recognising the limitations and dangers inherent in the use of the degree of folding and metamorphism for the determination of relative ages of beds, it is considered that these factors can be used in the Cobar district as an aid in fixing the relative age of groups of beds.

The type of deformation and degree of folding differ considerably in the various units. These criteria divide the rocks of the Cobar district into two classes. One division, which comprises the Canbelego Group, exhibits intensive folding. The intensity of folding is so strong that even the competent medium-grained sandstones are crumpled and puckered. The other division, consisting of the Cobar, C.S.A., Weltie and Mallee Tank Groups, shows a slighter, though still strong degree of folding.

Another point of distinction is in the response of incompetent and competent beds to pressure. In the Canbelego Group, both competent and incompetent beds are equally folded, while in the Cobar and C.S.A. Groups, the fine-grained rocks have been selectively distorted.

The stratigraphical succession of Cobar-C.S.A.-Weltie-Mallee Tank Groups (beginning with the oldest group) is mainly based on structure (see Plate 2).

There is a conformable passage between the Cobar and C.S.A. Groups. This was observed in several places along the west side of the Nurri Range within the Rookery-Nurri area, e.g., ½ mile south-south-west of the Field Camp and 3 miles east-north-east of Buckley's Tank. These occurrences clearly show that the C.S.A. beds are younger than the Cobar sandstones. Beds of the Weltie Group occurring to the east of the Rookery-Nurri area can be seen to overlie the C.S.A. Group. The stratigraphical position of the Mallee Tank Group is more doubtful. Its present position in the field is due to faulting, which brought the Mallee Tank members adjacent to beds of the C.S.A. and Cobar Groups in the west and into contact with the Weltie Group in the east (see Plate 3). However, as noted above, the C.S.A. beds overlie the Cobar sediments and are followed by the Weltie beds so that the Mallee Tank Group must be either older than Cobar Group or younger than Weltie. The latter is the only possible position for the beds.

An attempt was made to establish the relative stratigraphical position of the Mallee Tank beds by a traverse in a north-easterly direction from Mt. Lewis to cross the outcrop of limestone on "Kopje" property. Owing to the paucity of outcrops, the presence of igneous rocks (which may imply dislocation of the sediments), and the limited time available, no conclusive evidence was obtained. The information gained does not preclude the decision reached as a result of work further west, that the Mallee Tank beds are younger than the Weltie beds. It actually showed that the limestone occurs either between the C.S.A. and Weltie or above the Weltie sediments. If the former is the case the limestone must be discontinuous and must have been laid down in reef form.

The general similarity in lithology of the C.S.A. and Weltie Groups and the marked dissimilarity of the Mallee Tank sediments from either of those, together with the striking richness in fossils of the Mallee Tank beds, persuade the writers that the Mallee Tank Group is the youngest of those occurring in the area mapped.

Cherts and sandstones of the Canbelego Group appear to underlie Cobar sediments east of Stubb's Trig. Station. They are therefore older than the Cobar rocks.

Summarising, one can establish the following succession of groups in their order of age, beginning with the oldest -

Canbelego - Cobar - C.S.A. - Weltie - Mallee Tank Groups.

Within this succession the age of the Rookery Limestone (Mallee Tank Group) only is fixed by palaeontological data. Fossils present determine the age of this formation as Upper Silurian or Lower Devonian. Some information regarding the age of the other beds may be obtained by an examination of the distribution of orogenetic movements in Middle and Lower Palaeozoic time because the Canbelego Group exhibits a quite different type of deformation and degree of folding to the other Groups.

W.R. Browne (1947) deals in "A Short History of the Tasman Geosyncline of Eastern Australia" with the problem of orogenies which affect the Eastern portion of the continent. Adopting this author's findings, there were three orogenies which could have influenced the Cobar district. They are the Benambran orogeny at the close of the Ordovician Period, the Bowning orogeny at the end of Silurian time, and, in Middle Devonian, the Tabberabberan orogeny.

Cobar, C.S.A., Weltie and Mallee Tank Groups with their similar type of deformation and degree of folding seem to have been affected by the one orogeny, which must be of Lower Devonian age or younger as Upper Silurian - Lower Devonian is represented in the Rookery Limestone. The Tabberabberan orogeny of Middle Devonian age is, therefore, indicated.

The Bowning orogeny at the close of the Silurian Period, probably did not play more than a subordinate part (if any) in the deformation of these groups. Browne wrote (1947, p.627) "This Bowning orogeny varied in intensity from place to place and was on the whole most severe in the east." Sullivan (1948, 1949) suggested that the " discordant contact" between the Cobar slates and sandstones of the Cobar Group (where most of the ore bodies occur) was influenced by two periods or phases of orogeny. The first one caused the discordance between the incompetent slates and competent sandstones and the second one flexed the plane of discordance. It seems to the writers that the final deformation of this contact is due to the Tabberabberan orogeny. Two explanations of the forces which first produced the unconformity between slates and sandstones, as suggested by Sullivan, are possible. On the one hand a weak extension to the west of the Bowning orogeny could have been responsible. On the other hand this deformation might have been caused only by a more pronounced forerunner of the Tabberabberan orogeny.

The Canbelego Group, which is regarded for the present as older than the Cobar Group, exhibits a different type of deformation and degree of folding (strongly cleaved, crumpled and puckered). This points to an earlier orogeny than the Tabberabberan which caused the deformation and folding of the overlying groups (Cobar, C.S.A., Weltie, Mallee Tank). As Browne (1947) stated, the Benambran orogeny took place at the close of the Ordovician Period and, therefore, could be responsible for the deformation and folding of the Canbelego Group.

To sum up, then, probably the youngest rock in the area mapped is the fossiliferous limestone of the Mallee Tank Group. Its age is Upper Silurian or Lower Devonian. Below the Mallee Tank Group the next lowest fixed point is that given by the Benambran orogeny which is regarded as marking the close of the Ordovican Period. In between come in descending order of age -

Weltie Group
C.S.A. Group
Cobar Group.

These are, therefore, all Silurian sediments. The cystid found in the C.S.A. claystones suggests that the latter may be Upper Silurian in age.

The oldest Group - the Canbelego Group - having been subjected to the movements of the Benambran orogeny, is Pre-Silurian in age. It is probably Ordovician but could be older.

STRUCTURE.

All the sediments occurring in the area are strongly folded. The fold axes trend from approximately N10°W near Cobar to N30°W south of the Rookery-Nurri area and N40°-50°W at the same latitude on the Canbelego-Nymagee road. Folding is complex with, at least, three orders of folds ranging in wave length from several miles to a few hundred feet. Dips are high, generally from 70° to vertical. In places folds were observed to be asymmetrical. As is to be expected in sediments which tend to lense out within a short distance, the folding has not been uniform along the strike so that plunge changes are common and, in places, dramatic. The inconstant character of the forces operating have also contributed to the development of plunge, but it does not appear likely that cross folding occurred.

Faults are generally strike faults. Cross faulting is present but horizontal displacement, where observed, does not exceed 100 feet.

The Rookery-Nurri Area.

The positions of points referred to in this section are generally given relative to some topographic feature. As all the hills in the area are composed entirely of sediments of the Cobar Group an adequate idea of the topography may be obtained by reference to Plate 2. Mt. Nurri (1,377 feet) is the highest point and the main range of hills gradually falls in height to the south.

Folding. The reader is referred to sections A-A' and B-B', Plate 5, for a representation of the folding and faulting in the area.

The westernmost occurrence of Cobar sediments - on the isolated hill 2 miles west of the Field Camp (see Plate 2) - is in the form of a dome with the major axis striking a few degrees west of north. The plunge at the northern end is steeply to the north (65°) and at the southern extremity gently southerly. Dragfolds occur on both the eastern and western limbs. The main range has three anticlines and two synclines. A syncline apparently lies in the alluviated country between the isolated hill and the main range. The axis of a tightly appressed syncline passes close to Langford's shaft. It has been strongly to intensely sheared on either limb, particularly where plunge changes have added additional stresses. Shearing of various intensities is noticeable along the whole of the western flank of the main range (see Plate 2). It also occurs on the west of the hill to the north of the Field Camp. Between this hill and the main range there appears to be a major syncline. On the hill north of the camp, there is a major anticline with a small s yncline and anticline to the west. The axes of these folds appear to continue south through the main ridge.

The C.S.A. beds occupy all of the area mapped to the west of the Nurri range, with the exception of the hill south-west of Langford's shaft, and also appear in restricted areas between the Cobar and Mallee Tank beds to the east of the range. Outcrops are not good except for the quartzites of the Scoot Formation which, in places, clearly outline the structure. The more incompetent beds are intricately folded. A conformable passage has been mapped between Cobar and C.S.A. Groups south of "The Rookery" homestead track. Cleavage, in contrast to the bulk of the Cobar Group rocks, is slightly to moderately developed.

The Weltie Group, which is confined to the east of the area, is also notable for the paucity of outcrops. Folding is comparable in degree to that in the C.S.A. beds but cleavage is slight to absent.

The Mallee Tank Group, with the exception of a few minor outcrops along the strike of the beds, occurs in several bodies near and to the north of "The Rookery" homestead. Outcrops of the Rookery Limestone commonly consist of scattered boulders. The Bee

Quartzite occurs as patches of rubble or low rises. The highest is 40-50 feet above the level of the surrounding country. No structure is apparent in the quartzite but its relationship to the Rookery Limestone has enabled the structure of the group to be determined. There are three major anticlines divided by less pronounced synclines. Dips up to 70° have been measured although it is thought that the average dip is considerably less than this. The limestone and quartzite are not cleaved.

Plunge. Plunge is veryinconstant. The overall regional plunge appears to be to the south with a flattening in the south of the area. In detail there are numerous reversals (see Plate 2) giving dome and basin structures such as the dome which is responsible for the hill to the west of the main range. The infolding of small outliers of limestone in quartzite also indicate reversals of plunge. There are two sharp plunge changes in the sandstones on the west flank of the Nurri range. These are referred to in greater detail under "Economic Geology". The writers were not able to trace any pattern of plunge change indicative of cross-folding.

Faulting. Faulting has profoundly modified the distribution of the various stratigraphical units in the Rookery-Nurri area. Reliance has to be placed largely on this disturbance of the stratigraphical succession to establish the existence of the two main strike faults in the area since field evidence is scanty. There is a notable line of quartz reefs and rubble immediately west of the Mallee Tank sediments. A similar, though less pronounced occurrence is to be seen on the east of the same group. Wherever a pit or shaft has been sunk on one of the quartz blows, faulting can be seen to have taken place. The quartz may therefore be taken as indicative of faulting in these two zones. This conclusion is supported by -

(a) the truncation or non-existence of the C.S.A. beds immediately east of the Cobar Group.

(b) the failure of either the Mallee Tank or Weltie beds to outcrop west of the Nurri range.

(c) the existence of a probable unconformity which could only be due to faulting between the most north-easterly occurrence of Bee Quartzite and the sediments to the east.

Since the Mallee Tank sediments are considered the youngest, the area where they outcrop must form part of an infaulted block. Possibly to the east there are a number of minor faults rather than a single fault.

Owing to the complexity of folding it has not been possible to make any computation of the stratigraphical thicknesses of the various groups, so that no determination of the magnitude of throw of the faults can be attempted. However, the throw of the fault on the west of the Mallee Tank sediments must be at least several hundred feet.

Other, but minor, tensional strike faults exist, e.g., at the boundary between outcrop and soil to the west of Mt. Nurri where evidence of faulting was seen in an old shaft (see Plate 2). Contrary to some previous workers, the writers do not believe that extensive faulting occurred along the west flank of Nurri range.

Cross faulting was observed in several places, as shown on Plate 2, but the faults appear to have no regional significance. Horizontal displacement of beds ranges from 70-90 feet.

The Areas covered by Reconnaissance Mapping.

Plates 3 and 4 represent the areas subjected to regional and reconnaissance mapping by the 1949 field party. Plate 3 contains the data obtained in the field and is interpreted only to the extent that each outcrop is assigned to a stratigraphical group. In the compilation the general trend of the locality has been given to sediments for which no strike readings could be obtained. It will be seen that the mapping carried out in the areas north and south of the Rookery-Nurri area was more detailed than that carried out to the east. Plate 4 is an interpretation of the distribution of the various stratigraphical groups and of the structure. Cross and longitudinal sections (Plate 5, C-C'; D-D'; E-E') illustrate the major folding and plunge changes. The reader is referred to these plates to facilitate understanding the discussion of structure.

There appear to be four major structural components of that portion of the Cobar-Canbelego district which was mapped by the 1949 field party. They are -

1. The Cobar-Nymagee anticline, which passes through Bee Mountain and Nurri Trig. Stations, and continues south from the latter on an approximate bearing S30°E to the southern limit of mapping.

2. A large rather complex dome in the south-south-east, of which only the northern portion lies in the area under consideration. The sediments outcropping in the dome belong, for the most part, to the Canbelego Group. The name "Restdown Dome" is suggested.

3. A basin to the north-west of the dome. It is occupied by Weltie and C.S.A. beds and extends north of the Cobar-Nyngan road. It could be called "Meryula Basin".

4. A probable dome centred near Canbelego. This would be responsible for the occurrence of older sediments around and to the east of Cohn Trig. Station. As much of this suggested dome lies outside the area mapped it cannot be affirmed that the structure is closed to the north-east, but the general pattern of folding in the district indicates that it could well be a dome. In view of the uncertainty as to the nature of this component no name is proposed for it.

Cobar-Nymagee Anticline:

The crest of this anticline is marked to the north of the Rookery-Nurri Area by the Bee line of hills, consisting of Cobar sandstones and conglomerates. Dips indicate several folds in the Cobar sediments. A fault which runs at least two miles south from Queen Bee mine, 400 yards south-west of Bee Trig. Station, in the Cobar sandstones, gradually dies out into a shear zone which continues to the western flank of the Nurri range. To the west of the main occurrence of Cobar sandstones there is a further outcrop of these sediments, 2½ miles west of Nurri Trig. Station. This and the isolated hill, 1 mile south-west of Langford's shaft (see Plate 2), constitute the sole outcrops of Cobar sediments to the west. The remainder of the outcropping sediments belong to the C.S.A. Group. They display an irregular pattern of domes and basins (see Plate 3).

South of the Rookery-Nurri area the regional south plunge results in the disappearance of the Cobar sediments from the surface 1½ miles north-north-east of Scoot Trig. Station. Their re-emergence two miles farther south indicates that the general plunge has been reversed. To the west of the line of the Cobar-Nymagee anticline the Scoot Quartzite of the C.S.A. Group shows a similar structural pattern to that farther north. Outcrops are very limited east of the anticline but quartz rubble and the absence of Mallee Tank sediments suggest that the two faults, or fault zones, bounding the Mallee Tank Group in the Rookery-Nurri area, merge.

Restdown Dome:

Four major anticlines occur within the northern portion of the dome. They are evident from the outline of the Canbelego and Cobar sediments (see Plate 4). The axes pass through Mt.Lewis (so called locally but marked "Mt. Kalumba" on the county map of the area), Garner Trig. Station and a point about one mile east of Stubb's Trig Station - continuing south through Killen Trig. Station. The fourth anticline lies between the two last mentioned folds (see Plate 4). The synclines are generally shallow but that which lies approximately on the line from "Elliston" to "Coree" homesteads appears to be more deeply folded.

Faulting was observed in workings in the Restdown Gold Mines group. The most pronounced fault strikes on a bearing of N18°W (magnetic) from a dam 1 mile east of the main group of shafts. Costeans and shafts show the fault dipping from 65°-80°W. The footwall rocks have been very severely distorted. This suggests thrust faulting. No estimate of the throw can be made but the sediments on either side of the fault belong to the Canbelego Group. Air photos show a structural pattern in sediments 1 mile south-south-east of Pearsall's Tank. Field examination suggests that the pattern is due to jointing. Local shearing and intensified metamorphism at the point marked as a fault in Plate 3 was taken to indicate that movement had taken place.

Strong shearing was observed on the west flank of the hills one mile south-west of Kennedy's Tank, in Cobar sandstones. The cobar sandstone on the Fairview line of hills is also intensely cleaved and sheared. The Canbelego sediments forming the hills within a distance of 2 miles south-east, south and south-west of Pearsall's Tank are intensely cleaved.

Meryula Basin:

Soil and alluvium cover most of the region occupied by this basin which is drained by Yanda Creek. The major topographical feature is the low group of hills carrying Yanda Trig.Station. These are composed of Weltie cherts and quartzites. The bulk of the younger (Weltie) sediments occur in the North-west of the area mapped. This includes portion of Andrews' type area for the Weltie beds. In a railway cutting seven miles from Cobar the close folding to which even the Weltie beds have been subjected can be seen. The folds here are asymmetrical. The west limbs of the anticlines are almost vertical while the east limbs dip 40°. Two folds occur within 15 feet.

The basin is closed to the west by scattered occurrences of Cobar sediments. The westernmost of these is a small dome 2 miles west of Cohn Trig. Station. The hills on which this Trig. Station is established also consists of probable Cobar sediments, though there is a possibility that these beds belong to the Canbelego Group.

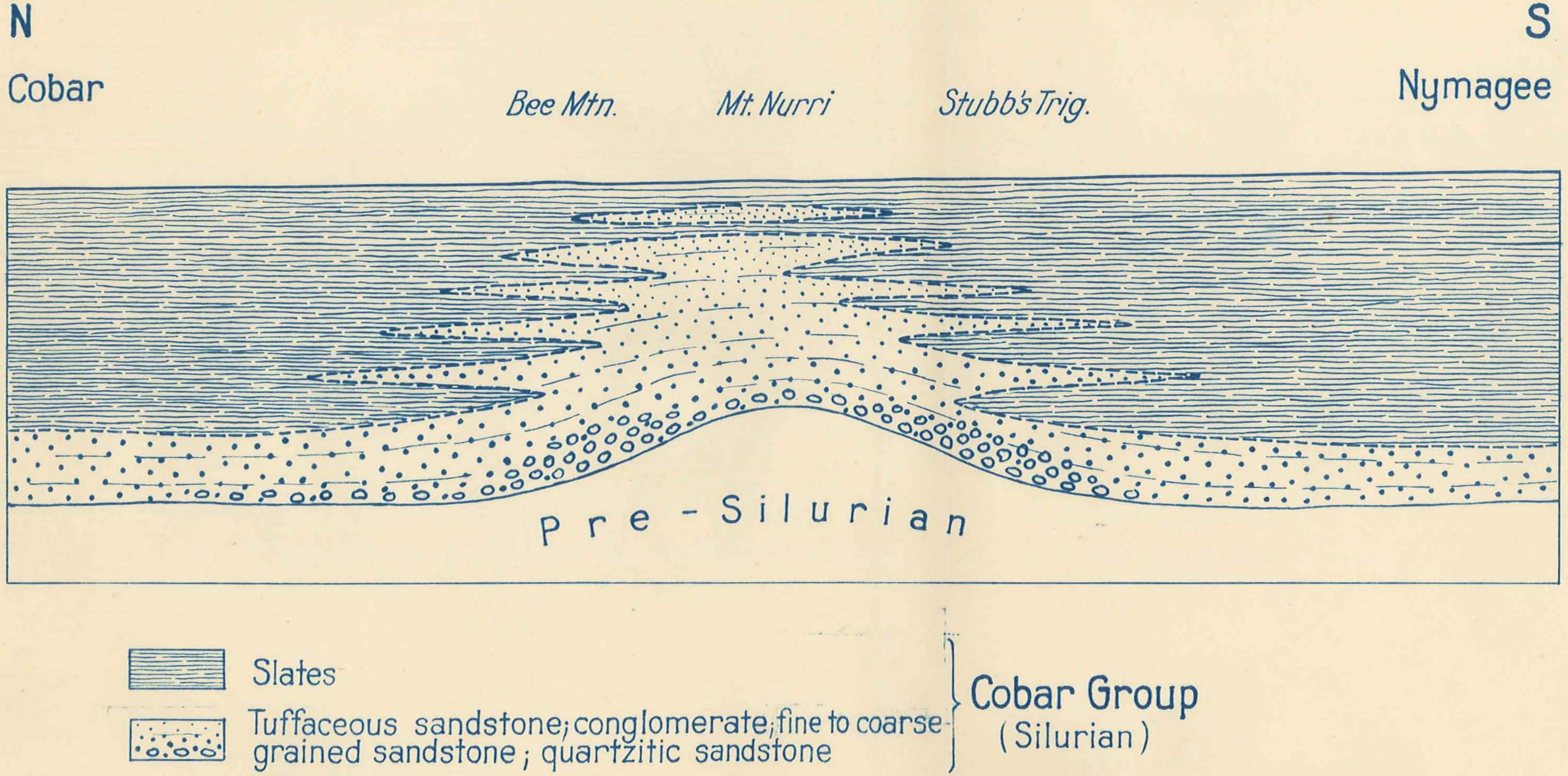
CHANGE OF FACIES.

A striking feature of the distribution of rocks in the Rookery-Nurri area is the absence of any appreciable development of Cobar slates. Since these slates are the hosts for most of the major economic mineral deposits in the Cobar field, their absence has obvious economic implications.

In the Cobar field the Cobar Group consists of sandstones and a thick sequence of slates which overlies the sandstones. The importance of the contact between the competent sandstones and incompetent slates has been emphasized in every report dealing with the ore occurrence in the Cobar field. This junction provided a plane of weakness along which tectonic movements took place, leading to the development of extensive shear zones. As most of the

Fig. 1

Schematic representation of facies change in the Cobar Group



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GEOLOGY & GEOPHYSICS JAN. 50

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Cobar ore bodies occur in the immediate vicinity of this junction, it was expected that similar conditions would be found in the area south of the Cobar-Bee mining field.

Mapping in the Rookery-Nurri area showed that here the Cobar slates are only poorly developed or are perhaps completely absent. An alternation of slates and sandstones in the youngest division of the Cobar Group probably represents the full extent of the incursion of Cobar slates to the south.

Since a conformable passage between the sandstones of the Cobar Group and the Buckley Formation (C.S.A. Group) was mapped, no major fault can be responsible for the absence of the Cobar slates and another explanation must be sought.

The following explanation is offered:-

Following the Benambran orogeny and the final uplift of the Ordovician sediments, gradual subsidence commenced once more, readmitting the sea and giving rise to the Silurian geosyncline.

The cycle of sedimentation began at Cobar with the deposition of coarse-grained sandstones and conglomerate (see Figure 1). Conglomeratic deposits on and south of Bee Mountain and around Stubb's Trig. Station point to the presence of a local updoming within the geosyncline in the early stages of this cycle of sedimentation. This incipient geanticline, which was probably more or less equidimensional, was probably due to early movements (forerunners) of the orogeny closing the period of sedimentation in the Silurian Period (Tabberabberan Orogeny, Middle Devonian).

With progressive sedimentation the trough to the north, and probably that to the south also, sank and the sediments deposited became finer grained. Most probably, further doming of this incipient "Nurri" geanticline took place as sedimentation continued. With further sinking of the area of sedimentation, the facies changed gradually from coarse-grained to fine-grained material. In the northern basin - and probably in the trough to the south, too - the sandy beds changed into a shaly facies giving rise to the important junction which was later deformed into an unconformity. As the sea was shallower in the vicinity of the "Nurri" geanticline, the sandy facies persisted for a longer period than at Cobar.

Oscillations in depth in a later stage of development produced rapid changes between sandy and shaly facies, resulting in thinly interbedded sandstones and shales. Where the conformable passage between the Cobar Group and the C.S.A. Group occurs, the seas were too shallow for shaly deposition.

Towards the end of the deposition of the Cobar Group, a general sinking of the area took place and conditions of sedimentation favoured the laying down of fine-grained sediments.

However, just south of "The Rookery" property, the mudstones of the Buckley Formation are absent. It is apparent that the shallow water conditions migrated south during the early stage of the deposition of the C.S.A. sediments and precluded the laying down of the mudstones in this area.

ECONOMIC GEOLOGY.

The only known metallic minerals found in the areas mapped are gold and silver, both in very small quantities. The gold came from the Restdown Gold Mines group on the old Cobar-Illewong-Nymagee telephone line and road. A number of shafts were sunk along a fault line at this point. No statistics of production are available but the yield is known to have been small. The silver was obtained from a shaft 2 miles south-west of Victoria

Tank (see Plate 3, verbal advice from Mr. Les Snelson, on whose property the shaft occurs). The shaft, which was sunk to a depth of about 180 feet, is interesting in that dolerite was encountered. Specimens were collected from the top of the mullock heap. They show disseminated sulphides.

Surface Indications of Ore.

The whole Cobar area has been intensely prospected throughout the years by both experienced prospectors and part-time fossickers. Their failure to find any ore may be taken as strong evidence that no ore bodies occur at the surface in the areas examined by the writers. The work done by the writers in the Rookery-Nurri area was fairly exhaustive, but that done elsewhere was essentially in the nature of a reconnaissance so that all outcrops were not examined.

In both areas there are a number of outcrops of massive iron oxide-impregnated mudstone and fine-grained sandstone (see Plates 2 and 3). Many of these have had shafts of various depths sunk on them. The shafts invariably pass at a depth of a few feet into bleached sediments with no indication whatsoever of the former presence of sulphide minerals. It is thus apparent that the limonitic outcrops, or "false gossans", are not derived from sulphide ore. In the course of work by Joklik in 1947 it was arranged for a magnetometer traverse to be run over one of the "false gossans" in the Rookery-Nurri area. The result was negative.

White reef quartz is widely distributed in belts throughout the area (see Plate 2). The quartz is commonly found only as rubble or with occasional outcrops. A particularly persistent zone is that along the eastern side of the Nurri range. This probably indicates a fault. Quartz also marks a line of faulting on which the Restdown group of gold mines is concentrated (see Plate 3). Possible sulphide mineralisation associated with quartz was observed from one locality. This is in brecciated iron-stained quartz east of Mt. Nurri on the westernmost of the inferred fault lines (see Plate 2.). Shallow costeans have been dug across the outcrop. Elsewhere the quartz is invariably barren. It is apparent, then, that there is little prospect of finding ore associated with the reef quartz in the areas mapped.

Prospects for Non-outcropping Ore.

Ore in the Cobar mineral province is regarded as being related to the synchronous granite and porphyry (Sullivan, 1948 1949) which extends in two arms north from Nymagee. The easternmost, which reaches north as far as Canbelego, is the better exposed. The western area is considered to underlie the Cobar-Nymagee anticlinal axis. It is represented in the Cobar district only by the strongly altered dolerite from the shaft on Mr. Snelson's property, the two pipes of porphyry south of Bee Mountain and igneous material from an old shaft 4 miles east of Cobar, called the Cobar-Lucknow shaft. The Cobar-Nymagee anticlinal zone was therefore regarded as being a potential ore-bearing region. Structurally, ore in the Cobar district is localised by -

(a) the "discordant contact" between the Cobar slates and sandstones (with the exception of the C.S.A. and Tinto lodes in C.S.A. sediments).

(b) shears in the slates at the bends of the discordant contact.

(c) plunge changes giving local domal structures.

The persistence of the more sandy facies in the south while shaly material (Cobar slates) was being deposited around Cobar (see "Change in Facies") meant that beds whose responses to pressure were markedly different did not lie in such close juxtaposition south of Bee Mountain as to the north. One could expect to find that the "discordance" is not so pronounced in the Rookery-Nurri area as in the Cobar-Bee area. This was observed. Since the discordant contact appears to have acted as an ore channel in the vicinity of Cobar, the reduction in its importance to the south could be expected to reduce the chances of ore entering the latter area.

Intense shearing in sandstone was observed in two places on the west flank of the Nurri range. One of these is in the sandstone immediately west and north-west of Langford's shaft (see Plate 2) and the second ½ mile north-north-west of the shaft, in the vicinity of two inaccessible shafts. Associated with each of these is a change in plunge giving the required domal structure. In the southernmost locality the plunge changes from a moderate south plunge to an almost vertical plunge and then reverts to a moderate south plunge. The change is less pronounced in the northern zone. There has been considerable disturbance and dislocation of the sediments so that it is impossible to determine the structure in detail. To the west of the two zones of shearing and change of plunge the structure is masked by alluvium. There is no evidence of faulting and the concealed sediments are probably sandstones and sandy slates. These would not provide favourable beds for replacement ore such as occurs at Cobar. The sheared sandstones give no indication of mineralisation other than small disseminated cubes of limonite after pyrite such as are common in certain beds of the Cobar sandstones.

It appears, then, that there is no ore associated with these structures, probably due to the absence of a suitable ore channel. Before one can form a definite opinion, however, a magnetometer or gravimeter traverse over the area is called for.

Elsewhere in the areas mapped no indications favourable to the existence of ore were found. In several of the outcrops of Cobar sediments farther east, e.g., one mile south of Kennedy's Tank and in the ridge ½ mile north of Fairview Trig. Station, intense shearing was observed but no other phenomena suggestive of the occurrence of ore. In this connection it is pointed out that, in the Cobar district, sandstones are noticeably devoid of ore and only if the shears persisted into slates would a favourable ore structure be obtained. This was not observed, but outcrops are poor.

A possibility exists that there are some small ore bodies along the fault on which the Restdown Gold mines are grouped.

<u>Non Metallic Minerals.</u>

Of the non-metallic minerals, the limestone on and north of "The Rookery" and on "Kopje" properties is a pure, hard, crystalline rock which, but for its geographical position, would doubtless find some use. It was used as a basic flux for smelting purposes at the Queen Bee Copper Mine. Magnesite nodules occur scattered over the surface in portion of the country occupied by C.S.A. beds. Deposits of these have been exploited from other parts of the district but no deposits likely to be of economic importance were seen in the areas mapped.

ACKNOWLEDGEMENTS.

The writers are indebted to the Cobar staff of Enterprise Exploration Co.,Pty.Ltd., particularly to Messrs.B.P. Thomson and R. E. Williams,for the co-operation extended by them. This included the loan of facilities and maps, the pointing out of geological features of interest that they had mapped, and helpful discussion on many aspects on the geology of the district.

Grateful acknowledgment is also made to Mr.P.M.Madden of "The Rookery", Mr.W.Morris of "Coree" and Mr.J.Forbes of "Elliston" properties for permission to camp on their respective properties and for many other kindnessess.

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→ Mineralization in the Cobar Nymagee province and its significance

COBAR DISTRICT N.S.W.

Areas investigated by the Bureau of Mineral Resources 1949

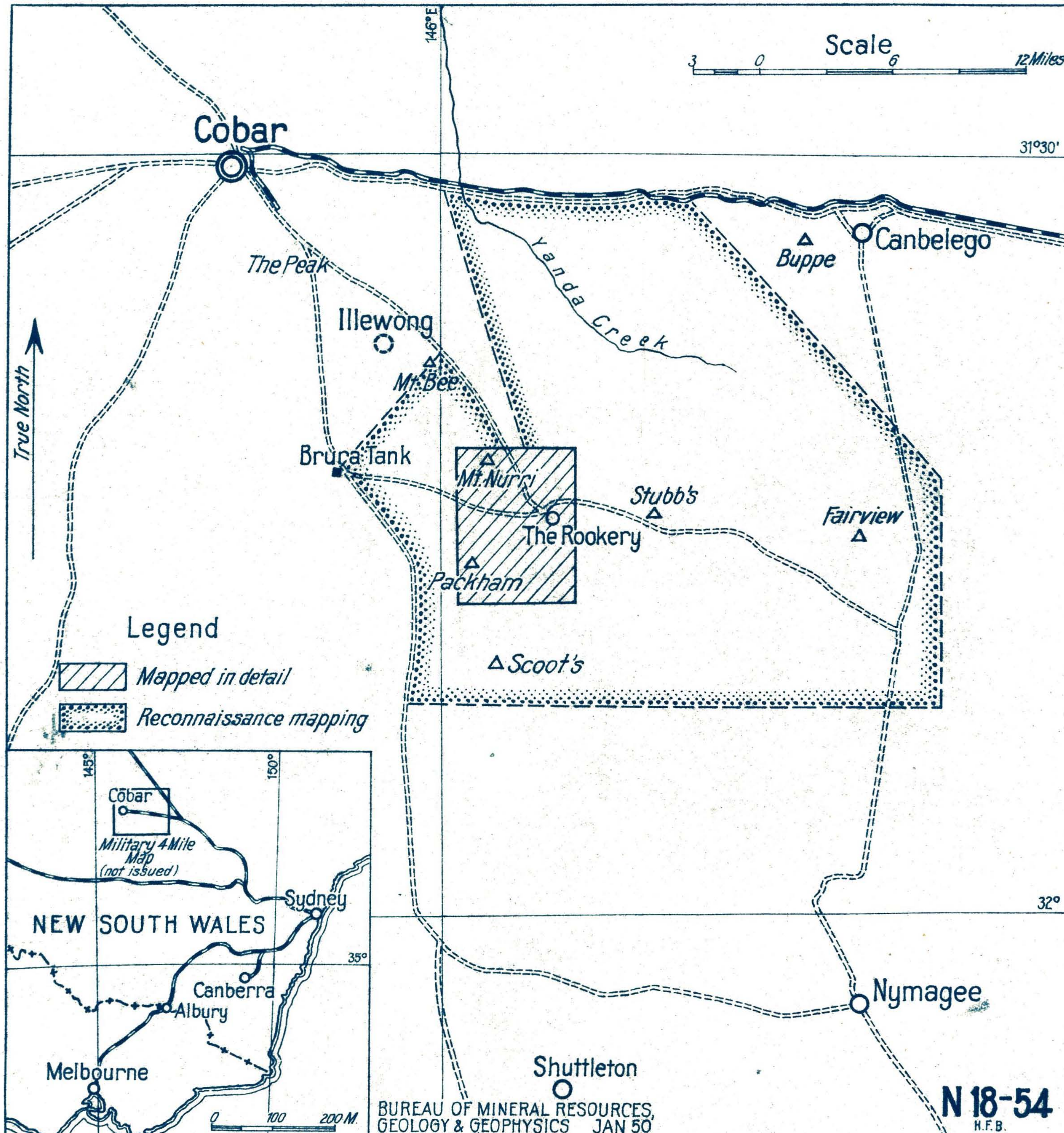


Plate 2
GEOLOGY
OF THE
ROOKERY - NURRI AREA
COBAR, N.S.W.
Geology by K.W.B. Iten, E.K. Carter, & H.J. Ward, May - August 1949
Scale of Miles
Nurri Trig
Langfords Shaft
Old Cobar - Nymagee Road
Clay Pit
HOMESTEAD
PADDOCK
The Rookery
County of Robinson
County of Mouramba
Brura Tank - The Rookery Track
Field Camp
Yard Tank
Buckleys Tank
True North
Magnetic
Geological boundaries, definite
Geological boundaries, approximate
Geological boundaries, concealed
Faults, definite
Faults, probable
Bedding strike, dip; & plunge & vertical bedding
Cleavage, strike & dip; & vertical cleavage
Sediments heavily impregnated with iron oxide
Quartz veins
Vehicle tracks
Fences
Tanks & dams
Shafts
Trig stations
Shear zones
RECENT
Alluvium
Soil
MALLEE TANK GROUP
LOWER DEVONIAN OR UPPER SILURIAN
Rookery Limestone
Bee Quartzite
SILURIAN
WELTIE GROUP
Fine-grained yellow Sandstones, Claystone, Mudstone.
Cherts
Quartzitic Sandstone, Quartzite
C.S.A. GROUP
SCOOT QUARTZITE
Quartzitic Sandstone, Quartzite
Fine-grained Sandstone
PACKHAM FORMATION
Yellow, argillaceous Sandstone, Claystone
White, argillaceous Sandstone
BUCKLEY FORMATION
Mudstone, Slates, sandy Slates & slatey Sandstones.
COBAR GROUP
Sandy Slates, slatey Sandstones, quartzitic Sandstones, fine-to medium-grained Sandstones, tuffaceous Sandstones.
Bureau of Mineral Resources, Geology, & Geophysics. Mar. 1949.
N18-56
W.T.C.

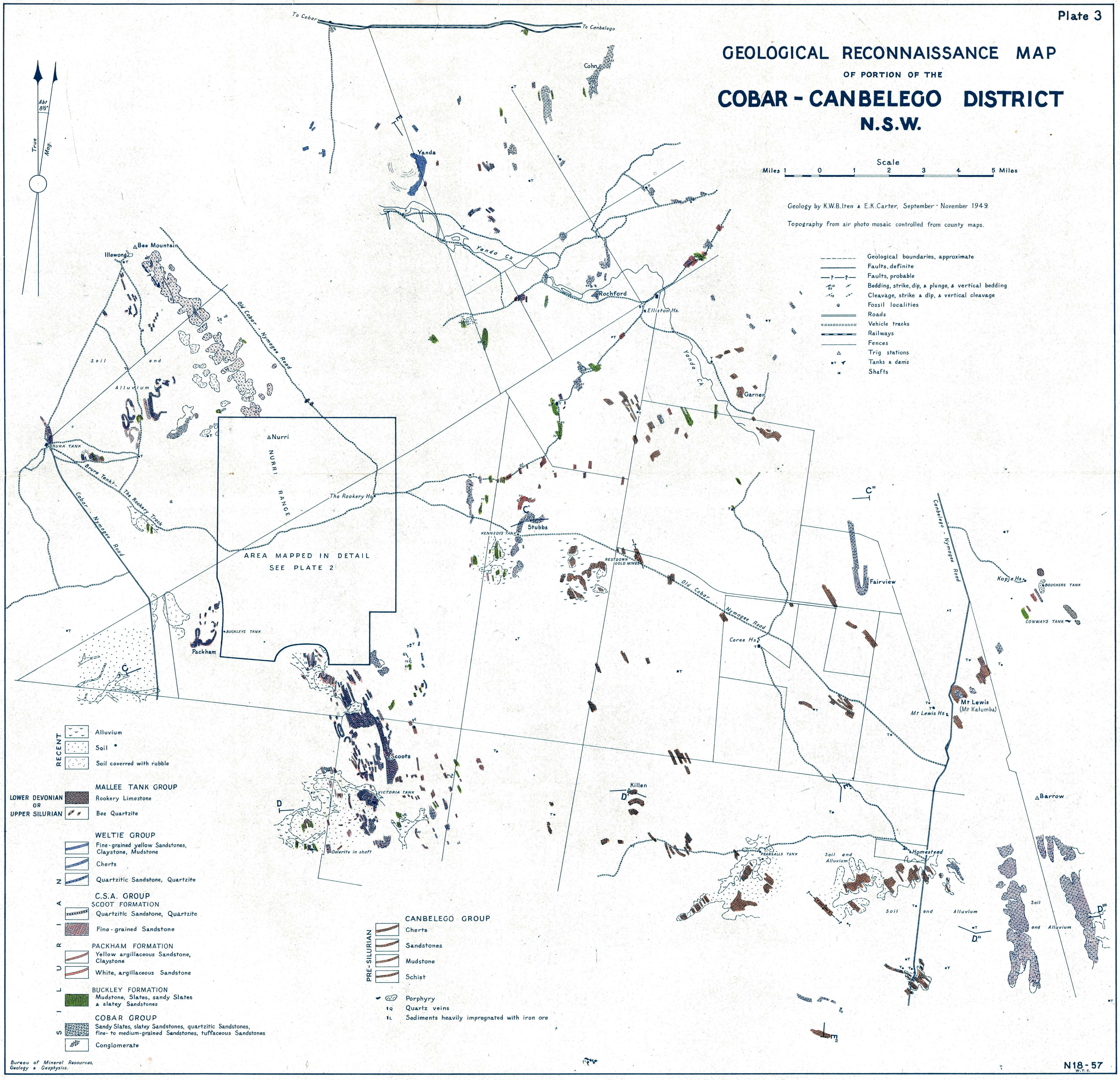


Plate 3
GEOLOGICAL RECONNAISSANCE MAP
OF PORTION OF THE
COBAR - CANBELEGO DISTRICT
N.S.W.
Scale
Miles 1 0 1 2 3 4 5 Miles
Geology by K.W.B. Iten & E.K. Carter, September - November 1949.
Topography from air photo mosaic controlled from county maps.
Geological boundaries, approximate
Faults, definite
Faults, probable
Bedding, strike, dip, & plunge, & vertical bedding
Cleavage, strike & dip, & vertical cleavage
Fossil localities
Roads
Vehicle tracks
Railways
Fences
Trig stations
Tanks & dams
Shafts
True
Mag.
Abt 8½°
To Cobar
To Canbelego
Cohn
Yanda
Yanda Ck
Rochford
Elliston Hs.
Yando Ck
Garner
Bee Mountain
Illewong
Old Cobar - Nymagee Road
Soil and Alluvium
Nurri
NURRI RANGE
The Rookery Hs
Brura Tank
The Rookery Track
Cobar - Nymagee Road
AREA MAPPED IN DETAIL
SEE PLATE 2
Kennedys Tank
Stubbs
Restdown Gold Mines
Old Cobar - Nymagee Road
Fairview
Canbelego - Nymagee Road
Kopje Hs.
Bouchers Tank
Conways Tank
Buckleys Tank
Packham
Coree Hs
Mt Lewis
(Mt Kalumba)
Mt Lewis Hs
Scoots
Victoria Tank
Dolerite in shaft
Killen
Barrow
Homestead
Pearsalls Tank
Soil and Alluvium
Soil and Alluvium
Soil and Alluvium
RECENT
Alluvium
Soil
Soil covered with rubble
LOWER DEVONIAN OR UPPER SILURIAN
MALLEE TANK GROUP
Rookery Limestone
Bee Quartzite
SILURIAN
WELTIE GROUP
Fine-grained yellow Sandstones, Claystone, Mudstone
Cherts
Quartzitic Sandstone, Quartzite
C.S.A. GROUP
SCOOT FORMATION
Quartzitic Sandstone, Quartzite
Fine-grained Sandstone
PACKHAM FORMATION
Yellow argillaceous Sandstone, Claystone
White, argillaceous Sandstone
BUCKLEY FORMATION
Mudstone, Slates, sandy Slates & slatey Sandstones
COBAR GROUP
Sandy Slates, slatey Sandstones, quartzitic Sandstones, fine- to medium-grained Sandstones, tuffaceous Sandstones
Conglomerate
PRE-SILURIAN
CANBELEGO GROUP
Cherts
Sandstones
Mudstone
Schist
Porphyry
Quartz veins
Sediments heavily impregnated with iron ore
Bureau of Mineral Resources, Geology & Geophysics.
N18-57

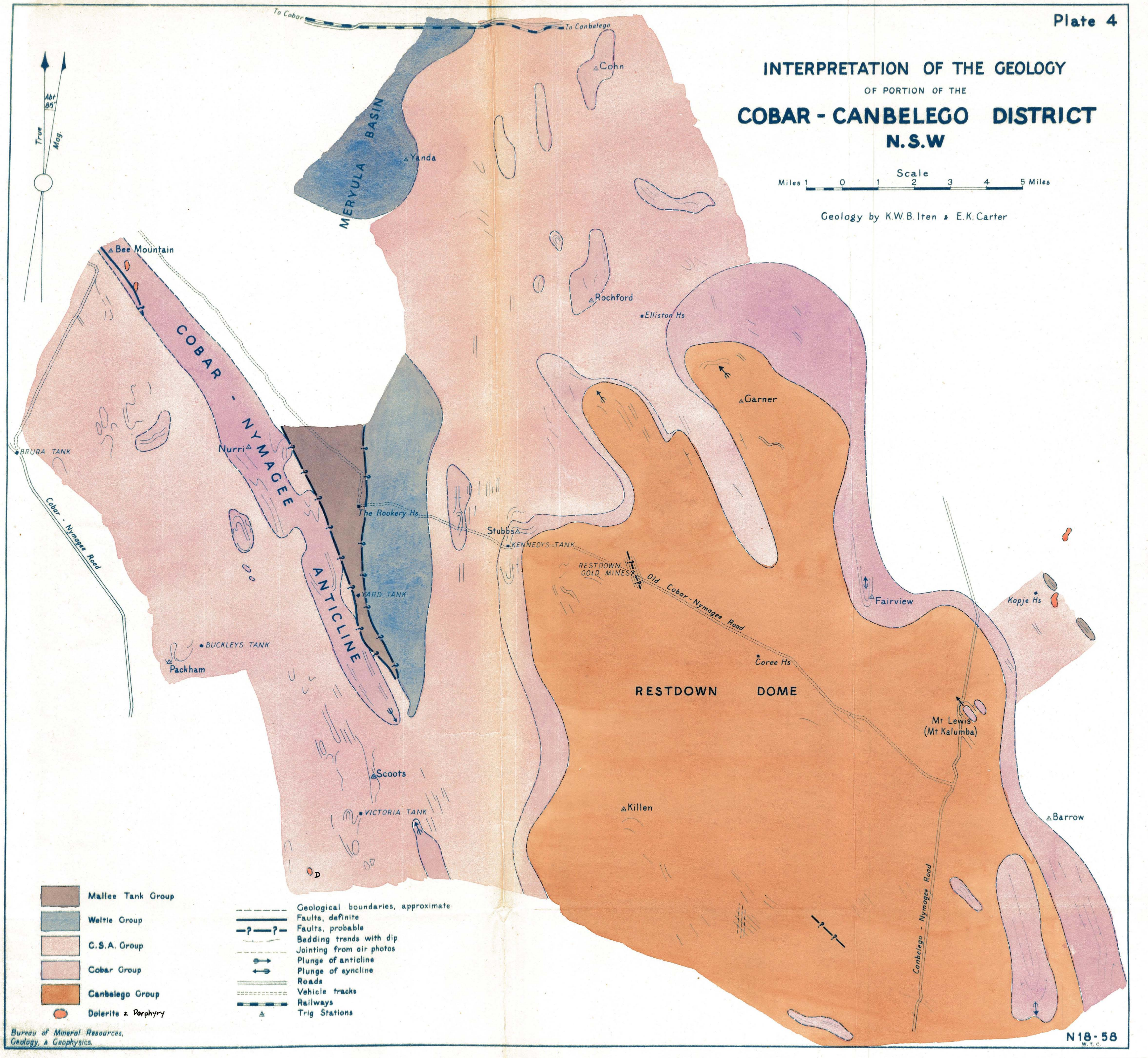
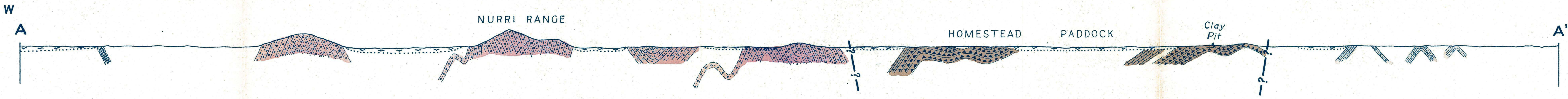
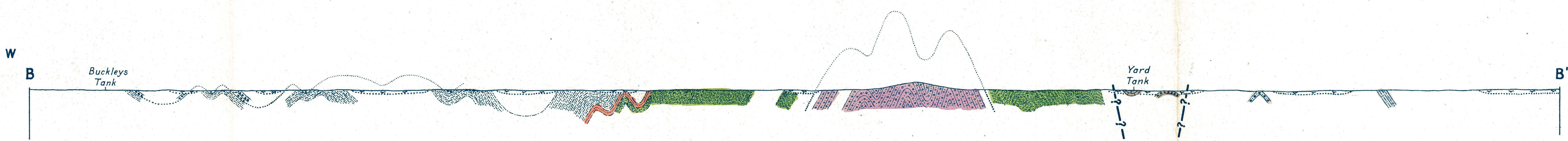


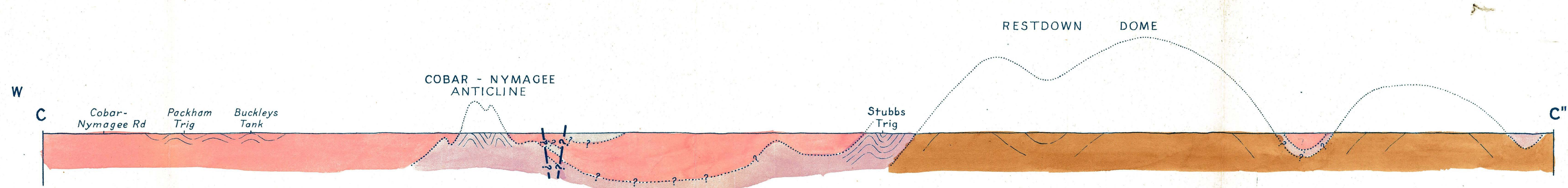
Plate 4
INTERPRETATION OF THE GEOLOGY
OF PORTION OF THE
COBAR - CANBELEGO DISTRICT
N.S.W
Scale
Miles 1 0 1 2 3 4 5 Miles
Geology by K.W.B. Iten & E.K. Carter
True
Mag.
Abt 8½°
To Cobar
To Canbelego
Cohn
Yanda
MERYULA BASIN
Bee Mountain
Rochford
Elliston Hs
COBAR - NYMAGEE ANTICLINE
Nurri
BRURA TANK
Cobar - Nymagee Road
The Rookery Hs
Stubbs
KENNEDYS TANK
RESTDOWN GOLD MINES
Old Cobar - Nymagee Road
Garner
Fairview
Kopje Hs
YARD TANK
BUCKLEYS TANK
Packham
Coree Hs
RESTDOWN DOME
Mr Lewis
(Mt Kalumba)
Scoots
VICTORIA TANK
Killen
Barrow
D
Canbelego - Nymagee Road
Mallee Tank Group
Weltie Group
C.S.A. Group
Cobar Group
Canbelego Group
Dolerite & Porphyry
Geological boundaries, approximate
Faults, definite
Faults, probable
Bedding trends with dip
Jointing from air photos
Plunge of anticline
Plunge of syncline
Roads
Vehicle tracks
Railways
Trig Stations
Bureau of Mineral Resources, Geology & Geophysics.
N18-58
W.T.C.



CROSS SECTION A - A'''' (Plate 2)

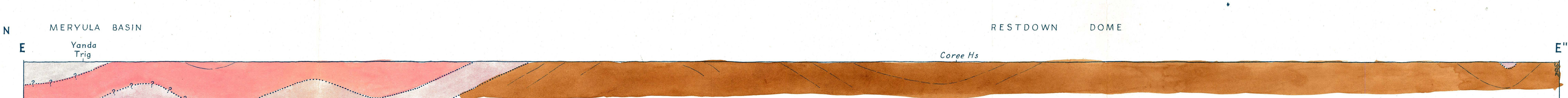


CROSS SECTION B - B''' (Plate 2)



CROSS SECTION C - C'' (Plate 3)

CROSS SECTION D - D''' (Plate 3)



LONGITUDINAL SECTION E - E'' (Plate 3)

SECTIONS

FROM PLATES 2 AND 3

COBAR CANBELEGO DISTRICT

N.S.W.

Scale - Plate 2

Miles 1 ¾ ½ ¼ 0 1 Miles

Scale - Plate 3

Miles 1 0 1 2 3 4 5 Miles

No vertical exaggeration

Geology by K.W.B. Iten & E.K. Carter

.... Geological boundaries, concealed

—?— Faults, probable

	Sections from Plate 3	Sections from Plate 2	
RECENT			Alluvium
			MALLEE TANK GROUP
LOWER DEVONIAN OR UPPER SILURIAN			Rookery Limestone
			Bee Quartzite
			WELTIE GROUP
SILURIAN			Fine-grained yellow Sandstones, Claystone, Mudstone
			Cherts
			Quartzitic Sandstone, Quartzite

	Sections from Plate 3	Sections from Plate 2	
			C.S.A. GROUP SCOOT QUARTZITE
			Quartzitic Sandstone, Quartzite
			Fine-grained Sandstone
SILURIAN			PACKHAM FORMATION Yellow argillaceous Sandstone, Claystone
			BUCKLEY FORMATION Mudstone, Slates, sandy Slates & slatey Sandstones
			COBAR GROUP Sandy Slates, slatey Sandstones, quartzitic Sandstones, fine- to medium-grained Sandstones, tuffaceous Sandstones
PRE-SILURIAN			CANBELEGO GROUP Cherts & Sandstones

Bureau of Mineral Resources, Geology & Geophysics. June 1950.