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COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF SUPPLY AND DEVELOPMENT.

BUREAU OF MINERAL RESOURCES
GEOLOGY AND GEOPHYSICS.

REPORT No. 1949/49
(Geol. Ser. No. 32)

RECONNAISSANCE SURVEY OF RADIO-ACTIVE MINERAL DEPOSITS IN THE PILBARA GOLDFIELD

by

W.C. Smith
Geologist

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PLANS.

I. SUMMARY.

A. Areas Inspected.

The areas inspected were Wodgina, Mount Francisco, Pilgangoora, Abydos (including Ailsa Downs) and Cooglegong (including Trig. Hill). These all lie west of Marble Bar, between the Coongan and Yule Rivers, within the area covered by the Marble Bar 4-mile Military Map (F50/8).

B. Radio-Active Mineral Occurrences.

The radio-active minerals found in this area are all of the pegmatitic assemblage which has rarely been a source of major production except in Madagascar. No hydrothermal concentrations of uranite (pitchblende) or secondary concentrations such as form the major sources of uranium in other countries, have been found in the Pilbara Goldfield. The occurrences found to date do not constitute likely sources of uranium under present economic conditions, but do indicate that this is a uranium-thorium province in which the discovery of payable concentrations is possible. Secondary concentrations of uranium minerals may occur associated with post-granite sediments such as those of the Nullagine System, but no carbonaceous sediments which would favou the deposition of such minerals as carnotite are known to exist in the area.

It is possible, also, that the larger streams contain workable alluvial deposits of monazite with cassiterite and perhaps some rare-earth tantalates. There is no evidence that such alluvial deposits exist, but very little sampling of the larger streams has been attempted, therefore a suggested program of boring has been set out in this report.

The following is a summary of the radio-active occurrences inspected.

1. Maitlandite, Nicolayite, Pilbarite and Hydrothorite.

Wodgina. No new occurrences of these minerals were found. The largest deposit at present known is the pilbarite lode at Wodgina (Ball, 1947), which is a biotite-rich lens in the pegmatite, about 2½ feet by 1 foot in vertical section, containing no more than a few pounds of pilbarite and hydrothorite. This is terminated at its southern end by a normal fault whose downthrow is to the south. The manager at Wodgina intends to continue the Collins Shaft immediately south of this fault, in search of beryl and tantalite, and may thus find an extension of the pilbarite-bearing lens.

2. Rare Earth Tantalates.

Cooglegong. The occurrence of yttrotantalite at Trig Hill was inspected. This is reported to have yielded about 600 lb. of yttrotantalite in the past, but reserves are now probably less than 200 lb.

A radio-active mineral, probably tantalopolycrase, was found in Reward Gully. It has been reconcentrated by the creek from rejects of old tin workings in the creek bank, and is very irregularly distributed; the total reserves are probably much less than 100 lb.

Abydos. A concentrate obtained from a creek near Pinger Well contained monazite and a little tantalopolycrase with cassiterite. The total tantalopolycrase in the creek probably does not exceed 20 lb.

3. Monazite.

Cooglegong. A very small quantity of monazite was found with the yttrotantalite at Trig Hill, and a concentrate of monazite and cassiterite was obtained from small pockets of eluvial material on the southern slope of a granite hill, four miles south of Cooglegong Crossing.

Abydos. Monazite occurs with cassiterite and tantalopolycrase in a small creek near Pinger Well, but total reserves in the creek are probably less than 100 lb. Rejects found at an old jig site near Pinger Well also contained monazite.

4. Radio-Active Columbite.

Four samples of columbite showed appreciable radioactivity when tested with a Geiger Counter. These were assayed by the Government Chemical Laboratories, W.A., and found to contain much less uranium and thorium than the rare earth tantalates or monazite.

Mount Francisco. In the south eastern corner of MC121 there is a small lode of columbite in a pegmatite dyke. This columbite contains 0.008 per cent. uranium and 0.21 per cent. thorium. About 20 lb. of columbite have been obtained from this lode, but less than 10 lb. are now visible.

Samples of alluvial and eluvial columbite were handpicked from dumps on ML119. The alluvial columbite contained 0.002 per cent. uranium and 0.13 per cent. thorium, and the eluvial columbite contained 0.004 per cent. uranium and 0.12 per cent. thorium. About 3,000 lb. of columbite have been obtained from this lease, but probably less than 1,000 lb. are now available, even if re-worked by more efficient means.

Abydos. A sample of columbite, reported to have been found on the former Ailsa Downs property, contained 0.008 per cent. uranium and 0.09 per cent. thorium. This may have been obtained from eluvial ground seven miles east of Abydos Homestead. As the occurrence was not inspected, no estimate of reserves can be made.

II. INTRODUCTION.

A. General.

A party consisting of one geophysicist, one geologist, and a local prospector, carried out a survey of deposits of radio-active minerals in an area between the Coongan and Yule Rivers, Pilbara Goldfield, W.A., during September and October, 1948. This was a continuation of the survey commenced in the previous year (Ball, 1947). Before the party set out, aerial photographs of the area covered by the Marble Bar 4-mile Map (F50/8) were received. These gave full coverage of the localities inspected, and were of great value in the field.

B. Method of Investigation.

Owing to the limited time available, the survey was mainly confined to an inspection of localities from which radioactive minerals had previously been reported. However, some other mineral localities were inspected, and the Geiger Counter was used extensively by the geophysicist, D. W. Keam, on many types of rocks and detrital material in the areas examined.

In this way an occurrence of radio-active columbite was found at Mount Francisco, and columbite and tantalite were therefore included among the minerals to be investigated.

The Geiger Counters used were "Austronic" portable sets which are manufactured in Australia. These are equipped with rate-meters with a number of counting ranges, permitting reasonably accurate counting of even highly radio-active samples. In this respect they proved superior to the Canadian portable set used by Ball (1947). The Australian counters were quite robust and developed no faults during the survey. In evaluating results obtained from the counters, large samples were not regarded as significantly radio-active unless they gave counts greatly exceeding 100 per minute above background, because granite examined by Ball (1947), which was found to contain less than 0.002 per cent. uranium, gave counts of more than 100 per minute above background. Furthermore, Senftle (1948) suggests that potassium-bearing minerals such as microline may give counts of about 60 per minute above background, due to the presence of radio-active potassium.

Alluvial samples were all concentrated by means of a yandie. This is an open-ended trough of wood or iron, with which aboriginals concentrate heavy minerals without using water. In the hands of an expert, using a complex rocking motion combined with winnowing, the yandie is quicker than, and at least as efficient as, an alluvial panning dish. As alluvial occurrences are commonly worked by means of yandie or dry-blower in the Pilbara Goldfield, yandied samples should provide a reasonable measure of recoverable quantities.

The irregular distribution of the radio-active minerals prohibited accurate quantitative sampling in the time available, but rough estimates of reserves were made. As no large occurrences were found and detailed sampling was not attempted, no plane-table surveys were made. All maps except the location map were prepared from air photographs using control-points obtained by radial-line plots. Detail was copied from the photographs by means of a sketchmaster, an instrument which superimposes an image of each photograph on the image of the paper on which the map is being drawn. It may be adjusted to vary the scale and to correct for tilt of the camera or slope of the ground.

C. Acknowledgments.

The party is greatly indebted to A. L. Kennedy, Manager of Wodgina for Tantalite Ltd., whose advice and assistance were freely given. His extensive knowledge of local minerals and mineral occurrences proved most valuable.

R. S. Matheson, a Senior Geologist of the Bureau, visited the party during the last week of the field work, and his advice greatly assisted in a general appreciation of the geological problems of the area.

Assays for uranium and thorium content of the four samples of radio-active columbite were carried out by the Government Chemical Laboratories, W.A.

III. RADIO-ACTIVE MINERALS OF THE PILBARA GOLDFIELD.

A. High-Grade (More than 20 per cent. uranium or 50 per cent. thorium).

Maitlandite) Nicolayite) Pilbarite) Hydrothorite) These are hydrous silicates of uranium, thorium, and lead; nicolayite, pilbarite and hydrothorite are considered to be progressive weathering products of maitlandite in that order. The uranium is present in fresh Maitlandite mainly as UO_2, but exists entirely as UO_3 in its weathering products. The minerals are usually surrounded by black pleochroic halos by means of which even microscopic grains may be readily detected. These halos are known locally as "cats eyes". The four minerals are all isotropic, but can be easily distinguished by the properties given in the following table (after Simpson, 1928), which also includes their uranium and thorium contents determined by gravimetric analyses (Simpson, 1919 and 1928).

Mineral	Maitlandite	Nicolayite	Pilbarite	Hydrothorite
Colour	Black	Bright yellow	Yellow to Orange	Pale pink or cream
Texture	Glassy	Sub-vitreous, dense	Earthy, porous, moderately tough	Earthy, very porous, fragile
Hardness	4	3.5	2.5 - 3	1 - 2
S.G.	4.31 - 4.45	4.13	4.68	Not known
R.I.	Not known	1.609-1.624	1.74	1.638
UO_2	35.60%	Nil	Nil	Nil
UO_3	Present	37.33%	27.09%	2.98%
ThO_2	24.72%	24.45%	31.34%	57.79%

B. Low Grade. (Less than 10% Uranium or 10% Thorium)

Tantalopolycrase) Tanteuxenite) Yttrotantalite) Calciosamarskite) These are rare earth tantalates, niobates and titanates, which generally contain uranium and thorium. Calciosamarskite and yttrotantalite are essentially tantalates and niobates of yttrium and erbium which are low in titanium, while tantalopolycrase and tanteuxenite form an isomorphous series of titanotantalates and niobates of yttrium and erbium, tantalopolycrase containing the greater amount of titanium (about 30 per cent.). The four minerals all crystallize in the orthorhombic system, but do not all have the same crystal structure. Palache, Berman and Frondel (1944) quote the approximate formula of yttrotantalite as $A_6B_7O_{25}$ and that of the other three as AB_2O_6, where A includes calcium and the rare earths with uranium and thorium, and B includes titanium, tantalum, and niobium. Published analyses of the minerals from the Pilbara Goldfield fit very closely to these formulae. The uranium and thorium contents are variable even within one locality, the highest recorded in the area being 8 per cent. UO_3 in one specimen of calciosamarskite (Carroll, 1945).

The specimens of these minerals reported from the Pilbara Goldfield are all very similar in appearance and physical properties, making accurate identification in the field almost impossible. They are generally dull brown on weathered surfaces but dark olive brown to black on fresh surfaces, with a subconchoidal fracture, greenish brown to brown streak, and resinous to brilliant resinous lustre. Their hardness ranges from 5¼ to 5½ and specific gravity generally from 5.4 to 5.8. Thin sections are isotropic, translucent to transparent, and vary in colour from olive yellow to olive brown and light brown. An exception to these is the yttrotantalite from Trig Hill, some of which has reddish yellow weathered surfaces and specific gravities up to 6.78 (Carroll, 1948). Some tantalopolycrase is of lighter colour, from bronze to olive brown on fresh surfaces, and this variety may have a specific gravity as low as 5.04.

Monazite) These are rare earth phosphates which generally
Xenotime) contain thorium and in many cases a little uranium.

Xenotime is a phosphate of the yttrium group of metals, and crystallizes in the tetragonal system. It generally occurs in the area only as minute inclusions in biotite, and is unlikely to form workable deposits. Monazite is a monoclinic phosphate of the cerium group of metals. Alluvial monazite commonly occurs in the Pilbara Goldfield as coarse crystals and grains, many of them several grams in weight. It is a mottled cinnamon-brown to brown, opaque mineral, which commonly contains microscopic intergrowths of albite. It is brittle, has an uneven fracture and one good cleavage, a somewhat resinous lustre on fresh faces, and a pale reddish-brown streak. Its hardness is 5 to 5½, and specific gravity about 5.0. The thorium content of specimens from the Pilbara Goldfield ranges from 3.46 to 5.24 per cent ThO_2, according to published analyses, including those of Simpson (1919).

Columbite) In the course of this investigation, it was found
Tantalite) that some columbites are radio-active. The presence of uranium in these was confirmed by qualitative tests, and four samples were supplied to the Government Chemical Laboratories, W.A., to be assayed for uranium and thorium. The richest of these was found to contain only 0.008 per cent. uranium and 0.21 per cent. thorium, although a Geiger count of 540 per minute above background was obtained from a 25 ounce sample.

Columbite and tantalite form an isomorphous series of niobates and tantalates of iron and manganese, which crystallizes in the orthorhombic system, columbite crystals being usually better formed than those of tantalite. No radio-active tantalite was found, but it is possible that such may exist. Columbite and tantalite are both greyish-black to black, opaque minerals which have an uneven fracture, brilliant submetallic lustre, grey to black streak, and hardness 6. Their specific gravities range from 5.2 for pure niobate (columbite) to about 7.9 for nearly pure tantalate (tantalite). The dividing line between columbite and tantalite is at a specific gravity of 6.55, representing 51.9 per cent. Ta_2O_5 by weight, or equal mols of tantalum and niobium. The specific gravities of the radio-active columbites found in the Pilbara Goldfield ranged from 5.6 to 5.9, representing 18 to 30 per cent. Ta_2O_5.

IV. GENERAL GEOLOGY

A. General.

As no geological map has yet been produced from the aerial photographs of the area covered by the Marble Bar 4-mile Military Map (F50/8), the location map (WA12A/1) included in this report has been prepared by superimposing geological boundaries from the frontispiece map of Geol. Surv. W.Aust. Bull. No.40 (Maitland 1908) on the military map. The geological map so obtained agrees generally with the results of a preliminary photographic interpretation, but is somewhat distorted owing to lack of accurate topographical data.

B. Warrawoona and Mosquito Creek Series.

The oldest known rocks in the Pilbara Goldfield are those of the Warrawoona Series which consists predominantly of metamorphosed volcanics (greenstones) with quartzites, jaspilites, and some schists of sedimentary origin. The volcanics vary from amphibolite schists to silicified pillow lavas and relatively unaltered amygdaloidal basic lavas which may generally be distinguished from those of the younger Nullagine System by their steeper dips and by the numerous quartz veins which intersect them. Micaceous and other schists of probable sedimentary origin are less common, but quartzites and jaspilites form prominent ridges in many areas. The generally near-vertical dip of these quartzites greatly assists identification of the Warrawoona Series in aerial photographs. The banded cherts and jaspilites are probably of sedimentary origin (McKinstry, 1939), and, when detailed mapping of the area is undertaken, they should prove to be of great value as marker beds, as they have in the Southern goldfields of the State (Miles, 1943). At Marble Bar Pool there are three jaspilite beds separated and underlain by pillow lavas, and a similar association, possibly representing the same horizon, is found on the road about 20 miles north of Nullagine.

There are no rocks between Marble Bar and Wodgina which have been correlated with the Mosquito Creek Series at Nullagine. This is essentially a sedimentary series consisting of slates, quartzites, grits, and conglomerates. Its exact relationship to the Warrawoona Series has not been proven, but, from the evidence obtained by Finucane and Maitland, it has been inferred that the Mosquito Creek Series unconformably overlies the Warrawoona Series. However, as the junction of the two series at Eastern Creek (Finucane, 1939) was obscured by talus, that apparent unconformity may be due to faulting; and aerial photographs show no unconformity between the "banded quartzite" southeast of Nullagine and the overlying beds which Maitland (1908) assumed to be the base of the Mosquito Creek Series. In describing his traverse from Mt. Elsie to Mosquito Creek, Maitland stated that he passed over schistose rocks (presumably Warrawoona Series) from which he was unable, in the course of several hasty traverses, to separate a series of grits, shales, and fine conglomerates (presumably Mosquito Creek Series), "as no obvious and well-marked stratigraphical break could be detected". An oblique aerial photograph taken facing southeast from Warrawoona suggests that, north of Nullagine, the Mosquito Creek and Warrawoona series may be conformable, but this has not been checked in the field. Thus, these two series may prove to be conformable as are the Whitestone and Greenstone Series of the Yilgarn (Ellis, 1939).

Both series are greatly folded and faulted, there being two systems of folding in each case. One is a system of sharp, sometimes overturned folds with intense drag folding of incompetent beds, particularly in the Warrawoona Series; the other is a system of wider cross-folds. Generally the tight folds of the Warrawoona Series trend N-S and those of the Mosquito Creek Series E-W. However, south of Marble Bar, the Warrawoona Series at Warrawoona trends NW-SE, so the E-W trend of the Mosquito Creek series may indicate a local variation in the direction of folding rather than a regional unconformity.

C. Granite.

Both the Warrawoona and Mosquito Creek Series have been intruded by acid, potash-rich, biotite granite. In many places, particularly in the Cooglegong area, there is extensive granitization of the sediments, and evidence of sedimentary structure in the granite, but there are also large areas of massive transgressive granite. In both metamorphic series there are numerous pegmatite dykes, quartz veins (some containing gold), mineralized shear zones and some porphyries, all probably related to the granite. The pegmatites and granite appear to be the source of all the radioactive minerals known to occur in the Pilbara Goldfield.

There is, asyet, insufficient evidence to show whether the variations in the granite are due to two or more ages of granitic intrusives or to two phases of the same granite.

D. Nullagine System.

Unconformably overlying the Warrawoona Series, Mosquito Creek Series, and the granite, are the sedimentary and volcanic rocks of the Nullagine System. These are best represented in the area between Marble Bar and Wodgina in a wide syncline, trending N-S between the Coongan and Shaw Rivers, which is modified by faults and minor folds, and forms a wide basin structure north of Glen Herring. East of the Coongan River the basal beds are well exposed in the Just-in-Time and Tassy Queen Mines (Finucane, 1938). They consist of a thickness of about 200 ft. of sandstones and shales, with lenticular beds of conglomerate conformably overlain by massive amygdaloidal lavas. In both mines, the base of this sedimentary group is a lenticular auriferous conglomerate, dipping SW at about 25°, which rests unconformably on schists of the Warrawoona Series. On the western side of the syncline, at Glen Herring and at the Black Range Crossing on the road from Marble Bar to Pilga, the basal beds are volcanics which lie unconformably on granite or on rocks of the Warrawoona Series. Overlying these volcanics is a massive quartzite which, at Glen Herring, is several hundred feet thick and forms very prominent ridges. It dips to the NE at 30°-40° and is overlain by more volcanics, above which is a thinner group of coarse felspathic sandstones and grits. These are also overlain by volcanics above which, in the centre of the basin, flat lying, probable arenaceous beds can be seen in aerial photographs. Thus, in the Marble Bar area, the Nullagine System contains at least four sedimentary groups separated by three groups of volcanics.

From descriptions given by Maitland (1908) and others, and from specimens seen in the field, the volcanics seem to vary from acid to basic and consist of lavas, flow breccias, tuffs, and porphyries (some of which are probably flows). Maitland described what appeared to be a devitrified rhyolite NW of Marble Bar, and amygdaloidal and vesicular andesites and basaltic lavas are found in many localities. The basal sedimentary group at Nullagine, which includes auriferous conglomerate, contains interbedded fine tuffs, and tuffs and breccias occur within the volcanic groups.

On the main road north of Nullagine there is a thickness of more than 100 ft. of massive felspar porphyry or porphyritic andesite, apparently conformably overlying quartzite which may be equivalent to that at Glen Herring, and a similar occurrence of porphyry and quartzite has been reported by Maitland (1908) at Elsie Crossing. Near Marble Bar, Finucane (1936) has described an intrusive porphyry and a flow porphyry which overlies the Warrawoona Series and the granite. These porphyries may be of Nullagine Age.

Possibly the highest group of rocks at present included in the Nullagine System in the Pilbara Goldfield is one containing limestones. Between Roy Hill and Bonnie Downs, there is a number of mesas consisting of horizontal, thinly interbedded, crystalline limestones and shales, capped by laterite. Both these and limestones near the Oakover River (Maitland 1908) contain unidentified vague markings which may represent fossils, and the limestones south of Bonnie Downs appear to overlie a sandstone from which two doubtful Cambrian fossils have been reported. This suggests that the limestone group and possibly some of the upper volcanics and sandstones of the Nullagine System may be of Cambrian age. At present, the whole of the Nullagine System is placed as late Pre-Cambrian (Forman, 1937).

E. Post-Granite Intrusives.

Several intrusive porphyries have been reported in the area, but, as they have not been found in the Nullagine Series, their exact age is doubtful. Some may have been associated with the granitic activity but others which intrude the granite may have been related to the sources of the Nullagine volcanics. Some felsites have been reported by Maitland (1908), but it is not clear whether they definitely intrude the Nullagine Series, so they may be of granitic origin.

Basic and intermediate dykes are very common, intruding the Warrawoona Series, Mosquito Creek Series, granite, and in some cases the lower part of the Nullagine System. Particularly where they intrude granite, the larger dykes form prominent, dark brown ridges, such as the Black Range at Hillside, which trend almost straight for many miles. The dykes are generally nearly vertical in dip, and appear to have followed tension faults and joints in the granite. The dyke rocks have been variously described as gabbro, diabase, dolerite, basalt, porphyrite, and epidiorite. A large dyke at Nullagine is about 1,500 ft. wide, and a fresh specimen from this contained 54.92 per cent. SiO_2 (Maitland, 1908). At present, these dykes are classified as post-Nullagine (Forman, 1937), but careful investigation and petrological study may show that some have been sources of Nullagine volcanics. Aerial photographs suggest that the large dyke at Nullagine may show such a relationship.

F. Laterite.

Throughout the area between Marble Bar and Wodgina, there are remnants of laterite capping flat-topped ridges of the Warrawoona Series and Nullagine System. There are also laterite caps on mesas on the granite plateaux and the coastal plain, and large areas of lateritic gibbers are common, particularly along the Turner River. Some ranges such as Wodgina have flat tops, representing the Miocene land surface, but no laterite cap. Few of the flat topped ridges and mesas shown on aerial photographs have been studied in the field, so it is possible that the laterite may be underlain in some places by thin beds of sediments such as the Oakover Beds which have been reported only from an area east of Marble Bar.

G. Travertine.

In the Turner River area there are several extensive outcrops of unfossiliferous limestone or travertine associated with fine red soil and lateritic gibbers. Crocker (1946) suggests that the travertine in South Australia was formed from calcareous loess augmented by cyclic lime (wind-borne lime derived from sea-spray). The existence of calcareous loess is suggested by aeolianite dunes which are thought to have been derived from windblown calcareous material from continental shelves exposed during Pleistocene time. As there are aeolianite dunes near Port Hedland, the travertine near the Turner River may have been formed in the same way as the South Australian travertine.

V. DESCRIPTION OF MINERAL OCCURRENCES

A. General.

Following the discovery of radio-active columbite at Mount Francisco, the geophysicist tested A. L. Kennedy's collection of local minerals with a Geiger counter, and found three columbites which were sufficiently radio-active to warrant further investigation. As no sample of the columbite from Pilgangoora was included in the collection, a brief visit was made to this locality, but the columbite was found to be non-radio-active.

B. Wodgina (See Plan No. WA12A/1 - no detailed plan included).

Wodgina is situated in a range of hills consisting of steeply dipping banded ferruginous quartzites, banded quartzites, slates, and metamorphosed volcanics (greenstones), of the Warrawoona Series, which is surrounded by flatter country composed principally of granite and later intrusives. The ferruginous quartzites form steep ridges whose flat tops represent the Miocene land surface. The metamorphic rocks have been intruded by numerous granitic and pegmatite dykes, some of which have been worked for tin, tantalite, and beryl.

The granitic dyke which constitutes the main tantalite lode contains the uranium and thorium minerals, maitlandite, nicolayite, pilbarite, and hydrothorite. Of these, the most common is pilbarite, but the largest visible occurrence of this mineral is in a biotite-rich lens, 2½ ft. by 1 ft. in vertical section (Ball, 1947), which would contain no more than a few pounds of pilbarite and hydrothorite. This lens is terminated at its southern end by a normal fault whose downthrow is to the south. A. L. Kennedy stated that he intended to continue the Collins Shaft immediately south of this fault, in search of beryl and tantalite, and may thus find an extension of the pilbarite-bearing lens.

About one mile NNW of the Main Lode at Wodgina, a small pegmatite on MC140 was examined. Several unusually high counts, up to 660 per minute above background, were obtained with a Geiger Counter in a pit about 6 ft. deep in the pegmatite, and a nearby dump gave a count of 150 per minute above background. Numerous samples from the positions where high readings were obtained gave no significant readings on the counter when removed from the area. No radio-active minerals were found, and concentration by means of a yandie gave no heavy minerals from the material in the dump. The activity is too high to be entirely due to radio-active potassium, so the occurrence remains unexplained, but it seems likely that the radio-active material is present in small quantities only.

Tantalite, microlite, and columbite, from the Wodgina area, including samples from MC140, showed very little radio-activity, the most active being a ½ lb. sample of columbite from the area north of Stannum, which gave a count of only 75 per minute above background.

C. Mount Francisco (See Plan No. WA12-2).

Mount Francisco is a small range of hills about 15 miles SSW of Wodgina. These hills consist of rocks of the Warrawoona Series, mainly metamorphosed volcanics (greenstones) and slates with only thin bands of quartzite, surrounded by granite and intruded by granite and pegmatite dykes. As at Wodgina, the pegmatites have been worked for tin, tantalite, columbite, and beryl, but only relatively small quantities have been obtained.

Cassiterite

On MC121, about ¾ mile NNW of the trig, there is a small pegmatite dyke, part of which, outcropping for about 20 ft. square, is rich in green mica and contains radiating crystals of tantalite. This pegmatite showed no significant radio-activity, and no radio-active minerals were found in it.

About ¼ mile south of this is another pegmatite about 200 ft. long, containing massive albite and quartz, which was worked by Rodgers, Hooley, and Radley, and yielded about 10 tons of clear white beryl, including eluvial material. It was stated locally that one assay indicated that the beryl lode may contain radio-active minerals, but, when tested with a Geiger Counter, no significant radio-activity was found anywhere on the pegmatite outcrop. A large quantity of freshly broken albite was examined, but no "cats-eyes" or other evidence of radio-active minerals were seen.

In the extreme southeast corner of MC121 there is a small occurrence of columbite in a vein of albite at the north-eastern end of a large pegmatite dyke. Large crystals of columbite up to 3 inches by 1 inch were visible over an area of a few square feet in the pegmatite, and some broken crystals were found in small heaps of broken rock nearby. A Geiger count of 750 per minute above background was obtained on the lode, and counts on the nearby heaps averaged 145 per minute above background. A 23 oz. sample of this columbite gave a count of 540 per minute above background, but, when assayed by the Government Chemical Laboratories, W.A., was found to contain only 0.008 per cent uranium and 0.21 per cent thorium. The specific gravity of one large crystal was 5.6, indicating a Ta_2O_5 content of about 18 per cent. The lode has yielded about 20 lb. of columbite, but less than 10 lb. are now visible.

Near the centre of the same pegmatite dyke there is a length of about 200 ft. containing helvite, and the Congo Tin Mine is situated at its southern end. However, no further radio-active minerals were found either in the pegmatite or in rejects from old eluvial tin workings just south of the Congo Tin Mine.

The pegmatite known as Hooley's Columbite Lode, on ML120, was not located, but a sample of columbite reported to have been taken from this lease was not radio-active.

The tin workings, five miles south of Mount Francisco, from which Simpson reported monazite and tanteuxenite (Carroll, 1945), were not located. The exact position of these workings was not known locally, but W. Hall of Port Hedland, who claimed to have worked in this area, considered that there are only very small quantities of monazite and tanteuxenite, as even the cassiterite was of very limited extent.

On ML119, six miles due north of Mount Francisco Trig. less than one mile east of the Wodgina track, there are two areas from which radio-active columbite has been obtained. The lease is on granite, although immediately to the north there are several small knolls of amphibolite schist, probably representing remnants of the Warrawoona Series. The lease is crossed by a vertically dipping basic dyke trending NW. The main workings were at the south end of the lease, in shallow alluvium at and above the junction of two small creeks which flow off the east side of a low hill of massive granite. An area about 150 ft. by 50 ft. was worked with sieve, yandie, and blower, and yielded about 3,000 lb. of columbite. A sample yandied from the dumps consisted of columbite with a little limonite (some pseudomorphous after pyrite), and contained no cassiterite or magnetite. A 2 lb. sample of the columbite, which was hand-picked from the dumps, gave a Geiger count of 360 per minute above background and, when assayed, was found to contain 0.002 per cent. uranium and 0.13 per cent. thorium. The average specific gravity of a number of clean crystals was 6.7, indicating a Ta_2O_5 content of about 22 per cent. North of the dyke on ML119 there is a small hill the crest of which is a lenticular outcrop of quartz, and, on the northern slope of this hill, a small quantity of columbite has been obtained from shallow eluvial material consisting principally of large pebbles of milky quartz. A 22 oz. hand-picked sample of this columbite gave a count of 180 per minute above background, and, when assayed was found to contain 0.004 per cent. uranium and 0.12 per cent. thorium. The average specific gravity of several crystals was 5.6, indicating a Ta_2O_5 content of about 18 per cent. If ML119 were worked over again by more efficient means, it would probably not yield more than 1,000 lb. of columbite, unless new alluvial ground were discovered.

D. Abydos and Ailsa Downs (See Plan No. WA12-3).

West of Abydos Homestead, the country, including the former Ailsa Downs property, consists of granite intruded by numerous basic dykes. There are a few small areas of amphibolite gneiss and possible remnants of the Warrawoona Series, but in general the granite is massive in character. Remnants of laterite occur east of the main road to Port Hedland, but none were found to the west, either in the aerial photographs or in the field.

About two miles NW of the site of the old Ailsa Downs Homestead, numerous irregular coarse-grained pegmatites occur in rough granite ridges. These pegmatites, which contain massive albite up to 16 ft. long, intergrown with quartz, weathered mica crystals up to 4 ft. across, and beryl, were the source of detrital and lode beryl worked by Watkins, Taplin, and Lamont. Watkins supplied to A. L. Kennedy at Wodgina a sample of large broken crystals of columbite intergrown with albite, and reported that it came from the same area as the beryl. However, when the area was inspected, no columbite was found near the beryl, either on the slopes or in the creeks. A 2 lb. sample of this columbite gave a Geiger count of 460 per minute above background, and when assayed was found to contain 0.008 per cent. uranium and 0.09 per cent. thorium. The largest crystal weighed 328 grams, and the specific gravity of a crystal containing no albite was 5.9, indicating a Ta_2O_5 content of about 30 per cent.

J. Parker of Port Hedland stated that he had obtained two bags of similar columbite, showing the same type of intergrowth, from a whitish coloured hill at a creek junction on the headwaters of the west branch of the Turner River. This lies seven miles west of Abydos Homestead, just inside the old Ailsa Downs boundary. Only one such hill can be seen on the aerial photographs, and the approach to it agrees with that described by Parker.

The whitish coloured material, probably travertine derived from weathering of albite, is locally known as "opaline". Parker stated that he sampled only a few small pits in what appeared to be a fairly extensive area of eluvial ground, but abandoned the area when he found there was no reasonable market for the columbite. Unfortunately this area was not inspected, as the information was obtained after the survey had been completed.

About one mile NE of the site of Ailsa Downs Homestead, there is a narrow belt of what appears to be granitized sediments forming ridges trending NNE for several miles. A. Jones reported that he had found detrital beryl and columbite further north along these ridges, but had not prospected the area sufficiently well to guide the party to the occurrence. No sample of this columbite was seen.

The small tinfield near Pinger Well, ten miles SW of Abydos Homestead, was inspected. This presumably is the area referred to by Simpson (1928), and from W. Hall's description includes Hall's Tin Find. It is locally known as Pinger Tinfield and has been tested by A. Jones and others, using a small jig, with disappointing results. Very little of the rejects remain, but a small concentrate was yandied from material near the jig site. This consisted mainly of magnetite, but contained about 10 per cent fine monazite and a few small grains of the dark variety of tantalopolycrase. The sample contained no columbite or gadolinite. A sample was yandied from alluvium in a small creek, about one mile west of Pinger Well, which A. Jones claimed to have given the best yield of tin. This sample weighed 18 oz. and gave a Geiger count of only 140 per minute above background. It contained approximately 2 per cent. tantalopolycrase (mainly the light coloured variety) and 10 per cent. fine monazite, but no columbite or gadolinite. The distribution of the wash in the creek is most irregular and the total tantalopolycrase and monazite available would probably be less than 100 lb.

E. <u>Pilgangoora</u> (See Plan No. WA12A/1 - no detailed plan included).

The tantalite and tin fields at Pilgangoora lie in the western side of a belt of metamorphic rocks of the Warrawoona Series, between two areas of granite. This belt is about 4 miles wide and trends N-S. The metamorphics are considerably granitized on their western margin, and intruded by numerous pegmatite dykes which contain cassiterite, columbite, and tantalite. There are also numerous small quartz veins which may be the source of the alluvial gold found particularly in the southern part of the field.

No significant radio-activity was observed in the field, and no radio-active minerals were found. The areas examined were the Wagon Wheels Patch, Websters Gully (Sixty Percent Gully), Paradise Gully, and Mount York Tin Mine.

At the Wagon Wheels Patch a small tantalite lode in a pegmatite and the tantalite-bearing alluvium were examined. The pegmatite resembled those at Wodgina in that it contained lepidolite and spodumene, but no radio-active minerals were seen in it.

One and a quarter pounds of concentrate yandied from the alluvium in Webster's Gully gave a Geiger count of less than 15 per minute above background, although it contained about 80 per cent. columbite. It may therefore be assumed that the columbite is non-radio-active.

Thirty-four ounces of concentrate yandied from Paradise Gully contained columbite of similar composition with a greater proportion of cassiterite and about 3 grains of gold.

Mount York Tin Mine is in a pegmatite dyke consisting principally of albite and quartz. In the mine cassiterite is associated with green mica and garnet, and is mainly confined to a number of narrow, parallel bands; it is found in both quartz and sugary, bladed, or massive, albite. The Geiger Counter indicated no radio-activity in any part of the pegmatite, and no radio-active minerals were found.

F. Cooglegong Area (See Plan No. WA12-4).

Cooglegong is situated in a large area of granite which, though massive in places, contains many remnants of the Warrawoona Series and areas of amphibolite gneisses, schists, and quartzites, which may represent granitized rocks of the Warrawoona Series. The granite has been intruded by numerous vertically dipping basic dykes, the largest of which form prominent straight ridges, such as the Black Range, several miles in length.

Trig Hill lies to the west of the Shaw River, near the margin of the granite. It consists of a small area of metamorphosed volcanics (greenstones) and thin quartzites of the Warrawoona Series, surrounded by granite containing amphibolite gneiss and schist. The hill has been intruded by an irregular massive pegmatite which appears to have been the source of yttrotantalite. The pegmatite is crossed by a small creek which carries cassiterite, presumably from pegmatite dykes farther upstream, but at and below the pegmatite it contains yttrotantalite. In the vicinity of the pegmatite the creek averages about three feet in width, and the depth of the alluvium varies from one to three inches. A concentrate weighing 3½ lb. was yandied from a quantity of alluvium representing the total content of the creek over a length of about four feet. This gave a Geiger count of 2090 per minute above background, and was found to contain about 60 per cent yttrotantalite and 2 per cent monazite. The yttrotantalite was of two varieties, one with a light reddish yellow weathered surface and the other with a dull brown weathered surface. The average specific gravity of the lighter coloured variety was 5.58, and that of the darker was 5.85. In the course of a Geiger traverse at 100 ft. intervals along the creek bed, only one place gave a count greater than 60 per minute above background. This was a position just below where the sample was obtained, the count being 420 per minute above background. This suggests that the bed of the creek is rich in yttrotantalite for a distance of less than 200 ft., probably about 100 ft. Eluvial yttrotantalite has been obtained from the vicinity of the pegmatite outcrop, mainly near its southern edge, but very little now remains. Lode material has also been reported ~~from the pegmatite~~, and some small holes have been blasted in the pegmatite near the top of the hill. These contained no visible yttrotantalite, and the Geiger count in the holes was no higher than on the greenstones. G. Lamont, who blasted some of the holes, and A. Jones, who worked on the field, claim that they have never seen lode material, but suggest that the eluvial yttrotantalite, which appeared very fresh, may have been confused with lode material. Local report indicates that the area has so far yielded about 600 lb. of yttrotantalite, but it is doubtful whether more than 200 lb. could now be obtained. A sample of yttrotantalite with specific gravity 5.79 from the Trig Hill pegmatite, analysed by Simpson, contained 2.38 per cent. uranium trioxide and 0.53 per cent. thorium dioxide.

A radio-active mineral of light brown colour and specific gravity 5.4, probably tantalopolycrase, was found with a little monazite in Reward Gully. This gully runs south into the head of the Two Mile Creek along the western side of a basic dyke which lies parallel to, and about two miles west of, the Black Range.

Along the western wall of the basic dyke there is a dyke of pegmatite. The alluvium in the gully has been worked for cassiterite, and the creek has since reconcentrated the minerals from the old rejects. The occurrence is very small, so no detailed investigation was made, but a sample was supplied to the Government Chemical Laboratories, W.A., for their information. A sample of tantalopolycrase with specific gravity 5.37 from Cooglegong, analysed by Brooking (Carroll, 1945) contained 6.69 per cent. uranium trioxide and 1.76 per cent. thorium dioxide.

A sample of monazite was reported to have been obtained from alluvial workings at the head of the Little Two Mile Creek. No monazite, however, was found on inspection, yandie concentrates containing only well formed crystals of cassiterite.

Portion of the bed of the Two Mile Creek had been exposed for sampling, but, although the alluvial material was rich in cassiterite, no monazite or other radio-active minerals were seen.

A little coarse monazite with finer cassiterite and garnet was yandied from very small eluvial pockets on the south side of a large granite hill, on the west side of the road, about four miles south of Cooglegong crossing. However, no workable quantities were seen, and the Geiger Counter indicated no appreciable radio-activity in any part of the granite or in the alluvium at the foot of the hill.

R. Johnson reported that the alluvium, which he had sampled and was preparing to work for tin at the Shaw Patch, contained very little monazite.

As the Shaw River Crossing at Hillside had been washed out, it was not possible to inspect the Ely's or Old Shaw Area. However, from a map seen at the Government Chemical Laboratories, W.A., the area inspected by Ball (1947) and referred to by him as Old Shaw was on Ely's Creek between the old and new wells. Local prospectors and natives state that they have found the workable alluvium to be restricted to narrow gutters, and this, together with Ball's evidence, suggests that the amount of yttrotantalite and monazite available would be small.

VI. CONCLUSIONS AND RECOMMENDATIONS.

Owing to the nature of the occurrences it is not possible to give an accurate estimate of available quantities without actually working the areas. If a sufficiently attractive price were offered for the minerals, or preferably for mixed concentrates containing tin, some of the known occurrences would be worked and further prospecting would be carried out. By this means, the quantity of monazite obtainable may be in the order of 10 tons, but that of such minerals as yttrotantalite would be much less. As very little work has been done on radio-active columbite, it is not possible to give any estimate of available quantities.

Owing to the nature and depth of the larger streambeds in the Moolyella and Cooglegong areas they have never yet been effectively sampled. In Cooglegong Creek, local prospectors have sampled some of the "pug" by means of an auger, but have been unable to sample the looser sands. The greater depth of such rivers as the Shaw, Talga and Yule would make sampling by means of an auger too slow and difficult.

At present, there is no evidence of workable quantities of heavy minerals such as tin and monazite in these larger streambeds, although the small but rich tin leads of the Moolyella area which lead into the Talga River may suggest such a possibility. To make a reliable evaluation of the area it would be necessary to undertake a well planned drilling programme, supervised by a geologist, and preferably carried out by experienced contract drillers. Only those streams which drain known tin and monazite fields need be sampled, and a few lines of closely placed bores at chosen sites should be sufficient to indicate the existence of any workable alluvial deposits. The following sites are suggested as those most likely to yield tin and monazite.

1. Shaw River below the Shaw Patch

   (a) near Hillside Station,
   (b) at its junction with Cooglegong Creek,
   (c) at the entrance to the Shaw Gorge,
   (d) below the mouth of the Shaw Gorge.

2. Cooglegong Creek

   (a) near where it cuts through the Black Range,
   (b) at its junction with the Shaw River.

3. Brockman Creek below Moolyella

   (a) at its junction with Moolyella Creek,
   (b) at its junction with the Talga River.

4. Talga River

   (a) at its junction with Brockman Creek,
   (b) at its junction with the Coongan River.

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In addition to references listed below, information was obtained from unpublished notes on minerals occurring in the Pilbara District, supplied by H. P. Rowledge.

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APPENDIX

DESCRIPTION OF SAMPLES

The uranium and thorium contents quoted for samples 1 to 4 have been determined by the Government Chemical Laboratories, W.A. The thorium was determined by gravimetric analysis.

1. Columbite from SE corner of M.C.121, Mount Francisco.

Lode columbite from small albite vein in pegmatite, about 100 ft. on bearing 204° from SE lease peg of M.C.121.

Crystals up to 3 inches by 1 inch.

Specific gravity 5.6, indicating Ta_2O_5 content of 18 per cent.

Uranium content, 0.008 per cent.

Thorium content, 0.21 per cent.

Geiger count on 23 oz. of columbite, 540 per minute above background.

Estimated reserves, less than 10 lb.

2. Columbite from S end of M.L.119, Mount Francisco.

Hand-picked from dumps of alluvial workings at junction of two small creeks on E side of low granite hill.

Rounded pebbles averaging about 20 grams weight.

Specific gravity 5.7, indicating Ta_2O_5 content of 22 per cent.

Uranium content, 0.002 per cent.

Thorium content, 0.13 per cent.

Geiger count on 2 lb. of columbite, 260 per minute above background.

Estimated reserves, less than 1,000 lb.

3. Columbite from N end of M.L.119, Mount Francisco.

Hand-picked from eluvial workings on N side of quartz blow.

Slightly rounded pebbles averaging about 30 grams weight

Specific gravity 5.6, indicating Ta_2O_5 content of 18 per cent

Uranium content, 0.004 per cent.

Thorium content, 0.12 per cent.

Geiger count on 22 oz. of columbite, 180 per minute above background.

Estimated reserves, less than 100 lb.

4. Columbite intergrown with albite, from Ailsa Downs.

Portion of sample supplied to A. L. Kennedy by D. Watkins. Source not known, but possibly from eluvial material on whitish hill, 7 miles E of Abydos Homestead, at creek junction on headwaters of west branch of Turner River.

Broken crystals with well developed faces, intimately intergrown with weathered albite. Largest crystal weighed 328 grams.

Specific gravity 5.9, indicating Ta_2O_5 content of 30 per cent.

Uranium content, 0.008 per cent.

Thorium content, 0.09 per cent.

Geiger count on 2 lb. of columbite and albite, 460 per minute above background.

Reserves unknown.

5. Concentrate from creek 1 mile W of Pinger Well, Abydos.

Yandied from irregular shallow alluvium in creek bed.

Approximate Composition

Tantalopolycrase, 2 per cent.; mainly light coloured variety; fine grains and fragments up to 0.1 gram weight; average specific gravity 5.2.

Monazite, 10 per cent.; fine grains.

Cassiterite, 50 per cent.; most passed 20 mesh screen.

Remainder magnetite, ilmenite, haematite, garnet, and felspar.

Geiger count on 7¾ oz. of concentrate, 80 per minute above background.

Alluvium sampled contained approximately 15 lb. per yard cassiterite, 3 lb. per yard monazite, and less than 1 lb. per yard tantalopolycrase.

Estimated reserves, probably less than 100 lb. of monazite and 20 lb. of tantalopolycrase.

6. Concentrate from jig site near Pinger Well, Abydos.

Yandied from rejects.

Approximate Composition

Tantalopolycrase, a few very small grains of dark variety.

Monazite, 10 per cent.; crystals and grains up to 0.1 gram weight, including one perfect doubly terminated prismatic crystal of specific gravity 5.0.

Remainder fine cassiterite, magnetite, garnet, and felspar.

No reserves.

7. Concentrate from creek at Trig Hill, Cooglegong.

Yandied from alluvium representing total content of creek for 4 ft. length, where creek crosses pegmatite.

Approximate Composition.

Yttrotantalite, 60 per cent.; coarse pebbles mainly exceeding 1 gram weight; two varieties, one with light reddish yellow weathered surface and specific gravity 5.58, and other with less weathered darker brownish surface and specific gravity 5.85.

Monazite, 2 per cent.; mainly coarse pebbles.

Remainder cassiterite, magnetite, garnet, and felspar.

Geiger count on 3½ lb. of concentrate, 2090 per minute above background.

Alluvium sampled contained approximately 100 lb. per yard yttrotantalite and 3 lb. per yard monazite.

Estimated reserves, probably less than 200 lb. of yttrotantalite and 6 lb. of monazite.

8. Concentrate from Reward Gully, Cooglegong.

Yandied from irregular shallow alluvium in creek, which has probably been reconcentrated from rejects of old tin workings in creek bank.

Approximate Composition

Tantalopolycrase, 30 per c nt.; several grains exceeded 1 gram weight; light brown on weathered surfaces dark olive brown on fresh faces; specific gravity 5.4.

Remainder cassiterite, magnetite, garnet, and felspar.

Geiger count on 2 lb. of concentrate, 460 per minute above background.

Estimated reserves of tantalopolycrase, probably less than 100 lb.

9. Concentrate from granite hill, 4 miles south of Cooglegong Crossing.

Yandied from very small pockets of eluvial material on south side of hill about 200 yards west of road.

Approximate Composition

Monazite, 30 per cent.; coarse angular fragments and crystals.

Remainder, cassiterite, magnetite, and garnet.

Estimated reserves negligible, there being insufficient to pay for working even by yandie.

10. Concentrate from Paradise Gully, Pilgangoora.

Yandied from shallow alluvium in small creek. (Eluvial material on banks of creek contains coarser columbite and gold but less cassiterite).

Approximate Composition.

Columbite, 60 per cent.; from fine grains to coarse pebbles up to 9.9 grams weight; average specific gravity 6.3, indicating Ta_2O_5 content of 43 per cent.

Cassiterite, 25 per cent.; mainly fine.

Gold, 7 oz. per ton of concentrate, excluding fines lost in yandie.

Remainder magnetite, limonite, garnet, and felspar.

Geiger count on 34 oz. of concentrate, 35 per minute above background.

Alluvium sampled contained approximately 30 lb. per yard columbite, 12 lb. per yard cassiterite, and 3 to 4 dwt. per yard gold.

As the concentrate was not radio-active no estimate of reserves was made. However, A. Jones has worked the area and states that it is suitable for working with sieve and yandie or sieve and dry-blower. There is no water available for a jig and the alluvium is too shallow and irregular to be stripped by mechanical means.

11. Concentrate from Webster's Gully, Pilgangoora.

Yandied from irregular shallow alluvium in creek. Older alluvium in creek banks has also been worked in the past.

Approximate Composition

Columbite, 80 per cent.; from fine grains to pebbles up to 4 grams weight; average specific gravity 6.25, indicating Ta_2O_5 content of 42 per cent.

Cassiterite 2 per cent.; mainly fine.

Remainder magnetite, limonite, garnet, and felspar.

Geiger count on 20 oz. of concentrate, 45 per minute above background.

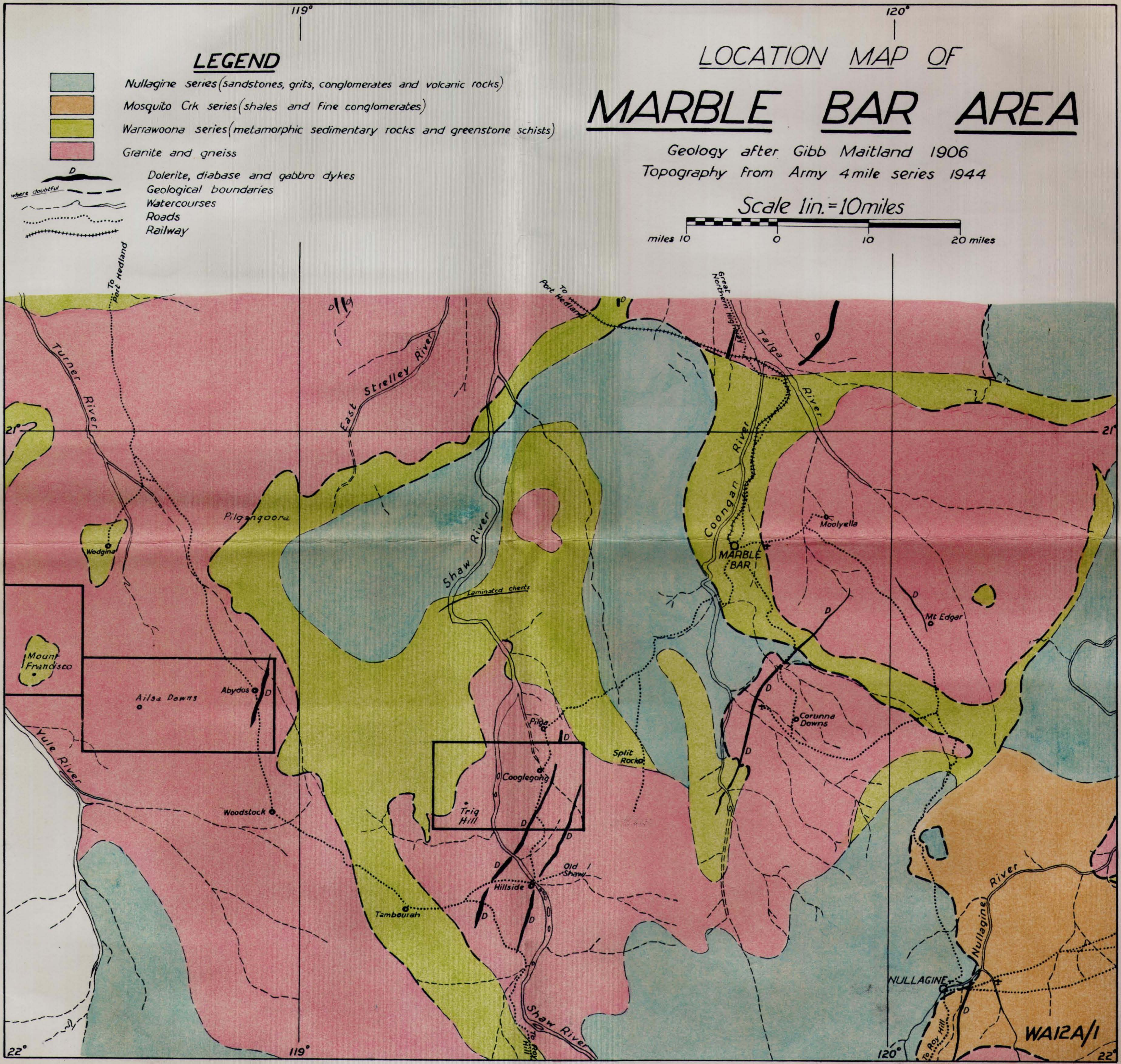
Alluvium sampled contained approximately 100 lb. per yard columbite and 2 lb. per yard cassiterite.

The alluvium has been worked out, and natives who tried working the creek during 1948 abandoned it after a short time.

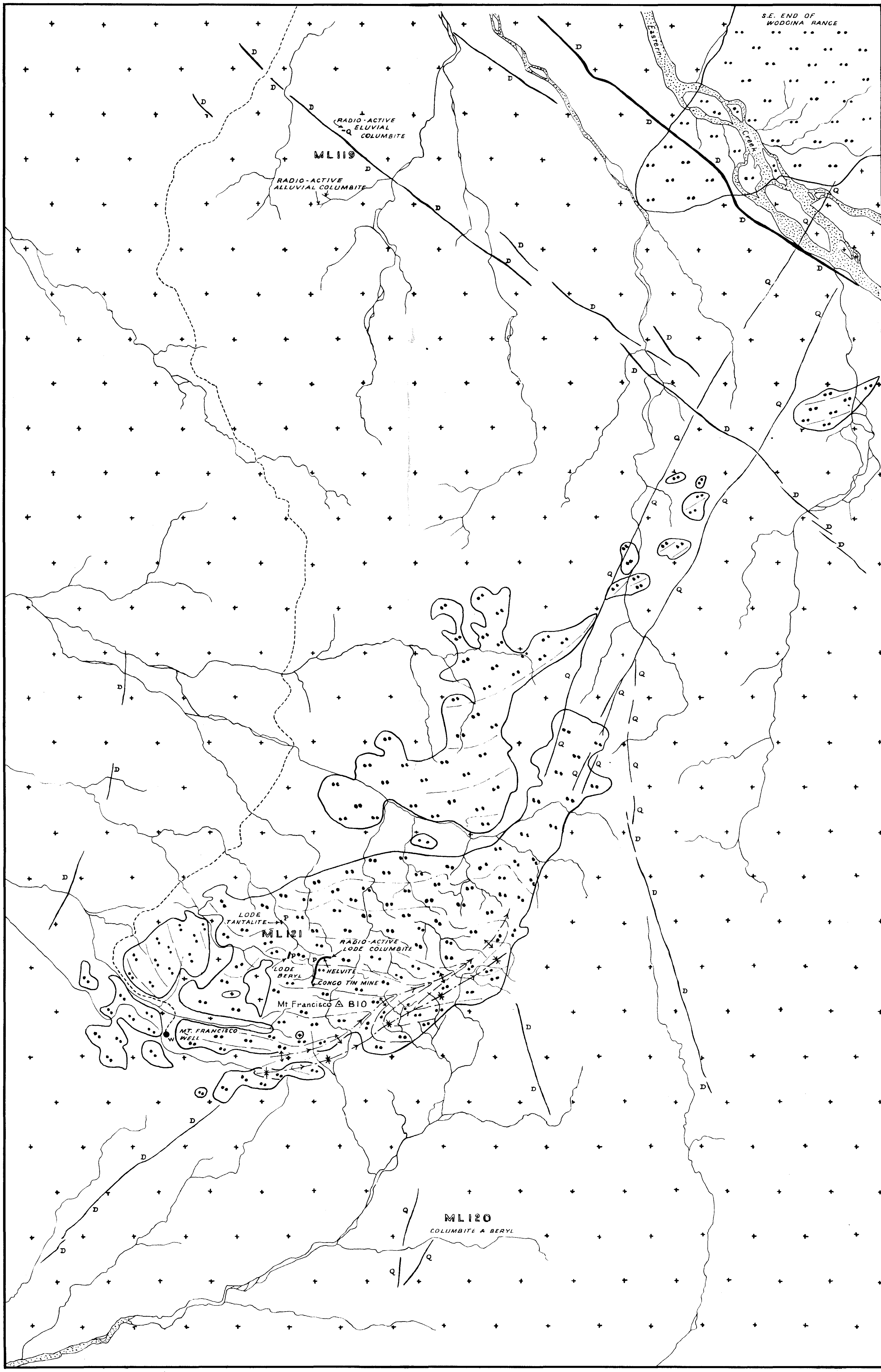
W. C. Smith

19th September, 1949.
CANBERRA, A.C.T.

(W.C. Smith)
Geologist.


LOCATION MAP OF
MARBLE BAR AREA
Geology after Gibb Maitland 1906
Topography from Army 4 mile series 1944
Scale 1in. = 10 miles
miles 10
0
10
20 miles
LEGEND
Nullagine series (sandstones, grits, conglomerates and volcanic rocks)
Mosquito Crk series (shales and fine conglomerates)
Warrawoona series (metamorphic sedimentary rocks and greenstone schists)
Granite and gneiss
D
Dolerite, diabase and gabbro dykes
where doubtful
Geological boundaries
Watercourses
Roads
Railway
119°
120°
21°
22°
To Port Hedland
Turner River
East Strelley River
Great Northern Highway
Talga River
Coongan River
Shaw River
Pilgangoora
Wodgina
Mount Francisco
Ailsa Downs
Abydos
Yule River
Woodstock
Laminated cherts
MARBLE BAR
Moolyella
Mt Edgar
Corunna Downs
Split Rock
Pilga
Cooglegong
Trig Hill
Old Shaw
Hillside
Tambourah
To Roy Hill
NULLAGINE
Nullagine River
WA12A/1

F50/A8/



GEOLOGICAL SKETCH MAP

M^T FRANCISCO AREA

PILBARA GOLDFIELD W.A.

Geology by W.C.Smith

Scale

Mile 1 ½ 0 1 Mile

REFERENCE

- Granite, gneiss & granitised rocks with pegmatites & quartz veins
- Warrawoona series (metamorphosed volcanics, quartzites, jaspilites & schists intruded by granite, granitic dykes, pegmatites & quartz veins)
- Pegmatite — P
- Quartz veins — Q
- Dolerite dykes — D
- Geological boundaries
- Bedding trend
- Pitch of anticline
- Pitch of syncline
- Well — W
- Trig station (with Lands Dept's No) — B10
- Faint vehicle track
- Sandy creek bed

MN

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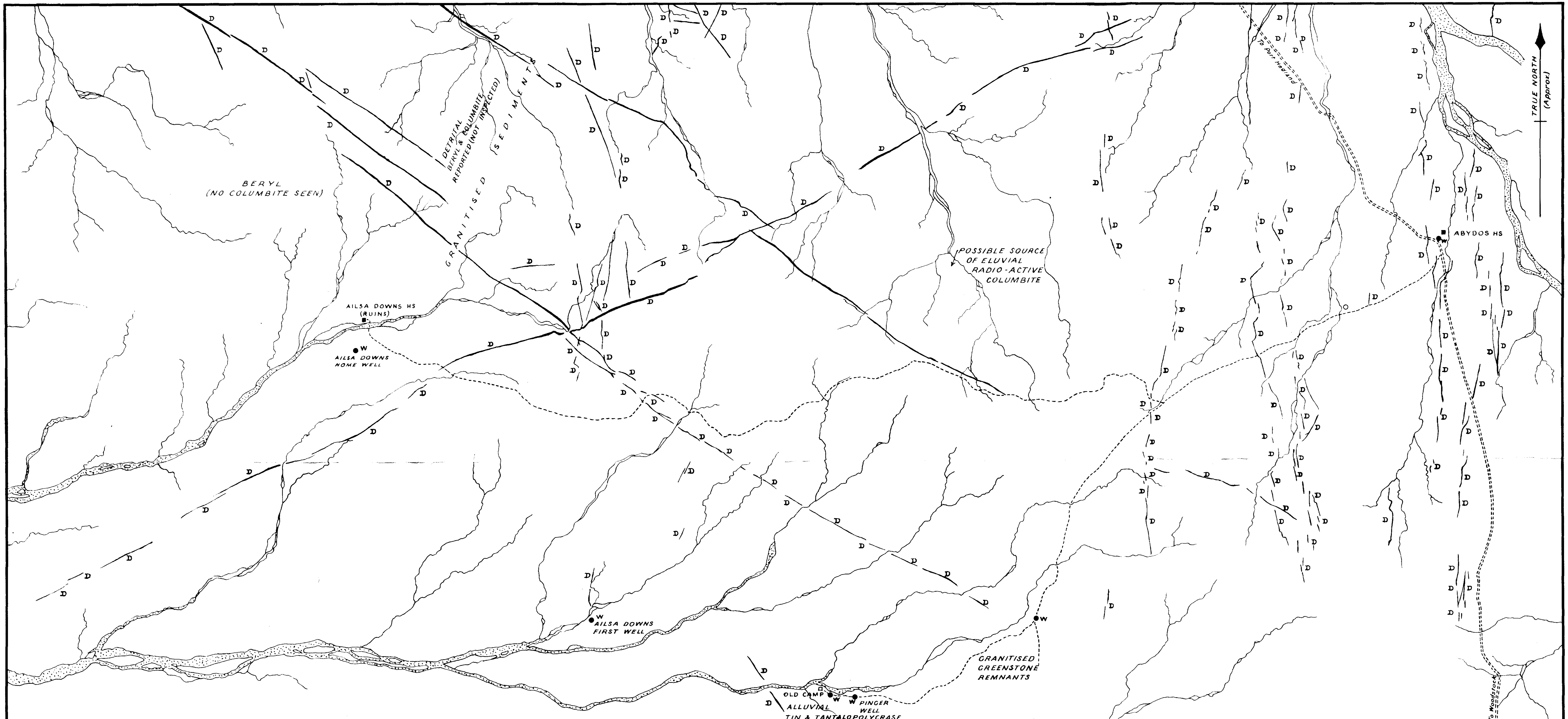
WA12-2



GEOLOGICAL SKETCH MAP

OF THE

ABYDOS - AILSA DOWNS AREA

PILBARA GOLDFIELD W.A.

Geology by W.C.Smith

Scale

Miles 1 ½ 0 1 2 3 Miles

REFERENCE

Dolerite dykes

Well marked roads

Faint vehicle tracks

Wells

Area consists of granite & gneiss with pegmatites & a few granitised remnants of the Warroona Series

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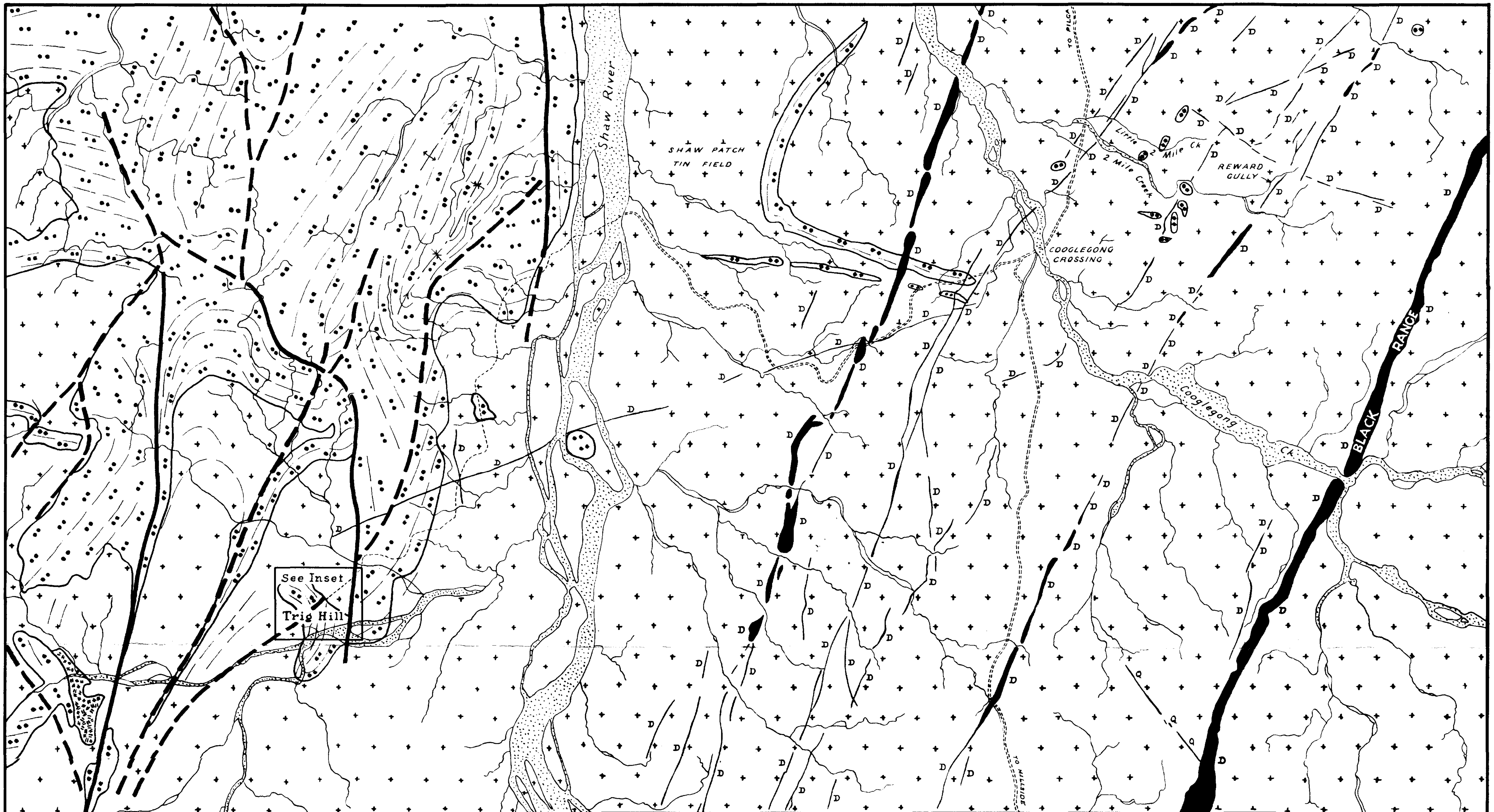
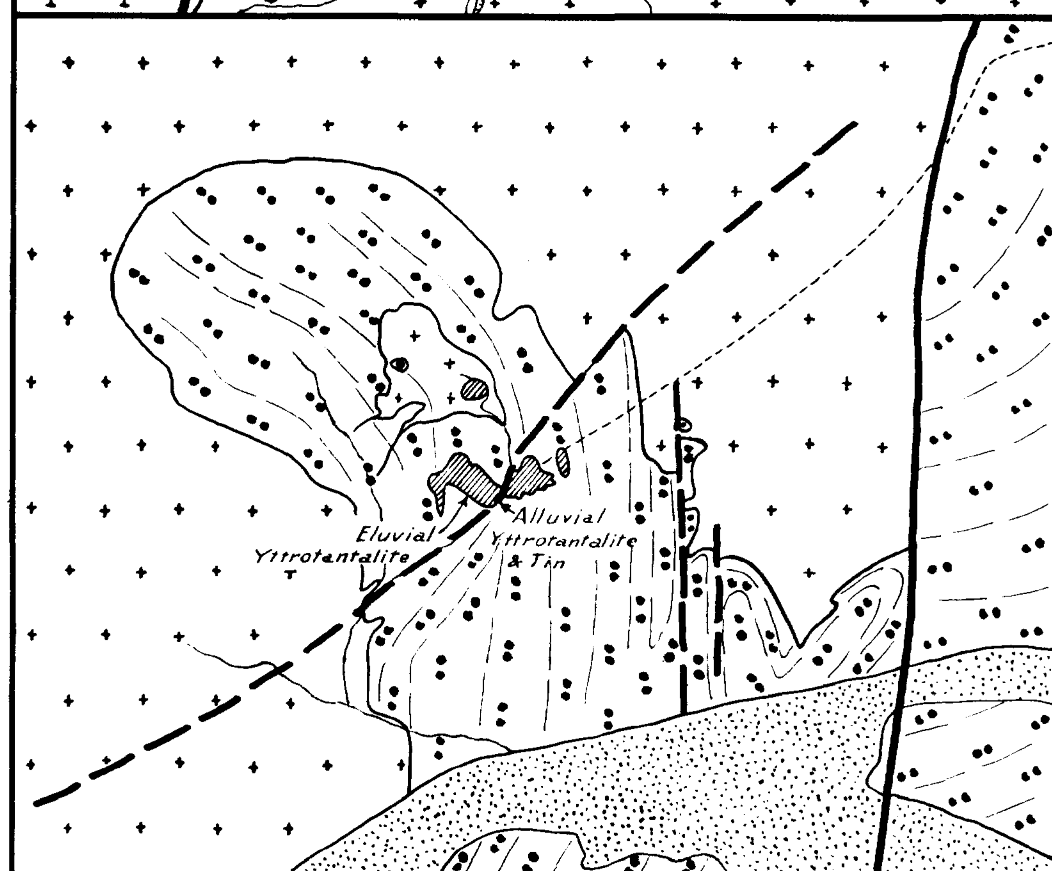
WA12-3

W.T.C





INSET - TRIG HILL

Scale

FEET 1000 500 0 1000 2000 FEET

GEOLOGICAL SKETCH MAP OF THE COOGLEGONG AREA

Geology by W. C. Smith

Scale

MILES 1 ½ 0 1 2 3 MILES

MN

Granite, gneiss & granitised rocks with pegmatites & quartz veins	
Warrawoona Series (metamorphosed volcanics, quartzites, jaspilites & schists intruded by granite, pegmatites & quartz veins & partly granitised in places	
Sandy Watercourses	
Faults, definite	
" probable	
Bedding trend	
Dolerite dykes	D D
Pegmatite dykes	
Quartz veins	Q
Geological boundaries	
Pitch of syncline	
Pitch of anticline	
Well marked road	
Faint vehicle track	

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