BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORD

Record 1980/45

The Arunta Block in the Huckitta 1:250 000 Sheet area: a review of data to June 1980.

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SUMMARY

The metamorphic and igneous rocks (crystalline basement) of the Arunta Block in the Huckitta 1:250 000 Sheet area crop out in three blocks - the Ambalindum, Mount Skinner, and Jervois Blocks - which are separated by major faults.

The Ambalindum Block contains felsic and mafic granulites (Division I) and rocks of the Harts Range Group (Division II). Both the Mount Skinner Block and the Jervois Block are part of the northern Arunta zone and contain extensive granites, the Bonya metamorphic complex of Division II, and the Ledan Schist/ Utopia Quartzite sequence of Division III. The Mount Skinner Block also contains an unmetamorphosed gabbro.

The Bonya metamorphic complex contains stratebound copper, lead, and scheelite deposits, small copper-vanadium lodes, and small crosscutting copper lodes. Molyhil, a scheelite-molybdenite mine, is in a roof pendant of calc-cilicate rocks in granite. Fluorite-barite veins occur in granite close to the unconformity with cover rocks of the Georgina Basin sequence.

1.0 INTRODUCTION

These notes summarise the results of a photo-interpretation of the Arunta Block in the Huckitta 1:250 000 Sheet area. Information from unpublished company reports and field data collected by BMR geologist were used to help identify units.

Photo coverage at 1:80 000 (black and white RC9) was flown in 1970. The area bounded by 135°15'E, 136°30'E, 22°30'S, and (approx.) 22°50'S was covered by colour aerial photography at (approx.) 1:25 000, in 1976. The 1970 photography is excellent and provides good contrast between units, which regretably is counterbalanced by the small scale. There is very little contrast in the colour photographs, which were flown at a time when thick dry grass and herbage concealed and "softened" outcrop. However, because of the better scale, the colour photographs have been used for compiling, and the black-and-white photographs used to supplement detail. Photography flown in the winter of 1978 by the Division of National Mapping has not been used, as it was not available in early 1979.

Base material to compile the information from the airphoto is not available, so no maps have been compiled at the time of writing (June 1979).

The basement (Arunta Block) consists of metamorphic rocks, granite, gabbro, and pegmatite. It is overlain by the Georgina Basin sequence and Tertiary and Quarternary sediments, and is, in places, deeply weathered. The lithological Divisions I, II, and III, used elsewhere in the Arunta Block, are also applicable in the Huckitta Sheet area. Division I consists of mafic and felsic rocks, almost always metamorphosed to granulite grade. Division II units contain a higher proportion of sedimentary rocks. Division III units are mature pelites and psammites. Division II units are less deformed than Division I units. Division III unconformably overlies Division II. All units are older than 1800 m.y. (See Shaw & Warren, 1975).

The most important tectonic features in the Sheet area are the major faults which break the basement up into blocks containing distinctive geological units. The principal faults, particularly the Delny-Mount Sainthill Fault and the Mount Baldwin Structure, have pronounced magnetic and gravity expression. These two structures mark the boundary between the northern and southern zones of the Arunta Block in the Huckitta Sheet area.

Before 1960 mica was mined from pegmatites in the central southern part of the Sheet area. Tungsten (scheelite) and molybdenum are presently being mined at Molyhil, from skarn ore in a roof pendant of calc-silicate rocks within granite. The Jervois orebodies, in the central-eastern part of the Sheet area, contain copper, lead, and tungsten (scheelite). They are stratabound and almost certainly volcanogenic in origin. Scheelite also occurs in the Bonya hills, in multi-stage concentrations located in calc-silicate pods within a series of amphibolites adjacent to pegmatites. Fluorite and barite veins which occur in granite in the central part of the Sheet area may also be the product of multi-stage processes of concentration.

2.0 TOPOGRAPHIC NAMES

Stream names in the text are generally used as they appear on the 1969 revision of Huckitta topographic Sheet. The one exception is the interchange of Yam Creek and Marshall River upstream of Marshall Bore. Early reports and continued local usage all refer to the stream rising in the Myponga Range as the Marshall River, and Yam Creek is used for the stream heading south of the Myponga Range. This avoids confusion since Yam Creek Bore and Yam Creek Dam are then on Yam Creek. (It is anticipated that this change will also appear on the revised topographic maps presently in preparation by Division of National Mapping).

Local usage refers to the low but rugged hills forming the catchment of Bonya Creek as "the Bonya hills'. However, there is also a trig. point called Bonya Hill, on a quartz ridge east of Bonya Bore.

The positions of many homesteads and roads have changed since the 1969 revision to the topographic map. The Plenty River Developmental Road, which runs across the southern part of the Sheet area before turning northeast and east, is now the main access into the Sheet area, and also serves places such as Tobermory to the east. Most of the tracks used to reach the abandoned mica mines have disappeared.

"Huckitta outstation" is now the homestead on the Huckitta pastoral holding. The homestead on the Jinka pastoral holding has been moved from Prosser's Soak to Dead Horse Soak. A mine, "Molyhil", has been established at approximately 22°46'S, 135°44'E, and a miner's homestead, "Baikal", at 22°48'S, 136°10'E.

Several dams and bores shown on the topographic map have been abandoned and others are now known by different names. These include "No 1 Dam" at 22°44'S, 135°16'E which is called Middle Dam, and Halfway Dam (22°42'S, 135°28'E) which is called Yam Creek Dam. Bonya Bore (22°47'S, 136°08'E) is not shown on the topographic map.

3.0 PREVIOUS GEOLOGICAL REPORTS

The earliest geological observations were made by Brown (1897) who journeyed from the Harts Ranges northeastwards to the Jinka Plain, where he panned the Oorabra Reefs unsuccessfully for gold. He also reported galena nodules in the Oorabra Arkose.

Joklik (1955) mapped the Harts Range Group in the southwest of the Sheet area, and reported on the mica mines of the Plenty River Mica Field, correlating the country rock with the Harts Range Group. He placed the deformed rocks at Mount Sainthill in a separate unit, but his map shows them as extending well beyond their actual area of outcrop. He reported them as an unconformable younger unit, whereas they have a gradational contact with the units from which they were formed (Smith, 1965).

Smith (1964 and 1965) incorporated several recently completed reports, notably Woolley (1959), into a regional geological map. The most important new features of this map were the delineation of extensive areas of granite and the recognition of the limited extent and nature of the deformed rocks at Mount Sainthill.

The Jervois copper, lead, and zinc lodes were discovered in 1929 (Hossfeld, 1931), and have been the subject of spasmodic interest since. The most detailed accounts have been prepared by Robertson

(1959) and Holmes (1972). Robertson also drew attention to scheelite deposits adjacent to the Jervois lodes. Watson (1976) suggested that the Jervois lodes may be volcanogenic in origin.

Scheelite was first mined in the Bonya hills in the 1930s (Madigan, 1937; Nye & Sullivan, 1942). The small copper lodes of the district, Kings Legend, Bonya, and Yarraman, may have been worked at this time, though there is no documentation of this. Most of the scheelite lodes in the Bonya hills were discovered in 1970-71 and were subsequently evaluated by Central Pacific Minerals, whose geologists prepared several reports dealing with the lodes and their geological setting. The most important of these reports is by Pietsch (1973), and incorporates detailed maps of the Bonya hills.

The fluorite-barite veins in the Jinka Granite adjacent to the Elyuah Syncline were investigated and drilled by Central Pacific Minerals N.L. (Ivanac & Pietsch, 1976).

Union Corporation Pty Ltd produced maps at 1:25 000 of the area east and south of the Jervois lodes during tenure of an exploration concession (Wright, 1974). The company reported small copper-vanadium prospects in layered metagabbro to the east of Jervois mine.

Dobos (1978) reported on geochemical and metamorphic aspects of the exposures in the Bonya hills and Jervois area, where the metamorphic grade is lower amphibolite.

Geochronological work has been limited in extent. K-Ar determinations were made by Hurley & others (1961) on three granites from the Huckitta Sheet area. Wilson & others (1960) included a sample from the Jinka Granite in an Australia-wide Rb-Sr study. Webb (1972) carried out a K-Ar determination on a single sample from the wall rocks of the Jervois lodes. Black (1980) made Rb-Sr determinations on granites, pegmatites, and some metamorphic rocks from the Bonya hills-Jervois areas, and reviewed previous work: the major granites were emplaced at about 1750 m.y. and were followed by pegmatites at about 1660 m.y. and high-level granites at about 1460 m.y. K-Ar systems were reset at about 1450 m.y.

4.0 GENERAL GEOLOGY

4.1 Major Structural Elements (See Fig. 1)

The western two-thirds of the Sheet area is dominated by the Delny-Mount Sainthill Fault Zone (Warren, 1978). This is a complex, anastomosing undulose system of faults and shears with a general trend slightly north of west. Zones of intensely deformed rocks are up to a kilometre wide. However, the effects of dynamic metamorphism, retrogressive metamorphism, and minor fractures extend for several kilometres on either side of the main fracture, and are especially prominent on the south side. The Fault corresponds to a major gravity and magnetic feature, caused by the different characteristics of the rock types in the blocks on either side. East of Mount Thring, photo-lineaments can be traced through sand plain and weathered outcrops. However, there is no evidence, either geological or geophysical, for a major structure continuing eastwards beyond Mount Thring.

The Mount Baldwin Lineament is a major lineasment on Landsat imagery, extending southeast from near Mount Baldwin and joining up with a geophysically defined structure, the Lake Caroline Structure, south and southeast of the Sheet area. The Lake Caroline Structure, on gravity and magnetic evidence, is a major structural break which marks the northeastern limit of the Harts Range Group. The Mount Baldwin Lineament is probably a major fault: west of Thring Creek, the Harts Range Group is of upper amphibolite to granulite metamorphic grade, whereas east of Thiring Creek, schists considered to be part of the same Group are metamorphosed at upper greenschist to lower amphibolite grade. In contrast, the grade of the Utopia Quartzite and Ledan Schist adjacent to the Marshall River rises from lower amphibolite (muscovite-biotite assemblages) to upper amphibolite (biotite-garnet-sillimanite) westwards towards the Mount Baldwin Lineament, suggesting that this block tilts east of the Mount Baldwin Lineament.

Walter & others (1978) showed that movement on the Toomba Fault after deposition of the Georgina Basin sequence had a sense of west-block-north and up, and produced low-angle overthrusting. Warren (in preparation) suggests that the Tarlton Fault is of similar form, but is exposed at a deeper tectonic level. If this is so, the overthrust sheets on the west of the Tarlton Fault should extend into the southeast part of the Huckitta Sheet area, but exposures in the critical area, from Mount Cornish south to the Marshall River, are poor. Plotting of the numerous quartz veins and other photo-lineaments may be helpful in evaluating this suggestion. Both the Toomba and Tarlton Faults are of considerable age, having existed since at least 1700 m.y.

West-block-up movement is also consistent with the distribution of metamorphic grade in the Harts Range Group relative to the Mount Baldwin lineament. High-angle overthrusting of the Harts Range Group northwards along the Mount Sainthill Fault would explain the steep dips in the fault zone and the granulite grade of the rocks south of the Fault.

The apparent movement on the fault at the western end of the Jervois Range is also west-block-up and northwards. There is probably an overthrust fault along the northern edge of the Jinka Plain.

On a regional scale thrusting is low-angle northwards in the eastern Arunta, as shown by Walter & others (1978), and low-angle southwards in the west as shown by Wells & Moss (in preparation). The Mount Sainthill Fault has overthrust to the north at a high angle, whereas the Delny Fault has overthrust at a high angle to the south.

The region south of the Delny-Mount Sainthill Fault System and west of the Mount Baldwin-Lake Caroline Structure falls within the Ambalindum Block of Shaw & Warren (1975). Within this block there is a major sub-block bounded by the Maparta Fault (Alcoota Sheet area), the Delny-Mount Sainthill Fault, and a fault trending west-southwest from just southwest of Yam Creek Dam. This sub-block, the Black Point Block, contains mafic and felsic granulites with a distinct magnetic anomaly and positive gravity anomaly. The remainder of the Ambalindum Block in the Huckitta Sheet area contains Harts Range Group with a little disturbed magnetic pattern.

The Mount Skinner Block (Shaw & Warren, 1975) extends eastwards from the Alcoota 1:250 000 Sheet area into the Huckitta 1:250 000 Sheet area to the north of the Delny-Mount Sainthill Fault Zone. It is apparently bounded on the east by the Oomoolmilla Fault at the northwestern edge of the

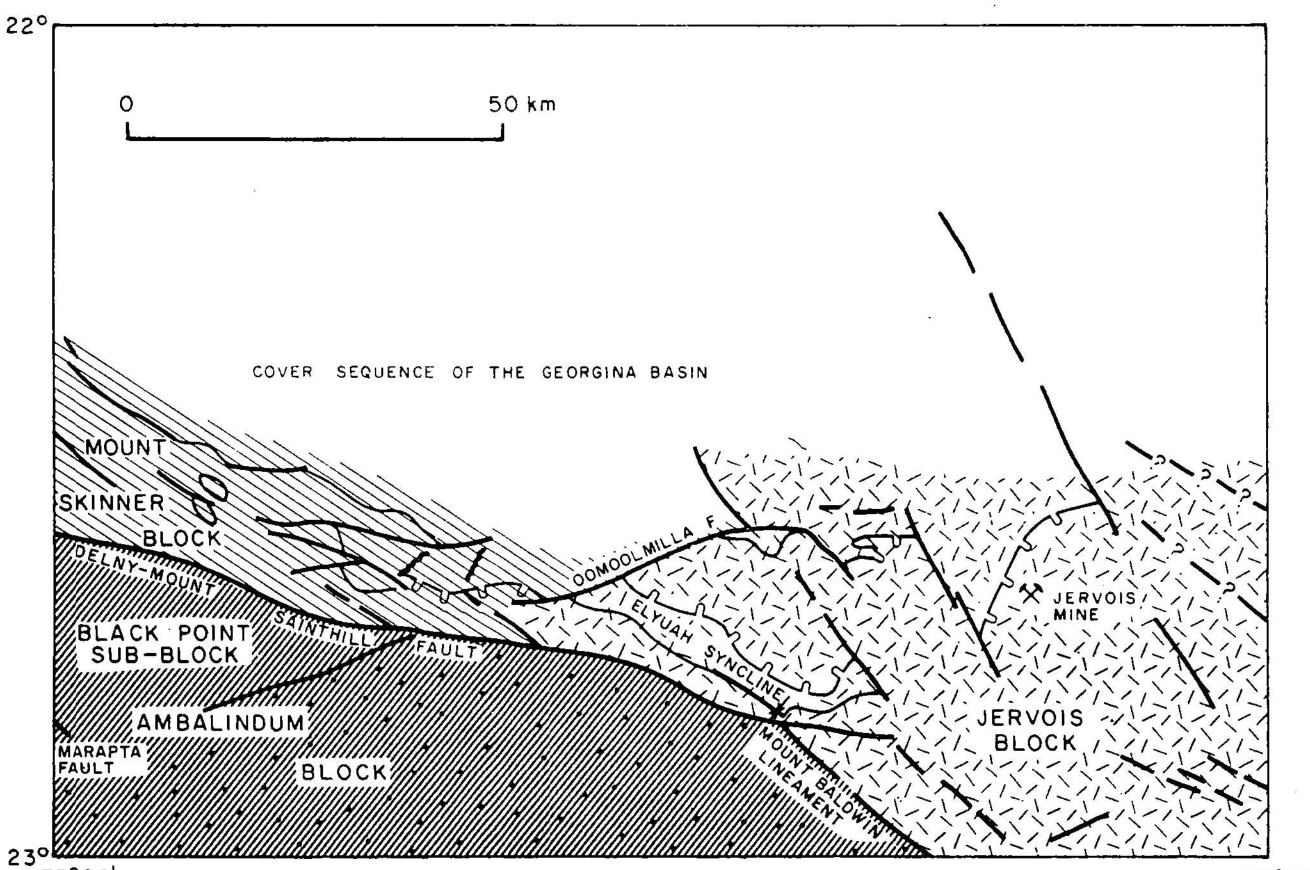

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Fig.1 Major structural elements of the Arunta basement in the Huckitta Sheet area

Jinka Plain. This fault marks the southeastern limit of an area characterised by WNW-trending elongate folds and faults. The Mount Skinner Block is distinctive in the amount of block faulting that postdates the cover sequence. The Devonian Dulcie Sandstone is now confined to the Mount Skinner Block though there is no indication that it was deposited only over the Mount Skinner Block.

The Jervois Block, bounded on the northwest by the Oomoolmilla Fault, on the west by the Mount Baldwin Lineament, and in the east (in the Tobermory and Hay River Sheet areas) by the Tarlton Fault, has been less subject to block faulting, although it contains numerous quartz reefs filling fractures. Airphoto interpretation suggest that the quartz-filled fractures on the Jinka Plain are minor faults which displace the Oomoolmilla Fault.

4.2 Ambalindum Block

The Ambalindum Block occupies the southwestern part of the Sheet area. It is bounded by the Delny-Mount Sainthill Fault and the Mount Baldwin Lineament. The Black Point Block is separated from the remainder of the Ambalindum Block by the Marpata Fault in the Alcoota 1:250 000 Sheet area, and by an unnamed fault trending west-southwest about 8 km south of Middle Dam.

4.2.1. Black Point Block

4.2.1.1. Outcrops along the western margin of Dneiper 1:100 000.

Outcrops along the boundary between the Huckitta and Alcoota 1:250 000 Sheet areas were visited during the mapping of the Alcoota 1:250 000 Sheet area in the 1970 field season, and specimens 70090645A, B & C were collected from very close to the boundary. These are garnet felsic gneiss, garnet-cordierite-felsic gneiss, and two-pyroxene granulite assigned to the Kanandra Granulite. A small outcrop of Mount Swan Granite occurs nearby. Outcrops adjacent to the Kanandra Gap-Mount Swan track to the northeast of 70090645 include some quartz-rich rocks.

Deep weathering severely affects the rocks immediately south of the Delny Fault. However, from observations made to the west, in the Alcoota Sheet area, the underlying rocks are probably granulites that have been sheared and have retrogressed to amphibolite or, very locally, greenschist facies.

Small bodies of Mount Swan Granite intrude the Kanandra Granulite, but mainly in the northern part of the outctop area, close to the Delny Fault.

4.2.1.2. Outcrops at Black Point

Outcrops west of the fence-line near Black Point consist of migmatitic felsic gneiss with minor garnet and biotite, mafic granulite, and hybrid "intermediate" rocks. Pegmatites crosscutting poorly preserved layering appear to have been metamorphosed.

East of the fence-line there is a large-scale fold with a slightly curved, north-south axis. The units in the fold include poorly exposed felsic rocks, mafic granulite, and a dark green, coarsely crystalline mafic rock thought to be a metamorphosed calc-silicate rock.

A small hill about 0.5 km east of Black Point contains some outcrop with the airphoto tone and (distant) appearance of a granite.

4.2.1.3. Outcrops in the Black Point Block from Middle Dam eastward

Observations on outcrops eastward from Middle Dam were made on a traverse crossing the Black Point Block from Middle Dam to the Huckitta-Dneiper fence-line and thence north along the fence-line. Some additional data are available for outcrops close to the faults bounding the block.

The dominant rock rypes are felsic gneiss, fine-grained leucocratic felsic gneiss, and mafic granulite. A layer of metapelite (garnet-sillimanite-biotite-quartz assemblage) is exposed close to the fence-line about 2 km south of Yam Creek.

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The felsic rocks immediately south of Middle Dam are mostly deformed to mica schist. They are intruded by gneissic granite. Ultrabasic rocks immediately east of Middle Dam contain minor nickel mineralisation (Freeman in press).

Retrogression from granulite grade is apparent in most specimens, but is variable in form. Some specimens show mechanical deformation and flaser textures. In some mafic granulites, the granoblastic texture is retained but the pyroxenes are partly replaced by blue-green hornblende. In some specimens of felsic rock, biotite partly replaces garnet.

Granite cross-cuts the granulites south of Yam Creek, both east and west of the fence-line. The only outcrops examined are of grey gneissic biotite granite, in the bed and on the north bank of Yam Creek.

4.2.2 Ambalindum Blcok (excluding Balck Point Block)

Most of the crystalline rocks in the remainder of the Ambalindum Block are assigned to the Harts Range Group.

Fine-grained light coloured biotite-feldspar-quartz gneiss crops out about 7 km east of Ghost Gum Bore, where it is interlayered with coarse-grained quartz-feldspar gneiss and felspar-biotite schist. Similar fine-grained gneiss crops out 1 km south of Mount Sainthill and also from about 2 km north of the Marshall Bore westwards in small isolated hills to about 4 km north of Yam Creek Bore. These outcrops include minor pods of mafic granulite. The unit is equated with unit $p\theta h_3$ in the Alcoota 1:250 000 Sheet area and with the Entia Gneiss in the Harts Ranges.

Porphyroblastic feldspar gneissic granite is exposed north of Marshall Bore, north of Yam Creek Bore, south of Mount Sainthill, and 10 km north of Plenty Bore, always adjacent to the fine-grained felsic gneiss, which it appears to inturde. The only sample thin sectioned (76096047B) is slightly richer in biotite than the Queenie Flat Granite, and carries accessory opaques rather than sphene; however, this gneissic granite is considered to be the lateral equivalent of the Queenie Flat Granite. The Queenie Flat Granite occupies the same stratigraphic position as the Bruna Gneiss and has a similar appearance in the field, but has been shown to be chemically distinct (Shaw & Warren, 1975).

Marble and calc-silicate gneiss are exposed from approximately 6 km southeast of Marshall Bore to about 7 km northwest of Yam Creek Bore. The marbles are best exposed immediately east of Yam Creek Bore and on the north bank of Yam Creek about 4 km west of the Bore. They are massive marble which contain diopside and rare phlogopite. To the north there are outcrops of massive calc-silicate granofels containing olivine, epidote, diopside, chlorite, and cummingtonite; para-anorthosite; and para-amphibolite. Farther north again there are thin amphibolite and layered calc-silicate rocks.

About 5 km east-southeast of Marshall Bore there is a well-layered, poorly exposed unit with a distinctive photo tone. The unit is also exposed in low rises about 2 km northeast of Wotan trig. pont. Samples consist of quartz, scapolite, diopside or hornblende, and in two samples from the northwestern outcrops, calcite. The rocks are distinctively fine-grained and finely layered. Wotan trig. is in a ridge of flaggy diopside-quartz rock, which is interlayered to the east and west with biotite-feldspar-quartz gneiss. West of Wotan (probably mainly in Illogwa Creek 1:250 000 Sheet area) there is a massive calc-silicate gneiss which is complexly folded. A very similar calc-silicate unit forms prominent ridges between Plenty Bore and Yam Creek, and is interlayered with similar biotite-feldspar-quartz gneiss in the hills west of the Dinkum Mine. Calc-silicate rocks, para-amphibolite, and scapolite-bearing rocks are poorly exposed in a low hill northeast of Ghost Gum Bore, where they are intruded by pegmatites. A lone hill of massive scapolite-bearing granofels occurs about 4 km southwest of Molyhil, surrounded by hills of biotite-feldspar-quartz gneiss.

The remainder of the Harts Range Group consists of biotite-feldspar-quartz gneiss, garnet-biotite-feldspar-quartz gneiss, and rare sillimanite-bearing gneiss. From the relationship between these gneisses and the calcareous units, it is postulated (see Fig. 2) that there are at least four separate calcareous sequences all with very similar lithology.

Amphibolites and mafic granulites form discontinuous layers and bounding in the biotite-feldspar-quartz gneiss. West of the Dinkum Mine there are also some small, cross-cutting, plug-like bodies of mafic rocks.

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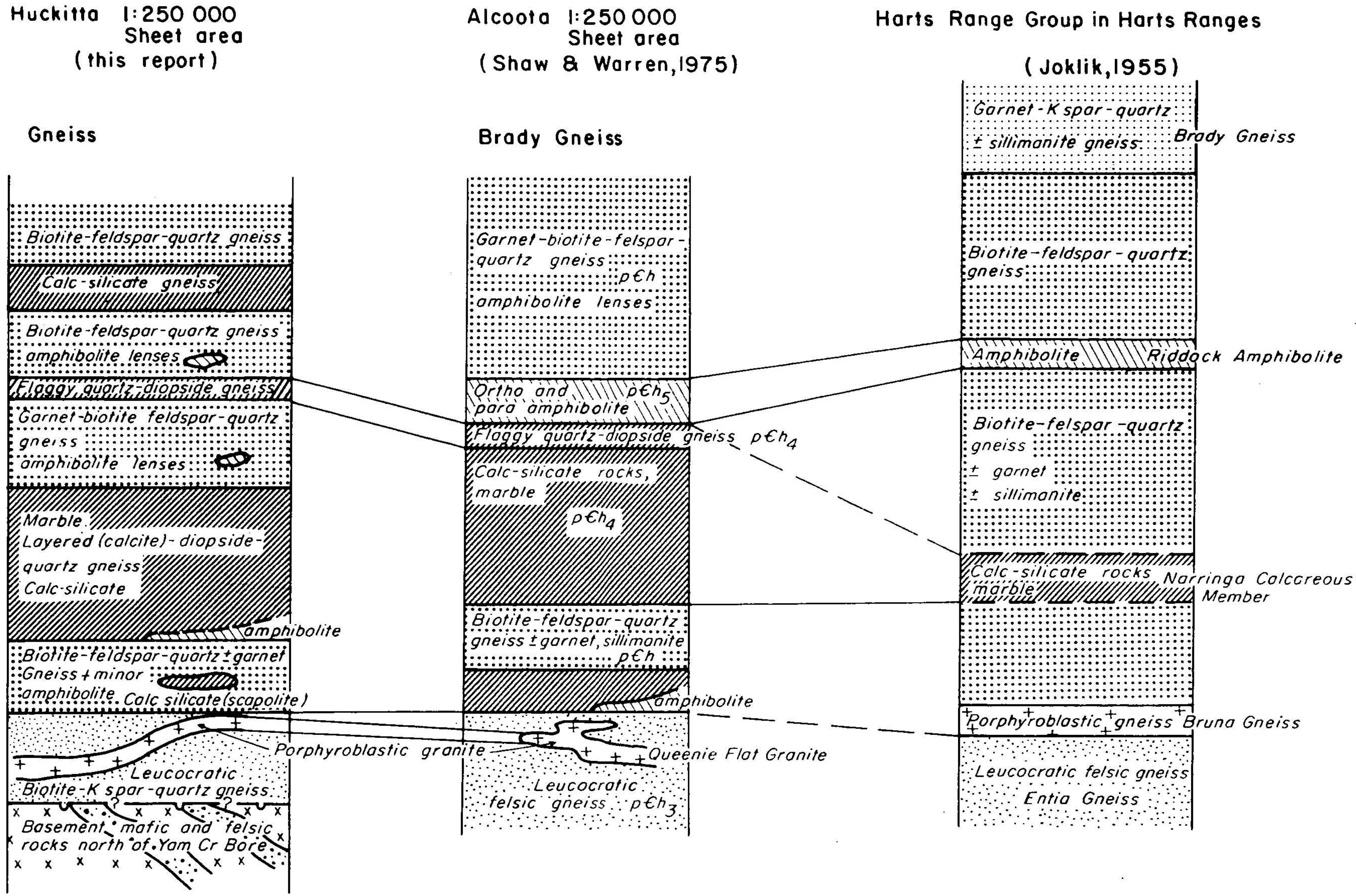

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Fig. 2 Schematic cross sections of Harts Range Group in the Huckitta and Alcoota 1:250 000 Sheet areas. Section as described by Joklik in the Harts Range is shown for comparison

One outcrop not part of the Harts Range Group occurs on the slopes of Tent Hill, south of Huckitta homestead; here weathered rocks have the texture of granite. The outcrop is separated by a few kilometres from all other crystalline rocks, and the nearest exposures, in the bed of the Plenty River adjacent to Huckitta homestead, consist of typical garnet-feldspar gneiss of the Irindura Gneiss.

A second area of rocks not part of the Harts Range Group is located northewst of Yam Creek Bore. (It is shown on the first edition of the Huckitta 1:250 000 geological map as "basic intrusives"). The predominant rock type is garnet-biotite-feldspar-quartz gneiss which is migmatised, and may be cordierite-bearing in part. Mafic granulite is also present. These are intruded by a strongly lineated leucocratic gneissic granite. Because of their proximity to the Mount Sainthill Fault Zone, the rocks are partly retrogressed to amphibolite grade. These rocks are most like the Strangways Metamorphic Complex, and their layering appears discordant with that in adjacent outcrops of the Harts Range Group. It is suggested this area represents exposed basement to the Harts Range Group.

No additional information has been obtained on the area mapped by Joklik (1955) in the southwest of the Huckitta 1:250 000 Sheet area.

4.3 Mount Skinner Block

Outcrops exposed in the Mount Skinner Block consist of rocks belonging to Divisions II and III, granites and unmetamorphosed gabbro.

Division II rocks crop out in the eastern third of Dneiper and the western third of Jinka 1:100 000 Sheet areas. Cordierite-felsic gneiss and mafic granulite (or possibly pyroxene hornfels) has been collected from southwest of Deep Bore, and felsic gneiss, some with cordierite, crops out about 4 km west-northwest of Elkera Bore. It is thought that much of the low ground between Yam Creek Dam and Deep Bore may also be occupied by felsic gneiss, but there are no field observations available for this area. Apart from these felsic gneisses, most of the outcrops are of metasediments, including biotite-feldspar-quartz gneiss, porphyroblastic andalusite gneiss, and calc-silicate units. Samples collected in 1959 include a marble from north of the Delny-Mount Sainthill Fault, adjacent to the fence-line between Dneiper and Huckitta. In the same area amphibolite is interlayered with quartzose metasediments. Rocks exposed beneath the deep weathering profile in the headwaters of Yam Creek have been identified merely as metasediments in the photo-interpretation, and may be mainly calc-silicates. The metamorphic grade is variable: mafic granulite has been collected from near Deep Bore, but the grade west of Yam Creek Dam is lower amphibolite (index minerals: cummingtonite, andalusite), and this grade apparently persists westward.

Outcrops of Ledan Schist and Utopia Quartzite extend southeast from Tower Rock to east of Dneiper. Facing from conglomerates in the outcrops southeast of Dneiper homestead shows that the Utopia Quartzite overlies Ledan Schist as in the Alcoota 1:250 000 Sheet area. The unconformity at the base of the Ledan Schist is not exposed.

The Mount Swan Granite which extends beyond the western edge of the Huckitta Sheet area is a distinctive "big-feldspar" granite that apparently does not extend east of Frazer Creek.

The Marshall Granite, a distinctive isotropic leucogranite with a border phase devoid of ferric minerals, crops out in low hills south of Deep Bore. Its areal extent is far less than is shown on the first edition of the geological map of Huckitta. It may be a post-orogenic, high-level intrusion, similar to the alaskite body north of the Jervois orebodies.

Smith (1965) assigned all granite in the Myponga Range to the Dneiper Granite, a "coarse-grained quartz-feldspar-mica granite". Field observations suggest there are in fact several granites in this part of the Mount Skinner Block:

(i) A very-well foliated gneissic granite is exposed in a ridge about 5 km west of Yam Creek Dam. It forms a sheet-like body whose layering is parallel to the layering in the enclosing gneisses. Photo-patterns indicating similar rocks occur south of the Myponga Range. Similar granite occurs in the pseudo-ring-structure about 10 km northwest of Yam Creek Dam (Photo patterns indicate that there are two granites within this structure).

(ii) North of the pseudo-ring-structure the rocks are felsic-leuco-gneisses, which have been shown as granites on the photo-interpretation.

(iii) About 5 km northwest of Elkera Bore there are low inselbergs of coarse-grained, foliated, pink granite (76096053) in an undulating plain, with a photo-pattern indicating that it is underlain by granite.

(iv) Little is known about the main mass of the Dneiper Granite as shown on the first aedition of Huckitta 1:250 000 geological map. A company report includes the remark that many outcrops in this area are "pyroxene granulite". (This may actually be gabbro).

(v) A late, cross-cutting granite with a faintly gneissic texture crops out about 5 km west of Yam Creek Dam.

Gabbro samples have been collected from several outcrops at the western end of the Myponga Range, where airphotos show there an extensive area of dark rocks is laced by light coloured dykes, thought to be pegmatites. This is consistent with a field observation, at the southern edge of this area, of unmetamorphosed, fine-grained mafic rocks intruded by pegmatites. Tindale (1931) reported an axe-making site in basic igneous rocks on the south side of the Myponga Range, so it is likely the gabbro extends south of the range. A small area of dark boulderly outcrops has been interpreted as gabbro northeast of Yam Creek Dam. The main gabbro area corresponds to a magnetic low, but has no effect on the regional gravity field; however, there are no gravity stations actually within the main gabbro area. The lack of a gravity anomaly suggests it may be a thin, sheet-like body rather than a plug-like intrusion. The gabbro is apparently unmetamorphosed as thin sections show ophitic texture and normal zoning of feldspars. (The McIntosh Gabbro in the Halls Creek Province is a pre-metamorphic gabbro that is relatively unaffected by later metamorphism becuase it was dry and large. Small gabbro plugs in the Alcoota Sheet area are metamorphosed. Therefore this gabbro may be pre-metamorphic, but have escaped metamorphism because it is a comaratively large body. If it is the same age as the gabbros of the Davenport Syncline, it should be pre-metamorphic.)

4.4. Jervois Block

The Jervois Block is a complex unit, with a relatively well exposed northern part and a deeply weathered and sand covered southern section. The northern part contains the economically important Bonya metamorphic complex, exposed in the Bonya hills and in the Jervois Mine area, and a number of granites. The southern part of the Bonya hills has been mapped in detailed by geologists of Central Pacific Minerals N.L. (Pietsch, 1973) the area adjacent to the Jervois lodes by Robertson (1959), and the area to the east by Wright (1974). The outcrops in the southern sandplain region are known only from inadequate reconnaissance data, which has permitted recognition of several areas (sub-blocks?) of different geological character, but provides no information on the relationships of the rocks in the areas.

4.4.1. Bonya hills

A reference section for the Bonya metamorphic complex extends from Charlottes Bore to Bonya Bore. The eastern half of this section is covered in detail by Pietsch (1973). The western half consists of a series of felsic gneisses. The large area of granite shown on existing maps east of Charlotte Bore is less extensive than has been shown on the first edition of the Huckitta geological map and has been photo-interpreted as mostly felsic gneiss, which has been subdivided into units on photo-tone. The gneiss is overlain by a section consisting of amphibolite, schist, amphibolite (Kings Legend amphibolite), and two units of schist. The schists are distinguished by andalusite content and by proportions of micas and quartz. The schists can generally be separated by photo-tone, but there are critical areas where ground checks are required, particularly where there is an apparent unconformity (Fig. 3).

Marble and calc-silicate rocks occur at boundaries between units within the Kings Legend amphibolites, and at the boundaries between the amphibolites and schists. Calc-silicate and amphibolite lenses also occur within the schist unit that crops out southeast of Damascus.

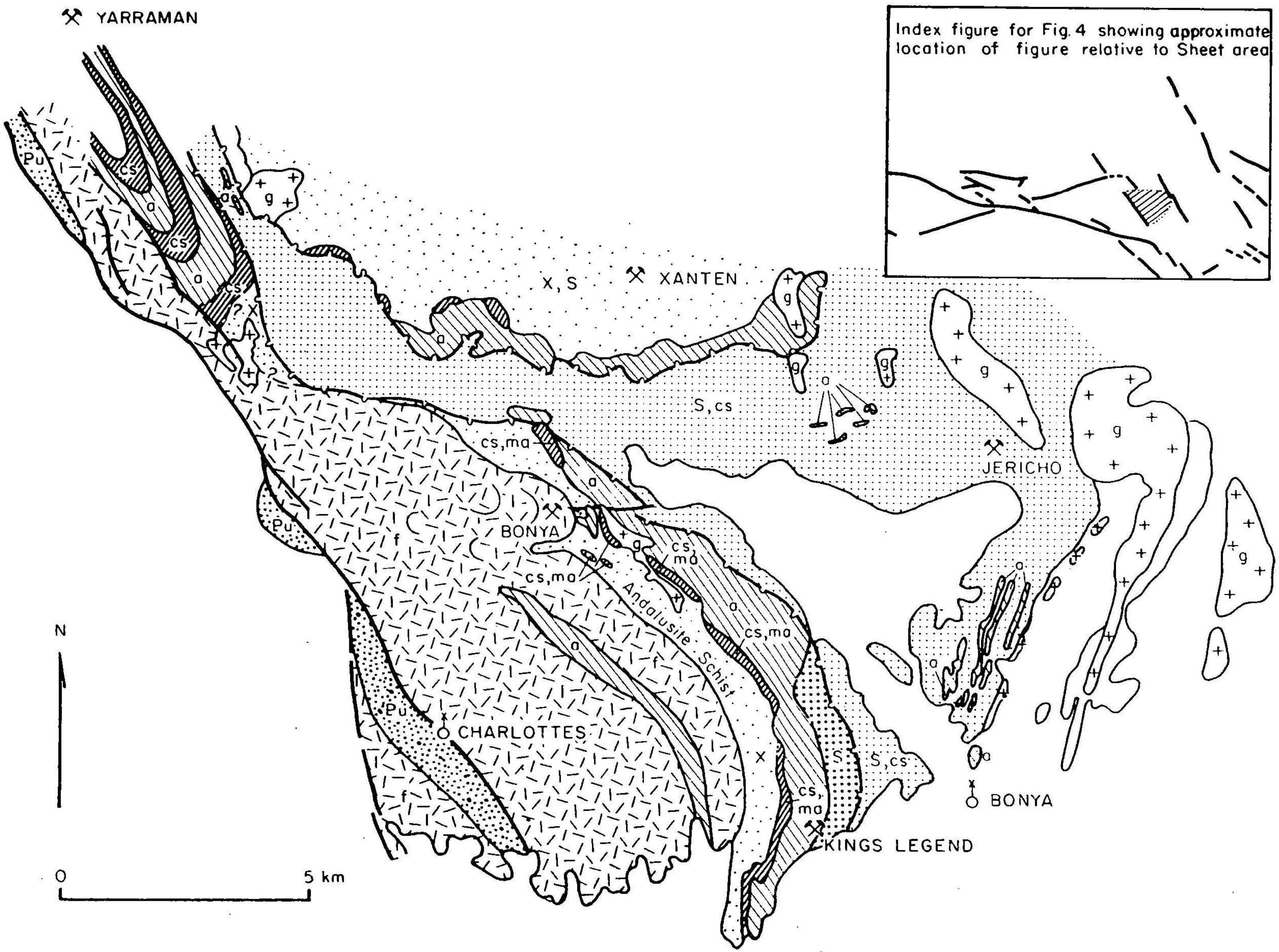

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Fig. 3 Generalised sketch map of the geological units in the Bonya hills (modified from Bowen and others, 1971). Showing location of probable uncomformity

Company geologists who mapped in detail the meralised horizons in the Bonya hills were unable to find facing structures in the well recrystallised schists and amphibolites. It may be possible to interpret facing from the volcanogenic deposits in and adjacent to the Kings Legend amphibolite. The detailed maps in Pietsch (1973) can be interpreted as indicating an east-facing sequence in the Kings Legend area, and a west-facing sequence at the western edge of the amphibolite, but it is highly improbable that there is an isoclinal fold in the amphibolite. A preferred interpretation is that the whole sequence from Charlottes Bore to Bonya Bore faces east, although this creates some problems when comparisons are made with the sequence containing the Jervois lodes. The distribution of units northwest of the Bonya Mine indicates a major unconformity within the Bonya metamorphic complex (see Fig. 3), postdating the fold adjacent to the Bonya Mine and the synform southeast of Yarraman Mine. (Figure 3 is a revision, based on interpretation of the 1:25 000 colour photography, of map of the Bonya Bore area by Bowen & others, 1971.

The economically most important part of the sequence is a discontinuous series of calcareous lenses at the base of the Kings Legend amphibolite. These lenses contain several of the scheelite deposits (Johannsens Pillar, Samarkand, Marrakesh and possiblly City of Medina). The detailed map in Pietsch (1973) also shows minor copper mineralisation at boundaries within the Kings Legend amphibolite, and a large number of small copper lodes and some tungsten mineralisation at the top of the amphibolite. The small copper and tungsten deposits extending southeast from Yarraman occur at an intermediate boundary within the amphibolite. As well as the Kings Legend Mine and satellite copper workings, small showings occur at the top of the amphibolite south of the track into Bonya Mine, along the foothills north of the abandoned track to Damascus, and immediately east of the track to Twin Bores. Photo-interpretation suggests Asmara (tungsten) is also at the top of the amphibolite. Scheelite concentration increases adjacent to pegmatites at most of the main lodes. The only scheelite deposits that cannot be fitted into this pattern are White Violet and Ultra Violet, both in calcareous lenses within the schist unit that underlies the Kings Legend amphibolite. In the correlation diagram (Figure 4) for the Bonya hills and Jervois Mine areas these two deposits, and the small copper lode at Xanten, are shown as being possibly at the same stratigraphic level as the Jervois lodes.

Bonya Mine (copper) is on what appears to be a pipe-like body of hydrothermal origin which, from its position in a fold axis, is perhaps structurally controlled. Ore-at-grass consists of sulphides and secondary minerals in a quartz breccia matrix. Xanten (copper) is in schists adjacent to a granitic intrusion. However, the ore occurs in a ferruginous quartz layer, which extends beyond the open pits, and there are also traces of copper minerals several hundred metres away adjacent to minor amphibolites. Therefore it is suggested that Xanten may be a volcanogenic deposit unrelated to the granite. Petra (copper) is a structurally controlled breccia body in amphibolite.

4.4.2. Area north of the Bonya hills

Rolling, low hills north of the Bonya hills are formed of granite and metamorphic rocks. The geomorphological regime, with poor exposures, makes photo-interpretation difficult, but extrapolation from the Bonya hills indicates that the western area south of Twin Bore is probably underlain by felsic gneisses, and the eastern section probably by the upper schist unit of the bonya metamorphic complex. Granite and felsic intrusions account for about half the exposures.

About 3 km east of Twin Bores, immediately north of a prominent quartz vein, there is a ferruginous quartzite, interlayered with well layered calc-silicate gneiss, containing races of secondary copper minerals. Amphibolite is poorly exposed to the north. Granite intrudes the rocks.

4.4.3 Jervois district

The best exposures of crystalline rocks east of the Jervois Range are in the the low hills immediately east of the Range, adjacent to the Jervois lodes. Farther east the outcrops are discontinuous and deeply weathered. The proportion of granite increases eastward, though not to the extent shown on the present 1:250 000 geological sheet. (See also Wright (1974) for compilations at 1:25 000 covering the area south and east of Jervois).

The dominant structure in the district is the north-plunging synform containing the Jervois orebodies (copper, zinc, lead, bismuth, and scheelite). Trend-lines in outcrops to the east and southeast are subparallel to the synform, indicating that it is a structure of regional significance. This supports the view, first put forward by Robertson (1959), that the sequence is right way up and the synform is a syncline. (If it is overturned, so is about 10 km of section). As in the Bonya hills, no facing structures have been recognised.

The rocks are a monotonous sequence of two mica schists, with calc-silicate layers and lenses, and minor basic horizons. Some layered metagabbros crop out about 6 km east of the mine sequence, and also southwest of Unka Bore. The proportion of calc-silicate rocks is greatest in the section that contains the Jervois base-metal lodes. This section also includes mica schist with porphyroblasts of cordierite, garnet-chlorite lenses, iron-rich garnet-quartz rock, and quartz-tourmaline rock. Breccia closely resembling volcanic breccia occurs in drill core from holes traversing the mineralised section.

The origin of the Jervois orebodies has been the subject of several theories over the years. Robertson (1959) considered them to be hydrothermal. (Granite occurs about 6 km south of the field and 8 km north of the field. Small pegmatites are common throughout the field). Later workers have stressed the strata-bound, lensoid nature of the orebodies and both Watson (1976) and Dobos (1978) suggested that the mineralisation was volcanogenic in origin. Watson stated that he could not see an obvious local source, but that the lensoid form of the orebodies was consistent with a distal source. However, material in drill core from the footwall beneath the Attutra-Marshall section of the line of mineralisation closely resembles lithic-tuff-breccia from the volcanogenic Woodlawn orebody. The volcanogenic source may therefore be concealed below surface. The scheelite-rich material in the hangingwall (stratigraphic top) of the Marshall orebody is consistent with the distal-in-space and late-in-time evolutionary model for volcanogenic orebodies proposed by Plimmer (1978). The sequence beneath the orebodies (footwall schists) is rich in muscovite, but sericitic alteration of volcanic rocks is apparent near many volcanogenic deposits. (The material considered to be volcanic breccia, and the cordierite-mica schist, are in the footwall whereas the scheelite is on the hangingwall. These both suggest that, if the lodes are volcanogenic, they are right-way-up and face west. This reasoning also supports the theory that the Jervois synform is a syncline).

Very small copper-vanadium lodes occur in a discountinuous metagabbro conformable with the enclosing schist about 6 km east of the Jervois orebodies.

Two possible correlations between the sequence enclosing the Jervois orebodies and the sequence in the Bonya hills are shown in Figure 4. In both correlations the Jervois lodes are considered to be at the same level as Xanten and White Violet. In Figure 4a, the sequence in the Bonya hills is assumed to face east. From this diagram it may be inferred that (i) the Kings Legend amphibolite has been removed from the core of the syncline at Jervois by erosion, (ii) some of the "granite" east of Unka Bore may be felsic gneiss. In Figure 4b the sequence in the Bonya hills is assumed to be overturned. The Kings Legend amphibolite then correlates with the metagabbro near Unka bore, and the felsic gneiss is absent from the Jervois area, because of erosion.

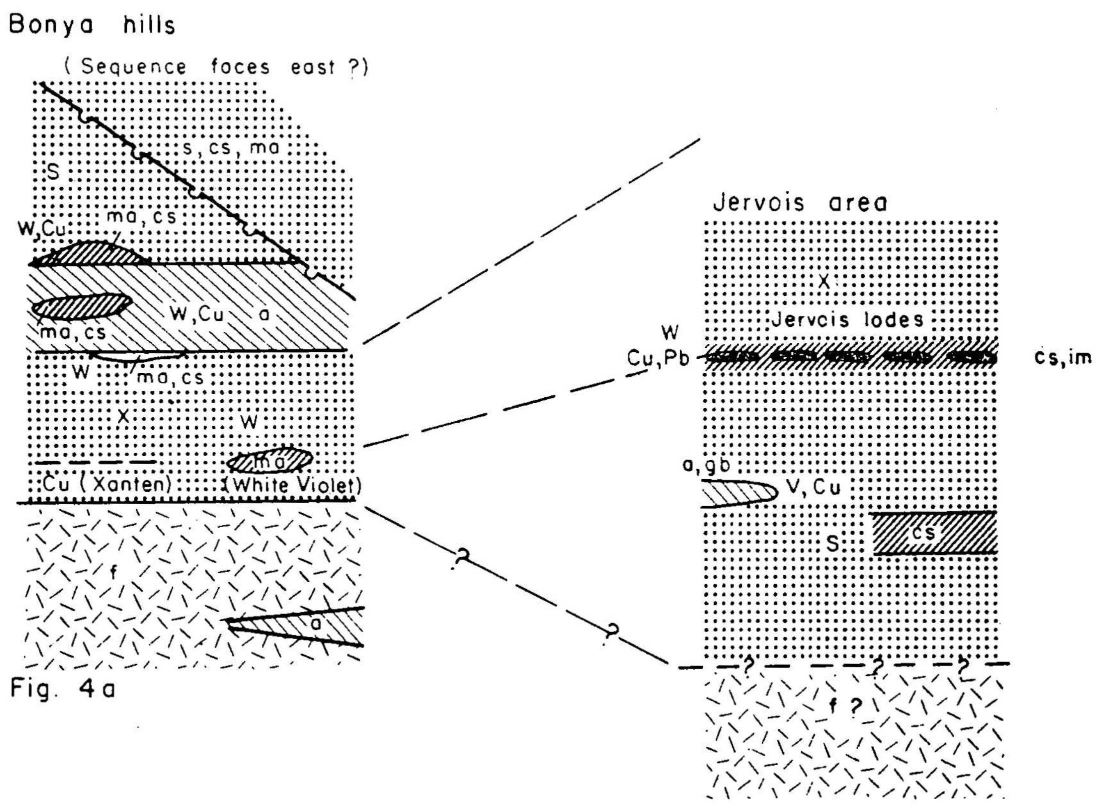

Fig. 4a

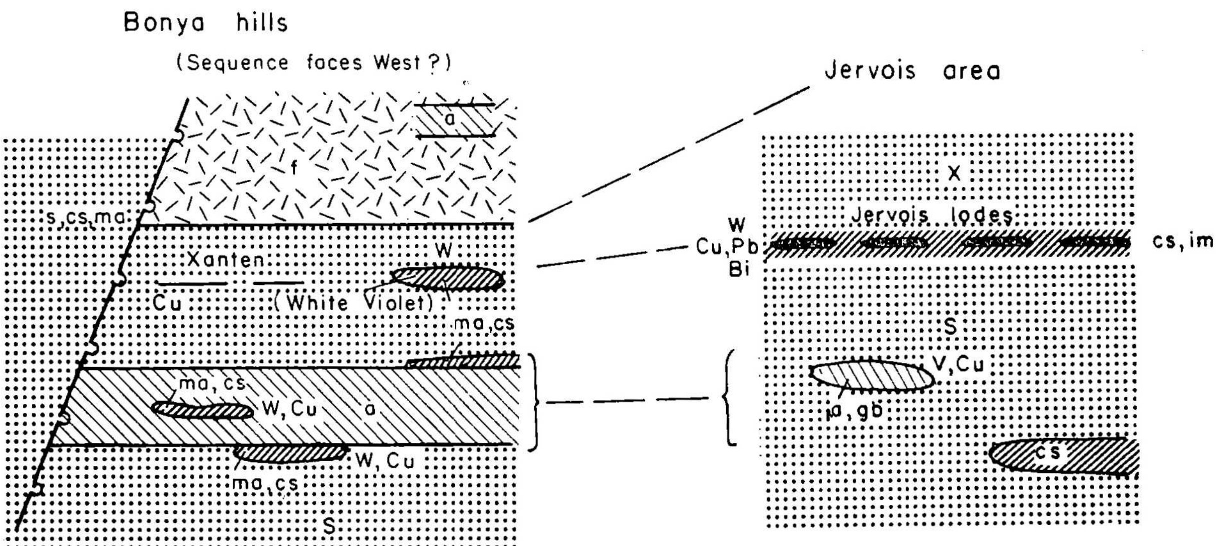

Fig. 4b

a	amphibolite	ma	marble
cs	calc-silicate rocks	s	schist
f	felsic gneiss	X	andalusite schist

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Fig. 4. Possible correlation between sequences in the Bonya hills and in the area from the syncline at Jervois eastwards

4.4.4. Scattered outcrops south of the Kings Legend mine

Weathered outcrops in the sandplain south of the Kings Legend are mainly felsic gneiss intruded by granite. Tourmaline is common in the prominent ridge southwest of Bakail, where there are fine-grained pure tourmaline rocks and tourmaline-rich felsic gneisses. The granite is a coarse-grained, grey, gneissic, biotite-granite. The felsic gneiss may correlate with the felsic gneiss in the Bonya metamorphic complex.

4.4.5. Outcrops between Mount Thring and Thring Bore

Mount Thring (at least the eastern slopes) is composed of vein quartz and deformed massive quartz, and is capped by laterite.

The two ridges southwest of Mount Thring consist of interlayered muscovite biotite schist and quartzite. The rocks are highly deformed, so that original quartz-rich layers are boudinaged. These outcrops are assigned to the Ledan Schist (Division III). Calc-silicate rocks are reported from the northwest side of these ridges (L.A. Johannsen, Fama Mines, pers. comm.) but it is not known whether these rocks are interlayered with the schist or are part of the Bonya metamorphic complex.

The eastern extension of the Delny-Mount Sainthill Fault separates the outcrops of Ledan Schist from biotite-quartz-oligoclase gneiss to the south. Muscovite is present in some out crops, showing that the metamorphic grade is lower amphibolite. However, the gneiss is compositionally similar to the Irindina Gneiss of the Harts Range Group. The scattered outcrops south of the Delny-Mount Sainthill Fault and east of Thring Creek are therefore correlated with the Harts Range Group.

4.4.6 Area from Thring Bore to Jervois homestead

A prominent ridge of quartzite crops out south of the Marshall River near Jervois homestead. The same quartzite also forms ridges extending northwest from south of the Jervois Station airstrip. Low ground between the ridges contains outcrops of mica schists. The quartzite and schist are intruded by tourmaline-bearing pegmatites and granite veins and also by granite west of the Jervois Station airstrip, (personal communication by geologists of C.P.M.). Trend-lines in low ground north of Jervois homestead indicate that similar rocks may crop out here also. About one kilometre southeast of Thring Bore similar quartzite is underlain by garnet-sillimanite gneiss. These outcrops are upper-amphibolite-grade equivalents of those close to Jervois homestead. The quartzites are assigned to the Utopia Quartzite, and the mica schists and garnet-sillimanite gneiss to the Ledan Schist of Division III.

4.4.7 Area between Bonya Creek and the Marshall River

Poorly exposed and deeply weathered rocks between Bonya Creek and the Marshall River are shown on the first edition of the Huckitta geological Sheet as mainly granite. Mapping by Union Corporation Pty Ltd (Wright, 1974) shows a similar distribution. However, the magnetic response is similar to that over the Bonya metamorphic complex. The only specimen in the BMR collection from this area is a calc-silicate rock. It may be that there are isolated roof pendants of metamorphic rocks producing the magnetic highs; alternatively the highs may be due to magnetite or hematite in the numerous quartz veins which cut the outcrops.

4.4.8. Granite in the Jervois Block

The western part of the Jervois Block is occupied by a single granite, the Jinka Granite, a medium to coarse-grained pink biotite granite with a slightly gneissic texture. Speicmens generally contain traces of muscovite and chlorite after biotite. It is difficult to collect specimens away from the numerous quartz veins (Oorabra Reefs) which cut the granite: the chlorite and perhaps the muscovite may have been developed in the same event as the quartz veins.

The Jinka Granite extends into the Bonya hills and probably continues eastward to the Tarlton Fault (Warren, in prep.).

Several other granites crop out in the Bonya hills, including a gneissic adamellite and leucocratic granites. Some of the "granite" shown in company maps between Bonya Bore, Tashkent, and the fault at the western edge of the Jervois Range is felsic gneiss.

About 7 km south of the Bellbird Mine in the Jervois district there are low hills and tors of a medium-grained grey granite with round xenoliths of amphibolite. This is assumed to be the type locality for the Jervois Granite (Smith, 1964). The first edition of the Huckitta Geological Sheet shows all granites south and east of these outcrops as Jervois Granite. The few specimens available from these outcrops resemble Jinka Granite.

Leucogranite (alaskite) crops out about 7 km northeast of Jervois Mine. The photo-tone of outcrops farther to the northeast also indicates granite. The large area of "basic intrusives" shown here on the first edition of the Huckitta Geological Sheet consists mostly of granite.

5.0 DISTRIBUTION OF METAMORPHIC GRADE

A simplified map of metamorphic grade is shown in Figure 5. Greenschist facies rocks occur only adjacent to the major faults, where wide zones of retrogressed rocks contain epidote and chlorite. Chlorite replaces biotite in many samples of granite, but it is not know whether this is a deuetric effect or is due to later faulting and local hydrothermal activity.

The boundary between lower and upper amphibolite facies is taken as the breakdown of muscovite to potassium feldspar and sillimanite. Generally the division is a clear one, but in the Bonya hills conditions must have been close to the isograd, as muscovite with fibrolite occurs in close proximity to andalusite.

The boundary of the granulite facies is taken as the formation of two pyroxenes together in mafic rocks. Most samples of basic granulite show evidence of later hydration to hornblende.

The assemblages in most rocks are consistent with a high geothermal gradient. The highest-temperature assemblage is in the kornerupine-bearing felsic gneiss south of Mount Baldwin. (These rocks are peobably in a fault slice within the Mount Sainthill Fault Zone). The only detailed study of metamorphic conditions is by Dobos (1978, unpublished) for the Bonya hills-Jervois area. Staurolite occurs here, but andalusite and cordierite also occur nearby, showing that the pressure was low.

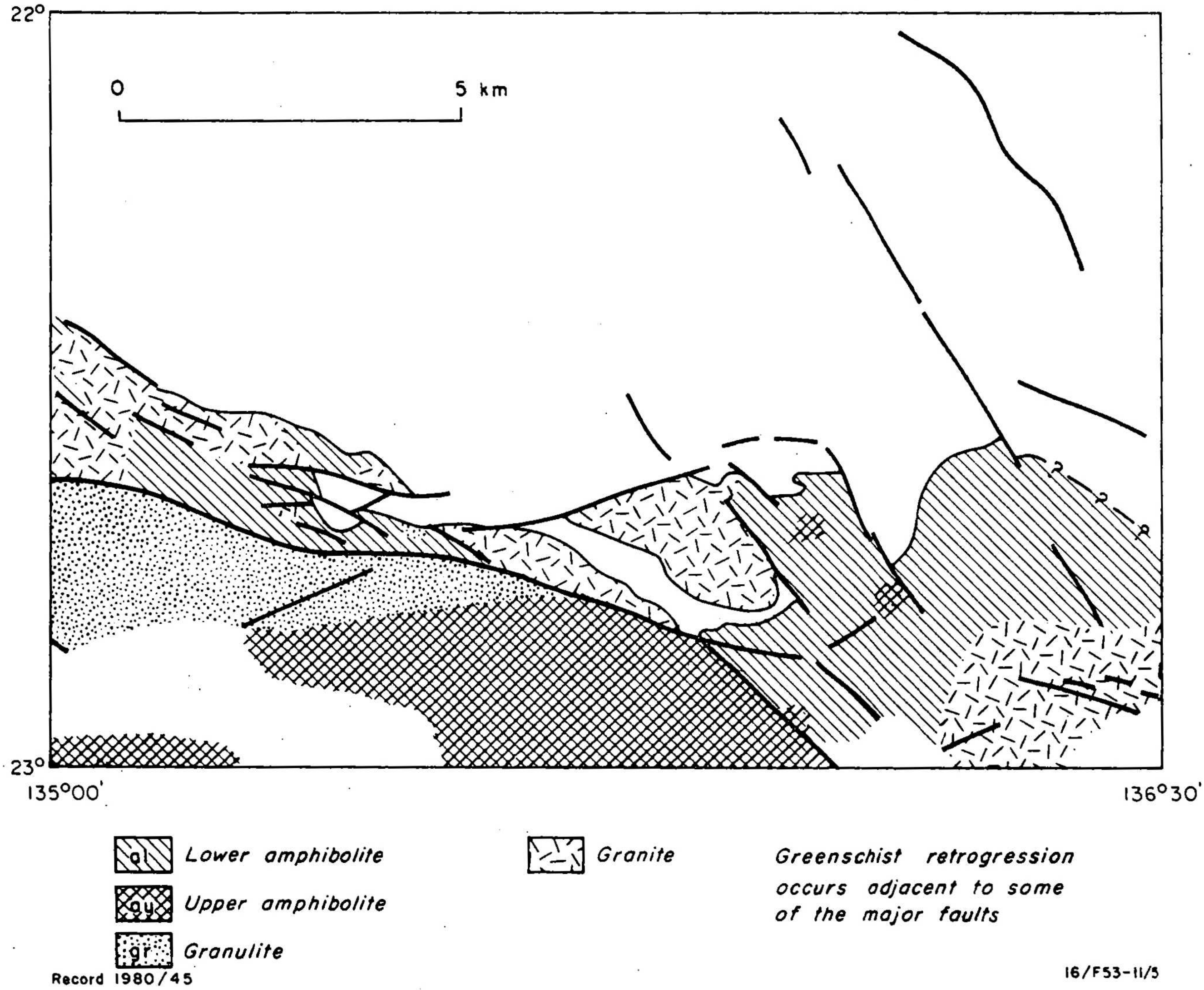

Fig. 5 Distribution of metamorphic grade

6.0 ECONOMIC GEOLOGY

The most important commodities obtainable from the Huckitta 1:250 000 Sheet area are tungsten, molybdenum, copper, lead, bismuth, barite, and fluorite. Mica was mined before 1960 from many of the pegmatites in the Harts Range Group.

6.1 Tungsten

Tungsten is being mined from Molyhil. The lodes are scheelite-molybdenite-pyrite disseminations in a roof pendant of skarn within the Jinka Granite. The distribution of scheelite seems erratic but is probably controlled by the composition of the calc-silicate rocks that were transformed into skarn. It is estimated that 50 tonnes of scheelite have been produced since the mine was opened in 1972 but detailed production figures are not available. Molybdenite ore has been stockpiled. A report on the diamond-drilling program is being prepared by the Northern Territory Geological Survey (Barraclough, 1979).

Scheelite occurs in the hanging wall (probably the stratigraphic top) of the Jervois lodes. At the southern end of the Jervois syncline, about 1.5 km east of the Bellbird Mine, there is a poorly exposed plug of fluorite-scheelite-vesuvianite rock (Pioneer Prospect). No scheelite has been produced from the Jervois lodes.

Most of the scheelite prospects in the Bonya hills are in cal-silicate lenses at the base and top of the Kings Legend amphibolite, or at intermediate boundaries. Calc-silicate bodies adjacent to later cross-cutting pegmatites are the most prospective locations, and it is thought there has been considerable mobilisation of "dilute' tungsten concentrations during magmatism. There has been some production from small workings, possibly as much as 1 tonne of scheelite in all. Jericho Mine was opened about 1972, but the scheelite recovery was poor and the mine has been closed until better treatment of the ore can be achieved.

6.2 Copper

The Jervois area contains the most important copper deposits of the area. These occur in elongate "strata-bound" lenses parallel to compositional layering. Some lenses also contain bismuth and zinc and some lenses contain lead. Although traces of mineralisation persist for about 7 km around the synform at Jervois, mineable concentrations are patchy. The mineralisation is not confined to a single horizon, as lenses overlap through a vertical section of about 500 metres. This section contains a high proportion of calc-silicate rocks, and lenses of garnet-chlorite rock and magnetite-quartz rock.

Production has been erratic and has consisted of small parcels of hand-picked ore, mainly from the oxidised zone. Exploratory drilling at the Bellbird was carried out by New Consolidated Goldfiels (Catley, 1965), and Petrocarb Exploration N.L. carried out an extensive drilling program in the Reward-Marshall area. Reserves proven by Petrocarb Exploration are 3.35 million tonnes containing 0.3 to 4.1% copper and 8.0 to 11.2% lead.

Union Corporation reported traces of copper-vanadium minerlisation in metagabbro east of the Jervois lodes.

The Copper lodes in the Bonya hills may be subdivided into stratigraphically controlled deposits and hypogene deposits. The stratigraphically controlled deposits are associated with the Kings Legend amphibolite, and occur in calcareous lenses at its top and base and within the amphibolite. All the deposits are too small to be economically important but small parcels of oxidised ore have been extracted from workings in the vicinity of the Kings Legend and along a line southeast from Yarraman. The workings at Yarraman are in skarn rock adjacent to a pegmatite, but it is not clear whether Yarraman is a skarn deposit introduced by the pegmatite or merely mobilised and metamorphosed by it.

The Bonya Mine is in the felsic unit at the base of the Bonya metamorphic complex, close to the axial zone of a major fold. Country rocks adjacent to the workings also include knotted schist and quartzite. Primary ore from the mine consists of sulphides, mainly bornite, chalcopyrite, and pyrite in a brecciated quartz matrix.

Petra is a small copper lode in amphibolite. Secondary carbonates are exposed in the shallow surface workings. The copper minerals appear to have been introduced into a breccia zone at one end of a quartz-filled tension joint during a late period of fracturing and faulting.

Xanten is a small copper lode with a ferruginous-quartz wall rock. The country rocks are mica schist and amphibolite. Leucocratic granite crops out about 200 metres to the northwest. Small bleached and malachite-stained outcrops of fine-grained quartz-rich rock occur west and southwest of the pit. The main copper-bearing lode has been opened to a depth of about 4 metres, but there is no recorded production. The ferruginous-quartz wall rocks persist over a strike length of 200 metres away from the principal copper-bearing outcrops. Xanten may be a hypogene quartz-pyrite-copper sulphide body introduced by the nearby granite, but there is a possibility that the mineralisation is volcanogenic, related to the nearby amphibolite lenses, and was originally a pyritic chert containing copper sulphides.

Central Pacific Minerals N.L. examined the Perenti Copper Prospect in the extreme west of the Sheet area, but found it too small to support a mine. The prospect is in a quartz breccia reef about 1000 m long in the Mount Swan Granite.

6.3 Fluorite and barite

Tension fractures filled by barite, and less commonly fluorite, cut the basal part of the Georgina Basin sequence and underlying granites. They are developed along the north side of the Elyuah Range, near Oorabra Rockholes, and west towards the Marshall River, near Molyhil, and in the northeastern part of the pseudo-ring-dyke south of the Myponga Range. Fluorite generally occurs only within granite basement but barite veins cut cover rocks, particularly the Oorabra Arkose. Central Pacific Minerals N.L. drilled the reefs on the north side of the Elyuah Range, and estimated that 370 000 tonnes of 40% fluorite ore was present. The origin of the barite and fluorite is uncertain. The barite, and presumably the fluorite, are younger than the Elyuah Formation (of Late Proterozoic age) and may be younger than the final folding of the Georgina Basin sequence (late Devonian?)

All deposits are close enough to the unconformity between basement and cover to suggest a causal relationship. They may have been deposited by circulating groundwater at low temperatures. The source of the fluorite may be the granites. (Fluorite is an accessory minerial in the granite northwest of Elkera No. 2 bore).

6.4 Vanadium

Small copper-vanadium lodes occur in metagabbros east of Jervois. The best value reported was 1.28% V_2O_5 on a spot sample (Wright, 1974).

6.5 Bismuth

Bismuth occurs in some of the Jervois lodes. There has been no production.

6.6 Molybdenum

Molybdenite occurs with scheelite at Molyhil. There has been no production (June 1979).

6.7 Lead

Lead occurs in the Jervois lodes. The highes reported value is 11% lead. High lead values are generally confined to the lodes close to Unca Creek (Reward and Marshall lodes). Robertson (1959) found lead values were higher in calcareous wall rock whereas copper values were higher in the micaceous wall rock.

6.8 Mica

Mica was obtained from some of the larger pegmatites in the Harts Range Group. Joklik (1955) icluded plans of some of the larger mines in the Huckitta Sheet area. Woolley (1959) also examined many of the pegmatites in the south of the Sheet area. Most of the pegmatites crop out in low rises and some were discovered only because their quartz core extended above the sand and alluvial cover.

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