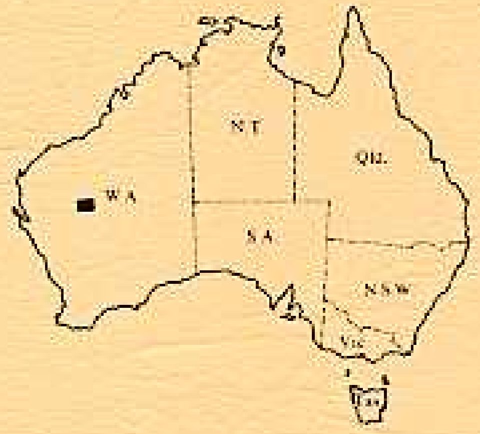
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
1:250 000 GEOLOGICAL SERIES—EXPLANATORY NOTES

PEAK HILL

WESTERN AUSTRALIA

SECOND EDITION



SHEET SG/50-8 INTERNATIONAL INDEX

WESTERN AUSTRALIA
INDEX TO GEOLOGICAL MAPS
SCALE 1:250 000

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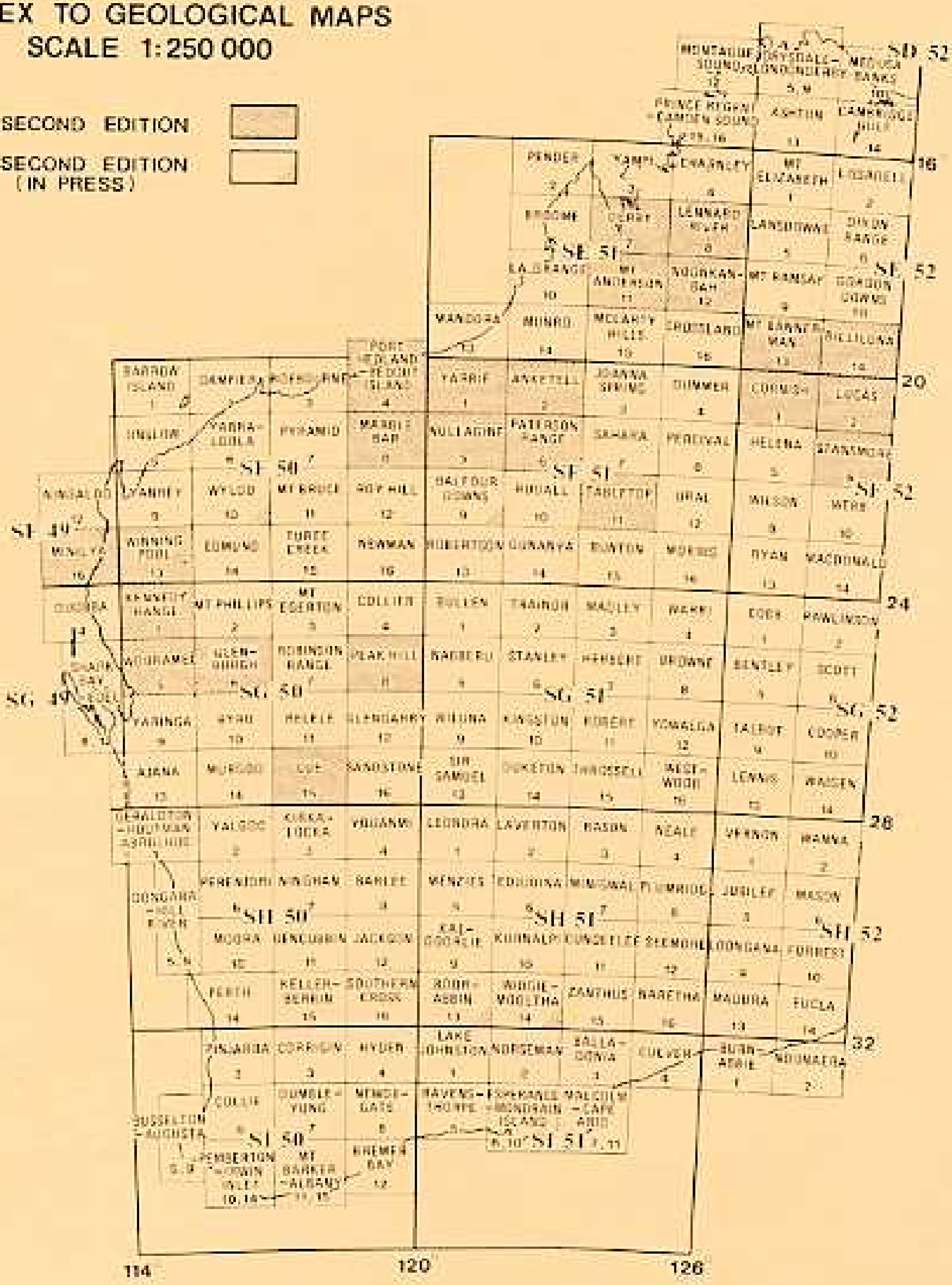

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BY

R. D. GEE

PERTH, WESTERN AUSTRALIA 1987

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Explanatory Notes on the Peak Hill Geological Sheet

by R. D. Gee

INTRODUCTION

The first edition of the PEAK HILL* 1:250 000 sheet was produced by MacLeod (1970) following what was largely reconnaissance mapping in an area whose complexity was not recognized at the time. Following extensive systematic regional-mapping programs in the mid 1970s, which for the first time defined the tectonic features along the northern margin of the Yilgarn Block, it became evident that this sheet required further geological mapping. This was done progressively between 1977 and 1981 and is now released as the second edition of PEAK HILL Explanatory Notes.

These notes should be read in conjunction with the first edition notes, in which background information on history and water supplies is given and not repeated here. These notes emphasize the geological importance that this key area holds in gaining an understanding of the tectonic history of the Capricorn Orogen.

Cattle and sheep grazing remains the major land use, but since the first edition many of the old gold shows, that were dormant at that time, have reopened. Also the Great Northern Highway, which passes through the centre of PEAK HILL, has been totally reconstructed and sealed.

PHYSIOGRAPHY AND CAINOZOIC GEOLOGY

PHYSIOGRAPHIC FEATURES

Two of the State's major west-flowing rivers, the Gascoyne and Murchison, rise in PEAK HILL. A third major drainage system (Lake Gregory) rises in the eastern part of the sheet, and feeds easterly into the Lake Nabberu drainage, one of the major early Tertiary palaeodrainages (van de Graaff and others, 1982). The triple point of the drainage divides lies on the relatively high flat plains 30 km southeast of Mount Leake. The drainage divides, which vary from 580 to 680 metres ASL, are the remnants of the extensive plateau surface that was subject to deep weathering in the early Tertiary. Only minor remnants of the laterite plateau occur on these drainage divides, as most of the area has been subject to some dissection. These uplands are characterized by outcrop areas extensively strewn with boulders, particularly vein quartz, shed from the once-continuous lateritic blanket. The old townsite of Peak Hill itself lies on the Murchison-Gascoyne divide.

Scree and sheet-wash slopes mantle the upland areas, and pass down into broad alluvial plains which contain the major water courses. These flat plains are covered with recent alluvium but seem to be extensively underlain by an older indurated alluvium which, when dissected in the headward region, forms rugged miniature canyons. The areas to the north, underlain by the gently folded rocks of the Bangemall Group, are more extensively dissected than the rocks of the fold belt in the southern part. The upland areas between the interfluves are well

* Sheet names are printed in capitals to avoid confusion with similar place names.

52150-2

exposed, form characteristic cuestas and mesas, and are generally without remnant laterite caps. However, the development of silcrete on hilltops indicates that these areas have been subject to the lateritization process.

CAINOZOIC GEOLOGY

Mapping of the Cainozoic units is based upon lithology and geomorphological expression, and older (Tertiary) and younger (Quaternary) units are recognized. Pisolitic aluminous laterite (*Tl*) is well developed on granites and folded sediments of the Glengarry Group, and more ferruginous types occur on the volcanics and banded iron-formation. The unit *Qs*, which is a reddish iron-stained quartz sand, occurs on top of the two major areas of lateritic plain, namely, the interfluve area southeast of Mount Leake and in the far northeast. These sand sheets are the windblown reworked upper portion of the original laterite profile.

Valley calcrete (*Czk*) is a deposit of chalky limestone and opaline silica which occurs in sheet-like bodies along the axes of the major fossil valleys of the palaeodrainage system. Although these deposits outline the present drainages, they are believed to have formed early in the dissection of the laterite blanket by a chemical replacement and cementation of the earliest post-laterite alluvium. This older alluvium, elsewhere referred to as the Wiluna Hardpan (Bettenay and Churchward, 1974), is an important Cainozoic unit, however, it is only seen in the vertical incised sections of the higher reaches of the watercourses and cannot be effectively represented on the geological map. These deposits probably accumulated in depressions in the undulating lateritic blanket, which marked the positions of the early Tertiary trunk drainages. This suggests that the present drainages follow the old palaeodrainages, and that the present drainage divides may be old features dating back into the early Tertiary. In the upper regions of the Gascoyne South Branch, remnants of the laterite blanket slope gently down into the valley floors.

The younger Quaternary units are more clearly related to present erosional processes. Colluvium (*Qc*) consists of rock and quartz fragments, loamy silts and sands, which drape the slopes of the uplands. These pass down into the blankets of alluvial sand and silt in the valley floors. In the Lake Gregory drainage system two additional units are recognized, reflecting its more highly saline nature. Saline silt and mud on saltlake surfaces is designated *Ql*, and is invariably surrounded by gypsiferous and calcareous dunes (*Qg*).

TECTONIC SETTING

PEAK HILL covers the marginal part of an orogenic belt that developed around 1.8 Ga on the northern edge of the Yilgarn Block. The northern margin of the Yilgarn Block has three segments each of different geological expression. In the west the basement rocks are continuously exposed and become progressively reworked in the Gascoyne Province. In the east, the Yilgarn Block is overlain by the flat-lying Earaheedy Group (Bunting, 1986) of an age about 1.65 Ga, which to the north becomes progressively deformed in the Stanley Fold Belt—a typical slate belt. The central segment is a tectonic inlier of an earlier (about 1.8 Ga) fold belt consisting of thick trough and shelf sediments and mafic volcanics, which are complexly deformed and moderately metamorphosed.This middle segment is actually the western part of the Nabberu Basin and is more properly thought of as a tectonic province rather than a sedimentary basin. It provides a window into the major early Proterozoic orogenic belt called the Capricorn Orogen, that lies between the Yilgarn and Pilbara Cratons. Much of this orogenic belt is covered by the Bangemall Group (about 1.1 Ga) so that its full nature is uncertain.

PEAK HILL covers this window and therefore provides an understanding of the southern margin of the Capricorn Orogen. The main tectonic features (Fig. 1) include the following: the fold belt derived by the deformation of the Glengarry and Padbury Groups; the two basement highs called the Marymia and Goodin Domes; a small onlap of the Earaheedy Group from the eastern part of the Nabberu Basin; and a major onlap of the sediments of the Bangemall Basin from the north. These major tectonic units provide the framework for these explanatory notes.

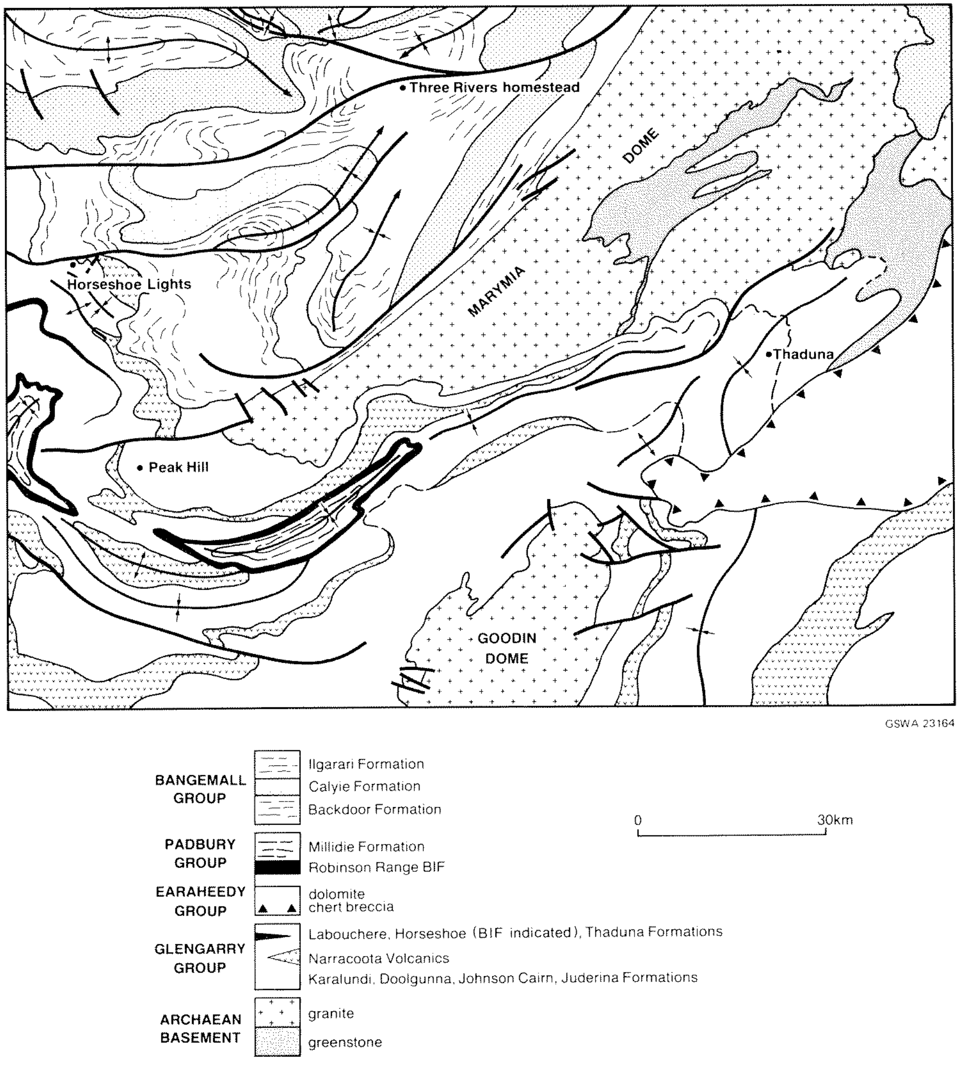

Figure 1. Geological and structural interpretation of Peak Hill Sheet SG 50–8. The Mount Leake Sandstone is deleted from this figure.

ARCHAEAN ROCKS OF THE BASEMENT DOMES

MARYMIA DOME

Greenstone assemblages

Two greenstone belts occur in the eastern part of the Marymia Dome, here called the Baumgarten belt and the Plutonic Well belt. Both belts are poorly exposed, but have been extensively prospected for nickel and base metals, by rotary drilling, and their lithological distribution is well known. This subcrop data is shown on the accompanying map, and not just the outcrop data. No coherent structure or stratigraphy is identified from either belt, as they are extensively intruded or interleaved with granitoids.

The Baumgarten belt appears to be broadly antiformal with tholeiitic basalt and ultramafics in the core, structurally overlain by metasediments. The ultramafics include spinifex-textured serpentinized peridotites, and talc-tremolite-carbonate-chlorite schists. The metasediments consist of quartz-sericite schist, cleaved tuffaceous and ferruginous shale, and flaggy schistose gritty quartzite. Felsic agglomerate and lapilli tuff occurs in the anticlinal core of folded Glengarry Group, 10 km south-southwest of Yowereena Hill. These contain fragments of porphyry with phenocrysts of rounded and embayed quartz and albitized plagioclase. Much of the extensive floodplain south of Yowereena Hill is probably underlain by greenstones of this belt.

The Plutonic Well belt has a strike extent of 50 km and seems to consist of a south-facing sequence of ultramafics, metasediments, tholeiitic basalt and further sediments. A feature of the sediments in this belt is the highly ferruginous and gossanous layers in the metasediments, which are highly sulphidic cherts at depth.

An isolated raft of coarse recrystallized foliated and boudinaged flaggy quartzite occurs within the granites, to the south of the Plutonic Well belt. This is similar to those quartzites in the Baumgarten belt, and provides an interesting comparison with the orthoquartzite-bearing greenstone belts of the Youanmi and Sandstone areas. Orthoquartzite is an uncommon rock type in Yilgarn greenstones, and its presence here suggests a northerly extension of the Southern Cross Province of the Yilgarn Block, under the Glengarry Sub-basin.

Granitoid phases

Most granitoids in the eastern Marymia Dome are medium- to coarse-grained, massive, biotite adamellite with little, or a weak, foliation. Toward the west the adamellite becomes more affected by a cataclastic foliation, whereby lenticles of recrystallized potash feldspar and aggregates of small chloritized biotite flakes define a foliation which wraps around sericitized plagioclase laths. Epidote, carbonate and muscovite are secondary metamorphic minerals. Rafts of quartz-magnetite-amphibole BIF are common in these foliated granites.

Gneissic phases

A variety of ortho- and para-gneisses with complex interfoliated relationships occurs in the western part of the dome. The regional gneiss (*An*) is a more recrystallized version of the cataclastic granitoid further east, although granodioritic components lacking potash feldspar are more prevalent. The more porphyritic precursors of granite produce augen gneiss. Textures are equigranular, polygonal and in places blastomylonitic.

Enclaves of non-granitoid include calc-silicate gneiss, quartzite, BIF, and orthoamphibolite. Calc-silicate gneisses are pale-coloured banded gneissic rocks, commonly associated with bedded quartzite, consisting of quartz, microcline, oligoclase, hornblende, diopside, epidote, and minor muscovite. Banding is due to variation in quartz and plagioclase content. Metamorphosed quartzites are banded lepidoblastic-textured quartz-rich rocks with variable amounts of epidote and plagioclase as they merge into the calc-silicate gneiss, or variable amounts of magnetite and grunerite as they merge into meta-BIF. The more mafic amphibolites consist of amphibole, diopside, oligoclase, epidote, sphene, and ilmenite, and have a banded appearance. These probably represent metamorphosed mafic intrusions.

These gneissic rocks are clearly non-greenstone in character, and together with their higher metamorphic grade, relate more closely to the gneissic assemblages of the Yarlarweelor Gneiss Belt and the northern marginal parts of the Yilgarn Block (Williams, 1986).

Structural features

A set of northeasterly trending, unaltered dolerite dykes is present in the more massive granites in the eastern part of the dome. In the western part, the dykes become progressively more sheared and altered, along with the shearing in the granitoids. Dyke emplacement pre-dates the shearing.

The attitude of shear foliation, in the central and western part of the dome, defines an antiform which is upright and slightly asymmetric to the south. Foliation is most intense along the southern margin, close to the unconformity contact with the mantling Glengarry Group. Along this southern marginal zone, the foliation is near vertical or in places dips back to the north, and has a strong down-dip stretching lineation. These structural features are related to the upward rise of the Marymia Dome as a semi-plastic diapir at relatively low temperatures. The high-grade (amphibolite) assemblages of the paragneisses is possibly inherited from an earlier metamorphism. Some indication of the P-T conditions during this stage can be obtained from the metamorphic assemblages of the overlying Peak Hill Metamorphics.

GOODIN DOME

This granitic basement high, which straddles the boundary of PEAK HILL and GLENGARRY, has a diameter of some 40 km. It consists of a pink biotite adamellite, generally unfoliated and without any known greenstone enclaves. Bunting (1982) provides on analysis from GLENGARRY which indicates a rather potassic (K_2O/Na_2O = 4.8/4.45) granite.

In contrast to the Marymia Dome, the contact with the overlying Glengarry Group is a smooth, gently dipping unconformity without any shearing. However, the contact is extensively cut by vertical faults, which indicates an upward rise of the dome by block faulting, rather than crystal-plastic flow. Numerous dolerite dykes cut the granite and, invariably, these are cut by the unconformity surface of the cover sequence.

STRATIGRAPHY OF THE GLENGARRY SUB-BASIN

PEAK HILL METAMORPHIC SUITE

Gee (1979) applied this term to those metasediments in the Peak Hill Mining district which, by virtue of their metamorphism and deformation, could not be easily related to the Glengarry Group. At that time, it was thought this suite represented a Proterozoic sedimentational and tectonic event earlier than the Glengarry Group. Further work, particularly additional examination of the sandstone-carbonate-chert facies of the lowermost Glengarry Group elsewhere in the western Nabberu Province, has shown that the Peak Hill Metamorphic Suite is more likely to be the metamorphosed equivalent of the lower Glengarry Group. Because of the structural and stratigraphic uncertainties in this complex area, the Peak Hill Metamorphic Suite is rightly retained as a useful lithostratigraphic term, although it is convenient and appropriate to describe the unit under the broad heading of Glengarry Group stratigraphy.

Lithological types

Two broad lithological units are recognized, a predominantly muscovite-bearing pelitic schist (*Pls*) in the east, at a lower structural level, and a more psammitic schist (*Plm*) at a higher structural level. The area of pelitic schist (*Pls*) is poorly exposed but seems to consist mainly of medium-grained quartz-muscovite schist, probably derived from a silty shale precursor. Another conspicuous, but volumetrically not unimportant rock type, is a lepidoblastic-textured flaggy quartzite with intrafolial folds and remnants of cross-bedding. An enigmatic rock type is a banded quartz-feldspar-muscovite gneiss of uncertain origin, but suggestive of small porphyry bodies.

The overlying psammitic unit is dominantly medium- to coarse-grained quartz-muscovite schist, commonly with small (2 mm) albite and magnetite porphyroblasts and rare garnet. These rocks are probably gritty, arkosic sandstones. A variety of metasediments occurs in the structurally lower part of this unit, in a broad arcuate band some 1 000 m wide, wrapping around the top of the *Pls* unit and passing through Mount Pleasant, Peak Hill townsite, and heading back to the northeast. These rock types include: muscovite quartzites with magnetite; chlorite-graphite schist; carbonaceous metachert; amphibolitic calc-silicate schist; and impure marble.

The more flaggy quartzites are foliated and lineated lepidoblastic-textured flaggy rocks, with minor potash feldspar and green muscovite. These contain vestiges of low-angle cross-bedding and are clearly sedimentary orthoquartzites. Other finer grained quartzites have millimetre-size lamination, defined by grain-size variation and stylolitic carbonaceous stringers. A distinctive feature of these finer-grained rocks is the presence of moulds of a fibrous lenticular mineral, lying in radiating rosettes on bedding surfaces, forming after possible gypsum. These are, possibly, metamorphosed cherts.

Pelitic rocks are represented by quartz-chlorite-garnet schists with variable amounts of magnetite, muscovite, biotite, epidote and carbonate. These schists are commonly banded with pale purplish-grey quartz-carbonate-potash feldspar layers, in which dolomite may reach up to 80%. Some bands up to 1m thick of pale-grey marble occur within these schists, a distinctive feature of which is paler coloured ooids up to 3 mm in diameter. Because of metamorphic recrystallization these have no noticeable expression in thin section. Another calc-silicate variety consists of graphite-muscovite-biotite schist with porphyroblasts of tremolite.

These metamorphics are derived from arkosic sandstone, orthoquartzite, cherts, greywacke, shale, marl, and dolomite, all of which are known to occur in the lower Glengarry Group.

Structural and metamorphic features

The overall structure of the Peak Hill Metamorphics is a southwest-plunging antiform. Metamorphic facies reach the greenschist-amphibolite transition in the tectonically lower parts of this antiform. There is evidence, in the form of upward fining of metamorphic grain size, and progressive disappearance of garnet and biotite at higher tectonic levels, of a gradational metamorphic boundary into the recognizable Glengarry Group rocks. The upper boundary was taken by Gee (1979) at the Crispin Conglomerate.

Several phases of structural fabric are seen in the schists. The most conspicuous foliation, which is subparallel to the major lithological layering, is defined by micaceous foliae. It is, in fact, a transposition foliation as shown by cross foliae of early micaceous trails within the more quartzo-feldspathic foliae. The main foliation wraps around porphyroblastic minerals such as garnet and tremolite, suggesting metamorphism prior to the main foliation development. The main schistosity is commonly crenulated by angular-style microscopic and mesoscopic chevron folds, unrelated to any new metamorphic mineral growth.

The regional antiformal structure is defined by the arcuate attitude of the main foliation, as well as the major lithological banding. Several marker beds are recognized, such as the metachert that passes through Peak Hill. These original bedding units also outline a number of near-isoclinal reclined folds which are refolded by the broad antiform. The late chevron folds are thought to be axial planar to the antiform, but a proper understanding requires further structural mapping.

STRATIGRAPHIC UNITS OF UNCERTAIN RELATIONSHIPS

Three formations, the Finlayson, Maraloou, and Crispin, are bracketed in the reference of the map as having uncertain stratigraphic relationships. Sandstone and shale in the southeast corner of PEAK HILL, which are the extensions of what was mapped as Finlayson Sandstone and Maraloou Shale on GLENGARRY (Elias and others, 1982), are designated accordingly on PEAK HILL. Additional work since the compilation of the sheet, aimed at synthesising the entire Glengarry Sub-basin, has established that the Finlayson is a direct correlate of the lower part of Juderina at the base of the Glengarry Group. However, the overlying shale units, Johnson Cairn and Maraloou do not correlate, and it now appears that the Maraloou Shale, as defined by Elias and others (1982), is high in the Glengarry Group. Consequently the shales designated as Maraloou on PEAK HILL should now be regarded as Johnson Cairn Shale.

The Crispin Conglomerate, which overlies the Peak Hill Metamorphics, consists of boulders (up to 1 m in diameter) of the white metamorphic quartzites, in a schistose sandstone matrix. Gee (1979) previously suggested that it marked the basal unit of the Glengarry Group, where it overlay the Peak Hill Metamorphics. Although it is more probably a conglomerate layer within the Doolgunna Formation, which is known to contain at least two conglomerate layers in the White Well area. Stratigraphic relationships in the Glengarry Sub-basin are shown diagrammatically in Figure 2.

GLENGARRY GROUP

Juderina Formation

At the type locality 3 km north of Juderina Bore, on the northwestern margin of the Goodin Dome, there is a sequence consisting of a basal orthoquartzite unit (3 m thick), overlain by two interlayered sericitic siltstone and orthoquartzite units. These units are separated by two sericitic sandy siltstone units which contain chert-breccia layers. This thicker multilayered sequence, up to the last prominent orthoquartzite, should be regarded as the Juderina Formation, rather than just the basal orthoquartzite.

The lowermost orthoquartzite unit consists of a medium- to fine-grained silica-cemented mature quartz sandstone, with abundant planar herring-bone cross-bedding units (up to 50 cm thick) and rectilinear or linguoid ripple marks on planar-bedding surfaces. The actual unconformity surface is visible in many localities around the Goodin and Marymia Domes, where it is seen to be smooth and generally without a conglomeratic phase, such that the basal bed is the normal well-sorted quartz sandstone. In some localities, lenses of vein-quartz cobbles (up to 1 cm in diameter), trails of heavy minerals, and lenses with ferruginous cement occur in the basal bed. In general the higher sandstone beds become slightly more feldspathic, and some develop a brown mottled appearance, probably indicative of the presence of former carbonate cement.

A distinctive feature of the shale units is the presence of chert-breccia beds which liberate conspicuous bouldery scree. The best development of such breccias lies in the folded areas 10 km northeast of Thaduna, where chert breccia with remnant stromatolitic forms is present. These breccias are erroneously designated as *Eg(b)* on the geological map. More recent studies of the cherty shale units of the Juderina-Finlayson unit around the entire Glengarry Sub-basin, but particularly on GLENGARRY, has established that these chert breccias are silicified microbial mats of carbonate and evaporite minerals. It should be noted that other areas of chert breccia also designated as *Ey(b)*, in the Lake Gregory area, are part of a younger chert breccia developed in the lowermost Earaheedy Group.

The Juderina Formation is interpreted as a transgressive shoreline deposit of well-washed sand that developed on a flat unconformity surface. At times when clastic supply was short, sabkha environments developed.

Johnson Cairn Shale

Johnson Cairn Shale occurs above the Juderina Formation in the areas northeast of Thaduna, around the Goodin Dome and, as noted above, in the southeast corner of PEAK HILL where it is probably erroneously designated as Maraloou. It is absent in the western part of the sheet, around Peak Hill, where the Juderina passes straight up to the Doolgunna Formation; consequently Johnson Cairn Shale was not established in the original Glengarry Group stratigraphy by Gee (1979).

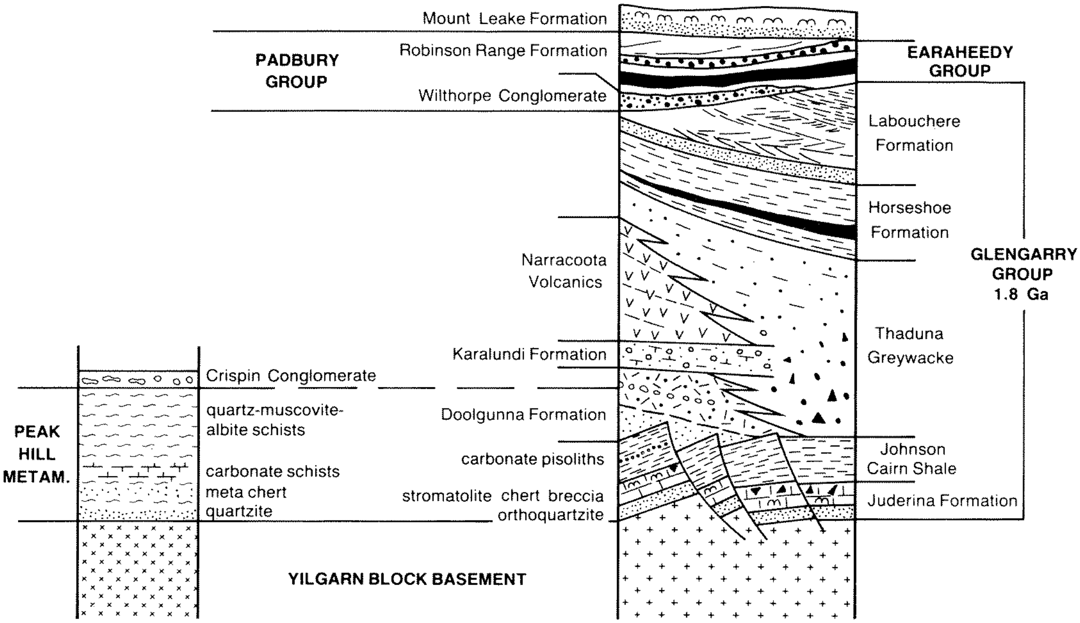

Figure 2. **Stratigraphic relationships — Glengarry Sub-basin.**

Johnson Cairn Shale is a laminated varicoloured iron-rich shale, often with graded silty layers and carbonate beds. In the type area, in the synclinal zone 13 km northeast of Thaduna, it conformably overlies the highest sandstone unit of the Juderina, is about 250 m thick, and is overlain by Thaduna Greywacke. Around the Goodin Dome, it is 150 m thick and is overlain by Doolgunna Arkose.

Its characteristic surface expression is flaky chocolate-coloured rubble, strewn with sparse pale-coloured carbonate and magnesite scree. This material is shed from thin beds, generally about 10 cm thick, of both purplish laminated micritic dolomite, and white pisolitic dolomite-magnesite rocks. The best exposure of such rocks occurs at 119°16′00″E, 25°57′30″S, where both dolomite and magnesite pisoliths occur in beds of laminated micritic dolomite. Polished slabs reveal that the pisoliths have grown over the laminated matrix, but are themselves cut by the slaty cleavage. The pisoliths are therefore authigenic and are not oolites. They are best interpreted as caliche nodules that grew in carbonate muds.

The environment of deposition is considered to be a quiet, relatively shallow marine basin devoid of clastic input, into which mainly red marine mud accumulated.

Doolgunna Formation

This formation, formerly thought of as purely an arkose unit (Gee, 1979), is now recognized as having a lower sandstone phase designated *Gd*(*s*), as well as the true arkose *Gd*(*a*). The best section lies along a transect extending 15 km east-southeast from Don Well. The stratigraphically lowermost part is approximately 300m of quartz sandstone, capped by a pebbly conglomerate. This is overlain by the main thick arkose (5 km thick) which contains, in its middle part, an important coarse-conglomerate marker horizon.

The lowermost quartz sandstone is flaggy and well sorted, with abundant trough cross-bedding. Many beds contain abundant weathered-out shale intraclasts. The pebble-conglomerate bed, which separates the sandstone and arkose phase, is 2 m thick and is composed predominantly of chert pebbles 1–5 cm in diameter. Many pebbles are of slab shape, but no imbrication is observable. Provenance of the pebbles is problematical but may be the silicified carbonate and chert beds of the Juderina. This pebble-conglomerate horizon probably marks the transition from an early shallow-water fluvial phase of the Doolgunna, to the submarine turbiditic arkosic facies.

The arkosic part of the Doolgunna is almost invariably deeply weathered and has a geomorphic expression and composition similar to deeply weathered granite. Individual arkose beds may be stacked one upon the other, or separated by thin shale beds. Arkose beds range in thickness from less than 1 metre up to massive beds 4 m thick, and may display gross upward-fining grading, bottom scouring of the shale, rip-up clasts, single or multiple graded units and convoluted wavy bedding, typical of turbidite beds. The lower parts of the graded units may contain clasts of vein quartz up to 2 cm in diameter, but the bulk of each bed consists of angular quartz, together with an equal abundance of kaolinized pseudomorphs after feldspar grains. Thin sections from the few rare outcrops of fresh arkose indicate an equal abundance of quartz, microcline and oligoclase, with chloritized and bleached biotite. Some chert clasts are also present. The great bulk of the arkose is granite-derived, although actual granite clasts are rare, having been seen only in one outcrop 6 km east of John Bore on Doolgunna Station.

A coarse conglomerate member, about 10 m thick, occurs in the middle of the thickest part of the Doolgunna Formation, on the northwestern part of the Goodin Dome. It is best exposed at a point 1 km north of White Well, and can be followed through a number of near-isoclinal folds for 40 km along strike.

The main conglomerate bed is 4 m thick. It consists of a chaotic mixture of rounded and angular pebbles and boulders (up to 2 m in diameter) of vein quartz, chert breccia, chert with microbial laminations, dolomite, and quartz sandstone. A provenance largely from rock similar to the Juderina Formation is suggested. Shale intraclasts torn off adjacent arkose sequences are present, and the matrix of the conglomerate is granule vein quartz and decomposed feldspar. These components are resedimented arkose from earlier in the sequence.

This thick conglomerate bed is without stratification and contains disoriented, unsorted clasts of both exotic and indigenous provenance. Some of the thinner conglomerate beds show crude upward-fining of pebbles and matrix.

This conglomerate unit is possibly a coarse debris flow, down the face of a submarine arkose wedge. The ultimate origin is probably the eroding Juderina Formation that capped rising granitoid horsts.

The Doolgunna Formation occurs continuously at its normal stratigraphic position in the western part of PEAK HILL. It reaches its greatest thickness of 5 km on the northeastern flank of the Goodin Dome, however, it is not known to make contact with the Goodin Dome granite. It is about 1 000 m thick along the central-southern margin of the Marymia Dome, but only a few hundred metres thick at its western end. It is absent from the northeasterly areas where its place is taken by Thaduna Greywacke. On the eastern flank of the Goodin Dome, the actual arkose is thin (possibly about 1 000 m), however, further to the east there are extensive areas of feldspathic arenite lying above the actual arkose, and designated on the map as *Gd(s)*. These enigmatic rocks which are interbedded with thinly bedded feldspathic wacke could equally be considered as distal facies of Thaduna Greywacke.

The Doolgunna Formation is considered to be a thick clastic wedge that spread throughout most of the Glengarry Sub-basin from an unidentified source area. Although there is a close spatial relation with the Goodin Dome. The Juderina everywhere seems to separate the arkose from the granite. A source from the fragmenting northern margin of the Yilgarn Block to the south is more likely.

Karalundi Formation

Karalundi Formation (Gee, 1979) is a mixed sequence of clastic carbonate, chert, and tuff, about 1 500 m thick, lying conformably between Doolgunna Formation and Narracoota Volcanics on the southern limb of the major synclinorium. The base is a simple layer of fine-grained massively bedded orthoquartzite which is well exposed at a point 3 km southwest of Don Well. Above this is an interbedded sequence of feldspathic sandstone, kaolinitic siltstone and thin orthoquartzite. This association becomes more ferruginous higher in the sequence.

Medium- to fine-grained, poorly sorted, ferruginous black sandstone is the most distinctive rock in this formation. It contains both well-rounded and angular quartz grains, and feldspar clasts set in a hard black cement. Upward-fining beds, convolute lamination, and low-angle cross-bedding are common in these beds which appear to be shallow-water marine deposits. These sandstones are interbedded with ferruginous and siliceous shales which commonly contain silty lenses with ripple-drift lamination. Basaltic water-lain tuff and minor carbonate beds appear in the upper part of the formation.

Another distinctive rock is hematite-magnetite jasper which occurs as steeply inclined pipes up to 20 m in diameter. It has a distinctive colloform texture caused by patterns in the hematite dusting, throughout the jasper, and by pale chert that fills dilational cracks on the jasper. This fissure material commonly contains euhedral magnetite. These jasper pipes are interpreted as colloidal hydrothermal deposits formed in fumarolic pipes associated with the basic volcanism.

The Karalundi represents the transition from deep-water arkosic turbidites to shallow-water marine or even fluvial conditions, and records the commencement of basaltic volcanism.

Narracoota Volcanics

Most of the Narracoota is of tholeiitic basalt but, at upper levels, more magnesian basalts appear. The tholeiitic basalts are either schistose or massive. In several places coarse block breccias are present, with angular blocks varying in size from a few centimetres up to a metre, set in an identical matrix. Pillows have been only rarely observed, but interflow cherty sediments, vesicles, and chalcedonic veins are common. The basalts vary from fine to medium grained, and the latter have ophitic textures. A characteristic feature of all basalts is the abundance of sills and irregular plugs of intrusive dolerite—a feature which makes difficult the distinction between basalt and dolerite in poorly exposed areas. Indeed, many of the areas previously mapped as dolerite are now known to be extrusive, as shown by the above mentioned features. The dolerite sills in the eastern part of the sheet occur at the general stratigraphic level of the Narracoota Volcanics, and many could be extrusive flows, rather than sills.

The tholeiitic basalts are ususally altered; clinopyroxene shows varying degrees of alteration to actinolite, and plagioclase to saussurite. More advanced metamorphism, particularly at lower tectonic levels, produces actinolite, epidote, clinozoisite, albite and calcite assemblages. Chemically (Hynes and Gee, 1986) these rocks are similar to low-potash tholeiite from mid-ocean ridges but with slightly lower Ti/Fe and Zr/Fe ratios. They can reasonably be interpreted to have formed by mantle melting in a rifting environment.

At Mikhaburra, at the top of the main pile of tholeiite, there is a volcaniclastic sequence of quartz-chlorite phyllite, tremolite-chlorite phyllite with remnant clastic textures, and interbedded feldspathic lithic greywacke. Elsewhere, at the top of the pile, and particularly in the axial zone of the main synclinorial zone, there are talc-tremolite schists with centimetre-scale fragmental texture. These schists have MgO values ranging from normal tholeiite values of about 8% to 24%, and therefore have komatiitic affinities (Hynes and Gee, 1986).

The maximum thickness of the pile occurs at Mikhaburra where possibly 6 km of thickness occurs. Possibly a thickness of 4 km occurs on the northern limb of the major synclinorium at Noonyereena Hill. The unit thins to the east and is absent from the Thaduna area; it is represented by thin sills and flows in the area east of Goodin Dome. Variations in stratigraphic thickness, although difficult to define accurately because of localized strong shearing, permit the identification of a major volcanic pile, some 50 km long (extending west into ROBINSON RANGE) and up to 6 km thick, along a tectonic line that could be the hinge line of Glengarry Group sedimentation.

The top of the volcanic pile in the central synclinorial zone (around Wembley, Peak Hill and Horseshoe Lights) is marked by a conspicuous bed, only 1 to 2 m thick, of a crudely bedded, fragmental-textured magnetite-hematite chert. This bed is probably an exhalative chert, and is a locus for gold mineralization.

Thaduna Greywacke

The type area of this unit is in the Thaduna area where a greywacke sequence, with a thickness possibly as much as 5 km, conformably overlies the Johnson Cairn Shale. This distinctive unit can be followed to the west along the axis of the major synclinorium for over 100 km, where it is seen to interfinger with, and eventually overlie the Narracoota Volcanics. Although this unit does not outcrop strongly, it does occur extensively under a thin veneer of colluvium on the pediments around Peak Hill and east of Mount Beasley.

Thaduna Greywacke is a thick turbidite sequence of graded beds of coarse- to fine-grained lithic, feldspathic and mafic wacke with subordinate interbedded slaty mudstone. It is invariably deeply weathered, exhibiting red, purple, black and chocolate colours. Individual wacke beds are generally of the order of 1 to 2 m thick, and contain a variety of sedimentary structures such as single and multiple-graded cycles, shale intraclasts, flute marks, load casts, convolute lamination and slump folds. Identifiable lithic fragments include altered basalt, jasper and ferruginous shale. Feldspar is abundant but invariably saussuritized and now albitic, but seems to have been predominately calcic plagioclase. Epidote, clinozoisite, fibrous amphibole and chlorite occur as aggregates after basalt clasts, or growths in the matrix. Greywacke from the immediate Thaduna area is predominantly from a basaltic derivation, but further to the east, alkali feldspar and quartz become important, indicating a mixed provenance from granite (or recycled arkose) as well as basalt.

In the lower few hundred metres of the Thaduna Greywacke, in the Wembley, Peak Hill and Horseshoe area, are a number of semi-continuous jasperoidal chert beds similar to that which marks the top of the Naracoota Volcanics in the same general area. These cherts contain diffuse breccia textures, and consist of medium- to fine-grained granoblastic polygonal quartz with abundant hematite dusting on grain boundaries; they are liberally peppered with euhedral magnetite. The immediate adjacent shaly rocks are often highly kaolinized. These beds are interpreted as exhalative cherts developed in the shaly sediments that provided the first cover of the volcanic pile.

The Thaduna Greywacke provides an extensive cover over the volcanics, and attains its greatest thickness where it takes the place of the volcanics and the Doolgunna Formation. It is interpreted as proximal turbidites marking a deep trough, marginal to a rapidly accumulating volcanic pile.

Horseshoe Formation

The Horseshoe Formation is a unit of carbonate-cemented subgreywacke, chloritic shale and banded iron-formation that occupies the Horseshoe Range.

The lowermost 300 m is an interbedded dark grey-green greywacke and chloritic shale, rhythmically interbedded on scales from centimetres up to one metre. A typical greywacke bed is graded in the lower part and laminated in the upper part. Rare fragments of chert, gneiss and sericitic shale occur. The subgreywacke is composed of about equal proportions of quartz, microcline and albite-oligoclase in single-crystal grains up to 2 mm in diameter. Detrital biotite and muscovite are present. The matrix contains fine chips of the above minerals, plus opaques, chlorite and sericite, with abundant carbonate cement. The interbeds are of laminated green shale consisting of fine quartz, biotite, chlorite and magnetite. Both greywacke and shale are stained by manganese dioxide. These rocks differ from the Thaduna Greywacke because of their finer bedding lamination, carbonate cement, and a modal composition which indicates derivation from granitic and metamorphic terrain, rather than mafic volcanics.

A prominent iron-formation member occurs in the middle of the unit. At Mount Beasley it is about 250 m thick and consists of three bands of iron-formation each about 40 m thick, intercalated with quartz-chlorite-magnetite shale. The iron-formation bands consist of alternating layers of chert-magnetite-stilpnomelane rock, chloritic shale, and chert, on a scale of 20 to 100 mm. Each layer also shows fine lamination at the millimetre scale.

Above the iron-formation is about 500 m of further calcareous, manganiferous shale and subgreywacke, which at Horseshoe Range is enriched at the surface in manganese and iron oxides.

The actual iron-formation member has a limited strike extent of 50 km, and the thinning-out zone is seen 25 km southeast of Mount Beasley where the main member thins to a number of iron-formation beds only a few centimetres in thickness. The Horseshoe Formation marks the filling of the deep trough, the cessation of volcanogenic sedimentation, and a transient period of quiet shallow-water sedimentation during which chemical sediments precipitated in isolated depressions.

Labouchere Formation

The sequence of quartz sandstone and sericitic quartz siltstone on the western side of the Horseshoe Range, correlates directly with the Labouchere Formation on ROBINSON RANGE as mapped by Barnett (1975) and redefined by Gee (1979). The lower 300 m consists of medium-grained, well-sorted quartz sandstone with sparse feldspar, in a siliceous cement. Individual beds range from 0.1 to 3 m in thickness, with low-angle trough cross-bedding and linguoid ripple marks.

Interbedded sericitic quartz siltstone and phyllitic shale, together with more argillaceous and micaceous quartz sandstone, appear higher in the sequence. Small linguoid ripples and planar megaripples occur within planar sandstone beds that range in thickness from 0.1 to 1.5 m. These features indicate that the Labouchere Formation was deposited on a stable marine shelf that was swept by sediment-dispersal currents.

PADBURY GROUP

The Padbury Group, as redefined by Gee (1979), is represented on PEAK HILL by the sequence of conglomerate, iron-formation and calcareous sediments that is tightly infolded into, but unconformably overlying, the Glengarry Group in the major synclines. Evidence for unconformity has been detailed by Gee(1978), which on PEAK HILL is indicated by scattered occurrences of conglomerate along a surface of stratigraphic and structural discordance.

The age of the Padbury Group lies between the age of Glengarry Group (1.8 Ma) and the last plutonic event in the eastern Gascoyne Province (1.5 Ma). It is possibly correlated with the Earaheedy Group on the basis of the common occurrence of granular iron-formation (Bunting and others, 1977).

Wilthorpe Conglomerate

Five localities of coarse conglomerate are mapped around the iron-formation hills that define the western end of the Robinson Syncline and the eastern arms of the Millidie Syncline. Isolated exposures of shallow-dipping conglomerate at 118°31′E, 25°32′S and 118°39′E, 25°42′S are seen to sit unconformably over steeply dipping Glengarry Group. At 118°32′E, 26°42′S, pebbly and boulder sandstones occur conformably below iron-formation, and at 118°50′E, 25°47′S, coarse boulder-scree fields are present immediately adjacent to iron-formation.

Clasts in these conglomerates range from a few centimetres up to 1 m in diameter, and consist predominantly of vein quartz, coarse iron-cemented sandstone, and fine-grained silica-cemented sandstone, of types that can be matched with parts of the Glengarry Group.

Best exposures of Wilthorpe Conglomerate occur on ROBINSON RANGE where it can be interpreted as a fluvial deposit, although the association with shale seen on PEAK HILL suggests that this unit records the position of large rivers that spread across a peneplain surface, over which shale, chert, and (eventually) terriginous muds were deposited.

Robinson Range Formation

This unit which has a total thickness of 1 000 m consists of a lower banded iron-formation and an upper granular cherty iron-formation separated by chloritic-sericitic-hematitic shale. The lower BIF is underlain by chert and green chlorite-hematite shale which, with upward passage, contains increasing numbers of laminated hematite-?magnetite-chert beds.

The granular iron-formation is characterized by: bun-shaped lenses of granular and oolitic chert, 10–20 mm thick; more continuous beds of the same thickness of red jasper; and beds of clastic ironstone up to 1 m thick. The ironstone beds contain spherical granules of chert (0.5 mm in diameter) and clasts (up to 10 mm in size) of fine-grained hematitic shale, green chloritic shale, chert, and specular hematite, plus larger fragments of jasper. Some of the thicker ironstone beds contain cross-bedding. All clasts have been derived from the immediate sedimentary environment. Bunting (1986) made a detailed petrographic study of similar iron-formations (possible correlates) in the Earaheedy Group. He concluded that they were deposited as chemical precipitates of iron oxide, iron silicates and oolitic chert on a stable marine shelf—the banded varieties signifying deeper water, and the granular varieties signifying a more shallow, wave-disturbed environment.

Millidie Formation

Exposure of this unit (the highest in the Padbury Group) is poor, being limited to iron- and manganese-stained shale and sandstone, with extensive development of calcrete presumably over dolomite. Considerable thicknesses of shale, dolomite and sandstone occur in the core of the Millidie Syncline on ROBINSON RANGE (Barnett, 1977).

EARAHEEDY GROUP

A sequence of conglomerate, sandstone, chert breccia and stromatolitic dolomite, which can be correlated with the Yelma Formation, extends into PEAK HILL from the main Earaheedy Sub-basin to the east. The Earaheedy Group is 1.7 Ga old (Bunting, 1986; Richards and Gee, 1986).

Evidence for basal unconformity

Doubt has previously been expressed (Goode, 1981), that the Glengarry and Earaheedy Groups are separate entities of different ages, as interpreted here. However, unconformable relations can be demonstrated in a number of localities around the area of onlap of Glengarry over Earaheedy Group. Two kilometres southeast of Freshwater Bore (119°59′E, 25°41′S) a poorly sorted, quartzose, feldspathic sandstone, with conglomerate lenses, overlies Finlayson

(Juderina) Sandstone with 90° of strike discordance. Clasts in the conglomerate are of felsic volcanics (from the Baumgarten greenstone belt), plus cream chert and quartzite. This is overlain by chert breccia and dolomite. Ten kilometres southeast of Baumgarten, similar but coarser conglomerate overlies schistose felsic-volcanogenic sediments of the greenstone belt. This conglomerate is the Yadgymurrin Conglomerate Member of the Yelma Formation (Bunting, 1986) and is especially significant because it contains boulders (up to 1 m diameter) of microbial-laminated and brecciated cream chert, red jasperoidal chert, and silica-cemented orthoquartzite, all of which can be matched with intervals in the Glengarry Group.

At 119°39′E, 25°40′S, a point 8 km south-southeast of Ord Well, some two metres of flat-lying brown-mottled (after carbonate cement) feldspathic sandstone overlies steeply dipping Johnson Cairn Shale, and is in turn overlain by microbial-laminated and ripple-laminated grey dolomite, and finally capped by chert breccia.

At 119°39′E, 25°48′S, beside the Doolgunna-Yerrida track, vertical Glengarry Group shale is unconformably overlain by crudely stratified, flat-lying chert breccia. Bedding in the chert breccia is defined by variations in granularity and accentuated by horizontal stylolites. The stylolites indicate the chert breccia is the remnant of an exhumed thick sedimentary sequence. At the actual contact the shale is silicified and slightly brecciated in a manner resembling fossil scree.

The regional distribution and disposition of all these rocks in the Lake Gregory area, which defines an open gently east-plunging syncline in contrast to the tight strongly west-plunging folds of the Glengarry Group, is sufficient evidence alone to establish an unconformity.

Facies of the Yelma Formation

Typically the Yelma Formation is composed predominantly of quartz sandstone with shale and dolomite. Bunting (1986) detailed its facies variations in the Earaheedy Sub-basin, and noted the proliferation of chert breccias in the western extent of its outcrop. A section from the Yelma Formation, deduced from available evidence on Peak Hill is postulated as follows:

	Thickness (approx.) m
TOP	
massive chert breccia and shale association	50
stromatolitic dolomite	10
bedded sandstone and chert-breccia association	20
feldspathic sandstone and conglomerate association	30
BASE	

The basal sandstone and conglomerate association has been described above in respect of the unconformity evidence.

The association of bedded sandstone and chert-breccia is well exposed at 119°46′E, 25°39′S, southwest of Lake Gregory. The clearly recognizable sandstone beds contain scattered pebbles of chert and show trough cross-bedding. Portions of beds are totally replaced by quartz cement to give a cherty appearance and in these patches are developed bedding-parallel stylolites. Poorly stratified chert-breccia beds are clearly interbedded with the sandstone.

These breccias contain abundant angular slabby fragments of cherts, silicifed shale and silicified sandstone, closely packed to resemble fossil scree. Colloform vughy growths, filled with sparry quartz, occur interstitially to the slabs and as irregular patches in the shale. These silicified rocks probably were an interbedded sequence of carbonate-cemented sandstone and intraformational carbonate or chert-clast stones that were deposited on a bank of shallow-marine carbonate, sand and evaporites. The bank was subject to subaerial exposure, desiccation and replacement by silica.

The carbonates are grey-blue, wavy-laminated, micritic, calcitic dolomite, with abundant bioherms of conical, columnar and domical stromatolites. In the prolific bioherms in the dolomite outcrops in the vicinity of Combine Well, Grey (1984) identified *Yelma digitata* Grey and *Ephyaltes* form indet. Grey. *Pilbaria deverella* Walter is also present (Grey, in prep.). *P. deverella* and *Y. digitata* characterize the Sweetwaters Dolomite Member of the Yelma Formation to the east (Grey, 1984).

The association of massive chert-breccia and shale occurs in the centre of the open syncline, just west of Lake Gregory. Best profiles occur in the creek embankment at 119°50′E, 25°36′S, where two types of breccia are seen. One type is a brecciation *in situ* of laminated shale, in which is seen all stages in the production of a disoriented flake breccia, with a coarse cherty matrix plus abundant quartz spar. The other type is an extremely poorly sorted, unstratified, matrix-supported breccia of mixed-clast type including shale, silicified sandstone, sparry chert and dolomite. Huge blocks of chert up to 10 m in size are present. The origin of this massive breccia unit is uncertain, but it is suggested it may be scree breccia in a shallow-marine shelf supersaturated in silica. These rocks require further study, but one important point to emerge to date is that the chert breccias are not Cainozoic silcrete, but Proterozoic sedimentary units of curious sedimentological significance.

MOUNT LEAKE SANDSTONE

Gently dipping beds of clean quartz sandstone occur in a line of exposures from Bilyuin to Mount Leake, and these clearly unconformably overlie the steeply inclined Glengarry Group. It is predominantly a fine-grained, well-sorted, well-rounded, quartz sandstone commonly containing small rounded glauconite. It abounds in medium-scale trough cross-bedding. Its maximum thickness is of the order of 20 m.

Cream-coloured cherty pods up to 1 m thick occur discontinuously along the unconformity, in small depressions on what otherwise is a flat smooth surface. The basal 10 cm in one such pod, at Mount Leake, is a wrinkled laminated chert with well-defined stromatolite columns.

Lithological similarity with the Yelma Formation invites correlation. However, correlation with the Padbury Group is unlikely in view of the steep dips in the Robinson Syncline only 5 km to the northwest. It most probably is a remnant of a sequence younger than the Earaheedy and Padbury Groups. Horwitz (1976) reported a K-Ar date of 1573 Ma from glauconite from Mount Leake Sandstone near Bilyuin.

BANGEMALL BASIN

BANGEMALL GROUP

The southern margin of the eastern facies (Collier Subgroup) of the Bangemall Group covers the northern third of PEAK HILL. Lithostratigraphic terminology follows that of Muhling and Brakel (1985) who present comprehensive descriptions of the units and integrate them into a model of basin evolution. Only brief lithological summaries are given here.

Wonyulgunna Sandstone

This unit unconformably overlies the granites of the Marymia Dome in the far northeastern part of the sheet, and joins with the main area of Wonyulgunna Formation on COLLIER and BULLEN. It is a unit, 800 m thick, of coarse-grained, moderately sorted, thickly bedded, quartz sandstone. Its basal beds are commonly pebbly, and thin chert beds occur low in the sandstone. It is uncertain from evidence on PEAK HILL how this unit relates to the other formations, but Muhling and Brakel (1985) note that it is overlain by the Backdoor Formation.

Backdoor Formation

Unconformable contacts of Backdoor Formation against pre-Bangemall rocks are preserved at two localities. Three kilometres east of the Great Northern Highway at 119°21′E, 25°13′S, a brecciated and recrystallized white laminated chert some 3 m thick rests on granite, and is overlain by about 50 m of siliceous shale followed by an interval (5 m thick) of streaky, textured black chert with undulatory bedding. Three kilometres east-northeast of Horseshoe Lights mine is a similar, recrystallized, white, brecciated chert resting unconformably on dolerite and ultramafic phyllite of the Glengarry Group. Elsewhere the contact is faulted.

Predominantly, the Backdoor Formation consists of interbedded varicoloured (grey, yellow, brown, buff, maroon) shale and fine-grained siliceous sandstone. A substantial thickness of dolomite, with current and probable microbial laminations, occurs in the structural domal area 20 km northeast of Bryah homestead.

Calyie Sandstone

The Calyie Sandstone is a thick (100 m) sheet of thickly bedded, massive, well-sorted, medium-grained, quartz sandstone that forms all the prominent ridges. Sandstone beds commonly have shale intraclasts, and large-scale megaripple-type cross-bedding. It characteristically forms a double topographic ridge due to a more friable poorly cemented middle interval.

Ilgarari Formation

This unit is restricted to synclinal areas, where it is poorly outcropping and usually highly oxidized. It consists of dark-green and brown shale, interbedded with micaceous siltstone, and manganese-stained fine-grained glauconitic quartz sandstone.

STRUCTURAL DEVELOPMENT

STRUCTURES OF THE GLENGARRY FOLD BELT

The term Stanley Fold Belt was applied by Hall and Goode (1978) for the entire zone of folding in what was then referred to as the "Nabberu Basin." Bunting (1986) documented this fold belt with emphasis on structures in the eastern Earaheedy Sub-basin. With the clear recognition that the eastern and western parts of this so-called sub-basin are stratigraphically and structurally different, it is appropriate to designate the folded supracrustal sequences in the western Nabberu Province as the Glengarry Fold Belt.

A complex sinuous synclinorial trace lying between the Marymia and Goodin Domes dominates the structure of the Glengarry Fold Belt on PEAK HILL. This structure owes its complexity to two periods of tight regional folding and a history of faulting involving normal faults, reverse faults, wrench faults and possibly early thrusts. All of these structures are related to basement control, and are focussed more-or-less coaxially into the region between the two basement domes.

The simplest and latest folds are those synclines, clearly outlined by the Padbury Group iron-formations. These folds are characterized by amoeboid (*e.g.* the Millidie Syncline) and arcuate (*e.g.* Robinson Syncline) shapes, steep dips, upright axial surfaces, and steeply plunging fold axes. The Robinson Syncline, for example, is canoe-shaped, and minor folds at each end plunge centrally back into the axial plane at about 70°. An axial-plane fracture cleavage is developed in the iron-formation and a slaty cleavage in the shaly rocks. This cleavage relates to the transposition (crenulation) foliation in the phyllitic rocks underneath.

Several arcuate co-planar fold traces, aligned parallel to the main synclinorial trace in the western part of the area, are mostly second-generation fold structures. However, the regional outcrop patterns of the Narracoota Volcanics in the area south of Peak Hill (domes, lobes and incongruent vergences) indicate the presence of early folds. For example, the western curve of the lobate structure, 11 km southwest of Peak Hill, is a downward-facing syncline (*i.e.* a synformal anticline), but the mushroom-shaped lobe itself, on stratigraphic evidence, is anticlinal. Similarly, the curvature on the neck of this lobe (8 km south-southwest of Peak Hill) is an antiformal syncline. Minor folds in the cherty exhalative bed that lies between the volcanics (stratigraphically below) and greywacke, have highly variable axes dispersed in the regional axial plane (approximately 300/80°S), and have earlier stretching lineations bent around the axes.

Further north, over the important east-west fault, regional folds outlined by the Horseshoe Formation are polyclinal and plunge steeply (about 60°) west. An earlier tight anticline and complementary synclinal is present in the underlying greywacke. These folds are revealed by the cherty beds within, and at the base of, the Thaduna Greywacke, and would have had initially a recumbent attitude.

On the southern margin of the Marymia Dome, west of Noonyereena Hill, the basal bed of the Juderina Formation contains zones of very high strain. In places (*e.g.* at 119°05′E, 25°34′S) the quartzite has a mylonitic fabric with abundant minor intrafolial isoclines, with variable axial plunge and a strong stretching lineation that is generally down-dip.

The northeastern extent of the synclinorium is terminated by a regional southwest-plunging syncline that has many minor folds and simple slaty axial-plane cleavage. Structural complications appear in this syncline to the west of "Neds Creek," where the stratigraphy is much thinner on the northern limb than on the southern limb. This discrepancy cannot be explained by asymmetry of the syncline, as both the northern limb and the unconformity are moderately southerly dipping, and again may be taken as evidence of early thrusting. The trace of this regional syncline is split by an anticline coming off the Goodin Dome, and the southern branch forms a major synclinal zone flanking the eastern side of the Goodin Dome.

Several styles of faults are present. Around the Goodin Dome, the base of the Glengarry Group is cut by abundant high-angle faults, most of which do not penetrate high in the sequence. These are interpreted as early normal (horst-and-graben) faults related to early stretching of the basin, and in some instances seem to be reactivated by a later east-west dextral wrench faulting. This style of deformation of the Goodin Dome contrasts with the more ductile behaviour of the Marymia Dome. A number of dislocations subparallel to bedding and fold trends, are interpreted as high-angle thrusts which have moved north-side-up.

In summary, the structural sequence in the Glengarry Fold Belt is interpreted as follows: an early period of basin and basement stretching; initial rise of both basement domes with more pronounced effects of the Marymia Dome producing tight and possibly recumbent folds; erosion and deposition of the Padbury Group; and reactivation of the Marymia Dome with upward and southward movement, causing folding of the supracrustal sequence and high-angle thrusting from the northwest.

STRUCTURES OF THE BANGEMALL GROUP

Bangemall Group rocks in the northwest corner of PEAK HILL are buckled by gently plunging, open-style folds with arcuate axial traces that swing from easterly to northeasterly. This style and orientation of folding is indicative of the eastern end of the rectilinearly folded Edmund Fold Belt, where it interacts with the open amoeboid folds of the Bullen Platform (Muhling and Brakel, 1980). The arcuate nature of the fold traces also parallels the northern margin of the Marymia Dome.

Dips of bedding in the folds seldom exceed 30°, cleavage is generally absent, and the two main anticlines present show slight asymmetry indicating overfolding from the north. All the regional folds plunge gently toward a structural depression in the "Three Rivers" area. Some of the seemingly complex outcrop patterns are the result of faulted saddles and domes.

Both regional anticlines are cut by major faults, whose presence is revealed by mismatches in the reconstructed stratigraphy. These faults are also arcuate, parallel to the fold traces, and have the appearance of break thrusts dipping at an undetermined angle to the north, and with a dextral transcurrent component. The major fault just north of Horseshoe Lights, which brings Bangemall and Glengarry rocks into contact, could also have a dextral component.

The unconformity is cut by northeast-trending thrusts and some late northwest-trending dextral off-sets. In general the unconformity is intact over most of its length, however, running parallel to the Marymia Dome is an arcuate fault which has the characters of a post-folding normal fault of unknown dip, with a downthrow to the north. The overall structural history of this part of the Bangemall Basin is interpreted as a southeasterly directed folding movement toward the Marymia Dome, followed by a fault-bounded rise of the dome.

ECONOMIC GEOLOGY

GOLD

After Telfer, the Peak Hill mining centre is the second most important Proterozoic goldfield in the State, having produced in excess of 10 000 kg. MacLeod (1970) gives some precise production figures up till 1967 for various deposits. However, because of uncertainty over locations and names of producing centres, individual production figures may have little meaning. After checking old survey records, and locating old mines on the ground, it is now believed that the individual occurrences are accurately located and named on the new map.

The biggest single historical producer is Peak Hill itself which produced over 8 200 kg, from its discovery in 1892 up until the period of dormancy in the 1970s. Since the gold revival in the early 1980s, all known occurrences have again become active to varying extents, although only Horseshoe Lights has become a major mine. MacLeod (1970) records that Horseshoe Lights produced 760 kg from an average ore grade of 6.2 g/t, from 1952 to its closure in 1954, because of "exhaustion of economically mineable ore".

Regional controls of gold mineralization appear to be stratigraphic; lithological and structural control seems important only at the local scale. Horseshoe Lights, the western Peak Hill group, Wembley, Heines Find, Mikhaburra, Cashman, and Ruby Well all lie at or close to the top of the Narracoota Volcanics. In this type of deposit, some mineralization is clearly in quartz veins, however, at least at Mikhaburra and Horseshoe Lights, the host rocks are cherty sediments. These deposits could be volcanic exhalative, and the main characteristics of Horseshoe Lights suggesting this origin, are summarized below.

The Horseshoe Lights orebody lies immediately above an extensive fragmental- and colloform-textured chalcedonic bed which caps the basalts. Small isolated phases of felsic volcanics also occur at the level just below the cherty rock. The orebody lies on the western limb of a complexly faulted, south-plunging coupled anticline-syncline structure. The material above the cherty layer, which hosts the orebody is essentially a quartz-sericite-limonite schist of uncertain and probably varied origin. The variations include laminated and crenulated phyllitic siltstone, breccia with sheared porphyroclasts of vein quartz, blastomylonitic fine-grained quartz-mosaic schist, and single-crystal "quartz-eye" schist. Some tuffaceous component is possible. The gold occurs in steeply south-plunging *en echelon* lenses of highly ferruginous material, which may be folded repetitions of lenses in the one stratigraphic level, or stacked stratigraphic lenses. The ore occurs in the oxidized zone, and its original nature is not at present apparent. It is suggested that the ferruginous bodies represent massive pyrite lenses containing disseminated gold and chalcopyrite. Pervasive potassic alteration can also be inferred from the abundance of sericite. The operating company, Barrack Mines Ltd, has a current mill capacity of 400 000 tonnes per year and in June 1986 announced reserves of 836 760 tonnes of 6.43 g/t.

A second major type of gold deposit in the region is characterized by quartz-vein networks in arenaceous sediments, exemplified by Peak Hill, St Crispin, Hit or Miss, Goodin Find, and possibly the primary deposits at Horseshoe. If the favoured correlation of the Peak Hill Metamorphics and the Doolgunna Formation is correct, then all of these deposits, with the exception of Horseshoe, would occur in the same stratigraphic unit of thick arkosic sandstones. Although, again, much of the mineralization is clearly in quartz veins, its exact primary nature is not known, and a palaeoplacer origin cannot be ruled out. Features of the Peak Hill deposit suggesting local stratigraphic control are described below.

The Peak Hill gold deposit lies stratigraphically just below a broad antiformal culmination of the distinctive marker quartzite in the Peak Hill Metamorphics. The west-dipping and possibly west-facing sequence in the mine area consists of: chlorite-biotite-carbonate-amphibole schist (?metamorphosed marl), underlain by the cherty quartzite; an upper lode zone of carbonaceous pyritic chloritic schist; a further band of metamorphosed marl; a lower lode zone of pyritic carbonaceous schist; and then the thick unit of quartz-muscovite-albite schist (?meta-arkose) characteristic of the regional metamorphics in the area. The old open cut was developed in oxidized supergene ore on the two lode zones, and the four levels of the old underground mine developed the lodes to a depth of 130 m. The gold mineralization is reputed to occur preferentially in quartz veins within the carbonaceous lodes, and in the lodes themselves. Carbon-in-pulp treatment of the tailings dump at Peak Hill (Geopeko–Grants Patch Joint Venture) has produced 323 kg of gold during 1983-1986.

The Peak Hill goldfield has also produced significant amounts of eluvial nugget gold. The Horseshoe deposit has produced all its gold from the sheetwash colluvium that comes off the lower Horseshoe Formation. Nugget gold has also come from the colluvium and hardpan, surrounding the main Peak Hill deposit and Goodin Find.

COPPER

Thaduna Mining Area has been a major producer of cupreous (*i.e.* fertilizer additive) ore in the State, having produced nearly 40 000 tonnes averaging 8.3%, between 1942 and 1971. Marston (1979) gives detailed descriptions of the five individual occurrences that comprise the group, all of which are located over northwest-trending shear zones that cut the tightly folded Thaduna Greywacke at a high angle. Only the largest, the actual Thaduna deposit, described in detail by Blockley (1968), need be outlined here. The primary mineralized zone is an anastomosing quartz-filled vertical fault zone, some 600 m long, that carried about 1% copper as chalcopyrite together with minor pyrite. These quartz bodies have selvages of graphitic material and bordering alteration zones of chlorite plus calcite. A rich supergene zone developed over the primary zone during the period of extensive lateritization. This secondary zone has a depth zonation of chrysocolla-malachite-cuprite-chalcocite down to a depth of more then 50 m. All production has come from this oxidized zone. Despite extensive exploration, particularly in the greywackes to the east towards the known outcrops of Narracoota Volcanics, no further copper occurrences have been found. This type of vein copper is not an attractive exploration target, however, the chances of stratiform copper in the stratigraphically underlying carbonate-chert-sandstone-shale sequence remains a possibility, which seems not to have been adequately tested.

Minor production of cupreous ore has come from in and around Horseshoe Lights and Cashman. At Horseshoe Lights, Marston (1979) records intermittent production (1946-1950) from the then dormant gold workings. Up to 1% Cu, as disseminated chalcopyrite, was encountered in drilling the unoxidized zone below the old pits. However, recent drilling associated with current ore-reserves drilling has encountered some high copper values. The occurrence of copper-stained gossanous material (Motter B) in sheared metamorphosed felsic agglomerate, 4 km southeast of the mine, is probably the minor producer noted by Low (1963, p 116).

A quartz-limonite-chrysocolla-malachite vein occurs in the Narracoota Volcanics, 200 m east of the Cashman gold workings. Considerable exploration within the basalts, apparently using Keeweenawan copper models has failed to find any additional copper prospects.

MANGANESE

The Horseshoe manganese field was a major State producer of metallurgical ore in the period 1948 to 1969, when some 491 322 tonnes were produced. The ore was relatively low grade, in the 35–40% Mn range, and 15–20% Fe range. The main producing deposit is Horseshoe, 2 km south of Mount Beasley, and numerous other smaller deposits occur in the area west of Ravelstone.

MacLeod (1970) considered the manganese to be bog deposits in infillings of old drainage lines or fossil swamps on the old plateau surface. The deposits do occur as discontinuous lenses on the lateritized weathering surface but seem not to be related to any recognizable palaeodrainage systems; rather, they are clearly related to the Horseshoe Formation as a stratigraphic unit. It is significant that all deposits occur over dark-coloured chloritic calcareous siltstone and shale, which contain abundant dustings of manganese oxide. No mineralogical or chemical work has been done on these rocks because of the difficulty of obtaining fresh material, however, it is likely that they contain primary (*i.e.* sedimentary) manganese oxides and carbonates, and that the manganese deposits are a lateritic enrichment of the rocks. Reserves of these deposits are generally regarded as being depleted, however, because of the evident stratigraphic control, there must be potential for large-tonnage low-grade resources of this strategic metal.

IRON ORE

Sofoulis (1970) identified 200 small patches of iron ore overlying the iron-formation units of the Robinson Range Formation around the rims of the Millidie and Robinson Synclines. These occur as thin crusts of hematite and goethite, and assuming a thickness of 15 metres, would aggregate to a resource of only some 24 million tonnes in the range of 50-65% Fe. Although the area has been held under Temporary Reserve for iron ore, no drilling has been undertaken and the grades below the surface crusts are unknown, but judging on exploration results from the similar cherty peloidal iron formations in the Earaheedy Group (Bunting, 1986; p 91) subeconomic grades would be expected. These deposits in no way compare with resources in the Hamersley Iron Province, and unless they can be shown to have special characteristics, they are of little value as future resources.

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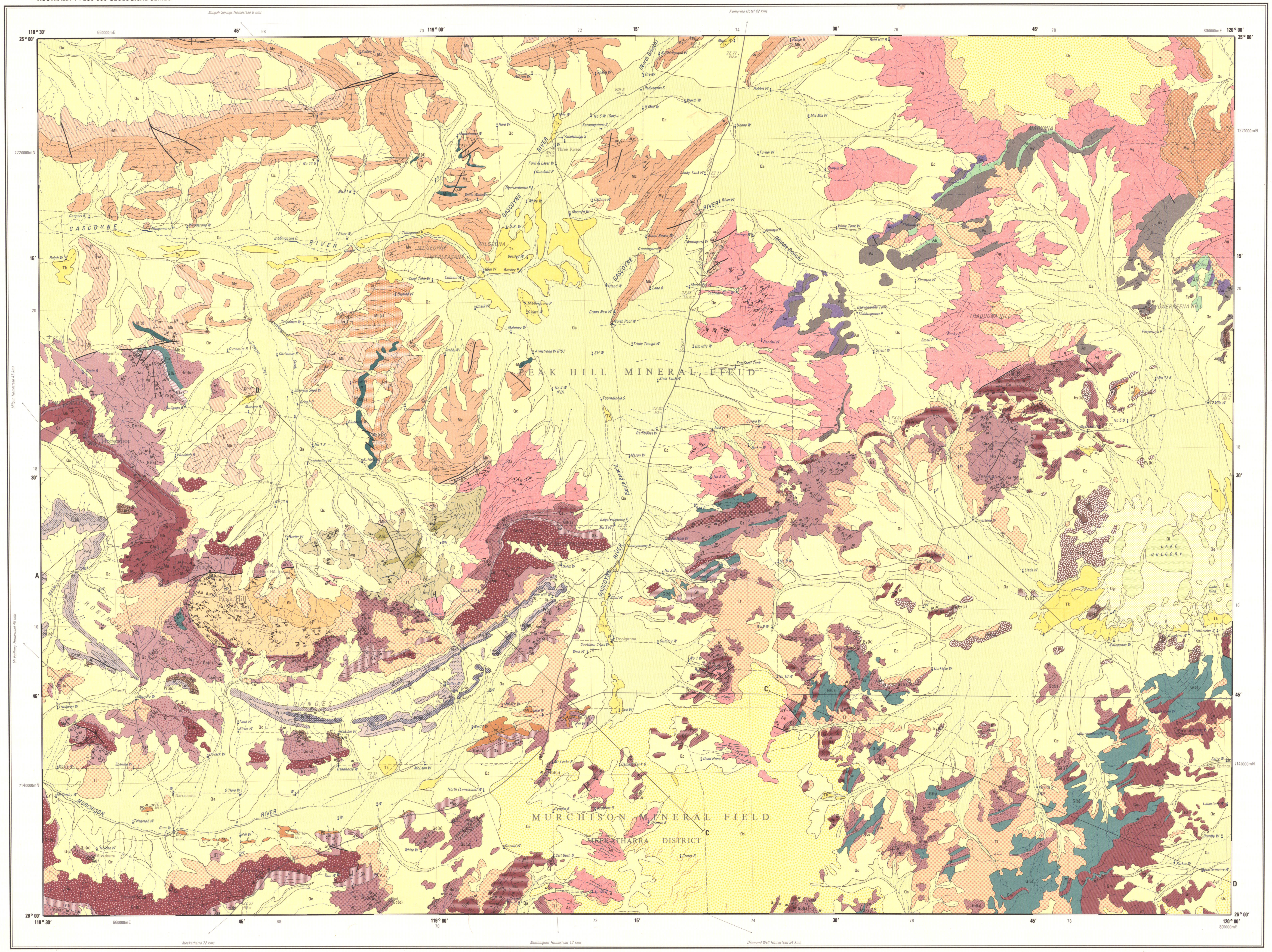
PEAK HILL

AUSTRALIA 1 : 250 000 GEOLOGICAL SERIES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET SG 50- 8



SYMBOLS

Geological boundary
Fault
Trace of regional folds
anticline
syncline
Minor fold axis
Bedding
inclined
horizontal
overturned
trend, lithological
Slaty cleavage
inclined
vertical
Crenulation cleavage
Gneissic and schistose foliation in metamorphic rocks, inclined
Lineation
Stromatolite locality
Mineral field boundary
Highway with national route marker
Formed road
Track
Telegraph line
Townsite, less than 1000
Homestead
Building
Locality
Landing ground
Horizontal control, minor
Vertical control, height accurate
Sand dunes
Watercourse, intermittent
Pool
Windpump on Well or Bore
Well
Bore
Waterhole
Rockhole
Spring
Position doubtful
Mining centre
Mine, not working
Prospect
Mineral occurrence
Copper
Gold
Manganese

INDEX TO ADJOINING SHEETS

EDMUND SF 50 - 14	TUREE CREEK SF 50 - 15	NEWMAN SF 50 - 16	ROBERTSON SF 51 - 13	GUNANYA SF 51 - 14
MT PHILLIPS SG 50 - 2	MT EGERTON SG 50 - 3	COLLIER SG 50 - 4	BULLEN SG 51 - 1	TRAINOR SG 51 - 2
GLENBURGH SG 50 - 6	ROBINSON RANGE SG 50 - 7	PEAK HILL SG 50 - 8	NABBERU SG 51 - 5	STANLEY SG 51 - 6
BYRO SG 50 - 10	BELELE SG 50 - 11	GLENGARRY SG 50 - 12	WILUNA SG 51 - 9	KINGSTON SG 51 - 10 (+ 1° 30′)
MURGOO SG 50 - 14 (− 1°)	CUE SG 50 - 15 (− 30′)	SANDSTONE SG 50 - 16 (0)	SIR SAMUEL SG 51 - 13 (+ 30′)	DUKETON SG 51 - 14 (+ 1°)

The lines indicate magnetic declination, 1980
+ means declination is east and correction must be added to compass bearing to give true bearing
− means declination is west and correction must be subtracted from compass bearing to give true bearing
Annual change is −1′ westerly

Geology by R.D. Gee 1977-81

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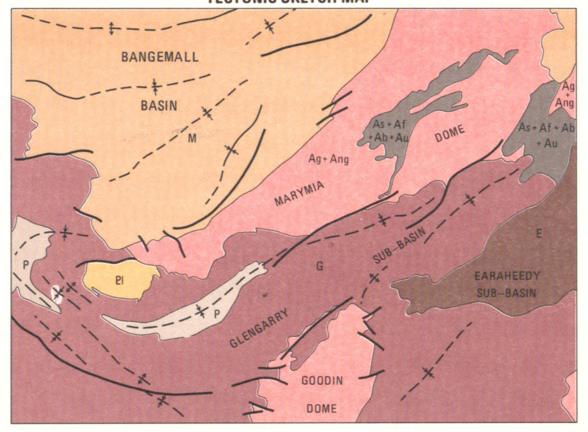
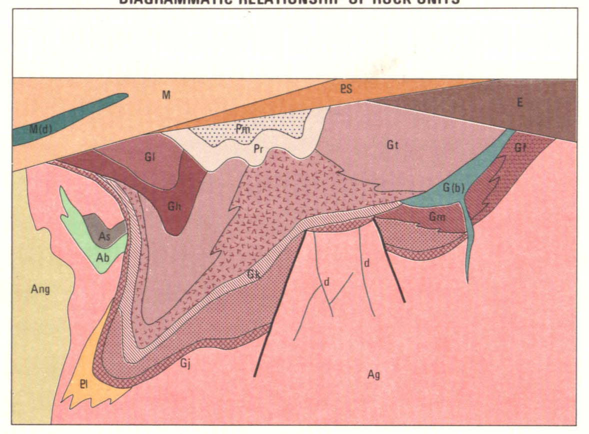
TECTONIC SKETCH MAP



SCALE 1 : 250 000

TRANSVERSE MERCATOR PROJECTION
ZONE 50 AUSTRALIAN MAP GRID

DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS



REFERENCE

QUATERNARY

Ql	Saline silt and mud on salt lakes
Qg	Gypsiferous and calcareous sand in dunes peripheral to salt lakes
Qa	Alluvial sand and silt in drainages
Qc	Colluvial gravel on scree slopes and sheet wash plains
Qs	Reddish eolian sand

TERTIARY

Tk	Calcrete
Tl	Laterite

PROTEROZOIC

Bangemall Group (M)

M(d)	Dolerite sills in Bangemall Group
Mz	**ILGARARI FORMATION** : manganese-stained sandstone, siltstone and mudstone
My	**CALYIE FORMATION** : well-bedded, clean quartz sandstone
Mb	**BACKDOOR FORMATION** : shale and black laminated chert
Mb(c)	Dolomite
Mb(b)	Chert breccia
Mw	**WONYULGUNNA SANDSTONE** : thickly bedded quartz sandstone

ĒS	**MOUNT LEAKE SANDSTONE** : cross-bedded quartz sandstone, with minor glauconite, and basal silicified stromatolitic carbonate

Padbury Group (P)

Pm	**MILLIDIE CREEK FORMATION** : impure sandstone, siltstone and shale; minor carbonate and granular iron-formation
Pr(g)	**ROBINSON RANGE FORMATION** : granular iron-formation
Pr(s)	Sericitic ferruginous shale
Pr(ib)	Banded iron-formation
Pw	**WILTHORPE CONGLOMERATE** : conglomerate with sandstone matrix

Earaheedy Group (E)

Ey	**YELMA FORMATION** : quartz sandstone
Ey(c)	Stromatolitic dolomite
Ey(b)	Chert breccia
Ey(o)	Conglomerate

Glengarry Group (G)

G(b)	Dolerite sills in Glengarry Group
G(s)	Quartz sandstone and siltstone
G(x)	Quartz-muscovite-chlorite schist after felsic tuff and agglomerate
Gl	**LABOUCHERE FORMATION** : quartz sandstone and sericitic siltstone in an upward fining sequence
Gh	**HORSESHOE FORMATION** : sub-greywacke, manganiferous shale and siltstone
Gh(i)	Iron-formation member
Gt	**THADUNA GREYWACKE** : lithic and feldspathic greywacke turbidite
Gt(q)	Prominent chert-hematite jasper bed
Gn(u)	**NARRACOOTA VOLCANICS** : Ultramafic lava and tuff; now mostly chlorite-tremolite-talc phyllite
Gn(q)	Prominent jasper bed
Gn(b)	Tholeiitic basalt
Gk	**KARALUNDI FORMATION** : ferruginous shale and siltstone; iron-cemented gritty sandstone, dolomite, chert, basaltic tuff
Gd(a)	**DOOLGUNNA FORMATION** : arkose
Gd(o)	Conglomerate
Gd(s)	Feldspathic and quartz sandstone; granule conglomerate
Ga	**JOHNSON CAIRN SHALE** : varicoloured shale, with pisolitic magnesite and dolomite beds; minor greywacke
Gj	**JUDERINA FORMATION** : cross-bedded and ripple-marked; fine-grained flaggy mature sandstone; and sericitic siltstone
Gc	**CRISPIN CONGLOMERATE** : boulder conglomerate in sandstone matrix
Gm	**MARALOOU FORMATION** : shale and minor dolomite
Gf	**FINLAYSON SANDSTONE** : thickly bedded, mature sandstone

Stratigraphic relationship to main Glengarry Group sequence is uncertain

Peak Hill Metamorphics (Ēl)

Ēlm	Quartz-muscovite-albite-magnetite schist
Ēls	Muscovite schist
Ēq	Quartzite

d	Dolerite dyke
q	Quartz vein

ARCHAEAN

As	Pelitic metasedimentary rocks, quartzite, banded iron-formation
Af	Felsic agglomerate; lapilli tuff
Au	Chlorite-tremolite schist after ultramafic volcanics
Ab	Metamorphosed tholeiitic basalt

Ag	Biotite adamellite
Ang	Granodiorite gneiss
Ai	Quartz-magnetite-amphibole rock; metamorphosed banded iron-formation
Anc	Calc-silicate gneiss and amphibolite

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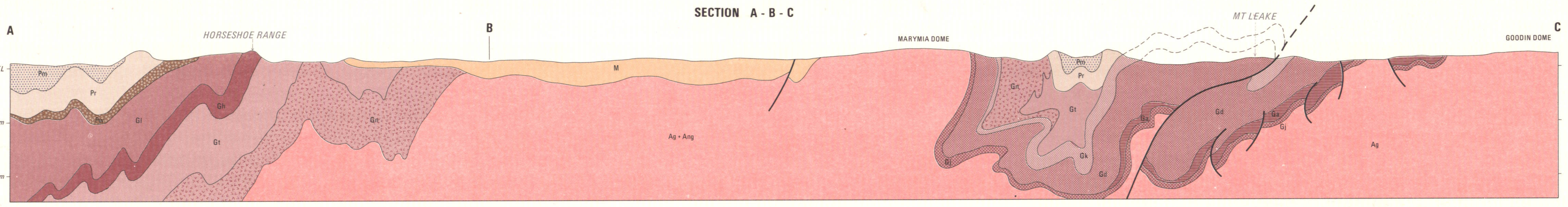
PEAK HILL
SHEET SG 50- 8

SECOND EDITION 1985

DIAGRAMMATIC SECTIONS

NATURAL SCALE

SECTION A - B - C



SECTION C′ - D