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THE GEOLOGY OF THE PEAK HILL AREA

by R. D. Gee

ABSTRACT

A thick geosynclinal sequence of arkose, conglomerate, basalt, greywacke, sandstone and shale, possibly as much as 20 km thick, occurs in the Glengarry Sub-basin of the Nabberu Basin. This sequence is called the Glengarry Group, and eight of its constituent formations are defined and described. It is probably 2.0-1.8 b.y. old. A shallow-water clastic facies, a thick volcanic pile, and a deep turbidite trough are identified.

This sequence is unconformably overlain by the Padbury Group (probably 1.7-1.6 b.y. old), which is a chemogenic sequence with a coarse basal conglomerate called the Wilthorpe Conglomerate. The Wilthorpe Conglomerate was the coarse conglomeratic part of the Labouchere Formation as originally defined. The Labouchere Formation was previously assigned to the Padbury Group, but the revised formation is now placed in the Glengarry Group.

Metamorphosed sedimentary rocks in the vicinity of Peak Hill townsite are called the Peak Hill Metamorphic Suite, and are unconformable beneath the Glengarry Group. These metamorphics form a mantle of the Marymia Dome, which has a core of reworked Archaean basement. In the Glengarry Sub-basin, deformation is by crumpling between basement domes.

Regional correlations suggest that the Glengarry Group forms part of an ensialic geosyncline, now largely covered by the Bangemall Group, between the Hamersley Basin and the Yilgarn Block.

INTRODUCTION

Two main problems outlined by Bunting and others (1977) in their preliminary synthesis of the Proterozic stratigraphy and structure along the northern margin of the Yilgarn Block were the relationship of the Padbury Group to the older rocks of the Glengarry Sub-basin, and the stratigraphic relationships within that older sequence. In an attempt to clarify these problems, the area surrounding Peak Hill has been re-mapped, and the Proterozoic stratigraphy in the eastern part of Robinson Range Sheet has been re-examined. This paper summarizes this reappraisal, and establishes a stratigraphic framework which should serve as the basis for continuing studies in the western part of the Nabberu Basin.

EVOLUTION OF STRATIGRAPHIC CONCEPTS

MacLeod (1970) erected the first stratigraphy for the area when he introduced the terms "Peak Hill, Horseshoe, Labouchere and Robinson Range Beds". Although recognizing the possibility of a Proterozoic age, he opted for an Archaean age. During mapping of the Robinson Range Sheet, Barnett (1975) identified this entire succession as having the overall features of a Proterozoic basin. He formalized some of the stratigraphic units, and included them in the Padbury Group, which was defined to include only those units which formed a continuous sequence.

Subsequently, evidence emerged for the existence of a thick sequence older than the Padbury Group, which until its stratigraphy could be clarified, was termed the "pre-Padbury" by Elias and Williams 1977, Williams and others 1978, and the "Glengarry axial sequence" by Bunting and others (1977). The most compelling evidence at that stage was the exposed unconformity between conglomerate assigned to the Labouchere Formation and granitoid of the Yarlarweelor Gneiss Belt. Williams and others (1978) also pointed out that the "pre-Padbury" displayed a more complex structure and a higher grade of metamorphism than the Padbury Group.

During selective remapping on the Peak Hill sheet, it became evident that an unconformity lay *within* rocks assigned to the Labouchere Formation, and as the type section of the Labouchere Formation falls within the "pre-Padbury", some terminological revision is now necessary.

PROTEROZOIC STRATIGRAPHY

EARLY PROTEROZOIC METASEDIMENTARY INLIERS

Peak Hill Metamorphic Suite

This is the metasedimentary sequence in the area within a 7 km radius of the Peak Hill townsite. It occurs unconformably below the Glengarry Group, and does not display the high metamorphic grades and the advanced gneissic fabrics of the Archaean parts of the Marymia Dome. The suite corresponds more-or-less to the "Peak Hill Beds" of MacLeod (1970). It represents a sequence of terrigenous clastics, chert and carbonate, which have been repeatedly deformed and metamorphosed to upper greenschist facies. Its age is uncertain, but is presumed to represent Early Proterozoic sedimentation, tectonism, and metamorphism.

The western part of the exposed area is quartz-muscovite-magnetite schist, interlayered with flaggy quartzite. The quartzite is fine grained, has lepidoblastic texture (elongate quartz in a metamorphic mosaic), and contains minor amounts of potash feldspar, biotite, and muscovite. Lamination is defined by grain-size variations on a millimetre scale, and by stylolitic carbonaceous stringers. No evidence of cross-bedding is evident. A distinctive feature is the presence of moulds of a fibrous lenticular mineral having a radiating habit similar to gypsum (selenite). These features suggest that the quartzite is metamorphosed chert.

Calc-silicate schist and granofels contain albite, calcite, epidote and quartz in a granoblastic mosaic. Biotite and chlorite impart a foliation. Poikiloblastic garnet and magnetite are also present. These rocks are metamorphosed calcareous siltstones, and indicate upper greenschist facies.

The eastern part of the Peak Hill Metamorphic Suite is more homogeneous than the western part, and is not so obviously metasedimentary. Mostly the rocks are retrogressed and granulated quartz-muscovite-plagioclase-sericite gneiss, some of which is banded paragneiss and some of which is probably sheared granitoid. Porphyritic adamellite occurs 15 km east of Peak Hill townsite, but its relationship to the metasedimentary sequence, whether intrusive or unconformable, is unknown.

Sequence at Horseshoe Lights

Stratigraphically below the Thaduna Greywacke at Horseshoe Lights is a sequence that does not fit conveniently into the regional stratigraphy. The rocks here are quartzite, quartz-muscovite-sericite schist, garnetiferous felsic agglomerate and lapilli tuff of mafic composition. The fabric in the pelitic schist demonstrates repeated deformation, and together with the metamorphic grade suggests that the pelites and volcanics correlate with the Peak Hill Metamorphic Suite.

It is possible that the quartzite at the Horseshoe Lights Mine is equivalent to the base of the Glengarry Group, and that the overlying arkose and greywacke are the Doolgunna Arkose and Thaduna Greywacke respectively. There is certainly a contrast in deformation and fabric on either side of the quartzite; and an unconformity is inferred,

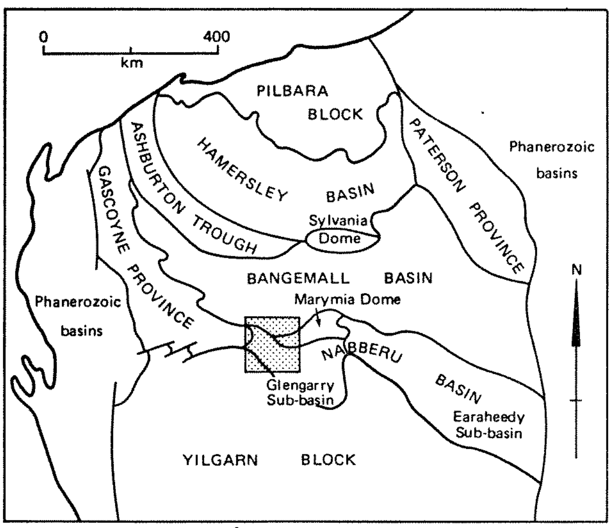

Figure 33 Location diagram showing relation of area to tectonic units in the northern part of the Western Australian Shield.

although there is no direct evidence of this. Nevertheless, this is the interpretation placed on Figure 33, but the metamorphic rocks are not specifically assigned to the Peak Hill Metamorphic Suite.

GLENGARRY GROUP

Definition

The Glengarry Group is a newly defined group, of greywacke, terriginous clastics, carbonate and volcanics that unconformably overlies Archaean basement, and is unconformably overlain by the Padbury Group in the Glengarry Sub-basin. It includes what has been informally termed the "Axial Sequence" and "pre-Padbury" by previous writers, and also includes most of what has previously been termed the Labouchere Formation.

Basal formations of the Glengarry Group

The base of the Glengarry Group is exposed more or less continuously along the southern margin of the Glengarry Sub-basin, where the orthoquartzitic Finlayson Sandstone (Elias, Bunting, and Wharton 1979) rests unconformably on Archaean granite of the Yilgarn Block. Over most of its extent, the Finlayson Sandstone is overlain by the Maraloou Formation—a calcareous shale sequence. Together, these two formations constitute the shelf facies of the Glengarry Group in the southern part of the sub-basin.

Within the Glengarry Sub-basin is a basement high of Archaean granite, called the Goodin Dome. This is unconformably overlain by a sandstone similar to the Finlayson Sandstone. Physical continuity cannot be established between them, and furthermore the sandstone at Goodin Dome is overlain by a thick arkose unit, which marks the appearance of the axial sequence in the northern part of the Glengarry Sub-basin. For these reasons, this sandstone blanketing the Goodin Dome is given a new name, Juderina Sandstone.

On the northern margin of the Glengarry Sub-basin a continuous basal orthoquartzite unconformably overlies the basement, and is conformably overlain by the same arkose unit as around the Goodin Dome. This orthoquartzite is also placed in the Juderina Sandstone. Previously this northern boundary has been interpreted as a fault (Bunting and others 1977), but in view of the stratigraphic consistency, it is more properly regarded as a folded, but essentially intact, unconformity.

The Juderina Sandstone on the edge of the Marymia Dome extends westerly toward the Peak Hill mine area, where it passes into a boulder conglomerate of comparable thickness to the Juderina Sanstone and retains the same stratigraphic position. This unit is termed the Crispin Conglomerate.

Crispin Conglomerate

The Crispin Conglomerate is that formation of boulder pebble and granule conglomerate and coarse sandstone which occurs at the base of the Glengarry Group, where it overlies the Peak Hill Metamorphic Suite. It extends in an arc of continuous exposure from a point 5 km south of Peak Hill townsite, eastward to the vicinity of the old Saint Crispin gold mine. It is about 200 m thick.

The lower part is schistose, sericitic granule conglomerate and coarse sandstone, which contains abundant pebbles and boulders of metamorphic-textured quartzite averaging 0.1 m in diameter and ranging up to 1.5 m in diameter. The matrix is schistose, and the generally well-rounded boulders are now prolate ellipsoids because of tectonic flattening and stretching in the cleavage.

Toward the top of the formation, pebbles become sparse, and the rock is simply a schistose, sericitic granule conglomerate and sandstone, in which low-angle trough cross-bedding is recognizable. The sericite is mainly derived by granulation of abundant detrital muscovite. A fluvial origin is envisaged for the Crispin Conglomerate.

Juderina Sandstone

The Juderina Sandstone is a well-bedded orthoquartzitic sandstone at the base of the Glengarry Group around the northern part of the Goodin Dome. Its type area is 3 km north of Juderina Bore (119°12′E, 25°53′S), where it is 30 m thick.

Around the Goodin Dome, the bedding in the sandstone is strictly conformable with the contact over a distance of 3 km, and is only disturbed by post-depositional faulting. Where visible, the contact is sharp, non-conglomeratic, and totally without intrusive features. Dolerite dykes occur in the granite, but are absent in the Juderina Sandstone.

The correlate of the Juderina Sandstone, along the southern margin of the Marymia Dome is 50 m thick. The beds in the lowermost metre are of feldspathic sandstone containing small pebbles of vein quartz, which are now flattened and stretched. Angular discordance occurs between the underlying gneiss and the sandstone.

The sandstone has a recognizable sedimentary texture, together with cross-bedding and ripple marks. In the region adjacent to the Marymia Dome, it appears to be a facies variant of the Crispin Conglomerate, the facies change correlating with a change of basement type from Archaean gneiss to the Peak Hill Metamorphic Suite. The Juderina Sandstone is interpreted as a transgressive shoreline deposit developed on a flat unconformity surface.

Finlayson Sandstone

The Finlayson Sandstone (Elias, Bunting and Wharton, 1979) extends into the area of Figure 33 only at the locality 10 km southwest of Mikhaburra where it is a ripple-marked and cross-bedded orthoquartzite 10 m thick resting unconformably on granite of the Yilgarn Block.

At this locality, the basal orthoquartzite is overlain by an alternation of sandstone and slaty siltstone about 100 m thick. Overlying this is magnetite-bearing sandstone and quartzose-feldspathic microconglomerate, which marks the appearance of the Doolgunna Arkose.

Doolgunna Arkose

The Doolgunna Arkose is a thick sequence of medium- to coarse-grained arkose and minor quartz-pebble conglomerate and argillaceous siltstone, which on the southern side of the Glengarry Sub-basin appears to lie conformably above the basal orthoquartzite, and which is conformable with the overlying Karalundi Formation. Around the northern margin of the Goodin Dome, there is a gap in exposure between the Juderina Sandstone and the arkose, but on the northern side of the sub-basin, the correlate of the Juderina Sandstone passes upward into arkose by the appearance of arkose beds within the sandstone.

In the type area, 14 km southeast of Ruby Well Find, arkose is spectacularly exposed in breakaway country, as it is in the area 13 km northeast of Doolgunna (off the area of Fig. 34). It is invariably deeply weathered and has the topographic expression of deeply weathered granite. It weathers in buff and reddish-brown colours.

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 m up to 4 m, and display gross upward-fining grading, bottom scouring of the shale,

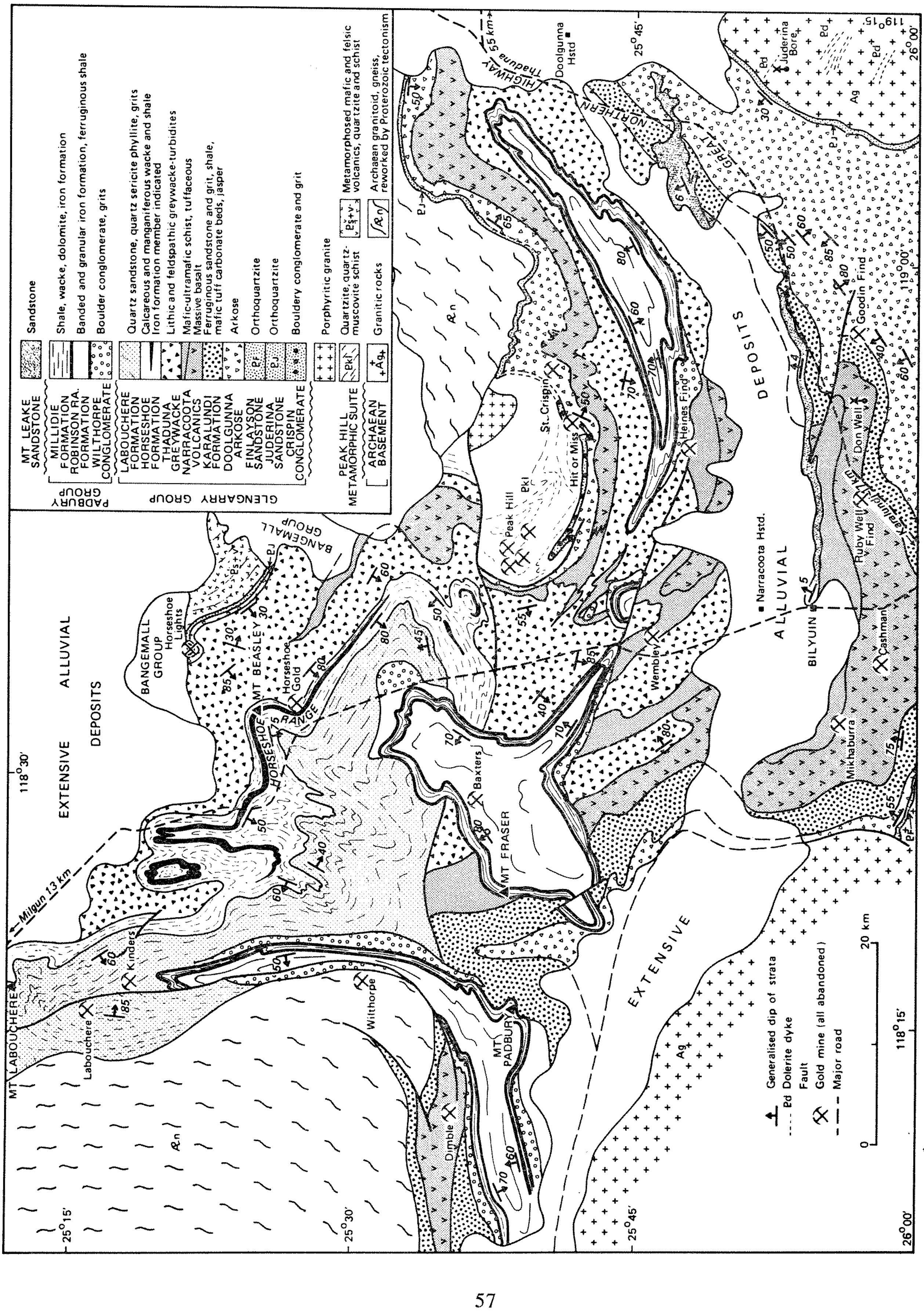

Figure 34 Geological map of parts of Peak Hill and Robinson Range 1:250 000 sheets

and diffuse, trough-type cross-bedding. The lower parts of the arkose beds may contain rounded clasts of vein quartz, up to 20 mm in diameter, and fragments of the underlying shale, but the bulk of each bed consists of angular quartz, microcline and plagioclase up to 10 mm in diameter. Feldspar grains are as abundant as quartz, and the rocks are true arkose.

Strangely, no granite clasts are found, and it appears that the source granite was disaggregated into consituent crystals, perhaps by a balance of deep chemical leaching and rapid mechanical breakdown.

The Doolgunna Arkose is continuous throughout this part of the Glengarry Sub-basin, but there are rapid thickness variations. It is possibly 5 km thick around the northern part of the Goodin Dome, about 1 000 m thick along the southern margin of the Marymia Dome, and only a few hundred metres thick at the western end of the Marymia Dome. East of the area of Figure 34, in the Doolgunna-Thaduna area, mapping has established that the Doolgunna Arkose passes laterally into the Thaduna Greywacke.

The Doolgunna Arkose is considered to be a thick clastic wedge emanating from the Goodin Dome, and spreading extensively through the Glengarry Sub-basin. It is interpreted as a complex piedmont deposit, involving fluvial, shallow-marine and possibly lacustrine processes. Although a close spatial connection exists between the arkose and the granite, the two rocks have not been found in contact. Presumably the Juderina Sandstone must be missing in some areas.

Karalundi Formation

The Karalundi Formation is a mixed clastic-carbonate-chert-tuff sequence, about 1 500 m thick, lying conformably between Doolgunna Arkose and the Narracoota Volcanics in the southern part of the Glengarry Sub-basin. The type area is along the east-west fence line 11 km north-northwest of Karalundi (south of the area of Fig. 34), and good exposures occur adjacent to the Great Northern Highway between 8 and 12 km north from Karalundi along the highway.

The base is the single layer of fine-grained, massively bedded orthoquartzite which is exposed 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 cement angle cross-bedding are common in these beds, which appear to be shallow-water marine deposits. These rocks are interbedded with ferruginous and siliceous shales, which commonly contain silty lenses with ripple-drift lamination.

Basaltic tuff, minor pillow basalt, and carbonate beds appear in the upper part, being conspicuous in the section 11 km north-northwest of Karalundi. The tuffs are clearly waterlain, being well bedded, with upward fining grading, and planar and ripple-drift lamination. They contain fragments of shale and basalt in a matrix of fine chlorite, epidote, saussuritized plagioclase, calcite, ilmenite, and magnetite. Calcite also occurs as large idioblastic authigenic crystals.

Carbonate beds range from only a few centimetres to several metres thick, and are either finely laminated (commonly with cross-lamination) or oolitic.

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 due to grain-size differences in the cherty material, these differences being outlined by cellular patterns of hematite staining. Euhedral magnetite is abundant, commonly forming clusters within or around the cellular structures. Veins of identical material also penetrate the interpillow material in the basalt. These jasper pipes are interpreted as colloidal hydrothermal deposits formed in fumarolic pipes associated with the basalt volcanism.

The top of the formation is taken as the continuous bed of ferruginous, cherty sandstone which extends for 10 km southwest from Ruby Well Find.

The Karalundi Formation represents a transition from fluvial to shallow-water marine environments, and records the commencement of basalt volcanism.

Narracoota Volcanics

At the lower stratigraphic levels, the Narracoota Volcanics is a massive basalt, and at upper levels mafic-ultramafic phyllite. It conformably overlies the Karalundi Formation in the type area which is specified as the Mikhaburra-Cashman area, 10 to 15 km south of Narracoota.

Basalt, about 4 km thick, is exposed in this area. It is generally massive, but is sheared in some places. Pillowed and fragmental types are also present. The basalts are usually altered; the clinopyroxene shows varying degrees of alteration to actinolite, and the plagioclase to saussurite. More advanced alteration produces actinolite, epidote, clinozoisite, albite and calcite.

At Mikhaburra, at the top of the main pile of massive basalt, is a volcanoclastic sequence of quartz-chlorite phyllite which displays clastic textures, interbedded with clay-pellet quartz sandstone and feldspathic-lithic greywacke. This horizon seems to mark a change to predominantly mafic-ultramafic pyroclastic volcanics, which occur extensively in the general area northeast and northwest of Narracoota.

Although some of this rock is simply sheared basalt, much of it is talc-tremoite-chlorite phyllite with only minor amounts of altered feldspar, and characterized by a fragmental texture on a scale of millimetres. The fragments are usually of similar material to the matrix. Despite the intense shearing, some of these rocks still exhibit remnants of devitrified glass fragments.

The total thickness of the Narracoota Volcanics is about 6 km, but the complex deformation in the upper part makes an accurate estimate impossible. However, the formation does seem to have its maximum thickness along an axis from Ruby Well Find through Mikhaburra, perhaps extending into the Dimble area. In this latter area, Elias and Williams (1977) record considerable amounts of magnesian lavas, containing olivine, skeletal clinopyroxene, and devitrified glass. The Narracoota Volcanics lens out in the Doolgunna and Horseshoe areas by interfingering with Thaduna Greywacke.

Thaduna Greywacke

Extensive areas of greywacke, covered by a thin veneer of alluvium, but excellently exposed in water courses, have been encountered within and to the north of the major synclinorial axis (Fig. 34). These rocks, which bear a striking resemblance to the Thaduna Beds (MacLeod, 1970), hold a constant stratigraphic relationship to the Narracoota Volcanics in the area shown in the central part of Figure 33, and interfinger with the greywacke in the distal parts of the volcanic pile.

Additional field investigations between Doolgunna and Thaduna show that the Doolgunna-Karalundi-Narracoota stratigraphic interval passes laterally into a thick sequence of greywacke. Consequently the greywacke discussed here appears to be the same litho-stratigraphic unit as the undefined Thaduna Beds. For the present, it is convenient to use Thaduna Greywacke as a formal term to include all this greywacke in the Glengarry Sub-basin. The type locality of the Thaduna Greywacke is taken as the area surrounding the Thaduna Mine.

The Thaduna Greywacke is a thick turbidite sequence consisting of graded beds of coarse- to fine-grained lithic and feldspathic wacke with subordinate interbedded slaty mudstone. Like the arkose, the greywacke is invariable deeply weathered, exhibiting red, purple, buff and chocolate colours. The wacke beds contain a variety of sedimentary structures, such as single and multiple graded cycles, shale intraclasts, flute marks, load casts, convolute lamination and slumping. Individual wacke beds are generally of the order of 1 to 2 m thick.

Identifiable lithic fragments include basalt, jasper and shale, but the deep weathering limits petrographic study. Feldspar is abundant as discrete clasts and as matrix, but the relative contributions of microline and plagioclase are unknown. The only petrological descriptions of these rocks are of drill core from Thaduna by Trendall (1970). He described: lithic fragments of shale, tuff, lava, and siltstone; clasts of epidote, amphibole, quartz and albite; and matrices rich in chlorite and hematite. Such assemblages are consistent with derivation from the Narracoota Volcanics.

These rocks are interpreted as proximal turbidites marking a deep trough marginal to a rapidly accumulating submarine basalt pile.

Horseshoe Formation

The Horeshoe Formation is the unit of carbonate-cemented greywacke, shale and banded ironstone that occurs in a section extending for 3 km west from the Horseshoe gold mine, across the Horseshoe Range. It is used in the same sense as the 'Horseshoe Beds' of MacLeod (1970). No specific base is defined, as it is transitional upwards from the correlate of the Thaduna Greywacke, but for mapping puroses it is taken as the sudden break in slope at the eastern side of the Horseshoe Range. The top is taken as the base of the prominent orthoquartzite which marks the base of the conformably overlying Labouchere Formation. It is about 1 000 m thick.

The lowermost 300 m on the eastern slopes of Horseshoe Range is an interbedded dark-grey-green greywacke and chloritic shale, interbedded on a scale of centimetres up to about one metre. A typical greywacke bed is graded in the lower part, and planar laminated in the upper part. Rare fragments of chert, gneiss and sericitic shale occur up to one centimetre in diameter. The rock is composed of about equal proportions of quartz, microcline, and lamellae-twinned albite-oligoclase, in single-crystal grains up to 2 mm in diameter. Detrital flakes of muscovite and biotite are also present. The matrix contains fine chips of all the above minerals, together with opaques, chlorite and sericite and abundant carbonate cement.

The interbeds are of laminated green shale composed 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 features, their darker colour, and a modal composition which indicates derivation from granitic and metamorphic terrain, rather than from mafic volcanics.

The most prominent member at Horseshoe Range is an iron-formation. At Mount Beasley, it is 250 m thick, and consists of three bands of iron-formation, each about 40 m thick, intercalated in quartz-chlorite-magnetite shale. These prominent bands consist of beds of chert-magnetite-?stilpnomelane iron-formation, green shale, and chert, alternating on a scale of 20 to 100 mm. Each bed shows lamination on a scale of millimetres.

Above the iron-formation is about 500 m of more calcareous, manganiferous shale and greywacke, which at Horseshoe Range is heavily replaced by supergene manganese and iron oxides. This upper part is better exposed in the areas 10 to 15 km to the south, where there is calcareous greywacke and shale similar to the lower part.

The iron-formation member has a limited strike extent of 50 km, and 25 km south-southeast of Mount Beasley, it thins to a number of beds or iron-formation less than 1 m thick.

The Horseshoe Formation marks the filling of the deep geosynclinal 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 unconformity that marks the top of the Glengarry Group is now known to occur within what has previously been called the 'Labouchere Formation' within the Padbury Group. The major part of this formation is in conformable sequence with the Glengarry Group, and the coarse conglomerate at the top of the formation as originally defiined is now regarded as the basal unit of the Padbury Group, the Wilthorpe Conglomerate.

In accordance with the original usage of MacLeod (1970) and the intention of Barnett (1975) the name Labouchere Formation is now applied to the thick sequence of sandstone and slaty sericitic siltstone that can be traced from the type area at Mount Labouchere to the Horseshoe Range, where it conformably overlies the Horseshoe Formation.

At Mount Labouchere, the formation consists of medium-to coarse-grained orthoquartzite at the base, overlain by an interbedded sequence of quartzose feldspathic wacke and phyllitic shale, in which the wacke becomes better sorted and the shale proportion increase at higher levels. The term 'wacke' was used to indicate sandstones containing more than 10 per cent matrix, which in this rock is sericitic and argillaceous. However, they are not related in any way to greywacke turbidites, and in order to preserve the distinction, the term sandstone is used in this paper.

The section is 5 000 m thick in the Mount Labouchere area but is incomplete because of faulting. The greatest thickness occurs in the area 30 km south-southeast of Mount Labouchere, where an additional 2 000 m of sericitic slate with siltstone and sandstone appears, before being cut out by the unconformity at the base of the Padbury Group.

The sequence on the western side of the Horseshoe Range is comparable to that at Mount Labouchere. The basal quartz, which is the most conspicuous marker horizon in the Glengarry Group, is again about 300 m thick, but has become better sorted and contains thin, shale interbeds. It is medium grained, with well-rounded quartz grains and sparse feldspar in a siliceous cement. The beds range from 0.1 to 3 m in thickness, and low-angle trough cross-bedding and linguoid ripple marks are present.

The overlying sequence consists of beds of argillaceous sandstone, some with detrital muscovite and feldspar, intervals of sericitic quartz siltstone with thin interbeds of ripple-marked clean sandstone, and fine-grained sericitic and laminated mudstone (now phyllite in places).

Cross-bedding of various types, such as small linguoid ripples, and planar and tangential megaripples occur within normally planar beds which range from 0.1 up to 1.5 m in thickness. These features, together with the presence of shale, indicate that the Labouchere Formation was deposited on a marine shelf. The sedimentary structures record sediment-dispersal currents.

PADBURY GROUP

The definiton of the Padbury Group (Barnett, 1975) is amended to exclude the Labouchere Formation (and the Horseshoe Formation) and to include the newly defined Wilthorpe Conglomerate. Barnett (1975) noted that the topmost 1 000 m of what he refferd to as the "Labouchere Formation" consisted of conglomerate and quartzose-feldspathic granule sandstone, and it is only this conglomeratic unit, the Wilthorpe Conglomerate, that remains in the Padbury Group.

Evidence for regional unconformity below the Padbury Group

Unconformity between the Padbury and Glengarry Groups is indicated by the following evidence.

1. A proven unconformity lies between the Wilthorpe Conglomerate and basement gneiss at locality 118° 18'20"E, 25°28'40"S.
2. Discontinuous lenses of boulder conglomerate (correlated with the Wilthorpe Conglomerate) occur at several other localities (Fig. 34) immediately below the Robinson Range Formation.
3. Angular discordance on the local and regional scale, between bedding in the Wilthorpe Conglomerate and cleavage in underlying phyllite is observable, although the unconformity surface itself is not exposed.
4. The Wilthorpe Conglomerate and the Robinson Range Formation overlie a variety of rock types which represent different stratigraphic levels in the Glengarry Group.
5. The Wilthorpe Conglomerate contains clasts of distinctive rocks which can be matched with particular stratigraphic units low in the Glengarry Group.
6. There is a contrast between the Glengarry Group which contains several generations of cleavage and phyllitic schistosity, as well as metamorphic garnet, muscovite, biotite and tremolite, and the Padbury Group which generally has only one cleavage and is unmetamorphosed.

Wilthorpe Conglomerate

The type area of the Wilthorpe Conglomerate lies 5 km east-northeast of the Wilthorpe Mining Centre. Here it consists of boulder and cobble conglomerate, passing upward through feldspathic sandstone with abundant pebble beds into siltstone and shale with thin, white chert layers, and is finally conformably overlain by the Robinson Range Formation. This predominantly conglomeratic unit occurs more or less continuously around the Padbury Syncline.

At the unconformity locality on the western side of the Padbury Syncline large boulders up to 1 m in diameter directly overlie the unconformity, and together with granite clasts form a conglomerate with a matrix of feldspathic sandstone containing abundant detrital muscovite. Clasts within the body of the Wilthorpe Conglomerate consist predominantly of fine-grained silica- or hematite-cemented orthoquartzite, that can be matched with the Karalundi Formation, and with Finlayson-type sandstone. Clasts of vein quartz and lepidoblastic-textured metamorphic quartzite are also common. Seldom do the coarse conglomerates actually outcrop; they are usually expressed as talus slopes of well-rounded boulders up to 3 m in diameter. The coarse conglomerate beds appear to be up to 100 m thick.

The conglomeratic sandstone occurs in lensoid units, several metres thick, which define a crude stratification. Imbrication of pebbles and low-angle trough-type cross-bedding are evident. There is commonly an upward fining of all clasts within the sedimentation unit.

The conglomeratic rocks have a cleavage, and the pebbles are deformed by brittle-style cracking, a feature common to all occurrences of the Wilthorpe Conglomerate. Some pebbles, however, show some evidence of stretching, flattening, and mineral lineation, but their fabric is not consistent with respect to the cleavage, and some of these deformed pebbles also participated in the sedimentary imbrication. It is suggested that at least some of these pebbles are recycled from an older, previously stretched conglomerate.

The Wilthorpe Conglomerate has its maximum thickness of about 1 000 m around the Padbury Syncline, an area adjacent to the Yarlarweelor Gneiss Belt. It is only intermittently exposed beneath the Robinson Range Formation further east, and is commonly covered by scree of iron-formation.

One area of reasonably good exposure below the Robinson Range Formation on the northern side of the Robinson Syncline consists of finely interbedded white chert and hematitic and sericitic shale with rare pebbles, which passes conformably up into the iron-formation. At another locality in the southeast part of the Millidie Syncline (118°34'00"E, 25°42'30"S) a similar chert-shale sequence contains interbeds up to 10 m thick of flaggy cross-bedded sandstone and pebbly siltstone containing well-rounded clasts of orthoquartzite up to 0.1 m in diameter.

These features suggest a discontinuous development of the conglomeratic phase, and furthermore, the fluvial features lead to the suggestion that the Wilthorpe Conglomerate records the position of large rivers that spread out over a peneplaned surface over which chert and ferruginous silts were elsewhere being deposited.

Robinson Range Formation

In the western part of the area, the Robinson Range Formation consists of a prominent layer of finely laminated chert-magnetite banded iron-formation, underlain by hematitic shale, which contains thin beds of banded iron-formation, and overlain by laminated chlorite-hematite shale. Barnett (1975) noted an upper zone in the main iron-formation layer in which bedding is indistinct, and clastic textures are apparent.

This feature is most characteristic of the Robinson Range Formation in the Robinson Syncline, where two regionally concordant ridges are separated by magnetite-bearing hematite-sericite shale. The lower unit is a true banded iron-formation, but the upper unit is a granular iron-formation with discontinuous bedding on the outcrop scale.

The granular iron-formation is characterized by lenses of granular and oolitic chert 10-20 mm thick, more continuous beds of the same thickness or red jasper, and beds of clastic ironstone up to 1 m thick. Clasts in the ironstone include spherical granules of chert 0.5 mm in diameter, fine grained hematitic shale, green chloritic shale, chert, and specular hematite up to 10 mm in diameter, and larger fragments of jasper. All clasts appear to have been derived from the immediate sedimentary environment. None of the original Fe-silicate mineralogy is preserved.

These rocks bear a striking similarity to the granular iron-formations of the Frere Formation in the eastern part of the Earaheedy Sub-basin, rock which Hall and Goode (1978) interpret as precipitates of iron silicates and chert in a shallow-marine environment disturbed by current activity. The lithological similarity is the basis of the proposed correlation of the Padbury and Earaheedy Groups (Bunting and others, 1976).

Millidie Formation

This is the higest stratigraphic unit of the Padbury Group, and is best exposed in the Millidie Syncline, where there is at least 1 500 m of feldspathic wacke, with sandstone, chert, dolomite, sericitic and hematitic shale and granular iron-formation. Exposure in the Padbury and Robinson Synclines is particularly poor, there being only iron- and manganese- stained shale and sandstone, with extensive developement of calcrete, presumably over dolomite.

Mount Leake Sandstone

Gently dipping beds of orthoquartzitic sandstone occur in a line of exposures from Bilyuin to Mount Leake. These beds unconformably overlie the vertically dipping Glengarry Group, the unconformity being well exposed on the southern slopes of Mount Leake. This unit is defined as the Mount Leake Sandstone and has its type section at Mount Leake (119°09'30"E, 25°47'00"S) where it is 15 m thick.

Characteristically it supports a chalcedonic cap with large colloform and breccia structures of uncertain origin, but it is suggested that the rock originally had a carbonate cement. Below this cap, the rock is a silica-cemented, fine-grained, well-sorted and well-rounded orthoquartzite, commonly containing small rounded flakes of glauconite. It is flaggy bedded, and abounds in trough crossbedding. Resting directly on the unconformity at Mount Leake is a thin stromatolite layer that has been totally replaced by chert.

The stratigraphic relations of the Mount Leake Sandstone are unknown; it could be an outlier of Bangemall Group, or part of a westerly extension of the Earaheedy Group, or a remnant of a new sedimentary sequence, as yet unidentified in the Glengarry Sub-basin.

TECTONIC DEVELOPMENT

Geosynclinal phase

Reconstruction of the Glengarry Sub-basin is shown in Figure 35. It is postulated that the almost continuous blanket of basal sandstone and conglomerate is broken

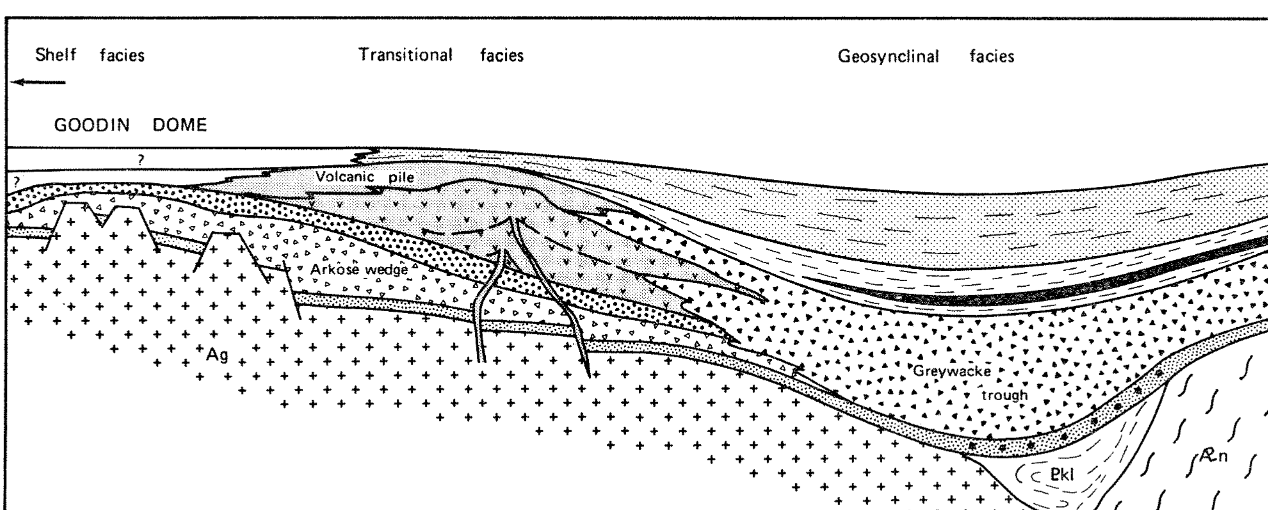

Figure 35 Diagrammatic section of the Glengarry Sub-basin from Goodin Dome northward to Horseshoe area, showing distribution of facies, and relationship of arkose wedges, volcanic pile and greywacke trough. Symbols are same as in Figure 34.

only over the Goodin Dome, where block-faulting elevated granite into a palaeo-high which was the source for the arkose wedges.

A deep geosynclinal trough developed across the northern margin of the cratonic Yilgarn Block, possibly located on a major crustal suture between different types of Archaean basement. The relationship between the geosynclinal and stable-shelf facies is not discussed here, however, it is worth noting that the Karalundi Formation appear to mark the transition from shelf to trough. The thick volcanic pile is localized along the hinge line of basin development. Calcareous shale, shallow-water conglomeratic sandstone, tuff and basalt lava were laid down here. At the same time, volcanogenic debris slumped off the volcanic pile, and was transported into the trough by dense turbidity currents to form greywacke.

The deposition of carbonate-cemented greywacke and a lens of banded iron-formation marks the termination of rapid subsidence and the filling of the trough. Then followed a period of vigorous fluvial and near-shore arenaceous sedimentation.

Main Deformation Phase

Bunting and others (1977) and Williams and others (1978) have previously interpreted deformation in terms of Archaean basement domes, driven by upward-rising Proterozoic granites. This picture is consistent with the revised stratigraphy, and it is further evident from the complex depositional and deformational history that this was a long-continuing episodic process.

Identification of an overall coherent structure in the Glengarry Group is obscured by the strong deformation, both before and after deposition of the Padbury Group. However, regional facings reveal a synclinorium more-or-less coincident with the synclinorium expressed by the Padbury Group. Contacts of the Glengarry Group with the metamorphic rocks of the Marymia Dome are still intact, but possibly as much as 10 km of stratigraphic thickness is absent adjacent to the bulbous end of the Yarlarweelor Gneiss Belt; this points to the region being a major shear zone. Infolded and metamorphosed remnants of the Glengarry Group occur in this reworked basement area. A 1.7 b.y. age for metamorphic muscovite (Williams and others, 1978) dates the main metamorphic event of the Glengarry Group. Consistent with the polyphase deformation, evidence of strain-slip and crenulation cleavage overprinting slaty cleavage is ubiquitous, but regional examples of refolded structures have not been identified. One of the most conspicuous pre-Padbury structures is the major east-west fault that emanates from a strong shear zone between the Yarlarweelor Gneiss Belt and the Yilgarn Block and extends to the western end of the Marymia Dome (Fig. 36). The nature of displacement on this fault is uncertain.

Second phase sedimentation and deformation

Following the orogenic climax, there was a period of uplift, erosion, and peneplanation, and then the Padbury Group was deposited as an upward-fining sequence of fluvial clastics and chemogenic rocks. The appearance of greywacke in the Millidie Formation indicates a return to active basinal sedimentation, but the record of this is incomplete.

Deformation of the Padbury Group followed the same earlier pattern—compression between reactivated basement domes and the stable basement of the Yilgarn Block (Fig. 36). Upright, near-isoclinal folds, spectacularly outlined by the Robinson Range Formation, are clearly related to basement domes. The Padbury Syncline is arcuate around the end of the Yarlarweelor Gneiss Belt; the Robinson Syncline is arcuate about the Marymia Dome; and the amoeba-shaped Millidie Syncline is crumpled between the two domes.

The last recorded tectonic event in the Yarlarweelor Gneiss Belt is the emplacement of Proterozoic granite dated about 1.6 to 1.5 b.y. (Williams and others, 1978). This event dates the deformation of the Padbury Group, and hence places a younger age limit on Padbury Group sedimentation.

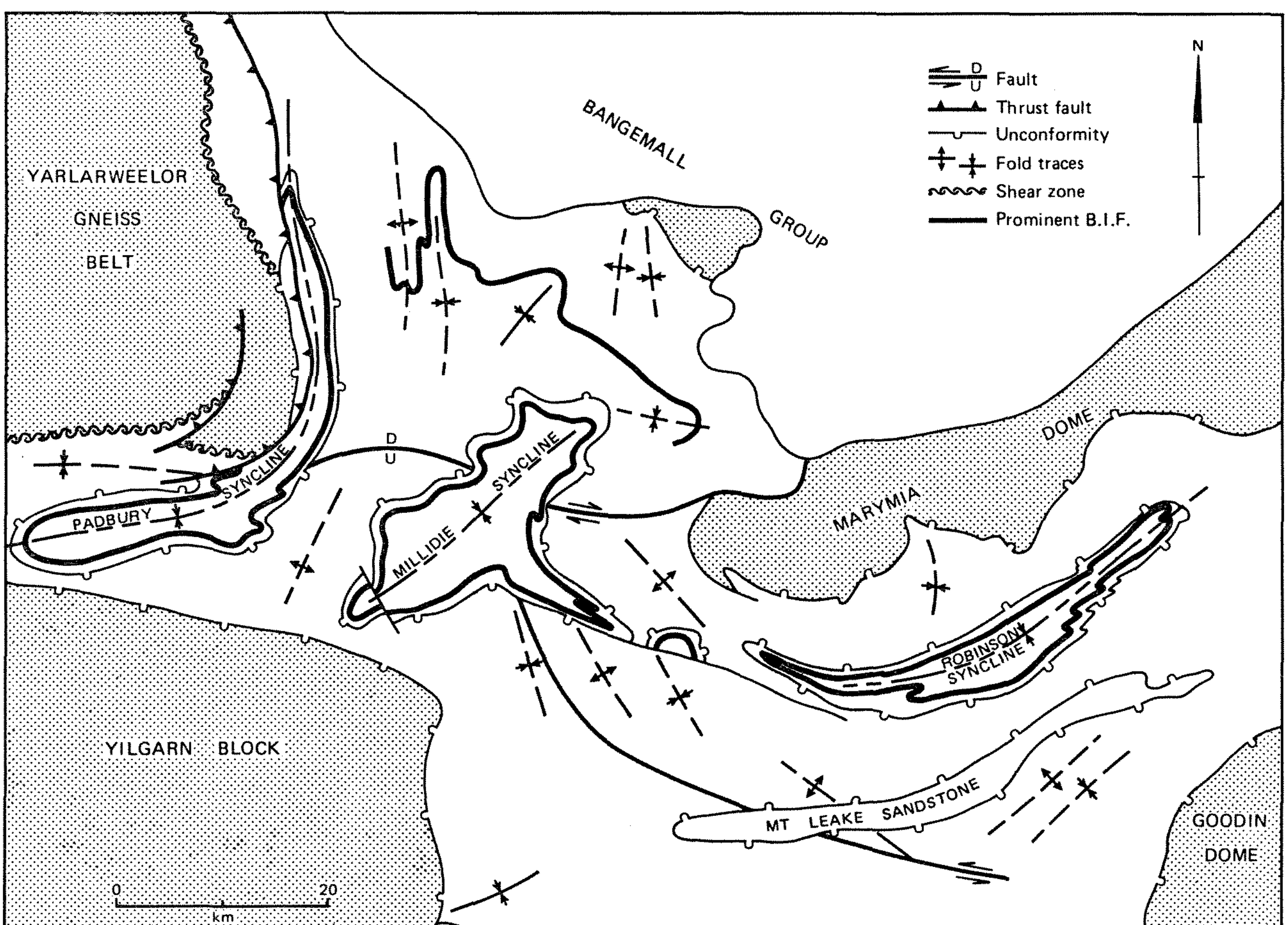

Figure 36 Structural map,showing relationship of regional folds to basement highs and domes (shaded). The area of this figure is the same as Figure 34.

IMPLICATIONS FOR THE PROTEROZOIC GEOLOGY OF W.A.

The identification of a major unconformity between the Padbury Group and the Glengarry Group, and the discovery of abundant granular iron-formations in the Padbury Group, which are similar to those in the Earaheedy Group, supports the proposal of Bunting and others (1977) that the Earaheedy Group in the eastern part of the Nabberu Basin unconformably overlies the Glengarry Group. No additional evidence is forthcoming from this present study to clarify the ages of the various sedimentary sequences, but the conclusions are consistent with the previously suggested ages of 1.7 to 1.6 b.y. for the Padbury Group and 1.8 to 2.0 for the Glengarry Group (Williams and others, 1978).

It is not the intention of this paper to present a tectonic synthesis of the northern margin of the Yilgarn Block, as this requires elucidation of the relationships between the geosynclinal and stable-shelf facies of the Glengarry Group, and an examination of the easterly extension of the Glengarry Group toward the Earaheedy Group. However, it is appropriate to examine possible relationships with other major sequences on the Precambrian Shield of Western Australia.

Most striking is the gross lithological similarity of the Glengarry and Wyloo Groups, both of which are thick geosynclinal sequences containing arkose, greywacke, carbonates and basalt. These two sequences have a comparable age, the Wyloo Group being later than the Woongarra Volcanics (Trendall, 1979), and hence younger than 2.0 b.y. (Arriens, 1976). Furthermore, there is almost a physical continuity between the two sequences, expressed by the infolded belts of Proterozoic metamorphic rocks throughout the Gascoyne Province Williams and others, 1979). This reconstruction points to an elongate belt of thick greywacke and volcanic fill of geosynclinal dimensions occupying the broad area between the Hamersley Basin and the Yilgarn Block, and suggests the emergence of a major, and hitherto unrecognized, tectonic element in the Western Australian Shield.

Relatively small elongate belts of fluvial sandstone and conglomerate occur throughout the Gascoyne Province (Williams, Williams, and Chin, 1979). They uncoformably overlie the metamorphic rocks, and clearly post date the orogenic climax, however they have been deformed during the emplacement of the Proterozoic orogenic granitoids. These sediments may correlate, by virtue of their similar tectonic setting, with the Padbury Group.

These broad chronostratigraphic relations, together with the currently accepted ages for the basement units in the Western Australian Shield, are shown diagramatically in Figure 37. This figure presents a model for the Proterozoic tectonic evolution for the region between the two stable Archaean cratons in the Western Australian Shield.

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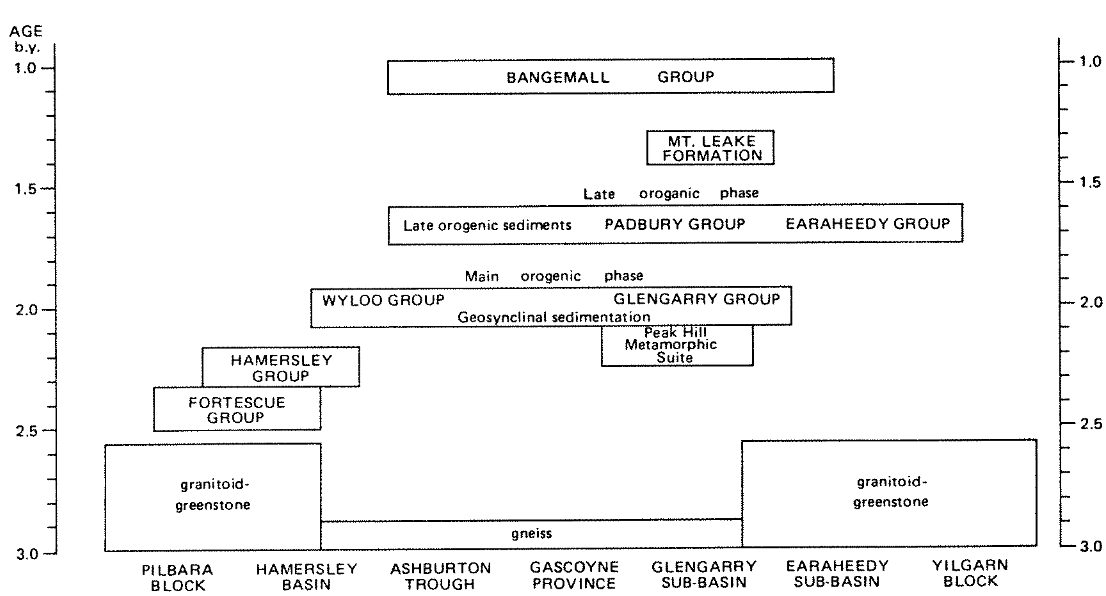

Figure 37 Diagram showing relationships of Padbury and Glengarry Groups to other major sedimentary and tectonic events in the region between the Pilbara and Yilgarn Blocks