XPLANATORY
NOTES

GEOLOGY OF THE NEWMAN 1:100 000 SHEET

by I.M. TYLER

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

DEPARTMENT OF MINERALS AND ENERGY

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

GEOLOGY OF THE NEWMAN 1:100 000 SHEET

by
I. M. Tyler

Perth 1994

MINISTER FOR MINES
The Hon. George Cash, J.P., M.L.C.

ACTING DIRECTOR GENERAL
L. C. Ranford

DIRECTOR, GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Pietro Guj

ISSN 1321–229X
National Library of Australia Card Number and ISBN 0 7309 4468 9

A preliminary edition of these notes was published in 1990 as
GSWA Record 1990/3

Cover photograph:

Mount Newman viewed from the west. The upper cliffs and summit consist of Brockman Iron Formation of the Hamersley Group, and form the flat-lying lower limb of the Mount Newman Syncline. To the north a ridge of steeply dippling Brockman Iron Formation forms the steep limb of the succeeding asymmetrical anticline. Interlayered banded iron-formation and metadolerite sills of the Weeli Wolli Formation occup the foreground.

Contents

Figure

Tables

Geology of the Newman 1:100 000 sheet

by

I. M. Tyler

Introduction

The NEWMAN* 1:100 000 geological sheet (SF50-16-2851) covers an area bounded by latitudes 23° 00'S and 23° 30'S and longitudes 119° 30'E and 120° 00'E. Located within the sheet area is the town of Newman (population 5466 in 1981) which provides accommodation for workers at the Mount Whaleback and Marra Mamba iron ore mines of the Mount Newman Mining Co. Pty. Ltd. The climate is arid and the area is dominated by the rugged, spinifex-covered hill country of the Ophthalmia Range which rises to 1055 m at Mount Newman.

Early geological investigations in the area are summarized in the first edition explanatory notes for the NEWMAN 1:250 000 geological sheet (Daniels and MacLeod, 1965). Later work will be referred to in the text as appropriate.

The NEWMAN 1:100 000 sheet occupies an area towards the southeast corner of the Pilbara Craton. The main tectonic units are the Sylvania Inlier, the Hamersley Basin and the Bangemall Basin (Fig. 1). Rocks forming the Sylvania Inlier consist of Archaean (>2750 Ma) granitoid, regarded by Tyler (1991) as forming cratonic basement similar to that exposed in the northern Pilbara granite–greenstone terrane (Hickman, 1983). Contacts between the Sylvania Inlier and rocks forming the younger, late Archaean to early Proterozoic (2750–2300 Ma) Hamersley Basin (Trendall, 1983), are generally tectonic, however unconformable relationships have been preserved. The Hamersley Basin is occupied by three groups of rocks (Table 1; see also Trendall and Blockley, 1970; Trendall, 1975; Trendall, 1979): the mafic volcanic-dominated Fortescue Group; the banded iron-formation (BIF)-dominated Hamersley Group; and the clastic metasediment-dominated Turee Creek Group. The rocks have been interpreted as recording the evolution of a continental margin that developed as an initial rift in relatively cold and brittle continental crust (Blake and Groves, 1987) and evolved into a stable shelf or platform (Horwitz and Smith, 1978; Ewers and Morris, 1981; Morris and Horwitz, 1985; Trendall, 1983). The early Proterozoic Capricorn Orogeny of Gee (1979), (dated at 2200–1600 Ma by Libby et al., (1986)) has been interpreted as the result of a collision between the Pilbara and Yilgarn cratons (Tyler, 1991; Thorne and Seymour, 1991). During the collision the southern margin of the Pilbara Craton acted as a foreland, and the Hamersley Basin and the Sylvania Inlier were deformed as part of the Ophthalmia Fold Belt, interpreted as a foreland fold and thrust belt (Tyler, 1991). The middle to late Proterozoic (1500–1100 Ma) Bangemall Basin (Williams, 1990) is not exposed but is known from two oil exploration wells in the Fortescue Valley in the northeast part of NEWMAN. Outside NEWMAN rocks of the Bangemall Group, deposited in the Bangemall Basin, are known to unconformably overlie Hamersley Basin rocks (Williams and Tyler, 1989), and represent deposition on a shallow marine shelf (the Pingandy Shelf) developed in an intracratonic setting (Muhling and Brakel, 1985). The geological history of NEWMAN is summarized in Table 2.

* Map sheet names are printed in capitals, to avoid confusion with identical place names.

Sylvania Inlier

Archaean (>2750 Ma) granitoid rocks form the Sylvania Inlier on NEWMAN. These granitoid rocks, elsewhere in the inlier intrude deformed and metamorphosed greenstone belts (Tyler, 1991; Williams and Tyler, 1989), and are probably equivalent to the tin granites of the northern Pilbara (Hickman, 1983).

The granitoid rocks mainly comprise widespread medium, even-grained syenogranite to monzogranite dykes, veins and patches in a medium to coarse, even-grained (*ge*) to sparsely porphyritic (*gv*) monzogranite to granodiorite. Phenocrysts may be either microcline or plagioclase and rarely exceed 10–15% of the rock. Even-grained varieties grade into sparsely porphyritic varieties.

Granitoid rocks are recrystallized and mineral assemblages are metamorphic, comprising greenish-brown biotite, epidote, albite or oligoclase–andesine, microcline (usually perthitic), muscovite and quartz, with minor amounts of sphene, apatite, flourite and opaques. Albite is characteristically sieved by fine, unoriented grains of epidote and muscovite.

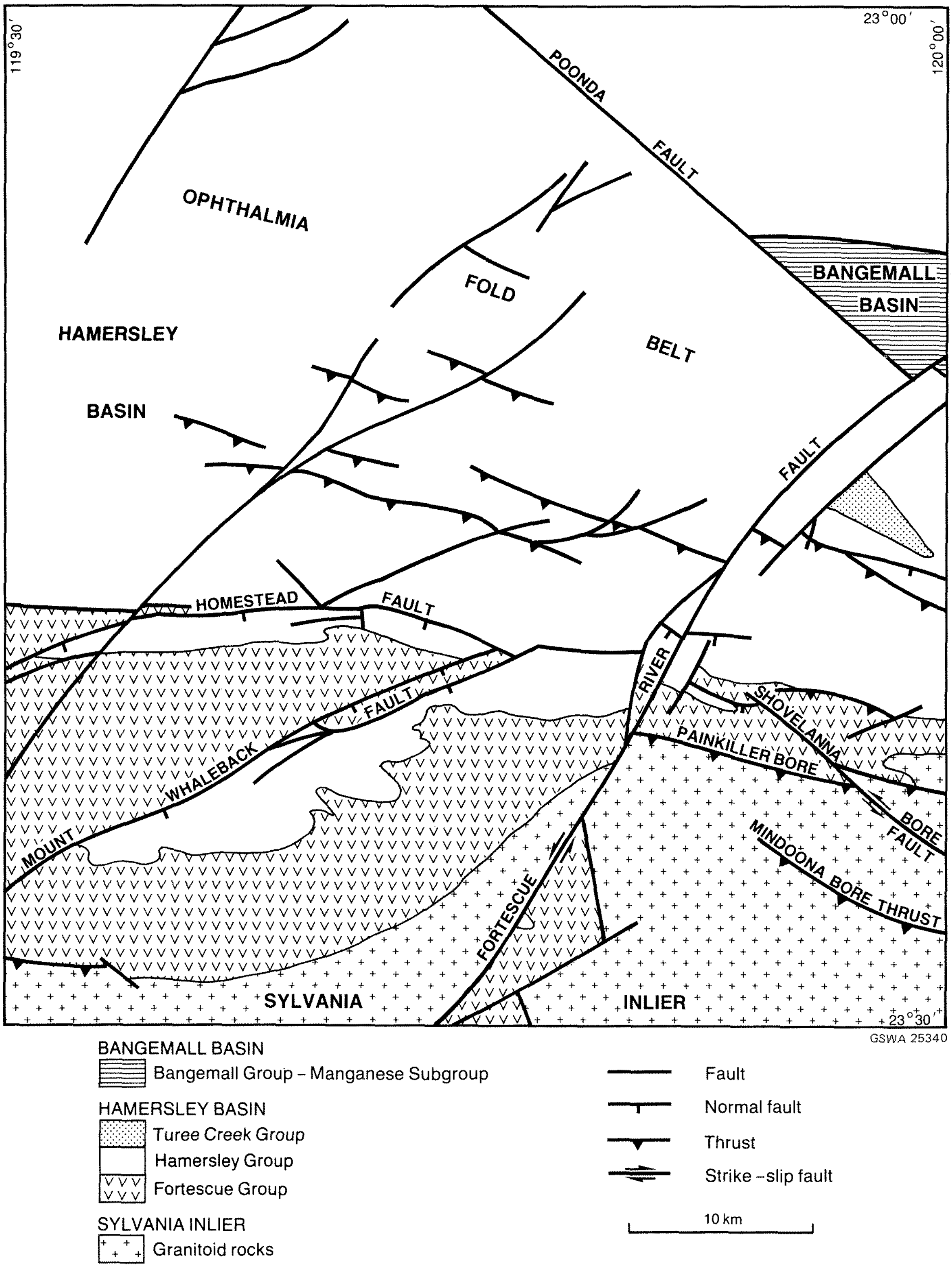


Figure 1. Simplified geological map of NEWMAN, showing the main tectonic units

Table 1. Precambrian stratigraphy of Newman

Basin	*Group*	*Formation*	*Member*
BANGEMALL BASIN	Bangemall Group Manganese Subgroup		
~ ~ ~ unconformity ~ ~ ~			
HAMERSLEY BASIN	Turee Creek Group		
	Hamersley Group	Boolgeeda Iron Formation	
		Woongarra Volcanics	
		Weeli Wolli Formation	
		Brockman Iron Formation	Yandicoogina Shale Member Joffre Member Whaleback Shale Member Dales Gorge Member
		Mount McRae Shale	
		Mount Sylvia Formation	
		Wittenoom Dolomite	
		Marra Mamba Iron Formation	West Angela Shale Member Mount Newman Member MacLeod Member Nammuldi Member
	Fortescue Group	Jeerinah Formation	
		Upper mafic volcanic unit	
		Basal metasedimentary unit	
~ ~ ~ unconformity ~ ~ ~			
granite–greenstone terrane			

A petrographically unusual suite of mafic to felsic coarse-grained rocks (*go*) outcrop in the southwest corner of NEWMAN. Leucocratic and melanocratic varieties are present with subhedral megacrysts of albite up to 3 cm long, in a matrix of medium-grained albite, green biotite and quartz. Sphene, apatite and allanite are also present with minor carbonate and chlorite.

Igneous features typical of layered mafic intrusions are common (cumulus textures, rhythmic layering) and it has been speculated (Tyler, 1991) that the unusual composition of the rocks (monzodiorite to quartz diorite) is the result of metasomatism of a gabbro intrusion, the Western Creek Gabbro, probably during intrusion of the main granitoid. The rocks were recrystallized and homogenized during later burial metamorphism.

Post-granitoid minor intrusions

A swarm of north-northeast to northeast-trending mafic dykes (d_l) intrude the granitoid rocks. They are not seen to intrude the overlying Fortescue Group. Based on their orientation and field relationships, Tyler (1991) regarded the dykes as equivalent to the Black Range dyke swarm of the northern Pilbara (Hickman, 1983).

The dykes have undergone static burial metamorphism under greenschist facies conditions with mineral assemblages comprising amphibole, plagioclase (oligoclase–andesine replacing relict laths of labradorite) and quartz, with minor sphene, apatite, Fe-oxides, chlorite, epidote and biotite. Primary igneous textures are commonly preserved.

Hamersley Basin

Fortescue Group

Basal metasedimentary unit (Fs)

The basal metasedimentary unit is of variable thickness (up to 500 m) and consists of interbedded parallel-laminated conglomerate, coarse sandstone and shale. On NEWMAN exposed contacts with the underlying granite–greenstone terrane are faulted. An unconformity may be present between the Outcamp Well area and the Fortescue River in the southwestern corner of NEWMAN. Conglomerates, ranging from a few centimetres to several metres thick, are poorly sorted with subangular to subrounded clasts. Both clast-supported varieties, with a coarse matrix, and matrix-supported varieties, with a fine, shaly matrix, are present.

Upper mafic volcanic unit (Fbu)

The upper mafic volcanic unit is up to 1.2 km thick and overlies the basal metasedimentary unit. It consists of both massive and amygdaloidal fine- to medium-grained metabasalt, together with mafic tuff. Igneous textures are preserved with chlorite–actinolite replacing pyroxene and epidote–sericite–albite intergrowths pseudomorphing feldspar laths. Flows may develop spinifex-type textures,

Table 2. Summary of the geological history of Newman

(1) Intrusion of the Western Creek Gabbro into greenstones and an early granitoid.

(2) Intrusion of the main granitoid, metasomatism of part of the Western Creek Gabbro.

(3) Intrusion of north-northeast mafic dykes (d_1).

(4) Period of uplift and erosion followed by rifting and initiation of the Hamersley Basin with eruption of mafic volcanics of the Fortescue Group (c. 2750 Ma).

(5) Stable shelf conditions, deposition of the Hamersley Group dominated by banded iron-formations (c. 2500 Ma).

(6) Deposition of the clastic metasediment-dominated Turee Creek Group. Evidence of static metamorphism or burial metamorphism of Hamersley Basin rocks (M_h)under greenschist facies conditions preserved in granitoid rocks.

(7) Capricorn Orogeny (2200–1600 Ma). Formation of the Ophthalmia Fold Belt (D_{1c}, D_{2c}) and uplift of the Sylvania Inlier during collision of the Pilbara and Yilgarn cratons. Capricorn Orogeny metamorphism (M_c) of Hamersley Basin rocks under pumpellyite–actinolite facies and greenschist facies conditions. Grade reaches albite–epidote facies conditions in the Sylvania Inlier.

(8) Uplift and erosion, formation of the Bresnahan Basin (c. 1600 Ma). Mount Whaleback Fault forms as part of associated fault system. Formation of main hematite orebodies.

(9) Uplift and erosion, establishment of the Bangemall Basin (1500–1100 Ma). Poonda Fault active.

(10) Intrusion of north-northeast mafic dykes (d_7).

(11) Late, sinistral faulting (?Phanerozoic) on northwest Shovelanna Bore Fault and northeast Fortescue River Fault.

(12) Formation of the Hamersley Surface in late Mesozoic/early Tertiary. Formation of Marra Mamba orebodies. Uplift and dissection of surface.

however the rocks do not have high-Mg compositions. The textures are regarded as primary igneous features and are thought to be the result of rapid cooling.

Jeerinah Formation (Fj)

The Jeerinah Formation is up to 2 km thick, including up to 850 m of mafic sills. It conformably overlies the upper mafic volcanic unit but at the eastern end of the Ophthalmia Dam (see Blockley et al., 1980) and to the west of Noddy Bore, the formation unconformably overlies granitoid rocks of the Sylvania Inlier. The formation comprises interbedded shaly mudstone, laminated siltstone and chert, with minor felsic tuff and dolomite units in the upper part. Near Mount Whaleback a metabasalt unit (*Fjb*), containing well developed pillows (Blockley et al., 1980), occurs beneath the Marra Mamba Iron Formation.

Mafic sills (Fd)

Mafic sills are intruded throughout the Fortescue Group and can make up nearly 50% of the exposed section. They consist of fine- to coarse-grained metadolerites, some of which are layered and have pyroxenitic bases. The sills preserve ophitic to poikilitic igneous textures. Clinopyroxene may be preserved as plates up to 7 mm across that show alteration to chlorite and/or actinolite. Plagioclase laths are invariably albitized and can be replaced by intergrowths of sericite and epidote/clinozoisite. Fe-oxides are leucoxenized. Pumpellyite is present in some samples.

Hamersley Group

Marra Mamba Iron Formation (Hm)

The Marra Mamba Iron Formation can be divided into three members (Slepecki, 1981; Kneeshaw, 1984; Blockley et al., 1993). The lowest is the Nammuldi Member consisting of 70 m of yellow-weathering chert and cherty BIF with some shale bands. Towards the top of the unit podding of chert bands is common with the development of a marker band known as the 'potatoes'. The middle unit is the MacLeod Member comprising 25 m of interlayered shale and thin BIFs. The upper unit is the Mount Newman Member consisting of 50 m of BIF interbedded with 18 thin shale bands.

Wittenoom Dolomite (Hd)

The Wittenoom Dolomite is poorly exposed. It has an estimated thickness of 150 m (Daniels and MacLeod, 1965). Drill holes indicate that the Mount Newman Member of the Marra Mamba Iron Formation is overlain by 36 m of Mn-rich shale in the Newman area (Slepecki, 1981). This shale unit has been named the West Angela Shale Member and has been placed at the base of the Wittenoom Dolomite (Blockley et al., 1993). Elsewhere the shale is overlain by massive crystalline dolomite that passes up into interbedded thin shale, chert, dolomite and BIF (Trendall and Blockley, 1970; Tyler et al., 1990).

Mount Sylvia Formation and Mount McRae Shale (Hs)

The Mount Sylvia Formation in the Newman area has been described by Kneeshaw (1975). The unit is 45 m thick and consists of three BIF bands separated by interlayered shale and dolomite. A BIF band marks the top and bottom of the unit. The upper BIF is the distinctive Bruno's Band that provides a marker horizon throughout the Hamersley Basin. At Mount Whaleback a 21-m thick feldspathic sandstone is present between the central and upper BIF bands.

The Mount McRae Shale is also described by Kneeshaw (1975) and consists of 30 m of black graphitic and chloritic shale, interbedded with chert and, in the upper part, with BIF. At Mount Whaleback the BIFs are mineralized. In the middle of the unit several zones contain abundant pyrite nodules up to 5 cm across.

Brockman Iron Formation (Hb)

The Brockman Iron Formation is the thickest and economically most important iron-formation unit within the Hamersley Group. It was divided into four members by Trendall and Blockley (1970), that, on NEWMAN, have a total thickness of approximately 520 m (Kneeshaw, 1975).

The Dales Gorge Member (*Hb(D)*) is the basal member comprising an interlayered sequence of 17 BIF and 16 shale 'macrobands' (Trendall and Blockley, 1968, 1970; Ewers and Morris, 1981). At Mount Whaleback the upper part of the Mount McRae Shale is included within the local definition of the Dales Gorge Member (Kneeshaw, 1975). The unmineralized unit is 119 m thick at Mount Newman (Trendall and Blockley, 1970).

The Whaleback Shale Member (*Hb(W)*) consists of 30 m of shale interbedded with chert and BIF (Kneeshaw, 1975). Three zones are present; a basal shale zone, a central chert band and an upper shale zone. The lower shale zone is dominated by pyritic black shale, while the upper unit is dominated by carbonate-rich material (McConchie, 1984). A prominent BIF outcrops at the base of the central chert band. The Whaleback Shale forms a prominent strike gully within the ridge of iron formation and is useful in unravelling local structure.

The Joffre Member (*Hb(J)*) consists dominantly of BIF with minor shale bands. The unit is 340 m thick at Mount Whaleback (Kneeshaw, 1975). It is overlain by the poorly exposed Yandicoogina Shale Member that, on NEWMAN, consists of 30 m of shale and BIF.

Weeli Wolli Formation (Hj)

The Weeli Wolli Formation consists of interbedded BIF, chert and shale intruded by several metadolerite sills (*Hjd*). BIF is typically jaspilitic. Daniels and MacLeod (1965) measured a 366 m section near Kalgan Creek, half of which was metadolerite.

The metadolerite sills consist of fine- to medium-grained metadolerite with preserved subophitic igneous textures. Relict pyroxene is common and may be altered to chlorite, or more rarely to stilpnomelane and/or actinolite. Feldspars are albitized. Chlorite, epidote, pumpellyite and prehnite are also present. Fe-oxides are typically leucoxenized.

The metadolerites are generally regarded as sills as chilled margins and transgressive relationships can be seen. However, pillows have been reported in outcrops from Coondina Creek, 3 km north of Eagle Pool (Trendall, A. F., pers. comm. 1987). From their morphology the pillows are thought to represent intrusion into wet sediment.

Woongarra Volcanics (Hw)

The Woongarra Volcanics are well exposed. The unit is is about 300 m thick (Daniels and MacLeod, 1965) and comprises quartz-phyric and K-feldspar-phyric rhyodacite and rhyolite, with a discontinuous jaspilitic BIF horizon in its central part. Albitized plagioclase and secondary chlorite are present in a devitrified, commonly sperulitic-textured quartzo-feldspathic groundmass. In some rocks textures are preserved which are consistent with a fragmental, tuffaceous origin. A distinctive rock, that has the appearance of a welded tuff, is seen at the top of the unit. This contains blocks of jaspilitic BIF up to 20 cm across.

Boolgeeda Iron Formation (Ho)

The Boolgeeda Iron Formation is the uppermost unit of the Hamersley Group and is 220 m thick. It can be subdivided into upper and lower iron formations separated by a poorly exposed median shale unit (Trendall and Blockley, 1970).

The lower BIF is typically a dense, black to dark brownish, well-laminated rock having a flaggy appearence in outcrop. The upper BIF is typically finer grained and finely laminated, having a shaly appearence.

Turee Creek Group (*TU*)

Finely laminated, dark-brown shale outcrops in the core of a syncline, 10.5 km southeast of Kalgan near the eastern margin of NEWMAN. This conformably overlies the Boolgeeda Iron Formation and is correlated with the Turee Creek Group.

Metamorphism

Smith et al., (1982) recognized burial metamorphism (M_h) in Hamersley Basin rocks. Evidence of static metamorphism under greenschist facies conditions in granitoid rocks in the southwest corner of the sheet has been interpreted by Tyler (1991) as due to the same episode of burial metamorphism.

Capricorn Orogeny

Rocks of the Sylvania Inlier and the Hamersley Basin have been extensively deformed during the early Proterozoic (2200–1600 Ma) Capricorn Orogeny (Tyler, 1991). In the Sylvania Inlier deformation takes the form of faults and shear zones. In the Hamersley Basin large-scale, generally west-northwest-trending folds form the Ophthalmia Fold Belt.

Previous interpretations of the deformation of the Hamersley Basin have interpreted folding as a passive response of the cover to vertical movements of basement blocks (e.g. MacLeod, 1966; Gee, 1979). Gee (1979) attributed folding on NEWMAN to large-scale slumping off a rising Sylvania 'Dome' (see also Kneeshaw, 1975). However, deformation in both the basement and cover can be shown to be directly linked (Tyler, 1991), forming part of a northerly directed fold and thrust system. Orogenic deformation is interpreted as the result of a collision between the Pilbara and Yilgarn cratons (Tyler, 1991; Thorne and Seymour, 1991).

A Rb–Sr isochron giving an age of 2235 ± 54 Ma has been reported from an inlier of Archaean granitoid unconformably overlain by Fortescue Group rocks at the eastern end of the Ophthalmia Dam (Blockley et al., 1980).

The age was anomolous when compared with the known age of the overlying Fortescue Group rocks (2750–2500 Ma; Trendall, 1983) and was interpreted as the result of equilibration of Sr isotopes with Proterozoic water from the Hamersley Basin during uplift. As such, the age may represent a maximum age for deformation.

Deformation in the Sylvania Inlier

The Fortescue River Fault divides the Sylvania Inlier into two parts; an intensely deformed eastern two-thirds and a lesser deformed western third (Tyler, 1991). Granitoid rocks exposed in the southeast corner of NEWMAN are well foliated, and the western end of the Mindoona Bore Thrust, which is exposed in the Jimblebar greenstone belt to the east (Tyler, 1991; Williams and Tyler, 1989), can be traced as a shear zone. Although not exposed, the Painkiller Bore Fault is interpreted as extending on to NEWMAN, forming the basement–cover contact east of the Fortescue River. This structure is interpreted as a south-dipping thrust (Tyler, 1991). Granitoid rocks in the southwest corner of the sheet are unfoliated.

Ophthalmia Fold Belt

Two phases of deformation have been recognized in the Ophthalmia Fold Belt (Tyler, 1991): an early event (D_{1c}) which produced small-scale layer-parallel folds restricted to zones of high strain; and a later regional-scale fold and thrust event (D_{2c}).

Folds related to the early deformation phase are restricted to particular stratigraphic horizons. Folds are tight to isoclinal and have a well-developed tectonic cleavage. Good examples of D_{1c} folds occur at the base of the Boolgeeda Iron Formation near the radio transmitter 30 km north-northeast of Newman and at Eagle Pool. D_{1c} folds are present at the top of the Jeerinah Formation 9 km northwest of Newman, and have also been recognized at the base of the Marra Mamba Iron Formation.

Large-scale D_{1c} folds have not been recognized and the structures are interpreted as the product of movement along bedding planes. Movement directions are not known but the bedding plane shears probably represent an early stage of regional thrusting.

The second fold phase (D_{2c}) corresponds to a major regional fold event and folding occurs on all scales. D_{2c} folds refold D_{1c} structures. The folds trend west-northwest and range from upright to near recumbent. They are generally north-facing, close to tight folds that are commonly conjugate in form. They are of buckle-type and folds are non-cylindrical with subhorizontal axes, and are impersistent, dying out both laterally and vertically along their axial surfaces. Fold profiles vary from parallel to flattened parallel, near similar, forms.

At Mount Whaleback the relationship of smaller scale folds to the larger scale folds is well exposed. Folding here is asymmetrical and overturned, with smaller scale folds fanning around larger structures. Folds with steeply inclined axial surfaces occur on long, shallow-dipping limbs, and folds with gently inclined axial surfaces occur on short, steeply dipping to overturned limbs. Variations in the tightness of folds is controlled by the thickness of bed and its competency relative to adjacent lithologies.

Regionally, the most intense deformation within the Ophthalmia Fold Belt occurs north of the Sylvania Inlier (Tyler, 1991). Two structural zones are recognized; a zone of overturned north-facing folds, and to the north of that a zone of reverse faulting and associated folds having steeply inclined to upright axial surfaces. In general the folds become progressively tighter and more overturned as the contact with the Sylvania Inlier is approached. Reverse faulting takes the form of steep, south-dipping faults with throws varying from a few metres to several hundred. These reverse faults are believed to root into a flat-lying sole thrust that underlies the fold belt. The position of the thrust is controlled by the relatively less competent Fortescue Group. Folding continues to the north of the reverse faults and shortening is thought to be taken up by movement on a blind extension of the sole thrust.

An axial plane cleavage is well developed, with slaty cleavage in shale passing into a spaced cleavage in adjacent BIF and chert. In the Mount McRae Shale cleavage can be seen to wrap around pyrite nodules with pressure shadows developing in the plane of the cleavage.

Metamorphism

Smith et al., (1982) interpreted the regional recrystallization of Hamersley Basin rocks under prehnite–pumpellyite to lower greenschist facies conditions as the result of burial metamorphism. The occurrence of a well-developed axial plane cleavage in Hamersley Basin rocks exposed on NEWMAN indicates that recrystallization under pumpellyite–actinolite facies and lower greenschist facies conditions (M_c) in this part of the southeast Hamersley Basin actually occurred during the deformation that formed the Ophthalmia Fold Belt. Metamorphic conditions were probably similar to those established during the earlier burial event. In the Sylvania Inlier east of the Fortescue River, granitoid rocks and the d_l mafic dykes are foliated and recrystallized under albite–epidote amphibolite facies conditions (Tyler, 1991).

The Mount Whaleback Fault system

The Mount Whaleback Fault system exposed on NEWMAN comprises two main structures: the east-northeast-trending Mount Whaleback Fault itself; and the easterly trending Homestead Fault. Faulting can be related to the development of the middle Proterozoic (1600 Ma) Bresnahan Basin, exposed to the southwest of NEWMAN (Tyler et al., 1990).

The Mount Whaleback Fault is complex, with the single fault which is present at Western Ridge splitting into two at Mount Whaleback. The main throw is transferred by a series of splay and subsidiary faults to a parallel fault

1 km to the south. Dip values of 65°–75° have been recorded on this fault (Kneeshaw, 1975). In its hanging-wall are two flat-lying normal faults; the East Pit Footwall Fault and the Central Fault, that together form the floor to the hematite ore body (Tyler, 1991). Both faults root into the main fault. Numerous smaller scale normal faults occur throughout the mine area.

Bangemall Basin

Bangemall Group

Manganese Subgroup

Dolomite, siltstone, sandstone and glauconitic sandstone were intersected in two oil exploration wells drilled in the Fortescue valley, 9 km and 11 km northeast of Kalgan Siding. The sequence lies to the north of the Poonda Fault (Fig. 1) and is not exposed. It is thought to be part of the Manganese Subgroup of the Bangemall Group (Tyler et al., 1990).

The Poonda Fault

The Poonda Fault (Fig. 1) is not exposed and its direction of dip is not known; however, it has a complex history. Initial movement must have been north-block-up in order to juxtapose Wittenoom Dolomite, which underlies much of the Fortescue valley, against upper Hamersley Group. Later movement was contemporaneous with Bangemall Group deposition and was north-block-down.

Post-Bangemall Basin faulting

The Shovelanna Bore Fault, a northwest-trending sinistral fault (Williams and Tyler, 1989) occurs at the eastern margin of NEWMAN, offsetting the Painkiller Bore Fault (Fig. 1). It degenerates into a series of conjugate folds and kinks which refold D_{2c} structures near the Ophthalmia Dam. Minor kink bands, faults and chevron folds affect rocks at Mount Whaleback and post-date the Mount Whaleback Fault.

The youngest set of faults on NEWMAN trend northeast and have a sinistral sense of movement. The most prominent structure is the Fortescue River Fault which offsets the Mount Whaleback Fault and the Poonda Fault. The Ethel Lineament has been identified within Tertiary sediments in the Fortescue valley to the northeast (Williams, 1989). It lies along the trend of the Fortescue River Fault and suggests that the fault may have been active in Tertiary times.

Minor intrusions

Several dolerite dykes (d_7) trend northeast to north-northeast and cut across the Hamersley Basin rocks. They intrude along fault lines that have similar orientations and age relationships to the Fortescue River Fault. The dykes are typically thin (1–10 m) and mineral assemblages, which consist of clinopyroxene and plagioclase with minor amounts of quartz, hornblende and biotite, are fresh, except for minor very low-grade alteration.

Cainozoic geology

A prominent feature of the Cainozoic geology of NEWMAN is the Hamersley Surface (MacLeod et al., 1963; Campana et al., 1964; Twidale et al., 1985), an uplifted and dissected peneplanation surface of probable late Mesozoic to early Tertiary age. Residual deposits (*Czr*) that form part of this surface are lateritic and may be ferruginous. Surficial iron enrichment produces thin deposits of hematite–goethite ore on banded iron-formation. Ridges of Brockman Iron Formation rise above the surface as monadnocks and are cloaked by these residual deposits.

An early stage of the dissection of the Hamersley Surface produced extensive valley-fill deposits. These typically take the form of partly consolidated and cemented colluvium (*Czc*). Colluvium may also be deposited on top of the Hamersley Surface, adjacent to monadnocks. Calcrete (*Czk*) occurs extensively along the main drainages particularly where they cross the Wittenoom Dolomite. Associated with the calcrete are ridges of massive opaline silica (*Czo*).

Extensive areas of sheetwash plain (*Qw*) consisting of alluvium and colluvium, together with areas of eolian sand (*Qs*), form the floodplain of the Fortescue River and Warrawanda Creek. Alluvium (*Qa*), comprising unconsolidated silt, sand and gravel is deposited along present drainage channels. Colluvium (*Qc*) forms recent talus slopes adjacent to both bedrock outcrops and Tertiary outcrops.

Economic geology

Iron

Hamersley Group rocks form part of the Hamersley Iron Province (MacLeod et al., 1963) and extensive exploration for iron ore has taken place. At present the Mount Newman Mining Co. Pty. Ltd. is producing ore from the Brockman Iron Formation at its Mount Whaleback Mine and from the Marra Mamba Iron Formation at the nearby Marra Mamba Mine. Brief histories of the discovery and development of the mines are given by Kneeshaw (1975) and Slepecki (1981). Significant enrichment has not been found associated with either Weeli Wolli Formation or Boolgeeda Iron Formation BIFs.

The Mount Whaleback orebody has been described by Kneeshaw (1975) and is developed predominantly in the Dales Gorge Member of the Brockman Iron Formation and the upper part of the Mount McRae Shale. It occurs in two west-plunging synclines truncated by the Mount Whaleback Fault and its subsidiary structures. The ore is massive, hard, martite–hematite (Kneeshaw, 1984) grading to 69% Fe. Primary banding can be recognized but the mineralized section has been reduced to 65 m (54% of its original thickness) by the ore-forming process. Reserves of low phosphorus, high-grade ore (>64% Fe, <0.05% P) are in excess of 1400 million tonnes. Ore is present 325 m below the water table. In general, other orebodies developed in the Brockman Iron Formation are of the higher phosphorus martite–(hematite)–goethite ore type (Kneeshaw, 1984), and are not currently economic. Ore formation was the result of a supergene-enrichment process enhanced by later burial metamorphism and took place in the early to middle Proterozoic. The necessary fluid flow was controlled by faulting which occurred during the formation of the Bresnahan Basin (Tyler, 1991). The ore formation processes have been decribed in detail by Morris (1980, 1985) and Morris et al., (1980).

Significant enrichment and ore formation has taken place in the Mount Newman Member of the Marra Mamba Iron Formation (e.g. Neale, 1975; Slepecki, 1981). Ore formation is concentrated in synclinal structures and the orebodies are commonly buried beneath alluvial and colluvial deposits adjacent to outcropping Nammuldi Member. Ore formation took place in the late Mesozoic to early Tertiary (Morris, 1985). Ore is of the martite–limonite type and is generally soft. Limited production has taken place at the Marra Mamba Mine (Slepecki, 1981).

Ochre

Between 1938 and 1941 1651 tonnes of red ochre were mined from Boolgeeda Iron Formation, 29 km north-northeast of Mount Newman (Matheson, 1945). A further 8 tonnes were produced from Weeli Wolli Formation, 7 km north of Mount Newman homestead. The exact location of the second deposit is not known.

Crocidolite

The occurrence of a seam of crocidolite has been reported in a tributary gorge to Coondiner Creek (Trendall and Blockley, 1970). The seam is up to 8 cm thick and occurs in the upper part of the Dales Gorge Member of the Brockman Iron Formation, forming the core of a medium-scale anticline.

References

BLAKE, T. S., and GROVES, D. I., 1987, Continental rifting and the Archaean–Proterozoic transition: Geology, v. 15, p. 229–232.

BLOCKLEY, J. G., TRENDALL, A. F., De LAETER, J. R., and LIBBY, W. G., 1980, Two anomalous isochrons from the vicinity of Newman: Western Australia Geological Survey, Annual Report 1979, p. 93–96.

BLOCKLEY, J. G., TEHANAS, I., MANDYCZEWSKY, A., and MORRIS, R. C, 1991, Proposed stratigraphic subdivision of the Marra Mamba Iron Formation and the lower Wittenoom Dolomite *in* Professional Papers: Western Australia Geological Survey, Report 34, p.47–63.

CAMPANA, B., HUGHES, F. E., BURNS, W. G., WHITCHER, I. G., and MUCENIEKAS, E., 1964, Discovery of the Hamersley iron deposits: Australasian Institute Mining and Metallurgy, Proceedings, v. 210, p. 1–30.

DANIELS, J. L., and MacLEOD, W. N., 1965, Newman, W.A.: Western Australia Geological Survey, 1:250 000 Geology Series Explanatory Notes.

EWERS, W. E., and MORRIS, R. C., 1981, Studies on the Dales Gorge Member of the Brockman Iron Formation: Economic Geology, v. 76, p. 1929–1953.

GEE, R. D., 1979, Structure and tectonic style of the Western Australian Shield: Tectonophysics, v. 58, p. 327–369.

HICKMAN, A. H., 1983, Geology of the Pilbara Block and its environs: Western Australia Geological Survey, Bulletin 127.

HORWITZ, R. C., and SMITH, R. E., 1978, Bridging the Pilbara and Yilgarn Blocks: Precambrian Research, v. 6, p. 293–322.

KNEESHAW, M., 1975, Mt Whaleback iron orebody, Hamersley Iron Province *in* Economic Geology of Australia and Papua New Guinea, Volume 1. Metals *edited by* C. L. KNIGHT: Australasian Institute of Mining and Metallurgy, Monograph 5, p. 910–916.

KNEESHAW, M., 1984, Pilbara iron ore classification — a proposal for a common classification for BIF-derived supergene iron ore: Australasian Institute Mining and Metallurgy, Proceedings, v. 289, p. 157–162.

LIBBY, W. G., De LAETER, J. R., and MYERS, J. S., 1986, Geochronology of the Gascoyne Province: Western Australia Geological Survey, Report 20.

McCONCHIE, D., 1984, A depositional environment for the Hamersley Group: palaeogeography and geochemistry, *in* Archaean and Proterozoic Basins of the Pilbara, Western Australia: Evolution and Mineralisation potential *edited by* J. R. MUHLING, D. I. GROVES, and T. S. BLAKE: University of Western Australia, Department of Geology and Extension Service, Publication No. 9, p. 144–190.

MacLEOD, W. N., 1966, The geology and iron deposits of the Hamersley Range area: Western Australia Geological Survey, Bulletin 117.

MacLEOD, W. N., de la HUNTY, L. E., JONES, W. R., and HALLIGAN, R., 1963, Preliminary report on the Hamersley Iron Province, North West Division: Western Australia Geological Survey, Annual Report 1962, p. 44–54.

MATHESON, R. S. 1945, Report on red ochre deposits, ML370H, Ophthalmia Range: Western Australia Geological Survey, Annual Report 1944, p. 92–95.

MORRIS, R.C., 1980, A textural and mineralogical study of the relationship of iron ore to banded iron-formation in the Hamersley Iron Province of Western Australia: Economic Geology, v. 75, p. 184–209.

MORRIS, R. C., 1985, Genesis of iron ore in banded iron-formation by supergene and supergene–metamorphic processes — a conceptual model, *in* Handbook of strata-bound and stratiform ore deposits, volume 13 *edited by* K. H. WOLF: Amsterdam, Elsevier, p. 73–235.

MORRIS, R. C., and HORWITZ, R. C., 1985, The origin of the iron-formation–rich Hamersley Group of Western Australia — deposition on a platform: Precambrian Research, v. 21, p. 273–297.

MORRIS, R. C., THORNBER, M. R., and EWERS, W. E., 1980, Deep-seated iron ores from banded iron-formation: Nature, v. 288, p. 250–252.

MUHLING, P. C., and BRAKEL, A. T., 1985, The geology of the Bangemall Group, the evolution of an intracratonic Proterozoic basin: Western Australia Geological Survey, Bulletin 128.

NEALE, J., 1975, Iron deposits in the Marra Mamba Iron Formation at Mining Area 'C', Hamersley Iron Province *in* Economic Geology of Australia and Papua New Guinea Volume 1. Metals *edited by* C.L. KNIGHT: Australasian Institute Mining and Metallurgy, Monograph 5, p. 924–932.

SLEPECKI, S., 1981, Marra Mamba iron ore — a case history in exploration and development of a new ore type: Australasian Institute of Mining and Metallurgy, Annual Conference, Sydney, p. 195–207.

SMITH, R. E., PERDRIX, J. L., and PARKS, T. C., 1982, Burial metamorphism in the Hamersley Basin, Western Australia: Journal of Petrology, v. 23, p. 75–102.

THORNE, A. M., and SEYMOUR, D. B., 1991, Geology of the Ashburton Basin, Western Australia: Western Australia Geological Survey, Bulletin 139.

TRENDALL, A. F., 1975, Hamersley Basin, *in* Geology of Western Australia: Western Australia Geological Survey, Memoir 2, p. 118–141.

TRENDALL, A. F., 1979, A revision of the Mount Bruce Supergroup: Western Australia Geological Survey, Annual Report 1978, p. 63–71.

TRENDALL, A. F., 1983, The Hamersley Basin *in* Iron Formations — Facts and Problems *edited by* A. F. TRENDALL and R. C. MORRIS: Amsterdam, Elsevier, Amsterdam, p. 69–129.

TRENDALL, A. F., and BLOCKLEY, J. G., 1968, Stratigraphy of the Dales Gorge Member of the Brockman Iron Formation in the Precambrian Hamersley Group of Western Australia: Western Australia Geological Survey, Annual Report 1967, p. 48–53.

TRENDALL, A. F., and BLOCKLEY, J. G., 1970, The iron formations of the Precambrian Hamersley Group, Western Australia: Western Australia Geological Survey, Bulletin 119.

TWIDALE, C. R., HORWITZ, R. C., and CAMPBELL, E. M, 1985, Hamersley landscapes of the northwest of Western Australia: Revue de geographie physique et de geologie dynamique, v. 26, p. 173–186.

TYLER, I. M., 1991, The geology of the Sylvania Inlier and the southeastern Hamersley Basin: Western Australia Geological Survey, Bulletin 138.

TYLER, I. M., HUNTER, W. M., and WILLIAMS, I. R,, 1991, Newman,W.A., (second edition): Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes.

WILLIAMS, I. R., 1990, Bangemall Basin, *in* The Geology and Mineral Resources of Western Australia: Western Australia Geological Survey, Memoir 3.

WILLIAMS, I. R., 1989, Balfour Downs, W A (second edition): Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes.

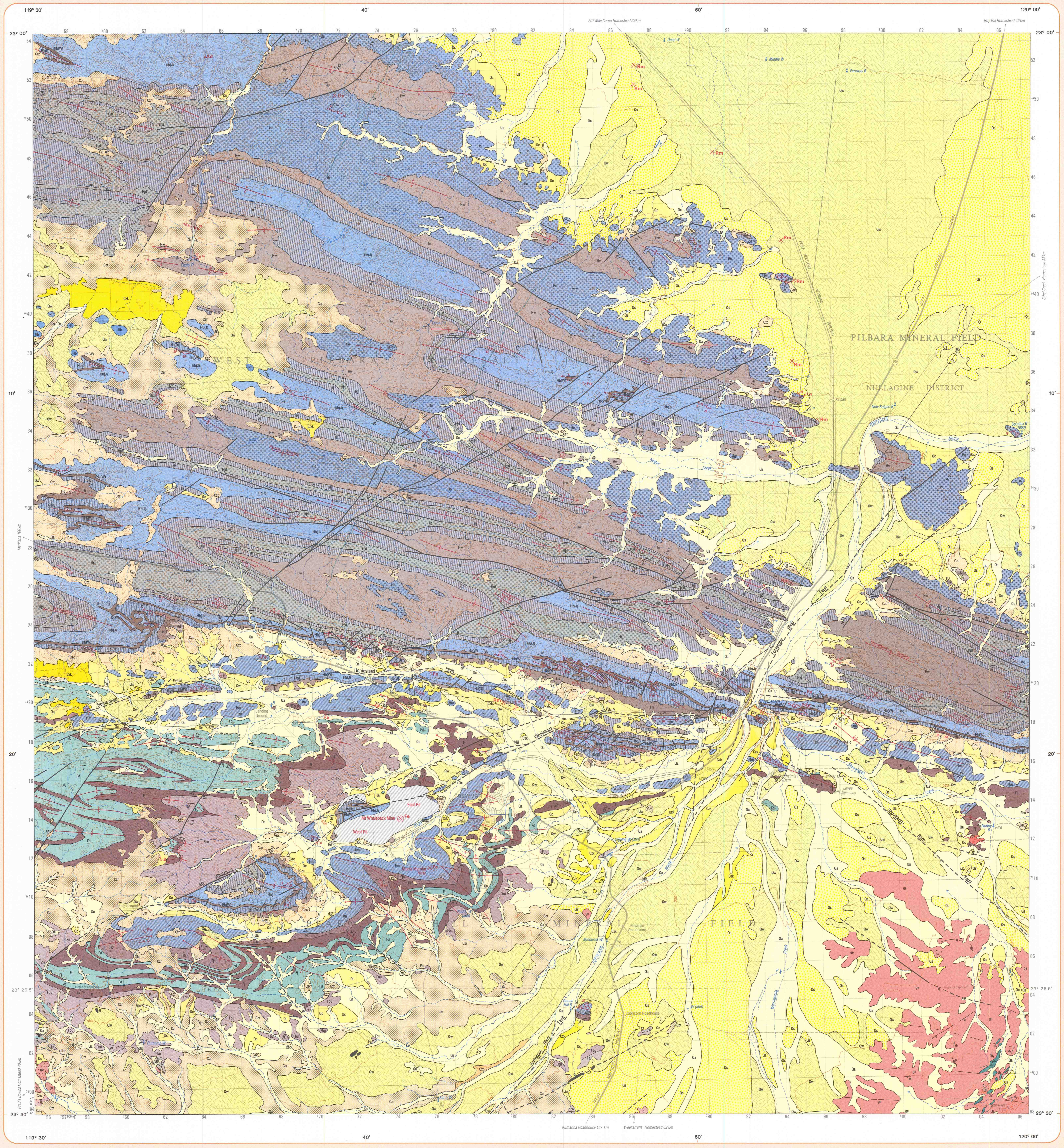
WILLIAMS, I. R., and TYLER, I. M., 1991, Robertson W.A., (second edition): Western Australia Geological Survey, 1:250 000 Geological Series Explanatory Notes.

NEWMAN

AUSTRALIA 1:100 000 GEOLOGICAL SERIES

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

SHEET 2851



PHANEROZOIC — CAINOZOIC — QUATERNARY

Qa	Qs	Qw	Qc

- Qa Alluvium — unconsolidated silt, sand and gravel
- Qs Eolian sand — in sheets and dunes
- Qw Alluvium and colluvium; red-brown sandy and clayey soil
- Qc Colluvium — unconsolidated quartz and rock fragments in soil

Czc	Czr	Czk	Czo

- Czc Colluvium — partly consolidated valley-fill deposits
- Czr Laterite including surficial hematite-geothite deposits over banded iron-formation. Forms Hamersley Surface
- Czk Calcrete — sheet carbonate usually formed in major drainage channels
- Czo Opaline silica — vuggy white opaline silica developed in calcrete and on partially consolidated valley fill

PROTEROZOIC

- q Quartz veins
- d_7 Dolerite dykes

Turee Creek Group

- TU Undifferentiated: mudstone

Hamersley Group (HAMERSLEY BASIN)

- Hb **BOOLGEEDA IRON FORMATION**: fine-grained, finely laminated, dark grey-brown to black, flaggy iron-formation, minor chert, jaspilite and shale
- Hw **WOONGARRA VOLCANICS**: quartz-or feldspar-phyric rhyolite and rhyodacite as sills or flows, tuff and minor jaspilitic banded iron-formation (2470 ± 30 Ma, U-Pb; 2370 Ma, Rb-Sr)
- Hj **WEELI WOOLLI FORMATION**: interlayered banded iron-formation and metadoleritic sills, minor shale
- Hjd Medium- to coarse-grained massive grey-green metadolerite sills usually foliated
- Hb **BROCKMAN IRON FORMATION**: banded iron-formation, chert and minor shale (2490 ± 20 ma, U-Pb)
- Hb(J) **Joffre Member:** banded iron-formation, chert and minor shale. Overlain by **Yandicoogina Shale**
- Hb(W) **Whaleback Shale:** shale and chert with minor banded iron-formation
- Hb(D) **Dales Gorge Member:** interbedded banded iron-formation and thin shale bands

2500 Ma

- Hs **MOUNT McRAE SHALE and MOUNT SYLVIA FORMATION**: interbedded shale, chert and thin banded iron-formation
- Hd **WITTENOOM DOLOMITE**: dolomite, interbedded thin chert, shale and dolomite in upper part
- Hm **MARRA MAMBA IRON FORMATION**: chert, ferruginous chert and banded iron-formation with minor shale

ARCHAEAN

- Fd Metadolorite sills intruded into FORTESCUE GROUP, medium- to coarse-grained, massive grey-green rock usually foliated

Fortescue Group

- Fj **JEERINAH FORMATION**: interbedded mudstone, siltstone and chert with minor felsic tuff, dolomite and sandstone
- Fjb Metabasalt, pillows locally well developed
- Fbu Upper mafic volcanic unit: metabasalt and minor mafic metatuff intruded by metadolerite sills
- Fs Basal metasedimentary unit: metasandstone and metaconglomerate, minor phyllite

c.2750 Ma

- d_1 Metadolerite and amphibolite dykes

BASEMENT ROCKS OF THE SYLVANIA INLIER

>2750 Ma

g	ge	gv	go

- g Granitoid rocks, undifferentiated, deeply weathered
- ge Medium, even-grained, metagranite to metagranodiorite
- gv Medium-grained, metagranite to metagranodiorite with sparse feldspar phenocrysts
- go Mesocratic to melanocratic metamonzodiorite to metaquartz-diorite. A coarse plagioclase cumulate phase is locally present

Symbols

Geological boundary

Fault
- accurate
- normal
- reverse
- concealed

Fold showing direction of plunge
- anticline
- syncline
- overturned anticline
- overturned syncline
- locality of superimposed fold
- Capricorn Orogeny
  - Ophthalmia Fold Belt
    - small-scale fold showing orientation of axial surface, direction of plunge and nature of vergence (Z, S or M)
    - D1c ... 52 60
    - D2c
      - vertical
      - inclined ... 62 10
      - plunge of D2c fold axis
- Late, post-orogenic fold, usually associated with faulting ... 57 19

Bedding
- inclined ... 83
- vertical
- strike and dip of overturned strata ... 60
- dip estimated from aerial photography
  - horizontal
  - 0°–15°
  - 15°–45°
  - 45°–90°
  - vertical

Younging
- pillow lava

Cleavage, slaty or spaced
- Capricorn Orogeny
  - Ophthalmia Fold Belt
    - inclined ... 87
    - vertical

Foliation, metamorphic
- Capricorn Orogeny
  - inclined ... 30
  - general trend of foliation

Isotopic age determination site

Mineral field boundary

Highway ... 95

Formed road

Track

Railway

Siding ... Kalgan

Townsite, population 1000-10 000 ... NEWMAN

Building

Yard ... Yd

Horizontal control; major, minor

Watercourse, intermittent

Pool ... P

Well ... W

Bore ... B

Windpump

Tank ... T

Abandoned ... (abd)

Contour line, 20 metre interval ... 320

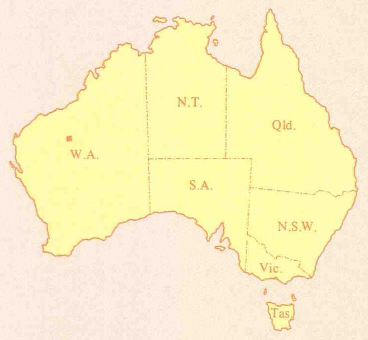
Mine, open cut or quarry
- major
- minor

Prospect

Made ground and mining area

Petroleum exploration well, dry, abandoned

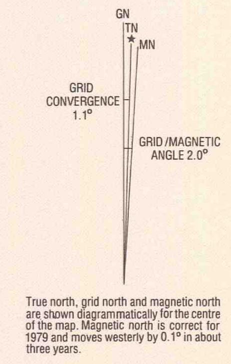
Mineral occurrence
- Crocidolite ... Ad
- Iron ... Fe
- Ochre ... Oc
- Road metal ... Rm



MOUNT GEORGE 2653	MOUNT MARSH 2753	WARRIE 2853	NOREENA DOWNS 2953	MOUNT COOKE 3053	WOBLEGUN 3153
	ROY HILL		BALFOUR DOWNS		
MUNJINA 2652	SF 50-12 WEELI WOLLI 2752	ROY HILL 2852	ETHEL CREEK 2952	SF 51-9 BALFOUR DOWNS 3052	TALAWANA 3152
GOVERNOR 2651	OPHTHALMIA 2751	NEWMAN 2851	MURRAMUNDA 2951	JIGGALONG 3051	ROBERTSON 3151
	NEWMAN			ROBERTSON	
KUNDERONG 2650	SF 50-16 PRAIRIE DOWNS 2750	WARRAWANDA 2850	MUNDIWINDI 2950	SF 51-13 BOBBYMIA 3050	SAVORY 3150

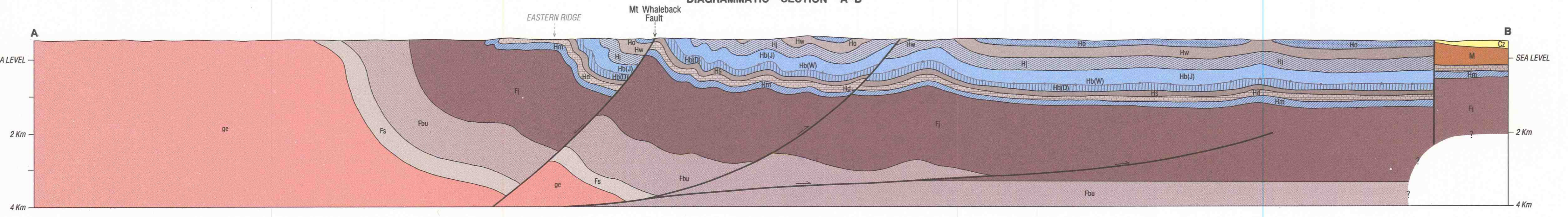
1 : 100 000 maps shown in black

1 : 250 000 maps shown in brown



True north, grid north and magnetic north are shown diagrammatically for the centre of the map. Magnetic north is correct for 1979 and moves westerly by 0.1° in about three years.

DIAGRAMMATIC SECTION A - B



- Cz Cainozoic deposits of the Fortescue Valley
- M Manganese Subgroup of the Bangemall Basin

HON. JEFF CARR, M.L.A.
MINISTER FOR MINES
D.R. KELLY, DIRECTOR GENERAL OF MINES

P.E. PLAYFORD
DIRECTOR, GEOLOGICAL SURVEY
OF WESTERN AUSTRALIA

SCALE 1:100 000

1000 Metres 0 1 2 3 4 5 6 7 8 9 10 Kilometres

TRANSVERSE MERCATOR PROJECTION

Grid lines indicate 1000 metre interval of the Australian Map Grip Zone 50

Geology by: I.M. Tyler 1983-1985

Cartography by the Surveys and Mapping Division, Department of Mines, Western Australia.

Topographic information supplied by the Division of National Mapping, Department of Resources and Energy (1975) and modified from geological field survey (1983).

Published by and available from the Geological Survey of Western Australia Department of Mines, 100 Plain Street, Perth, Western Australia.

Printed by the State Printing Division, Department of Services, Western Australia.

NEWMAN

SHEET 2851 FIRST EDITION 1989