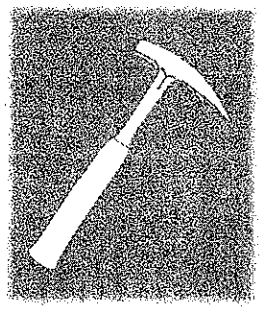

Stratigraphic subdivision of the Willyama Supergroup

— Olary domain, South Australia

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Introduction

The Olary domain of the Curnamona Province (Laing *et al.*, 1995) has long been recognised as containing rocks equivalent to the Willyama Supergroup (Willyama Complex of Mawson, 1912; Willyama Supergroup of Willis *et al.*, 1983; Clarke *et al.*, 1986; Flint and Parker, 1993). However, definition of the stratigraphic succession at Olary has been hampered by incomplete mapping and a lack of interpretative synthesis, and the succession has hitherto remained informal (Flint and Parker, 1993; Ashley *et al.*, 1995).

A limited part of the Olary domain has been mapped by MESA at 1:25 000 scale (Forbes and Pitt, 1980; Bulloo and Outalpa 1:50 000 sheets) with the remainder mapped at 1:170 000 (Campana, 1955) and 1:250 000 scale (Forbes, 1991). More detailed non-Government mapping projects cover a large proportion (~90%) of the domain; these include university theses (~40) and exploration company maps (~15; 1962-96). MESA, through the author, has synthesised these data into a lithological map of the Olary domain (Laing, 1995a). The map comprises thirteen 1:25 000 scale sheets covering all but the eastern, poorly exposed unmapped periphery of the Olary domain (Fig. 1). The disparate lithological classifications of the input maps have been melded into a uniform classification, which draws extensively on the lithological classifications developed by the New South Wales Geological Survey in the Broken Hill domain (Stevens and Willis, 1983), and their modification in the Olary domain by Ashley and Plimer (University of New England, unpublished data, 1993).

A lithostratigraphic interpretation followed the lithological synthesis, incorporating the structural observations and stratigraphic younging data of the input maps. Products of the interpretation comprise a litho-stratigraphic map (Laing, 1995b, summarised on Fig. 1), a structural synthesis map (Laing, in prep. a), and a set of sections depicting inferred lithostratigraphic relationships within the Olary domain (Fig. 2). The study also subdivides the granitoid rocks into a suite of pre- to syntectonic, and syntectonic, bodies (Laing, 1995b); a complete documentation, with comprehensive referencing of input maps, is being prepared (Laing, in prep. b).

This paper presents descriptions, mutual relationships and formal definition of the lithostratigraphic succession of the Willyama Supergroup in the Olary domain, South Australia. Type localities are provided for all units, but these require ground evaluation and possibly modification prior to recognition as type sections.

Existing units extended to the Olary domain

The Willyama Supergroup was defined by Stevens *et al.* (1983) and Willis *et al.* (1983) in the Broken Hill, Olary, and Mount Painter regions. The Willyama Supergroup was subdivided at group, formation and member level in the Broken Hill region, but remained undifferentiated in the Olary and Mount Painter regions. The present work subdivides the Willyama Supergroup in the Olary domain at group, formation and member level (Laing, 1995a; Laing *et al.*, 1995). The component groups remain essentially unchanged from the Broken Hill domain, but new units have been recognised at formation and member level (Fig. 3).

New units

Morialpa Migmatite

Derivation of name

From 'Morialpa' (homestead) in the type locality.

Type locality

The area from 'Morialpa' northeast towards Weekeroo Woolshed; 393600mE–427300mN to 394300mE–429500mN; Plumbago South 1:25 000 map sheet.

Description

Migmatite and composite gneiss[2]. Two end-members: concordant tabular migmatite bodies with strong foliation and layer-parallel neosome, and discordant irregular migmatite. Several recorded younging observations in the 'Weekeroo' area in these gneissic rocks must be viewed with doubt. No significant metalliferous mineralisation is known.

Thickness

1-3 km.

Relationships

The upper contact is defined by the top of the migmatite or composite gneiss, and in the concordant migmatite bodies this passes upwards into the Tommie Wattie or George Mine Formations. The lower contact is not known. The Morialpa Migmatite is the lowest known unit of the Willyama Supergroup in the Olary domain. The concordant migmatite units are viewed as stratigraphic units, in the same way that the Clevedale Migmatite at Broken Hill has stratigraphic connotation (Willis *et al.*, 1983). The discordant migmatite units are associated genetically with intrusive granitoids and possess no stratigraphic significance. There is significantly

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[2] Migmatite = palaeosome plus quartzofeldspathic neosome >50%. Composite gneiss = palaeosome plus quartzofeldspathic neosome 10–50%

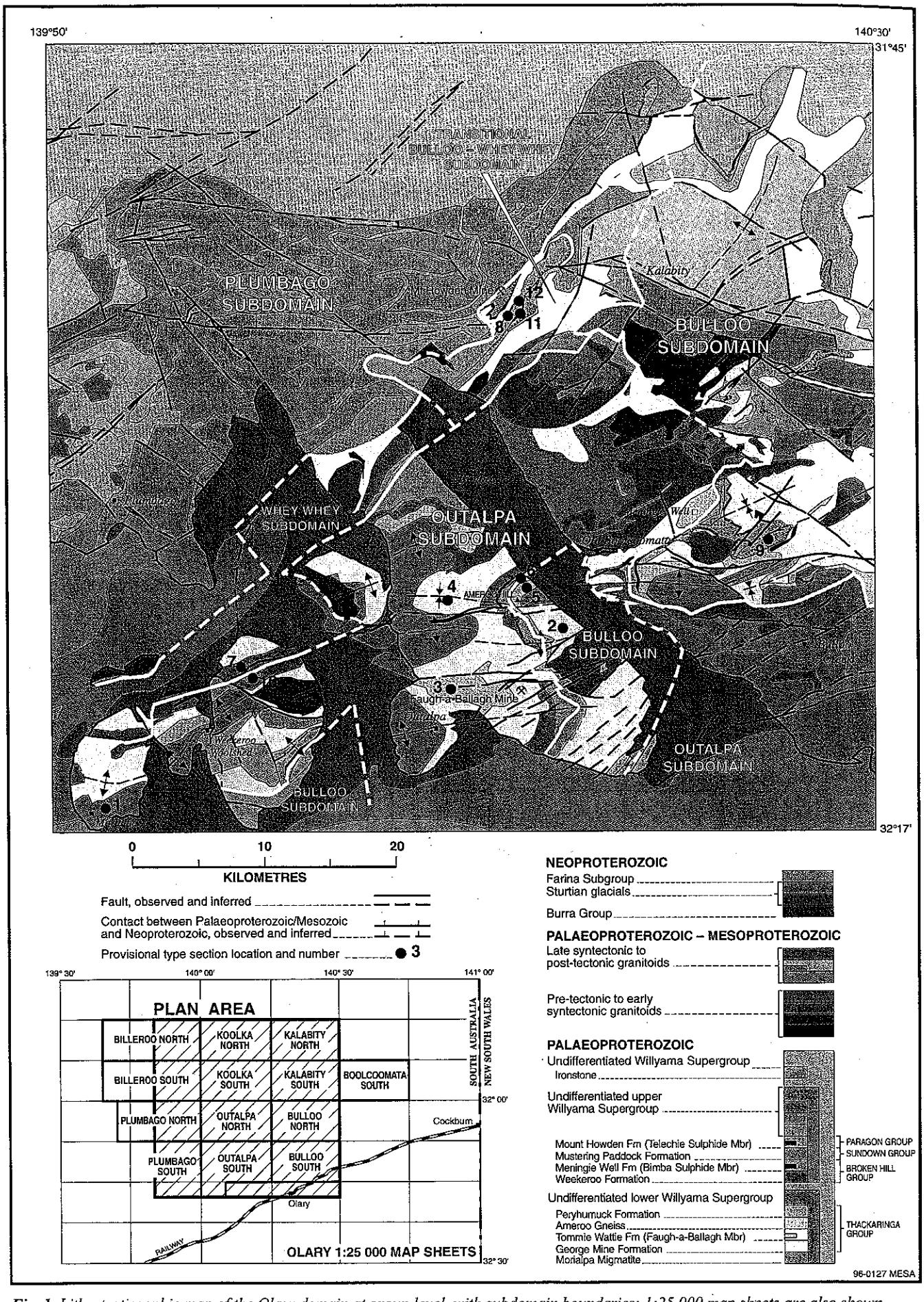

Fig. 1 Lithostratigraphic map of the Olary domain at group level, with subdomain boundaries; 1:25 000 map sheets are also shown.

more volume of discordant migmatite in the Olary domain than in the Broken Hill domain. Unfortunately, the present mapping information does not permit satisfactory distinction between the two types, and for present purposes all migmatite bodies (mappable at 1:100 000 scale) are assigned to the Morialpa Migmatite.

The Morialpa Migmatite corresponds with the lower part of the 'quartzofeldspathic suite' of previous workers (Ashley *et al.*, 1995). The Morialpa Migmatite correlates with the Clevedale Migmatite in the Broken Hill domain, and given that it contains composite gneiss in places, it also corresponds with at least part of the Thorndale Composite Gneiss in the Broken Hill domain. Mapping in the Olary domain commonly differentiates inconsistently between migmatite and composite gneiss in different areas. In general at Olary, 'composite gneiss' lying above migmatite has been allocated to the George Mine or Tommie Wattie Formations, and where it is interlayered with migmatite it has been allocated to the Morialpa Migmatite.

George Mine Formation

Derivation of name

From George Mine in the type locality.

Type locality

West of George Mine, 6 km southwest of 'Old Boolcoomata'; 428500mE–444200mN to 428000mE–442100mN; Outalpa South 1:25 000 map sheet.

Description

Plagioclase-rich metasediment, quartzofeldspathic metasediment and composite gneiss, and minor calc-silicate, calc-albitite and ironstone (magnetite and/or haematite). Minor Pb–Zn–Ag–Cu mineralisation occurs in and around the ironstone lithologies.

Thickness

1-3 km.

Relationships

The upper contact is defined by the base of the lowermost significant plagioclase-rich metasediment of the Peryhumuck Formation. The Peryhumuck is not recognised where the uppermost plagioclase-rich metasediment is thin or diffuse; in these cases the George Mine Formation directly underlies the Meningie Well Formation. The lower contact is the upper contact of the Morialpa Migmatite, and in many cases this corresponds to the lowermost 'marker' lithology of plagioclase-rich metasediment, calc-albitite, or ironstone (magnetite and/or haematite). A discrete plagioclase-rich unit (the 'Abminga metavolcanic') at or near the base contains relict quartz phenocrysts, and forms a distinctive marker unit. The George Mine Formation correlates with the Tommie Wattie Formation in the Outalpa and Whey Whey subdomains. The latter lacks the calc-albitite and ironstone lithologies of the George Mine Formation.

The formation correlates in a general way with the Cues Formation and, where it is present, the Lady Brassey Formation in the Broken Hill domain. The common occurrence of disseminated to locally abundant magnetite and/or amphibole in albitic gneisses of the George Mine Formation, particularly in the northern part of the Olary domain, correlates with similar rocks of the Ednas Gneiss and Redan Gneiss in the Broken Hill domain (Stevens and Corbett, 1993). These gneiss units are correlated in a general way with the Thorndale Composite Gneiss and the Clevedale Migmatite. The George Mine Formation therefore correlates with the Thackaringa Group and the underlying Thorndale Composite Gneiss and Clevedale Migmatite. The George Mine Formation, together with the Tommie Wattie Formation, corresponds with the upper part of the 'quartzofeldspathic suite' of Ashley *et al.* (1995). A widespread thick plagioclase-rich metasediment unit at or near the base, which includes an interpreted felsic metavolcanic at Abminga, corresponds to the 'lower albite' of previous workers (Ashley *et al.*, 1995). Zircon U–Pb determination on a sample of metavolcanic from Abminga yielded an age of 1699±10 Ma (Cook *et al.*, 1994).

Tommie Wattie Formation

Derivation of name

From Tommie Wattie Bore in the type locality.

Type locality

A large area northwest and west of Ameroo Hill, between Tommie Wattie Bore and Ameroo Springs Well, 8 km south of 'Bimbowrie'; 423000mE–447000mN to 422000mE–445200mN; Outalpa North and South 1:25 000 map sheets.

Description

Plagioclase-rich metasediment and well-bedded quartzofeldspathic metasediment, the former in thin, well-defined units within the envelope of the latter. The well-bedded nature is alluded to by previous workers as 'bedded schist or layered schist'. Locally abundant sedimentary structures, mostly cross-bedding and related traction current structures, occur in quartzofeldspathic beds. Minor Pb–Zn–Ag–Cu mineralisation occurs at the Chick in Green, Weekeroo, Maggie, Boundary, and Iron Idol mines and prospects.

Thickness

1-2 km.

Relationships

The upper contact is defined by the base of the lowermost marker unit of the Weekeroo Formation, generally amphibolite (in the type area) or siliciclastic metasediment (as in the Waterfall Bore area) overlying the uppermost plagioclase-rich metasediment of the Tommie Wattie Formation. The lower contact is the upper contact of migmatite of the Morialpa Migmatite, or in some cases poorly to non-bedded composite gneiss. The Tommie Wattie Formation correlates with the George Mine Formation in the Bulloo subdomain. It lacks the calc-albitite and ironstone lithologies of the George Mine Formation, and shows a greater abundance of metasediments and sedimentary structures. The Tommie Wattie Formation, together with the George Mine Formation, corresponds with the upper part of the 'quartzofeldspathic suite' of previous workers (Ashley *et al.*, 1995), unit 7 ('layered schist') of Grady *et al.* (1989, fig. 6) in the local Ameroo Hill sequence, and 'bedded schists' of Grady *et al.* (1989) in the Waterfall Bore area. The 'upper' and 'lower albite' of Ashley *et al.* (1995) is absent in the Tommie Wattie Formation, except perhaps as thin inconsequential units. The formation correlates in a general way with the Cues Formation in the Broken Hill domain.

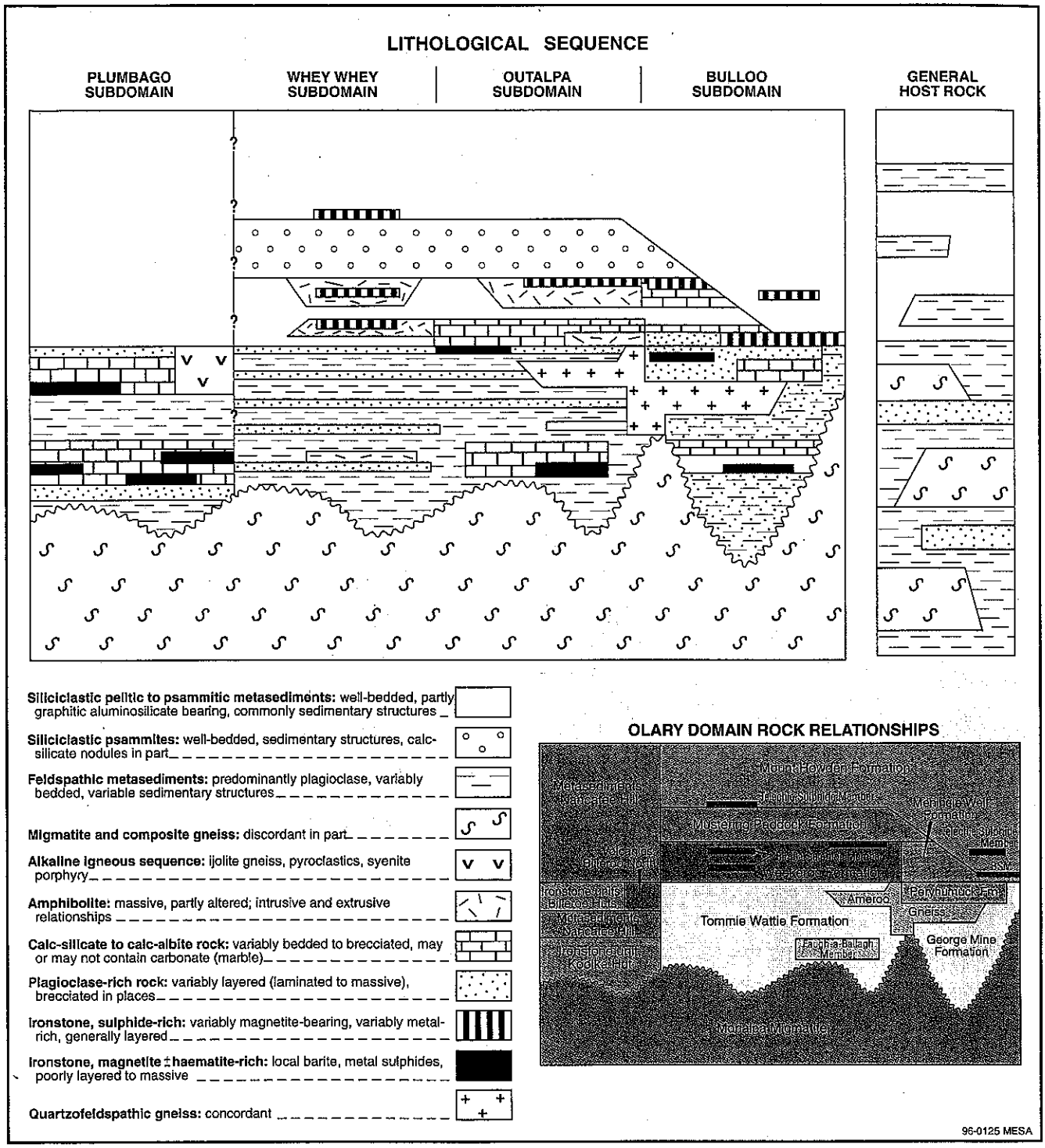

Fig. 2 Lithological sections and lithostratigraphic relationships in the four subdomains of the Olary domain, and a generalised section showing metasedimentary style.

Faugh-a-Ballagh Member

Derivation of name

From Faugh-a-Ballagh Mine east of the type locality.

Type locality

The area midway between Faugh-a-Ballagh Mine and 'Outalpa'; 422000mE–437200mN to 424650mE–438500mN; Outalpa South 1:25 000 map sheet.

Description

Calc-albitite and plagioclase-rich metasediment in quartzofeldspathic metasediment. Minor amphibolite and ironstone (magnetite and/or haematite). There are no recorded stratigraphic younging data, nor any significant mineralisation.

Thickness

0.5–1 km.

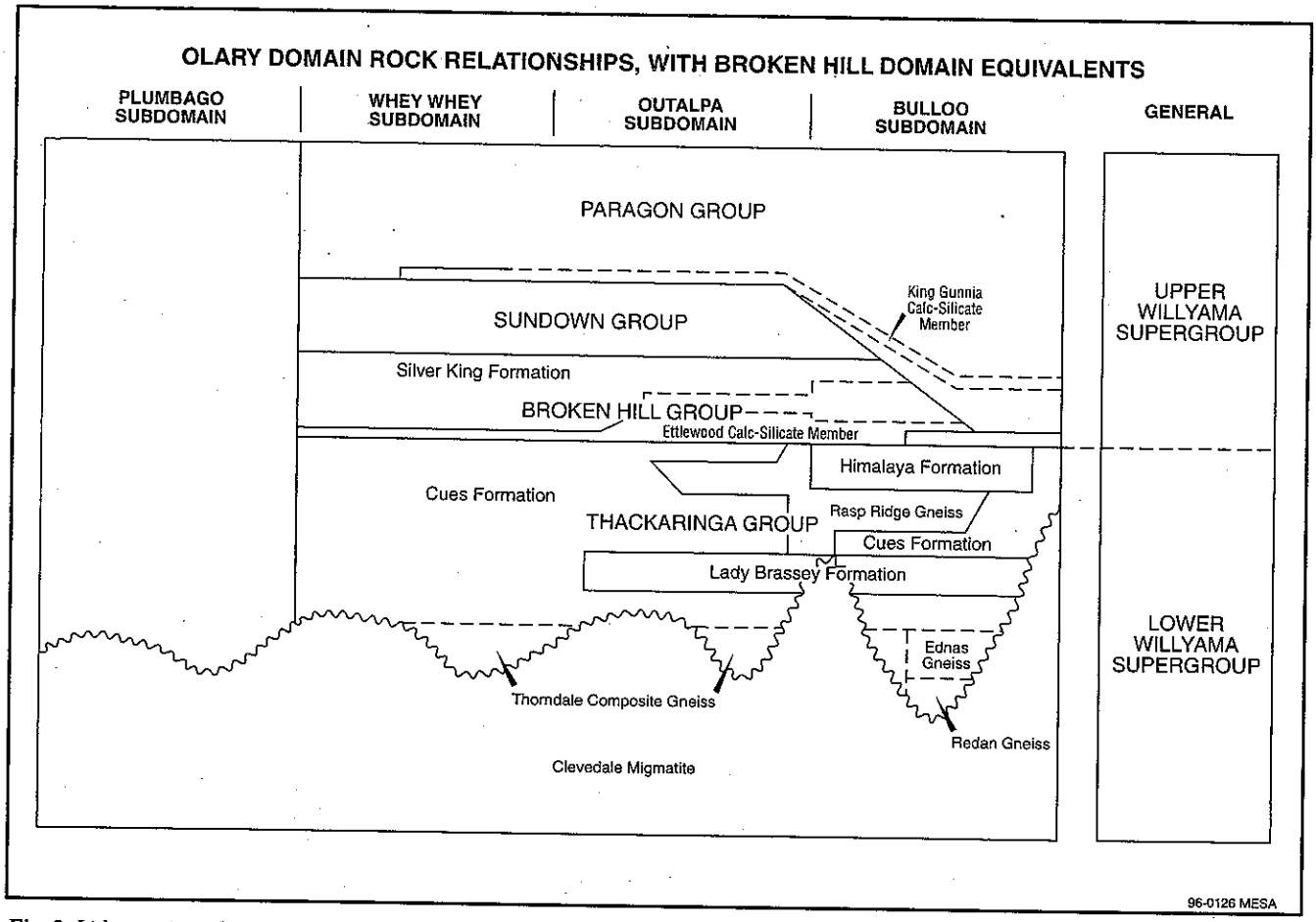

Fig. 3 Lithostratigraphic correlation with the Broken Hill domain.

Relationships

The contacts are defined by the contacts of calc-albitite or plagioclase-rich metasediment with homogeneous feldspathic metasediments of the Tommie Wattie Formation. The lower contact is in some cases poorly to non-bedded composite gneiss or migmatite of the Morialpa Migmatite.

The member corresponds in a general way to part of the Cues Formation in the Broken Hill domain. The Faugh-a-Ballagh Member lies within the 'quartzofeldspathic suite' of previous workers, corresponding with the 'lower albite' (Ashley *et al.*, 1995). Although it is not recognised as a separate unit in the George Mine Formation of the Bulloo subdomain, it is present *de facto* as thin units of calc-albitite and plagioclase-rich metasediment.

Peryhumuck Formation

Derivation of name

From Peryhumuck Mine in the type locality.

Type locality

Peryhumuck Mine and Ameroo Hill area, 6 km west of 'Old Boolcoomata'; 426200mE–446250mN to 426200mE–446400mN; Outalpa North 1:25 000 map sheet.

Description

Plagioclase-rich metasediment, commonly laminated and less commonly massive, with minor thin ironstone (magnetite and/or haematite dominated) and quartzofeldspathic metasediments. Thin calc-silicate units may also be present. Sedimentary structures (cross–bedding and graded bedding) are recorded in several areas. Sporadic Pb–Zn–Ag–Cu mineralisation is associated with ironstone lenses.

Thickness

100–500 m.

Relationships

The upper contact is defined by the top of the uppermost significant plagioclase-rich metasediment in the succession. In places this is specifically the uppermost laminated white to grey plagioclase-rich metasediment. Above this unit occurs a calc-silicate or calc-albitite unit which marks the (base of the) Meningie Well Formation. In places (e.g. the type area) this unit is lenticular, and the Peryhumuck Formation passes upward directly into the Mustering Paddock or Mount Howden Formation. The Peryhumuck Formation is not recognised where the uppermost plagioclase-rich metasediment is thin or diffuse; in these cases the sequence underlying the Meningie Well Formation is ascribed to the George Mine Formation. The lower contact is the base of the thick plagioclase-rich metasediment unit(s).

The formation correlates directly with the Himalaya Formation in the Broken Hill domain. The Peryhumuck Formation corresponds with the 'upper albite' of the 'quartzofeldspathic suite' of Ashley *et al.* (1995), and unit 3 ('quartz–albite granofels') of Grady *et al.* (1989, fig. 6) in the local Ameroo Hill sequence. Zircon U–Pb provides ages of 1785±16 Ma (Burdens Dam) and ~1775 Ma (Mount

Howden; Cook *et al.*, 1994). Given the evidence for a younger age of the sequence, from geochronological samples in adjacent units and by correlation with the Broken Hill domain (Page and Laing, 1992), these estimates are interpreted as the age of detrital zircons.

Ameroo Gneiss

Derivation of name

From Ameroo Hill in the type locality.

Type locality

Ameroo Hill area, 7 km west of 'Old Boolcoomata'; 425900mE–445000mN to 425100mE–445000mN; Outalpa South 1:25 000 map sheet.

Description

Variously described as a metagranitoid, massive felsic rock, locally foliated, biotite gneiss, granite gneiss, and adamellite gneiss. It is essentially a variably foliated leucocratic quartz–feldspar–biotite gneiss. The metagranitoid of Ashley *et al.* (1995) in the type area is described as having A-type granite affinities. Other large but lenticular granitoid bodies in the same stratigraphic position are generally strongly foliated, and all are essentially concordant with the enclosing metasedimentary sequence. They are annotated G1 on the Olary 1:100 000 lithostratigraphic map (Laing, 1995b), and include units at Ameroo Hill, 'Weekeroo', Flachuber, Mount Mulga, and Meningie Well. There are no reliable stratigraphic younging data, nor any recorded mineralisation.

Thickness

200–1 000 m.

Relationships

Both contacts appear to be well defined. The upper contact is defined by the top of the metagranitoid, and coincides in several areas with the base of the Peryhumuck Formation. In other areas it coincides with the base of siliciclastic metasediment of the lower Weekeroo Formation. The lower contact is the base of the metagranitoid. In at least one locality the base lies against Morialpa Migmatite. It is possible that some bodies of the Ameroo Gneiss are syntectonically produced by anatexis and deformation localised around migmatite cores. These bodies would not necessarily have stratigraphic significance, and would comprise granitoid types G1b in Laing (1995b). Stratiform granitoid bodies like the Ameroo Hill body are granitoid type G1a, and are inferred to represent synsedimentary felsic volcanics or granitoid sills, or early tectonically emplaced granitoid intrusives.

The Ameroo Gneiss correlates directly with the Rasp Ridge Gneiss in the Broken Hill domain. The Ameroo Gneiss was not accommodated in previous stratigraphic schemes, although by default it lay within the 'quartzofeldspathic suite' of Ashley *et al.* (1995). It is unit 2 ('adamellite gneiss') of Grady *et al.* (1989) in the local Ameroo Hill sequence. Zircon U–Pb on a metagranitoid sample at Ameroo Hill yielded an age of 1703±6 Ma (Cook *et al.*, 1994).

Weekeroo Formation

Derivation of name

From Weekeroo Woolshed.

Type locality

6 km northeast of Weekeroo Woolshed; 405000mE–440300mN to 405500mE–439350mN; Plumbago South 1:25 000 map sheet.

Description

Massive amphibolite, quite heterogeneous, and variably brecciated and altered to calc-silicate assemblages. Discontinuous on a regional scale. Underlain and interleaved by siliciclastic pelitic metasediments. A range of textures, mostly igneous, has been reported, varying from ophitic, vesicular, and porphyritic, to pillows with chilled margins. Metasedimentary interbeds have also been reported. The breccias contain only amphibolite clasts (Grady *et al.*, 1989). Some observers consider the amphibolite to be locally intrusive (Campana and King, 1958; Talbot, 1967; Grady *et al.*, 1989), others locally extrusive (Jones *et al.*, 1962; Grady *et al.*, 1989), while Campana and King (1958) interpreted them as metamorphosed sedimentary rocks. Pillows are observed in the 'Weekeroo' area (Jones *et al.*, 1962; Grady *et al.*, 1989), rendering at least some of the amphibolite extrusive in origin. Extensive metasomatic alteration of the amphibolite has been described by Davis (1989) and Taylor (1985). Cross-bedding in metasediments is recorded at various locations. Pb–Zn–Mn mineralisation has been

Pillow lava, Weekeroo Formation. (Photo 43891)

recorded (unpublished data of the author) along the contacts of thin Fe/Ca/Mn carbonate/oxide/silicate units of the Bimba Sulphide Member (Grady *et al.*, 1989).

Thickness

Several horizons totalling 200–500 m.

Relationships

The amphibolite appears to be grossly concordant, but with locally discordant relationships to the enclosing metasediments, including sheared and interleaved margins (Jones *et al.*, 1962; Grady *et al.*, 1989). It is the constituent and only formation of the Broken Hill Group in the Outalpa and Whey Whey subdomains. The Weekeroo Formation is correlated with the Meningie Well Formation in the Bulloo subdomain, which contains no amphibolite, but does not occur in the Plumbago subdomain. The Weekeroo Formation contains local lenses of Bimba Sulphide Member.

The upper amphibolite unit is provisionally correlated with the Silver King Formation in the Broken Hill domain, but this will be clarified with more detailed geochemical characterisation of the component amphibolites. The lower pelitic metasediments correlate with the Freyers and/or Allendale Metasediments in the Broken Hill Group. The Weekeroo Formation was not satisfactorily accommodated in previous Olary stratigraphic schemes. It corresponds with unit 6 ('albitite, calc-silicate and amphibolite') of Grady *et al.* (1989, fig. 6) in the local Ameroo Hill sequence.

Meningie Well Formation

Derivation of name

From Meningie Well in the type locality.

Type locality

Area between Meningie Well, Blue Dam, and Gum Creek, 9 km northeast of 'Old Boolcoomata'; 444500mE–449100mN to 444500mE–449750mN; Bulloo North 1:25 000 map sheet.

Description

A combination of thin units and lenses of calc-silicate, calc-albitite, marble, sulphidic ironstone, and banded iron silicate formation (these being termed 'marker units', as discussed below) in a siliciclastic pelitic to psammitic metasediment sequence which is commonly graphitic. The ironstone and banded iron silicate formation are ascribed to the Bimba Sulphide Member. Stratigraphic younging data are recorded at Mount Perseverance and Walparuta. Significant Pb–Zn–Ag–Cu mineralisation occurs in and adjacent to the Bimba Sulphide Member.

Thickness

Varies systematically, from thickest in the southeast at Meningie Well (300–500 m), to a few metres in the north where it is represented by the Bimba Sulphide Member. It is not present in the western part of the Bulloo subdomain, where the Peryhumuck Formation is overlain by the Mustering Paddock and Mount Howden Formations.

Relationships

Overlain by graphitic and pelitic siliciclastic metasediments of the Mount Howden Formation, and at Ameroo Hill by the Mustering Paddock Formation. The upper contact is defined by the uppermost 'marker' unit (or lens), rather than graphitic metasediment, which may occur both above and below the marker unit. In the type locality the uppermost 'marker' unit appears to comprise banded iron silicate formation or sulphidic ironstone within graphitic metasediment. This provides an alternative possible stratigraphic interpretation in which this ironstone unit is the Telechie Sulphide Member within the Mount Howden Formation.

The Meningie Well Formation is underlain by plagioclase-rich metasediments and composite metasedimentary gneiss of the Peryhumuck Formation and the George Mine Formation. The lower contact is defined by the lowest 'marker' unit (or lens). In places the contact lies within plagioclase-rich metasediments, which contain significant calc-silicate assemblages in their upper part, and the contact is placed at the base of the calc-silicate-bearing plagioclase-rich metasediments. The lower contact of the Meningie Well Formation is more readily defined magnetically than lithologically, given the presence of plagioclase-rich units in both the Meningie Well Formation and the underlying Peryhumuck Formation. The former has a poorly to non-magnetic signature, while the latter commonly contains disseminated magnetite or magnetite-rich ironstone, and has a strong curvilinear magnetic signature. The Meningie Well Formation includes the Bimba Sulphide Member. The latter is defined as sulphidic ironstone and banded iron silicate formation, but these units are locally intimately mixed with the other marker units, hence the definition of Bimba Sulphide Member is *sensu lato*. In some areas it is the only representative of the Meningie Well Formation, and is an economically significant facies of the latter.

The Meningie Well Formation, dominated by calc-silicate and plagioclase-rich marker units, is correlated with the Weekeroo Formation in the Outalpa and Whey Whey subdomains, which is dominated by amphibolite and lesser calc-silicate. The Meningie Well Formation has close affinities with the Allendale Metasediments and Ettlewood Calc-silicate Member in the lower part of the Broken Hill Group in the Broken Hill domain, but the presence of the Bimba Sulphide Member also shows affinities with the upper Broken Hill Group. The Meningie Well Formation is regarded as spanning the complete Broken Hill Group. It has, however, a more plagioclase-rich signature than the Broken Hill Group at Broken Hill. The Meningie Well Formation corresponds with a significant proportion of the 'calc-silicate suite' of Ashley *et al.* (1995).

Bimba Sulphide Member

Derivation of name

From Bimba Mine in the type locality.

Type locality

The area around Bimba Mine, Mount Howden and Mount Howden Mine, 10 km west of 'Kalabity'; 424400mE–466500mN to 424250mE–466600mN; Koolka South 1:25 000 map sheet.

Description

Sulphide-rich ironstone and banded iron silicate formation define the Bimba Sulphide Member *sensu stricto*. Their mineralogy includes pyrite, pyrrhotite, and variable magnetite, garnet, siderite, apatite, grunerite, calcite, vesuvianite, fluorite, scheelite, sphalerite, chalcopyrite, arsenopyrite, galena, and cobaltite (Ashley *et al.*, 1995; Grady *et al.*, 1989). There is commonly more than one horizon of sulphidic ironstone and banded iron silicate formation, and these are intimately combined with thin units and lenses of calc-silicate, marble, calc-albitite and plagioclase-rich metasediment in a thin siliciclastic graphitic pelitic to psammitic metasediment sequence. It is not clear whether this is due to fold repetition or stratigraphic repetition, in combination with facies variation. For these reasons it is useful to recognise a Bimba Sulphide Member *sensu lato* (see below). No stratigraphic younging data have been mapped within the member. Pb–Zn–Ag–Cu–Co–pyrite–pyrrhotite mineralisation occurs in disseminated, vein, laminated, and rare massive sulphide bodies (Ashley *et al.*, 1995). This has been drill-tested at a number of locations around the Olary domain (Yates and Randell, 1993).

Thickness

Varies from one ironstone in the order of 1 m thick, to several ironstones several metres thick, separated by an interval of up to several tens of metres. The total thickness is 50-100 m.

Relationships

The Bimba Sulphide Member lies within the Weekeroo Formation and the Meningie Well Formation. In some areas it is the only representative of the Meningie Well Formation. Isolated ironstones at the top of the Meningie Well Formation may be underlain by graphitic metasediment, and these can be regarded as Bimba Sulphide Member extending upwards into the Mount Howden Formation. Such stratigraphically high ironstones may be indistinguishable from the Telechie Sulphide Member. The Bimba Sulphide Member is correlated with ironstones and sulphide mineralisation (mainly in the upper part) of the Broken Hill Group at Broken Hill.

Mustering Paddock Formation

Derivation of name

From Mustering Paddock Bore, 3 km northeast of the type locality.

Type locality

3 km southwest of Mustering Paddock Bore, 5 km northeast of Weekeroo Woolshed; 405500mE–439350mN to 405650mE–439000mN; Plumbago South 1:25 000 map sheet.

Description

Predominantly psammitic and psammopelitic metasediments, siliciclastic, thin to thick bedded, with common sedimentary structures, and local calc-silicate ellipsoids (Ameroo Hill). Stratigraphic younging data are locally abundant as cross-bedding and graded bedding, up to several tens of centimetres, in thin to thick psammite and metagreywacke beds (Grady *et al.*, 1989). No mineralisation is recorded.

Thickness

100–300 m.

Relationships

Overlies amphibolite of the Weekeroo Formation, lenticular calc-silicates of the Meningie Well Formation and, in the Ameroo Hill area, the Peryhumuck Formation. It is overlain by graphitic pelitic metasediments of the Mount Howden Formation and, at Telechie Valley, by the Telechie Sulphide Member. It is the constituent and only formation of the Sundown Group in the Olary domain, and is correlated with the Sundown Group in the Broken Hill domain. The Mustering Paddock Formation corresponds to the lower part of the 'pelite suite' of previous workers in those areas where the 'pelite suite' has a distinctive psammitic unit at its base.

Mount Howden Formation

Derivation of name

From Mount Howden and Mount Howden Mine (Cu–Co) in the type locality.

Type locality

Near Mount Howden and Mount Howden Mine; 424250mE–466600mN to 424100mE–467300mN; Koolka South 1:25 000 map sheet. This section occupies both limbs of a local fold to maximise the exposure.

Description

Pelitic, psammopelitic and lesser psammitic metasediments, fine-grained, and siliciclastic. Graphitic at base and variably throughout, with aluminosilicates (generally andalusite with local coarse chiastolite, and minor sillimanite) in some units. Calc-silicate beds and lenses, and local tourmaline, occur in several parts of the sequence. Small-scale sedimentary structures are locally abundant in psammitic beds. They are mostly traction current types, small-scale (<100 mm), and relatively fine grained (silt to fine sand size). A sulphidic ironstone, the Telechie Sulphide Member, at the base carries Cu–Pb–Zn mineralisation.

Thickness

Unknown due to lack of top, but is a minimum of 0.5-1 km and probably exceeds 2 km.

Relationships

It is the uppermost unit in the Willyama Supergroup and Paragon Group. The lower contact is locally against the Mustering Paddock Formation (Sundown Group) in the Outalpa and Whey Whey subdomains, but more extensively against the Meningie Well Formation (Broken Hill Group) in the Bulloo subdomain, including the Bimba Sulphide Member. In the Bulloo subdomain, the unit also directly overlies the Peryhumuck Formation. These latter relationships, which represent the absence of the Sundown and Broken Hill Groups, appear to be disconformable. The formation is the constituent and only formation of the group

in the Olary domain, and is correlated with the Paragon Group in the Broken Hill domain. Component formations at Broken Hill, for example Bijerkerno Metasediments, may be present at Olary. The Mount Howden Formation corresponds largely to the 'pelite suite' of Ashley *et al.* (1995). The unit is present in the Plumbago subdomain, where it is at least 1 km thick, but lack of stratigraphic younging data preclude its differentiation from possible similar metasediments in the Meningie Well Formation type interval or even the George Mine Formation type interval.

Telechie Sulphide Member

Derivation of name

From Telechie Valley, east of Mount Howden.

Type locality

Telechie Valley; 426000mE–467600mN to 426200mE–467600mN; Koolka South 1:25 000 map sheet.

Description

Sulphide-rich ironstone carrying Cu–Pb–Zn mineralisation.

Thickness

1–?20 m.

Relationships

Constituent member of the Mount Howden Formation and the Paragon Group. It occurs at and above the contact between the Mustering Paddock and Mount Howden Formations. It has been ascribed previously to the informal 'Bimba formation' (Hemming and Lewis, 1979) but it lies above the base of the Mount Howden Formation in the type area, and in the Waukaloo Syncline. In the Meningie Well–Bulloo Well area, a number of small lenses of banded iron formation within pelitic, partly graphitic metasediment above the main units of the Meningie Well Formation have been drafted on the 1:100 000 map sheet (Laing, 1995b) along the upper contact of the Meningie Well Formation because of scale limitations. However, these ironstones lie strictly within the Mount Howden Formation ('pelite suite' of Ashley *et al.*, 1995, p.27) and may correspond to the Telechie Sulphide Member. They consist of quartz, magnetite, garnet, grunerite, manganese fayalite, and apatite. Lithologically these ironstones are similar to the distinctive banded iron formations in the Broken Hill domain, in the Broken Hill Group and also at the base of the Sundown Group (Laing, 1977). These Telechie Sulphide Member ironstones mark the base of the thick metasedimentary succession which forms the upper Willyama Supergroup, hence they may correlate with the iron formation at the base of the Sundown Group in the Broken Hill domain. The Telechie Sulphide Member may correlate in a broad way with the King Gunnia Calc-silicate Member.

Unassigned lithological units

The Plumbago subdomain in the northwest has been mapped in some detail by several workers, but with no recorded stratigraphic younging data. The area broadly east of 140°30'E, including the area around Aldockra Hill, is a poorly exposed and mapped area also without stratigraphic younging data. These areas are divided into unassigned lithological units, the former with relative clarity (supported by magnetic data), and the latter into broad lithological units only.

Plumbago subdomain

A lithological sequence can be mapped extensively in this subdomain, but its translation into lithostratigraphy is prevented by repetition of lithological packages, with a suggestion of sequence symmetry, and a lack of younging data. The repeated lithological packages consist of:

- a thick (~1–2 km) metasediment package, partly graphitic, non-magnetic; informally named the Nancatee metasediments
- a thinner (~0.1–1 km) sequence of plagioclase-rich horizons, calc-silicate and calc-albitite horizons, and ironstone horizons, one moderately and one strongly curvilinear magnetic; informally named the Billeroo Huts ironstone unit and Koolka Hut ironstone unit, respectively.

The Nancatee metasediments can be ascribed lithologically to the Mount Howden Formation where they are graphitic (e.g. at Koolka Hill), and possibly the Tommie Wattie Formation where they are non-graphitic. The Billeroo Huts and Koolka Hut ironstone units are lithologically similar to the Peryhumuck Formation or the underlying George Mine Formation. The former is the more likely as the ironstone units are thin and generally abut against the metasediments, with little 'room' for intervening Peryhumuck Formation.

The Plumbago subdomain contains a distinctive package of alkaline intrusive and extrusive rocks in the Billeroo Huts ironstone unit at Billeroo North (Bell *et al.*, 1979). This unit, informally named the Billeroo North volcanics, represents a significant, unusual facies of the Thackaringa Group, which appears to be limited, on the basis of its localised aeromagnetic extent, to the Billeroo North area. The Billeroo North volcanics are strongly magnetic, and it is nevertheless possible that some strong curvilinear units elsewhere in the Plumbago subdomain, currently ascribed to the Koolka ironstone unit, represent lateral repetitions of the volcanics. The Bimba and Telechie Sulphide Members have not been recorded in the Plumbago subdomain.

Age and rate of deposition of the Willyama Supergroup

The dated metagranitoid at Ameroo Hill, near the top of the Thackaringa Group, is the closest stratigraphic sample at Olary to samples in the Broken Hill domain which were dated by Page and Laing (1992) at 1693±5 Ma (Parnell Formation, middle Broken Hill Group), and 1680–1690 Ma (Hores Gneiss, at the top of the upper Broken Hill Group). If the Ameroo Gneiss is an extrusive metavolcanic, its age of 1703±6 Ma indicates deposition of the Broken Hill Group between 1703 and 1680 Ma. If the Ameroo Gneiss, as seems more likely from its textures, is an intrusive, possibly subvolcanic unit, the ages indicate a somewhat older maximum age for the Broken Hill Group. The Abminga metavolcanic age of 1699±10 Ma for the lower Thackaringa Group more tightly constrains the Broken Hill Group to a maximum age somewhat less than 1699±10 Ma. Taking all these considerations together, the Broken Hill Group may be

synchronous across the Olary and Broken Hill domains, with an age span between 1705 and 1680 Ma. The Abminga metavolcanic would be near its maximum indicated age of 1709 Ma. The depositional timespan of the Thackaringa and Broken Hill Groups would be ~30–35 million years which, given their combined thickness of ~3–4 km, indicates a mean depositional rate of 1 mm/year.

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