

Making sense of the Eastern Goldfields stratigraphic story

by

MC De Paoli, J Sapkota, and S Wyche

Introduction

Since Woodall (1965) defined the first formal stratigraphy for the Kalgoorlie greenstones, various researchers, explorers and miners have used a plethora of names to describe the Archean geological units in the Eastern Goldfields. Local stratigraphic components shown on published 1:250 000- and 1:100 000-scale geological maps in the Eastern Goldfields region of the Archean Yilgarn Craton are based mainly on mapped outcrop distribution. As much of the geology is poorly exposed and deeply weathered, field relationships are difficult to establish in many places.

The Geological Survey of Western Australia (GSWA) is developing a seamless geological interpretation map of the Eastern Goldfields based on published mapping enhanced by new geochronological, geochemical and geophysical data. While there have been previous stratigraphic interpretations of Eastern Goldfields geology (e.g. Gemuts and Theron, 1975; Williams, 1976), this map will be the first synthesis of formal stratigraphy for the entire Eastern Goldfields region. The current project area (Fig. 1) extends between Leinster in the north and Norseman in the south. The first release, in 2014, covered the Lawlers and Coolgardie–Kambalda regions. Recent annual releases have included the Teutonic Bore, Leonora–Kookynie and Ora Banda – Siberia regions. The next release, in 2017, will include the geological interpretation around Menzies and Davyhurst.

Rationale

In current representations of Yilgarn Craton geology, the Eastern Goldfields Superterrane (Cassidy et al., 2006) constitutes the eastern part of the craton that is separated from the Youanmi Terrane to the west by a major crustal feature, which is evident in geophysical (Wyche et al., 2013) and isotopic (Wyche et al., 2012) data. This feature broadly coincides with a mapped structure, the Ida Fault (Fig. 1). The superterrane is bounded to the north by the Capricorn Orogen and to the south by the Albany–Fraser Orogen. Its eastern edge is covered by Phanerozoic rocks of the Canning Basin.

The Eastern Goldfields Superterrane is a structural entity that has been divided into fault-bounded tectono-

stratigraphic terranes. The most widely published subdivision comprises four terranes: the Kalgoorlie, Kurnalpi, Burtville, and Yamarna Terranes (Fig. 1; Cassidy et al. 2006; Pawley et al., 2012). Terranes were defined on the basis of distinct lithological associations, geochemistry, and ages of volcanism (Swager, 1997). Other versions of the Eastern Goldfields terrane configuration (e.g. Barley et al., 2008) show different boundaries suggesting different lithological associations.

By analogy with other Archean cratons, the Yilgarn terrane model was interpreted to suggest that the present configuration of the Yilgarn Craton is a result of accretion of a number of pre-existing ‘continents’ in a series of collisional events between c. 2800 and 2650 Ma (e.g. Myers, 1995). With the completion of more comprehensive mapping over the region (Geological Survey of Western Australia, 2016b), and the acquisition of a substantial body of geochronological (e.g. Kositsin et al., 2008; Geological Survey of Western Australia, 2016a) and geochemical (e.g. Barnes et al., 2012; Geological Survey of Western Australia, 2016c) data, more complex evolutionary models that might involve rifting with or without accretion have been suggested (e.g. Czarnota et al., 2010; Barnes et al., 2012).

New geophysical, geochronological and geochemical data, combined with regional mapping programs, across the Yilgarn Craton, have highlighted problems and limitations with the terrane representation. There is a broad correspondence between the terranes and geochemical and stratigraphic associations, and isotopic data suggest different episodes of crust generation that also broadly correspond to the terranes (Wyche et al., 2012). However, there are many examples where clearly related lithological units transgress terrane boundaries.

The new geological interpretation incorporates formal stratigraphy (Fig. 2), which is described in detailed explanatory notes that are routinely prepared and published in the online GSWA Explanatory Notes System (ENS) database. Entries include type sections or areas, geochronological constraints and detailed lithological descriptions. All formally named units are registered in Geoscience Australia’s Australian Stratigraphic Units Database. As the new interpretation proceeds, the new formal stratigraphy will more faithfully reflect the geology as seen on the ground.

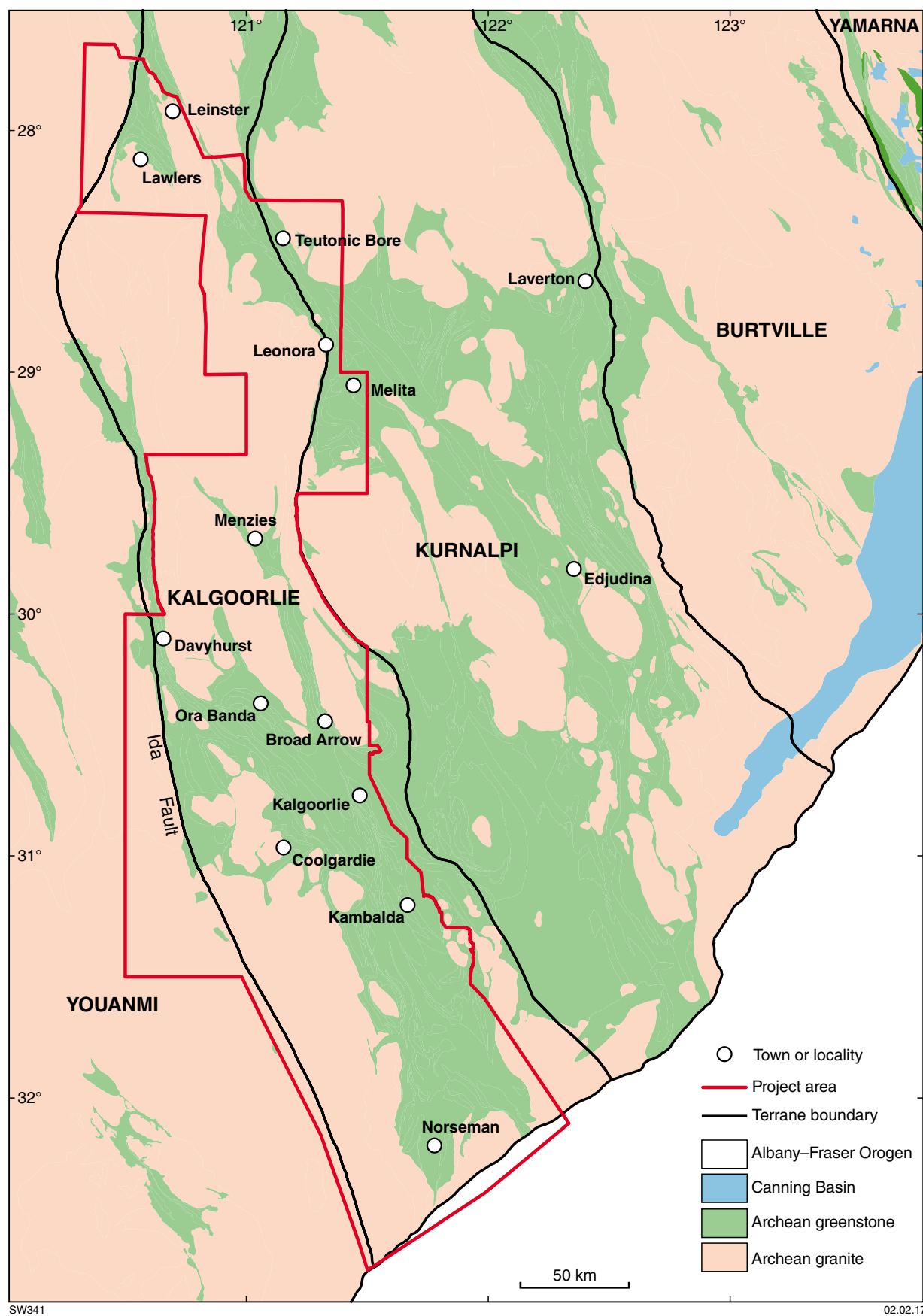


Figure 1. Current extent of the seamless geological bedrock interpretation over the Eastern Goldfields Superterrane

Eastern Goldfields stratigraphy

The current program involves interpretation of the western part of the Eastern Goldfields Superterrane between Norseman and Leinster (Fig. 1). Associations largely assigned to the Kalgoorlie Terrane form the Kalgoorlie, Black Flag and Mount White Groups. The Gindalbie Group, in the western part of the Kurnalpi Terrane of Cassidy et al. (2006) includes volcanic associations that Barley et al. (2008) assigned to their Gindalbie Terrane. Overlying siliciclastic successions, the 'late, syntectonic basins' of Swager (1997), have been distinguished as separate formations. It is likely that the Kalgoorlie, Black Flag, Mount White and Gindalbie Groups, along with other volcanic associations to the east and north within the Cassidy et al. (2006) Kalgoorlie and Kurnalpi Terranes will ultimately be assigned to an 'Eastern Goldfields Supergroup'.

Age constraints

Most mafic–ultramafic successions cannot be dated directly because of the lack of suitable minerals, typically zircon, for analysis. Thus age ranges for formations and their components are inferred from such things as maximum depositional ages of interbedded, overlying or underlying sedimentary rocks; intrusive rocks that can be dated such as granite or differentiated mafic sills; and ages of overlying or underlying felsic volcanic rocks that can also be dated.

Kalgoorlie Group

The Kalgoorlie Group (2726–2680 Ma), comprises most of the lower mafic–ultramafic package in greenstone belts between Norseman and Leinster. It locally overlies, or is structurally juxtaposed against, older (>2800 Ma) mafic–ultramafic successions such as the Trevors Bore Formation around Leonora and the Cock Robin Formation around Menzies. The various rock successions that form the greenstone belts within the Kalgoorlie Group are not physically continuous but they have similar stratigraphy and the same age range. Variations in detailed stratigraphy and the chemical character of stratigraphically equivalent units across major structures and between greenstone belts suggest that, although products of the same geological event, at least some of the successions may have been deposited in distinct basins. Where there are continuous successions, they have been distinguished as subgroups (Fig. 2). To date, the mapped subgroups include the Hannans (Kalgoorlie–Kambalda area), Coolgardie, Vettors (Ora Banda area), Broad Arrow, Marshall Pool (Teutonic Bore area) and Two Sisters Subgroups (Lawlers area). At Lawlers and Coolgardie, the typical Kalgoorlie Group succession appears to be underlain by a mafic–ultramafic succession with similar characteristics but there are presently no geochronological or geochemical constraints that allow this succession to be assigned to the Kalgoorlie Group.

The Kalgoorlie Group has been intruded by mafic–ultramafic sill complexes, such as the Bounty Igneous Complex near Lawlers and the Williamstown Dolerite near Kalgoorlie, at different stratigraphic levels.

Black Flag and Mount White Groups

The Black Flag Group (2692–2665 Ma), which comprises felsic and mafic volcanic and volcanoclastic rocks, overlies the Kalgoorlie Group in the Kalgoorlie–Coolgardie–Kambalda region. To the north, in the Lawlers region, the Mount White Group, which is similar to the Black Flag Group in lithofacies characteristics, age and stratigraphic relationships, is exposed in a syncline west of Leinster. Equivalent successions to the Black Flag Group have not been recognized in the Leonora area.

Both the Black Flag and Mount White Groups have been extensively intruded by mafic sills such as the Powder Gabbro that intrudes the Black Flag Group west of Kalgoorlie.

Gindalbie Group

The Gindalbie Group, which outcrops in volcanic centres at Melita and Teutonic Bore, comprises bimodal (basaltic to rhyolitic) and calc-alkaline volcanic successions with associated intrusive rocks and quartz-rich sedimentary rocks. It hosts volcanogenic massive sulfide mineralization at Teutonic Bore. Felsic volcanic rocks of the Gindalbie Group have been directly dated from a number of volcanic centres and range in age from c. 2694 to 2680 Ma.

Uppermost siliciclastic sequences

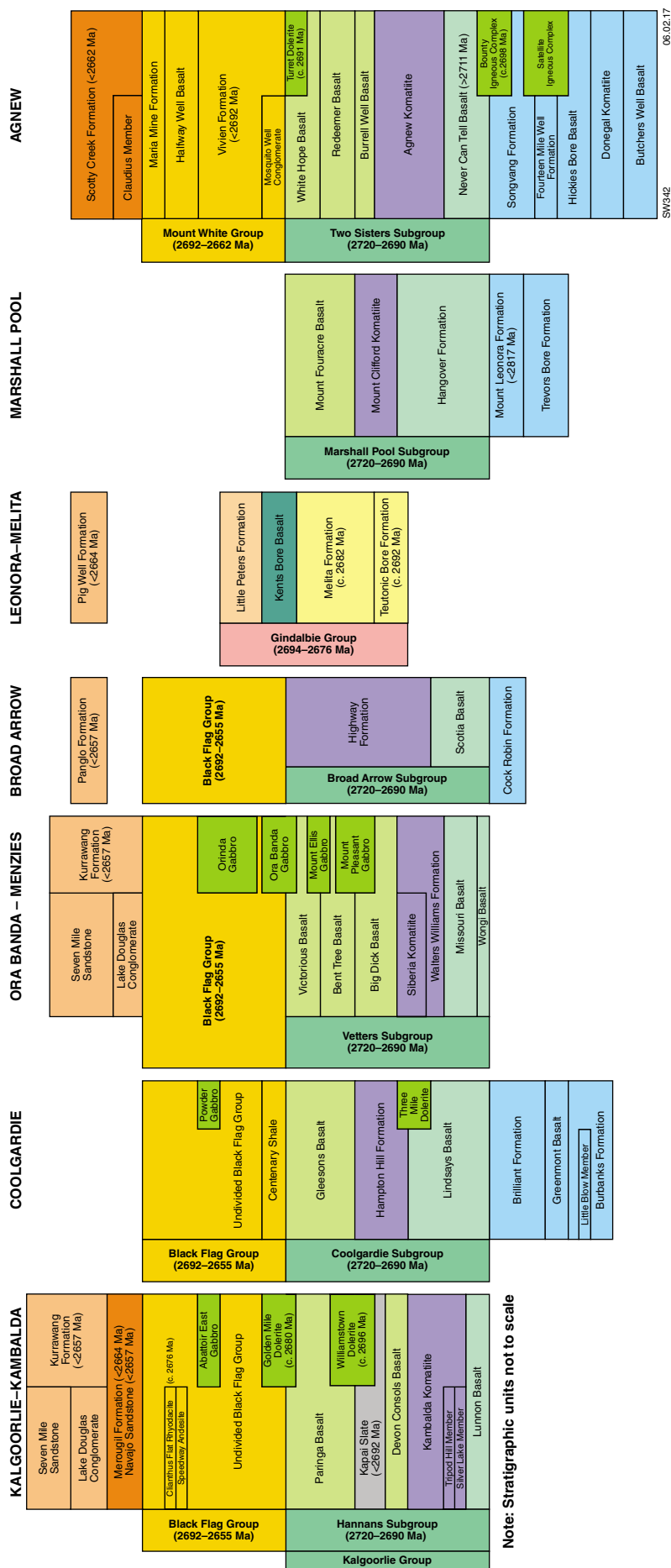
Siliciclastic and felsic volcanoclastic rocks that unconformably overlie the Mount White and Black Flag Groups include the Scotty Creek Formation (2662–2640 Ma) in the Lawlers region, the Pig Well Formation (2664–2662 Ma) to the east and southeast of Leonora, the Navajo Sandstone (2657–2640 Ma) southwest of Kalgoorlie, and the Merougil Formation (2664–2640 Ma) west of Kambalda.

The Kurrawang Formation (<2657 Ma) overlies the Black Flag Group and Navajo Sandstone west of Kalgoorlie along a low-angle unconformity. The lower part of the Kurrawang Formation has an exotic clast provenance represented by banded iron-formation, granite, gneiss, metasedimentary rocks and felsic volcanic rocks.

The future

The next stage of the program will see completion of interpretation of the successions between Norseman in the south and Wiluna, to the north of Leinster, that correspond to the area typically shown as the Kalgoorlie Terrane. Future interpretation to the east will embrace the region of relatively juvenile crust indicated in isotopic data (Wyche et al., 2012) that corresponds to the Kurnalpi Terrane.

GSWA is also acquiring a large amount of high-quality geochemical data, mainly derived from diamond drillholes where available. These data will be used to characterize various stratigraphic components and will provide fundamental constraints on tectonic models. The most comprehensive overview of Yilgarn granites is that of Cassidy et al. (2002). New geochemical, geophysical



Note: Stratigraphic units not to scale

Figure 2. Formal stratigraphic associations between Kambalda and Leinster in the current release of the East Yilgarn seamless geology. The thickness of the stratigraphic units is not to scale.

and geochronological data are being used to implement a granite nomenclature scheme (Cassidy et al., 2002) that is consistent with formal stratigraphy across the craton.

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