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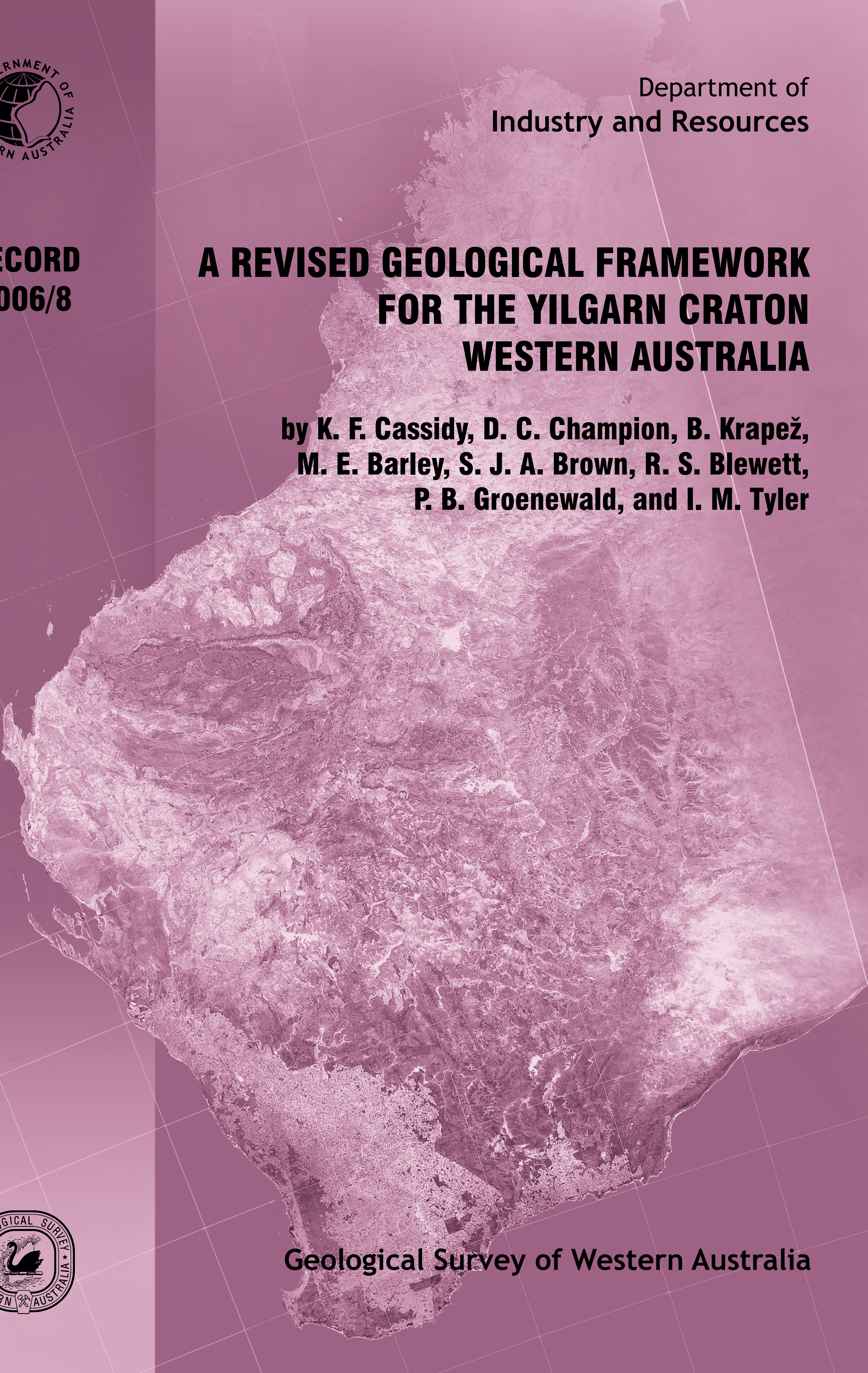
A REVISED GEOLOGICAL FRAMEWORK FOR THE YILGARN CRATON WESTERN AUSTRALIA

by K. F. Cassidy, D. C. Champion, B. Krapež, M. E. Barley, S. J. A. Brown, R. S. Blewett, P. B. Groenewald, and I. M. Tyler



Geological Survey of Western Australia

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

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K. F. Cassidy[1], D. C. Champion[1], B. Krapež[2], M. E. Barley[2], S. J. A. Brown[2], R. S. Blewett[1], P. B. Groenewald[3], and I. M. Tyler[3]

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by

K. F. Cassidy[1], D. C. Champion[1], B. Krapež[2], M. E. Barley[2], S. J. A. Brown[2], R. S. Blewett[1], P. B. Groenewald[3] and I. M. Tyler[3]

Abstract

New geological and geochronological data have been used to revise the geological framework of the Archean Yilgarn Craton of Western Australia. The Yilgarn Craton is subdivided into six terranes, three of which constitute a superterrane. Along the western margin the Narryer Terrane and South West Terrane are dominated by granite and granitic gneiss, whereas the Youanmi Terrane and Eastern Goldfields Superterrane are composed of north-trending greenstone belts separated by extensive granite and granitic gneiss. The Youanmi Terrane is the amalgamation of the Murchison and Southern Cross Domains and possibly represents the nucleus, or protocraton, onto which the Narryer Terrane and Eastern Goldfields Superterrane were accreted.

The Eastern Goldfields Superterrane comprises three tectono-stratigraphic terranes, defined on the basis of distinct volcanic facies, geochemistry, and age of volcanism. From southwest to northeast, these are the Kalgoorlie, Kurnalpi, and Burtville Terranes, with each terrane containing a number of domains. These terranes and domains are bounded by interconnected fault systems. From west to east, the terranes are bounded by the Ida, Ockerburry and Hootanui Fault Systems. Ongoing mapping, geochronology, geochemistry, and interpretation of regional geophysical data will continue to refine the character and boundaries of tectonic units of the Yilgarn Craton.

KEYWORDS: Archean, Yilgarn Craton, Western Australia, terranes, tectonic units.

Introduction

This Record presents a revised geological framework for the Archean Yilgarn Craton. This framework is based on remapping and re-evaluation of geological data at various scales, combined with new geophysical, geochemical, isotopic, and geochronological data. The data have been largely acquired since 1996 during a series of AMIRA International Limited (AMIRA) and Minerals and Energy Research Institute of Western Australia (MERIWA) projects undertaken by Geoscience Australia (GA), the University of Western Australia (UWA) and Monash University, Victoria, in collaboration with the Geological Survey of Western Australia (GSWA). The identification of major terranes and their boundaries in the eastern part of the Yilgarn Craton, and an improved understanding of its tectonic evolution, is based on the results of AMIRA projects P437A (Barley et al., 2002), P482/M281 (Cassidy et al., 2002) and P624 (Barley et al., 2003), in conjunction with the Predictive Mineral Discovery Cooperative Research Centre (pmd*CRC) Y2 project (Blewett and Hitchman, 2004).

The nomenclature and boundaries of the tectonic units of the Yilgarn Craton have been modified from those of Tyler and Hocking (2001) to accommodate our better understanding of their tectonic evolution. The four-fold tectonic unit hierarchy scheme applied herein consists of Craton > Superterrane > Terrane > Domain. Terranes are defined as fault-bounded bodies of rock of regional extent, characterized by a geological history different from those adjacent to them (Neuendorf et al., 2005). A superterrane is defined as a grouping of related, adjacent terranes. Domains are defined as fault-bounded, geologically contiguous blocks within terranes. The amalgam of all of these elements is the craton.

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Terranes of the Yilgarn Craton

The Yilgarn Craton is one of three areas of crust in Western Australia that stabilized before 2.4 Ga. It consists of metavolcanic and metasedimentary rocks, granites, and granitic gneiss that formed principally between c. 3.05 and 2.62 Ga, with a minor older component (to >3.7 Ga; e.g. Nelson, 1997; Pidgeon and Hallberg, 2000; Cassidy et al., 2002; Barley et al., 2002, 2003). Voluminous granite intrusion between 2.76 and 2.62 Ga was coincident with Neoarchean orogeny, resulting in amalgamation and assembly of several tectonic units to form the Yilgarn Craton (Myers, 1993, 1995; Barley et al., 2003).

The Yilgarn Craton has traditionally been subdivided into four geologically distinct provinces — the Eastern Goldfields, Southern Cross, and Murchison Provinces and the Western Gneiss Terrain (Gee et al., 1981). The criterion used to distinguish the Western Gneiss Terrain was its predominant gneiss content compared with the predominantly granite–greenstone provinces, each of which was described as having 'a unified lithology, structural history, and perhaps even stratigraphy' (Gee et al., 1981, p. 44). The relationship between these provinces, however, was enigmatic, and the boundaries largely hypothetical and not based on observed geological features. Myers (1993, 1995), Wilde et al. (1996), Myers and Swager (1997), and Witt et al. (1998) subdivided parts of the Yilgarn Craton into superterranes and terranes based on greenstone belt shapes and trends, rock associations, and ages of greenstone deposition, granite intrusion, and deformation. This subdivision was not incorporated into the tectonic units of Western Australia map by Tyler and Hocking (2001), which largely followed the framework of Myers and Hocking (1998), because the status of some of the 'terranes' was regarded as controversial (e.g. Groenewald et al., 2000).

Swager et al. (1992) and Swager (1995, 1997) subdivided the southeastern Yilgarn Craton into a number of terranes (such as the Kalgoorlie and Kurnalpi Terranes), and further subdivided those terranes into domains. Subsequent studies by Barley et al. (2002, 2003) and Cassidy et al. (2005) resulted in modifications to the original terrane and domain definitions and the introduction of additional terranes and domains. Further refinement of the terranes and domains by Blewett and Hitchman (2004) resulted in rationalization, including amalgamation, of some the terranes and the recognition of new terranes and domains in the very easternmost part of the craton. Terranes and domains are now separated from one another by regional fault systems with the original boundaries obscured by considerable post-amalgamation deformation and the intrusion of later granites.

The Yilgarn Craton is subdivided here into six terranes, three of which constitute a superterrane (Fig. 1). In the west the Narryer Terrane and the South West Terrane are dominated by granite and granitic gneiss, whereas the central Youanmi Terrane and the Eastern Goldfields Superterrane are composed of north-trending greenstone belts separated by extensive granite and granitic gneiss. Table 1 summarizes the features of each of the terranes. The new framework differs from that of Tyler and Hocking (2001), as well as the subdivisions of Myers and Swager (1997) and Witt et al. (1998), with the recognition that what were the Murchison and Southern Cross Granite–Greenstone Terranes are domains of the new Youanmi Terrane, and the modification of terranes and domains within the Eastern Goldfields Superterrane. No modifications have been made to the Narryer and South West Terranes. Boundaries of the terranes and superterrane presented here will be more completely validated by ongoing mapping, geochronology, geochemistry, and interpretation of regional geophysical data.

In the discussion that follows, reference is made to greenstone belts, metamorphic belts, and structural elements that have been described in some detail in previous reviews of the geology of the Yilgarn Craton (e.g., Geological Survey of Western Australia, 1990; Groenewald et al., 2000; Groenewald and Riganti, 2004). The reader is referred to those publications and the references therein.

Narryer and South West Terranes

The Narryer Terrane and the South West Terrane form the northwestern and southwestern parts of the Yilgarn Craton respectively. They are retained as separate terranes in the current framework. Additional work is required on the boundaries and geological components of each terrane to establish their relationship with the adjacent Youanmi Terrane.

The Narryer Terrane is the oldest known component of the craton and includes several ages of gneisses derived from early to middle Archean granitic rocks and interleaved metasedimentary and mafic–anorthositic meta-igneous rocks. It is of considerable geological significance because it contains the oldest known rocks in Australia (c. 3.73 Ga Manfred Complex: Kinny et al., 1988) and metasedimentary rocks with detrital zircons as old as 4.4 Ga (Froude et al., 1983; Wilde et al., 2001). Rocks of the Narryer Terrane were metamorphosed at high grade and intruded by granite and pegmatite between 3.3 and 3.05 Ga, and were multiply deformed, metamorphosed, and intruded by granite between c. 2.75 and 2.62 Ga (Myers, 1988; Nutman et al., 1993). The boundary between the Narryer and Youanmi Terranes is marked by the Balbalinga Fault in the southeast and the Yalgar Fault in the northeast (Myers, 1993).

The South West Terrane consists of high-grade granitic gneisses and metasedimentary and meta-igneous rocks that have experienced multiple phases of deformation and granite and pegmatite intrusion between c. 2.75 and 2.62 Ga (Myers, 1993; Wilde et al., 1996). Although the South West Terrane has been informally divided into three domains on the basis of the interpretation of geophysical and geochronological data (Wilde et al., 1996), the exact nature of the domains, as well as the location of the boundaries between them, is poorly constrained, and this subdivision is not incorporated into the present overview. Supracrustal sequences in the South West Terrane range in age from c. 3.2 – 2.8 Ga in the Chittering, Jimperding, and Balingup metamorphic belts to c. 2.72 – 2.67 Ga in the Saddleback greenstone belt (Wilde et al., 1996).

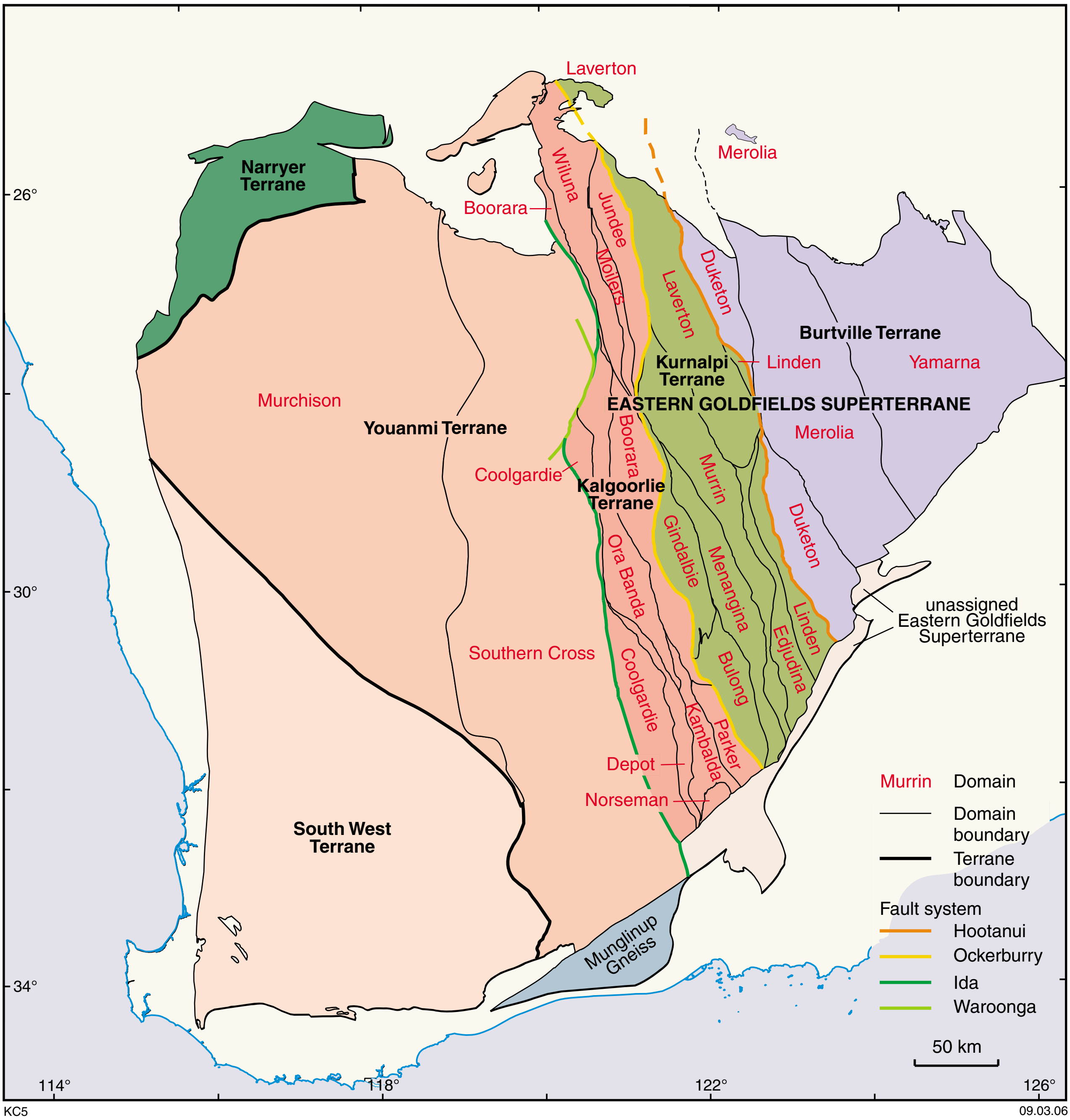

Figure 1. Tectonic division of the Yilgarn Craton, showing subdivision into terranes and domains

Quartzite in the Jimperding metamorphic belt contains detrital zircons with a spectrum of ages from older than 3.73 to 3.17 Ga (Wilde et al., 1996), indicating a complex and variably old provenance. Granites in the South West Terrane have emplacement ages from c. 2.75 to 2.62 Ga, with the majority younger than 2.69 Ga (Nemchin and Pidgeon, 1997). Granulite-facies metamorphism was synchronous with emplacement of c. 2.64 – 2.62 Ga charnockitic granites (Nemchin et al., 1994). Intrusive and volcanic rocks at Boddington were metamorphosed to upper greenschist to lower amphibolite facies at c. 2640 Ma. The boundary between the South West Terrane and the Youanmi Terrane is poorly defined.

The older crustal components of the Narryer and South West Terranes are thought to have accreted to the Youanmi Terrane after 2.8 Ga (Myers, 1993; Nutman et al., 1993; Qiu and Groves, 1999; Cassidy et al., 2005), with collision of the Narryer Terrane at c. 2.75 Ga, and continued deformation and metamorphism and granite intrusion between 2.75 and 2.65 Ga (Myers, 1993). Nutman et al. (1993) suggested that rocks of the Narryer Terrane were emplaced over the Youanmi Terrane at c. 2.75 Ga. Collision of the South West Terrane with the Youanmi Terrane is inferred to have resulted in the emplacement of volumetrically abundant granites at 2.64 – 2.62 Ga and coincident high-grade metamorphism (Wilde et al., 1996; Qiu and Groves, 1999).

Table 1. Summary of features of the terranes of the Archean Yilgarn Craton (modified from Cassidy et al., 2005)

Terrane	*Age of initial crust formation*	*Depositional ages of greenstones*	*Emplacement ages of granites and gneisses*	*Age of deformation and metamorphism*
	(Ga)			
Narryer Terrane	3.8–3.4	?3.73	3.73–3.6, 3.48, 3.3 3.0, 2.75, 2.68–2.62	c. 3.3, ?2.75, 2.68–2.62
South West Terrane	?3.5–3.0	?3.0, ?2.8, 2.7	?3.2, 2.8, 2.68–2.62	?2.68–2.62
Youanmi Terrane	?3.4–2.9	3.01–2.92, 2.81, 2.76–2.72	3.01–2.92, 2.81, 2.76–2.68, 2.66–2.62	>2.74–2.68, 2.66–2.63
Eastern Goldfields Superterrane				
Kalgoorlie Terrane	?3.0–2.8	?2.94, ?2.81, 2.74–2.66	2.81, 2.75–2.74, 2.68–2.66, 2.65–2.63	2.67–2.63
Kurnalpi Terrane (western domains)	2.9–2.8	2.71–2.68	2.7, 2.68–2.66, 2.65–2.63	2.67–2.63
(eastern domains)	?3.1–2.9	>2.8, 2.72–2.68	?2.95, 2.71, 2.68–2.66, 2.65–2.63	2.67–2.63
Burtville Terrane	?3.0–2.8	2.81, 2.77–2.66	?2.95, 2.8–2.77, 2.69–2.63	?2.67–2.63

Youanmi Terrane

The Youanmi Terrane combines the Murchison and Southern Cross Granite–Greenstone Terranes of Tyler and Hocking (2001). It is named after the historical mining locality of Youanmi in the central part of the Youanmi Terrane. The Murchison and Southern Cross 'Granite–Greenstone Terranes' are here regarded as domains and are the subject of ongoing mapping, geochronology, and interpretation of regional geophysical data. They have a broadly similar lithostratigraphy and tectonic history (e.g., Chen et al., 2003) implying that they are related. The Youanmi Fault, invoked by Myers (1993, 1997) and Myers and Swager (1997) as the boundary fault between their West Yilgarn and Southern Cross Superterranes, is probably related to D_3 deformation throughout the central Yilgarn Craton (Chen et al., 2004) and is considered herein to represent a domain-bounding structure.

Geochronological data indicate periods of volcanism and sediment deposition within the Youanmi Terrane at c. 3.05–2.93, 2.81, and 2.76–2.72 Ga (Pidgeon and Wilde, 1990; Schiøtte and Campbell, 1996; Wang et al., 1998; Pidgeon and Hallberg, 2000; Geological Survey of Western Australia, 2005). A c. 3.05–2.93 Ga lower succession is characterized by mafic and ultramafic volcanic rocks and banded iron-formation, with minor felsic volcanic rocks and local basal quartzite. Quartzites in the Illaara and Maynard Hills greenstone belts in the central Southern Cross Domain have maximum depositional ages of c. 3.13 Ga, with detrital zircons up to 4.35 Ga (Wyche et al., 2004). In the Marda–Diemals greenstone belt in the central Southern Cross Domain, a c. 2.73 Ga upper succession composed of felsic–intermediate volcanic rocks and clastic sedimentary rocks unconformably overlies the lower succession. This succession has some common features with other felsic volcanic rocks in the Southern Cross and Murchison Domains (e.g. Watkins and Hickman, 1990; Pidgeon and Hallberg, 2000), although limited geochronological data suggest that they have been deposited at different times. Along the eastern margin of the Murchison Domain are a series of c. 2.81 Ga layered mafic intrusions (e.g. Windimurra and Narndee), associated with minor 2.81 Ga felsic volcanism (Ahmat, 1990; Geological Survey of Western Australia, 2005).

Granite and granitic gneiss, dominated by monzogranite, were emplaced at c. 2.76–2.68 and 2.66–2.62 Ga (Cassidy et al., 2002; Geological Survey of Western Australia, 2005). A minor amount of sanukitoid-like granodiorite was emplaced at c. 2.76–2.75 Ga in the Meekatharra–Mount Magnet district in the northeastern Murchison Domain (Cassidy et al., 2002). The 2.76–2.73 Ga felsic magmatism in the Youanmi Terrane, as well as 2.75 Ga granites in the Narryer Terrane, may be related to collision between those terranes (Nutman et al., 1993; Cassidy et al., 2005).

The Youanmi Terrane is isotopically distinct from other terranes in the Yilgarn Craton and possibly represents the nucleus, or protocraton, onto which younger terranes (Narryer Terrane, Eastern Goldfields Superterrane) were accreted. A pre-3.05 Ga age for the initial formation of the Youanmi Terrane is based on neodymium and hafnium isotope depleted-mantle model ages (Nd and Hf T_{DM}) for granites and felsic volcanic rocks that indicate a 3.4–3.1 Ga felsic crustal component (Barley et al., 2003; Griffin et al., 2004; Cassidy et al., 2005). Detrital and xenocrystic zircon ages that suggest sources of c. 4.3, 3.8, and 3.4–3.1 Ga age (Myers, 1995; Pidgeon and Hallberg, 2000; Wyche et al., 2004; Geological Survey of Western Australia, 2005) may provide evidence of older components in the Murchison and Southern Cross Domains. Future work may further subdivide the Youanmi Terrane.

Eastern Goldfields Superterrane

The Eastern Goldfields Superterrane (EGST) contains at least three tectono-stratigraphic terranes, defined on the basis of distinct volcanic facies, geochemistry, and age of volcanism that ranges from older than 2.81 to 2.66 Ga. Tectonic juxtaposition occurred after c. 2.66 Ga (e.g. Swager, 1997; Barley et al., 2002, 2003). From southwest to northeast, these are the Kalgoorlie, Kurnalpi and Burtville Terranes. Each terrane is divided into structurally bound domains (Fig. 1) that preserve dismembered, thrust-repeated parts of the succession and locally have distinct volcanic facies relationships (Swager et al., 1992; Swager, 1997; Barley et al., 2002). Proterozoic overprinting of Archean rocks along the southeastern margin of the EGST (Fig. 1) precludes division of this area into terranes and domains.

The terranes and domains in the EGST are bound by interconnected systems of faults (Swager et al., 1992, Swager, 1995, 1997; Liu et al., 2001) that have been defined as part of the pmd*CRC Y2 project (see Champion, 2004). From west to east, these terrane-bounding fault systems are the Ida, Ockerburry and Hootanui Fault Systems (Fig. 1). The Ida Fault System is not clearly established north and south of the Davyhurst – Mount Ida district. To the north the Waroonga Fault System truncates the Ida Fault System (Fig. 1; Champion, 2004), whereas to the south it has been extensively intruded by late granites. Domain-bounding fault systems have been established within each terrane. For example, the eastern boundary of the Ora Banda Domain is the Bardoc Fault System. Further refinement of the terrane- and domain-bounding fault systems will continue as new data becomes available. For example, Jones (in prep.) has demonstrated that the eastern margin of the Bulong Domain of the Kurnalpi Terrane is probably the Roe Hills Fault and the current framework and nomenclature has been changed to accommodate this new information.

Kalgoorlie Terrane

The Kalgoorlie Terrane comprises predominantly young (2.71 – 2.66 Ga) and minor old (>2.73 Ga) lithostratigraphic sequences. Older (>2.73 Ga) greenstone successions in the Norseman, Boorara, and Wiluna Domains (Nelson, 1997; Barley et al., 2003) are overlain by younger greenstones. Further research is required on these older successions to determine whether they represent autochthonous basement to the younger greenstones. Clearly defined lithostratigraphic sequences are restricted to areas in the Kambalda and Ora Banda Domains in the southern Kalgoorlie Terrane. In these areas the 2.71 – 2.66 Ga greenstone successions are divided into the c. 2.71 – 2.69 Ga tholeiitic and komatiitic mafic–ultramafic Kambalda Sequence and c. 2.69 – 2.66 Ga felsic volcaniclastic Kalgoorlie Sequence (Swager et al., 1992; Krapež et al., 2000; Barley et al., 2002, 2003). Similar lithostratigraphic sequences are present in the Boorara and Jundee Domains in the northern part of the Kalgoorlie Terrane (Swager, 1995, 1997; Messenger, 2000; Barley et al., 2003).

The Kalgoorlie Sequence, incorporating the Black Flag Group (Swager et al., 1992), comprises felsic volcaniclastic and epiclastic rocks of trondhjemite–tonalite–granodiorite (TTG) type, with subordinate lavas that were deposited between 2.69 and 2.66 Ga (Krapež et al., 2000; Brown et al., 2001; Barley et al., 2002). Several depositional and magmatic sequences in the Kalgoorlie Sequence can be grouped into unconformity-bound lithostratigraphic packages that record deposition in a series of transtensional, deep-marine intra-arc basins (Krapež et al., 2000; Barley et al., 2003).

Kurnalpi Terrane

The Kurnalpi Terrane includes c. 2.72 – 2.70 Ga mafic volcanic rocks, calc-alkaline complexes, feldspathic sedimentary rocks, and mafic intrusive rocks, and c. 2.69 – 2.68 Ga bimodal rhyolite–basalt and felsic calc-alkaline complexes that extend along a linear belt at the western edge of the terrane, principally in the Gindalbie Domain (Swager, 1995, 1997; Brown et al., 2001; Barley et al., 2003). The c. 2.72 – 2.71 Ga andesitic volcaniclastic rocks and fine-grained sandstone–shale units ('banded iron-formation') in the eastern part of the Kurnalpi Terrane are separated out as the Edjudina Domain (Barley et al., 2002). The Bulong Domain at the southern part of the Kurnalpi Terrane comprises rocks from the Kurnalpi and Kalgoorlie Terranes that are inferred to have been tectonically interleaved along a complex terrane boundary (Barley et al., 2003).

Rocks of the c. 2.72 – 2.68 Ga Edjudina, Murrin, and Menangina Domains are interpreted, on the basis of geochemistry, as representing an arc basin, whereas geochemical similarity between intermediate rocks in these domains and the Gindalbie Domain, combined with the trends in age, epsilon Nd, and the distinct volcanic facies, suggest that the Gindalbie Domain represents an assemblage developed during rifting of the Kurnalpi Terrane (or similar) arc. In combination the data are interpreted to suggest that distinct arc-related terranes formed over about 60 m.y., and possibly formed along the same convergent margin, but were probably not adjacent during volcanism (Barley et al., 2002, 2003).

The c. 2.81 Ga Laverton Domain includes mafic and ultramafic volcanic rocks, banded iron-formation, fine-grained volcanogenic sedimentary rocks, and possibly younger-than-2.87 Ga mafic and ultramafic volcanic rocks and banded iron-formation of the Dingo Range greenstone belt (Barley et al., 2003). The Laverton Domain sequence may represent autochthonous basement to the younger rock units in the Edjudina and Linden Domains.

Burtville Terrane

The Burtville Terrane consists of three poorly defined domains. The Hootanui Fault System (Fig. 1) forms the boundary between the Kurnalpi Terrane and the Duketon Domain of the Burtville Terrane. The Duketon Domain includes c. 2.81 Ga intermediate and felsic volcanic rocks and associated mafic(–ultramafic) rocks in the central and eastern parts of the Duketon greenstone belt as well as greenstone assemblages dominated by mafic and ultramafic volcanic and fine-grained sedimentary rocks (Barley et al., 2003). The Merolia and Yamarna Domains contain variably deformed and metamorphosed mafic and felsic volcanic and sedimentary sequences of undetermined age. Further work is required to validate the character and boundaries of the current divisions in the Burtville Terrane.

Ages of volcanism

SHRIMP U–Pb zircon data show minor peaks in the age of the volcano-sedimentary sequences across the EGST at c. 2.95 and c. 2.81 Ga, with a major peak at 2.72 – 2.65 Ga (Nelson, 1997; Barley et al., 2002, 2003; Geological Survey of Western Australia, 2005). The older ages are restricted to the minor old sequences in the Kalgoorlie Terrane as well as the Laverton Domain in the Kurnalpi Terrane and Duketon Domain in the Burtville Terrane. Neodymium isotope data have been interpreted to indicate that the volcano-sedimentary sequences across the EGST represent marginal arcs rather than purely oceanic arc systems, and recycling of crust (>3.0 – 2.8 Ga) along a complex convergent margin, with the youngest crust represented by rocks of the Gindalbie Domain and some intermediate volcanic rocks from the Menangina and Murrin Domains of the Kurnalpi Terrane (Barley et al., 2003). Hafnium isotope data suggest that there were periods of addition of newly generated crust–lithosphere (positive epsilon Hf) and that these episodes also reworked crust that originally formed at c. 3.05 Ga or earlier (Barley et al., 2003). Overall, there is a dominance of continental-margin signatures as well as evidence of magmatic recycling of older arc-related crust. The terranes are interpreted to have been part of the same arc – back-arc system, dismembered, and then reassembled by accretionary tectonics (Krapež et al., 2000; Barley et al., 2003).

Granitic magmatism

The history of granite magmatism, with the exception of the high-high field strength element (high-HFSE) granites, is broadly similar across the EGST (Champion and Sheraton, 1997; Cassidy et al., 2002). High-Ca, mafic and high-HFSE granites correspond to specific volcanic associations in the greenstone belts in terms of timing as well as chemistry. Low-Ca and syenitic granites have no known extrusive equivalents in the EGST. High-HFSE and syenitic granites are largely, but not exclusively, concentrated within a north-northwesterly trending zone (characterized by young Nd T_{DM} ages) that approximately corresponds to domains (Gindalbie, Menangina, Murrin) in the western part of the Kurnalpi Terrane (Barley et al., 2003; Cassidy et al., 2005).

Most magmatism occurred between c. 2.72 Ga and 2.63 Ga, with minor older (>2.73 Ga) granites in the Kalgoorlie Terrane, Laverton and Linden Domains in the Kurnalpi Terrane, and Duketon Domain in the Burtville Terrane (Hill et al., 1989; Nelson, 1997; Cassidy et al., 2002; Dunphy et al., 2003; Geological Survey of Western Australia, 2005). Intrusion of granites post-dates greenstone deposition in the Kurnalpi and Burtville Terranes, but is contemporaneous with TTG-related felsic volcanic and sedimentary rocks in the Kalgoorlie Terrane (Barley et al., 1998, 2002). Although each granite group was long-lived, there are distinct periods where particular groups are most common: c. 2.72 – 2.68 Ga was dominated by emplacement of high-HFSE and high-Al TTG-type high-Ca granites, whereas c. 2.67 – 2.65 Ga was dominated by emplacement of transitional TTG-type high-Ca granites, with minor mafic and syenitic granites (Champion and Sheraton, 1997; Champion and Cassidy, 2002). Between 2.65 and 2.63 Ga, low-Ca and minor syenitic granites were emplaced across the EGST (Champion and Sheraton, 1997; Cassidy et al., 2002) and, in places, act as stitching plutons across terrane- and domain-bounding structures.

The high-Ca, low-Ca, and high-HFSE granites have a clear crustal component involved partly, or solely, in their genesis (Champion and Sheraton, 1997; Champion and Cassidy, 2002). Many granites contain older inherited zircons, consistent with Nd-isotopic data, that clearly indicate that extensive older crust must have been present (Hill et al., 1989; Champion and Sheraton, 1997; Cassidy et al., 2005). There is a distinct Nd T_{DM} age change across the boundary between the Kalgoorlie Terrane and the Youanmi Terrane, consistent with the interpretation that the EGST represents younger crustal growth onto the pre-existing Youanmi Terrane (Champion and Sheraton, 1997; Cassidy et al., 2005).

Synorogenic sedimentary rocks

Synorogenic siliciclastic sequences are preserved as erosional synclinal remnants generally adjacent to terrane- or domain-bounding fault systems in the Kalgoorlie and Kurnalpi Terranes. Detrital zircon ages indicate deposition after c. 2.66 Ga (Nelson, 1997; Krapež et al., 2000; Fletcher et al., 2001; Barley et al., 2003). Detrital zircon ages also indicate multiple older sources with ages of c. 2.73, 2.81, 3.0 – 2.95, and, less commonly, older than 3.40 Ga. These ages correspond to ages of greenstones and granites, but some (c. 3.0 and >3.40 Ga) have no recognized source in the EGST (Barley et al., 2002, 2003). Whole-rock Nd and detrital-zircon Hf isotopic data are consistent with a complicated history involving both mantle-derived magmatism and recycling of older crust since c. 3.1 Ga (Barley et al., 2003). The sequences were deposited after terrane amalgamation, and are probably synorogenic to collision between the EGST and the Youanmi Terrane (Yilgarn protocraton; Krapež et al., 2000; Barley et al., 2003).

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