A new lithostructural framework for the central Yilgarn Craton

by A. Riganti, S. Wyche, and S. F. Chen

Abstract

A new lithostructural framework for the central Yilgarn Craton has been introduced following completion of the GSWA mapping program in the region. Discrete greenstone belts with common stratigraphic elements and structural histories are the building blocks in the new scheme, and have been assigned unique codes within the GSWA State-wide map units database.

KEYWORDS: Archean, greenstone, structural terranes, Yilgarn Craton.

Introduction

Since 1997, new mapping by the Geological Survey of Western Australia (GSWA) in the central Yilgarn Craton has resulted in the production of fifteen 1:100 000-scale map sheets with Explanatory Notes and associated publications and presentations, along with a large volume of newly acquired geophysical, geochemical, and geochronological data. All available geological information has been incorporated into the first edition of the Central Yilgarn Geological Information Series (GIS) digital package (Geological Survey of Western Australia, 2006a).

The lithostructural framework for the central Yilgarn Craton, developed during the course of this work, provides a new context for the understanding of geological relationships and tectonic evolution gained during detailed mapping of the region. Lithostructural units have been defined for the area to allow a unique set of codes to be developed accordingly for use in a digital environment.

Geological setting of the central Yilgarn

The area covered by the Central Yilgarn GIS dataset falls within the northern part of the newly defined Southern Cross Domain of the Youanmi Terrane (Fig. 1; Cassidy et al., 2006). The Youanmi Terrane combines the Southern Cross and Murchison Granite–Greenstone Terranes of Tyler and Hocking (2001), which are now recognized to have a broadly similar lithostratigraphy, geochronology, and tectonic history (e.g. Chen et al., 2003), as well as an isotopically distinct signature from the other terranes of the Yilgarn Craton based on neodymium and hafnium isotope depleted-mantle model ages (e.g. Barley et al., 2003; Griffin et al., 2004). The Southern Cross Domain is separated from the Murchison Domain (formerly the Murchison Granite–Greenstone Terrane) by major shear zones such as the Youanmi shear zone, and is bounded to the east by the Ida and Waroonga fault systems (Fig. 1) — structures that have been extensively obscured by later granite intrusions.

The northern part of the Southern Cross Domain is characterized by a number of discrete greenstone belts with overall common lithostratigraphic elements and structural histories. The age of the greenstones is not well constrained but the major, mafic-dominated successions were probably deposited at about 3.0 Ga (e.g. Chen and Wyche, 2001). The structural complexity, lack of key geochronological data from the mafic sequence, and absence of regional stratigraphy have obstructed direct correlations between greenstone belts in the central Yilgarn Craton. Strong deformation and poor exposure effectively preclude the establishment of detailed stratigraphic successions within most belts. However, their common lithological associations and deformational histories distinguish them from the c. 2.7 Ga greenstones of the adjacent Eastern Goldfields Superterrane (Fig. 1). A representative stratigraphic sequence for the greenstones in the northern part of the Southern Cross Domain has quartzite and quartz–mica schist at the base of the succession. These quartzites contain 4.2 to 3.1 Ga detrital zircons indicating greenstone deposition on, or adjacent to, continental crust (Wyche et al., 2004). The majority of the greenstone belt successions are dominated by mafic rock types, mostly tholeiitic basalts with some spinifex-textured komatiitic basalts and gabbroic units, with subordinate ultramafic rocks. Banded iron-formation (BIF) and chert are dominant at lower to middle stratigraphic levels. The abundance of BIF and paucity of ultramafic lavas are characteristic of the Southern Cross greenstone belts, and contrasts with

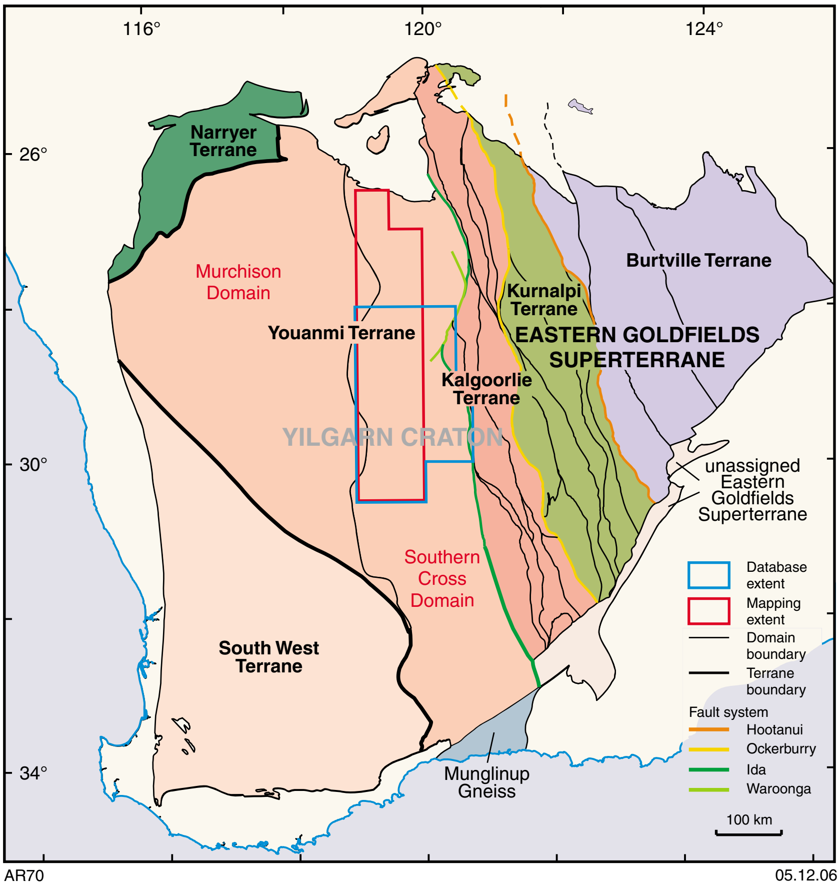

***Figure 1.** Tectonic subdivisions of the Yilgarn Craton, showing terrane and domain boundaries, as well as the areal extent of GSWA mapping (red box) and the Central Yilgarn GIS dataset (blue box). Modified after Cassidy et al. (2006)*

the scarcity of BIF and abundance of ultramafic rocks in greenstone sequences of the adjacent Eastern Goldfields Superterrane.

In parts of the northern Southern Cross Domain the c. 3.0 Ga mafic-dominated succession is unconformably overlain by a sequence of weakly metamorphosed felsic to intermediate volcanic rocks, followed by weakly metamorphosed clastic sedimentary rocks. In the Marda–Diemals greenstone belt (Fig. 2), this upper sequence is represented by the felsic to intermediate calc-alkaline Marda Complex in which basal conglomerates and sandstones that were derived from the underlying greenstones are overlain by andesite, rhyolite, and rhyolitic ignimbrite, dated at c. 2732 Ma (Geological Survey of Western Australia, 2006b). The clastic sedimentary rocks are represented by the Diemals Formation, which has a maximum age of c. 2729 Ma (Geological Survey of Western Australia, 2006b). In the Gum Creek greenstone belt, just north of the area embraced by the first edition of the Central Yilgarn GIS, the poorly exposed upper succession also contains c. 2720 Ma felsic volcanic rocks and clastic sedimentary rocks, including abundant carbonaceous shales (Chen et al., 2006).

The greenstone belts in the northern part of the Southern Cross Domain share a common structural history (Chen et al., 2004). D_1 north–south shortening produced low-angle thrusts, isoclinal folds, and a gently dipping foliation, with a locally pronounced down-dip mineral lineation. D_1 structures are only locally preserved, and are commonly represented by a folded foliation and F_1 folds refolded by D_2. D_2 deformation was dominated by east–west shortening, with the formation of large, originally north-trending, upright folds with an axial-planar foliation that overprinted D_1 structures. Inhomogeneous east–west compression during D_3 resulted in impingement of competent granitic blocks into less competent, north–south-oriented greenstone belts. This led to development of northwest-trending sinistral and northeast-trending dextral regional-scale shear zones along the margins of the granitic blocks. These shear zones are linked by northerly trending zones of intense deformation, in which shortening is accommodated by the formation of folds and reverse faults in the greenstones, and by a coaxial flattening fabric in granitic rocks. Lateral escape of the greenstones is indicated by the progressive rotation of early macroscopic folds into parallelism with the strike-slip shear zones. Brittle deformation later than D_3 is also present in the northern part of the Southern Cross Domain, but is poorly constrained in age.

Greenstone belts of the Southern Cross Domain are surrounded by granite and gneiss ranging in age from c. 2810 to 2635 Ma (Geological Survey of Western Australia, 2006b). The majority of granite plutons were probably intruded pre- to syn-D_2, because some contain a north-trending gneissic banding and foliation. Granites are strongly deformed in D_3 shear zones and preserve well-developed shear-sense indicators such as S-C fabrics and rotated porphyroclasts. Granitic gneisses, on the other hand, are commonly slightly older than the deformed and undeformed granites (Geological Survey of Western Australia, 2006b), and preserve an earlier, northerly trending D_2 fabric both adjacent to, and away from, the greenstone belts.

Southern Cross Domain lithostructural units

No formal stratigraphy has been established for the mafic-dominated portion of the greenstone succession

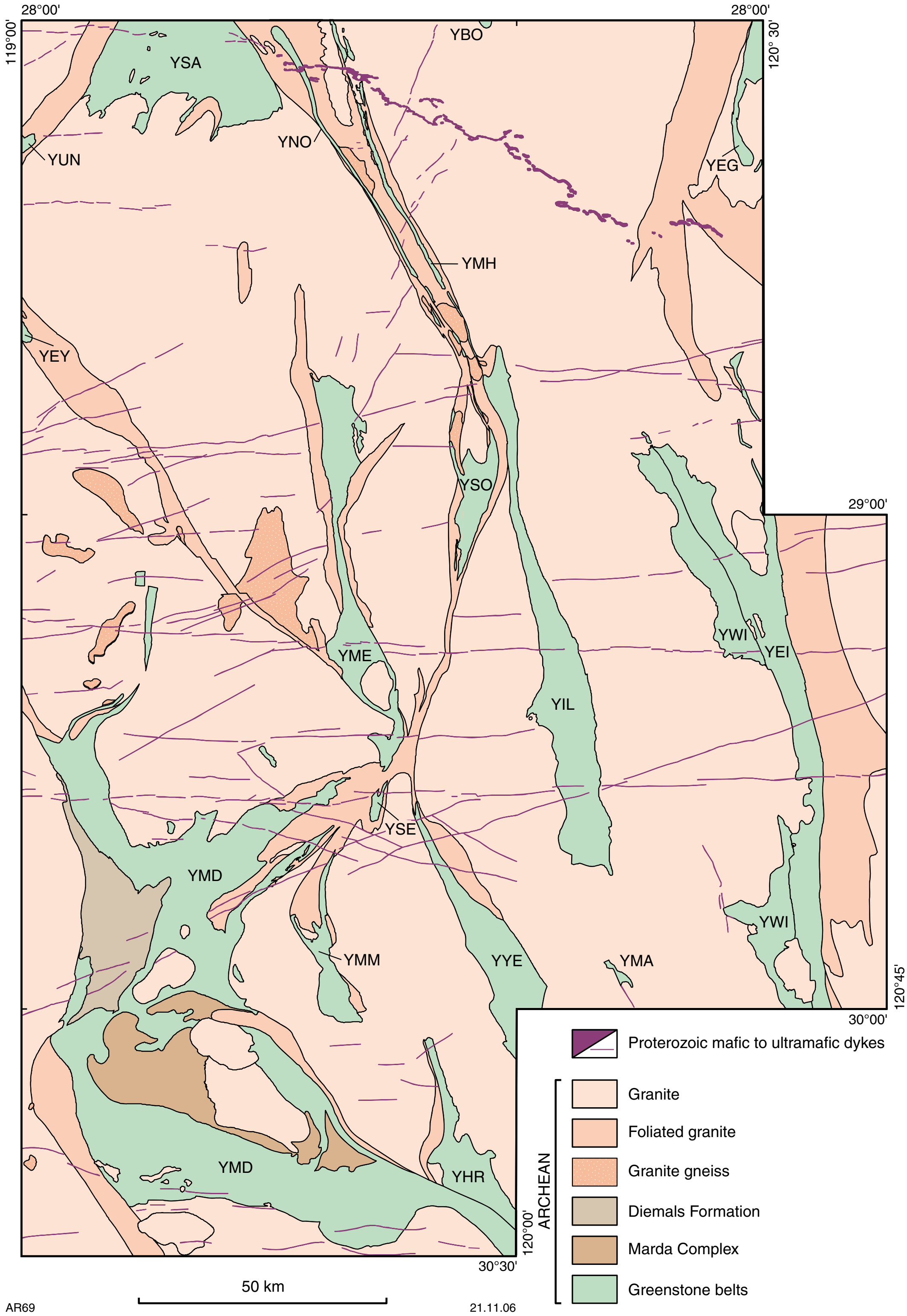

Figure 2. Simplified interpreted bedrock geology for the area covered by the Central Yilgarn GIS dataset, depicting the lithostructural units identified to date. Acronyms for greenstone belts: YBO = Booylgoo Range, YEI = East Ida, YEY = East Youanmi, YHR = Hunt Range, YIL = Illaara, YMA = Maninga, YMD = Marda–Diemals, YME = Mount Elvire, YMH = Maynard Hills, YMM = Mount Manning, YNO = North Cook Well, YSA = Sandstone, YSE = South Elvire, YSO = South Cook Well, YWI = West Ida, YUN = Unaly Hill, YYE = Yerilgee. YEG indicates undifferentiated greenstones from the Eastern Goldfields Superterrane

in the northern part of the Southern Cross Domain, due to a lack of dateable horizons and marker beds. Nonetheless, the occurrence of greenstone belts as spatially discrete entities, together with their lithological similarities and shared deformational histories, makes individual greenstone belts the most suitable building blocks for a new lithostructural framework in the central Yilgarn Craton (cf. Van Kranendonk, 1998).

Seventeen greenstone belts of variable areal extent have been named in the area covered by the first edition of the Central Yilgarn GIS digital dataset (Fig. 2), and rock types are now described according to the greenstone belts in which they occur. This allows a better characterization of lithologies from different areas and within individual belts (both in terms of variations or similarities), and represents a first step towards the definition of a formal stratigraphy and a more comprehensive tectono-stratigraphic framework for the region. In addition to naming litho-structural units, lithological codes have been modified from the original published 1:100 000-scale maps to be consistent with the new GSWA coding scheme (Tyler et al., 2004) that closely follows international guidelines on rock nomenclature. In this scheme, more emphasis is given to metamorphic rock codes (particularly in rocks metamorphosed to upper greenschist or amphibolite facies), and mineralogical, textural, and structural features of the rocks are listed in consistent order (unlike previously published codes). Therefore, in the central Yilgarn dataset, each rock type is characterized by a code that defines its age, lithology, and the lithostructural affiliation for any particular outcrop. For example, 'A-bb-YSA' defines an Archean basalt of the Sandstone greenstone belt of the Yilgarn Craton, whereas 'A-mtq-YMH' refers to a metamorphosed quartz arenite in the Maynard Hills greenstone belt. Lookup tables in the database provide a full tectono-stratigraphic characterization of individual rock units (e.g. terrane, domain, age, etc.). The system, as designed, is flexible and open to further updates. In particular, it allows more detailed breakdown of stratigraphy, including the introduction of more formal nomenclature, as more data become available.

Formal stratigraphic units have been defined wherever possible for this part of the central Yilgarn Craton. The volcanic rocks of the Marda Complex have been assigned group status, and their high-level intrusive equivalent, the Butcher Bird Monzogranite, has been correspondingly included in the formal stratigraphy of the complex. Metasedimentary rocks of the Diemals Formation have also been formally described, as have some mafic units such as the Forest Belle Gabbro in the East Ida greenstone belt. For granite intrusions with boundaries clearly outlined by outcrop distribution, aeromagnetic images, or geochemistry, formation names have been introduced (e.g. 'A-_pr-gm' for the Pigeon Rock Monzogranite, the underscore indicating that a suite has not been formally identified yet). For all units where formal names have been assigned, the naming conventions and descriptions conform with those used by GSWA throughout Western Australia. The large majority of granitic rocks in the central Yilgarn have poorly defined intrusion boundaries, and some post-date accretion of the Youanmi Terrane with the Eastern Goldfields Superterrane. For this reason, only their affiliation to the Yilgarn Craton is recognized in their characterization (e.g. 'A-gm-Y' for a monzogranite). Similarly, the boundaries of gneissic units that might precede accretion are commonly difficult to define due to poor exposure and outcrop fragmentation, and for this reason these rocks have also simply been assigned to the Yilgarn Craton.

Conclusions

The establishment of a lithostructural framework for the central Yilgarn Craton in a GIS environment provides a powerful tool for geologists working in the region. The approach allows particular lithologies to be better characterized according to their distribution and relationships. The resulting detailed breakdown of greenstone successions will allow spatial analysis to be carried out that will improve our understanding of the geological evolution of these sequences, as future mapping or analytical work that leads to the establishment of a formal stratigraphy can easily be accommodated within the structure of the database. Finally, spatial analysis of lithostructural units in relation to the distribution of known mineralized occurrences (also provided in the Central Yilgarn GIS package) may lead to advances in our understanding of tectono-stratigraphic controls on different styles of mineralization.

The implementation of a new lithostructural scheme for the Southern Cross Domain in the Central Yilgarn GIS dataset has already provided the framework for a fresh look at structural and stratigraphic problems, such as the correct positioning of the Ida Fault relative to the surface geology, and the consequent subdivision of the Mount Ida greenstone belt into components of the Youanmi Terrane and Eastern Goldfields Superterrane (Geological Survey of Western Australia, 2006a). Future expansion of the database will include more recent mapping, and detailed notes and descriptions covering the entire region. Ultimately, the Central Yilgarn GIS will be integrated with other databases covering the east Yilgarn Craton and Murchison regions to provide a fully integrated tectono-stratigraphic framework embracing the whole of the Yilgarn Craton.

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