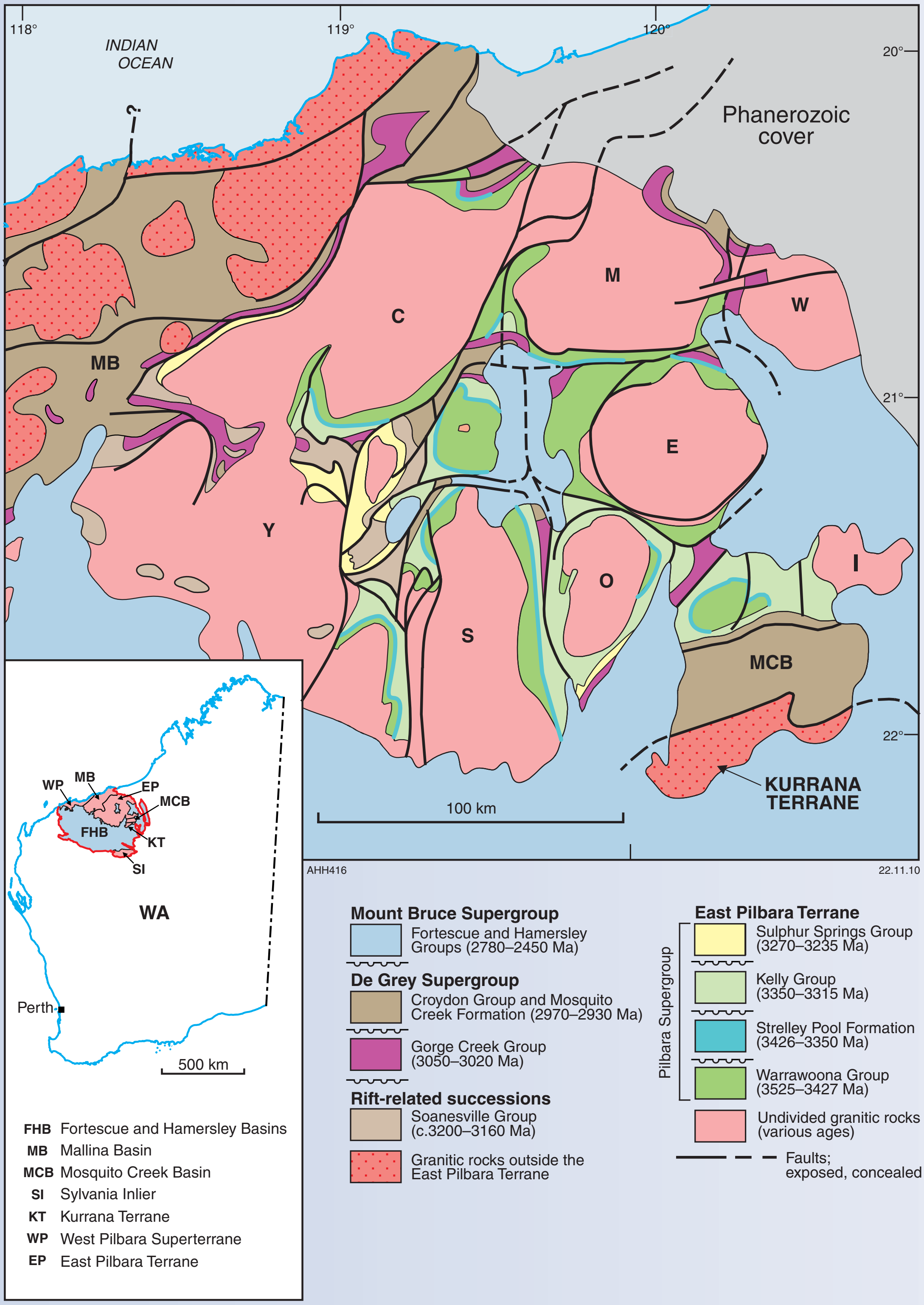

Figure 1. Simplified geological map of the East Pilbara Terrane showing eight granite–greenstone domes. Most of the domes are separated by Paleoarchean–Mesoarchean boundary faults within the greenstones. Dome names: C = Carlindi; M = Muccan; W = Warrawagine; Y = Yule; E = Mount Edgar; S = Shaw; O = Corunna Downs; I = Yilgalong. Modified from Van Kranendonk et al. (2006, fig. 1).

Pilbara Supergroup of the East Pilbara Terrane, Pilbara Craton: updated lithostratigraphy and comments on the influence of vertical tectonics

by AH Hickman

Abstract

Since the entire lithostratigraphy of the northern Pilbara Craton was formally revised in a Geological Survey of Western Australia Record in 2006, evidence from new mapping and geochronological data has led to various lithostratigraphic revisions, in particular for the 3.53–3.23 Ga Pilbara Supergroup. This paper provides a summary of the changes and briefly introduces the question of the relationship between the stratigraphy of the Pilbara Supergroup and its tectonic environment.

The lithostratigraphic changes made since the 2006 publication are:

i) the Soanesville Group has been removed from the Pilbara Supergroup because it marks the commencement of plate-tectonic processes

ii) the Budjan Creek Formation, previously assigned to the 3.27–3.23 Ga Sulphur Springs Group, is reassigned to the Soanesville Group based on its sedimentology and interpreted tectonic setting

iii) the Strelley Pool Formation has been removed from the Kelly Group

iv) the Dresser Formation has been correlated with the McPhee Formation, based on reinterpretation of its age from 3.52 Ga to 3.48 Ga

v) a basaltic succession underlying the Dresser Formation is correlated with the North Star Basalt instead of the Coonterunah Subgroup.

The stratigraphy of the Pilbara Supergroup must have been influenced by its depositional setting within an environment of vertical tectonics. This paper reports an example where the distribution of one formation — the Apex Basalt — provides some support for this concept, and examination of the variable distribution of several other formations, combined with thickness and facies data, is expected to provide additional evidence.

KEYWORDS: Pilbara Supergroup, lithostratigraphy, Soanesville Group, Budjan Creek Formation, Strelley Pool Formation, Dresser Formation, Apex Basalt, vertical tectonics, East Pilbara Terrane, Pilbara Craton, tectonic environment, plate tectonics, depositional setting, Sulphur Springs Group.

Introduction

In 2006, the lithostratigraphy of the northern Pilbara Craton was formally revised and redefined (Van Kranendonk et al., 2006, 2007a). New evidence from university researchers, additional geochronology, and ongoing evaluation of data from the Pilbara Craton mapping project, have resulted in further revisions for the Pilbara Supergroup, which comprises the greenstone succession of the Paleoarchean East Pilbara Terrane (Hickman, 2008, 2010; Hickman and Van Kranendonk, 2008; Hickman et al., 2010; Van Kranendonk et al., 2010). The accumulated changes to the lithostratigraphy of the Pilbara Supergroup are now causing a problem because the most comprehensive lithostratigraphic reference works (Van Kranendonk et al., 2006, 2007a) are now partly out-of-date. This paper summarizes and briefly explains the recent revisions, and presents them in the context of an updated interpretation of the evolution of the Pilbara Supergroup. The revised lithostratigraphy has been incorporated into Geological Survey of Western Australia's (GSWA's) Explanatory Notes database, and is being used in GSWA's GIS products.

Previous interpretation of the Pilbara Supergroup

The Paleoarchean East Pilbara Terrane of the Pilbara Craton (Fig. 1) is distinguished by its structural style, which has no close analogues in terranes formed by plate-tectonic processes. Numerous publications over the last 35 years have explained its characteristic 'dome-and-syncline' pattern, well displayed on geological maps and satellite imagery, as the product of vertical tectonic processes; earliest accounts were by Hickman (1975, 1981, 1984) and recent contributions have included those by Van Kranendonk et al. (2006, 2007a,b). GSWA geological mapping between 1995 and 2003 revealed that, rather than consisting of alternating domes and synclines, the regional outcrop pattern was produced by a cluster of adjoining granite–greenstone domes (Van Kranendonk et al., 2002). Boundary faults within the greenstones separate these domes (Fig. 1). In total, there are eight granite–greenstone domes, and there are 20 greenstone belts (Fig. 2).

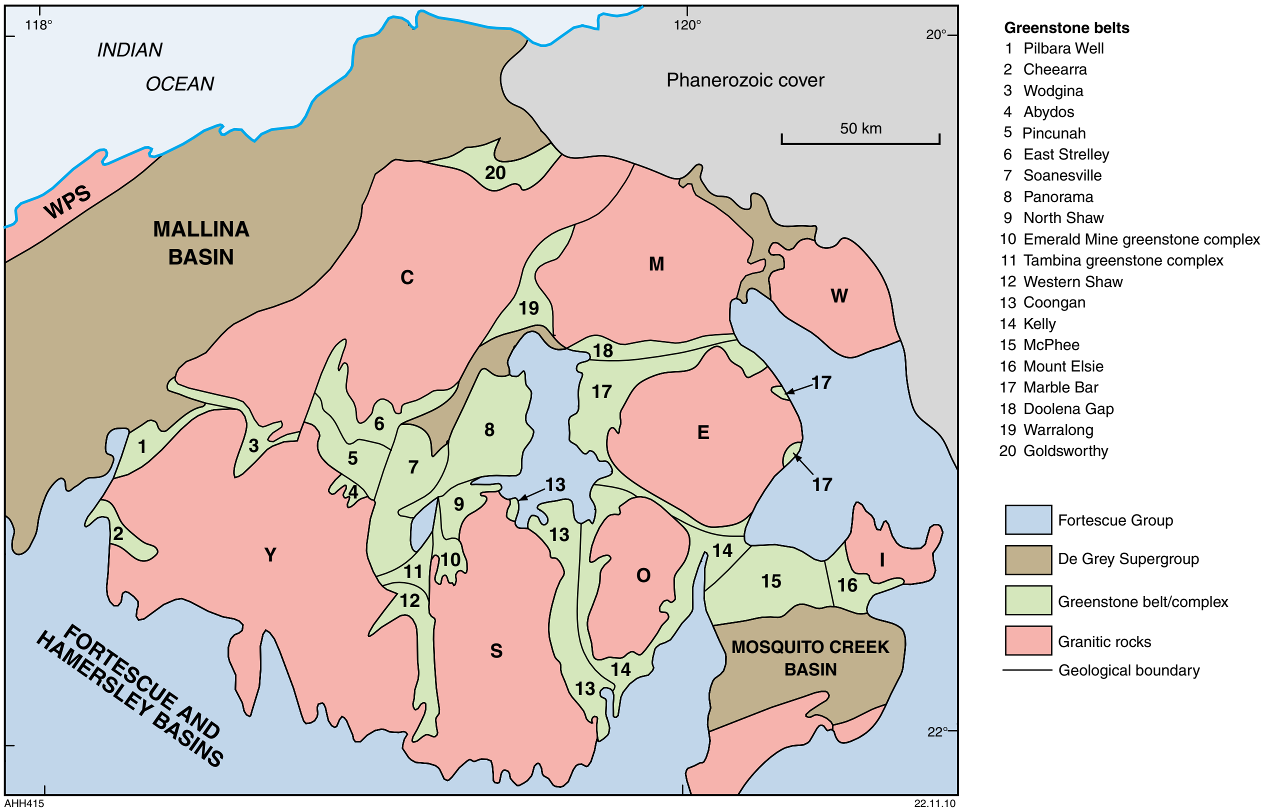

Figure 2. Greenstone belts and complexes of the East Pilbara Terrane. Dome names as in Figure 1. WPS = West Pilbara Superterrane. Modified from Van Kranendonk et al. (2006, fig. 4).

As defined by Van Kranendonk et al. (2006), the Pilbara Supergroup comprises the greenstone succession of the East Pilbara Terrane, and is divided into four groups, as shown in Figure 3:

- 3525–3427 Ma Warrawoona Group (predominantly volcanic);
- 3350–3315 Ma Kelly Group (volcanic formations above a thin basal sedimentary formation of the group, the Strelley Pool 'Chert');
- 3270–3230 Ma Sulphur Springs Group (volcanic formations overlying a basal sedimentary formation, the Leilira Formation);
- 3230–3165 Ma Soanesville Group (predominantly sedimentary).

Revisions to the Pilbara Supergroup

Figure 3 shows an older version of the lithostratigraphy (modified from Van Kranendonk et al., 2006) with five lithostratigraphic units discussed in this paper highlighted in red. Figure 4 presents the revised stratigraphic column for the Pilbara Supergroup. This lithostratigraphy is described as 'generalized' because the thicknesses and compositions of the formations vary between different greenstone belts. With the exception of the change to the Budjan Creek Formation (below) all of the individual changes summarized in this paper have already been published but with little or no explanation, except for the changes involving the Strelley Pool Formation (Hickman, 2008).

Soanesville Group

The Soanesville Group outcrops in the western part of the East Pilbara Terrane where it overlies the 3.27–3.23 Ga Sulphur Springs Group. The lower part of the Soanesville Group is composed of a >2500 m-thick succession of siliciclastic sedimentary rocks containing minor chert and BIF; in contrast, the upper part of the group is composed of volcanic rocks in the formally defined Honeyeater Basalt (references in Van Kranendonk et al., 2006), and may include unnamed volcanic formations in the Wodgina and Pilbara Well greenstone belts (Van Kranendonk et al., 2010). Stratigraphic relations between the unnamed formations and the Soanesville Group will remain uncertain without further mapping and geochronology.

Van Kranendonk et al. (2006) removed the Soanesville Group from the Gorge Creek Group (Lipple, 1975; Van Kranendonk et al., 2004) because recent mapping had indicated an erosional unconformity between the two successions. Previously, the Gorge Creek Group had been included in the Pilbara Supergroup, and the revision by Van Kranendonk et al. (2006) retained the Sulphur Springs Group in this supergroup while moving the Gorge Creek Group into the De Grey Supergroup (Van Kranendonk et al., 2004). The contact between the Soanesville Group and the underlying Sulphur Springs Group was described as a disconformity by Van Kranendonk et al. (2006). Based on an interpretation that hydrothermal alteration at the top of the underlying Sulphur Springs Group extends into the lower part of the Soanesville Group, Van Kranendonk et al. (2006) inferred no significant age difference between the two groups. However, a transition between the Sulphur Springs Group and the Soanesville Group was questioned when Rasmussen et al. (2007) dated monazite within the Soanesville Group at c. 3.19 Ga, and interpreted this to be the approximate age of deposition. This result indicates that the Soanesville Group is 40 million years younger than the Sulphur Springs Group. Additional geochronology was subsequently reported by Van Kranendonk et al. (2010) to support the interpretation that the Soanesville Group was deposited after c. 3.20 Ga.

The contact between the 3.27–3.23 Ga Sulphur Springs Group and the <3.2 Ga Soanesville Group marks a major change in the crustal evolution of the Pilbara Craton. From 3.53 to 3.23 Ga the Pilbara crust was progressively thickened by a succession of plume-related magmatic events that involved ultramafic–mafic–felsic volcanic cycles, contemporaneous granitic intrusion, vertical deformation, and metamorphism (Van Kranendonk et al., 2002). The 3.53 to 3.23 Ga crust formed during these events is now preserved as the East Pilbara Terrane. Rifting of this terrane probably commenced towards the end of deposition of the Sulphur Springs Group (Hickman, 2004). Post-3.2 Ga deposition and tectonic activity was interpreted by Van Kranendonk et al. (2010) to indicate a Mesoarchean Wilson cycle that reached the stage of arc accretion at 3.07 Ga, followed by 3.07–2.90 Ga extension and accretion, with orogenic

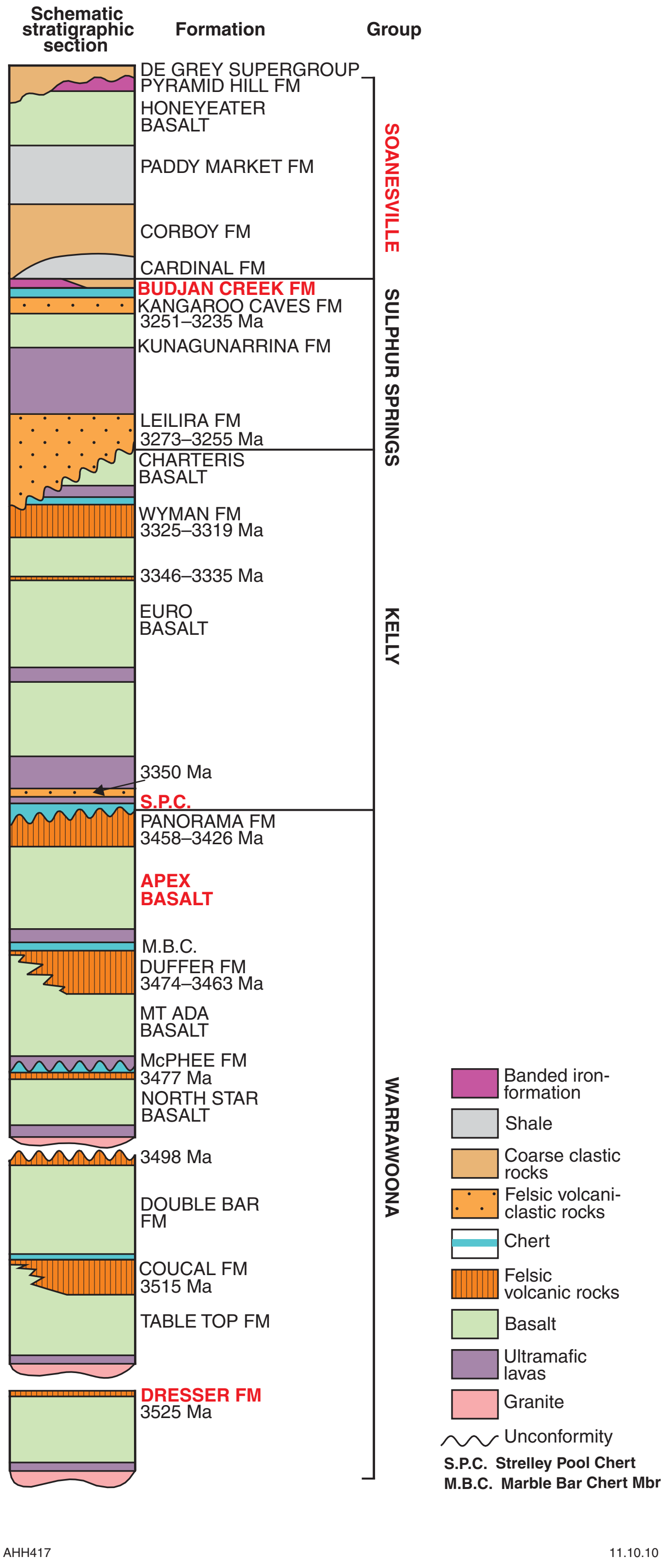

Figure 3. Summary of the lithostratigraphic column of the Pilbara Supergroup published in the last formal revision (Van Kranendonk et al., 2006, fig. 5). Stratigraphic names in red highlight units discussed in this paper.

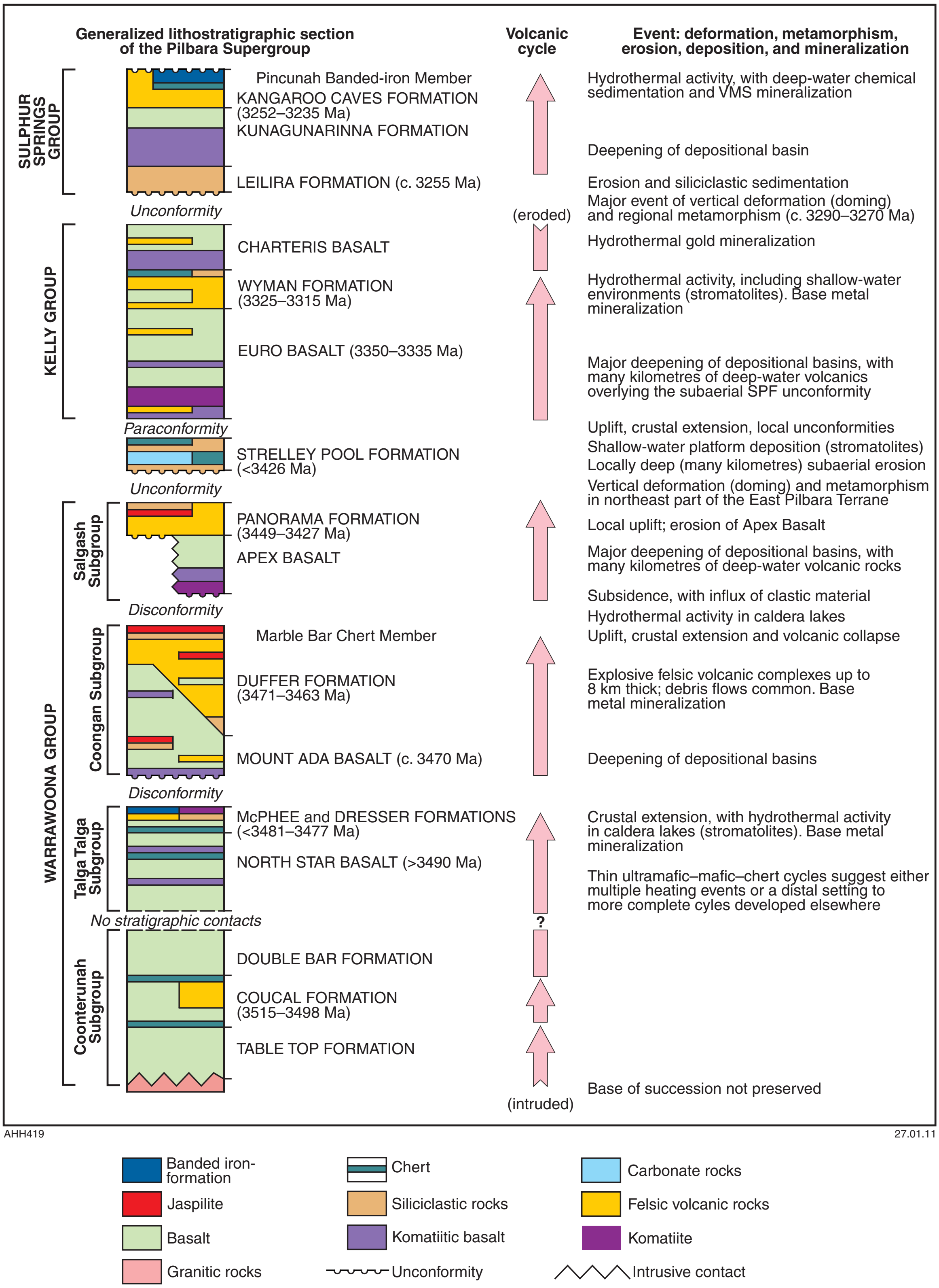

Figure 4. Revised generalized lithostratigraphy of the Pilbara Supergroup (this paper). The succession is interpreted in terms of eight successive volcanic cycles, most of which are separated by unconformities. Events of deformation, metamorphism, erosion, sedimentary deposition, and mineralization are briefly noted.

deformation. The earliest stage of this Wilson cycle is represented by thick clastic sedimentation in the lower part of the Soanesville Group.

Sedimentological observations made by Eriksson (1981) within the lower Soanesville Group of the Pincunah and Soanesville greenstone belts (Fig. 2) are still relevant today, although he mistakenly grouped this <3.2 Ga succession with c. 2.95–2.93 Ga formations of the De Grey Supergroup. Eriksson (1981) interpreted the lower Soanesville Group as a submarine mid-fan to outer fan succession deposited during intracratonic rifting.

Budjan Creek Formation

The Budjan Creek Formation (Fig. 3) is a succession of clastic sedimentary rocks that unconformably overlies the 3.35–3.31 Ga Kelly Group north and west from Nullagine. U–Pb zircon data indicate a maximum depositional age of c. 3.22 Ga (Van Kranendonk et al., 2006). Eriksson (1981) described the composition and sedimentary structures of the formation, and interpreted the depositional environment as one of intracratonic rifting progressing to deposition on a rifted continental margin. Numerous stacked progradational cycles were interpreted as evidence for sinking graben and deepening lakes. Van Kranendonk et al. (2006) used the maximum depositional age of 3.22 Ga to tentatively assign the Budjan Creek Formation to the top of the Sulphur Springs Group, but the sedimentology of the formation and its rift-related deposition now strongly support its inclusion in the Soanesville Group.

Strelley Pool Formation

The 3.43–3.35 Ga Strelley Pool Formation is a succession of clastic sedimentary rocks, carbonate rocks, and chert that separates the volcanic successions of the Warrawoona and Kelly Groups in eleven greenstone belts of the East Pilbara Terrane (Hickman, 2008). The formation was deposited in shallow-water shelf, stromatolite reef, estuarine, beach, sabkha, lacustrine, and fluviatile environments. Extensive silicification of primary carbonate and fine-grained clastic rocks has locally transformed much of the formation into secondary 'chert', explaining why it was initially named (Lowe, 1983), and for many years referred to, as the 'Strelley Pool Chert'. The Strelley Pool Formation is only 10 to 50 m thick in most areas, although in the Doolena Gap greenstone belt it is almost entirely composed of 1000 m of quartzite. The regional distribution of the Strelley Pool Formation across more than 30 000 km^2 of the East Pilbara Terrane (Hickman, 2008), together with sedimentological evidence, indicates that it was deposited across a regionally peneplained land surface.

As recorded by Hickman (2008), the formation is absent in some greenstone belts where the Euro Basalt of the Kelly Group directly overlies formations of the Warrawoona Group. This feature could be due to non-deposition of the Strelley Pool Formation across upland areas.

Van Kranendonk et al. (2002) interpreted the Strelley Pool Formation (then 'Strelley Pool Chert') to conformably overlie the Panorama Formation and to be genetically related to it. Later, Van Kranendonk et al. (2004, 2006) re-assigned the Strelley Pool Formation to the Kelly Group on the basis that it overlies a regional unconformity and represents the first stage of the mantle plume event that was responsible for the Kelly Group. Hickman (2008) reviewed more-recent evidence indicating that only the upper volcaniclastic part of the Strelley Pool Formation is genetically related to the Euro Basalt. In the East Strelley and Panorama greenstone belts (Fig. 2), detailed stratigraphic studies have found this upper part of the formation to consist of a boulder conglomerate containing lithified clasts derived from the underlying part of the Strelley Pool Formation (Allwood et al., 2007; Wacey et al., 2010). Above the conglomerate is a thin volcaniclastic unit that includes silicified volcanic ash. Lowe (1983) recorded ashfall tuff and volcaniclastic units at the top of the formation that he interpreted to represent distal volcanic deposits. Mantle plume events are commonly preceded by uplift and erosion, so the relatively thin topmost section of the Strelley Pool Formation, above the conglomerate, may be of similar age to the Euro Basalt. However, the main part of the Strelley Pool Formation contains no volcaniclastic material, and is composed of sedimentary facies indicating depositional environments unrelated to volcanism.

Other lines of evidence that argue against the main part of the formation being deposited as the first stage of the Kelly Group mantle plume event include:

- Previous plume events in the Warrawoona Group, as represented by five volcanic cycles (Fig. 4), involved volcanic eruption less than about 10 million years after deposition of the last volcanic unit of the preceding cycle. Unless the Kelly Group plume event was very different from its predecessors, this suggests that it commenced no earlier than c. 3.36 Ga (Euro Basalt volcanism commenced at 3.35 Ga).

- Previous plume events in the Pilbara Supergroup did not produce volcanic cycles commencing with widespread deposition of conglomerate, sandstone, and carbonate rocks. It could be argued that the Sulphur Springs Group, which unconformably overlies the Kelly Group, does contain a basal clastic succession, the Leilira Formation. However, the Leilira Formation differs from the Strelley Pool Formation in that it (a) contains felsic volcanic and volcaniclastic components and wacke (Van Kranendonk, 2000); and (b) is of similar age to the overlying volcanic formations of the group (Buick et al., 2002).
- Geochronology on the clastic sedimentary rocks of the Strelley Pool Formation in four greenstone belts (reviewed by Hickman, 2008) reveals detrital zircon populations ranging from 3.51 to 3.43 Ga, ages consistent with detritus derived by erosion of the underlying Warrawoona Group. Of the 129 zircon grains analysed, 12 of the youngest had U–Pb model ages of between 3.43 and 3.40 Ga, and two zircons had ages close to 3.36 Ga. These data do not support deposition of the main part of the Strelley Pool Formation shortly before eruption of the volcanic rocks of the Kelly Group at 3.35 Ga.

Dresser Formation

Van Kranendonk et al. (2006) placed the Dresser Formation in the Coonterunah Subgroup of the Warrawoona Group based on a preliminary SHRIMP U–Pb zircon date of 3525 ± 2 Ma for a felsic volcaniclastic unit. However, the maximum age of deposition of this rock was later revised to 3481 ± 3.5 Ma (Van Kranendonk et al., 2008) when it was recognized that a younger concordant zircon population was also present. Hickman and Van Kranendonk (2008) therefore supported a correlation between the Dresser Formation and the 3.48 Ga McPhee Formation of the Talga Talga Subgroup (Van Kranendonk et al., 2007a,b). The Dresser and McPhee Formations are each composed of basalt, chert, carbonate rocks, and minor felsic volcaniclastic rocks, and both formations underlie the 3.47 Ga Mount Ada Basalt. The Dresser Formation also contains hydrothermal barite, evaporites, and stromatolites not present in the McPhee Formation. This is explained by the interpretation that the Dresser Formation was deposited in a caldera setting (Van Kranendonk et al., 2006).

Basalts underlying the Dresser Formation

Following revisions to the interpreted age and stratigraphic position of the Dresser Formation, the underlying basaltic succession in the Panorama greenstone belt has been correlated with the North Star Basalt of the Talga Talga Subgroup (Hickman, 2010).

Apex Basalt

Throughout the Marble Bar greenstone belt, the Apex Basalt is an approximately 3000 m-thick formation of komatiite, komatiitic basalt, tholeiitic basalt, and thin units of chert. The formation disconformably overlies the 3.47 Ga Duffer Formation and conformably underlies felsic volcanic rocks of the 3.45 to 3.43 Ga Panorama Formation. The Apex Basalt is 2500 m thick in the eastern part of the Warralong greenstone belt, but is absent in the western Warralong, Panorama, and Coongan greenstone belts where the Panorama Formation directly overlies the Duffer Formation. These stratigraphic differences can be explained by differential uplift of the granite–greenstone domes (Fig. 1) across the boundary faults prior to 3.45 Ga. If the boundary faults were active following 3.47 to 3.46 Ga deposition of the Duffer Formation they could have controlled the extent of the depositional basins of the Apex Basalt. Alternatively, if the boundary faults became active shortly after deposition of the Apex Basalt, this could have led to it being eroded across those domes that were uplifted. Hickman and Van Kranendonk (2004) interpreted the boundary faults as 3.30 to 2.95 Ga structures, and the present suggestion that pre-3.43 Ga Warrawoona Group stratigraphy was influenced by these boundaries is a new concept. Evidence that the Apex Basalt was eroded from the Coongan greenstone belt may lie in the existence of numerous dolerite dykes that intrude the 3.47 Ga Duffer Formation in this greenstone belt; a similar situation exists in the Marble Bar greenstone belt where dolerite dykes in the Duffer Formation were feeders to the overlying Apex Basalt (Hickman and Van Kranendonk, 2008). More-detailed mapping is required to establish if any of the dolerite dykes of the Coongan greenstone belt are truncated at the base of the Panorama Formation.

Discussion

Figure 4 presents a revised lithostratigraphic succession for the Pilbara Supergroup, and interprets the main events that were responsible for the deposition of the succession. A key feature of the Pilbara Supergroup is that it is composed of vertically repeated ultramafic–mafic–felsic volcanic cycles, each of which is attributed to plume-related partial melting of the upper mantle and lower crust (Van Kranendonk et al., 2002; Smithies et al., 2005). Another important feature is the presence of several unconformities in the succession (Fig. 4). Two major unconformities separate the three groups, and disconformities or paraconformities separate the volcanic cycles within the groups. Some of the disconformities are marked by laterally discontinuous clastic sedimentary lenses formed by erosion of small-scale surface structures at the tops of the cycles. These structures were most likely formed either by crustal extension (related to regional doming or local subvolcanic intrusion) or by volcanic collapse that produced calderas. Alternating stages of uplift and subsidence are evident from the repeated examples of subaerial erosion and/or shallow-water deposition followed by pillow basalt successions more than 3000 m thick (Mount Ada, Apex, Euro, and Charteris Basalts). Such rapid and major variations in basin depth are best explained by periods of domal uplift and basin subsidence. Structural evidence (Hickman, 1984; Collins, 1989; Van Kranendonk et al., 2002, 2006, 2007a,b; Hickman and Van Kranendonk, 2004) demonstrates that the domes were formed by vertical uplift. Geochemical evidence (Smithies et al., 2005, 2007; Van Kranendonk et al., 2007a,b) supports a relationship to mantle plumes. Stratigraphic evidence, such as that discussed here for the Apex Basalt, could be investigated to provide more information on differences in the timing and amounts of uplift and subsidence in the eight granite–greenstone domes.

Conclusions

Further work since a formal lithostratigraphic definition of the Pilbara Supergroup (Van Kranendonk et al., 2006) necessitates revision of its composition and succession. The Soanesville Group is now formally excluded from the Pilbara Supergroup because its deposition marked a major change in tectonic processes operating in the Pilbara Craton (Van Kranendonk et al., 2010). The age, sedimentology, and interpreted tectonic setting of the Budjan Creek Formation support assignment to the Soanesville Group instead of the Sulphur Springs Group. The Strelley Pool Formation is no longer assigned to the Kelly Group for reasons previously published (Hickman, 2008), and is interpreted to be a sedimentary formation that separates the Warrawoona Group from the Kelly Group. The 3.48 Ga Dresser Formation has been moved from the Coonterunah Subgroup to the Talga Talga Subgroup following revised geochronology and a new correlation with the McPhee Formation; accordingly, basalts underlying the Dresser Formation in the Panorama greenstone belt (Fig. 2) have been assigned to the North Star Basalt (Hickman, 2010). All these revisions are shown on Figure 4.

The restriction of the Apex Basalt to particular greenstone belts is now thought to be the result of differential vertical movement (several kilometres) of the east Pilbara domes between 3.46 and 3.45 Ga. The domes differ not only in size but also in variable amounts of uplift. This raises the possibility that regional thickness variations in other formations are also at least partly due to variations in the amplitude and timing of domal uplift, and to varying subsidence in the different greenstone basins. Differences in uplift may be explained by varying extents of intrusion by the four granitic supersuites of the East Pilbara Terrane. These supersuites were largely responsible for inflation of the domes between 3.49 and 3.23 Ga (Hickman and Van Kranendonk, 2004; Van Kranendonk et al., 2006). Available geochronology indicates that the volumes of individual supersuites vary considerably between the domes, and some domes lack any intrusions of some supersuites (Van Kranendonk et al., 2006, Figs 10–13).

References

Allwood, AC, Burch, IW, Walter, MR 2007, Stratigraphy and facies of the 3.43 Ga Strelley Pool Chert in the southwestern part of the North Pole Dome, Pilbara Craton, Western Australia: Geological Survey of Western Australia, Record 2007/11, 22p.

Buick, R, Brauhart, CW, Morant, P, Thornett, JR, Maniw, JG, Archibald, NJ, Doepel, MG, Fletcher, IR, Pickard, AL, Smith, JB, Barley, ME, McNaughton, NJ and Groves, DI 2002, Geochronology and stratigraphic relationships of the Sulphur Springs Group and Strelley Granite: a temporally distinct igneous province in the Archaean Pilbara Craton, Australia: Precambrian Research, v. 114, p. 87–120.

Collins, WJ, 1989, Polydiapirism of the Archaean Mt Edgar batholith, Pilbara Block, Western Australia: Precambrian Research, v. 43, p. 41–62.

Eriksson, KA 1981, Archaean platform–trough sedimentation East Pilbara Block Australia, *in* Archaean Geology *edited by* JE Glover and DI Groves: Second International Archaean Symposium Perth, 1980, Geological Society Australia, Special Publication no. 7, p. 235–244.

Hickman, AH 1975, Precambrian structural geology of part of the Pilbara region: Geological Survey of Western Australia, Annual Report 1974, p. 68–73.

Hickman, AH 1981, Crustal evolution of the Pilbara Block, *in* Archaean Geology *edited by* JE Glover and DI Groves: Second International Archaean Symposium, Perth, 1980, Geological Society Australia Special Publication no. 7, p. 57–69.

Hickman, AH 1984, Archaean diapirism in the Pilbara Block, Western Australia, *in* Precambrian Tectonics Illustrated *edited by* A Kröner and RE Greiling: Schweizerbarts'che Verlagsbuchhandlung, Stuttgart, p. 113–127.

Hickman, AH 2004, Two contrasting granite–greenstone terranes in the Pilbara Craton, Australia: evidence for vertical *and* horizontal tectonic regimes prior to 2900 Ma: Precambrian Research, v. 131, p. 153–172.

Hickman, AH 2008, Regional review of the 3426–3350 Ma Strelley Pool Formation, Pilbara Craton, Western Australia: Geological Survey of Western Australia, Record 2008/15, 27p.

Hickman, AH 2010, Marble Bar, WA Sheet SF 50-8 (third edition): Geological Survey of Western Australia 1:250 000 Geological Series.

Hickman, AH and Van Kranendonk, MJ 2004, Diapiric processes in the formation of Archaean continental crust, East Pilbara Granite–Greenstone Terrane, Australia *in* The Precambrian Earth: Tempos and Events *edited by* PG Eriksson, W Altermann, DR Nelson, WU Mueller, and O Catuneau: Elsevier, p. 54–75.

Hickman, AH and Van Kranendonk, MJ 2008, Archean crustal evolution and mineralization of the northern Pilbara Craton — a field guide: Geological Survey of Western Australia, Record 2008/13, 79p.

Hickman, AH, Smithies, RH and Tyler, IM 2010, Evolution of active plate margins: West Pilbara Superterrane, De Grey Superbasin, and the Fortescue and Hamersley Basins — a field guide: Geological Survey of Western Australia, Record 2010/3, 74p.

Lipple, SL 1975, Definitions of new and revised stratigraphic units of the eastern Pilbara Region: Geological Survey of Western Australia, Annual Report 1974, p. 58–63.

Lowe, DR 1983, Restricted shallow-water sedimentation of early Archaean stromatolitic and evaporitic strata of the Strelley Pool chert, Pilbara block, Western Australia: Precambrian Research, v. 19, p. 239–283.

Rasmussen, B, Fletcher, IR and Muhling, J 2007, In-situ U–Pb dating and element mapping in three generations of monazite: Unravelling cryptic tectonothermal events in low-grade terranes: Geochimica et Cosmochimica Acta, v. 71, p. 670–690.

Smithies, RH, Van Kranendonk, MJ and Champion, DC 2005, It started with a plume — early Archaean basaltic proto-continental crust: Earth and Planetary Science Letters, v. 238 (3–4), p. 284–297.

Smithies, RH, Champion, DC, Van Kranendonk, MJ and Hickman, AH 2007, Geochemistry of volcanic units of the northern Pilbara Craton: Geological Survey of Western Australia, Report 104, 47p.

Van Kranendonk, MJ 2000, Geology of the North Shaw 1:100 000 sheet: Geological Survey of Western Australia 1:100 000 Geological Series Explanatory Notes, 86p.

Van Kranendonk, MJ, Hickman, AH, Smithies, RH and Nelson, D 2002, Geology and tectonic evolution of the Archean North Pilbara Terrain, Pilbara Craton, Western Australia: Economic Geology, v. 97, p. 695–732.

New geoscience

Van Kranendonk, MJ, Smithies, RH , Hickman, AH, Bagas, L, Williams, IR, and Farrell, TR 2004, Event stratigraphy applied to 700 million years of Archaean crustal evolution, Pilbara Craton, Western Australia: Geological Survey of Western Australia, Annual Review 2003–04, p. 49–61.

Van Kranendonk, MJ, Hickman, AH, Smithies, RH, Williams, IR, Bagas, L and Farrell, TR 2006, Revised lithostratigraphy of Archean supracrustal and intrusive rocks in the northern Pilbara Craton, Western Australia: Geological Survey of Western Australia, Record 2006/15, 57p.

Van Kranendonk, MJ, Smithies, RH, Hickman, AH and Champion, DC 2007a, Secular tectonic evolution of Archaean continental crust: interplay between horizontal and vertical processes: Terra Nova, v. 19, p. 1–38.

Van Kranendonk, MJ, Smithies, RH, Hickman, AH and Champion, DC 2007b, Paleoarchean Development of a Continental Nucleus: the East Pilbara Terrane of the Pilbara Craton, *in* Earth's Oldest Rocks — Developments in Precambrian Geology 15 *edited by* MJ Van Kranendonk, RH Smithies and VC Bennett: Elsevier, Amsterdam, p. 307–37.

Van Kranendonk, MJ, Philippot, P, Lepot, K, Bodorkos, S and Pirajno, F 2008, Geological setting of Earth's oldest fossils in the ca. 3.5 Ga Dresser Formation, Pilbara Craton, Western Australia: Precambrian Research, v. 167, p. 93–124.

Van Kranendonk, MJ, Smithies, RH, Hickman, AH, Wingate, MTD and Bodorkos, S 2010, Evidence for Mesoarchean (~3.2 Ga) rifting of the Pilbara Craton: the missing link in an early Precambrian Wilson cycle: Precambrian Research, v. 177, p. 145–161.

Wacey, D, McLoughlin, N, Stoakes, CA, Kilburn, MR, Green, OR and Brasier, MD 2010, The 3426–3350 Ma Strelley Pool Formation in the East Strelley greenstone belt — a field and petrographic guide: Geological Survey of Western Australia, Record 2010/10, 64p.