The Mount Belches Formation — Black Flag Group, a late basin, or something else?

by C. Hall

Abstract

New data and field observations suggest that sedimentary rocks of the younger-than-2666 Ma Mount Belches Formation in the Eastern Goldfields Superterrane are not part of the late-basin succession (Penny Dam conglomerate) or a lateral equivalent of the upper part of the Black Flag Group, but rather a separate unit that underlies the late-basin successions, analogous to the Porcupine assemblage in the Abitibi Province of Canada. Regional mapping has increased the known extent of the Mount Belches Formation, with outcrops on either side of the Kalgoorlie–Kurnalpi terrane boundary, indicating that the Kalgoorlie and Kurnalpi Terranes amalgamated before c. 2666 Ma. New SHRIMP U–Pb zircon data suggest a correlation between deformation in the Mount Belches Formation and a D_2 extensional event described in the Kurnalpi Terrane to the north.

KEYWORDS: Mount Belches Formation, Black Flag Group, sedimentary basins, Porcupine Assemblage, terranes.

Introduction

Late-basin successions of the Eastern Goldfields Superterrane (Cassidy et al., 2006) commonly contain conglomerates and sandstones deposited in basins that are locally fault bound or lie within synclines parallel to the regional north-northwest structural trend. These units rest unconformably on older greenstone successions such as the Black Flag Group (Kalgoorlie Terrane), and are regarded as having been deposited after north–south thrusting and recumbent folding associated with D_1, but before the main regional east–west shortening event of D_2 that produced the north-northwest structural trend (Swager et al., 1995; Swager, 1997; Krapez et al., 2000; Brown et al., 2001, Weinberg et al., 2003). In the Kurnalpi Terrane (Fig. 1), late-stage sedimentary rocks include the Penny Dam and Yilgangi conglomerates, which are successions of polymictic conglomerates and intercalated sandstones (Krapez et al., 2000; Brown et al., 2001). The Mount Belches Formation (Fig. 1), a thick sequence of quartzofeldspathic sandstones, mudstones with minor pebbly conglomerates, and banded iron-formation (Ahmat, 1995; Krapez et al., 2000; Brown et al., 2001), has been mapped as a lateral facies equivalent of the Penny Dam conglomerate (e.g. Swager et al., 1995). Krapez et al. (2000) constrained the maximum depositional age of the Mount Belches Formation to c. 2666 Ma by sensitive high-resolution ion microprobe (SHRIMP) U–Pb analysis of detrital zircons, and included the Mount Belches Formation and Penny Dam conglomerate in their 'Kurrawang Sequence', which they suggested was a submarine fan within a remnant-ocean basin, deposited before 2655 Ma, prior to the D_2 regional compressional event.

In contrast, Painter and Groenewald (2001) argued that the Mount Belches Formation has undergone at least two deformation events, with pre-D_2 folds (west-northwesterly trend) folded by north-northwesterly trending F_2 folds. Evidence cited by Painter and Groenewald (2001) for the earlier folding included a bedding-parallel foliation, irregularities in facing direction in the Mount Belches Formation, and regional-scale fold-interference patterns indicated by aeromagnetic traces of the iron-rich Santa Claus Member of the Mount Belches Formation. These features, resulting from the development of the Randall Dome, indicate that the Mount Belches Formation has undergone a more complex deformation than is commonly observed in the late-basin successions.

In this paper the Mount Belches Formation and its relationship to the late-basin successions and the Black Flag Group are discussed in terms of their significance with respect to the structural and stratigraphic subdivisions of the Eastern Goldfields Superterrane.

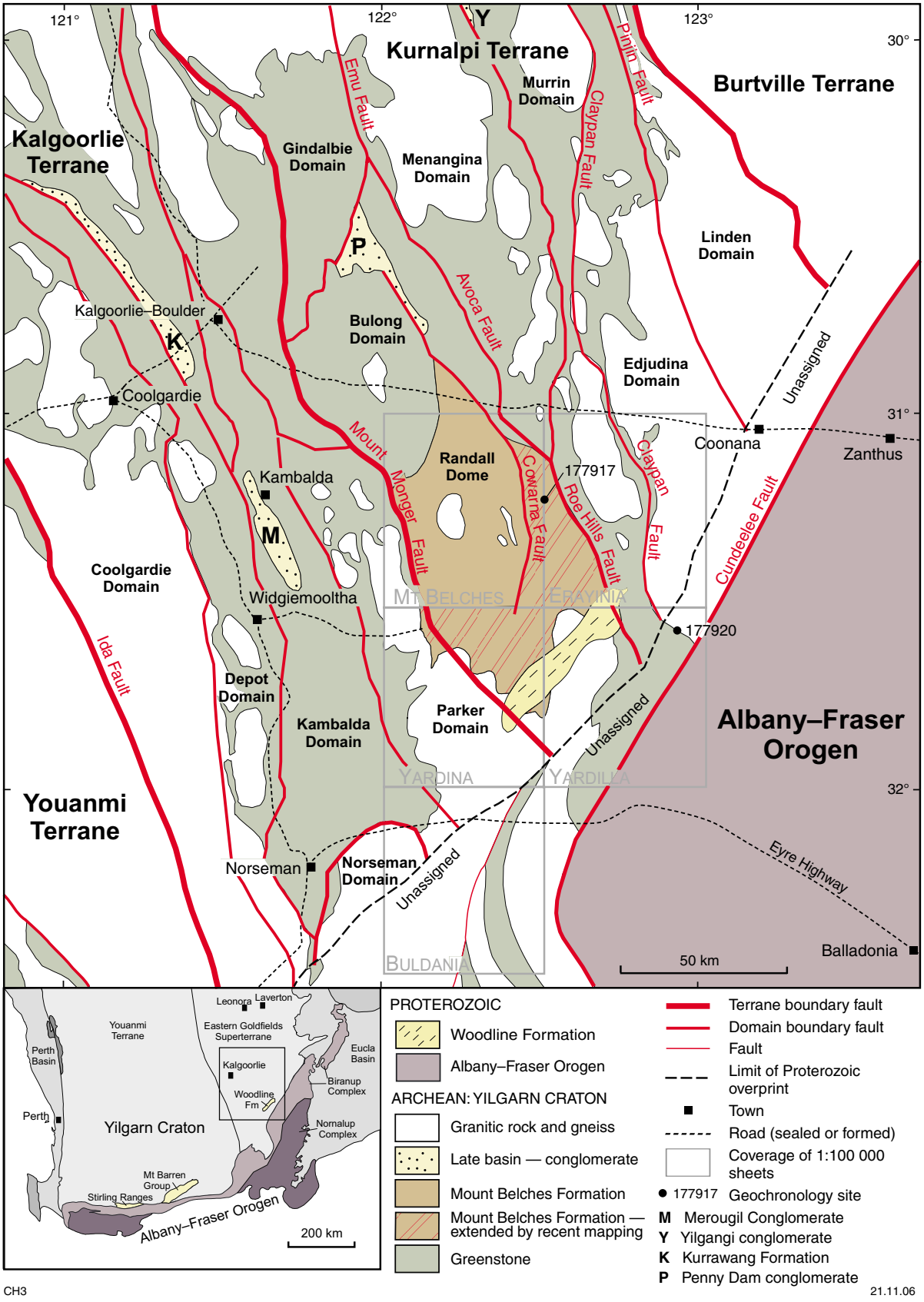

Figure 1. Locality guide and simplified geology showing the position of the Mount Belches Formation with respect to late-basin sedimentary units

Mount Belches Formation

The Mount Belches Formation is a sequence of metamorphosed fine- to coarse-grained sandstones interbedded with siltstones and mudstones, minor chert, banded iron-formation, and granular to pebbly conglomerate. The sandstone–mudstone sequences commonly display normal grading, scours, parallel- and cross-laminations, and soft-sediment deformation, indicative of turbidity current deposition according to Krapez et al. (2000). Petrographically, the sandstones contain relict detrital quartz grains interspersed with biotite clots and poikiloblastic plagioclase, with subordinate amounts of amphibole, chlorite, muscovite, and carbonate, and accessory amounts of magnetite, zircon, titanite, and apatite. A similar mineral assemblage is present in the mudstone layers, but staurolite, andalusite, and garnet are also present where the metamorphic grade reaches amphibolite facies.

The Mount Belches Formation, the late basins, and the Black Flag Group

Recent 1:100 000-scale mapping on Mount Belches* (Painter and Groenewald, 2001), Erayinia (Jones, 2006), Yardina (Hall et al., 2006), and Yardilla (Jones and Ross, 2005) to the east and south of the area studied by Krapez et al. (2000) has increased the known extent of the Mount Belches Formation (Fig. 1) so that: (1) the eastern margin of the Mount Belches Formation is now known to be bound to the east by the Roe Hills Fault rather than the Cowarna Fault (Jones, 2006); (2) the unit extends 20 km farther south than had previously been recognized; and (3) exposure includes a large anticlinal structure called the Randall Dome (Painter and Groenewald, 2001). In contrast, late-basin siliciclastic sedimentary rocks of the Kurrawang Formation and Merougil Conglomerate in the Kalgoorlie Terrane, and the Yilgangi and Penny Dam conglomerates in the Kurnalpi Terrane, lie in narrow north-northwesterly trending, elongate, regional 'D_2' synclinal basins (Fig. 1).

* Capitalized names refer to standard 1:100 000 map sheets (Fig. 1).

In the northwestern part of Yardina (Hall et al., 2006) the Mount Belches Formation is exposed on both sides of the interpreted Mount Monger Fault (Fig. 1), which forms the boundary between the Kalgoorlie and Kurnalpi Terranes (Cassidy, 2004; Cassidy et al., 2006). Rocks of the Mount Belches Formation at the southern end of the Randall Dome are well-bedded siliciclastic sandstones and mudstones that have been metamorphosed to amphibolite facies (Hall et al., 2006). The sedimentological and mineralogical characteristics of the Mount Belches Formation in this area are very similar to sandstones and mudstones that have been metamorphosed to amphibolite facies in the southwestern corner of Yardina, regarded by Hill et al. (1992) and Krapez et al. (2000) as a lateral equivalent of the Black Flag Group of the Kalgoorlie Terrane.

Late-basin sedimentary units are typically bound to the west by observed or interpreted faults (e.g. Merougil Conglomerate of Swager et al., 1995). The Mount Monger Fault is not exposed on either Mount Belches or Yardina, but has been inferred from interpretation of aeromagnetic data and intersection of a fault zone from a drillhole in the northwest corner of Mount Belches (Painter and Groenewald, 2001). If the Mount Belches Formation-like rocks in southwestern Yardina are actually part of the Mount Belches Formation rather than the Black Flag Group, then deposition of the Mount Belches Formation must post-date the amalgamation of the Kalgoorlie and Kurnalpi Terranes.

Deformation in the Mount Belches Formation

Early deformation (D_1) in the Eastern Goldfields Superterrane is poorly defined, but has been identified by bedding-parallel S_1 foliations associated with refolded F_1 folds and local thrust stacking (Swager, 1997). In the Mount Belches Formation, Painter and Groenewald (2001) identified folding of a pre-D_2, bedding-parallel foliation by open F_2 folds. Although Painter and Groenewald (2001) made the comment that the relationship of this early fabric in the Mount Belches Formation to the regional D_1 event is unclear, it suggests deposition earlier than the late-basin successions which do not have a pre-D_2 fabric.

The maximum depositional age for the Mount Belches Formation of c. 2666 Ma post-dates the minimum age of D_1 (Kalgoorlie Terrane), which has been interpreted as c. 2675 Ma (Kent and McDougall, 1995; Swager, 1997; Nelson, 1997). However, Blewett et al. (2004) described an extensional event within the D_2 deformational regime (D_{2E}) in the Kurnalpi Terrane to the north as having occurred at c. 2662 Ma. According to their scheme, this was followed by D_{2b} east–west shortening. A microgranite that lies about 15 km east of the southern end of the Roe Hills Fault and eastern margin of the mapped Mount Belches Formation (Jones and Ross, 2005; Jones 2006) has a strong early lineation folded by D_2 east–west compression. SHRIMP U–Pb zircon dating of the microgranite yielded a crystallization age of 2664 ± 3 Ma (Wingate and Bodorkos, in prep., GSWA 177920). Thus the earliest recognized deformation in the southwestern part of the Kurnalpi Terrane appears to correspond to the D_{2E} extensional deformation of Blewett et al. (2004).

A Canadian analogue of the Mount Belches Formation

In the Abitibi Province of Canada the Timiskaming assemblage is a suite of rocks similar in character and setting to the late basins in the Eastern Goldfields (e.g. Blewett et al., 2004). This assemblage, also found in narrow elongate corridors, is dominated by clastic sedimentary rocks (polymictic conglomerates and sandstones) with subordinate volcanic rocks that have a depositional age range from 2687 to 2675 Ma (Ayer et al., 2002). Unconformably beneath the Timiskaming assemblage, but above the Archean granite–greenstone basement, are rocks of the Porcupine assemblage (Ayer et al., 2002). This assemblage, dominated by sandstones and siltstones displaying Bouma cycles, is interbedded with minor

conglomerates and iron formation (Ayer et al., 2002). The characteristics and relative abundance of the different units in the Porcupine assemblage are very similar to those described for the Mount Belches Formation (Painter and Groenewald, 2001), suggesting that the Mount Belches Formation lies in a similar stratigraphic setting within the Eastern Goldfields Superterrane.

Conclusion

New geochronological data and field observations suggest that the Mount Belches Formation is not part of the late-basin sequence (Penny Dam conglomerate) or the Black Flag Group, but is a separate turbidite-dominated unit similar in character to the Porcupine assemblage in the Abitibi Province of Canada. If the Mount Belches Formation is a much more widespread unit than has previously been described, then the fact that it has been deposited on both sides of the Mount Monger Fault constrains the age of major movement on this terrane boundary to before c. 2666 Ma. Earlier interpretations of the Mount Belches Formation as a lateral equivalent of the Penny Dam conglomerate, or rocks that may belong to the Mount Belches Formation as lateral equivalents of the upper Black Flag Formation, highlights a problem in the definition of what constitutes a 'late basin' in the Eastern Goldfields Superterrane.

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