Continental extensional setting for the Archean Belingwe Greenstone Belt: Comment and Reply

COMMENT

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Hunter et al. (1998) used stratigraphic data from the basal Manjeri Formation of the Archean Belingwe Greenstone Belt to support an ensialic model for the entire structurally complex belt. They claimed their data refute claims by Kusky and Kidd (1992) that a several kilometers-thick pile of 2692 ± 9 Ma (Chauvel et al., 1993) basalts and komatiites in the upper part of the greenstone belt is allochthonous.

Hunter et al. (1998) claimed that Kusky and Kidd (1992) stated the entire Manjeri Formation formed in a foreland basin, yet in other places they claimed we suggested the entire Upper Greenstone succession (Manjeri, Reliance, Zeederbergs, and Cheshire Formations) is allochthonous, and represents a single tectonic environment. We have not made such statements, but agree with Hunter et al. that rocks of the basal part of the Manjeri Formation were deposited in an extensional and/or passively subsiding shallow marine setting, with fluvial and transitional marine-fan delta influences higher in the autochthonous sequence. Kusky (1998) suggested the basal part of the Manjeri Formation is a remnant of a regionally extensive passive margin sequence deposited on the southeastern edge of the proto-Zimbabwe craton, in the interval of 2831–2700 Ma, prograding over older gneissic rocks and a 2904–2831 Ma rift sequence preserved in the Lower Greenstone sequences. We interpret the middle clastic part of the Manjeri Formation as a drowning sequence, reflecting the transition into a flysch basin. The upper part of the Manjeri Formation is consistently a strongly deformed banded iron formation. Only the middle part of the sequence was interpreted by Kusky and Kidd (1992) to be a foreland basin deposit, and data presented by Hunter et al. lend further support to this interpretation.

Kusky and Kidd (1992) and Kusky and Winsky (1995) suggested the Mberengwa allochthon (consisting of komatiites and basalts of the Reliance and Zeederbergs Formations) was emplaced over the Manjeri Formation using the banded iron formation at the top of the Manjeri Formation as the regional detachment at 2700–2650 Ma. The data presented by Hunter et al. (1998) are limited to the basal part of the 2831–2700 Ma Manjeri Formation. It is most unlikely that the basal Manjeri Formation has anything to do with a thrusting event that postdates deposition of these rocks by up to 130 m.y.

Hunter et al. presented misleading statements about local basement sources for the Manjeri Formation (implying the entire formation), when their chemical data is limited to the basal 20 m (Spring Valley Member) of section. These data have no significance for whether or not the structurally overlying Reliance and Zeederbergs Formations are allochthonous. In both interpretations, this basal part of the Manjeri Formation was deposited on the older gneissic terrane, and Hunter et al. produced geochemical confirmation of this relationship. It would have been informative if Hunter et al. had presented data on the upper part of the Manjeri Formation, which may, if the allochthonous model is correct, show a transition into a sequence containing a contribution from sources in the eroding allochthon. Interestingly, Hunter (1997) showed that the middle (Rubweruchena) Member of the Manjeri Formation is less fractionated than the underlying Spring Valley Member, consistent with the transition from a passively subsiding environment to a foreland basin as inferred by Kusky and Kidd (1992). These data were not reported by Hunter et al. (1998).

The facies analysis of the upper Manjeri Formation (Rubweruchena Member) presented by Hunter et al. is non-unique—they suggested graywackes, shales, sandstones, and conglomerates were deposited in a basin by “small-scale alluvial fans or fan-deltas.” This could be a continental extensional basin as postulated by Hunter et al., or a foreland basin in which allochthonous plateau basalts were exposed, as suggested by Kusky and Kidd (1992). Foreland basins characteristically show sources, including the exposed allochthon and the underlying basement terrane exposed in normal fault scarps on the outer trench slope.

Hunter et al. previously denied, but now dismiss as insignificant, evidence of deformation along the contact between the Manjeri and Reliance Formations, despite remarkable similarities between this shear zone and stratigraphically controlled regional detachment zones of mountain belts worldwide (Kusky and Winsky, 1995). Hunter et al. attributed deformation along the Manjeri-Reliance contact to strain accommodation in a tightly folded syncline. However, their model did not explain why this particular contact is ubiquitously deformed, whereas other contacts with similar rheological contrasts and orientations are not deformed. It also did not account for the kinematics of the shear zone, which show subhorizontal lineations and movement directions in the low-grade chert-tectonites, with relative northward movement of the Mberengwa allochthon with regard to the Manjeri Formation and gneiss terrane, nor the presence of thrust ramps that cut out part of the upper Manjeri Formation, with consistent ramping up to the northwest.

Hunter et al. ended by pondering the paradox of how regionally similar volcanic belts might be deposited contemporaneously in isolated rifts across the craton. They simply were not. To support their model, Hunter et al. misquoted several previous works, including a report of alleged “basement zircon xenocrysts in more felsic units” (Wilson et al., 1995); Wilson et al. (1995) presented no data from the Upper Greenstones at Belingwe, but only from the underlying 2.9 Ga greenstone assemblage. Likewise, data of Chauvel et al. (1993) are overstated by Hunter et al. to support geochemical contamination of komatiites of the Reliance Formation by older continental crust. Chauvel et al. (1993) were more cautious in the interpretation of their Pb and Nd isotopic data. They simply noted that if there is contamination in the komatiites, it amounts to less than 1%, and they considered this as only one possibility along with others, including fractionation, alteration, and problems associated with sampling different, widely separated lava flows. Their samples were also considered to be contaminated by fluids that circulated through nearby late faults.

In summary, Hunter et al. (1998) presented data that confirm field relationships in the Belingwe Greenstone Belt but bear no relationship to the emplacement of the Mberengwa allochthon.

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REPLY

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The core arguments of Kusky and Kidd's Comment rest on whether there is evidence for a major allochthon in the Belingwe Greenstone belt. We see no evidence of an allochthon.

Kusky and Kidd (1992) suggested downwarping of the crust in front of a large accreting block and consequent deposition of the rocks we have described as the Rubweruchena Member of the Manjeri Formation as a drowning sequence. The Rubweruchena Member, where present, consists of 0–150 m of poorly sorted conglomerate, pebble beds, and sands. Erosion of an allochthon as suggested by Kusky and Kidd (1992) would create a basin with a thick sedimentary succession. It seems unlikely that the accretion of an allochthon many kilometers thick and ~45 000 km^2 would generate a basin fill only 0–150 m thick.

Kusky and Kidd's argument that the basal Manjeri Formation was deposited from 2831 Ma is unrealistic. The 2831 Ma age was recorded from a reworked dacitic clast in underlying rocks that were uplifted, deformed, and eroded prior to deposition of the Manjeri Formation. In contrast, we believe that the Manjeri Formation is broadly conformable with the rest of the Ngezi Group, and it is more likely that the sedimentary succession was laid down in a relatively short period around 2.7 Ga.

Material contributed to the Rubweruchena Member from a postulated advancing allochthon of Reliance and Zeederbergs Formations would dominate the modal mineralogy of the Rubweruchena Member, reduce the apparent fractionation of rare earth element (REE) patterns, lower the model age of the source terrain, and raise the ε_{Nd}. We observed none of these features in the sedimentary record of the Manjeri Formation; the mineralogy of the Rubweruchena Member is continental. REE patterns from the Rubweruchena Member indicate heterogeneous local basement sources throughout deposition (Hunter, 1997). This conclusion is reinforced by model ages from the Spring Valley and Rubweruchena Members (Hunter et al., 1998). Sm-Nd model ages from the eastern side of the belt (3234–3708 Ma) reflect the age range of the underlying granitoids, and younger model ages from the west (2969–3103 Ma) mirror the underlying greenstones. Most ε_{Nd} are negative and show a distinct bimodality between east and west for a stratigraphic age of 2700 Ma (the age of the volcanic rocks and probably the stratigraphic age of the sediments; Fig. 1). As would be expected, ε_{Nd} values from the Reliance Formation directly overlying the Manjeri Formation are positive at 2700 Ma (Chauvel et al., 1993).

The evidence of deformation at the contact between the Manjeri and Reliance Formations was described by us (Bickle et al., 1975) and has been discussed in several papers (Bickle et al., 1994 and references therein). The Jimmy Member is certainly a plane of strain accommodation, but it is not a mylonite developed on a large-scale detachment as suggested by Kusky and Kidd (1992). Grassineau et al. (1999) showed fine-scale, unambiguously biogenic, heterogeneity in S and C isotopic ratios in samples from this horizon ($\delta^{34}S$ –15‰ to +17‰ in sulfide, $\delta^{13}C$ –38‰ to –28‰ in kerogen); this heterogeneity is inconsistent with deformation of the gossan in a major shear zone.

Wilson has recognized the Manjeri unconformity widely across the Zimbabwe craton. This work, in several papers (summarized in Wilson et al., 1995), presents evidence for inherited (xenocrystic) zircons in the Upper Bulawayan. Several studies have confirmed continental contamination of the volcanic pile at Belingwe (e.g., Scholey, 1992). The conclusion is strong: the succession is ensialic. The arguments of Kusky and Kidd are contradicted by the sedimentary evidence in the Manjeri Formation, and the large scale thrusting they propose is precluded by preservation of fine-scale biogenic heterogeneity in the Jimmy Member.

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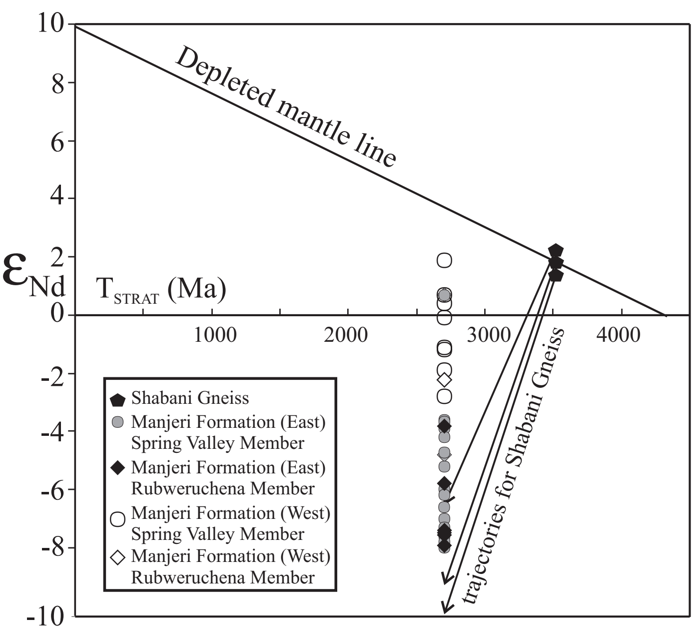

Figure 1: Plot of ε_{Nd} against T_{STRAT} for Manjeri Formation. ε_{Nd} calculated for T_{STRAT} = 2700 Ma.

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