Ensialic origin for the Ngezi Group, Belingwe greenstone belt, Zimbabwe: Comment and Reply

COMMENT

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The Belingwe greenstone belt has long been regarded as the archetype of an Archean greenstone belt deposited on preexisting continental crust. On the basis of published geological maps and reports, Kusky and Kidd (1992) reinterpreted the belt as a structurally complex fragment of an allochthonous oceanic plateau. Critical to this model is a shear zone, postulated to lie along the boundary between autochthonous shallow-water sedimentary rocks of the Manjeri Formation and structurally overlying ultramafic and mafic lavas of the Reliance and Zeederbergs Formations. Blenkinsop et al. (1993) provided a field description of part of this shear zone, but they disagreed with Kusky and Kidd (1992) that it represents a major tectonic discontinuity.

Blenkinsop et al. (1993) disputed the allochthonous oceanic plateau interpretation by presenting a detailed description of shallow-water sedimentary rocks of the Manjeri Formation underlying the shear zone and by attempting to establish links between this entirely sedimentary sequence and the entirely mafic volcanic-plutonic succession above the shear zone. The uppermost Manjeri Formation contains a deepening-upward sequence (Grotzinger, 1989; Kusky and Kidd, 1992; Blenkinsop et al., 1993), grading from graywacke-argillite flysch into a thin, highly folded sulfide-rich banded chert–shale interval. The drowning of the shallow-water shelf may represent a response to thrust load–induced subsidence. In younger mountain belts, drowning sequences are typically overlain by the tectonic load that produced the subsidence. Likewise, Kusky and Kidd (1992) interpreted the volcanic Reliance and Zeederbergs Formations, which overlie shelf sandstones and the deepening-upward sequence, to represent the tectonic load (Mberengwa allochthon) that induced drowning of the Manjeri platform.

Blenkinsop et al. (1993) considered it unlikely that any significant fault would remain along the same stratigraphic level across the entire 5-km-long area they mapped, but our recent field work confirms the presence of footwall cutoffs just outside their map area, where ultramafic lavas of the Reliance Formation are juxtaposed with shallow-water carbonates, and the upper 300 m of the Manjeri Formation are omitted (see also Martin, 1979; Scholey, 1992). The fault does *not* remain along the same stratigraphic horizon on a regional scale, but cuts through the section a few kilometres north and south of the boundaries of the area mapped by them (e.g., Scholey, 1992). Blenkinsop et al. (1993) stated that the structural relief at the *base* of the Manjeri Formation makes it unlikely that the detachment would remain along the same stratigraphic level at the *top* of the formation, despite the fact that the formation is several hundred metres thick. Where not cut out by footwall ramps, the top of the Manjeri Formation is a deep-water deposit that is not unlikely to have been a smooth depositional surface. During emplacement of the lavas it would have behaved like similar shale or salt horizons in younger mountain belts, forming a regional decollement with large footwall flats.

Blenkinsop et al. (1993) described the basal Reliance Formation as "moderately foliated," with unstrained pillows 16 m above the contact, and undeformed rocks nearby, 200 m above the base of the ultramafic lavas. The presence of this foliation contrasts markedly with the essentially unstrained nature of the rocks on either side of this zone. In our field work at the Manjeri Formation type locality, we found that the top of the formation is marked by a 3-m-thick interval of intensely folded, phacoidally cleaved chert tectonite exhibiting asymmetric C-S foliation surfaces, separated by stringers of Fe-rich argillite, repeated along numerous layer-parallel and oblique contractional faults. This is succeeded by a 3-cm-thick phyllonitic fault gouge–shear zone (not mud) juxtaposing the deformed chert bands with ultramafic schist, and then 16 m of poor exposure containing no fewer than six thin, ultramafic high-strain and mylonite zones. Elsewhere along the same contact, where not cut out by late faults, the basal Reliance Formation is marked by up to 200 m of ultramafic mylonite and phyllonite, in places wrapping around blocks of Manjeri Formation quartzite. Attributing little significance to the high-strain zone at the top of the Manjeri Formation and in the base of the Reliance Formation, Blenkinsop et al. (1993) contrasted it with some rather thick shear zones found along parts of the bases of some younger ophiolites. They did not compare it to other, equally significant, but thinner shear zones found along other parts of these same ophiolites, and marking many other large thrusts within orogenic belts of the world (for shaly fault rocks, e.g., Champlain thrust: 1 cm–6 m thick, 100 km displacement [Rowley, 1982]; Glaurus thrust: ~1 m thick, 35(+) km displacement [Trümpy, 1969]). Blenkinsop et al. (1993) estimated displacements along the fault at a "few tens of meters," on the basis of asymmetric folds within the decollement horizon. In contrast, Kusky and Kidd (1992) noted a lack of any root zone for the allochthonous volcanics and, using the geometry of the regional folds, estimated a minimum displacement of 28 km along this same detachment. Also, as a supporting argument for large-scale transport, if the Reliance and Zeederbergs Formation were erupted over the Manjeri Formation, why are there no related feeder dikes or sills cutting the underlying formation?

Blenkinsop et al. (1993) suggested that the allochthonous model cannot be correct, claiming that the volcanic stratigraphy does not resemble oceanic crust, nor Bickle's (1986) model of Iceland. This is precisely the reason Kusky and Kidd (1992) made the analogy between the Belingwe lavas and Phanerozoic oceanic plateaus (*not* normal oceanic crust), which consist of thick sequences largely or entirely of subaquatic lavas and sills, perhaps with local komatiites. By comparison with younger oceanic plateaus, the apparent lack of sheeted-dike complexes in the Belingwe belt suggests that it was produced by off-axis magmatism. Storey et al. (1991) noted that Phanerozoic komatiites are associated with oceanic plateaus (e.g., Gorgona with the Caribbean plateau), and that oceanic plateaus represent a good modern analog for many komatiite-tholeiite lava sequences in Archean greenstone belts. We agree, and we think that the Belingwe belt represents one such example and might be related to a regional tectonic event involving accretion and dismemberment of small oceanic plateaus or seamounts. Blenkinsop et al. (1993) appear to have had difficulty envisioning how such a tectonic event could disperse fragments of an oceanic plateau across a 45 000 km^2 area (the central Zimbabwe or Rhodesian craton). However, the Zimbabwe craton is dwarfed by the >5 000 000 km^2 North American Cordillera, containing the ~150 000 km^2 accreted and tectonically dispersed Wrangellian oceanic plateau.

In summary, Blenkinsop et al. (1993) provided the first detailed field description of the shear zone along the Manjeri-Reliance contact. Kusky and Kidd (1992) postulated this fault on the basis of published maps of the Rhodesian Geological Survey and stated the need for detailed field work aimed at determining the significance of published descriptions of structural disruption at the top of the Manjeri Formation. The significance of this shear zone remains enigmatic; with present data, it can be interpreted as a major tectonic boundary or a flexural slip interface related to regional folding. Further field and geochronological investigations aimed at deciding between these two possibilities, and perhaps others, are needed.

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REPLY

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Kusky et al. dispute new evidence given in Blenkinsop et al. (1993) for the original interpretation of the Ngezi Group as an ensialic greenstone succession. We welcome the opportunity to discuss this problem in light of their recent visit to the field area.

We agree that drowning induced by a tectonic load is one possible interpretation of the deepening-upward succession in the Manjeri, but we have pointed out that there are other equally viable alternatives (Blenkinsop et al., 1993).

The maximum thickness of the Manjeri Formation is 250 m in the northeast part of the Belingwe belt, so we question how Kusky et al. know that 300 m of section has been omitted from "just outside our mapping area." The footwall cutoff attributed by Kusky et al. to a detachment fault is due to movement on a north-northeast–striking system of faults that are part of the craton-wide sinistral Popoteke set (Wilson, 1990). Most of the thickness variations in the Manjeri (e.g., Martin, 1979), which might be misinterpreted as ramping, are depositional variations due to topography of the surface upon which the Manjeri Formation was deposited, as shown by the smooth outcrop of the top of the Manjeri compared to its base.

Kusky et al. point out that thrusts with large displacements may be thin: we recognize this very well (Blenkinsop, 1989), and we do not question that ophiolites may rest, in places, on very thin faults. We accept that some displacement has occurred on the Manjeri-Reliance contact, and that the thickness of the contact gives no information about the magnitude of displacement. However, we clearly need to emphasize our argument that known ophiolites have a highly strained dynamothermal aureole at least 100 m thick *somewhere* along their base. We have found no evidence *anywhere* for "the ultramafic mylonites at the base of the Belingwe greenstone belt [that] are comparable to dynamothermal aureoles found at the bases of younger obducted ophiolites" (Kusky and Kidd, 1992), and no evidence of "up to 200 m of ultramafic mylonite and phyllonite" (Kusky et al., Comment above).

We agree that so far there are no recorded occurrences of possible feeder dikes cutting the Manjeri and extending into the Reliance-Zeederbergs volcanic pile. However, likely contenders for the feeder-plumbing system of the Ngezi Group volcanics are the several swarms of Mashaba-Chibi dikes, which intrude the pre-Manjeri basement east and southwest of the Ngezi Group, and the areally much more extensive sill-like intrusions of the Mashaba ultramafic suite (Wilson, 1979, 1990). On petrologic grounds, some of these latter intrusions are probably the remains of open-system magma chambers. They were emplaced at or just below the base of the Manjeri and its equivalents throughout much of the south-central region of the Zimbabwe craton and are largely stratigraphically controlled. In the southern part of the Belingwe belt, ultramafic sills of the Ingolubi complex, which we relate to the Mashaba igneous suite, intrude the Mtshingwe Group, disrupt the Manjeri Formation, and intrude the Reliance Formation. One sill, clearly recorded on the published map (Orpen et al., 1985), can be traced for ~9 km within the Reliance Formation and was folded with the first deformation that affected Reliance and Manjeri strata (Orpen, 1978).

We do not regard as fortuitous the close spatial relation between much of the Mashaba ultramafic suite and the Ngezi Group. We emphasize that the various sills and complexes are igneous rocks intruded into continental crust; they are *not* the tectonically emplaced remains of ophiolite fragments.

We agree with Kusky et al. that the Manjeri-Reliance contact sill poses some problems and that further detailed work is necessary. Particular attention must be paid to the cause of thickness variations in the Manjeri Formation, the existence and significance of footwall cutoffs, and sampling fresh material from the contact. We urge the use of the original definition of the Ngezi Group to include the Manjeri Formation, and that the term "Mberengwa allochthon" not be used until allochthoneity has been proven. Sedimentological, geochemical, and structural evidence presented by Blenkinsop et al. (1993) in support of an ensialic origin for the Ngezi Group has not been refuted by Kusky et al.

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