**ARE THE UPPER GREENSTONES AT BELINGWE (ZIMBABWE) ALLOCHTHONOUS?;**
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Understanding processes operative during the Archean (4.55 - 2.5 Ga) is fundamentally important because rocks of this age comprise approximately half of Earth's continental mass. Many Archean rocks are part of a specific litho-tectonic association known as "granite-greenstone terranes". The tectonic regime operative during the formation of these granite-greenstone terranes is a controversial and hotly-debated topic (1). Perhaps most critical for resolving these arguments is determining original relationships between mafic volcanic rocks of the greenstone belts, and older granitic gneisses. Some students of Archean terranes purport that greenstone volcanics were deposited unconformably over pre-existing granitic gneisses in a continental rift setting (1). Other workers support large structural breaks between greenstone belts and granitic gneisses, and depict the granite-greenstone terranes as remnants of collisional tectonics in oceanic or arc settings (1). It is extremely important to distinguish between these two models as the first implies that continental crust existed prior to greenstone belt formation, whereas the second provides a mechanism for the generation of continental crust.

Proponents of the continental-rift/unconformity model for greenstone belt evolution have relied on well-exposed unconformities between gneisses and overlying volcanics at Point Lake and Cameron River in Canada's Northwest Territories (2, 3, 4, 5), at Steep Rock Lake in southern Canada (6, 7), and at Belingwe (Mberengwa), Zimbabwe (8). In the past couple of years, large structural breaks have been recognized between the gneisses and volcanics in the Point Lake Belt (9, 10), the Cameron River area (11), and postulated at Steep Rock Lake (7, 9, 12). Detailed mapping in these areas has shown that the greenstone belts have been transported along basal detachment faults, and structurally emplaced over continental-type gneisses and sediments. These greenstone belts have been reinterpreted as structural slivers of oceanic and island arc material thrust over the gneisses and sediments during collisional tectonics (9, 10, 11, 13). This leaves Belingwe (Mberengwa) as one of the few remaining well-exposed and well-studied examples of a greenstone belt interpreted to have formed on pre-existing continental crust.

Lower portions of the Archean Belingwe greenstone belt (Fig. 1) rest unconformably upon deformed and metamorphosed 3.6 billion year old quartzo-feldspathic gneisses, metapelitic gneisses, and mafic intrusions (19). This "lower greenstone assemblage" (Mtshingwe Group) consists of mafic, ultramafic, intermediate, and felsic volcanic rocks, pyroclastic deposits, and a wide variety of sedimentary rocks. A well-exposed unconformity separates the "lower greenstones" from the "upper greenstone succession" or Ngezi Group (8, 14, 15). The Manjeri Formation at the base of the Ngezi Group immediately overlies this unconformity, and is marked by basal conglomerates and beach sandstones. These grade up into a sequence of shallow-water sedimentary rocks exhibiting tidal structures and stromatolitic limestones. Upper portions of the Manjeri Formation grade up into distinctly different deep-water sediments, including 5-10 meters of chert, and nearly 70 meters of graded arenaceous and argillaceous beds which may be turbidites. These deep-water deposits are capped by what has been variably described as "a sulfide-bearing ironstone (now gossan)" (8), and a "persistent horizon of predominantly sulfide facies banded iron formation" (16). Bickle et al. (8) describe "small shears and tight asymmetric folds" at the top of the iron formation, but attribute little significance to these structures. Martin (17) reports that the iron formation is locally brecciated. By analogy with similar banded rocks in other Archean and younger orogens, it is probable that this horizon is a detachment surface, accounting for the internal strain. Overlying the "iron formation" (high strain zone?) of the Manjeri Formation is up to 6.5 km of ultramafic and mafic lavas and plutonic rocks of the Reliance and Zeederbergs Formations (18). The sharp change from an entirely deep-water sedimentary sequence which lacks volcanics to such a thick sequence of volcanic/plutonic rocks which lacks sediments is striking, and supports the concept of a decollemont along the top of the Manjeri Formation.

The Cheshire Formation is a heterogeneous succession of sedimentary rocks that forms the stratigraphically highest level of the Ngesi Group, located along the main synclinal axis of the Belingwe greenstone belt. It is approximately 2.5 km thick and consists of a variety of lithofacies including conglomerate, immature sandstone, siltstone, limestone, cherty limestone, stromatolitic limestone, and minor banded iron formation of "very low" metamorphic grade (17). Martin (17) documented a general trend across the main synclinal axis such that thicker, and more abundant conglomerates characterize the eastern flank of the syncline, passing laterally across depositional strike into thinner and finer-grained conglomerates along the western flank of the syncline. The western flank is also characterized by abundant limestones which extend laterally along strike for distances of over several kilometers. Clasts of the Zeederbergs Formation in conglomerates of the Cheshire Formation (17) indicates that the Zeederbergs Formation was being uplifted and eroded during deposition of the Cheshire Formation.

Most previous tectonic models for the Belingwe greenstone belt assume that the Manjeri/Reliance contact is a modified conformable contact, but overall stratigraphic and structural relationships suggest alternatively that a large tectonic break may be hidden near the top of the Manjeri Formation. If so, the Belingwe

greenstone belt bears many similarities to younger passive margin sequences overlain by thrust loads made partly of ophiolitic fragments, and it may thus contain a record of Archean ocean opening and closing similar to "Wilson Cycles" described from younger orogenic belts. The Manjeri Formation may represent an Archean passive margin sequence which was flexed downward to deeper water depths and "drowned" under the weight of advancing thrust loads. In this scenario the sedimentary record of this drowning sequence begins with the thin cherts and continues through the turbidites(?) and banded iron formation in the upper parts of the Manjeri Formation. The thrust sheets may be preserved as the distinctive Reliance and Zeederbergs Formations, whereas the thin, highly-folded shaley layer which separates these from the possible drowning sequence is suggested to be the detachment along which the thrust sheets were transported. Similarly thin zones of enormous displacement are known from younger mountain belts (e.g., Champlain thrust in the Taconic orogen). In this model, as the thrust sheets are transported and uplifted, they are partially eroded and form a culminating molasse (Chesire Formation) deposited in a basin subsiding adjacent to a migrating and uplifting accretionary prism. The west to east coarsening of the Cheshire Formation suggests a westward directed transport direction.

| Group | Formation | Lithology | Thickness | Postulated Tectonic Environment |
|---|---|---|---|---|
| *Ngezi Group* | Chesire Fm | conglomerate, limestone, siltstone, shale | up to 2.5 km | molasse ? |
| | | | | unconformity? |
| | Zeederbergs Fm | basalt | up to 5.5 km | ophiolitic allochthon |
| | Reliance Fm. | komatiite and komaiitic basalt | 0.5 - 1.0 km | |
| | | | | major fault ? |
| | Manjeri Fm. | shallow through deep water sediments | 100 meters | passive margin and drowning sequence |
| Unconformity | | | | |
| *Mtshingwe Group* | Koodoovale Fm. | conglomerate, agglomerate | | rift sequence |
| | Bend Fm. and Brooklands Fm. | komatiite, komatiitc basalt, sediments | ~ 4 km | |
| | Hokonui Fm. | intermediate to felsic volcanics and pyroclastics | ~ 8km | |
| Unconformity ? | | | | |
| basement complex | Chingezi gneiss<br>Mashaba tonalite (2.9 Ga)<br>Shabani gneiss (3.5 Ga) | | | older continental crust |

Fig. 1. Stratigraphy and tectonics of the Belingwe greenstone belt, Zimbabwe.

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