A CONTINUOUS RECORD OF TECTONIC EVOLUTION FROM 3.5 Ga TO 2.6 Ga IN SWAZILAND AND NORTHERN NATAL

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The $\sim$3.5 Ga-old bimodal suite underlying an extensive area in south-western Swaziland comprises the oldest-dated sialic rocks in the Kaapvaal structural province(1). The suite consists of leucocratic, layered tonalitic-trondhjemitic gneisses and amphibolites characterized by the effects of repeated high strains(2). This suite is considered to represent a sialic basement on which metavolcanic and metasedimentary rocks, now preserved as scattered 'greenstone' remnants, accumulated. Direct evidence to confirm this temporal relationship is lacking, but structural data from the Dwalile, Assegaai and Commondale areas indicate that (i) the bimodal gneisses experienced a complex structural history prior to the first recognizable deformation in the supracrustal rocks (i.e. D_1 in the supracrustals is equivalent to $D_n + 1$ in the gneisses) and (ii) scattered remnants of the Dwalile rocks infolded with the bimodal suite structurally overlie the gneisses and are preserved in synformal keels (2)(3). Significant proportions of metaquartzites and metapelites are present in the Assegaai 'greenstone' sequence, the presence of which implies the existence of felsic crust in the source area from which these sediments were derived, a conclusion that is consistent with the structural data.

Ultramafic and pillowed mafic rocks of komatiitic and tholeiitic affinity are present in all four 'greenstone' remnants, but each contains distinctive lithologies. The Assegaai sequence is characterized by the abundance of clastic and chemical sediments that are a minor component of the Commondale and Nondweni remnants. In the former there is a prominent sub-volcanic intrusion composed of multiple layers of massive serpentinite (in which relict cumulate olivine is present locally) alternating with spinifex-textured (olivine and pyroxene) layers. There is a consistent relationship in the thicknesses of the individual layers, i.e. where the serpentinite layers range from 10 to 40 m in thickness the spinifex-textured layers are 1 to 3 m thick. At Nondweni the sequence is dominated by pillowed tholeiites interlayered with high-magnesium basalts and basaltic komatiites (up to 22% MgO). The latter show well developed pyroxene spinifex but peridotite komatiites and units with olivine spinifex are entirely absent. Silicification of the volcanics considered to be contemporaneous with extrusion is not uncommon. Within the volcanic sequence are numerous graded air-fall tuffs and flows of rhyolite compositions. A zone with biogenic or stromatolitic structures is also preserved.

These subtle lithologic differences may reflect different levels of exposure and/or ages of accumulation. The Nondweni greenstones show a consistent northwesterly younging direction in rocks which are not highly strained and which are separated by poorly exposed areas of high strain, suggestive of tectonic interslicing. In contrast the Assegaai and Commondale rocks show evidence of early reclined folds, which may be a reflection of deeper infolding. Preliminary geochronologic data indicate that the Dwalile 'greenstones' are of similar age to the Barberton greenstones(1). Pb-Pb isotopic data from a single komatiitic flow at Nondweni define an age of 3.15 Ga that is consistent with an Rb-Sr age of $\sim$3.1 Ga for an associated rhyolite(4). However, Sm-Nd data define an age of 3.6 Ga for komatiitic, tholeiitic and rhyolitic flows. Possible explanations are that either the Pb-Pb and Rb-Sr systems were reset at $\sim$3.1 Ga subsequent to extrusion at $\sim$3.6 Ga, or, on eruption 3.1 Ga ago, the extrusions interacted with $\sim$ 3.5 Ga-old felsic crust leading to a range of initial Nd isotopic compositions of the mafic rocks and the generation of rhyolites by remelting of that crust(4).

Subsequent to the D1 event (Table 1), mantle-derived tonalitic plutons (Tsawela and Braunschweig) and the meta-anorthositic Mponono layered intrusive sheet were emplaced into the bimodal gneisses and Dwalile greenstones. All these rocks were strongly and repeatedly deformed under amphibolite-facies conditions (Table 1).

Sheet-like granitoid batholiths were intruded at $\sim$3.2 and $\sim$3.0 Ga, the locus of emplacement migrating northwards with decreasing age. The $\sim$3.2 Ga-old multiphase sodic granitoid intrusion screens the Assegaai and Commondale greenstone remnants from their underlying gneissic basement. Intrusion occurred in the interval between D1 and D2 in the Assegaai and Commondale areas. A chemically and mineralogically similar granite also intrudes the Nondweni 'greenstones' but neither its age nor structural style have yet been studied.

At a high structural level, a second sheet-like, but more potassic granite, the vast multiphase Lochiel batholith, was intruded at $\sim$3.0 Ga north of Dwalile. Following this period of widespread emplacement of granitic magmas emergence above sea-level of stable continental crust took place. Subaerial weathering of this dominantly granitoid terrane was accompanied in the north by the development of braided stream systems draining southeast off the flank of the NE-trending Lochiel batholith(5) into the Pongola basin(6). Minor contemporaneous volcanism accompanied the fluvial sedimentation and heralded a period of subaerial extrusion of lavas (the 2.94 Ga-old Nsuze Group), that range in composition from basalt to rhyolite and attain a thickness of $\sim$ 8.5 km SE of Piet Retief(7). No ultramafic nor high-MgO flow units are present and the sequence is characterized by the simultaneous extrusion of mafic and acidic lavas. Typically porphyritic andesites are also present.

The Nsuze Group is preserved in a series of inliers in the south where its thickness decreases in part due to truncation by the upper (Mozaan) group of the Pongola Supergroup or by the Palaeozoic Natal Group. Volcanic rocks are less abundant in the southern inliers. Shallow water subtidal and tidal-flat sediments including stromatolitic carbonate sands are prominent in the Wit Mfolozi inlier. A heterolithic unit 1.5 km thick dominated by pyroclastic rocks interlayered with shallow marine sediments forms the base of the Nsuze Group south of Babanango. This unit is truncated towards the east by a 4.0 km thick sequence of tidalite sediments with interlayers of basaltic andesite lavas. Transport directions in the inliers are from the north and northwest.

Sedimentation in the Mozaan group was largely controlled by the interaction of a braided alluvial plain and a macrotidal basin(8). Mozaan sediments are not preserved south of the Wit Mfolozi inlier either as a result of removal by erosion or of non-deposition.

The Mozaan Group is typically deformed into gently dipping, doubly plunging synclinal structures resulting from interference of NW and NE-trending axial traces. Adjacent to the southern margin of the Kaapvaal Province, tight E-trending folds with vertical axial surfaces are dominant reflecting a response to deformation related to the development of the Natal thrust zone at $\sim$ 1.1 Ga. The Nsuze Group is highly strained adjacent to the Swaziland border apparently related to a 20 km wide belt of NW-trending folds and faults with left-lateral movement within which the dyke-like, mafic Usushwana Intrusive Suite was emplaced at $\sim$ 2.87 Ga(9).

The significance of the Pongola Supergroup lies in the fact that it demonstrates the co-existence of stable continental crust in southeastern Africa and metastable crustal conditions in southern central Africa dominated by extrusion and intrusion of voluminous komatiitic and tholeiitic magmas.

Emplacement of large volumes of granitic magmas principally into Pongola rocks terminated Archaean evolution. Multiple gneiss domes separated by screens of Mozaan sediments of high metamorphic grade developed in southern Swaziland adjacent to the belt of NW-striking, highly strained Nsuze rocks. Subsequently a thin sheet (300 to 1000 m thick) of potassic granite was emplaced at the unconformity between the Mozaan Group and its gneissic granitoid basement. The final pulses of granite plutonism resulted in the emplacement of sharply transgressive, typically coarse-grained, porphyritic plutons ranging in size from 40 km^2 to 650 km^2 about which narrow contact aureoles are developed in the Mozaan sediments. Rb-Sr isotopic data have yielded only whole-rock errorchrons for these rocks(10).

The concentration of post-Pongola granitoids within the core of the Pongola depository suggests that depression of the depositional basin promoted partial melting of the lower crust, which would be consistent with the proposed model for the genesis of the granitic melts based on geochemical data(11). The post-Pongola granites differ in their setting from other Archaean granites in southern Africa(5).

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TABLE I SUMMARY OF GEOLOGICAL AND STRUCTURAL EVENTS PRE-PONGOLA

SOUTHWESTERN SWAZILAND (Jackson, 1984)			ASSEGAAI (Talbot, et al., in press)			COMMONDALE (Smith and Hunter, in prep.)		
EVENTS			EVENTS			EVENTS		
AGE	GEOLOGICAL	STRUCTURAL	AGE	GEOLOGICAL	STRUCTURAL	AGE	GEOLOGICAL	STRUCTURAL
~3.5	Bimodal layered gneisses Dwalile metamorphic suite (ultramafic, mafic volcanics; minor clastic and chemical sedimentation)		?	Bimodal layered gneisses, Assegaai supracrustal suite (ultramafic, mafic volcanics and sub-volcanic intrusions, clastic and chemical sedimentation important)		?	Bimodal layered gneisses, Commondale supracrustal suite (ultramafic, mafic volcanics and sub-volcanic intrusions, minor clastic and chemical sedimentation)	
		D_1 Flat-lying F folds			D_1 (early) Sub-horizontal and listric zones of cataclasis. D_1 (late). Transition to ductile flow, generation of F_1 eastward verging recumbent folds.			D_1 · generation of recumbent F_1 folds; thrusts parallel to axial surfaces of F_1 folds (?)
~3.3 ?	Intrusion of Tsawela tonalite. Mafic dykes Intrusion of anorthositic Mponono Intrusive Suite		~3.2 (?)	Intrusion of Anhalt sodic granite sheet		? ?	Intrusion of Braunschweig tonalite Intrusion of Bazane sodic granite sheet; hornblende granodiorite and related leucotonalite intrusions	
		D_2. Intense F_2 folding on flat-lying XY planes of bulk strain						
?	Mafic dykes	D_3. Local ductile shear zones D_4. Tight to isoclinal F_4 folds, vertical to gently dipping NE trending axial surfaces D_5: Gently dipping ductile shear zones, displacement upwards to NW			D_2 · F_2 concentric parallel folds with steeply dipping NNE-trending axial surfaces D_3. Minor disharmonic conjugate folds, NE-trending strike slip faults in metasediments D_4. NW-trending mylonite zones			D_2. F_2 folds with steeply dipping NNE/NE-trending axial surfaces D_3. Mylonitic shearing along granite-supracrustal contacts; faults in supracrustals D_4: Open to tight F_4 folds with steeply dipping NW-trending axial surfaces D_5: WNW and NW mylonitic shearing
~3.2	Intrusion of quartz monzonite pods							
~3.0	Multiphase intrusion of Lochiel granite Sheet	D_6. Folding and mylonitic re-foliation of D_2 fabrics near Lochiel granite	~3.0 ~2.96	Multiple intrusion of Lochiel granite sheet Pegmatitic granite (?)				

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