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Progressive structural overprinting during convergence of arcs and accretion to the Kaapvaal Craton: Evidence from the northern Natal belt, South Africa

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The Kibaran-age Natal belt of South Africa consists of three main terranes, the Margate, Mzumbe and Tugela terranes, considered to represent former island arcs that have been accreted to the southern margin of the Archaean Kaapvaal Craton [1,2]. The Tugela Terrane forming the northernmost part of the Natal belt has been subdivided into four thrust units with different lithostratigraphic characteristics, assembled in an imbricate thrust stack [3]. A structural study has been conducted on one of these, the so-called Madidima tectono-stratigraphic unit that shows the largest rock-compositional variety amongst the four units, including felsic and mafic metavolcanics and intrusives, pelitic and calcareous-pelitic schists, marble and quartzite.

The analyses of structures from outcrop to microscale revealed a sequence of five distinct overprints that affected this area (D_1 to D_5), all of which produced ductile deformation fabrics. The first two events developed axial planar foliations, with S_2 overprinting the earlier S_1 as documented in garnet-bearing pelitic schists. S_1-S_2 relations and the F_2 fold geometry are preserved in rare low-strain zones and point to largely coaxial deformation D_2. The subsequent overprint is strongly non-coaxial, rotating the pre-existing structures (S_0, S_1, S_2) towards a flat-lying orientation that is now dominating the structural grain of the Madidima unit. The younger overprints (D_4, D_5) are only locally observed, with F_4 asymmetric open folds and crenulations in appropriately oriented pre-existing structures. The latest ductile event, D_5, is recorded in granitoid dykes cutting the main foliation at a high angle. These dykes are deformed into low-amplitude folds with a weak axial-planar gneissic fabric.

While D_1 structures are too scarce to be readily interpreted within a larger-scale tectonic framework, all other structures can be related to progressive NE-SW directed compression, and top-to-the-northeast tectonic transport during simple-shear dominated deformation. The transition between D_2 and D_3 is a change from an initially coaxial deformation to non-coaxial deformation, reactivating and intensifying the S_2 to a pervasive shallow-dipping foliation with a strong SW trending stretching lineation, and formation of intrafolial folds aligned in that S-L fabric. While D_4 marks a return to folding and microfolding with less intense top-to-the-northeast shearing, D_5 records essentially bulk pure shear and is interpreted as marking gravitational collapse of an overthickened thrust stack.

Thus, the sequential structural overprinting simply reflects a progression of deformation stages within a single, protracted orogenic episode of mainly NE-directed arc convergence and accretion to the craton

margin in the north. At least two of the deformation events involve reactivation (with or without rotation) of existing structures rather than the formation of discrete new S-L fabrics. Hence, the regionally dominant foliation is, strictly speaking, a composite structure having evolved through up to four stages of the deformation history, (D_1, D_2, D_3, D_5). Without the presence of the late dykes the evidence for D_5, and hence gravitational collapse, may well have gone unrecognised.

References:

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