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Structural evolution and tectonic context of the Mfongosi Group, Natal thrust front, Tugela terrane, South Africa

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Abstract

The Mesoproterozoic Natal Metamorphic Province of Kwazulu–Natal in South Africa is an assemblage of several tectonic units, including accreted oceanic island arcs, obducted oceanic crust and deformed basin material. The highly deformed Mfongosi Group occurs at the leading edge of collision (the Natal thrust front), against and directly overlying the southern margin of the Kaapvaal Craton. Structures within the Mfongosi Group record "local" D_1 and D_2 events, the first of which was "oblique obduction", with predominantly N- to NNE-verging thrusting (D_1). This was followed by sinistral transpression combined with vertical constriction, forming SW-plunging kink folds and SW-plunging prolate pillow basalts (D_2). The third and final event (D_3) was E–W to ESE–WNW extension in a post-thrusting phase, defined by fibrous antitaxial quartz–calcite veining. The westernmost portion of the Mfongosi Group, the Ngubevu area, shows significantly higher finite strains (up to $R_f = 12$) compared to central Mfongosi and eastern Nkandlha areas ($R_f = 1.5$ and less), suggesting highly oblique, largely NE-directed initial collision. Deformation of the NTF in the context of nappe emplacement is constrained by $^{40}Ar/^{39}Ar$ dating of post-cataclastic nematoblastic/porphyroblastic hornblende of the Manyane amphibolite close to the thrust between the Tugela nappe and the Mfongosi Group in the Mfongosi area. Hornblende overgrew the products of low-temperature deformation during the "local" D_1 and D_2. A minimum age of 1171 ± 16 Ma (95% conf., including J-error; weighted by $\sqrt{}$MSWD; MSWD = 4.3) is obtained for the tectonic juxtaposition of the Tugela nappe against the southern portions of the "Mfongosi Basin". This "local" D_1 and D_2 of the Mfongosi Group pre-dates the regional "oblique D_1" and "left-lateral D_2" previously determined for the central and southern terranes of the Natal Metamorphic Province by other researchers. Comparison of the 1171 ± 16 Ma age, with ages for shearing and intrusion, suggests that thrusting and/or mylonite-forming events migrated southwards throughout the Natal Metamorphic Province, being separated by approximately 25 million years. Thrusting and/or mylonite-forming events occurred in the nappe zone from ca. 1135 Ma to 1077 Ma, followed by a period of "quiescence" during which granites intruded, in turn followed by late-tectonic deformation of the southern Mzumbe and Margate terranes from ca. 1004 Ma to 970 Ma. Such a scenario supports previously-proposed indentation models with their implications of oblique convergence and late-tectonic escape of island arcs to the E/ENE (African azimuths).

Keywords: Mesoproterozoic; South Africa; Mobile belt; Structure; Natal thrust front; $^{40}Ar/^{39}Ar$ dating

1. Introduction

The Namaqua–Natal Metamorphic Province represents Mesoproterozoic collision in southern Africa between 1250 Ma and 950 Ma (Moores, 1991; Dalziel et al., 2000). This collision formed the Namaqua–Natal–Falkland–Maudheim Belt, to which researchers have assigned a

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central role in the formation and break-up of the Rodinia supercontinent (Groenewald et al., 1991; Hoffman, 1991; Moores, 1991; Jacobs et al., 1995; Dalziel et al., 2000; Fig. 1). Several features make the Namaqua–Natal Metamorphic Province (NNMP) unique in the context of modern research on mobile belts. Firstly, the tectonic history of the leading collisional edge, in the form of the Mfongosi and Ntingwe Groups, of the Natal Metamorphic Province (eastern portion of the NNMP) has not been definitively resolved by modern dating techniques. Secondly, unlike most other Mesoproterozoic belts within Rodinia, neither the craton nor the Natal Metamorphic Province has been affected by significant Pan-African metamorphism or deformation. The Natal Metamorphic Province is consequently an ideal region in which models of Rodinian Mesoproterozoic tectonostratigraphic sequences, deformation styles and mobile belt evolution may be reconstructed and critically examined.

Numerous subdivisions of the Natal Metamorphic Province (hereafter the ''Natal Sector''), which is a complex assemblage of terranes in northern Natal, South Africa, have been proposed (Matthews, 1959, 1972; Cain, 1975; Matthews and Charlesworth, 1981; Thomas, 1989a,b). This study focuses primarily on the structural evolution of the leading edge of collision in the Natal Sector and the deformation of the ''Mfongosi Basin'', in which the Mfongosi and Ntingwe groups were deposited. This structural evolution is placed in the context of previous research on the nappe zone and accreted island arcs to the south of the Kaapvaal Craton, for which a comprehensive dating and geochemically-defined provenance framework exists. Detailed aims will be outlined after a brief introduction to the Natal Sector.

2. Subdivisions of the Natal Sector

The northernmost tectonostratigraphic unit of the Natal Sector comprises a deformed and metamorphosed melange of basin sediments and potentially pyroclastic basalts. This unit is termed the Natal thrust front (NTF; Figs. 2 and 3), which is divisible into the Ntingwe and Mfongosi Groups. The Ntingwe Group consists of greenschist-facies metasediments with dolomite, limestone, mudstone, shale and conglomerate/breccia protoliths (Matthews, 1959, 1972; Matthews and Charlesworth, 1981). The Mfongosi Group

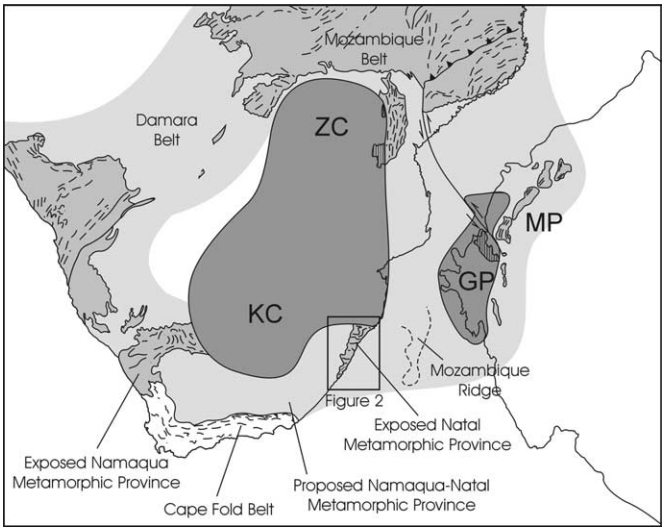

Fig. 1. Palaeoconstruction of the major structural features of the Kaapvaal Craton and Grunehogna Province (Antarctica). Adapted from Martin and Hartnady (1986), Groenewald et al. (1991), Moores (1991), Jacobs et al. (1993) and Jacobs and Thomas (1994). The ''loose fit'' model of De Wit et al. (1988) is preferred (as opposed to the ''tight fit'' model of Roeser et al., 1996). In the former, Proterozoic crust occurs between the Kaapvaal Craton (KC) and the Grunehogna Province (GP: ZC = Zimbabwe Craton; MP = Maudheim Province). The position of Fig. 2 is shown.

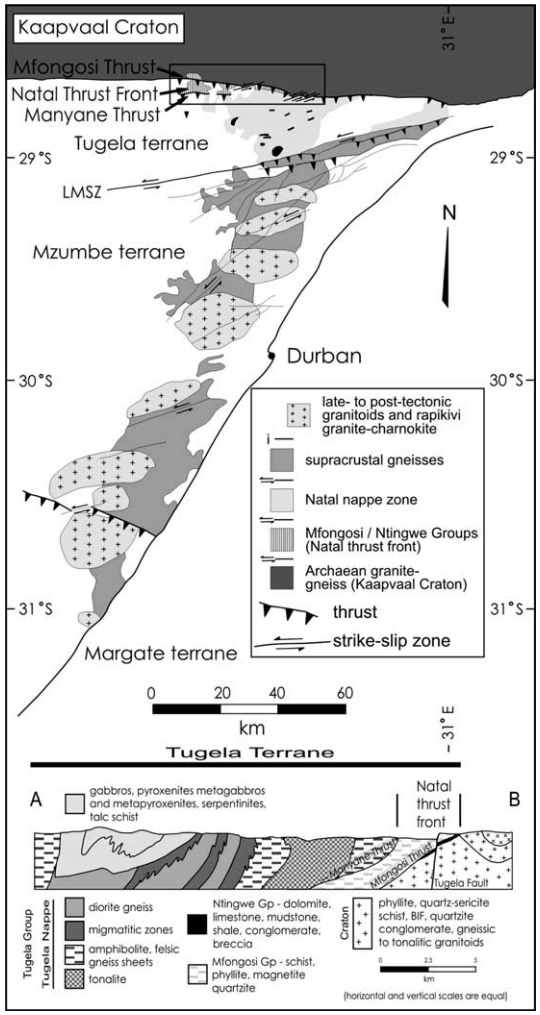

Fig. 2. Simplified map of the Natal Metamorphic Province (the ''Natal Sector''), showing the N–S distribution of tectonic units and lithologies (after Matthews and Charlesworth, 1981; Thomas, 1989b; Jacobs et al., 1993). The Natal thrust front, incorporating the Mfongosi and Ntingwe Groups, occurs at the extreme northern edge of the inlier (see Fig. 3). The position of the Ngubevu area is shown for reference (boxed in area). The Lilani–Matigulu Shear Zone (LMSZ) forms the contact between the nappe zone and the Margate terrane while also defining the sub-outcrop of the southern margin of the Kaapvaal Craton.