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Crustal growth during island arc accretion and transcurrent deformation, Natal Metamorphic Province, South Africa: New isotopic constraints

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ABSTRACT

The Natal Metamorphic Province consists of, from north to south, the Tugela, Mzumbe, and Margate Terranes. These were accreted to the southeastern margin of the Kaapvaal Craton in the late Mesoproterozoic, and followed by intrusion of a large suite of A-type granitoid bodies. New U–Pb data from zircon, titanite, and monazite further constrains the temporal framework of these geological events.

The Tugela and Mzumbe Terranes record protracted magmatism in an island arc complex from ~1200 Ma to 1160 Ma, followed by the accretion of these terranes onto the southern margin of the Kaapvaal Craton at ~1150 Ma. Arc magmatism in the Margate Terrane continued until ~1120 Ma and was followed by extension and bimodal volcanism immediately prior to accretion to the Kaapvaal/Mzumbe continental margin at ~1090 Ma. This accretion was accompanied by high-pressure and high-temperature metamorphism, juxtaposition of the Mzumbe and Margate Terranes along the Melville Thrust, and the formation of a number of syntectonic intrusive units derived from melting of the pre-existing arc crust. After accretion, extensional collapse is evidenced by the intrusion of mafic/ultramafic and alkaline intermediate magmatic suites at ~1085 Ma, resulting from mafic underplating and/or lower crustal delamination. Nd and Hf isotopic data imply the magmatic rocks of the Natal Metamorphic Province were derived from relatively juvenile continental crust, initially generated by island arc magmatism and subsequently reworked during the accretion event(s). The combined Kaapvaal-NMP region (the southern margin of the enlarged Kalahari Craton) then experienced extensive sinistral transcurrent deformation centred along a series of discrete steep shear zones that are found from the Kaapvaal cratonic margin to the southernmost portion of the Natal Metamorphic Province. This deformation is accompanied by low-pressure, (ultra)high-temperature metamorphism, isobaric cooling, and intrusion of the voluminous A-type Oribi Gorge Suite porphyritic granites and charnockites throughout the Mzumbe and Margate Terranes.

1. Introduction

The Mesoproterozoic Natal Metamorphic Province (NMP) is comprised of ~1.3–1.0 Ga lithotectonic terranes which were accreted onto the SE margin of the Archaean Kaapvaal Craton (Figs. 1 and 2). From south to north these terranes are the Margate, Mzumbe, and Tugela Terranes (Thomas, 1989a). The NMP, along with a similar age metamorphic province in the Northern Cape of South Africa and southern Namibia, form part of the Namaqua-Natal belt that is thought to be associated with arc accretion and escape tectonics whereby late sinistral shearing in Natal is mirrored by conjugate dextral shears in Namaqualand (Jacobs et al., 1993) that formed immediately prior to the assembly of the Rodinia supercontinent. The timing of intrusion, deformation and metamorphism, and the geochemical/isotopic composition of the rocks within the NMP, has been the focus of many studies (see references and data compilations within Eglington, 2006 and McCourt et al., 2006). This study adds to the growing body of geochronological and isotopic data of the NMP, places further constraints on its orogenic evolution, and will address several outstanding questions concerning the temporal framework of the Natal Orogeny.

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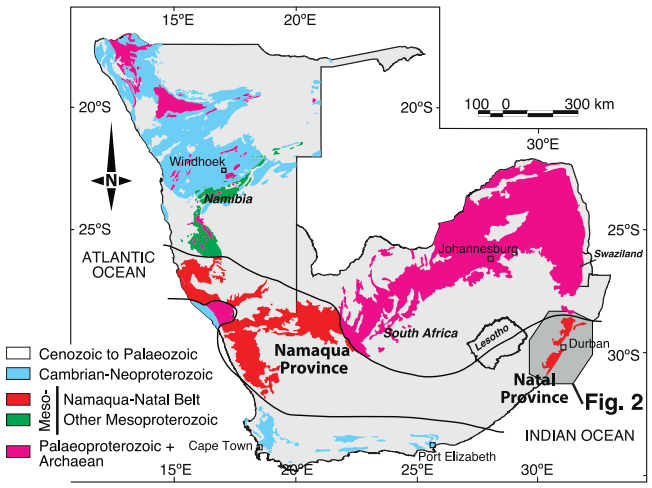

Fig. 1. Simplified geological map of southern Africa outlining the regional extent to the Namaqua-Natal belt, modified after Schlüter (2006).

Most of the previous studies have been conducted piecemeal over the last 25 years, and employed a variety of geochronological techniques by various laboratories. This approach has ensured that there still remain several ambiguities, unresolved questions and untested hypotheses. In order to provide a consistent U–Pb zircon geochronological data framework by laser ablation inductively coupled plasma-mass spectrometry (ICP-MS) and isotope-dilution thermal ionization mass spectrometry (ID-TIMS) techniques, we have re-sampled most of the main intrusive units from the Mzumbe and Margate Terranes and dated some units for the first time. This geochronological framework is augmented by the first whole-rock and zircon Hf isotope data from Natal, coupled with U–Pb zircon, titanite, and monazite age data recording metamorphism and whole-rock Nd isotopes of many of the intrusive units throughout the Mzumbe and Margate Terranes. This dataset is used to provide an up-to-date and comprehensive interpretation of the timing and nature of the tectono-magmatic events in the NMP.

2. Regional setting

The Tugela Terrane comprises a series of NE directed, flat-lying thrust nappes, predominantly composed of supracrustal sequences; mainly layered amphibolites with subordinate quartzofeldspathic gneisses and ultramafic rocks with some intrusive tonalitic orthogneisses (Matthews, 1972; Thomas et al., 1994; Johnston et al., 2001). The terrane underwent upper-amphibolite to lower-granulite grade metamorphism, overprinted by greenschist facies assemblages (Bisnath et al., 2009). Matthews (1972) interpreted the terrane as an ophiolite complex, which was obducted over the rigid Kaapvaal cratonic margin at about 1135 Ma (Jacobs et al., 1997). The southern margin of the Tugela Terrane is defined by the major sub-vertical Lilani-Matigulu Shear Zone, which coincides with the southernmost geophysical boundary of the Kaapvaal Craton (De Beer and Meyer, 1984; Barkhuizen and

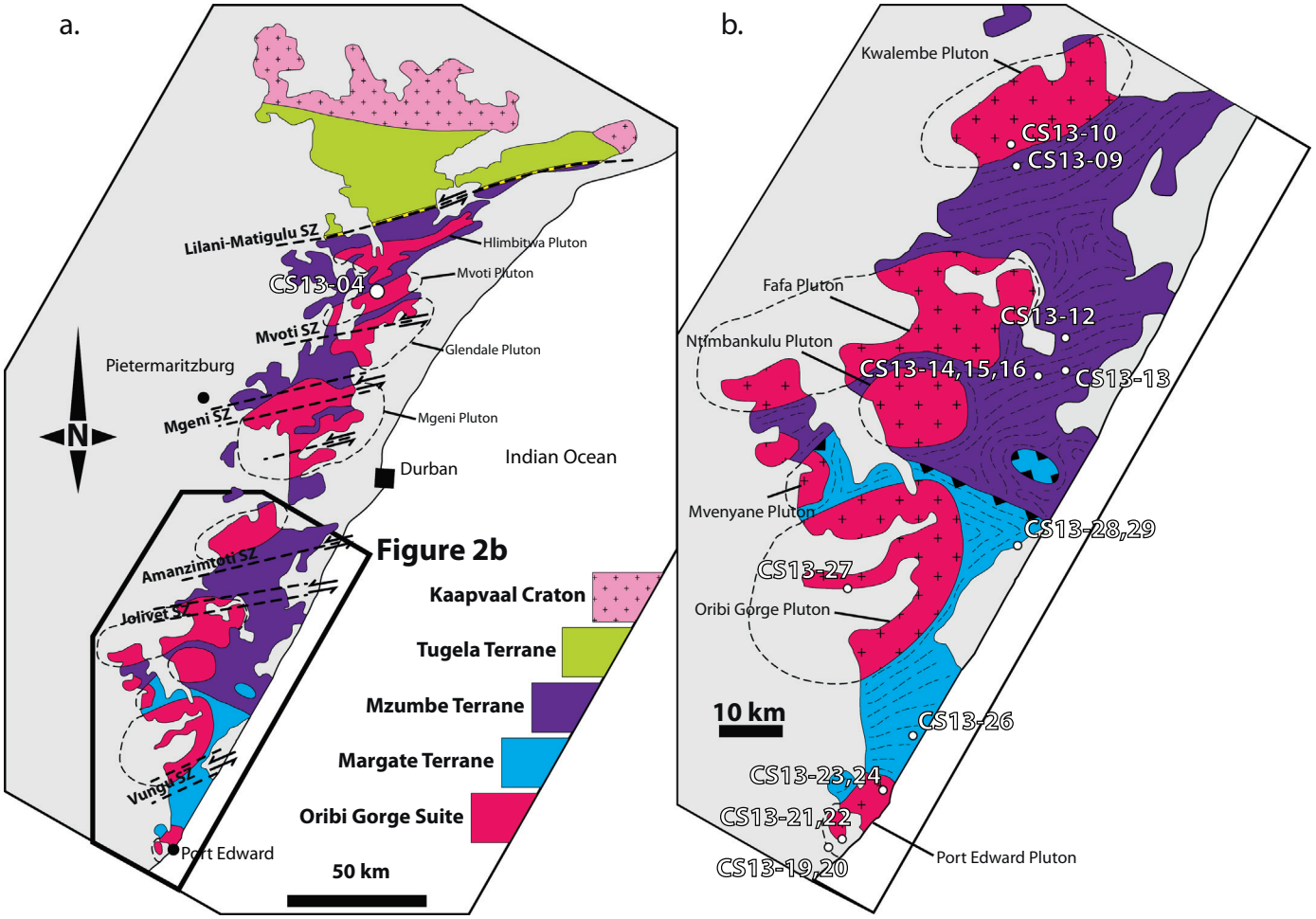

Fig. 2. (a) Simplified geological map of the NMP showing the areal extent and relative positions of the Margate, Mzumbe, and Tugela Terranes along with the Kaapvaal Craton and the Oribi Gorge Suite; (b) inset of the southern NMP with sample localities. Geological maps fashioned after Thomas (1988).