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Geochemistry and U–Pb zircon dating of the high-K calc-alkaline basaltic andesitic lavas from the Buanji Group, south-western Tanzania

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ABSTRACT

SHRIMP zircon U–Pb and Sm–Nd isotopic data together with major and trace elements data are presented for the basalt andesitic lavas from the Buanji Group, south-western Tanzania in order to establish their emplacement age, ascertain their mantle sources and processes responsible for their generation. Zircon U–Pb data shows that the Buanji Group lavas were emplaced at 1674 ± 15 Ma and do not therefore belong to the Neoproterozoic Bukoban Supergroup. Having erupted on top of sedimentary rocks, the 1674 ± 15 Ma age of the volcanic rocks provides the younger limit to the age of deposition of underlying un-dated sediments.

The Bunaji Group lavas are amygdaloidal and contain euhedral phenocrysts of plagioclase + orthopyroxene + clinopyroxene as well as subhedral quartz and opaque minerals mainly magnetite with quartz filling in the interstices. As a suite, they are compositionally uniform and are classified as high-K calc-alkaline basaltic andesites. The samples display coherent and fractionated REE patterns with La/Sm_{CN} and La/Yb_{CN} ratios of 2.48–2.72 and 4.03–5.92, respectively; and are characterized by negative Eu anomalies ($Eu/Eu^* = 0.76–0.84$). They are depleted in Nb, Ta, Ti and Sr but enriched in the most incompatible elements Rb, Ba, Th, U, K, and Pb leading to high ratios of Ba/Ta (531–1358) and Ba/Nb (35–91, with one outlier). They exhibit Hf/Yb ratios = 1.31–1.52, sub-chondritic ratios of Nb/Ta (13–18) and Zr/Hf (32–38), characteristics of shallow melting of mantle derived magmas. The samples display Th/Nb ratios of 0.48–0.95 and have εNd (1.67 Ga) values of +0.22 to +2.34 which are much lower than the corresponding εNd (1.67 Ga) mantle value of +6.55; characteristics indicative of contamination by the older crust.

The geochemical features of the Buanji Group high-K calc-alkaline basaltic andesites are interpreted in terms of derivation of these rocks by partial melting of the a spinel lherzolite mantle wedge that has been metasomatized by the subduction related fluids in a late Paleoproterozoic continental convergent margin. The resultant magmas were subsequently contaminated by the felsic crust prior to their emplacement.

1. Introduction

Geochemical studies of continental Proterozoic volcanic rocks provide important insights into the composition of mantle and the interplay between the mantle and crustal magma sources at that time (e.g. Halama et al., 2003). Three main mantle source components have been advocated to explain the geochemical signatures of the erupted Proterozoic rocks: (1) the Depleted MORB Mantle (DMM), mantle sources of mid-ocean ridge basalts; (2) the Ocean Island Basalt (OIB)-like mantle, mantle source for ocean island basalts; and (3) Sub-continental lithospheric mantle (SCLM), representing the mantle below the continental crust (e.g. Rashid and Sharma, 2001; Halama et al., 2003; Korsch et al., 2011). The predominance of Proterozoic volcanic rocks formed at convergent margins over those derived from the SCLM and mantle plumes akin to the Continental Flood Basalts (CFB) is well documented (e.g. Condie and Kröner, 2013 and references therein). In particular, Condie and Kröner (2013) proposed that the contribution of accreted oceanic arcs to continental growth during the post-Archaen times is limited to 10% whereas continental arcs contribute about 40–80%. Supporting this view is the identification of a few Early Proterozoic island arcs (Korsch et al., 2011) but more Proterozoic continental arcs (Cawood and Korsch, 2008) in Australia. This is also true for continental growth along the convergent margin which lasted for 300 Ma (1850–1522 Ma) predominated by continental arcs in the SW Fennoscandia (Åhäll and Connelly, 2008).

The Buanji Group of south-western Tanzania (Fig. 1) is largely a sedimentary dominated Group with igneous activity capping the sedimentary cycle in form of effusive volcanism represented by the amygladoidal lavas and numerous gabbro and dolerite

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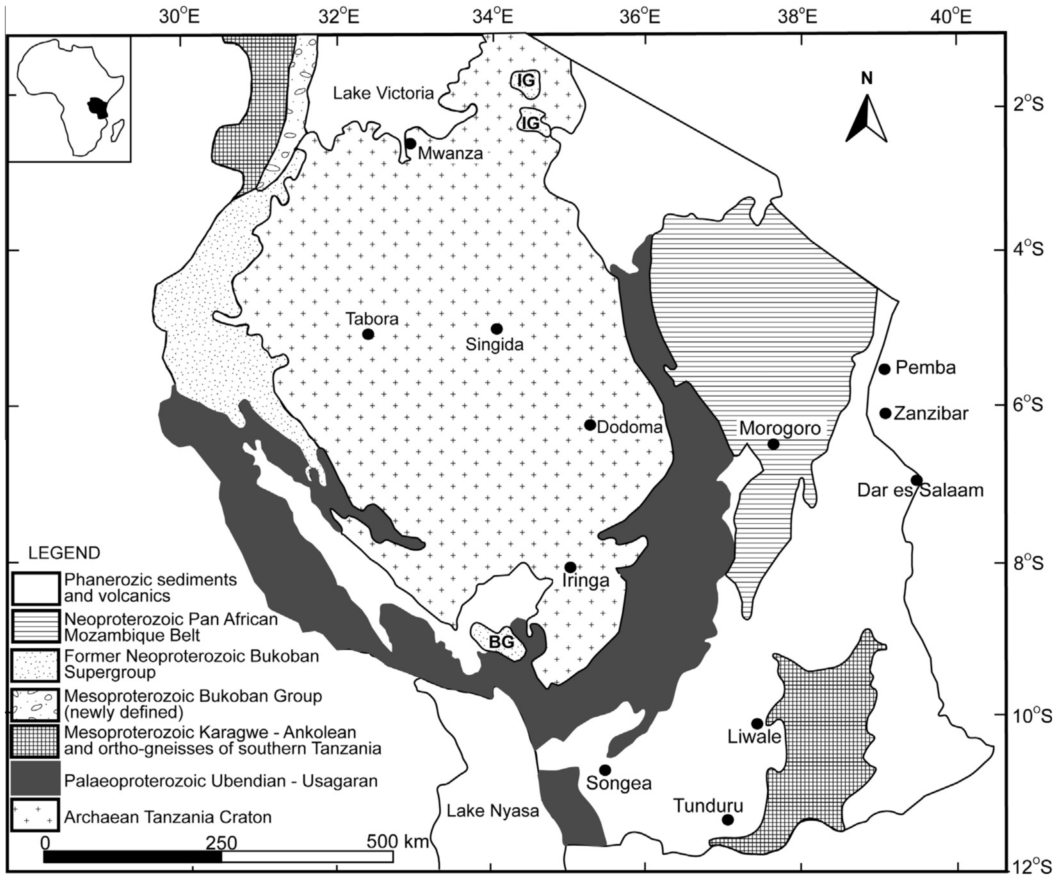

Fig. 1. Geological map of Tanzania showing the major tectono-lithostratigraphic units (modified after Pinna et al. (2008)). The Ikorongo Group (IG) and Buanji Group (BG, the focus of this study shown in Fig. 2) which were in past considered to correlate with the Neoproterozoic Bukoban Supergroup are indicated.

dyke intrusions (Harpum and Brown, 1958; Harpum, 1970). The sedimentary rocks associated with the lavas are conglomerates, quartzites, brown and green shales, dolomites and dolomitic limestones, micaceous siltstones and sandstones, which unconformably overlie the ~2.0 Ga Ubendian high grade metamorphic rocks, anorthosites, gabbros and granitic intrusive (Lenoir et al., 1994). The Buanji Group rocks have been lithostratigraphically correlated with the rocks of the Neoproterozoic Bukoban Supergroup of western Tanzania (Harpum, 1970) and are thus, traditionally regarded as having formed during the Neoproterozoic.

Previous work on the Buanji Group rocks is limited to geological mapping and descriptions (Harpum and Brown, 1958) and lithostratigraphical correlations (Harpum, 1970) and modern geochemical and geochronological works on the lavas associated with the sedimentary rocks are lacking. This paper presents SHRIMP U–Pb zircon dating, major and trace element geochemical data as well as Sm–Nd isotopic data on the amygladoidal lavas from the Buanji Group of southwest Tanzania. The data are used to put constraints on the magmatic emplacement of the volcanic rocks and consequently the deposition age of the underlying sediments, mantle sources and petrogenesis. The new SHRIMP U–Pb zircon data shows that the Buanji Group lavas were emplaced during the late Palaeoproterozic and correlation with Neoproterozoic Bukoban Supergroup is henceforth flawed. Major and trace element data together with Sm–Nd isotopic data shows that the Buanji Group volcanic rocks were formed by partial melting of spinel lhezorlite at a continental convergent margin and that crustal contamination played a significant role in their genesis.

2. Geological setting

The geology of the area for which the Buanji Group rocks are a part (Fig. 2), was mapped by Harpum and Brown (1958) and described on Quarter Degree Sheet 246, which encompasses the Chimala area and below is the summarized geology of the area. Rocks of the Buanji Group comprise an assemblage of continental sedimentary rocks and lavas, which lie unconformably on the Palaeoproterozoic (~2.0 Ga) Ubendian high grade metamorphic rocks, anorthosites, gabbros and granitic intrusives (Lenoir et al., 1994; Boven et al., 1999). The Ubendian metamorphic rocks include micaceous schists, gneisses and migmatites, garnetiferous quartzites and marbles. The metamorphic rocks are considered to be of sedimentary origin that underwent profound regional metamorphism and migmatization (Lenoir et al., 1994; Boven et al., 1999). The Buanji area was subjected to compressional deformation resulting in several regional and local thrusts (Harpum and Brown, 1958).

According to Harpum and Brown (1958), the largely sedimentary rocks of the Buanji Group are divided into lower, middle and upper divisions with a maximum thickness of approximately 27 m, 40 m and 50 m, respectively. The lower division is made of conglomerate composed of pebbles of jasper and agate, reddish shales (Fig. 3c) with occasional quartzitic sandstones. The middle division consists of quartzite (locally known as the Gofio quartzite) and cupriferous shales, above which lies a thin member made up of green shales associated with numerous horizons of dolomitic limestone. In some places, the shales are micaceous and are usually interbedded with siltstones and quartzitic sandstones. Although the nature of Cu mineralization is uncertain, field observations indicate