THE BANGWEULU BLOCK OF NORTHERN ZAMBIA: WHERE IS THE PRE-UBENDIAN CRUST ??

Bert De Waele[1]; Alexander A. Nemchin[1] and A.B. Kampunzu[2]

[1]*Tectonics Special Research Centre, Department of Applied Geology, Curtin University of Technology, GPO Box U 1987, Perth Western Australia 6845, Australia*
[2]*Geology Department, University of Botswana, Private Bag 0022, Gaborone, Botswana*

1. INTRODUCTION

The Bangweulu block (BB) of northern Zambia is a Paleoproterozoic terrane composed of granitoids, gneisses and acid volcanics, which is overlain by shallow marine and fluvial sedimentary sequences of the Mporokoso Group. The BB formed during magmatic events between 2000 and 1800 M.y. ago, during accretion of Archean crust to the southern side of the Tanzania craton, along the Ubendian belt. No exposed pre-Ubendian crust has been documented, but moderately high Sr-isotopic ratios and the whole rock chemical composition of the granitoids suggest a magmatic source that included substantial amounts of older sialic crust.
In this paper we present new U-Pb SHRIMP zircon data for the various granitoids of the Bangweulu block, and younger granitoids exposed in the Irumide belt to the south, together with Nd isotope data, which provide evidence for the presence and composition of older sialic crust below northern Zambia.

2. GEOLOGY

The earliest magmatic event of the Bangweulu block (Group 1a) is recognized in the northeast, and within the Irumide belt to the south, creating the protolith of a series of strongly deformed granitoid gneisses dated between 2050 and 1940 Ma. Within the Irumide belt the Mkushi gneiss in the southwest consists of biotite granite gneisses while the Luwalizi granite to the northeast consists of mildly deformed biotite granite. Near the termination of the Irumide belt to the northeast against the Ubendian belt, Group 1a plutons are strongly deformed mylonites within NW directed shear zones. Group 1b granitoids and associated volcanics of the Bangweulu block were emplaced between 1880 and 1860 Ma and consist of mainly undeformed high-K calcalkaline biotite granites and acid volcanics. Rhyolitic tuffs within deformed sedimentary rocks to the southeast and intermediate and basic volcanics near Mpika form part of the Group 1b magmatic event within the Irumide belt. Group 1a and Group 1b magmatism represent two phases of volcanic arc magmatism associated with the Ubendian Orogen, and compose the bulk of exposed crystalline rocks of the Bangweulu block.
Group 2 and 3 granitoids postdate the Ubendian Orogeny, and predate Irumide tectonism (~1015 Ma). Group 2 granitoids occur only within the Irumide belt and consist of biotite granites, emplaced between 1660 and 1560 Ma. In the southwest these granites are known as the Lukamfwa Hill granite gneiss, while in the northeast they are known as the Mutangoshi gneiss. Group 3 plutons are limited to the far northeastern part of the Irumide belt, and represent limited anorogenic magmatism. No Group 3 granitoids were identified in this study, and they will not be discussed.

The latest magmatism between 1050 and 970 Ma is associated with the emplacement of Irumide Orogeny Group 4 granitoids, and represents a major phase of K-feldspar phyric granite magmatism. Group 4 magmatism represents syn-to post-tectonic intrusions. Peak metamorphic conditions within the Irumide belt were constrained from high-grade migmatites at ~1015 Ma.

3. ISOTOPIC DATA

3.1. Group 1a granitoids

Two samples of Group 1a granitoids were analyzed during this study. One sample was collected from the Mkushi gneiss in the SE of the Irumide belt, and yielded a U-Pb SHRIMP zircon date of 2036 ± 7 Ma, interpreted as the emplacement age of the precursor to the Mkushi Gneiss. Another sample was collected from the Luwalizi granite in the NE of the Irumide belt, which yielded an emplacement age of 1942 ± 6 Ma. T_{chur} model ages 2400 ± 17 and 2372 ± 23 Ma, with initial e_{Nd} values (all e_{Nd} values in this paper are based on the emplacement age of the rock) of –6.4 and –5.2 for the Mkushi gneiss and Luwalizi granite respectively. The initial ε_{Nd} values indicate involvement of older crust in the generation of these granitoids, while the T_{chur} model ages indicate a minimum age of 2400 ± 17 Ma for this crustal component.

3.2. Group 1b granitoids and volcanics

A total of two volcanics and two granitoids were collected from the Bangweulu block near Mansa. The granites yielded zircon U-Pb SHRIMP emplacement ages of 1860 ± 13 and 1862 ± 8 Ma, and the volcanics yielded extrusion ages of 1862 ± 19 and 1868 ± 7 Ma. Nd isotopic data is similar for both granites and volcanics, with T_{chur} model ages for the granites of 2159 ± 14 and 2116 ±11 Ma and 2135 ± 14 and 2095 ± 9 Ma for the acid volcanics. The granites record initial e_{Nd} values of –3.5 and –3.0, while the volcanics record –3.6 and –2.9. The slightly negative initial ε_{Nd} values indicate some involvement of older crustal material in both granites and volcanics, while similarities in Nd ratios suggests a similar magma source for both. T_{chur} ages indicate a minimum age of 2159 ± 14 Ma for this crustal source.

Two samples each were collected of two different rhyolitic tuffs, which occur conformably within the metasedimentary sequences of the Irumide belt. Extrusion ages of 1879 ± 13 and 1856 ± 4 Ma were obtained from magmatic zircon, and indicate that these tuffs are broadly coeval with the volcanics of the Bangweulu block. One sample of a tuff recorded a slightly positive initial ε_{Nd} value of 1.5 with T_{chur} model age 1762 ± 10 Ma. The three other samples recorded initial ε_{Nd} values of –14.8, -11.2 and –6.6 with T_{chur} model ages of 3238 ± 55, 2961 ± 152 and 2532 ± 109 Ma. The three latter samples indicate substantial crustal reworking, with initial e_{Nd} values $<$-6.6, and T_{chur} model ages older than 2532 ± 109 Ma. The oldest T_{chur} model age of 3238 ± 55 Ma can be taken as the minimum age of participating crust in the generation of these lavas.

Five samples were analyzed of intermediate and mafic volcanics near Mpika. No direct age constraint has been obtained for these lavas, but field evidence, including the presence of pillow lava's, indicates that these volcanics were deposited along with the sedimentary succession, in shallow marine environment, and can as such tentatively be equated to the rhyolitic tuffs elsewhere in the Irumide belt. The volcanics yielded initial

e_{Nd} values between –6.1 and –1.9, with T_{chur} model ages between 2909 ± 31 and 2338 ± 109 Ma, indicating broadly similar amounts of involvement of older crust in their petrogenesis. The negative initial e_{Nd} values indicate participation of older crust in their formation with the maximum T_{chur} model ages of 2909 ± 31 Ma, indicating the minimum age of this crust. Whether this crustal source material represents underlying sialic components, or is due to mixing of sediment sources remains unclear.

3.3. Group 2 granitoids

Two samples were analyzed from the Lukamfwa granite gneisses in the southwest of the Irumide belt for which emplacement ages of 1639 ± 14 and 1650 ± 4 Ma were obtained on magmatic zircon. Initial e_{Nd} values are –12.0 and –5.0, with T_{chur} model ages of 3199 ± 229 and 2310 ± 55 Ma. The negative ε_{Nd} indicate the participation of significant amounts of older crust in their petrogenesis, while the model age of 3199 ± 229 Ma can be considered a minimum age of that crustal component. The range of initial ε_{Nd} values and model ages is similar to the range observed in Group 1 granitoids and volcanics, possibly indicating similar source materials for Group 1a, 1b and Group 2 rocks, or crustal reworking of Group 1a and b lithologies in the generation of Group 2 melts.

3.4. Group 4 granitoids

Two granites were analysed from the southwestern part of the Irumide belt, and yielded emplacement ages of 1037 ± 16 and 1036 ± 13 Ma. Initial e_{Nd} values of –14.5 to –19.4 were obtained indicating substantial amounts of crustal derivation. T_{chur} model ages range from 2948 ± 18 to 2808 ± 35 Ma, reflecting the participation of underlying crustal material of at least 2950 M.y. old.

4. DISCUSSION

New U-Pb SHRIMP data on several magmatic rocks of the Bangweulu block and adjacent Irumide belt, have not directly confirmed the presence of pre-Ubendian rocks. Magmatism in northern Zambia can be subdivided into five different magmatic events. Group 1a and Group 1b magmatism represent two different phases of the Ubendian Orogeny and related magmatism that shaped the Bangweulu block. Group 1a granitoids occur within the Irumide and Ubendian belts, but have not been identified within the Bangweulu block, and occur in the time span 2050-1940 Ma. Group 1b magmatism consists of extrusion of acid volcanics and broadly coeval intrusion of granites on the Bangweulu block, with minor extrusions of acid lavas within the Irumide basin to the southeast. Group 2, 3 and 4 magmatism are confined to the Irumide belt and consist of 1660-1550 Ma old granites, 1360 Ma old syeno-granites and 1050-970 Ma old K-spar phyric granitoids. Nd isotopic data gives indirect evidence for the possible existence of underlying older sialic crust, with moderately low to very low initial ε_{Nd} values in all granitoids, and a maximum T_{chur} model age of 3238 ± 55 Ma. The data demonstrate that participation of underlying sialic crust or of old sedimentary material could have been an important process in the generation of all granitoids and volcanics of northern Zambia.