MITT.ÖSTERR.MINER.GES. 145 (2000)

GEOCHEMISTRY, PETROGENESIS, U/PB- AND U/PB ZIRCON AGES OF GRANITOID ROCKS FROM WALLAGGA AREA, WESTERN ETHIOPIA

by

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Dissertation zur Erlangung des Doktorgrades an der
Formal- und Naturwissenschaftlichen Fakultät der Universität Wien

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Wien, Juni 2000

The western Ethiopian Precambrian rocks constitute two distinct rock associations, namely, the migmatized eastern and western high-grade gneisses and the central low-grade volcanosedimentary rocks with dismembered mafic-ultramafic (ophiolitic) associations. Both, the high- and low-grade rocks are intruded with intrusive rocks of a wide compositional spectrum, ranging from gabbros to granites. Geochemical characteristics, petrogenesis, tectonic setting and ages of formation of these intrusives are not well understood. Thus, this study used field relationships and modern analytical techniques, such as XRF, INAA, and ICP-MS, to obtain whole-rock major and trace element abundances, EMPA and SEM for mineral analyses, and TIMS for isotopic ratio measurements and age determinations of selected granitoid bodies.

The results have shown the presence of three granitoid types, viz., (1) the volcanic arc granite (VAG) represented by Ujjukka granite and granodiorite, Dhagaa Booqa granite, and Guttin K-feldspar megacrystic granite, (2) the anatectic Suqii-Wagga two-mica granite, and (3) the within-plate or anorogenic granitoids, including Tullu Kapii syenite, Ganjii monzogranite, Homa granite, and Tuppii granite. The VAGs originated in a two-step process in which batch equilibrium melting of basaltic or andesitic material producing tonalitic magma was followed by fractional crystallization. However, the relatively high Rb/Sr, Rb/Ba, and low CaO/Na_2O (< 0.3) ratios in the Suqii-Wagga two-mica granite indicate derivation of the source magma from a plagioclase-poor pelitic precursor rock. Moreover, pronounced negative Eu anomalies and LILE modeling suggested fractional crystallization dominated by plagioclase. Garnet-biotite exchange thermometry and phengite barometry indicate crystallization of the Suqii-Wagga granite at ≈ 7 kb and $\approx 670°C$. The anorogenic granitoids, on the other hand, range from peralkaline to metaluminous composition, with rare mildly peraluminous varieties. They are characterized by high total alkalis, FeO_T/MgO ratios, REE, Y, Nb, Ta and low CaO, MgO, and Sr. Chondrite-normalized Rare Earth Element (REE) patterns show relatively enriched light REE, moderate to strong Eu negative anomalies, and more or less flat heavy REE distributions.

Wide ranges of major and trace element compositions among the various anorogenic granitoids are attributed to a variation of sources, crystal fractionation, and assimilation. The low initial $^{87}Sr/^{86}Sr$ of 0.70281 and ε_{Nd} values of > +4 are consistent with generation of a monzodioritic magma (that fractionated into the Ganjii monzogranite) from accreted or underplated juvenile oceanic crust or subcontinental mantle. The Tullu Kapii syenite also yielded $\varepsilon_{Nd,\,622\,Ma}$ of +2.4 and +3, consistent with the results obtained from the Ganjii monzogranite, suggesting generation from a similar source.

U/Pb and Pb/Pb zircon chronometry revealed that the VAG, as represented by the Ujjukka and Guttin granitoids, was emplaced at 815–730 Ma. The anatectic Suqii-Wagga granite and the Ganjii monzogranite were emplaced at ≈700 Ma and 620–625 Ma, respectively. This change of styles of granite magmatism in the study area from subduction-related VAG → anatectic granite (possibly representing collisional orogeny) → anorogenic granite is supported by the decrease of ages in the same direction.

The precambrian history in western Ethiopia was concluded by the ≈ 630 Ma tectonothermal event and subsequent anorogenic granite magmatism at 620–625 Ma. The emplacement of the sediment-derived Suqii-Wagga two-mica granite in the area and presence of inherited zircons of Mesoproterozoic-Archean ages in the granitoids emplaced in both the high- and low-grade terranes imply significant contributions of older, possibly mature, crustal material in the magmatic evolution of western Ethiopia.