Geochemical Evolution and Age of the Kenticha Tantalum Pegmatite, southern Ethiopia

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ABSTRACT

Geochemistry of drill core samples from the huge, shallowly dipping, Kenticha Ta-pegmatite suggests an upwardly increasing internal evolution. Fractionation indices (K/Rb, K/Cs, Al/Ga, Zr/Hf) vary systematically from bottom to top: granitic wall zone (K/Rb ~36), pegmatitic lower intermediate zone (K/Rb ~33), spodumene-rich upper intermediate zone (K/Rb ~20). Spatial geochemical variation within individual pegmatite zones is yet rather restricted. U-Pb tantalite dating indicates emplacement of the Kenticha pegmatite around 530 Ma, within the range of regional post-collisional granitoid magmatism.

Keywords: *Ethiopia, pegmatite, rare-element mineralization, internal zonation, whole rock geochemistry, U-Pb dating.*

INTRODUCTION

Mineralized pegmatites of the rare-element class occur in the Kenticha pegmatite field of southern Ethiopia. One of them is worked at the Kenticha Tantalum Mine, which produces around 80 t tantalum concentrate (~55 % Ta_2O_5) annually from pegmatite regolith. Subsurface exploration of the hard rock pegmatite is presently carried out by the mining company to evaluate the extent of the primary tantalum mineralization. In order to investigate the internal evolution and chemical zonation of the pegmatite body we have carried out a whole rock geochemical survey of drill core samples. In addition, U-Pb dating of tantalite from the Kenticha pegmatite was performed to delineate the temporal relationship between mineralization, pegmatite formation, and regional granitoid magmatism.

KENTICHA PEGMATITE FIELD

The Kenticha pegmatite field is situated within the Neoproterozoic Adola Belt which constitutes the southernmost extension of the Arabian-Nubian Shield. The belt is made up of strongly deformed units of low grade metamorphic volcanosedimentary successions and high grade quartzo-feldspathic gneisses, juxtaposed along N-S striking thrust and shear zones. Pegmatites of the Kenticha field are emplaced in low grade metamorphic pelitic schists, serpentinites, and talc-tremolite schists. Intrusion of circular to elliptical biotite granite plutons occurred roughly between 570 and 520 Ma (Worku, 1996). Most of the pegmatites strike N-S to NNE-SSW, their emplacement occurred close to a roughly NNE-SSW striking shear and thrust zone which is also intruded by a two-mica granite body (Fig. 1). A regional zonation of pegmatite types has been observed (Zerihun et al., 1995), apparently representing progressive mineralogical and geochemical differentiation with increasing spatial distance from the two-mica granite (Fig. 1). Pegmatite types include barren feldspar-muscovite pegmatites, Nb-(Ta) bearing beryl-columbite pegmatites, and Ta-Li mineralized albite-spodumene to complex-spodumene pegmatites (Fig. 1).

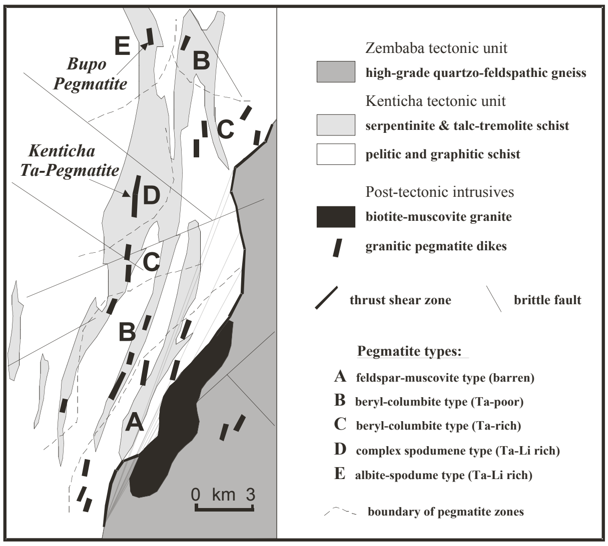

FIGURE 1. Geological sketch map of Kenticha pegmatite field (modified after Zerihun et al., 1995).

KENTICHA RARE-ELEMENT PEGMATITE

The Ta-mineralized Kenticha rare-element pegmatite constitutes a flat-lying to shallowly E- to SE-dipping, N- to NNE-striking intrusion. It is exposed along a serpentinite ridge over more than 2 km length and 400 - 700 m width (Poletayev et al., 1991). Thickness of the pegmatite sheet varies between 40 to 90 m. It displays asymmetric internal textural/mineral zonation with - from the base to the top - a granitic to aplitic wall zone, a lower intermediate zone of muscovite-quartz-albite-microcline pegmatite, an upper intermediate zone of albite – quartz – spodumene – muscovite – microcline pegmatite (with beryl, apatite, amazonite, amblygonite, and lepidolite), and discontinuous lenses of blocky micro-cline, quartz core, and lepidolite greisen (Fig. 2, next page).

Compositional differentiation of columbite-tantalite minerals (Tadesse & Zerihun, 1996) corresponds to this zonation with Ta-rich members (Mn-tantalite) found in, and mined from, the upper intermediate and the core zones. Late- to postmagmatic alterations of the pegmatite include albitization, sericitization, microclinitization, amazonitization, greisenization, and kaolinitization (Zerihun et al., 1995).

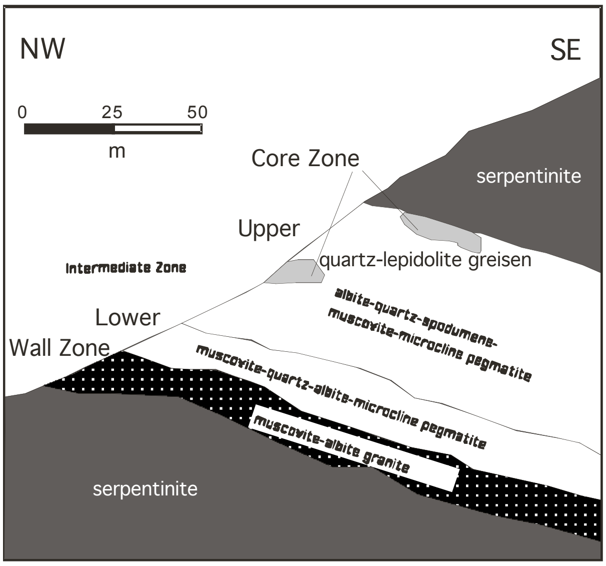

FIGURE 2. Generalized cross section and internal zonation of Kenticha rare-element pegmatite (simplified after Zerihun et al, 1995).

GEOCHEMISTRY OF PEGMATITE ZONES

Drill cores from ten boreholes covering the Kenticha pegmatite along strike and width were sampled, each sample representing a core section of 1.5 – 2.0 m. Whole rock geochemical data were derived by XRF (ICP-MS analysis for Ta, Li, Be is still in progress).

The basal layer of the Kenticha pegmatite consists of a geochemically specialized (very low Ba, Sr, Zr, REE, very high Rb, Cs, Nb), highly fractionated (K/Rb ~36), muscovite-albite granite or 'alaskite' (Na_2O 2.63 – 6.99 %). The granite is peraluminous (A/CNK ~ 1.22) and displays also very variable K_2O contents (0.71 – 4.67 %). P_2O_5 values ~0.18 % are akin rare-element granites of the low- to intermediate P-type, which are considered to be highly fractionated members of post- to anorogenic I-type granitoids (Linnen & Cuney, 2005). The pegmatitic lower intermediate zone is geochemically only slightly more fractionated than the granitic wall zone (Table 1), while the upper intermediate zone is clearly the most differentiated part (K/Rb ~20, K/Cs ~ 120, Al/Ga ~ 1700) of the Kenticha pegmatite.

TABLE 1. Average values of fractionation indices in Kenticha pegmatite zones. (UIZ = Upper Intermediate Zone).

	K/Rb	K/Cs	Al/Ga	Zr/Hf
UIZ: spodumene-rich unit	20	121	1718	6.9
UIZ: saccharoidal albite unit	20	133	1743	n.d.
UIZ: blocky microcline unit	22	204	2698	10.0
Lower Intermediate Zone	33	253	2185	9.0
Wall Zone (granite)	36	382	2196	14.3

Geochemical variation within each zone is rather restricted and there appears to be no spatial control of the degree of fractionation along strike (or width) of the pegmatite. This suggests that the pegmatite generating magma (± fluid phase) must have been rather homogeneous in composition.

Thickness and areal extent of the Kenticha pegmatite are almost similar to the giant Tanco pegmatite in Canada (Černý, 2005). However, average values of fractionation indices of the most evolved spodumene zone (Table 1) do not match respective data from Tanco (K/Rb ~6, K/Cs ~19, Al/Ga ~961; Zr/Hf ~4; Černý, 2005), indicating a lower overall degree of geochemical evolution of the Kenticha pegmatite.

U-PB AGE DATING

U-Pb age determinations were performed on leached tantalite fragments from the spodumene zone and the quartz core of the Kenticha pegmatite as well as from the Bupo pegmatite (see Fig. 1 for location). Results indicate that both pegmatites were emplaced around 530 Ma. They are temporally related to the post-collisional phase of granitic magmatism (570-520 Ma), although the nearest dated biotite granite (Lega Dima pluton; Worku, 1996) is 20 Ma older than the pegmatites. Tantalite from the spodumene zone at Kenticha, strongly overprint by late- to postmagmatic fluids, gave an age around 520 Ma.

REFERENCES CITED

Černý, P. (2005) The Tanco Rare-Element Pegmatite Deposit, Manitoba: Regional Context, Internal Anatomy, and Global Comparisons. In: Linnen, R.L. & Samson, I.M. (eds.) Rare Element Geochemistry and Mineral Deposits, Geol. Assoc. Canada (GAC) Short Course Notes, 17, 127-158.

Linnen, R.L. & Cuney, M. (2005) Granite-related rare-element deposits and experimental constraints on Ta-Nb-W-Sn-Zr-Hf mineralization. In: Linnen, R.L. & Samson, I.M. (eds.) Rare Element Geochemistry and Mineral Deposits, Geol. Assoc. Canada (GAC) Short Course Notes, 17, 45-68.

Poletayev, J.A., Verbvsky, O.N., Teweldemedhin, T., Musa, E., Alemayehu, B. & Manaye, Y. (1991) The geology and rare metal potential of the Kenticha pegmatite deposit, p. 113. Internal report (unpubl) Ethiopian Mineral Resource Development Corp, Minstry of Mines and Energy, Addis Ababa, Ethiopia.

Tadesse, S. & Zerihun, D. (1996) Composition, fractionation trend and zoning accretion of the columbite-tantalite group of minerals in the Kenticha rare metal field (Adola, southern Ethiopia). Journal African Earth Sciences, 23, 411-431.

Worku, H. (1996) Geodynamic development of the Adola Belt (southern Ethiopia) in the Neoproterozoic and its control an gold mineralization, p. 156. Ph.D. Thesis. Technische Universität Berlin, Germany.

Zerihun, D., Garbarino, C. & Valera, R. (1995) Granite pegmatite system in Kenticha (Adola, Sidamo, Ethiopia) rare metal pegmatite belt: petrochemistry, regional pegmatite zoning and classification. SINET: Ethiopian Journal of Science, 18, 119-148.