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Analytical fingerprint for tantalum ores from African deposits

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Illegal mining of gold, diamonds, copper, cobalt and, in the last decade, “coltan” has fuelled ongoing armed conflicts and civil war in a number of African countries. Following the United Nations initiative to fingerprint the origin of conflict materials and to develop a traceability system, our working group is investigating “coltan” (i.e. columbite-tantalite) mineralization especially in Africa, also within the wider framework of establishing certified trading chains (CTC). Special attention is directed towards samples from the main Ta-Nb-Sn provinces in Africa: DR Congo, Rwanda, Mozambique, Ethiopia, Egypt and Namibia. The following factors are taken into consideration in a methodological approach capable of distinguishing the origin of tantalum ores and concentrates with the utmost probability: (1) Quality and composition of coltan concentrates vary considerably. (2) Mineralogical and chemical compositions of Ta-Nb ores are extremely complex due to the wide range of the columbite-tantalite solid solution series and its ability to incorporate many additional elements. (3) Coltan concentrates may contain a number of other tantalum-bearing minerals besides columbite-tantalite.
In our approach, coltan concentrates are analyzed in a step-by-step mode. State-of-the-art analytical tools employed are automated scanning electron microscopy (Mineral Liberation Analysis; MLA), electron microprobe analysis (major and trace elements), laser ablation-ICP-MS (trace elements, isotopes), and TIMS (U-Pb dating).

Mineral assemblages in the ore concentrates, major and trace element concentration patterns, and zoning characteristics in the different pegmatites from Africa distinctly differ from each other. Chondrite-normalized REE distribution patterns vary significantly between columbite, tantalite, and microlite, and also relative to major element compositions of columbites. Some locations are characterized by low REE concentrations, others are highly enriched. Samples with Kibaran age either show flat patterns for most tantalites, rising values from the LREE to the HREE, or trough-like patterns. Eu anomalies are strongly negative in columbite-tantalite from the Alto Ligonha Province in Mozambique, from the Namaqualand Province (Namibia, South Africa), and from Zimbabwe. Four main age populations of coltan deposits in Africa were revealed: (1) Archean (>2.5 Ga), (2) Paleoproterozoic (2.1-1.9 Ga), (3) early Neoproterozoic (“Kibaran”, 1.0-0.9 Ga), and (4) late Neoproterozoic to early Paleozoic (Pan-African; ca. 0.6-0.4 Ga).

Currently, we focus on the resolution of the fingerprinting system from region via ore province down to deposit scale, establishing a large and high-quality analytical data base, and developing fast-screening and low-cost methods. Analytical flow-charts and identification schemes for coltan ores will be presented at the Conference. The analytical results obtained so far indicate that a certification scheme including fingerprinting of sources of coltan ores is feasible. The methodology developed is capable to assist in the establishment of a control instrument in an envisaged certification of the production and trade chain of coltan.