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Mineralogy and geochemistry of pegmatite-hosted Sn-, Ta–Nb-, and Zr–Hf-bearing minerals from the southeastern part of the Bastar-Malkangiri pegmatite belt, Central India

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Abstract

Primary tin and rare metal mineralization in the Bastar-Malkangiri pegmatite belt, Central India, is associated with granitic pegmatites hosted by metabasic and metasedimentary rocks. The rare metal minerals, identified from six mineralized pegmatites at Govindpal, Mundaguda, Mundval, Dhuramagurah, Haladikunda and Bacheli, include cassiterite, columbite–tantalite, wodginite, microlite, fersmite and Hf–zircon. Ta–Nb-poor cassiterite is ubiquitous and the most abundant ore mineral in all the mineralized pegmatites. Subtle differences are noted in the ore mineral assemblages and in the compositions of individual minerals in different pegmatites. Ta–Nb oxides are represented by microlite ± wodginite ± manganotantalite in Li–F ± P-bearing LCT pegmatites (Govindpal, Mundaguda and Mundval). In contrast, least evolved members of the LCT-type pegmatites are characterized by the presence of ferrocolumbite (Dhuramgurah, Haladikunda) and rare ferrotantalite (Bacheli). The compositional variations of columbite–tantalite (in terms of Ta/(Ta + Nb) and Mn/(Mn + Fe) ratios) and zircon (in terms of Hf contents) from different pegmatites correlate with the degree of fractionation of the pegmatitic melt.

In the Govindpal pegmatite, Ta–Nb-poor cassiterite occurs as aggregates of grains, small pockets and veinlets in the intermediate and core zone. The Ta–Nb oxides are restricted to the core margin. Texturally and compositionally distinct Ta–Nb-rich cassiterite, along with Ta–Nb oxides and Hf–zircon, occur as irregular inclusions in Ta–Nb-poor cassiterite at the core margin. The field evidence, textural relations and compositions of the ore minerals suggest that the main mineralizing event was associated with hydrothermal precipitation of Ta–Nb-poor cassiterite which postdated precipitation of manganotantalite, wodginite, microlite, Hf–zircon and Ta–Nb-rich cassiterite in the Govindpal pegmatite. The crystallization of Ta–Nb oxides was facilitated possibly by the removal of Li and F from the melt and that of Ta–Nb-rich cassiterite by increasing oxygen fugacity. Calculated higher Fe^{3+}/Fe^{2+} in wodginite compared to manganotantalite suggests such a possible increase in oxygen fugacity. Anastomosing veins of microlite in Ta–Nb-poor cassiterite was the last mineralizing event in this pegmatite. The consistently high Ti-contents of this subsolidus vein-microlite compared to primary Ta–Nb oxides (manganotantalite, wodginite and microlite) might suggest contamination by ingress of metamorphic fluid during its formation.

Keywords: Granitic pegmatite; Cassiterite; Columbite–tantalite; Wodginite; Microlite; Hf–zircon; Rare metal; Mineralogy; Geochemistry; Central India

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1. Introduction

The Bastar (Chattisgarh)-Malkangiri (Orissa) Pegmatite Belt (BMPB; Fig. 1) in Central India is perhaps the most productive tin belt in India. Previous work in the BMPB was conducted by scientists from the Geological Survey of India (GSI), Atomic Minerals Directorate for Exploration and Research (AMD) and diverse international agencies such as UNDP (New York) and BRGM (France). Although many data were acquired, these are not readily available due to the restricted nature of Government reports. Fermor and Kellerschon (1909) first reported the occurrences of Sn in the area. Crookshank (1963) carried out preliminary geological investigations in the BMPB and adjoining areas. More recent studies in the BMPB include: classification and characterization of the spatially associated granites (Babu, 1994; Rameshbabu et al., 1993a; Rameshbabu, 1999; Pal, 2000; Pal et al., 2001); general description and/or classification of the pegmatites (Babu, 1983; Mookherjee et al., 1979; Lamba and Agarkar, 1988; Singh et al., 1991; Rameshbabu, 1993, 1999; Rameshbabu et al., 1993b; Singh, 1998); identification and compositional characterization of rare metal-bearing minerals (Anon, 1978; Mookherjee et al., 1979; Guha and Roychowdhury, 1983; Schulling, 1983; Babu, 1985; Acharya et al., 1989; Somani et al., 1997, Rameshbabu, 1999; Babu et al., 2002); and fluid inclusion studies (Pal et al., 1998; Pal, 2000).

Previous studies did not provide sufficient microtextural details of the ore minerals with relevant photomicrographs (or scanning electron microscope images). There is a paucity of mineralogical and compositional data on the ore minerals from individual pegmatites and the group of pegmatites in general. Although several rare metal minerals are reported from different pegmatites, the paragenetic sequence of these minerals is not well understood. We have

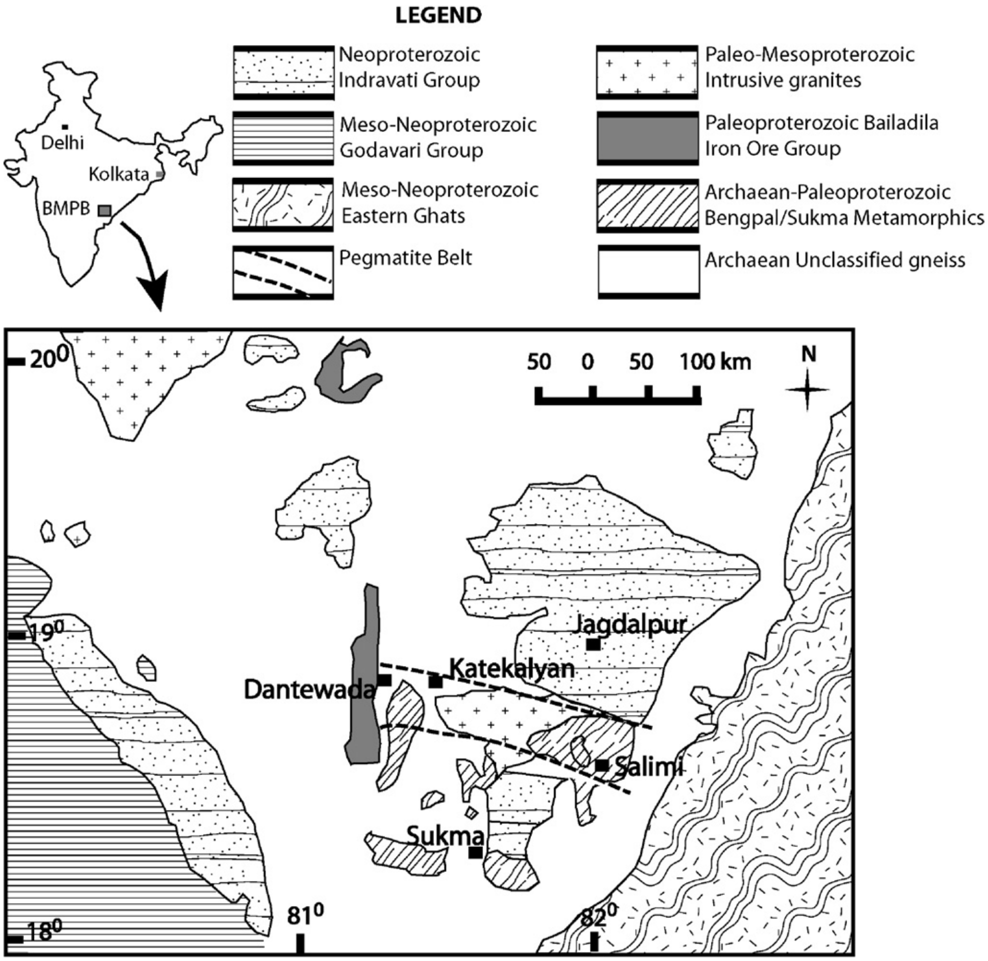

Fig. 1. Regional geological map of the Bastar-Malkangiri Pegmatite Belt (modified after Babu, 1994).