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Magmatic controls on Pb-Zn and W-Sn metallogenic variations: Difference in sources, oxygen fugacity and differentiation degree

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The Nanling Metallogenic Belt (NMB) in South China hosts significant Jurassic granitoid-related Pb-Zn and W-Sn deposits, yet the magmatic controls on metallogenic specialization remain unclear. This study investigates the Dafang Pb-Zn-associated granitoid and compiles regional data to decipher magmatic influences on ore-type variations. The Dafang intrusion (157.0±0.8 Ma) is potassic, alkaline and meta-luminous, displaying I-type characteristics with negative εHf(t) (−6.7 to −10.2) and Paleoproterozoic crustal sources (1.6–1.7 Ga Hf model ages).

Comparative analysis reveals two distinct granitoid classes: Pb-Zn-mineralized types derived from amphibolite with high oxygen fugacity (Ce^{4+}/Ce^{3+} ~104.8) and low differentiation (Rb/Sr ~0.8; Nb/Ta ~12.5), versus W-Sn-related granitoids from metasedimentary sources with lower fO_2 (Ce^{4+}/Ce^{3+} ~46.7) and higher differentiation (Rb/Sr ~59.0; Nb/Ta ~5.3). W-Sn systems exhibit elevated halogens and volatile-driven differentiation, where fluid exsolution enhanced W-Sn mobilization through fluid-rock interaction.

Jurassic asthenospheric upwelling and crustal thinning triggered lower crustal melting in the NMB. Mantle metasomatism increased melt chlorine content, facilitating chalcophile element extraction. Protolith melting temperatures further influenced W-Sn segregation. Collectively, Pb-Zn versus W-Sn metallogeny in the NMB is controlled by three key factors: (1) source composition (amphibolite vs metasedimentary), (2) magmatic oxidation state, and (3) differentiation intensity. High fO_2 and limited differentiation in mafic-derived melts promoted Pb-Zn mineralization, whereas reduced fO_2 and extreme differentiation in crustal melts enabled W-Sn enrichment through volatile-assisted element transport. This framework links granitoid petrogenesis to metallogenic diversity in South China's Mesozoic ore systems.

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