

The Paleoproterozoic Mg And Mg-Fe Borate Deposits of Liaoning and Jilin Provinces, Northeast China

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Abstract

A Paleoproterozoic sequence of metasediments and metavolcanics in Liaoning and Jilin provinces, northeast China, plays host to a large number of borate deposits that are a significant source of boron to China. The mineralogy and geochemistry of the deposits allow them to be divided into Mg-rich, Fe-poor deposits (mainly comprised of suanite and szaibelyite) and Mg-Fe-rich deposits in which the borates are mainly present as ludwigite.

There are regional variations in the lithology and thickness of the greenschist-amphibolite-grade metasediments that host the borate orebodies, but they share many common features. The exclusive host to the borates is provided by Mg-rich carbonate intercalations within tourmaline-bearing leptynites, which are interpreted to be the metamorphosed equivalents of evaporites enclosed within volcanic tuffs. This unit is immediately underlain by biotite leptynites, which are also interpreted to be metamorphosed tuffs, and is further underlain by magnetite-microcline leptites that are thought to have formed by metamorphism of primary red beds. The orebodies are overlain by albite-microcline-rich leptites, which are believed to be the equivalents of tuffs and pyroclastic rocks that were altered by Na-K-rich evaporite brines.

Overall, geological, geochemical, and boron isotope studies indicate that the borates are metamorphosed nonmarine evaporites. The morphology and geology of the Mg-rich deposits suggests they formed in shallow, wide playa lakes, in which small Fe-rich deposits precipitated on the basin margins, while brines rich in boron and Mg accumulated and precipitated salts in the basin centers. The Fe-rich borate bodies tend to be larger and lack the spatial zonation of the Mg-rich deposits, suggesting that they were deposited in narrower and deeper basins.

The regional geology and geochronology of northeast China indicate that tectonic evolution of the area started with subduction of oceanic crust below an Archean craton, followed by continental collision and later development of extensional basins. In modern collisional settings, subduction and crustal thickening both result in metasomatism of the upper lithosphere with boron-enriched fluids, and the associated volcanism is generally accompanied by geothermal activity that leaches the crust of this boron. In the case of the Liaoning deposits, we suggest the geothermal fluids accumulated in local basins, where they underwent evaporation in an arid climate that had already led to the formation of red beds. The overlying leptynites indicate the evaporites were subsequently buried below layers of volcanic ash and pyroclastic rocks. Later granitic intrusions led to metamorphism and dehydration of the original hydrated borate minerals, the development of skarn-type alteration in some areas of the borate deposits, and the transport of boron-rich fluids into immediate hanging walls of the orebodies. These boron-rich fluids reacted with the overlying aluminosilicate rocks to form tourmaline-rich layers and veins.