

Carbonate-Hosted Zn-Pb Deposits in the Hakkari-Şırnak Region: A Newly Discovered Tethyan Metallogenic Province in Turkey

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The Hakkari-Şırnak region lies on the Arabian platform to the south of the Bitlis-Zagros suture zone, consisting of a thick autochthonous sequence deposited during the Paleozoic and Miocene. The Zn-Pb mineralization in the Hakkari-Şırnak region is located in the Palaeozoic-Mesozoic carbonates of the Arabian platform.

Three different types of Zn-Pb mineralization occur in the region. The first occurs in strata-bound Middle Triassic-Jurassic carbonates with a substantial lateral extent, such as in the Karakaya and Meskantepe deposits. Mineralization occurs as cm- and m-thick parallel ore zones that are generally oxidized in situ to oxide-carbonate Zn-Pb ores. These are primarily smithsonite, hemimorphite, (hydro)zincite, cerussite, goethite, siderite, limonite and anglesite with calcite, dolomite, rare barite, galena, sphalerite, and pyrite. Hydrothermal brecciation and dolomitic alteration of wall rocks are widespread. The ore averages 22% Zn, 5% Pb, 24% Fe, and 0.6% Ba, with As (0.2%), Cd (0.1%), Mo (302 ppm), Sr (155 ppm), Tl (109 ppm), and Hg (35 ppm). Primary sulfides are preserved in the oxidized zone in some deposits and include sphalerite, galena, and pyrite/marcasite showing a spheroidal and colloform-banded texture, with quartz, calcite, and dolomite gangue. The second type occurs as veins in fault and fracture zones that are continuous only over several hundred meters, such as in the Kurşuntepe, Işıkveren, and Akkaya deposits. Oxide and sulfides are intermixed and comprise sphalerite, galena, pyrite, barite, smithsonite, goethite, limonite, and cerussite. This ore has a higher Ag content (up to 400 ppm in Akkaya) compared to the first type (Ag <10 ppm). The third type is a replacement style occurring in karst cavities and consisting mainly of smithsonite and cerussite with minor galena.

The $\delta^{34}\text{S}$ values vary between -3.4‰ and $+3.3\text{‰}$ for sphalerite and galena in the first and second types of mineralization, and average $+26.4\text{‰}$ for barite in the second type. The narrow range of $\delta^{34}\text{S}$ values of sphalerite and galena and the volume of ore indicate a large and homogeneous sulfur source. Although the sulfur seems to be of magmatic origin, the lack of magmatism excludes this source. However, $\delta^{34}\text{S}$ values of barite indicate a seawater source. The lead isotope ratios of galena are slightly heterogeneous and relatively radiogenic ($^{206}\text{Pb}/^{204}\text{Pb}$ between 18.325 and 18.756; $^{207}\text{Pb}/^{204}\text{Pb}$ between 15.579 and 15.700; and $^{208}\text{Pb}/^{204}\text{Pb}$ between 38.421 and 39.034), and are indicative of a crustal source. Fluid inclusions in quartz from primary sulfide lenses from the first type (strata-bound) and sphalerite from the second type (vein type) have average homogenization temperatures of 188°C (between 170° and 200°C) and salinities between 3.5% and 18% NaCl equiv, indicating two fluids, and 211°C and 15.6% NaCl equiv, respectively. The salinities of fluid inclusions in barite are, on average, 1.5 NaCl equiv.

The style of mineralization and geochemical data of the Hakkari-Şırnak Zn-Pb deposits bear comparison with MVT-style mineralization in terms of the strata-bound character of the mineralization, radiogenic lead, simple mineralogy, and lack of magmatism. They also resemble SEDEX-type deposits in terms of slightly higher homogenization temperature and lower salinity

than MVT deposits, ore zones parallel to each other, and high contents of As, Mo, Sb, Tl, and Hg.