Journal of the Virtual Explorer, 2005
Volume 20
Paper 15
http://virtualexplorer.com.au/

Geology of the Beltana Willemite Deposit

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Keywords: willemite

Abstract: Geology of the Beltana willemite deposit

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Extended Abstract

The following introduction to the Beltana willemite deposit is from Groves et al. (2003). Beltana is the largest willemite (Zn_2SiO_4) deposit in Australia, located in the Arrowie basin, northern Flinders Ranges. The host rocks are Lower Cambrian carbonates called Woodendinna Dolomite and Wilkawillina Limestone. Originally discovered in 1966 from stream surveys, the premining resources at Beltana were 850000 tons with 36% Zn. Half of the known resources have now been mined out during two separate opencut campaigns. An associated uneconomic lead deposit contains >800000 tons of ore at 8.9% Pb, 3.6% Zn and 1% As.

In addition to Beltana, there are several nonsulfide zinc occurrences in the region between Aroona and Reaphook (~100km), along the Norwest fault. The Norwest fault trend was probably a basin margin during Cambrian deposition and could be a control for the nonsulfide zinc mineralisation in the area. The Beltana area also has complex fold interferences from two different fold orientations of the Delamerian Orogeny (~500Ma) that meet in this area. At least three different karsting events have been suggested for the carbonate rocks, Cambrian, Triassic-Jurassic and Tertiary. K-Ar dating of Beltana corodanite ($MnPbMn_6O_{14}$) gives ages of 435Ma, indicating post-Delamerian mineralisation. There are granitoids of this age in the nearby Mt Painter province, and the ore fluids at Beltana could be related to granitoid intrusions at depth.

All mineralisations in Beltana are structurally controlled and associated with hematite-dolomite alteration and most are associated with karsts. The willemite ore occurs next to a Cambrian syndepositional growth fault (Beltana fault) and on or adjacent to major Delamerian thrust faults[1]. Additional structures are extensional faults related to karst collapses. The footwall of the orebody is mostly karst collapse breccia consisting of coronadite-cemented and hematite-altered dolomite clasts. The lower karstic contact is made of hematite-rich clay and ironstone. In the alteration halos around the willemite orebody, hematite and zincian dolomite replace host carbonates and primary rock textures have been progressively destroyed. The hanging wall consists of Neoproterozoic sediments (Callanna beds and Rawnsley quartzite), which have also partially collapsed into the karst structures.

Major ore minerals at Beltana are willemite[2], coronadite, hedyphane - ($(Ca,Pb)_5(AsO_4)_3Cl$), mimetite($Pb_5(AsO_4)_3Cl$) and smithsonite ($ZnCO_3$). There are no significant sulfides at Beltana and the ore zones are anomalously low in sulfur. The major gangue minerals are manganocalcite, dolomite and quartz. Most willemite occurrences in the Flinders Ranges are associated with manganocalcite, which at least at Beltana post-dates willemite deposition.

Both single- and two-phase fluid inclusions have been found from the Beltana manganocalcite, quartz and willemite. They show highly variable salinities and temperatures (50-170°C) and this has been interpreted as fluid mixing but other interpretations are also plausible. The components in the mixing model are a low temperature, low salinity, meteoric fluid and a warmer salt-saturated metalliferous fluid, mixing in a low to moderate-temperature hydrothermal system of zincian dolomitisation and hematite precipitation. As hematite came out of solution, the pH dropped and chloride activity increased, causing dissolution and brecciation of host carbonates. Metals were probably transported as chloride complexes because silver is absent and Fe^{3+} abundant in the ore fluids. Dropping temperature and pH-buffering by the carbonates eventually caused precipitation of zinc minerals in an oxidised, low pH environment.

High-grade nonsulfide zinc-occurrences are active exploration targets around the world. The Beltana willemite deposit shares many features with larger deposits e.g. in Brazil and Zambia, and is one of many in the northern Flinders Ranges. The resources at Beltana have only been studied and mined near the surface and there is a lot of potential for further exploration, especially with deeper drilling.

[1] http://www.datametallogenica.com/pages/minidisc/html/beltana_files/Beltana-fieldmine/Beltana05.jpg

[2] http://www.datametallogenica.com/pages/minidisc/html/beltana_files/Beltana-fieldmine/Beltana02.jpg

References

Groves, I. M., Carman, C. E., and Dunlap, W. J. (2003). Geology of the beltana willemite deposit, flinders ranges, south australia. Economic Geology, 98:797–818.

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