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Distribution of trace elements in the secondary minerals of Zn-Pb deposits: new results from Belgium and Moroccan willemite deposits

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New observations and chemical-mineralogical analyses of willemite (Zn_2SiO_4) mineralization from non-sulfide Zn-Pb deposits of La Calamine (Eastern Belgium) and Bou Arhous (Moroccan High Atlas) have been carried out. This study aims at evaluating the critical element distribution and migration, in order to establish the potential of such deposits. In both cases, willemite occurs as a variety of types that continuously formed between the protore stage (sulfides) and the late supergene stage (carbonates and hydrated phases).

Based on microscopic observations, different types of willemite may be distinguished by their shapes and zoning characteristics, supporting 1) a polyphase non-sulfide mineralisation, after the protore stage, 2) local dissolution–reprecipitation processes of willemite and 3) coprecipitation of willemite and secondary Pb minerals such as cerussite and galena. A significant change of major elements composition obtained by EPMA in the different generations of willemite is recorded. LA-ICP-MS measurements of minor and trace elements also reveal a strong variability between the various willemite types.

In the La Calamine samples, we measure abnormal high contents in P, Cd, As, Pb, Ag and Sb, the three latter ones being related to tiny galena inclusions. The Ga and In contents are very low (less than 4 ppm) or below detection limits, respectively. Significant Ge contents up to 250 ppm are observed. In the samples from Bou Arhous, willemite is variably enriched in Ge (up to 1000 ppm). Depending on the willemite generation, this substitution is positively or negatively correlated to the Zn-Pb substitution. According to the nature of zoning (sector *versus* oscillatory), the incorporation of Ge was either controlled by crystallographic factors or by the nature of the mineralizing fluids.

While, in the case of Belgium, the Ge concentrations measured in willemite are very similar to those in sphalerite (averaging 250 ppm), the Moroccan willemite are enriched compare to the primary sulfides (less than 100 ppm). This may indicate that sphalerite played a role of precursor, but an additional input of minor and trace elements by external fluids is also necessary. This conclusion is in agreement with the current models suggesting that a strict supergene origin of willemite in numerous deposits is disputable and a contribution of low temperature hydrothermal fluids for willemite precipitation should be considered.

References

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