Geophysical Research Abstracts,
Vol. 11, EGU2009-3738, 2009
EGU General Assembly 2009

Evidence for microbial activity in the formation of carbonate-hosted Zn-Pb deposits

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To date evaluation of bacterial processes in the formation of carbonate-hosted Zn-Pb deposits is largely based on sulphur isotope evidence. However, during a past few years, textural criteria, have been established, which support the bacterial origin of many of these deposits. This has received a strong support from micro-, and nano-textures of naturally growing bacterial films in a flooded tunnel within carbonates that host the Piquette Zn-Pb deposit (Druschel et al., 2002).
Bacterial textures, micro- and nano textures found in carbonate-hosted Zn-Pb deposits are: i)wavy bacterial films up to a few mm thick to up to a few cm long composed of peloids, ii)semimassive agglomeration of peloids in the carbonate matrix, and iii)solitary peloids dispersed in the carbonate matrix.
Peloids are usually composed of a distinct 50-90um core most often made up of Zn-bearing calcite surrounded by 30-60um thick dentate rim composed of ZnS. Etching of Zn-carbonate cores reveals 1 – 2um ZnS filaments, and numerous 15 to 90nm large ZnS nano-spheres (Kucha et al., 2005). In massive ore composite Zn-calcite – sphalerite peloids are entirely replaced by zinc sulphide, and form peloids ghosts within banded sulphide layers.

Bacterially derived micro- and nano-textures have been observed in the following carbonate-hosted Zn-Pb deposits:

1)Irish-type Zn-Pb deposits. In the Navan deposit the basic sulphur is isotopically light bacteriogenic S (Fallick at al., 2001). This is corroborated by semimassive agglomerations of composite peloids (Zn-calcite-ZnS corona or ZnS core-melnikovite corona). Etching of Zn-calcite core reveals globular 0.5 to 1um large fossilised bacteria with some nano-size spheres as well (Kucha et al., 1990). In the Silvermines and Ballinalack ores wavy bacterial film-like textures composed of peloids made up of Zn-calcite or Zn-siderite cores and ZnS rims are known (Kucha et al., 1990).

2) Alpine Zn-Pb deposits. Bleiberg sulphides, Austria, Zn-Pb ores display the 34S%■ values from -32 to -2 (n=284), with mean close to 20%■ (Schroll & Rantitsch, 2005). Cardita and Crest ores contain wavy bacterial films (-28.84 to -27.91%■). Semimassive globular sphalerite with globules varying in size from 90 to 180um is a basic ZnS type in the Bleiberg ores with light sulphur from (-30.49 to -26.4%■). Based on sulphur isotope data, um-sized bacterial filaments, and spherical nano-textures seen in etched ZnS globules, sulphate reducing bacteria (SRB) involvement is suggested (Kucha et al. 2005).
ZnS globules were formed by replacement of original peloids (i.e. bacterial colonies) and/or by agglomeration

of original 10-15nm ZnS spheres secreted by SRB. The growth of peloids was promoted by unbalanced electric charges on the surfaces of these ZnS nano-spheres.

3) Upper Silesian MVT Zn-Pb deposits. Sulphur isotopes vary between 2 and 12%■, (mean 5%■) for early stage sulphides, main stage sulphides are characterised by S signature -2 to -15%■. Redeposition of ZnS from the horst to graben structures produced “pulvery” sphalerite with -19%■ (Haranczyk, 1993). Sulphide stalactites containing oxysulphides have S%■ vales of -23.7. Bacterial microtextures occur mainly within oxysulphides and at the contact between Fe-smithsonite replaced by banded sphalerite (Kucha et al., 1990).

4) La Calamine and Engis, Belgium, contain bacterial micro- and nano-textures in ores related to karst cavities, and paleoweathering crusts (Kucha et al., 1990). The biogenic textures are represented by clumps of peloids, and bacterial mats occurring in banded sphalerite composed of replaced peloids. Peloids are composed of Zn-calcite cores and ZnS rims, oxysulphides, thiosulphates, vaesite and chalcedonic silica.

Bacterial microtextures in all of the above mentioned deposits are as a rule associated with oxysulphides i.e. compounds with mixed and intermediate sulphur valences (Kucha et al., 1989). The origin of oxysulphides is probably related either directly to incomplete bacterial reduction of the sulphatic sulphur, or reaction of bacterial H2S with sulphatic S present in the fluids. Some of peloids are composed of oxysulphides (Kucha & Stumpfl, 1992; Kucha, 2003). Therefore, an interpretation of the S isotopic signature of bacterial textures should consider not only microbial community structure, but also the oxidative part of the sulphur cycle proceeding through compounds with mixed sulphur valences.

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