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Impact of sulphate reducing bacteria on micro-mineralogy and geochemistry of Triassic sulphides, Bleiberg Zn-Pb deposit, Austria

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Bleiberg is a large world-class Pb-Zn-deposit in the Eastern Alps. Massive to semi-massive early-diagenetic zinc ores from Bleiberg display $\delta^{34}\text{S}$ values that comply with bacteriogenic sulphate reduction in an open system, i.e. $\delta^{34}\text{S}$ difference sulphide sulphur and seawater sulphate at 40%. Under the reflected light microscope the fine grained sphalerites display mm-scale banding. The higher magnification of SEM reveals a set of micro- to nano-textures, i.e. spherical textures, i.e. peloids (40 to 90 μm in diameter) and ZnS spheres (30 to 50 nm large). The etched sphalerite shows filamentous micro-textures (ca 0.3 x 1 μm filaments) similar to those seen in the recent, natural, biofilms of sulphate reducing bacteria accumulating ZnS nano-spheres. A combination of fossilised bacterial filaments and nano-spheres composed of ZnS can be explained best as direct micro-texture resulting from bacterial activity responsible for sulphide mineralisation. Fossil bacteria relics are composed of ZnS, and are invariably accompanied by oxysulphides, i.e. compounds with mixed and intermediate sulphur valences. Oxysulphides display characteristic optical properties related to average sulphur valences – the higher the valence the lower the reflectivity. R% values measured in oxysulphides vary between 30 and 7% in air. Oxysulphides contain Fe, S and O as main elements, but are enriched up to a few wt.% in As, Pb, Zn, Ni and less Ag. Sphalerite hosting oxysulphides is also enriched in Fe, As, Ni and Pb. Unusual geochemistry of precipitates related to fossil bacteria is interpreted as typical bacterial response to metal toxicity described in recent microbiology studies. Re-crystallization of this protosphalerite is the next stage. These observations visualize how large orebodies of zinc-rich ores (Zn/Pb ~ 10) have been formed by bacterial activity at Bleiberg deposit.

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Membranalytic ability of oxides depends on crystal chemistry and dielectric constants through interfacial solvation

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The model presented explains oxide surface interactions with phospholipids (PLs) constituting biological cell membranes [1]. Oxides have differential ability to lyse cell membranes [2, 3]. The sequence of decreasing membranalytic ability of oxides is exactly opposite to that of increasing dielectric constant, quartz \geq amorphous silica $>$ $\text{Al}_2\text{O}_3 >$ $\text{Fe}_2\text{O}_3 >$ TiO_2 . Oxides with smaller values of dielectric constant are interpreted as having more charge transfer (ΔN), hence being more polarizable, more covalent, chemically “softer”, and less hydrophilic compared to oxides with larger values of the dielectric constant (Fig. 1) [1, 4, 5].

The PL headgroups in the membrane bilayer interact with the oxide surface. The headgroup is represented by the tetramethylammonium ion, TMA^+ . Unfavorable adsorption entropy ($\Delta S_{\text{ads, TMA}^+} < 0$) on quartz disrupts PL bilayer structure, and favorable Gibbs free energy of exchange between TMA^+ and background electrolyte Na^+ ions ($\Delta G_{\text{exc, TMA}^+/\text{Na}^+} = \Delta G_{\text{ads, TMA}^+} - \Delta G_{\text{ads, Na}^+} < 0$) maximizes extent of lysis. For am. SiO_2 , bilayer disruption is limited because $\Delta S_{\text{ads, TMA}^+} > 0$, even though $\Delta G_{\text{exc, TMA}^+/\text{Na}^+}$ is $<$ 0. Stishovite and other oxides have $\Delta S_{\text{ad, TMA}^+} <$ 0, but now $\Delta G_{\text{exc, TMA}^+/\text{Na}^+}$ is $>$ 0, at the low pHs ~ 5 of cellular fluids.

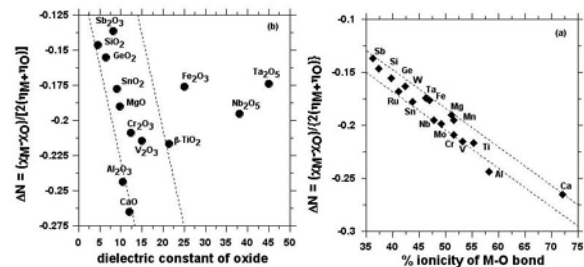


Fig. 1. Relation between dielectric constant, ionicity and polarizability (ΔN) of metal-oxide bond.

References

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