

Can we use the mineralogical and chemical composition of medieval slags to understand historical smelting technologies?

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Slags from the Pb/Ag medieval (XIVth century) smelting plant located at Bohutín, Příbram district, Czech Republic, were studied from the mineralogical and geochemical points of view. Two types of slags were distinguished: (i) quenched slags formed mainly by Pb-rich glass and unmelted residual grains of SiO₂ and feldspars and (ii) crystalline slags mainly composed of Fe-rich olivine (fayalite) and glass. From the chemical point of view, slags exhibit low concentrations of CaO (up to 5.3 wt%) reflecting a lack of addition of CaCO₃ as a melting agent (this flux is routinely applied in modern Pb metallurgy) [1, 2]. High concentrations of PbO (up to 34.4 wt%) indicate a low efficiency of the medieval extraction process. The mean log viscosity value of slags, using the model of Giordano *et al.* [3] for 1200°C, varies from 1.652 to 2.499 Pa s (mean: 2.119 Pa s). Such high viscosities indicate either high SiO₂ content (which can be related to unmelted quartz grains) or low metal extraction and lower ability to flow out of the furnace. The projection of the bulk composition of slags onto the SiO₂-PbO-FeO ternary system was used for temperature estimates of slag formation, being probably between 800-1200°C. Better temperature estimates are impossible because of the lack of experimental data on complex PbO-rich systems chemically similar to medieval slags. The morphology of olivine crystals was used to estimate the cooling rate of the melt, which for some slags indicates > 1450°C/h. However, known cooling regimes in natural melts (mainly forsterite-based) cannot be fully applied to fayalite-dominated slag melts [2].

[1] Ettler *et al.* (2000) *C. R. Acad. Sci. Ila* **331**, 245-250.

[2] Ettler *et al.* (2009) *Archaeometry* **51**, (in press) doi: 10.1111/j.1475-4754.2008.00455.x). [3] Giordano *et al.* (2006) *Chemical Geology* **229**, 42-56.

What is extreme? Methanotrophy at pH 1 or without oxygen?

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Typically, either hot, very acidic or alkaline habitats are considered 'extreme', but energy limitation may make the life of organisms just as difficult. Here we compare two groups of methanotrophs that we have enriched and/or isolated in our laboratory under unusual conditions.

Members of the verrucomicrobial genus *Methylacidiphilum* have recently been isolated from three highly acidic, geothermal areas independently [1]. They grow aerobically at 37-65°C and at pH 0.8-6, with a minimum generation time of 10 h. In addition to their pH and temperature optimum, they markedly differ from proteobacterial methanotrophs in having ≥3 copies of pMMO genes and no extensive internal membrane system. Yet, major metabolic pathways appear similar.

Another new group of methanotrophic bacteria was enriched by incubating freshwater sediments anaerobically with constant supply of methane and nitrite. The enrichment was dominated (up to 80 %) by bacteria of the 'NC10' phylum [2]. Growth was very slow, with a doubling time in the order of 1-2 weeks. The enrichment culture oxidized methane and reduced nitrite stoichiometrically to CO₂ and N₂. In order to understand the physiology and ecological niche of these anaerobic methanotrophs, we carried out metagenomic, proteomic and physiological studies. Main metabolic pathways could be partially elucidated by the analysis of the assembled genome of the dominant 'NC10' bacterium and by enzyme assays. Although these bacteria also live under anaerobic conditions, their biochemical pathways are entirely different from marine microbes coupling methane oxidation to sulfate reduction [3].

We hypothesize that, owing to the difficulty in activating methane under anaerobic conditions, microbial methane oxidation is more challenging under anaerobic, mesophilic conditions than aerobically at low pH and high temperature.

[1] Semrau *et al.* (2008) *Trends in Microbiology* **16**, 190-193.

[2] Raghoebarsing *et al.* (2006) *Nature* **440**, 918-921.

[3] Hallam *et al.* (2004) *Science* **305**, 1457-1462.