Genetic considerations in microbial silicification

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The encrustation and entrapment of microbes in silica sinter is an inevitable outcome of life in some hydrothermal systems, where disequilibrium conditions lead to the spontaneous precipitation of amorphous silica. As some of the oldest evidence for life on Earth is found in >3.5 Gyr cherts, understanding factors that control the silicification process is critical to the study of life's antiquity. Research to date has largely focused on the relative rates at which different microbes become encrusted with silica. These studies have generally demonstrated that microbes play a largely passive role in the silicification process, where their surface layers, or any other exposed surfaces for that matter, become encrusted with silica simply as a consequence of living in systems where its precipitation is inevitable. The influence of silica on the life of the microbe, however, has been given much less attention. In both the field and the laboratory, bacteria grow under conditions that are highly supersaturated with respect to amorphous silica, and in some cases, biological responses, such as sheath thickening for cyanobacteria, or increased EPS production in biofilms, have been noted. In order to better understand the dynamic interplay between microbe and mineral in these systems, we examined several relevant bacteria (i.e., a sheathed and unsheathed cyanobacteria, and a biofilm-forming thermophile) for biological responses to the silicification process that are manifest at the proteome level. Polyacrylamide gel electrophoresis was used to separate proteins that were regulated in response to the silicification process for identification via mass spectroscopy. Our results indicate that microbes are genetically equipped to respond to the silicification process, and although at present there is insufficient data to make any phylogenetic inferences, this study raises interesting questions regarding the role of silica in the survival of Earth's earliest life forms.

Lithogeochemical identification of Ni-Cu mineralised intrusions using fertility analysis

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Nickel and cobalt numbers

A novel lithogeochemical exploration methodology for nickel sulphide and PGE deposits utilising lithogeochemistry of barren cumulates was developed. The essential part of the *fertility analysis* is to identify whether target has experienced sulphide saturation and segregation. For that purpose two parameters, nickel and cobalt numbers, were introduced:

Ni#=100*Ni/(Ni+Cu)
Co#=100*Co/(Ni+Cu+Co)

Fractionation of olivine from ultrabasic-basic magma brings the Ni# down but Co# remains at the same level, whereas segregation of sulphides increases the Co# significantly in the residual melt and in sulphides equilibrium with it. Therefore the Ni# describes the privitiviness of the magma from which sulphides have segregated and the Co# indicates the nickel depletion. In primitive komatiitic and picritic systems the Ni# is greater than 75, in basaltic 50-75 and in more evolved flood basalts <50. The calculation is reliable if sulphides are a cumulus phase, i.e. >0.3 wt%.

In studied Ni-Cu ores Co# was low, at 1-5, but it increased in the stratigraphic units above the ore. In the ultramafic intrusions the range was quite narrow, at 2.9-15, but in differentiated mafic intrusions the range was as wide as 3-60. In depleted intrusions Co# was uniformly high, >10.

Fertility analysis

The parameters of the *fertility analysis* quantifying the requirements of the Ni-Cu sulphide ore formation are: 1) primitive character of the magma, 2) extent of sulphide saturation, 3) Ni-rich, chalcophile undepleted magma, 4) magmatic sulphides that are in equilibrated with a large amount of magma, 5) coeval primitiviness and sulphide segregation, 6) sulphide accumulation and 7) fractionation or mobilisation of sulphides. The values of the parameters and value of the *overall discrimination index, OD*, are calculated from the whole-rock analyses of the rock samples (Lamberg 2005). Mineralised samples are excluded from the analysis.

In the test with extensive lithogeochemical datasets of the Svecofennian intrusions of Finland (7517 samples / from 353 targets), Thompson Ni belt, Canada (287/27) and Cape Smith belt, Canada (287/27), the *fertility analysis* successfully discriminated between fertile and barren targets.

In low grade PGE deposits, Kevitsa and Duluth, Co# was found to correlate negatively with total PGE grades indicating that Co# may be a potential tool for identifying PGE potential intrusions and their parts and localising mineralised reefs.

References

Lamberg, P. (2005) *Geol. Surv. Finland Bull.* **402**, 264 pp.