



Distribution and behaviour of Se and Te in Volcanogenic Massive Sulfide (VMS) systems.

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Introduction

Volcanogenic Massive Sulphides (VMS) are examples of sulphide ore deposits that are known to be variably enriched in both Te and Se. Some VMS deposits, though not all, display very high Se/Te ratios and represent some of the most Se-rich hydrothermal deposits known; others are notably Te enriched with low Se – the reasons for this diversity in geochemistry are poorly understood. The Cyprus ophiolite hosts classic VMS mineralisation. This ophiolite is extremely well preserved including the sea floor topography, faults and lava stratigraphy. The complete sequence of black-smoker mineralization, analogous to that observed in modern oceans, is also preserved from root zones where the hydrothermal fluids that produced the surface VMS, ochres, umbers and off axis Au-rich silicified precipitates were able to circulate. The Cyprus VMS deposits are predominantly rich in pyrite but are variably enriched in Cu, which is economic and currently being extracted from the largest deposit at Skouriotissa by Hellenic Mining. They are also variably enriched in Au, Zn and Pb which have been extracted historically from a number of the deposits. Selenium is recorded as being present up to 3% at Skouriotissa, associated with Au and Pb-rich ores. This PhD aims to identify the processes which have led to the uneven distribution of elements in these ores.

Recently, the Geological Survey Department of Cyprus (GSD) has conducted a geochemical survey of trace elements in soils that includes the major and minor metals associated with the VMS (e.g. Cu, Au, Pb, Zn and Se and Te) for the whole of southern Cyprus, including the areas around the VMS and their underlying feeder zones. This survey has indicated significant variation and contrasting Te and Se anomalies across differing underlying geology and provides a rare example of thorough coverage of a Te and Se dataset in soils across an entire region. Recent work at Leicester (Jowitt et al., 2012) modelled the release of base metals from source rocks into the VMS deposits, but did not analyse for Se and Te. The PhD project will make effective use of large datasets provided by the GSD, and work in collaboration with Hellenic Mining and the GSD.

The PhD will examine the variation in the metal and Te and Se content of different VMS, their source rocks and weathering products, to understand the petrogenetic, hydrothermal and surface processes responsible for them. This will involve integrated geochemical sampling utilising the GSD database, samples and existing data at Leicester (Jowitt et al., 2012) study, and targeted sampling of the underlying geology on Cyprus. Source rock leaching will be modelled to quantify the release of

Te and Se from source rocks into VMS deposits. The PhD project forms a component of the “Te and Se Cycling and Supply (TeaSe)” consortium project funded under the NERC Security of Supply of Minerals programme. This is a major project involving researchers from eight universities and research institutes and over twenty industrial partners. The research carried out by the PhD student will feed into the wider TeaSe work programme and it is anticipated that the student will attend and present their results at internal TeaSe workshops and national and international conferences over the course of the project.

Training Opportunities

The student will receive training in fieldwork, ICP-MS analysis and complimentary SEM and LA-ICP-MS mineralogical analysis and modelling of fluid-rock interaction beneath the VMS system. The patterns of metal distribution observed will be related to the geology, geochemistry and structures of each deposit to produce a predictive model for the origin of the concentration and distribution of Te, Se and metals in VMS ore systems. This project will equip the student with the skills necessary for a successful high-level career in the mineral exploration industry or in academia.

Wider Opportunities

Cardiff University is part of the Great Western Four (GW4+) NERC Doctoral Training Partnership along with Bristol, Bath and Exeter universities and other partners such as the British Geological Survey. During the course of their project the student will have access to the various training programmes organised by GW4+ research themes relating to the Solid Earth and Natural Hazards and Resources, as well as any in-house training for Cardiff analytical facilities. It is anticipated that the student will attend one or more NERC Advanced Training short courses relating to fieldwork and/or advanced data analysis and statistics over the course of the project. The PhD student will attend UK and European workshops and conferences, and the various Impact Meetings planned under the TeASe project. They will be encouraged to publish their results, where possible, over the course of the project to gain experience of writing for publication and the peer-review process at an appropriately early stage.

References

- Jowitt S., Jenkin G.R.T., Coogan L. and Naden J. (2012). Quantifying the release of base metals from source rocks for volcanogenic massive sulfide deposits: Effects of protolith composition and alteration mineralogy. *Journal of Geochemical Exploration*, 118, 47-59
- Prichard H.M., Knight R.D., Fisher P.C., McDonald I., Zhou M-F., and Wang C.Y. (2013) Distribution of platinum group elements in magmatic and altered ores in the Jinchuan intrusion, China: an example of selenium remobilization by postmagmatic fluids. *Mineralium Deposita*, 48, 767-786.
- Prichard H.M. and Maliotis J. (1998). Gold mineralization associated with low-temperature, off-axis, fluid activity in the Troodos ophiolite. *Cyprus Journal of the Geological Society*, 155, 223-231

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Applications

The project is jointly funded by NERC and the School of Earth and Ocean Sciences, Cardiff University and is open to applications from UK national students. **The deadline for applications is Monday the 22nd of June 2015.** The student will be expected to start their studies in late September 2015.

Applications should be made online at: <http://www.cardiff.ac.uk/for/prospective/postgraduate.html>