Comparing and contrasting our knowledge base and gaps in ancient volcanogenic massive sulphide (VMS) deposits via comparisons to modern seafloor massive sulfide (SMS) systems.

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INTRODUCTION

Seafloor massive sulphide (SMS) deposits have provided critical information on how ancient volcanogenic massive sulphide (VMS) deposits have formed. The original discoveries on mid-ocean ridges, coupled with new research in arc environments has greatly shaped our understanding how seafloor hydrothermal systems in the modern and ancient record formed. The modern environment provides us the ability to understand SMS/VMS in real time and deposits are relatively pristine, whereas ancient VMS deposits are often deformed and metamorphosed, which has obscured many original SMS features and textures, but provide other advantages not available in modern SMS deposits (e.g., 3D geometry of VMS). This presentation will compare key information that can be gleaned from the modern and ancient SMS/VMS environments and how it provides us a comprehensive understanding of seafloor hydrothermal deposit formation.

THE MODERN SMS RECORD

The modern SMS record has provided unparalleled understanding of modern equivalents of ancient VMS deposits. For example, the tectono-magmatic relationships to SMS formation are very well understood from the modern record (eg de Ronde, Butterfield and Leybourne, 2012), unlike the ancient record where tectonic setting is inferred from proxies (e.g., mapping, lithogeochemistry)(eg Piercey, 2011). Unlike ancient VMS deposits, modern seafloor hydrothermal systems allow direct sampling and subsequent analysis of hydrothermal fluids and their compositions and the physicochemical parameters of SMS formation (e.g., P, T, Eh, pH, fO_2)(eg German and Von Damm, 2003). Further, recent research on modern arcs has demonstrated the importance of magmatic fluids in SMS/VMS formation using various chemical and isotopic methods (de Ronde *et al*, 2011; Yang and Scott, 2013), which are not as reliable or unusable in the ancient record (eg He isotopes); most of our understanding of magmatic fluid contributions in the ancient record is circumstantial, at best (eg Brueckner *et al*, 2014), and remains a fundamental unanswered question in ancient deposits!

THE ANCIENT VMS RECORD

Compared to the modern record, the fluid chemistry, metal budgets, and physicochemical conditions of ancient deposit (since ~3.5 Ga), is largely inferred from sulphide and alteration mineral assemblages, or from poorly preserved fluid inclusions (eg Brueckner *et al*, 2014; Hannington, 2014). Further, tectonic setting of deposition is inferred from regional stratigraphic assemblages, lithogeochemistry, radiogenic isotopes and U-Pb geochronology (eg Piercey, 2011). Yet despite these uncertainties in tectonic setting there are >700 VMS deposits of varying age that contain mineral resources and are hosted in stratigraphic and tectonic sequences that are vastly more diverse than has been explored on the modern seafloor to date (eg Huston *et al*, 2010; Franklin *et al*, 2005). Moreover, because these deposits are mined they have been extensively drilled and our understanding of the 3D geometry of host rocks, mineralization, and alteration are much better than for SMS (eg Schetselaar *et al*, 2016). In many ancient VMS camps post-VMS deformation has resulted in tilting of stratigraphy and the exposure of the roots of the VMS hydrothermal system, allow researchers to understand the relationships between subvolcanic intrusive complexes and VMS formation, the regional-scale semi-conformable alteration systems and metal leaching reservoirs for VMS, and the regional stratigraphic, magmatic, and tectonic assemblage evolution, which are not easily observable in the modern record (eg Gibson and Galley, 2007; Jowitt *et al*, 2012; Piercey, 2011). Finally, the secular evolution of VMS deposits allows one to use VMS deposits as proxies for ancient tectonics, crustal evolution, and ocean redox evolution; modern SMS are a snapshot of modern tectonic-crustal-ocean redox environment, which likely differed significantly at some points in the past (Huston *et al*, 2010; eg Slack, Grenne and Bekker, 2009).

CONCLUDING REMARKS

Volcanogenic massive sulphide (VMS) deposits are probably the best understood mineral deposit type in the ancient geological record. Our outstanding understanding is because of the ability to observe SMS forming in the seafloor environment and comparing them to ancient deposits dispersed through geological time. It is ongoing comparisons and feedback between researchers studying modern SMS and ancient VMS that will allow us to further advance our understanding of ancient VMS and modern SMS processes.

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