Subject offered for a contract starting October 2019

SUBJECT TITTLE: Comparing the magnetic signature of hydrothermal areas and oceanic core complexes at the SWIR and the MAR

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Presentation of the subject: (1 or 2 pages)

Research Background

The particular physical and chemical environment of hydrothermal areas and oceanic core complexes (OCC) usually make them gain different magnetic properties compared to nearby areas, making magnetism effective to study these particular areas situated in the mid-ocean ridges. For example, the magnetization of massive sulfide minerals such as pyrite and chalcopyrite is usually lower than their surrounding basalt (*Fujii et al., 2018*), resulting in negative magnetic anomalies over some basalt-hosted hydrothermal areas (*Tivey,1993; Szitkar et al., 2014, 2015; Tivey and Dyment,2010; Zhu et al., 2010*). Therefore, we can use magnetism to explore submarine sulfide minerals. By contrast, due to the serpentinization process in some ultramafic-hosted hydrothermal areas and OCCs, abundant magnetite production during this process makes these areas present positive magnetic anomalies (*Tivey and Dyment, 2010; Szitkar et al., 2015,2017,2018; Dyment et al.,2018*). In addition, magnetite may be oxidized and transformed during this process (*Fujii et al., 2018*), making magnetism also useful to study the formation and evolution of hydrothermal areas and OCCs.

Until now, there is a large number of magnetic studies on hydrothermal sites at the Mid-Atlantic Ridge (*Tivey et al., 1993, 1996, 2003, 2006, 2010; German et al., 2008; Szitkar et al., 2014a, 2014b, 2015a, 2015b, 2017, 2018; Dyment et al., 2018*). *Tivey et al.* (1993) used near-bottom magnetic data to analysis the structure of the TAG hydrothermal area which is the first one found at the Mid-Atlantic ridge. A Significantly reduced magnetic anomaly was detected over this area and they concluded that TAG is a basalt-hosted hydrothermal area with a pipe upflow zone and alteration area. Subsequently, *German et al.* (2008) also studied a basalt-hosted hydrothermal area (4°48'S) at the Mid-Atlantic ridge and found that there were a few discrete low magnetization areas and wide alteration zone. In addition, *Szitkar et al.* (2014) also used near-bottom magnetism to study the magnetic anomaly mechanism of Krasnov basalt-hosted hydrothermal area and they concluded that the presence of thick hydrothermal deposits and the alteration process are the two main cause of the magnetic anomaly in this area. At the same time, they summarized the possible sources of magnetic anomalies at basalt-hosted hydrothermal areas as three: 1) the presence of hydrothermal deposit; 2) demagnetization due to alteration processes; and 3) thermal demagnetization during hydrothermal activity.

Differing from basalt-hosted hydrothermal areas, ultramafic-hosted hydrothermal areas usually present positive magnetic anomaly (*Tivey,2010; Szitkar et al.,2014, 2017,2018; Dyment et al., 2018*). Due to variations in temperature and size among the sites, the strength of magnetization is usually different. The possible causes of the positive magnetization are also three (*Szitkar et al., 2014*): 1) the production of magnetite during serpentinization gives rise to magnetization of the ultramafic rocks. 2) hydrogen production during serpentinization may protect ferromagnetic minerals from oxidizing. and 3) the significant size of the sites is also a factor controlling the strength of anomalies. As a key contribution, magnetite production during serpentinization is largely controlled by the temperature of hydrothermal areas. In the low-temperature ultramafic-hosted hydrothermal areas, such as Lost City(~116°C) (*Szitkar et al., 2017*), serpentinization favors brucite formation rather than magnetite, producing weak positive magnetization (2 A/m), whereas in high temperature serpentinization, such as Rainbow (~350°C), iron is directly forming magnetite, making these areas to present a strong positive magnetization (30A/m). In addition, the content of magnetite production is also variable in different temperature environment. When temperature under 200°C, the system is dominated by Fe-rich brucite and the content of magnetite is limited, leading to weak positive magnetization in this areas and slow increase of magnetite production versus temperature, but when the temperature is above 200°C, the magnetite production increase dramatically, leading to strong magnetic anomaly over these areas (*Szitkar et al., 2018*).

Overall, many hydrothermal areas located in the Mid-Atlantic Ridge have been studied and the magnetism of these areas is quite well described. However, there are very few studies（*Zhu et al., 2010; Wu et al., 2017*；*Zhou et al., 2018*）on the magnetic signature of hydrothermal areas and OCCs at the South-West Indian Ridge which resembles the Mid-Atlantic Ridge in tectonic and spreading environment. The magnetic structure and evolution of these hydrothermal areas and OCCs have not been fully understood. Fortunately, through several cruises of China conducted at the SWIR, we have obtained a lot of data including near-bottom magnetic data, bathymetry and samples in this area. So, we propose to analyze the SWIR magnetic data at sites Longqi, Yuhuang, Duanqiao and compare the results to the magnetic signature of typical hydrothermal areas and OCCs on the Mid Atlantic Ridge such as Rainbow, TAG, and Lost City. In this way we expect a better understanding of the hydrothermal areas and OCCs at the SWIR and, more generally, of the processes at work in both areas.

Research Method

In the study of this project, we plan to use some data processing methods such as adaptive filtering (*Zhou et al., 2018*), IGRF correction (*IGRF working group, 2010*), correction method for the AUV (*Honsho et al., 2009; Wu et al., 2018*) and reduction-to-the-pole (RTP) (*Szitkar et al.,2015*) and magnetization inversion methods like Bayesian approach (*Honsho et al., 2012*) and 3D focused inversion method to get more precise data and magnetization distribution of the study area. At the same time, we will also measure rock magnetic properties such as susceptibility and Natural Remanent Magnetization and petrology such as rock properties and mineral construction (*Maffione et al., 2014*) to establish our inversion model and give more rational interpretation of the structure and evolution of the study areas. Given these results, we will compare magnetic signature of hydrothermal areas and OCCs at the SWIR with the typical ones at the MAR.

Perspective Results

After this project, we intend to get better know of some typical hydrothermal areas and OCCs at the SWIR. For instance, we would get the magnetization distribution of different kinds of hydrothermal areas according to the inversion results and get to know the evolution the hydrothermal areas and OCCs according to the evidences of paleomagnetism and petrology connecting with the magnetization distribution. Finally, we would summarize magnetic signature of different kinds of hydrothermal areas and OCCs, which will be a good implication to explore and study other unfound or inactive ones at the SWIR.

Collaborative ramework

This project will benefit from a collaboration between the Second Institute of Oceanography (SIO), Hangzhou, China, and Institut de Physique du Globe de Paris (IPGP). Both of them have access to research vessels and submersible vehicles and they all have done a lot of works at the MAR and SWIR respectively, which can ensure the base of this project.

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