27. Schmucker-Weidelt Kolloquium für Elektromagnetische Tiefenforschung

# Exploration of Seafloor Massive Sulfide Deposits with the Novel EM Induction System *MARTEMIS*

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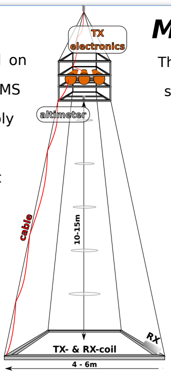
## Introduction

Past investigations of seafloor massive sulfides (SMS) have focused on actively forming sites. New technologies are needed to explore for SMS deposits, which have finished their active phase and are possibly covered by sediments or lava.

In Swidinsky et al. (2012) our workgroup demonstrated that transient electromagnetics (TEM) may be used for the detection of SMS deposits under sediment cover. The method may also yield valuable information about its depth and thickness.

Experiments with the new MARTEMIS system at the Palinuro Seamount (Tyrrhenian Sea) and in the vicinity of the TAG hydrothermal field (Midatlantic Ridge) serve as proof of principle.




## MARTEMIS

The marine transient electromagnetic induction system MARTEMIS (see sketch to the left) is a coincident loop TEM system for the detection and characterization of conductive seafloor features like SMS:

- adjustable coil size (4m x 4m – 6m x 6m),
- transmitter currents up to 60A,
- operation of coil close to seafloor (5 - 10m),
- continuous measurement,
- operation at speed of 0.3 - 0.6kn.

Additional sensors may be mounted to the system, e.g. two extra pairs of electrodes to the coil frame to measure the ambient electrical field (see Fig. 3).

## Palinuro Seamount, Tyrrhenian Sea

*Cruises POS483 (2015) & POS509 (2017)*

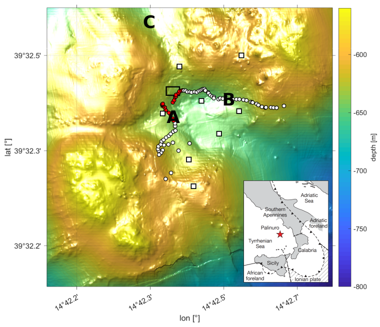



***Fig. 1***: Bathymetric map of Palinuro Seamount with area of previous drillings with SMS recovery (black rectangle), 700m long profile line of MARTEMIS system (circles), stationary OBEM receivers (squares) and marked areas A - C with anomalous EM responses.

In 2015, TEM measurements with the MARTEMIS system (Fig. 1) showed anomalous responses (red circles, **A**) in the vicinity of the area where SMS had previously been recovered in drilling cores (black rectangle).

1D inversions of TEM data (Fig. 2) confirm the existence of a sediment covered layer of conductive material (**A**) and an additional layer at greater depth (**B**), which hints at a so far unknown mineralization.

Measurements were continued in 2017. While results from the TEM measurements are still being processed, measurements of the ambient electrical field were already processed on-board (Fig.3). They not only revealed anomalous responses around the drilling sites (**A**), but also an additional anomaly (**C**).

Gravity cores taken at the sites identified by EM measurements (**B** & **C**) contained sulfide rich sediments, thus, ground truthing the interpretation of EM measurements!

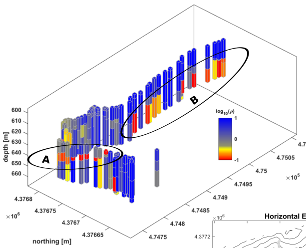



***Fig. 2*** (left)
1D inversion results of TEM measurements, conductive features (ρ ~ 0.1Ωm) in red.

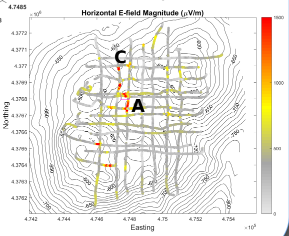



***Fig. 3*** (bottom)
Amplitude of ambient horizontal electrical field along track lines measured during POS509 (2017).

## 3-Mounds (@ TAG Field), Midatlantic Ridge

*Cruise JC136 (2016)*

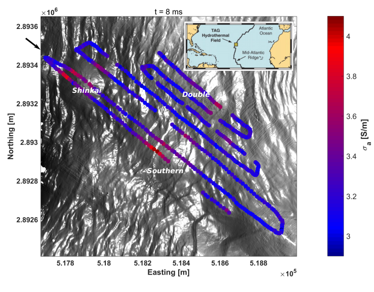



***Fig. 4***: Illuminated bathymetric map of workarea *3-Mounds*. Colored dots show a time slice (8ms) of the apparent conductivity (Swidinsky & Weiss, 2017) along the track of the MARTEMIS system. Conductivity anomalies are evident in the region of the known mounds. 1D inversion results along the marked profile line are shown in Fig. 5.

Regional scale experiments were carried out in the vicinity of the TAG hydrothermal field in 2016. Measurements in the workarea *3-Mounds* were taken along an 8km long profile line (Fig. 4). Values of the apparent conductivity show anomalous values in the vicinity of the three mound structures. 1D inversion results (Fig. 5) show conductive features at the western flanks of Shinkai and Southern Mound. Laboratory investigations confirm that such high conductivities require the presence of high grade SMS (Fig.5, top).

### Outlook

We aim to improve interpretation of geophysical data by linking physical properties (e.g. electrical conductivity) to geochemical and petrological properties. This laboratory work is carried out on SMS samples available at GEOMAR.

### Acknowledgements

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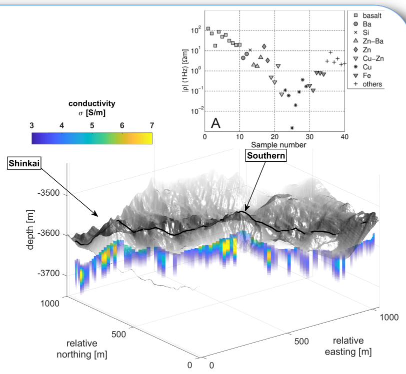


***Fig. 5***: 3D view of bathymetry with stitched 1D inversion results of TEM measurements (shifted down for better visibility) along profile 6 (see Fig. 4). Conductive features (yellow) are evident on the western flanks of Shinkai and Southern Mound. Resistivity of SMS samples (top, from Spagnoli et al., 2016) from various geological settings sorted by composition show comparable high conductivities for high grade SMS.

***References***

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