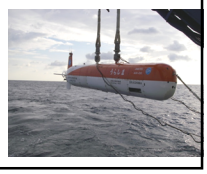
Marine Electromagnetic Sounding on Submarine Massive Sulphides using Remotely Operated Vehicle (ROV) and Autonomous Underwater Vehicle (AUV)

Tada-nori Goto[1], Junichi Takekawa[1], Hitoshi Mikada[1], Keizo Sayanagi[2], Makoto Harada[2], Takao Sawa[3], Noriko Tada[3] and Takafumi Kasaya[3]

(1) Graduate School of Engineering, Kyoto University
(2) Inst. Oceanic Research and Develop., Tokai University
(3) Japan Agency for Marine-Earth Science and Technology

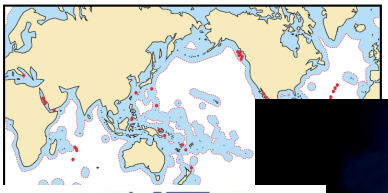


Summary of today's talk

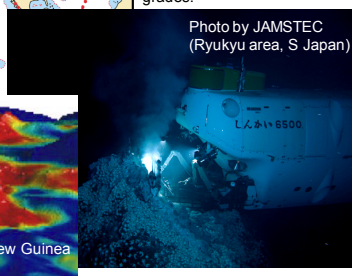
1) Numerical Study
- Proposal of AUV-CSEM:
  A new survey technology for shallow sub-seafloor structure imaging such as seafloor massive sulphide (SMS)
- Numerical studies show us that AUV-CSEM is feasible.

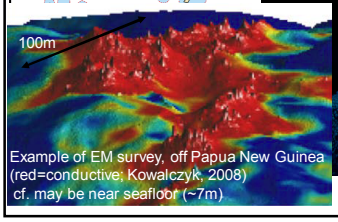
2) In-situ Resistivity Measurements
- Proceeding the real AUV-CSEM survey, we applied in-situ resistivity measurements of seafloor rocks/sediments to a SMS using ROV
- The obtained surface resistivity/IP distributions correspond to the know the SMS and surrounding chimney distributions.

SMS=Submarine Massive Sulphide



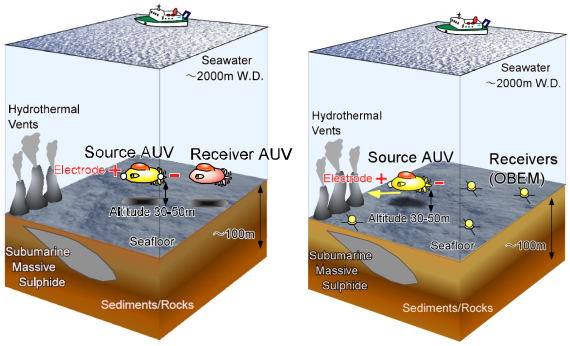
The SMS has attracted mining companies because of world-wide requirement of metals and its compactness with high grades.





Example of EM survey, off Papua New Guinea (red=conductive; Kowalczyk, 2008)
cf. may be near seafloor (~7m)

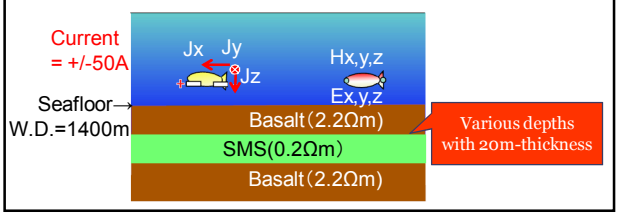
AUV-CSEM survey



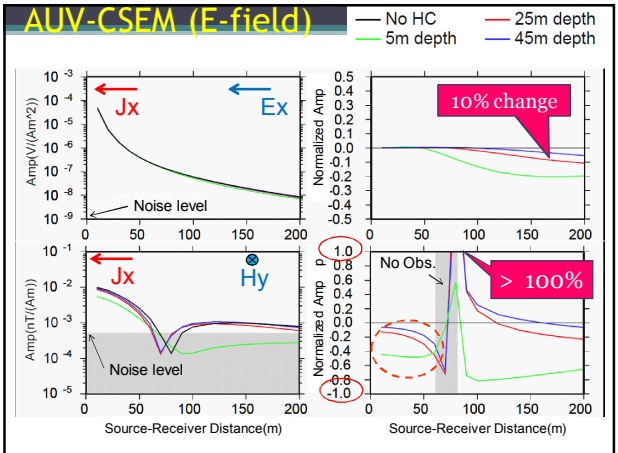
AUV=Autonomous Underwater Vehicle
CSEM=Controlled-Source EM survey

Numerical Calculation

- Noise level: 10 μV for E-field, 1nT for H-field
- Source Electrode/Receiver altitude = 30m from seafloor
- Numerical CSEM code "EM1D" (by Ki-Ha Lee)
- Source: Horizontal & Vertical source dipoles
  [Jx, Jy, Jz] with 5m dipoles, 1Hz.
- Receiver: [Hx, Hy, Hz]+ [Ex, Ey, Ez]
  with 5m receiver dipole. 4 waves are stacked (4 sec.)

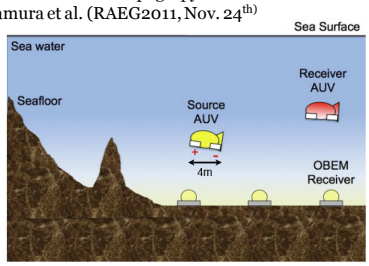


AUV-CSEM (E-field)



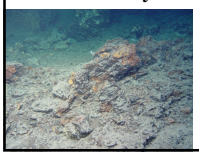
Complicated Structure with AUV-CSEM

- 2D sub-seafloor structure
  => Imamura et al. (22nd Morning)
- 3D structure & seafloor topograpy
  => Imamura et al. (RAEG2011, Nov. 24th)

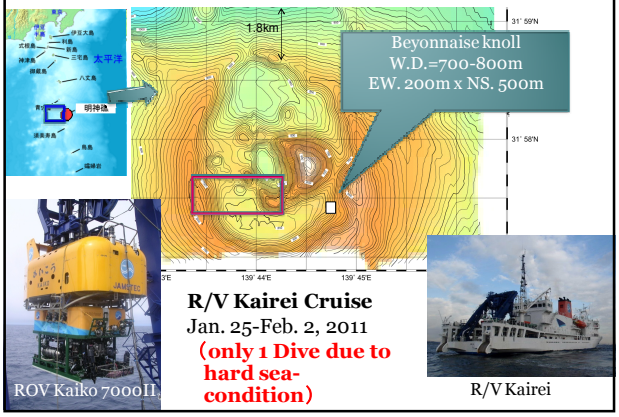


Electrical property of SMS

- Question: Does the SMS truly indicate low resistivity?
- We conducted in-situ resistivity mea-surement at known SMS offshore Japan.
- The ROV-based DC resistivity meter, developed for a test version of AUV-based transmitter, is used for the survey.



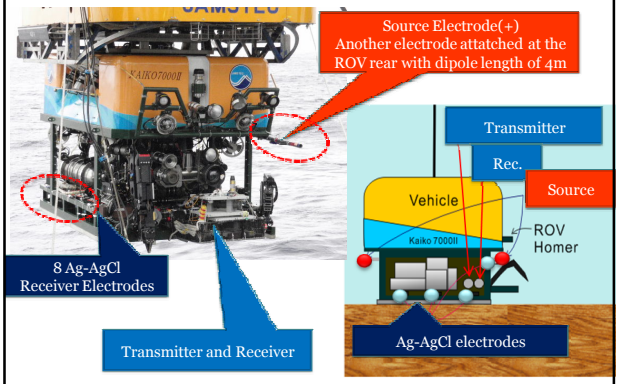
SMS survey at the Izu-Bonin Island, Japan



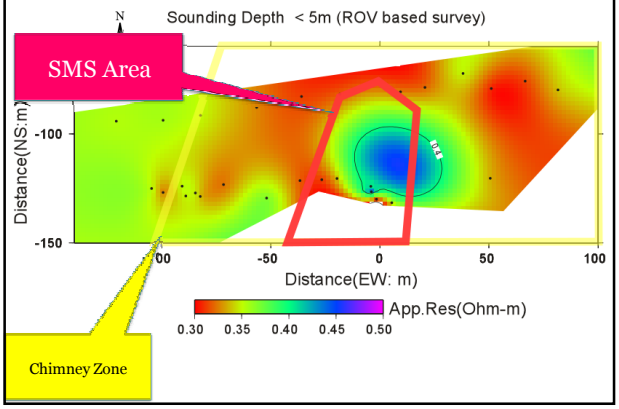
R/V Kairei Cruise
Jan. 25-Feb. 2, 2011
(only 1 Dive due to hard sea-condition)

R/V Kairei

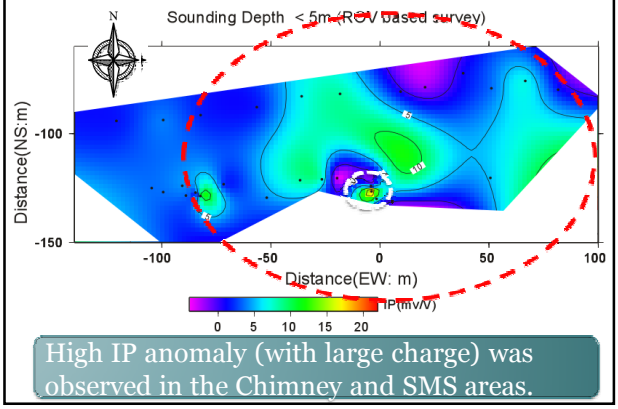
ROV Kaiko 7000II Dive #499



App. Resistivity Mapping around SMS



Induced Polarization Mapping



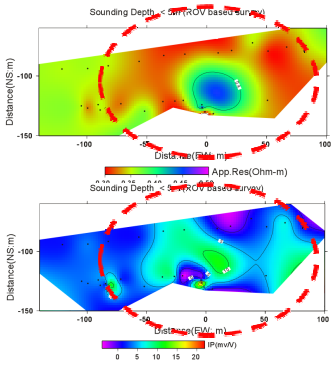
High IP anomaly (with large charge) was observed in the Chimney and SMS areas.

App. Res. and IP mapping

Low App.Resistivity
at the Chimeney Zone
(0.35-0.4Ωm
for sediments/rocks)
* Partly high app. res.

High IP effect
at the Chimeney Zone

* Highest at the site
showing high app. res



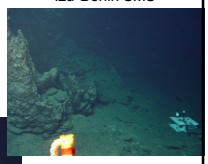
Summary

- AUV-CSEM survey is feasible.
Underwater magnetometer is suitable for receiver.
- The in-situ resistivity measurement shows low resistivity and high IP features of the chimney and SMS zones.
- The SMS zone partly does not indicate low resistivity feature, while the IP value obviously high at the site. Although we do not have the reasonable explanation, we believe that it reflects the inclusion style of metallic deposits in rocks/sediments.
- The Japanese AUV "Urashima" is ready to dive.
The AUV experiment with OBEM is conducted around the real SMS in the next month at the Izu-Bonin Island.

Thank you for your attention.

AUV "Urashima"

Izu-Bonin SMS



Japanese OBEM