EXPLORATION FOR COBALT RICH FERROMANGANESSE CRUSTS

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OUTLINE

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- COBALT RICH MANGANESE CRUST
- WHY SEABED MINING
- WHAT ARE THE MINERALS USED FOR
- JOGMEC CONTRACT AND SURVEY PLAN
- PRE-CUISE
- STUDY AREA
- TRAINING
- CONCLUSION
- EXTRAS

JOGMEC'S OBJECTIVES

- Sample for research evaluation
- Conduct acoustic survey
- Data collection
- Train 4 persons from developing nations

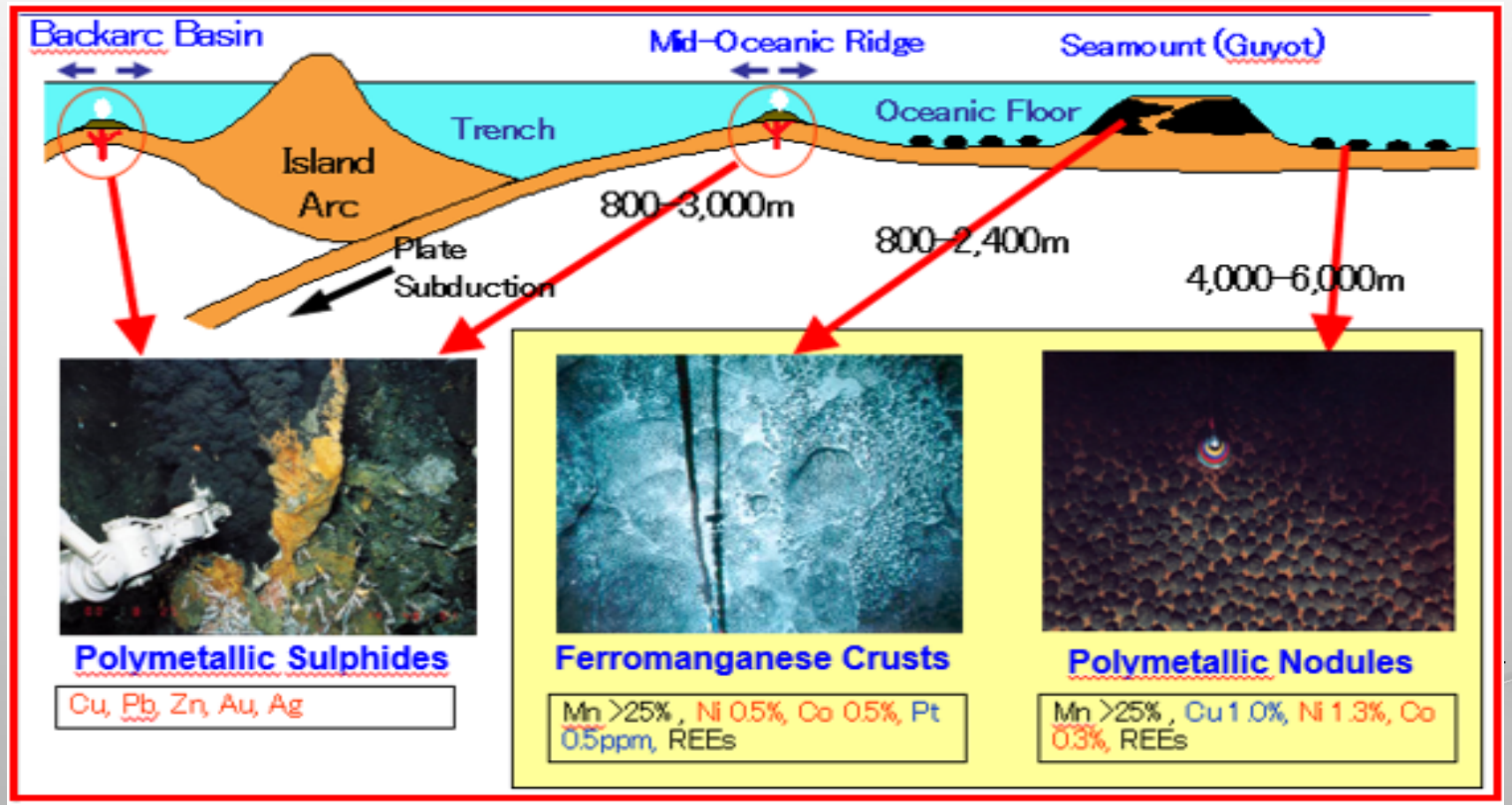
PERSONAL OBJECTIVES

- Learn more Seabed mining exploration since it's a relatively new area of science
- To improve skills in the planning and executing of research
- To acquire additional skill of core sample preparation, description and elemental analysis
- Improve my social networking

SEABED MINERALS

- *WHAT ARE THEY?* MINERALS FOUND ON THE OCEAN SEABED

3 MAJOR MINERALS

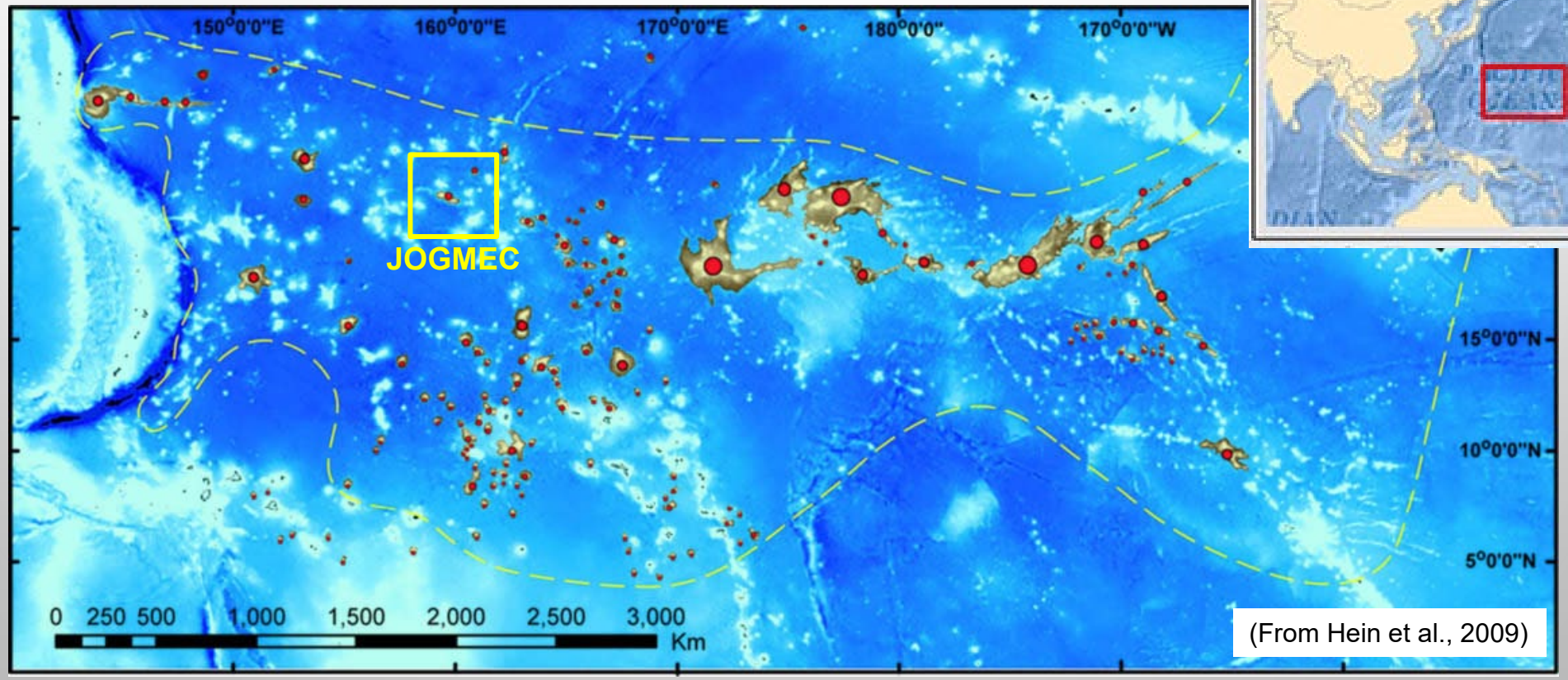


COBALT-RICH FERROMANGANESE CRUST

- Occur throughout the global ocean on seamounts, ridges, and plateaus where currents have swept clean of pelagic sediments
- Precipitate out of cold ambient seawater onto hard-rock substrates forming pavements up to 250 mm thick
- Forms water depths of about 400-4000 m, with the thickest and most cobalt-rich crusts occurring at depths of about 800-2500 m
- Fe-mn crusts have been considered to be almost exclusively of abiotic origin
- However, it has recently been suggested that these crusts may be a result of biomineralization
- Precipitation, accumulation and distribution of elements, such as fe, mn, ni and co in fe-mn crusts are not controlled by microbial activity
- Bacteria and algae are only physically incorporated into the crusts when dead plankton settle on the ocean floor and are trapped on the crust surface
- Crusts generally grow at rates of 1-6 millimetres per million years
- Surfaces are botryoidal, which may be modified to a variety of forms by current erosion. In cross-section, crusts are generally layered, with individual layers displaying massive, botryoidal, laminated, columnar, or mottled textures; characteristic layering is persistent regionally

Criteria for the Exploration Area

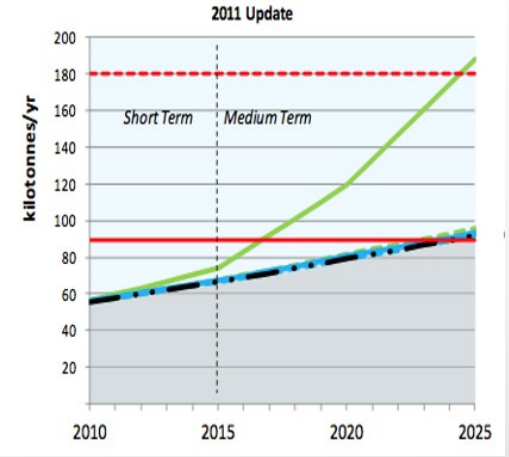
(1) large volcanic edifices shallower than 1,000 to 1,500 m; (2) substrates older than 20 Ma; (3) areas of strong and persistent current activity; (4) volcanic structures not capped by large atolls or reefs; (5) a shallow and well-developed OMZ; (6) slope stability; (7) absence of local volcanism; and (8) areas isolated from input of abundant fluvial and eolian debris. Exploitation criteria included (9) average Co contents ~0.8%; (10) average crust thicknesses ~40 mm; and (11) subdued small-scale topography.



The dashed line encloses the largest region in the global ocean that has permissive conditions for development of thick, cobalt-rich crusts.

WHY SEABED MINERAL EXPLORATION?

- World's demand for minerals continues to increase
- The social and environmental impacts of on land mining are increasingly controversial
- Deep seabed resources are believed to contain a higher concentration, and a higher number of different types, of valuable minerals in one deposit than their terrestrial alternatives.
- Seabed mining has a smaller footprint, than land mining. (Does not impact waterways, has reduced carbon emission)
- Additionally, seabed mining does not require additional roads, surface ore-transport systems, buildings etc.



MIT rare metals publications(2016)

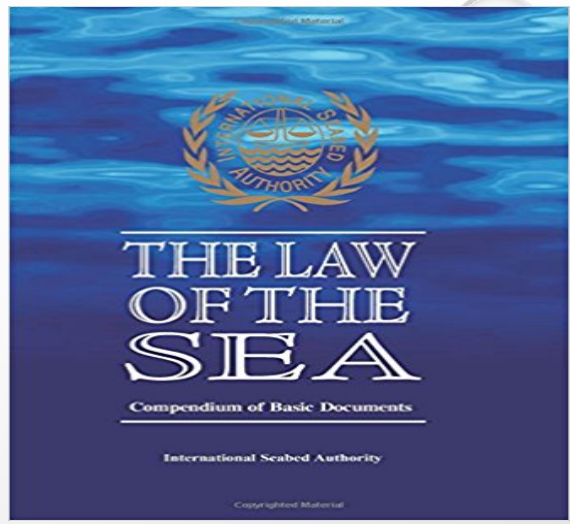
WHAT ARE SEABED MINERALS USED FOR?

- Cobalt is used for making super alloys .e.g. jet engines, alloys for prosthetics, batteries etc
- Copper is used in electrical wires (60%), roofing and plumbing (20%) and industrial machinery (15%). A small part of copper supply is used in production of compounds for nutritional supplements and fungicides in agriculture.

- Nickel is used in 46% for making nickel steels (stainless steel; 34% in nonferrous alloys and super alloys; 14% electroplating, and 6% into other uses such as magnets and various uses alloyed with other metals etc
- Vanadium is used for alloys with iron for making high strength steel, high speed tools, and surgical instruments.
- Titanium is used for making stainless steel, pigments, additives, coatings, aerospace and marine metals resistant to corrosion industrial, jewellery, architectural , medical, nuclear waste storage

- Manganese is essential to iron and steel production, - high tensile steel, aluminium alloys, unleaded gasoline, dry cell batteries
- Rare earth elements –are used in a range of high technology such as TV screens, mobile phones, super conductors, magnets, lasers, nuclear batteries and a host of new evolving technologies.

INTERNATIONAL SEABED AUTHORITY



- International organization established in 1994 to regulate mining and related activities in the international seabed beyond national jurisdiction, an area that includes most of the world's oceans.
- Came into existence upon the entry into force of the 1982 United Nations Convention on the Law of the Sea, which codified international law regarding territorial waters, sea-lanes, and ocean resources.
- Headquartered in Kingston, Jam., and has more than 150 state members.

- Its supreme authority is the assembly (all ISA members are represented). The assembly sets general policies, establishes budgets, and elects a 36-member council, which serves as the ISA's executive authority.
- The council approves contracts with private corporations and government entities for exploration and mining in specified areas of the international seabed, oversees implementation of the seabed provisions of the Convention on the Law of the Sea, and establishes provisional rules and procedures (subject to approval by the assembly) by which the ISA exercises its regulatory authority.
- The secretary-general of the ISA is nominated by the council and is elected by the assembly to a four-year term. The current sec-gen is Michael W Lodge

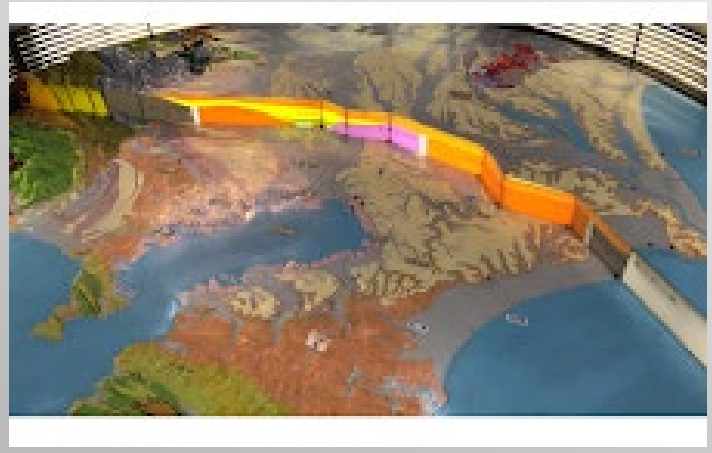
- In 2006 the ISA established the Endowment Fund to Support Collaborative Marine Scientific Research on the International Seabed Area to assist and encourage scientists from developing countries to contribute to world

JOGMEC'S CONTRACT AND SURVEY PLAN

Contract signed in January 2014 for a period of 15years

Stage and years	Exploration	Environmental survey	R&D
Stage 1 (2014-2018)	Preparation work		
	Ore reserve survey: rough resource evaluation by core sampling and acoustic survey;collection of data	Environmental baseline studies; collection of environmental data	Desk studies and pre-research and development of mining, ore dressing, and smelting technologies
Stage 2 (2019-2023)	Detailed evaluation of the blocks to select 1/3 of promising blocks	Environmental baseline studies	Research and development in mining, ore dressing and smelting technologies
Stage 3 (2024-2028)	Selection of the blocks to be developed from the 10 year selection of promising blocks	Environmental impact assessment	Verification of technologies for mining, dressing and smelting recovery, and economic evaluation

PRE-CRUISE



Geological map Kanto plain

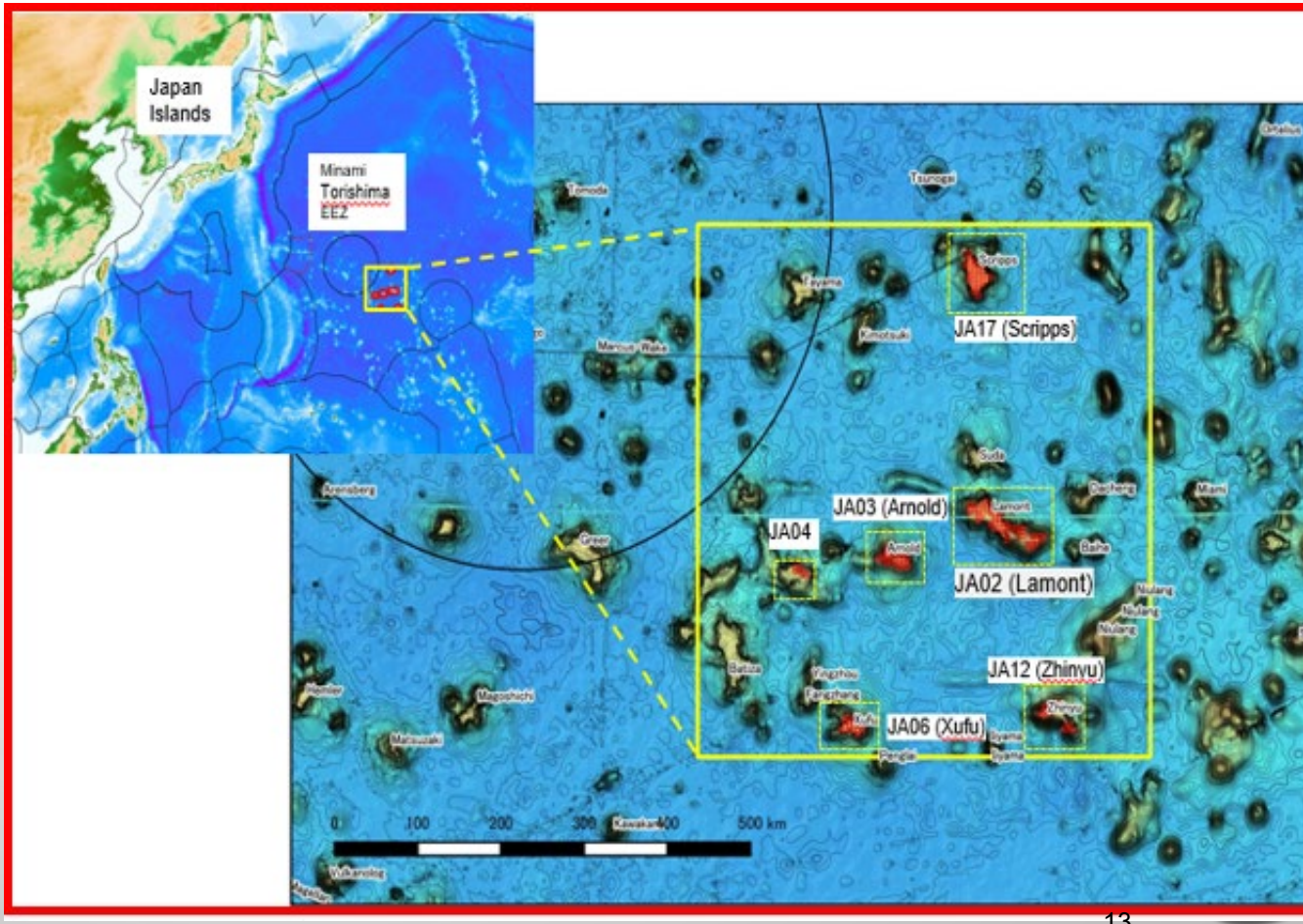
- Meet and greet trainees, JMEC and JOGMEC officials
- Series of lectures on seabed minerals
- Past and ongoing research
- Geological survey of Japan

AT- SEA

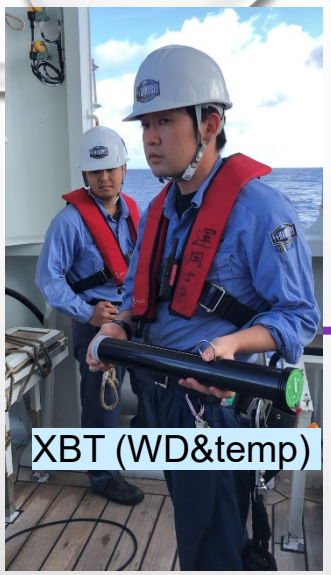

JMEC
Training Programme of Exploration for Cobalt-rich Ferromanganese Crusts, 2016
Hydrothermal Deposit → Volcanogenic Massive Sulfide Deposit → Kuroko Type Deposit
Japan Mining Engineering & Training Center

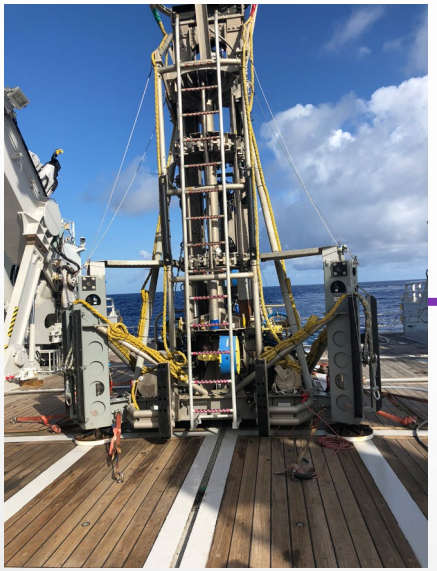
SITE MAP (MINAMI TORI SHIMA)

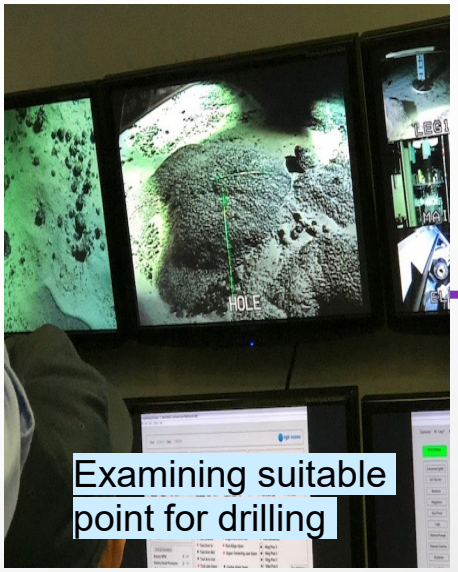
- North Pacific
- Lies about 1,850 km southeast of Tokyo.
- Quarternary limestone and coral. This island is coral reef
- announced to hold rare earth minerals deposits, estimated at 16 million tons at about a depth of 5,700 meters
- target areas were Lamont Guyot (JA02 seamount) and Xufu Guyot (JA06 seamount)



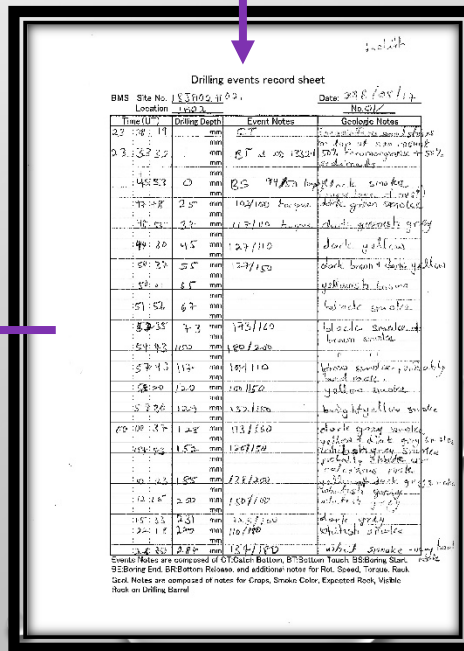
AT-SEA TRAINING


XBT (WD&temp)

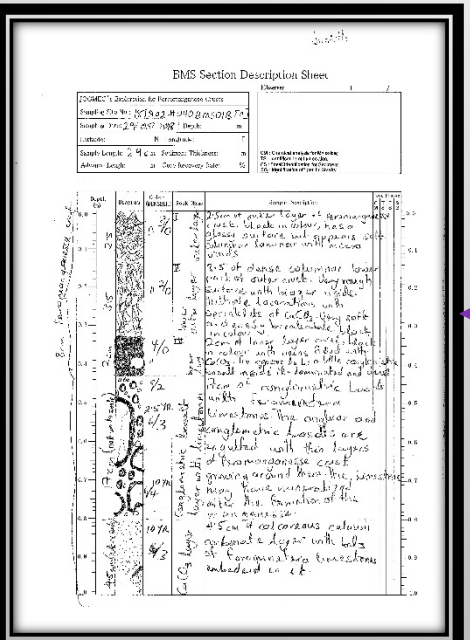




Examining suitable point for drilling

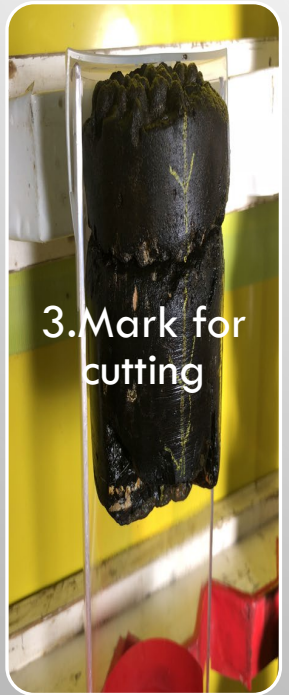

Drilling events record sheet

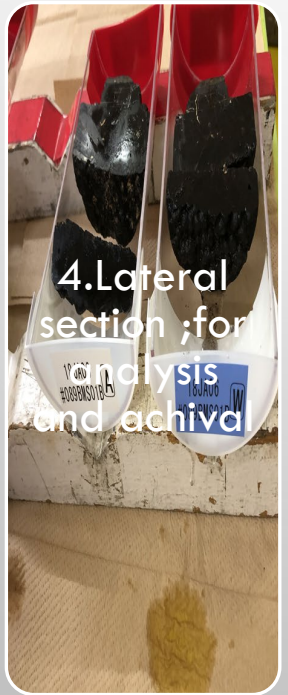

Sample retrieval

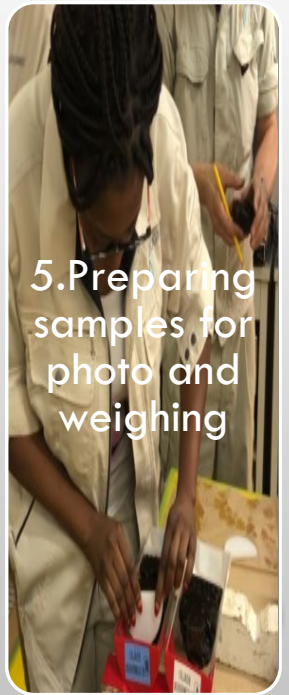

BMS Section Description Sheet


1.wash


2.weighed


3.Mark for cutting

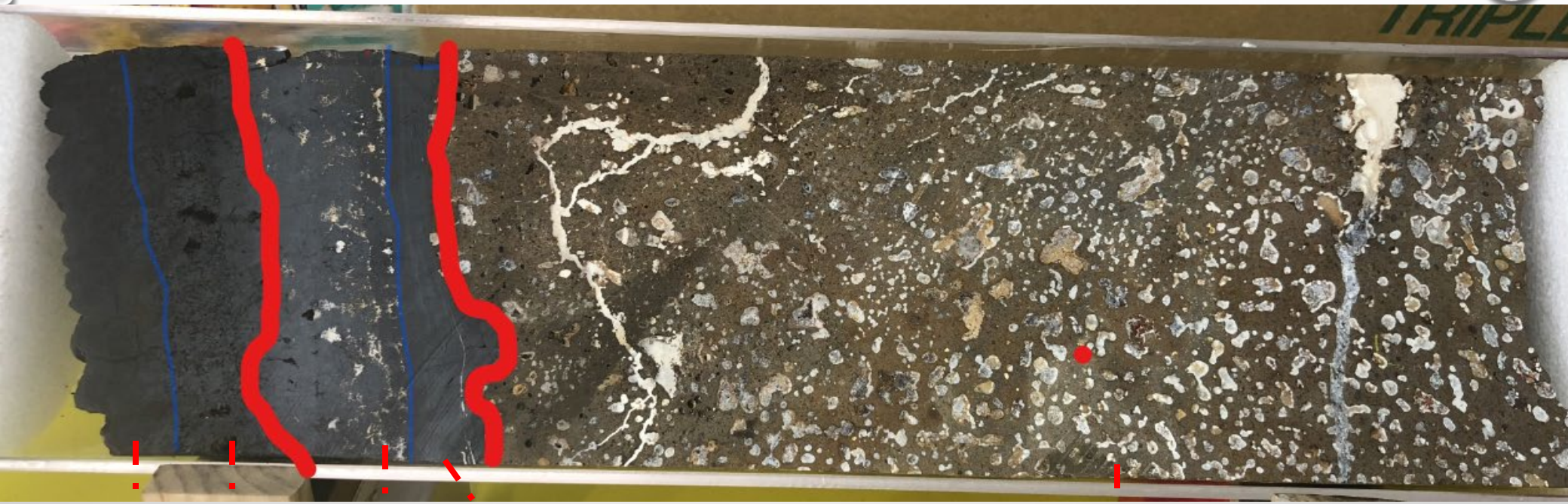

4.Lateral section ;for analysis and achival


5.Preparing samples for photo and weighing


6.


7.Cut samples are bagged and weighed

CORE DESCRIPTION



2cm Less dense uppermost layer of outer crust. Soft columnar laminar with brown veins

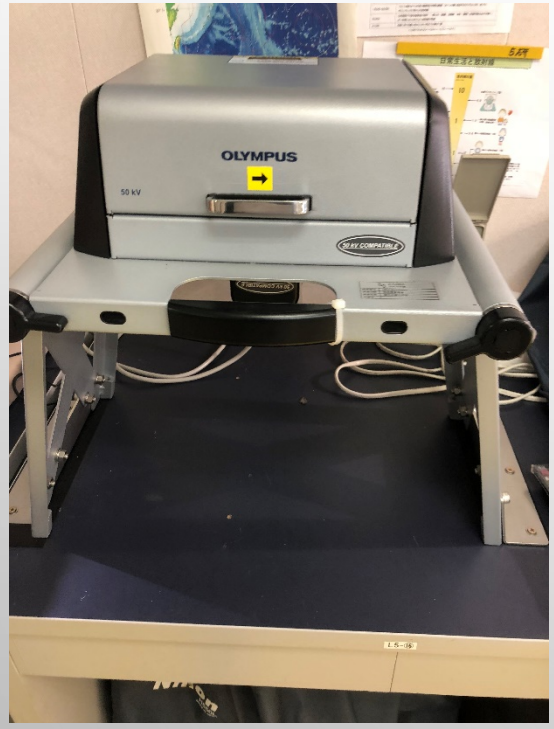
2cm Lower outer crust with microvoids, bigger voids ,rough layer, columnar with more veins

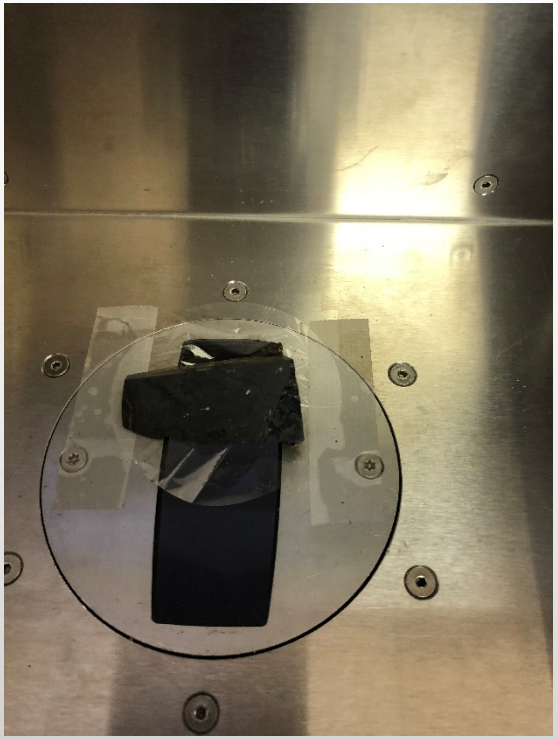
3.5cm Upper most inner layer. Black loose phosphatised laminar with limestones filling the voids

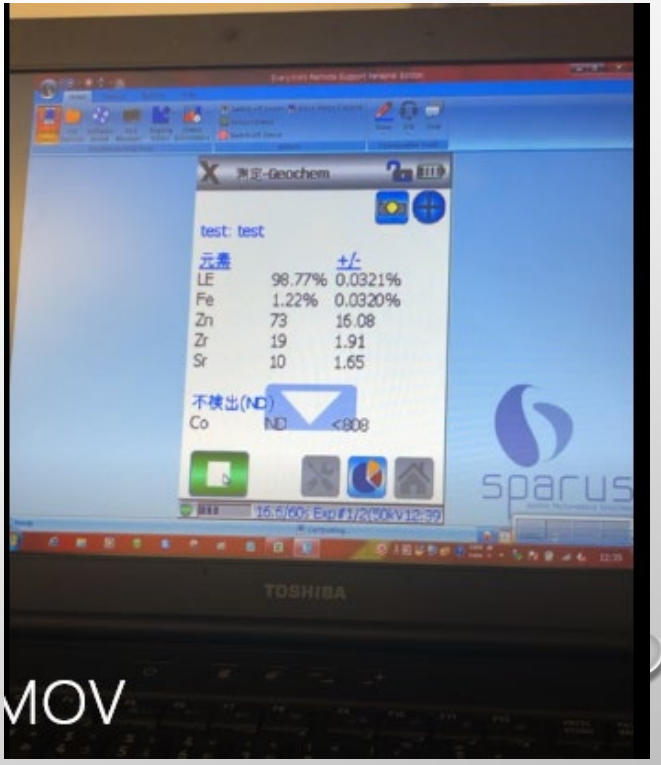
1.5cm Finely laminated black very smooth bacterial mat layer. Firm and glossy surface

23cm of amygdaloidal basalt layer. Fine grained rock comprising of dark and white minerals. irregular bubbles filled $CaCO_3$ and mineralized $CaCO_3$ or calcite. Lacerations filled with foramineferra limestones at the top and bottom

XRF GEOCHEM


OLYMPUS
50 kV




測定-Geochem
test: test
元素 ±/-
LE 98.77% 0.0321%
Fe 1.22% 0.0320%
Zn 73 16.08
Zr 19 1.91
Sr 10 1.65
不検出(ND)
Co ND <808
sparus
TOSHIBA
MOV

OBSERVATIONS

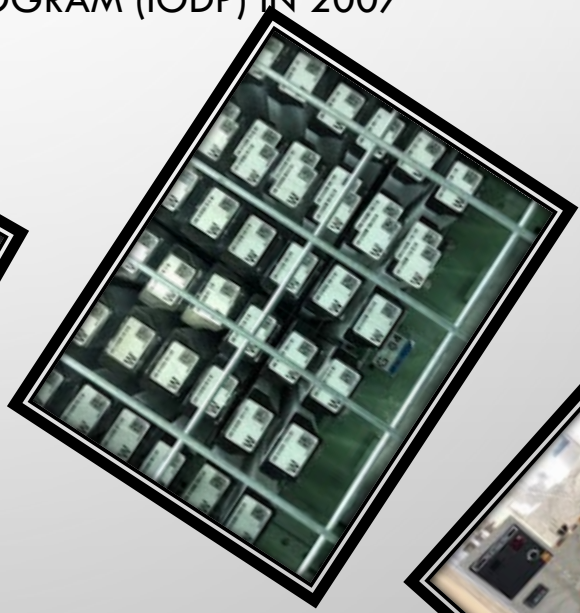
Crusts occur on a wide-variety of substrate rocks, which makes it difficult to distinguish the crusts from the substrate using remotely sensed data, such as geophysical measurements hence geochemical methods must be deployed

AT THE END OF THE SURVEY

- 32 days of cruise
- 21 days of actual drilling
- 60 holes drilled
- 38 at "JA02 seamount (lamont guyot)"
- 22 at "JA06 seamount (xufu guyot)"
- Recovery rates at 87.3% and 70.6% (ave. 81.6%)
- 2 expendable bathy themograph (XBT) surveys
- 1 CTD

KOCHI CORE CENTER

- LOCATED IN MONOBE CAMPUS OF THE KOCHI UNIVERSITY
- JOINTLY MANAGED BY THE KOCHI UNIVERSITY AND JAPAN AGENCY FOR MARINE-EARTH SCIENCE AND TECHNOLOGY (FROM 2004)
- FULL-SCALE ACTIVITIES AS CORE CURATION FACILITY, ONE OF THE WORLD'S THREE MAJOR CORE REPOSITORIES IN INTEGRATED OCEAN DRILLING PROGRAM (IODP) IN 2007



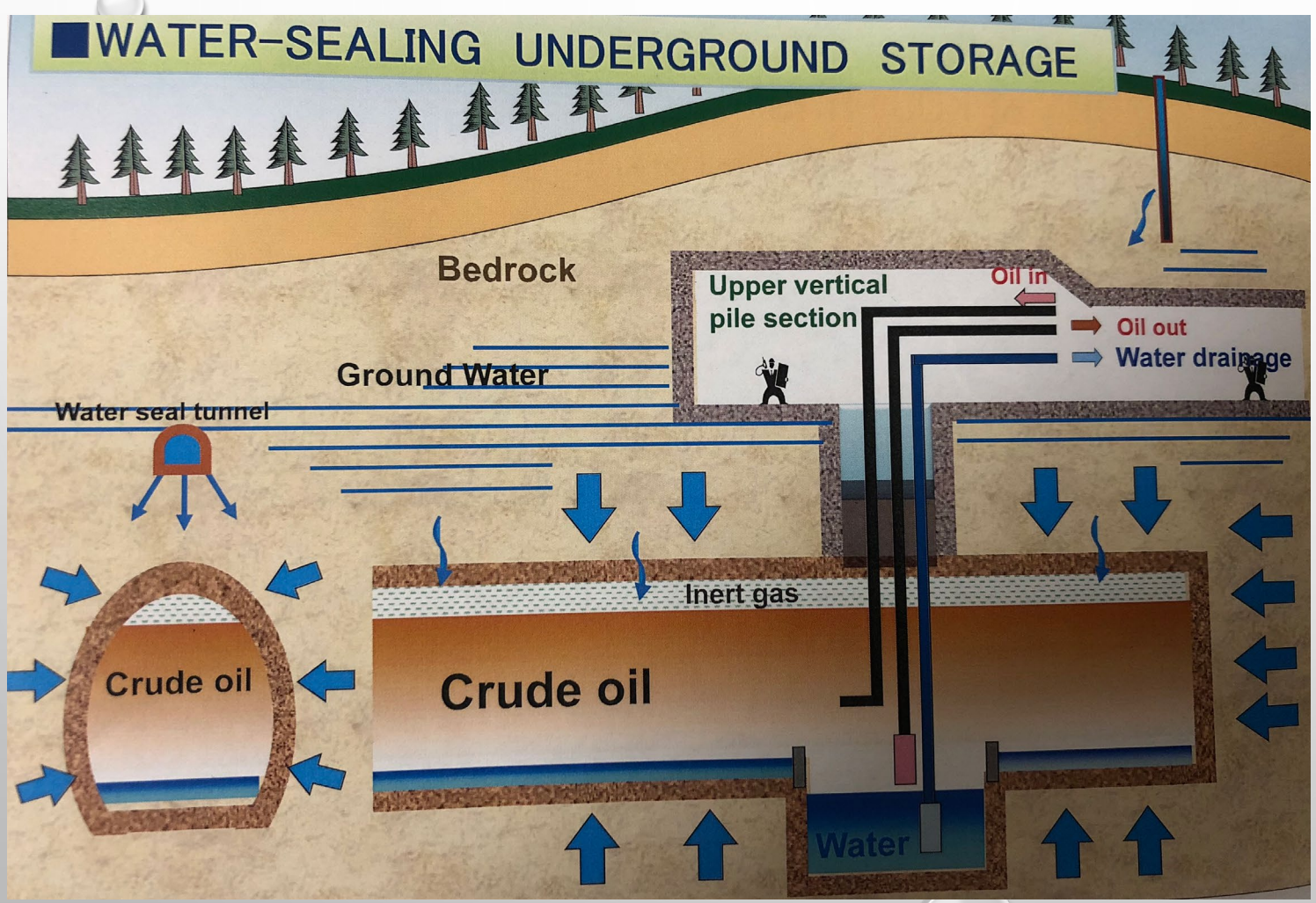
Center for Advanced Marine Core Research

Kochi Institute for Core Sample Research

- Geochronological group
  - *Geomagnetic chronology*
  - *Isotopic chronology*
- Global Environmental Research Group
  - *Micropaleontogy*
  - *Inorganic and organic geochemistry*
  - *Marine Resources*
  - *Core analysis*

- Physical Property research group
  - *Continuous measurements of physical properties (Fault, earthquakes and Tsunami)*
- Geochemical Research Group
  - *High precision isotopic geochem*
  - *Sedimentology (diagenesis)*
- Geomicrobiology
  - *Life in biosphere and limit of life*

KUJU STOCKPILLING BASE



- Storing petroleum in canverns drilled in bedrock
- Lower risk of spills and diffusion
- Less vulnerable to earthquakes and other natural disasters
- Land required limited to that needed for actual facility

ACHIEVEMENTS/CONCLUSION

- Knowledge about the seabed minerals; Seafloor Massive Sulphides (SMS), Polymetallic Nodules/Manganese Nodules and Cobalt-rich Crusts (CRC).
- skill of research planning and execution was greatly improved
- exposure and interaction with JOGMEC, JAMSTEC and Kochi Core centre presented new ideas on how and where to approach research and how to mechanically execute it successfully.
- Their origin and distribution across the globe and the need to explored and exploited

RECOMMENDATIONS

- The duration of the program should be extended because there was so much to do with very limited time
- trainees should be made to observe the advanced geochemical (ore grade and specific gravity) analysis which are carried out after the cruise to complete the learning cycle