# Magnetostratigraphic Analysis of ferromanganese deposits

Muhammad Bin Hassan  Prof. Dr. Luigi Jovane
muhammadbinhassan@usp.br  jovane@usp.br

## Introduction

Ferromanganese deposits (nodules / crusts) are iron-oxyhydroxides and manganese oxides. These are chemical precipitates on the seafloor that grow over periods of tens of millions of years. Their secular records of chemical, mineralogical, and textural variations are archives of deep sea environmental changes. However environmental reconstruction requires reliable high-resolution age dating.

Ultrafine-scale magnetostratigraphy utilizing SQUID microscopy is a new chronological tool for estimating ages and growth rates for ferromanganese deposits. It provides chronological constraints with the accuracy promised by the astronomically calibrated magnetostratigraphic time scale.

## Objectives

- To determine the suitability of ferromanganese deposits for magnetostratigraphy;
- To date the Fe-Mn deposits utilizing magnetostratigraphic techniques;
- To reconstruct paleoenvironment, based on the dated Fe-Mn deposits;
- To compare results from Rio Grande Rise and Tropic seamount.

## Study Area

- Tropic seamount is located in the north-east Tropical Atlantic (23.5° N, 20.4° W, Fig. 3) which is 650 km southwest of Canary Islands, Tropic Seamount has an area of about 770 km². Samples have already been collected using Remotely Operated Vehicle (ROV).
- Rio Grande Rise is located in the south-west Atlantic (31.0°S, 35.0 °W, Fig. 3). Samples will be collected using ROV in September-October 2018. ROV provides a nice spatial resolution in terms of sample location and water depth.

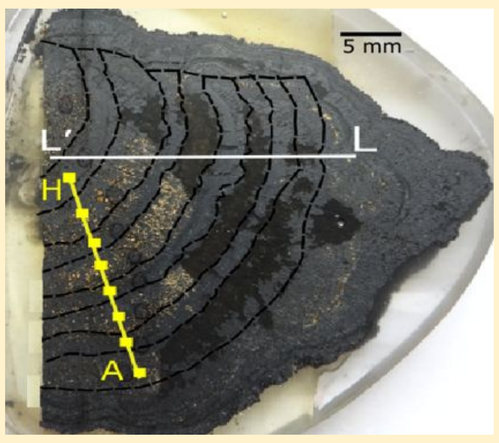


Fig. 1: Fe-Mn nodule sample. The line L-L´ shows geochemical measurements while the line A-H shows magnetic measurements.

## Hypothesis

It is hypothesized that ultrafine scale magnetostraigraphy of ferromangeanese deposits provides reliable high resolution age dating, consequently giving a better understanding of the paleoenvironmental conditions involved in the formation and growth of these deposits (Fig. 2).

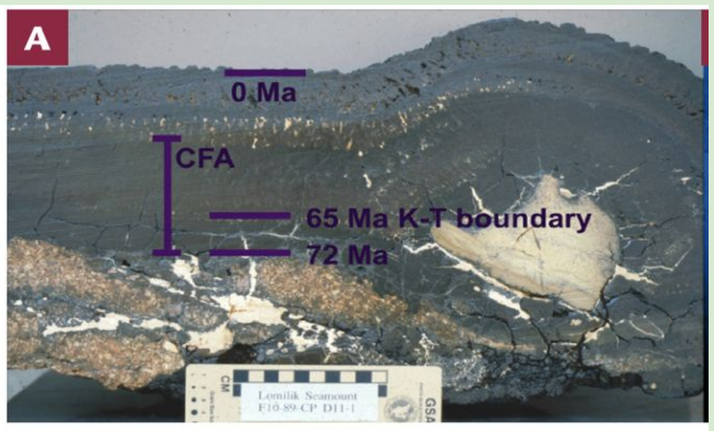


Fig. 2: CFA= Carbonate Fluorapatite, (Source, Koschinsky and Hein, 2017)


Fig. 3: Location of Rio Grade Rise & Tropic Seamount

## Materials and Methods

Samples are delicate and fragile, it is intended to fix them with epoxy resin. The samples will be cut per required experiment.

Scanning SQUID microscopy will be the fundamental method to characterize distinctive magnetic parameters, *e.g.,* Natural Remanent Magnetization (NRM)

Other rock magnetic and paleomagnetic measurements such as, Hysterisis parameters, calculation of First Order Reversal Curves (FORCs), Isothermal Remanent Magnetization (IRM) and Anhysteric Remanent Magnetization (ARM) etc., will be applied on the samples using Alternating Gradient Magnetometer (AGM) or Vibrating Sample Magnetometer (VSM).

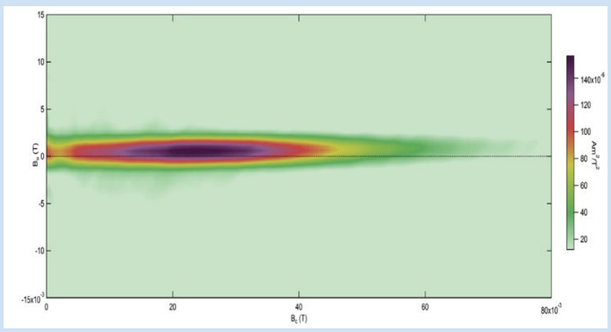

Fig. 4: FORC of one of the sub-samples "D"

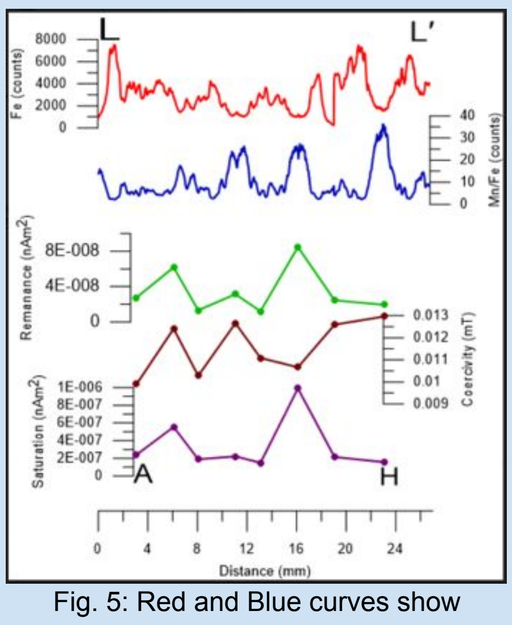


Fig. 5: Red and Blue curves show geochemical results while green, brown and purple curves show rock magnetic measurements.

## Preliminary Results

A ferromanganese nodule sample from Clarion-Clipperton Zone was collected by Agassiz Trawl method at water depth 4130m. (Fig. 1)

It was realized that the sample had a variety of elements including Ni, Co, Cu, Ti, REY and the distinctive Iron rich layers corresponded to porous part, while Manganese rich layers corresponded to consolidated part of the sample (Fig. 1&5).
The geochemical studies (μ-XRF analysis) was performed at Laboratório Nacional de Luz Síncrotron (LNLS), (Benites et al., 2018; submitted).

FORCs of 8 sub-samples (Fig. 4) revealed the presence of non-interacting single domain magnetic particles with the coercivity ranges between 4 mT to 50 mT.
Magnetic measurements were performed at Centro Oceanográfico de Registros Oceanográficos (CORE) IOUSP by using Alternating gradient Magnetometer. (Fig. 4&5)

## Acknowledgement

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Website; Lab CORE

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