EARTHSCIENCES

Lunar magnetism, moonquakes and mantle overturn

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Key words:	Moon, seismology, petrology, planetary science, core dynamo, paleomagnetism
Research theme(s):	• Geophysics and Geodynamics • Planetary Evolution and Materials
Eligible courses for this project:	• DPhil in Earth Sciences • Environmental Research (NERC DTP) • Intelligent Earth (UKRI CDT)

Overview

The Moon is enigmatic with a highly debated paleomagnetic record from Apollo samples[1–4], and unusual seismic signatures from moonquakes[5]. This project will look at the influence of melts within the lunar interior and their role in driving both of these processes. Dense, ilmenite-rich cumulates that crystallized at the top of the lunar magma ocean are gravitationally unstable drove mantle overturn, leading to a mush layer above the core-mantle boundary[6,7]. It has recently been proposed that such a layer could drive short-lived, intense magnetic fields[8].

This project will look at existing petrological, seismological and paleomagnetic observations from the Apollo missions, to better-characterize signatures associated with mantle overturn and the fate of ilmenite-rich cumulates. We will apply for a suite of Apollo samples from NASA for petrological and paleomagnetic analyses to test current hypotheses regarding the mechanism driving the lunar dynamo during the first 2 billion years of the Moon's geological history.

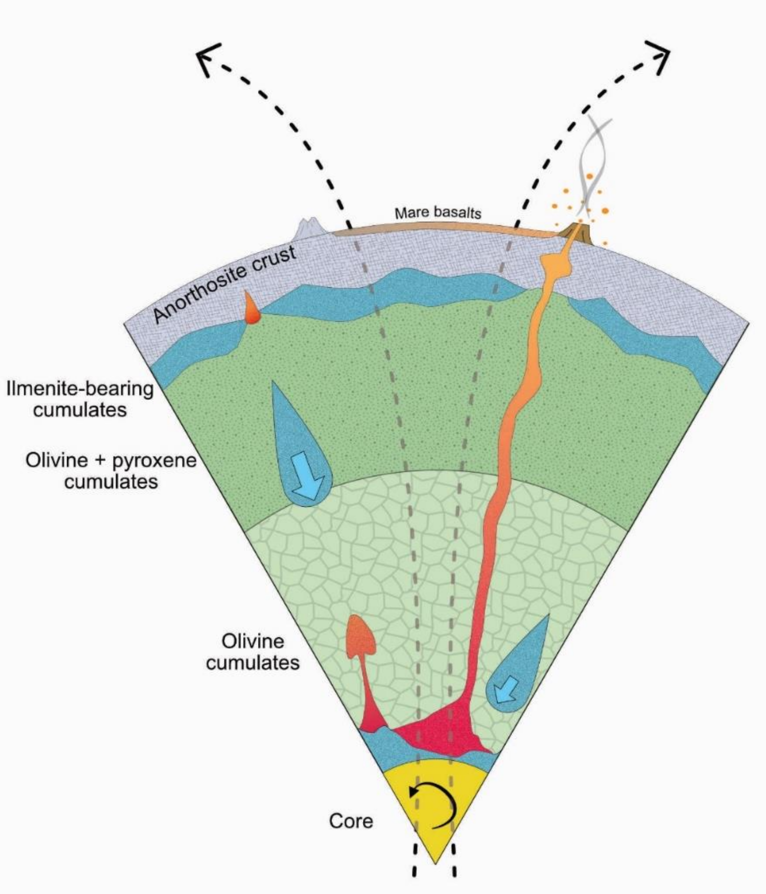

Figure showing a possible mechanism linking lunar mantle overturn driven by the sinking of ilmenite-bearing cumulates, generation of an intense lunar dynamo, and the eruption of high-Ti mare basalts.

Methodology

The project will involve collating existing data sets, and determining the temporal history of the Moon within statistical uncertainty. The student will become familiar with interpreting seismological, paleomagnetic and petrological data and the appropriate statistical treatment of such datasets. Once Apollo samples are acquired, the student will learn how to carry out a range of paleomagnetic experiments in the Oxford Magnetism Group laboratory, and will also have the opportunity to collect geochemical and petrological data and undertake phase equilibrium modelling.

Timeline

Year 1: Data interpretation, collation, coding and statistical analyses. The student will also receive training on how to make scientific figures, good data management practices, and will have the opportunity to present research findings at national-level conferences.

Years 2 and 3: The student will write a proposal for NASA based on their initial findings to request a suite of Apollo samples for further analyses. The student will receive training in paleomagnetic techniques, petrological analyses and phase equilibrium modelling. The student will have the opportunity to present their results at international conferences such as LPSC and the AGU fall meeting and will be encouraged to submit a first-author manuscript for publication.

Year 4: New results will be placed in context of existing datasets to draw conclusions regarding the role of mantle overturn in governing the geophysical and geodynamic behaviour of the Moon. Support will be given for thesis-writing, submission of additional manuscripts, networking at international conferences, and future career development.

Training & Skills

- Paleomagnetic analysis using a superconducting rock magnetometer, paleomagnetic furnaces and AF demagnetizer
- Petrographic analysis and electron microscopy
- Quantum diamond microscopy image acquisition and data analysis
- Seismic data interpretation
- Scientific reading, writing and presentation skills
- Python coding and programming skills

References & Further Reading

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Further Information

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