Pallasite Paleomagnetism: A Quest for Quiescence of the Core Dynamo

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Overview

Introduction:
• Pallasites as paleomagnetic recorders

Motivation:
• Evidence for a two phase dynamo life

Results:
• Records of a quiescent period?

Interpretations:
• What have we learnt about core dynamo dynamics?

Further Work and Conclusions
The Pallasites

Introduction

Results

Interpretations

Conclusions

Motivation
FeNi Metallic Microstructures

- Clear Zone
- Cloudy Zone
- Tetraenite Rim
- Kamacite
- Widmanstätten Breakdown
- Plessite

Reflected Light Microscope Image
The Cloudy Zone

X-PEEM Image

Kamacite  Tetrataenite Rim  Cloudy Zone

Bright: Ni rich  Dark: Fe rich

Islands: 50% Ni, 50% Fe
Matrix: 25% Ni, 75% Fe
How cloudy zone forms and hence how it gives a time resolved record.

Cloudy Zone Formation

Bryson et al, EPSL (2014)
X-PEEM and XMCD

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Motivation
A Two-Phase Dynamo?

Long-lived magnetism from solidification-driven convection on the pallasite parent body

James F. J. Bryson, Claire I. O. Nichols, Julia Herrero-Albillos, Florian Kronast, Takeshi Kasama, Hossein Alimadadi, Gerrit van der Laan, Francis Nimmo & Richard J. Harrison

Introduction

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Motivation
A Quest for Quiescence

MARJALAHTI
Islands: 118 nm
Cooling rate: 7.5 K/Myr
(Yang et al, 2010)

BRENHAM
123 nm
6.6 K/Myr

IMILAC
143 nm
4.3 K/Myr

ESQUEL
157 nm
3.3 K/Myr

Time
Cooling rate

200km

Introduction
Motivation
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A Period of Quiescence

**BRENHAM**

- CZ 1
- CZ 2
- CZ 3
- CZ 4

**MARJALAHTI**

- CZ 1
- CZ 2
- CZ 3
- CZ 4
- CZ 5

**IMILAC**

- Region 1
- Region 2
- Region 3
- Region 4

**ESQUEL**

- Region 1
- Region 2
- Region 3
- Region 4
- Region 5
- Region 6
A Period of Quiescence
Core Dynamo Dynamics

Field Intensity (μT)

Quiescent

Compositional Convection

Time (non-linear)
Why is there still a small field?

A remanent field left behind from the initial thermally driven dynamo?
A Look at Other Mechanisms

Mechanical Stirring?

Dywer et al, Nature (2011)
Further Work

Core Dynamo Modelling

Studying more pallasites and other types of meteorite

Geochemistry of pallasites

Introduction ● ● ● ● ● Motivation ● ● Results ● ● ● ● ● Interpretations ● ● ● Conclusions ● ● ●
Further Work

Conclusions

• A low intensity magnetic field is present for some time between a thermally-driven core dynamo and a dynamo driven by core solidification.

• Core dynamo excitation may be driven by several different mechanisms during the dynamo’s lifetime.

• The relationship between composition and magnetisation of FeNi microstructures may allow us to measure more complete time resolved records.
Thank You For Listening
Correlating magnetisation and Ni content

![Graph showing Ni content vs. Magnetic Intensity](image)

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Frequency distribution:

- Matrix
- Cloudy Zone

**Introduction**

**Results**

**Interpretations**

**Conclusions**