Deformation processes on parent bodies and what this means for fluids.

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Deformation Introduction

Mineral deformation

Fabrics and lineations

Deformation mechanisms

Controls on volatiles fluids

What are the large-scale implications?
1) Deformation Introduction
Key Principles

Stress: Force per unit area, acting on the rock.

Strain: The resultant deformation in the rock caused by stress.
1) **Uses ellipses (or ellipsoids) to quantify the amount of strain. More specifically the ratio between the major and minor axis.**

2) **Assumes no volume loss has taken place.**

3) **Understands the kinematics not the dynamics.**
Rheology

Bri,le

Deformation

Ductile

Deformation

Shortening

Extension

✓
Rheology

Deformation

Ductility

Shortening

Extension

✓

✗
2) Evidence For Deformation: Microstructures
Impact Shock $\sim 20$ GPa
Evidence for Deformation

Impact Shock ~ 20 GPa
3) Evidence For Deformation:

Fabrics and Lineations
Foliation:
  Penetrative planar fabric, in the rock.

Lineation:
  Penetrative linear fabric, in the rock.
CAI orientations from CT scans

3D Surface of CT CAI

Dip: 17.56° W ± 4.81°

Strike: 030°-040°

Rose Diagram
1) This is a point-to-point technique for determining whole rock deformation in anti-clustered rocks such as sandstones and conglomerates (Fry, 1979).

2) Can be used to tell the deformation in the matrix.

3) Choose chondrules as their initial aspect ratio is known.

4) Results were: Strike = 038°, with uniaxial shortening = 20%.
1) This is a technique that measures the strain of a sample in 3D by graphing the strain axis of an ellipsoid X/Y and Y/Z. (Flinn, 1962)

2) The term “k” describes the shape of the deformation. \( k < 1 = \text{Oblate or “pancake”} \). \( k > 1 = \text{Prolate or “Cigar” shaped} \). Result: \( k = 0.27 \)

3) As CAIs were probably not spherical to begin with this would represent a MAXIMUM shortening value.

4) Squashed in one direction: 49%
• Long axis orientations extracted from CT imagery were plotted on a stereonet plot. This showed a mean lineation trend of $214.07^\circ$ and a plunge of $3.44^\circ$. The back angle of the lineation is $34^\circ$, which is consistent with the foliation.
4) Deformation Mechanisms
What is the cause of this fabric?

Overburden Generated
(Cain et al., 1986)

Impact Generated
(Sneyed et al., 1988)
What is the cause of this fabric?

Overburden Generated (Cain et al., 1986)

Impact Generated (Sneyed et al., 1988)
a) Centrifugal Deformation

\[ \sigma_3 < \sigma_2 < \sigma_1 \]
1) Lineations point out from the pole like spokes on a wheel.

2) Would drive fluids away from the poles.

3) For 20% uniaxial compression on a 100km body would required a period of 40 minutes to 2 hours!
1) Lineation due to central uplift.

2) Lineations could be a proto-shatter cone.

3) Forms lineations as the basin relaxes after an impact.
5) Controls on Volatile Fluids.
1) Shock stage correlates to decreased porosity in CV3s

2) Low pore space hampers hydroconductivity.

(Gattacceca et al., 2005)
CV Parent Body

Oxidized:

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Magnetite, metamorphism of CAIs, fayalite rims on olivine.

Reduced:

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Magnetite, low metamorphism, phyllosilicates
The End.