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SPACE ADVANCED RESEARCH TEAM

2010 European Planetary Science Congress

Kinematic Impacts – Improved Modeling of Asteroid Deflection
Experimental and Numerical Approach

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MOTIVATION

Aims to model the kinematic impact asteroid deflection scenario….long-term impact evolution of the solar system

Limited by:

- Kinematic impacts that occur at the Centre of Mass of the asteroid

- Characterisation of the asteroid (analogue) physical/material characteristics

- Assumptions regarding the ejecta distribution and profile

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MODELLING – APPROACH

Developing a model to account for:

- Impacts onto non-spherical, initially rotating bodies

- Occur from a given proximity to the CoM

- Variation in impact geometry

- Variation in asteroidal composition (Athen, Apollo etc)

Provide a realistic and improved deflection and cratering response of (kinematic) impacting events

Support this development, wished to provide validation data through experimental cratering events

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EXPERIMENT - APPROACH

ESA Education Office – 2010 Spin Your Thesis! Campaign

8 m Large Diameter Centrifuge, with a payload capability of 80 kg

Intended to:

- Reproduce and investigate impact cratering events onto porous asteroid analogue bodies

- Provide cratering response data – validation and advancement of numerical models

Assess projectile density and target material (asteroid analogue) porosity as a function of crater formation and ejecta distribution

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SIMILARITY ANALYSIS

Crater's volume can be expressed as:

$Projectile's:$

$a = Radius$

$\delta = Density$

$U = Velocity$

$g = Gravity$

$$V = f\left[a, U, \delta, \rho, Y, g, n...\right]$$

Standard tools of dimensional analysis:

$$\frac{\rho V}{m} = f\left[\frac{ga}{U^2}, \frac{Y}{\rho U^2}, \frac{\rho}{\delta}, n, \pi_M\right]$$

$Target\ Material$

$\rho = Density$

$Y = Strength$

$n = Porosity$

Further reduced to:

$$\left[\frac{ga}{U^2}\right]$$

$$\frac{(g_C)(a_C)}{U_C^2} = \frac{(g_A)(a_A)}{U_A^2}$$

$$a_A = a_C\left(\frac{g_C}{g_A}\right)\left[\left(\frac{U_A}{U_C}\right)^2\right]$$
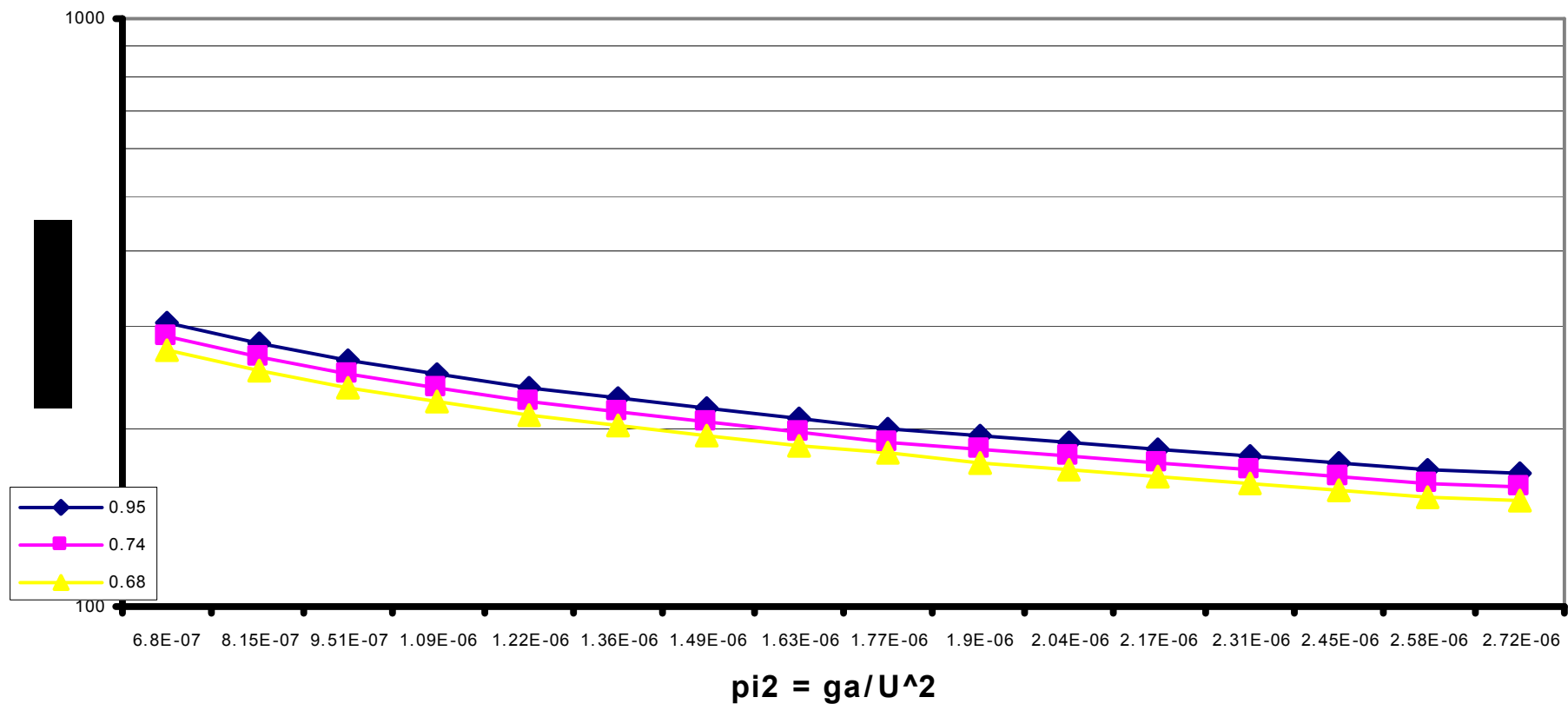
'Gravity regime' dominates the cratering process

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SIMILARITY ANALYSIS

Increasing role of gravity

pi2 = ga/U^2

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EXPERIMENT

Target material - mixture of quartz sand and expanded perlite

Table 2: Target Material Mixture

| Mixture (Percentage by Mass)			(Similar, but not identical to Housen & Holsapple 2002)	
Expanded Perlite	Quartz Sand	Water	Average Density (g/cm^3)	Average Porosity (%)
100	0	0	0.103	96
21	27	52	0.443	74
11	59	30	0.668	68

EXPERIMENT

For each sample, impact events occurred at increasing levels
of acceleration

- Recorded each impact onto high speed cameras

- Measured the crater diameter, shape, cross-section depth

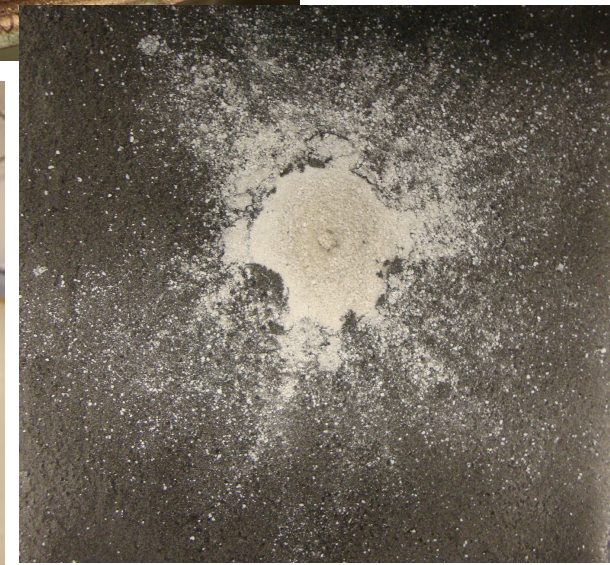- Preserved selected samples through application of a epoxy resin
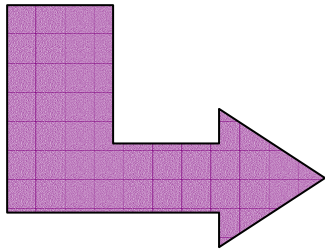
Enable later topographical scans

Analysis of possible microscopic compaction as a
function of distance via a SEM

OBSERVED TRENDS

- With very high porosity samples (96 %), under increasing acceleration:

  - More ejecta remained within the crater bowl.

  - Noticeable & increasing central peak

  - Crater becomes smaller, with some irregular impact craters.
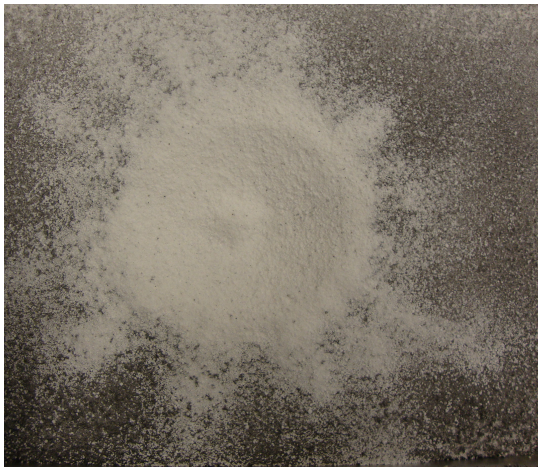
OBSERVED TRENDS

- At high porosity (approx 70 %) sample, under increasing acceleration:

    - Crater becomes slightly wider, with an decreasing depth.

    - Much less ejecta escapes the crater rim.

- At mid porosity (approx 60 %) under increasing acceleration:

    - Crater shape is far more coincident between tests

    - Decreasing crater size, with less ejecta

CLOSING REMARKS & FUTURE WORK

- Ongoing analysis will provide data for the advancement and validation of numerical code

  - Include detailed material characterisation of the asteroid-analogue target material and cratering response

  - Analysis is ongoing – data was collected last week!

- 2010 Spin Your Thesis! Campaign provided a solid foundation, and prove of concept for the experimental design

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Thank you for your Time

ANY QUESTIONS?

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