Using Asteroid Collisions to Search for Buried Ice

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Water in Asteroids and Meteorites Workshop

Observatoire de Paris
29 September 2011

Why ice? Where is the ice?

The main-belt comets

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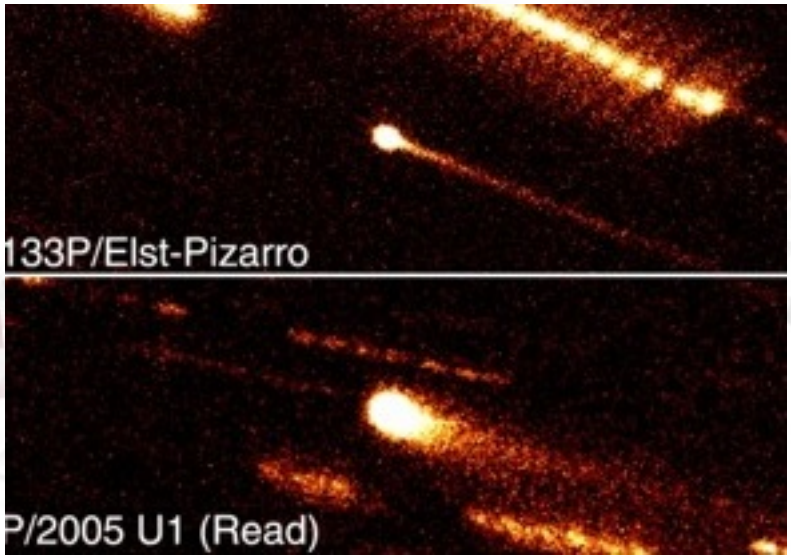
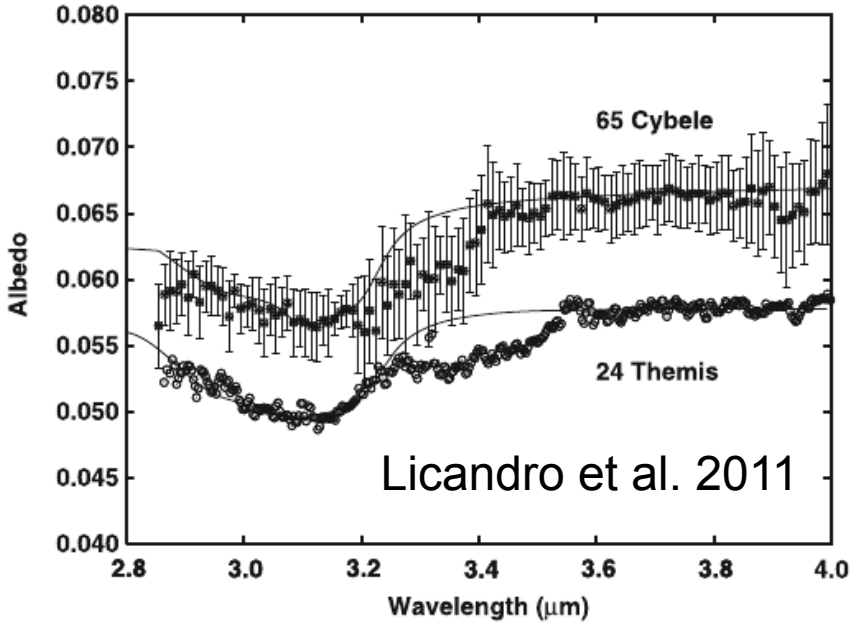
3 μm absorption features

Ice can survive in the outer-main belt



Hsieh & Jewitt 2006



A fine frost covers much of Themis and Cybele

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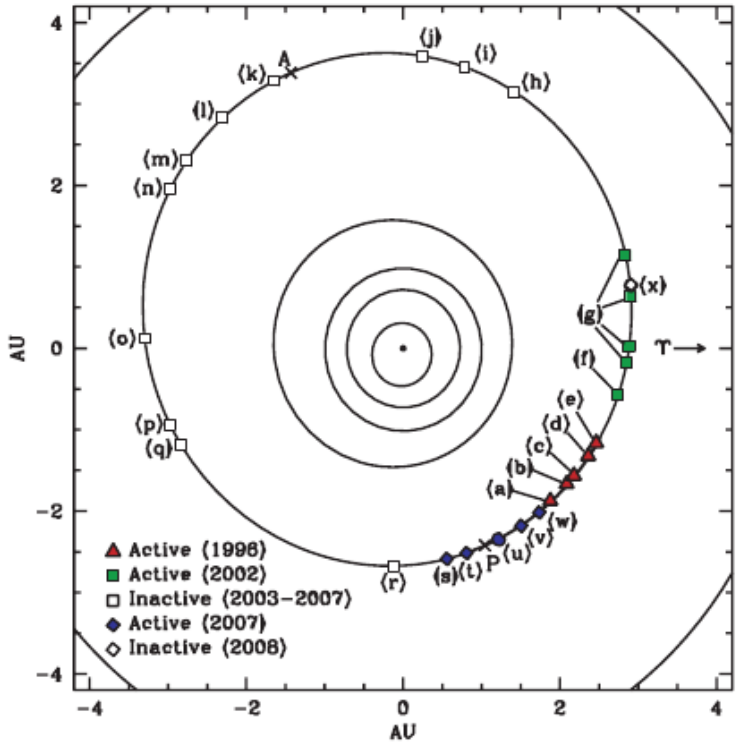
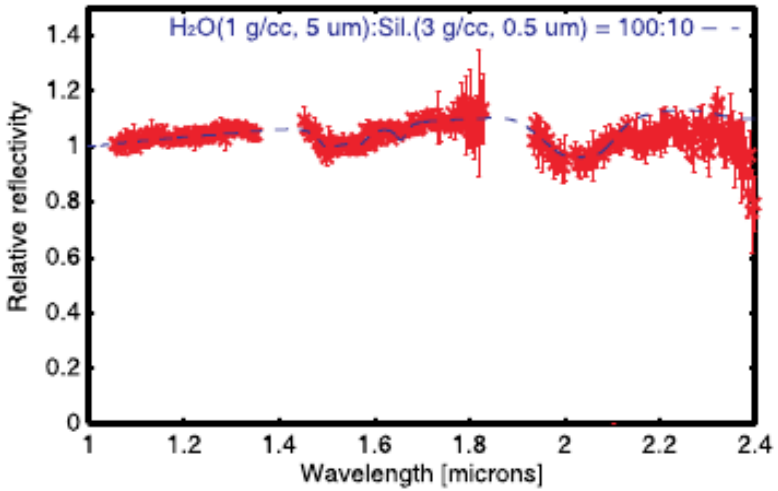
Seasonal activity of 133P/Elst-Pizarro and 238P/Read

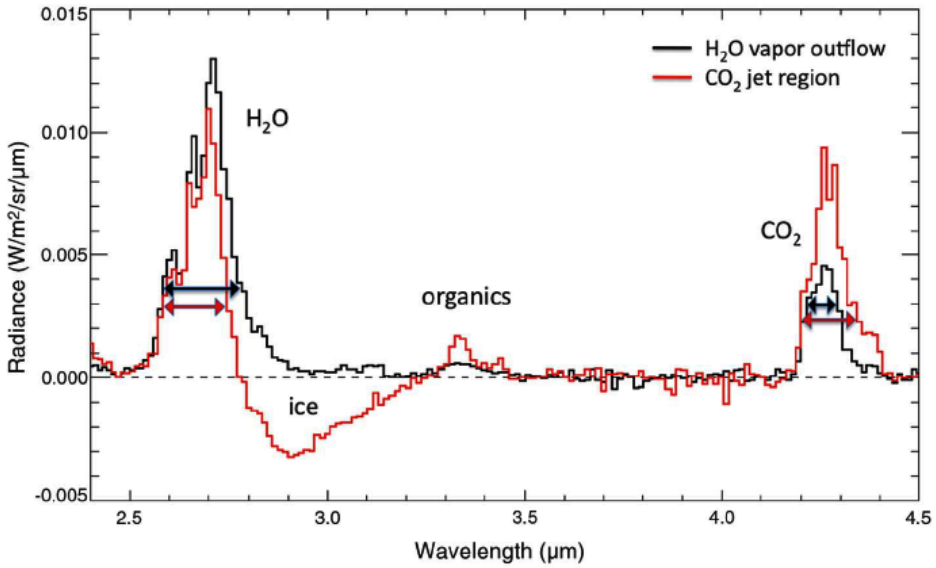
Buried ice, but not at a uniform depth

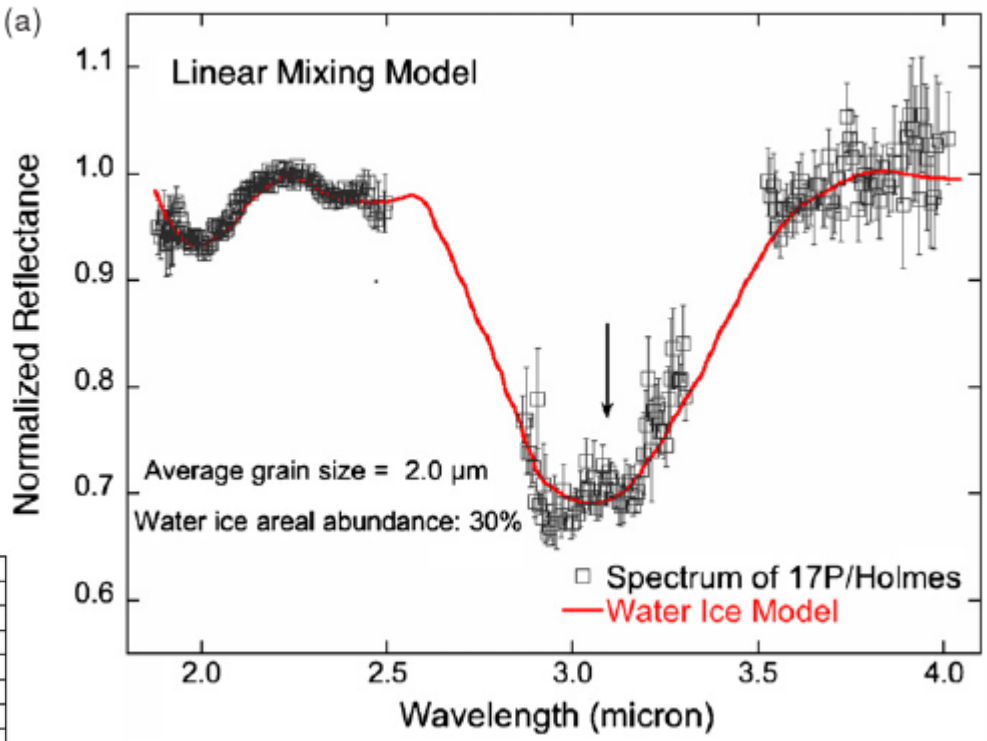


Hsieh et al. 2011

The ice on and in comets

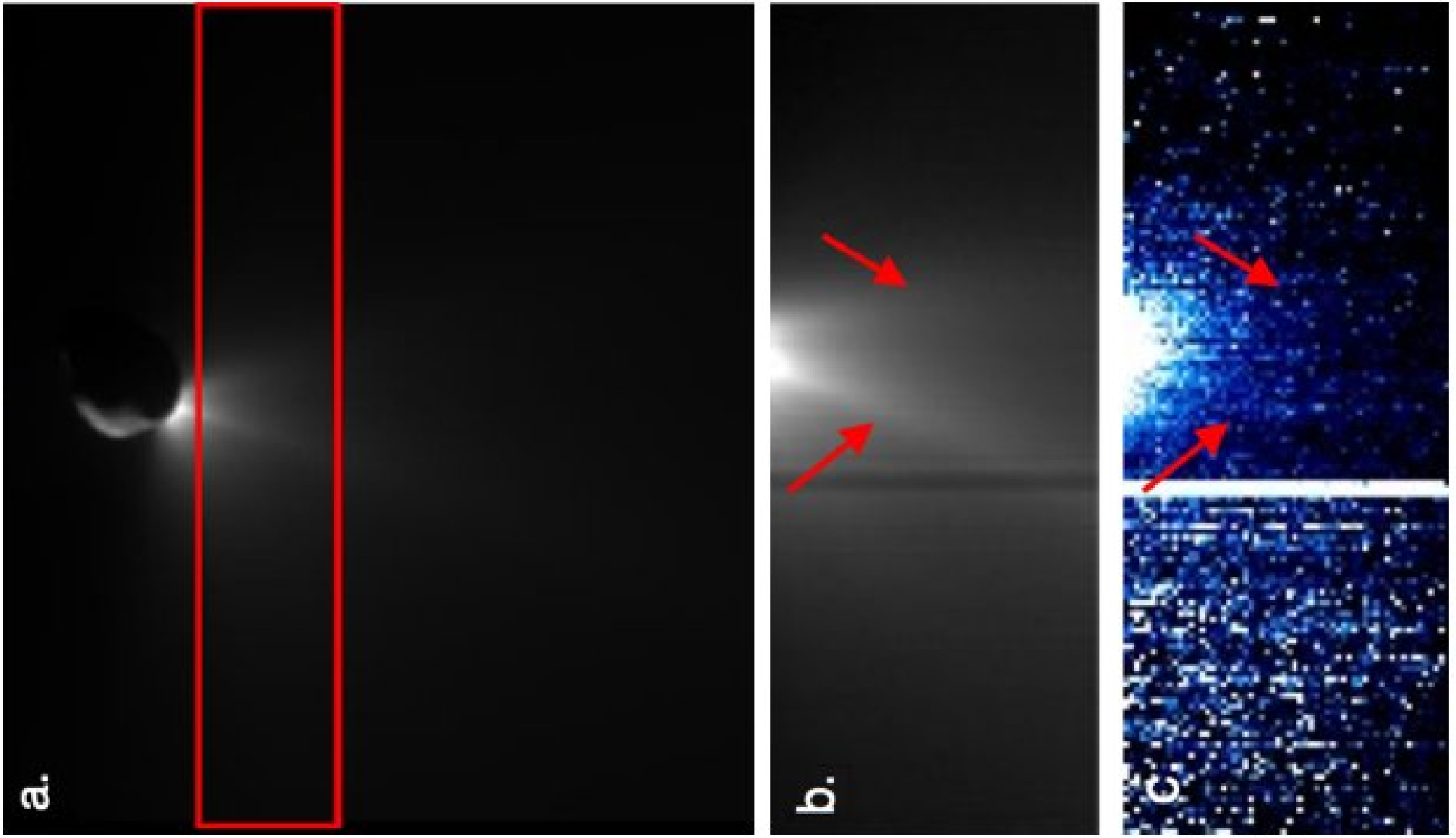






Kawakita et al. 2004 Yang et al. 2009

A'Hearn et al. 2011



Sunshine et al. 2007

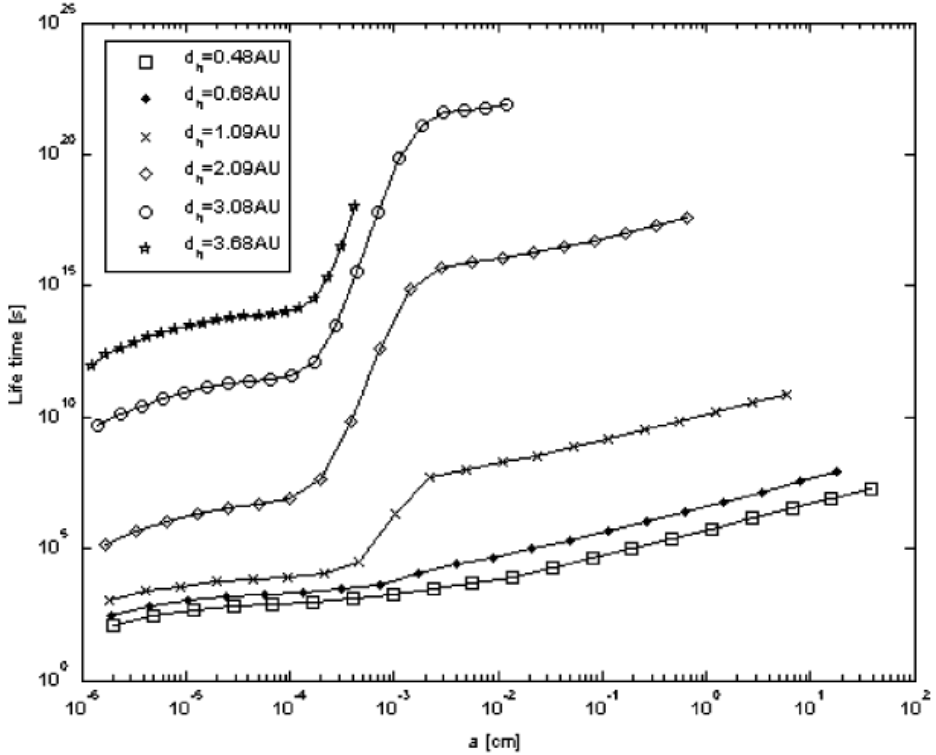
Collisions

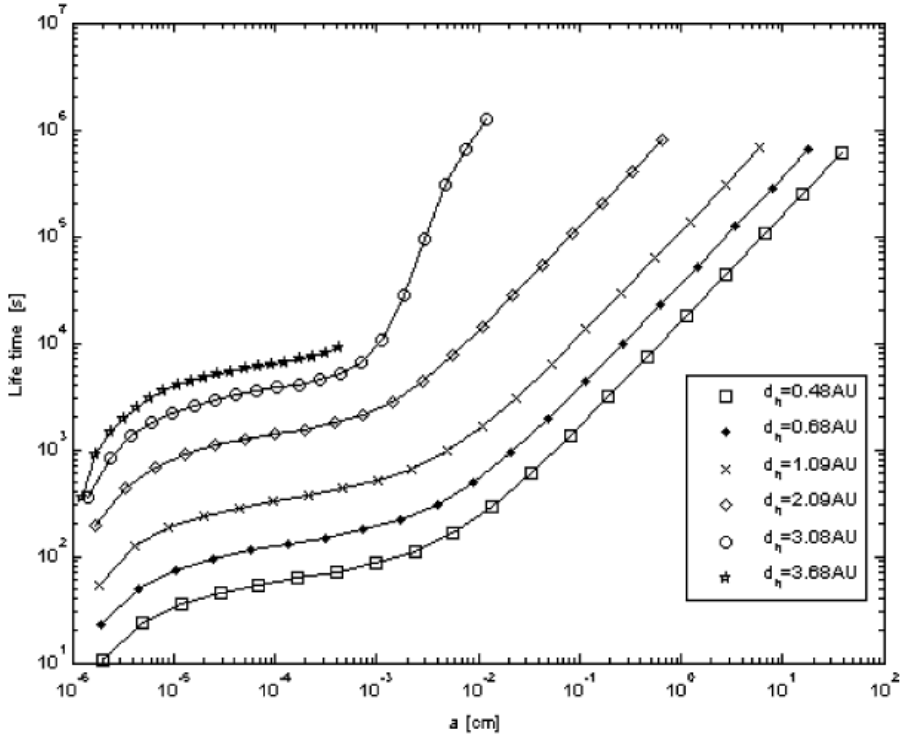
- With Deep Impact, we could probe the depth at which ice is buried within comet Tempel 1's nucleus.

- With naturally occurring asteroid collisions, we can do the same.

Icy grain lifetimes (Beer et al. 2006)

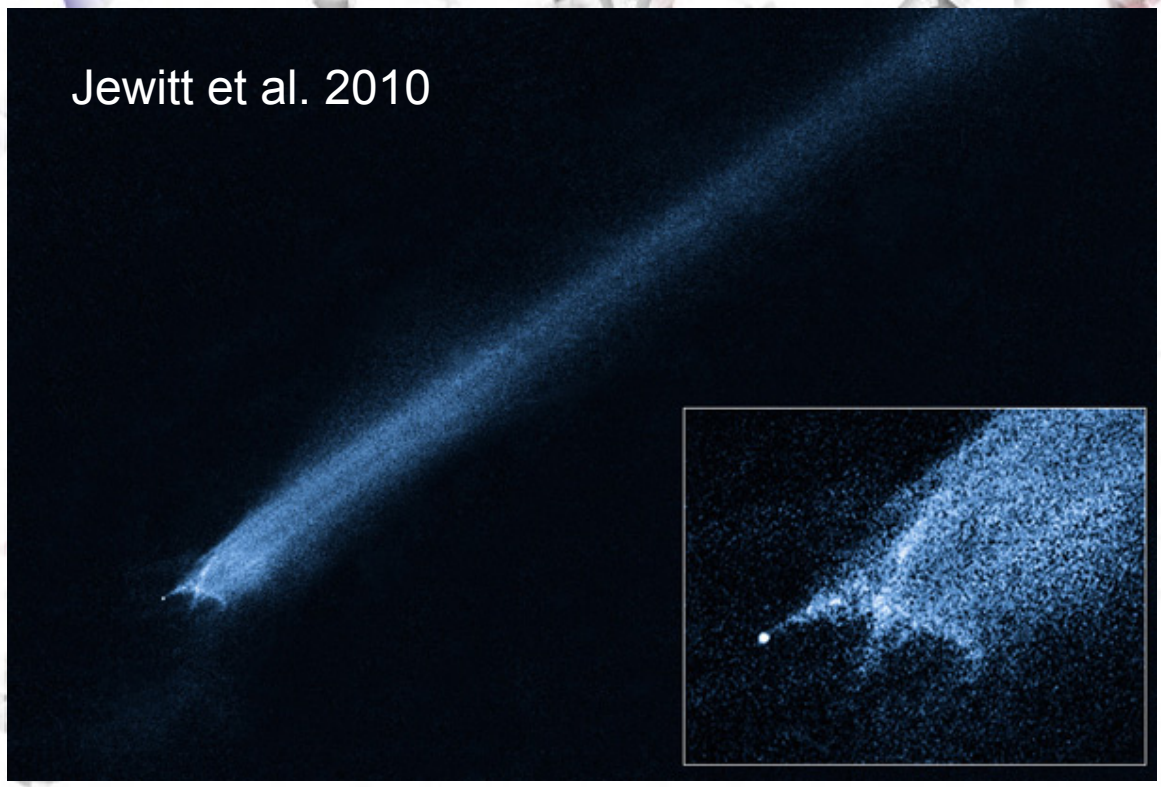
- Depends on the dust/ice ratio of the ice grains.
  - Pure ice grains are cooler than dirty ice grains.
  - Their lifetimes are 10 to 10^5 times longer.
  - More or less independent of dirt fraction





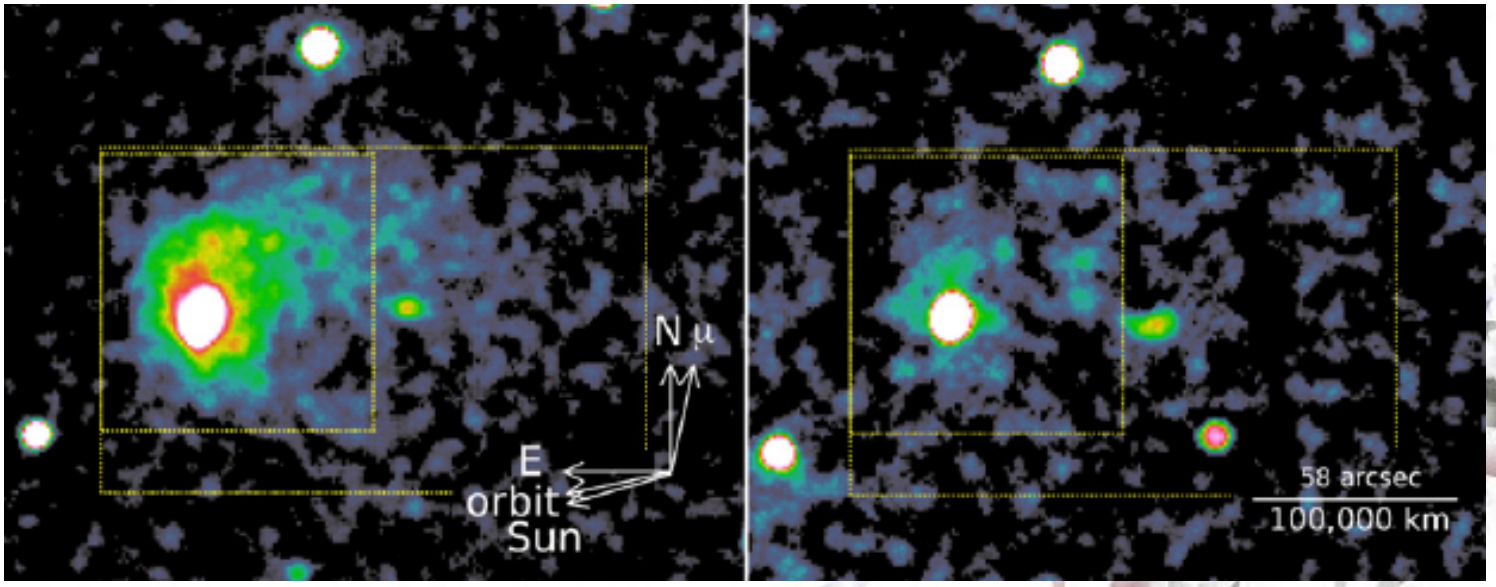
P/2010 A2 (LINEAR)

- ~100 m asteroid impacted by an ~10 m asteroid
- Faint: V = 18 mag (integrated)
- Long lived: discovered about a year after the collision
- May occur 1/year.



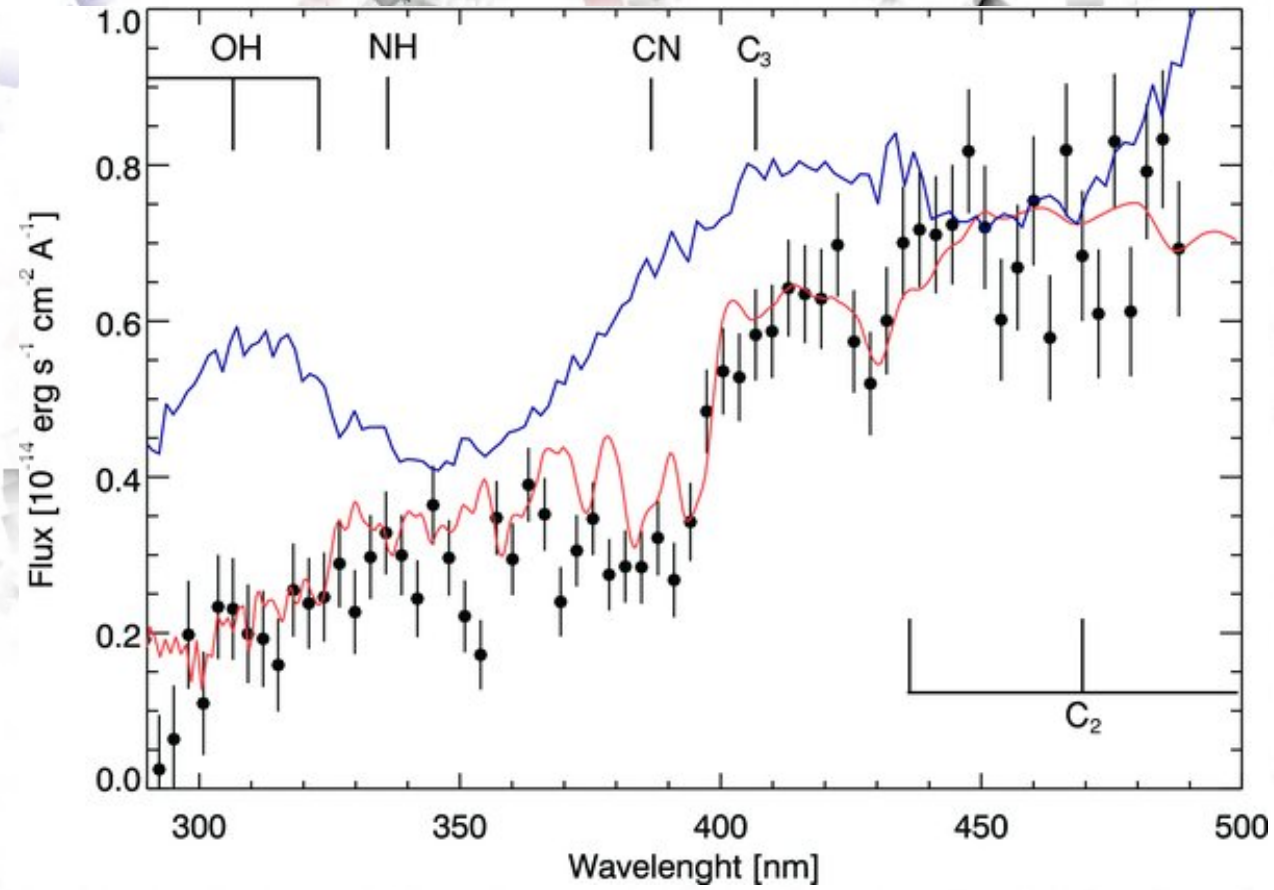
(596) Scheila

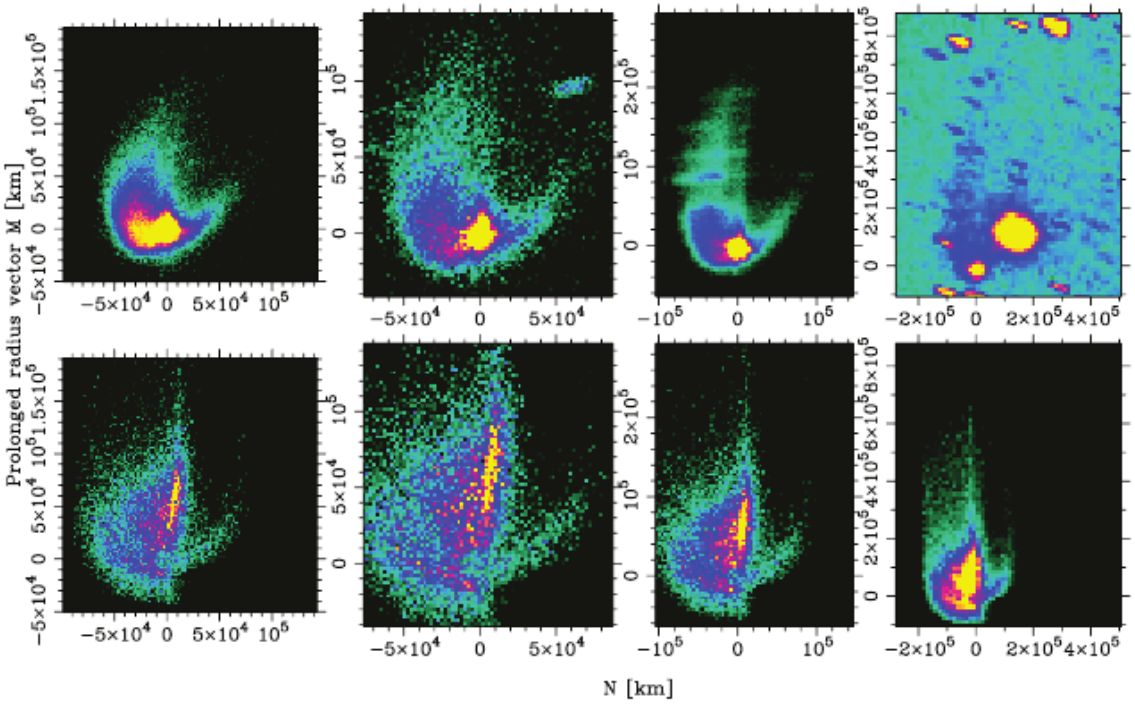
- Large primitive asteroid
  - D / T-type
  - D = 113 km
- Impacted by a 10-100 m asteroid
- Discovered 11 Dec 2010, pre-discovery images from 3 Dec were immediately reported
- Short-lived event: dust was all but gone within 2 months
- May occur ~once every 5 years.

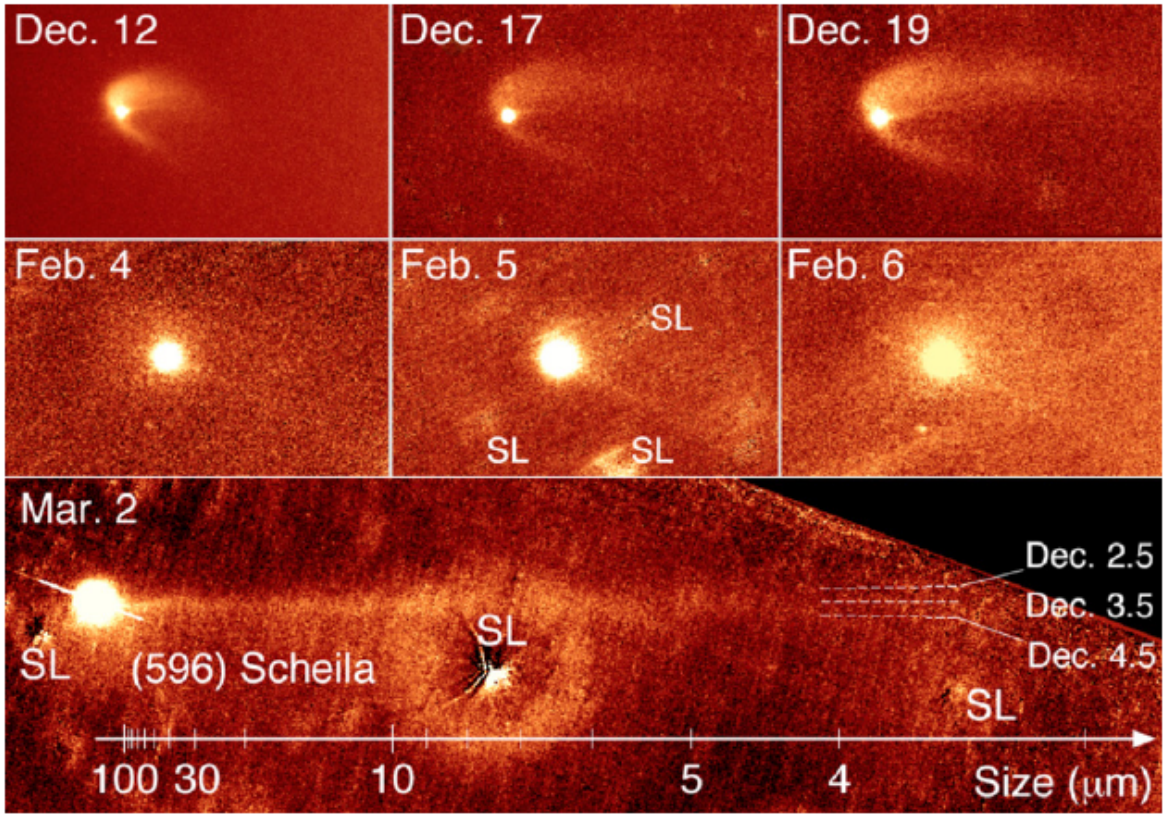


Bodewits et al. 2011

- Observed grains > 1 μm
- Dirty ice: tau = 10^3 – 10^6 s
- Pure ice: tau = >10^8 s







Moreno et al. 2011:
Impact = Nov 24 - 30

Ishiguro et al. 2011:
Impact = Dec 3.5 +/- 1

Prospects for Discovery

- Pan-Starrs: The whole available sky as seen from Hawaii will be observed 3 times during the dark time in each lunar cycle
  - Potentially discover < 3 week old events
- LSST will cover the entire available sky every three nights.
  - Potentially discover < 3 day old events

Prospects for Observations of Ice

- IRTF+SpeX
  - > Scheila-like events
- Gemini+GNIRS / Subaru+ICRS
  - Scheila-like events, but only very early on
  - SNR ~ 20 in 1 hour
- SOFIA+FLITECAM
  - < Scheila-like events
- JWST+NIRSpec
  - P/2010 A2 events?