

# Detecting Volatiles on Comets (and Asteroids)

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#### Using LEGO® to simulate ESA's touchdown on a comet

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Methods Of Determining Light elements from Unequivocal Stable isotope compositions (MODULUS or Ptolemy)





# Jilin Meteorite (1976)





















# Wet Mars?



## Allan Hills 84001

Stepped Combustion Data from ALH 84001,106



 $\overline{PS}$ 





Takács - Kiss (Uni. Sydney) - Szabó (Uni. Szeged)



# RosettaLaunch:07:17:44, 2<sup>nd</sup> March 2004





## Rosetta Comet Rendezvous





 $\overline{PS}$ 







#### (67P/Churyumov-Gerasimenko)







#### **Comet 67P/Churyumov-Gerasimenko**

3-D reconstruction of nucleus based on March 12, 2003 Hubble Space Telescope observations











EJOLVED GAS ANALYSIS SYSTEM #2 NOTE THAT ALL CARRIER GAS BLEED PIPEWORK NEEDS TO (HELIUN ?) BE KEPT WARM (~ Q "L) Pump TO PREVENT GASES CONDENSING OXYGEN = GAS MASS CHRONATOGRAPH SECTROMETER ALIQUOT CRYOGENIC TRAPS -> CALIBRATION ZA AT 400°C CONTAINING MOLECULAR GAS H20 -> H2 SIEVE (TO TRAP CO2, H2O, SO2 AND N2) FURNACE AMBIENT TO 1200°C (IDEAL) AMBIENT TO SOO'L (MINIMUM FOR & = VALVE USEFUL SLIENCE ) = CAPILLARY TUBING = WIDE -BORE TURING OXYGEN : GENERATES FROM KMAD4 @ 200°C OR CUO @ 450-850°C. THE LATTER CAN BE USED TO RE-ADSORD 1PW 14-JAN-93 EXLESS OXYGEN













#### Philae "RoLand" The Lander





#### APXS - Alpha Particle X-Ray Spectrometer (elemental composition of the comet's surface)



CIVA - Six identical micro-cameras (panoramic pictures & spectrometer for composition and texture of samples collected from the surface)







CONSERT - Comet Nucleus Sounding Experiment by Radiowave Transmission (probes the internal structure of the nucleus)

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MUPUS - Multi-Purpose Sensors for Surface Science (sensors to measure the density, thermal and mechanical properties)



#### ROLIS - Rosetta Lander Imaging System (high-resolution images during the descent and stereo-panoramic images of surface areas)





ROMAP – Rosetta Lander Magnetometer and Plasma Monitor (determines the local magnetic field and comet/solar wind interactions)



SESAME - Surface Electrical, Seismic and Acoustic Monitoring Experiments (permittivity, propagation of sound and dust impact monitoring)



#### SD2 - Sample and Distribution Device (drills up to 20 cm into the surface and collects samples)



COSAC - Cometary Sampling and Composition Experiment (determination of organic compounds)



Ptolemy - MODULUS (Methods Of Determining and Understanding Light Elements from Unequivocal Stable isotope compositions)



# **Ptolemy** Evolved Gas Analyser - How it works...





# Ptolemy Evolved Gas Analyser - How it works...





# Ptolemy Evolved Gas Analyser





# Ptolemy Mass Spectrometer





# Ptolemy The Wiring Challenge





# Ptolemy During FM Electrical Testing





# Ptolemy Pipework Detail





# Ptolemy The Completed Flight Model















1. 2 hr 50 min prior to close approach, and Rosetta has the +Z instrument axis, and thus the Ptolemy vent pipe pointing toward Lutetia.

2. 1 hour prior to close approach and the spacecraft attitude has barely changed.

3. Sub-Solar point 3 measurement: spacecraft attitude has still barely changed, outgassing is at a minimum.

T. Rosetta is tracking Lutetia - large outgassing event

4 and 5. Measurements at one and two hours after close approach, with Ptolemy taking background spectra of spacecraft outgassing.





#### Low mass range spectra, combined over the entire flyby

High mass range spectra, combined over the entire flyby









#### Ptolemy pressure proxy measurement during the Lutetia flyby

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# Thank you

谢谢你



