Exploring the Basaltic Lava Flows of Oceanus Procellarum: Requirements for an Exploration Architecture that Optimises Scientific Return from Field Activities

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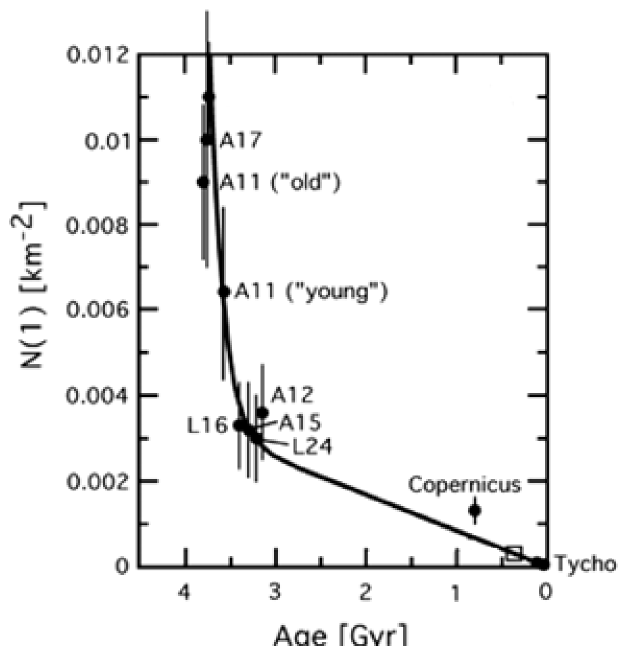
Basalt flows in Oceanus Procellarum

Scientific Drivers:

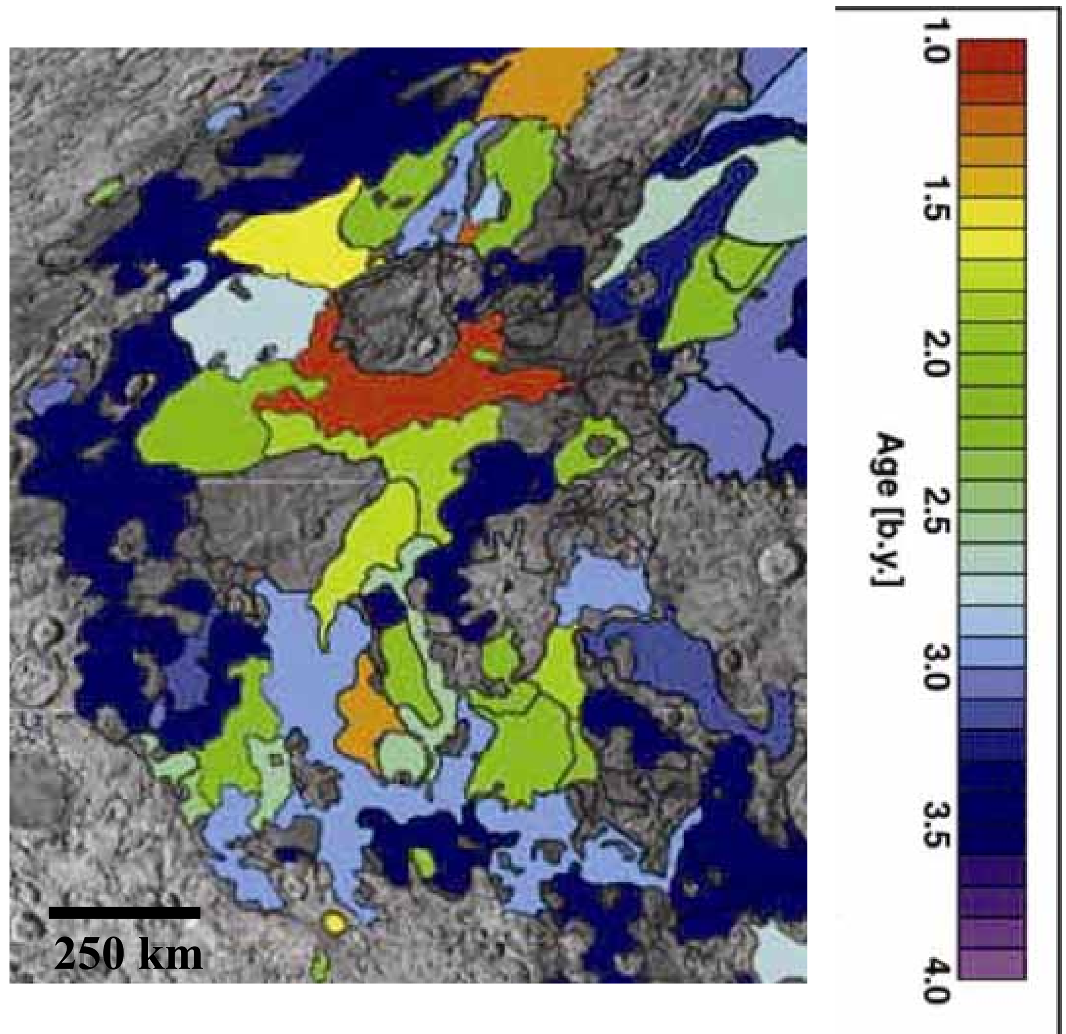
•Cratering chronology

• Geochemical evolution of lunar mantle

• Palaeoregoliths

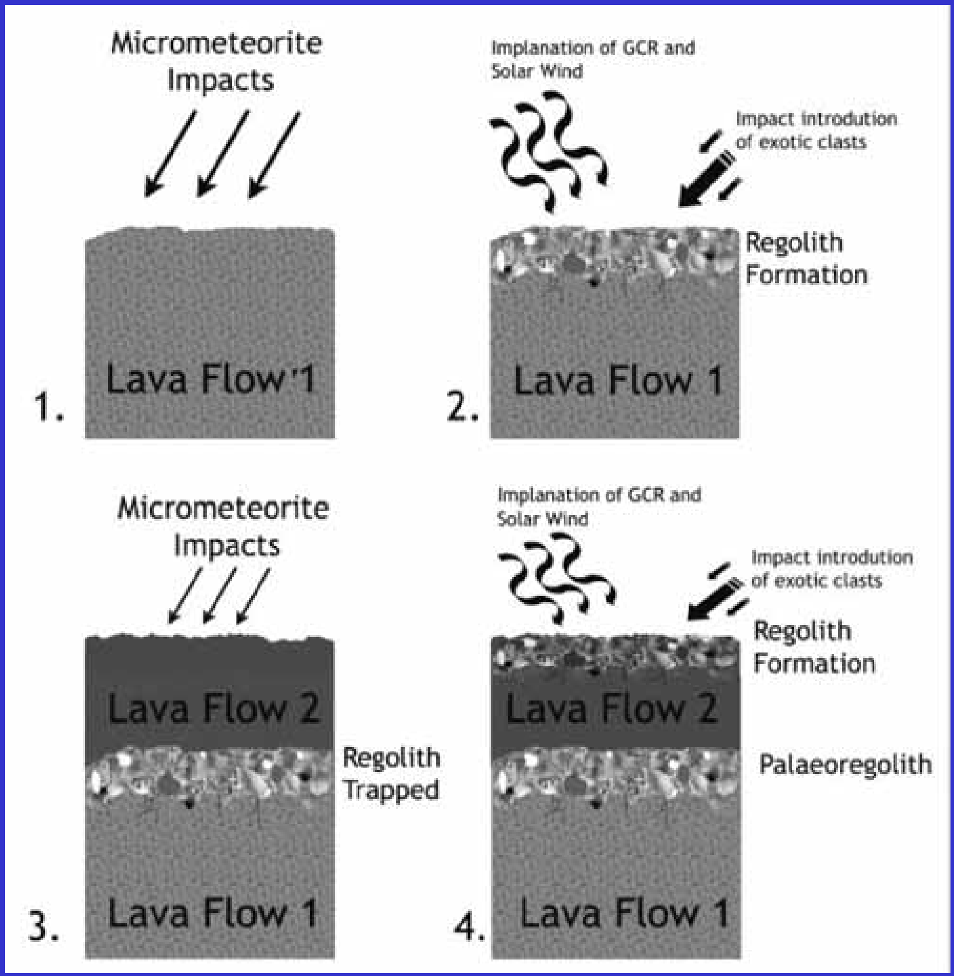


Stőffler et al. (2006)



H. Hiesinger *et al.*, *JGR*, 108, E7, 1.1 – 1.27, (2003)

Lunar stratigraphy and the importance of palaeoregoliths



Treasures in the regolith

Secular changes in the xenon and krypton abundances in the solar wind recorded in single lunar grains

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NOBLE gases implanted into the lunar surface trace elemental and isotopic abundances in the solar wind during the Sun's lifetime, and so potentially provide a valuable record of the ancient Sun

Terrestrial nitrogen and noble gases in lunar soils

M. Ozima[1], K. Seki[2], N. Terada[2]†, Y. N. Miura[3], F. A. Podosek[4] & H. Shinagawa[2]†

The nitrogen in lunar soils is correlated to the surface and therefore clearly implanted from outside. The straightforward interpretation is that the nitrogen is implanted by the solar wind, but this explanation has difficulties accounting for both the abundance of nitrogen and a variation of the order of 30 per cent in the $^{15}N/^{14}N$ ratio. Here we propose that most of the nitrogen and some of the other volatile elements in lunar soils may actually have come from the Earth's atmosphere rather than the solar wind. We infer that this hypothesis is quantitatively reasonable if the escape of atmospheric gases, and implantation into lunar soil grains, occurred at a time when the Earth had essentially no geomagnetic field. Thus, evidence preserved in lunar soils might be useful in constraining when the geomagnetic field first appeared. This hypothesis could be tested by examination of lunar farside soils, which should lack the terrestrial component.

Planetary science

Earth's lunar attic

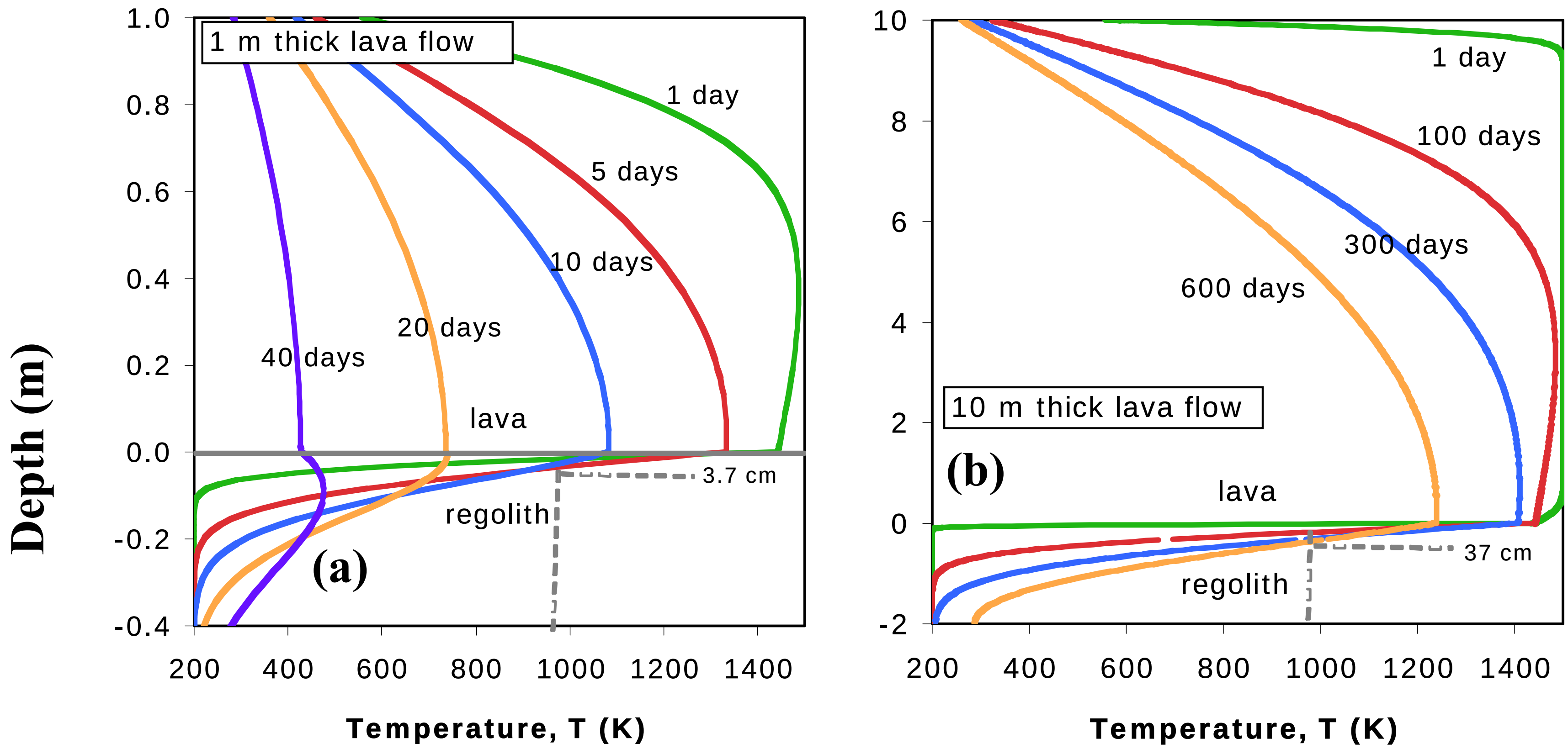
Clark R. Chapman

Rocks blasted long ago from the surface of Earth and other planets may be preserved on the Moon. Although hard to identify, they could hold a unique record of the chemical history of the planets and even evidence of life.

Two decades ago, it was realized that a few unusual meteorites in our museums are actually pieces of Mars[1]. Isotopic ratios derived from gas trapped inside the rocks indicate their provenance. Meteorites that originated on the Moon were soon recognized, and one that might be from Mercury[2]. Calculations of the interplanetary transport[3] of material support the possibility that such rocks are being carried to the Earth, and of course there has been speculation that ancient Earth, Venus and Mars. As a result, venusian meteorites delivered to the Moon aeons ago (long before the global volcanism on Venus that largely ended half a billion years ago) might remain and could give insight into the history of Venus during epochs for which evidence in the planet itself has been obliterated.

The paper's charming title, "Rummaging through Earth's attic for remains of ancient life", reveals its theme. The authors propose that, very roughly, 20,000 kg of mainly

Survival of implanted volatiles



Temperature profiles through lava and regolith as a function of time after flow emplacement (initial lava temperature: 1500K) for (a) 1 m and (b) 10 m flow thicknesses. The 973 K (700 °C) isotherm is represented by a dashed line; the maximum penetration of this isotherm into the regolith is ~3.7 cm for a 1 m thick flow, and 37 cm for a 10 m thick flow. A density of 1660 kg m-3, and thermal conductivity of 0.011 W m-1 K-1, were adopted for the regolith [12-14]; corresponding values for the basalt were 2980 kg m-3 and 1.5 W m-1 K-1 [15-17].

Implications for the Exploration Architecture

(1) The ability to conduct 'sortie-class' expeditions to non-polar localities far from the proposed lunar base.

(2) Adequate provision for sample collection and return capacity (> 100 kg per sortie)

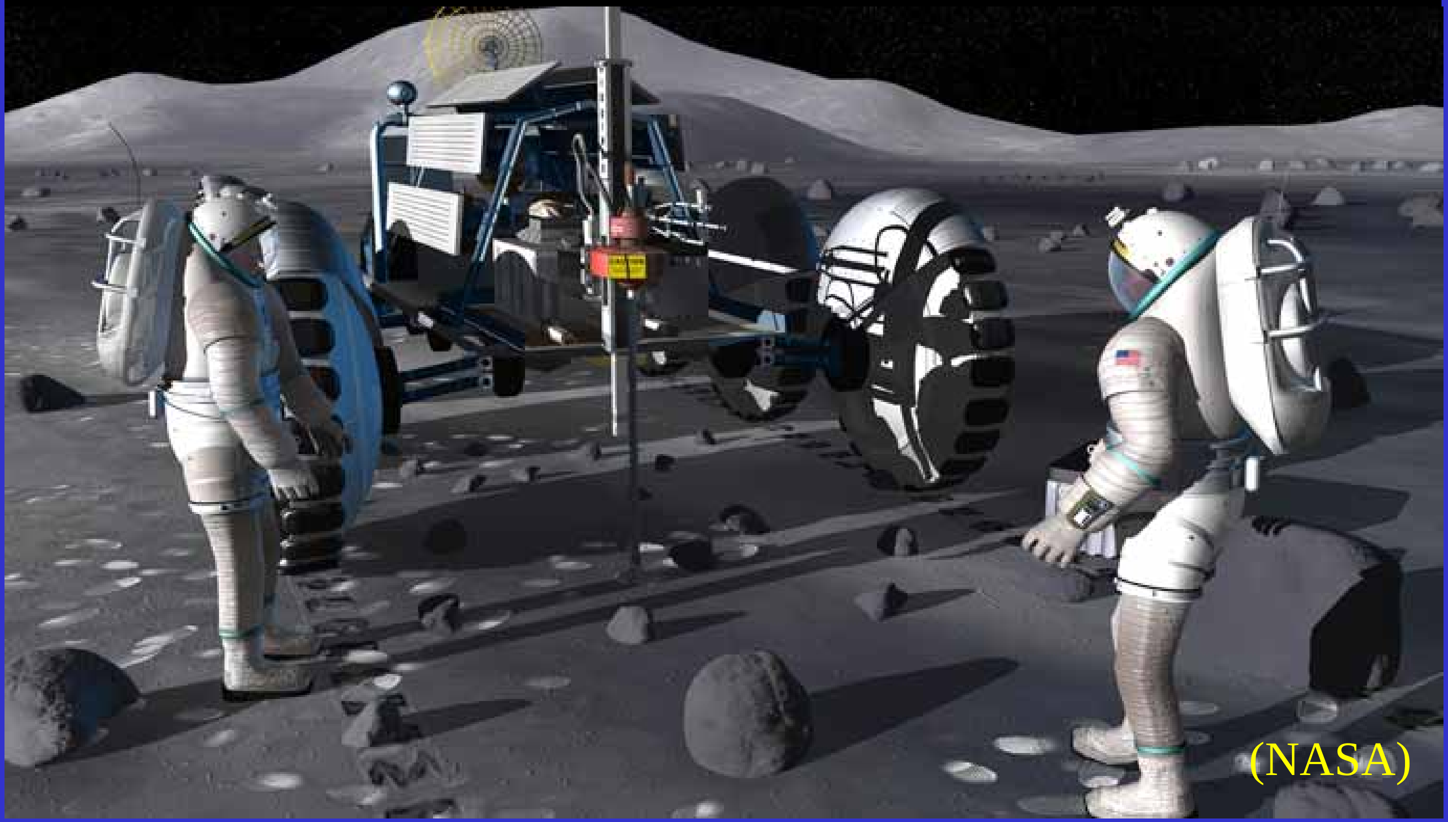
(3) Provision for surface mobility – in the specific case of the Procellarum basalt flows a range of order 100 km would permit access to a number of different units with a wide range of ages; this in turn implies provision of a pressurized rover.

(NASA)

(4) Provision of the means to detect and sample palaeoregoliths

– GPR is a suitable detection technique

– Sampling may require drilling to ~ 100m depths



(NASA)

(5) Provision for storage, transport and on-site processing of core samples and intelligent selection of sub-samples for return to Earth