An In Situ Automated Rock Thin Section Instrument

Authors: Christopher Dreyer¹, Kris Zacny², R. C. Anderson³, John Skok¹, John Steele¹, Gale Paulsen², Mattias Szczesniak², Jim Schwendeman¹

Overview
We present a conceptual design of the In Situ Automated Rock Thin Section Instrument (S-ARTS). We have studied the limiting steps toward the development of the instrument, which enables us to present estimates of power, mass, lifetime, and number of thin sections produced by a given system. We have developed methods for rough cutting, epoxy/slide application and grinding/polishing to finished thin section quality. An automated thin section device and petrographic microscope will enable “sample-return science” from a non-sample-return mission.

Scientific Context
Thin section analysis provides a perspective to understanding planetary surfaces that will be uniquely different from the viewpoint obtainable from any previous orbital or surface missions. A thin section instrument will provide the first definitive data for understanding the surface of planetary bodies. For example, 1) understanding the diversity across interfaces between weathered and unweathered lithologies would provide insights into the history of the planets surface processes, 2) providing valuable information on the composition, and potential environments of formation of surface minerals, and 3) help establish the chronological history of the surface by providing a mineral context for in situ age dating of materials.

Technical Context
Thin sections are used to identify minerals, their structural aspects (cleavage, fractures, mineral zoning) and rock textures that indicate the mode of formation of the rock. We have studied the limiting steps toward the development of the instrument, which enables us to present estimates of power, mass, lifetime, and number of thin sections produced by a given system. We have developed methods for rough cutting, epoxy/slide application and grinding/polishing to finished thin section quality. An automated thin section device and petrographic microscope will enable “sample-return science” from a non-sample-return mission.

Instrument Work Flow
Thin section preparation is traditionally a manually intensive task. The schematic below major tasks in a spacecraft context. Work proceeds clockwise starting at the top with iteration possible between steps. We are presenting a design concept for the items in bold.

We envision the production of a thin section to be performed as a series of autonomous steps with periodic verification by a science and engineering team in mission operations.

Test Beds: TRL3/4 validation
The technical problem is most similar to the development of drilling, sample processing capabilities 50 thin sections of basaltic rock. Processing time of 1 thin section over several days. System requirements: 100m wire, 5mm thick GRITS abrasive, initial rock fits within ~20mm cube.

Conceptual Design
Solid model of the conceptual design shown in center. Performance estimates are given in the table lower center and are based on work in TRL3/4 test beds.

Rough Cutting Test Bed
The diamond wire saw requires less energy, reduces over-cutting waste (kerf), produces less dust, it can cut in multiple directions, and reduces system mass and volume relative to other cutting devices. A capstan design allows up to 200m of wire in rel. small vol. (1500 cm³).

Adhesive Application
The application of glue to bind a sample to a microscope glass slide. Investigated approaches: UV cure, thermostet, combined slide and epoxy, and slide-free approaches. Requirements include compatibility with the space environment, opaque, high refractive index, does not alter the sample, and does not obscure significant chemical signatures.

GRITS: Grinding/Polish Test Bed
Grinding Rocks Into Thin Sections is a combined dry grinder and polisher. By careful control of force 4mm of rock can be removed and the surface finished with an adequate thin section polish. The test bed has been used to test several different grinding/polishing wheels and explore load, speed and oscillation parameters. We have successfully shown the ability to produce thin sections.

Microscope images show success of GRITS dry grinding/polishing. The section can be used for petrographic analysis and was prepared in a method compatible with spacecraft.