Abstracts

SAMPLING ELYSIUM LAVAS (13°N, 203°W). C. C. Allen, Lockheed Engineering and Sciences Company, 2400 NASA Road 1, Houston TX 77058, USA.

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Elysium is the second largest volcanic province on Mars. A landing site on this unit is proposed at 13°N, 203°W, in a dark region north of Cerberus Rupes. The site was chosen to provide the chemical composition and mineralogy of an Elysium lava flow.

Criteria for Landing Site Selection: The proposed landing site was selected to usethe Pathfinder APXS and multispectral cameras in order to characterize rock chemistry and mineralogy. Site selection was based on three criteria:

Is the site important? Will the data from this site have planetary significance?

Is the site accessible? Can the Pathfinder spacecraft land safely at this site and perform the desired analyses?

Is the site representative? Will the samples analyzed by Pathfinder be representative of the geology for which the site was chosen?

Is the Site Important? The chemical and mineralogical compositions of major rock units are of extreme importance in deciphering a planet's geologic history and interior structure. Our current knowledge of Mars is deficient in this regard, lacking any analyses of unequivocal martian rocks. Chemical and mineralogical analysis of at least one major rock type should be a primary goal of any Mars lander.

The most widespread map unit in the Elysium province, and one of the largest in the entire Pathfinder landing zone, is member 2 of Tanaka et al. [1]. This unit, covering 1.06×10^6 km^2, is interpreted as lava flows from the latest widespread volcanic activity in the area. Member 2 is mapped as lower Amazonian in age, with a cumulative crater density (>2 km) of 329 ± 18 per 10^6 km^2. The lavas originated from Elysium Mons and associated fissures. Flow fronts over 100 km in length have been mapped. The landing site was chosen to sample this major volcanic unit.

The friable material analyzed by the Viking landers is generally interpreted as weathering products of mafic rocks [2]. The chemical compositions of samples from both Viking sites were essentially identical, and the samples' spectral signatures matched those of widespread martian bright areas. Thus, much of the planet's surface is thought to be mantled with windblown dust. Pathfinder analyses can show whether or not the Elysium lavas are possible sources for this dust.

The SNC meteorites, generally believed to be derived from Mars, are all basalts [3]. Chemical and isotopic differences among the meteorites show derivations from several lavas, separated either vertically or horizontally on the martian surface. The SNCs strongly indicate that basalts occur somewhere on Mars. Compositional data from Elysium lavas can show whether or not they are a reasonable source for the SNCs.

A lava analysis from a known site would provide valuable ground truth for photogeologic interpretation. Chemical and mineralogical composition can be used to determine lava viscosity. With this calibration point, measurements of flow dimensions can be used to derive eruption parameters basic to the understanding of the volcanic province.

Geophysical models require the compositions and densities of martian crust and mantle rocks. The current uncertainty as to rock type allows for a wide range in geophysical parameters. Knowledge of the chemical composition of an extensive unit like the Elysium lavas could strongly constrain these models.

Knowledge of martian lava composition is of considerable importance to the study of comparative planetology. To zero order the surface of the Earth is dominated by eruptive mafic and intrusive sialic rocks. Knowledge that the lunar rocks show the same basic dichotomy is fundamental to our understanding of that body. The Venera and Vega analyses strongly suggest that the same two rock types dominate the surface of Venus [4]. Pathfinder should provide the composition of one of these major rock types on Mars.

Is the Site Accessible? The proposed site, 13°N, 203°W, is within the Pathfinder landing zone. The site lies between the 0 and −1 km contours, on a regional slope of approximately 1:500 [5]. Viking orbiter imagery shows no scarps or large craters at the landing site.

The landing ellipse is entirely within an east-northeast/west-southwest trending dark area that measures 1500 km × 300 km. A small percentage of the area is covered by light-toned northeast-southwest-trending streaks, interpreted as dust deposits in the wind shadows of topographic obstructions. The dark material is interpreted as lava flows denuded of dust by the wind [6]. Thus, Pathfinder should have a high probability of landing on a relatively dust-free lava flow.

The Viking landers touched down in bright areas dominated by windblown dust deposits. Both sites, however, contained numerous large rocks, which could have been analyzed by a mobile system such as that on the Pathfinder rover. Thus, even if Pathfinder were to touch down on a dust deposit, it should be able to find lava outcrops or boulders to analyze.

Is the Site Representative? The Columbia River Basalt Group (CRBG) in the U.S. Pacific northwest is one of the largest (200,000 km^2) and youngest (17–6 Ma) flood basalt provinces on Earth [7]. Fissure eruptions produced flows tens to hundreds of meters thick, with some flows traceable for over 300 km. Over 5000 samples, representing all the flows in the CRBG, have recently been analyzed by XRF [8]. These analyses are a unique dataset by which to judge Pathfinder analyses from Elysium.

The CRBG can be divided into six chemically distinct formations, with the Grande Ronde Formation comprising 85% of the volume of the entire group [9]. Individual lava flows within the Grande Ronde display striking chemical uniformity. Flows can be reliably distinguished, based on major- and minor-element compositions, even hundreds of kilometers from their sources [9].

If Pathfinder landed anywhere in the Columbia River basalts, APXS analysis of a random dark rock would be indistinguishable from any other analysis of the same lava flow, which could be hundreds of kilometers in length. To first order, in fact, such a random analysis would be highly representative of the entire CRBG. By analogy, the composition of any lava rock from 13°N, 203°W on Mars should be representative of the fresh lavas across much of the Elysium province.

Conclusions: The proposed Pathfinder landing site presents the opportunity to determine chemical and mineralogical compositions of an Elysium lava flow. The flow is part of a geologic unit of planetary significance. The proposed site appears suitable for landing, and lava surfaces should be accessible to the Pathfinder instruments. By analogy to terrestrial flood basalts, any lava analyzed by Pathfinder is likely to be representative of the entire Elysium province.

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MARS PATHFINDER AND THE EXPLORATION OF SOUTHERN AMAZONIS PLANITIA.

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The southern region of Amazonis Planitia provides a variety of target terrains for a roving vehicle such as the Mars Pathfinder Mission. A landing site is proposed at 4°N latitude 162°W longitude. This area has a reference altitude of between 0 and –1 km and consists of relatively smooth Amazonian-aged deposits within the entire 100 × 200 km landing ellipse. The proposed landing site is within the Upper Member Medusae Fossae Formation deposits (Amu) and near the boundary with Middle Member Medusae Fossae Formation deposits (Amm) and Member 1 Arcadia Formation plains (Aa_1). Slightly further afield are 107-km-diameter Nicholson crater, its ejecta deposits, and knobby terrain of proposed Hesperian age (HNu) [1]. Depending on the exact landing site of the spacecraft and the traverse distance of the rover, these materials also may be sampled.

Regional Geologic Setting: The Medusae Fossae Formation consists of a series of fine-grained, layered deposits of enigmatic origin generally within the area 12°N–11°S and 127°–190°W. The fine-grained nature of the material is revealed through low thermal inertia values [2,3], little to no radar return [4], greater than expected crater depth-diameter ratios for fresh impact craters [5], and the presence of eolian erosional features such as yardangs [6]. The origin of this material remains controversial—theories include ignimbrite deposits from explosive volcanic eruptions [7], ancient polar deposits that have ended up in their present location as a result of extensive polar wander [8], an exhumed chemical boundary layer caused by a subregolith paleowater table [4], or simply thick deposits of eolian-emplaced debris [1]. Analysis of the chemical composition of the material may help to resolve the origin of this mysterious and unique martian terrain.

The proposed landing site lies within the Upper Member of the Medusae Fossae Formation, a discontinuous region of deposits that tend to be smooth and flat to gently rolling. In some locations, this material has been sculpted by eolian processes into ridges and grooves, which may allow direct observation of different layers within the material. To the west lies the Middle Member of the Medusae Fossae Formation, which is similar to the Upper Member except for appearing rougher and more deeply eroded. The rover probably will have difficulty traversing this terrain and therefore sampling of only the outlying regions is desired for comparison with the Upper Member.

To the northwest of the proposed landing site is the Member 1 Arcadia Formation plains. These plains are characterized by smooth, flat topography occasionally interrupted by knobs and hills of presumed Hesperian- or Noachian-aged material. Mare-type wrinkle ridges are common, suggesting that these plains are of volcanic origin. Since this area is located to the southwest of Olympus Mons, the volcanism of the region is likely related to volcanism of the Tharsis region. The Member 1 plains are the oldest unit of the Arcadia Formation and are stratigraphically similar in age to portions of Alba Patera and the Olympus Mons aureole [1,9].

Approximately 200 km southwest of the proposed landing site is the 107-km-diameter crater Nicholson. Although relatively fresh in appearance, Nicholson is partially embayed by the Medusae Fossae deposits and therefore appears to be intermediate in age between the Member 1 Arcadia formation on which it is superposed and the Upper and Middle Members of the Medusae Fossae Formation. The ejecta blanket of the crater is still preserved although slightly reworked. Analysis of this ejected material should provide information about changes in target composition with depth in this vicinity.

Information from Mars Pathfinder Rover: The instruments onboard the Mars Pathfinder Rover can help address several questions regarding the terrain in this region. Among these questions are: (1) What are the chemical composition and mineralogy of the different geologic units at the landing site and within the traverse distance of the rover? (2) Are there regional variations in chemical composition/mineralogy within the same stratigraphic unit? (3) What is the magnetic susceptibility of the material at the lander site? (4) What is the ratio of fine-grained to rocky material at each location? (5) What is the composition of the dust that will probably accumulate on the rover during its traverse? (6) What is the appearance of different geologic features from surface level and what can the resolution of the imaging system reveal about layering in, erosion of, and possible origin of these features? (7) What is the trafficability of the different units traversed by the rover?

The camera systems and the APXS sensor will provide the answers to most of these questions. The ability of the APXS sensor to analyze both soil and rocks should provide a much better understanding of the materials composing the martian surface in this region. Analysis of exposed layers within ridges, grooves, and hills by the APXS and multispectral capabilities of the imaging system can provide information about chemical and mineralogic variations within the near-surface region. This information will provide constraints on the potential origin(s) of the features studied.

This particular landing site was selected primarily to address the question of the composition and possible origin of the Medusae Fossae Formation deposits. These deposits appear to be a unique landform on Mars and have intrigued a large number of investigators. Why are the deposits concentrated in this region of the planet? The crater density and superposition relationship to surrounding terrain suggests a young age for this material. What process or processes occurred to create this material in relatively recent time? Do these deposits imply anything about possible environmental changes for Mars? It is hoped that the instruments onboard the Mars Pathfinder lander and rover can provide new constraints on the theories advanced about this enigmatic region of Mars.