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Center for Radiophysics and Space Research

ITHACA, N. Y.

FINAL TECHNICAL REPORT

for

NASA Grant NAGW-193

Jupiter/Voyager Data Analysis

(National Aeronautics and Space Administration)

Principal Investigator: J. Veverka

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Prepared by: J. Veverka, Principal Investigator

A. INTRODUCTION

This grant originally involved investigations of various aspects of sulfur in the Jovian satellite system (April 1, 1981 to May 31, 1983); during its last year, the objectives were expanded to include related analysis of Saturn satellite data.

In addition to the Principal Investigator, two Research Associates (Dr. Peter Thomas and Dr. Jonathan Gradie), as well as several graduate students (Jay Goguen, Bonnie Buratti, and Damon Simonelli) participated in this research.

B. SUMMARY OF RESEARCH

Jupiter Satellites

The original goals of the project were to see to what extent the unusual spectral properties of Io and of the small inner satellites of Jupiter (Veverka et al., 1982) could be accounted for by "sulfur glass" or at least by sulfur-rich glasses. On Io such materials could be produced by volcanic processes, whereas for the small satellites contamination from Io and impact processes would be involved. The results of this phase of our work were summarized in the paper "Glass on the Surfaces of Io and Amalthea," by Gradie et al., (1984). The major conclusions were:

The surface of Io is probably rich in sulfur compounds if not in elemental sulfur itself. Widespread volcanic activity involving sulfur suggests that thermally modified sulfur and sulfur compounds may be responsible for much of the vivid coloration observed. Highly colored sulfur glass, i.e., molten sulfur quenched below 150 K probably does not form easily in pools and flows, since heating by hot material from below will keep the topmost layer warm ($T > 150$ K) for relatively long times. Ejecta from vents and fumaroles are more likely sources for quenched sulfur. Laboratory experiments and calculations suggest that in plumes only molten droplets from 10 to 100 μm diameter are likely to quench rapidly enough to retain their cooled sulfur allotropes and polymeric sulfur. In fumaroles, molten droplets < 1 μm can quench if flight times are short enough for them to land on the cold surface while still molten.

If silicate lavas are common on a surface rich in sulfur then silicate glasses enriched in sulfur may form. Our laboratory experiments with basaltic glasses show that iron precipitates out in a colloidal sulfide phase, an observation which confirms earlier results in the case of sulfur contamination of soda-silica-lime glasses. These colloidal sulfide phases darken and redden the basaltic glasses. The known spectral characteristics of the dark areas on Io (i.e., calderas and their immediate vicinities) are consistent with those of our basalt-sulfur glasses. However, Voyager spectral coverage is insufficient to make definite identifications of volcanic basalt-sulfur glass on Io. For this purpose measurements in the 1 μm spectral region, such as those that will be obtained by the Galileo orbiter, are needed.

The surface of Amalthea is almost certainly contaminated with sulfur diffusing inward from Io. The spectral reflectance properties of silicate impact glasses should be modified by this sulfur contamination. Our results suggest that basalt-sulfur glasses can be made to match the spectral reflectance of Amalthea in the spectral region observed by Voyager. However, such glasses do not match the preliminary spectral reflectance of Amalthea between 0.87 and 1.7 μm reported by Neugebauer et al. (1981). More extensive observations are needed to resolve this issue.

The composition of the brighter, greener area on Amalthea remains unexplained. It is conceivable that the drop in reflectivity near 0.6 μm can be associated with the very broad 1 μm absorption feature observed in some of our basalt-sulfur glasses.

A copy of the Gradie et al. paper is included in Appendix 1.

Another major thrust of our sulfur research was to see whether the fact that the characteristic spectrum of pure sulfur depends on temperature (Gradie and Veverka, 1984) can be used to set limits on the abundance of sulfur as a surface constituent of Io. The results of this phase of our work are summarized by Veverka et al. (1982) (Appendix 2). To date it has not proved possible to find any evidence that any of the regions on Io have a temperature-dependent spectral reflectance--a strong indication that pure ordinary sulfur (S_8) is not a major surface component.

Saturn Satellite Research

The Saturn satellite research carried out under this grant included the reduction, analysis and interpretation of Voyager imaging observations of (a) Saturn's small satellites (Thomas et al., 1983a); (b) the unusual retrograde satellite Phoebe (Thomas et al., 1983b); and (c) of Hyperion (Thomas et al., 1984). The Hyperion study showed that this satellite is in an unusual non-synchronous spin state. Abstracts of these three contributions are reproduced in Appendix 3.

Closely related work on satellite photometry included a study of Iapetus (Squyres et al., 1984), of Io (Simonelli and Veverka, 1984), of Europa (Buratti and Veverka, 1984), and of Saturn's icy satellites (Buratti and Veverka, 1983).

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APPENDIX 1

Glass on the Surfaces of Io and Amalthea

J. Gradie, S. J. Ostro, P. C. Thomas, and J. Veverka

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