A RETURN TO IO: SCIENCE GOALS AND IMPLEMENTATION:

J. R. Spencer[1], W. D. Smythe[2], R. Lopes-Gautier[2], and A. S. McEwen[3], [1]Lowell Observatory, 1400 W. Mars Hill Rd., Flagstaff AZ 86001, spencer@lowell.edu, [2]JPL, 4800 Oak Grove Dr., Pasadena, CA 91109, [3]University of Arizona, Tucson, AZ 85721.

Science Goals: Io remains one of the most fascinating objects in the solar system: the only place beyond Earth where we can watch hard-rock geology in action. In its high heat flow Io resembles the early Earth, providing a present-day analog to some of the processes that dominated the Earth's geology at the time that life first appeared. Io's usefulness as an early-Earth analog has been underscored recently by the detection of very high eruption temperatures, hotter than terrestrial basaltic lavas [1]. These temperatures are most plausibly interpreted as resulting from ultramafic lava compositions, analagous to the komatiites that were common on Earth in the Precambrian but which have been virtually absent during the Phanerozoic. The large scale of many Io eruptions also provides useful analogs to Phanerozoic terrestrial eruptions, such as flood basalts, which are important for the Earth's geological and biological evolution but which occur too rarely to be witnessed by humans on our own planet. By providing living examples, Io can thus play the same role in understanding large-scale planetary volcanism that volcanically active terrestrial regions have played in understanding the results of smaller-scale volcanic processes seen in the geological record worldwide.

Despite the recent close flybys [2,3,4], Galileo, with its 1980-vintage instrumentation and very low data rate, has not been able to answer many fundamental questions about Io. These include the following:

1) What is the composition, and compositional range, of Io's lavas? Answering this question will give a critical window into Io's interior. High-resolution Galileo images have shown dark, fresh, lava surfaces but have not been able to obtain diagnostic spectra of these small but critical regions, though there are hints of diagnostic silicate absorption features in very low-resolution image-derived spectra.

2) What is the range of eruption mechanisms on Io? Galileo has made important contributions to this question, revealing both slowly inflating and rapidly emplaced lava flows, but its temporal and spatial coverage has been too intermittent for detailed studies.

3) What is the age of Io's surface? Galileo has been unable to obtain the wide-area, high-resolution coverage needed to detect the few small impact craters that could easily exist given current estimates of resurfacing rates.

4) What is the composition of Io's volcanic gases? These provide another important window on the interior. Progress has been made with Hubble UV spectroscopy [5], but spatial resolution is severely limited.

5) What is the magnitude, time evolution, and spatial distribution of Io's total heat flow? This provides an important constraint on models of the tidal heating that is the engine behind Io's volcanism, and provides insights into Europa's internal energy budget because of the coupled nature of the two satellites. Heat flow estimates require disentangling the volcanic and re-radiated solar components of Io's thermal emission [6], and are currently hampered by our limited understanding of Io's bolometric albedo distribution and limited maps of Io's thermal emission.

Implementation: To answer most of these questions, a return to Io is needed. To obtain good temporal coverage while minimizing radiation dose and delta-V, a Galileo-type Jovocentric eccentric orbit with perijove near 5.9 R_J may be preferred, allowing repeated Io flybys. Data return and distant monitoring would be carried out between Io flybys. Galileo has so far survived five passes within 5.9 R_J, and rad-hard technology developed for the Europa orbiter should allow an Io mission to survive many such passes.

Minimum instrumentation for such a mission would include a high-resolution imager, a visible/NIR spectrograph for compositional and volcanic emission studies, and a 10 - 20µm thermal mapper for heat flow and lava cooling studies. Atmospheric studies could be accomplished with an additional UV spectrometer and/or onboard mass spectrometer, and a magnetometer could provide additional insights into Io's internal structure at minimal extra cost. Further insights into Io's interior might be possible via studies of tidal deformation by laser altimeter. Large solar panels may prove feasible for use at Jupiter.

Such a mission would have less stringent delta-V and radiation dose constraints than the planned Europa orbiter, and could thus probably be carried out with significantly lower cost than EO.

References: [1] McEwen A. S. et al. (1998) *Science 281* 87. [2] McEwen A. S. et al. (2000) *Science 288* 1193. [3] Lopes-Gautier, R. et al. (2000) *Science 288* 1201. [4] Spencer, J. R. et al. (2000) *Science 288* 1198. [5] Spencer, J. R. et al. (2000) *Science 288,* 1208. [6] Veeder, G. J. et al. (1994) *J. Geophys. Res., 99,* 17095.