GALILEO MULTI-INSTRUMENT SPECTRAL OBSERVATIONS OF 243 IDA AND DACTYL

by J.C. Granahan, F.P. Fanale (University of Hawaii, 2525 Correa Rd., Honolulu, HI 96822), R. Carlson, L.W. Kamp, K.P. Klaasen (JPL), P. Helfenstein, P. Thomas (Cornell), A.S. McEwen (USGS), C. Chapman (PSI), J.Sunshine (MIT), M.J.S. Belton (NOAO), and the Galileo NIMS and SSI instrument teams.

On October 29, 1993 the Galileo spacecraft encountered the asteroid 243 Ida and its satellite Dactyl with a variety of remote sensing instruments. These included the solid state imager (SSI) instrument and a near infrared mapping spectrometer (NIMS). The SSI instrument is a CCD camera which imaged the 243 Ida system in 6 discrete visible wavelength filters ranging from 0.4 to .99 micrometers. The NIMS instrument is an imaging spectrometer which obtains spatial/spectral data between .7 to 5.2 micrometers in as few as 17 to 204 channels. These data sets were combined to conduct a spectral/spatial analysis of 243 Ida and Dactyl to evaluate the composition of these objects.

A variety of results were returned from the observations of 243 Ida. One side of 243 Ida is almost spectrally homogeneous. A combined SSI/NIMS spectral band area analysis revealed that the orthopyroxene/(orthopyroxene + olivine) is approximately 0.28 +-0.03. The differences observed on this side were subtle ones which could be due to photometric effects and/or minor grain size differences. This class of spectra is consistent with infrared observations conducted from Earth[6]. They also dominate the lower spatial resolution NIMS observations at a variety of geometries. The SSI color data found a spectral heterogeneity on the opposing side of 243 Ida (in a region not viewed or resolved by NIMS) which is characterized by a higher reflectance at 0.41 microns and a deeper 1 micron band feature[5]. These data suggest either an increase of the relative abundance of pyroxene with respect to the rest of 243 Ida and/or an increase of grain size. Due to the surprising discovery of the existence of Dactyl, the satellite of 243 Ida, it was possible to calculate the density range of 243 Ida. Belton *et al.* [2] calculated a density using a range of most probable circular orbits of 2.0 to 2.6.

There were also several spectral observations of Dactyl obtained by the Galileo spacecraft. SSI observations found that Dactyl possessed a deeper 1 micron spectral feature than was found anywhere on 243 Ida [7]. The NIMS data set also indicated a higher abundance of pyroxene, with a suggestion of clinopyroxene, than was found on 243 Ida [3]. Linear spectral mixing models also suggest a relative increase of pyroxenes present on the optical surface as compared to 243 Ida. Analysis of the combined SSI/NIMS data set found that both data sets are consistent in a deeper 1 micron band feature (centered at around .96 microns) than found on 243 Ida and a less "red" spectral continuum slope than 243 Ida. An asteroid's spectral continuum slope is determined by drawing a line from a point around 0.73 microns to a point 1.5 microns. Such "red" slopes are thought to be indicative of NiFe content [4]. Hence, this slope measurement may indicate that Dactyl has a lesser amount of NiFe on its surface than are present on 243 Ida.

These results have many implications for asteroid science. 243 Ida is a typical S asteroid and a member of the Koronis asteroid family. The following are some of the possible interpretations of the above spectral results:

GALILEO MULTI-INSTRUMENT SPECTRAL OBSERVATIONS OF 243 IDA AND DACTYL
by J.C. Granahan, *et al.*

I. 243 Ida has an orthopyroxene/(orthopyroxene + olivine) ratio consistent with those of LL chondrite meteorite materials. The density determinations of Belton [2] are consistent of 243 Ida being composed of ordinary chondritic material such as LL chondrites with a moderate amount of pore space. This would imply that S asteroids such as 243 Ida are primitive objects which have not been geologically reprocessed much since the formation of the solar system. It would also imply that some unknown "weathering" processes alters the optical surfaces of asteroids to introduce a "red" continuum slope to asteroid materials..

II. Although the spectra of 243 Ida has an orthopyroxene/(orthopyroxene + olivine) ratio consistent with those of LL chondrites, it has a "reddish" spectral slope much like those of mesosiderites. Gaffey [4] and Bell [1] would interpret this slope be due to NiFe that has been subjected to igneous differentiation processes such as pallasites and other stony irons. This would imply that 243 Ida is of a stony iron composition; with Dactyl being processed through igneous processes with less of a NiFe content. This interpretation would imply that the present orbits of Dactyl are not well characterized enough for a density calculation or 243 Ida must have an unbelievably high amount of pore space.

III. There are other analogous meteorites that have orthopyroxene/(orthopyroxene + olivine) ratio similar to that of 243 Ida and ordinary chondrites. These include meteorites such as acapulcoites, lodranites, IIICD irons, etc. These include achondrites and stony irons with low amounts of NiFe and sufficiently low density values to meet those values calculated by the Galileo team. This interpretation implies that 243 Ida is a partially differentiated object like an acapulcoite, a meteorite which is an intermediate in differentiation between an ordinary chondrite and a basalt. Or it could imply that 243 Ida was a differentiated object like lodranites, which could be the asteroidal equivalent of planetary mantle materials. Dactyl has a spectrum implicit of a higher pyroxene content, possibly hinting of clinopyroxene, that would imply an igneous derived object. The problem with this interpretation is that there are no laboratory spectra of these meteorite types that have been ground up into simulated asteroid regolithes to provide accurate analogs for comparison to asteroids.

[1]Bell, J.F. *et al.* (1989) Asteroids: The big picture, in Asteroids II, pp. 921-945.
[2]Belton, M.J.S., *et al.* (1994) Determination of the orbit of (243) 1 and the mass of 243 Ida, Bull. of the Amer. Astron. Soc., Vol. 26, No.3, pp. 1154.
[3]Carlson, R.W. *et al.*(1994) Infrared imaging spectroscopy of asteroid 243 Ida and discovery spectra of satellite 1993 (243) 1, Bull. of the Amer. Astron. Soc., Vol. 26, No.3, pp. 1156.
[4]Gaffey, M.J. *et al.* (1989) Reflectance spectroscopy and asteroid surface mineralogy, in Asteroids II, pp. 98-127.
[5]Helfenstein, P. *et al.* (1994) Regolith and composition of Ida: Clues from color and photometry, Bull. of the Amer. Astron. Soc., Vol. 26, No.3, pp. 1158.
[6]Tholen, D.J. and Spencer, J.R. (1992) Close encounters of the asteroidal kind: A preview of unpcoming encounters with 243 Ida and 4179 Toutatis, Bull. of the Amer. Astron. Soc., Vol. 24, No.3, pp. 934.
[7]Veverka, J. *et al.* (1994) Ida's satellite: What is it like?, Bull. of the Amer. Astron. Soc., Vol. 26, No.3, pp. 1155.