THE CLEMENTINE MISSION SCIENCE RETURN AT THE MOON AND GEOGRAPHOS;

R. W. Vorder Bruegge[1], M.E. Davies[2], D.M. Horan[3], P.G. Lucey[4], C.M. Pieters[5], A.S. McEwen[6], S. Nozette[7], E.M. Shoemaker[6], S.W. Squyres[8], and P.C. Thomas[8]. [1]SAIC, 400 Virginia Ave., S.W., Ste. 810, Wash., D.C., 20024. [2]RAND Corp., 1700 Main St., Santa Monica, CA, 90407. [3]Naval Research Lab., Code 8111, 4555 Overlook Ave., S.W., Wash., D.C., 20375-5000, [4]U. Hawaii, Planetary Geoscience Div., 2525 Correa Road, Honolulu, HI, 96822. [5]Brown U., Dept. Geological Sciences, Providence, RI, 02912. [6]USGS, 2255 N. Gemini Dr., Flagstaff, AZ, 86001. [7]SDIO/TNI, The Pentagon, R 1E167, Wash., D.C., 20301-7100, [8]Cornell U., 312 Space Sciences Bldg., Ithaca, NY, 14853.

Introduction: The Clementine Mission is being built and flown by the Naval Research Laboratory under the sponsorship of the Strategic Defense Initiative Organization of the United States Department of Defense in joint-cooperation with NASA, and will explore the Moon and the near-Earth asteroid (NEA) 1620 Geographos with lightweight sensors developed by the Lawrence Livermore National Laboratory. A NASA Science Team for this mission will be selected by way of a NRA in April 1993. The instrument suite includes imaging cameras that cover a spectral range from the near-ultraviolet to the mid-infrared, a laser ranger, and, potentially, a charged particle telescope. To be launched in early 1994, Clementine will be in lunar orbit from February through May 1994, at which time it will depart the Moon for a flyby of 1620 Geographos in August 1994. This mission represents an outstanding opportunity for scientists interested in the Moon and asteroids. It is anticipated that the data returned from this mission will permit: an assessment of global lunar crustal heterogeneity at a resolution of less than 1 km; an assessment of the lithologic heterogeneity of Geographos at a scale of 100 m or better; and an assessment of surface processes on Geographos on the order of 10 m. This abstract describes the basic mission of Clementine and some of the key scientific questions that will be addressed. Additional material on the Clementine mission, its data handling and processing, and its instrument suite is presented elsewhere in this volume [1, 2, 3].

Clementine Mission: Clementine will be launched in late-January 1994 using a Titan-IIG rocket and will be inserted into a 5-hour, elliptical polar orbit at the Moon with a perilune of ~400 km at 30°S latitude. After one lunar-month, the perilune will be rotated to 30°N latitude, where it will remain for another lunar-month. During this period a global imaging data set will be obtained, as well as altimetry coverage between 60°N and 60°S. On May 3, 1994, the spacecraft will leave lunar orbit and enter an Earth-centered phasing orbit. Following two Earth swingbys, the spacecraft will make a close lunar swingby on May 27 and depart for an encounter with Geographos on August 31. The Geographos flyby distance is currently baselined at 100 km.

Four instruments to be tested by Clementine will provide the most valuable scientific return. These include ultraviolet/visible (UV/Vis) and near-infrared (NIR) imaging systems, a mid-infrared imaging system (usually referred to as the "long-wave" IR or LWIR), and a laser ranger (LIDAR) high resolution imaging and ranging system. The LIDAR ranger will provide a lunar altimetry data set between 60°N and 60°S with along-track spacing of ~1 km and across-track spacing of ~40 km at the equator. The vertical resolution will be limited by 40-m range bins, though the actual performance may vary with albedo and surface roughness. Some basic characteristics of the imaging systems are provided in Table 1. Three of these cameras will have multispectral capability via filter wheels. The bandpass centers for these filters were selected to maximize the return of lithologic data and are shown in Figure 1. The fourth camera (LWIR) has a single broadband filter. The multispectral capabilities of the Clementine cameras will permit it to address many of the same questions addressed by Galileo at the Moon and at Gaspra but with broader spectral coverage and at a somewhat higher resolution.

Clementine at the Moon: The global data set collected by Clementine at the Moon will permit investigation of a variety of key questions based on the compositional heterogeneity of the surface. Based on similar Galileo multispectral data, Belton and co-workers [4] determined that the ejecta from the Orientale impact basin was derived primarily from the crust with little, if any, mantle penetration and excavation. This finding is consistent with the formation of Orientale at a late stage in the basin-forming epoch, after a thick lunar crust had been established, and is one example of how impact craters may be used as probes of the lunar interior. In another example Pieters [5] used telescopic reflectance spectra to determine that the impact event which created the 61 km-diameter crater Bullialdus excavated material from a compositionally-layered pluton within the uppermost 6 km of the lunar crust. The spatial resolution of the Clementine multispectral data should permit global lithological mapping on a scale as good or better than that which Galileo obtained and which can be obtained for the near-side of the Moon from Earth-based telescopes.

In another experiment, the Clementine LIDAR ranging experiment will provide a key data set for a variety of investigations. By combining the topography with gravity data, it becomes possible to map the density distribution of the lunar crust. It also provides a key information resource in almost all lunar geological studies [6]. The topography can be used in structural studies to estimate basin volumes and lava flow thicknesses, as well as to estimate lithospheric loads in flexure studies.

Clementine at Geographos: The August 1994 flyby of 1620 Geographos will permit investigation of the relationship of NEAs to Main Belt asteroids, comets, and meteorites. The specific measurements and scientific objectives for Galileo imaging at Gaspra [7] will hold for Clementine at Geographos: Global properties - size/shape, volume, period and pole position, cratering statistics and 'age' of surface; Surface morphology - crater morphology as a function of diameter, ejecta patterns, evidence of past internal activity, spallation features; Compositional features - surface composition and compositional heterogeneity; and Regolith properties - ejecta dispersal, stratigraphy, photometric properties. A primary goal in the exploration of asteroids is to examine the diversity of these objects. Key differences between Gaspra and Geographos are location and size. Gaspra is a mainbelt object approximately four times the size of the NEO Geographos. It will be interesting to examine the effects these differences have on some of the processes on small bodies such as cratering rate [8] and regolith processes [9-11].

References: (1) G. Shoemaker, LPSC XXIV (this volume), 1993. (2) A. McEwen, LPSC XXIV (this volume), 1993. (3) P. Lucey, LPSC XXIV (this volume), 1993. (4) M.J.S. Belton *et al.*, *Science*, **255**, p. 570, 1992. (5) C.M. Pieters, *Geophysical Res. Lett.*, **18**, p. 2129, 1991. (6) LGO Science Workshop Members, Contributions of a Lunar Geoscience Observer (LGO) Mission to Fundamental Questions in Lunar Science pp. 86, 1986. (7) M.J.S. Belton *et al.*, *Space Sci. Rev.*, **60**, p. 413, 1992. (8) C. Chapman *et al.*, 29th Plenary Meeting of COSPAR (Abstracts of the World Space Congress), p. 348, 1992. (9) Thomas *et al.*, *EOS, Trans. AGU*, **v. 73**, #43, p. 334, 1992. (10) McEwen *et al.*, 29th Plenary Meeting of COSPAR (Abstracts of the World Space Congress), p. 348, 1992. (11) C. Chapman *et al.*, LPSC XXIII, p. 219, 1992.

Table 1 - Some Characteristics of the Clementine Imaging Sensors

Instrument	Array Size	Bandpass (microns)	# Filters	Lunar Coverage	Pixel Resolution (m) Moon	Geographos
UV/Vis	288 x 384	0.25 - 1.0	5 or 6	Global	125 - 325	~ 25
NIR	256 x 256	1.0 - 3.0	6	Global	200 - 500	~ 40
LWIR	128 x 128	7.0 - 9.5	1	Partial (TBD)	50 - 125	~ 10
LIDAR	288 x 384	0.4 - 0.75	4	Partial (TBD)	40 - 100	< 5

Figure 1. Clementine multispectral filter set superposed on reflectance data for four lunar mineral separates. 0.95 micron band may be replaced by a broadband filter for navigational purposes.