orthopyroxene is likely to have been emplaced as a result of erosion and entrainment of the wall rock, and the olivine may be associated with new magmatic or juvenile volcanic material. An example of the Group 3 small pyroclastic deposits is that of J. Herschel crater (62°N, 42°W).

1.2. Objectives

The availability of Clementine high-spatial-resolution, multispectral data for the Moon allows us to characterize the compositions of lunar pyroclastic deposits at a level of detail that was previously unattainable [*Nozette et al.*, 1994; *McEwen and Robinson*, 1997]. A key issue involves the nature and distribution of new magmatic or juvenile pyroclastic materials. Although it is thought that low-albedo glasses and devitrified beads are the dominant components of many regional pyroclastic deposits, other components (such as finely or coarsely fragmented basalt clasts, and reworked country rock of either highlands or mare composition) also may be present in varying proportions [e.g., *Nagle*, 1978]. Identification and characterization of juvenile volcanic components are vital for understanding the primary mafic materials on the Moon and for constraining their eruption conditions and mechanisms.

In this paper, the Clementine UVVIS data are used to perform a compositional analysis of 15 small lunar pyroclastic deposits at 11 sites on the Moon (Figures 3 and 4; Table 2). The small pyroclastic deposits are the focus of this study because of their possible relative youth (~1 b.y. [*Spudis*, 1989]), their broad global distribution and relatively large population, and the fact that their small sizes may have limited the accuracy of early Earth-based (most commonly 1 to 10 km spectral spot size) spectral analyses. This analysis is complementary to that of *Weitz et al.* [1998], who used Clementine UVVIS data to study seven regional pyroclastic deposits. *Weitz et al.* [1998] supported previous identifications of iron-bearing glasses as major juvenile components of these deposits, and they characterized the distributions of glassy and devitrified materials to constrain models of their eruption dynamics in volcanic plumes. By comparing compositional data for both small and large pyroclastic deposits, the nature of juvenile materials in both types of deposits can be constrained. The objectives of this work are to (1) examine the spatial distribution of pyroclastic materials at a single site to determine whether evidence of multiple eruptions can be observed, (2) understand the extent of compositional variations among small lunar pyroclastic deposits, and (3) characterize the juvenile components of the small pyroclastic deposits.

2. Methods

2.1. Clementine Data Processing

The Clementine data were obtained by the UVVIS camera at five wavelengths or bands: 415, 750, 900, 950, and 1000 nm (0.415, 0.75, 0.90, 0.95, and 1.0 μm). The U.S. Geological Survey Integrated Software for Imagers and Spectrometers (ISIS) software [*Eliason*, 1997; *Gaddis et al.*, 1997a; *Torson and Becker*, 1997; *McEwen et al.*, 1998] was used to process the raw Clementine images and to create multispectral mosaics. Input files are predominantly single long-exposure files, with occasional use of merged long- and short-exposure data to improve saturated areas. Radiometric calibration and data processing steps were conducted in 11 phases [*McEwen et al.*, 1998; *Eliason et al.*, 1999], including electronic offset and gain corrections, dark-current subtraction, nonlinearity and temperature-dependent offset corrections, readout or frame transfer correction, flat-field and exposure-time corrections, normalization to a 1-AU distance and conversion to 1-AU relative radiance, conversion to reflectance, photometric normalization (to standard viewing angles of phase=30°, emission=0°, and incidence=30°), subpixel-level coregistration to nearest 0.2 pixel, projection to Sinusoidal Equal-Area, and automated mosaicking. The photometric correction is applied to permit accurate comparison of frame-to-frame reflectance values; the correction is a hybrid function involving separate corrections at different phase angle ranges [*McEwen*, 1991, 1996; *McEwen et al.*, 1998]. The hybrid photometric correction was derived from analyses of Galileo Solid-State Imager (SSI) data (primarily at the 756-nm wavelength) at phase angles of 20° to 100°, supplemented by analyses of low-phase (0° to 4°) Clementine data [*Buratti et al.*, 1996], and disk-integrated photometric models of P. Helfenstein (personal communication, 1998). Clementine data used in this analysis have original phase angles of 14° to 60° (Table 2). The data were spectrally calibrated from digital numbers (in counts/ms) to bidirectional reflectance (percent reflectance, within 5% of absolute) at the standard viewing geometry using reflectance properties of soil at the Apollo 16 landing site to facilitate compositional analyses (C.M. Pieters et al., Clementine UVVIS data calibration and processing, available at http://www.planetary.brown.edu/clementine/calibration.html, 1997) (hereinafter referred to as Pieters et al., online document, 1997).

Possible sources of error in the Clementine data include residual calibration errors (~1% filter-to-filter; Pieters et al., online document, 1997), photometric variations within a scene, uncorrected topographic effects, and scattered light. Residual photometric effects include wavelength-dependent variations (currently unaccounted for in the photometric normalization) at levels of about 0.2% across a Clementine frame and ~0.5% between frames. Topographic effects, particularly those due to steep slopes, can change the effective phase angle and thus alter the apparent brightness of a feature. Although characterization of the effects of topography on analyses of Clementine data are underway [e.g., *Jolliff*, 1999; *Robinson et al.*, 1999], no attempt has been made yet to include a topographic correction in the current Clementine data processing. Scattered light is a possible anomalous brightness in which high-albedo units influence the measured values of low-albedo units (and vice versa) to varying degrees at different wavelengths [e.g., *Gaddis et al.*, 1995; *Li et al.*, 1999]. In the Clementine data, at a wavelength of 415 nm (where scattered light appears to be most significant), scattered light has an estimated magnitude of ~10% in residual brightness near the lunar limb, and it falls to a value of ~3% at a distance of 200 pixels [*Robinson et al.*, 1999].

2.2. Interpretation of Lunar Multispectral Data

In the UVVIS spectral range of the Clementine data, iron-bearing silicate minerals (such as pyroxene and olivine) and volcanic glasses have characteristic Fe^{2+} electronic transition absorption bands near 1.0 μm [e.g., *Burns*, 1993]. The presence and composition of these components can be characterized by the position, shape, and depth of their mafic