EJECTA DISTRIBUTION AND RELATIVE AGES OF THE IMBRIUM, SERENITATIS, AND CRISIUM BASINS. W. A. Ambrose[1], [1]Bureau of Economic Geology, The University of Texas at Austin, University Station, Box X, Austin, TX 78713-8924, william.ambrose@beg.utexas.edu.

Introduction: LOLA data reveal an extensive system of ejecta features associated with the Serenitatis, Crisium, and Imbrium Basins (Fig. 1). These ejecta features consist of radial valleys, asymmetric secondary craters, and crater chains. The distribution, orientation, and overlapping relationships between these ejecta features provide an improved insight into the sequence of basin formation. This sequence is confirmed to be from oldest to youngest, (1) Serenitatis, (2), Crisium, and (3) Imbrium, consistent with findings from a recent study of the Sculptured Hills east of Mare Serenitatis [1]. Overlapping relationships between Imbrium and Crisium ejecta northwest, north, and northeast of the Crisium Basin provide a context for refining previous interpretations of the age of terrain in areas marginal to these basins [2, 3, 4, 5, 6].

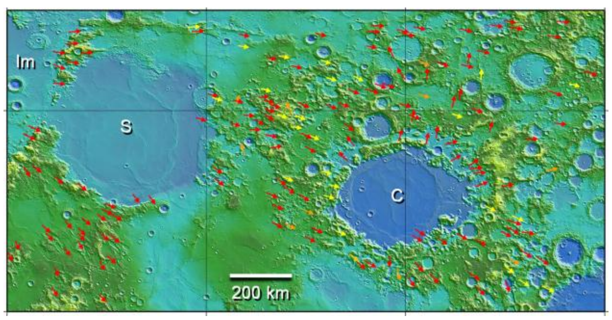

Figure 1. LOLA topography and ejecta features associated with the Serenitatis Basin (S), Crisium Basin (C), and the east and southeast margins of the Imbrium Basin (Im). Ejecta are denoted by arrows. Orientation of arrow indicates direction of ejecta formation. Arrow colors: red= radial valleys; yellow = asymmetric secondary craters; orange = crater chains. Details of the Serenitatis Basin and Serenitatis Highlands are shown in Fig. 2. Details of the Crisium Basin are shown in Fig. 3.

Serenitatis-Crisium Highlands: Highlands east of Mare Serenitatis and northwest of Mare Crisium are composed of hills and lineated terrain that contain ~20 radial valleys and ~10 shallow-floored, asymmetric secondary craters (Fig. 2). Asymmetric secondary craters also occur in peripheral areas of the Nectaris, Crisium, and Humorum Basins [7, 8, 9, 10]. Serenitatis-Crisium highlands also include the Sculptured Hills, terrain composing knobby highlands material and light plains units in the vicinity of the Taurus Mountains and the Apollo 17 landing site, and extending northward along the east rim of the Serenitatis Basin [11, 12]. The morphology of the Sculptured Hills and highlands terrain to the east superficially suggests an origin as Serenitatis ejecta. However, the dominant orientation of lineated terrain in this area is azimuth 245 (azimuth 0 defined as due north), radially aligned with the Imbrium Basin. Moreover, the presence of radially aligned ejecta that overlap craters such as Posidonius and Le Monnier which post-date the Serenitatis impact event are inconsistent with a Serenitatis origin. The great distance of ejecta features in the Serenitatis-Crisium highlands and Sculptured Hills from the center of the Imbrium Basin (~1,200 km) may call into question their origin as Imbrium ejecta. However, Imbrium ejecta occur at comparable or greater distances in the Southern Highlands northwest of the Nectaris Basin [8, 13]. Other Imbrium ejecta north of the Serenitatis-Crisium highlands, 1,000 to 1,200 km from the center of the Imbrium Basin, with orientations ranging from azimuths 260 to 275, overlap Lacus Somniorum and highlands terrain near Franklin and Cepheus (Fig. 2).

Serenitatis ejecta. Four radial valleys in the Serenitatis-Crisium highlands do not share the dominant alignment (azimuth 245) of Imbrium ejecta and are interpreted to be Serenitatis ejecta (Fig. 2). They occur 200 to 220 km east and southeast of Posidonius, with azimuths ranging from 270 to 285. Although radial valleys in the Taurus-Littrow region have orientations consistent with a Serenitatis origin, they are also subparallel to Imbrium ejecta west of the Crisium Basin that have an average azimuth of 240 and therefore may instead be of Imbrium origin. In contrast, radial valleys (average azimuth 215) in Montes Haemus on the south rim of the Serenitatis Basin, west of Plinius, are clearly of Serenitatis origin, having an oblique orientation relative to Imbrium ejecta to the southwest (Fig. 2).

Crisium Basin and Imbrium Ejecta: Crisium is an elongate Nectarian basin formed by a low-angle impact [12, 13, 14, 15]. It has two well-developed ejecta fields distributed northeast and southeast of the basin (Fig. 3), reflecting an oblique impact from the west [9].

West and Southwest Margins. The majority of ejecta on the west and southwest margins of the Crisium Basin were previously interpreted from Lunar Orbiter data as Imbrian terra and plains material [5, 6]. Examples include Tisserand A (~20.5ºN, 49.6ºE), a shallow-floored asymmetric crater that impinges on the west margin of the Crisium Basin, interpreted in this study as an Imbrium secondary crater. Other examples

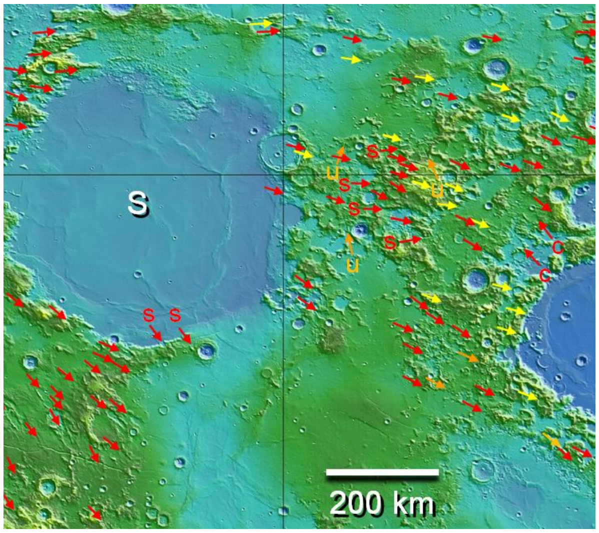

Figure 2. LOLA topography and ejecta features associated with the Serenitatis Basin (S) and the Serenitatis-Crisium Highlands. Ejecta are denoted by arrows. Orientation of arrow indicates direction of ejecta formation. Arrow colors: red= radial valleys; yellow = asymmetric secondary craters; orange = crater chains. Ejecta provenance is indicated by s (Serenitatis), c (Crisium), and u (unknown) adjacent to arrows. Unlabeled arrows indicate Imbrium provenance.

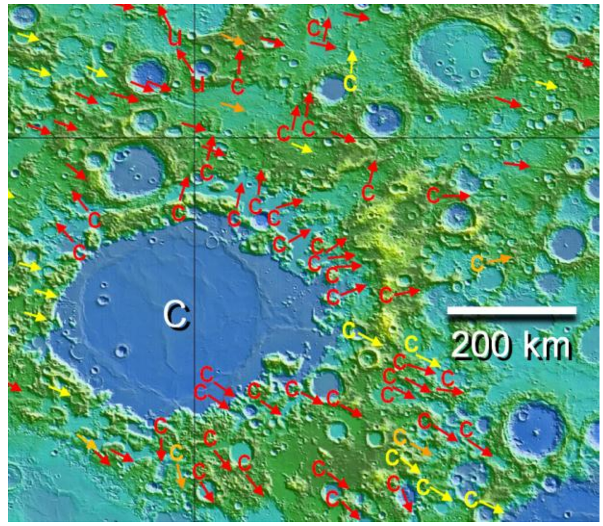

Figure 3. LOLA topography and ejecta features associated with the Crisium Basin (C). Ejecta are denoted by arrows. Orientation of arrow indicates direction of ejecta formation. Arrow colors: red= radial valleys; yellow = asymmetric secondary craters; orange = crater chains. Ejecta provenance is indicated by c (Crisium), and u (unknown) adjacent to arrows. Unlabeled arrows indicate Imbrium provenance.

include lineated terrain south of Franz (~15.5ºN, 40.5ºE), northeast of Macrobius (~23ºN, 47ºE), and south-southwest of Tralles A (~25.5ºN, 46.5ºE). However, an unnamed asymmetric secondary crater between Macrobius and Macrobius A (19.7-20.2ºN, 41.8-43.2ºE), previously mapped as Imbrian [5], may be Serenitatis ejecta, being more degraded than other nearby ejecta. Elongate scoured terrain west of Apollonius A (~6-8ºN, 52-55ºE), are likely Imbrium ejecta, owing to being well-preserved and being oriented subparallel to other Imbrium ejecta to the northwest.

North and Northeast Margins. An extensive (400-km) field of southeast-trending ejecta features, inferred to of Imbrium origin, occurs north of the Crisium Basin (Fig. 3). The presence of both Imbrium and Crisium ejecta provides age constraints for features in this region. For example, superposition of Imbrium ejecta onto Geminus glacis, not recognized in [4], confirms Geminus to be post-Imbrian in age. In addition, southeast-trending radial valleys ~60 km east of Burckhardt A (~31ºN, 63ºE) onto terrain mapped as Imbrium plains units [3] suggests this terrain may instead be Nectarian in age.

References: [1] Spudis P. D. (2011*) LPS XLII*, Abstract #1365. [2] Wilhelms D. E. (1987) *USGS Prof. Paper 1348*, 302 p. [3] Casella C. J. and Binder A. B. (1972) *Geol. Map Cleomedes Quad.*, http://www.lpi.usra.edu/resources/mapcatalog/usgs/I707/. [4] Grolier M. J. (1974) *Geol. Map Geminus Quad.*, http://www.lpi.usra.edu/resources/mapcatalog/usgs/I841/. [5] Scott D. H. and Pohn H. A. (1972) *Geol. Map Macrobius Quad.*, http://www.lpi.usra.edu/resources/mapcatalog/usgs/I799/. [6] Olson A. B. and Wilhelms D. E. (1974) *Geol. Map Mare Undarum Quad.*, http://www.lpi.usra.edu/resources/mapcatalog/usgs/I837/. [7] Clark M. (2006) *The Lunar Observer, June*, 4–10. [8] Ambrose W. A. (2009) *LPS XL*, Abstract #1015. [9] Ambrose W. A. (2010) *LPS XLI*, Abstract #1061. [10] Ambrose W. A. (2011) *LPS XLII*, Abstract #1035. [11] Wolfe E. W. et al. (1981) *USGS Prof. Paper 1080*, 280 p. [12] Head J. W. (1974) *Moon 9*, 355-395. [13] Wood C. A. (2003) *The Modern Moon*, 209 p. [14] Spudis P. D. et al. (1997) *LPS XXVIII*, Abstract #1296. [15] Schultz P. H. and Stickle A. M. (2011) *LPS XLII*, Abstract #2611.