The evolving lunar highlands: new views on lunar crust formation

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Overview: The lunar crust provides a waelth of information about the early history and broad-scale petrogenesis of the Moon. Based on analyses of samples returned by Apollo and Luna missions, the current paradigm of the Lunar Magma Ocean (LMO) was developed [1], in which the LMO cooled and differentiated to a small dense core, an inner mantle, and an outer primary crust composed of plagioclase, which later was intruded by secondary magmatism [1-3]. However, it is now acknowledged that the returned Apollo and Luna samples may not represent the Moon's global geological makeup.

New perspectives: New datasets from experimental and computational studies, remote sensing of the lunar surface, new gravity data, geochronology, geochemistry, and new samples from the lunar meteorite collection have tested and built upon the foundation of the old lunar formation models [e.g., 2,4-10]. Many of the feldspathic meteorites contain fragments (clasts and mineral debris) of anorthositic rocks that can be divided into three distinct groups [6]: 1) 56% of them only contain magnesian anorthosites (MAN); 2) 19% of them only contain ferroan anorthosites (FAN); and 3) 25% of them contain anorthosites that span a coninuous range from hyperferroan to highly magnesian. Thus, MAN rocktypes seem to be characteristic of many feldpathic highland crustal areas [4,7]. However, it is currently hard to account for such rock types from the traditional LMO model [1, 6].

We will summarize recent discoveries that constrain the old views and alternative lunar magma ocean models. These new assessments provide us with new views of the complexities of lunar evolution.

[1] Wood *et al.* (1970) *Proc. Lunar Sci. Conf. 1*, 965-988 [2] Shearer *et al.* (2006) *Rev. Min. Geochem.* **60**, 365-518 [3] Warren & Wasson (1977) *Proc. Lunar Sci. Conf. 8th* 2215-2235 [4] Arai *et al.* (2008) *EPS* **60**, 433-444 [5] Borg *et al.* (2015) *MaPS* 50, 715-732 [6] Gross *et al.* (2014) *EPSL* **388**, 318-328 [7] Takeda et al. (2006) *EPSL* **247**, 171-184 [8] Zuber et al. (2013) *Science* **339**, 668-671 [9] Elardo et al (2011) *GCA,* 75, 3024-3045 [10] Elkins-Tanton et al. (2011) *EPSL* 304, 326-336.