Magmatic Evolution 2. A New View of Post-differentiation magmatism. C.K. Shearer[1], C.R. Neal[2], L.R. Gaddis[3], B.L. Jolliff[4], and A.S. Bell[1]. [1]Institute of Meteoritics and Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131 (cshearer@unm.edu), [2]Department of Civil & Env. Eng. & Earth Sciences, University of Notre Dame, Notre Dame, IN 46556. [3]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, Arizona. [4]Washington University, St. Louis, Mo 63130.

Introduction: Lunar magmatism is represented by numerous episodes of intrusive and extrusive activity ranging from ~ 4.4 Ga to perhaps younger than 1.0 Ga [1]. These magmatic episodes shaped the lunar crust and are expressions of the thermal evolution of the mantle, lithosphere, and crust. Lithologies representing these periods (excluding the primary ferroan anorthositic suite) include magnesian suite, alkali suite, high-Al basalts, KREEP basalts, cryptomare basalts, mare basalts, felsic volcanics, and pyroclastic deposits. The role of magnesian anorthosites within these magmatic rock suites is still a point of debate. In “New Views of the Moon” (first edition, hereafter NVM1) Chapter 4 “Thermal and Magmatic Evolution of the Moon” [2] examined the timing, composition, and petrogenesis of lunar magmatism and its relationship to lunar thermal evolution. More recently, several missions, new state-of-the-art sample measurements, new lunar samples (meteorites), and sophisticated modeling have provided a new perspective on lunar magmatism. We use these new observations to expand our understanding of these episodes of lunar magmatism.

New Observations: The intent of this writing team is to integrate new measurements, observations, and models into our understanding of lunar magmatism at the beginning of the 21st century. Here, we highlight only a few of these new observations.

Crystallization ages of the first stages of post-differentiation magmatism: Recent studies indicate ages for primordial crust (ferroan anorthosites), first stages of secondary crust (Mg-suite magmatism), and model ages for KREEP and mare basalt sources overlap at approximately 4.38 Ga [3,4]. What is the origin of such a major thermal-magmatic event?

Role of volatiles and volatile-elements in lunar magmatism: Since the return of samples by the Apollo program, the Moon has been considered “dry.” However, numerous recent studies have revealed that H-species played a role in lunar magmatism [5-7]. Estimates of the relative proportions of H-species (e.g. H_2, OH, H_2O) at the low fO_2 of the Moon indicate that H_2 is an important constituent of basaltic magmas and related volatiles [8]. What was the H-speciation and systematics of H and other volatiles in lunar magmas? What role did volatiles play in mantle melting and lunar magmatism?

Pyroclastic glass deposits: Studies of pyroclastic glass beads indicate that their eruption was driven by volatiles. Observations from LRO and M^3 indicate that the distribution of volcanic glass across the lunar surface is much more widespread than previously documented [9,10]. These deposits represent many eruptive styles. What is the relationship between volatile composition and abundance during such eruptions? Do these deposits represent melting of fundamentally different mantle sources than the crystalline mare basalts?

Felsic magmatism: Felsic material was discovered in samples returned by Apollo; however, this type of nonmare volcanism is rare. Examples occur in the PKT, but data relating the samples to geologic context is scarce. LRO observations have identified volcanic features with silica- or alkali-feldspar-enriched volcanics, and these volcanics extend to the lunar farside [11-12]. How are these expressions of nonmare magmatism generated? Over what duration and environment were these magmas produced?

Models for the relationship between basin formation and magmatism: NVM1 explored the role of impact-basin formation initiating melting and providing pathways for magmas to the lunar surface [2]. The relationship between magmatism and impacts has been modeled and vigorously debated [e.g. 13,14]. More recently several models have explored the effect of the South Pole-Aitken basin formation on triggering magmatism in the mantle beneath the antipodal nearside [e.g. 15]. Depending on the age of SPA, this event could trigger either mare magmatism starting at ≈ 3.85 or the 4.38 Ga thermal-magmatic event.

***Magmatism < 1Ga*:** Since NVM1, new observations suggest magmatic and fumarolic activity has occurred as recently as 10-100 Ma [1,16]. Such young magmatism requires a new approach to understanding the thermal history of the Moon.

References: [1] Braden et al. (2014) *Nat. Geosci.* 7, 787-791. [2] Shearer et al. (2006) *RIMG* 60, 365-518. [3] Borg et al. (2015) *MAPS, 50 715-732*. [4] Shearer et al. (2015) *Am. Mineral. 100, 294-325*. [5] Saal et al. (2008) *Nature* 454, 192-195. [6] Hauri et al. (2011) *Science* 333, 213-215. [7] McCubbin et al. (2010) PNAS 107, 11223-11228. [8] Sharp (2013) EPSL 380, 88-97. [9] Bennett et al. (2016) Icarus in press. [10] Besse et al. (2014) *JGR Planets* 119, 355-372. [11] Lawrence et al. (2010) LPSC 41, abstract #1906. [12] Jolliff et al (2011) *Nat. Geosci.* 4, 566-571. [13] Ivanov and Melosh (2003) *Geology* 31, 869-872. [14] Elkins-Tanton et al. (2004) *EPSL* 222, 17-27. [15] Kring et al. (2015) ESSIB III, abstract #3009. [16] Schultz et al. (2006) *Nature* 444, 184-186.