EOLIAN DEPOSITS OF PYROCLASTIC VOLCANIC DEBRIS IN METEOR CRATER. C. M. Altomare[1], A. L. Fagan[2], and D. A. Kring[3]. [1]Lafayette College, Easton, PA 18042, USA altomarc@lafayette.edu, [2]Lunar & Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, USA, fagan@lpi.usra.edu. [3]Lunar & Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, USA, kring@lpi.usra.edu.

Introduction: Barringer Meteorite Crater (1.2 km diameter), more commonly known as Meteor Crater (MC), was excavated by an impacting iron asteroid ~50 ka (e.g., [1-3]). As Earth's best preserved impact crater, it is fundamental to our understanding of impact cratering processes and is a classic analogue for impact craters on other planetary bodies. The crater is located 29 km SE of the San Francisco Volcanic Field (SFVF), Arizona and 53 km E of Flagstaff, Arizona.

Erosion has affected the crater walls, causing sediments to accumulate on the crater floor. Recently, a ≥86 cm-thick eolian deposit was discovered adjacent to the southwest crater wall beneath a layer of colluvium (Fig. 1). The deposit contains sediments derived from the local target material, as well as unexpected pyroclastic volcanic ash and cinder debris. Two thin ash horizons in the crater floor (Fig. 1) were previously described by Shoemaker and attributed to the volcanic cinder cone Sunset Crater (0.9 ka). It's unknown if these ash layers are related to the recently discovered eolian deposit [3,4]. Here we report petrologic analyses of the pyroclastic debris and explore possible sources for the volcanic material.

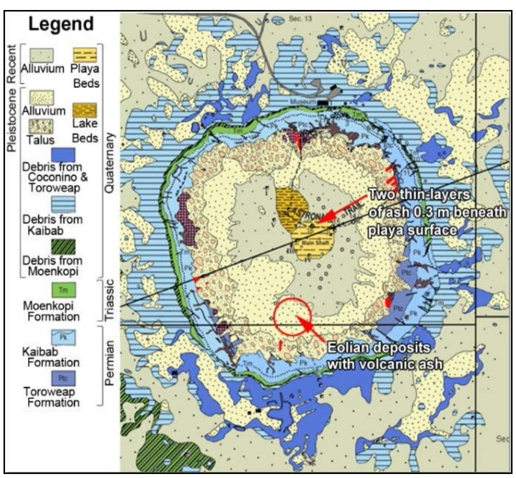

Fig. 1. Geologic map of Meteor Crater [3]. Red arrows identify deposits of interest.

Methods: Major and minor element analyses were made with a Cameca SX-100 Electron Microprobe (EMP) at NASA Johnson Space Center (JSC). The instrument was calibrated using JSC standards of known composition and operated with a 15 keV accelerating potential, 20 nA beam current, 1μm beam diameter, and 30s on-peak counting times.

Mineral compositions were compared with data from the literature to identify potential volcanic sources in the region. Potential sources must satisfy a set of conditions: (1) have similar mineral compositions to those in the MC samples, (2) be located where pyroclastic debris can be transported to MC, and (3) have suitable ages.

Results: *Petrography.* MC51211-1a is a 2-layered sample with a porosity of 11.5%. The lower, coarser horizon contains sand-sized sedimentary particles of hematite-cemented quartz siltstone, quartz-sand-bearing micritic carbonate, and micritic carbonate. The overlying, finer-grained layer is a mixture of sedimentary particles and volcanic ash (≤2 mm). Sedimentary particles in both horizons are poorly sorted, but those in the lower layer have low sphericity and are generally sub-rounded, while the upper layer shows diversity in both sphericity (low to high) and shape. The volcanic particles are coarse to medium silt-sized fractions and are poorly sorted, displaying a diverse range of sphericity and shape, which is typically more angular than the sedimentary particles. Volcanic particles in the overlying layer are composed of olivine, plagioclase, and clinopyroxene phenocrysts; some particles are vesicular and others are microcrystalline.

MC51211-4a, collected ~86 cm above sample 1a, has a 20.2% porosity. It contains ash-sized sedimentary and volcanic particles. Sedimentary particles are composed of silt-sized quartz, sutured quartz, micritic carbonate, sand-sized hematite-cemented quartz siltstone, and quartz-sand-bearing micritic carbonate. These particles are poorly sorted with diverse sphericity and shape. Vesicular, silt-sized volcanic particles are usually dominated by olivine, plagioclase, and clinopyroxene phenocrysts, but also include microcrystalline textures. Volcanic particle shapes are more angular than those among the sedimentary particles.

Mineral Chemistry. Forty-two particles of ash and cinder were analyzed using the EMP from samples MC51211-1a and -4a. Samples contained microcrystalline plagioclase (An_{72-55},$Ab_{43-27}$$Or_{2-1}$), sometimes associated with groundmass pyroxene (Wo_{44},En_{45-37},Fs_{19-12}) and/or olivine (Fo_{81-75}). Olivine phenocrysts (Fo_{86-72}) and/or plagioclase phenocrysts (An_{74-58},Ab_{41-25},Or_1) may also be present. Olivine phenocrysts are normally zoned with rims of Fo_{84-73} (Fig. 2a).

Discussion: *Potential Source Constraints*: Vesicular particles containing Mg-rich olivine, Ca-rich plagioclase, and Ca-rich clinopyroxene came from either a basaltic or basaltic andesite vent. The angularity and poor sorting of the volcanic particles, plus the thickness of the deposit, suggest a nearby source. The age of the eolian deposit relative to the ages of potential sources provides an additional constraint. The eolian deposit superposes MC lake deposits ~12 ka in age [1]. Sources younger than ~12 ka could have deposited the pyroclastic debris within the crater through atmospheric transport during an eruption. Alternatively, material from older sources could have been redeposited via secondary transport.

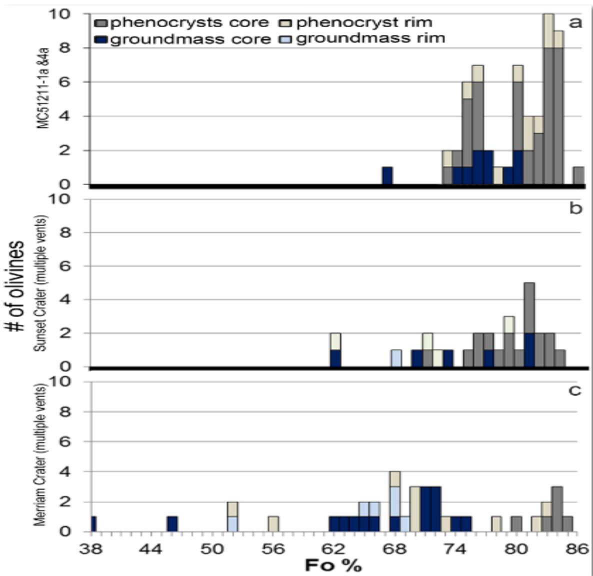

Fig. 2. Olivine Forsterite histograms for (a) MC51211 [this study], (b) Sunset Crater [5,6] and (c) Merriam Crater samples [6,7].

Potential Sources and Suitability: Five potential volcanic sources for the eolian deposit include two sources >12 ka (West Sunset Mountain and Merriam Crater), two sources with unreliable ages (SP Mountain and Saddle Mountain), and one that erupted <12 ka (Sunset Crater). Petrologic data from the literature indicate volcanic particles from Sunset (Fig. 2b) and Merriam (Fig. 2c) craters are similar to those from MC. Petrologic data for the other vents was not available.

West Sunset Mountain & Merriam Crater. Basaltic West Sunset Mountain (4-8 Ma) is ~13 km south of MC [8]. Winds in the area can transport material distances of tens of km. Sunset Mountain's proximity to MC potentially allowed ash and cinder to be reworked and transported by winds that had only a slightly different direction than current SW to NE prevailing winds [9,10]. Merriam Crater cinder cone is farther away (~42 km) and located NNW from MC. Its age is estimated as either 150±30 ka [11] or 293±10 ka [12]; thus, this source likely predates both MC and the eolian deposit therein. Its ash could also be reworked and transported to MC, but it would require a period when wind blew strongly N to S.

SP & Saddle Mountains. The basaltic andesite SP Mountain cinder cone is in the northern region of the SFVF. Its age is debated [13,14], with some ages reported at 71 ± 4 ka [15] and 5.5 to 6 ka [16]. If SP predates MC, it is unlikely to be the source of the pyroclastic debris due to the required ground transport distance (~82 km) and the necessity of NW to SE prevailing winds. If, however, SP is younger than MC, then an explosive eruption could transport particles to MC in an ash cloud. Similarly, Saddle Mountain is a young (17 ka [17]) basaltic andesite source. Its age, however, which is younger than that of MC, but older than the MC lake deposits on which the eolian deposit sits, would require secondary reworking and transport. That seems less likely given the distance (~78 km) and topographic barriers between it and MC.

Sunset Crater. Basaltic Sunset Crater is younger (0.9 ka) than both MC and the lake sediment fill that the eolian deposit covers. It is ~57 km NW of MC. MC sample phenocrysts are compositionally indistinguishable from Sunset xenocrysts (Fig. 2b). Moreover, material originating from the vent is known to cover at least ~315 km^2 and nearly reaches the edges of Flagstaff, Arizona, where layers of ash and cinder are up to 10 cm thick [18]. A thinner layer of ash could have been deposited in MC and then been reworked locally by winds on the crater floor.

Conclusion: The source of the volcanic particles within Meteor Crater is unclear, but Sunset Crater and Merriam Crater are the most likely sources. Both basaltic cinder cones have similar mineral compositions to the MC sample and are <60 km from MC. Sunset is younger than MC, so its ash could have been deposited directly into the crater. Merriam, on the other hand, is older, which would require the reworking and secondary transport of ash to MC after it formed. It will be prudent, however, to analyze samples from West Sunset and SP mountains to determine if they are also similar to those in MC before drawing final conclusions.

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