MOJAVE CRATER: POSSIBLE SOURCE FOR MARTIAN METEORITES. S. C. Werner[1], H. J. Melosh[2], H.Y. McSween[3], Y. Liu[4,3], I.P. Baziotis[3], R.J. Bodnar[5], P.S. DeCarli[6], and L. A. Taylor[3]. [1]Center for Earth Evolution and Dynamics, University of Oslo, NO-0316 Oslo, Norway, (Stephanie.Werner@fys.uio.no). [2]Dept. of Earth, Atmos. & Planet. Sci., Purdue Univ., West Lafayette, Indiana 47907,USA. [3]Dept. of Earth & Planet. Sci., Univ. of Tennessee, Knoxville, TN 37996, USA. [4]JPL, California Instit. of Tech., Pasadena, CA 91109, USA. [5]Dept of Geosc., Virginia Tech, Blacksburg, VA 24061. [6]Poulter Laboratory, SRI International, Menlo Park, CA 94025, USA.

Introduction: The Mojave Crater on Mars has a diameter of about 55 to 60 km; it is situated at 7.5^{o}N and 33.0^{o}W at the joint of Simud and Tiu Valles in Xanthe Terra (Fig. 1). It attracted attention for its well preserved landforms resembling the morphology of alluvial fans in arid environments [1-3], and suggesting a very young formation age. However, because of its large size, speculations on the age range from late Hesperian [4, 5] to late Amazonian age.

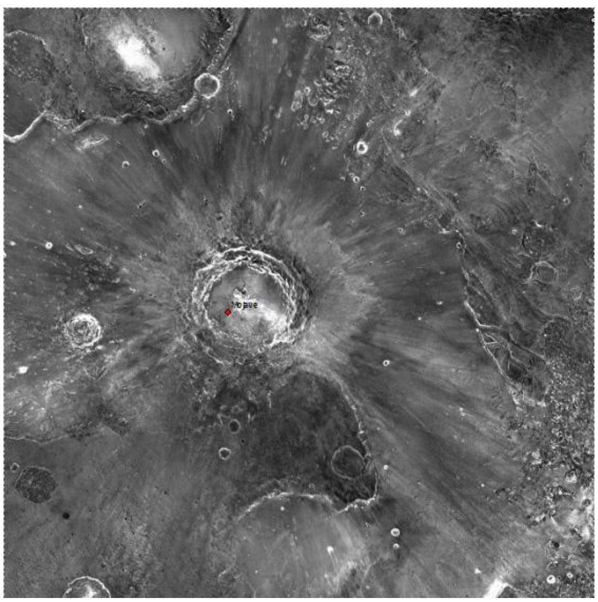

Figure 1: *5^o x 5^o THEMIS Night-time mosaic with Mojave at the center, a well preserved morphology and ray pattern is observed.*

Crater Statistics and the Age of Mojave Crater: We performed crater counts on the entire continuous ejecta blanket and on the flat parts of the crater interior. Figure 2 summarizes the resulting crater size-frequency distributions and interpreted absolute ages. Considering all craters, (partially) buried and fully exposed, of the continuous ejecta blanket, the resulting cumulative crater size-frequency distribution reveals at least one significant resurfacing event. The oldest absolute model age is found on the crater ejecta for the crater diameter range D > 1.1 km, with our best fit model age of 2.93 +0.35/-0.77Ga (large statistical error bars!) using crater-production function and cratering chronology according to [6]. One could interpret this as the crater age [e.g., 5], who also reported subsequent resurfacing, but apparently did not consider very small craters.

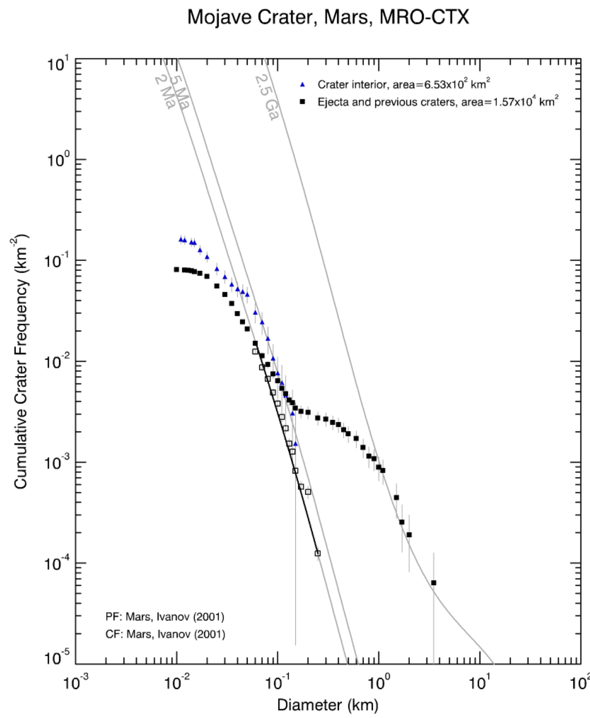

Figure 2: *Crater size-frequency distributions and absolute model ages for the continuous ejecta blanket and crater interior using crater production function and cratering chronology according to [6].*

Our crater counts show a well pronounced and strong resurfacing event and the removal of craters with diameters between 1.0 and 0.1 km in diameter. The shape of the crater size-frequency distribution suggests that this event occurred at once, rather than by continuous infill of, for example, aeolian sediments, or due to cyclic deposits under obliquity variations. The sudden and strong emplacement of material can be interpreted as the ejecta emplacement itself: According to simple crater morphometry assumptions, both the estimated ejecta blanket thickness of Mojave Crater and depth-diameter relation of the erased craters in the ejecta units yield on average a deposit layer thickness of about 200-250m. Variations of the ejecta thickness occur with the distance from the crater center and are in agreement with larger craters being only partially buried at the ejecta blanket edges. Craters emplaced after the ejecta emplacement and in the crater interior suggest absolute model ages between 1 and 5 Ma, based on craters in the diameter range of 50 m to 250 m in diameter. The crater size-frequency distribution for crater diameters smaller than about 50 m in diameter departs from the predicted isochron (Fig. 2) indicating resurfacing activity in agreement with continuous aeolian or other cyclic deposition.

Young large rayed craters were suggested as possible sources for Martian meteorites [7], which range between in diameter between 2. 6 and 29 km, and have been dated by cratering statistics to have formed in the most recent 15 Ma [8]. Statistically, a 60-km-sized crater could form every 50 millions of years. Mojave Crater exposes features similar to the crater class of very young rayed craters, (Fig. 1), and chains of secondary crater clusters are clearly visible on the plateau units and on the floors of Simud and Tiu Valles. These secondary chains coincide with ray patterns observed on THEMIS night-time mosaics (Fig. 1). Observed crater distributions on the channel floors, for example of Simud Vallis, and of the same geological background unit are strongly influenced by the near field secondary craters produced by Mojave, but do not show such a pronounced resurfacing event as we observe in the ejecta unit.

Therefore, we conclude that the formation age of Mojave Crater can be as young as a few (1-5) millions of years. We will use new cratering rate estimates by [9] to fine-tune our age estimate.

The geology and petrology of the Mojave area: The Mojave impact site geology, being situated at the channel floor between Simud and Tiu Valles in Xanthe Terra, suggests that the ejected rock possibly crystallized in the Noachian, however, the channel formation of Simud and Tui Valles includes significant erosion and also sedimentary deposition. The target could be modified by tectonic and shock-induced brecciation, as well as by aqueous alteration and metamorphism by fluid flow.

This already limits the meteorite connection to ALH 84001 and the recently discovered meteorite NWA7034 [15], unless crystallization ages are underestimated for shergottites due to the measurement procedure [16] or shock induced alterations [17].

Mojave's connection to Martian meteorites: Cosmic-ray exposure (CRE) ages of Martian meteorites are less than 20 Ma [18]. One example could be the Tissint meteorite, which was collected in Morocco in 2011 after its fall was observed [10]. For Tissint cosmic-ray exposure (CRE) ages of 0.7 Ma [11] or 1.1 Ma [12] have been reported. Tissint can be grouped with a few other meteorites based on the CRE age [13, 14], its composition [11, 14], and peak shock pressure modification of minerals [13, 14]. Tissint shows a number of rather large (up to 75 x 150 μm^2 ringwoodite) grains of high pressure mineral that had time to crystallize and grow at high pressure in this meteorite as it was being launched. Evidence of large ringwoodite grains [13, 14] are used to calculate the peak pressure and temperatures during the impact event. This gives a time at which the meteorite was maintained at high pressure of about 1 second, implying a rather large source crater-estimates range from 50 to 90 km diameter, as described in [14]. This is much larger than that inferred for any other Mars meteorite, and also much larger than other known rayed craters on Mars. However, the crystallization ages of this meteorite group range between 173 to 596 Ma (the latter is Tissint, which is the oldest [19]), and do not fit the geological setting of the Mojave crater area.

Implications: Two lines of evidence join together to imply, for the first time ever, that at least one group of Martian meteorites can be connected to a source crater of significantly larger size than previously suggested. We report the possible identification of Mojave crater as the parent of some of the Martian meteorites, which all have CRE ages lower than 20 Ma.

Outlook: Which of the meteorite groups, or whether a so far undiscovered group, could be sourced by Mojave as recently as a few millions of years ago remains unresolved. However, we found a large, very young impact crater on Mars, which could be a prime candidate for a sample return mission, not only to calibrate cratering chronology, but also to study only 1 Ma-old aqueous activity on Mars.

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