

PARENT CRATERS FOR THE SNC METEORITES P.J. Mouginis-Mark, T.J. McCoy, G.J. Taylor and K. Keil, Planetary Geosciences Divn., Dept. Geology and Geophysics, SOEST, Univ. Hawaii, HI 96822.

INTRODUCTION: The recognition that the SNC (shergottites, nakhlites, Chassigny) meteorites are probable Martian samples opens new possibilities for the assessment of the geologic evolution of Mars. As with any geologic samples, knowing where the samples are derived from is extremely desirable. In the case of the SNC meteorites, it may be possible to constrain the source area by examining the morphology and distribution of meteorite craters that may satisfy some of the chronological and petrological constraints imposed by these rocks. At the same time, it may also be possible to evaluate the models for the genesis of the SNC's by determining if appropriate geologic settings exist to satisfy the requirements imposed.

SAMPLE CONSTRAINTS: Measurements by a variety of techniques and workers (1) yield 1.3 Ga crystallization ages for the nakhlites and Chassigny. Ages for the shergottites are considerably less clear. A whole rock Sm-Nd age of 1.27 Ga may be the crystallization age, consistent with ages for nakhlites and Chassigny. Mineral isochrons, by a variety of methods (Rb-Sr, Sm-Nd, Ar-Ar), yield ages which are collectively known as the 180 Ma event. This 180 Ma age may either be a crystallization age or a shock age for the shergottites; identification of candidate meteorite craters that fit either of these conditions may thus help in defining the age interpretation of the samples. Petrologic examination of the SNC meteorites adds further constraints to possible source craters. Shergottites (2) and nakhlites (3) were emplaced as phenocryst-bearing lava flows and have markedly different compositions, indicating different magma sources. Chassigny (a cumulate of 90 vol. % olivine) formed in a magma chamber. Thus the single ejection event must have sampled two lava types and an intrusive rock. Shock effects range from severe (shergottites) to virtually non-existent (nakhlites). Cratering studies (4, 5) suggest that either large craters (>20 km dia.) and/or oblique impact events could have ejected the SNC's from Mars without introducing significant shock effects. Furthermore, it is inferred that this event may well have been unique, since there are only young (~1.3 Ga) SNC's, with no samples from the older Martian volcanic regions (such as the ridged plains) or the cratered highlands.

CANDIDATE CRATERS: We use the following criteria to select candidate SNC parent craters:

- 1) The craters are located on volcanic terrain that has a low cumulative crater count (i.e., is young). We use the lava flow maps developed by Scott and coworkers (6) to define the stratigraphy of the Tharsis region, which appears to be the only region on Mars where regionally extensive young volcanic flows occur.
- 2) The morphology of the crater has to be "fresh", as demonstrated by the existence of such features as radial striations on the ejecta lobes, well-preserved secondary craters, the lack of small superposed primary craters on the ejecta blanket, or a contiguous sharp rim crest.
- 3) Craters must either be >10 km diameter (to eject a block of sufficient size to account for the low cosmic ray exposure age) or highly oblique.

OBSERVATIONS: A search of the Viking Orbiter images of the Tharsis region of Mars that have a spatial resolution better than 300 m/pixel identified 23 craters in the size range 10.3 - 35.7 km diameter that fit some of our morphologic and petrologic criteria. Fig. 1 illustrates the location of each crater. Of these 23 candidates, 8 craters appear to be the strongest candidates, and we describe both their best and worst attributes for being the candidate SNC parent crater:

#1: 29.2 km dia., 24.8°N, 29.2°W. Best: An oblique impact into a young segment of the Olympus Mons aureole material. Landslides may have mixed many different lava types into this single deposits, and aureole could contain materials with both 180 Ma and 1.3 Ga ages. Crater is very fresh based on swirl pattern of interior and well preserved secondary crater chains. **Worst:** Origin and age of aureole unclear. Target rocks could be very old since they may come from basal layers of Olympus Mons. **#2: 13.7 km dia., 26.3°N, 98.1°W. Best:** Impact occurred on edge of volcano, may have sampled both the surrounding plains and the flanks. Fresh lobate

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ejecta demonstrates young age of crater. *Worst*: No unusual geometry to crater. Target rocks not the youngest in Tharsis and very hard to explain the 180 Ma crystallization age. **#3: 34.2 x 18.2 km dia., 25.2°N, 97.6°W.** *Best*: Most obvious oblique impact crater on young age Tharsis lavas. Crater probably excavated material from surrounding plains and flanks (including intrusives?) of volcano to sample multiple magma types and ages. Well preserved ejecta lobes indicate young age of crater. *Worst*: Rim of crater cut by channel (lava?) from volcano, which implies that volcanic activity continued after impact. Target rocks not the youngest in Tharsis: were younger materials 180 Ma rocks, other parts of Tharsis must be significantly younger than this age. **#4: 14.8 km dia., 18.5°N, 131.9°W.** *Best*: At summit of Olympus Mons, low atmospheric pressure or shape of volcano may have aided ejection. Target surface very young, and could well be either 1.3 Ga or 180 Ma, but not both ages. *Worst*: No scenario where two surfaces of very different ages can be developed for the summit, permitting both nakhlites and shergottites to be emplaced on the surface. **#5: 11.6 km dia., 10.8°N, 135.2°W.** *Best*: Crater formed on very young lava flows, which could be 1.3 Ga or 180 Ma. *Worst*: Only one lava type, with only a single age, so that samples could not have both 1.3 Ga and 180 Ma ages. Crater has typical geometry for fresh impact, so unclear why this crater would eject SNC's but no other comparable crater would do the same. **#6: 33.8 km dia., 22.2°N, 98.0°W.** *Best*: Three craters on young/medium age target. Small craters must have formed within ejecta blanket of larger crater, permitting different sample ages, but all three craters appear young based on preservation of ejecta and rim deposits. *Worst*: Not the youngest target material in Tharsis, so 180 Ma age would imply that other areas of Tharsis have significantly younger age. Non-unique setting for craters. **#7: 18.5 km dia., 37.7°N, 99.5°W.** *Best*: large crater on ejecta blanket of a second large crater. Another small crater between these two. Lobate flows from Alba Patera and surrounding lava plains could represent the two magma types. *Worst*: Target rocks are some of the older ones in Tharsis. If 180 Ma sample was ejected by this crater, significant modification to Mars cumulative crater curves (7) would have to be made. **#8: 22.6 km dia., 43.1°N, 117.5°W.** *Best*: Slightly oblique impact based on non-symmetric distribution of ejecta blanket. Impact into lobate flows from Alba Patera and surrounding lava plains. *Worst*: Target rocks some of the oldest in Tharsis. If 180 Ma sample was ejected by this crater, significant modification to Mars cumulative crater curves (7) would have to be made. Ejecta blanket has been slightly eroded, removing distal ramparts and modifying the surface of the lobes.

CONCLUSIONS: 1) It is clear that there are only a few (~20) craters of sufficient size that satisfy both the petrologic criteria of the SNC's and the proposed 1.3 Ga crystallization ages. Indeed, only ~8 fit the criteria well. 2) No crater location can be found where two geologic surfaces of appropriate ages (180 Ma and 1.3 Ga) are adjacent to each other. Thus the 180 Ma age for the shergottites is most likely a shock age rather than a crystallization age.

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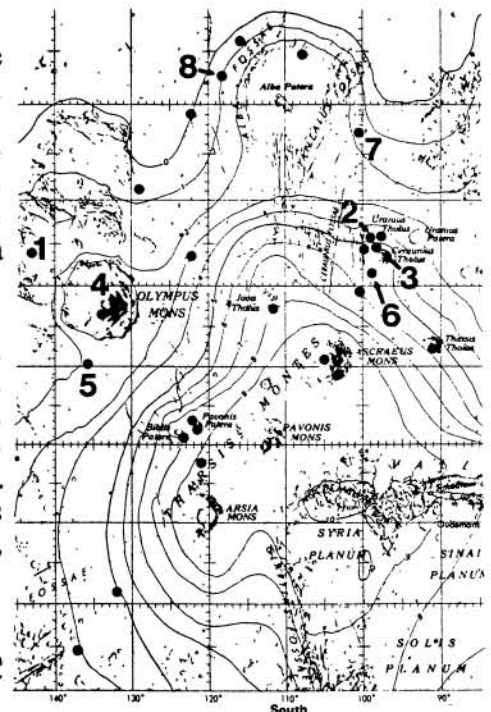


Fig. 1: Map showing location (dots) of each candidate SNC parent crater. Numbered craters are described in text.