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Martian Meteorite Chronology and Effects of Impact Metamorphism

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Body : Martian (SNC) meteorites provide important clues to processes of alteration or shock at the surface of the planet as many of them contain secondary phases and/or high-pressure assemblages, which are the products of aqueous alteration and impact events, respectively. They include gabbros (shergottites), pyroxenites (nakhlites), and dunites (chassignites), and a single orthopyroxenite, ALH 84001. Pb-Pb isotope systematics of Martian meteorites favor three groups of formation ages: 4.3 Ga for depleted shergottites, 4.1 Ga for ALH 84001 and intermediate and enriched shergottites, and 1.3 Ga for nakhlites and Chassigny [1]. This contrasts with the young mineral isochron ages obtained by Ar-Ar dating or phosphate-based chronometers (e.g., U-Pb, Sm-Nd). In addition to Pb-Pb isotope systematics [1], we have obtained preliminary Sm-Nd and Lu-Hf mineral isochron data for the shergottite NWA 480 and find an age of ~345 Ma in contrast to its ~4.1 Ga Pb-Pb age. For the nakhlites MIL 03346 and Yamato-000593, we find Sm-Nd and Lu-Hf ages at ~1335 Ma, consistent with their ~1.3 Ga Pb-Pb age. Hence, all shergottites unambiguously show evidence of resetting events, which is not the case for nakhlites. We interpret the young ages indicated by shergottite Rb-Sr, Sm-Nd, Lu-Hf, and U-Pb internal isochrons as recent resetting by fluids, impacts, or both. Internal isochrons date the last closure, whether initial cooling or late resetting, of the chronometric system in coexisting minerals. Problems arise in part because the carriers of the parent and daughter nuclides have been wrongly assigned to major rather than accessory minerals, and in part because, with the exception of the Pb-Pb chronometer, the rock samples have been strongly leached and, hence, the parent and daughter nuclides became fractionated in the process.
The Rb-Sr, U-Pb, Sm-Nd, and Lu-Hf mineral isochrons of shergottites show young age clusters around 180, 350, 475, and 575 Ma. Each cluster of young mineral isochron ages can be associated with a different ejection age [2], which is best explained by local resetting events. Major break-up events in the asteroid belt have been identified at 160 and 450 Ma [3, 4]. Ar-Ar dating of glass spherules collected on the surface of the Moon show an increase in impact rates over the last 800 Ma [5]. Ar-Ar dating and U-Pb dating of zircons or baddeleyites are techniques commonly used to date terrestrial or lunar impact events and which may also apply to SNC meteorites (e.g., 6, 7). Young mineral ages are nevertheless not as ubiquitous on the Moon. We suggest that this is a consequence of the presence of water in the Martian ground [8, 9], as inferred from layered warm or hot ejecta blankets draped around craters [10]. Water pressurized upon impacts is expected to increase the efficiency of resetting, notably of phosphate and glasses.
[1] Bouvier et al., 2009. EPSL 280, 285-295. [2] Fritz et al., 2007. EPSL 256, 55-60. [3] Nesvorny et al., 2005. Science 312, 1490. [4] Bottke et al., 2007. Nature 449, 48-53. [5] Zellner et al., 2009. GCA 73, 4590-4597. [6] Bogard et al., 1979. GCA 43, 1047-1055. [7] Ozawa et al., 2009. MAPS 44, A5297. [8] Leshin et al., 1994. Science 265, 86-90. [9] Blichert-Toft et al., 1999. EPSL 173, 25-39. [10] Carr et al., 1977. JGR 82, 4055-4064.