OLD SHERGOTTITES AND YOUNG IMPACT AGES

J. Blichert-Toft[1], A. Bouvier[2], J.D. Vervoort[3], P. Gillet[1], and F. Albarède[1]. [1]Ecole Normale Supérieure de Lyon, France. E-mail: jblicher@ens-lyon.fr. [2]University of Arizona, Tucson, USA. [3]Washington State University, Pullman, USA.

Abundant isotopic data obtained on basaltic shergottites for different long-lived radiogenic systems (^{87}Rb-^{87}Sr, ^{147}Sm-^{143}Nd, ^{176}Lu-^{176}Hf, U-Pb) give internal isochron ages that cluster around 180 and 330-475 Ma [1]. The general view that these ages represent the time of shergottite crystallization was questioned by Blichert-Toft et al. [2] and more recently by Bouvier et al. [3]. We argue that (i) regardless of the uncertainties, cratering chronology [4] and stratigraphy [5] assign to most of the Martian surface an age >2 Ga; (ii) evidence of old Pb-Pb ages in basaltic shergottites, for which the labile component (dominated by apatite) has been removed by acid leaching, is overwhelming; (iii) the preservation of ^{142}Nd and ^{182}W anomalies [6, 7] in shergottites is at odds with young ages; and (iv) other indications of old ages for Martian meteorites exist, such as 2.5-4.0 Ga old fission tracks in phosphate grains [8] and ^{39}Ar-^{40}Ar ages in excess of emplacement ages [9, 10].

New Pb isotopic compositions of leached whole-rock fragments and maskelynite separates of Shergotty and Los Angeles fall on the ~4.1 Ga Zagami isochron of [3], which we interpret as dating the crystallization of the basaltic shergottite suite. In contrast, Sm-Nd and Lu-Hf internal isochrons give, as expected, young ages, namely respectively, 170 ± 41 Ma (MSDW = 6.3) and 187 ± 89 Ma (MSDW = 5.1) for Shergotty and 178.8 ± 4.6 Ma (MSDW = 0.95) and 158 ± 14 Ma (MSDW = 0.97) for Los Angeles. Both the ~180 and ~450 Ma cluster ages are observed by Ar-Ar chronometry in Martian meteorites, as well as in ordinary chondrites [11], and recently also by U-Pb chronology of shocked [12] baddeleyite in shergottites [13]. We surmise that these isotopic systems were reset by strong impacts on the Martian surface, which in turn raised global rock temperatures to 200-400°C [14], thereby creating the conditions for permafrost to melt and induce aqueous circulation and alteration near the surface. Such a scenario is supported by the atmospheric-like δD values measured in shergottite apatites [15, 16]. Consequently, the young ages of shergottites date the last re-equilibration of phosphate (the main carrier of U, Sr, and REE) with Martian groundwater before the last dry-out of these water bodies.

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