A PESSIMISTIC PERSPECTIVE ON THE HABITABILITY OF EARLY MARS: SIMULATIONS FOR THE NORTHWEST AFRICA 8159 ENVIRONMENT.

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Introduction: Mars hosted hydrothermal activity and appreciable quantities of surface aqueous fluids during ancient geological periods [1-12]. Hence, analytical investigations of Martian meteorites can provide insights into the aqueous processes and water-rock interactions that have affected these unique rocks on the surface of the Red planet. However, the habitability of Mars during past geological epochs remains a mystery, and it is yet unclear whether aqueous flows and water-rock reactions have been sufficient to yield and support microbial habitats on the Red planet [6, 8, 12, 13]. We have previously explored the Martian meteorite Northwest Africa (NWA) 8159 through nanoscale analytical techniques [13-15]. NWA 8159 is a unique augite-rich shergottite of early Amazonian age (2.37 ± 0.25 Ga [16], as it samples an era and lithology on Mars that is not represented elsewhere in meteorite collections. In this research, we provide numerical simulations via the HYDROTHERM 3 [17] and VS2DI softwares [18] for the aqueous flux and thermodynamics of the NWA 8159 host rock environment on Mars.

Methodology: We used the Hydrotherm (HT) 3 code and VS2DI software of the USGS [17-18] to simulate the aqueous processes in the putative NWA 8159 environment. The boundary conditions of our simulations were constrained by the acquired mineralogical and volatile composition datasets after analyzing the NWA 8159 rock. The physical parameters that we applied to the designed Martian geological setting of NWA 8159 (Fig. 1) were assigned according to [4] and [13], so that these are consistent with Mars' field strength, surface and subsurface thermodynamic conditions. Our models are represented on a 45 x 97 grid, with a total of 4365 cells (very high resolution).

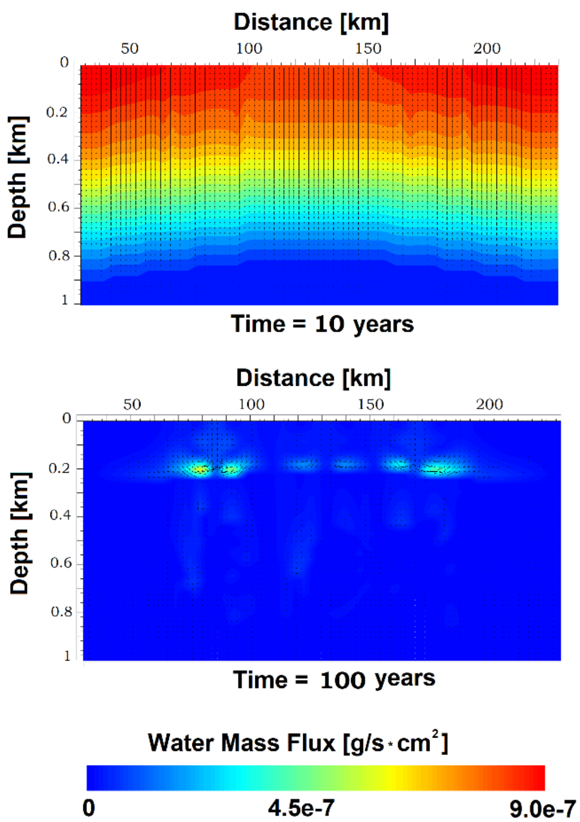

Fig. 1: Water flux in the NWA 8159 geological environment; the two time steps of the simulation (10 yr and 100 yr) demonstrate the water flux evolution therein. Negligible and weak flows are shown in blue colors, and the strongest flows are illustrated in red color. Fluids' T_{max} = 175 °C.

Results: Our simulations indicate that fluid flows in the NWA 8159 basaltic setting lasted for approximately 100 years (Fig.1). Low temperature fluxes (T ≤ 175 °C) may have kept the near surface (depth ≤ 250 m) hydrothermal cells active for slightly more than 100 years, with appreciable Water Mass Flux ≥ 7.0e-7 g/s·cm^2. Conclusively, although such transient flows may have not provided a potential bioenergetic yield to the system, they should have energized water-rock reactions and the release of organic compounds and prebiotic nutrients in the Martian subsurface.

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