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Investigating Mars' recent surface habitability via correlative petrology and highly siderophile element systematics in meteorites

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Establishing the distribution and history of bioessential elements, e.g., C-H-N-O-P-S, among Martian meteorites is fundamentally important to understanding potential habitability beyond Earth. The Tissint meteorite, an observed fall with a crystallisation age of 547 ± 20 Ma[1], was shocked at ≥29 GPa during impact ejection at ~1 Ma[2] and preserves a range of organic compounds considered to be of Martian origin[3]. To investigate the significance of the theorised retention of Martian surface material incorporated into Tissint at its moment of impact ejection, we here report Re-Os isotope systematics and highly siderophile element (HSE including Os, Ir, Ru, Pt, Pd, Re) abundances characteristics of four different fragments (~10 to 40 mg) of Tissint using a new study approach[4] in which sample fractions were compositionally mapped prior to digestion.

Our results document intra-sample HSE abundance variations (Os, 0.1-2.4; Ir, 0.3-0.9; Ru, 0.2-5.1; Pt, 6.5-31; Pd, 12.8-34.5; Re, 0.4-0.8) and their relationship to known textural features and mineral distributions. Internal variability in Tissint's HSE patterns (Re/Os, 0.2-3.1; Pt/Os, 2.7-170.3; Os/Ir, 0.2-7.4) and $^{187}Os/^{188}Os$ compositions (0.11-0.17), as well as corresponding textural characteristics, support a model in which Martian regolith and a chondritic component were assimilated during recent impact shock events. These findings lead us to propose a model in which sulphur has been mobilised and has transferred HSE extraneous to Tissint's earlier parent magma during impact. Thus, elemental and isotopic characteristics of this assimilated sulphur place key constraints on recent and potentially transient conditions favourable to life on the Martian surface.

[1]Brennecka *et al,* 2014, MAPS vol. 49. [2]Walton *et al.,* 2014, GCA vol. 140. [3]Jaramillo *et al.,* 2019, GRL vol. 46(6). [4]Mari *et al*., 2019, GCA vol. 266.