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Voluminous felsic crust formation from the Hadean ultramafic protocrust

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How did felsic crust form and segregate from the primordial olivine-rich mantle? Based on experiments on serpentinite-basalt interaction, thermodynamic modeling, and trace element partitioning, we hypothesize that felsic material that subsequently segregated as the Hadean crust could have been generated due to shallow (< 0.5 GPa) interaction of the primordial ultramafic hydrated proto-crust with basaltic melts [1, 2]. We performed a new series of experiments on variable ratios of serpentinite-to-basalt at 0.1 GPa, 1100°C and 5 days duration. An optimal serpentinite percentage favorable for production of felsic (62 - 69 wt% SiO_2) melts varies between 50 and 80 wt% (**Fig. 1**). The melts coexist with high-Mg olivine-rich harzburgitic, dunitic or wehrlitic residue, depending on the starting serpentinite-to-basalt ratio. Subsequent segregation of the melts from the ultramafic residue and primordial protocrust is able to produce 20 - 40 % of felsic crust at the beginning of the Hadean eon.

Values of Lu/Hf = 0.16 and, thus, $^{176}Lu/^{177}Hf = 0.022$ for the experimental felsic glasses plotted in the εHf(T) vs. age (Ma) of **Figure 2** are consistent with data from Hadean detrital zircons worldwide [3-7]. Extensive melting could be possible at the beginning of the Hadean, where the basaltic melts from the magma ocean infilled fractures in the quenched ultramafic protocrust. Renewed melting could still occur by a similar process due to low-velocity impacts during the whole Hadean. Such a mechanism of felsic crust formation that could start at 4.5 Ga required prior alteration of the early-solidified magma ocean by liquid water and may have been also effective on Mars.

References: [1] Borisova et al. (2021). Frontiers in Earth Science, 9, doi: 10.3389/feart.2021.640464. [2] Borisova et al. (2022). Geology 50 (3), 300–304. [3] Belousova, E. A., et al. (2010). Lithos, 119(3-4), 457-466. [4] Drabon, N., et al. (2021). Proceedings of the National Academy of Sciences, 118(8), e2004370118. [5] Drabon, N., et al. (2022). AGU Advances, 3, e2021AV000520. [6] Kemp, A. I. S., et al. (2010). Earth and Planetary Science Letters, 296(1-2), 45-56. [7] Naeraa, T., et al. (2012). Nature, 485(7400), 627-630.

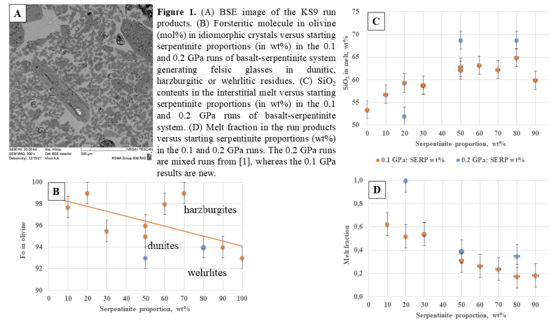

Figure 1. (A) BSE image of the KS9 run products. (B) Forsteritic molecule in olivine (mol%) in idiomorphic crystals versus starting serpentinite proportions (in wt%) in the 0.1 and 0.2 GPa runs of basalt-serpentinite system generating felsic glasses in dunitic, harzburgitic or wehrlitic residues. (C) SiO_2 contents in the interstitial melt versus starting serpentinite proportions (in wt%) in the 0.1 and 0.2 GPa runs of basalt-serpentinite system. (D) Melt fraction in the run products versus starting serpentinite proportions (wt%) in the 0.1 and 0.2 GPa runs. The 0.2 GPa runs are mixed runs from [1], whereas the 0.1 GPa results are new.

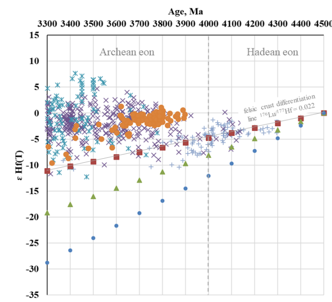

Figure 2. εHf(T) versus age (Ma) of zircons from [3 - 7] databases. The felsic crust 1 differentiation line corresponds to the average Lu/Hf = 0.16 and $^{176}Lu/^{177}Hf = 0.022$ observed in our experiments. The felsic crust 2 is after [7].