Coupled climate-geochemical modeling of the connections between break-up of Rodinia, weathering of continental flood basalts, snowball glaciations and the strontium cycle

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Isotope records of marine seawater composition (e.g. $\delta^{13}C$, $^{87}Sr/^{86}Sr$) display significant variability at the end of the Precambrian, in particular associated with the break-up of the Rodinia supercontinent and spanning the Cryogenian snowball Earth events ca. 716 and 635 Ma. Here we explore the time interval 950–630 Ma to address the long-term evolution of the Neoproterozoic seawater chemistry and climate and to investigate perturbations to the Earth-system over this period. We apply GEOCLIM, a powerful coupled climate-geochemical model to test the effect of the breakup of the supercontinent Rodinia and the emplacement and subsequent weathering of Large Igneous Provinces (LIPs: Willouran-Gairdner, Guibei, Gunbarrel anf Franklin events) on the carbon cycle. The strontium cycle and its isotopes are implemented in the model in order to assess the influence of lithologic and paleogeographic changes on the weathering of continental silicates and climate. To this end, new $^{87}Sr/^{86}Sr$ data from marine carbonates of various Neoproterozoic successions (Northwestern Canada, Eastern Greenland, Svalbard, Siberia and Saudi Arabia) were produced to build a more complete Sr isotope record spanning the Neoproterozoic and to provide initial conditions in our simulations. In addition, Sr and Nd isotopes ratios were measured on Neoproterozoic mafic rocks and Nd isotopes on fine-grained sediments to track the timing of emplacement and weathering of the major LIP relative to glaciations.

Geological history of 4-Vesta: ^{26}Al-^{26}Mg dating on eucrites and diogenites

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Eucrites and diogenites are achondrites belonging to a magmatic series coming from 4-Vesta. Eucrites are basaltic rocks, while diogenites are ultrabasic cumulates. We used the ^{26}Al-^{26}Mg chronometer for precise dating of eucrites and diogenites and revealing the geological history of 4-Vesta.

Basaltic eucrite textures suggest a formation and rapid cooling on the surface in lava flows or dikes while cumulative eucrites evidence deeper and slower cooling. This study reveals that those two types of eucrites belong to two different age populations and cannot be used together for external isochrons. Ages obtained for basaltic eucrites suggest a formation of the eucrite crust during a short and ancient period of magmatic activity on 4-Vesta between 4564 to 4563 Ma. Disturbance observed for the $^{26}Mg^*/^{24}Mg$ ratio in plagioclase fraction in one basaltic eucrite (Y-792510) suggest also a metamorphism episode likely related to shock.

Results obtained for the cumulative eucrites show younger ages compared to the basaltic type. This suggests that some inner parts of Vesta were still warm until ~4560 Ma. Ghosh at al. [1] show ^{26}Al decay is probably the heating source for Vesta differentiation and basaltic eucrite magmatic activity, and may have also kept the mantle hot during a few Ma [2], explaining the slow cooling rate evidenced by the younger age of cumulative eucrites.

Finally, our incapacity to date diogenites with the ^{26}Al-^{26}Mg chronometer suggests a younger age for them (< 4560 Ma) Diogenite are thought to be formed in intrusion within the eucrite crust during a second period of magmatic activity on 4-Vesta [3, 4], probably generated by the remelting of the magma ocean cumulates [5, 6]. This remelting cannot be related to the ^{26}Al decay because at this time, the ^{26}Al was completely extinct. A mantle overturn could be a process to explain this remelting event.

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