Calcium carbonate veins in ocean crust record a threefold increase of seawater Mg/Ca and Sr/Ca in the past 30 Million years

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Carbonates in the basaltic ocean crust form during low-temperature alteration and provide a significant sink of CO_2 in the global carbon cycle. Coggon *et al.* [1] calculated ancient seawater Mg/Ca and Sr/Ca ratios based on the record of calcium carbonate veins in the ocean crust and proposed that these ratios were quite uniform throughout the period between 170 and 24 Ma, but then suddenly increased by a factor of 4 to present-day seawater composition. This increase, although delayed by tens of millions of years, is interpreted as an effect of decreasing ridge flank hydrothermal activity, which may be related to a decrease in ocean crust production rate in the late Cretaceous. The goal of this study was to use calcium carbonate veins in reconstructing seawater Mg/Ca and Sr/Ca ratios with a specific emphasis on young sites (≤ 57 Ma) in cold ridge flanks. While our data fill gaps in the critical interval of compositional change in the past 30 Ma, they strongly corroborate the results of Coggon *et al.* [1] in showing simultaneous increases in Mg/Ca and Sr/Ca. Our data also indicate that the Mg/Sr ratio of seawater did not change in the Neogene. We find this to be at odds with a hydrothermal driver of seawater compositional change which should not leave Mg/Sr unchanged. We suggest that a scenario first proposed by Wallmann [2], can explain both the observed trends and the time lag between the late-Cretaceous and the Neogene compositional canges of seawater. The late Cenozoic decrease in ocean crust production rate led to an increase in the average age of the crust und thus to a sea level drop. Lower sea level caused a shift of carbonate deposition from the shelves to the pelagic ocean. Finally, subduction-recycle delayed transfer of CO_2 from deep-sea carbonates to volcanic arcs in combination with accelerated erosion increased the carbonate alkalinity input to the oceans and boosted the Ca sink flux by carbonate formation.

[1] Coggon *et al.* (2010) *Science* **327**, 1114–1117. [2] Wallmann (2001) *Geochim. Cosmochim. Acta* **65**, 3005–3025.

How Jupiter's two-phase gas-driven migration shaped the inner Solar System

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Accretion simulations cannot adequately reproduce the terrestrial planets, in particular Mars' small mass [1]. Currently, the best solution to this problem assumes that the terrestrial building blocks were initially concentrated in a narrow annulus from 0.7-1 AU [2]. These initial conditions could have been sculpted by Jupiter's two-phase migration in the gaseous Solar Nebula: Jupiter first migrated inward due to standard type 2 torques, then back outward once Saturn grew and was trapped in 2:3 resonance [3]. If the turnaround point or "tack" occurred when Jupiter was at 1.5 AU then the inner disk of material would be truncated at 1 AU, forming a small Mars (Figure 1). In this scenario, the asteroid belt was first emptied and then re-filled by Jupiter: S-type asteroids (red in Figure 1) originated between 1-3 AU and C-types (blue) originated between the giant planets and beyond Neptune [4].

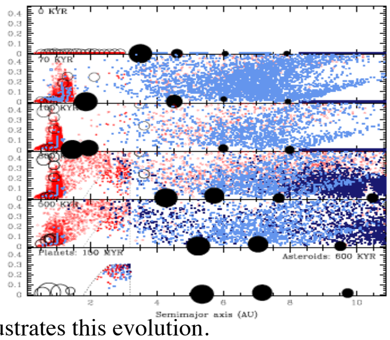

Figure 1: illustrates this evolution.

In the absence of migration, primitive C-type asteroids represent a plausible source for Earth's water [5]. In the context of the 'grand tack' model [4], this same population may still deliver water to the growing Earth: for every C-type planetesimal injected into the asteroid belt, ~10 were scattered onto eccentric orbits that intersect the terrestrial planet-forming region. These scattered C-types can deliver several oceans of water to the growing Earth.

[1] Raymond *et al.* (2009) *Icarus* **203**, 644–662. [2] Hansen (2009) *ApJ* **703**, 1131–1140. [3] Masset & Snellgrove (2001) *MNRAS* **320**, L55-L59. [4] Walsh *et al.* (2011, in press) *Nature*. [5] Morbidelli *et al.* (2000) *M&PS* **35**, 1309–1320.