Subduction dynamics and magmatic arc growth: Numerical modeling of isotopic features

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Convergent margins are the sites of a substantial mass transfer, where the Earth's crust material is recycled back to the mantle, which in turn induces a new crust formation. Several aspects of magmatic arc formation are consequently discussed in literature but still poorly understood. Among these are (i) influence of subduction dynamics on the crust growth, (ii) slab and mantle contributions to the crust formation, (iii) dynamics of mantle partial melting, and (iv) the way of material transport to the surface (fluid or melt). We have developed a coupled geochemical-petrological-thermomechanical 2D numerical model of retreating subduction, which includes spontaneous initiation of subduction, slab retreat and bending, aqueous fluid release and transport, melting of slab and mantle, and resulting magmatic arc formation. This model allowed us to investigate the dynamics of subduction, mantle wedge plumes development and magmatic arc growth and displacement. Our numerical experiments showed that subduction rate varies strongly with time and plays a crucial role in a rate of crustal growth and composition of newly formed crust. The goal of the present work is to combine numerical modeling method with geochemical approaches. Geochemical features of each process are tracked by markers in the model, which includes element partitioning between minerals and fluid and/or melt. Particularly we study ^{231}Pa-^{235}U and ^{238}U - ^{230}Th - ^{226}Ra systems, which are known as good tracers to constrain both melt and fluid contribution and sources of a new crust material.

Biological control on earth evolution

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Rubisco specificity and compensation controls support the Gaian hypothesis that the Earth's atmosphere and surface environment are primarily regulated by biochemical, not geochemical processes. In this view, biological processes set the pressure, nitrogen, oxygen, carbon dioxide, methane, N_2O and water vapour contents of the atmosphere, and manage the surface temperature via greenhouse feedbacks. If so, biology, by its command of kinetics and disequilibrium, trumps abiological geochemistry, to set the environmental framework (e.g. pH) within which inorganic geochemistry works.

The main control on pressure is the biological nitrogen cycle, depending on nitrogenase. In addition, anammox emission of N_2 adds to the atmospheric reservoir. The large sustained atmospheric burden of N_2 influences the greenhouse by pressure broadening. Though abiotic lighting fixation supplements the productivity of the biological cycle and presumably preceded it, lightning is controlled by atmospheric water vapour and hence greenhouse temperature. The surface temperature of the planet is set by the co-evolution of solar insolation, pressure, and the biologically-regulated atmospheric burden of greenhouse gases. By controlling surface temperature, these sustain liquid and atmospheric water. Rubisco specificity manages the greenhouse via its control on carbon gases. The CO_2 compensation boundary divides the oxic CO_2-led greenhouse from the anoxic CH_4-led system. Rubisco I-catalysed photosynthesis fails when O_2 is above the O_2 compensation limits, setting bounds to the oxic atmosphere. Over the aeons, the Sun has steadily brightened, yet liquid water has been present on the surface (albeit with glacial episodes) since 3.8 Ga ago and throughout life's history. Prior to ~2.3 Ga ago, the mid-Archean air was probably warmed by a strong methane-led greenhouse, sustained by methanogens. Since the rise of oxygen, the managing greenhouse warmer must have been CO_2, assisted by trace CH_4 and N_2O, fine-tuned to rubisco I specificity with productivity feed-back loops that also manage pressure in a co-evolving system.