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Earth's deep carbon cycle; from geodynamics to climate

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The global emission of carbon dioxide and associated gases from volcanoes presents irrefutable evidence that carbon in the Earths exosphere (atmosphere, oceans, shallow surface environments) may not be treated as a closed system. Primary feedback of carbon into the deep Earth takes place via subduction, and operates on long geological time scales, which may not be in a steady state. Improving our understanding of the flux of carbon from deep reservoirs is emerging as a critically under-quantified parameter required in order to assess, for example, long-term atmosphere evolution and short-term climate change. Additional deep carbon reservoirs and fluxes to consider include deep crustal metamorphic and sedimentary rocks, but these are small in comparison to the Earth's primary carbon reservoir.

The bulk carbon content of the Earth is considered to be around 10^{20}kg , of which ∼99.99% is stored below the crust, in the deep Earth. Therefore as a first objective we need to assess the volcanic flux of carbon. Nearly all Earth's carbon is stored in the mantle, it is transferred to the atmosphere directly through volcanism (degassing). How has this changed through time? From the geological expression of volcanism we expect two components to this flux (a) quasi-steady state and (b) catastrophic/episodic. Today it is convenient to consider the dynamic situation of a mantle plume during its ∼30 Ma duration journey rising through the mantle and the regional plate tectonic heterogeneity of the crust characterised by volcanically active rift zones. Alternative dynamic models may serve better for the assessment of the early Earth (Hadean), which would have involved additional catastrophic outgassing associated with bolide impacts. Many of these processes have recently become accessible through the detailed

study of diamond, which is an important deep carbon reservoir that spans geological time (>3 Ga), and retains isotopic variations, and which are interpreted in terms of large scale geodynamics.

Ultimately, reappraisal of the Earth's deep carbon cycle will require the interaction and collaboration between multi-disciplinary research fields including geochemistry, cosmochemistry, high-pressure mineralogy and petrology, organic and inorganic carbon specialists and so on. The immediate understanding of mantle degassing may be improved through combining satellite remote sensing (eg CO2 and "pollutant" gases) with improved ground-based measurements of volcanic emissions.