Origin of the CO_2 fluxes of the Icelandic Hotspot

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Carbon dioxide plays a major role in climate change and warming of the Earth's atmosphere. In order to assess past and predict future climate perspectives, it is vital to assess all sources of CO_2 contributing to the global fluxes. The deep Earth's CO_2 fluxes have been evaluated based on degassing of volcanic complexes and geothermal systems. However, passive degassing of CO_2 through tectonically active areas has not been included into such models, such degassing potentially contributing significantly to the Earth's CO_2 fluxes.

The sources of CO_2 degassing of active and off-rift systems in Iceland were studied using carbon isotope systematics of gases and groundwaters. The range of CO_2 concentrations, δ^{13}C-CO_2 and ^{14}C-CO_2 was large, ~5-75·10^4 ppm, -27.4 to +2.0 ‰ and 0.6 to 118 pMC, respectively. Sources of CO_2 were evaluated by comparing the measured chemical and isotope composition with those simulated using isotope geochemical models. Three major sources of CO_2 were identified: (1) dissolution of partially degassed basaltic rocks formed at the surface or shallow depths, (2) atmospheric CO_2 through air-water exchange at surface, and (3) input of gas at depth with similar carbon and isotope composition as the pre-erupted melt of the upper mantle and lower crust beneath Iceland.

The CO_2 flux of the Icelandic crust was estimated to be ~5-10·10^{10} mol/yr. Similar fluxes of 7-23·10^{10} mol/yr have been obtained using CO_2/^{3}He values and ^{3}He flux estimates [1]. Passive degassing through tectonically active zones off-axis account for as high as ~50% of the total flux with significant proportion of the CO_2 originating from the mantle. The CO_2 partial pressures within active volcanic and geothermal systems correspond to ~0.5-10 bar with a flux of ~500-3000·10^5 mol CO_2/km^2/yr, Off-axis, the CO_2 partial pressures of mantle origin were estimated to be ~10^{-6} bar, with an average flux of <5·10^5 mol/km^2/yr but as high as 125-1600·10^5 mol/km^2/yr for the most tectonically active ones.

The results indicate that diffusive CO_2 fluxes of deep origin in tectonically active areas outside active volcanic regions may be a significant contribute to the Earth's CO_2 degassing

[1] Barry et al. (2014) Geochim. Cosmochim. Acta 134, 74–99.