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Large scale sediment degassing during contact metamorphism of shales in volcanic basins

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Organic maturation during contact metamorphism is well known, although most studies are concerning the localized effects of one intrusion only. Large scale fluid generation can occur when a sedimentary basin is intruded by multiple igneous sills during formation of Large Igneous Provinces, like the Karoo Basin, South Africa (∼183 Ma). In this study we aim at quantifying the generation of organic and inorganic devolatilization reactions in such basins. Geochemical data from boreholes intruded by multiple sills are used to constrain our model.
Both depth and thickness of the intrusions are important parameters in determining the hydrocarbon yield. Modeling also illustrates an essential dependence on the background temperature of the sediments. The organic-rich formations are commonly located at the base of a sedimentary basin, which coincides with the intrusion level of the thickest sills (>100 meters) and the warmest parts of the basin. Hence, conditions are favorable for large-scale contact metamorphism of the sedimentary rocks.
Our model is applied to borehole data from the organic-rich Ecca Formation in the Karoo Basin to get realistic estimates of the fluid generation in the shales. We show how the thermal influence of multiple levels of sill intrusion results in much larger fluid generation than what can be attributed to separate, single intrusions. A shale formation squeezed between two thick sills is exposed to extensive contact metamorphism. Geological evidence suggests that the root system of breccia pipes originates in such a heavily metamorphosed formation, implying a pressure-buildup in association with the devolatilization reactions.
Basin scale extrapolation of our modeling shows that several thousand gigatons of carbon gases were generated during the contact metamorphic event. The generated fluids were effectively released to the atmosphere through the deep-rooted pipes. Such large scale release of greenhouse gases to the atmosphere has the ultimate consequence of perturbing the global carbon cycle with catastrophic outcome for life on Earth.