



Breccia pipes in the Karoo Basin, South Africa, as conduits for metamorphic gases to the Early Jurassic atmosphere

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The Toarcian (Early Jurassic) event was manifested by globally elevated temperatures and anoxic ocean conditions that particularly affected shallow marine taxa. The event coincided with the emplacement of the vast Karoo-Ferrar Large Igneous Province. Among the suggestions for trigger mechanisms for the climatic perturbation is metamorphic methane generation from black shale around the sills in the Karoo Basin, South Africa. The sill emplacement provides a mechanism for voluminous in-situ production and emission of greenhouse gases, and establishes a distinct link between basin-trapped and atmospheric carbon. In the lower stratigraphic levels of the Karoo Basin, black shales are metamorphosed around sills and the sediments are cut by a large number of pipe structures with metamorphic haloes. The pipes are vertical, cylindrical structures that contain brecciated and baked sediments with variable input of magmatic material. Here, we present borehole, petrographic, geochemical and field data from breccia pipes and contact aureoles based on field campaigns over a number of years (2004-2014). The metamorphism around the pipes show equivalent metamorphic grade as the sediments around nearby sills, suggesting a more prominent phreatomagmatic component than previously thought. The stratigraphic position of pipes and the breccia characteristics strengthens the hypothesis of a key role in the Toarcian carbon isotope excursion.