



Sills, aureoles and pipes in the Karoo Basin, South Africa, as triggers for Early Jurassic environmental changes

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Most of the Large Igneous Provinces (LIPs) formed during the last 260 million years are associated with climatic change, oceanic anoxia, or extinctions in marine and terrestrial environments. Current hypotheses involve A) degassing of carbon either from oceans or shallow sea-bed reservoirs, B) carbon and sulfur degassing from flood basalts, C) degassing from sedimentary basins heavily intruded by LIPs. Here we present new data on gas generation and degassing from the Karoo LIP, based on fieldwork, borehole studies (geochemistry, petrography), and thermal modeling. Our data expand and corroborate earlier work on the sub-volcanic processes in the Karoo Basin. We show that 1) hundreds of breccia pipes are rooted in Early Jurassic sill complexes and contact aureoles within the organic-rich Eccu Group, 2) statistical analyses reveal a fractal distribution of pipes and that they are overdispersed at small scales (<50 m), but clustered at larger scales (>800 m), 3) contact aureoles show a reduction in organic matter content towards the sill contacts, reduced to zero in the nearest zones, producing more carbon gas compared to thermal model calculations, 4) we find up to 3 permil reduction in the $\delta^{13}C$ of the organic matter remaining in the aureoles, and finally 5) some pipes contain recent oil seeps. We conclude that the sill-pipe system released thermogenic gases to the Early Jurassic atmosphere and that the pipes may have acted as permanent fluid flow pathways.