Mantle carbon mobilization during supercontinent break-up: Evidence from kimberlites and their diamonds

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The assembly and break-up of supercontinents occurred repeatedly throughout Earth's history. It is commonly argued that increasing mantle plume activity due to the thermal insulation effect of a stagnant continental lid is the main cause of supercontinent break-up. However, recent numerical models suggest that mantle temperatures beneath supercontinents are only slightly elevated and therefore additional destabilizing mechanisms must operate. Cratonic North America including Greenland (hereafter Laurentia) anchored the Neoproterozoic Rodinia supercontinent, which reached stability at 900 Ma. While it is evident from the geologic record that Rodinia's demise began with strong rifting activity along the western and southern margins of Laurentia at ca. 750 Ma, break-up along the eastern and northern margins is poorly constrained. New and published ages for North American kimberlites and related rocks reveal that continuous CO_2-rich magmatic activity occurred proximal to the eastern and northern margins of Laurentia between 680 and 550 Ma, after a prolonged 'shutdown' of deep-seated CO_2-rich magmatism during maximum Rodinia stability. Although Sr-Nd-Hf-Pb isotope compositions of these North American kimberlites indicate a convecting upper mantle origin from beneath the rifting 'supercraton', new data for Baffin Island and Greenland suggest that intense interactions with the cratonic mantle occurred. These interactions may have prompted diamond formation beneath Laurentia, and it has been suggested that some diamonds formed <50 Myr prior to the host Neoproterozoic kimberlite magmatism beneath Greenland. Our model suggests that significant mantle carbon mobilization as low-degree melts – and entrapment in the form of diamond - occurred during the waning stages of Rodinia. We discuss the destabilizing effects of such redox-controlled processes on continental lithosphere and argue that they may be a fundamental cause, and not a consequence, of supercontinent break-up.