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Magmatic characteristics of incipient rifting

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Magmatism in regions of rifting through thick continental lithosphere is characterized by SiO2-poor, CO2-rich compositions that require the action of carbonates and oxidized conditions in the source regions. Ultramafic lamprophyres and kamafugites are rare potassic alkaline igneous compositions that may be explained by partial melting of mixed source assemblages consisting of carbonate-bearing ultramafic veins in more normal peridotite mantle. However, the reason for the enrichment in carbonates and the source of the carbon has never been satisfactorily explained.

Recent geochemical studies of carbonate-rich igneous rocks emplaced during the early stages of rifting indicate isotopic growth of Sr, Nd and Hf that can be explained by veining to produce carbonate- and mica-bearing assemblages within 30-300 Ma of emplacement, indicating that many cratonic rifts may only be successful in producing rifts at the Earth's surface after considerable periods of magmatic activity in the lowermost mantle lithosphere. The first stages of cratonic breakup may be point-source magmatic impregnations into the lithosphere from below, followed by their widening and joining into linear thinning of the lithosphere to produce rifts in the underside of the lithosphere before tectonic rifts at the surface become apparent. The first major magmatic activity at the surface comes when oxidation of the mantle causes a severe melting-point depression, resulting in the production of carbonate-rich melts from carbon that had been accumulated slowly under reducing conditions through the lifetime of the lithosphere. Ultramafic lamprophyres and many kamafugites may be indication of this incipient melting at depths of 120-160km, and thus of the breakup of cratonic lithosphere. Examples are the ultramafic lamprophyres bordering the Labrador Sea and the kamafugites of western Uganda.