

Views of plate tectonics and mantle metal budgets from alkaline and carbonate magmas

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Low-volume alkaline silicate and carbonate magmas are products of volatile-controlled incipient melting processes in the Earth's mantle. Although this form of melting is ubiquitous beneath the thick and cold portions of continental lithosphere, such melts rarely reach the Earth's surface due to a combination of their small volumes, reactive nature, and great depths of origin. In spite of being rare at surface, the impact of alkaline and carbonate magmatism on the dynamic stability of mantle lithosphere and its metal endowment may be disproportionately large, but it is difficult to grasp in the absence of spatial and temporal constraints on melt mobility.

We review evidence from major alkaline and carbonatite provinces for metasomatic overprinting of the underlying continental mantle lithosphere, and evaluate how these processes influenced plate tectonic evolution in these regions. Key examples from Greenland and Africa show that metasomatic weakening of mantle lithosphere by pervasive alkaline and carbonate melts is frequently the first step in continent fragmentation ultimately leading to supercontinent dispersal. A major obstacle in identifying carbonate melt metasomatized mantle is the use of differentiated 'surface' carbonatite compositions as proxies for geochemical processes operating at great depths. We assess the robustness of some of the classic geochemical proxies, such as Ti/Eu and Zr/Sm, and identify new promising fingerprints of passing carbonate melts in the deep mantle lithosphere.

New evidence from the Kaapvaal craton, one of world's best endowed metallogenic provinces, shows that redox- and volatile-controlled alkaline melting events can effectively mobilize sulphide-hosted PGE and base metal budgets from eclogite components within the thick mantle lithosphere. Such precursor alkaline magmatic events, heralding the formation of major continental rifts and mantle plume impingement, can enhance the metal contents of subsequent asthenosphere-derived mafic magmas, thereby upgrading ore-forming potential. However, economic metal deposits only form when geologic conditions during magma emplacement in the crust are favorable, with mantle metal budgets being less critical.