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Crustal reworking and the carbon cycle

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The global carbon cycle plays an important role in the long term self-regulation of the Earth's surface conditions. However, the complex interaction between its deep, solid Earth component (i.e. crust and mantle), Earth's fluid envelope (i.e. atmosphere and hydrosphere) and plate tectonic processes is a subject of ongoing debate. Throughout Earth history, outgassing through volcanic regions may have largely exceeded carbon removal by burial and subduction into the mantle, yet the long-term geological records show that Earth has not experienced run-away carbonation of the atmosphere. An important carbon sink that is not yet adequately accounted for is the deep continental crust.

Using the abundance of collisional belts and passive margins, the change in metamorphic burial rates and the variation in sediment composition, we demonstrate that the lower crust constitutes an important, long-term, carbon reservoir that influences the concentration of carbon at the surface through weathering, metamorphic decarbonation, partial melting and crustal assimilation during volcanic activity. Our analyses show that peaks in orogenic activity throughout the Phanerozoic coincide with the entrapment of primary COH-bearing melt inclusions (MI) and fluid inclusions (FI) in high grade metamorphic mineral.

We argue that the fluctuation in orogenic activity throughout the Wilson cycle has a critical role in achieving balance in the long-term carbon cycle during the Phanerozoic. Additionally, the presence of MI and FI, as well as major graphite deposits and S-type granite intrusions in the Precambrian support the idea that periods of efficient plate tectonics regimes at < 0.85 Gyrs and 1.7-2.1 Gyrs favour storage of carbon in the lower crust for period of time exceeding 2.0 Gyrs.

To conclude we argue that the increase in cumulate length of passive margins and crustal reworking from the mid-Paleoproterozoic onwards played a critical role in buffering the concentration of atmospheric carbon and stabilizing the surface conditions required for the development of complex life in late Neoproterozoic.