Deep carbon cycling over the past 200 million years: evaluating contributions from tectonic settings

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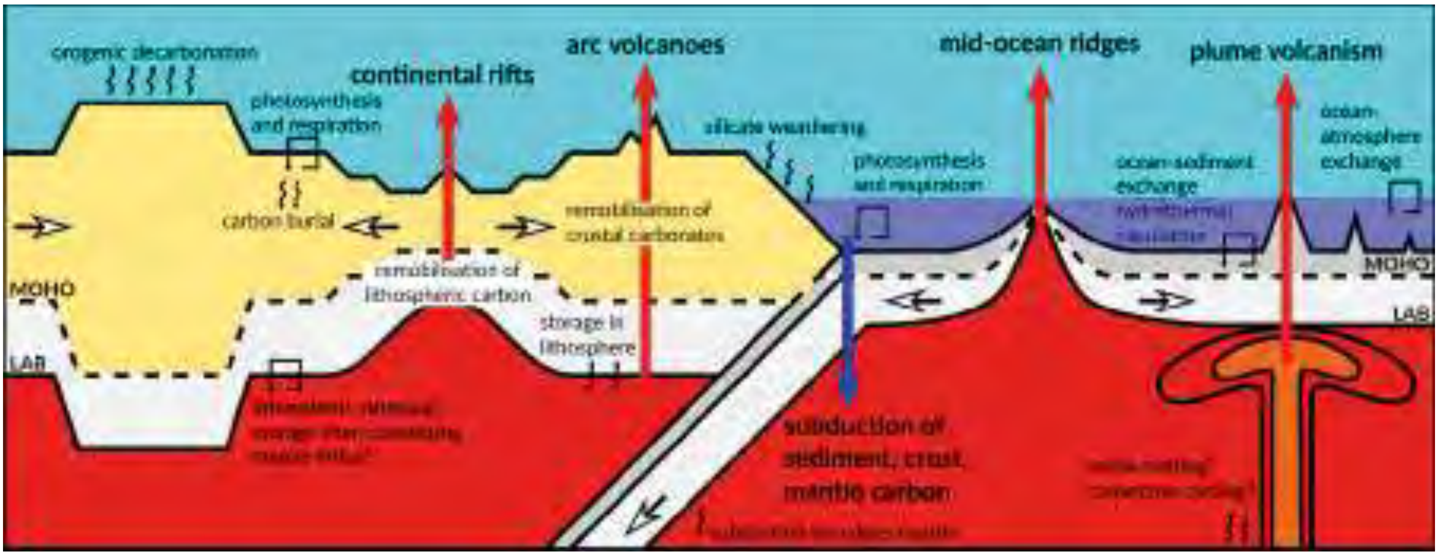
Carbon is a key control on the surface chemistry and climate of Earth. Significant volumes of carbon are input to the oceans and atmosphere from deep Earth as volcanic CO2 and are returned to large carbon reservoirs in the mantle during subduction. Tectonic settings (e.g. arcs, mid-ocean ridges, and continental rifts) are known to emit dramatically different, temporally and spatially variable fluxes of carbon, and represent a first-order influence on carbon outgassing from the deep Earth. The relative abundance of different tectonic settings throughout Earth's history therefore plays a vital role in maintaining the deep carbon cycle on geological timescales. Over the past ten years the Deep Carbon Observatory has made enormous progress in constraining estimates of volcanic carbon outgassing flux at different tectonic settings. In this study, we review these recent developments to estimate carbon inputs and outputs at present-day plate boundaries. Using plate boundary evolution modelling and our understanding of present-day carbon fluxes, we extend a time series of estimated carbon fluxes from different tectonic settings through the past 200 million years. We highlight the increasing importance of carbonate-intersecting subduction zones over time, and the potential for immense carbon outgassing at continental rift zones. Using our quantitative approach, we additionally suggest that carbon outgassing throughout geological time is mostly balanced by ingassing at subduction zones. Our results illustrate the vast uncertainties that exist in both simulating the organisation of the Earth's tectonic plates over time, and also in reconstructing the corresponding in- and outgassing fluxes. This synthesis summarises our current understanding of fluxes at tectonic settings and their influence on atmospheric CO2, and provides a framework for future research into past deep carbon cycling.



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Temperature modelling and the link with gas hydrates

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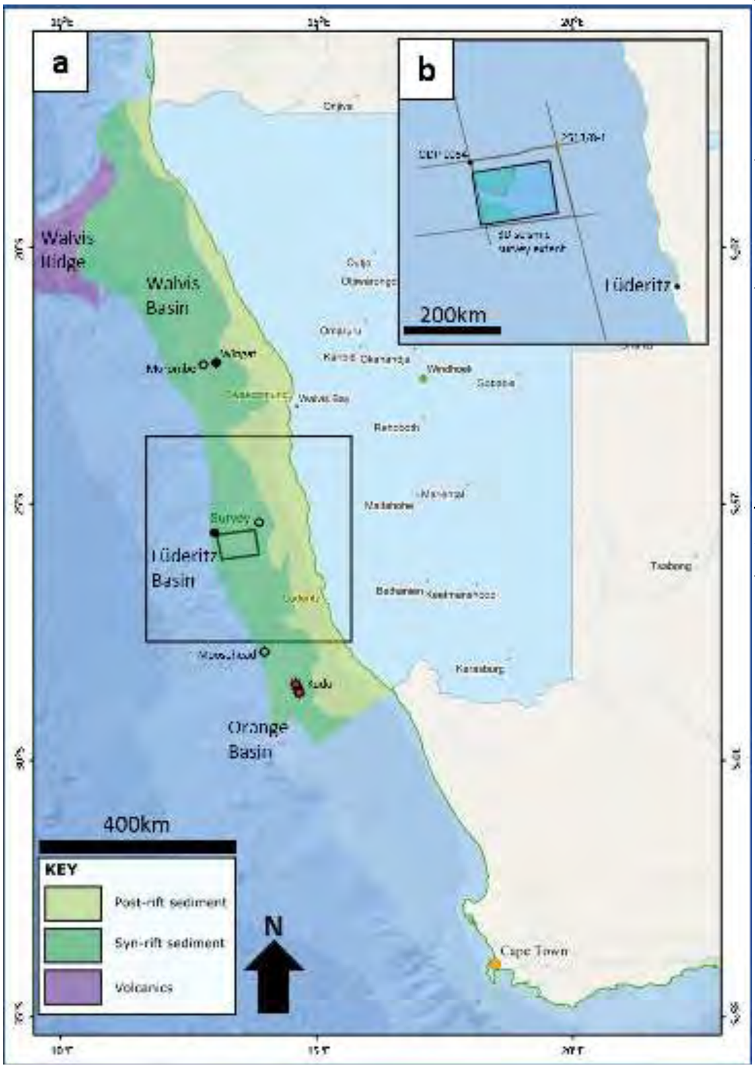
Discussion of gas hydrates usually centres around their environmental impact, their potential as a future energy source and a shallow hazard. Estimates of gas hydrates globally vary but it is agreed they constitute one of the largest methane sinks in the world. Equally given their widespread occurrence in offshore domains, they are being researched as a potential energy source for energy hungry nations without large inherent traditional hydrocarbon reserves such as China, India and Japan. For petroleum engineers sub seafloor frozen gas hydrates present a drilling hazard and are often avoided. Gas hydrate stability is primarily governed by temperature and pressure conditions and utilising this dependency and the ambient pressure we can estimate the subsurface temperature of the base of the gas hydrate stability zone. Mapping the presence of the base of the gas hydrate stability zone (BGHZ) through identification of seismic markers known as bottom simulating reflectors (BSR), the gas hydrate stability field can be utilised to estimate temperature. This in turn allows the calculation of a geothermal gradient and estimation of surface heatflow. This project further expands this approach by utilising widespread seismic data to develop a tool to estimate temperature in a non-invasive manner. Conventionally, sub-seafloor temperature measurements are taken from direct temperature probe measurements requiring drilling. Seismic reflection velocity data can be manipulated using empirical relationships governing thermal conductivity to develop an understanding of the thermal structure in the subsurface without drilling. This combined approach should be useful to oil companies seeking to understand source maturity and reservoir temperature.



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