

## Analogues between water in granite melts and petroleum formation

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Water is ubiquitous within the Earth's crust and has long been recognized as a critical component in deep crustal areas undergoing metamorphism [1]. Similarly, water in granite melts has been shown to be critical to granite melting points, mineral phase relations, element partitioning between melt and mineral phases, and transport properties [2]. Although the specific role of water remains an issue in petroleum formation, experimental studies on petroleum source rocks pyrolysed with and without water clearly indicate that water is an important component [3]. Petroleum formation involves two overall reactions. The first of these reactions is the thermal decomposition of kerogen, which is the insoluble and dominant organic solid phase in thermally immature source rocks. With initial heating, kerogen partially breaks down to a soluble polar-rich high-molecular-weight tarry phase referred to as bitumen. A net volume increase associated with this reaction results in the bitumen expanding into the micro-porosity to form a continuous bitumen phase impregnating the groundmass of the source rock. Experiments have shown that water is not important in this step, but water in the original micro-pores and in surrounding fractures provides a source for dissolved water in the bitumen. Similar to water dissolved in granite melts, the solubility of water in bitumen plays a significant role. It is this dissolved water in the bitumen phase and not the surrounding bulk water in fractures or voids that becomes critical in the second overall reaction, which is the thermal decomposition of the polar-rich bitumen phase to a hydrocarbon-rich oil phase. During this overall reaction, the dissolved water provides a source of hydrogen that promotes thermal cracking and facilitates immiscibility between the bitumen and oil phases. These conditions result in a net volume increase and the expulsion of the oil from the water-laden bitumen in the source rock. The ability of water in pyrolysis experiments to simulate organic phases like those observed in nature helps petroleum-formation studies move away from sole emphasis on organic components (i.e. saturates/aromatic/resin/asphaltene) and, like granite-melt studies, allows examination of the collective behaviour of both components and phases.

[1] Winkler (1967) *Petrogenesis of Metamorphic Rocks*. Springer-Verlag, New York. [2] Mysen & Richet (2005) *Silicate Glasses and Melts*. Elsevier, New York. [3] Lewan (1997) *Geochim. Cosmochim. Acta* 61, 3691-3723.

## Asphaltene content as a measure of oil losses related to the Deepwater Horizon oil spill

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The asphaltene content of spilled oil on open and coastal waters and coastal sediments was examined as a means of determining the fate of the estimated 4.9 million barrels of oil released from the damaged BP Macondo-1 wellhead of the Deepwater Horizon platform in the Gulf of Mexico (April 20 to July 15, 2010). A particularly salient issue is where has all of this spilled oil gone? Asphaltenes are the highest molecular-weight fraction in crude oils and are the most recalcitrant to water washing, volatilization, and biodegradation. Comparing the asphaltene content of spilled oils with those of the original oil released from the leaking wellhead allows one to determine the portion of oil lost. The lost portion of oil collectively includes that removed by volatilization, oxidation, water washing, dispersion, and microbial degradation. Critical to the application of this method is that a representative sample of the original oil is available and that degradation does not significantly affect the asphaltene content of the spilled oils. Two samples were collected from a riser insertion tube at the wellhead and are considered representative of the original oil. Although asphaltenes are the most recalcitrant fraction of crude oils, their composition can change with degradation. Possible alterations to the asphaltene fraction of the spilled oils were evaluated with stable carbon isotope and elemental analyses. Spilled-oil samples were collected between May 7 and July 10, 2010 and are divided into three groups; 1) open water, 2) coastal water, and 3) coastal sediment. The open-water group consists of spilled oils floating on the water at distances greater than 5 km from the coastline. Comparing the uncorrected asphaltene contents of these spilled oils with that of the original oils indicate spilled oil in open waters may represent less than 40 wt% of the original oil, and spilled oil in the coastal waters and sediments may represent less than 20 wt% of the original oil. These preliminary results suggest that significant quantities (more than 60 to 80 wt%) of the Deepwater Horizon spilled oil were lost within the first 81 days and provide input values for mass-balance calculations regarding the fate of the spilled oil.