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Influence of fluid overpressure, maturation of organic matter, and tectonic context during the development of 'beef': physical modelling and comparison with the Wessex Basin, SW England

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Bedding parallels veins of fibrous calcite ('beef') are common in the Wessex Basin of SW England, as in other basins worldwide. The Wessex Basin contains at least three potential source rocks for oil: the Kimmeridge Clay, the Oxford Clay and the Lower Lias. We have studied classical outcrops of (1) the Blue Lias, between Lyme Regis and Charmouth, and (2) the late Jurassic Purbeck Fm at Lulworth Cove. Beef is common in both areas. Analysis by environmental scanning electron microscopy (ESEM) revealed common components of calcium, silicon, aluminium and organic matter. However, between Lyme Regis and Charmouth the beef is flat lying and apparently undeformed, whereas at Lulworth Cove it contains folds and reverse faults, in association with post-rift inversion structures.

So as better to understand the conditions of formation of 'beef, we have developed new techniques of physical modelling. In our experiments, mixtures of coloured silica powder and beeswax microspheres (50% by volume) formed two basal layers of source material, whereas the overburden was of pure silica powder. By submerging the materials in water, we avoided the high surface tensions, which otherwise arise within pores containing both air and liquids. Also we were able to measure pore fluid pressure by observation of water level in a model well. We built and deformed the models within a rectangular box, which rested on an electric flatbed heater. During heating, the basal temperature of the model surpassed the melting point of beeswax (62°C), reaching a maximum of 90°C. To test three different contexts of deformation, we used a piston to apply horizontal displacements. Thus the experimental variables were (1) rate of heating, (2) amount and sense of piston displacement, and (3) piston velocity. When the piston was stationary, rapid melting led to compaction of the source layer and to development of high overpressure (lithostatic or above). The wax migrated through pore space and into open hydraulic fractures, where it later congealed. Most of the fractures were horizontal and in apparently random positions. In experiments, for which the piston moved outward, causing horizontal extension of the model, some of the intrusive bodies were dykes, especially close to the piston, whereas others were sills. In experiments, for which the piston moved inward, causing compression of the model, all of the structures were thick sills, in places containing folds and faults.

By comparing our experimental results and field data for the Wessex Basin, we infer two stages for the genesis of 'beef' in SW England, one during the Mesozoic, in a tectonic context that was extensional or static, and the other during the Tertiary, in a context of compressional inversion of the Wessex Basin.