Jurassic 'burn-down' events and organic matter richness in the Kimmeridge Clay Formation

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Monika Kodrans-Nsiah inspects an exposed section of the Kimmeridge Clay Formation on Dorset's "Jurassic Coast." Credit: Ian Harding (NOCS)

The sediments of the Kimmeridge Clay Formation were deposited during the Late Jurassic between around 160 and 145 million years ago, the age of the reptiles. They are the main oil source rock in the North Sea. However, within this unit beds rich in organic matter are interspersed with organic-poor sediments. New evidence demonstrates that organic-poor sediments were probably caused by post-depositional

loss of organic matter during so-called 'burn-down' events.

The Kimmeridge Clay Formation is named after the English village of Kimmeridge on Dorset's 'Jurassic Coast', a favourite haunt of fossil hunters. The sediments comprising the formation, which is particularly well exposed here, were probably deposited in shallow marine environment with an average water depth of 50-100 metres.

"We were particularly interested in the transition between organic-rich and organic-poor sediments," said Dr Ian Harding of the University of Southampton's School of Ocean and Earth Science at the National Oceanography Centre, Southampton (NOCS), and a member of the team that investigated the underlying processes.

A long-held hypothesis is that the organic-rich beds were the result of elevated planktonic productivity in sunlit surface waters, possibly accentuated by enhanced preservation of the resulting organic matter by the oxygen-depleted bottom waters resulting from this excess productivity.

A second possibility was that a cyclic rise and fall of the interface between oxygenated and oxygen-depleted waters was responsible for the transition between organic-rich and organic poor sediments. According to this theory, when oxygenated waters reached the seabed, organic matter already deposited would have been oxidised and degraded. These post-depositional 'burn down' events could have alternated with periods during which the bottom waters had little oxygen, favouring preservation of organic matter.

"The first theory emphasises changes in the amount of organic matter reaching the seabed, while the 'burn-down' theory puts more weight on the relative dominance of preservation or degradation after it has got there," said Dr Harding.

To distinguish between these two theories, he and colleagues from the University of Bremen and the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, analysed the chemical composition and organic content of a sediment core from a borehole in Swanworth Quarry in Dorset, originally drilled as part of the Natural Environment Research Council (NERC) Rapid Global Geological Events Project run by NOCS' Prof. John Marshall.

Monika Kodrans-Nsiah, a PhD student jointly supervised by Dr Harding and Dr Karin Zonneveld (Bremen) was responsible for analysing the fossilised organic cysts of various species of dinoflagellate, a group of tiny aquatic organisms, found in the sediments. Different dinoflagellate species are known to be adapted to different environmental conditions, so studying the distribution of 'dinocyst' fossils helps reconstruct past environments.

The lower part of the core was rich in organic carbon, with abundant dinocysts, and its chemical composition was indicative of anoxic conditions, implying that sediments were deposited and preserved in an oxygen-deficient environment.

However, the chemical composition of the uppermost sediments indicated the presence of oxygenated water when they were deposited. This transition was sudden, occurring at a drilling depth of 122.37 metres, but changes in organic content and dinocyst distributions were more gradual.

"It looks likely that influxes of well-oxygenated bottom water caused the oxidation and degradation of organic matter and cysts after they were deposited," said Dr Harding: "This would explain the gradual reduction in the amount of organic matter above the transition, and provide support for the idea of 'burn-down' events during the Jurassic."

More information: M. Kodrans-Nsiah et al. Are the Kimmeridge Clay deposits affected by "burn-down" events? Palynological and geochemical studies on a 1 metre long section from the Upper Kimmeridge Clay Formation (Dorset, UK). *Sedimentary Geology* 222, 301-313 (2009).

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