

## Oceanic redox conditions during the Early Aptian Oceanic Anoxic Event (OAE1a) in the Vocontian Basin, SE France

Ko Nifuku<sup>2</sup>, Tatsuhiko Sakamoto<sup>1\*</sup>, Koichi Iijima<sup>1</sup>, Saburo Sakai<sup>1</sup>, Katsuhiko Suzuki<sup>1</sup>, Ryoko Senda<sup>1</sup>, Francisco J. Jimenez Espejo<sup>1</sup>, Haruyoshi Maeda<sup>2</sup>

<sup>1</sup>JAMSTEC, <sup>2</sup>Kyoto Univ.

Extensive oxygen-depleted environment was occasionally developed in the Phanerozoic oceans, which is called Oceanic Anoxic Events (OAEs). OAEs had significant impact on marine life evolution and global climate, and they formed vast of petroleum source rocks. Therefore, OAEs played important roles in the Earth history. However, detailed environmental changes during OAEs are not fully understood. The present study developed a new methodology for precise and efficient estimation of paleo-redox conditions and applied it to the Early Aptian OAE (OAE1a). The relationship among lithology, bioturbation intensity, and redox-sensitive trace element contents were examined in the Lower Aptian black shale, marl, and limestone sequence in the Vocontian Basin, SE France. Three major lithofacies were recognized in the studied interval, and they represent particular bioturbation intensity and trace element contents. Black shale (Facies 1) is scarcely bioturbated well-laminated dark, organic and pyrite-rich lithofacies with redox-sensitive trace element enrichments. It is interpreted to have been deposited under anoxic condition. Dark gray marl (Facies 2) is scarcely bioturbated massive dark lithofacies with relatively high organic carbon and pyrite contents. Trace element contents represent low to high values. Its depositional environment is estimated to be anoxic to slightly oxygenated condition. Gray marl, light gray marl, and limestone (Facies 3) are weakly to intensively bioturbated light, organic and pyrite-poor lithofacies without trace element enrichments. It is interpreted to have been deposited under slightly to fully oxygenated condition.

This relationship allowed development of a combined ichnological and geochemical approach to reconstruct paleo-redox conditions. In this approach, redox-sensitive trace element ratios were employed for dark, organic and pyrite-rich lithofacies (i.e. Facies 1 and 2) to estimate paleo-redox conditions, and burrow density was used as a proxy for light, organic and pyrite-poor lithofacies (i.e. Facies 3). Finally, a precise and detailed reconstruction of oceanic redox conditions at the OAE1a in the Vocontian Basin was brought by this combined approach. It was revealed that benthic environments during OAE1a were fluctuating on the order of 10-100 kyr, representing alternation of anoxic and slightly oxygenated conditions. Such short-term fluctuations were also recognized before and after OAE1a in the studied site, when benthic conditions were more oxygenated. These findings will be an important key for elucidating mechanisms of dysoxia/anoxia formation during OAEs.

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