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Sedimentary facies and ichnological analysis of the Lower Toarcian OAE sequence in Toyora area, West Japan

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It is well known that during the Phanerozoic a global oceanic anoxic event (OAE) occurred episodically, which simultaneously accompanied a mass extinction event in the marine biota. One of the first ordered OAEs is known as the middle to late Permian super anoxia that lead the largest mass extinction of the shallow marine biota throughout history of the Earth (e.g. Isozaki, 1 997). During the Early Toaecian (Early Jurassic), a second ordered OAE prevailed in the world oceans which led to a prominent turnover of marine biota in both shallow and deep water settings (e.g. Hallam, 1987; Hori, 1993). The Early Toarcian OAE event is characterized by deposition of bituminous black muddy sediments that lacks apparent remains of benthic organisms in association with negative stable carbon isotope excursion (e.g. Jenkyns, 1988; Hesselbo et al., 200 7; Cohen et al., 2007). The Early Toarcian OAE deposits in the Tethys realm (e.g. Europe) has been studied extensively from the viewpoints of geochemistry, sedimentology and palaeontology, but little was investigated for the contemporaneous strata deposited in the Panthalassa.
The Nishinakayama Formation distributed in the Toyora area, Yamaguchi Prefecture, west Japan is correlated to the Pliensbachian to Lower Toarcian by ammonite biostratigraphy (Hirano, 1973). This formation contains fine-laminated, bituminous black shales with sedimentary pyrite, in the middle part, which are contemporaneous with and similar in lito- and biofacies to the Early Toarcian OAE strata in Northwest Europe (Tanabe et al., 1982). The biostratigraphic, palaeoecological and taphonomic aspects of the molluscan fauna of Nishinakayama Formation have been extensively investigated and their relationship to the Early Toarcian OAE has been suggested (Tanabe, 1991). Nevertheless, little is known for the activity of benthic organisms in relation to the OAE event.
In this study, we investigated the activity of the benthic organisms as recorded in the sediments as trace fossils for the Upper Pliensbachian to the Lower Toarcian succession exposed in the Sakuraguchi-dani Valley.
For this purpose, 52 rock samples and 34 ammonite fossil samples were successively obtained from the sequence, with making a detailed geologic column. In the field, laminae and trace fossils which were visible to the naked eye were observed elaborately, and lamina index was given to all rock samples. In addition, soft X-ray images of 17 rock samples were taken in the laboratory in order to estimate the degree of bioturbation and trace fossils which were invisible to the naked eye.
With reference to the scheme for the relationships among lithofacies, sedimentary fabrics, and ichnofacies (e.g. Savrda and Bottjer, 1991, 1989; Rohl et al., 2001), lamina index was used to estimate the sedimentary environment and activity of benthic organisms for the Lower Jurassic succession exposed in the Sakuraguchi-dani Valley.
As a result, beds accompanying trace fossils and bioturbation are recognized at two horizons within the OAE sequence. This fact strongly suggest that the Early Toarcian OAE event recorded in the Sakuraguchi-dani Valley section was not a single event but was interrupted by short-term oxygenation events during the interval.
Furthermore, international correlation of the OAE horizon between the Northwestern Panthalassa

(Toyora area) and European Tethys regions by means of ammonite biostratigraphy revealed that the Early Toarcian OAE in the shallow Panthalassa began earlier and continued longer than in Tethys Sea.

Keywords: OAE, Early Toarcian, Nishinakayama Formation