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Ocean redox histry during the Early Triassic

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The greatest mass extinction occurred at the end of the Permian. A substantial biotic recovery was delayed until the end of the Early Triassic, which lasted about 5 million years. This was an unusually long delay for biotic recovery after a mass extinction, the Early Triassic therefore has often been viewed as an interval when global conditions repeated hostile to life. Several euxinic phases during Early Triassic have been reported. However, ocean redox history information of whole Early Triassic epoch is not enough. Here we show euxinic ocean appeared several times in the Early Triassic and euxinic conditions gradually became much stronger toward the end of the Early Triassic. The most severe condition occurred just before the recovery. However, this condition suddenly disappeared and dissolved oxygen levels abruptly increased in the Middle Triassic. This phenomenon coincided with biotic recovery in the Middle Triassic. Dibenzothiophenes and arylisoprenoids are detected which provide unequivocal evidences for depositional environment euxinia and photic zone euxinia at ˜80 m water depth. These biomarkers became more abundant toward the end of the Early Triassic. Okenane, a biomarker for photic zone euxinia at ˜20 m water depth, is never detected without the end of the Early Triassic. Moreover, crocetane which is a biomarker for anaerobic methanotrophic Euryarchaeota (ANME) is detected from the middle Spathian to the latest Spathian. Crocetane indicates existence of methane in the Early Triassic sea. This methane might be derived from methane hydrates. Anaerobic oxidation of methane is the chemical reaction: the consumption of methane and the formation of sulfide (e.g. hydrogen sulfide) from sulfate at a molar ratio of 1:1 by consortia of ANME and sulfate-reducing bacteria. Dissolved oxygen in the sea would have to be eliminated at least twice of hydrogen sulfide generated by anaerobic oxidation of methane given the stoichiometry of the reaction. The overproducing of hydrogen sulfide would induce the uprise of chemocline. Consequently, anaerobic oxidation of methane might make the sea with euxinic condition. The most severe euxinic condition at the end of Early Triassic was possibly caused by anaerobic oxidation of methane triggered by melting methane hydrates. This is a model case that melting methane hydrates is not only a driver of global warming but also a driver of ocean euxinia.