Oxygen isotopes and temperature

Oxygen isotopes in marine carbonate is often used for reconstructing ancient palaeotemperatures and/or palaeosalinities. Choose a specific short-lived event (<2 Myr) between 1 to 50 million years ago and write a short synopsis of the event based on oxygen isotope ratios. The text box provided below is the maximum amount of text allowed (Times New Roman, font size 11, single line spacing) and should include at least 3 references. You can include a page of figures in the text box overleaf.

The T-OAE is thought to represent a time of severe global environmental change and is associated with the extinction of many marine organisms (Aberhan and Fürsich, 1996; Harries and Little, 1999; Erba, 2004). Foremost among these changes is the hypothesis that the T-OAE interval contains a large-scale perturbation to the global carbon cycle, which is recorded in this stratigraphic interval as a prominent negative CIE; carbon isotope analyses ($\delta^{13}C$, from organic carbon, carbonate carbon, and fossil wood) from T-OAE strata display a negative CIE of up to 6 ‰ (e.g., Hesselbo et al., 2000; 2007; Kemp et al., 2005; Hermoso et al., 2009).

The Toarcian CIE has been estimated to have a total duration anywhere between 0.2 – 2 Myr; however, recent estimates suggest durations of ~300 kyr and 500 kyr (Sell et al., 2014 and Boulila et al., 2014 respectively). Based on this duration, the carbon isotopic record of the T-OAE shows similarities to that of the Paleocene-Eocene Thermal Maximum (PETM), which has been suggested to be the result of a massive, transitory release of carbon to the ocean-atmosphere system via marine clathrate destabilization (Dickens et al., 1995), volcanic outgassing (Svensen et al., 2004), oxidation of organic-rich matter (Kurtz et al., 2003; Higgins and Schrag, 2006), or a combination of these drivers (Panchuk et al., 2008).

The temporal association of the T-OAE with the emplacement of the Karoo-Ferrar large igneous province (LIP) (Pálfy and Smith, 2000; Svensen et al., 2007; Sell et al., 2014; Burgess et al., 2015) has led to the proposition that this is the likely driver of the T-OAE and the CIE through the injection of mantle derived CO_2 into the atmosphere. This would lead to a cascade of environmental effects including global warming, increased precipitation and continental weathering, ocean anoxia and acidification, and marine extinctions. Importantly, some of the Ferrar volcanic sills intrude through coal seams, which may have released additional amounts of methane and carbon dioxide into the atmosphere (McElwain et al., 2005; Svensen et al., 2007; c.f. Gröcke et al., 2006). Interestingly, the onset of the CIE observed in some locations contains 'steps,' which have been interpreted to represent discrete methane clathrate destabilization events controlled by changes in ocean circulation on orbital timescales. In particular, Kemp et al. (2005) suggested that these steps in the carbon isotope record from Yorkshire, UK, were generated by the destabilization of methane clathrate reservoirs on precessional timescales.

Several studies have challenged the hypothesis that the CIE represents a global perturbation to the carbon cycle and suggest that it was only a localized phenomenon. This conclusion is driven by a failure to identify the CIE in some localities, casting doubt on the severity of this event, and also the utility of the Toarcian CIE as a global chemostratigraphic marker. The bulk of the published studies on the T-OAE are concentrated in the European Tethyan and Boreal regions (Figure 1); thus, there is some doubt as to whether the T-OAE was a global phenomenon and was instead restricted to this region (van de Schootbrugge et al., 2005; Wignall et al., 2006; McArthur et al., 2008). Potential drivers of the CIE in this context have focused on regional oceanographic processes that controlled the local carbon isotopic composition of contemporaneous seawater (e.g., Küspert, 1982). In these scenarios, locally expressed CIEs are generated due to basinal restriction and vigorous local organic matter remineralization (van de Schootbrugge et al., 2005; Wignall et al., 2006; McArthur et al., 2008; Guex et a., 2012; Neumeister et al., 2015). These competing hypotheses make it imperative to further explore the carbon isotope record of the T-OAE elsewhere to help better understand the true nature of the Toarcian carbon cycle.