Onset of North Atlantic Deep Water production coincident with inception of the Cenozoic global cooling trend

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Hohbein et al. (2012) propose an early Mid-Eocene onset of North Atlantic Deep Water (NADW) production by interpreting a mounded deposit at the south-west end of the Faroe-Shetland Basin (FSB) as a contourite drift, which they term the 'Judd Falls Drift (JFD)'. We argue that this deposit is not a contourite drift; we also question how their model of early NADW production fits with current understanding of the development of the Faroe-Shetland Basin and the wider Arctic–NE Atlantic region, neither of which was convincingly discussed by these authors. Our reasons are based on the following:

1. Sedimentology of British Geological Survey borehole 99/3. In this borehole, the unconformity at the base of the JFD (the Intra-Eocene Unconformity (IEU) of Hohbein et al.) is marked by ferruginous conglomeratic sandstone atop a thick Ypresian deltaic succession (Leslie et al., 2010). This is a subaerial or shallow marine erosion surface, and not a 'deep-sea hiatus' as stated by Hohbein et al. The overlying Middle–Upper Eocene marine sediments – assigned wholly to the JFD – comprise sandy mudstone and mudstone with sporadic distal turbidite layers. In contrast with established contourite facies models, these deposits display no evidence for significant changes in current velocity, and bioturbation has not destroyed original lamination and bed contacts.

2. <u>Structural arguments.</u> The domal, downlapping, plastered-drift morphology of the JFD, as depicted in Figure DR1 of Hohbein et al., would require the disposition of the IEU in its present form during deposition of the JFD. That the IEU is a subaerial/shallow-marine unconformity means that its current structural – folded – disposition is unlikely to reflect its original geometry. If, instead, the IEU was restored to a flatter disposition prior to folding, then the overlying stratal terminations could equally be related to a downlapping slope-apron as the older deltaic succession was tilted and submerged. The presently observed structure of the Eocene succession is related to folding associated with the growth of the Judd and other anticlinal domes since the Mid-Eocene, with a significant phase of folding in Early/Mid-Miocene times (Ritchie et al., 2011).

3. <u>Palaeogeographic arguments.</u> Hohbein et al. state that the 'current regime responsible for deposition of the JFD may have been fundamentally similar to today's hydrographically significant deep overflow through this important gateway'. On the basis of the following observations we disagree that an oceanic gateway existed at this time across the Greenland-Scotland Ridge (GSR).

    a. Post-breakup Eocene sedimentation in the FSB was interspersed with phases of uplift and compression. This tectonism forced episodic recurrence of marginal deltaic systems, channelized incision of the contemporary shelf, and shelf-margin progradation particularly around the southern margin of the basin (Ólavsdóttir et al., 2010; Ritchie et al., 2011). For most of the Eocene, the FSB was a semi-enclosed basin, with no deep-water outlet to the south of the GSR.

    b. There is compelling evidence from ^{13}C, ^{18}O, taxonomic and sedimentologic data from numerous DSDP and ODP sites in the North Atlantic that the GSR was a topographic barrier to any form of north to south deep-water overflow during the Palaeogene, and that no true deep connection existed before the Mid-Miocene when the present synclinal form of the Faroe Bank Channel was created, and a deep-water conduit established (Stoker et al., 2005). This tectonic event was coincident with deep-water breaching of the Arctic gateway (Jakobsson et al., 2007), and the synchronous onset of contourite drift accumulation either side of the GSR was an immediate response to these early Neogene deep-water gateway connections (Laberg et al., 2005).

c. The palaeoenviroment of the Arctic and NE Atlantic region was predominantly warm and temperate during Early Eocene times (Ruddiman, 2001). Despite a gradual decline in temperature from the Mid-Eocene it seems unlikely that large ice sheets were permanently established prior to 34 Ma (Tripati et al., 2005). As NADW is defined as a water mass that forms in the polar North Atlantic Ocean by winter chilling of saline surface water (Ruddiman, 2001), we query how any kind of thermohaline flow comparable to the present-day NADW regime could have been active during the Eocene.

In summary, sedimentologic and structural evidence provides no support for a contourite drift and palaeogeographic considerations suggest it is unrealistic to assume that a pattern of oceanic circulation, similar to the present NADW, was active so early in the breakup of the NE Atlantic region.

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