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Fine-Grained Volcanic Material within the Early Eocene (T50) Balder Formation: Implications for Hydrocarbon Exploration in the North Sea and Faroe-Shetland Basins*

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Abstract

The North Atlantic Igneous Province is a large-scale magmatic system that includes abundant igneous intrusions and volcanic rocks, throughout the North Atlantic, NW Europe and Greenland. This phase of magmatic activity resulted in the separation of Greenland from NW Europe, with initial seafloor spreading ca. 55.5 Ma, which coincided with deposition of the Balder Formation (BF) throughout the North Sea and Faroe-Shetland basins (NSB and FSB respectively; Jacqué and Thouvenin 1975; Knox and Morton 1983). Thick siliciclastic units were deposited in the BF during a time of magmatism-related uplift of surrounding landmasses (e.g. Scotland and Norway), and these provide some of the major hydrocarbon discoveries found within the early Paleogene stratigraphy of the NSB and FSB (Mitlehner 1996; Mudge 2014). A key characteristic of the BF is its use as a regional stratigraphic marker horizon that can be identified in wire-line and seismic data. This marker horizon has been linked to an abundance of basaltic volcanic material that was deposited in >200 layers within predominantly claystones, siltstones and sandstones during the early Eocene (Jacqué and Thouvenin 1975; Pedersen et al. 1975; Roberts et al. 1984). Detailed analysis of thin-sections, during this study, shows that volcanic material is present within the BF of the NSB although its presence within the FSB is not clear due to a lack of available core. It is also uncertain as to how this volcanic material formed and what processes led to its deposition within the sedimentary stratigraphy of these areas. Although preliminary results suggest that the original tephra was produced during hydrovolcanic eruptions, as shown by an abundance of poorly vesicular and blocky shards (Figure 1).

Logging of available core from UK and Norwegian sectors of the NSB has provided detailed information for this study, regarding the depositional history of the BF. It is apparent from this that suggestions by previous authors, that the >200 basaltic layers in the NSB are representative of >200 eruptive events cannot be true. Instead, it is likely that a large amount of this volcanic material has been reworked and redeposited in the basins. Thin-section analysis of samples from the NSB, and onshore age-equivalent strata in E. Anglia (UK), have revealed that it is difficult to identify the amount of volcanic material within the BF, because most of the material is no longer preserved and is now

predominantly present as secondary clay minerals due to extensive palagonitisation. This high degree of alteration, along with the highly interbedded nature of the strata, causes mud-losses and cavings when drilling through the BF. However, these characteristics may increase the suitability of the BF as a seal, particularly where it occurs above thick siliciclastic fan deposits, potentially creating stratigraphic traps for hydrocarbons. Such traps have been exploited in the North Sea, for example in the Balder Prospect; however, the stratigraphy of the BF in the FSB requires further investigation to allow an assessment of its hydrocarbon potential to be made. Investigations made on samples from onshore in E. Anglia show that volcanic material can be removed created a secondary porosity within the deposits, which could increase the BF's potential as a suitable reservoir for hydrocarbons.

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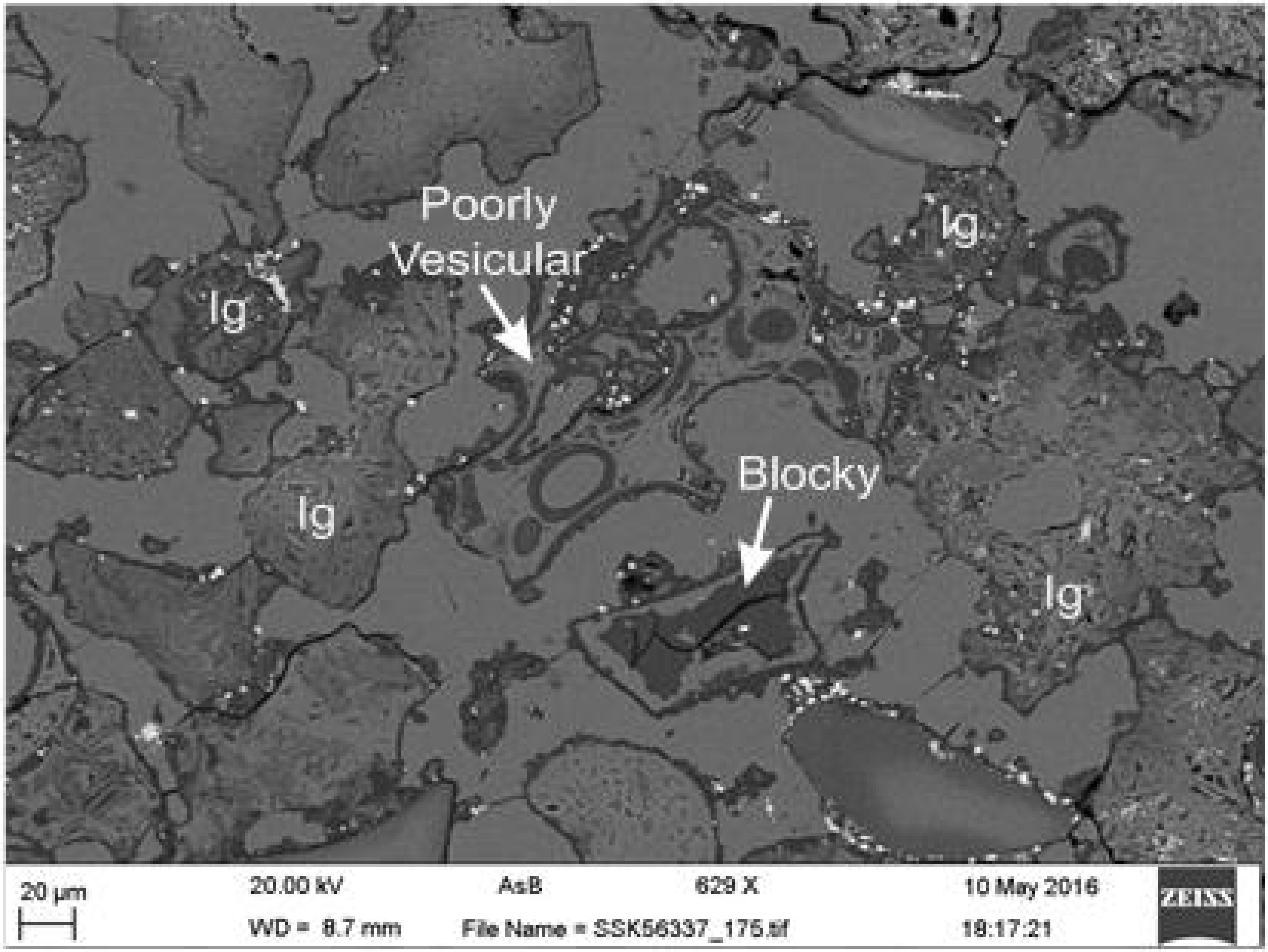

Figure 1. Backscatter SEM image of altered juvenile blocky and poorly vesicular fine ash and crystalline igneous accidental lithics, from the BF of UK Well 22/03a-1.