Proceedings of the Geologists' Association 126 (2015) 156–162

Contents lists available at ScienceDirect

Proceedings of the Geologists' Association

journal homepage: www.elsevier.com/locate/pgeola

Viewpoint

Pleistocene ice as a factor in supposed Neogene exhumation of the southern British Isles

John C.W. Cope [a,*], David Q. Bowen [b]

[a] Department of Geology, National Museum of Wales, Cathays Park, Cardiff CF10 3NP, UK
[b] School of Earth and Ocean Sciences, Cardiff University, Cardiff CF10 3AT, Wales, UK

ARTICLE INFO

Article history:
Received 17 October 2014
Received in revised form 19 December 2014
Accepted 20 December 2014
Available online 21 January 2015

Keywords:
Palaeogene
Neogene
Deformation
Exhumation
Glaciation
Southern British Isles

ABSTRACT

Until recently exhumation of much of the southern British Isles, outside of the area of well-documented Neogene folding in south-eastern parts of England has been ascribed to large-scale early Palaeogene erosion following igneous underplating in the Irish Sea and surrounding areas during the early Cenozoic. Recent publications have, however, identified Neogene structures over parts of this area and claim that a thick Neogene succession has been deposited and then eroded. Herein we suggest that such a claim has overlooked the thick ice-sheets that once covered the area that could largely explain the observed uplift figures. We conclude that the structures in the Irish Sea are of composite age and their Neogene component is minor.

1. Introduction

The post-Cretaceous history of the southern British Isles is in part very well known, but in other parts the subject of considerable controversy. In south-eastern and central southern England that history is well constrained by preserved rock successions. Palaeogene rocks are preserved in the London and Hampshire basins; in the latter, rocks of up to Early Oligocene (Rupelian) age are preserved, showing that the asymmetric downfolds in which these rocks crop out are of post-Rupelian age, whilst on the eroded regions of the Weald Anticline of south-east England, outliers of Lenham Beds, now regarded as probably of latest Miocene (Messinian) age, rest directly on Chalk, showing that the folding and much of the subsequent erosion of south-east England can be constrained as having occurred between the Late Oligocene and latest Miocene times (Fig. 1).

In other areas of Britain, Palaeogene sediments are very patchily preserved. Pull-apart basins along the line of the Sticklepath-Lustleigh Fault running from Torbay to south Pembrokeshire preserves some thick Late Palaeogene sediments (Tappin et al., 1994) (Fig. 1). Late Palaeogene (possibly extending into earliest Neogene) sediments are also preserved in the Cardigan Bay Basin, (Wood and Woodland, 1968; Woodland, 1971), and in the St George's Channel Basin but few other outcrops are known.

Outside of this area, in north-western parts of Britain is a thick succession of lavas and associated intrusions, principally of Eocene age (Bell and Williamson, 2002). These form part of an extensive suite of igneous rocks that has been related to the opening of the northern part of the North Atlantic (White, 1988). It is generally accepted that this igneous activity is connected to the Icelandic plume (Saunders et al., 1997) and has played a significant part in the Tertiary evolution of the British Isles.

2. Reconstructing the missing record

Over large areas of northern and western England, and over Wales, there is little or no direct evidence of its Palaeogene history, but, largely because of the existence of important hydrocarbon reserves in the Eastern Irish Sea Basin (EISB), a considerable effort has been put into apatite fission track analysis as a tool to understanding the history of this area and its surroundings. Earlier models (e.g. Lewis et al., 1992) suggested that parts of Northern England had lost some 3 km of cover through Palaeogene erosion, but Holliday (1993) showed that their assumptions of thermal conductivity and ambient Palaeogene temperatures were both incorrect, resulting in figures that had considerably over-estimated the amount of erosion.

* Corresponding author. Tel.: +44 029 2057 3157.
E-mail address: john.cope@museumwales.ac.uk (John C.W. Cope).

http://dx.doi.org/10.1016/j.pgeola.2014.12.006

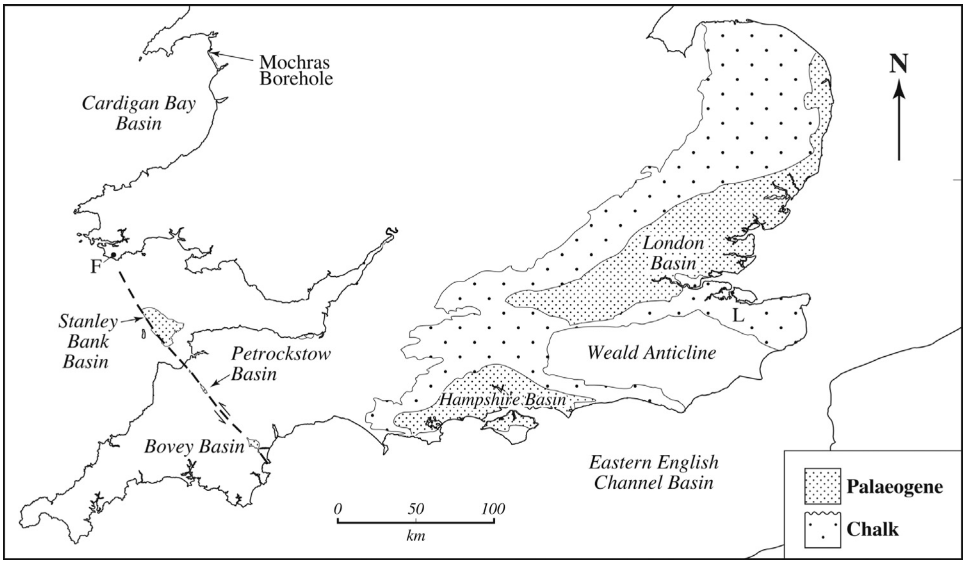

Fig. 1. Principal Palaeogene outcrops in southern Britain. The outcrop of the Chalk is also shown to identify more readily the Neogene structures in the area. The position of the Sticklepath-Lustleigh Fault and its basins are shown. F, Flimston, Pembrokeshire where the most northerly Palaeogene outcrop associated with the fault occurs.

On the basis of the figures amended in this fashion, Cope (1994) suggested that a hot-spot centred in the Irish Sea, south of the Isle of Man, could explain both the patterns of uplift and erosion suggested by the fission track data and the major positive gravity anomaly over the area. The amended figures could also be explained in terms of likely thicknesses of the eroded rocks and were entirely consistent with their likely local developments. Such uplift too could also explain the regional dip to the south-east of the southern British Isles and the curve in the outcrop of the Mesozoic rocks in southern and eastern England, north of the Chiltern Hills (Cope, 1994, fig. 1). Thomson (1995) suggested that underplating, rather than a hotspot, provided a better explanation of the phenomena reported by Cope (1994) and Cope (1995) accepted that this was a possible cause.

In a recent study of the crustal thickness and structure of the British Isles Davis et al. (2012) concluded that their observations supported the hypothesis that underplating had occurred and that vertical movements during the Cenozoic were principally controlled by epeirogeny connected with the Icelandic plume; they recognised that horizontal shortening had occurred, but suggested that it was on a very much smaller scale (an order of magnitude smaller) than hitherto suggested. Further, they suggested that there was poor correlation between crustal shortening and patterns of denudation. In a robust rejection of these conclusions Hillis et al. (2013) claimed that Davis et al.'s map of Cenozoic denudation (2012, fig. 10) was 'highly inaccurate' and pointed out that results from compaction studies, vitrinite reflectance and apatite fission track analysis showed over 1 km of denudation in areas where Davis et al. had claimed 0–500 m of denudation and that techniques including line balancing of sections, had shown shortening in places sufficient to generate some 1.5 km of Neogene erosion.

Al Kindi et al. (2003) had identified a discrete area of positive free air gravity anomaly over the Irish Sea that they had concluded could be explained by underplating of some 8 km just south of the Isle of Man, but with 6–8 km of underplating over an area including much of the northern part of the Irish Sea, Anglesey, the Isle of Man, and much of North Wales (significantly including the Mochras area (Fig. 2a)). There is a remarkably close correlation between that area of 6–8 km of underplating (Al Kindi et al., 2003, fig. 1) and the area that Cope (1994, fig. 1) had suggested had lost 2 km of sediments through uplift and erosion (though this was not acknowledged by Al Kindi et al., 2003) (Fig. 2a and b).

Since then Holford et al. (2005) and Hillis et al. (2008) have argued that the uplift responsible for the exhumation of Cardigan Bay, North Wales and areas to the north was principally Neogene and not Palaeogene and that there has been a subsequent major Neogene erosional episode. These authors also suggested that the fission track figures for the EISB, formerly attributed to large-scale uplift and subsequent erosion in the early Palaeogene, could instead be explained by elevated Palaeocene thermal gradients.

However, a study by Green (2002) had looked specifically and in detail at early Tertiary heat-flow in northern England. His conclusions on the basis of new apatite fission track analyses were that there was an early Tertiary palaeogeothermal gradient of 61 °C/km and that high areas consisting predominantly of Lower Palaeozoic rocks, such as Scafell (the highest point in the Lake District of northern England) had lost some 700 m of rock in the Palaeogene whilst the surrounding lowlands, consisting predominantly of Permian and later rocks, had lost some 1.5–2 km of rock over the same interval. Interestingly this paper also answers another problem that its author does not refer to. It provides an eminently satisfactory answer to the origins of the differentiation of topography into high and low ground not only of northern England, but also of North Wales, which was underplated to the same extent, to judge from the gravity figures of Al Kindi et al. (2003). It seems clear now that the present topography owes its primary origins to the early Palaeogene rapid uncovering of the highs in the Palaeozoic basement and subsequent differential erosion of the more resistant Palaeozoic rocks on the one hand and the softer Mesozoic cover on the other. The result was a surface of relatively low relief that was subsequently uplifted and gently deformed and subject to long-term Tertiary weathering and denudation (Battiau-Queney, 1994) to form the 'upland plains' (Brown, 1960; Walsh, 2001); these plains were then modified to produce the present landforms of Wales (Bowen and Livingston, 2012).

The conclusions of Holford et al. (2005) and Hillis et al. (2008) are also at odds with the stratigraphical record and raise major problems which these authors do not appear to have appreciated. The Neogene deposits of Britain are widely scattered and mostly very thin. In the south-east of England small outliers of the Lenham Beds, now regarded as probably of latest Miocene (Messinian) age