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Under-representation of faults on geological maps of the London region: reasons, consequences and solutions

D.T. Aldiss *

British Geological Survey, Keyworth, Nottingham NG12 5GG, UK

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ABSTRACT

London lies mainly within an area of long-term tectonic stability known as the London Platform. This is characterised by relatively thin Cretaceous and Palaeogene sequences overlying Palaeozoic basement at shallow depths, less seismic activity than surrounding areas and, according to published geological maps, little faulting.

However, observations of temporary exposures and borehole records, and other studies, show that in reality faults are numerous and widespread in the London region. Their relative absence on the geological maps is a consequence of past mapping methods, coupled with the relative uniformity of extensive bedrock units such as the London Clay Formation and the Chalk Group, and the widespread presence of Quaternary and anthropogenic deposits, and of urban development. However, complementary approaches to geological surveying, including the use of geophysical data and satellite-based radar interferometry, together with geological modelling in three dimensions using subsurface information, provide the means to accurately survey fault systems even in the most densely urbanised areas.

Such work shows that earth movements in the London area, apparently including near-surface fault displacements, have taken place during the late Quaternary and continue at the present. These findings are important to civil engineering projects and hydrogeological studies in the London area and to understanding local tectonic development.

1. Introduction

The megacity of London, UK, lies on the southern edge of the London Platform (the western part of the Anglo-Brabant Massif), an area of crustal stability during the Mesozoic and Cenozoic (Brenchley and Rawson, 2006). The western portion is underlain by part of the Midlands Microcraton, which has been largely stable since the Proterozoic, and the eastern part is founded on a buried north-west to south-east trending Caledonide fold belt, apparently largely stable since the mid-Palaeozoic (Fig. 1). In marked contrast, the Weald Basin, to the south, is founded on an east–west trending Variscan orogenic belt, which underwent crustal extension and subsidence during the Mesozoic, followed by inversion dating from the mid-Cretaceous until the Miocene (Chadwick, 1993; Pharaoh et al., 1993; Busby and Smith, 2001; Chadwick and Evans, 2005). In the Weald Basin, folded and thrust Late Palaeozoic rocks are overlain by Permo-Triassic, Jurassic and Cretaceous successions exceeding 20 km in vertical thickness in places. In the core of the London Platform, Palaeozoic rocks occur at less than 350 m below the surface, overlain by relatively thin mid- to Late Cretaceous successions. Older Mesozoic strata were never deposited there, or were subsequently largely eroded. Those that remain within the London Platform have been interpreted as being preserved within inferred localised grabens, presumably formed by reactivation of older structures (Owen, 1971; Ellison et al., 2004). The London Platform was finally buried following marine transgression during the Albian (Rawson, 2006), but there is nevertheless still some difference in the thickness of the Late Cretaceous Chalk Group deposited on the London Platform and in the area of the Weald Basin, for example during the Cenomanian (Rawson, 2006; Mortimore, 2011). Part of the regional variation in the thickness of the entire Chalk Group is due to differences in the extent of post-Cretaceous erosion, but a comparison of the interval between the base of the Chalk Group and the base of the Seaford Chalk (in the younger part of the sequence) shows that it increases from about 150 m in the London area (Ellison et al., 2004) to about 250 m in the Lewes district of the South Downs (Lake et al., 1987).

Rifting and crustal extension occurred in the North Sea from the mid-Cretaceous onwards through the Cenozoic. In the southern North Sea, extending north-eastwards from the area of Fig. 1, the Chalk Group is thicker and was deposited for longer, into the Palaeocene, than on the London Platform (Downing et al., 1993;

* Tel.: +44 115 936 3129.
E-mail address: dta@bgs.ac.uk

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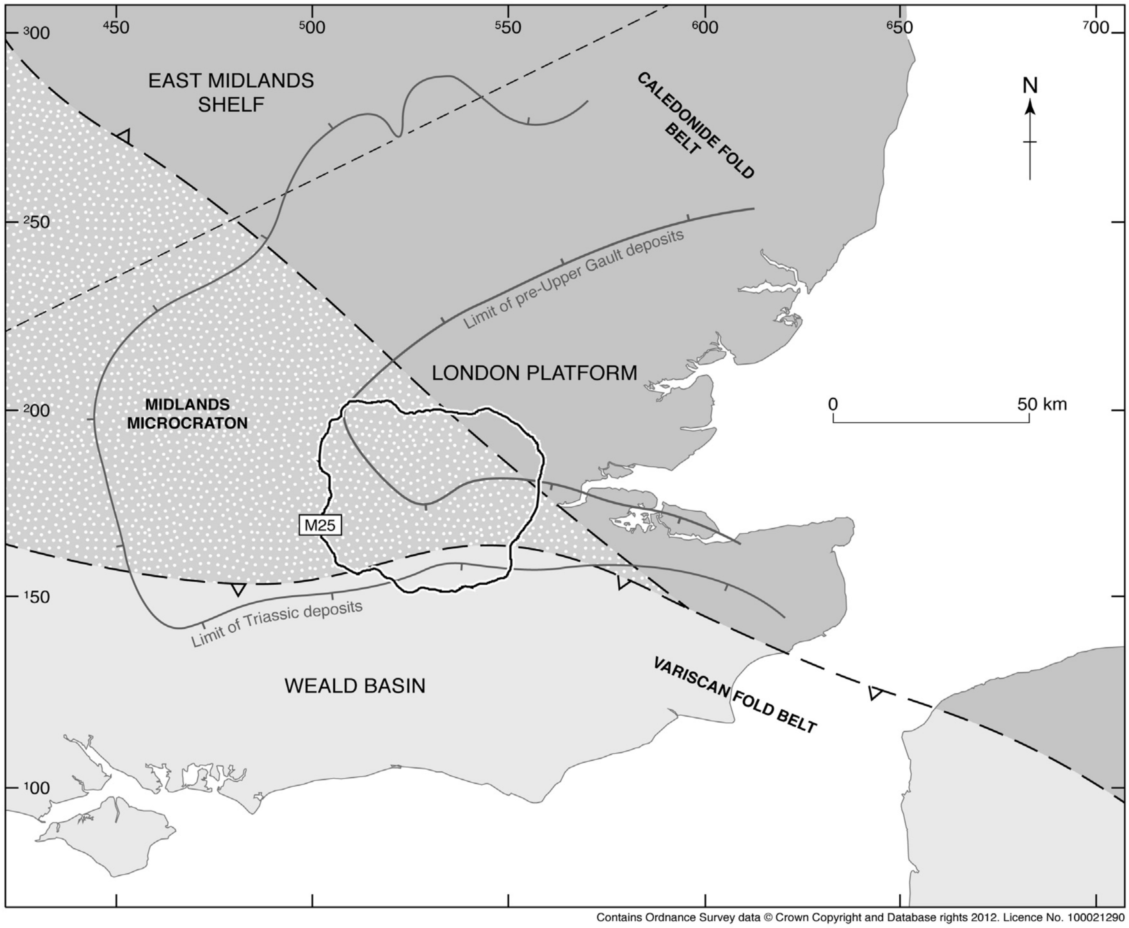

Fig. 1. Summary of tectonic units in south-eastern England. Basement terrains named in smaller, bold type. Post-Caledonian depositional areas named in larger, regular type. Extent of Triassic and pre-Upper Gault Cretaceous formations after Sumbler (1996). Position of London indicated by M25 orbital motorway.

Rawson, 2006). Although parts of the London Platform experienced a series of marine transgressions during the Palaeogene, forming the deposits of the London Basin (Fig. 2), the onshore successions are thinner and less complete than those offshore, reflecting their position on the basin margin (Knox, 1996; King, 2006).

The perception that the London Platform is an area of very long-term tectonic stability is supported by the apparent sparseness of faults in the area, as shown by medium-scale geological maps (Fig. 2). To the north of the glacial limit (Fig. 2), faults that might be present in the bedrock are likely to be difficult to recognise by conventional field geological mapping methods due to the extensive cover of Quaternary deposits. However, even if that part of the London Platform is disregarded, the contrast in fault density with the Wealden area is striking. The principle exception is within the Wimbledon–Woolwich tectonic axis, where periclinal folding is accompanied by *en echelon* faulting (Ellison et al., 2004). It is likely, *a priori*, that the Palaeogene rifting in the southern North Sea extended south-westwards into the London Basin, cutting across the dominant structural fabric of the Caledonide basement, but very few faults within this system appear on BGS geological maps.

The same impression is conveyed by the distribution of recorded earthquakes in England and the surrounding offshore areas, which shows that much of central and south-east England, including the London Platform, experiences very little seismic activity (Fig. 3). Only three, historical, earthquakes are recorded from the London area, although these do include the Colchester earthquake of 1884, which is the most damaging earthquake in Britain so far recorded (Musson, 2007).

However, although the London Platform is an area of relative tectonic stability it is not devoid of past earth movement. As pointed out by Ellison et al. (2004) and by de Freitas (2009), for example, there is evidence of extensive faulting in London and the surrounding area. It appears that faults have been under-represented on the geological maps produced by the British Geological Survey (BGS) and its predecessors, the Institute of Geological Sciences and the Geological Survey of Great Britain. This paper examines the reasons for this having occurred, some of the kinds of evidence that demonstrate or imply the existence of faulting to the geological surveyor, and the means by which our knowledge of local fault patterns is now being improved. In addition, it presents evidence for some faulting having occurred at or very close to the surface in the area of central London during the later part of the Quaternary.

An accurate and representative map of fault distribution and patterns of displacement (amongst other structural elements, such as fold and joint patterns) is a pre-requisite for understanding the tectonic development of a region. Moreover, in the London area, there is evidence for some local tectonic control of Late Cretaceous sedimentation (Mortimore et al., 2011) and it is likely that similar control influenced local aspects of Palaeogene deposition (Ford et al., 2010). Aside from its scientific relevance, faulting is an important influence on the design and execution of civil engineering works, and on the hydrogeological characteristics of the ground (de Freitas, 2009; Newman, 2009; Newman et al., 2010). Indeed, many of the faults in London may not be simple planes of movement ('sharp deformation breaks with shearing displacement' in the sense of Gillespie et al., 2011), but