London - Structure

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The Palaeozoic strata of the district encompass three structural provinces. The largest is the London Platform, part of a relatively stable rigid crust known as the Midlands Microcraton. The concealed Caledonide fold belt of eastern England probably underlies the extreme north-east of the district (Pharaoh et al., 1987), and a zone of transition between the London Platform and the Variscan fold-thrust belt lies in the south.

North–south-trending seismic reflection profiles traverse the extreme southernmost part of the district. One line south of Croydon passes just west of the Warlingham Borehole and shows a gently southward-dipping reflector in the sub-Mesozoic sequence. Kearey and Rabae (1996) named this feature the Addington Thrust (Figures 2; 42), interpreting it as a structure analagous to the Variscan thrusts to the west (Chadwick et al., 1983; Donato, 1988). The structure was reactivated in Mesozoic times when it became a growth fault during the development of the Weald Basin. The residual gravity anomaly map (Figure 43) provides further insight into this structure. It shows a gravity low in the south of the district that was formerly interpreted as part of a concealed basin containing Carboniferous strata (Falcon and Tarrant, 1951) but information from the Warlingham Borehole (Worssam and Ivimey-Cooke, 1971) failed to confirm this hypothesis. The trend of the anomaly is oblique to the structure contours (Figure 2) and, therefore, it is unlikely to be caused by changes in the elevation of the basement surface; Kearey and Rabae (1996) concluded that it provides further evidence for the existence of the Addington Thrust. They interpreted the anomaly as a thrust-slice, wedge-shaped in cross-section, of relatively high density Upper Palaeozoic rocks.

Other inferred structures in the Palaeozoic strata are the Streatham Anticline and a fault beneath the Thames estuary, both bringing strata of Silurian age to subcrop beneath the sub-Mesozoic unconformity (Figure 2). Bedding dips of up to 45° are recorded in boreholes close to the structures, but the Palaeozoic strata elsewhere in the district have a low dip.

Between the gravity low in the south and a high in the north-east, an area with a steep gravity gradient trends north-east to south-west. Superimposed on this regional trend are three linear zones of locally steep gravity gradients, shown as dark shading on Figure 43. They are interpreted as being due to pronounced variations in the thickness of Mesozoic strata, possibly brought about by a movement on syndepositional growth faults. Other structures in the Mesozoic syn-rift succession below the Cimmerian unconformity (at the base of the Lower Greensand Group), are interpreted largely on borehole evidence, but it is assumed that they are caused by reactivation of deeper seated structures. They include a small graben beneath central London inferred because of the preservation of Inferior Oolite proved in the Meux’s Brewery Borehole (Table 1) and a larger graben at Cliffe inferred from the distribution of the Oxford Clay in boreholes (Owen, 1971).

Structures in the post-rift Upper Cretaceous and Palaeogene strata of the district are better known than those in older strata because of surface exposure and information from a large number of boreholes. Data on the structure of the base of the Chalk (Figure 44) is sparse, but the structure contours of the Chalk– Palaeogene boundary and base of the London Clay (Figure 45) reveal considerable detail.

The geological structure of the district is relatively simple, being dominated by a broad north-east-trending syncline (the London Basin). The main limbs, coincident with the slopes of the North Downs in the south of the district and the Chiltern Hills in the north-west, dip generally less than 2°.

Superimposed on the southern limb of the syncline are numerous east-north-east-trending periclines with limb dips up to a maximum of 7°. Close to faults, dip is steeper and vertical dips have been recorded (Plate 5). Some of these folds are asymetrical, with steeper north-facing limbs. In the axial part of the London Basin, subsidiary folds are broader in wavelength and lower in amplitude, with limb dips less than 2°.

The main faults at the surface are the en echelon Wimbledon, Streatham and Greenwich faults (Figure 45). Their location has been determined largely on the evidence of borehole data, but they have been exposed at several localities. For example, the Streatham Fault was proved in a sewer tunnel [317 740] at Brockwell Park where a maximum throw of 15 m was recorded, and two branches of the Greenwich Fault were formerly exposed in railway cuttings [3721 7605 and 3735 3638] (Whitaker, 1872). The main faults show a downthrow to the north in the order of 10 to 30 m. The Greenwich Fault passes north-eastwards into the steep northern limb of the Greenwich Anticline. It separates an area to the north with broad folds from one to the south where there are many periclines

Other faults shown on the geological maps are inferred from borehole records, for example at Richmond Park [19 72] and Camberwell [32 78]. Small faults in the Chalk, many with slickenslides, have been recorded at numerous outcrops and temporary exposures in the district. Most are normal faults with throws less than 2 m, for example, in a sewer tunnel at Nunhead [357 754], in the railway cutting east of Banstead [250 604], in a sewer tunnel at Carshalton [277 632] (Dewey and Bromehead, 1921), on the chalk escarpment near Crookhorn Wood [67 62], and at the Thames Barrier [415 795] (Carter and Hart, 1977).

In central London where there is a high density of boreholes, prominent kinks in structure contours on the base of the Palaeogene surface (Figure 45) are interpreted as north-west-trending faults with throws of up to 5 m. These have not been verified in exposures and appear to counter the conclusions of Skempton et al. (1969) who did not identify a regional pattern of joint orientation in the London Clay in surface exposures. More recently, planar deformation zones of tectonic origin have been described in the London Clay (Chandler et al., 1998), associated with minor folds.

Small faults are recorded also in the Lambeth Group at Bushey and in excavations for the Underground railway between Oxford Street and Regent's Park (Bromehead, 1925). Small reverse faults were seen in a former London Clay pit near Lewisham [372 755] (Dewey and Bromehead, 1921), and in borehole core in the Lambeth Group between Stratford and Barking (unpublished BGS manuscript).

There is no published information about the regional distribution either of small faults or joints. A regional set of north-west-trending near-vertical extension fractures is apparent in the London Basin as a whole (Bevan and Hancock, 1986), although this orientation is modified, at least locally, as illustrated by the principal joints in the Chalk measured in exposures at Northfleet [632 737] (Figure 42).

Tectonic events

The timing of deformation events in the post-rift, Late Cretaceous to Palaeogene strata is not well known. Mortimore and Pomerol (1997) suggested that deep seated structures may have been active during deposition of the Chalk, leading to thicker successions of the Lewes Chalk and Seaford Chalk (late Turonian and Coniacian in age) in London and the Thames estuary area compared with the North Downs. Similarly, there is some evidence for minor inversion in Late Cretaceous–early Palaeogene times, which led to a greater amount of uplift and erosion of the Chalk in central London than in the North Downs (Mortimore and Pomerol, 1997).

Intra-Palaeogene tectonic activity, presumably driven by movement on the major deep-seated fractures, has been suggested from the London area but remains speculative (Ellison et al., 1996). Possible evidence for contemporary subsidence is the relatively thick Lambeth Group in west and central London compared with that found farther east (see for example Figure 14a) (see also Hester, 1965).

The main phase of folding in the district is assumed to have taken place in the Oligocene to early Miocene Helvetic phase of the Alpine orogeny. Interaction of the principal north–south compressive stress direction with the pre-existing deep-seated, east-north-east-trending structural fabric caused development of the en echelon Greenwich–Wimbledon Fault system and the en echelon, asymetrical folds in the Chalk and Palaeogene strata.

An assessment of tectonic activity in Pliocene and more recent times is hampered because there are few reference deposits in the London Basin. In regional terms, the height of deposits of probable Pliocene age is up to 180 m above OD in the Chiltern Hills and indicates a maximum uplift in the east of the London Basin equivalent to 0.9 mm per year over the past two million years (Worssam, 1963; West, 1972).

Further evidence for relatively recent neotectonic activity is found in the terrace gravels of the River Thames. The oldest terrace, at the greatest topographical elevation, is about 500 000 years old. The subsequent development of terrace gravels at progressively lower levels in the river valleys is now thought to be due to land uplift equivalent to 0.7 mm per year over the last 250 000 years (Maddy, 1997). There is also a possibility that neotectonic movement on the Greenwich Fault has led to the difficulty in correlating the River Terrace Deposits between central London and north Kent (see pp.61–62).

Whether or not uplift continues to the present day is currently in debate (Bingley et al., 1999) as there are conflicting lines of evidence concerning the interplay of sea level changes and land movement. For example, archaeological evidence indicates that the River Thames was not tidal in Roman times, and occupation levels in London were at least 2 m below current high tide level. This apparent relative rise in sea level was investigated further in the justification for the construction of the Thames Barrier. The increasing heights of storm tide surges and records from a Greater London tide gauge are thought to indicate an 8 mm per year rise in the level of the Thames estuary (Muir Wood, 1990). In contrast, estimates of global sea level rise are 1 to 2 mm per year (IPCC, 1995). Muir Wood (1990) estimated that 3 to 6 mm per year of the difference between these two figures could be due to the increase in tidal range, leaving up to 4 mm per year rise in water level possibly due to land sinking in Greater London.

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