Residual gravity anomalies across England from a 3D gravity-stripping model: preliminary evidence for Paleozoic basins and crustal structure

Donato J A[1], Pullan C P[2] and Butler M[3]

[1] Merlin Energy Resources Ltd., Newberry House, New Street, Ledbury, Herefordshire, HR8 2EJ

[2] CP Exploration, Butts Farm Barn, The Butts, Potterne, Devizes, Wiltshire, SN10 5LR

[3] UK Onshore Geophysical Library (UKOGL), 84 Coombe Road, New Malden, KT3 4QS

May 2026

Abstract

A ten-layer 3D gravity model has been constructed across large parts of England and Wales with layers representing stratigraphic intervals ranging between Lower Carboniferous to Tertiary. The model is based upon published structure maps augmented with unpublished seismic interpretations. The modelled rectangular area covers 200,000 sq km, extending in a N-S direction from northern England to the English Channel (British National Grid (BNG): 500^{000} to 000^{000}) and in an E-W direction from East Anglia to Wales (BNG: 650^{000} to 250^{000}). The calculated gravity effects of the ten individual modelled layers have been summed, and the resulting total subtracted from the observed gravity field, thus revealing a residual gravity map. This map is an attempt to remove the gravity effect of the shallower, better-understood structures, leaving anomalies related to deeper, less-understood features. The map reveals residual anomalies at various wavelengths.

Short wavelength anomalies are small in amplitude and may correlate with Silurian-Devonian (Old Red Sandstone) basins, such as the Ludlow, Wantage and postulated Luton-Cambridge Basins, or with areas of thicker Tremadocian sediments. Analysis of the gravity data suggests the presence of a thickened sequence of low-density material of probable Paleozoic age, extending for some 200km along the southern coastline of England.

Long wavelength anomalies are significantly larger in amplitude and speculatively suggest the gravity field to be divided into a series of broad residual gravity domains. In northern England, the residual gravity field is positive and includes two areas of higher residual values, one to the west centred over the Irish Sea, and one to the east rising over the Southern North Sea. In southwest England, residual values are also high, with a clear north-easterly boundary defined by a strong and linear gravity gradient extending from the Bristol Channel to beyond the Isle of Wight. A triangular area of lower residual values crosses southeast England and south Wales and extends south-eastwards into the eastern English Channel. Residual gravity gradients separate the domains and may be related to discontinuities associated with a tectonic amalgamation of different crustal blocks. The boundaries of the Midlands Microcraton and the Variscan Front are not clearly represented within the residual gravity data.

Introduction

In a previous study (Donato and Pullan, 2022), undertaken as part of the investigations of the Beneath Britain Group in association with the UK Onshore Geophysical Library (UKOGL), a series of 2.5D gravity and magnetic modelled profiles have been constructed across England. This study revealed numerous residual gravity anomalies, thought to originate from deeper features buried beneath the better-understood and shallower geological structures. Residual gravity features of both short and long wavelength were identified. At shorter wavelengths, many of the features were explained by the presence of granitic plutons or Paleozoic basins, some previously known and others newly proposed. At longer wavelengths, a broad low-gravity regional field with an amplitude in excess of 20mGal was identified. This was investigated further by Donato *et al.* (2024), who compared the anomaly to the expected gravity effect of thickened crust located approximately below the Midlands Microcraton and extending across southern England. It was concluded that part of the regional field may be attributed to the depth to the Moho boundary but that additional effects, including possible crustal density changes, were likely to be present within the regional field.

The study described here attempts to extend and refine these two previous gravity studies by the use of a detailed ten-layer 3D gravity model, spanning over 200,000 sq km and extending in a N-S direction from northern England to the English Channel and in an E-W direction from East Anglia to Wales. The layers represent stratigraphic intervals ranging between Lower Carboniferous and Tertiary. Their thickness and structure are based upon published depth maps augmented with unpublished seismic interpretations. The purpose of this paper is to describe the methodology and construction of the 3D residual gravity map, and to present the map in the expectation that it will elucidate the deeper features with greater clarity and therefore aid future interpretation studies. Brief comments on the possible interpretations of selected residual anomalies are, however, also provided.

The observed gravity field derived from Chacksfield and Edwards (2006) is shown within Figure 1(a). The Bouguer Anomaly has been calculated onshore with the Free Air Anomaly calculated offshore. A high-pass gravity gradient map is shown in Figure 1(b). This was derived by subtracting a 48km low-pass Zurflueh-filtered version (Zurflueh, 1967) from the observed field. Areas of steeper gradient are shown by darker shading and allow linear trends to be more clearly identified. The green contours, signifying depth to Moho, highlight thinner crust beneath the Irish Sea area and a zone of slightly thickened crust located approximately beneath the Midlands Microcraton (Donato *et al.*, 2024). The Microcraton's triangular form (red dashed outline) with our preferred alternative suggestion for the north-easterly margin (cyan dashed line, slightly modified from Pharaoh *et al.*, (2023)) is flanked on all sides by linear residual gravity gradients. To the south, approximately E-W lineaments follow the trend of Variscan deformation. To the north-west, NE-SW trends align with the series of Welsh Borderland Faults (Woodcock and Gibbons, 1988). The area to the north-east is less clearly defined, including a series of NW-SE trends but also incorporating WSW-ENE trending offsets, two of which are highlighted by the white arrows and are sub-parrallel to parts of the our preferred alternative edge (cyan dashed line).

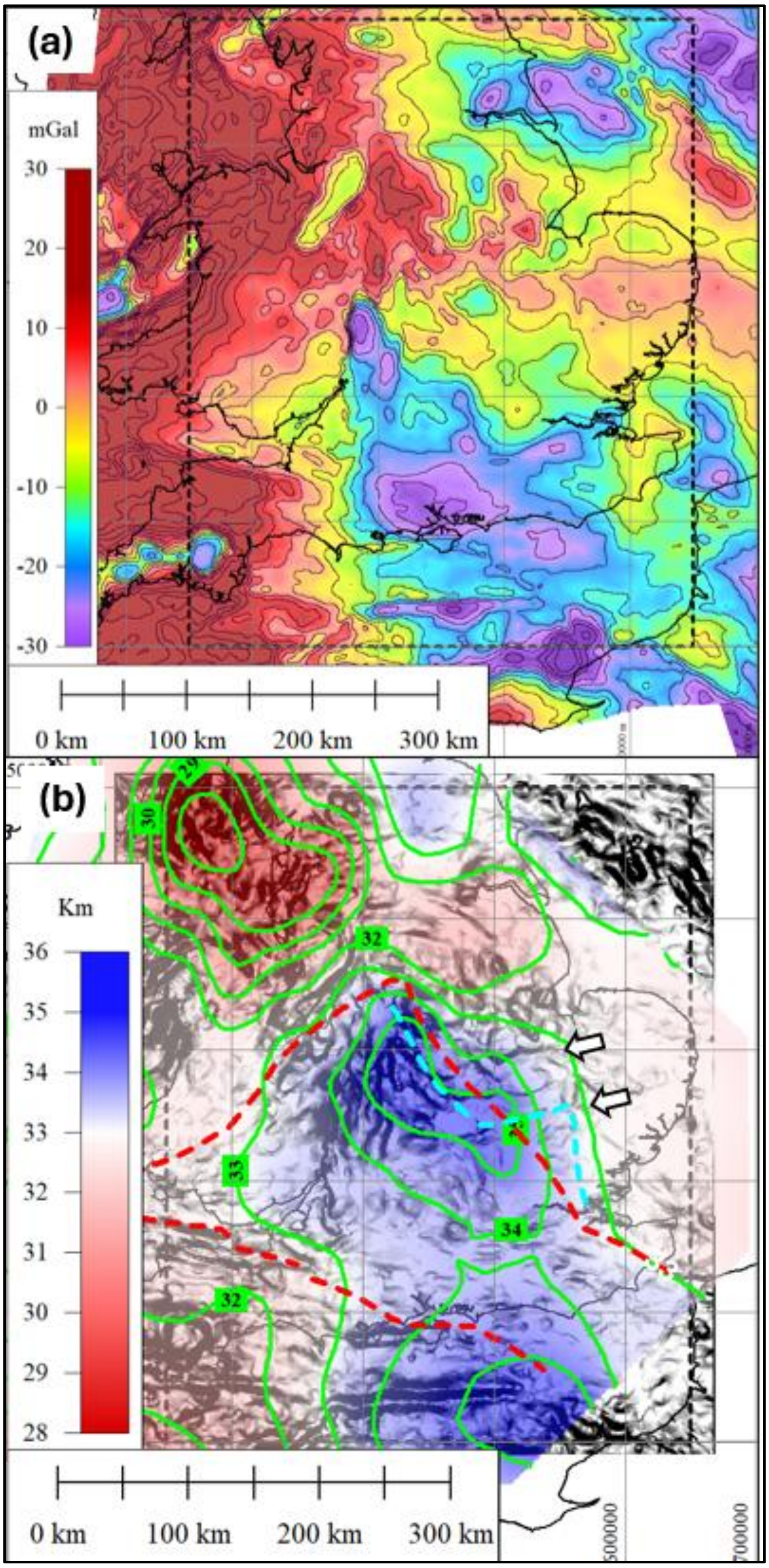


Figure 1(a) *BGS Observed gravity anomaly map derived from Chacksfield and Edwards (2006). Bouguer Anomaly is calculated onshore and Free Air Anomaly offshore. Areas of high gravity are shaded red with low areas shaded blue. The contour interval is 5mGal. The area of the 3D model is shown by the black dashed rectangle.* ***(b)*** *High-pass gravity map (see text for details) with dark shading showing zones of steeper dip. The green contour lines and associated red/blue shading show depth to Moho ranging approximately between 28 and 35km. The approximate position of the Midlands Microcraton is shown by the red dashed triangle (Butler, 2018) with our more recently preferred alternative north-eastern edge shown by the cyan dashed line (slightly modified from Pharaoh et al., 2023). An area of thickened crust, shaded blue, is located approximately beneath the Midlands Microcraton (Donato et al., 2024). Steeper gradient trends are thought to be related to deformation/fault zones, some located approximately along the flanks of the Microcraton. Both* ***(a)*** *and* ***(b)*** *contain British Geological Survey materials © UKRI 1991.*

3D Gravity Model *Horizon Structure Maps*

The ten-layer 3D gravity model incorporates various depth horizon grids as shown in Figures 2(a) to 2(h). Modelled layers include the following intervals: sea water (Layer 1), Tertiary (Layer 2), Chalk (Layer 3), Lower Cretaceous (Layer 4), Jurassic (Layer 5), Permo-Triassic (Layer 6), Carboniferous Coal Measures (Layer 7), Namurian (Layer 8), Dinantian (Layer 9) and granitic intrusions (Layer 10). As described below, layer structures are based upon numerous published depth structure maps in conjunction with recent unpublished seismic interpretations (Butler, ongoing studies).

For the onshore area, the Base Permo-Triassic and younger horizon grids rely heavily on the published maps of Whittaker (1985). Within southern England, the maps of Whittaker have been augmented with unpublished seismic interpretation by the authors (ongoing studies). Within the Carboniferous sequences of northern England, the mapping incorporates published maps, including those provided in BGS subsurface memoirs (Kirby *et al.*, 2000; Aitkenhead *et al.*, 2002; Smith *et al.*, 2005; Pharaoh *et al.*, 2011) together with additional published material (Jones *et al.*, 2023; Wijanarko *et al.*, 2025). The areal extent of these maps has been increased using our unpublished seismic interpretations. Unfortunately, there are some areas for which no published Carboniferous interpretations appear to be available, and the extent of mapping incorporated is shown by the dotted outlines in Figures 2(g) and 2(h). Carboniferous mapping in South Wales has been based upon various data sources, including the BGS cross-sections provided on BGS Sheets 229, 230, 231, 232, 246, 247, 248, 249 and 261, the South Wales Kirkland 1993 Geological Map and cross-sections (UKOGL website), the Shell seismic lines SG89-R-01V and SG89-R-02V (UKOGL, 2024) and the following wells: Margam Park No 1 and No 2, Cynheidre No 3, Rudry, Coedely Colliery No 2, Glyn Colliery No 1, Werndon Clay Pit, Universal Colliery, Pen-Ffordd-Goch, Great Western Colliery Hetty Pit No 2, Gypsy Lane BH and Standard Colliery No 2 Pit.

For the offshore areas, the English Channel structure is based upon maps provided on the North Sea Transition Authority website (2019), but it also incorporates interpretation by the authors for parts of the Bristol and English Channels. Additional published mapping undertaken by the BGS has also been integrated (Evans, 1990; Hamblin *et al.*, 1992). Western areas, including parts of Cardigan Bay and the Bristol Channel, incorporate material from Tappin *et al.* (1994). Within the Southern North Sea, the mapping integrates the interpretation provided by Arsenikos *et al.* (2015), North Sea Transition Authority (2019) and Fairhead *et al.* (2023). The Irish Sea area incorporates mapping from Jackson *et al.* (1995) and Pharaoh *et al.* (2016).

A tenth layer (Figure 2(i)) has been incorporated in an attempt to calculate, and hence illiminate, the effect of various granitic intrusions. The assumed granite structures are based upon published interpretations (Bott *et al.*, 1958; Bott, 1961; Smart *et al.*, 1964; Bott, 1967; Allsop, 1985; Donato, 1993; Rabae and Kearey, 1997; Busby *et al.*, 2006; Kimbell *et al.*, 2006; Donato, 2019; Donato and Pullan, 2022; Donato *et al.*, 2025) together with ongoing studies associated with the postulated Bakewell, Fownhope and Dover Straits Granites. Those granites located on the margins and to the south of the study area, including the Church Stretton, Cornubian Batholith, Central Channel, Barfleur Granites, Dover Straits and North Foreland granites have not been included within this tenth layer model.

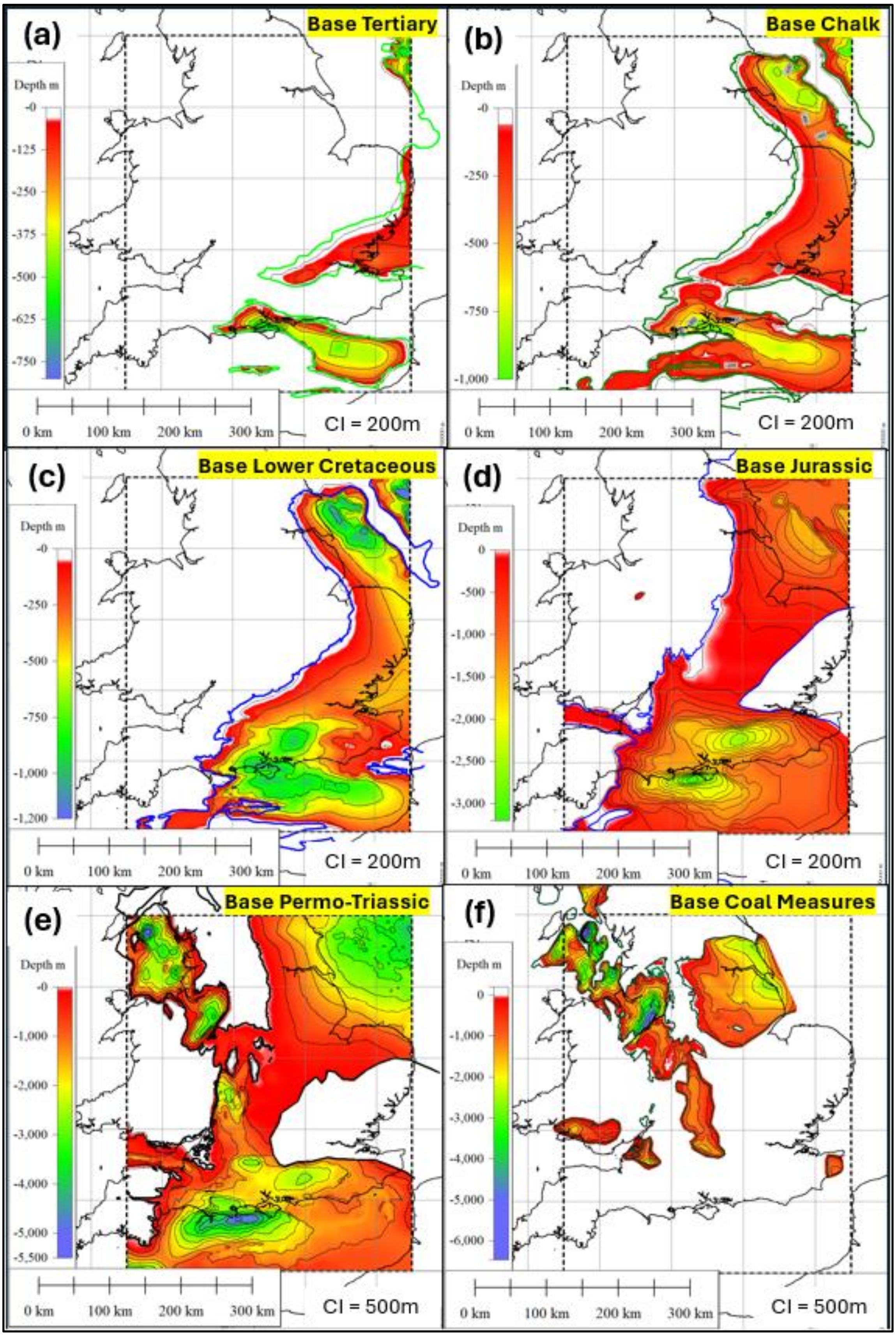


Figure 2 *- continued below.*

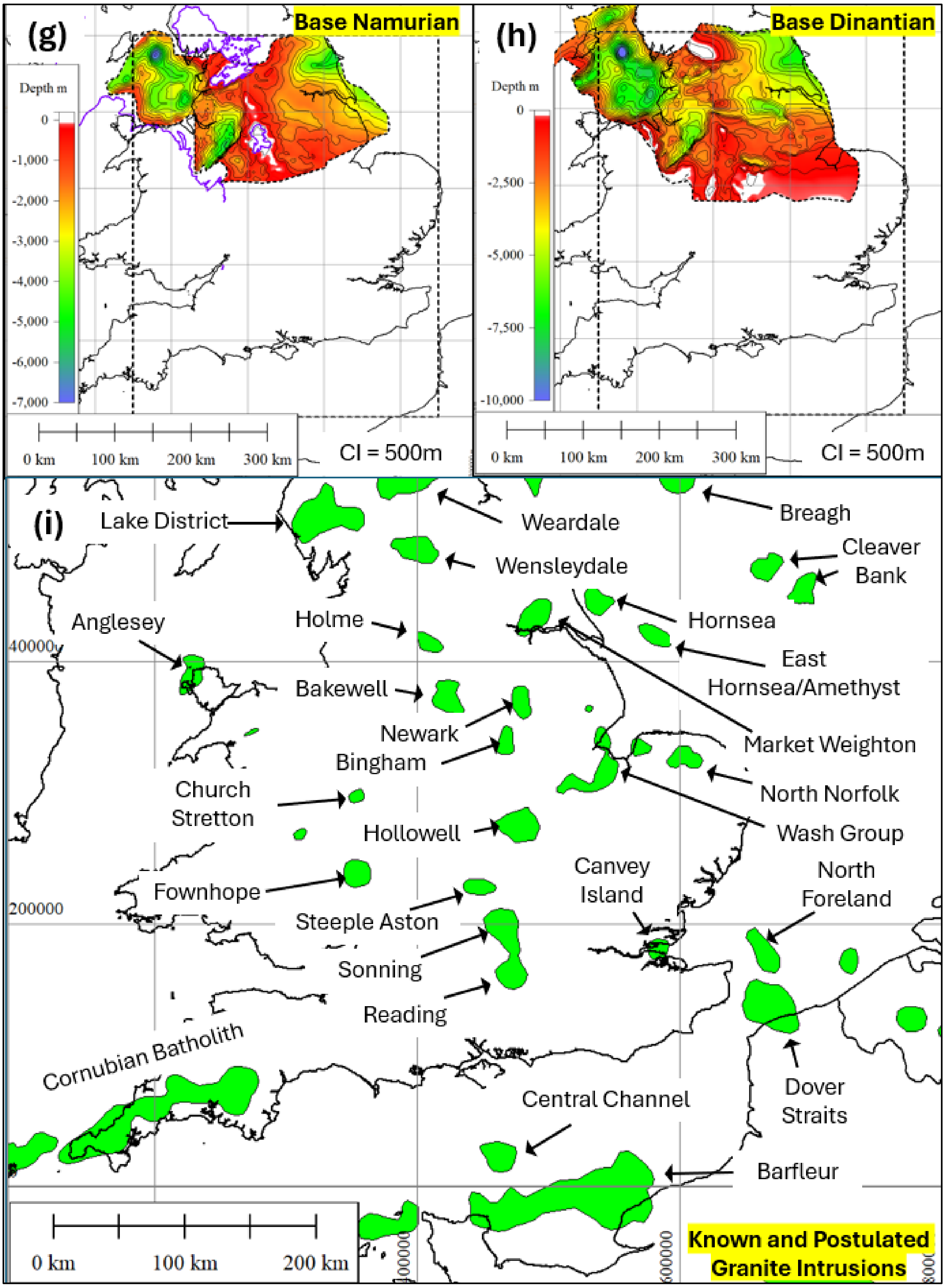


***Figure 2** – continued from previous page, caption below*

Figure 2 *(extends over the previous two pages). Horizon depth structure grids with depths shown in mss and with contour interval of either 200 or 500m. Shallow areas are shaded red with deeper areas shaded green/blue. Sea water (Layer 1 - not shown).* ***(a)*** *Base Tertiary (Layer 2).* ***(b)*** *Base Chalk (Layer 3).* ***(c)*** *Base Lower Cretaceous (Layer 4).* ***(d)*** *Base Jurassic (Layer 5).* ***(e)*** *Base Permo-Triassic (Layer 6).* ***(f)*** *Base Carboniferous Coal Measures (Layer 7).* ***(g)*** *Base Namurian (Layer 8) and* ***(h)*** *Base Dinantian (Layer 9). In* ***(g)*** *and* ***(h)*** *the dotted lines enclose the extent of the mapped areas.* ***Figure 2(i)*** *shows the locations of known and postulated granitic intrusions (Layer 10).*

3D Gravity Model *Horizon Density Maps*

Density values have been provided from an ongoing study of density data obtained by analyses of well logs available on the UKOGL website, combined with published material, primarily obtained from Busby *et al.* (2006) and Kimbell *et al.* (2006). Cumulative density distributions of the results obtained are shown in Figure 3. Details of the various published sources and a map showing the distribution of the data points are provided within the Appendix. Laterally-varying density values were applied to each of the structural layers as described below and as shown in Figure 4.

For each layer, density values obtained were computer gridded. As expected, the resultant grids showed a 'noisy' contour pattern superimposed upon smoother semi-regional variations. The smoother variations are considered real and are thought to be related to density changes associated with lithological changes, depth of burial and structural inversion effects. Consequently, the grids were smoothed by hand in an attempt to extract the broader-scale variations and to minimise the more local variability (noise). Density data points differing from expected values by more than 0.2gm/cc were considered spurious and were ignored for the purposes of gridding and data analysis. These ignored, suspect values represented less than 4% of the total number of data points. Figure 4(k) shows the agreement between the observed density values and the corresponding values from the smoothed density grids. This suggests that, where good density control exists, the smoothed density grids provide reliable density values within a likely error range of approximately ±0.05gm/cc. Figure 4(j) shows the density data point distribution together with the areas of good reflection seismic data control (blue shading). Exploration for coal, oil and gas has focused upon the main sedimentary basins where the gravity stripping process is more critical. Consequently, these are the areas of better well density control, coupled with good seismic control, resulting in reliable structural mapping (see Figures 6(a) and 6(b)).

The Permo-Triassic interval was treated as a single layer, and the data suggested that this was acceptable apart from the area in the north-east where Permian (Zechstein) density values vary significantly (see Figure 4(e)). Within the Southern North Sea, thick halite ridges and domes are common, introducing low density values. West of this area, the presence of thick anhydrite and dolomite intervals (Smith, 1989) introduce high density values. For this reason, a simple Zechstein density model was developed over this local area. Fyfe and Underhill (2023) mapped isopachs for the Plattendolomit, Hauptdolomit, Werraanhydrit and Zechsteinkalk intervals. In the model constructed here, these units were allocated a density of 2.9gm/cc, with the remaining Zechstein thickness allocated a density of 2.1gm/cc (assumed to be halite). The overlying Triassic section has a much lower density variation than the Zechstein interval across the Southern North Sea and therefore the use of a constant density of 2.5gm/cc is acceptable. The local density model calculated the resultant average density as a thickness weighted mean of these six layers.

This was then incorporated into the wider area, resulting in the map of Figure 4(f) for the overall Permo-Triassic interval density.

Granite density outcrop measurements shown in Figure 3 are derived from the following granites: Cheviot, Weardale, Shap, Skiddaw, Wensleydale, Foxdale, Dhoon, Eskdale, Dartmoor, Bodmin Moor, Land's End, Scilly Isles and Lundy (Bott *et al.*, 1958; Kimbell *et al.*, 2006)

Density maps for the Lower Cretaceous (Figure 4(c)), Jurassic (Figure 4(d)) and Permo-Triassic (Figure 4(f)) all show higher density areas approximately corresponding with the Weald and English Channel sedimentary basins. This is thought to be partly related to structural inversion. In particular, analysis of the Jurassic density data from the Weald Basin suggest the values to be enhanced by a combination of lithological changes coupled with local uplift of up to 2km, similar in value to other estimates (Chadwick, 1983; Butler and Pullan,1990;; Scotchman, 1994; Law, 1998; Jones, 1999; Jones *et al.*, 2002; Hillis *et al.*, 2008; Andrews, 2014; Blaise *et al.*, 2025).

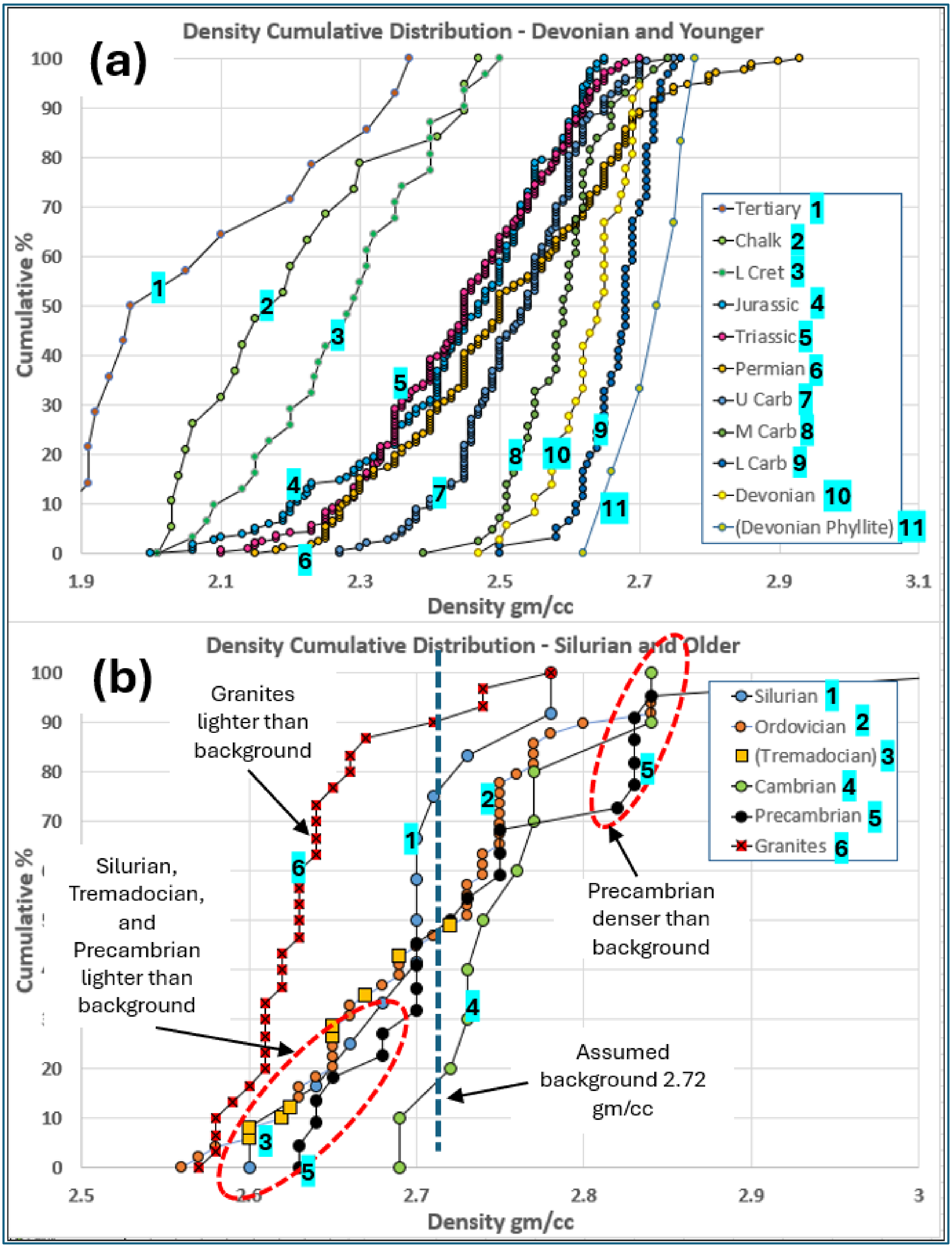


Figure 3 *Results of density evaluation. Cumulative density distribution curves are shown for **(a)** Devonian and younger sediments and **(b)** Silurian and older sediments and including granites with ages mostly younger than Silurian. The Devonian Phyllite and Tremadocian points form subsets of the Devonian and Ordovician data.*

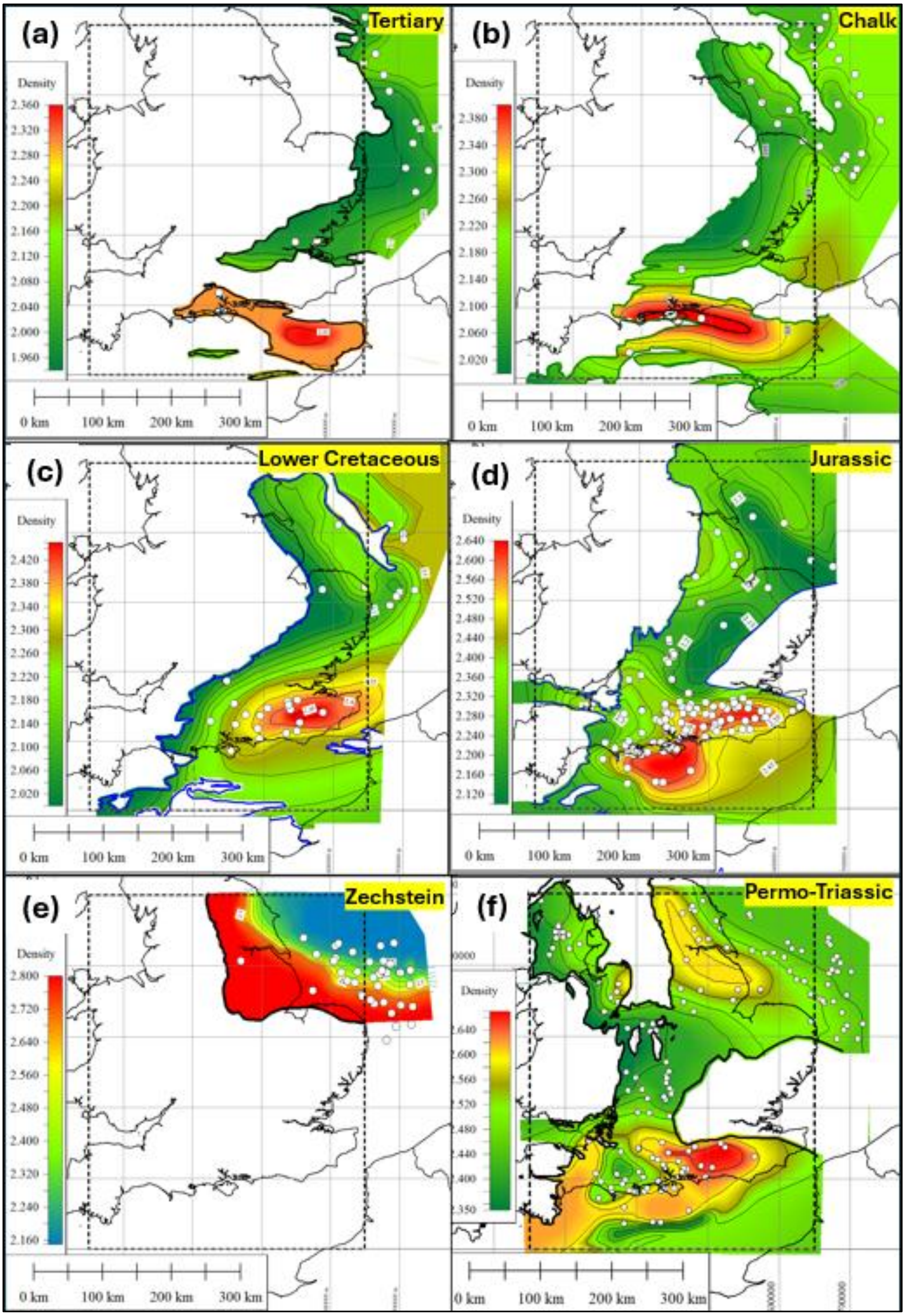


Figure 4 *- continued below.*

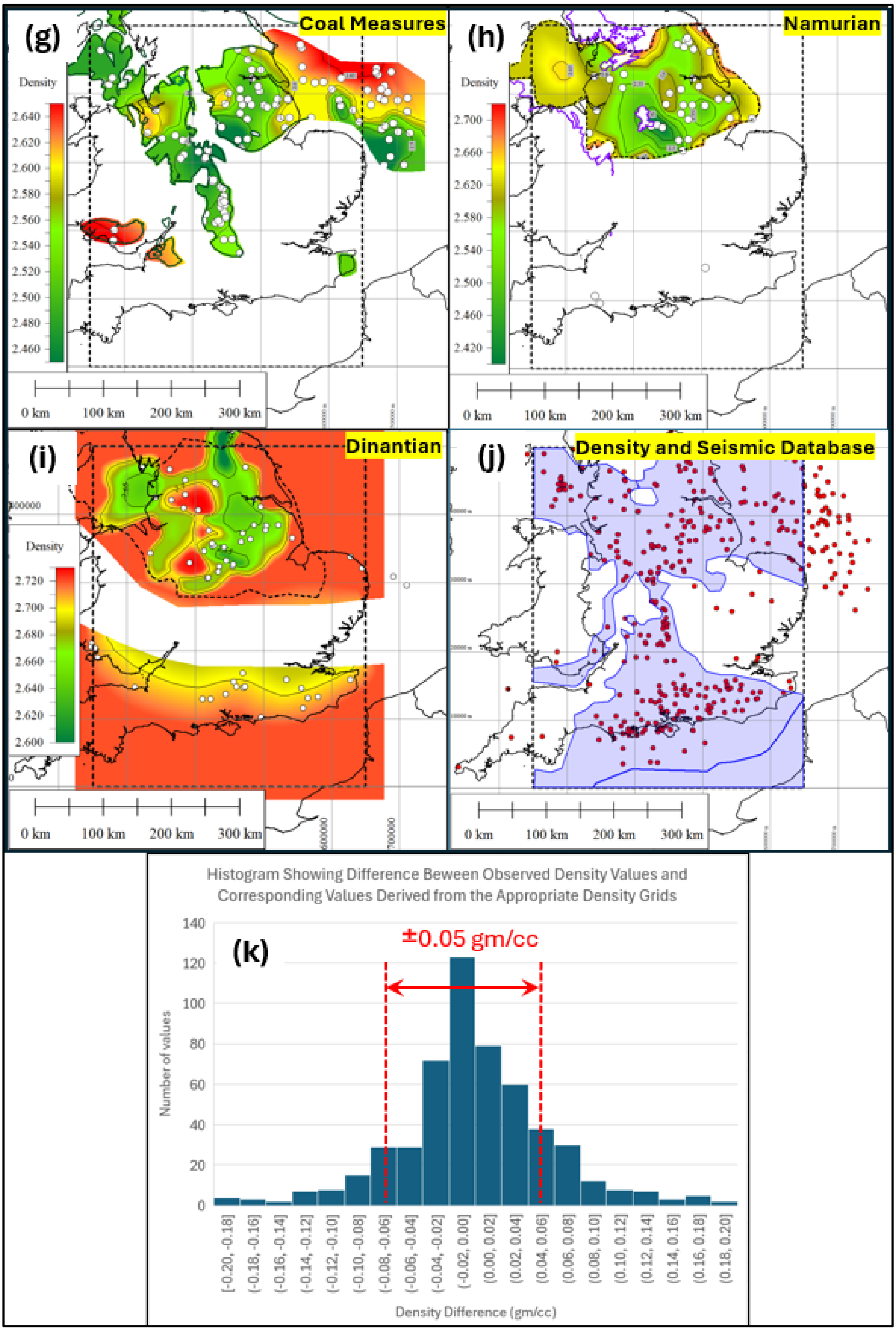


Figure 4 *caption below*

Figure 4 *(extends over the previous two pages). Layer density maps. Low density areas are shaded green/blue with higher density areas shaded red. The contour interval is 0.05gm/cc. White dots show the locations of density measurements relevant to the specific layer. Layer 1 is sea water with an assumed constant density of 1.017gm/cc (not shown).* ***(a)*** *Tertiary (Layer 2).* ***(b)*** *Chalk (Layer 3).* ***(c)*** *Lower Cretaceous (Layer 4).* ***(d)*** *Jurassic (Layer 5).* ***(e)*** *Zechstein. A Zechstein layer has been incorporated into the Permo-Triassic interval (Layer 6), see text for details.* ***(f)*** *Permo-Triassic (Layer 6).* ***(g)*** *Carboniferous Coal Measures (Layer 7).* ***(h)*** *Namurian (Layer 8).* ***(i)*** *Dinantian (Layer 9).* ***(j)*** *Distribution of density data points (red dots) and areas of good reflection seismic coverage (blue shading). See Appendix for further details of the density data coverage. Granite densities (Layer 10) are assumed constant for each separate granite, with values varying between 2.58 and 2.62gm/cc.* ***(k)*** *Histogram comparing differences between observed density values and corresponding values obtained from the gridded maps.*

3D Gravity Model *Calculated Results*

The gravity effect of each of the ten individual layers has been calculated against an assumed background of 2.72gm/cc. Three example components of the total calculated gravity map are shown in Figure 5. This illustrates the isopachs and calculated gravity anomalies for the combined intervals of the Tertiary and Upper Cretaceous and for the Lower Cretaceous and Jurassic. The individual interval for the Permo-Triassic section is also shown. The calculated gravity results for all intervals have been summed to produce the total calculated gravity anomaly map as shown in Figure 6(a), with anomaly values ranging between 0 and -58mGal.

A summary database map is superimposed upon the total gravity field in Figure 6(b). Density data points are shown by red dots, with areas of good seismic coverage located within the red outlines taken from Figure 4(j). As expected, the main sedimentary basins, shown by the low gravity anomalies (blue shading), correspond to the areas of comprehensive well density and seismic data control. The magnitude of the gravity-stripping process will be greatest within these areas, and they correspond to the regions of more reliable data control (see error estimates below).

The cumulative gravity values for each individual layer are shown in Figure 6(c). The largest contributions to the total anomaly originate from three layers; Permo-Triassic (Layer 6), Jurassic (Layer 5) and Chalk (Layer 3). Density and seismic data control is good for Layers 5 and 6 (Figures 4(d), 4(f) and 4(j)) but only moderate for Layer 3 (Figure 4(b)).

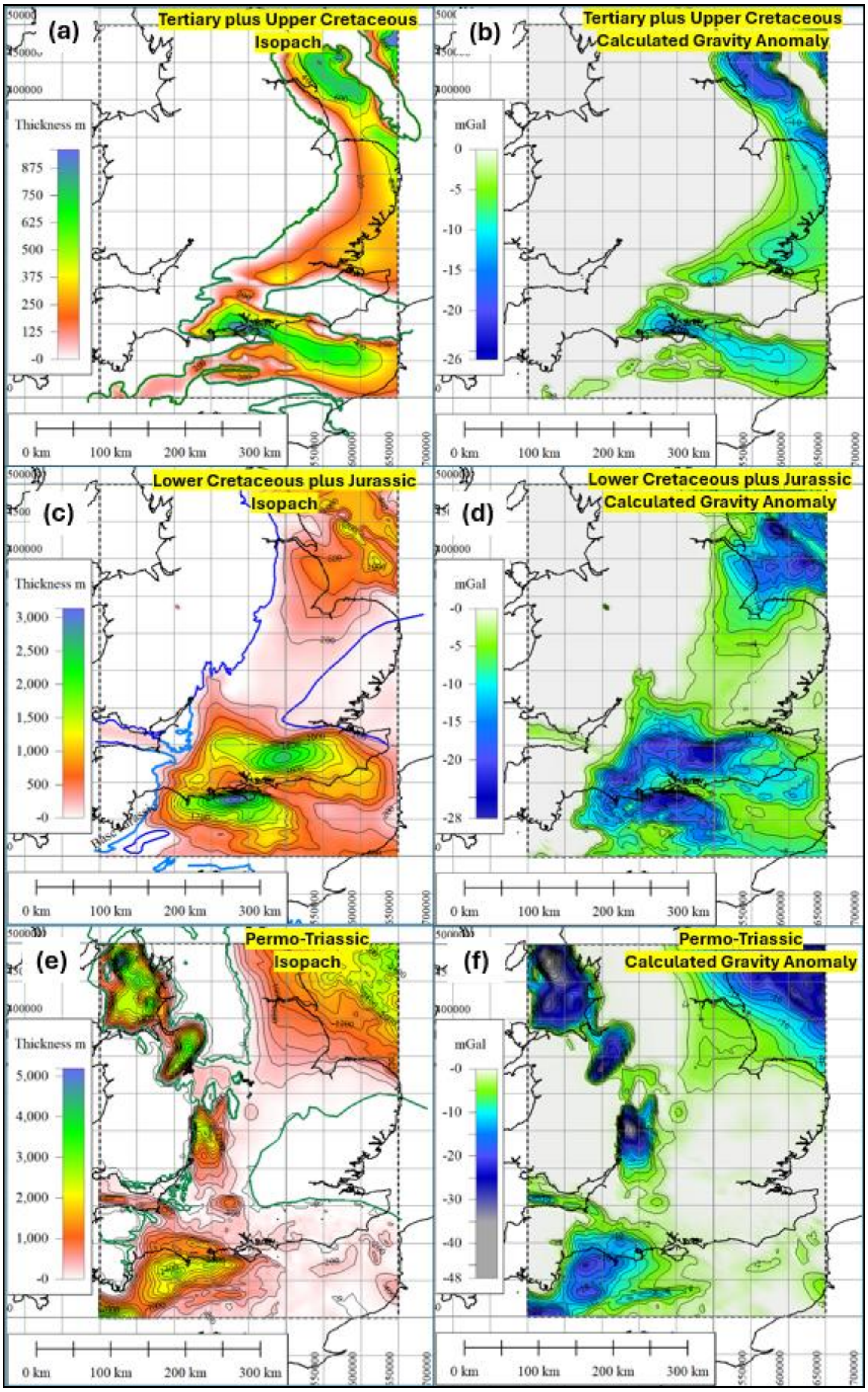


Figure 5 *Combined isopachs and calculated gravity anomalies for the Tertiary and Upper Cretaceous intervals ((a) and (b)), for the Lower Cretaceous and Jurassic intervals ((c) and (d)) and for the Permo-Triassic section ((e) and (f)).*

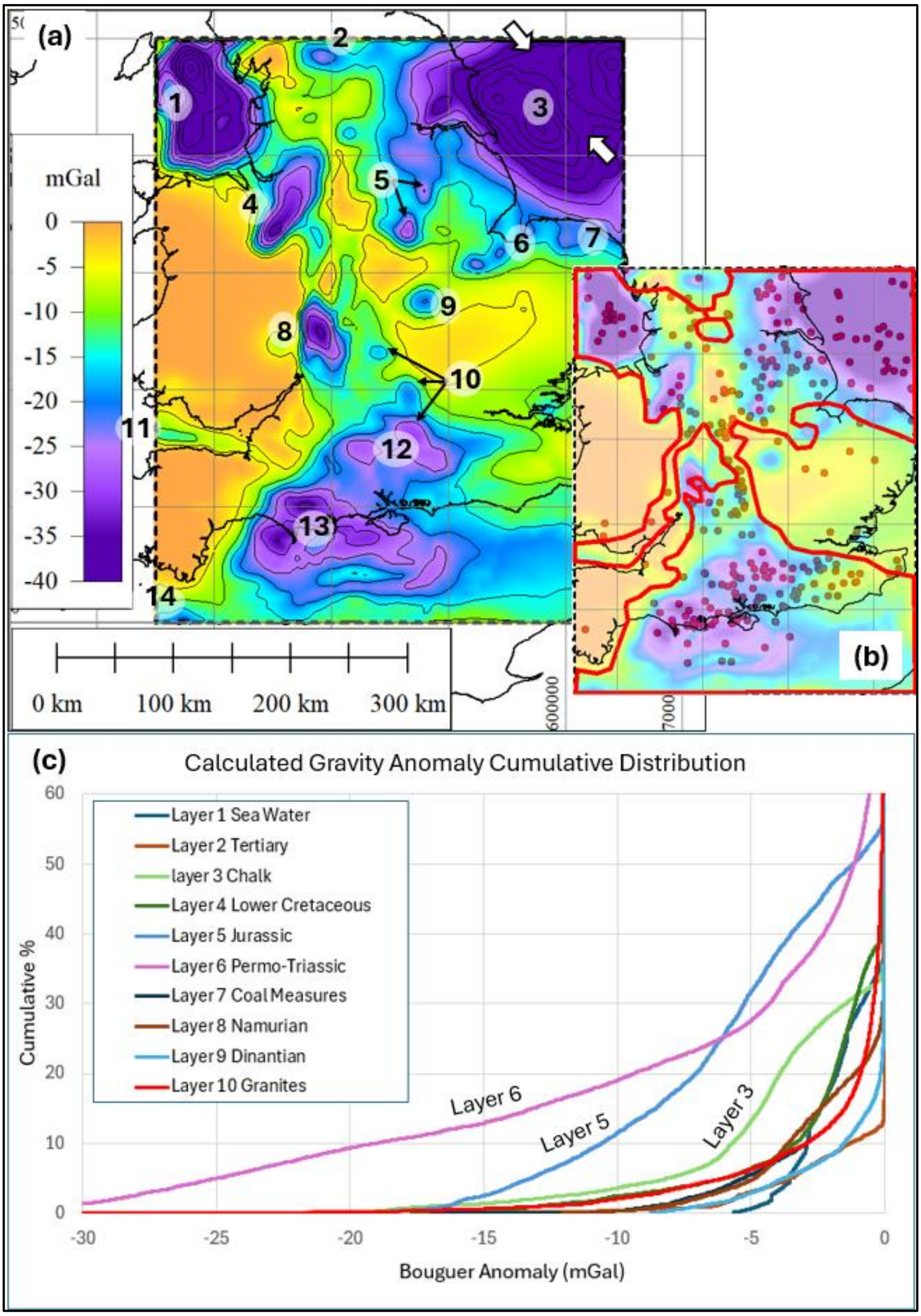


Figure 6(a) *Total gravity anomaly map calculated from the 3D model incorporating the gravity effect of all layers including granites. Primary gravity anomalies are labelled 1-14. The contour interval is 5mGal.* ***(b)*** *Summary map showing the density (red dots) and seismic (within red outlines taken from Figure 4(j)) databases superimposed upon the calculated total gravity field (orange/yellow to purple shading).* ***(c)*** *Cumulative distribution showing the individual layer contributions to the total calculated gravity anomaly of 6****(a)****. Layers 3, 5 and 6 are the main contributors to the total calculated anomaly.*

Significant features observed within the total claculated anomaly map of Figure 6(a) are labelled 1 to 14 and are briefly described below. For cases where the gravity anomalies have been considered and gravity modelled by Donato and Pullan (2022), the relevant profile numbers are provided.

- *Anomaly 1* - East Irish Sea Basin, general area of low gravity values mainly associated with thick Permo-Triassic sediments, with local, deeper lows associated with internal sub-basins (Figure 2(e)) (Jackson *et al.*, 1995; Pharaoh *et al.*, 2016).
- *Anomaly 2* - Gravity low anomaly associated with the Wensleydale Granite (Figure 2(i)) (Bott, 1961, 1967; Kimbell *et al.*, 2006).
- *Anomaly 3* - Composite gravity low comprising the gravity effect of the Market Weighton (Profile 6) (Bott *et al.*, 1978), the Hornsea and East Hornsea/Amethyst Granites (Figure 2(i)) (Donato and Megson, 1990) and the thick sediments within the Southern North Sea Basin (Figures 2(b), 2(c), 2(d) and 2(e)) (Fairhead *et al.*, 2023). The NW-SE trending gravity ridge (arrowed in the northeast corner of Figure 6(a)) is related to inverted, denser sediments along the Sole Pit Inversion Axis.
- *Anomalies 4 and 8* - Cheshire Basin and Worcester Graben, respectively, with low gravity anomalies mainly associated with thick Permo-Triassic sediments (Figure 2(e)) (Profiles 3, 4, 8, 9 and 10) (Whittaker, 1985; Butler, 2018).
- *Anomaly 5* - Anomalies relating to the Newark and Bingham Granites (Figure 2(i)) (Donato, 2019).
- *Anomaly 6* - Group of gravity low anomalies associated with the Wash Granites, including the Boston, Hunstanton, Wisbech and Spalding Granites, labelled Wash Group in Figure 2(i) (Profiles 7, 8 and 12) (Allsop, 1987).
- *Anomaly 7* – Gravity low associated with the North Norfolk Granite (Figure 2(i)) (Profile 9) (Chroston *et al.*, 1987).
- *Anomaly 9* - Gravity low anomaly associated with the Hollowell Granite (Figure 2(i)) (Profile 8) (Allsop, 1987).
- *Anomaly 10* – Low anomalies associated with the Reading, Sonning and Steeple Aston Granites (Figure 2(i)) (Profiles 10, 15, 16, 17, 18, 19 and 19A) (Hopkins, 1979; Rabae & Kearey, 1997)
- *Anomaly 11* – Low amplitude E-W trending anomaly produced by Jurassic and Permo-Triassic sediments within the Bristol Channel Basin (Figures 2(d) and 2(e)) (Brooks & Thompson, 1973).
- *Anomalies 12 and 13* - Gravity lows over the Wessex (Whittaker, 1985) and Central Channel (Hamblin *et al.*, 1992) Basins containing thick Lower Cretaceous, Jurassic and Permo-Triassic sediments. The Wessex Basin anomaly does not extend eastwards over the Weald Basin which contains thin to absent Permo-Triassic section. Parts of the basins are strongly inverted and therefore contain denser sedimentary sequences (Figures 2(c), 2(d) and 2(e)) (Profiles 14, 15, 19, 20 and 21).
- *Anomaly 14* - Northern part of low gravity values associated with the Plymouth Bay Basin, containing thick, mainly Permo-Triassic sediments (Figure 2(e)) (Harvey *et al.*, 1994; Pullan and Donato, 2021).

D Gravity Model *Error Estimates*

There are two primary potential sources of error in the calculated anomaly values: structure and density. Estimating possible error within the published structure grids is difficult. The main low gravity anomalies are associated with basinal areas that have been explored, mainly for coal, oil and gas, and consequently contain dense seismic coverage with numerous well control points. In such areas, the horizon grids will be reliably controlled by the comprehensive database, and any associated errors will be small. As discussed earlier, uncertainty in the density values lies with the range of ±0.05gm/cc. This density range has been applied to a series of simple flat layer-cake models located at points within the deeper parts of selected sedimentary basins. In this way, Monte Carlo calculations predict total potential errors for the Pewsey Basin (Whittaker, 1985; Chadwick, 1986; Booth, et al., 2011) (±3mGal), English Channel (±4), Weald (±2), Cheshire Basin (±5), East Midlands (±4) and East Anglia (±1). This uncertainty is broadly in accord with Donato and Pullan (2022), who suggest that residual anomalies greater than ±5mGal merit further consideration and imply the influence of additional sources not included in the initial gravity model.

Residual Gravity Map

The residual gravity field shown in Figures 7(a), 7(b), 8 and 9 is obtained by the subtraction of the calculated field (Figure 6(a)) from the observed field (Figure 1(a)). To emphasise longer-wavelength and possibly crustal-associated features, a 100 km low-pass filter has been applied to the residual field using the 21.3-unit regional filter of Zurflueh (1967) (Figures 7(b) and 9).

The residual gravity map shows values varying widely between +69 and -37mGal. In Figures 7 and 8, positive areas exist to the northwest, northeast and southwest, enclosing a triangular area of generally lower values located over central-southern England and parts of the English Channel. No clear anomalies appear associated with the north-west and north-east margins of the triangular form of the Midlands Microcraton, nor with the linear feature interpreted as the Variscan Front. This absence suggests that none of these boundaries correspond to prominent density contrasts and therefore cannot be distinguished as discrete geological structures within the gravity data.

Possible origins for the residual anomalies may be suggested by reference to the cumulative density curves of Figure 3. Negative residual lows may be associated with the lower relative densities of Devonian (ORS) sequences and/or unmodelled granitic intrusions (Figure 3(a)). Positive residual anomalies may be related, for example, to the higher relative densities of Devonian phyllites (Figure 3(a)) present within southwest England and the western English Channel. Ordovician, Cambrian and Precambrian sequences generally show relatively limited deviation of densities away from the background value of 2.72gm/cc. Consequently, these intervals may not be easily differentiated within the residual anomalies. Silurian and Tremadocian sequences, however, record some slightly lighter values (Figure 3(b)) and may appear as low amplitude residual gravity lows. The Precambrian data record a range in density values, varying between approximately 2.65 and 2.85gm/cc, suggesting that Precambrian sequences could be represented by local areas of either low or high residual anomalies (Figure 3(b)).

An interpretation of the residual gravity features obtained, coupled with an integration of observed magnetic anomalies, is currently in preparation but preliminary comments on selected residual gravity features are provided below.

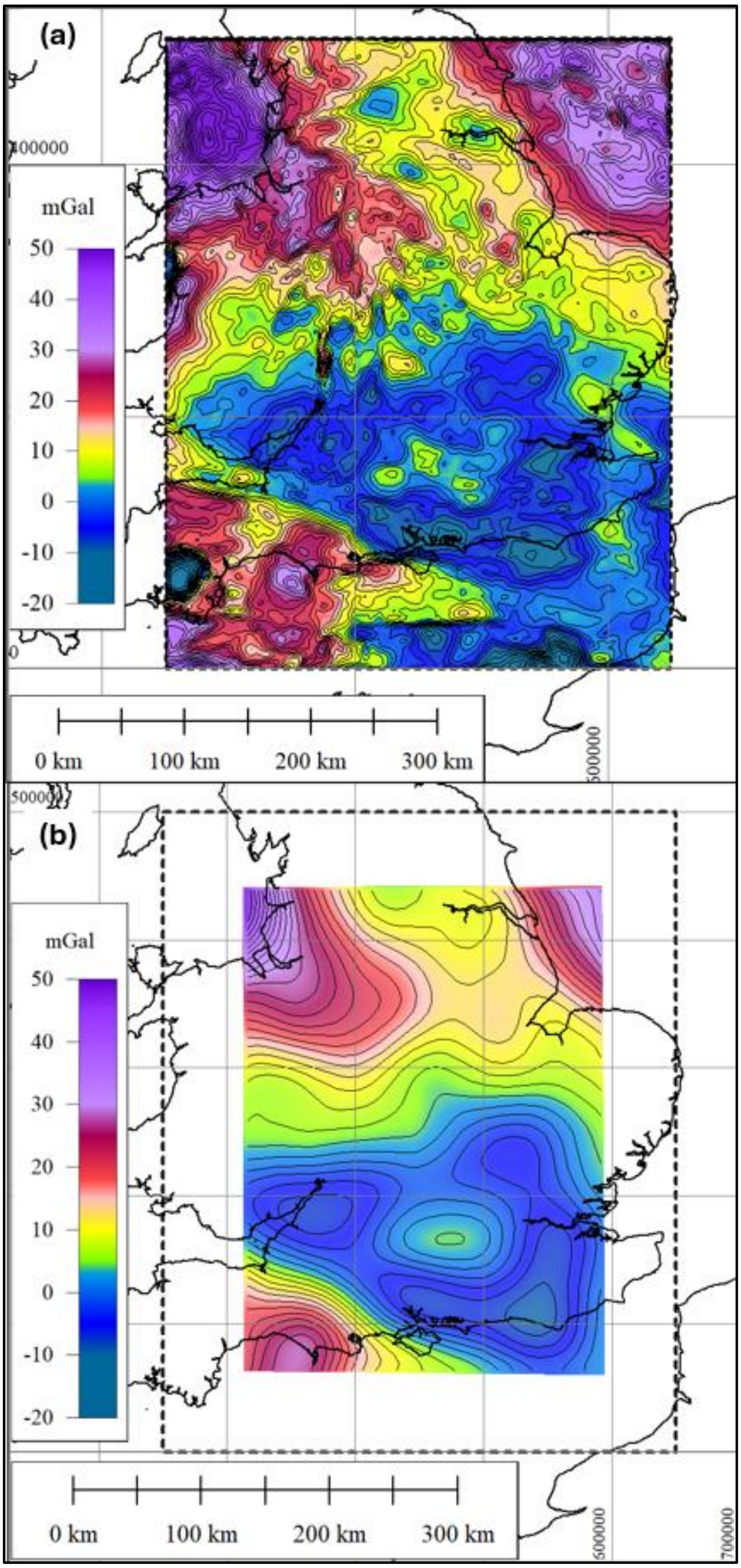


Figure 7(a) *Residual gravity field.* ***(b)*** *Residual gravity field with 100km low-pass filter applied using the 21.3-unit regional filter of Zurflueh (1967). In both (a) and (b), the contour interval is 2mGal.*

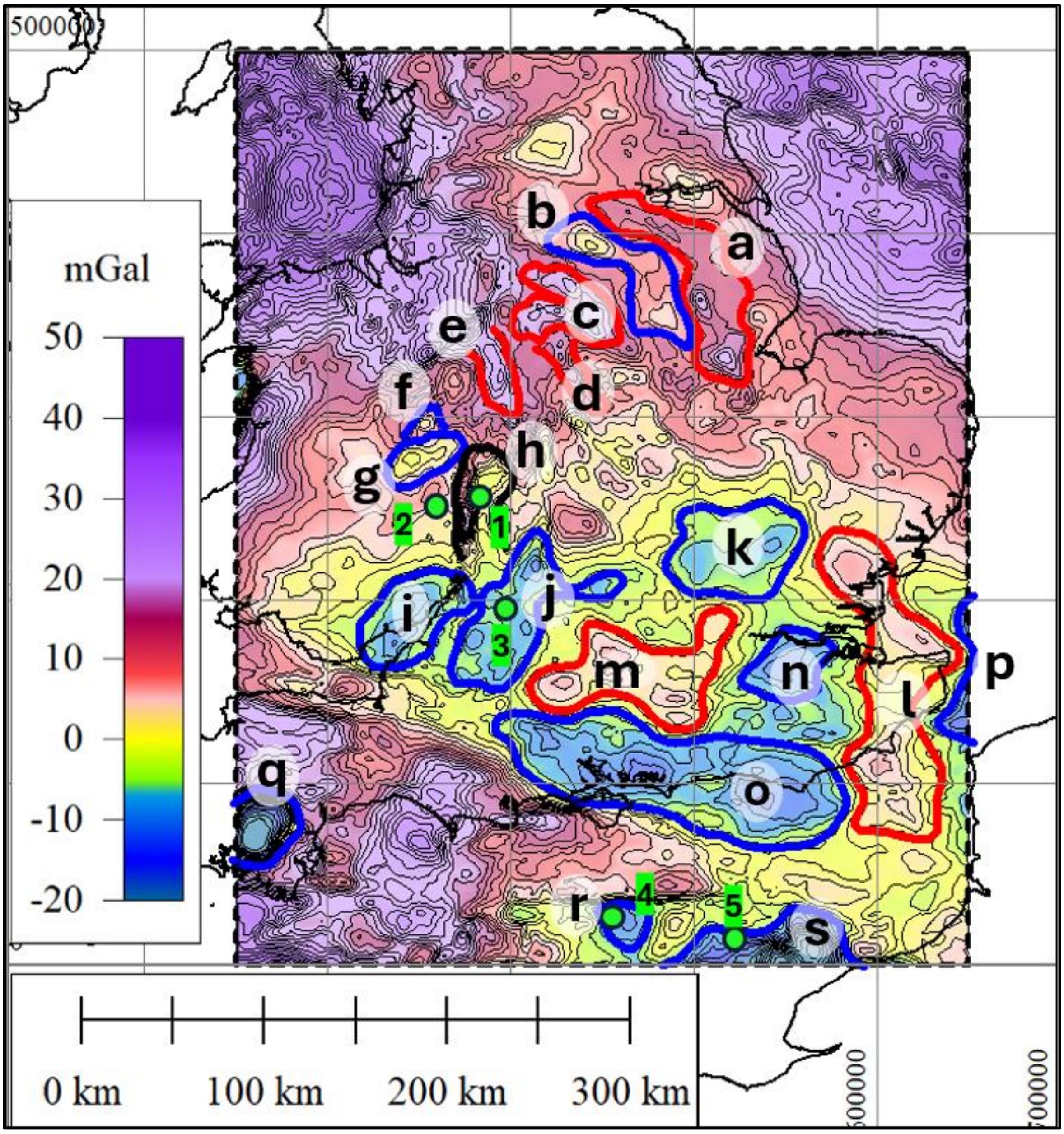


Figure 8 *Residual gravity field with selected shorter wavelength features labelled 'a' to 's' and listed in the table below. Positive and negative anomalies are outlined with red and blue solid lines respectively, with the composite anomaly, 'h', outlined in black. The locations of wells mentioned in the text are shown on a green background as:- 1 Kempsey-1, 2 Fownhope-1, 3 Cooles Farm-1, 4 Pointe de Barfleur-1 and 5 Nautile-1.*

Residual Gravity Feature with Approximate Amplitude (mGal)			Possible Source
a & b	NW-SE Trending Anomalies	mGal a +8 b -8	Related to Furness-Norfolk and Burnley-Stamford Magnetic Anomalies
c	Derbyshire Dome	+6	Structural High underlain by Bakewell Granite (see below)
d	Derby (Snelston) Ridge	+8	Mineralised Dinantian Ridge over Basement High
e	South Staffordshire Horst	+8	Lower Paleozoic Structural High
g	Ludlow Basin	-6	Silurian Sediments
h	N-S Gradient, Western Edge of Worcester Graben	+12 -6	Precambrian Density Change? (see text for details)
i	Usk Basin	-6	Thick Silurian/Lower Devonian Sediments
j	Composite Anomaly	-4 -6	Thick Tremadocian and Silurian/Lower Devonian Sediments of Wantage Basin
k	Luton-Cambridge Basin	-6	Devonian Sediments
l	Safron Walden Lineament and Southerly Extension	+8	Basement High to East of Saffron Waldon Lineament
m	Central England Anomaly	+8	Shallow Precambrian Basement Core to Central England
n	Warlingham Anomaly	-6	Thick Devonian/Lower Paleozoic Sediments?
o	South Coast Anomaly	-10	Thick Paleozoic Sediments?
Proven and Postulated Granites with Approximate Amplitude (mGal)			
f	Church Stretton Granite		-6
p	Composite Anomaly – North Foreland and Dover Straits Granites		-20
q	Dartmoor Granite		-40
r	Central Channel Granite		-15
s	Barfleur Granite		-35
c	Bakewell Granite (beneath Derbyshire Dome)		-7

Table listing shorter wavelength residual gravity features with likely sources.

<u>Residual Gravity Map</u> *Shorter-Wavelength Residual Anomalies*

The shorter-wavelength gravity anomalies are shown in Figure 8 and are labelled ‘a’ to ‘s’. They are of small amplitude, varying between 6 and 12mGal. These amplitudes are typically only slightly larger than the estimated potential error within the stripping process of up to ±5mGal. Consequently, the lower-amplitude residual anomalies need to be considered with caution. The observed wavelengths imply a source depth probably less than 10km.

For anomalies ‘a’ to ‘e’ within northern England, the gravity effect of the complete Carboniferous and younger section has been removed. Therefore, these residual anomalies will originate from pre-Carboniferous intervals. For anomalies ‘f’ to ‘l’ however, only the gravity effects of the Upper Carbonifeous and younger section have been removed. However, since the Namurian interval is missing over large parts of southern England, and the Lower Carboniferous is generally present in limestone facies with density similar to the assumed background value, residual anomalies ‘f’ to ‘l’ may also originate primarily from pre-Carboniferous intervals. Along the margins of the modelled area, anomalies ‘p’ to ‘s’ relate to proven and non-proven granites that have not been removed in the stripping process.

It is not the intension here to provide a comprehensive interpretation of the residual features. However, brief descriptions and possible origins for the anomalies are given below, together with the maximium residual anomaly amplitude.

- *Residual Anomalies ‘a’ and ‘b’* – The anomalies are located between two broad residual gravity highs positioned over the Irish Sea and Southern North Sea Basins. A small part of the positive ‘a’ anomaly lies over the Nocton High (Pharaoh *et al.*, 2011) and parts of the negative ‘b’ anomaly overlie both the Newark Granite (Allsop, 1987) and the Gainsborough Trough (Pharaoh *et al.*, 2011; Andrews, 2013). There appears to be a correlation between residual gravity anomalies ‘a’ and ‘b’ and the Furness-Norfolk and Burnley-Stamford Magnetic Anomalies (Beamish *et al.*, 2016; Donato and Pullan, 2022). This correlation has not been previously recognised and is currently under investigation. (Amplitude ‘a’ +8mGal, ’b’ -8mGal).
- *Residual Anomaly ‘c’* – High anomaly ‘c’ overlies and extends slightly to the east of the Derbyshire Dome (Maroof, 1973, 1975; Smith *et al.*, 1985; Aitkenhead *et al.*, 2002). A buried granite, the Bakewell Granite, may exist beneath the eastern flank of the Derbyshire Dome (Figure 2(i) and comments below). (Amplitude +6mGal).
- *Residual Anomaly ‘d’* – The feature is a narrow NW-SE trending gravity high located to the south of the Derbyshire Dome and following the Derby (or Snelston) Ridge which comprises mineralised Dinantian rocks above a basement high (Corfield *et al.*, 1996; Cornwell *et al.*, 2001). The Ridge extends to the south from the area of the buried Bakewell Granite. (Amplitude +8mGal).
- *Residual Anomaly ‘e’* – The N-S trending gravity high anomaly is probably related to structural and/or lithological features within the Lower Paleozoic section of the South Staffordshire Horst (Powell *et al.*, 2000). (Amplitude +8mGal).
- *Residual Anomaly ‘g’* – The anomaly is a gravity low overlying the Ludlow Silurian Basin (Griffiths & Gibb, 1965). (Amplitude -6mGal).
- *Residual Anomaly ‘h’* – The composite feature comprises N-S trending adjacent high and low residual anomalies located along the western side of the Worcester Graben (Brooks, 1968; Whittaker, 1985; Barclay *et al.*, 1997; Butler, 2018). These features may be an artefact related to inadequate stripping of the large observed negative gravity anomaly associated with thick Permo-Triassic section within the graben. However, similar residual features were also observed in the separate stripping exercise undertaken by Busby and Smith, (2001) and Busby *et al.*, (2006). An alternative, but speculative, explanation may suggest a variation in Precambrian basement type/density beneath the western edge of the Worcester Graben. The Kempsey-1 well (Label 1 in Figure 8), drilled within the residual gravity low, records a low average Precambrian density of 2.68gm/cc, whereas Fownhope-1 (Label 2 in Figure 8), drilled to the west of the residual high, records a high Precambrian density of 2.75gm/cc. Such a density difference of 0.07gm/cc would be capable of

producing the observed residual anomalies. If this is the case, a possible Precambrian density boundary can be followed in a N-S direction for almost 70km, being lost to the south below the gravity effect of thick Tremadocian sediments. This boundary may be related to the Malvern Fault Zone and the edge of the Wrekin Terrane (Pharaoh *et al.*, 2023). (Amplitude +12mGal (positive trend) and -6mGal (negative trend)).

- *Residual Anomaly 'i'* – Seismic evidence suggests that the negative anomaly is associated mainly with the thicker preservation of Lower Devonian and Upper Silurian intervals within the Usk Basin (Miliorizos *et al.*, 2021). In this area, the Old Red Sandstone sediments appear to have the dominating gravity effect (paper in preparation). (Amplitude -6mGal).
- *Residual Anomaly 'j'* – The anomaly is of low amplitude and may be a composite negative anomaly associated with the presence of thick sequences of low density Devonian and Tremadocian sediments. The eastern part of the residual low lies over the thick Devonian and Upper Silurian sediments of the Wantage Basin (Donato and Pullan, 2022). The central and western parts overlie Tremadocian sediments shown mainly subcropping the Variscan unconformity (Butler, 2018). The Cooles Farm-1 well (Label 3 in Figure 8) penetrated over 1600m of Tremadocian section (2.6gm/cc) and is located towards the centre of the residual gravity low. (Amplitude -4 to -6mGal).
- *Residual Anomaly 'k'* – The negative anomaly is probably associated with the Luton-Cambridge Devonian (ORS) Basin (Allsop, 1985). The basin appears to comprise east and west sub-basins divided by a NW-SE trending buried basement ridge. (Amplitude -6mGal).
- *Residual Anomaly 'l'* – The feature is an elongate N-S trending linear positive residual anomaly extending for approximately 180km from Chelmsford via Dungeness to the Eastern English Channel. It possibly forms the eastern side of the Midlands Platform and may be related to a thinning of Lower Paleozoic section reflecting a basement high. It suggests a long southerly extension to the Safron Walden Lineament (Pharaoh, et al., 2023)). Gradient 'w' (Figure 9) defines its western edge (see long wavelength anomalies discussed below) with anomalies 'k' and 'n' lying to the west and anomaly 'p' to the east. (Amplitude +8mGal).
- *Residual Anomaly 'm'* – The feature forms a marked positive residual anomaly, here termed the Central England Anomaly. A steep gravity gradient defines its southern margin, trending east–west before turning northeastwards toward London. Along this northeast segment, the gradient coincides with the northwestern edge of the 'n' negative anomaly, the Warlingham Anomaly, interpreted as a possible deep Paleozoic basin. Throughout its length, the gravity gradient shows a strong correspondence with the southern boundary of the Central England Magnetic Anomaly (Beamish et al., 2016). This alignment underscores the structural importance of the boundary as (i) a major gravity gradient, (ii) a deep magnetic basement susceptibility contrast, and (iii) a controlling feature on the Warlingham Anomaly. Seismic evidence indicates that, beneath the Carboniferous, the Paleozoic section rises across the 'm' Anomaly, implying a shallower Precambrian basement (Butler, 2018). The Central England Magnetic Anomaly, with sources thought to lie within the Precambrian (Busby *et al.*, 1993; Busby & Smith, 2001), approximately correlates with the residual gravity anomaly. Collectively, these observations support an interpretation of the Central England Anomaly as indicating a Precambrian 'core' to central England. (Amplitude +8mGal).
- *Residual Anomaly 'n'* – The anomaly is a northeast-southwest trending gravity low, currently with differing interpretations (Kearey & Rabae, 1996; Donato *et al.*, 2024). Three

options have been proposed; firstly, a dramatic thickening of the Paleozoic section, possibly comprising thick Devonian and Lower Paleozoic sediments (Profiles 14 and 19 of Donato and Pullan (2022)), secondly, a buried granite intrusion (granite option of Profile 15), and thirdly, a major thrust above a wedge of low-density Upper Paleozoic rocks. Recent work examining reflection seismic data across the 'n' feature has revealed the presence of deep synclinal reflectors corresponding with the gravity low. Their presence is thought to have eliminated the granite option and an interpretation involving thick Paleozoic Sediments is preferred. (Amplitude -6mGal).

- *Residual Anomaly 'o'* – The anomaly is significant with an amplitude of approximately -10mGal. It extends along the south coast of England for approximately 200km and was previously noticed by Busby and Smith (2001). Donato and Pullan (2022) suggest that the feature may be related to the extent of thick Paleozoic sediments which may in part be tectonically thickned. (Amplitude -10mGal).

Anomalies 'f', 'p', 'q', 'r' and 's' described below are thought to relate to granitic intrusions and, apart from the Bakewell Granite (see 'c' above and comments below), their gravity effects have not been removed in the gravity stripping process.

- *Residual Anomaly 'f'* – The low amplitude negative gravity feature is interpreted to originate from the Church Stretton Granite (Donato, 2007). (Amplitude -6mGal).
- *Anomaly 'p'* – Recent work, including the construction of a gravity profile crossing the Dover Straits and extending from London to Northern Belgium, suggests that the 'p' anomaly may be a composite negative anomaly related to the proposed North Foreland and Dover Straits Granites. (Amplitude -20mGal, the centre of the gravity low lying to the east of the 3D modelled area).
- *Anomaly 'q'* – The deep circular gravity low is associated with the Dartmoor Granite (Bott *et al.*, 1958; Taylor, 2007; Watts *et al.*, 2024). (Amplitude -40mGal).
- *Anomaly 'r'* – The circular negative gravity low is tentatively thought to be related to a granitic intrusion. The Pointe de Barfleur-1 well (Label 4 of Figure 8) (Bureau de Recherches Geologiques et Minieres, BRGM, 2025), located towards the centre of the gravity low, encountered granite at 1210mMD at the base of the well. The gravity low is located immediately south of, and trends parallel to, the Central Channel Shear Zone (Beeley and Norton, 1998). This fault zone correlates with a south-dipping residual gravity gradient, suggesting the zone to be aligned with a change in basement density/type, possible the northern edge of the Normannian Terrane (Shail & Leveridge, 2009). (Amplitude -15mGal).
- *Anomaly 's'* – The low gravity anomaly extends over the northern edge of the large Barfleur Granite (Baptiste, 2016). Well Nautile-1 (Label 5 of Figure 8) (Bureau de Recherches Geologiques et Minieres, BRGM, 2025), drilled on the north-western flank of the gravity low, penetrated 18m of granite (1031-1049mMD, average density 2.60gm/cc) at the base of the well. (Amplitude -35mGal).
- *Negative Gravity Component within Anomaly 'c'* – Current investigations of the 'c' Anomaly (paper in preparation), incorporating an updated and more detailed seismic interpretation across the Derbyshire Dome, indicate the presence of an underlying Bakewell Granite (Figure 2(i)). Gravity stripping of the mapped sedimentary sequences associated with the Dome and its flanks reveals a localised negative component, with an amplitude of approximately –7 mGal, superimposed on the more regional positive field. This negative residual is consistent with a lower-density intrusive body beneath the Dome and supports the interpretation of a concealed granite. (Amplitude -7mGal).

Residual Gravity Map *Anomaly Profiles*

As shown in Figure 9, two sets of long profiles have been constructed across the residual gravity map of Figure 8. These profiles illustrate possible changes in the long-wavelength background residual gravity values. The two sets of profiles are described below and are also discussed in the section discussing longer wavelength residual gravity features.

The first set of profiles, labelled SW01 to SW06 (Figure 9), cross south-west England. These six profiles have been added to produce an ensemble average shown by the solid red line (the six individual profiles are each shown with a 10mGal offset to avoid over-plotting). The profiles illustrate a long-wavelength background shift in the residual field, reducing by over 30mGal across a gradient within a horizontal distance of approximately 40km. Genc (1988) observed this gradient and considered it to originate from a combination of vertical density contrasts at the base of the upper crust and also posssibly at the Moho interface. The dashed black line of Figure 9(b) shows the calculated results of a very simple 2D rectangular step-model located beneath the gradient and dropping from 2.5 to 15km with a density contrast of 0.055gm/cc. The horizontal location of the step is shown by the short vertical dashed black line in Figures 9(a) and 9(b). The model suggests that the gradient originates from slightly higher densities located beneath southwest England, probably at upper/middle crustal levels. This may be compatible with the higher density values observed within Devonian phyllites (Figure 3(a)) seen within this area. The boundary suggested by these profiles approximately matches with the 'v' Gradient discussed below.

The second set, labelled X330 to X530, extend with north-south orientation across the full length of the 3D modelled area. As before, an ensemble (thick red line) and a simple 2D model (black dashed line) have been produced. In this case, a background drop in residual values of approximately 12mGal is seen from north to south, occuring over a horizontal distance of approximately 100km. The location of the 12mgal gradient is shown in Figure 9(a) and 9(c) by the grey shaded area between the red dashed lines. The broad width of the gradient suggests a deep source, possibly a combination of a variation in Moho topography coupled with a lower crustal density change (see Figure16 of Donato *et al.*, 2024). By way of simple illustration, the black dashed line in Figure 9(c) is taken from a 2D step-model dropping from 20 to 30km with a density contrast of 0.035gm/cc. Assuming this simplistic model, the possible boundary associated with the gravity gradient is shown by the black dashed line within the centre of the shaded gradient zone of Figure 9(a) and 9(c). This boundary approximately matches with the 'x' Gradient discussed below. The long-wavelength lower gravity residual values in the south have been previously noted by Busby *et al.* (1993).

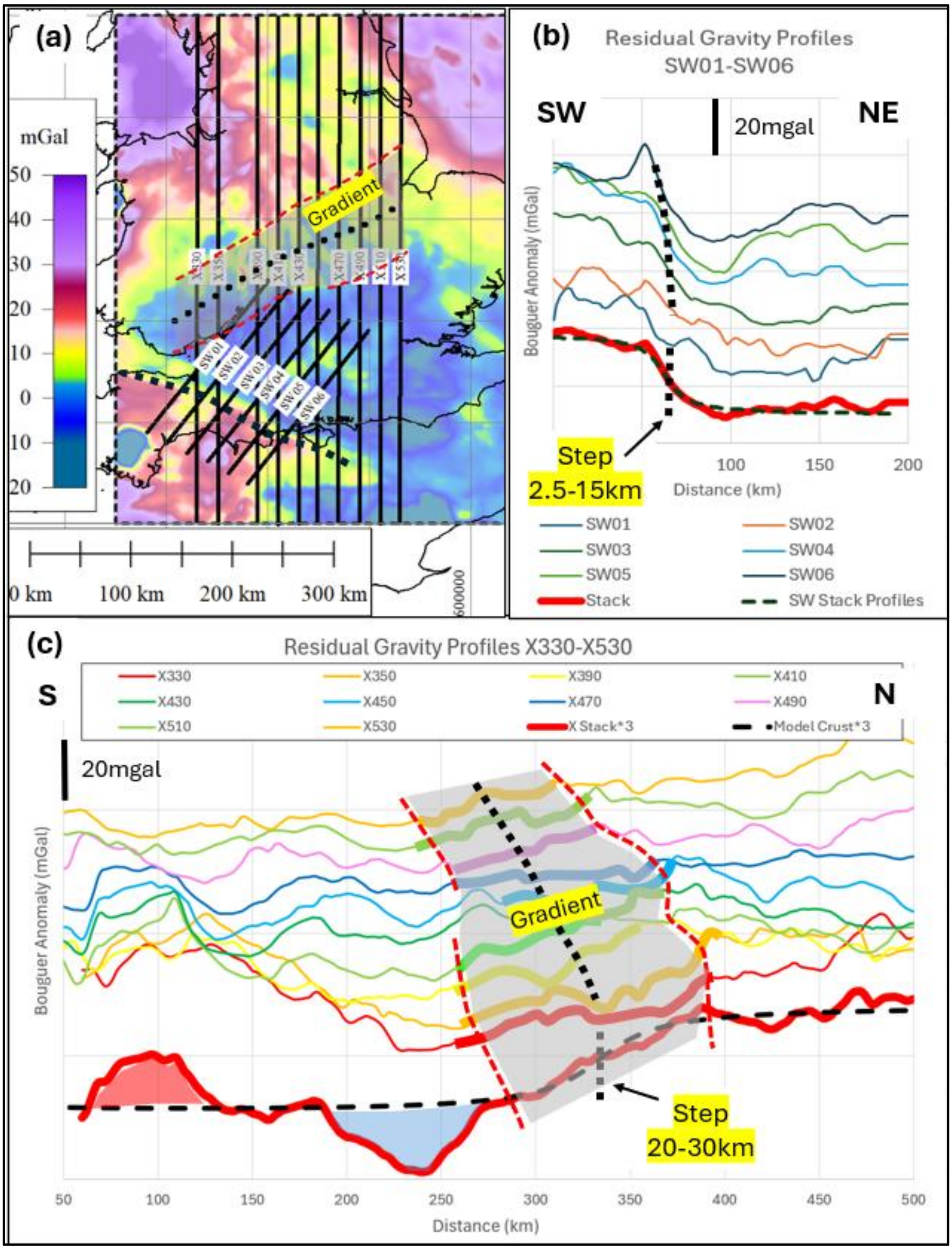


Figure 9(a) *Location of Residual Gravity Profiles superimposed on the residual gravity map of Figure 8.* ***(b)*** *SW-NE trending residual gravity profiles with 10mGal offsets. The location of the drop in long-wavelength residual values is shown by the black dashed line.* ***(c)*** *N-S trending residual gravity profiles with 10mGal offsets. These profiles have been laterally shifted slightly to align the wide gradient zone, shown by the grey shaded area between red dashed lines. In both (b) and (c), the lower thick red lines show an ensemble average of the individual profiles. For clarity in (c), the red line is shown at three times the vertical scale. The negative anomaly shaded blue is related to the large Anomaly 'o' (Figure 8) with the positive anomaly shaded red caused by the generally higher residual gravity values located to the southwest.*

Residual Gravity Map *Longer-Wavelength Residual Anomalies*

The low-pass filtered version of the residual gravity map is shown within Figure 10. The map emphasises longer wavelength anomalies with amplitudes varying between -10 and +40mgal. These amplitudes are much greater than the estimated potential error in the stripping process. Consequently, the longer-wavelength features are considered to be highly significant. Source depths are probably located within the middle/lower crust, at the Moho interface or within the upper mantle.

The residual gravity field may be considered as a series of six possible gravity domains:-

(i) a northwestern area, 'NW', with residual values rising to over +50mGal and located approximately to the northwest of the 't' gradient,
(ii) a northeastern area, 'NE', with high residual values reaching to over +30mGal and located to the northeast of the 'u' gradient,
(iii) a northern area, 'N', of reduced but still positive residual values within the range +10 to +20mGal and located north of the 'v' gradient,
(iv) a southern area, 'S', with slightly negative residual values located within a triangular zone approximately defined by the 'v', 'w' and 'x' gradients,
(v) a southwestern area , 'SW', with residual gravity values in excess of +10mGal and with a steep gravity gradient 'x' marking its northeasterly extent,
(vi) a possible eastern area, 'E', with slightly positive residual values and lying to the east of the 'w' gradient. This area is not well-defined as it is located on the eastern margin of the 3D modelled area.

The boundaries between the gravity domains are of particular interest indicating positions of crustal discontinuities, possibly of a tectonic origin. A brief description of the domains and their possible boundaries are given below.

- ***The 'NW' Domain*** - Over the Irish Sea and extending into northwest England, the 'NW' Domain approximately correlates with an area where crustal thickness reduces to 27km from peripheral values in excess of 30km (Figure 1(b)). Data defining the crustal thickness is however sparse, particularly for the area between the Isle of Man and Cumbria. The thinner crust may contribute significantly to the positive gravity values, although this effect may be partially lessened by a reduction in crustal density and the presence of a low-density, low-velocity body at considerable depth (Donato *et al*, 2024). The existence beneath the Irish Sea of a deep, low P-wave velocity anomaly has been identified by Arrowsmith *et al.* (2005) and this may be related to an area of crustal underplating (Brodie and White, 1994; Al-Kindi *et al.*, 2003; Shaw Champion *et al.*, 2006; Maguire *et al.*, 2011; Davis *et al.*, 2012; Luszczak *et al.*, 2018).

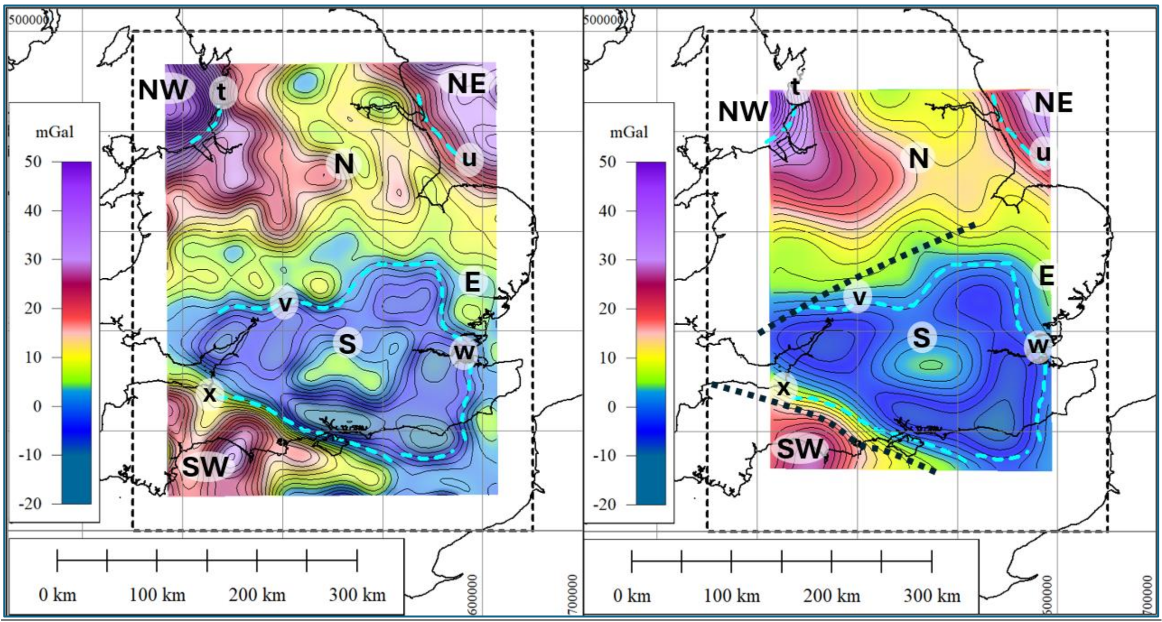


***Figure 10** Residual gravity field with (a) 50km and (b) 100km low-pass filters applied. In (a), areas of steeper gravity gradient are highlighted with dark shading. Lineaments discussed in the text are marked with cyan dashed lines and labelled 't' to 'x'. Proposed gravity domains are labelled NW, NE, N, E, S and SW. The crustal boundaries of Figure 9(a) inferred from the analysis of the long profiles have been added to the righthand image as black dotted lines.*

- ***The 'NE' Domain*** - Over the Southern North Sea, gravity values rise north-eastwards despite the expected negative gravity effect from the thickening sedimentary successions. This is explained by Fairhead *et al*. (2023) to be related to crustal thickness effects modelled using the long-wavelength global Moho Model, CRUST-1.0 (Laske *et al.*, 2013). Chadwick and Pharaoh (1998), however, in their detailed interpretation of BIRPS seismic data, define much shorter-wavelength crustal features in which the Dowsing-South Hewett Fault Zone appears as a crustal dislocation, with thicker crust of up to 35km located immediately to the northeast of the fault. This crustal structure is supported by the gravity models of Kearey and Rabae (1996) who explain the northeasterly rise in gravity values as a significant change in lower crustal composition, with higher-density lower crust present to the northeast of the Dowsing -South Hewett Fault Zone. This possible crustal boundary may correspond with the 'u' gradient of Figure 10.
- ***The 'N' Domain*** – The black dotted line of Figure 9(a) marks the approximate position of a deep crustal density change and it defines the southern edge of the 'N' Domain, passing approximately from South Wales to East Anglia with WSW-ENE orientation. The southern extent of the Furness-Norfolk and Burnley-Stamford Magnetic Anomalies, thought to be associated with Ordovician magmatism (Pharaoh *et al.*, 1993), also terminates approximately along the line of this possible crustal dislocation. There is also an offset in Moho depth (Figure 1(b)) that occurs approximately along the same line. The suggested deep crustal boundary has not previously been recognised and the reasons for its existence are unclear.
- ***The 'S' and 'E' Domains -*** The generally lower residual gravity values of the 'S' Domain lie beween three gradients: 'v', 'w' and 'x'. The 'v' gradient of Figure 10 broadly parallels the

crustal boundary inferred from the analysis of the long profiles (Figure 9(a)), although it is displaced slightly to the south. In this study, the 'v' gradient is interpreted as a composite feature, reflecting both the deeper crustal gradient and the shorter-wavelength gravity expression associated with the northern limit of Devonian and Silurian Basins on the Midlands Platform. The 'w' gradient aligns with the eastern margin of the Central England Magnetic Anomaly (Beamish et al., 2016), possibly marking the eastern extent of the Midlands Platform. Lee et al. (1991) recognised the northern onshore segment of the 'w' gradient in East Anglia, describing it as a diffuse boundary marking the eastern limit of east to northeast trending gravity lineaments. More recently, Pharaoh *et al.* (2023), using inverted magnetic data, have identified the line of the 'w' gradient over the onshore portion north of the River Thames, calling it the Saffron Walden Lineament. The residual gravity gradient presented here suggests that this feature may extend farther than previously mapped, continuing southwards through Kent and reaching the coastline near Hastings. Variscan structures seem not to be strongly expressed within residual data of the 'S' Domain. The 'E' Domain lies to the east of the 'w' gradient and is poorly covered by the area of existing modelling. The 'x' gradient is discussed within the 'SW' Domain section below.

- ***The 'SW' Domain*** – This area is marked by higher gravity values with a well-defined northeasterly boundary along the 'x' gradient. Pullan & Donato (2021) interpret the 'x' gradient as a terrane boundary, along which the Southwest England structural block was translated northwestward, during the Carboniferous, to its current position from a location at the western end of the Rhenohercynian Zone of continental Europe. This is in agreement with earlier interpretations by Holder and Leveridge (1986) and Woodcock *et. al*. (2007).

Conclusions

A ten-layer 3D gravity model has been constructed across a large part of England. This has been used to produce a residual gravity map, displaying features interpreted to originate from pre-Carboniferous structures, including granites, Paleozoic basins and internal structuring within the Paleozoic. Residual anomalies at both short and long wavelength have been defined with the longer wavelength features probably associated with mid-deep crustal features.

The shorter-wavelength residual anomalies are generally low in amplitude, typically less than 10 mGal, and appear to reflect variations in Paleozoic sediment thickness. Negative anomalies generally coincide with areas where Paleozoic sequences are relatively thick, whereas positive anomalies mark areas where these sequences thin over basement highs. Along the English south coast, a large, elongate negative anomaly extends for approximately 200 km with an east–west orientation. This feature is interpreted as indicating a substantial zone of thickened Paleozoic sediments developed within a major basinal structure.

The longer-wavelength residual anomalies have a significantly larger range, varying between +40 and -10mGal. They may be considered as representing six different gravity domains ('NW', 'NE', 'N', 'S', 'E' and 'SW'), possibly related to variations in crustal thickness and/or crustal composition. The high residual values of the 'NW' Domain appear to be related to an area of crustal thinning and/or underplating, located mainly beneath the Irish Sea. This suggests Moho topography as a possible source. The 'NE', 'SW' and 'S' Domains, however, do not appear similarly related to Moho topography, suggesting an alternative source, possibly involving density changes within the crust. Areas of steeper gravity gradient exist between the domains, and these may indicate the positions of crustal discontinuities, possibly of a tectonic origin. Within the southern part of the 'S' Domain, a previously unrecognised and possibly significant dislocation/fault trend has been identified, located along the south of the 'm' Anomaly.

Clearly, there are many questions remaining and the residual gravity features, including both those newly suggested here and those unexpectedly missing such as the Midlands Microcraton and Variscan Front, require further investigation. It is hoped that the residual gravity map presented will assist ongoing and future research.

Acknowledgements

We acknowledge the important contribution of our colleague and friend Andy McGrandle, who sadly passed away during the preparation of this manuscript. Andy provided helpful discussion and advice, including the initial recognition of the limited representation of the Midlands Microcraton within the gravity data. We also recognise his valued contributions to related work over the years, and we remember with gratitude his consistently friendly, knowledgeable and supportive manner.

Kostas Dimitropoulos kindly allowed the use of his 3D gravity modelling software upon which the 3D models were run. Much of the well density data incorporated within the 3D models were obtained from the UKOGL website. The BGS allowed access to their GravMag Interactive 2.5D interpretation software, used for the step-models considered. The ideas described here are, however, those of the authors, and any shortcomings are their full responsibility.

References

Aitkenhead, N. et al., 2002. *British regional geology: the Pennines and adjacent areas (Fourth edition),* London: HMSO for British Geological Survey.

Al-Kindi, S. et al., 2003. The trace of a hot convective sheet. *Geology,* Volume 31, pp. 207-210.

Allsop, J. M., 1985. Evaluation of gravity and magnetic anomalies in the Warboys area, north of Cambridge. *Proceedings of the Geologists' Association,* Volume 96, pp. 263-273.

Allsop, J. M., 1987. Patterns of late Caledonian intrusive activity in eastern and northern England from geophysics, radiometric dating and basement geology. *Proceedings of the Yorkshire Geological Society,* Volume 46, pp. 335-353.

Andrews, I. J., 2013. *The Carboniferous Bowland Shale gas study: geology and resource estimation,* London: British Geological Survey for Department of Energy and Climate Change.

Andrews, I. J., 2014. *The Jurassic shales of the Weald Basin: geology and shale oil and shale gas resource estimation,* London UK: British Geological Survey for Department of Energy and Climate Change.

Arrowsmith, S. J. et al., 2005. Seismic imaging of a hot upwelling beneath the British Isles. *Geological Society of America,* 33(5), pp. 345-348.

Arsenikos, S. et al., 2015. *Seismic interpretation and generation of key depth structure surfaces within the Devonian and Carboniferous of the Central North Sea, Quadrants 25 – 44 area. Geological Survey Commissioned Report CR/15/118,* Keyworth: British Geological Survey.

Ates, A. & Kearey, P., 1993. Deep structure of the East Mendip Hills from gravity, areomagnetic and seismic reflection data. *Journal of the Geological Society,* Volume 150, pp. 1055-1063.

Baptiste, J., 2016. *Cartographie structurale et lithologique du substratum du Bassin parisien et sa place dans la chaîne varisque de l'Europe de l'Ouest : approches combinées géophysiques, pétrophysiques,géochronologiques et modélisations 2D,* Orléans: Université d'Orléans, PhD Thesis.

Barclay, W. J., Ambrose, K., Chadwick, R. A. & Pharaoh, T. C., 1997. *Geology of the country around Worcester, Sheet 199 (England and Wales),* Keyworth, Nottingham: Memoir of the British Geological Survey.

Beamish, D., Kimbell, G. & Pharaoh, T., 2016. The deep crustal magnetic structure of Britain. *Proceedings of the Geologists' Association,* Volume 127, pp. 647-663.

Beeley, H. S. & Norton, M. G., 1998. *The structural development of the Central English Channel High - constraints from section restoration.* London: In Underhill, J. R. (ed) Geological Society Special Publications.

BGS, 2024. *Geoindex Offshore.* [Online]
Available at: https://mapapps2.bgs.ac.uk/geoindex_offshore/home.html

Blaise, T. et al., 2025. Timing of inversion of the Weald–Boulonnais basin inferred from calcite U–Pb geochronology of brittle structures along the Opal Coast, northern France. *Jounal of the Geological Society,* Volume 182, pp. 2024-222.

Booth, K. A. et al., 2011. *Geology of Devizes district. Sheet description of the 1:50 000 Series Sheet 282 (England and Wales).,* Keyworth, Nottingham: British Geological Survey,.

Bott, M. H. P., 1961. Geological interpretation of magnetic anomalies over the Askrigg Block. *Quartely Journal of the Geological Society of London,* Volume 117, pp. 491-493.

Bott, M. H. P., 1967. Geophysical investigations of the Northern Pennine basement rocks. *Proceedings of the Yorkshire Geological Society,* Volume 36, pp. 139-168.

Bott, M. H. P., Day, A. A. & Masson-Smith, D., 1958. The Geological Interpretation of Gravity and Magnetic Surveys in Devon and Cornwall. *Series A. Mathematical and Physical Sciences,* 251(992), pp. 161-191.

Bott, M. H. P., Robinson, J. & Kohnstamm, M. A., 1978. Granite beneath Market Weighton, east Yorkshire. *Journal of the Geological Society (London),* Volume 135, pp. 535-543.

Brodie, J. & White, N. J., 1994. Sedimentary basin inversion caused by igneous underplating: northwest European continental shelf. *Geology,* Volume 22, pp. 147-150.

Brooks, M., 1968. The geological results of gravity and magnetic surveys in the Malvern Hills and adjacent districts. *Geological Journal,* Volume 6, pp. 13-30.

Brooks, M. & Thompson, M. S., 1973. The geological interpretation of a gravity survey of the Bristol Channel. *Journal of the Geological Society,* Volume 129, pp. 245-271.

Bureau de Recherches Geologiques et Minineres, BRGM, 2025. *InfoTerre.* [Online]
Available at: https://infoterre.brgm.fr/

Burley, A. J., 1971. Geophysical Surveys in the Warlingham borehole in The stratigraphy of the Geological Survey Borehole at Warlingham, Surrey. Worssam, B C (editor). *Bulletin of the Geological Survey of Great Britain,* Volume 36, pp. 112-121.

Busby, J. P., Kimbell, G. S. & Pharaoh, T. C., 1993. Integrated geophysical/geological modelling of the Caledonian and Precambrian basement of southern Britain. *Geological Magazine,* Volume 130, pp. 593-604.

Busby, J. P. & Smith, N. J., 2001. The nature of the Variscan basement in southeast England: evidence from integrated potential field modelling. *Geological Magazine,* Volume 138, pp. 669-685.

Busby, J. P., Walker, A. S. D. & Rollin, K. E., 2006. *Regional Geophysics of South-east England. Version 1.0 on CD Rom,* Keyworth, Nottingham: British Geological Survey.

Butler, M., 2018. Seismostratigraphic analysis of Paleozoic sequences of the Midlands Microcraton. In: A. A. MONAGHAN, J. R. UNDERHILL, A. J. HEWETT & J. E. A. MARSHALL, eds. *Paleozoic Plays of NW Europe.*. Special Publications ed. London: Geological Society, pp. 66-77.

Butler, M. & Pullan, C. P., 1990. Tertiary structures and hydrocarbon entrapment in the Weald Basin of southern England. *Geoloical Society of London, Special Publications v.55,* pp. 371-391.

Chacksfield, B. C. & Edwards, J. F. W., 2006. *1:1 000 000 UTM Series: Gravity Anomaly Maps,* Keyworth, Nottingham: British Geological Survey.

Chacksfield, B. C., Edwards, J. W. F. & Royles, C. P., 2006. *1: 1 000 000 UTM Series: Magnetic Anomaly Maps,* Keyworth, Nottingham: British Geological Survey.

Chadwick, R. A., 1983. *Hydrocarbon prospectivity of the Weald and eastern English Channel. Volume 4: geological structure,* Keyworth: IGS Deep Geology Unit report to Department of Energy 83/3/4.

Chadwick, R. A., 1986. Extension tectonics in the Wessex Basin, southern England. *Geological Society of London,* Volume 143, pp. 465-488.

Chadwick, R. A., Kenolty, N. & Whittaker, A., 1983. Crustal structure beneath southern England from deep seismic reflection profiles. *J. geol. Soc. London,* Volume 140, pp. 893-911.

Chadwick, R. A. & Pharaoh, T. C., 1998. The seismic reflection Moho beneath the United Kingdom and adjacent areas. *Tectonophysics,* pp. 255-279.

Chadwick, R. A., Pharaoh, T. C., Williamson, J. P. & Musson, R. M. W., 1996. *Seismotectonics of the UK 172pp,* Nottingham: British Geological Survey.

Chroston, P. N., Allsop, J. M. & Cornwell, J. D., 1987. New seismic refraction evidence on the origin of the Bouguer anomaly low near Hunstanton, Norfolk. *Proceedings of the Yorkshire Geological Society,* 46(4), pp. 311-319.

Colman, T. B. et al., 1995. *Exploration for volcanogenic mineralisation in south-west Wales, Mineral Reconnaisance Programme Report No 137,* Keyworth: British Geological Survey.

Corfield, S. M. et al., 1996. Inversion tectonics of the Variscan Foreland of the British Isles. *Journal of the Geological Society, London,* Volume 153, pp. 17-32.

Cornwell, J. D., 1977. Geophysical Surveys in Stratigraphy of the Steeple Aston Borehole, Oxfordshire. Poole, E G (editor). *Bulletin of the Geological Survey of Great Britain,,* Volume 57, pp. 43-51.

Cornwell, J. D. et al., 2001. The Snelston Ridge: evidence for a concealed ridge of mineralized Dinantian rocks to the south of the Derbyshire Dome. *Proceedings of the Yorkshire geological Society,* 53(4), pp. 257-264.

Cornwell, J. D. & Cave, R., 1986. *An airborne geophysical survey of part of west Dyfed, South Wales, and some related ground surveys,* British Geological Survey: Mineral Reconnaissance Programme Report No. 84.

Cornwell, J. D. et al., 1996. *Sources of low amplitude aeromagnetic anomalies in UK sedimentary basins and establishment of a magnetic properties database,* Keyworth: British Geological Survey Technical Report, WK/96/4C.

Cornwell, J. D. & Walker, A. S. D., 1989. Regional Geophysics. In: J. A. Plant & D. G. Jones, eds. *Metallogenic models and exploration criteria for buried carbonate-hosted ore deposits : a multidisciplinary study in eastern England.* Keyworth Nottingham: Institute of Mining Metallurgy, pp. 25-51.

Davis, M. W. et al., 2012. Crustal structure of the British Isles and its epeirogenic consequences. *Geophs. J. Int.,* Volume 190, pp. 705-725.

Donato, J. A., 1993. A buried granite batholith and the origin of the Sole Pit Basin, UK Southern North Sea. *Journal of the Geological Society,* pp. 255-258.

Donato, J. A., 2007. A Geophysical Ramble across Southern Shropshire - Speculations based upon an East-West Cross-Section. *Proceedings of the Shropshire Geological Society,* Volume 12, pp. 1-4.

Donato, J. A., 2019. *Gravity modelling across two postulated granite batholiths within the UK onshore East Midlands Shelf.* [Online]
Available at: https://ukogl.org.uk/beneath-britain/100-Gpdf

Donato, J. A., 2025 (2). Crustal structure beneath central-soutern England: speculative boundaries based upon an integration of gravity and magnetic data. *(in press).*

Donato, J. A. & Megson, J. B., 1990. A buried granite batholith beneath the East Midland Shelf of the Southern North Sea. *Journal of the Geological Society of London,* Volume 147, pp. 133-140.

Donato, J. A. & Pullan, C. P., 2022. *The deep structure of England from gravity and magnetic profiling.* [Online]
Available at: https://ukogl.org.uk/beneath-britain/400-Dpdf

Donato, J. A., Pullan, C. P. & Dimitropoulos, K., 2024. *Moho structure beneath England and the regional gravity background field.* [Online]
Available at: https://ukogl.org.uk/beneath-britain/500-Mpdf

Donato, J. A., Pullan, C. P. & Lockham, G. E. V., 2025. *Exploring the newly-defined Holme Granite beneath the UK Pennine Basin: geophysical and geological evidence.* [Online]
Available at: https://ukogl.org.uk/beneath-britain/700-Epdf

Dunning, F. W., 1985. *Geological Structure of Great Britain, Ireland and surrounding seas. Geological Society Mapchart.* London: Geological Society, Burlington House, Piccadilly, London W1V 0JU.

Ellis, P. F. & Kearey, P., 1984. An Investigation of the Reading-Newbury magnetic anomaly. *Journal of the Geological Society of London,* Volume 141, pp. 349-356.

Evans, C. D. R., 1990. *United Kingdom offshore regional report: the geology of the western English Channel and its western approaches,* London: HMSO for the British Geological Survey.

Fairhead, J. D. et al., 2023. Gravity imaging of sub-Zechstein geological structures in the UK sector of the North Sea using the gravity layer stripping method. *Petroleum Geoscience,* Volume 29, pp. petgeo2023-009.

Fyfe, L. J. C. & Underhill, J. R., 2023. A regionl geological overview of the Upper Permian Zechstein Supergroup (Z1 to Z3) in the SW margin of the Southern North Sea and onshore Eastern England. *Journal of Petroleum Geology,* pp. 223-256.

Genc, H. T., 1988. *Gravity and other geophysical studies of the crust of southern Britain, PhD Thesis.* Edinburgh: University of Edinburgh.

Griffiths, D. H. & Gibb, R. A., 1965. Bouguer Gravity Anomalies in wales. *Geological Journal,* 4(2), pp. 335-342.

Hamblin, R. J. O. et al., 1992. *United Kingdom offshore regional report: the geology of the English Channel,* London: HMSO for the British Geological Survey.

Harvey, M. J. et al., 1994. Tectonic evolution of the Plymouth Bay Basin. *Proceedings of the Ussher Society,* Volume 8, pp. 271-278.

Hillis, R. R. et al., 2008. Cenozoic exhumation of the southern British Isles.. *Geology,* 36(5), pp. 371-374.

Holder, M. T. & Leveridge, B. E., 1986. Correlation of the Rhenohercynian Variscides. *Journal of the Geological Society of London,* Volume 143, pp. 141-147.

Hopkins, D. T., 1979. A 3-D interpretation of a circular gravity feature south of Reading. *Abstr. Geophys J. R. Astr. Soc.,* Volume 57, p. 275.

Jackson, D. I. et al., 1995. *United Kingdom offshore regional report: the geology of the Irish Sea,* London: HMSO for the British geological Survey.

Jones, D. J. R. et al., 2023. Deep geothermal resource assessment of early carboniferous limestones for Central and Southern Great Britain. *Geothermics,* p. 109(3):102649 http://dx.doi.org/10.1016/j.geothermics.2023.102649.

Jones, D. K. C., 1999. On the uplift and denudation of the Weald. In: Smith, B.J., Wuallzy, W.B. & Warke, P.A. (eds) 1999. Uplift, Erosion and Stability: Perspectives on Longterm Landscape Development. *Special Publication Geological Society London,* Volume 162, pp. 25-43.

Jones, S. M. et al., 2002. Present and past influence of the Iceland Plume on sedimentation.. *Goelogical Society London, Special Publication,* Volume 196, pp. 13-25.

Kearey, P. & Rabae, A. M., 1996. An Interpretation of the gravity anomaly at Warlingham, Surrey. *Geol Mag,* 133(5), pp. 619-624.

Kearey, P. & Rabae, A. M., 1996. Relic subduction in the southern North Sea recognised from deep seismic reflection and gravity data. *Tectonophysics,* Volume 258, pp. 115-124.

Kimbell, G. S., Carruthers, R. M., Walker, A. S. D. & Williamson, J. P., 2006. *Regional Geophysics of Southern Scotland and Northern England, Version 1.0 on CD-ROM,* Nottingham: British Geological Survey.

Kirby, G. A. et al., 2000. *Structure and evolution of the Craven Basin and adjacent areas, Subsurface Geology Memoir,* Keyworth, Nottinham: British Geological Survey.

Laske, G., Masters, G., Ma, Z. & Pasyanos, M., 2013. Update on CRUST1.0 - A 1-degree global model of Earth's crust. *Geophysical Research Abstracts, 2658,* Volume EGU General Assembly Vienna, Austria.

Law, A., 1998. Regional uplift in the English Channel: quantification using sonic velocity. In: Underhill, J.R. (ed.) Development, Evolution and Petroleum Geology of the Wessex Basin.. *Special Publication,* Volume 133, pp. 187-197.

Lee, M. K., Pharaoh, T. C. & Green, C. A., 1991. Structural Trends in the Concealed Basement of Eastern England from Images of Regional Potential Field Data. *Annales de la Societe Geologique de Belgique,* Volume 114, pp. 45-62.

Luszczak, K., Persano, C. & Stuart, F. M., 2018. Early Cenozoic denudation of central west Britain in response to transient and permanent uplift above a mantle plume. *Tectonics,* Volume 37, pp. 914-934.

Maguire, P., England, R. & Hardwick, A., 2011. LISPB DELTA, a lithospheric seismic profile in Britain: analysis and interpretation of the Wales and southern England section. *Journal of the Geological Society,* Volume 168, pp. 61-82.

Maroof, S. I., 1973. *Geophysical Investigations of the Carboniferous and pre-Carboniferous formations of the East Midlands of England,* PhD Thesis: University of Leicester.

Maroof, S. I., 1975. The Structure of the concealed pre-Carboniferous basement of the Derbyshire Dome from gravity data.. *Proceedings of the Yorkshire Geological Society,* 41(6), pp. 59-69.

Miliorizos, M. N., Reiss, N., Melis, N. S. & Rutter, W. A. J., 2021. *Structure of the Inner Bristol Channel and Severn Estuary: regional mapping and seimic interpretation yield a refined model for mountain front deformation and inversion.* s.l.:s.n.

Mortimore, R. et al., 2011. Chalk: its stratigraphy, structure and engineering geology in east London and the Thames Gateway. *Quarterly Journal of Engineering Geology and Hydrogeology,* Volume 44, pp. 419-444.

North Sea Transition Authority, 2017. [Online]
Available at:
https://datanstauthority.blob.core.windows.net/external/DataReleases/GeologicalMaps/SNS_OS.zip

North Sea Transition Authority, 2019. [Online]
Available at:
https://datanstauthority.blob.core.windows.net/external/DataReleases/GeologicalMaps/EC_OS.zip

Pedley, R. C., Busby, J. P. & Dabek, Z. H., 1993. *GRAVMAG Interactive 2.5D Gravity and Magnetic Modelling.* Nottingham: British Geological Survey.

Pharaoh, T. C. et al., 2023. The Charnwood Terrane revisited: an integrated petrogenetic and petrophysical model for crustal structure in S Britain. *Journal of the Geological Society,* Volume DOI: https://doi.org/10.1144/jgs2023-001, p. Preprint Acepted for Publication.

Pharaoh, T. C., Brewer, T. S. & Webb, P. C., 1993. Subduction-related magmatism of late Ordovician age in eastern England. *Geological Magazine,* Volume 130, pp. 647-656.

Pharaoh, T. C. et al., 2016. *Seismic interpretation and generation of depth surfaces for late Palaeozoic strata in the Irish Sea Region,* Keyworth: British Geological Survey Commissioned Report, CR/16/041. 65pp..

Pharaoh, T. C. et al., 2011. *Structure and evolution of the East Midlands region of the Pennine Basin,* Keyworth: Subsurface memoir of the British Geological Survey.

Plant, J. A. & Jones, D. G., 1989. *Metallogenic models and exploration criteria for buried carbonate-hosted ore deposits: a multidisciplinary study in eastern England,* London: Institute of Mining and Metallurgy, Keyworth: British Geological Survey.

Powell, D. W., Griffiths, D. H. & King, R. F., 1955. Gravity and Magnetic Anomalies in North Wales. *Quarterly Journal of the Geological Society,* Volume 111, pp. 375-397.

Powell, J. H., Glover, B. W. & Waters, C. N., 2000. *Geology of the Birminham area, Sheet 168,* Keyworth: Memoir of the British Geological Survey.

Pullan, C. P. & Donato, J. A., 2021. *The Eastern Extension of Southwest Enland under the Mesozoic Southern England Basin and its Variscan Dextral Translation.* [Online] Available at: https://www.earth.ox.ac.uk/wp-content/uploads/2022/01/SW-England-Pullan-and-Donato.pdf

Rabae, A. M. & Kearey, P., 1997. Granites of the western Anglo-Brabant Massif. *Annales de la Société géologique de Belgique,* 120(2), pp. 217-226.

Scotchman, I. C., 1994. Maturity and burial history of the Kimmeridge Clay Formation, onshore UK: a biomarker study. *First Break,* 12(4), pp. 193-202.

Shail, R. K. & Leveridge, B. E., 2009. The Rhenohercynian passive margin of SW England: Development, inversion and extensional reactivation. *Geoscience,* Volume 341, pp. 140-155.

Shaw Champion, M. E., White, N. J., Jones, S. M. & Priestley, K. F., 2006. Crustal velocity structure of the British Isles; a comparison of receiver functions and wide-angle seismic data. *Geophys. J. Int.,* Volume 166, pp. 795-813.

Smart, J. G. O., Sabine, P. A. & Bullerwell, W., 1964. The Geological Survey boring at Canvey Island, Essex. *Bull. Geol. Surv. Gt. Brit.,* Volume 21, pp. 1-36.

Smith, D. B., 1989. The late Permian palaeogeography of north-east England. *Proceedings of the Yorkshire Geological Society,* Volume 47, pp. 285-312.

Smith, K., Smith, N. J. P. & Holliday, D. W., 1985. The deep geology of Derbyshire. *Geological Journal,* Volume 20, pp. 215-225.

Smith, N. J. P., Kirby, G. A. & Pharaoh, T. C., 2005. *Structure and evolution of the south-west Pennine basin & adjacent areas, Subsurface Memoir,* Keyworth, Nottingham: British Geological Survey.

Tappin, D. R. et al., 1994. *United Kingdom offshore report: the geology of Cardigan Bay and the Bristol Channel,* London: HMSO for the British Geological Survey.

Taylor, G. K., 2007. Pluton shapes in the Cornubian batholith: new perspectives from gravity modelling. *Journal of the Geological Society of london,* Volume 164, pp. 525-528.

Thomas, M. D. & Brooks, M., 1973. The geological significance of a negative gravity anomaly in the South Wales Coalfield. *Geological Journal,* 8(2), pp. 189-206.

UKOGL, 2024. [Online]
Available at: https://ukogl.org.uk/

Watts, A. B. et al., 2024. The Permian Cornumbian granite batholith, S W England; Part 2: Gravity anomalies, structure, and state of isostacy. *GSA Bulletin,* 136(9-10), pp. 4381-4397.

Whittaker, A., 1985. *Atlas of Onshore Sedimentary Basins in England and Wales.* s.l.:Blackie and Son Limited.

Wijanarko, R. M., Underhill, J. R., Brackenridge, R. E. & Fyfe, L. J., 2025. Basin Transaction in the vale of Pickering, North Yorkshire: Implications for Energy Resources and Geological Storage. *Geological Society, London, Energy Geoscience Conference Series,* pp. https://doi.org/10.1144/egc1-2024-16.

Woodcock, N. H. & Gibbons, W., 1988. Is the Welsh Borderland Fault System a terrane boundary?. *Journal of the Geological Society, London,* Volume 145, pp. 915-923.

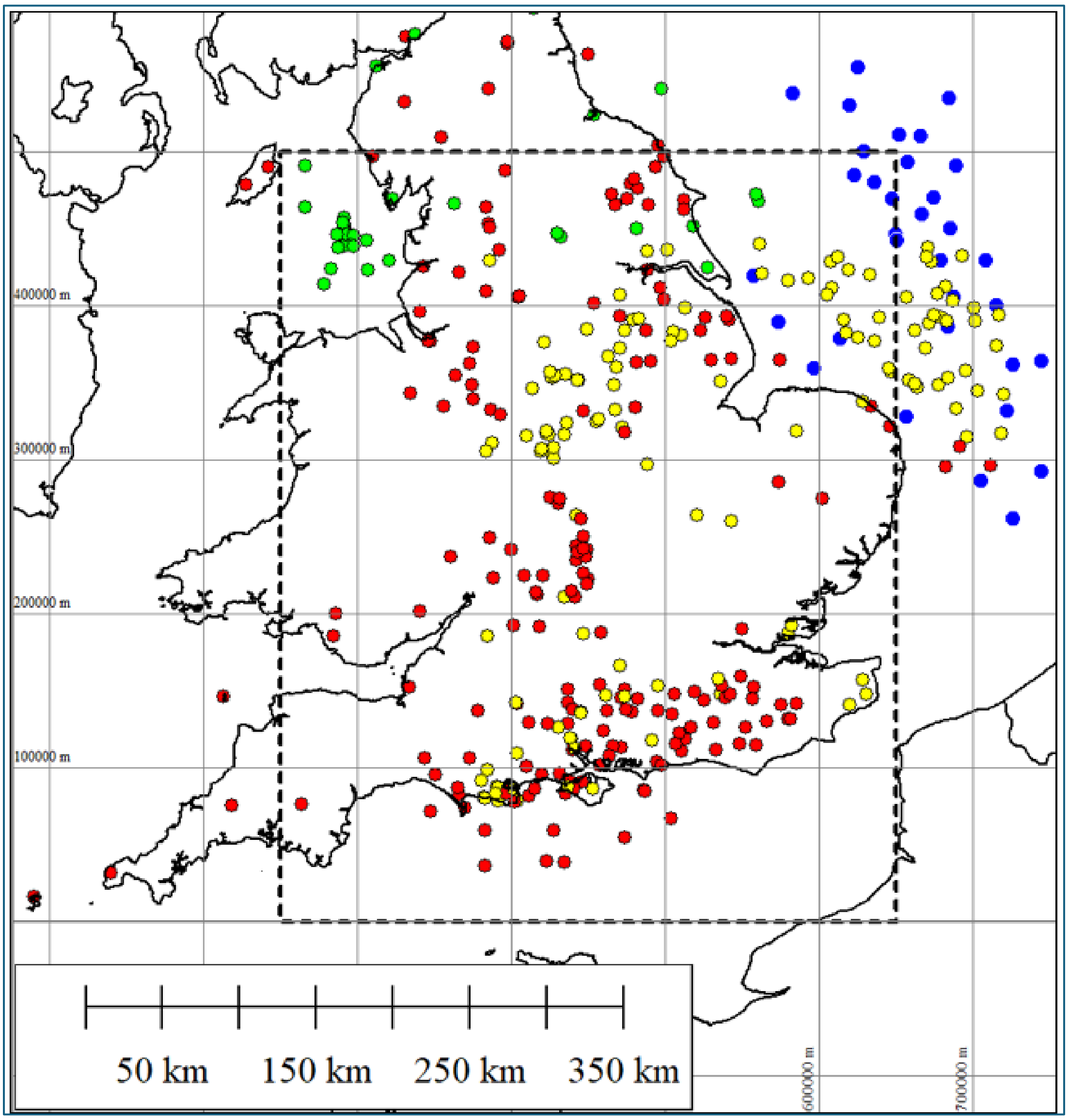
Woodcock, N., Soper, N. & Strachan, R., 2007. A Rheic cause for the Acadian deformation in Europe. *Journal of the Geological Society, London,* Volume 164, pp. 1023-1036.

Zurflueh, E. G., 1967. Applications of two-dimensional linear wavelength filtering. *Geophysics,* pp. 1015-1035.

Appendix

Sources and Locations of Density Data

Rock density values have been derived by analyses of well log data available on the UKOGL website combined with published material. Locations of the density data are shown in the figure below with details listed beneath. Location coordinates are not available for all of the data considered but the distribution of most of the data measurements are shown. Density data evaluations undertaken for the current study are shown by red dots, with data derived from Busby *et al.* (2006) and Kimbell *et al.* (2006) shown by yellow dots and green dots respectively. Blue dots show spot locations extracted from the density maps of Fairhead *et al.* (2023). The area of the 3D gravity-stripping study described here is shown by the black dashed polygon.



47/29-1	*Bouldnor Copse-1*	*Goodworth-1*	*Mappowder-1*	*Shrewton-1*
53/12-2	*Boulsworth*	*Guiting Power-1*	*Marchwood-1*	*Somerton-1*
53/16-1	*Bransgore-1*	*Halton Holegate-1*	*Margam-13*	*Southampton-1*
53/18-1	*Broadford Bridge-1*	*Hedge End-1*	*Marishes-1*	*Southard Quarry-1*
97/12-1	*Brockham*	*Hellingly-2*	*Martinstown-1*	*Southwater-1*
97/19-1	*Burford-1*	*Hesketh*	*Middleton-1*	*Stanmer-1*
97/19-1	*Burton Agnes-1*	*Heywood*	*Musbury-1*	*Staverton*
97/24-1A	*Burton Row*	*Hibaldstow-1*	*Napton Fields*	*Steeple Aston*
98/11-2	*Bushey Farm A1*	*High Hutton-1*	*Netherhampton-1*	*Stockbridge-1*
98/13-1	*Butlin Farm*	*Highworth-1*	*Netherton-1*	*Stockbridge-4*
98/18-1b	*Canvey Island*	*Hollies Barn*	*Nettlecombe-1*	*Storrington-1*
98/22-2	*Caythorpe 2*	*Holme Chappel-1*	*New Yatt*	*Stoupe Beck*
98/23-1	*Chessell-1*	*Holtye-1*	*Normanby-1*	*Swinden*
98/7-2	*Chickerell-1*	*Hook Lane-1*	*North Leigh*	*Thornton-le-Clay-1*
99/12-1	*Chilworth-1*	*Horley*	*North Stafford-1*	*Tipanheck*
99/16-1	*Claxby-1*	*Horndean-1A*	*Northbrook*	*Twyford Lane*
99/18-1b	*Cloughton*	*Horndean-4*	*Norton Ferris-1*	*Upper Enham-1*
Albury-1	*Codsall*	*Horse Hill-1*	*Odiham*	*Usk-1*
Alfold-1	*Collingham-1*	*Humbly Grove-1*	*Old Alresford-1*	*Vicarage Farm*
Alkborough-1	*Cooles Farm-1*	*Hurn-1*	*OX1D1*	*Wainbody Wood*
Apley Barn	*Cowes-1*	*Huscote*	*OX2A1*	*Wallcrouch-1*
Arreton-2	*Coxbridge-1*	*Iden Green-1*	*OX2C1*	*Warmsworth-1*
Ash Farm	*Cranbourne-1*	*Iden Green-1*	*OX2D1*	*Washington-1*
Ashington-1	*Croxteth*	*Ince Marshes-1*	*P33 Amble*	*Welford Park Station*
Ashour-1	*Detention-1*	*Kelstern-1*	*Palmers Wood-1*	*Wessenden*
Ashow	*Duggleby-1*	*Kemira-1*	*Pickering-1*	*Whenby-1*
Aston Tirrold	*Eaglesden-1*	*Kempsey*	*Pickford Green*	*Whitmoor*
Bacton-2	*East Worldham-1*	*Kirby Lane-1*	*Portland-1*	*Willoughbridge-1*
Balcolme-1	*Edenbridge-1*	*Kirby Misperton-1*	*Potwell-1*	*Wilmingham-1*
Barnard Gate	*Elworth-1*	*Knockholt*	*Prees-1*	*Windrush-1*
Baxters Copse-1	*Erbistock-1*	*Lakenheath*	*Redfern Farm*	*Winterbourne Kingston-1*
Becklees	*Errington-1*	*Lee-on-Solent-1*	*Ringmer-1*	*Withycombe Farm*
Belvoir-1	*Everton-1*	*Lidsey-1*	*Roddlesworth*	*WM1A Wearmouth*
Biddenden-1	*Farley South-1*	*Lingfield-1*	*Rotherfield-1*	*Wressle-1*
Biscathorpe-1	*Fifehead Magdalen*	*Lockerley-1*	*Saltfleetby-1*	*Wytch Farm-X14*
Black Cat-1	*Four Ashes*	*Locton East-1*	*Sandhills-1*	*Yarnbury-1*
Blacklocks Hill	*Fownhope-1*	*Lomer*	*Scupholme-1*	*Yarnfield-1*
Blakenhall-1	*Furzedown-1*	*Long Eaton-1*	*Seaborough-1*	
Boots Green-1	*Glyncastle*	*Longhorsley-1*	*Sherbourne-1*	
Bordon-1	*Godley Bridge-1*	*Lymington-1*	*Shipbourne-1*	

Table listing wells and boreholes for which log data (usually available only over limited depth intervals) were used to estimate density values for various stratigraphic units.

Published material from which density data have been extracted: -

Ates & Kearey (1993), BGS Engineering Geology Laboratory Report Numbers (8, 34, 40, 88, 101, 115, 135, 139, 140, 143, 180), Bott et al. (1958), Burley (1971), Busby et al (2006), Colman et al. (1995), Cornwell (1977); Cornwell & Cave (1986), Cornwell & Walker (1989), Cornwell et al. (1996); Ellis & Kearey (1984), Fairhead, et al. (2023), Griffiths and Gibb (1965), Kimbell et al. (2006), Mortimore et al. (2011), Plant and Jones (1989), Powell (1955), Thomas & Brooks (1973).