The Bakewell Granite, a postulated granite intrusion located beneath the eastern flank of the Derbyshire Dome, Northern England, UK.

John A. Donato[1*] and Christopher P. Pullan[2]

[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*

[*]*Corresponding author. Email: johndon8@btinternet.com*

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Abstract

As part of the ongoing studies of the Beneath Britain Group in association with the UK Onshore Geophysical Library (UKOGL), a seismic interpretation has been completed spanning the Derbyshire Dome and surrounding area. The interpretation uses well information tied to reflection seismic data, coupled with previously described refraction seismic studies. Depth structure maps at Base Permo-Triassic, Base Carboniferous Coal Measures, Base Namurian and Base Lower Carboniferous have been produced. These structure maps have enabled the construction of a four-layer 3D gravity model extending for 3,000 sq km across the Derbyshire Dome and flanking areas. The model calculates the gravity effect of the Carboniferous and younger sediments, allowing the calculation of a residual gravity map related to the pre-Carboniferous section. This map shows a residual gravity low extending over almost 500 sq km with an amplitude of -7mGal, and with clear north-south and northwest-southeast orientations. The existence of this gravity anomaly has been noticed before and named as the Bakewell Gravity Low, but has not been previously seen with such clearly-defined characteristics. The feature has been modelled as a buried granite batholith, here named as the Bakewell Granite, and alternatively as a pre-Carboniferous low-density basin. The granite option is preferred. The modelling suggests the granite to have a tabular form, with thickness of approximately 1km in the west, thickening to 2km in the east. It shows a similar structural form to the western Lake District late-Ordovician granites. The base of the proposed granite may be associated with a deep seismic refractor. In this case, an easterly tilt of the granite block of approximately 4° is suggested. The batholith has an associated mass deficit of approximately 8.3 x 10^{13} kg, much smaller than that associated with the larger Weardale Granite at 8.7 x 10^{14} kg (Bott and Masson-Smith, 1956). Despite its small size and low mass deficit, the Bakewell Granite appears to have exhibited an intermittent tectonic influence in both a vertical and horizontal sense. A stable tectonic area exists above the granite, with more pronounced structuring and faulting located along its eastern and western flanks. The granite is positioned above the structural ridge defined by the Burnley–Stamford Magnetic Anomaly, itself attributed to a deep source of Late Ordovician or possibly Precambrian age.

Introduction

The Derbyshire Dome is a broad, upwarped block of the South Pennines in central England, within the Derbyshire Peak District National Park (Figure 1). Its surface topography, generally between 200m and 300m above sea level, forms a high limestone plateau, the White Peak, characterised by rolling uplands, dry valleys and steep-sided dales. Geologically, the Dome exposes a stable core of Lower Carboniferous limestones, surrounded by outward-dipping belts of Namurian sandstones and shales and an outer fringe of Westphalian Coal Measures.

For much of the nineteenth and early twentieth centuries, geologists believed that the Derbyshire Dome was underlain by a large, concealed granite pluton (Ford, 1999). This idea arose from attempts to explain the region's hydrothermal mineralisation and the dome-like uplift of the Lower Carboniferous Limestone. Early workers (Evans and Maroof, 1976; Brown et al., 1980) argued that a cooling granite body at depth could have driven the circulation of mineralising fluids responsible for the Derbyshire Orefield. The structural form of the Dome, combined with analogies to the Cornubian Batholith, made the 'hidden granite hypothesis' an attractive explanation.

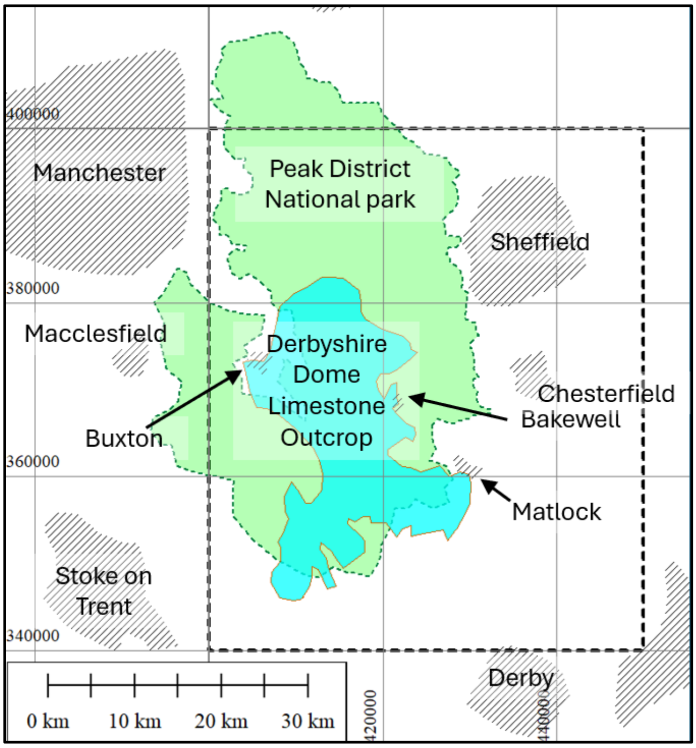

Figure 1 *The location of the Derbyshire Dome in Northern England. The outcrop of Lower Carboniferous Limestone is shown by the cyan polygon with the Peak District National Park shown in green. The black dashed rectangle shows the area of the 3D gravity model described here.*

From the mid-twentieth century onwards, however, new borehole, gravity and seismic datasets began to challenge this assumption. Deep drilling at Woo Dale (1947), Eyam (1970) and Caldon Low (1977) revealed that the pre-Carboniferous basement beneath the Dome was not granitic but represented a heterogeneous assemblage of Devonian sandstones (Caldon Low BH), Ordovician volcanics (Woo Dale BH) and Ordovician shales (Eyam BH). These results suggested that the Derbyshire Dome sits on a structurally complex basement rather than on a single felsic intrusive body.

Geophysical studies, particularly refraction profiles (Rogers, 1983), reinforced this reinterpretation. They revealed major basement faults, such as the Bonsall Fault, separating crustal blocks with contrasting seismic properties. Integration of refraction results with gravity data (Rogers, 1983) did, however, suggest the presence of a 'hidden layer' of considerable thickness with anomalously low density. However, this suggestion was not pursued and by the 1980s, the granite hypothesis had been abandoned. Modern interpretations emphasise that Derbyshire's mineralisation relates to westerly flowing saline fluids migrating from the Carboniferous shale basin on the east (Ford, 1999). In addition, recent studies (Sheldrick et al., 2025) suggest that the Carboniferous-Early Permian magmatism was sourced from within the mantle, with its near-surface locations controlled by major faults. Consequently, neither mineralisation nor magmatism appear directly related to any possible buried granite.

The work presented here includes a modern interpretation of all existing reflection seismic data located on and around the Dome and tied to all available well data. An integration of this interpretation together with refraction and gravity data has created a 3D gravity model, used to strip away the gravity effect of the Carboniferous and younger sequences. The resulting residual gravity map displays a significant gravity low associated with pre-Carboniferous heterogeneity. This gravity low is interpreted in terms of a buried granite, the Bakewell Granite, thus possibly resurrecting the earlier discarded 'hidden granite hypothesis'.

Database

The database comprises well information, seismic reflection and refraction data, and gravity and magnetic potential field measurements. The seismic and well database is shown in Figure 2 superimposed upon BGS solid geology mapping. Reflection seismic coverage is highly variable, with comprehensive control on the flanks of the Derbyshire Dome but no lines acquired over the central area of Lower Carboniferous outcrop. The results of four seismic refraction lines are,

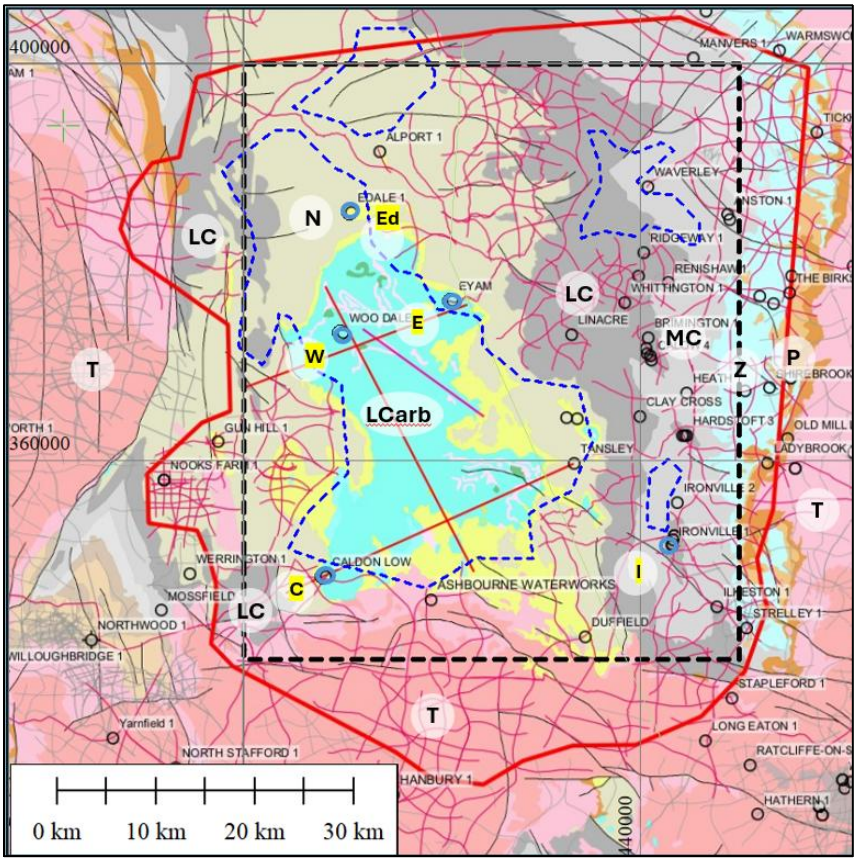

__Figure 2__ Well and seismic database superimposed upon the BGS solid geology map (including surface faults), labelled as follows: T-Triassic, P-Permian, Z-Zechstein, MC-Middle Coal Measures, LC-Lower Coal Measures, N-Namurian, LCarb-Lower Carboniferous. Reflection seismic data used in the interpretation are shown as red lines, with the peripheral uninterpreted lines shown in grey. Areas lacking in reflection seismic coverage are highlighted by the blue dashed polygons. The four straight red lines crossing the Derbyshire Dome Lower Carboniferous limestone outcrop show the location of four refraction seismic lines (Rogers, 1983). Key wells are marked as E-Eyam BH, Ed-Edale-1, W-Woo Dale BH, C-Caldon Low BH and I-Ironville-5. The area of study lies within the red polygon and the black dashed rectangle shown in this and subsequent figures marks the area of the 3D gravity model. Contains British Geological Survey materials © UKRI.

however, available over this central area (Rogers, 1983). Well control is similarly distributed with numerous wells located on the flanks but few in the central area.

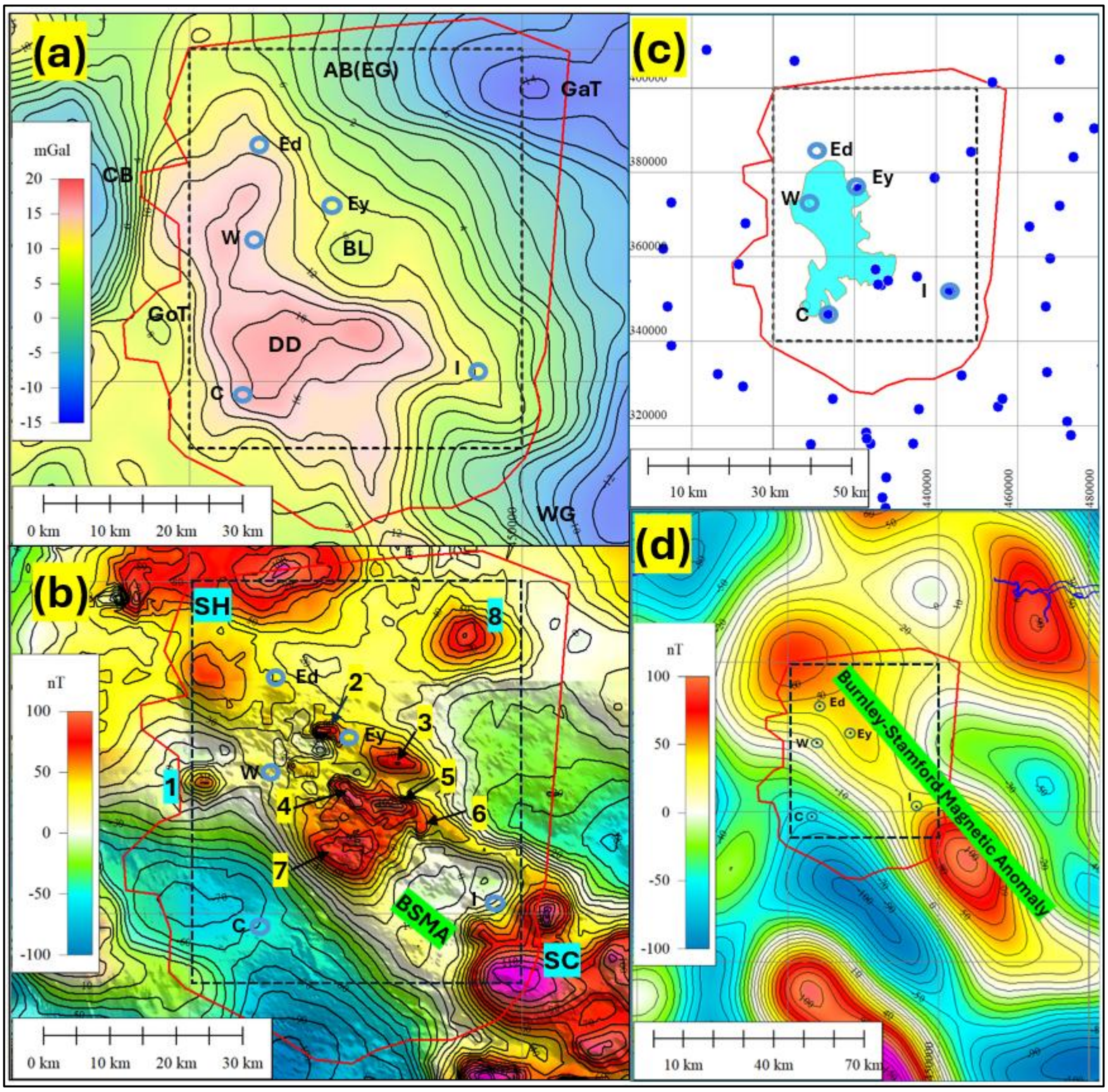

Figure 3 (a) *BGS Bouguer Anomaly gravity map. Contour interval 1mgal. The black dashed rectangle shows the area of the 3D gravity model. Selected features are labelled as CB-Cheshire Basin, AB(EG)-Alport Basin (Edale Gulf), GaT-Gainsborough Trough, BL-Bakewell Low, GoT-Goyt Trough, DD-Derbyshire Dome, WG-Widmerpool Gulf and well locations as Ed-Edale-1, Ey-Eyam BH, W-Woo Dale BH, I-Ironville-5 and C-Caldon Low BH.* ***(b)*** *BGS Total Magnetic Intensity. Contour interval 10nT. Features are colour-coded for likely depth of source; shallow-yellow, mid-cyan and deep-green. Notable features are labelled as SH-Southern Holme Granite Magnetic Anomaly, BSMA-Burnley-Stamford Magnetic Anomaly, SC-Strelley Centre and Anomalies 1 to 8 (discussed in the text). The southern three-quarters of (b) incorporates a shaded relief image taken from the BGS High Resolution Magnetic Survey of the Midlands (1998).* ***(c)*** *Blue dots show the location of the well density database with the cyan polygon showing the Lower Carboniferous outcrop of the Derbyshire Dome.* ***(d)*** *Filtered long-wavelength component of the magnetic data shown in (b). The NNW-SSE trending Burnley-Stamford Magnetic Anomaly may clearly be seen. In (a), (b) and (d), positive anomalies are shaded red with negative anomalies shaded green/blue. Contains British Geological Survey materials © UKRI.*

As shown in the following table, four wells penetrate to pre-Carboniferous levels. In the Caldon Low BH, after penetrating 365m of Lower Carboniferous limestones and dolomites, the well drilled a sequence of 170m of sandstone, siltstones and mudstones of Lower Carboniferous or Devonian age (the Redhouse Sandstones) without reaching the base of the sequence (Aitkenhead and Chisholm, 1982). The Eyam BH terminated within Lower Ordovician mudstones beneath approximately 1800m of Lower Carboniferous carbonates (Dunham, 1973). An average

Well	Date	TD Depth (m)		TD Formation Age
		md	ss	
Edale-1	1938	230.7	28.3	Middle Carboniferous
Woo Dale BH	1947	312.1	69.6	Lower Ordovician
Eyam BH	1970	1851.0	1621.0	Lower Ordovician
Caldon Low BH	1977	535.4	200.4	Devonian
Ironville-5	1984	1308.0	1215.5	Upper Cambrian-Lower Ordovician

density of 2.74 gm/cc was recorded in the well for the Ordovician mudstones (Maroof, 1973). Pre-Carboniferous volcanic rocks with a thickness more than 38m were encountered in the Woo Dale BH beneath 270m of Lower Carboniferous limestones with a basal breccia. Cope (1979) suggests a likely age for these volcanics as Ordovician. Ironville-5 penetrated a sequence of Upper, Middle and Lower Carboniferous sediments, terminating within an 80m sequence of Upper Cambrian-Lower Ordovician weakly-metamorphosed sands and shales with thin basic intrusives. Density logs run in the well (British Petroleum, 1984) indicate an average density of 2.72 gm/cc for this 80m section.

Gravity and magnetic maps are illustrated in Figures 3(a) and 3(b). The gravity data were derived by gridding digitised contours from the maps of Chacksfield and Edwards (2006) who used a Bouguer correction density estimated from the distribution of main geological formations. This mapping is thought more appropriate than the digital data available on the BGS website which uses a constant Bouguer correction density. The BGS gravity map shows a prominent gravity high associated with the Derbyshire Dome, and flanking lower gravity values related to the Cheshire, Alport (Edale), Gainsborough, Goyt and Widmerpool Basins. The magnetic map of Figure 3(b) includes downloaded BGS data, with the southern part of the map derived from the BGS Hi-RES1 English Midlands Survey (BGS, 1998). These data are shown with dark gradient shading superimposed. Magnetic anomalies are labelled in Figure 3(b) (following Chapter 13 of Aitkenhead (1985)) and originate from sources at various depths within the Carboniferous and pre-Carboniferous rocks. Short wavelength features (numbers 2 to 7) have comparatively large amplitudes and originate from Dinantian igneous rocks located mainly within a few hundred metres of the surface (Aitkenhead et al., 1985). Longer wavelength features occur at SH, 1, 8 and SC. SH appears to be an anomaly flanking the southern side of the Holme Granite (Donato et al., 2025). Anomalies numbered 1 and 8 can be modelled at depths between 1.5 to 2 km. They have no significant associated gravity anomaly and, although of smaller amplitude, show similar characteristics to the Late Ordovician granodiorite intrusions located further south (Lee et al., 1991; Pharaoh et al., 1993)). SC appears to be associated with the Strelley Volcanic Centre (Pharaoh et al., 2011), evidence for which may be seen in well data (particularly Strelley-1 which penetrated through approximately 350m of Lower Carboniferous lava and tuff). On reflection seismic sections, the top and base of this volcanic interval may be mapped locally. The Burnley–Stamford Magnetic Anomaly (BSMA) (Beamish et al., 2016; Donato and Pullan, 2022) trends NW to SE beneath the central and northeastern flank of the Derbyshire Dome. It represents the dominant long-wavelength magnetic feature in the region and is inferred to arise from sources buried to at least 4–6 km (Donato & Pullan, 2022, Profiles 2–5). Following the removal of the gravity effect of the granite and the Carboniferous and younger sediments, Donato et al. (2026) have calculated positive residual gravity values (their residual gravity anomaly 'c') with a position and trend approximately aligning with the BSMA. This supports an overall interpretation of a deeply-buried structural ridge, with the magnetic source attributed to a Late Ordovician (Pharaoh et al., 1993) or Precambrian (Cornwell & Walker, 1989) age, coupled with an overlying tabular granite block. The BSMA also follows the trend of the shallower Lower Carboniferous features (Aitkenhead et al., 1985). There appears to be a relationship between the shallower and deeper magnetic trends but the reasons for their correspondence are unclear.

Seismic Interpretation and Depth Conversion

Figure 2 shows the reflection seismic database with thin red lines indicating the interpreted sections. Figure 4(c) illustrates an example composite seismic line with the four mapped horizons shown: Base Permo-Triassic, Base Coal Measures, Base Namurian and Base Carboniferous. The horizons have been identified by well-tops data downloaded from the UKOGL website (2026) for the 37 wells located within the interpretation area. The number of well ties for the Base Permo-Triassic, Base Coal Measures, Base Namurian and Base Carboniferous horizons were 6, 14, 11 and 4 respectively. Confidence in horizon interpretation decreases with depth, with the Base Carboniferous event being unreliable in some areas because of a combination of poor reflection amplitude, weak lateral continuity and the limited availability of well-tie points. Depth conversion was undertaken using a simple time-depth function for the top three horizons (Figure 5). Such a simple approach was not suitable for the Base Carboniferous surface, however, because of velocity changes depending on Lower Carboniferous facies variations between limestone and shale intervals. Limestones showed higher velocities, with velocities for the shales being dependent on depth of burial and inversion effects. Consequently, for this deepest layer, a combination of mapped time thickness coupled with a contoured interval velocity map was employed, allowing for the facies change. After depth conversion, mis-ties between well depths and seismically-mapped depths produced an RMS error of 93m. This is considered adequate for the purposes of generating a gravity model although the possible unreliability in some areas of the Base Carboniferous mapping should be taken into consideration.

Unfortunately, the coverage of seismic reflection data does not extend across the main part of the Derbyshire Dome (Figure 2). Here, existing refraction data have been integrated. Rogers (1983) conducted four seismic refraction profiles using quarry blasts as seismic sources. He identified two primary basement refractors. North of the Bonsall Fault (called the Cronkston-Bonsall Fault in Aitkenhead et al., 1985 and Sheldrick et al., 2025 and see Figure 7(b)), he observed two refractors, an Upper Basement and a Lower Basement Refractor. He interpreted the Upper Refractor as originating from near to the Base of the Carboniferous Limestone, forming a smooth structural dome. The Lower Refractor was considered to originate possibly from Charnoid-type basement. Since no additional refractions were observed from any horizon between the two primary refractors, a 'hidden' or low velocity zone was inferred. For an example of one of his refraction line results, see Figure 4(a) and (b). The Upper Basement Refractor approximately ties to the base of the Carboniferous Limestone at 31.2m TVDSS in the Woo Dale BH (top volcanics of possible Ordovician age (Cope, 1979)) and at 1573m TVDSS in the Eyam BH (top Ordovician shales). Locations for all depths to the Upper Basement Refractor (approximately Base Carboniferous Limestone) as calculated by Rogers are shown by the green circles of Figure 7(b).

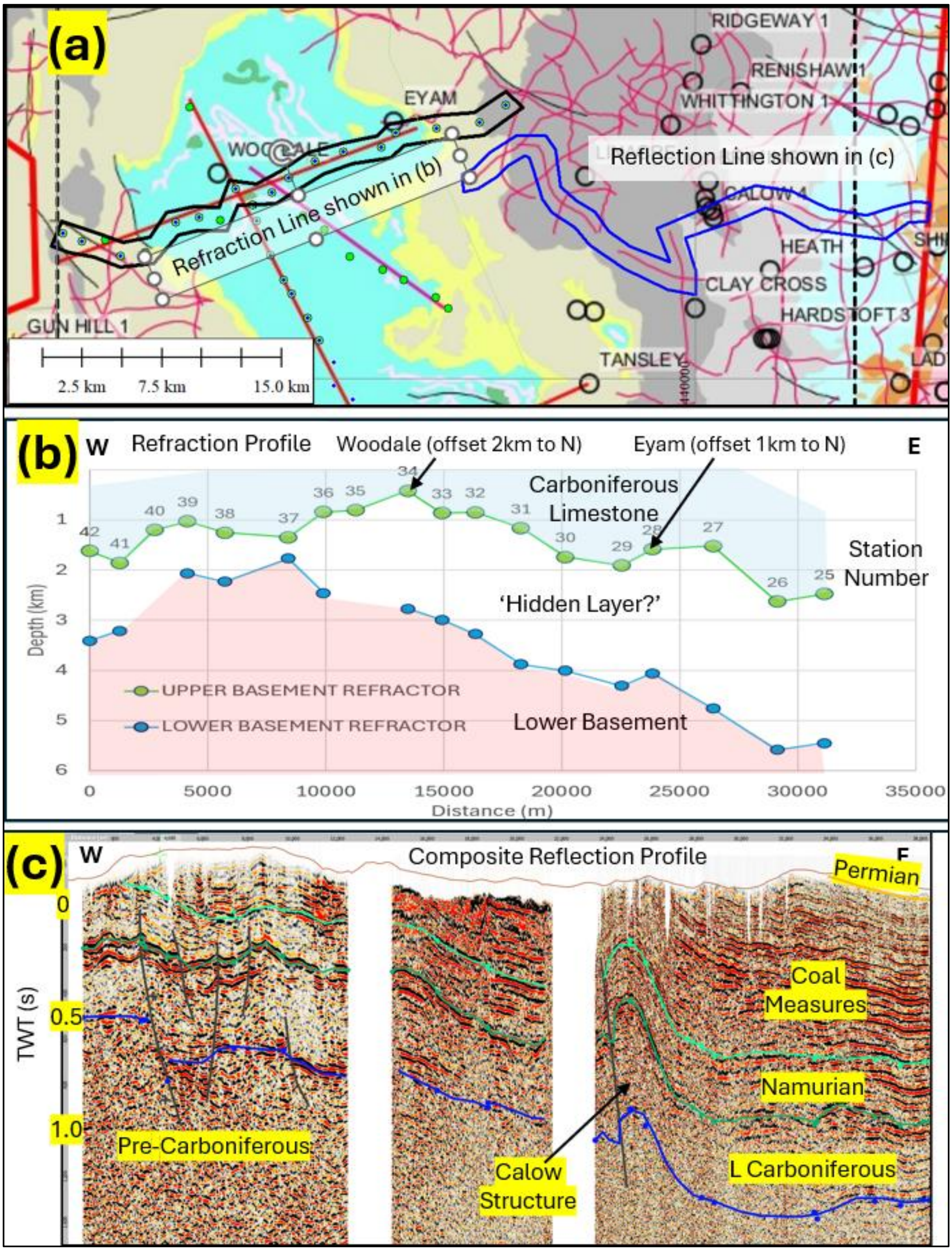

Figure 4(a) *Map showing the locations of example seismic refraction and reflection lines superimposed upon the BGS solid geology map.* ***(b)*** *Seismic refraction results redrawn from Rogers (1983) showing the Upper (green circles) and Lower (smaller blue circles) Basement Refractors with the 'Hidden Layer?' located between.* ***(c)*** *Example composite seismic reflection profile, with lines coloured orange-Base Permo-Triassic, cyan–Base Coal Measures, green-Base Namurian and blue–Base Carboniferous. The refraction and reflection seismic datasets have been merged to produce the Base Carboniferous depth structure map of Figure 7(b). Contains British Geological Survey materials © UKRI.*

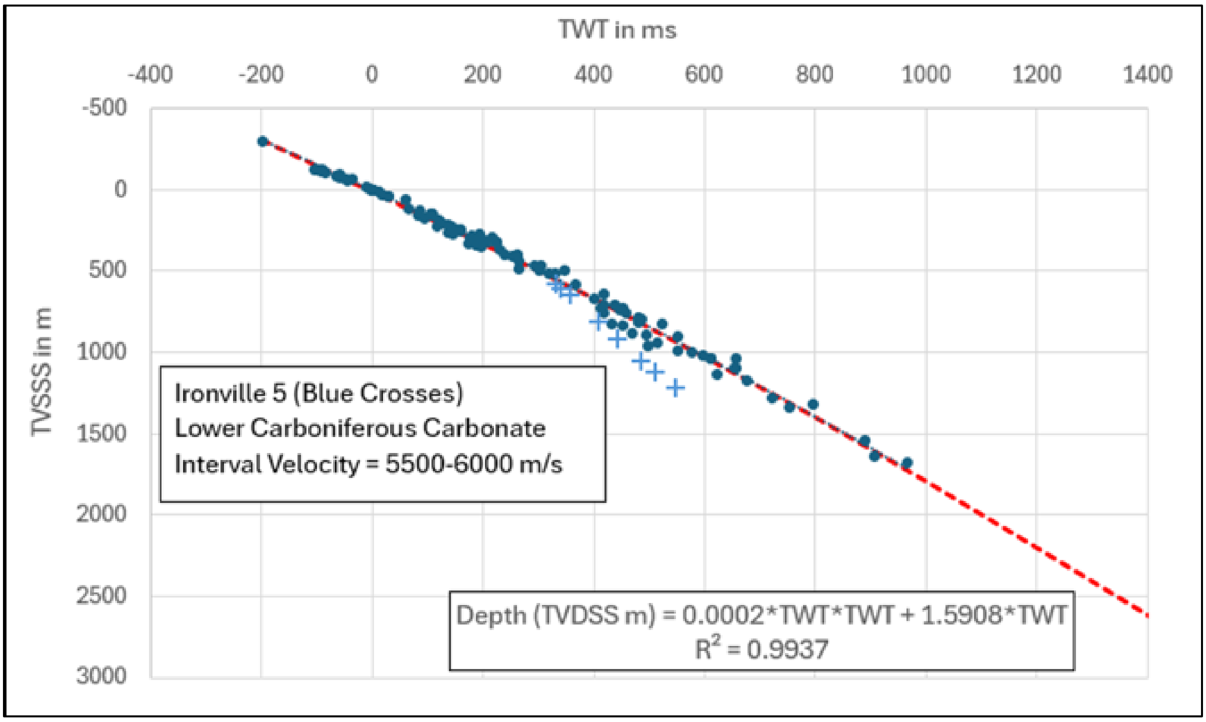

Figure 5 *Time-Depth well-tops downloaded from the UKOGL well database for various wells within the study area. The assumed function used for depth conversion to Base Permo-Triassic, Base Coal Measures and Base Namurian is shown by the red dashed line with the equation listed in the inset box. Blue crosses show time-depth points taken from the Lower Carboniferous interval penetrated in the Ironville-5 well. These illustrate a faster interval velocity for the predominantly limestone Lower Carboniferous section. Consequently, depth conversion to the Base Carboniferous has utilised the interpreted Lower Carboniferous TWT thickness, coupled with a laterally-varying Lower Carboniferous interval velocity.*

The depth structure maps produced across the area are shown in Figure 6(a) and (b) and Figure 7(a) and (b), with the Base Carboniferous map of Figure 7(b) being a combination of the results from the seismic reflection and refraction data. The four maps shown all extend over an identical area. At Base Carboniferous level (Figure 7(b)), the map shows a structural high approximately corresponding to the extent of the Derbyshire Dome and cut by two NW-SE trending faults, the Bakewell and Bonsall Faults (Smith et al.,1985). The structural high is flanked by the basinal areas of the Alport Basin (Edale Gulf) (AB(EG), Gainsborough Trough (GaT), Goyt Trough (GoT) and Widmerpool Gulf (WG). The Widmerpool Gulf is thought to have joined with the Goyt Trough by extending along the southern side of the Bonsall Fault but this area has experienced inversion (Fraser and Gawthorpe, 1990) and associated erosion (Andrews, 2013), resulting in the present-day structural high as shown on the map. The Base Namurian map (Figure 7(a)) shows Namurian section present on the flanks of the Dome with, on its eastern side, a relatively uniform easterly dip. A similar structural picture is seen on the maps of Figure 6(a) and (b), although the map of Figure 6(a) shows a thicker Permo-Triassic section to be present on the southern flank of the Dome.

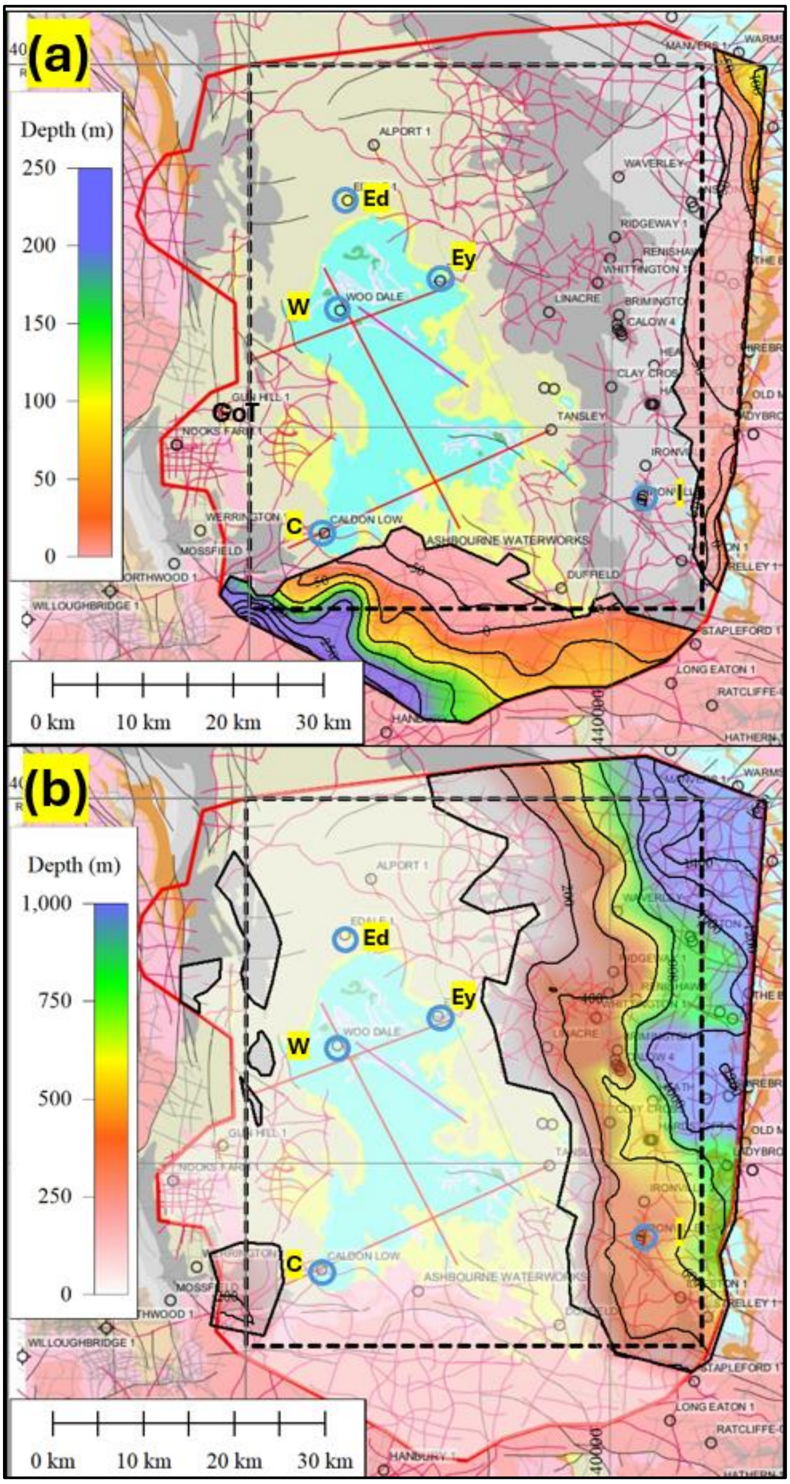

__Figure 6(a)__ Depth map to Base Permo-Triassic superimposed on BGS solid geology map. Contour interval 50m __(b)__ Depth map to Base Coal Measures. Contour interval 200m. Contains British Geological Survey materials © UKRI.

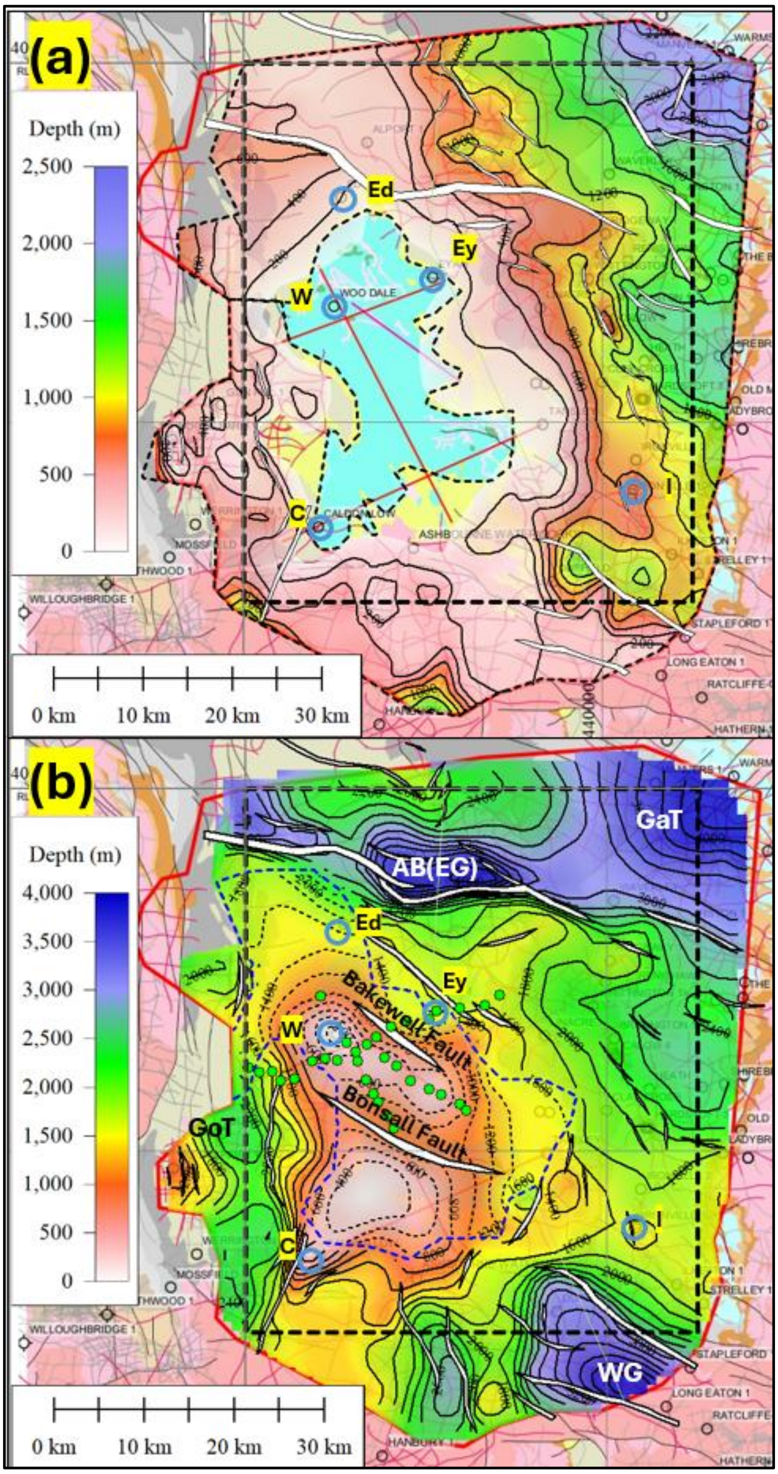

Figure 7(a) *Depth map to Base Namurian. Contour interval 200m. The black dashed line shows the area of outcropping Lower Carboniferous section.* ***(b)*** *Depth map to Base Carboniferous (slightly smoothed). Contour interval 200m. The blue dashed outline shows the main area with no seismic reflection coverage. Within this area, contours are dashed and follow the refraction survey results of Rogers (1983) with the locations of control point values shown by the green dots. Labels as Figure 3(a). Contains British Geological Survey materials © UKRI.*

Gravity Modelling

Using the depth structure maps of Figure 6(a) and (b) and Figure 7(a) and (b), a four-layer (Permo-Triassic, Coal Measures, Namurian and Lower Carboniferous) 3D gravity model was constructed using a grid interval of 1km by 1km. This model extends for 5000 sq km over the area of the black dashed rectangle of Figure 8(a). Densities for each layer were based upon values derived from well density logs (data downloaded from the UKOGL website, 2026) and were input to the gravity model using four density grid maps broadly following those of Donato et al. (2026) but with the inclusion of six additional well control points in the general area (Hanbury-1, Bramley Moor-1, Bosley-1, Heywood-1, Nooks Farm-1 and Ironville-5). Lower Carboniferous densities vary across the 3D area between 2.73 and 2.65 gm/cc, with the lower values used in the basinal areas. Namurian and Westphalian values lie between 2.40 - 2.60 gm/cc and 2.40 – 2.50 gm/cc respectively. The Permo-Triassic interval is generally thin and produces only a minor gravity contribution with density value assumed as 2.45 gm/cc. The location of the well density database is shown in Figure 3(c). Density control is good on the flanks of the Dome for the Namurian, Westphalian and Permo-Triassic sediments. Lower Carboniferous density control is less good but is considered adequate for the gravity model. The gravity field for each of the four modelled layers was calculated and the four results summed to produce the total gravity field as predicted by the four-layer model. This is shown in Figure 8(a). This predicted field was then subtracted from the observed gravity map of Figure 3(a), producing the residual map of Figure 8(b). Assuming the stripping to have been effective, the gravity effect of the Carboniferous and younger rocks will have been removed revealing the gravity effect of only the pre-Carboniferous rocks, as seen in Figure 8(b).

The most significant feature on the residual gravity map (Figure 8(b)) is the N-S and NW-SE trending gravity low of approximately -7mGal amplitude. Two possible interpretations for the residual gravity low are illustrated by the two simple 2D profiles shown in Figures 9(a) and 9(b). These profiles were constructed along the red dashed line of Figure 8(b). A constant regional field of 18mGal has been subtracted from the observed gravity profile. This value follows the regional field estimated by Donato et al. (2026). In the profiles the residual gravity curve is modelled in two ways. The first interpretation option assumes the presence of a buried granite block (Figure 9(a)), here called the Bakewell Granite. A possible outline shape for the causative low-density granitic body is shown by the green dashed line in Figure 8(b). The second interpretation option (Figure 9(b)) assumes the presence of a pre-Carboniferous low-density basin with faulted margins. These two options are discussed in detail below.

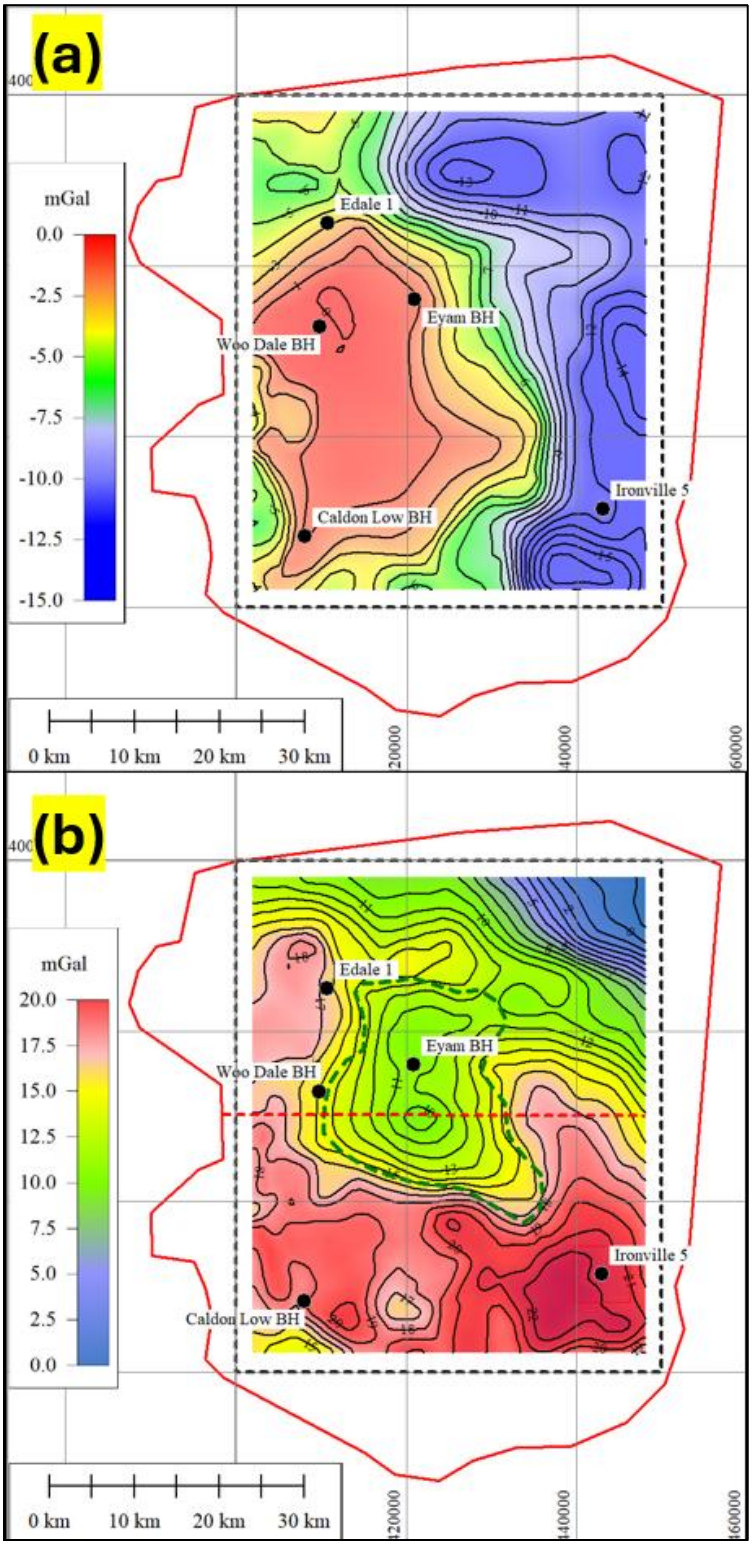

Figure 8(a) *Predicted gravity response derived from the four-layer 3D structural model. Contour interval 1mGal.* ***(b)*** *Residual Gravity map resulting from the observed gravity of Figure 3(a) minus the predicted gravity of Figure 8(a). By this gravity stripping process, Figure 8(b) shows only the gravity effect of the pre-Carboniferous rocks. The Eyam BH is located near to the centre of the residual gravity low. The red dashed line shows the location of the cross-section of Figure 9. The green dotted outline shows the approximate extent of the postulated Bakewell Granite.*

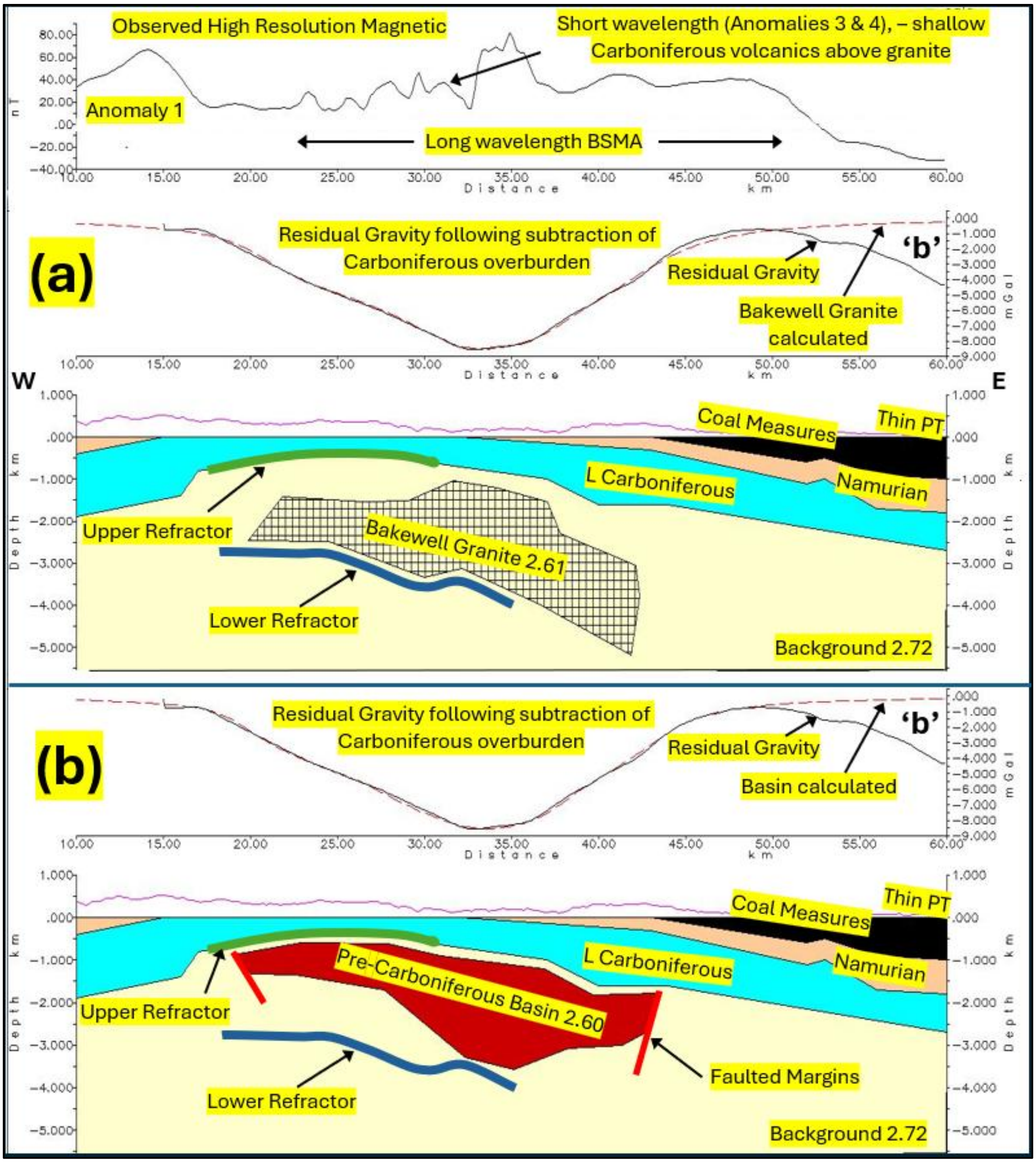

Figure 9 *Simple 2D gravity model along the profile shown in Figure 8(b). The residual gravity curve is produced following the subtraction of the modelled effect of the four-layer (Permo-Triassic, Coal Measures, Namurian and Lower Carboniferous) 3D model. Two possible options for the residual anomaly are illustrated. In (a), the residual low is explained by the presence of a granite intrusion, the Bakewell Granite. In (b), the presence of a pre-Carboniferous low-density basin with faulted margins is assumed. As discussed in the text, the granite option is preferred. The Carboniferous structure of (a) and (b) is taken from the interpretations of Figures 6 and 7. The locations of the Upper and Lower Refractors of Rogers (1983) are also shown. The proposed granite and basin have assumed densities of 2.61 and 2.60 gm/cc respectively. The deviation between the residual and calculated gravity curves marked as 'b' is due to the presence of the 'b' Residual Anomaly described in Donato et al (2026).*

Discussion

Previous Studies

There are three key PhD theses that consider the deep basement structure beneath the Derbyshire Dome (Maroof, 1973; Rogers, 1983; McDonald, 1984). In summary, their work shows that the Dome is underlain by two distinct pre-Carboniferous basement units, separated by the important NW-SE trending Bonsall Fault (Figure 7(b)).

(i) The northeastern compartment comprises basement interpreted as Ordovician volcanics and shales, consistent with borehole data from Woo Dale BH and Eyam BH. This is underlain by a lower density basement and, according to McDonald, this may include Cambrian sediments. Rogers (1983), using a merged refraction and gravity interpretation, interprets a 'hidden layer' with a thickness of 2 to 3km and a density of 2.61gm/cc located between the Upper and Lower Basement Refractors. Although Rogers did not suggest the presence of a granite, this configuration is very similar to the granite option of Figure 9(a).

(ii) Rogers and McDonald agree that the basement of the southwestern compartment differs from that to the northeast. Rogers (1983) believes it to be composed of rocks attributed to Precambrian Charnian-type, similar to those in Charnwood Forest. McDonald (1984), however, suggests relatively thin Devonian sediments, consistent with the Caldon Low BH, above possibly thick Ordovician sediments. McDonald, therefore, infers a southerly downthrow of basement across the Bonsall Fault, apparently differing from the changing throw direction observed at the surface (Aitkenhead et al., 1985).

Two Interpretation Options

The well-defined southwestern limit of the residual gravity low (Figure 8(b)) agrees well with the location and trend of the Bonsall Fault. In agreement with the earlier work summarised above, this suggests a distinct change in basement type across the Fault. The suggestion from Figure 9 is that the northeastern basement compartment may be underlain either by a tabular granitic intrusion (Option 1) or by a low-density sedimentary basin (Option 2). The Eyam BH, which drilled to Ordovician shales, is located within the centre of the residual low. Therefore, for the basin option to be possible, the sedimentary basin would have to be of Ordovician or older age, possibly the Cambrian sediments suggested by McDonald (1984).

Option 1, Sedimentary Basin

The faulted basin option suggests a density at 2.60gm/cc and thickness up to 2km (Figure 9(b)). Donato et al. (2026) have reviewed Ordovician, Cambrian and Precambrian density data, recording 93 values with a mean density of 2.72gm/cc, averaged over all three sequences. This compares with the mean density of 2.74gm/cc measured for 11 samples taken from the Ordovician sediments (Maroof, 1973) of the Eyam BH at the centre of the residual gravity low. Consequently, although not conclusive, it seems that the basin model is unlikely, as it would involve a 2km sequence with a possible combination of Ordovician, Cambrian and/or Precambrian sediments exhibiting an unrealistically low density.

Option 2, Buried Granite

The granite option model assumes a density of 2.61gm/cc and thickness up to approximately 2km. In this case, the density of 2.61gm/cc for the granitic intrusion lies within the likely range for granites (Donato et al., 2026). In addition, the Lower Basement Refractor of Rogers (1983) may be at, or closely below, the base of the granitic intrusion, similar to the refractors observed by Masson et al. (1998) beneath the buried granite near Killarney in southwest Ireland. Brooks et al. (1984) have also recorded a wide-angle reflection originating approximately from the base of the Cornubian Batholith, suggesting that some granites may form with a seismically recognisable basal interface, although in this case a thrust-related boundary is suggested. The granite model is also in general agreement with the form of the Rogers (1983) integrated gravity and refraction approach, where he suggests the presence of a thick low density 'hidden layer'. In addition, the approximately eliptical outline of the anomaly is more likely to represent the shape of a granitic intrusion rather than a faulted basin.

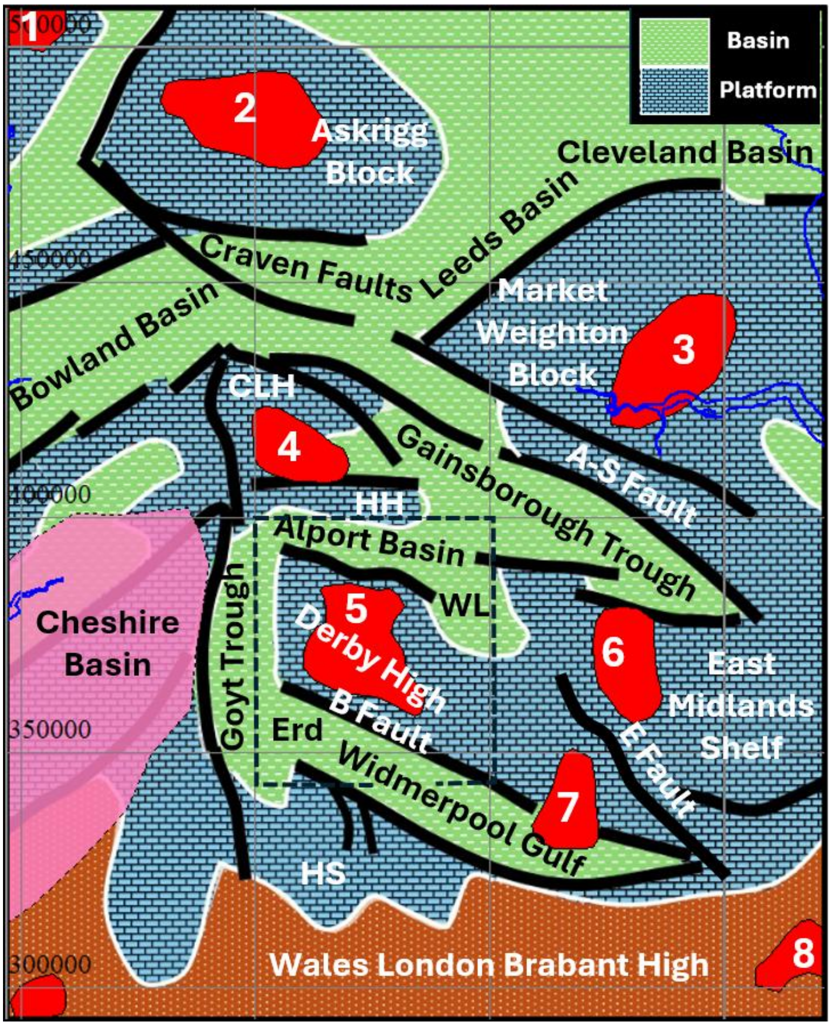

Figure 10 *Early Carboniferous paleogeography with major syn-rift faulting and postulated granite intrusions. The intrusions are shown with red shading and are numbered as follows:- 1-Lake District, 2-Wensleydale, 3-Market Weighton, 4-Holme, 5-Bakewell, 6-Newark, 7-Bingham and 8-Wash. Carboniferous paleogeography is uncertain beneath the thick Permo-Triassic sediments of Cheshire Basin, shown as pink. Abbreviated nomenclature is as follows:- CLH-Central Lancashire High, A-S Fault-Askern-Spittal Fault, HH-Holme High, WL-Welbeck Low, B Fault-Bonsall Fault, E Fault-Eakring Fault, HS-Hathern Shelf and Erd-Area of inverted and eroded Widmerpool Gulf. The early Carboniferous paleogeography is derived, with minor modification, from various sources including Fraser and Gawthorpe (1990), Corfield et al. (1996), Andrews (2013) and Fraser et al. (2024).*

Vertical Tectonic Influence

If the granite option is correct, we may expect to see the tectonic influence of the low density granitic intrusion (Bott, 1987). Figure 10 shows a summary map of Early Carboniferous paleogeography (derived from various sources including Fraser and Gawthorpe (1990), Corfield et al. (1996), Andrews (2013) and Fraser et al. (2024)) with locations of major syn-rift faulting and postulated and proven granite intrusions shown. The postulated Bakewell Granite may have influenced the position of the Derby High, including the Derbyshire Dome, with its flanking Edale, Goyt, Widmerpool and Welbeck Lower Carboniferous depocenters.

The likely magnitude of the vertical uplift provided by the granite blocks may be estimated in a semi-quantitative way,. Figure 11 compares the mass deficit for various northern England granites including those shown on the map of Figure 10. These masses have been calculated by integration of the associated gravity anomalies as modelled by Donato et al. (2026). Since it is difficult to define accurately the background gravity level, there will be some uncetainty in these values and they will probably represent underestimates. Nevertheless, there is clearly a wide variation in volumes for the granite masses, resulting in differences in their uplift potential. The Weardale, Lake District and Wensleydale Granites offer potential for high bouyancy and uplift. In contrast, the four granites located between the Gainsborough Trough and Widmerpool Gulf (i.e. the Bingham, Newark, Bakewell and Holme Granites) comprise a family of four much smaller

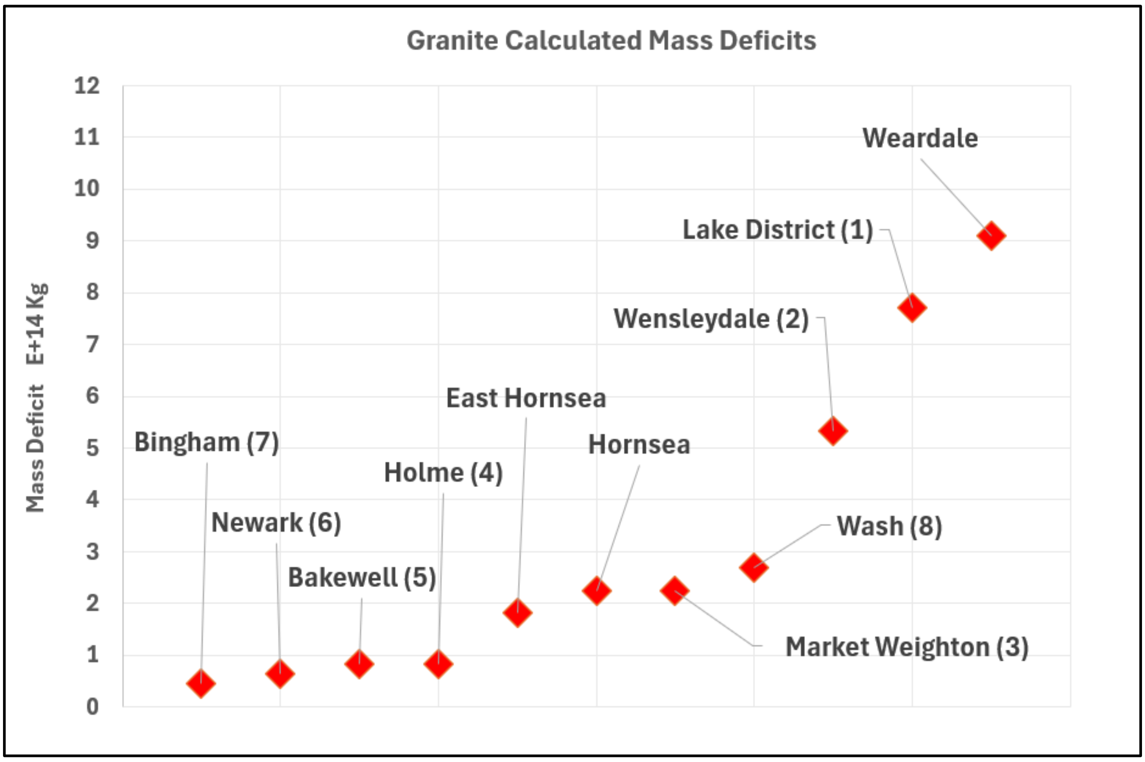

Figure 11 *Calculated mass deficits for various northern England granites including those shown in Figure 10. Granites are named with the numbers used in Figure 10. Granite masses vary by a factor of approximately 10, with the largest being the Weardale and Lake District Granites and the smallest being the Bingham, Newark, Bakewell and Holme Granites.*

granites offering more limited vertical uplift potential. The larger granites, such as Weardale, Lake District and Wensleydale, are associated with broad, tectonically-stable crustal blocks. In contrast, the smaller bodies, particularly the Holme and Bingham Granites, appear to exhibit a markedly diminished tectonic control.

Reefs and Mud Mounds

Bott (1987) suggests that the vertical buoyancy effect of buried granites may be more pronounced during phases of tectonic rifting. At these times, faulting associated with tensional forces allow the granite blocks to be uplifted in an attempt to attain isostatic equilibrium. Fraser and Gawthorpe (1990) describe a series of episodic rifting events occurring in northern England during the Lower Carboniferous. They describe the onset of rifting during Frasnian to Fammenian, with two subsequent rifting phases, the first during late Chadian to early Arundian and the second during mid-late Asbian. According to the Bott (1987) model, these pulsed rifting events may have allowed the Bakewell Granite to produce a succesion of low-relief structural highs. A granite-induced weak structural high may have formed during the mid-late Asbian rifting pulse (Sequence EC5 of Fraser and Gawthorpe (1990)). This may have contributed to the production of a shallow-water environmet allowing the deposition of Asbian-Brigantian age reefs fringing the Derbyshire Dome.

Horizontal Tectonic Influence

At the southwestern edge of the postulated Bakewell Granite, Aitkenhead et al. (1985) describe a change in structural style following the approximate line of the Bonsall Fault (Figure 12). Northeast of the fault, vertically above the area of the postulated granite, they describe an area

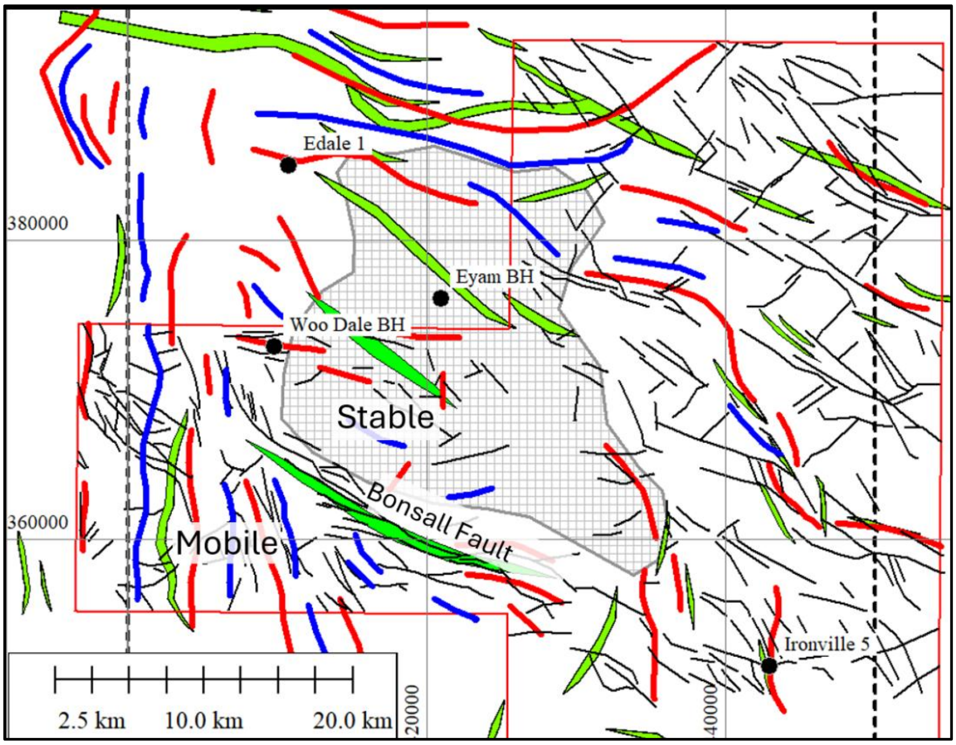

Figure 12 *Summary map showing surface and near-surface Carboniferous structures on and around the proposed Bakewell granite. The location of the postulated buried granite is shown by grey cross-hatching. The red polygon outlines BGS Carboniferous structure maps, available on 1:50k Sheets 100, 111, 112 and 125. Carboniferous anticlines and synclines (red and blue lines respectively) and faults (black lines) are taken from these BGS maps. The locations of anticlines and synclines outside of the BGS mapping area are taken from Edinburgh Oil and Gas PLC (1990) and Rogers (1983). The Lower Carboniferous faults, as interpreted in this study, are shown in green.*

of tectonic stability with wide and gentle synclines and anticlines. Southwest of the fault, beyond the edge of the proposed granite, they define the area as a mobile zone comprising a series of higher-amplitude and more steeply-dipping and faulted synclines and anticlines with N-S and NNW-SSE trends. Following Aitkenhead et al. (1985), these two areas are marked as 'Stable' and 'Mobile' in Figure 12. A similar change in structural style, from stable to more mobile tectonics, has been observed over the flanks of the Holme Granite pluton block (Donato et al., 2025). Granites may have acted as buttresses to the horizontal NW-SE Variscan compression (Corfield et al., 1996) by limiting tectonic activity above the granite-cored stable block and confining the more active tectonic zones to the granite flanks. In similar ways, Critchley (1984) suggests that the Weardale Granite provided a rigid resistance to Variscan compressional movements and Masson et al. (1998) suggests the buried granite near Killarney acted as a baffle to northward-directed Variscan thrusting.

Lake District and Wensleydale Analogy

Many of the granites shown within Figure 10 are modelled as thick homogenous plutons. Such an example is the Devonian Weardale Granite (c. 400 Ma (Woodcock et al., 2019)), modelled by Kimbell et al. (2010) and Lee (1990) as a pluton of 9km to 11km thickness. This granite is imaged on reflection seismic data as a massive and relatively unreflective body underlain by a series of strong reflections (Chadwick and Evans, 2005). By contrast, the western Lake District batholiths of late Ordovician age (c. 450 Ma (Stone et al., 2010)) appear on reflection seismic data as a series of stacked, tabular or lenticular unreflective granitic layers of approximately 1km thickness, interleaved between bands of country rock (Evans et al., 1993). Kimbell et al. (2010) suggest that the Devonian granites of northern England are generally more massive, homogenous and deep seated, rather than tabular in nature as for the Ordovician granites including Wensleydale (Kimbell et al., 2006). Kimbell et al. (2010) also note differences in trend, possibly inherited from earlier basement fabrics, with the Early Devonian granites exhibiting an ENE trend while the Ordovician granites appear with a more WNW orientation. The gravity model for the postulated Bakewell Granite shows a tabular form of thickness 1-2km and the shape of the residual anomaly includes components with a WNW trend. It may be, therefore, that the Bakewell Granite shares a similar form to the western Lake District and Wensleydale Granites and consequently may be of a similar Late Ordovician age.

Interpretation Preference Summary

Following a seismic interpretation of the Derbyshire Dome area, a four-layer 3D gravity model has been created. This model has been used to strip away the gravity effect of the Carboniferous and younger sequences revealing a residual gravity low extending over almost 500 sq km with an amplitude of -7mGal. The residual low originates from the pre-Carboniferous section, and two options have been considered for its origin, a sedimentary basin and a buried granitic block. The granite option is preferred for the following reasons:-

(1) the residual anomaly outline is smoothly elliptical, characteristic of a pluton or tabular intrusion rather than a fault-bounded basin,

(2) the inferred 1–2 km-thick tabular granitic geometry matches regional analogues such as the western Lake District granites with their stacked tabular geometry as revealed on reflection seismic data and described by Evans et al. (1993),

(3) earlier work by Rogers (1983) identifies a thick low-velocity, low-density 'hidden layer' whose geometry and density approximately match the proposed tabular granite intrusion,

(4) the Lower Basement Refractor of Rogers (1983) lies at or just below the proposed granite base, consistent with granites elsewhere that demonstrate a basal granite interface,

(5) the basin option requires an unrealistically low density for Ordovician/Cambrian sediments,

(6) the gravity anomaly overlies the Burnley–Stamford Magnetic Anomaly (BSMA), a deep structural ridge that is a plausible location for granite emplacement but an unlikely site for a 2km-thick low-density sedimentary basin,

(7) the granite block exerts both a horizontal buttress effect along its flanks and a vertical stabilising or uplifting influence, behaviour far more consistent with a rigid intrusive low-density granitic body rather than with a sedimentary basin.

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