OR/15/026 Concealed geology

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Gunn, A G, Mendum, J R and Thomas, C W. 2015. Geology of the Huntly and Turriff Districts. Sheet description for the 1:50 000 geological sheets 86W (Huntly) and 86E (Turriff) (Scotland). *British Geological Survey Internal Report*, OR/15/026.

Regional gravity and aeromagnetic data can provide both qualitative and quantitative information on the physical nature of subsurface geology. These potential fields integrate the effects of density and magnetisation structure throughout the upper crust and so contain a variety of frequencies that effectively represents the geological structure at various depths. Commonly, observed gravity and magnetic anomalies can be related directly to the surface expression of geological formations or structures and the data can be used to model the extension of these features at depth; models based on anomalies unrelated to the exposed geology are more speculative.

Gravity data

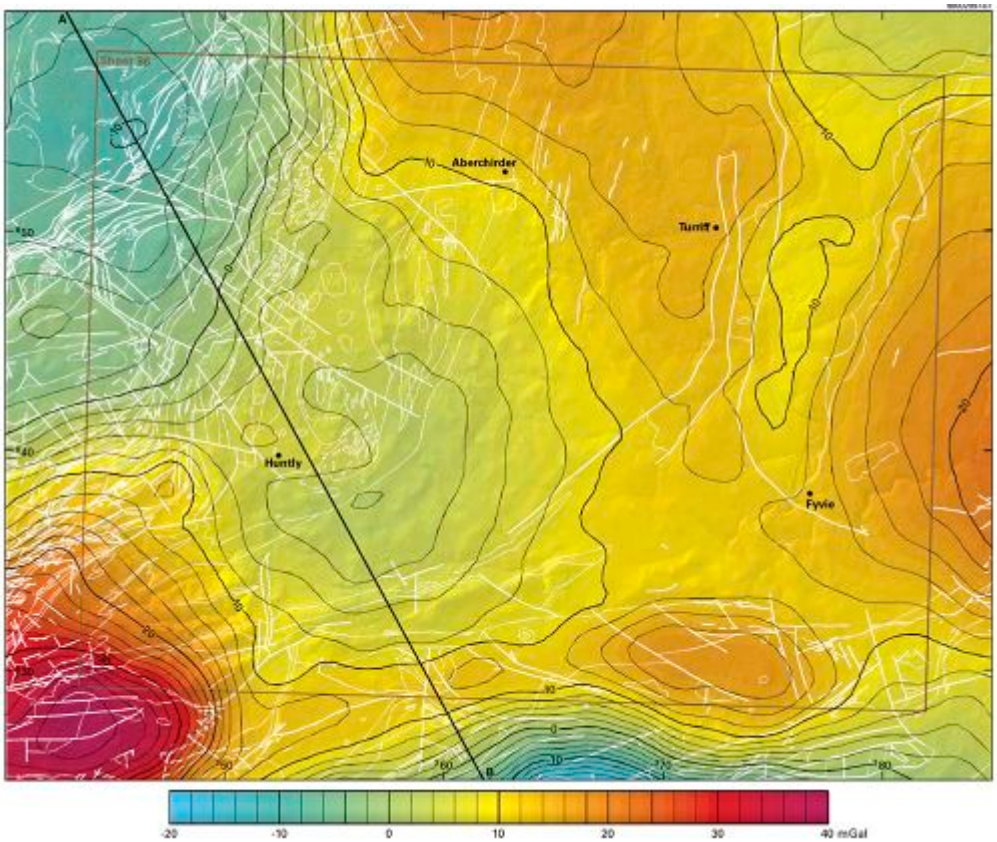

Figure 7 Bouguer gravity anomalies in the Huntly and Turriff districts. Values based on a reduction density of 2.75 Mgm^{-3}. The underlying white lines relate to the generalised bedrock geology, based on the 1:250 000 geological map.

Bouguer gravity anomalies are derived from point observations of gravity, corrected for latitude, elevation and local terrain effects. In the Huntly–Turriff district, Bouguer gravity anomalies range from about -10 mGal in the north-west of the region over Argyll Group metasedimentary rocks west of the Portsoy Shear Zone (PSZ) to over 40 mGal in the south-west over the dense, iron-rich gabbros of the Upper Zone of the Bogancloch sector of the Insch intrusion (Figure 7). The positive anomaly

associated with the Bogancloch sector extends north-west at least as far as the PSZ and appears to include the Succoth–Brown Hill mass to the north. Gunn et al. (1996)[1] presented supplementary gravity data (14 new ground stations) from the Succoth–Brown Hill Intrusion that showed a closed positive 20 mGal Bouguer gravity anomaly over the body. When the regional field is subtracted a residual positive anomaly of 7 mGal remains, situated over Brown Hill and Evron Hill. The main part of the Insch intrusion is also associated with an elongate gravity maximum, which is displaced to the northern side of the mass by the effects of the adjacent low-density Bennachie Granite to the south.

There is a broad regional gravity high over the Dalradian strata of the Southern Highland Group of the Buchan region east of the PSZ but the Huntly intrusion itself is not directly associated with a significant gravity maximum. Given the relatively high density of exposed rocks in the Huntly intrusion, the lack of a significant anomaly suggests that the rocks of the Huntly intrusion do not extend to significant depths and the current exposed level may be close to the base of the intrusion.

Devonian strata in the Turriff basin are associated with a recognisable trough in the Bouguer gravity anomaly values, but at the eastern margin of the region, gravity values rise again towards a local maximum over the Maud intrusion of the North-east Grampian Basic Suite.

Magnetic data

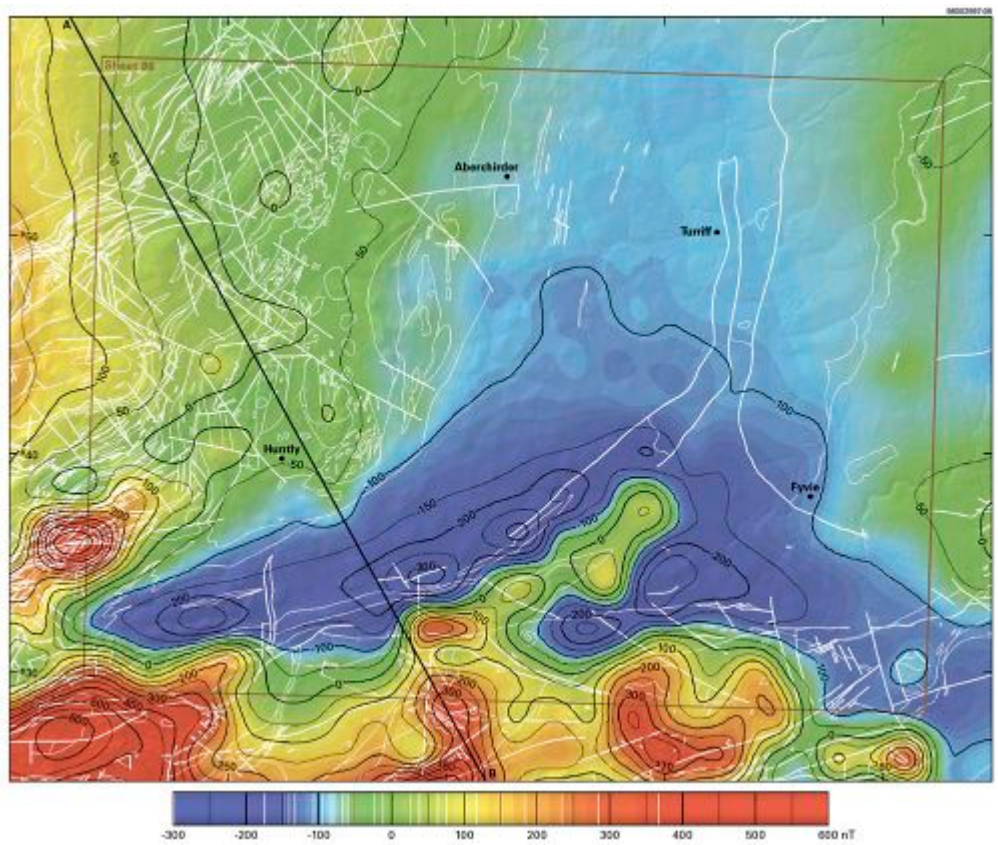

Figure 8 Total field magnetic anomaly in the Huntly and Turriff districts. Contours based on data collected at 305 m above ground level on east–west flight lines 2 km apart. The underlying white lines relate to the generalised bedrock geology, based on the 1:250 000 geological map.

Total field magnetic data (Figure 8) collected at 305 m above terrain along east–west flight lines approximately 2 km apart have also identified significant anomalies associated with the eastern and western (Bogancloch) parts of the Insch Pluton. Less prominent anomalies occur over some of the serpentinite masses along the PSZ. Magnetic data from a low-level helicopter magnetic survey carried out for mineral exploration by Exploration Ventures Limited (EVL) provides better resolution

of some features. These data identify an east-north-east-trending feature north of the Insch Pluton associated in part with the Hill of Foundland Pelite Member, which is locally rich in andalusite and magnetite. Detailed ground magnetic data collected in the Huntly district as part of the mapping and mineral reconnaissance programmes have been used to constrain geological boundaries in some areas. The olivine-bearing cumulate lithologies do show greater susceptibilities and can be delineated from the granular gabbros and the contaminated and xenolithic mafic igneous rocks.

Gravity and magnetic models

2D models

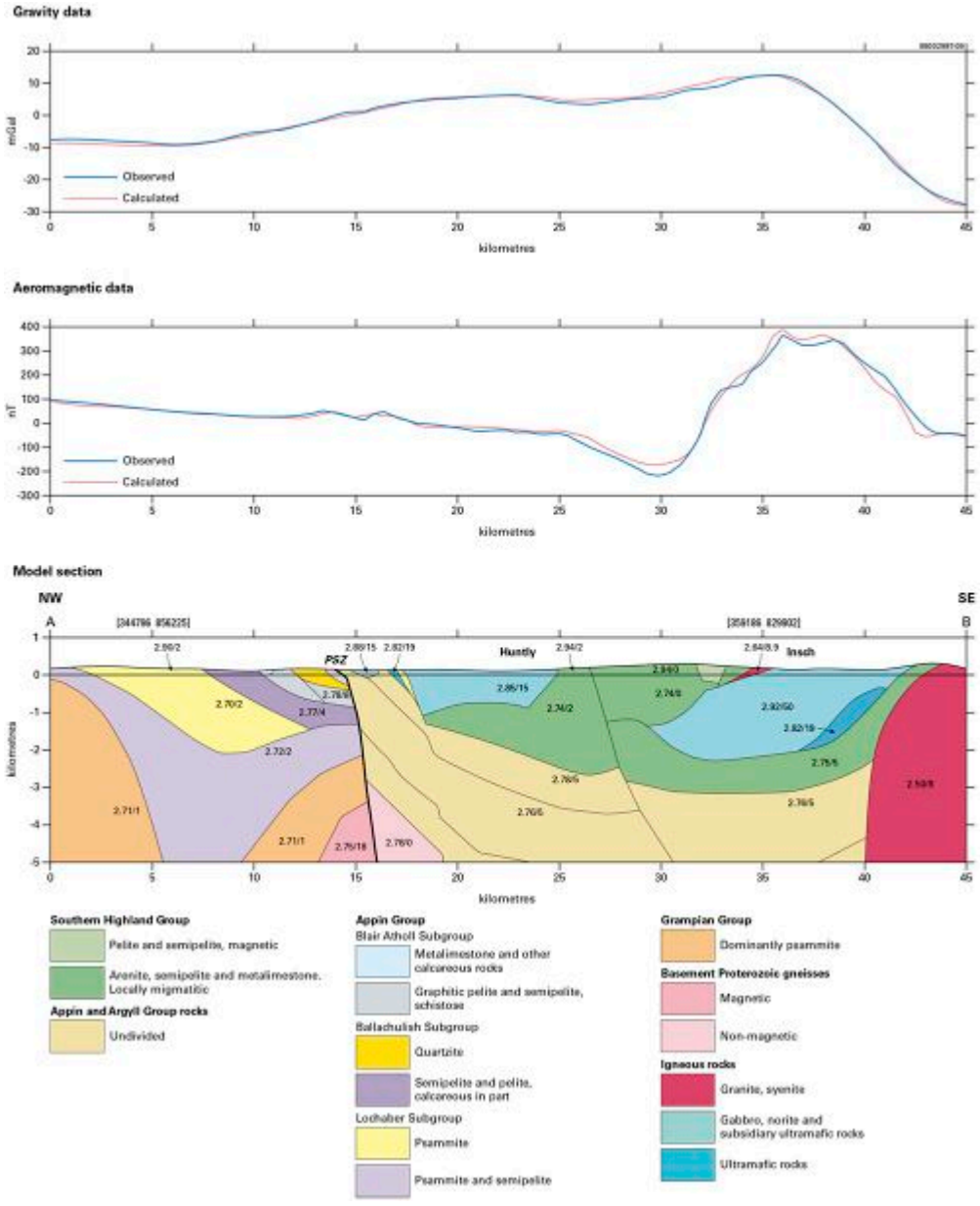

Figure 9 Part of a full-crust modelled section across the Huntly and Insch plutons. Location shown in Figure 7. The numbers cited inside the polygons indicate the bedrock density and magnetic susceptibility values used in the model.

A model geological section has been generated from the regional geophysical data along the line of section A–B shown in Figures 7 and 8. Part of the model section shows the Huntly Pluton to be less than a kilometre thick whereas the Insch Pluton may extend to a depth of about 2.5 km (Figure 9).

The Insch body is modelled with a density of 2.92 Mgm^{-3}, a bulk magnetic susceptibility of about 50.10^{-3} SI, and a small component (0.2 A/m) of natural remanent magnetisation (NRM) with an inclination of -26° and a declination of 149°. The thickness of the Huntly Pluton could be significantly increased if the bulk density of the mass was similar to the host strata. However, the gravity data suggest that the high density mafic and ultramafic rocks such as the West Huntly Cumulate body exposed on the Bin Hill cannot extend to great depth or certainly do not form a significant part of the intrusion at depth.

The main regional feature of the model is the nature of the crust beneath Southern Highland Group rocks east of the PSZ. At depths of about 8 km beneath the Buchan region, east of the Portsoy Shear Zone, Appin and Argyll Group strata are modelled on top of a high-density basement (2.78 $mMgm^{-3}$). Grampian Group strata are not modelled east of the PSZ. In contrast, the high density and high magnetisation basement, manifest as the regional magnetic anomalies near Lossiemouth and in the Inner Moray Firth, is confined to west of the PSZ.

2.5–3D models

The 2.5–3D models of the apparent density and magnetisation indicate that observed geophysical anomalies can be explained by reasonable values of density and susceptibility within the upper 4 km of the crust. In these models maximum apparent density contrasts over the Bogancloch sector of the Insch Pluton were close to 0.35 Mgm^{-3}, producing an implied density of 3 x 10 Mgm^{-3}. This is very similar to measured values for the iron-rich gabbros and quartz-norites. Maximum apparent susceptibilities for the magnetisation model were close to 100 $x10^{-3}$ SI in parts of the Maud mass. In the Bogancloch sector of the Insch Pluton apparent susceptibilities up to about 60 $x10^{-3}$ SI through 4 km would be sufficient to explain the observed magnetic anomalies over the main mafic rocks. In the case of the Huntly Pluton, the lack of significant magnetic anomalies suggests that the mafic-ultramafic rocks might be no thicker than 1 km. In contrast, Gunn et al. (1996)[1] constructed a 2.5D model for the Succoth–Brown Hill Intrusion constrained by the detailed magnetic and gravity data, borehole intersections and surface geology. If we model the intrusion as a series of steeply south-east dipping prisms and use an average density contrast of 0.175 Mgm^{-3}, the predicted maximum depth from surface of this ultramafic body is 2.5 km.

Turriff Basin

The Devonian Turriff Basin, with its fill of conglomerates and sandstone and faulted western boundaries, is reflected in the Bouguer gravity field as a trough with an amplitude of about 3 to 4 mGal. Ashcroft and Wilson (1976)[2] interpreted a residual gravity anomaly of about 4 mmGal over the basin in terms of a faulted wedge of Crovie Sandstone Group sandstone and shale overlain by coarse conglomeratic sedimentary rocks of the Gardenstown Conglomerate Formation, using a mean saturated density of 2.47 Mgm^{-3} based on measurements at 11 sites. They considered that this density value was affected by weathering. An observed increase in seismic velocity at the base of the weathered layer together with an estimate of density made from a gravity traverse suggested a mean density value closer to 2.60 Mgm^{-3}. Basin depths, modelled using a density contrast of 0.09 to 0.12 Mgm^{-3} were estimated at about 1 km in the northern part of the basin and about 1500 m in the southern part.

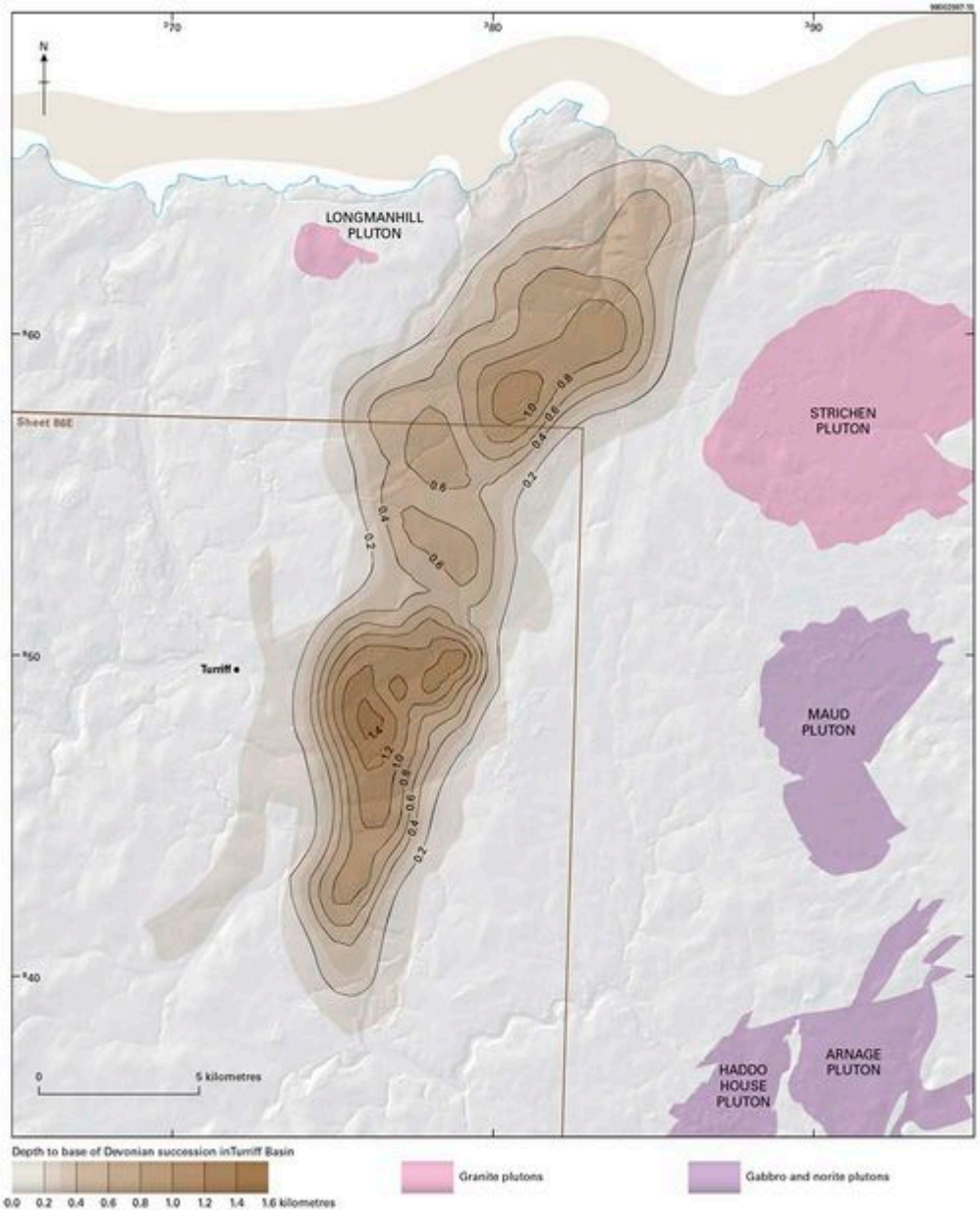

Figure 10 A geophysical model showing the depths to the base of the Devonian succession in the Turriff Basin.

A revised residual field has been defined using a minimum curvature gridding algorithm and a subset of the observed gravity data from a grid of mesh size 2 km. All data on or immediately adjacent to the Devonian strata were removed so that the regional field was designed to exclude the effects of these strata. The resultant residual field has been modelled as a series of vertical contiguous prisms of mesh size 1 km and a density contrast of 0.15 Mgm^{-3}. After eight iterations the root mean square residual anomaly was less than 0.3 mGal. The estimated thicknesses of the Devonian succession are thus around 800 m in the north, but reach around 1400 m in the southern part of the Turriff Outlier (Figure 10). Both models are equally dependent on the magnitude of the density contrasts used and the magnitude of the residual field modelled. They both imply that the central parts of the basin are thicker, supporting Read's suggestion (1923) that there may be concealed faulting with the Dalradian–Old Red Sandstone interface stepped at depth.

References

1. ↑ [1.0] [1.1] GUNN, A G, STYLES, M T, ROLLIN, K E, and STEPHENSON, D. 1996. The geology of the Succoth–Brown Hill mafic-ultramafic intrusive complex, near Huntly, Aberdeenshire.

Scottish Journal of Geology, Vol. 32, 33–49.
2. ↑ ASHCROFT, W A, and WILSON, C D V. 1976. A geophysical survey of the Turriff basin of Old Red Sandstone, Aberdeenshire. *Journal of the Geological Society of London*, Vol. 132, 27–43.

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