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# A Geophysical Ramble across Southern Shropshire - Speculations based upon an East-West Cross-Section

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DONATO, J. (2007). A Geophysical Ramble across Southern Shropshire - Speculations based upon an East-West Cross-Section. *Proceedings of the Shropshire Geological Society*, **12**, 1-4. Using data based largely on published papers and BGS mapping in the public domain, a 100 km long East-West section through Church Stretton and Bridgnorth has been constructed. By developing gravity and magnetic models, it has been possible to postulate feasible crustal configurations for the deep geology.

Implications for deep crustal studies in the region are discussed in the context of questions raised by members following the presentation of this thesis as a lecture to the Society on 11$^{th}$ October 2006.

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## 1. INTRODUCTION

The geophysical interpretation of the deep geology of South Shropshire which follows has been based on examination of the geophysics “unconstrained” by detailed knowledge of the local geology. Readers can refer to Peter Toghill’s *Geology of Shropshire* (2006) for details of the latter.

The geophysical data that has been employed has been largely based on BGS mapping in the public domain. Using this, a 100 km long East-West section has been constructed through Church Stretton and Bridgnorth stretching right across the County along Northing $^{2}95^{000}$ and into the areas to either side (Figure 1). By developing gravity and magnetic models, it has been possible to postulate feasible crustal configurations for the deep geology. This provides a basis for further consideration and refinement of the approach which has been suggested.

## 2. INTERPRETATION

The first interesting feature noted is the lineation trending E-W for several tens of kilometres just south of Titterstone Clee, marked by the two question marks on Figure 1. Nothing is shown on the published geological mapping, but could this be a weakness in the crust at some depth? *[In discussion, Michael Rosenbaum noted that significant disturbance in the strata had been encountered during driving of the Studley Tunnel, part of the Elan Valley aqueduct for Birmingham, just to the SW of Clee Hill; an E-W fault was encountered by the Shrewsbury & Hereford Railway when Ludlow Tunnel was driven, and this same fault forms the abrupt northern cliff beneath Ludlow Castle and the steep northern limb of the Ludlow anticline that extends beneath Mortimer Forest.]*.

The basic approach has been to utilise GIS to overlay the geophysical data sets onto the topography. For the latter, use has been made of the public domain satellite-derived DEM made available by NASA. The geology was deduced from the BGS mapping of the Bedrock displayed on their web site at 1:625,000 scale, combined with their geophysical data sets for gravity (as Bouguer anomalies) and magnetics (airborne).

If the gravity is low, this may well correspond to a sedimentary basin. Such areas are present in the North, centred on $^{3}45^{000}$ $^{3}25^{000}$ (the South Cheshire Basin) and the South, centred on $^{3}85^{000}$ $^{2}65^{000}$ (the North Worcester Graben). Along the South Shropshire E-W Section, the gravity is high and thus the bedrock density is also high.

The aeromagnetic data reveals anomalies in the ground associated with the presence of magnetic minerals (e.g. magnetite) which are generally igneous in character, and usually basic or ultrabasic in composition. One such area is centred on $^{3}60^{000}$ $^{2}77^{000}$ (Titterstone Clee) and another lies along the Church Stretton Fault.

 

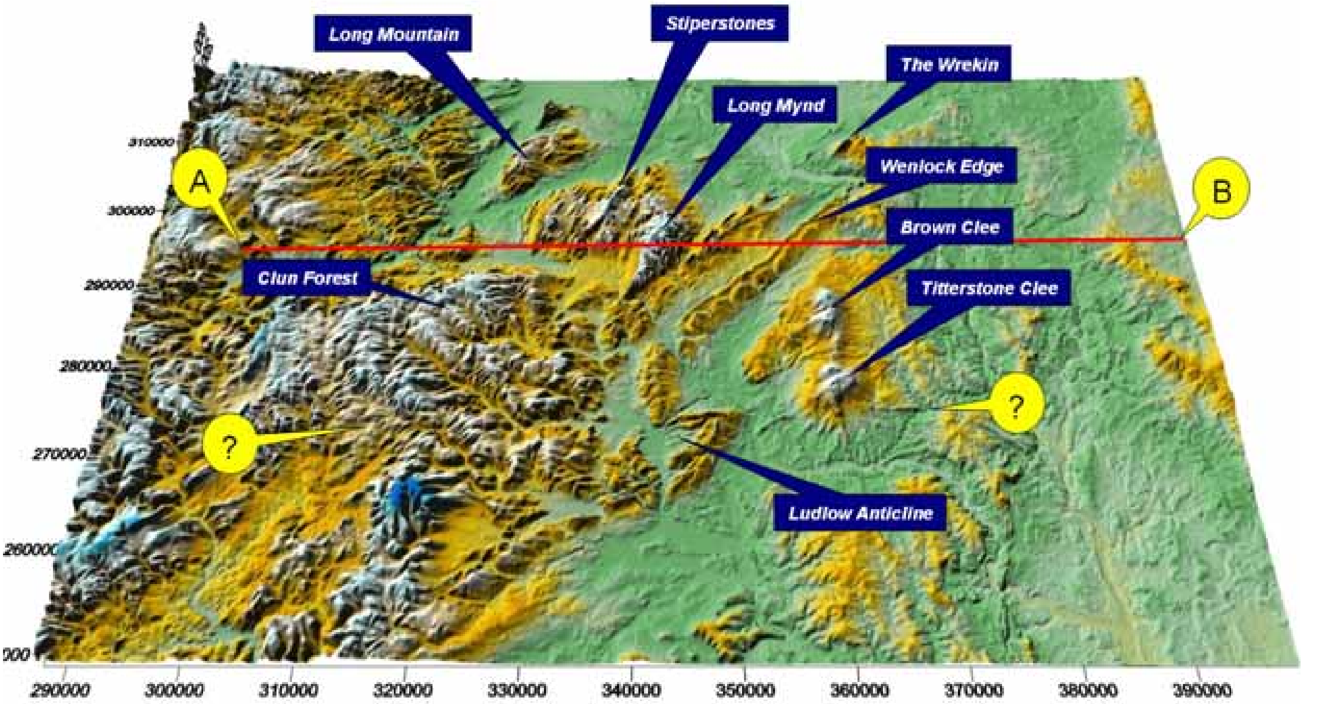


Figure 1. The location of the E-W section constructed by John Donato, based on a perspective view of the topography downloaded from NASA satellite radar imagery (the Shuttle Radar Topography Mission (SRTM)).

Before the chosen cross section could be constructed, controls needed to be identified. Published data that would be suitable, of sufficiently high quality and accuracy, included the LISP refraction seismics line (N-S), a BGS regional seismic line (NW-SE), and a magnetic and gravity profile to the E. All of these give tie points which the new model should fit. In order to illustrate the point, comparison may be drawn with the well-known Onny River section with its slightly angular unconformity between the Ordovician and Silurian by the stream, and then on the seismic section. The vertical exaggeration helps pick out these strata and the correspondence is remarkable.

With the tie points, construction of a series of models could begin. First densities and then magnetisation had to be deduced for each layer of the model. These theoretical values could then be adjusted to mimic the observed values. Alf Whitaker's atlas (1985) was used as an illustration of how such modelling could be effected, in this case identifying the depth to the Variscan Basement. The steps followed are:

1. Establish the topography
2. Colour code the surface to reflect the known geology
3. Add the tie points to the section (e.g. the base of the Silurian, Ordovician, Cambrian), to a depth of 7500 m
4. Be guided by the BGS cross section
5. Iterate a gravity model (using assumed densities derived from LISP and the BGS study)
6. Refine with the magnetics.

Deviations between observation and deduction could be reduced by adding, for example, the Church Stretton Fault, and, most interestingly, a granite pluton beneath Church Stretton. This pluton would need to have a density of 2.63, be about 6 km across and its top would lie about 1 km beneath the ground surface (Figure 2).

Considering the magnetics next, if a basic volcanic layer was added (e.g. near the top of the Uriconian) then the magnetic model approximates the observations very well, provided the volcanics are not present immediately above the granite pluton. Further improvement is gained by adding a small granite at 3 km depth a little to the West, at around $^{2}25^{000}$.

 

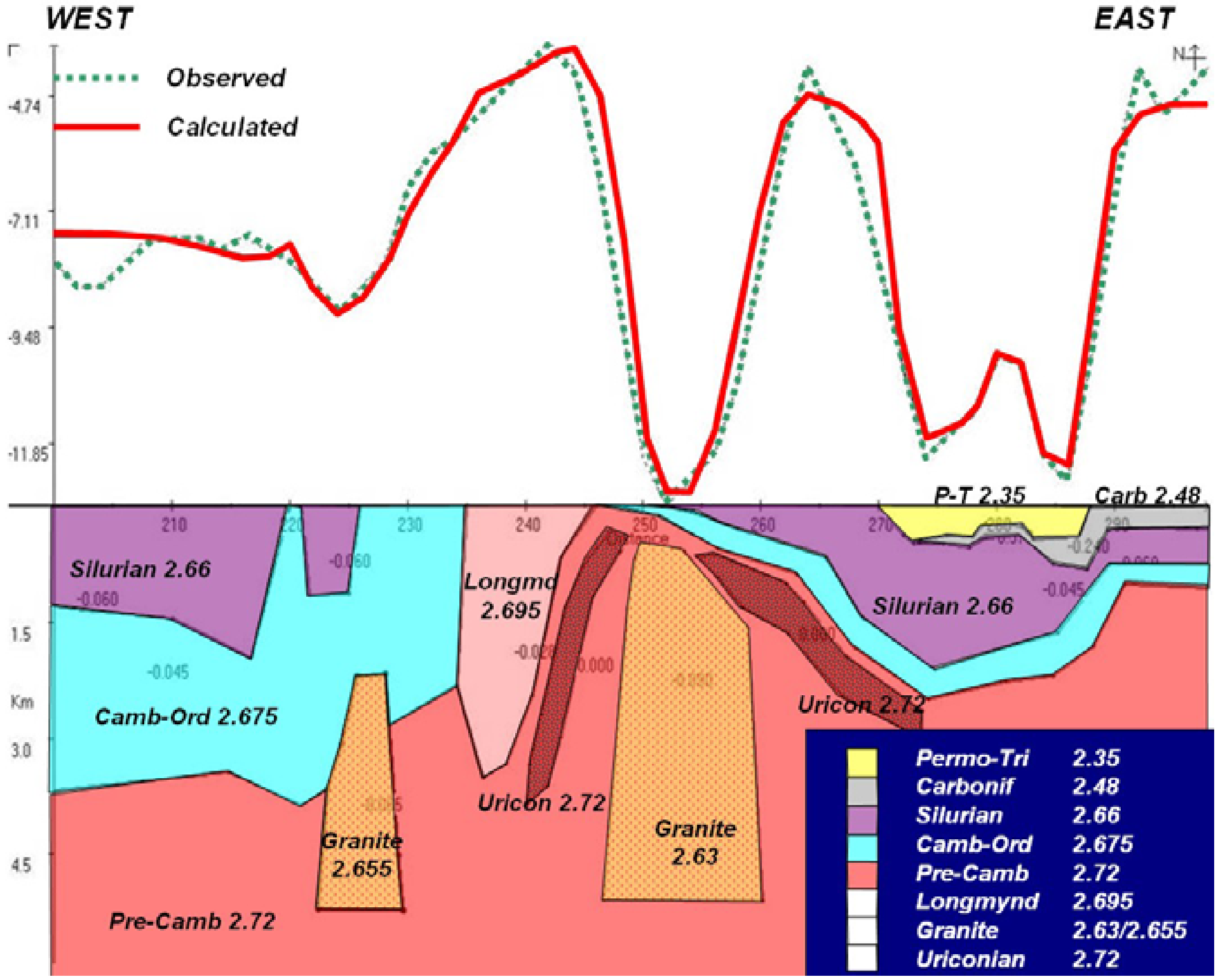


Figure 2. Model of the crust to a depth of 7 km based on gravity data supplemented by magnetics, showing a large hypothetical granite below Church Stretton and a smaller granite to the west of Corndon Hill (where a dolerite laccolith can be observed at ground level, visited by the Society on 7th June 2006). The correspondence between the model (using the values in the table) and the observed gravity measurements is close, as shown by the graph. Note the hypothetical Uriconian basic volcanics "draping" the main granite, which would account for the magnetic data.

Looking at the modelled section, it would appear that the granite pluton has exerted a tectonic control, acting as a buoyant feature maintaining a tectonic high and causing thinning of the sedimentary beds towards the pluton, thickening away on the flanks. Such behaviour is characteristic of extensional tectonic environments.

It can be speculated that the granite beneath Church Stretton could be late Precambrian. If so, could it perhaps be similar to the Ercall Granophyre (560 Ma), which itself may be just a small offshoot of the Church Stretton intrusion?

During the Ludlovian (418 Ma), the Church Stretton granite could have maintained a tectonic high leading to thinning of the Silurian strata. Holland & Lawson's 1963 paper contains a section across the whole of the Marches which shows a thin sequence of Silurian sitting on just about the right spot for the granite, centred on Gretton and would have the top of the granite about 500 m below ground level.

## 3. DISCUSSION

The lecture having finished, a number of questions were raised by the audience.

David C Smith noted the NW-SE lineament across the map, cutting across the Longmynd, along which gold has been found, and occurrences of tufa and dykes East of Tenbury. Perhaps there is a link to the deep structure implied by the geophysics.

David C Smith went on to speculate on other lithologies that might emulate the hypothetical granite, including (a) Shineton Shales, (b)

 

Stiperstones Quartzite (which may be slumped, thus deep water, as opposed to thin bedded and shallow), helped by Uriconian faults to create steeply dipping slivers on the geophysical sections. However, it is difficult to retain a low density at depths in excess of 5 km.

David Henthorne remarked on the SSDC radon survey, which revealed high radon counts which were not obviously linked to the surface geology. The deep granite offers a suitable host for zircon, which often contains uranium that decays to radon.

Peter Toghill then asked what the future of this approach was. For instance, it may be profitable to look more closely at the Pontesford Linley Fault, and 10 km North of the initial cross section.

#### ACKNOWLEDGEMENTS

This paper has been compiled by Michael Rosenbaum from the lecture to the Shropshire Geological Society presented by fellow member John Donato, 11th October 2006. The evening ended with a vote of thanks led by David Henthorne and a well deserved round of applause.

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