Magnetic mentor

David Pratt
Tensor Research
E david.pratt@tensor-research.com.au

Monochrome imaging

The first *Magnetic Mentor* column focussed on "Colour in magnetic imaging" and I want to extend the discussion in this second column to the role of unshaded monochrome images and their usefulness for the perception of depth changes and magnetic remanence detection. In both cases, the magnetic field attributes that you want to highlight have a relatively low dynamic range compared with the magnetic field.

Make sure you read the latest book from CSIRO written by Schmidt P, Austin J, Clark D, Leslie K, Lackie M, Foss C (Eds) (2025) and titled ***Exploration Magnetics: Theory and Practice***. This is a collector's item that you can purchase as a book or **download the free digital version**. In the Magnetic Mentor series, I will reference and link individual chapters for further reading.

Depth perception

Relative basement depth changes can be inferred in magnetic images by changes in smoothness of edges caused by geological boundaries or narrow linear formations. It is analogous to a cloudy pond covering rocks where the deeper rocks look less distinct than those near the surface. Monochrome images enhance your perception of depth by using a clipped linear stretch. The limited dynamic range of monochrome lookup tables (LUT) is well suited to enhancing depth perception, because depth variation typically has a limited dynamic range. The model generated image in **Figure 1(a)** was produced from steeply dipping magnetic formations truncated against a basement unconformity surface that is overlain by a half-graben. This model was chosen to help you understand the depth related changes that you can see in the **Figure 2** images from the Cloncurry district in north-west Queensland. Here, the Cambrian age half-graben is inferred by the depth changes, rather than direct detection. The change in smoothness is clearer for the first vertical derivative trace (**Fig. 1b**) but also evident in the anomalous magnetic field. In **Figure 2(d)**, the second vertical derivative produces a smooth dark grey region that closely maps the limits of the Cambrian basin.

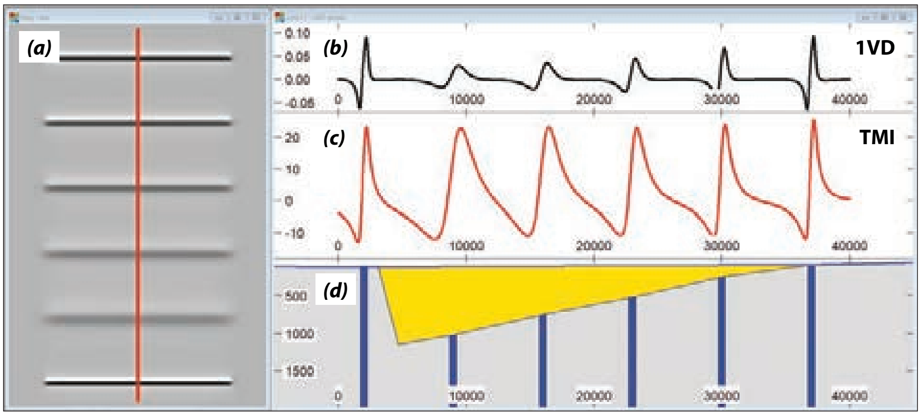

Figure 1. *A model example of a half-graben, truncating vertical magnetic formations at a range of depths from outcrop to ~1100 m. The theoretical grid of the model is shown as a monochrome image (a) and a cross-section view with the first vertical derivative (b), anomalous magnetic field intensity (c) and model section (d).*

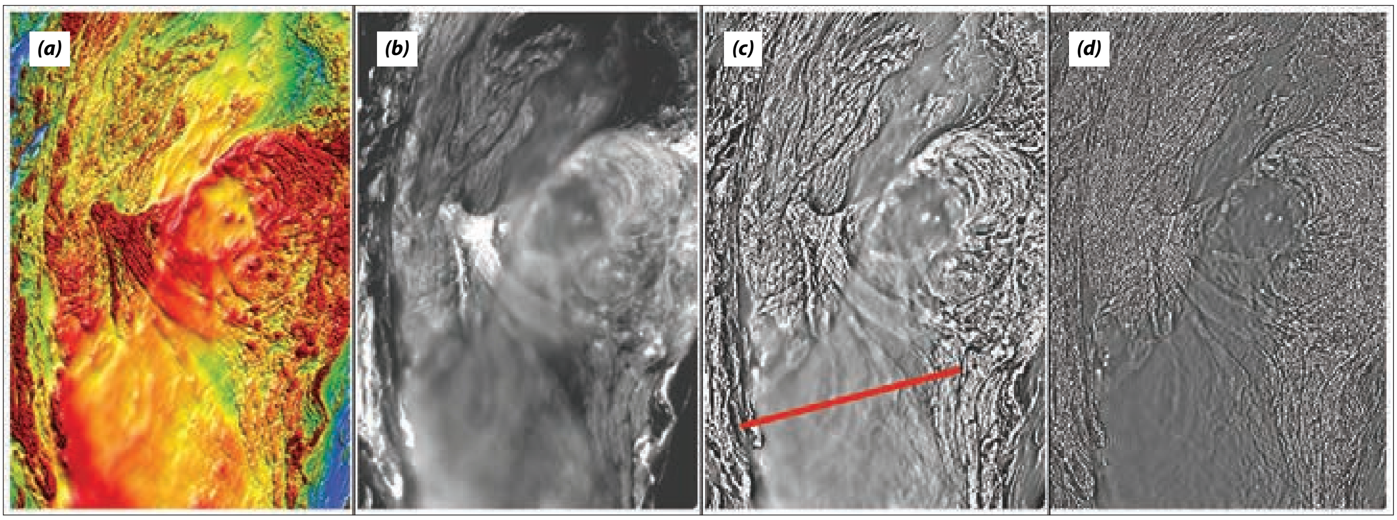

Figure 2. *Monochrome image enhancement example of a Cambrian half-graben that overlies Proterozoic basement rocks within the Mt Isa Inlier. The four images include a linear colour stretch (CET-R4TR) (a), reduction to the pole (RTP) (b), first vertical derivative (RTP) (c) and second vertical derivative (RTP) (d). The red line in (c) highlights a section of the half-graben that is equivalent to the model in Figure 1.*

Remanence perception

You can easily detect large remanently magnetised intrusions in colour images, but monochrome images are very helpful in complex geological zones with overlapping anomalies. I attribute this benefit to the ease of recognising the local regional background context. An example from the dramatic escarpment region of Arnhem Land in the Northern Territory has been selected to illustrate complex magnetic reversals as well as depth variations.

The colour image (**Figure 3a**) is included to illustrate perception differences between monochrome and colour. **Figure 3(b)** uses the CET-L1 mono lookup table and **Figure 3(c)** reverses the LUT direction. In this example, the region is divided into four zones by their magnetic character.

1. NNE trending, central, high amplitude shallow magnetic basement zone associated with the Mirarrmina Fault.
2. SW quadrant that looks like part of a maple leaf floating on water.
3. NW quadrant with NNE linear suite of anomalies.
4. Eastern side, NNW linear suite of dyke-related anomalies.

Apart from the basement horst block in Zone 1, the magnetic responses are dominated by the pervasive and remanently magnetised Oenpelli Dolerite (~1720 Ma) which intrudes the Kombolgie Sandstone (~1830 Ma) as a sill along with numerous dykes in the underlying sequence. The Arnhem Province basement rocks are overlain by the McArthur and Arafura basins and younger Cenozoic sediments.

Zone 2 is unusual in shape and not that common because the maple leaf outline is caused by the truncation of the sill along the picturesque, sub-vertical escarpment of the Kombolgie Sandstone. The dark blue colour along the northern edge (**Figure 3a**), brown arrow (**Figure 3b**) is caused by a low on the northern facing cliff edge. In **Figure 3(c)**, the colour table is reversed which makes the maple leaf style anomaly look normally magnetised and easier to understand. Small, circular positive anomalies are most likely caused by thinning of the sill or weathering (three green arrows) and the other north-east pointing green arrow shows a high trend, which is believed to be associated with one of the many narrow ravines that cuts the reversely magnetised sill. See [Chapter 12 of *Exploration Magnetics: Theory and Practice*] for more details on this topic.

The Zone 3 Oenpelli Dolerite dykes suggest similar depth to the sill on the western margin where they are covered by much younger Cenozoic sediments (< 66 Ma). As you move east, the depths appear to increase and may be related to deeper sections of the McArthur Basin or Arnhem Province basement rocks. The width and sharpness of the dyke anomalies is clear in the monochrome images. The south-east oriented cyan arrow indicates the direction of increasing depth which is more likely to be associated with the base of the McArthur Basin.

In Zone 4, a series of very narrow, normal and reversed anomalies trend in a north to north-west direction. I believe they are young, outcropping dykes and unrelated to the Oenpelli Dolerite. The normally magnetised Zone 1 provides a clear separation with Zone 3.

I note that Clive Foss is writing a series of articles on classic magnetic anomalies exhibiting remanence. His first ***Preview* article on the Black Hill Norite in South Australia** covers a lot of interesting material on this remanent anomaly and the underlying rock properties.

Summary

- Unshaded monochrome images are generally more effective than colour for emphasising depth-related smoothing of formation edges.
- The dynamic range of depth in most images is limited and well suited to monochrome visualisation.
- The regional background field is easier to recognise in monochrome images when searching for magnetic reversals.

Magnetic Mentor data access

A zip file containing the underlying data, lookup tables, useful references and government licence documentation is provided for each publication of the **Magnetic Mentor series**. This will eventually form a foundation for a training resource for those of you that want to experiment further with the data and underlying ideas.

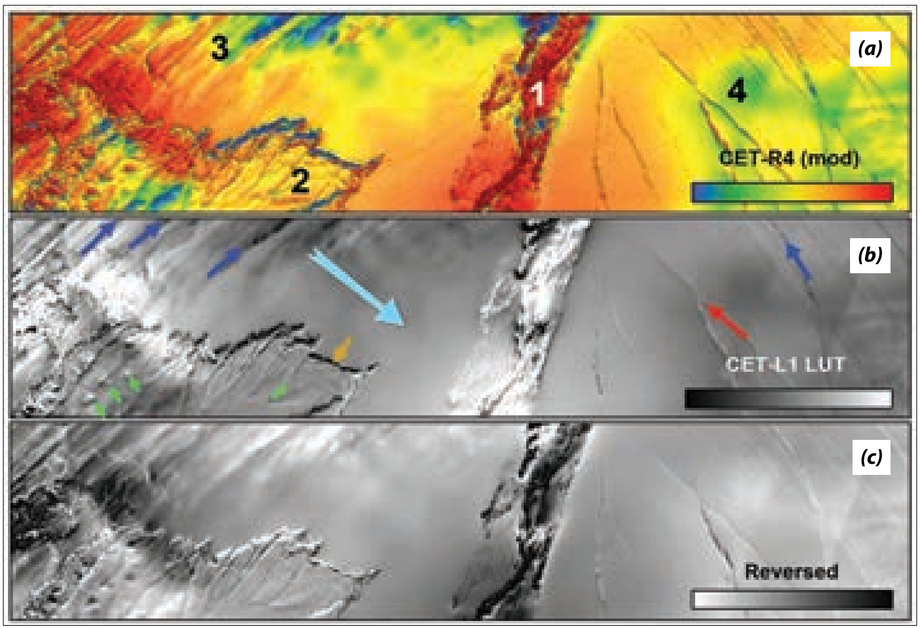

Figure 3. *Colour and monochrome image comparisons from an Arnhem Land, NT magnetic survey. (a) Linear colour stretch for comparison with a monochrome image, linear stretch (b) and reversed monochrome linear stretch (c). Numerals 1 to 4 define the magnetic domains and coloured arrows highlight important remanence and depth features that are referenced in the text.*