SOME RING-LIKE MAGNETIC ANOMALIES IN IMPACT STRUCTURES AND THEIR POSSIBLE CAUSES. P. J. Hawke[1], [1]School of Earth and Geographical Sciences, University of Western Australia, 35 Stirling Hwy, Crawley, 6009, Australia, phawke@ geol.uwa.edu.au.

Introduction: While not diagnostic of meteorite impact when used in isolation, geophysics is responsible for the initial discovery of many concealed craters. Airborne magnetics is one of the cheapest, and hence most widely available, of all the geophysical techniques.

Based primarily on studies of craters formed in crystalline rocks, the definitive papers on the geophysical signatures of impact craters [1],[2] suggest the main effect of extraterrestrial impact is to reduce the magnetic susceptibility of the target rock, resulting in an overall magnetic low or subdued zone. Local magnetic highs may be present, usually near the centre of complex structures. These are attributed to near surface magnetic basement within the central uplift of large structures or to shock, thermal and chemical processes forming new magnetic minerals or resetting magnetic remanence within the target rock or impact melt material. There are only a few case studies in the literature of magnetic surveys over true sedimentary targets, eg Mjølnir [3] and the sources of the observed magnetic anomalies are not well understood.

Circular magnetic anomalies: Three examples of ring-like anomalies identified in high-resolution magnetic surveys over impact structures formed in Australian sedimentary basins are presented here. A residual magnetic image for each structure is shown in Fig. 1, created by removing a second order polynomial trend from the total magnetic intensity.

The 12 km diameter Yallalie structure (30°27'S, 115°46'E) is formed in the Mesozoic sediments of the Perth Basin. While it is considered to be of possible impact origin due to the absense of shock metamorphic features, the geophysical data in [4] provide a convincing argument for its impact origin. An image of the magnetic data (Fig. 1a), collected at a 200 m line spacing and 60 m flying height, shows five concentric magnetic anomalies, centred on a single peak. These anomalies closely correlate with faults interpreted from seismic data to bound the central uplift and form terraces. The magnitude of the anomalies range between 4 and 12 nT.

The Foelsche structure (16°40'S, 136°47'E) is a partially concealed, 6 km diameter Proterozoic structure formed in the sedimentary and volcanic intrusive rocks of the McArthur Basin [5]. The structure was first recognised from magnetic data collected at a 500 m line spacing and 100 m flying height (Fig. 1b). The two concentric circular anomalies, with amplitudes of about 50 nT correlate with the outer extent of the central uplift and the crater rim.

Wolfe Creek (19°10'S, 127°48'E) is a small (880 m), young (300ka) crater formed in Devonian sandstone of the Canning Basin [6]. Magnetic data were collected at a very high resolution, 50 m line spacing and a 40 m flying height. This identified two roughly circular magnetic anomalies, coincident with the top and base of the crater wall, centred on a single peak (Fig. 1c). The amplitude of these anomalies is less than 4 nT.

Possible causes: Four possible causes of circular magnetic anomalies within impact structures are proposed. Melt rock generated by the impact is likely to form lenses of melt-fragment breccia (suevite) within the allochthonous breccia deposited on the complex crater floor and can be injected into floor as breccia dykes (Fig. 2a). Such material can carry a high magnetic remanance that is set at the time of impact. Local hydrothermal systems lasting several 10ka can be driven by the heat transferred to the target during the impact event, eg Haughton [7]. This may result in the production of new magnetic minerals from iron sources (pyrite, biotite, glauconite) within the otherwise non-magnetic sedimentary rock. Deeper magnetic sources concentrated along internal faults within the structure are expected to result from this process (Fig. 2b). A remanantly magnetised impact melt or post-impact hydrothermal activity are the most likely causes of the anomalies associated with the Mjølnir and Yallalie structures. A perfectly flat-lying magnetic unit, such as a dolerite sill, will not produce an anomaly that can be detected by a magnetic survey. Deformation of the target rock by the impact will change the dip and create truncations within this magnetic horizon (Fig. 2c) to produce magnetic edges that can be detected. A dolerite sill deformed in this manner is probably the cause of the circular magnetic anomalies observed at Foelsche. Finally, magnetic material may be deposited into the crater by normal sedimentary process after the impact event (Fig. 2d). While the magnetic response of Wolfe Creek can be partially explained by the drape of the survey, maghemite concentrated in the sandy post-impact fill by wind swirling around the crater floor is interpreted as the source of the magnetic anomaly coincident with the base of the rim wall at Wolfe Creek.

References:

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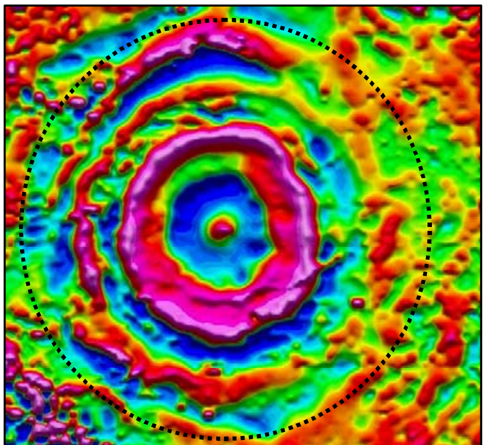

Fig. 1a.

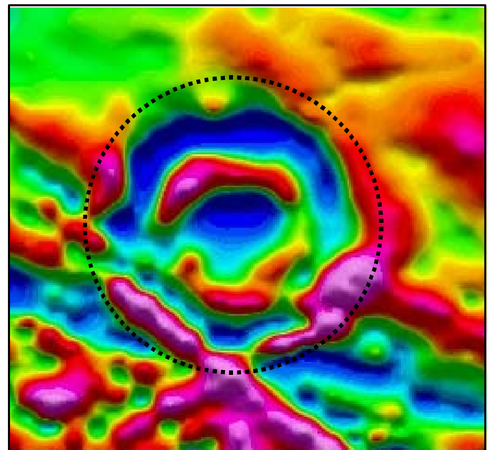

Fig. 1b.

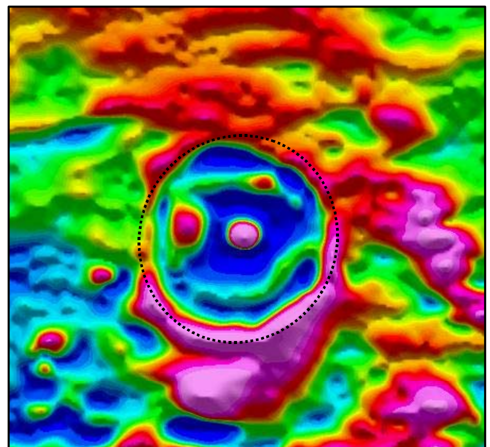

Fig. 1c.

Figure 1: Images of residual magnetic data for (a) Yallalie (b) Foelsche and (c) Wolfe Creek. A dotted line shows the extent of each crater. The scale in the lower right of each figure represents 1 km.

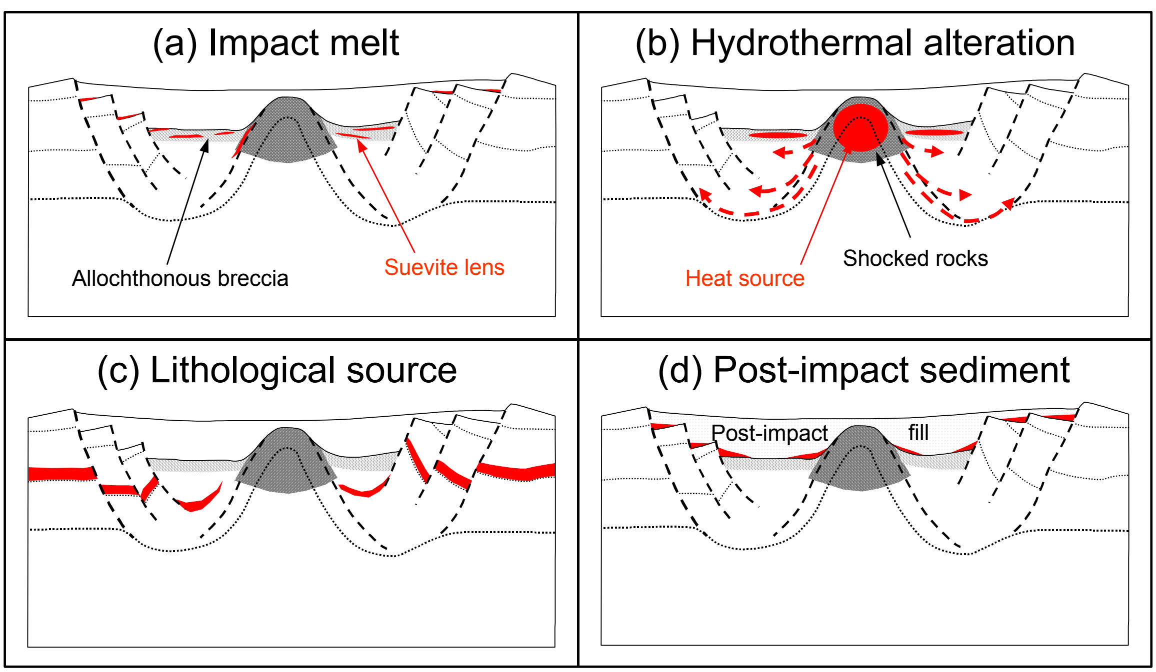

Figure 2: Methods of producing circular magnetic anomalies in impact structures.