PETROGRAPHIC AND ROCK MAGNETIC STUDY OF THE CENTRAL MAGNETIC ANOMALY, MANICOUAGAN IMPACT STRUCTURE, CANADA

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SUMMARY: Drill core from a localized magnetic high in the centre of the Manicouagan impact structure reveals highly altered granulite grade rocks rich in magnetic carriers. High magnetic susceptibilities and natural remanent magnetic intensities appear to be due to the formation of magnetic minerals by both shock decomposition and hydrothermal alteration. This contrasts with other processes that produce the magnetic low observed over the majority of impact structures.

The Manicouagan impact structure (51°21'N, 68°42'W) has a subdued magnetic anomaly low superimposed on regionally higher magnetic trends, typical of most impact structures [1]. The centre of the structure, however, is marked by a localized magnetic high of >1000 nT (fig. 1). This area is composed of shocked, felsic to ultramafic, granulite grade rocks of the Grenville Province in Quebec [2]. As part of a project to attempt to understand the magnetic character of impact structures [5], drill core from the anomaly, to a depth of 471.53 m, was analyzed for rock magnetic properties and mineralogy.

Optical petrography reveals a modal mafic mineralogy of orthopyroxene, garnet, clinopyroxene (titano- augite), kaersutite and minor biotite. Feldspars are consistently altered to sericite, clay minerals, devitrified glasses, and zeolites. The common zeolites present are thompsonite and natrolite. Garnet is commonly fractured and altered to opaque minerals. Clinopyroxenes are retrograded to kaersutite, biotite, and opaques. Alteration increases with depth, with orthopyroxenes breaking down to opaque minerals below 440 m. The entire sequence of felsic and mafic granulites (fig. 2) is rich in magnetic carriers. Hematization is variable, possibly due to the release of hematite from potassic feldspars during shock-metamorphism and/or alteration. Planar deformation features (PDFs) are strongest in quartz and orthopyroxene, but are largely masked in the feldspars due to the formation of maskelynite, clays and zeolites.

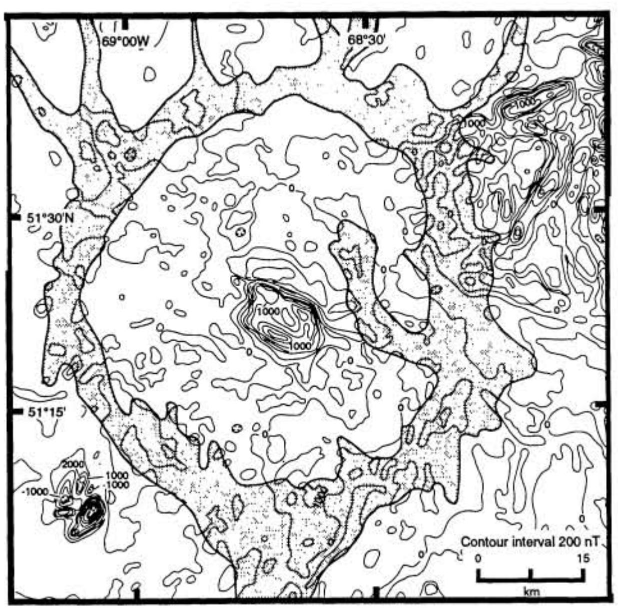

Figure 1. Magnetic anomaly map of the Manicouagan impact structure. The localized magnetic high is prominent in the centre of the structure.

Magnetic susceptibility increases from $\sim 10^{-3}$ SI at the top of the core to very high values of $\sim 10^{-1}$ SI at about 275 m, and remains at this value to the bottom of the hole at 471.53 m (fig .2). The increase in susceptibility at 275 m corresponds with a transition from leucocratic to meso-melanocratic granulite (fig. 2). Natural remanent magnetization (NRM) intensities are high in most of the core, ranging from 10^3 to 10^4 mA/m, and locally reaching 10^5 mA/m. Inclinations of the NRM are generally shallow, between -10° and +30° (fig. 2). Koenigsberger ratios (Q) are ~10 at the top of the core, but drop to ~1-2 by 275 m and remain at these values for the remainder of the core. High Q values indicate that NRM is dominating the magnetic anomaly, although this effect diminishes with depth as magnetic susceptibility increases.

The intense magnetic anomaly appears to be due to two factors: (1) shock decomposition of mafic minerals, noted at the Puchezh-Katunky structure in Russia, producing magnetite from garnet and pyroxene [3], and (2) later hydrothermal alteration resulting from the uplift of hot, high grade rocks from depth, permitting further iron oxidation, noted at the Manson structure, USA [4]. The formation of PDFs and maskelynite, followed by alteration of the feldspar glasses to form zeolites, suggests that both processes have been operative in forming magnetic carriers. Consequently, the creation of magnetic phases produces the magnetic anomaly high. This process contrasts with shock/alteration processes observed at other impact structures that can destroy magnetic phases and result in the reduction of magnetic field intensity [5]. It would appear, therefore, that although there is a common set of processes resulting in magnetic lows at impact structures, there can be second order processes related to target rock characteristics that complicate the resulting anomaly. This is in contrast to gravity observations that are more invariant [1].

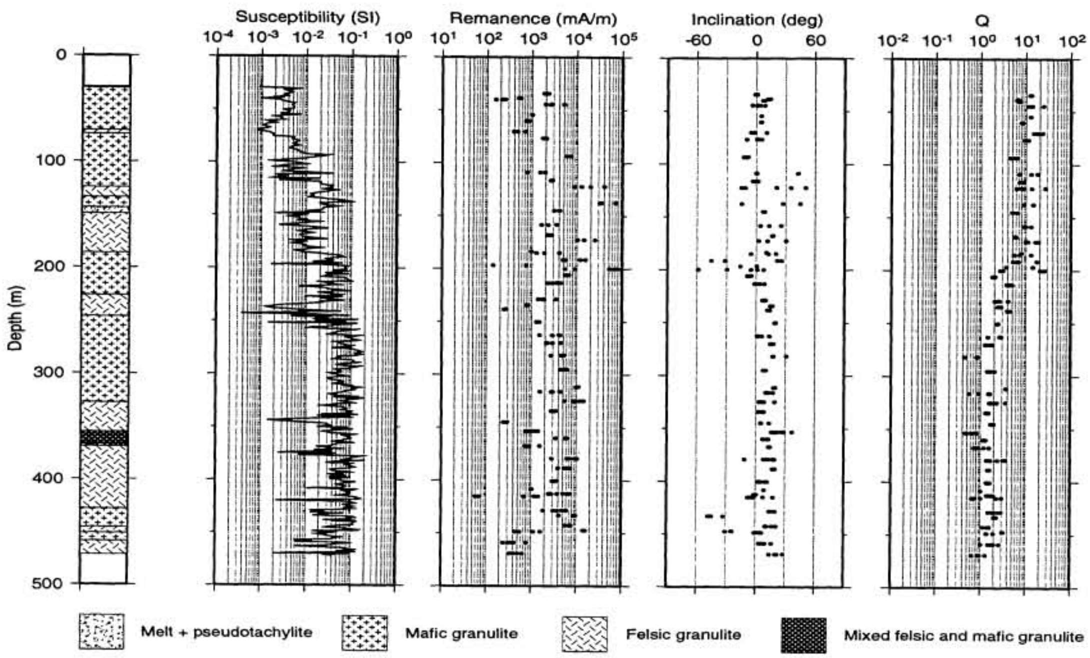

Figure 2. Drill log from the central magnetic anomaly region.

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