INTRODUCTION

Lake Wanapitei lies 40 km northeast of Sudbury, Ontario, and covers approximately 622 km^2 at an elevation of 267 m asl (Dence and Popelar 1972; Dressler 1982). The lake has been controversially identified as the site for a 37 Ma impact event (Dence and Popelar 1972; Winzer et al. 1976; Grieve 1991; Dressler et al. 1997). This paper will investigate one of the issues surrounding the concept of an impact event at Lake Wanapitei; whether the negative magnetic anomaly observed over the centre of the lake is due to bathymetric effects or possible magnetic overprinting due to the impact event. This investigation will also help constrain the crater's exact location and size.

REVIEW OF PREVIOUS EVIDENCE

The pattern of streams and lakes within 5 km of Lake Wanapitei is approximately concentric with the circular northern part of the lake, similar to the arcuate lakes around Deep Bay, Saskatchewan for which a hypervelocity impact origin has been demonstrated (Dence and Popelar 1972). The diameter of the impact crater is not well constrained having been identified as 6.75 km (Grieve and Ber 1994), 7.5 km (Dence and Popelar 1972; Pilkington and Grieve 1992; Dressler and Reimold 2001) and greater than 8.5 km (Winzer et al. 1976; Wolf et al. 1980). The impact event forming the Lake Wanapitei structure occurred 37 Ma ago based on K/Ar dating of glass and glassy whole-rock samples (Winzer et al. 1976). The dominant geophysical signature over impact craters is a residual negative gravity anomaly that extends slightly beyond the crater rim (French 1998). Gravity surveys by Dence and Popelar (1972) indicated an approximately circular depression of ~15 mgal centered over the circular portion of Lake Wanapitei.

MAGNETIC ANOMALY EVIDENCE

The moderately dominant magnetic anomaly associated with impact structures of diameters less than 10 km is a magnetic low ranging in amplitude from tens to a few hundred nanoteslas (nT) (Pilkington and Grieve 1992). Shock waves from impact events with central pressures of ~30 GPa can cause shock demagnetization and even shock remanent magnetization in rocks, leading to magnetic anomaly fields measured over terrestrial impact structures (Hargraves and Perkins 1969; Wasilewski 1973; Cisowski and Fuller 1978; Coles and Clark 1982; Pilkington and Grieve 1992). The random re-orientation of magnetization vectors in crystalline target rocks during the formation of the breccia lens may also contribute to the central magnetic low observed over impact craters (Pilkington and Grieve 1992; Scott et al. 1995).

MAGNETIC ANOMALY INVESTIGATION

To supplement previous aeromagnetic surveys of the Lake Wanapitei structure, a lake-based magnetic survey with over 320 line km was carried out in the summer of 2002 (L'Heureux et al. 2002). Simple levelling was applied to the raw Total Field grid shown in Figure 1a using a first order trend. In order to extract residual noise from the data, a directional high-pass filter perpendicular to the flight line direction with a decorrugation cut-off wavelength of 2000m was used. An amplitude limiting (20 nT) and low - pass filter was applied to the noise grid so that residual geological information was removed and only line level noise remained. The noise grid was then subtracted from the levelled grid to produce a microlevelled Total Field grid, see Figure 1b. At Wanapitei the Earth's inducing magnetising field is not vertical (inclination = 73^o, declination = -11^o), so the anomalies are not positioned over the source bodies. To aid in the interpretation of the local geology, the data were reduced to the magnetic pole (RTP) to place the magnetic anomalies directly over the source bodies.

To examine shallow features of interest in the Wanapitei area, a regional-residual separation was applied to remove undesirable long wavelengths that represent the deep structure. This was done by applying an upward-continuation filter (to an elevation of 200 m) to the microlevelled total field RTP grid to isolate the long wavelength (regional) field. The residual total field (RTF) grid was then calculated by subtracting the regional grid from the microlevelled total field RTP grid, see Figure 2.

Trend-Surface Analysis

The USGS_HGRAD GX was developed to calculate the magnitude of the horizontal gradient of a potential field grid using the gradient-component method of Thurston and Brown (1994). This GX was applied to the residual total field (RTP) grid to emphasize the prominent linear diabase dikes in the Wanapitei area. North-west trending dikes serve as a marker for the impact event since magnetic overprinting or brecciation of the crater floor will attenuate their magnetic anomaly. The resultant horizontal gradient grid was draped onto the 3D bathymetric profile (see Figure 3) to determine if the linear anomalies related to the dykes could be viewed across the deeper sections of the lake. If the linear positive horizontal gradient anomaly was discontinuous across the Massey Bay channel, which is the deepest section of the lake, then it can be inferred that the negative magnetic anomalies are still partially due to bathymetric effects, and not solely due to magnetic overprinting during an impact event since Massey Bay is over 3 km south of the potential impact zone.

Comment: Residual Total Magnetic Field (RTP) horizontal gradient map draped on bathymetry (viewed from the southeast). *Drape just TF on bathymetry to see if the circular low coincides with the bathymetry low… can I do any spatial stats on this? (Even if I have to normalize both the bathy and RTF to 1 to see if there's a relationship)

Compu-Drape

Corrections for variations in magnetic field strength resulting from changes in distance between the sensor and the source due to water depth were applied to the microlevelled total field (RTP) data using the PGW Compu-Drape algorithm in OASISmontaj (see Figure 4). Compu-Drape applies Cordell's 1985 chessboard technique in which sections of the magnetic grid are upward or downward continued in the Fourier domain to a series of parallel surfaces on the bathymetric grid. The magnetic field between these new surfaces is then interpolated to produce a new grid at a constant observation height above the lake floor.

DISCUSSION & CONCLUSION

The residual, horizontal and Compu-Drape grid investigations all revealed that the positive linear magnetic anomalies for the prominent northwest trending diabase dikes were discontinuous over the deep central ~7 km diameter and Massey Bay areas (Figures 2b, 3 & 4). It can be inferred that the negative magnetic anomalies are still partially due to bathymetric effects, and not solely due to magnetic overprinting during an impact event since a discontinuity exists over the deep channel. An impact event cannot be ruled out however, since the negative anomaly is greater in magnitude over the central region (~80 m deep) than the anomaly over the deeper (~120 m) channel area, which would not be expected if only bathymetric effects were present. The position and ~7 km size of the proposed impact crater has been identified according to the negative anomaly observed away from the Massey Bay channel (Figure 2b & 4).

Once the RTF data were draped onto the bathymetry using CompuDrape with a new observation height of -100m, there was no signature observed for the dykes across the deepest section of the lake, as would be expected if an impact event did not occur.

An impact event can not be fully confirmed from this lack of evidence however since the magnetometer was towed at a constant depth of -10m and high frequency signal may have degraded within the 120m+ depths of the lake before it could be observed in the collected record. Therefore a draped survey must be obtained in order to determine if an impact event may have occurred.

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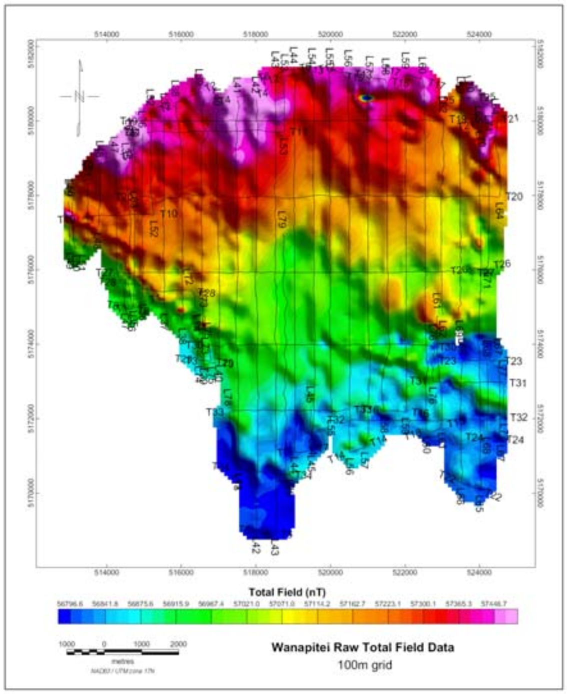
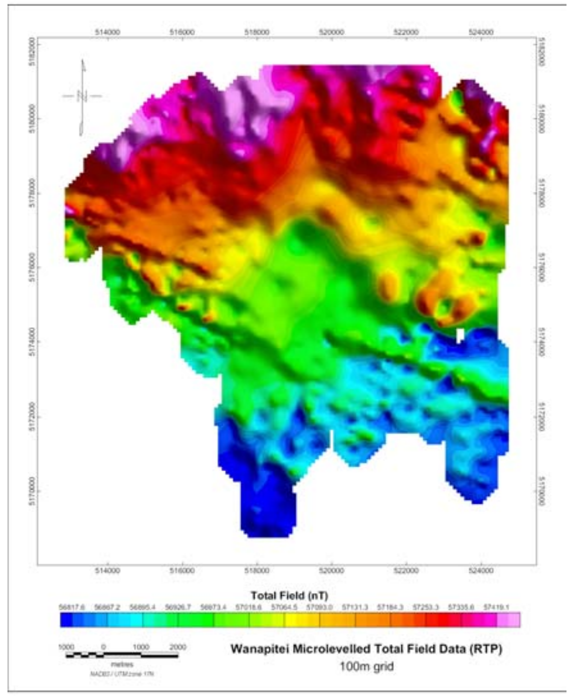
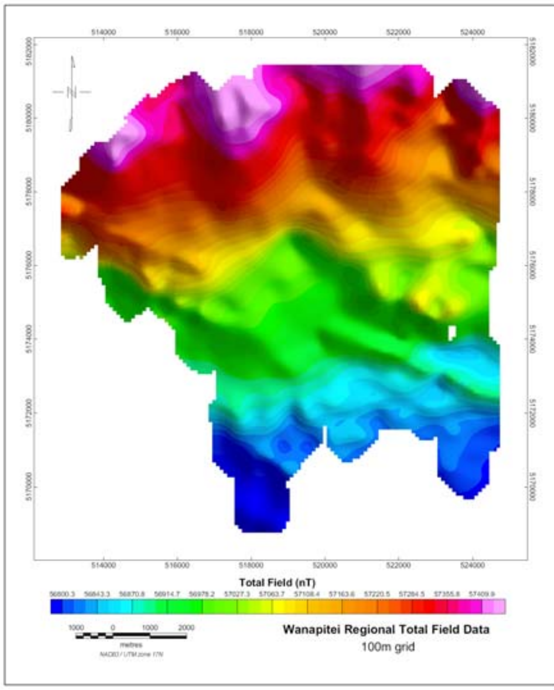

Total Field (nT)
Wanapitei Raw Total Field Data
100m grid


Total Field (nT)
Wanapitei Microlevelled Total Field Data (RTP)
100m grid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Total Field (nT)
Wanapitei Regional Total Field Data
100m grid
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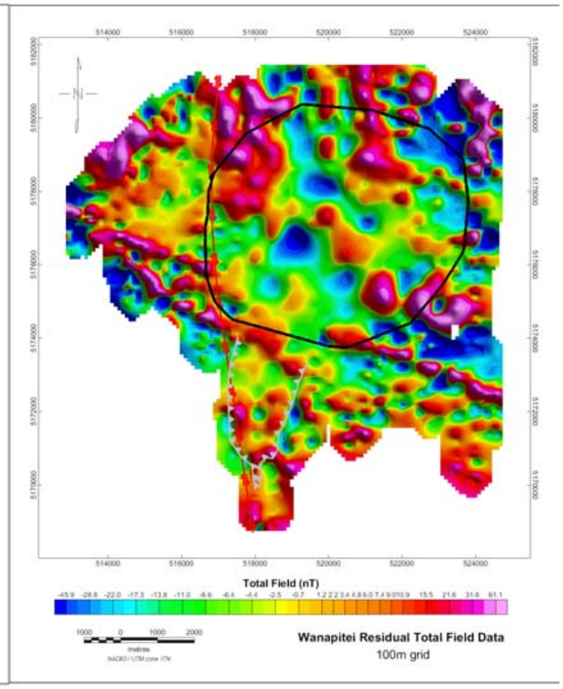
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Total Field (nT)
Wanapitei Residual Total Field Data
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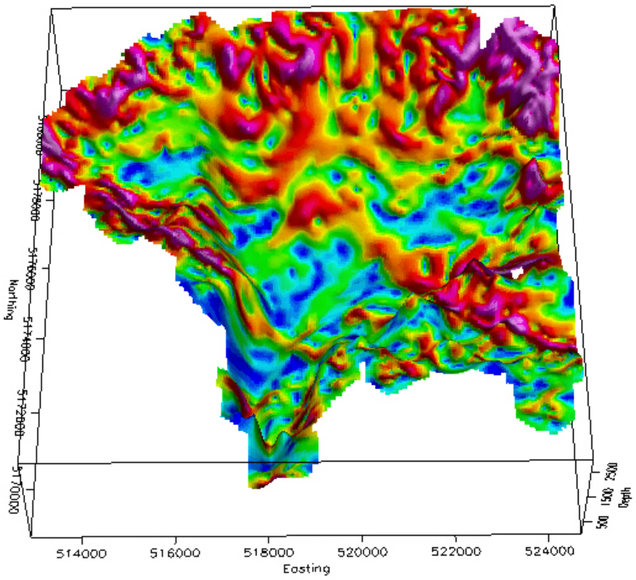

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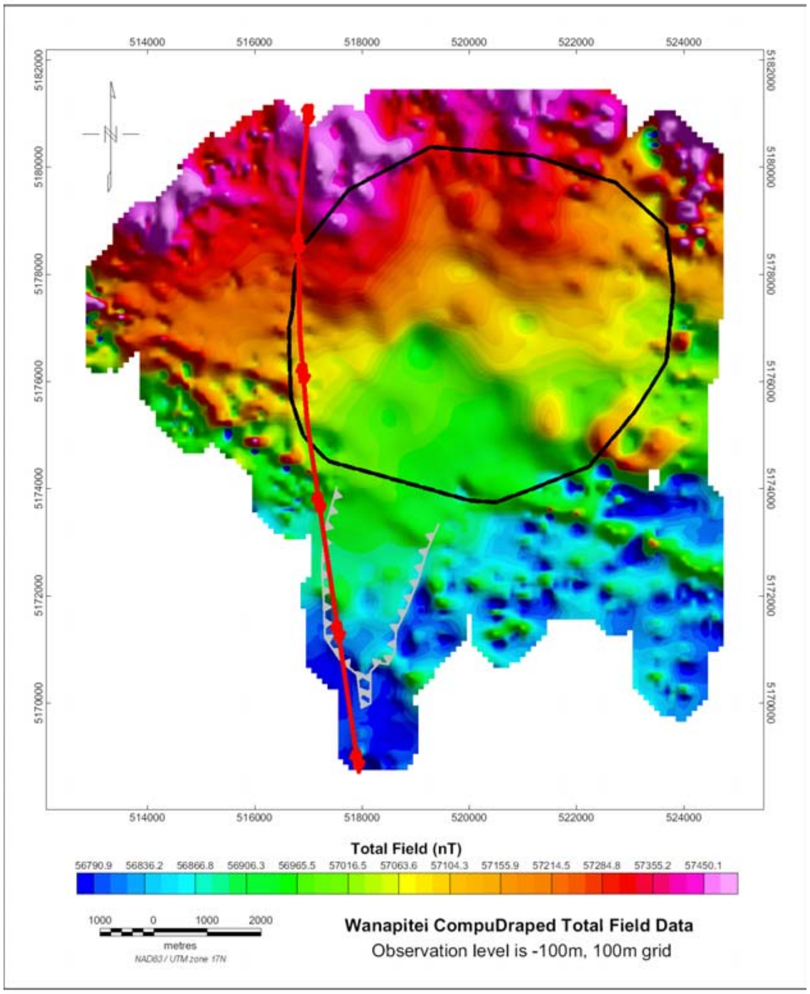

Wanapitei CompuDraped Total Field Data
Observation level is -100m, 100m grid

Figure 1: a) Raw Total Field data with North – South flight lines collected at 500 m line spacing and East – West tie lines collected at 2000 m line spacing, b) Microlevelled and reduced to the pole (RTP) Total Field data.

Figure 2: Extraction of the Regional-Residual Field: a) The microlevelled total field RTP grid was upward continued to 200 m to isolate the long wavelength (regional) field. b) The residual total field grid was created by subtracting the regional grid from the microlevelled total field RTP grid. Black line - potential crater diameter (~7km), Red line – major north-south fault, Grey line – deep Massey Bay channel.

Figure 3: Residual Total Magnetic Field (RTP) horizontal gradient map draped on bathymetry (viewed from the south).

Figure 4: Microlevelled total magnetic field data was draped to a constant -100 m observation height (using Compu-Drape) to remove the effects of different distances to the source body. The position of the proposed impact crater has been identified according to the negative anomaly observed away from the Massey Bay channel. Black line - potential crater diameter (~7 km), Red line – major north-south fault, Grey line – deep Massey Bay channel.