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Late Quaternary seismo-stratigraphy of Lake Wanapitei, Sudbury, Ontario, Canada: Arguments for a possible meteorite impact origin

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Abstract

Lake Wanapitei (132.75 km^2) fills what has been identified as an Eocene (c. 37 Ma) meteorite impact basin in the Canadian Shield near Sudbury, Ontario, Canada. The area was glaciated many times during the Pleistocene and the basin lies immediately north of the prominent Cartier Moraine built during the last glaciation by the retreating Laurentide Ice Sheet some 11,000 years ago. Study of the deeper geophysics of the basin using magnetic and gravity techniques, and confirmation of its origin, is hampered by lack of data regarding water depths, the form of the bedrock surface and the thickness and character of glacial and postglacial sediment. To this end, more than 300 km of high-resolution single channel seismic chirp and 200 kHz bathymetric data were collected from the basin in the summer of 2002. Water depths reach a maximum of 118 m and acoustic basement is defined by a glacially scoured bedrock surface. The overlying Pleistocene sediment fill exceeds 35 m in thickness and consists of a lowermost late-glacial succession of rhythmically laminated silty clays deposited when the basin was flooded by a deep and regionally extensive ice dammed water body (Glacial Lake Algonquin). Truncation of the upper surface of this succession across large parts of the lake floor records the drainage of Lake Algonquin and the isolation of Wanapitei Lake as a separate water body. Overlying Holocene sediment is up to 10 m thick but is markedly discontinuous and commonly occurs as mounded 'drifts' reflecting strong bottom currents and low inputs of modern sediment. The presence of apparently undisturbed Precambrian bedrock below large portions of the lake basin places significant constraints on the dimensions of any meteorite impact structure.

Keywords: Meteorite impact crater; Canadian Shield; Glaciation; Seismic stratigraphy

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1. Introduction

There are about 160 known meteorite impact craters on planet Earth with many other crater-like features where an impact origin has not been positively verified. The Lake Wanapitei basin near Sudbury, northern Ontario, Canada is one such feature. This has been interpreted as a submerged Eocene meteorite impact crater about 37 million years old on the basis of gravity, magnetic and petrographic data (Dence and Popelar, 1972). Interpretation of previously collected geophysical information is not straightforward due to a lack of knowledge of the basin bathymetry and the submerged bedrock geology. The area has undergone repeated glaciations which leads to uncertainty with regards to the

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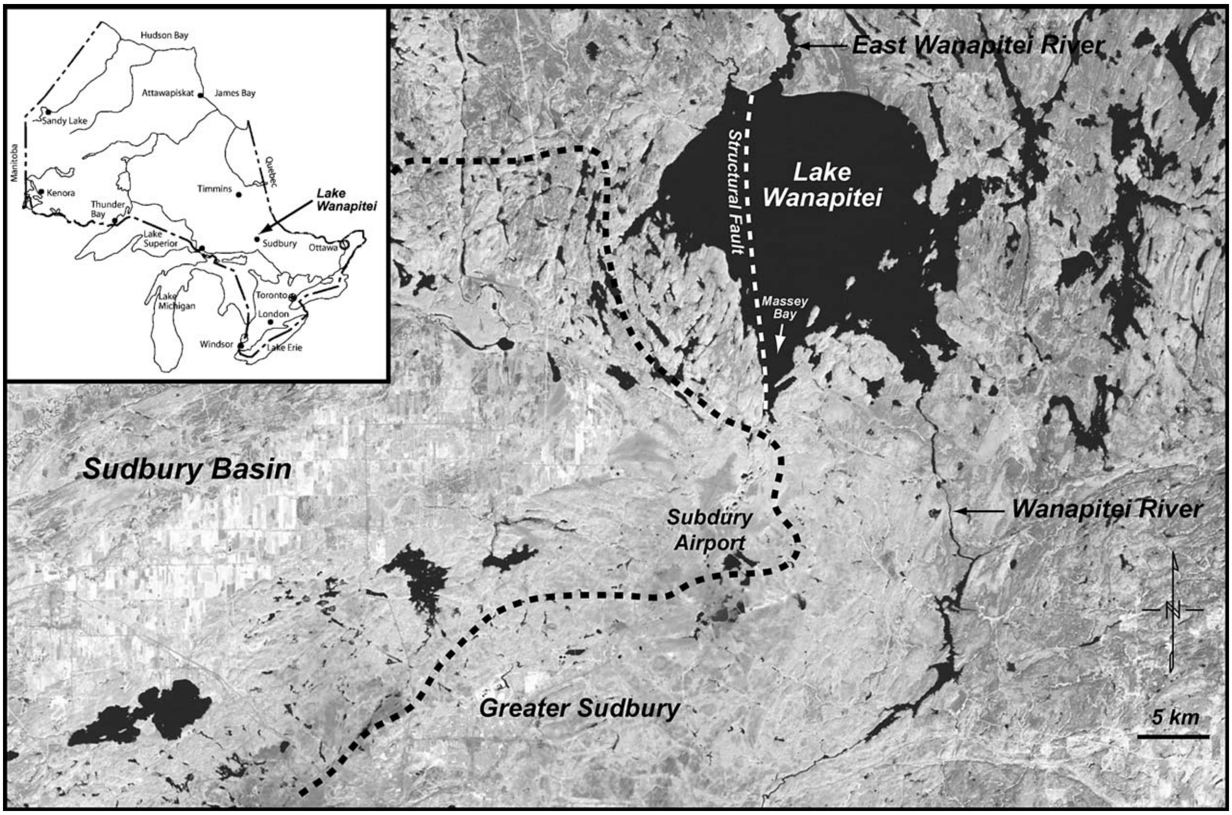

Fig. 1. Landsat 7 image (August 2000) of the Lake Wanapitei basin and surrounding area, Ontario, Canada. The gridded road network of the Sudbury urban area can be seen at mid-left. Dashed line shows the extent of the Sudbury Basin, a deformed 1.8 Ga old impact crater (Fig. 2).

thickness and origin of Pleistocene glacial sediment infill (L'Heureux et al., 2005). Much useful subsurface information has been collected at other submerged impact craters using high-resolution marine seismic reflection techniques (e.g. Brooks et al., 2005) and in this paper we present the results of a high resolution frequency modulation (FM) chirp sonar survey of the Lake Wanapitei basin (Figs. 1 and 2). More than 300 km track lines of high-resolution chirp seismic data were collected in 2002 to constrain the form of the bedrock surface and the geologically recent glacial history. This detailed information is also required to identify target areas for deep drilling of the basin. Presentation of this seismic data set, its interpretation and a comment on its geological significance, is the focus of this contribution.

2. Physical setting of Lake Wanapitei

Lake Wanapitei (46°45′N, 80°45′W) is 1 of more than 300 lakes within the reaches of the City of Sudbury in Ontario, Canada (Fig. 1). It is the largest (12 km wide with a surface area of 132.75 km^2) and deepest (>118 m) in the region, containing approximately 5 km^3 of water (Pearson et al., 2002). Wanapitei means 'molar tooth' in Ojibwa, referring to its tooth-like shape (Fig. 1), and the lake is noted for strong wind-driven currents and large surface waves. The basin is excavated into Precambrian rocks of the Canadian Shield on the eastern margin of the 1.8 Ga Sudbury Basin meteorite impact structure (Mungall et al., 2004) and straddles the suture between the Southern Province (Paleoproterozoic Huronian sedimentary rocks) and Archean Superior Province (granites, gneisses) (Fig. 2). A north–south oriented structural fault crosses the western part of the basin and controls the location of the East Wanapitei River that flows into the lake on its northern margin. The outflowing Wanapitei River emerges on its southeastern rim (Fig. 1) and is also fault controlled. The basin is crossed by numerous northwest trending olivine diabase dikes 50 to 120 m wide of the 1.2 Ga Sudbury swarm (Dressler, 1982; Krogh et al., 1987). These intrusions are relatively resistant to erosion compared to surrounding strata and form prominent 'ribs' on the Shield surface around the

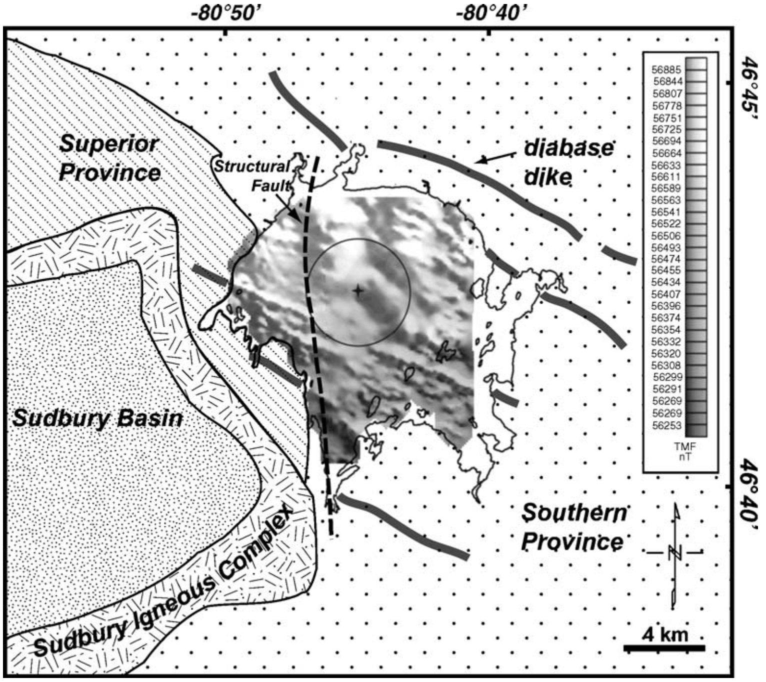

Fig. 2. Geology of Lake Wanapitei basin. The Lake Wanapitei Basin straddles the boundary between the Superior and Southern Provinces of the Canadian Shield and the Sudbury Basin. Magnetic imaging showing northwest trending dikes as 75–100 nT anomalies that cross the basin. A distinct magnetic low of about 100 nT in the magnetic field occurs over an area of 2–3 km in diameter (circled). Bedrock is too deep to be imaged by chirp seismic reflection and may be the product of meteorite impact or glacial overdeepening.

basin margin. Magnetic imaging show northwest trending dikes as 75–100 nT anomalies that cross the submerged portions of the Wanapitei Lake basin. A distinct magnetic low of about 100 nT in the magnetic field occurs over an area of 2–3 km in diameter (circled in Fig. 2) and is thought to constrain the location of the crater (L'Heureux et al., 2005). Dence and Popelar (1972) report the finding of suevitic breccias containing impact melt fragments and shocked quartz, along the southern shoreline of the basin and attributed to glacial transport from a submerged crater to the north (see also Dressler et al., 1997). These rocks yield an impact age of c. 37 Ma and is the primary evidence cited for a meteorite origin for the Wanapitei basin (L'Heureux et al., 2005).

2.1. Pleistocene glacial history

The Wanapitei Lake district has experienced numerous glacial and interglacial cycles of erosion and deposition during the Pleistocene though the depositional record is biased toward the last (Wisconsinan) glaciation. The glacial history of the Wanapitei region has been reconstructed from broad-scale mapping of discontinuous glacial sediment scattered across the knobbly surface of the Canadian Shield (e.g. Barnett and Bajc, 2002) but the nature of any glacial infill below Lake Wanapitei was unknown prior to our study. During the peak of the last (Late Wisconsin) glaciation some 20,000 years ago, the Laurentide Ice Sheet covered all of Ontario (Dyke, 2004). Ice thickness in the Sudbury area was probably in the vicinity of 2 km with a dominantly southwestward flow direction across the Wanapitei district (Boissonneau, 1968). Retreat of the Laurentide Ice Sheet margin to a position immediately south of Wanapitei Lake occurred approximately 11,000 years ago (Burwasser, 1979) as recorded by the west–east trending Cartier Moraine (Fig. 3B). This landform marks the northern limit of an extensive (100 km^2) spread of ice contact and kettled glaciofluvial sand and gravel (Fig. 3B). The deposit is thought to have formed as a linear, structurally controlled fan-delta by energetic subglacial waters flowing out of the Wanapitei Basin when it was still covered by ice (Barnett and Bajc, 2002). This subglacial water delivered sediment into Glacial Lake Algonquin which ponded along the southern margin of the retreating ice sheet south of the Cartier Moraine (Fig. 3A, B). Shortly thereafter, the Wanapitei Basin was evacuated by retreating ice and immediately flooded by the waters of Lake Algonquin

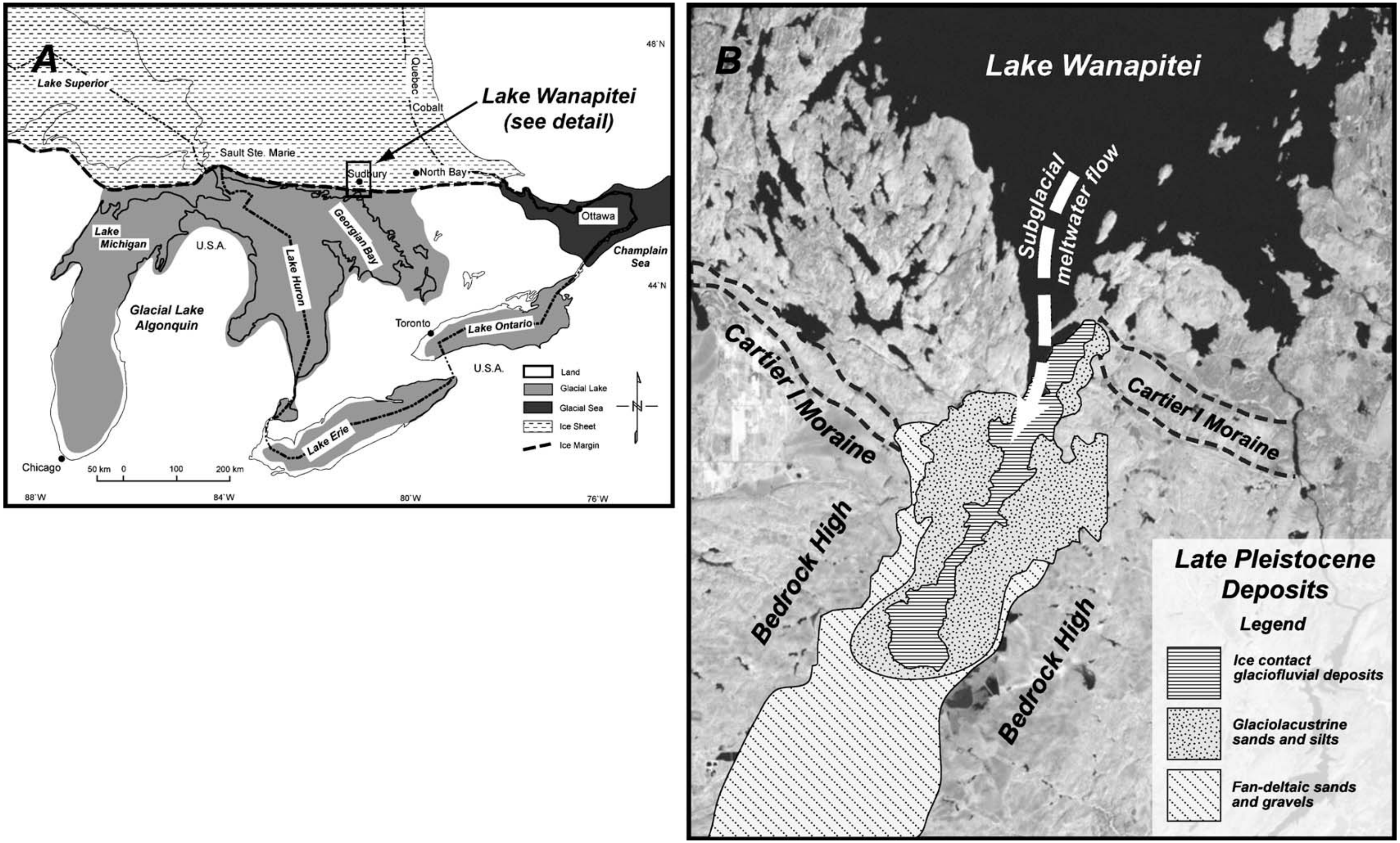

Fig. 3. (A) Late Pleistocene glacial setting of the study area showing the margin of the Laurentide Ice Sheet still covering the Wanapitei basin. (B) Ice contact fan delta sediments to the south of the basin were delivered by subglacial waters flowing from the Wanapitei basin and deposited in Glacial Lake Algonquin (modified from Barnett and Bajc, 2002).

as it expanded northwards, ushering in a phase of late glacial glaciolacustrine sedimentation in the basin (see below). The draining of glacial Lake Algonquin and the lowering of lake levels within the Sudbury region occurred sometime between 10,500 and 10,000 years ago (Barnett and Bajc, 2002; Eschman and Karrow, 1985). At this point, Lake Wanapitei was left isolated as a separate water body in which a postglacial depositional regime commenced.

3. Seismic methodology

An FM chirp seismic reflection survey was carried out to determine the thickness and stratigraphy of Pleistocene sediments within the Lake Wanapitei basin (Fig. 4) and the form and nature of the underlying bedrock surface. This seismic method provides excellent decimetre-scale resolution of individual layers and their basin-wide geometry (e.g. Schock et al., 1989; Stevenson et al., 2002; Gilbert, 2003) and thus can be used to deduce the depositional history in the absence of coring or observations of outcrop exposures.

The seismic system transmits a pulse that is linearly swept over a full frequency range of 2–12 kHz for 20 ms (‘chirp’ pulse). Density contrasts between the water–sediment interface and within the sedimentary layers result in changes in velocity of the signal as it passes through and is reflected within the medium. The acoustic signal return is received by two sets of hydrophones with proprietary amplitude and phase weighing functions applied to the transmitted pulse and a pulse compression filter used in place of match-filtering to increase the signal to noise ratio (EdgeTech, 1998). Data are recorded on a magnetic tape storage device and simultaneously sent to a thermal plotter to produce a paper record. Detailed specifications of the

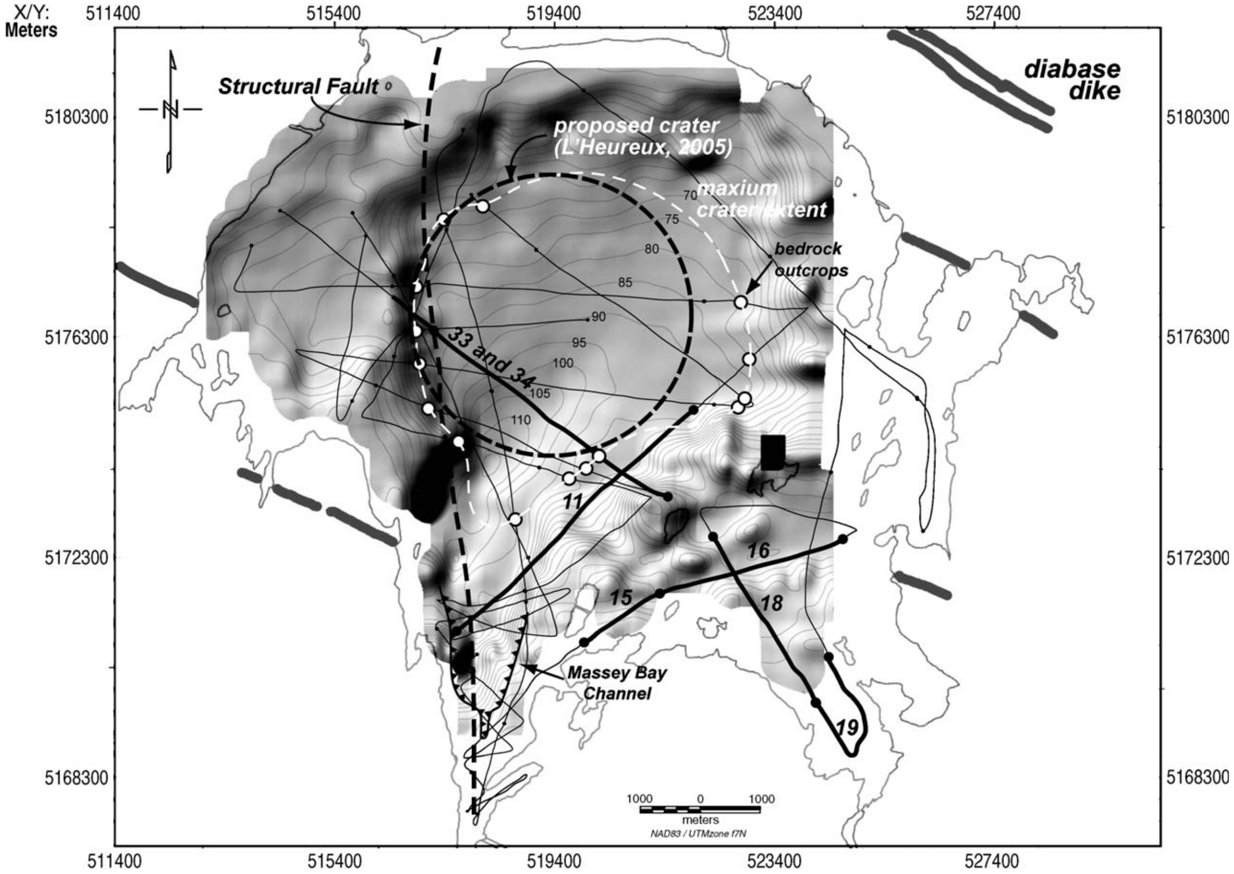

Fig. 4. Bathymetry of Lake Wanapitei basin and location of seismic track lines. Those track lines illustrated in this paper (Figs. 5–10) are bolded. The dashed circle outlined in black corresponds to the impact crater proposed by L’Heureux et al. (2005) on the basis of magnetic data. Outlined in dashed white is the maximum crater diameter, based on bedrock outcrops identified on seismic profiles collected during the course of this study. Within this area the bedrock surface below the Late Pleistocene sediment infill is too deep to be imaged either by seismic refection or magnetic data (Fig. 2). Diabase dikes are indicated in with thick lines.

EdgeTech high-resolution X-STAR digital sub-bottom profiling system with a SB-216S tow vehicle and magnetic tape data storage are described in the EdgeTech Technical and User's Manual (1998).

Data were collected along 45 track lines totalling more than 300 km of line data (Fig. 4) in the late summer of 2002. The X-STAR system was towed behind a research vessel at a speed of 3 km/h, at a water depth of approximately 0.5 m. Post cruise, the X-STAR SEG-Y format files were converted on an Intel-based Linux platform and the GPS coordinates from the headers extracted. Time delay values recorded in the field header information were applied to the traces to adjust for recording window. The SEG-Y files were converted to Seismic Unix format and seismic sections were generated using Seismic Unix scripts. Depth conversion from two way travel times were preformed with a calculated average water velocity of 1450 m/s based on the equations described by Kuperman and Lynch (2004) assuming an average water temperature of 7 °C, very low salinity and depths less than 100 m. A gamma filter was applied to the final sections to accentuate low-contrast reflections in the data and aid in interpretation. Seismic profiles were subsequently correlated with bathymetric data acquired with a 200 kHz echo sounder and interpolated with Oasis Montaj geophysical processing software using a bi-directional interpolation method with 15 m grid spacing.

4. Results

4.1. Bathymetry

Bathymetric data assembled for Wanapitei Lake identify a funnel-shaped basin with a wide gently sloping northern floor that narrows and steepens southward into a deep axial trough (Figs. 4 and 5). This trough is enclosed north and south, and is about 2 km wide and 5 km long with a maximum water depth of 118 m just north of Massey Bay (Fig. 1). The western limits of the trough are steep, linear and defined by rising bedrock that forms a prominent north–south oriented ridge along the trend of the structural fault (Fig. 4). West of the ridge, the basin floor is shallower and forms a broad shelf that shows a small central

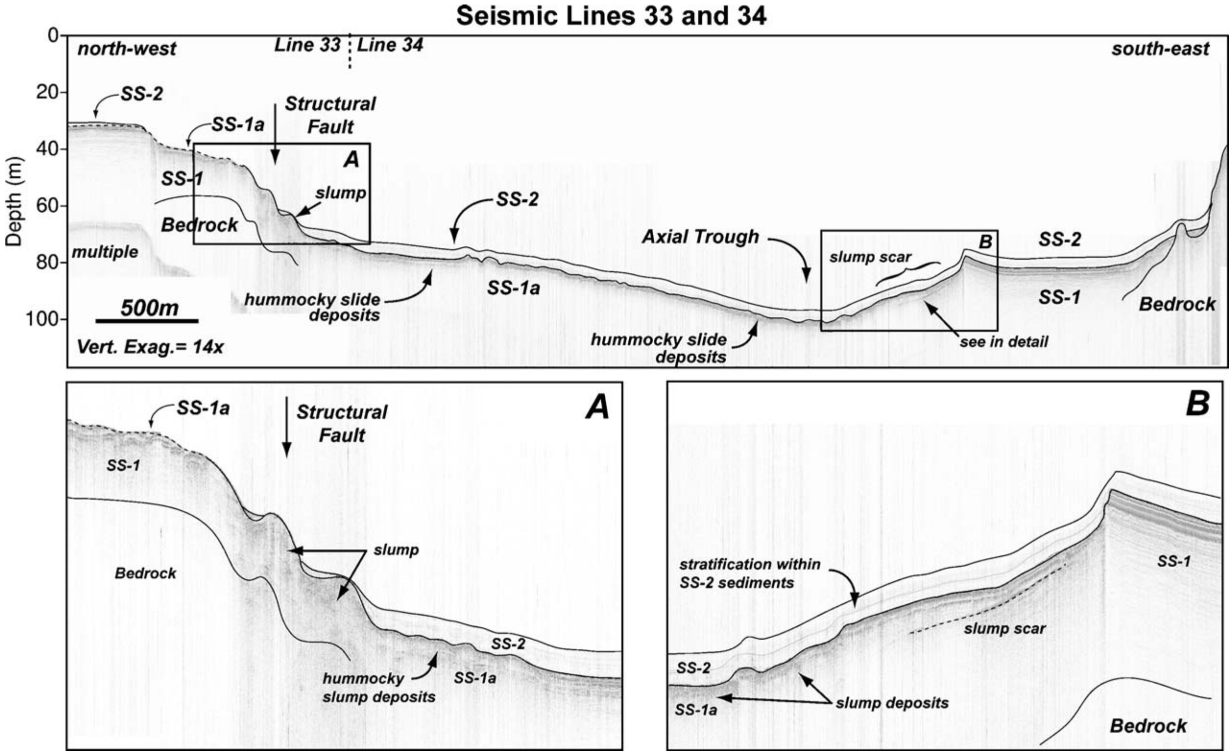

Fig. 5. Seismic track lines 33 (southern portion) and 34 (see Fig. 4 for location) showing the axial trough the structural fault in Lake Wanapitei. Inset shows detail of hummocky slump deposit (SS-1a) that underlies much of the trough floor and a slump scar along steep basin margin. Note overlying SS-2 sediment is undisturbed.

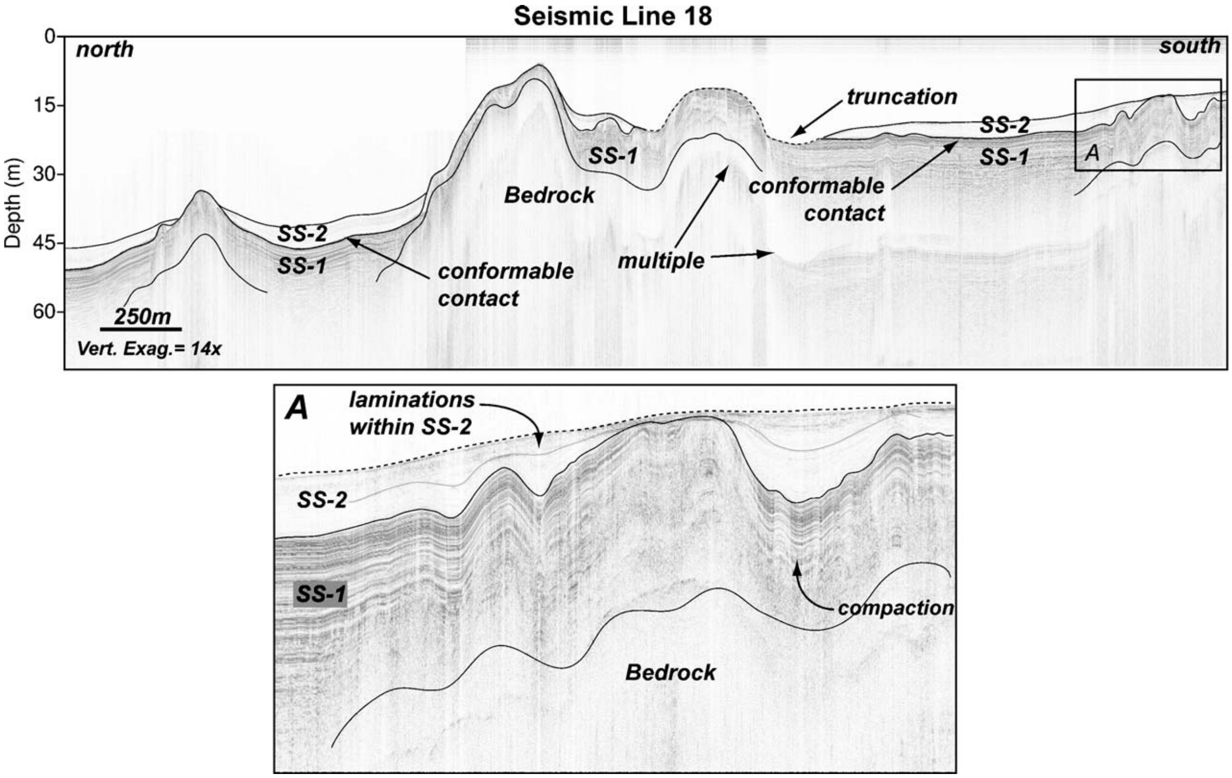

Fig. 6. Seismic track line 18 (see Fig. 4 for location). Insert shows only infilling of local depressions by SS-2 (and not draping of topography) indicating sediment starvation and strong bottom current activity. Possible compaction of SS-1 can be seen on the right portion of the inset.

depression where water depths approach 40 m. The western and eastern margins of the axial trough are bounded by scarps in some sections (Fig. 5). Around the eastern rim of the lake basin, the basin floor is much more irregular, showing a distinct knobbly topography (Fig. 4). As seen on the seismic profiles, sediment drapes the bedrock highs and infills the depressions (e.g. Fig. 6).

4.2. Seismic stratigraphic units

4.2.1. Acoustic basement

Bedrock in Wanapitei Basin is readily discriminated from overlying sediment on sonar profiles where the bedrock forms a distinct acoustic basement characterised by a lack of seismic signal penetration (Figs. 5–10). The bedrock surface can be most clearly identified

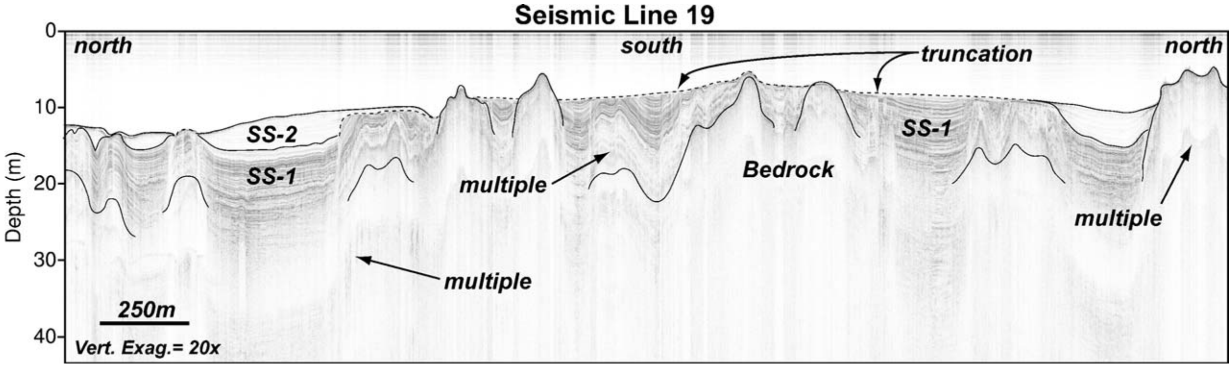

Fig. 7. Seismic track line 19 (see Fig. 4 for location). Truncation of SS-1 by the modern lake floor is clearly evident together with deformation arising from compaction of sediments over irregular bedrock surface. The local relief of the bedrock surface reflects the presence of relatively hard diabase dikes (Fig. 2). Note the discontinuous extent of overlying sediment (SS-2).

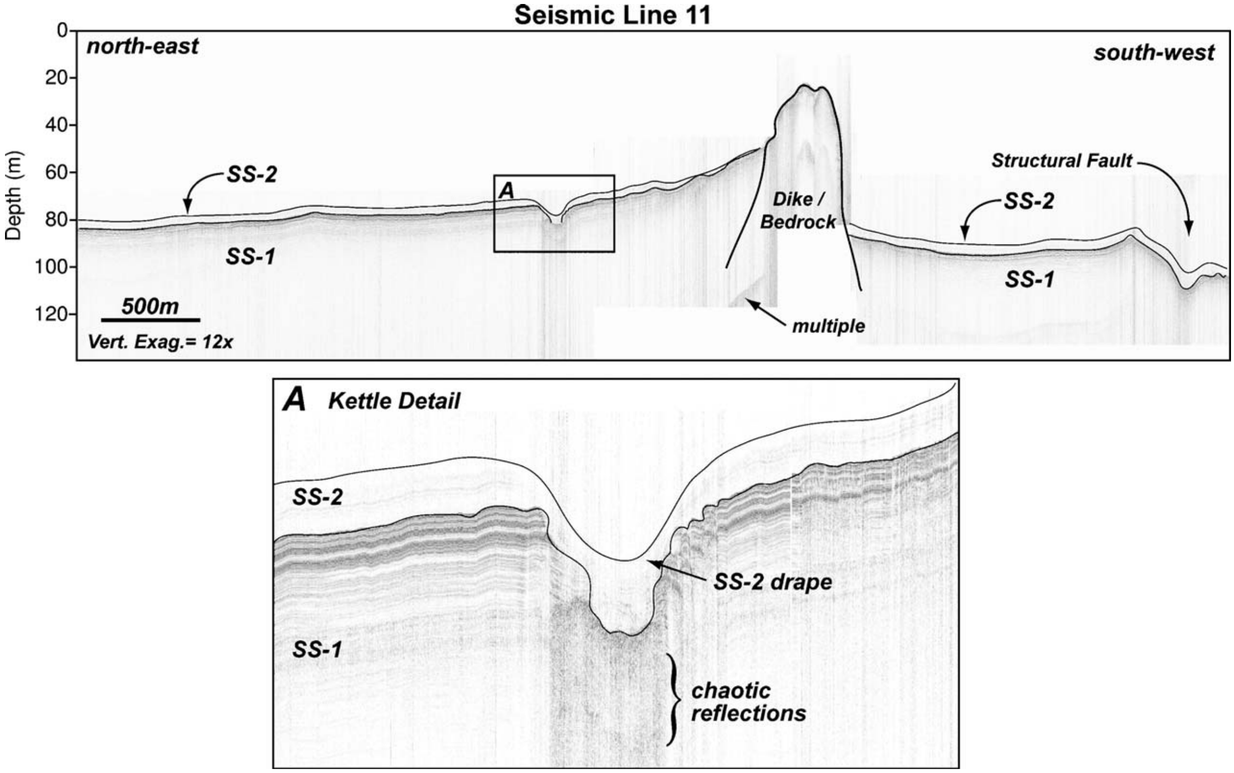

Fig. 8. Seismic track line 11 (see Fig. 4 for location) showing a prominent bedrock high created by diabase dike and the western margin of the axial trough created by a structural fault. Insert shows kettle basin formed by melt of ice trapped within late glacial sediments of SS-1.

across the eastern margin of the basin where it forms an undulating and irregular topography consisting of knobs, ribs and depressions typical of the moderate relief glacially scoured topography of the Canadian Shield that surrounds the basin (Figs. 1, 6 and 7). This seismic pattern is very typical of the bedrock floors of the many thousands of glacially scoured 'shield lakes' in Canada (e.g. Eyles et al., 2003). Disappointing signal penetration precluded identifying the bedrock surface on many of the track lines (Figs 5, 9 and 10). This may be the result of gas within the overlying sediments (as noted by Gilbert, 2003) or some characteristic of the sediments themselves. However, small-scale bedrock structures, such as dikes, can be clearly imaged (Figs. 8 and 9).

4.2.2. Seismic successions 1 and 2

Sediments overlying the bedrock surface below Lake Wanapitei are readily subdivided into two very distinct packages, referred to here as seismic successions (SS). An extensive lowermost succession (SS-1) rests on bedrock and consists of acoustically stratified seismic facies characterized, in general, by parallel and high frequency reflectors and locally by incoherent and deformed facies. An overlying uppermost, largely discontinuous succession (SS-2) consists of acoustically transparent or weakly laminated facies (Figs. 5–10). While these two successions were not cored in the course of the present study they are representative of the infill of many lakes across the Canadian Shield (e.g. Gilbert, 2003; Kaszycki, 1987; Shilts and Clague, 1992), forming a distinct stratigraphic 'couplet' of lowermost late glacial rhythmically laminated ('varved') glaciolacustrine silts and clays (SS-1), overlain by much thinner, fine-grained mostly discontinuous and reflection-poor Holocene sediment (SS-2).

In Lake Wanapitei, the seismic character of the SS-1 appears to be controlled by the form of the bedrock surface on which it rests. SS-1 is flat lying where it is thick and the underlying bedrock surface is of low relief (e.g. Figs. 8 and 9). However, where it is thinner (<10 m) in areas of strong bedrock relief, the succession shows distinctly undulatory reflectors that lie conformably on the bedrock below (Figs. 5–7). Below the axial trough of the lake and east of the structural fault, a subfacies SS-1a shows chaotic reflectors and a hummocky upper surface which are associated with upslope slumping on the steep lateral margins of the trough (e.g.

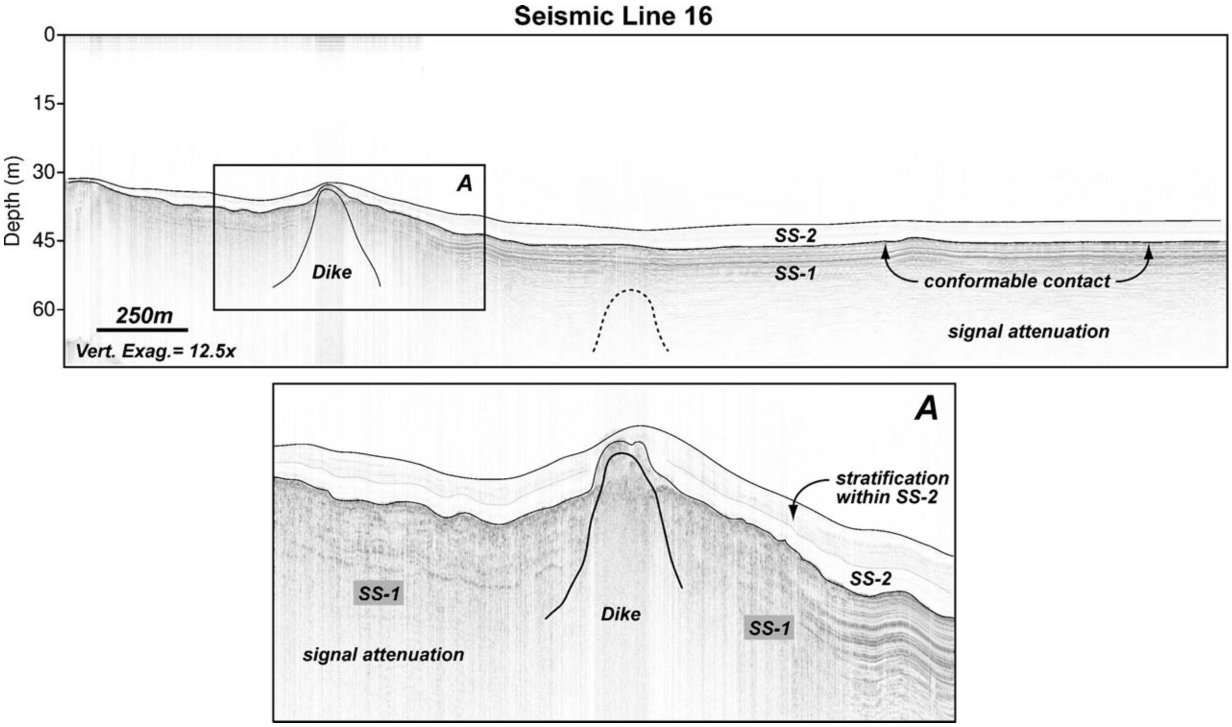

Fig. 9. Seismic track line 16 (see Fig. 4 for location) showing conformable contact between SS-1 and SS-2 in central part of Lake Wanapitei; elsewhere in the basin, SS-2 is discontinuous (e.g. Figs. 6 and 7).

Fig. 5). In this case, the hummocky surface form and underlying incoherent facies can be confidently interpreted as the product of mass flow from the steep side slopes of the trough and are similar to the slump deposits described by Syvitski and Schafer (1996) from the earthquake prone Saguenay Fiord in Quebec. Gilbert (2003) also noted hummocky forms in Devil Lake (Facies I) which were attributed to the lowering of lake levels due to the draining of Glacial Lake Iroquois. Such facies underlie large areas of the axial trough in Lake Wanapitei but noticeably do not affect younger SS-2 sediment (Fig. 10) indicating a late glacial age for resedimentation. Downslope resedimentation may have been triggered by various processes such as depositional oversteepening in areas of steep substrate slopes, sudden drainage of Glacial Lake Algonquin (when Lake Wanapitei was isolated as a separate waterbody), and/or earthquake activity known to be associated with

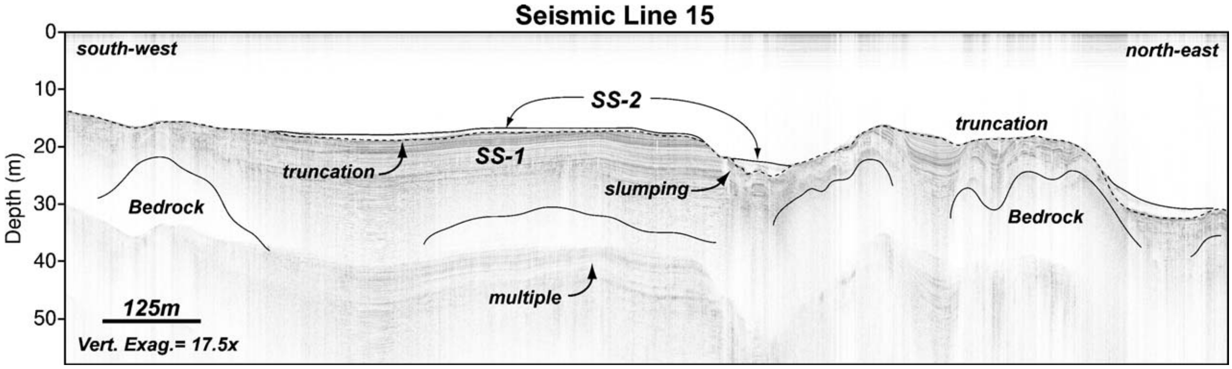

Fig. 10. Seismic track line 15 (see Fig. 4 for location) showing thick sediment package (SS-1), truncation of SS-1 by modern lake floor and the discontinuous nature of SS-2.

deglaciation and isostatic uplift. By contrast, the SS-2 drape that overlies slide deposits is undisturbed, indicating that downslope movement is no longer active in the basin. This may reflect the lack of any large sediment input in postglacial times (see below).

Smaller scale deformations within SS-1, though rare in Lake Wanapitei, take the form of chaotic reflections immediately below small, enclosed depressions in the lake floor that resemble pock-marks (Fig. 8). These might reflect the upward expulsion of water or gas but most likely record the trapping and burial of ice blocks such as small icebergs and the later melt of buried ice to form kettle hole basins (e.g. Eyles et al., 2003).

SS-1 can be confidently interpreted as the product of late glacial deposition in Glacial Lake Algonquin that is known to have invaded the Wanapitei Basin immediately after deglaciation. Lake Algonquin sediments are widely exposed in the Sudbury area as glaciolacustrine silt and clay rhythmites (Barnett and Bajc, 2002). The sediments most likely originated from meltwater-fed fan deltas entering the lake from the north and were deposited in the lake by underflows (quasi-continuous turbidity currents) filling in bedrock depressions and from suspension, draping the bedrock highs. Such facies are perhaps the most widespread of all glacial facies in Canada reflecting the enormous extent of late glacial water bodies dammed by the retreating ice sheet.

Unlike SS-1, the distribution of SS-2 is markedly discontinuous and its extent is strongly related to water depth. In deep water (>30 m), SS-2 sediment is up to 10 m thick and rests conformably on SS-1 (e.g. Fig. 9). This relationship indicates continuing sedimentation in the basin following the drainage of Glacial Lake Algonquin but a marked reduction in postglacial sediment supply and deposition rates given the thinness of the unit. Between 15 and 30 m water depth, SS-2 sediment is discontinuous and occurs as isolated mounded ‘drifts’ that have developed around bedrock highs (e.g. Fig. 6). In areas where water depths are less than 15 m, the modern lake floor truncates the upper part of SS-1 over large portions of the basin (Figs. 5 and 7) and SS-2 sediment is absent or present as small lunate shaped fills in small basins preserved on top of SS-1. The truncation of SS-1 over large portions of shallow water areas may reflect the drainage of Glacial Lake Algonquin when Lake Wanapitei was isolated at the beginning of the Holocene. This phenomenon has been noted from the floors of Lake Huron and Georgian Bay that experienced a similar late glacial water level history (Moore et al., 1994). Erosion and truncation of SS-2 may also have been the result of wave action affecting the deeper SS-2 deposits, which would have been brought into the wave base as lake levels fell. Evidence of erosion attributed to wave action has been shown to occur to water depths greater than 40 m in Devil Lake (Gilbert, 2003).

The discontinuous extent of SS-2 records both overall sediment starvation in the modern environment and scour by strong wind-driven currents which prohibit widespread pelagic accumulation of fine clay sized sediment. In Devil Lake, wave processes have been shown to prevent deposition in shallow water depths (Gilbert, 2003). Holocene sediment is typically transparent on seismic profiles (Eyles et al., 2000, 2003; Gilbert, 2003) and marks a dramatic reduction in the supply of clastic sediment to basins and the relative increase in importance of organic sedimentation during the present interglaciation (e.g. Moore et al., 1994). Gilbert (2003) noted a similar character in the uppermost facies of Devil Lake (Facies III) and coring this facies revealed black gyttja with an organic content ranging from 25% to 65%. The modern Shield surface, dominated by hard rock and only a patchy cover of Pleistocene sediment, does not generate significant volumes of clastic sediment for local rivers resulting in widespread sediment starvation in modern lakes.

No sediments older than the SS-1 can be identified on seismic records from Wanapitei Lake. This may be a consequence of the lack of penetration of the acoustic signal and/or the removal and reworking of preexisting sediment by glacial scour. The latter is highly likely as the basin was the source of substantial volumes of subglacial waters and coarse sediment flowing out from the margin of the Laurentide Ice Sheet when it lay south of the Wanapitei Basin along the Cartier Moraine (Fig. 3).

5. Constraints on the origin of the Lake Wanapitei basin

The Lake Wanapitei basin has been thought to have originated from an Eocene meteorite impact approximately 37 million years ago (Dence and Popelar, 1972; Wolf et al., 1980). Evidence cited by these authors includes an apparent circular shape of the basin, the finding of suevitic breccias in ‘float’ boulders along the southern margin of the lake and the presence of a circular gravity low (~15 mGal) under virtually the entire basin.

The circular shape of the basin is most evident along the northeast lake margin, east of the inflowing East Wanapitei River (Figs. 1 and 2). Here however, the shoreline comprises an extensive sand beach reflecting modern current activity and is unrelated (temporally and physically) to any Eocene event or underlying bedrock structure. The source of erratic boulders of suevite has never been identified but in the absence of any known outcrops in the district these boulders were inferred by previous workers to have been glacially eroded from the submerged portion of the Wanapitei basin and transported south as erratics (Dence and Popelar, 1972). Gravity data identifying a crater below Lake Wanapitei were corrected by these workers for the mass of lake water but not for terrain factors such as sediment infill thickness and bedrock topography. Additional seismic sections (this study) show that within the central portion of the basin sediment thickness is in excess of 35 m at water depths approaching 110 m.

Given the limitations of the database supporting a meteorite impact origin for the Lake Wanapitei basin, a key objective of this study was to identify the character of bedrock below the basin in order to constrain the geographic extent of cratering and deformed rock. In this exercise emphasis was placed on locating geologic structures that are known to traverse the entire basin. Of particular significance are several ~100 m wide diabase dikes belonging to the 1.2 Ga Sudbury dike swarm that outcrop as ribs on either shore (Fig. 2) and are inferred to cross the submerged portion of the Wanapitei basin. These intrusions are responsible for the strongly undulatory nature of the bedrock surface seen in the southeast quadrant of the basin (Fig. 7) and are easily identified as bedrock below the lake and sediment fill (e.g. Figs. 8 and 9). Their continuity across the submerged portions of the basin therefore affords potential vertical markers to assess any subsequent deformation that could be attributed to Eocene meteorite impact. L'Heureux et al. (2005) used total field magnetic data to confirm the continuity of dikes under the basin (Fig. 2) and were able to constrain the diameter of any impact crater to an area of <5 km in diameter where dikes could not be identified on magnetic data.

Acoustic signals fail to penetrate to bedrock anywhere in the inner target area identified in Fig. 4. Outside this area, seismic data are consistent with a bedrock character and surface form of that surrounding the lake basin. No disruption of this surface or underlying bedrock is apparent, nor does it show evidence attributable to impact cratering. In this regard, it is important to note that numerical modelling by L'Heureux et al. (2005) indicates that an impact crater with a diameter close to that shown in Fig. 4 should show evidence of widespread excavation, vaporization and melt to depths of 1.3 km. Correspondingly, any crater should be surrounded and underlain by a wide belt of deformed rock. High-resolution chirp seismic data presented here indicate that if Wanapitei Lake fills an impact crater, the latter is small and constrained to a relatively small portion of the submerged basin (Fig. 4). It is possible that the area identified as an impact crater is entirely the product of deep glacial erosion and overdeepening along the strike of the structural fault, and not do to an impact event. This is a key issue when attempting to differentiate between the effects of impact cratering and those of deep glacial erosion. Final resolution of this issue awaits the application of deep seismic methods and drilling across the axial trough of Lake Wanapitei.

6. Conclusion

The geophysical data presented here contribute to understanding the geology of a possible submerged Eocene impact crater basin in northern Ontario, Canada. In this paper we have shown how high resolution chirp seismic data can be used to constrain the size of the impact crater though we emphasize that the data by themselves do not confirm or negate an impact origin. Sonar data clearly identify the bedrock surface below the outer margins of Lake Wanapitei and constrain the location of any crater to an area of deep water with a diameter of less than 6 km where the bedrock surface is too deep to be imaged (Fig. 4). Deep drilling and coring is now required to examine the nature of the bedrock surface below a deep-water axial trough along the strike of the structural fault. Lying in an area subject to repeated Pleistocene glaciations, it is very likely that the basin, and evidence of a meteorite impact origin, has been substantially eroded by glacial activity.

Sonar data identify the nature of the glacial infill of the basin and the importance of glaciolacustrine sedimentation during late glacial times sometime after 10,500 years BP when the basin was deglaciated and immediately covered by the waters of Glacial Lake Algonquin. The modern lake can be said to be 'sediment starved', lacking any sizeable inputs of clastic sediment, as reflected in the markedly discontinuous extent of Holocene sediment (SS-2) and the widespread exposure of late glacial sediment (SS-1) across the modern lake floor. The discontinuous extent of such facies emphasises that the collection of seismic data and assessment of the broader distribution of Holocene lake floor sediments in any lake basin is essential to identify suitable locations for coring and for the study of postglacial climate.

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