Seismic shothole drillers' log records: A wealth of new permafrost-related geoscience information, Northwest Territories and northern Yukon, Canada

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ABSTRACT
Permafrost characteristics such as thickness, extent, and the presence of massive ground ice are often understood in detail at specific monitoring sites, but may be poorly constrained on regional bases. New research utilizing >275,000 seismic shothole drillers' log records collected throughout the Mackenzie corridor, Northwest Territories, and northern Yukon, greatly expands baseline geoscience and permafrost geology knowledge. Information interpreted from the drillers' log records include presence and thickness of massive ground ice, permafrost extent and thickness estimates in areas of discontinuous permafrost, occurrences of relic taliks, and the documentation of bottomfast ice extents in the offshore Mackenzie Delta.

RÉSUMÉ
Souvent, les scientifiques connaissent dans le détail les diverses caractéristiques du pergélisol, telles que l'épaisseur, la superficie et la présence de zones de glace massive au sol, dans des sites de surveillance précis, alors qu'on n'arrive pas à bien les définir à l'échelle régionale. Dorénavant, de nouvelles recherches permettent d'enrichir considérablement nos connaissances fondamentales en matière de géosciences et de géologie du pergélisol. Ces recherches ont été menées à partir de plus de 275 000 diagraphies de forage sismique, visant l'ensemble du corridor du Mackenzie, des Territoires du Nord-Ouest et du nord du Yukon. À partir de ces diagraphies de forage, les scientifiques ont tiré de nombreux renseignements, notamment la présence et l'épaisseur de zones de glace massive, des estimations de l'étendue et de l'épaisseur du pergélisol dans des zones de pergélisol discontinu, les cas relevés de talik (couche dégelée résiduelle) et ils ont documenté les étendues de glace stationnaire dans la zone hauturière du delta du Mackenzie.

1 INTRODUCTION

Over the past 3 years, research at the Geological Survey of Canada has undertaken the collection and digital rendering of all available seismic shothole drillers' log records from mainland Northwest Territories and Yukon held by Industry. Originally designed to aid surficial geology mapping activities, the immense amount and geographical extents of data have lent themselves to a much wider range of thematic geoscience and modelling reconstructions, including aspects of permafrost geology. Numbering >275,000 records (Smith and Lesk-Winfield, 2010a), with another ~70,000 records forthcoming, they extend across fifty-eight 1:250,000 map sheets, covering the Mackenzie corridor, Mackenzie Delta, and peripheral areas of petroleum exploration in the Northwest Territories and northern Yukon (Fig. 1). Although never intended for the uses to which they are now being applied, the seismic shothole drillers' log records provide an immense new resource of baseline, near-surface (10-60 m), lithostratigraphic geoscience data, contributing both important site-specific measurements, and reconstructions of regional trends and patterns (Smith and Lesk-Winfield, 2009; 2010b, c; Smith et al. 2009). This presentation highlights aspects of permafrost geology that have been elucidated from the data (Smith and Lesk-Winfield, in press).

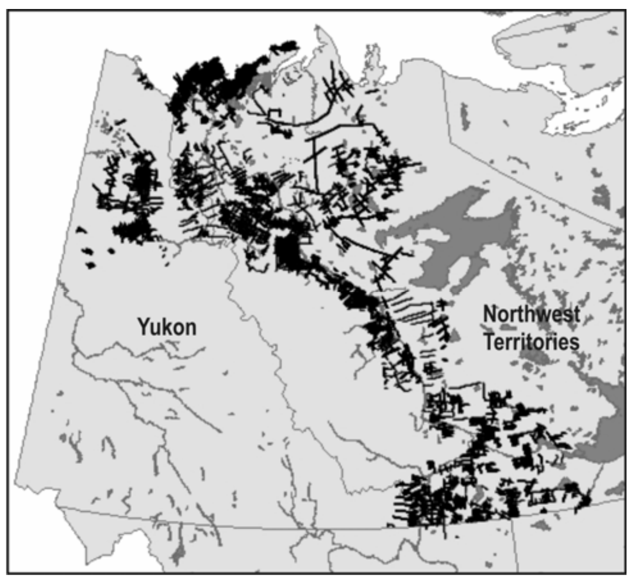

Figure 1. Spatial extent of seismic shothole drillers' log records (black lines) in Northwest Territories and northern Yukon (Smith and Lesk-Winfield, 2010a).

2 SEISMIC SHOTHOLE DRILLERS' LOGS

Seismic shothole log records are recorded by drill operators during geotechnical seismic operations when they auger/air-rotary drill holes to set explosive charges. Holes were drilled to varying depths, averaging 12-16 m, except in the Mackenzie Delta area where depths often range from 20-60 m. Database transcription of archival drillers' log records dating from the 1940s through to present, yielded over 14,000 unique log material descriptions. Standardization of terminology, spelling, punctuation, and removal of extraneous and/or vague descriptors (e.g., hard, soft, heavy, shattered) reduced the list to just over 4000 unique lithological descriptions, most of which pertain to permutations and combinations of <20 key terms. Descriptors of unconsolidated drift material include: muskeg, clay, silt, sand, gravel, rocks, boulders, and till. Bedrock descriptors include: shale, sandstone, limestone, coal, granite, rock, and bedrock. Sundry descriptors and adjectives include: frozen, ice, permafrost, wet, water, flowing hole, flowing sand, gas, sticky, cemented, blue, brown, black, and grey.

The shothole drillers are not, by nature, trained geologists and thus earth materials were logged at varying degrees of resolution and accuracy. There is no question that units such as clay and shale, and sand and sandstone are likely to have been misinterpreted at times. In some cases, the drillers made very detailed logs, recording the occurrence of even small (30 cm) lenses of material. Usually though, they simply noted major changes in lithology (e.g., 0-6 m, sand, clay, rocks; 6-15 m, shale). Elsewhere, they recorded the range of deposits encountered through the total depth of the hole, without actually identifying what individual unit thicknesses were (e.g., 0–10 m, clay, gravel, shale, sandstone). With these kinds of records, it is assumed but never entirely certain that the order of lithological units represents their stratigraphic position (e.g., clay at surface, underlain by gravel, underlain further by shale and then sandstone). Drillers may also have indicated the relative thickness and/or percent composition in the shothole of each lithological component (e.g., clay was the dominant material encountered, with lesser amounts of gravel, shale and sandstone). In cases of compound drift units such as "0–5 m, clay, sand, ice, boulders" it is assumed that the list follows decreasing material abundance.

As the compilation of drillers log records is largely new, they have yet to be extensively field verified. Users of the shothole drillers' log data are thus cautioned to employ the adage that if a record indicates a particular unit as being present, then it might well be there, but if it's not identified as being there, it doesn't necessarily mean it isn't, it may be that the driller simply didn't report it. That said, use of these drillers' log records by A. Duk-Rodkin and D. Huntley (GSC) in support of surficial geology mapping activities in the southern Mackenzie corridor over the past 3 years, and of other shothole drillers' logs in northern British Columbia (Levson et al. 2004) have demonstrated them to be a reliable, albeit simplified, lithostratigraphic archive.

Shothole locations are another potential source of uncertainty when dealing with this data. Coordinates were either transcribed/interpolated from surveyed shotpoint SEG files provided by Industry, or were digitized from seismic line maps. Presumably as the accuracy of surveying has increased over time, so too have the locations. Digitizing of points from seismic line maps follows a somewhat involved methodology, and is described in Smith and Lesk-Winfield (2010a; OF6049/doc/html/Background.htm). Correction of map-interpreted data with SEG files reveals them to be generally <150 m off of the surveyed SEG data. Surveys by this author of SEG-generated seismic lines in the Mackenzie Delta (most are still clearly visible on the landscape) reveal the majority of lines to be within ±50 m of their database coordinates.

2.1 Drillers' Logs and Permafrost Geology

There are several reasons why the seismic shothole drillers' log records contain potentially useful observations on permafrost geology. Having worked extensively with the data, and through discussions with drill operators, it is noted that drillers were adept at recording "difficult" and/or "unusual" materials including those that either hindered their progress, or led to collapse of the shotholes; examples of these included massive ice bodies, and gravel. Relative extents of frozen versus unfrozen ground would also have affected drilling rates, and thus have been noted to account for their progress. Another factor of potential benefit for the application of shothole drillers' logs to the study of permafrost geology is that once a hole was drilled the explosive charge would be inserted, and then would either be tamped in with sediments, or as was the case in many of the Mackenzie Delta seismic programs in the 1960s and 1970s, the holes were flooded with water which was then allowed to freeze-in the charge. Noting areas of unfrozen sediment was thus important to determining the manner in which the charge was seated in the hole, and how that might ultimately affect the transmission of the percussive energy wave into the ground. It was also useful for identifying potential reasons for "blow-outs" (indicating an undesired up-hole dissipation of energy and loss of signal/seismic resolution) once the charges were triggered.

As it pertains to permafrost geology, combinations and permutations of drillers' log terms *ice*, *frozen*, *wet*, and *water* are used to query records for subsequent interpretation. Reports of "permafrost" in the drillers' logs are problematic, in that it is unclear what exactly is meant by this. In some cases, it appears that "permafrost" was used to identify frozen ground, without actually identifying what the frozen materials were (e.g., 0-10 m, permafrost). In others, it is suspected that "permafrost" was used by the drillers to identify buried ice (e.g., 0-10 m, muskeg, clay, rocks, permafrost layers; or 0-10 m, clay, rocks, permafrost, sand). Further still, it appears that in some cases "permafrost" may have been confused for muskeg (e.g., 0-2 m, permafrost, 2-10 m, clay, rocks, shale; or 0-10 m, permafrost, clay, rocks). For these reasons, "permafrost" when occurring at depth, or for thicknesses considered unlikely to relate to a surface muskeg layer, is assumed to indicate frozen conditions, and hence can be used to discriminate unfrozen deposits above or below it (e.g., 0-6 m, clay, rocks, permafrost; 6-10 m, wet sand), but is not included in compilations of ice and/or massive ice below surface.

Note, for all intents and purposes, discussion in this paper regarding the thermal state of drillers' log records is made in relation to "ice-bonded permafrost." Sediments in drillers' log records described as being unfrozen (i.e., wet and/or water) could well lie above the zero-degree isotherm that most accurately determines the depth of permafrost. Thawing of "warm permafrost" as a consequence of kinetic energy dissipation (frictional and vibrational) by the coring process could also have occurred, but is considered unlikely by drill operators based on discussions with them.

Initial queries of the shothole drillers' log database yielded 30,617 records that included "ice" and/or "frozen;" an additional 9021 records were returned that included mention of "wet" and/or "water" along with "ice," "frozen" and/or "permafrost" (e.g., 0-6 m, frozen clay, rocks; 6-10 m, sand, gravel, water). A final query isolated 10,332 records that included "wet" and/or "water" for which no indication of stratigraphically over/underlying frozen material was found. The premise behind this final query was that information could be interpreted to either indicate non-permafrost conditions (e.g., 0-10 m, wet clay, gravel), or by inference, provide estimates of maximum permafrost thickness, if it were assumed that overlying sediments (despite not being reported so) were frozen (e.g., 0-8 m, clay; 8-12 m, wet sand). An additional 3489 records of ice/massive ice were interpreted from the Côté et al. (2003) collection of seismic shothole drillers' log records in the Mackenzie – Beaufort region.

Clearly, practical limitations posed by the relatively shallow nature of seismic shotholes (i.e., generally <20 m), suggests that assessments of minimum/maximum permafrost thicknesses are only likely to be useful in areas of extensive discontinuous permafrost, and possibly areas of thin permafrost in the sporadic discontinuous permafrost zone. Elsewhere, indications of unfrozen conditions below surface could be used to infer existing or relic taliks.

3 RESULTS AND DATA DISTRIBUTIONS

This section presents key thematic permafrost-related reconstructions derived from seismic shothole drillers' log records. Overall spatial distributions and simplified symbology derived from Smith and Lesk-Winfield (in press) are illustrated to demonstrate the potential of this dataset to advance permafrost geology studies in northwestern Canada.

3.1 Massive Ice

While massive ice is formally defined as being a mass of ground ice containing >250% gravimetric water content (Permafrost Subcommittee, 1988), in the present study, massive ice is simply defined as stratigraphic layers of ice with defined thicknesses (almost all are >1 m; Fig. 2A). That the drillers reported these as only "ice" does not preclude the presence of sediments or sediment layers within them. Records that identified the presence of "ice layer(s)" without actually defining their thickness are indicated by triangles (Fig. 2B).

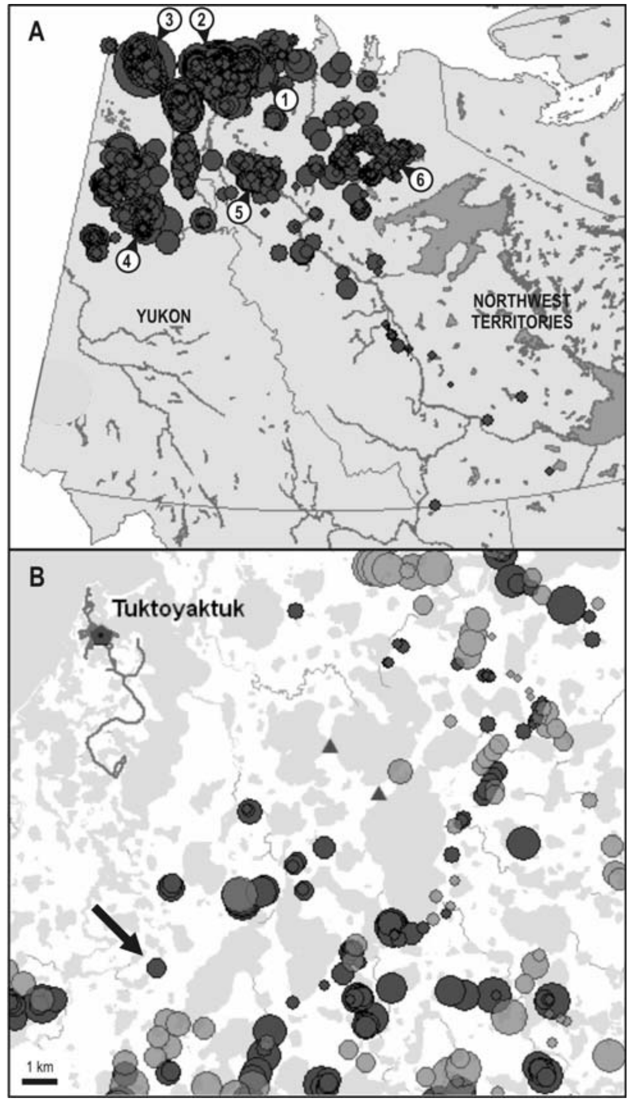

Figure 2. Massive ice records. **A** Distribution of shothole drillers' log records of massive ice represented by circular thickness-proportional symbols. Highest concentrations are found in the Tuktoyaktuk Peninsula – Richards Island – Beaufort coast areas (sites 1, 2, 3, respectively), with lesser occurrences in Eagle Plains (site 4), Little Chicago (northern Mackenzie corridor, site 5), and Colville Hills region (site 6). Few records are found in the central and southern Mackenzie corridor. **B** Detail of massive ice records southeast of Tuktoyaktuk, Northwest Territories. Dark circles are records derived from Smith and Lesk-Winfield (2010a); lighter circles are from Côté et al. (2003). Symbols illustrate thicknesses between 1 and 30 m; arrow points to a record interpreted to be 9.2 m thick (0-4.5 m, clay, rocks; 4.5-13.7 m, ice; 13.7-40 m, sand).

There are 1242 records of massive ice with defined thicknesses and 393 ice layer(s) (thickness undefined) records from the Smith and Lesk-Winfield (2010a) shothole database, and an additional 869 massive ice records from the Côté et al. (2003) database (Fig. 2).

Reported thicknesses range up to 60 m, and are in accordance with more precisely logged drill surveys (cf., Mackay, 1973; Mackay and Dallimore, 1992; Smith et al. 2005). Massive ice occurrences are most prevalent and generally thickest in the Tuktoyaktuk Peninsula, Richards Island, and Arctic Coastal Plain west of the Mackenzie Delta areas (Fig 2A, sites 1, 2, 3, respectively). Other concentrations include the Eagle Plain region of northern Yukon (site 4), and scattered occurrences in the Little Chicago (northern Mackenzie corridor; site 5) and Colville Hills region (site 6). Increasingly isolated, thinner, and rare massive ice occurrences are found southward along the Mackenzie corridor right to the territorial-provincial border (60°N). In comparison with established permafrost zones (Heginbottom, 2000), massive ice is most prominent in the continuous permafrost zone, and is conspicuously absent or rare in the extensive discontinuous permafrost zone, particularly as it defines the modern Mackenzie Delta (west of Middle Channel; cf., Smith and Lesk-Winfield, in press).

Mackay and Dallimore (1992) documented an association between sediment type and the situation of massive ice. Sediments overlying massive ice were found to be predominantly fine-grained, while those underlying massive ice tended to be coarse-grained (typically sand). Preliminary assessment of the shothole database lithostratigraphic records (Smith and Lesk-Winfield, 2010a) confirms this relationship throughout the Tuktoyaktuk Peninsula area. Analysis of this relationship across the data extents, and in different stratigraphic settings, awaits the final input of drillers' log records that cover a significant data gap across much of the central Mackenzie Delta. Characterization of massive ice distributions based on depth below surface is also being assessed using this database.

3.2 Presence of Ice (thickness undefined)

The use of seismic shothole drillers' logs to distinguish between massive ice and segregated ice lenses is imperfect as it presumes a level of detailed stratigraphic logging that was unlikely to have occurred. Shothole drillers' records that included ice as part of a compound sedimentary log (e.g., 0-10 m, clay, sand, ice) were excluded from the massive ice compilation, but are instead presented as a separate layer entitled "Ground Ice (unknown thickness)" (Fig. 3; Smith and Lesk-Winfield, in press). It is quite likely that many of these "Presence of Ice" records represent massive ice deposits, and indeed may predominantly reflect thinner such deposits. The portrayed regional massive ice distribution (Fig. 2A) may thus be accordingly biased towards thicker deposits.

There are 8653 records of "ice" (excluding seasonal sea, lake and river ice cover) in Smith and Lesk-Winfield's (2010a) shothole database, and an additional 2620 in the Côté et al. (2003) shothole database (Fig. 3). The distribution of the more abundant "ice" records expectantly mirrors that of the main "massive ice" locals, with some significant differences. Unlike the absence of massive ice records, ice is recorded sporadically in the Mackenzie Delta shotholes, but are absent from the majority of these shothole records. Similarly, ice records are also found across the central Anderson River area (Fig. 3A, site 1) in addition to the Colville Hills (site 2). Ice records are more prevalent than massive ice records in the northern part of Eagle Plain (northern Yukon; Fig. 3A, site 3), and particularly in the Ramparts River region west of Fort Good Hope in the central Mackenzie corridor (Fig. 3A, site

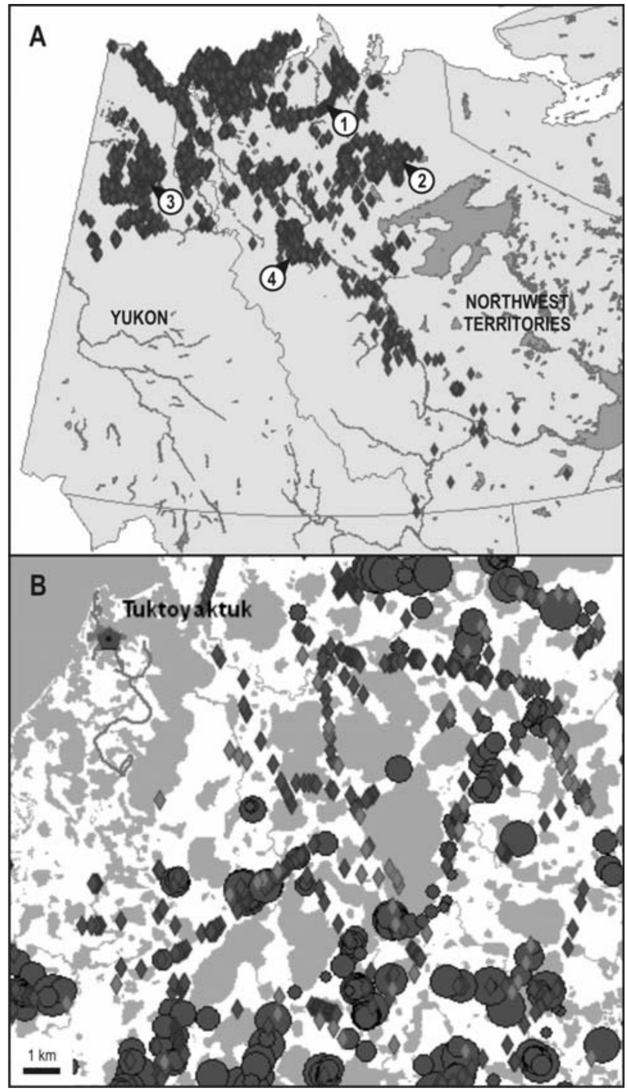

Figure 3. Ground Ice (thickness undefined) records. A Distribution of shothole drillers' log records of "ice" from compound sedimentary logs, represented by diamond symbols. Numbers refer to sites discussed in the text: Anderson River (1), Colville Hills (2), Eagle Plain (3), Ramparts River (4). B Detail of "ice" records southeast of Tuktoyaktuk, Northwest Territories, along with massive ice records (Fig. 2B). Dark diamond symbols are ground ice records derived from Smith and Lesk-Winfield (2010a), lighter diamond symbols are ground ice records from Côté et al. (2003).

4). Ice records are found throughout the southern Mackenzie corridor, but still remain sparse overall in comparison with the total shothole distribution. They are also decidedly less abundant than has been documented by geotechnical borehole and ditch wall field studies (Aylesworth et al. 2000; Burgess and Lawrence, 2000; Smith et al. 2005), suggesting that the seismic shothole drillers' logs do not effectively record thin ice layers. Detail of the Tuktoyaktuk region (Fig. 3B) illustrates both the widespread co-occurrence of massive ice and ice records, and the occurrence of ice records in areas without shothole-based massive ice observations. The abundance of ice and massive ice records in proximity to the margins of lakes southeast of Tuktoyaktuk (Fig. 3B) likely confirms the thermokarst origin for many of these basins.

3.3. Estimates of Permafrost Extent/Thickness

Stratigraphic analysis of permafrost-related drillers' log records permits estimation of ice-bonded permafrost thicknesses in areas where shothole depths (10-20 m) are comparable to that of measured permafrost thicknesses. Drillers' logs can be interpreted as recording either defined (e.g., 27 m: 0-27 m, frozen sand; 27-34 m, wet sand; [575 records]), maximum (e.g., 36 m: 0-36 m, frozen sand, wet clay; or 24 m: 0-6 m, frozen clay; 6-24 m, sand; 24-36 m, wet sand; [266 records]), or minimum estimates (e.g., 18 m: 0-18 m, clay, ice; or 6 m: 0-3 m, sand, clay, rocks; 3-6 m, ice; 6-12 m, gravel [25,846 records]).

Figure 4 illustrates minimum estimates of ice-bonded permafrost thicknesses in the Jean Marie River area of southern Mackenzie River, Northwest Territories, adjacent to the boundary between the sporadic discontinuous and extensive discontinuous permafrost zones (Heginbottom, 2000). Sites 1 and 2 (Fig. 4) are permafrost monitoring stations (Smith and Burgess, 2002). Site 1 has three monitoring stations, with zero degree isotherm depths ranging from 4-12.4 m, while site 2 reports a zero degree isotherm depth of 2 m. Two large X symbols shown on Fig. 4, one north of site 2 and another northwest of site 1, are observations reported by Smith and Burgess (2002) of "no permafrost present." Four "defined" permafrost thickness estimates between 1.52-6.10 m are situated in Fig. 4; site 3 indicates a permafrost depth of 1.52 m (log 0-1.52 m, frozen muskeg; 1.52-4.57 m, wet muskeg; 4.57-10.67 m, sand; 10.67-15.24 m, clay; shothole date March 19, 1969). More than 140 sites on Fig. 4 record minimum estimates of permafrost thickness between 1-10 m (square symbols); site 4 indicates permafrost thickness is >4.57m (log 0-4.57 m, frozen clay, rocks; 4.57-12.19 m, clay; 12.19-15.24 m, shale). There are 32 sites on Fig. 4 that indicate minimum estimates of permafrost thickness between 10-20 m (round symbols); site 5 is >10.6 m (log 0-10.67 m, frozen sand; 10.67-15.24 m, clay), and site 6 is >13.72 m (log 0-13.72 m, frozen sand; 13.72-16.76 m, clay).

3.4 Interpretation of Unfrozen Material Records

The identification of unfrozen materials ("wet" and/or "water") can be interpreted in several different ways

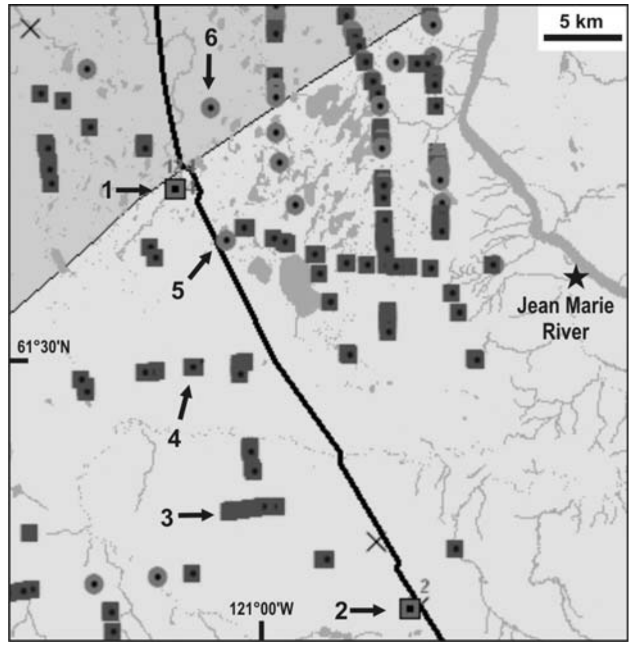

Figure 4. Seismic shothole drillers' log-derived estimates of minimum ice-bonded permafrost thicknesses in the Jean Marie River area, southern Northwest Territories. Squares represent sites with minimum estimates between 1-10 m; circles represent sites between 10-20 m. Numbered sites are referred to in the text. Dark, north-south oriented line is the path of the proposed Mackenzie Valley gas pipeline. Figure straddles the extensive discontinuous (dark shading) and sporadic discontinuous (lighter shading) permafrost zones.

depending on their stratigraphic situation, and the nature of over and underlying lithological records. In areas of sporadic and extensive discontinuous permafrost where wet sediments are described at surface, and with no indication of frozen material below, it may indicate that the site has no permafrost. In areas of thin permafrost such as is described in section 3.3 above, unfrozen sediments situated below frozen material can be used to constrain the depth of ice-bonded permafrost. While permafrost depths can be highly variable, reflecting such factors as sedimentology, vegetation, snow cover, and proximity to large water bodies, areas of permafrost in the territories outside of the sporadic discontinuous zone and parts of the Mackenzie Delta, is likely to have thicknesses greater than what most seismic shotholes are drilled to. Therefore, drillers' log records are unlikely to reliably constrain permafrost thicknesses in these areas. Interpretation of wet/water in drillers' logs from these areas is considered to largely record unfrozen materials relating to existing or relic taliks. Where shotholes are located below existing water bodies, the depths of unfrozen material can then be used to estimate talik thickness (e.g., 0-1.5 m, ice; 1.5-4.6 m, water; 4.6-42.7 m, wet clay). Where unfrozen sediments are reported at depth (several hundred records), or between frozen layers (14 records), they may represent relic taliks. In these cases, it is assumed that the site was previously covered by a lake or river, which subsequently has drained, or in the case of rivers, has experienced channel migration away from the site. Aggradation of permafrost back into the talik would occur in 3 dimensions, such that an area of unfrozen sediments/water could exist below upper frozen sediments. Such complex talik histories may be common in areas of the Mackenzie Delta as well as areas characterized by thermokarst lake formation and drainage. Caution however is required with any shothole drillers' log-based interpretations of taliks/permafrost thickness estimates in the Mackenzie Delta area owing to its complex geomorphic and thermal histories, sharp permafrost thickness gradients, and discontinuities between the base of ice-bonded permafrost and the base of the zero-degree isotherm (Taylor et al. 1996; Smith and Burgess, 2002).

3.5 Bottomfast Ice

Areas of sea ice that seasonally freeze down to the underlying sediments are referred to as bottomfast ice. In the Mackenzie Delta and coastal Beaufort Sea area, bottomfast ice extents are important as they control areas of overflow during the spring freshet, pose hazards to potential offshore infrastructure development (e.g., pipelines), and influence the development of surface permafrost conditions in marine sediments (Forbes and Taylor, 1994; Solomon et al. 2008). In seismic lines that extended offshore in shallow areas of the Mackenzie – Beaufort region, drillers often recorded thicknesses of ice and/or water overlying sediment. Offshore areas where ice was frozen right to the underlying sediments were identified either stratigraphically (e.g., 0-2.5 m, ice; 2.5-36 m, sand, clay), or as interpreted from a compound log (e.g., 0-18 m, ice, sand, gravel). Floating ice on the other hand was identified by logs such as: 0-1.5 m, ice; 1.5-5.2 m, water; 5.2-27.4 m, clay, silt; or, 0-31 m, ice, water, sand, clay. Figure 5 presents preliminary reconstructions of bottomfast and floating ice extents based on seismic shothole drillers' records in the outer Mackenzie Delta.

Areas of bottomfast ice (square symbols) are found in several of the channels and extending outward from many of the headlands. The bottomfast ice extents correlate well with those observed through field and radar studies (cf., Hirose et al. 2008; Solomon et al. 2008). Of particular significance though, is that the drillers' logs provide temporal records of bottomfast ice extents, largely from the 1960s-1970s, that allow both seasonal variations to be assessed, and document extents prior to any widespread study of its distribution. The drillers' log records can also be used predictively to test for areas of bottomfast ice outside of existing field/radar study areas.

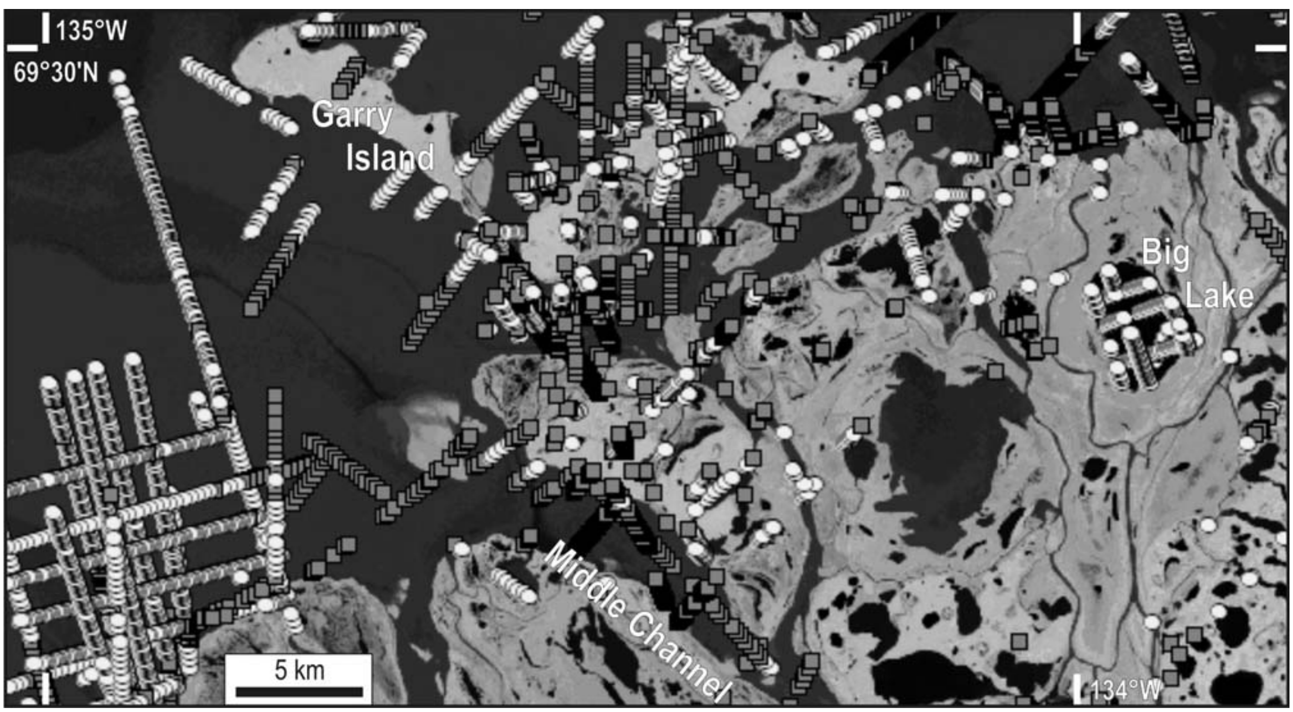

Figure 5. Map showing distribution of seismic shothole drillers' log-interpreted bottomfast ice (squares), and floating ice (circles) records in the outer Mackenzie Delta, Garry Island region of Northwest Territories. Records span the years 1968-2000. Coastal headlands and Middle Channel appears to be extensively occupied by bottomfast ice, while west of Garry Island there appears to be a prominent channel of floating ice. Big Lake and other terrestrial water bodies support floating ice covers, while many of the smaller lakes and ponds are indicated to freeze to the bottom.

They can also be used to identify areas of bottomfast and floating ice in lakes and river channels. Figure 5 illustrates that Big Lake is covered by floating ice (1.5-1.8 m thick), while the water body directly west of Big Lake freezes to the bottom (0-1.2 m, ice; 1.2-31 m, sand, clay). This then becomes a useful tool for remote sensing studies such as Hirose et al. (2008) and expands the knowledge of seasonal lake ice cover extent beyond the Mackenzie Delta. It may also be of use in documenting potential changes in ice thickness over time, and helping characterize areas of lake-associated talik formation.

4 CONCLUSIONS

The seismic shothole drillers' log records provide both an opportunistic and serendipitous documentation of ground ice and permafrost geology related observations. As part of normal lithostratigraphic core logging, and by noting sediment properties that were difficult to drill through, or influenced whether charges were frozen in or tamped in, the seismic shothole drillers coincidentally recorded observations that provide a wealth of regional litho- and thermostratigraphic information. Despite uncertainties inherent to the drillers' log records, a cautious interpretation of the data has yielded a number of regional permafrost-related reconstructions including: thickness and extents of massive ice, presence of ground ice (undefined thicknesses and morphology), estimates of ice-bonded permafrost thicknesses in areas of thin and discontinuous permafrost, identification of modern and relic taliks and their thicknesses, a unique temporal record of bottomfast ice extents in the offshore Mackenzie Delta, and the ability to identify terrestrial water bodies that seasonally either freeze to the bottom, or support floating ice covers.

Inherent strengths of the seismic shothole drillers' log data comes from the shear number of records and their widespread geographic distribution, particularly in areas where little or no formal field investigation has taken place. This may well be the greatest benefit of capturing the drillers' log records, in that they provide observations that can be used to direct future detailed scientific investigation. In this way, they will help improve the efficiency of field studies, and identify oddities and/or patterns in permafrost-geology that help to focus site specific and regional studies.

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