Understanding the Material Properties of the Ice-Bed Interface of the Greenland Ice Sheet: Subglacial Lakes or Pools of Sediment

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Introduction

Data from active seismic sources along with the program Reflectivity were used to determine the material at the ice-bed interface at a specified location L2 in northwestern Greenland, which is a proposed lake. If subglacial lakes are new, they may be features of climate change.

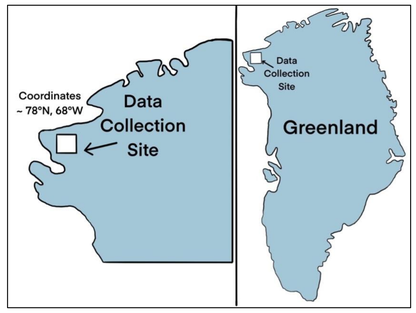

Figure 1.
Map of Greenland showing the collection site.

Hypotheses

- The ice sheet is frozen directly to the bedrock.
- The material at the ice-bed interface is water.
- The material at the ice-bed interface is sediment.

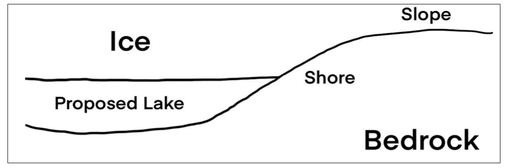

Figure 2.
Cross section of proposed lake.

Results

- A best fitting model was determined for each of the types of models; water, sediment, and bedrock. The time of the arrival and amplitude of the wave was clipped and normalized to have a maximum of one using a program that was written, called TimePicking.
- A type of normalization called L2 normalization was used to find the misfit between the seismograms from data and the synthetic seismograms.
- A global minimum, meaning the misfit is the lowest and the data and synthetic agree the most, occurs at model number 55, which is outlined in figure 6. The value for this misfit is 41.17.

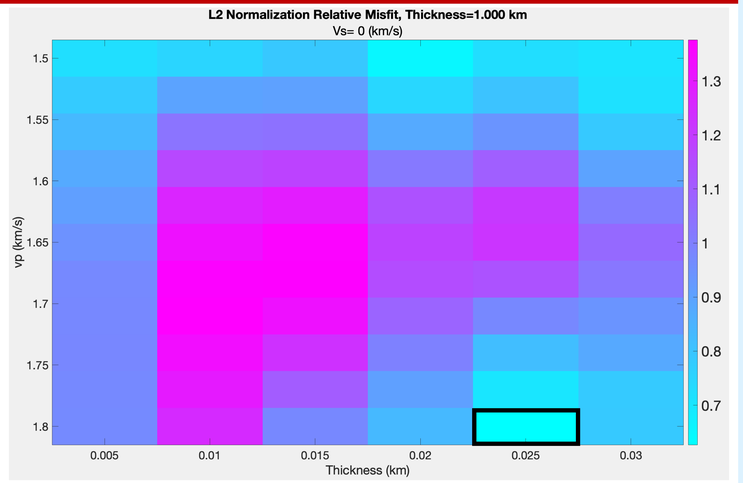

Figure 6.
Normalized relative misfit with a minimum at 0.25 km and 1.8 km/s.

Methods

Data were collected in northwestern Greenland above location L2 in 2018. The program Reflectivity was used to produce synthetic seismograms to compare with the seismograms from the data. Input parameters such as P-wave velocity (vp), S-wave velocity (vs), thickness, and density were varied in Reflectivity. The seismograms were compared using a series of codes that were written called ComparisonCodeWater, ComparisonCodeSediment, and ComparisonCodeBedrock.

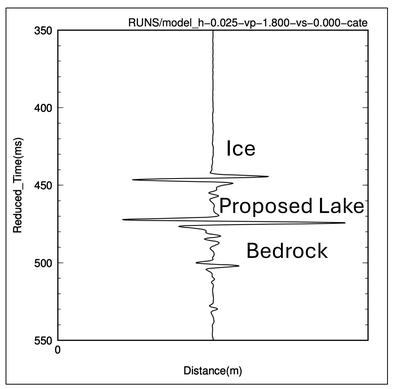

Figure 3.
Example of synthetic seismogram produced by Reflectivity.

<u>Parameters</u>:
Thickness= 0.025 km
vp= 1.800 km/s
vs= 0.000
Density= 1.000 g/cm^3.

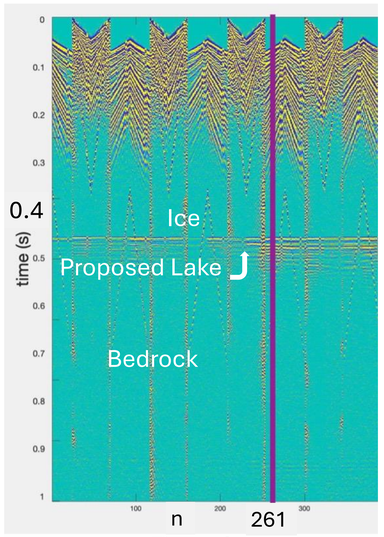

Figure 4.
Data from the active source experiment. N is the index of the seismograms. The purple line at n=261 is the index that the data was taken from for this project.

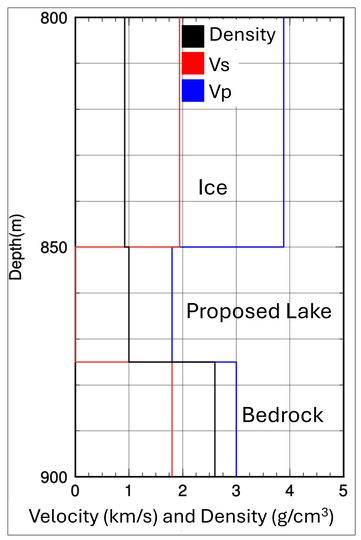

Figure 5.
Depth, velocity, and density profile of a water model with thickness of 0.015 km, vp of 1.5 km/s, vs of 0 km/s, and a density of 1 g/cm^3.

- The seismogram for closest matching model, model 55 is plotted with the seismogram from data in figure 7.
- There were global minimums for the sediment and bedrock models as well, but the misfit for water was found to be the lowest. The misfit values for sediment and bedrock are 43.82 and 94.31, respectively.

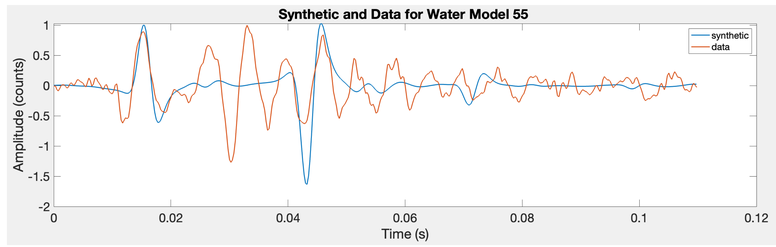

Figure 7.
Synthetic seismogram and seismogram from data plotted together for model 55.

Conclusions

- The results for water, sediment and bedrock basal models supports the hypothesis that the material at the ice-bed interface at location L2 is consistent with water. The model cannot distinguish if the water is saline or fresh.
- The best fitting model for water had parameters of a thickness of 0.025 km, a vp of 1.8 km/s, a vs of 0 km/s, and a density of 1 g/cm^3, but there is a model space of lower velocity and variable thickness that could also fit the data.

Future Work

- Additional models with different values for attenuation for the synthetic seismograms may lead to more accurate results. Also, changing the input parameters to have smaller step sizes would refine the results.
- Clipping the seismograms to different times leads to a different and more accurate result. The parameters for that model are a thickness of 0.010 km, a vp of 1.5 km/s, a vs of 0 km/s, and a density of 1 g/cm^3.

Acknowledgements

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