



Ground Truthing GPR Profiles: Half Moon Lake, Eau Claire, Wisconsin

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Introduction

The objective of this study was to expand ground-truthing of ground penetrating radar (GPR) profiles of Half Moon Lake. Ground-truthing involved coring along GPR profiles in order to assess the accuracy of past GPR profile interpretations of sites (Fig. 1). Coring results provide accurate thickness and makeup of the lacustrine sediment at site-specific locations. Analysis of these cores allows for more precise interpretations of the GPR patterns.

Anomalies along the mostly horizontal GPR reflection patterns exist at several points along GPR profiles. In the past, these anomalies have been interpreted as logs or mounds of woody sediment that date to the logging era. Cores from these anomalous sites allowed us to determine their composition and why they exist.

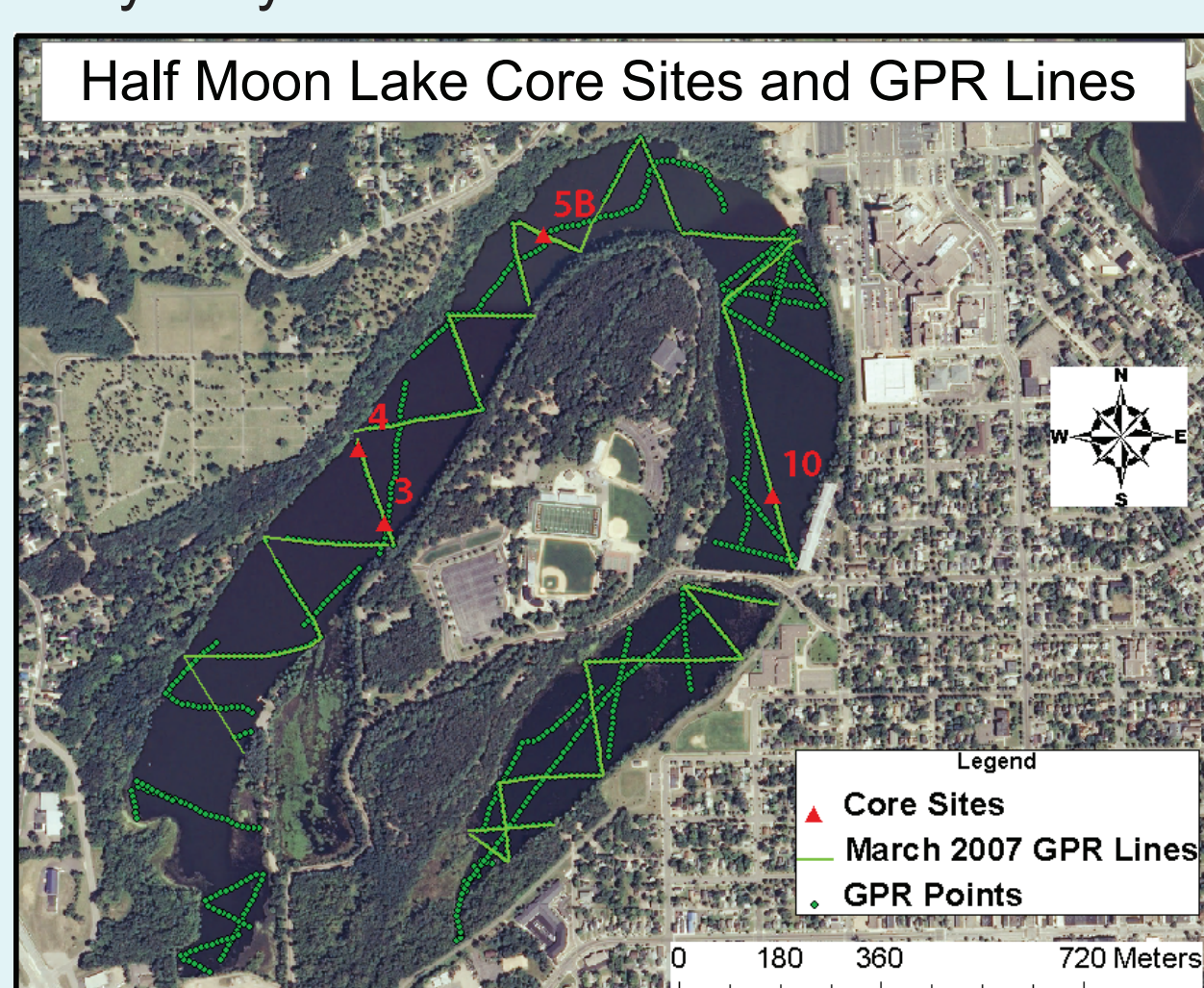


Fig. 1: GPR Lines and cores sites over an aerial photo

Study Area

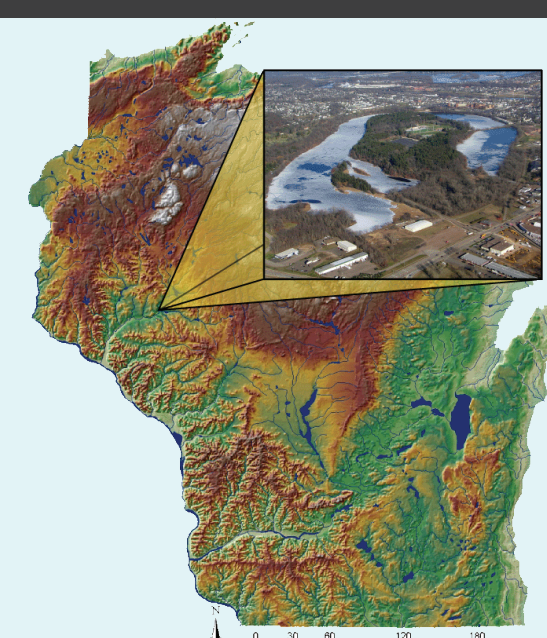


Fig. 2: HML Location

Half Moon Lake (HML), located in the city of Eau Claire, Wisconsin (Fig. 2), is presently in a eutrophic state. The abundance of vegetation growth is due to high levels of phosphorus in the lake, the major source of which is organic-rich sediment. Much, if not most, of this sediment may be a legacy of the logging era (mid 19th century to the 1920's). During much of that time, HML was used as a log-holding pond, both for sawmills along the lake's shoreline and for sawmills located downstream along the Chippewa River. Practices of the logging era resulted in the accumulation of significant quantities of organic-rich sediment in HML.

Previous Work

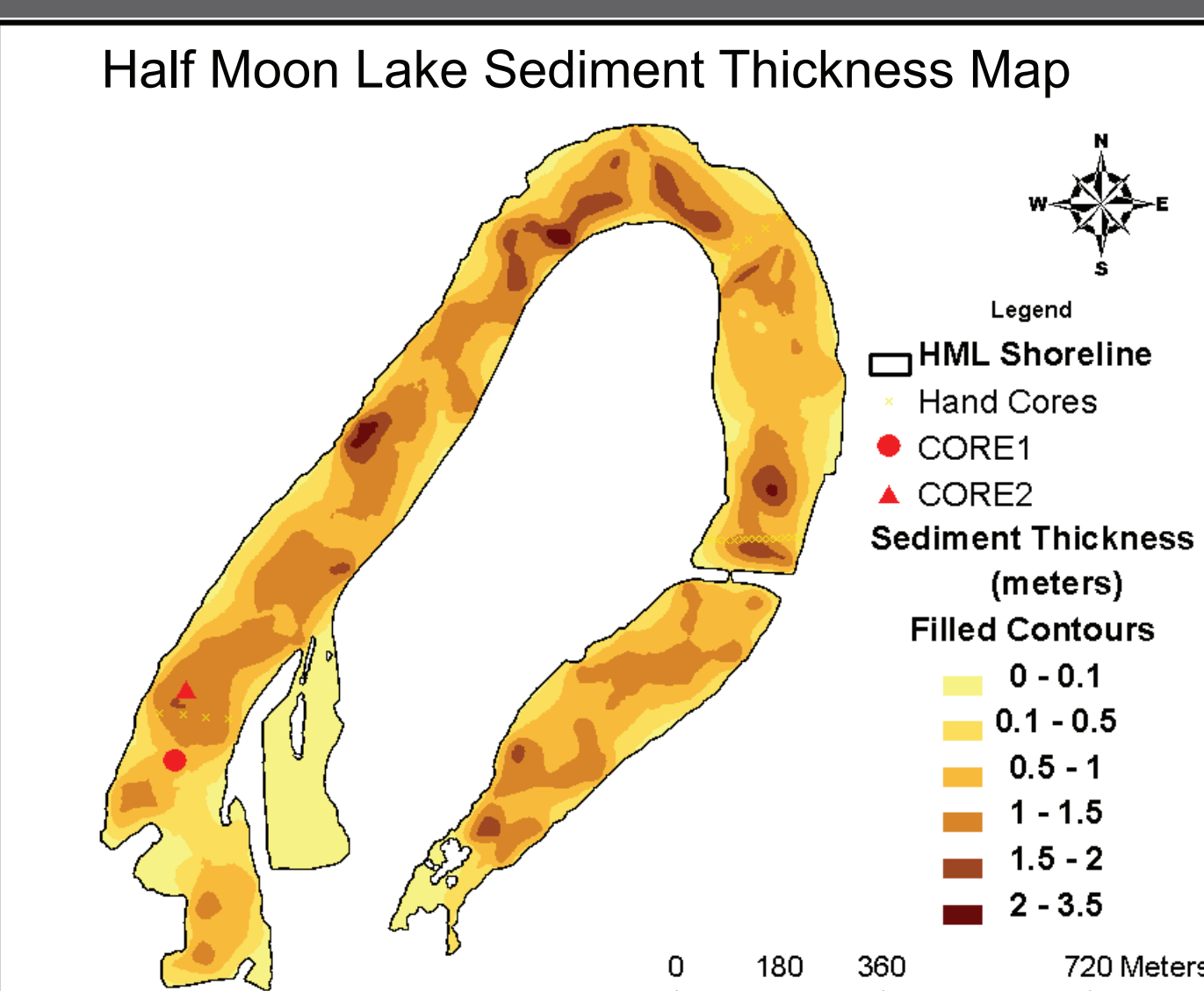


Fig. 3: HML sediment map created using ArcGIS (Dryer 2008)

To investigate, map, and identify subaqueous deposits in HML: 1) GPR was utilized to collect profiles of the industrial organic waste, 2) a Trimble ProXR GPS was used to map and georeference GPR transects, 3) a vibracore (without piston or monopod) was used to extract two lake sediment cores and ground truth GPR transects, 4) a sediment thickness map of industrial organic waste was created (Fig. 3).

Due to its non-invasive nature of imaging through sediments in sensitive environments, GPR was adopted as a methodology. GPR operates by transmitting electromagnetic (EM) pulses into the subsurface and measuring the return time from subsurface reflections.

Methods

In order to core HML's lacustrine sediment, a monopod and piston vibracoring system was used. The monopod system (Figs. 4,5) was fabricated at UW-Eau Claire following the design of Dr. Timothy Fisher (2004).

Cores were split and described at the National Lacustrine Core Repository (LacCore) at the University of Minnesota. High resolution photos of the cores were also taken, providing an accessible visual record that makes further descriptive analysis possible.

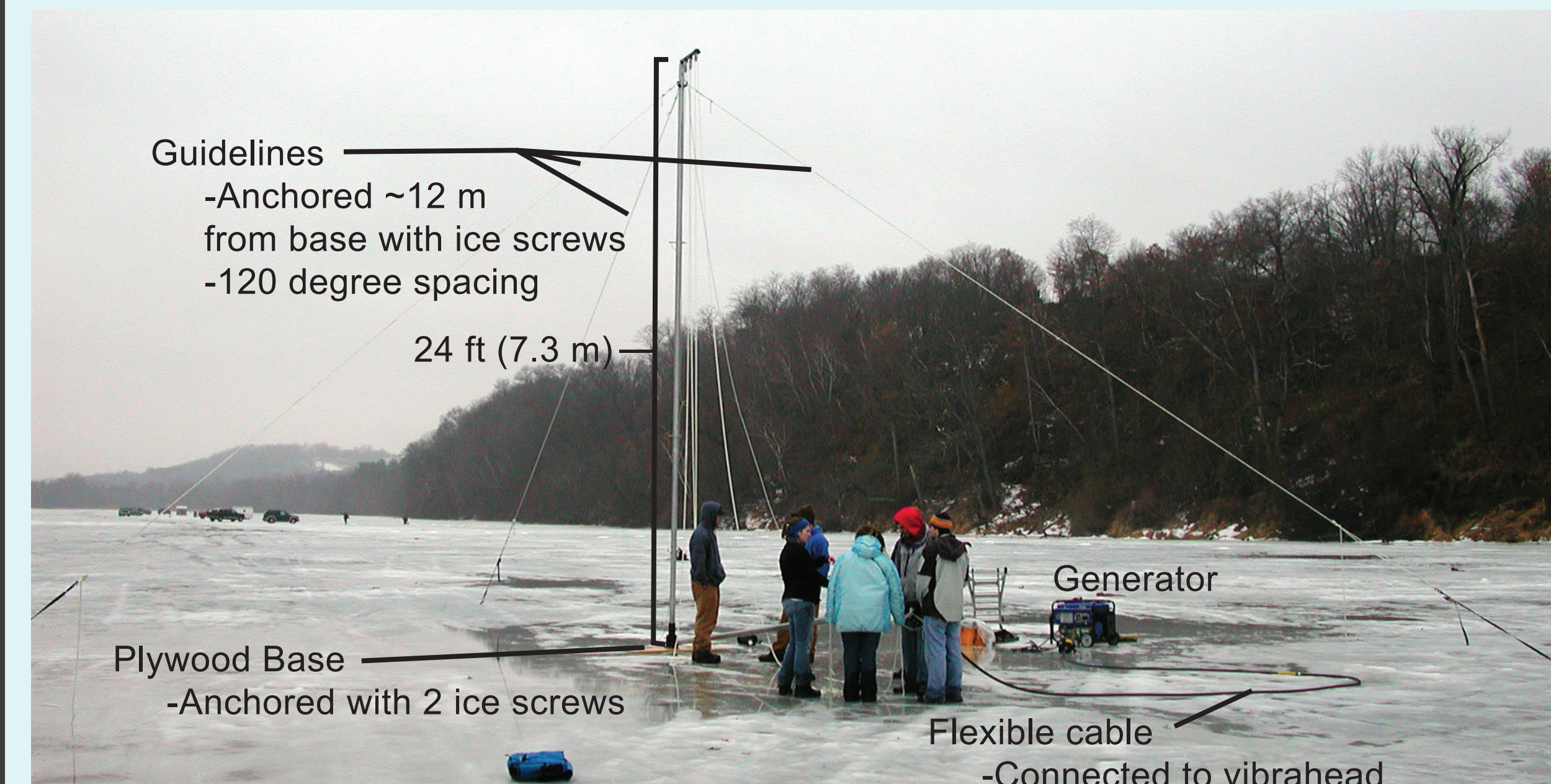


Figure 4: Vibracoring HML-5B with UWEC's Geography 364 class on February 11, 2009



Figure 5: The vibrahead and core tube are visible while coring HML-4

Results and Interpretation

HML-3

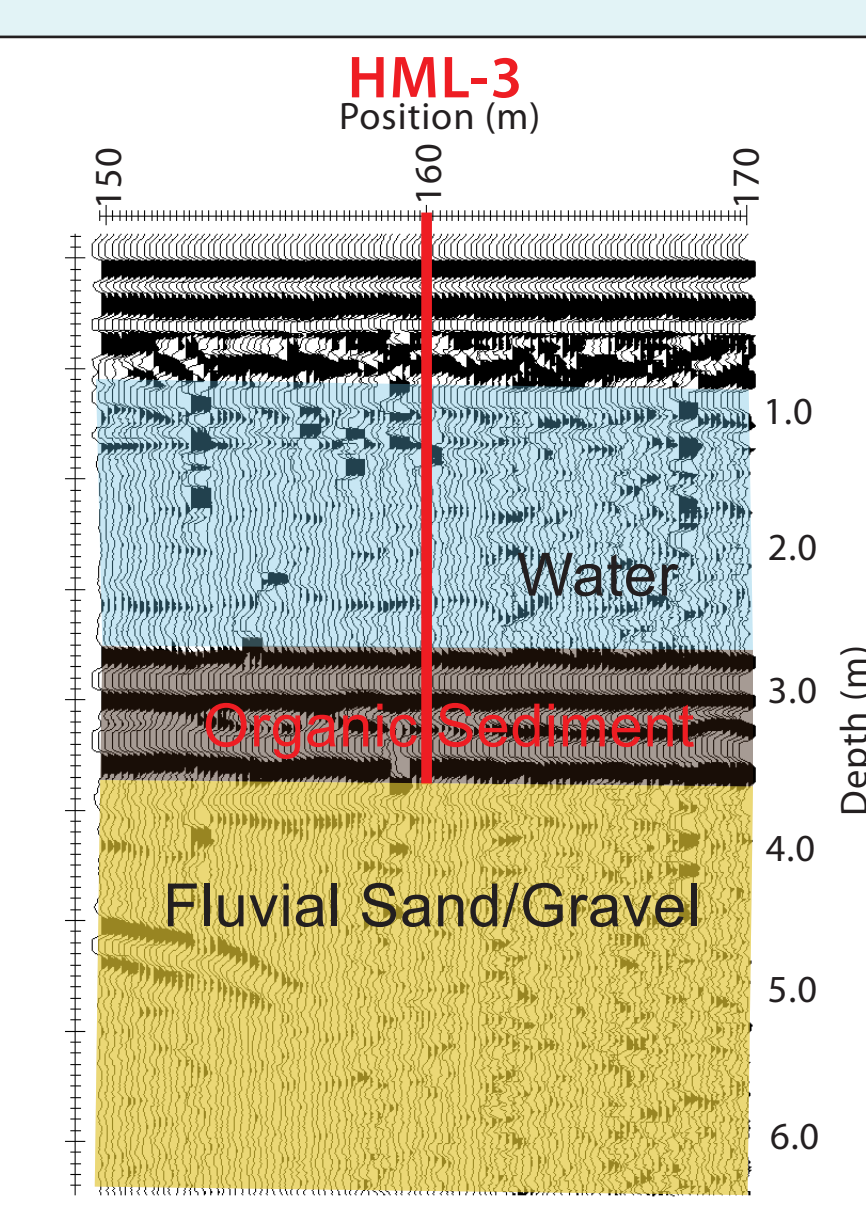


Figure 6: HML-3 GPR Profile

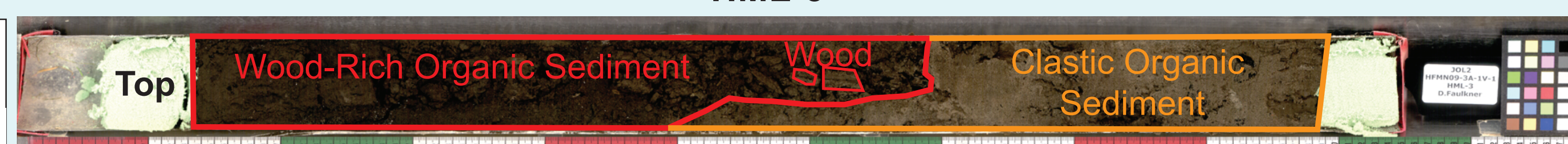


Figure 7: HML-3 Photo from LacCore

In all, we obtained cores from four sites on the lake; these sites are named HML-3, HML-4, HML 5-B, and HML-10. Two of these (HML-3 and 4) are located on the same GPR transect (Fig. 3). At HML-3, Dryer (2008) interpreted the continuous to semi continuous horizontal GPR reflection patterns (Fig. 6) as horizontally bedded organic sediment. He interpreted the underlying reflection-free zone as fluvial gravel. Dipping reflection patterns, which Dryer interpreted as bedrock, are not present at HML-3.

Our core from HML-3 supports Dryer's interpretation of the horizontal reflection pattern as approximately one meter of organic-rich sediment. It, however, reveals details not apparent in the GPR data. The upper 57 cm is rich with woody debris (including both bark and milled timber) (outlined in red, Fig. 7). This woody layer is underlain by sand enriched with organic material (bark and colloidal organics) that extends to a depth of at least 86 cm. Our core does not reveal what lies below this unit. We cored to a depth of 100 cm beneath the lake floor, where we encountered something (possibly fluvial gravels) that prevented us from going deeper. Then, as we raised the core tube out of the lake we lost approximately 15 cm of sediment from its bottom.

HML-4

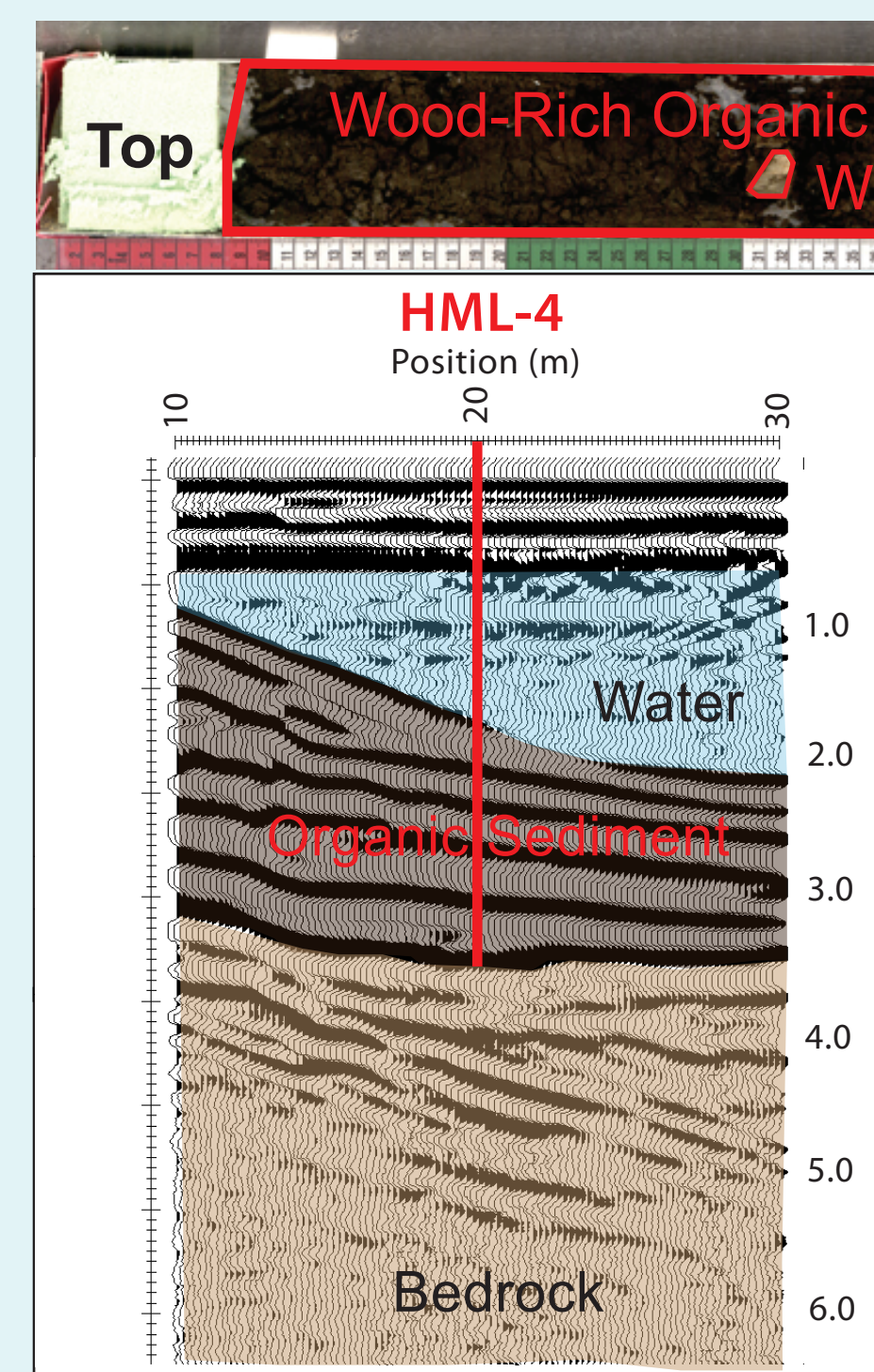


Figure 8: HML-4 GPR Profile

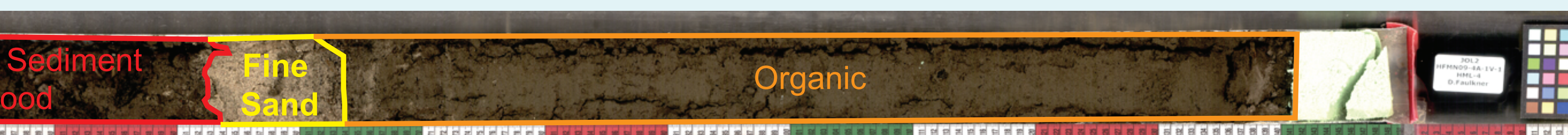


Figure 9: HML-4 Photo from LacCore

At HML-4, the GPR reflection patterns consist of a continuous to semi continuous horizontal and dipping pattern overlain by continuous to semi continuous horizontal pattern. Dryer interpreted these as bedrock (Mt. Simon sandstone) beneath horizontally bedded organic sediment (Fig. 8).

Similar to HML-3, our core from HML-4 largely supports Dryer's interpretation. And like the HML-3 core, HML-4 consists of a layer of wood-rich sediment over organic-rich clastic sediment. Clastic sediment in HML is not as sandy as noted in HML-3. The upper 45 cm is rich with wood debris (outlined in red, Fig. 9). Different from HML-3 is a 10 cm layer of fine-grained sand (yellow, Fig. 9) sandwiched between the uppermost unit and the lowest unit, which, similar to HML-3, consists of organic-rich clastic sediment (orange, Fig. 9). We cored to a depth of 142 cm beneath the lake floor and again encountered something that stopped us from going deeper. As we raised HML-4 out of the lake, we lost approximately 9 cm of sediment from the core bottom.

HML-5B

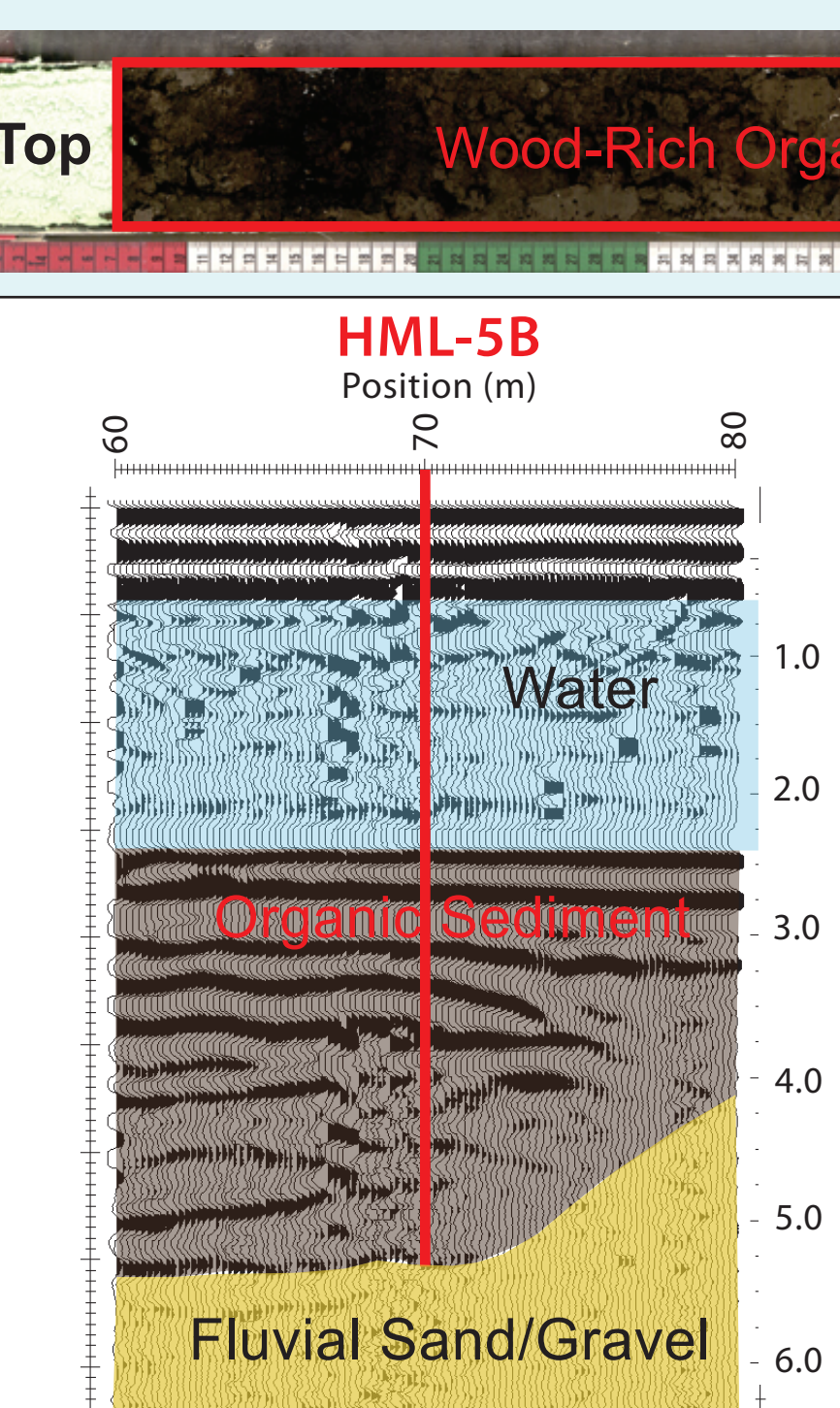


Figure 10: HML-5B GPR Profile

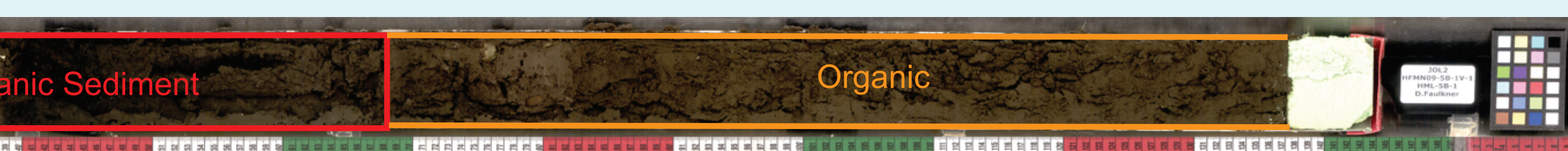


Figure 11: HML-5B Photo from LacCore

At HML-5B, the GPR data indicates a much thicker layer (compared to HML-3 and 4) of continuous to semi continuous horizontally bedded organic sediment as interpreted by Dryer (Fig. 10). The reflection free zone beneath the organic layer is interpreted to be fluvial sand/gravels based past ground-truthing done by Dryer.

HML-5B, like HML-3 and 4, support Dryer's interpretation. The upper 61 cm of core is composed of wood-rich sediment organic sediment (red, Fig. 11) above a layer of organic-rich sediment (orange, Fig. 11). Not distinguishable in the GPR is HML-5B's organic-rich layer composed of fine-grained silts that are almost clayey in nature as opposed to the clastic texture of the layer in HML-3 and 4. We cored to a depth of 270 cm before where we encountered something that prevented us from going deeper, losing approximately 7 cm of sediment at the core bottom when removed.

HML-10

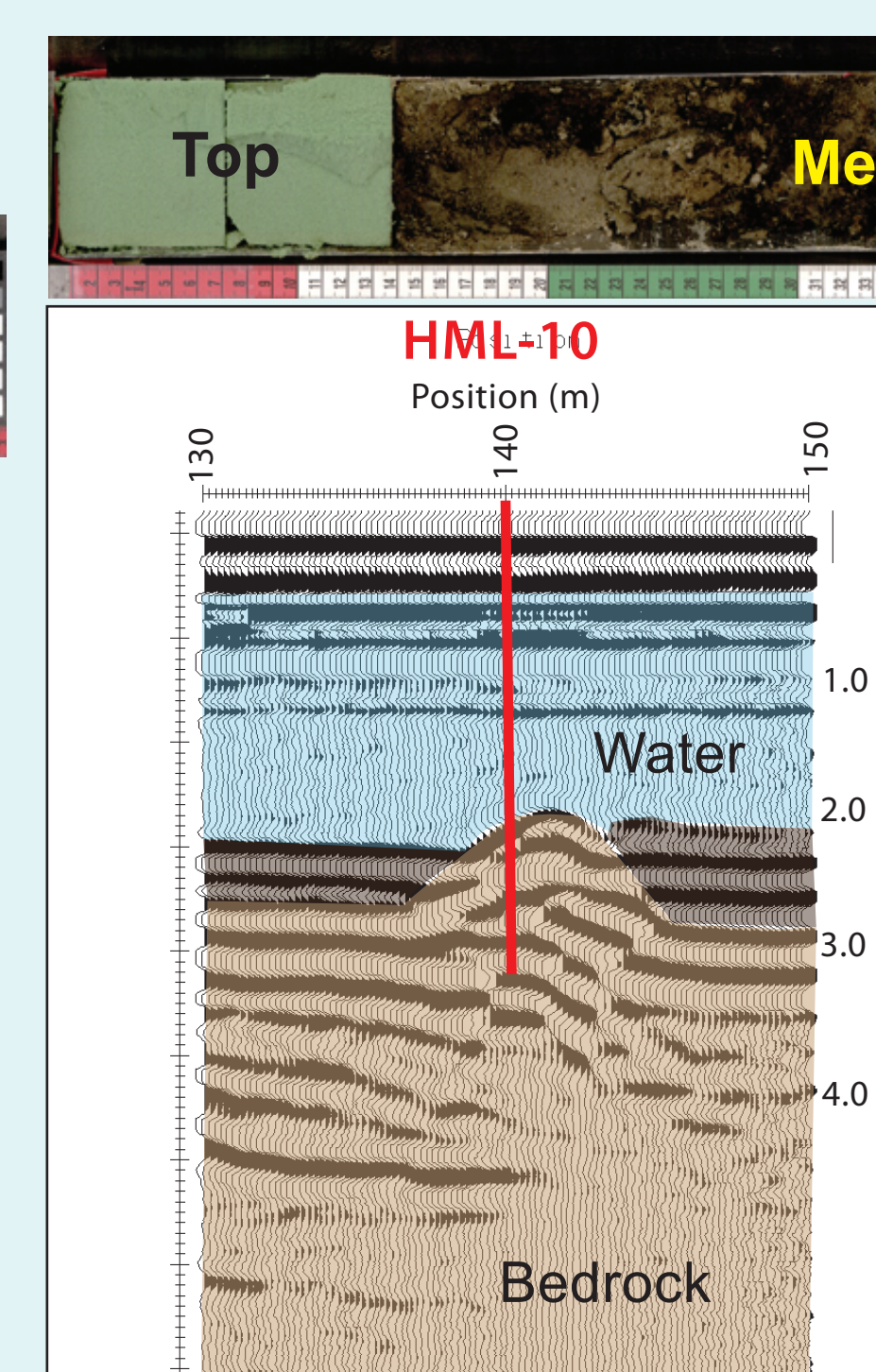


Figure 12: HML-10 GPR Profile



Figure 13: HML-10 Photo from LacCore

At HML-10, dipping convex-up reflection patterns suggest an anomaly in lacustrine sediment. Originally interpreted as a possible log, this profile and core seem to represent a sandstone bedrock high (Fig. 12).

HML-10 is of a completely different composition than the other three cores taken as part of this project and is absent of organic-rich sediment. The core is made up of sand increasing from medium-grained to coarse-grained from top to bottom (Fig. 13). Cobbles of Mt. Simon sandstone are present with pebbles of sandstone scattered throughout the bottom half of the core. These are possibly residual material weathered from the bedrock lying directly below. A piece of charred wood (4 cm in diameter) is located between two of the largest pieces of sandstone. A piece of milled wood is located just below the largest cobble of sandstone. HML-10 reached a depth of 120 cm. Approximately 3 cm of sediment was lost when removing the core from the lake.

Discussion and Conclusion

Ground penetrating radar provided a noninvasive means for estimating the depth of organic sediment in HML. However, anomalous reflection patterns, like the one at HML-10, indicate the necessity of ground-truthing GPR interpretations. Moreover, the GPR profiles do not reveal the lack of homogeneity in the lacustrine sediment. Based on our cores, the floor of the lake is underlain by a wood-rich unit containing little clastic sediment that is approximately 0.5 m thick (0.45-0.61 m in our cores). Beneath this lies a dark clastic sedimentary unit (mostly silt to fine sand) that contains wood (mainly bark) and colloidal organic material. More cores are clearly needed to establish the spatial extent of this sedimentary sequence in the lake.

In addition, more research is needed to determine why organic-rich clastic sediment is overlain by wood-rich organic sediment. We speculate that this sequence could be due to changes in how logs were transferred to the lake from the nearby Chippewa River in the late 1800s. (The Chippewa was a major thoroughfare for transporting logs from the northwoods to mills along the Lower Chippewa and Mississippi Rivers). In 1857, local entrepreneurs excavated a canal from the river to the southeast end of HML and built a retractable fin (or sheer) boom that could be positioned in the river during times of high flow (Fig. 14). In addition to diverting logs, the boom may have also diverted sediment into the lake. The fin boom remained in operation until 1880, when a flume was built to convey logs to HML from a reservoir on the north side of Eau Claire located on the Chippewa River (Dells Pond). As logs and water flowed into the flume from the reservoir surface, the flume would have transported little sediment to HML. Thus, the transition from organic-rich clastic sediment to wood-dominated sediment in our cores could mark the end of the fin boom and the beginning of the log flume era.

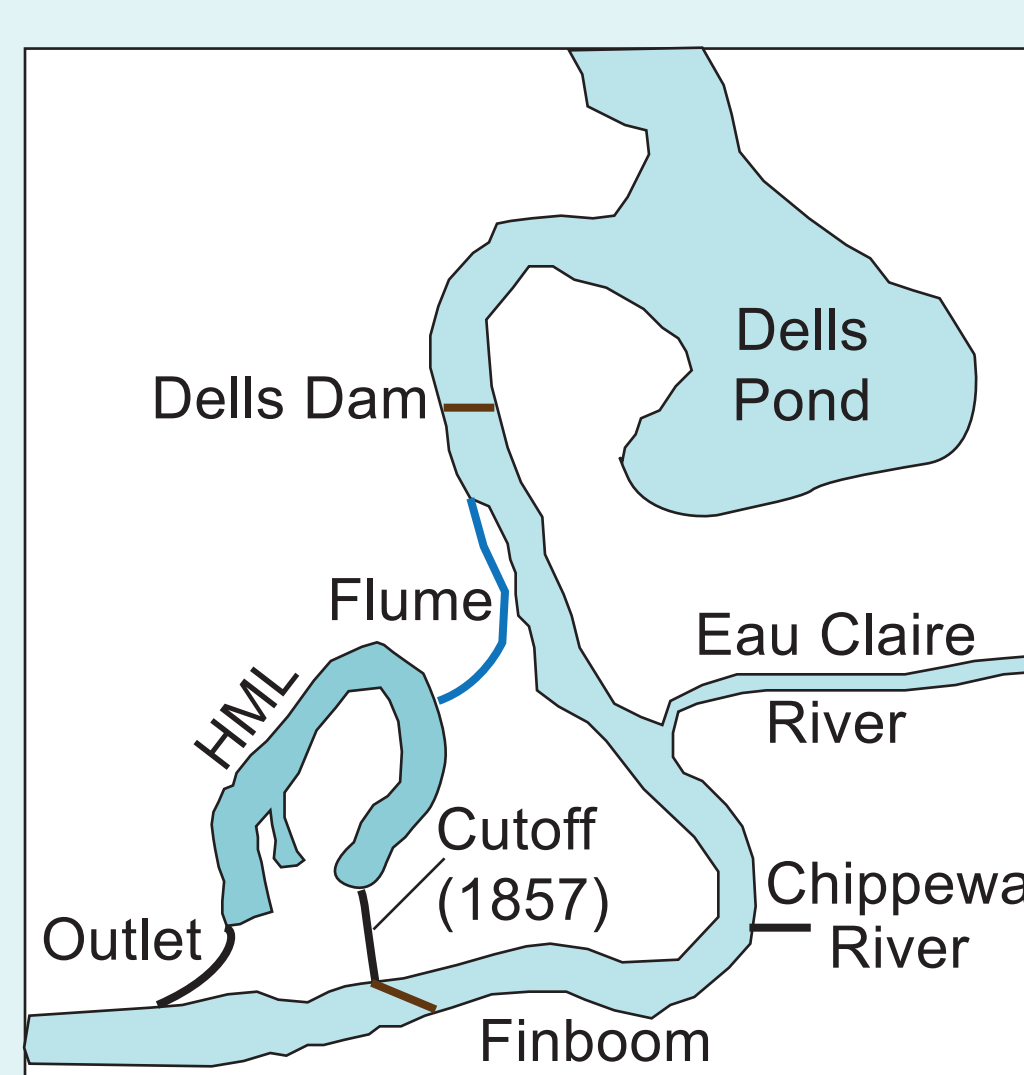


Figure 14: HML, 1857-1880

References

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Acknowledgements

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