Ground penetrating radar: a brief overview and case study

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Ground penetrating radar (GPR) is a recently evolving technique for detailed subsurface investigation of sedimentary environments. Field experiments at over a 100 sites have been conducted over the last year and half. These tests have provided insights into many areas of Western Canada and United States. The resulting profiles provide high resolution, continuous subsurface data on facies thickness and depths. The application of radar stratigraphic analysis (distinct reflection signature patterns) on the collected data provides both lateral and vertical geometry and stratification of sand bodies under investigation. Interpretations derived from the radar data coupled with other non-GPR data (i.e. seismic, borehole data) will aid in understanding the complex nature of depositional environments and provide useful analogues for comparison with ancient depositional systems.

Ground penetrating radar was used on the modern lacustrine William River delta, northern Saskatchewan, to better understand the subsurface sedimentology and reconstruct former depositional processes (Figure 1). Radar profiling of the wave-influenced sand deposits along transects up to 3.2 km in length provided high resolution continuous subsurface data of facies thickness and depths, lithology contacts, dip angle and dip direction of major sedimentary structures (Jol and Smith, in press; Figures 2 and 3).

A pulseEKKO IV radar system was used with 50 and 100 MHz antennae at a one metre step for all reflection surveys (Figure 4). Each step location was stacked with a sampling rate of 800 ps. The profiles were processed and plotted (wiggle trace format) using pulseEKKO IV software. Near surface velocity measurements were calculated from CMP surveys (Figure 5). A review of GPR principles and case histories is provided by Annan and Davis (1977), Beres and Haeni (1991), Davis and Annan (1986, 1988, 1989), Moorman (1990), Morey (1974), and Ulriksen (1982).

GPR has been found to be a very effective system in assessing subsurface stratigraphy, depth of lithofacies boundaries and large scale sedimentary structures. The resulting radar stratigraphy models could have considerable value to the exploration geophysicists / geologists in the aggregate, placer mining, oil and gas industries. In our experience, GPR was found to be most effective (resolution and depth of penetration) in quartzose, dry and/or wet (freshwater), clean (no clay), sandy and gravelly environments (Jol and Smith, in press). Other subsurface data acquisition methods with similar or comparable resolution, continuity, portability, cost effectiveness and time efficiency do not exist when assessing the shallow subsurface (0 - 30 m). Given these conditions, GPR is unmatched by any other methodology in earth sciences.

References

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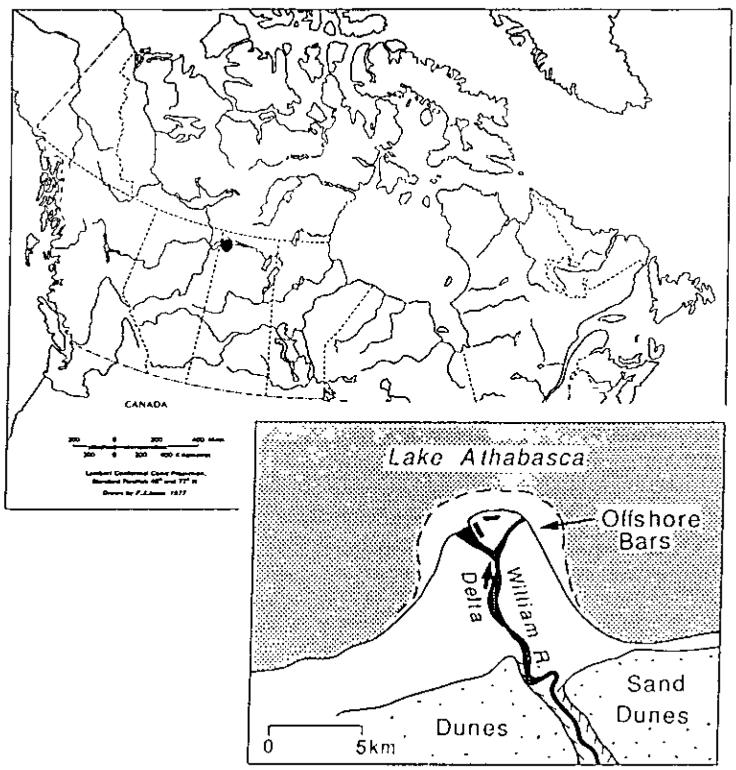

FIG. 1. Location map of the study area where GPR field experiments were carried out on the William River delta (above location in Canada, below location of surveys on the delta surface).

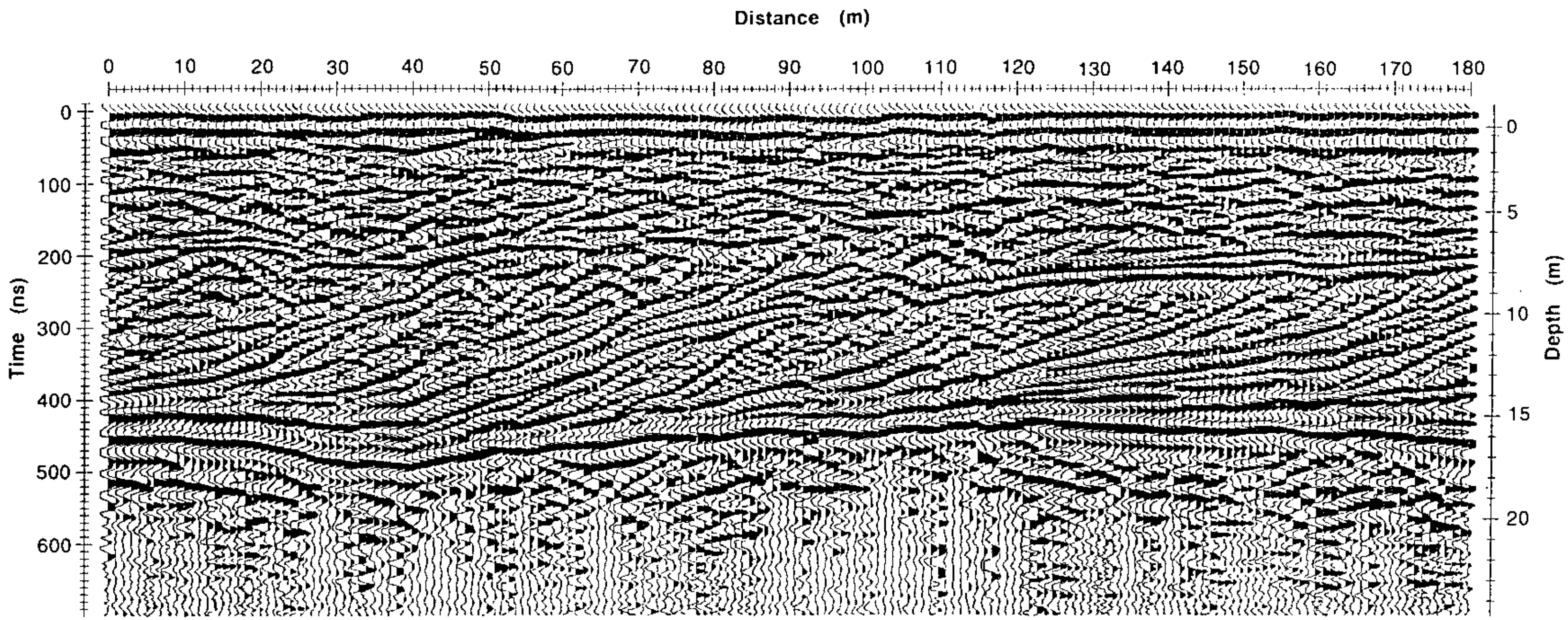

FIG. 2. Radar profile of the modern William River Delta, northern Saskatchewan. The survey parallels the right bank of the William River (Figure 1).

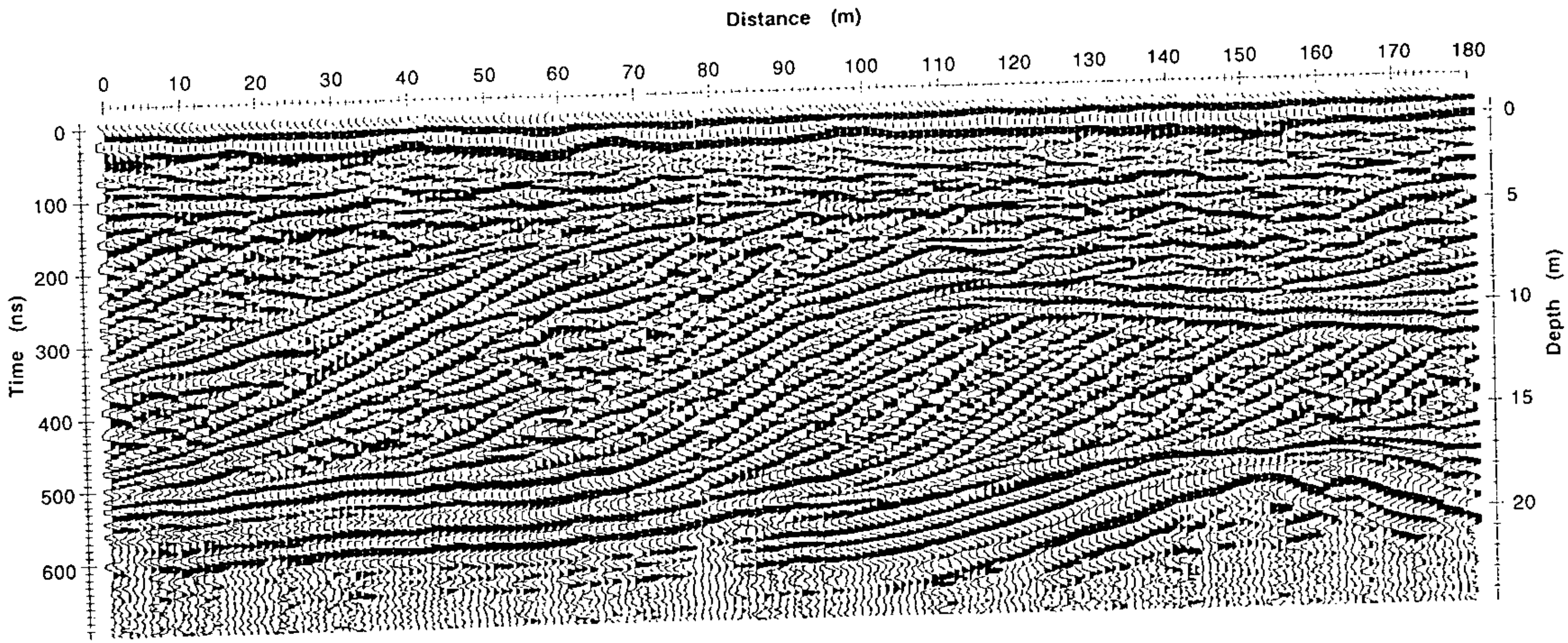

FIG. 3. Radar profile of the modern William River delta, northern Saskatchewan. The survey parallels the shoreface of the delta (Figure 1).

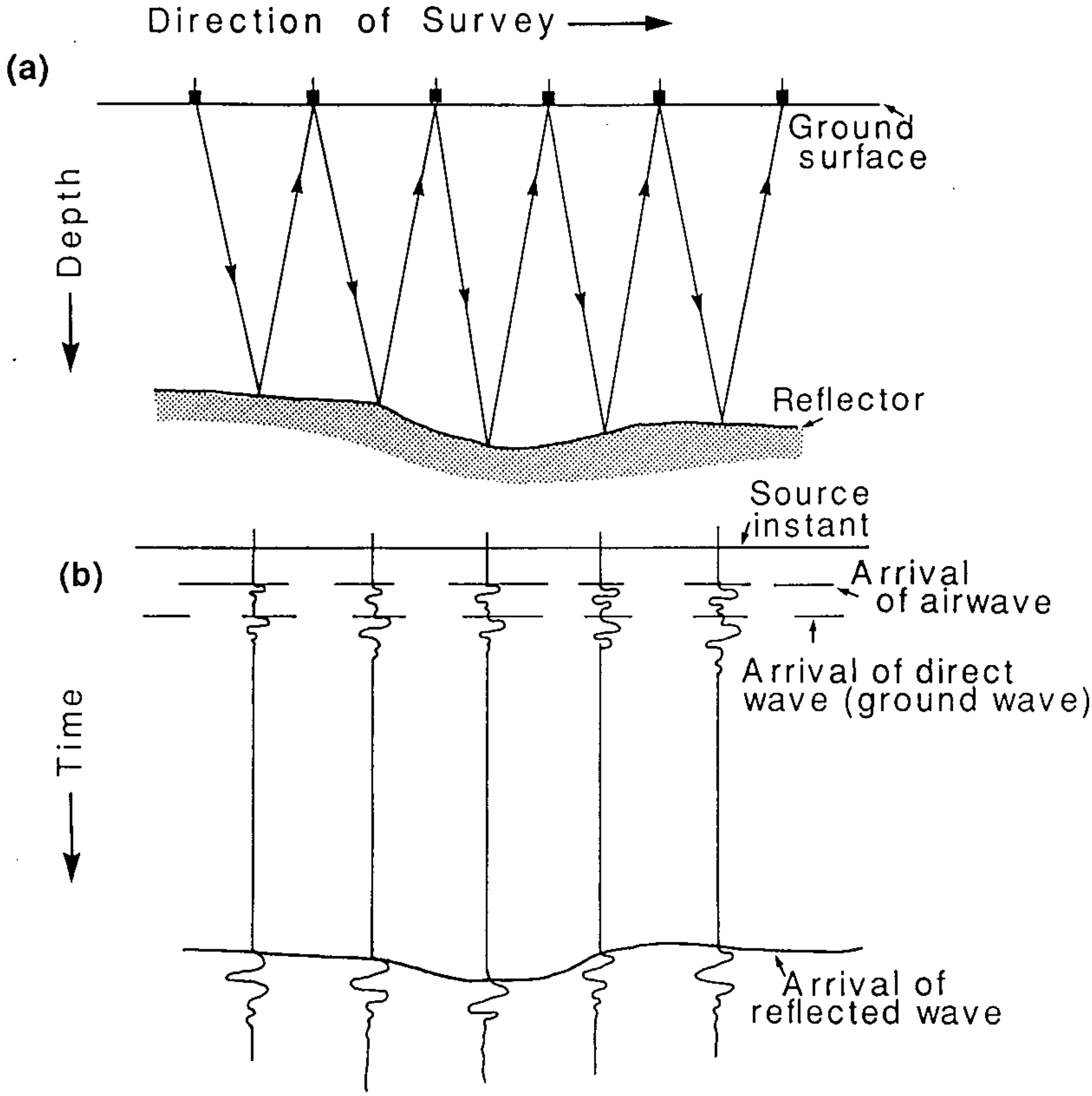

FIG. 4. Ground penetrating radar profiling procedure. (a) The step-like procedure involves repetitive moves of both the transmitter and receiver at a constat spacing. (b) Five schematicGPR traces, showing the arrival of airwave and ground-wave pulses and a lower reflected wave from a subsurface reflector.

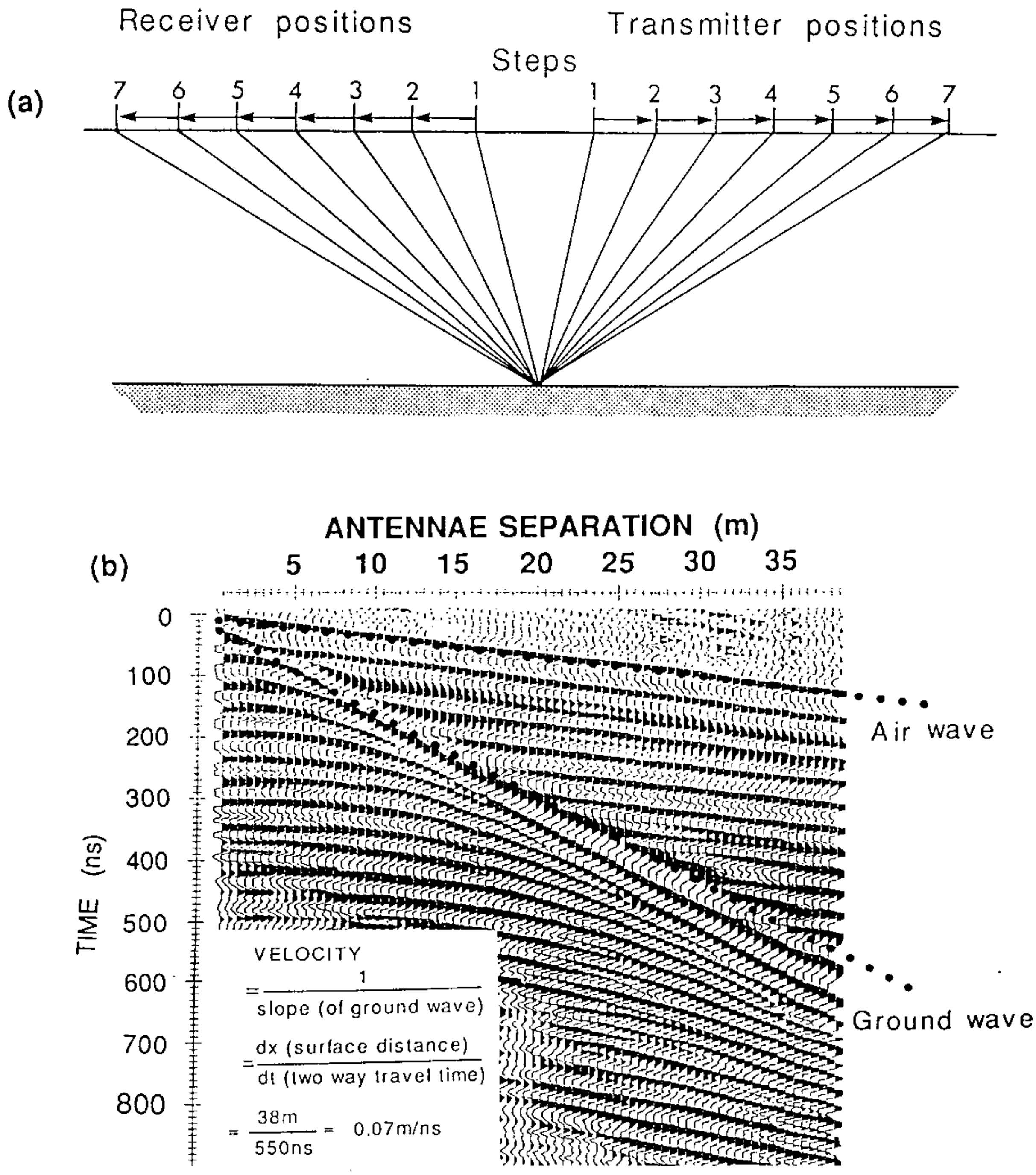

FIG. 5. (a) Common Mid Point (CMP) technique used to determine the electromagnetic propagation velcity of the surface sediments. (b) An example of a CMP profile used to calculate the near-surface velocity of the William River delta, northern Saskatchewan.