# Beginnings of Radio Depth Sounding (AKA Ice Penetrating Radar)

## Remembrances from Bill Isherwood (Dr. William Isherwood)

In 1963 I spent the summer on the St. Elias Icefield, in the Yukon Territory. I was involved in determining the thickness of the ice along various transects, using geophysical tools (seismic reflections, and gravity measurements to interpolate between seismic soundings). Our base camp was near the Hubbard-Kaskawulsh glacial divide, and our camp manager, Richard (Dick) Ragle, had previously been on several polar expeditions. As we discussed past experiences, Dick recounted their problems as he worked on an attempted tractor traverse of Greenland in 1958. His general story follows:

At the end of the first half of their planned over-snow vehicle crossing of the Greenland icecap (west coast to east coast), the plan was for his traversing party to be flown out by ski-equipped plane from somewhere near the crest of the icecap, leaving their over-snow transport vehicles for the next year's party to continue onwards with. While the traverse party awaited the landing of their pick-up by the ski plane, the plane's cockpit had an open radio channel with the ground party. As the plane approached their site for landing, they could hear the co-pilot reading off the plane's altitude -- based on a newly installed 'radar altimeter'. As they watched, the plane collided with the snow surface. Dick remembered that the (radar) altitude being reported by the co-pilot was many hundreds of feet, perhaps even thousands when they hit the snow. The key, they decided later, was that the radar (radio frequency) altimetry was not reflecting off the snow surface, but was penetrating the snow and reflecting off some lower reflector, perhaps even the bedrock. Later analysis provided one of first incentives to try determining ice thickness by sounding with radio waves, initially referred to as 'radio depth sounding' (now also known as 'ice-penetrating radar'). I've never seen this account in print, but it influenced my future.

The story went on; that all of the plane's crew survived – with only minor injuries. (If you're going to have low-angle plane crash, snow isn't too bad a place to do it.) But as their plane was destroyed, and no other plane was available; the traverse party had to 'rescue' the flight crew, prepare again their over-snow vehicles, and drive the entire party back to a better landing site – essentially back to the coast where they had started.

This 'discovery' that radio waves penetrate snow and ice spurred the Army Electronics Corps, at Fort Monmouth, NJ, to develop a 'radio depth sounding' system for determining ice thickness. I took that first system for its initial field trial to the Antarctic a couple years later, in the southern summer of 1965-66; on the Queen Maud Land

Traverse II (from the Pole of Inaccessibility to ‘Plateau Station’, via one very large switchback.

This first radio depth sounding system involved a radio frequency transmitter that sent (several times per second) radio frequency pulses to a ridged antenna mounted on a separate sled towed behind one of our snowcats, with a reflector bar above it. Spaced about 25 feet behind the transmitting antenna was another pair of receiving and reflector antennae, for receiving the return pulse and sending it to an oscilloscope. The oscilloscope sweep was triggered by the outgoing pulse, so the time lapse between outgoing pulse and reflection could be seen visually on the scope screen. Our traverse was also determining ice thickness with seismic reflections at regular intervals along our traverse (usually of about 40 miles). The two methods gave very similar results. The biggest difference was that the preparation for a seismic shot required drilling a hole for the explosives of over 50 feet deep (to minimize generation of surface waves), and quite a bit of time to lay out geophones and prepare to record the blast. On several occasions, something went wrong, requiring a complete repeat of the drilling and loading the explosive in the new hole. Meanwhile, the radio sounding operated not only at the fixed stations, but essentially continuously as we travelled. Overall, it was a great success; finding (among other things) the thickest ice found to date: close to 3600 m (almost 12,000 ft.; on Jan. 2).

After that field season, I went back to continue work on my MS degree at U of Utah, but was enticed to go back to the Antarctic again the following field season (1966-7), with upgraded radio depth sounding equipment, for use at quick helicopter stops – this time from a field camp based near the Byrd coast. The new system used a small oscilloscope that could be placed in front of the passenger’s seat of the helicopter (a UH-1D; i.e., “Huey”), and a set of relatively short wire antennae that could be laid out on the snow in a minute or so. The helicopter would land, I would jump out to lay out the two antennae in a parallel configuration; jump back in and look at the reflections and record the time differences (simply converted to depth), jump back out to pick up the antennae, and after noting the position from both our crude maps and the helicopter’s navigation system; then off we’d go again. The system worked very well and I was able to collect a great deal of data. The ice in that region was not close to the depths I had found on the East Antarctic Plateau, but did include both major outlet glaciers and larger feeder icefields.

Although I returned to the Antarctic again the following season, it was for a different project – installing and operating for the first year an array seismic station (to identify explosions at the Russian nuclear test site in the Arctic). But within a couple of years after my use of radio depth sounding, the method was adapted for use from airplanes, and the entire Antarctic ice thickness was ‘mapped’ with airborne radio sounding. Not surprisingly, an area with slightly deeper ice was found than those I found on the traverse.