Mapping railway ballast

Description of problem

Railway banks are often constructed with an insulating layer between the upper ballast material and the supporting layer below. The purpose of this insulating layer is to prevent fine material to reach the ballast. This investigation aimed to identify in which parts this insulating layer were installed, and in which parts it needed to be restored.

Equipment used

The data was acquired with three antennas simultaneously, so the RAMAC CUII equipped with a multi channel MC-16 module was used, with shielded antennas, both 800 MHz and 500 MHz. Data acquisition was made with GroundVision and a laptop computer.

Investigation method

The three different antennas were mounted on a frame in front of the railway engine. Two 800 MHz shielded antennas were mounted on each side of the tracks, and one 500 MHz antenna in the center between the tracks. The 500 MHz was placed in this mid-position as it was believed to be less disturbed by the reinforced concrete sleepers.

This arrangement made it possible to map both sides and the middle between the tracks simultaneously, with accurate positioning. An ordinary RAMAC encoder wheel, mounted to run on the track, was used to trig the measurements.

The antennas were placed 45 cm above the track, and the investigation speed, with three channels could be kept at 20 km/h.

Measurement settings

As it was known that the supportive layer should not be below 1 m depth, the measurement settings used could concentrate to be quite shallow. Settings for the 500 respectively 800 MHz antennas:

Number of samples: 150, 212
Sampling frequency: 5175, 10350
Time window: 29, 20
Point interval: 0.2 m
Velocity: 0.12 m/ns, decided by geotechnical drilling samples.

Critical elements

When choosing the appropriate antenna frequency, the distance between the concrete sleepers on the railroad is a crucial factor for the ability to “see” through the array of sleepers. In this case it was assumed that the distance between the antenna elements in the 500 MHz antenna was better suited to see below the sleepers than the 800 MHz antenna.

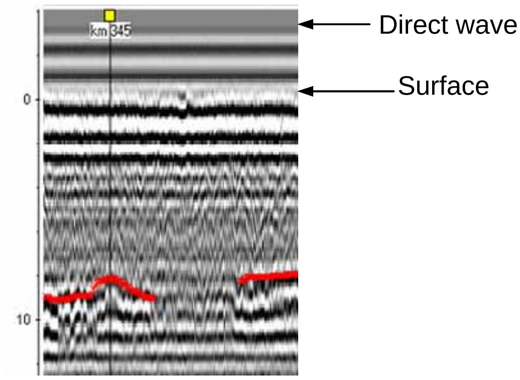
The antennas should be located as close to the ground as possible to retain the energy. However, due to the mechanical construction, the antennas were in this case placed almost a half-meter above ground.

Results

The processing and interpretation was made in Reflex. Processing steps included: Stacking of data (5 traces to 1 trace per meter), DC-shift and gain. In most cases the target reflector could be interpreted using an automatic tracking algorithm, so called phase-follower.

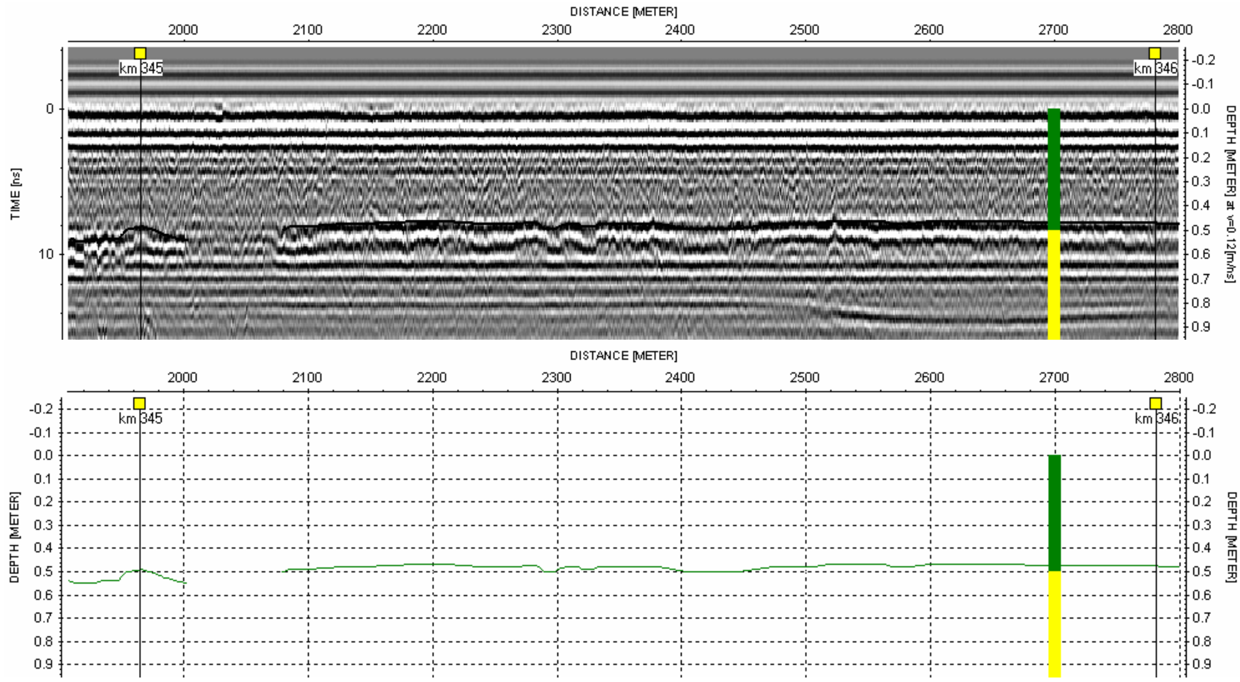
The fact that the antennas was elevated 45 cm had to be taken into account during interpretation. However, in the data the direct wave, together with ground surface was easily defined. The 500 MHz data did not reach much deeper than the 800 MHz antenna, and was not further used. The quality of the 800 MHz data was of course also superior, due to the fact that the antennas was situated outside the reinforced sleepers.

A detailed picture of 800 MHz radar data is shown to the right. As seen the direct wave appears at –3 ns (two-way travel time), corresponding to the antenna height of 45 cm.



The data also clearly shows the structure of the ballast material, as an uncountable number of small hyperbolas.

Below a 1000 m section is shown, acquired with one of the 800 MHz antenna, with both the radargram and the interpreted supporting layer (in green) at a depth of approximately 45 cm. The comparison with geotechnical drilling data at position 2700 m shows a very good agreement.



Conclusions

The mapping of railway ballast and the insulating layer above the supporting material could be done with the presented investigation technique. The measurements gave good interpretable results and very good data quality even with the antennas mounted 0.45 meter above the railway track.

A measurement speed of 20 km/h could be kept, with three channels and a trace interval of 20 cm, which has to be considered quite satisfying.

Head Office

MALÅ GeoScience AB
Skolgatan 11, SE-930 70 Malå, Sweden
Phone: +46 953 345 50 Fax: +46 953 34567
E-mail: sales@malags.com

Sales Offices

USA: MALÅ Geoscience USA, Inc., 2040 Savage Rd. Box 80430, Charleston, SC 29416
Phone: +1 843 852 5021, Fax: +1 843 769 7397, E-mail: sales.usa@malags.com

Malaysia: MALÅ GeoScience (Asia Pacific), 9G-B, Jalan Prima 9, Metro Prima, Kepong, 52100 Kuala Lumpur
Phone: +60 3 6250 7351, Fax: +60 3 6250 2072, E-mail: sales@malags.com