GPR Rough Terrain Antenna Applications in Mineral and Groundwater Prospecting

by Jan Francke*

The MALÅ Rough Terrain Antenna (RTA) concept was an immediate succcess with the exploration industry. The flexible, in-line (colinear), MALÅ RTA antennas efficiently produce high resolution ground penetrating radar data where traditional (parallel) GPR antennas fail.

Ground penetrating radar (GPR) has a long history in its application to shallow mineral and groundwater prospecting. From early university researchers using unwieldy antennas, oscilloscopes and electrostatic plotters in the 1970's, these low frequency GPR systems (<100 MHz) gained acceptance as being a viable complementary method to the traditional approach of drilling. Indeed, during this formative period in GPR's short history, nearly all commercial and research work performed was with low-frequency antennas, as high frequency systems were encumbered by an intrinsic complexity in antenna and circuitry design and lack of market demand for civil infrastructure applications.

Low frequency GPR systems are ideally suited to mineral and groundwater prospecting applications, but suffer from inherent size and speed of acquisition limitations. In order to achieve deeper penetration of radar energy into the subsurface, the frequency of an antenna must be lowered, thereby increasing its physical length. In some applications where extreme penetration is required up to 50 m, transmitter and receiver antennas can reach nearly 8 m length. Although somewhat feasible in open regions, these antennas become prohibitively cumbersome in the presence of any vegetation or difficult terrain. To achieve ideal profile resolution, cleared lines of up to 5 m in width are required for many surveys.

As shown below (figure 1), low frequency GPR systems generally require a field crew of three and significant clearance for the unwieldy antennas. Although capable of significant penetration, surveying requires the entire system to be carried between individual radar reading locations, usually spaced at 1 m intervals along a survey profile. In regions of significant topography or dense vegetation, conventional systems may limit acquisition rates to less than 2 km per day. These factors have inhibited the widespread use of GPR in most mineral or groundwater exploration projects to sites which provide open access and subdued topography. With the rapid growth of GPR in civil infrastructure applications, and a reduction in complexity of high frequency GPR systems, mining and groundwater applications for the technology have become less common.

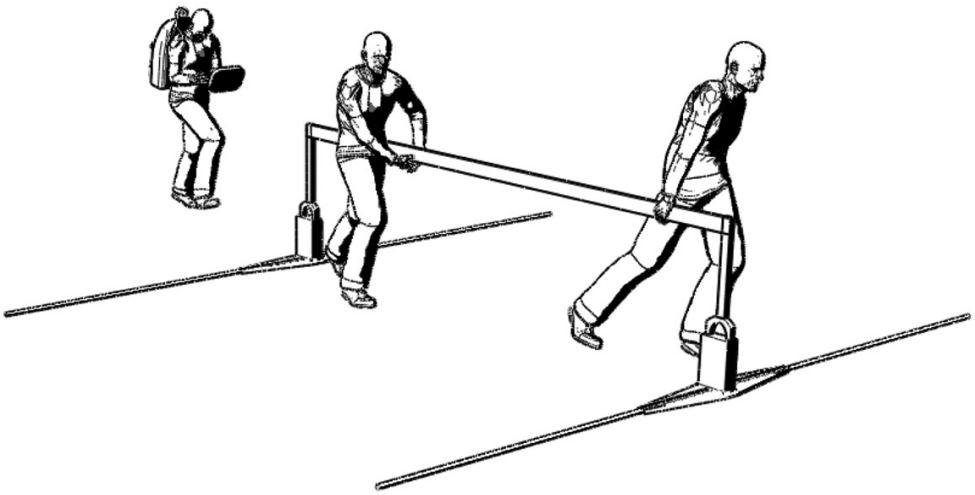

***Fig. 1**: Traditional low-frequency (GPR) antenna setup, parallel configuration*

In recent years, these limitations have been overcome with the market introduction of the MALÅ Rough Terrain Antenna (RTA) concept (figure 2). Rather than employing antennas, which are meters wide and difficult to use, the MALÅ RTA concept contains the transmitter and receiver electronics, as well as their antennas, within a rugged yet flexible tube. The system allows the entire GPR system to be towed by a single surveyor. As with most modern GPR systems, the position of the system can be tracked in real time using DGPS or robotic total stations.

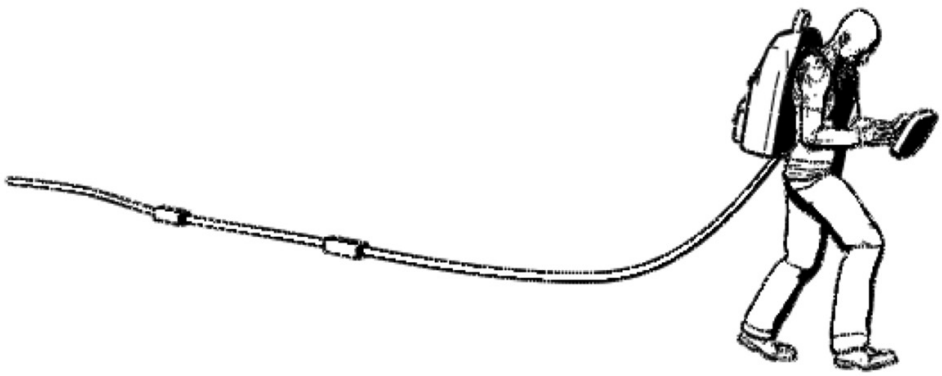

***Fig. 2**: MALÅ Rough Terrain Antenna (RTA) concept, co-linear configuration*

With this approach to GPR system design, vast regions of heavily vegetated or previously impossible to survey terrain may be covered in hours or days by a small survey crew, at a lower cost than with conventional GPR systems.

As with any GPR system, penetration is limited or impossible in certain clays and other electrically conductive environments. However, the advantages of dragging the flexible MALÅ RTA along a survey line, thereby allowing perfect ground coupling, as well as the ability to access nearly any environment or terrain and achieve finer spacings between radar readings at much higher speeds than conventional systems, place this new technology at the forefront of the geophysicist's toolbox when working in suitable environments.

Extensive comparisons of the data quality achievable with conventional GPR systems and the MALÅ RTA units have been conducted. Shown is a sample of data acquired atop a known gold-bearing paleochannel. The upper profile was acquired using a MALÅ 50 MHz RTA system with individual GPR readings every 25 cm, whilst the lower profile was surveyed along the same transect using a conventional 50 MHz GPR unit with readings every 1 m. Although having undergone the same processing routines, the RTA data are considerably more interpretable and appear to achieve somewhat greater penetration than the conventional antennas. Regardless of the thick vegetation in the region of these sample profiles, surveying with the RTA required only cursory trail clearing and approximately 15 minutes of acquisition time for the 330 m long profile. Conversely, preparation for surveying with the conventional GPR antennas involved clearing a track of nearly 3 m in width and required nearly 45 minutes to acquire.

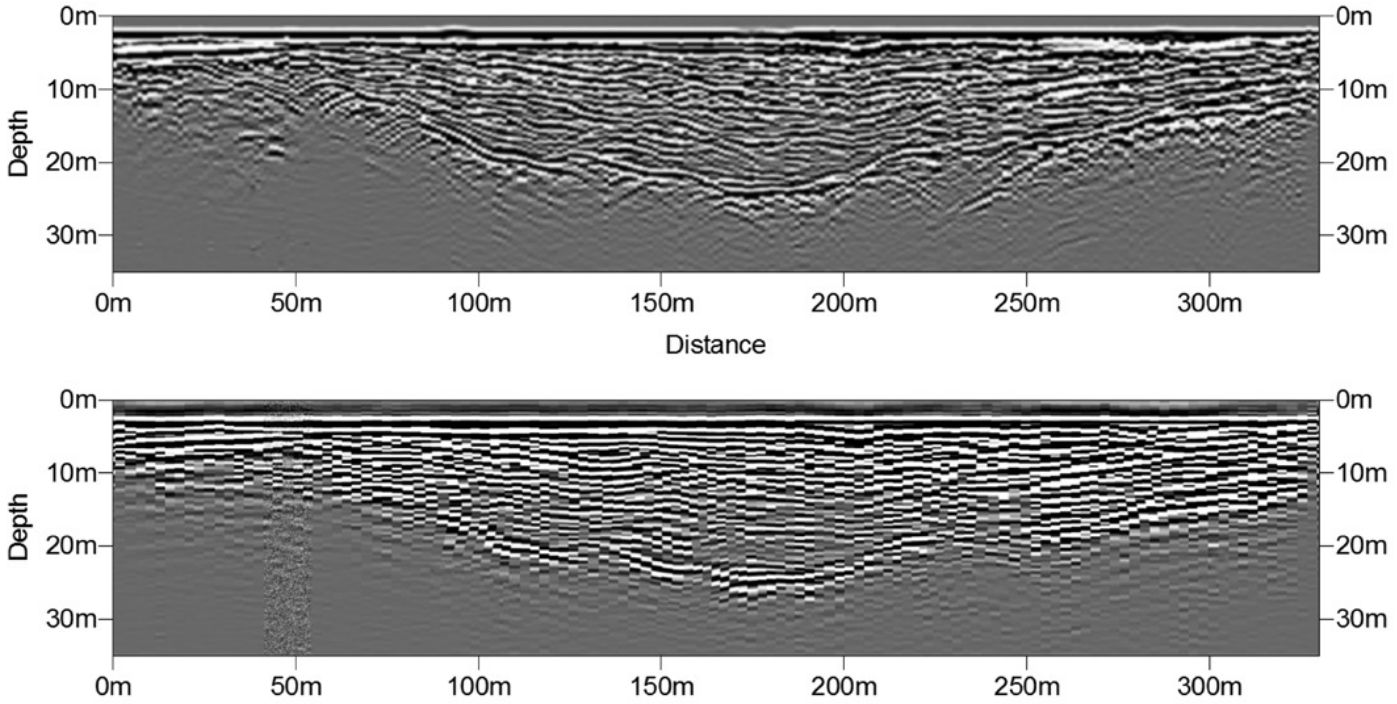

***Fig. 3**: Data comparison*
(Upper) MALÅ RTA 50 MHz GPR data
(Lower) Conventional 50 MHz GPR data (parallel configuration)

This significant improvement in GPR antenna design holds promise for increased acceptance of the technology across a variety of applications. To date, dozens of MALÅ RTA systems have been employed on every continent on projects ranging from kimberlite mapping in the Canadian Arctic to nickel exploration in the mountains of Papua New Guinea. Other applications have included glaciology, groundwater salinity studies, bathymetry and geotechnical investigations, with countless others planned.

***Fig. 4**: MALÅ RTA concept at work*

Although conventional GPR transmitters generally employ a higher output voltage to produce their electromagnetic energy, any increase in penetration appears to be negligible. The radar range equation, which governs GPR wave propagation in the subsurface, dictates that increases in transmitter power are required to be exponential in order to achieve effective penetration gains.

As the RTA concept allows for a truly continuous towed approach to surveying, individual readings may be acquired rapidly at significantly much finer station spacings than is practical with conventional GPR systems. In applications such as paleochannel mapping for alluvial gold and diamond deposits, this increase in profile resolution yields a more accurate and representative interpretation. ■

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