SUBSURFACE VIEWS

GPR INNOVATIONS
HARDWARE AND SOFTWARE

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In this issue

GPR Helps Solve the Mystery of the Hole in the Dune

Mt. Baldy, in the eastern part of the Indiana Dunes National Lakeshore, is the largest active dune along the southern Lake Michigan shoreline and a popular recreational facility for local residents and tourists (Figure 1). In July 2013, a 6-year-old boy walking on the dune fell into a hole that suddenly opened up underneath him. He was trapped for several hours more than 3 m below the surface until emergency workers dug down to rescue him (Figure 2). Afterward, because neither the formation process or the extent and significance of the hazard represented by this hole was known, Mt Baldy was closed to foot traffic in 2013 and remains so today.

Figure 1: Location of Mount Baldy

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To understand the development of these voids, a study of the architecture of the dune was undertaken by the Indiana Geological Survey[1] and Indiana University's Geological Sciences Department[2] using GPR and solid-earth cores. A pulseEKKO PRO GPR system with center frequencies of 50 and 100 MHz and a Noggin 250 MHz system (Figure 3) were used to collect survey lines perpendicular to the shoreline and longitudinal to the direction of sediment transport of the dune (Figure 4). Since the dune has a large amount of topography, to reconstruct the true geometries of the various layers and features, it was necessary to correct the GPR lines for the elevation changes in post-processing.

The data from the GPR transects and cores were used to define four major stratigraphic horizons. These include an upper and lower dune, separated by a paleosol (an ancient soil horizon) that developed on the top of the lower dune (Figure 5). The upper dune formed during the 20th century and corresponds to present-day Mt. Baldy; the lower dune formed 3000-4000 years after ancestral Lake Michigan fell from the peak mid-Holocene water level after the retreat of ice from the last ice age.

This study shows that the voids that closed Mt Baldy were apparently caused by trees that were rooted into

Figure 2: Rescue of boy trapped in the hole in the dune (Arizona Daily Star)

Figure 3: pulseEKKO PRO with 100 MHz antennas (left) and Noggin 250 SmartCart (right)

Figure 4: Three 250 meter and thirty-three 80 meter GPR lines were collected for the investigation

the paleosol that occurs on the surface of the lower dunes. The trees were buried and died as the sands that make up Mt. Baldy migrated landward during the early 20th century. These trees and paleosol are now being slowly unearthed as the dune continues to migrate. As they are exhumed, the trees decay in place through fungal growth; this creates voids of variable size, depth and orientation, depending on the diameter and density of the buried tree trunks and limbs. Fungus on the trunks when first buried probably rots the tree from base to top when exhumed. Thus, the risks of voids opening in the dune are depth and time dependent; the buried trees seemingly must lie within 3-5 m of the surface to allow fungal growth to resume and the elapsed time between burial and exhumation must be short enough so that the fungus does not die when deeply buried.

Nathan's hole (named after the rescued boy) is apparent on GPR profiles and can be seen as disrupted bedding on the 80 meter long transect that passed over the excavation to recover him (Figure 6). Interestingly,

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while the upper beds were apparently disrupted during excavation, it is believed that narrow, strong vertical reflectors below the hole represent a tree trunk that extends to the paleosol surface and may be responsible for the void in which Nathan was buried. The reflectors probably represent greater moisture in the rotting trunk.

Initially, geologists were baffled about what natural forces were responsible for creating voids in a dune and wondered if this was some new and unknown process that had never been seen or documented by researchers. But careful study and detailed GPR images helped to piece together a story that makes sense with known natural processes and solves the mystery of the holes in Mt. Baldy.

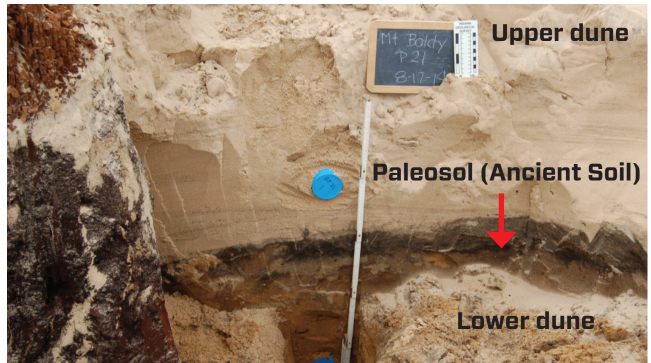

Figure 5: Image of ancient soil (paleosol) the trees grew on before being buried by the advancing dune sands.

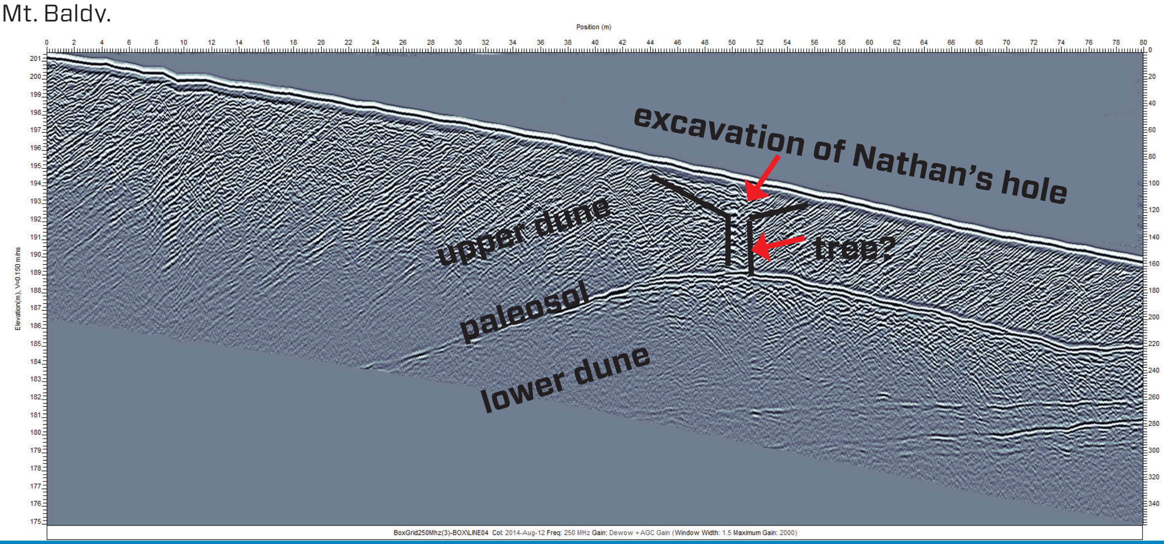

Figure 6: 80 meter long GPR profile collected with a Noggin 250 system. The location of "Nathan's hole" and the interpreted rotting tree that caused it are indicated.

Story courtesy of William Monaghan[1], Todd Thompson[1], Erin Argyilan[2] and Kevin Russell[2]

Streamline your Data Collection with SmartChariot

Our customers are always looking for ways to simplify GPR data collection and increase productivity in the field. This is especially true when large areas need to be surveyed; covering these areas with a GPR cart or hand-towed configuration is usually too time-consuming or simply not feasible. To meet this need, Sensors & Software designed the SmartChariot configuration for Noggin GPRs and pulseEKKO PRO transducers. The SmartChariot attaches to any vehicle with a trailer hitch and accommodates the Noggin 250, 500 or 1000 systems and pulseEKKO 500 and 1000 MHz transducers.

As with all of the Noggin configurations, the SmartChariot is compatible with the Noggin data acquisition on the Digital Video Logger (DVL). The SmartChariot has an integrated odometer ensuring regular triggering of the GPR at user defined intervals and provides a mount to attach a GPS for georeferenced data. The non-metallic SmartChariot structure minimizes undesirable transport platform interference and provides mechanical adjustment to allow the GPR to ride in very close proximity to the ground, maximizing penetration, resolution and data quality. The high density polymer skid-plate protects the system during use.

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Figure 1: GPR deterioration index map plotted in Google Earth showing bridge deck condition assessment.

The most common use of the SmartChariot is for road and bridge inspection. Figure 1 shows an example of data collected with a SmartChariot processed into a deterioration index map to assess the condition of the bridge deck.

The SmartChariot can also be used to detect utilities and other subsurface features on roads, sidewalks, parking lots and other large, smooth open areas. Figure 2 shows road data collected with the Noggin 250 SmartChariot configuration. The data clearly shows the classic hyperbolic response of a buried pipe, plus it delineates the road bed structure, and the in-filled trench. If features of interest are smaller and shallower, the Noggin 1000 can be deployed. Figure 3 shows shallow embedded road sensors detected with a Noggin 1000 deployed on a SmartChariot.

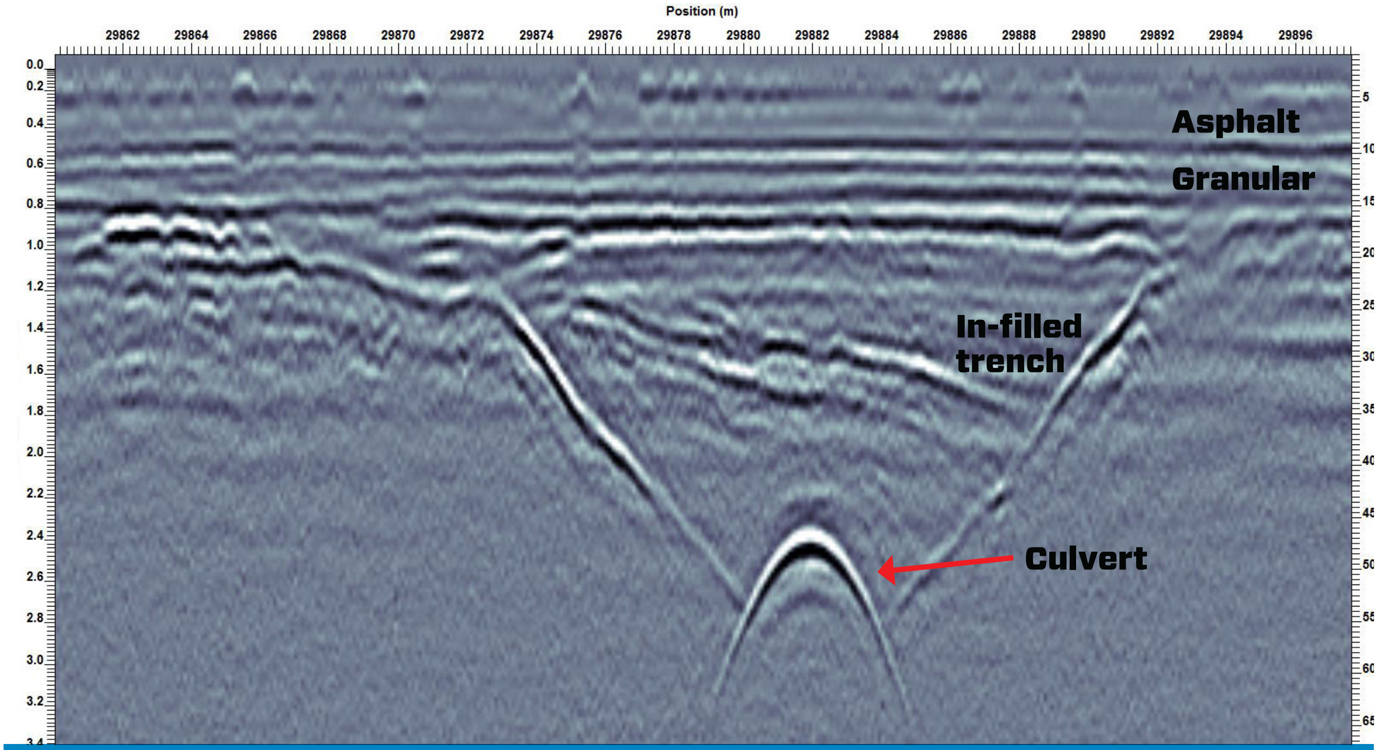

Figure 2: Hyperbolic pipe response is clearly visible in the in-filled trench. Construction layering under the asphalt is well defined at shallower depths.

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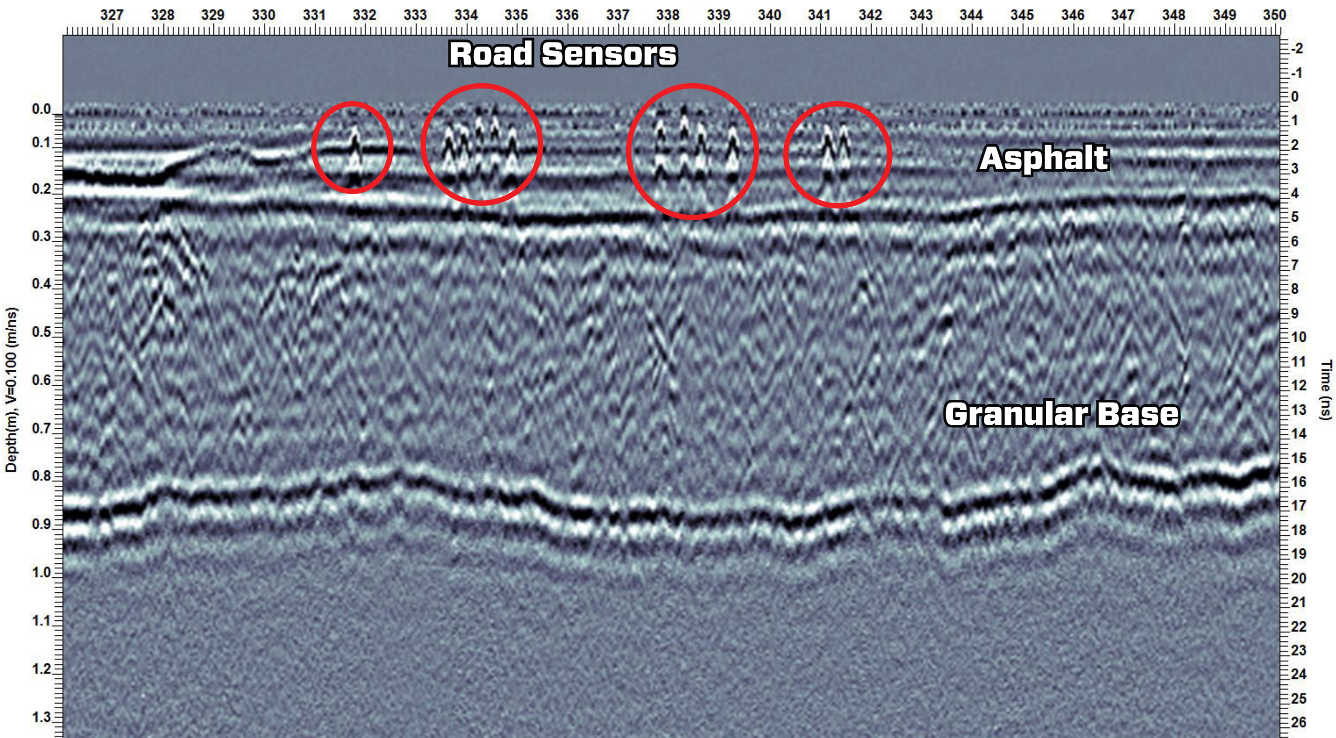

Figure 3: Data collected with the Noggin 1000 SmartChariot showing shallow road sensors and layering.

Noggin 250 SmartChariot configuration

Although most commonly towed behind a car or truck, the SmartChariot connects to any standard hitch and can also be deployed on smaller vehicles including golf carts, ATVs, motorcycles or even bicycles. This flexibility allows the SmartChariot to be used for surveys of large open areas, including parking lots, warehouse floors, and open fields such as golf courses and parks.

If you already own a SmartCart, integrating the SmartChariot into your field operations is a logical next step, as it uses the same Noggin or pulseEKKO PRO system, and runs the same DVL data acquisition software. This helps minimize the cost and learning curve, enabling you to quickly offer more service capabilities to your clients. For more challenging applications, SPIDAR based configurations can deploy two GPR units concurrently. Check with our custom system specialists for more details.

TIPS Forensic Investigations

GPR is a go-to tool for law enforcement professionals searching for buried forensic evidence. Here are a couple of tips when using GPR for forensic investigations.

1) Find Evidence, not Rocks: GPR technology is very sensitive to material changes which can result in many responses. The challenge is to differentiate responses from rocks, soil variations and other naturally-occurring subsurface objects from buried evidence such as containers of drugs, weapons or a body. One way to boost interpretation confidence is to look at the ground response above an observed object. Often it is possible to see a GPR response from disturbed soils strata where

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a hole was dug, particularly in layered soils. In the data example (Figure 1), the break in a horizontal layer directly above the GPR response from a buried object indicates the natural soil has been disturbed. Seeing this type of response helps determine that you have detected an object which was placed into the ground by excavating rather than something that has been buried by natural soil accumulation.

2) Evidence in a cross section: Most GPR operators are very familiar with looking at GPR cross sections and learn that upside-down U shapes (known as hyperbolas) are indicators of buried objects. However, when dealing with evidence such as buried bodies, investigators are less likely to see such typical shapes. Depending on the size, depth, GPR frequency and target orientation, cadavers tend to give a different response; it might be somewhat hyperbolic but the hyperbola is not usually well defined. The response is often caused by reflection from the bottom of the excavation and shows a flatter response with the response dipping slightly down at each side (Figure 2).

While these tips provide information of what to look for on cross-sections, Sensors & Software recommends using grid searches that enable depth slice maps to be created as the primary method for forensic investigations. Cross sections can be used to confirm the targets identified in the depth slice images generated from the grid data. For more information or training on forensic evidence searches with GPR, contact our forensic application specialists.

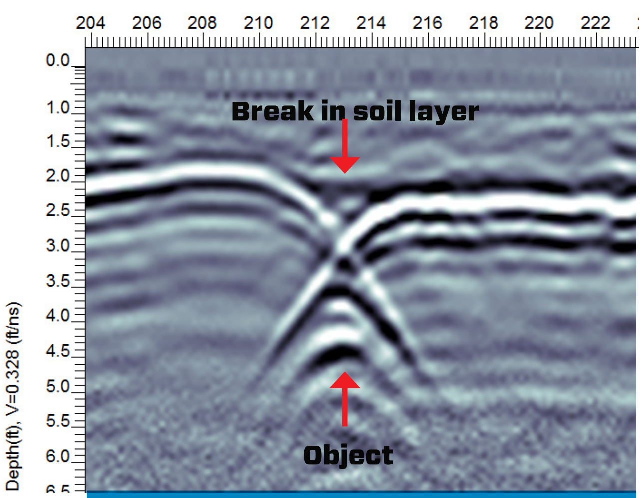

Figure 1: A Break in the Natural Soil

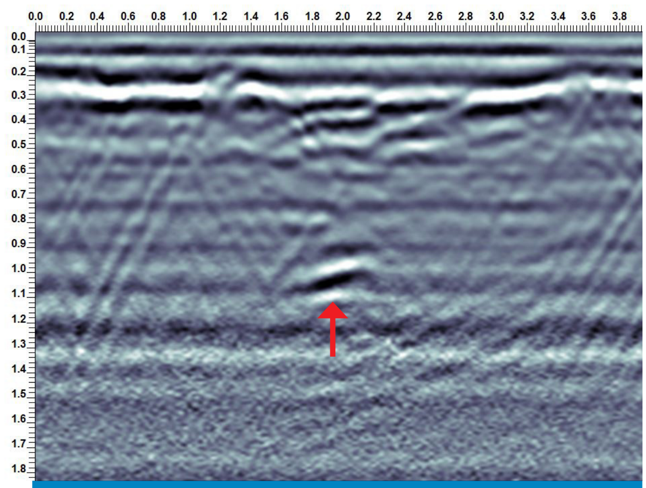

Figure 2: Subtle Evidence

Courses

Subsurface Imaging with GPR
Sensors & Software - head office, May 9, 2016

Concrete Scanning with GPR
Sensors & Software - head office, May 10, 2016

3-Day GPR course
Sensors & Software - head office, June 1-3, 2016

21st Annual Contaminated Site Management, GOW-EN Environmental - Toronto, Ontario June 8, 2016

Upcoming Tradeshows

International Conference of Ground Penetrating Radar GPR 2016
Kong Polytechnic University, Hung Hom, Hong Kong, June 13-16, 2016

Geological Society of America Convention (GSA) 2016
Colorado Convention Centre, Denver, Colorado, USA
September 25-28, 2016,

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