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Subsurface Views

Sensors & Software Inc.

GPR applications

Animal burrows

Our Ask-the-Expert forum often receives inquires about GPR for animal investigations. Questions include detecting animal burrows, buried animal nests or even the animal itself in its underground shelter.

While some of the requirements are impossible for GPR, e.g. imaging 10 mm long sea lamprey larva (too small) in their nests located in water up to 15 m deep (too deep), in many cases GPR has proven to be a valuable tool for biology research.

Our earliest biological application was in the 1980's - using GPR suspended above the water to count salmon swimming upstream through a narrow channel in a river.

Animal burrows, theoretically, are easy to map because the dielectric constant (K) contrast from the air-filled cavity (K=1) and the surrounding host material (typically, K=3-5) is quite large. The resulting high reflection coefficient should be easily detected by the GPR. Unlike nice round pipes, the irregular shape of the animal tunnels may not direct enough energy to the surface to produce an interpretable image. Collapsed tunnels also provide little or no contrast for imaging. Another challenge includes the somewhat random direction of burrows. Unlike pipes or even tree roots, the GPR operator must collect data on very closely spaced lines to image any sudden changes in direction.

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GPR 2010 - Lecce, Italy

The historic city of Lecce was the home for GPR 2010 in June. Chair Raphael Persico and his committee hosted an exceptionally solid technical meeting which attested to the future of GPR. The beautiful old stone castle "Carlos V" provided a unique setting for the technical sessions and exhibits.

The beautiful old stone castle "Carlos V" provided a unique setting for GPR 2010

A broad spectrum of GPR users and researchers presented the latest developments in GPR to about 200 attendees. Strong contingents from Europe and Asia Pacific were present but the number of North Americans was smaller than normal. A total of 50 exhibitors showed a variety of GPR products.

Tutorials and workshops before the formal start of the meeting provided useful venues to explore some topics in detail. The 3D workshop highlighted the problems and challenges of covering large areas and imaging these data in practical ways. Issues such as getting

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GPR 2010

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reliable positioning, handling large data volumes, and dealing with sensor differences in multichannel arrays were discussed and example results show-cased the progress that is occurring.

Technical sessions focused on common GPR themes. Wide ranging application areas included geological, archaeological, roads, concrete infrastructure, glaciological and planetary exploration uses of GPR. Other sessions addressed instrumentation advances, novel antenna developments, signal processing and numerical simulation improvements.

One trend that stood out was the steady evolution toward quantitative interpretation of GPR. Since its inception, GPR has primarily been a qualitative tool. While travel time and depth determinations are quantitative, the more subtle and very diagnostic information contained in the GPR signal amplitudes has been relatively untapped. There has been a slow and steady movement over the past 5 to 10 years towards using the full signal information. A truly exciting aspect of GPR 2010 was the number researcher papers demonstrating systematic methodologies exploiting signal amplitude.

The social program allowed the attendees to mingle and exchange ideas. The relaxed pace made this a most enjoyable aspect of the meeting. The conference dinner lasted till the wee hours of the morning with die-hards lingering over grappa and cigars in a wonderful outdoor setting.

Field demonstrations allowed instrument makers to demonstrate their latest products. Two test sites were provided. One site was a large area which provided vendors with the opportunity to show 3D imaging over a natural archeological site. A smaller site provided all attendees a chance to get involved with collecting data and see real-time results.

The student presentation session was one of the best. A panel reviewed the student submissions and selected 7 for a special oral presentation session. The presenter of the best paper was awarded a financial prize. The quality of these papers indicates that the GPR field will see a continuing stream of new advances and fresh ideas. The student session concept should definitely be promulgated to future GPR meetings.

As tradition holds, a session is conducted with past meeting chairs assessing submissions for hosting the next GPR meeting in 2 years time. Meeting sites generally alternate between Europe, North America and Asia-Pacific. The location of GPR 2012 will be Shanghai, PRC. ■

Animal burrows

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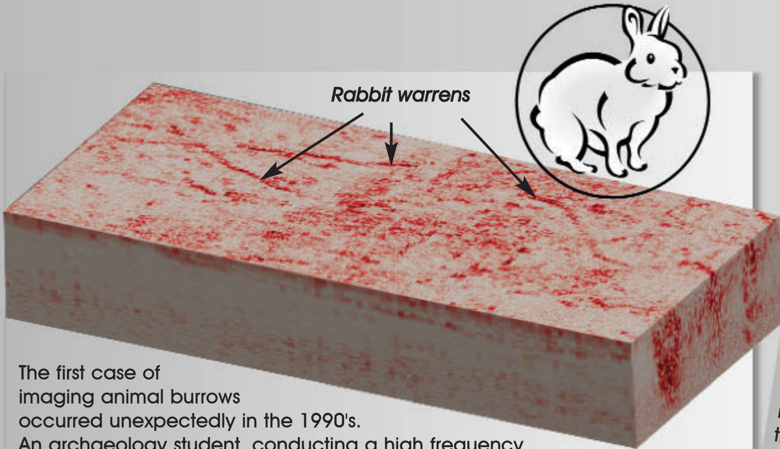
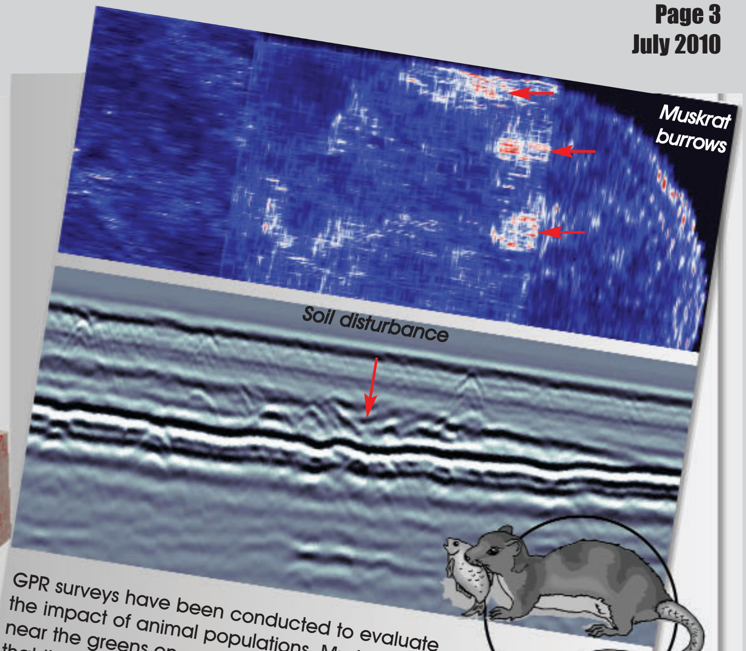
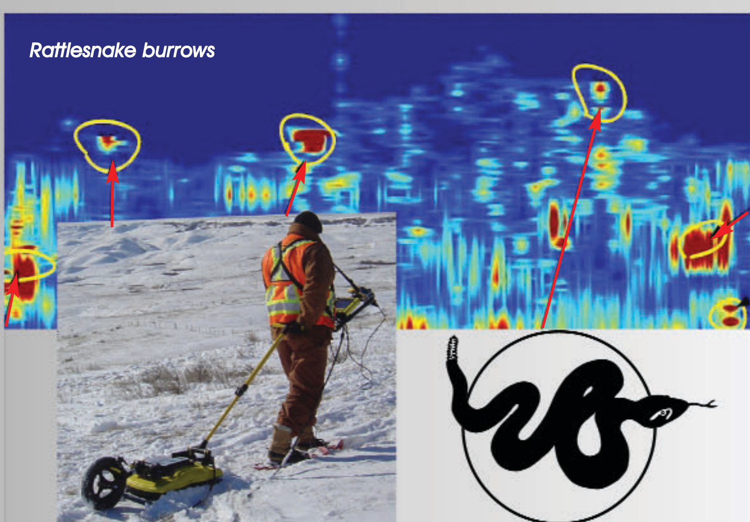


The first case of imaging animal burrows occurred unexpectedly in the 1990's. An archaeology student, conducting a high frequency, high resolution 3D GPR grid survey over the buried foundations of an ancient castle in the United Kingdom, noticed strong shallow reflections in the depth slice images. Closer inspection of the curvilinear patterns revealed the targets to be warrens from the local rabbit population.



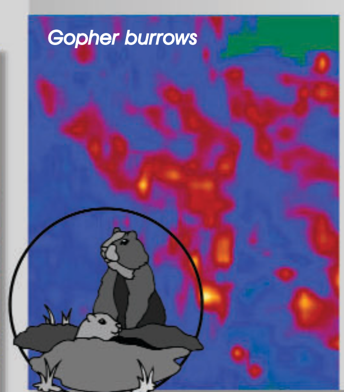
GPR surveys have been conducted to evaluate the impact of animal populations. Muskrats living near the greens on a golf course in Florida decided that the soft golf greens were an ideal place to establish a home. A detailed GPR survey of the green with a Noggin 500 SmartCart system revealed the depth and extent of the soil disturbed by these animals.



An important animal application for GPR include detecting the animal nests for protection of rare species.

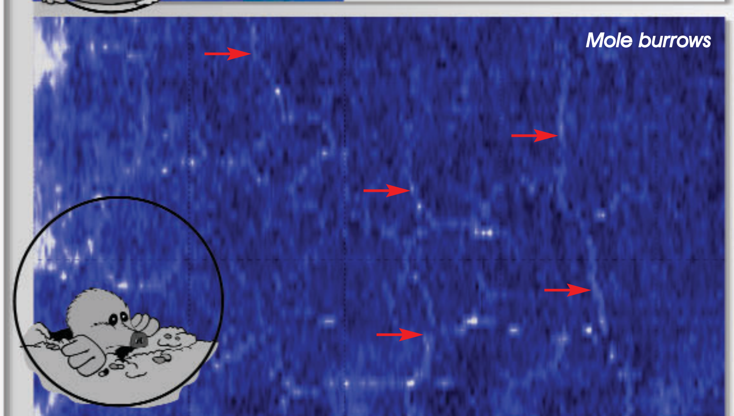
A pipeline construction project was planned in an area in Saskatchewan where the protected Prairie Rattlesnake was known to inhabit. A GPR survey was conducted to locate and delineate the snakes' wintering dens (hibernacula). This knowledge allowed the pipeline to be routed away from sensitive areas. The survey was conducted during winter to minimize the risk to the snakes and the GPR operators.

A grid of GPR data was collected over an area of 58 x 24 meters. To assist with data interpretation, previously identified hibernacula were included in the survey area so the target's GPR "signature" could be established. The depth slice shows several strong responses interpreted as hibernacula.



Prairie dogs (gophers) have an effect on livestock production. Up to 10% of the above-ground vegetation may be destroyed due to their burrowing and mound-building activities. Overall, prairie dogs may remove 18% to 90% of the available forage through their activities (according to United Wildlife Control).

This depth slice from a GPR survey conducted over a small area (7x5m) centered on the main entrance of a prairie dog burrow reveals a complex pattern of tunnels with a definite directional trend.



The ability to map the size of a colony also allows researchers to estimate animal populations. A GPR survey over an area 100 x 35m with line spacing of 1 m shows the large scale pattern of mole burrows.

As human populations clash with animal populations, GPR has proven invaluable as a non-destructive tool for investigating the depth, pattern and areal extent of animal burrows. Burrows are often shallow enough that, even in soils that limit GPR penetration, successful surveys can be conducted. Tight line spacing is key to accurate mapping of the rapidly-changing burrows, and aids in the detection of problem colonies, biological research and animal conservation.

Acknowledgements: *Mole data courtesy of TRICON Geophysik, Rattlesnake data courtesy of Global GPR* ▪

Technical Papers & Notes

1. **Analyzing the Velocity of Ground Penetrating Radar Waves: a Case Study from Koekelare (Belgium),** Workshop on Remote Sensing for Archaeology & Cultural Heritage Management, Rome, Sept.-Oct. 2008
   By: L. Verdonck, D. Simpson, W. Cornelis, A. Plyson, J. Bourgeois, **ref 399**

Upcoming GPR courses

One Day Noggin® Short Course
September 13, 2010
November 1, 2010

Our Noggin® short courses are offered throughout the year to anyone interested in learning more about GPR and subsurface imaging.

One Day Conquest™ Short Course
September 14, 2010
November 2, 2010

Our Conquest™ courses are offered to anyone interested in learning more about our concrete imaging instrument.

Imaging Concrete with GPR - August 17, 2010 - Mississauga, ON
- September 18, 2010 - New York, NY

See us at ...

Locate Rodeo
Atlanta, GA
August 5 - 8, 2010
http://www.locaterodeo.com/

NATIA 2010
Grapevine, TX
August 7 - 13, 2010
http://www.natia.org

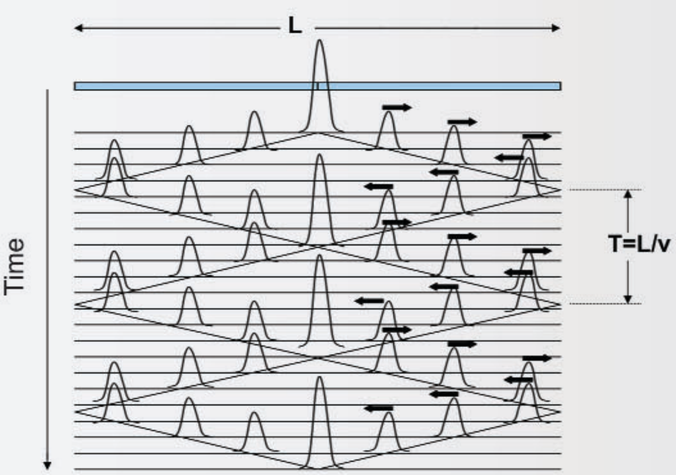
Near Surface 2010
Zurich, Switzerland
September 6 - 8, 2010
http://www.eage.org

CIS 2010
Orillia, ON
September 20 - 23, 2010
http://www.cis-sci-conference.info

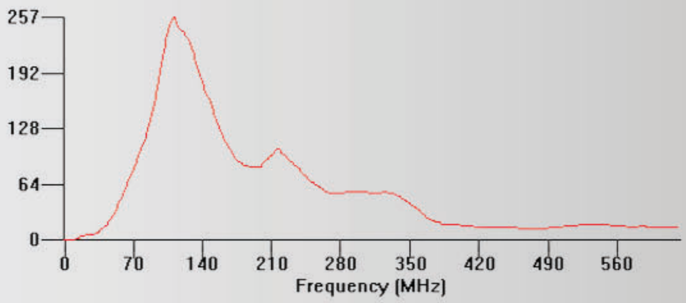
Ask-the-Expert

I notice that peak frequency of GPR data is lower when the antennas are on the ground versus in air. For example, my 200 MHz data has a peak of about 130 MHz. Why does this occur and is there any way to predict how much the peak frequency will drop?

GPR center frequency is controlled by the length of the antenna and the electromagnetic wave velocity in the material surrounding the antenna. Close ground coupling reduces the velocity causing a reduction in center frequency.



The above depicts how a charge pulse fed onto a simple wire dipole travels out from the feed point with time. The ends of the dipole act like a mirror reflecting the pulse back along the antenna. The pulses travel back and forth resulting in a time periodic repetition interval of T=L/v where v is the propagation velocity in the material surrounding the dipole. The electromagnetic fields emitted have the same periodicity.



Example of frequency pull down observed in the amplitude spectrum of data obtained with an antenna with a nominal frequency of 200 MHz.

Basic physics

1. The dominant frequency of the emitted electromagnetic field is defined by the time, T, that a current pulse takes to travel along the length, L, of the antenna. The dominant frequency is $f=1/T=v/L$. where v is the pulse velocity which is normally less than the speed of light c.
2. The velocity depends on the dielectric permittivity of the material(s) surrounding the antenna. The apparent permittivity seen by the fields, K_a, depends on the permittivity of the material supporting the metal antenna, the air, and the ground material plus the antenna geometry, ground roughness and antenna height.
3. Pulse velocity $v= c/\sqrt{K_a}$ and $f= c/L\sqrt{K_a}$. Thus the larger K_a, the lower the center frequency.
4. The exact frequency is not readily predicted since it depends non-linearly on site conditions. Reductions of 10% and 50% in frequency are observed. Highest reductions occur when the ground has a high permittivity as observed in water saturated soil. ▪

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