GPR Technology Vol 8, No. 31, July 2012

Subsurface Views

Sensors & Software Inc.

Unique applications

Ancient Beaver Dams

Prior to the arrival of Europeans in North America, ecologists have estimated that anywhere from 60 to 400 million beavers inhabited the continent. Over the course of the late Pleistocene to Holocene, beavers have been present from the Arctic tundra to the deserts of northern Mexico. Deposition of high volumes of sediment over short periods are recorded behind modern dams, thus over long time periods there is potential for beavers to be landform engineers as layer upon layer of sediment is stacked when they abandon and rebuild their dams in valley bottoms.

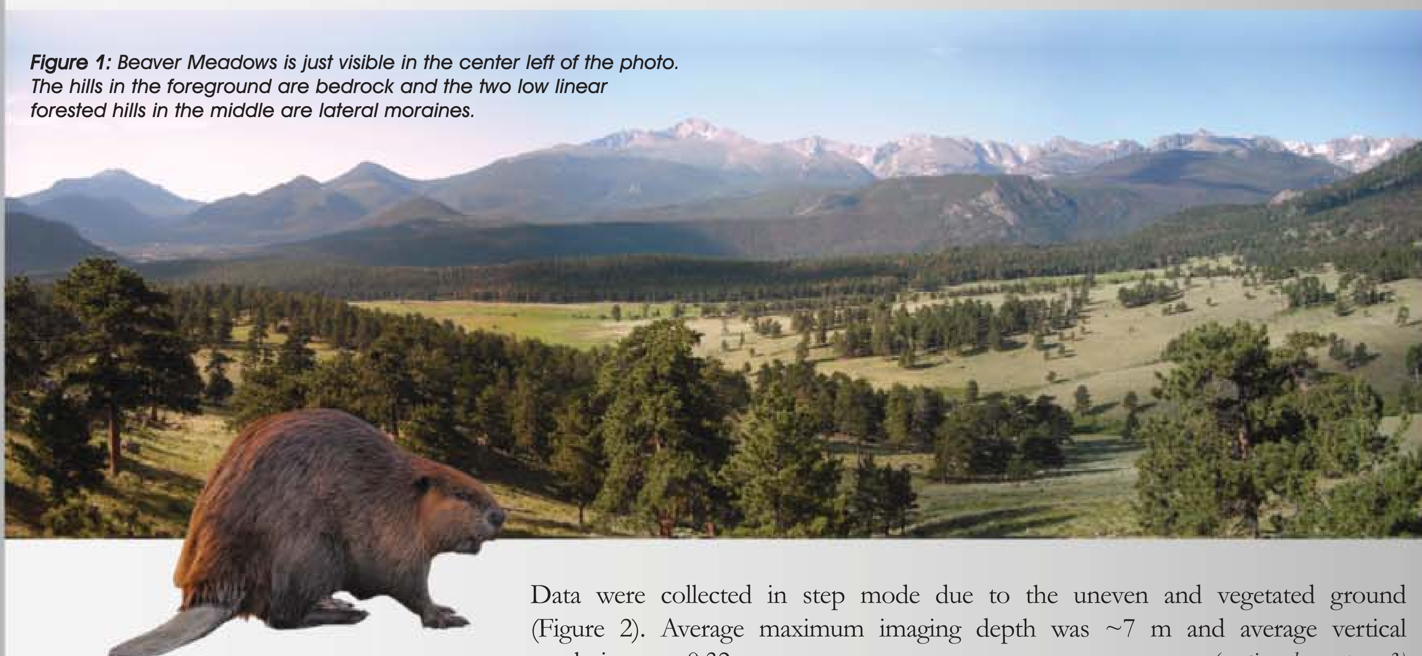

Figure 1: *Beaver Meadows is just visible in the center left of the photo. The hills in the foreground are bedrock and the two low linear forested hills in the middle are lateral moraines.*

In a novel application of GPR, geomorphologists from Colorado State University used a pulseEKKO PRO to unearth buried beaver dams to assess the impact of beaver activity on high-altitude valley sedimentation in the Rocky Mountains over the past 10,000 years.

Approximately 6 km of common offset reflection and 6 common midpoint (CMP) surveys were collected in Beaver Meadows, Rocky Mountain National Park, using 100 MHz antennae and a step size of 0.25 m.

Data were collected in step mode due to the uneven and vegetated ground (Figure 2). Average maximum imaging depth was ~7 m and average vertical resolution was 0.32 m.

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3 Million Foot SmartCart

The Construction Services Department of Fluor Federal Services located in Richland, Washington has used the Noggin 250 SmartCart to locate utilities since 2005.

The SmartCart uses an integrated odometer to trigger GPR data collection at equal intervals during surveys. The Digital Video Logger (DVL) tracks the distance the SmartCart has travelled.

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In this issue

This SmartCart has now been pushed more than 3 million feet!

3 Million Foot SmartCart

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Like your car's odometer, the DVL menu provides a Trip Odometer that can be zeroed by the operator. It also has a Total Distance Odometer which cannot be reset so it records the total distance the SmartCart has been pushed since it was manufactured.

Fluor contacted us recently to say that one of their SmartCarts has been pushed more than 3 million feet! The actual distance was 3247960.550 feet, equal to 615 miles or 990 kilometers. That represents a lot of work for both the operators and the SmartCart.

Although the system is a little beaten up and has been spray painted over the years, it still provides excellent data. According to Larry Peterson, Fluor's Operations Director, "This highlights the Noggin SmartCart's durability and the success we've had with it".

Photos courtesy of Fluor Federal Services. ■

Ask-the-Expert

Can I equate a GPR signal amplitude to a particular type of target?

GPR signal amplitude is not unique to a particular object. Everyone would want a GPR if you could simply set it to "Gold" and it would only respond when it found gold! Unfortunately, GPR signal amplitude is dictated by many factors; the most significant ones are:

1. Electrical Contrast: The electrical contrast in materials determines the reflection coefficient or, more simply, how much signal reflects from the object (Figure 1).

From	K	To	K	R	R (dB)
Air	1	Dry Soil	5	-0.38	-8.36
Dry Soil	5	Wet Soil	25	-0.38	-8.36
Dry Soil	5	Rock	6	-0.05	-26.83
Wet Soil	25	Rock	6	0.34	-9.31
Water	81	Gyttja	50	0.12	-18.41
Water	81	Rock	6	0.57	-4.85
Ice	3.2	Water	81	-0.67	-3.50
Permafrost	6	Wet Soil	25	-034	-9.31
Soil	12	Metal	1000000	-0.99	-0.06

***Figure 1:** Reflection coefficient from boundaries between materials.*

Materials with a high contrast, such as a metal object or an air void in soil will produce stronger reflection amplitudes than objects with low contrast (like a buried pottery jug in soil) .

2. Object Size and Orientation: The amount of GPR signal reflected back to the GPR receiver depends on the size and orientation of the object. Bigger objects reflect more signals (Figure 2).

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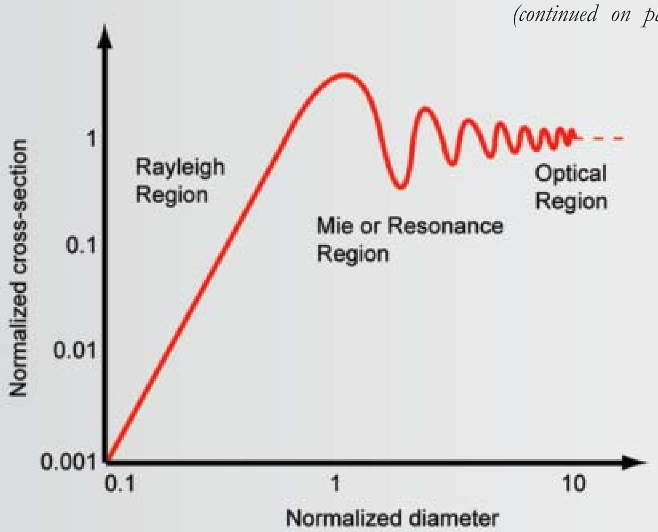

***Figure 2:** Scattering cross section gives a measure of the amount signal returned by a target depending on its size. In this case a normalized diameter of 1 is at a value representative of the GPR with a wavelength at the center frequency.*

Ancient Beaver Dams

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Two-way travel times from the GPR profiles were converted to depths using radar velocities estimated from a radar velocity contour map of the meadow. The map was constructed from the CMP data, saturation profiles and velocities estimated from diffractions along GPR profiles. Average radar velocity was 0.08 m/ns but varied considerably (0.05 – 0.12 m/ns) perpendicular to the valley axis due to differences in ground saturation.

Beaver Meadows is adjacent to a lateral moraine and is bordered by granite, gneiss and schist bedrock and Pleistocene till to the south (Figure 1). Today, there is no evidence of contemporary beaver activity and the meadow cannot support beaver colonies. Surficial evidence of past beaver dams is either expressed as subtle changes in topography and vegetation or is not visible.

Individual buried dams were identified on GPR profiles as unique radar packages containing chaotic discontinuous reflectors (interpreted to be the buried dam) that truncate parallel continuous reflectors upslope (interpreted to be pond deposits). This was confirmed by co-locating, when possible, topographic berms identified in the field as buried beaver dams (Figure 3).

Subsurface beaver dams can appear in a chain distributed longitudinally along the valley, stacked with vertical en echelon offset to one another. Beaver dams identified in the GPR data match well with dams and ponded areas visible on aerial photographs from 1938-2001 (Figure 4), with the exception of a few areas of high dam density. In these areas, the chaotic GPR reflectors associated with individual dams merge over a large area, making it difficult to identify individual dams.

To determine the impact of beaver damming on valley sedimentation, genetically-related strata corresponding to glacial, non-glacial, and beaver-induced sedimentation were identified and relative amounts compared. Most of the valley fill in Beaver Meadows is glacial in origin, with a thin (~1.3 m on average) alluvial drape. Thus beavers did not alter the basic landform of the valley.

30-40% of the valley fill on profile cross-sections, however, is attributed directly to beaver damming. Although beavers did not significantly raise the valley floor with successive stacking of sediments, they were key players at trapping the fine sediment that is present.

Fine sediment is crucial for supporting a lush wetland ecosystem. Without the continued presence of beavers, wetlands degrade when fine sediments are no longer trapped and previous sediment stored from past dams is exhumed by incising stream channels.

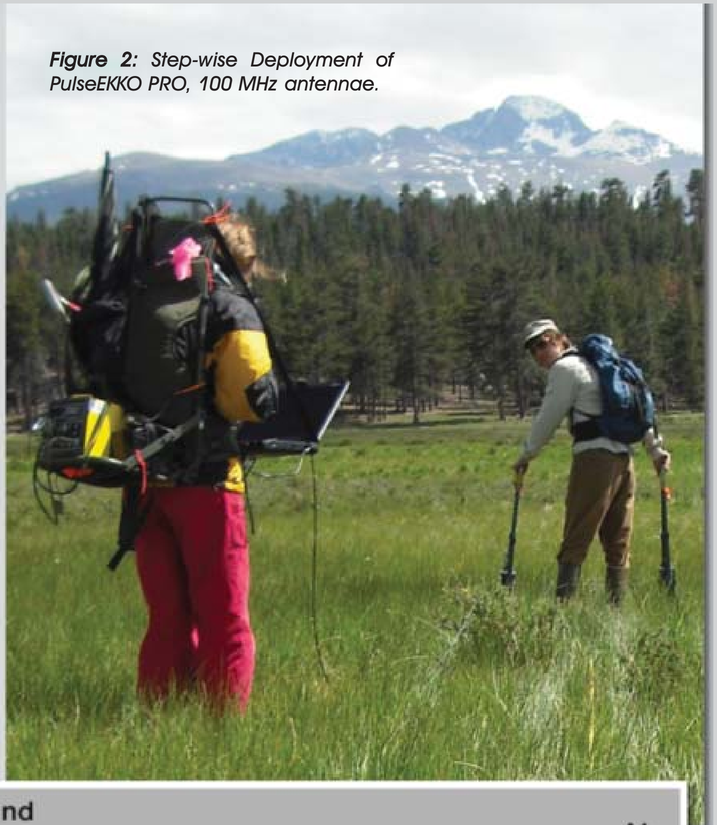

Figure 2: *Step-wise Deployment of PulseEKKO PRO, 100 MHz antennae.*

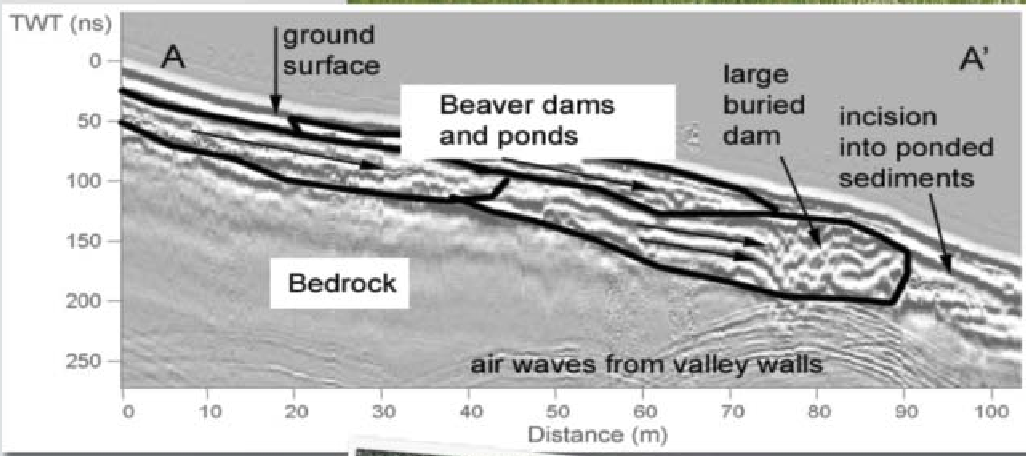

Figure 3: *A transect showing buried beaver dams and ponded sediments. 100 ns TWT is approximately 4 m using the average velocity of 0.08 m/ns.*

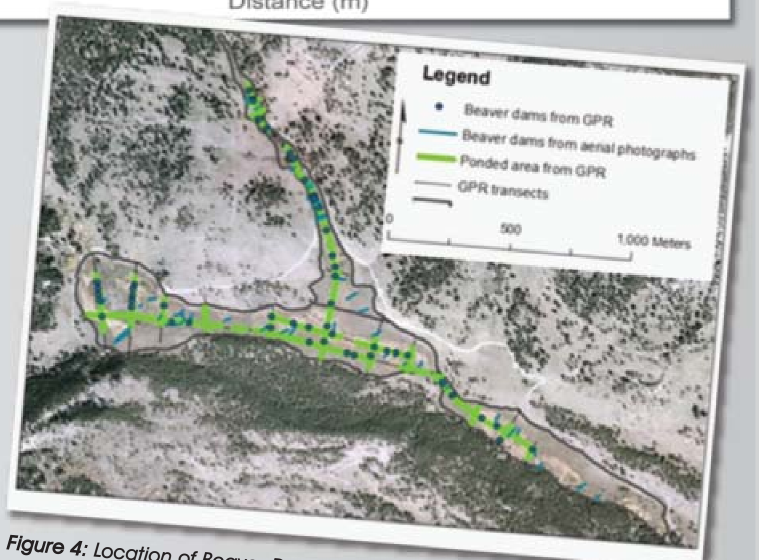

Figure 4: *Location of Beaver Dams and Ponds identified in the GPR profiles.*

Story courtesy of Natalie Kramer – Colorado State University

Technical Papers & Notes

1. Time-Domain Reflectometry – Air-Gap Problem in a Coaxial Line;
   Resource Geophysics and Geochemistry Division; 1977
   By: A.P. Annan, J.L. Davis **ref 440**

2. Time-Domain Reflectometry – Air-Gap Problem for Parallel Wire Transmission Lines; Resource Geophysics and Geochemistry Division; 1977
   By: A.P. Annan, J.L. Davis **ref 441**

Upcoming GPR courses & workshops

One Day Noggin® Short Course

September 10, 2012

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 11, 2012

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

Imaging Concrete with GPR workshops - August 14, 2012 - Washington, DC

See us at ...

Locate Rodeo 2012
Atlanta, GA
August 2 - 4, 2012
www.locaterodeo.com

CIS 2012
Calgary, AB
September 17 - 18, 2012
http://www.cis-sci-conference.info/cms/index.php

WaterPro Conference 2012
Nashville, TN
September 24 - 26, 2012
http://www.waterproconference.org/

ACI 2012
Toronto, ON
October 21 - 25, 2012
http://www.concrete.org/Convention/Fall-Convention/Front.asp

Ask-the-Expert

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GPR signals are similar to light waves and objects can preferentially direct the reflected signal like a mirror in the sun. If the object surface is not optimally aligned, little or no energy may be reflected in the receiver direction. The object will appear to have a low signal amplitude.

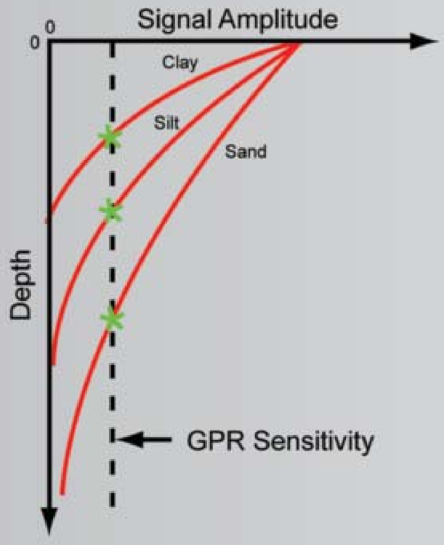

***Figure 3:** Signal amplitude decreases with depth depending on the absorption characteristics of the material.*

3. Signal Absorption: As GPR signals travel into the subsurface they spread out over a larger volume, thereby reducing amplitude. The signals are further being absorbed by host materials. Ground or host materials absorb energy but to varying degrees (Figure 3). As a result, amplitude constantly decreases as the GPR signal travels deeper into the ground. This means that a reflection from a very high contrast target like a metal object may generate low signal amplitude simply because the object is deep or host material attenuation is high.

A further factor is the **GPR transmitter power,** which may vary depending on the GPR model and local emissions regulations. With so many factors affecting GPR signal amplitude, it is not possible to reliably equate specific signal amplitudes to a particular material or type of target.

Despite the limitations on absolute signal amplitudes, relative amplitudes on a GPR cross-section can be highly diagnostic and are often used to help with target classifications. ■