Consultants Corner

Winter 2005

Seeing Below the Surface

For many of us, the thought of seeing below the surface of anything can be very exciting. Some want to see below the surface of the ocean; others want to know what lies beneath the surface of our own skin. For geophysicists, seeing below the surface of the earth's crust can be electrifying.

Geologists develop maps of the earth's surface with all its nooks and crannies. The beautiful color maps show where the rocks are and how they outcrop. Geophysicists take these maps a dimension further to below the ground level so that we can see caverns, aquifers, bedrock, faults and many other interesting things.

What the geophysicist is looking for are changes or contrasts in physical properties. You might recall from your physics class (you did go, didn't you?) some of these properties include electrical, magnetic, elastic (seismic), and density (gravity).

As children, we have all seen photos in books showing how, many years ago, the dinosaurs gave their lives in swamps and shallow seas to provide the oil we

A Lacoste & Romberg gravimeter in the field.

Setting up a Wenner array resistivity line. Here, the electrode spacing is about four feet.

consume. Layer upon layer of sand, rock, gravel and debris piled on top of their remains to form the earth as we know it today. We can actually get a more accurate picture of what's going on down there with several different geophysical techniques.

A technique called the resistivity method uses various electrical field arrays to view below the surface. One electrical field array is called the expanded Wenner. The process begins with placing four stainless steel rods, each about the size of a tent stake, into the ground approximately one foot apart in a straight line.

A refraction seismic line ready to read. The small object in the foreground is a geophone. The box in the center is the seismograph.

The two exterior rods, or current electrodes, transmit electrical current into the ground. The two rods in the center, the potential electrodes, are used as receiving rods. The voltage readings received from these rods help the geophysicist "see" below the surface.

The expanded Wenner array is sometimes referred to as electrical drilling. The farther apart the rods are, the deeper into the ground you will see. Although this isn't a perfect science, it can be very helpful in determining the type of foundation needed for that multi-million dollar structure. Changes in the

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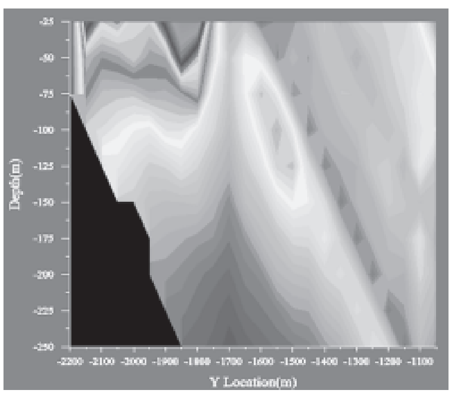
resistivity (a measure of how well the ground conducts electricity) will allow a geophysicist to identify features such as bedrock, groundwater, buried structures, and voids or cavities below the surface.

Density is a property that shows gravity at work. The geophysicist uses an instrument called a gravimeter to detect changes in gravity below the earth's surface. The denser an object is, the higher the reading on the gravimeter. So a large boulder under the ground can be seen because the gravitational pull of that boulder is stronger than the lower density soil around it. (Don't try this at home!). The gravimeter is such a sensitive instrument that corrections need to be made to the raw data depending on where you are in the world. These corrections are necessary due to changes caused by tidal effects of the sun and moon, elevation, terrain and latitude. The gravimeter can detect a change in altitude of as little as two feet! After all the corrections are made, the resulting contrast is primarily due to subsurface geology.



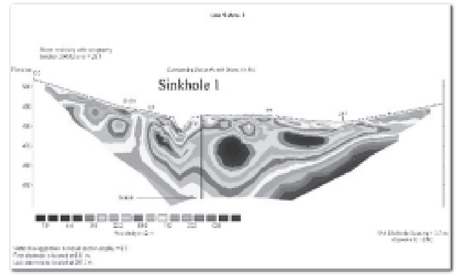
The results of 2-D smooth-model resistivity depth inversion.

The seismic refraction method uses another sensitive device called the geophone. A geophone can detect minute vibrations in the earth—even the vibrations produced by an airplane flying overhead. A string of geophones are laid out along a survey line and connected to a seismograph. A sledge hammer (or any of several other seismic energy sources) is then used to strike a metal plate on the ground, sending vibrations, or waves, into the earth. The seismic waves are refracted from rock interfaces back up to the surface where they are detected by the geophones. By plotting a graph of wave arrival times versus geophone distance, the geophysicist can determine the velocities of the seismic waves through the different rock layers, and the depths to these layers. The velocity information can be used to determine *rippability*, or the ability to cut through the material using a bulldozer.

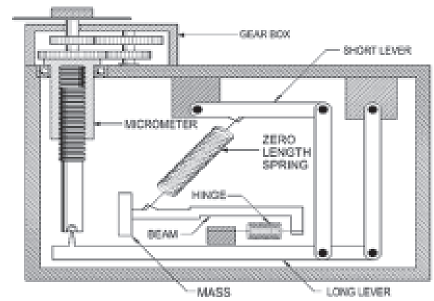
One other geophysical method is called CSAMT, or controlled-source, audio frequency magnetotellurics (whew!), but we won't even go there. Maybe another day…

These are just a few of the many different geophysical tools available for subsurface exploration. Much like the X-ray and ultrasound tests used by doctors to "see" inside the body, the different geophysical methods, in conjunction with traditional drilling and sampling, allow the geophysicist, geologist and engineer to develop a more accurate picture of the features hidden below the surface.

—*Joseph E. McKinney*



The results of 2-D smooth-model resistivity depth inversion over a sinkhole (buried void).



The inner workings of the Lacoste & Romberg gravimeter.

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