Geo-Earth offer our clients a selection of geophysica l techniques to complement their exploration efforts, **Geo-Earth** often provides tailored, bespoke techniques not commonly available. Geo-Earth like a challenge, so if there is a particular technique Geo-Earth can help engineer for technical solutions, please let us know.

The resistivity imaging method uses standard arrays developed for electrical resistivity sounding and profiling techniques and modifies them to create two dimensional resistivity profiles. A line of electrodes is placed at equal intervals along the desired profile. Four electrodes are used at one time. Two inject current into the ground and two read the electrical potential between them. The resistivity meter and switch box automatically read many combinations of current and potential electrodes from short offsets to long offsets starting at one side of the electrode spread and moving toward the opposite end. The short offsets look at the shallow earth, and the longer offsets look more deeply. **Geo-Earth** typically use either the dipole-dipole or the Wenner-Schlumberger array. The dipole-dipole array gives good horizontal resolution, but may have a poor signal to noise ratio (S/N) because the potential electrodes are outside of the current electrodes. The Wenner-Schlumberger array is more directed for vertical resolution, but it also gives reasonable horizontal resolution. This method has greater S/N than the dipole-dipole method because the potential electrodes are placed between the two current electrodes. The field data contain apparent resistivity values and geometry information. These data are then inverted to produce a two dimensional (X - Z) plot of resistivity values. This resistivity inversion section is then used to interpret subsurface lithology.

Two types of IP data are acquired: frequency domain and time domain. Time domain IP surveys involve measurement of the magnitude of the polarization voltage (Vp) that results from the injection of pulsed current into the ground. Polarization voltages primarily result from electrochemical action (ionic exchange) within the pores and pore fluids of the material being energized. The current is applied in the form of a square waveform, with the polarization voltage being measured over a series of time intervals after each current cut-off using non-polarizing electrodes. The measured value of Vp is divided by the steady voltage (observed whilst the current is on) to give the apparent chargeability of the ground. This provides qualitative information on the subsurface geology. TD-IP is primarily used in mineral exploration surveys.

Spectral IP surveys involve measurement of the magnitude and relative phase of the polarization voltage that results from the injection of an alternating current into the ground. Polarization voltages primarily result from electrochemical action (ionic exchange) within the pores and pore fluids of the material being energized. Measurements of the relative phase shift between the transmitted current and the measured signal and the magnitude of the polarization voltage are taken over a range of different frequencies. This results in a distinct IP response spectrum or 'dispersion' at each measurement position that can be used to determine capacitive parameters such as relaxation time and chargeability, and can be interpreted qualitatively or modeled quantitatively in 2D and 3D to estimate the distribution of clay or metallic mineralization

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The spontaneous potential (SP) method is a passive electrical technique that involves measurement of naturally occurring ground potentials. These can be generated from a number of different sources although all require the presence of groundwater to some degree. The two main sources of interest in environmental and engineering studies are streaming potentials, due to movement of water through porous subsurface materials, and diffusion potentials resulting from differing concentrations of electrolytes within the groundwater. SP measurements are made using a pair of non-polarising electrodes. These normally comprise a pot containing a copper electrode immersed in a saturated copper sulphate solution. A porous base to the pot enables the electrolyte to percolate out and make contact with the ground. The potential difference between the two pots is measured using a high impedance voltmeter.

SP is acquired with a stationary reference electrode (SE) and moving the measuring electrode (ME) along lines or grids to measure variation in potential. Data are usually interpreted in a qualitative manner, and are routinely used to locate zones of seepage in earth fill dams and levees, assessing seepage from dams and embankments, fluid migration pathways in landfills, mapping coal mine fires and for the study of drainage structures, shafts, tunnels and sinkholes. SP measurements can also be quantitatively inverted in a stochastic sense to generate models of charge distribution potential which are highly effective at identifying vertical features such as mine shafts and sinkholes.

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is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of theradio spectrum, and detects the reflected signals from subsurface structures. GPR can have applications in a variety of media, including rock, soil, ice, fresh water, pavements and structures. In the right conditions, practitioners can use GPR to detect subsurface objects, changes in material properties, and voids and cracks. GPR uses high-frequency (usually polarized) radio waves, usually in the range 10 MHz to 1 GHz. A GPR transmitter emits electromagnetic energy into the ground. When the energy encounters a buried object or a boundary between materials having different permittivities, it may be reflected or refracted or scattered back to the surface. A receiving antenna can then record the variations in the return signal. The principles involved are similar to seismology, except GPR methods implement electromagnetic energy rather than acoustic energy, and energy may be reflected at boundaries where subsurface electrical properties change rather than subsurface mechanical properties as is the case with seismic energy. The electrical conductivity of the ground, the transmitted center frequency, and the radiated power all may limit the effective depth range of GPR investigation. Increases in electrical conductivity attenuate the introduced electromagnetic wave, and thus the penetration depth decreases. Because of frequency-dependent attenuation mechanisms, higher frequencies do not penetrate as far as lower frequencies. However, higher frequencies may provide improved resolution. Thus operating frequency is always a trade-off between resolution and penetration. Optimal depth of subsurface penetration is achieved in ice where the depth of penetration can achieve several thousand metres (to bedrock in Greenland) at low GPR frequencies. Dry sandy soils or massive dry materials such as granite, limestone, and concrete tend to be resistive rather than conductive, and the depth of penetration could be up to 15-metre (49 ft). In moist and/or clay-laden soils and materials with high electrical conductivity, penetration may be as little as a few centimetres.

Ground-penetrating radar antennas are generally in contact with the ground for the strongest signal strength; however, GPR air-launched antennas can be used

The GPR method uses high-frequency electromagnetic waves to provide detailed subsurface cross sections.

•microwave energy reflected back to the surface from different materials produces various electrical results

•Metal objects produce the strongest results, determining location, depth and size

•GPR can also identify excavations, for example where tanks were removed, and can delineate the boundaries of landfills and buried lagoons

•higher-frequency antennas (typically 900 or 1,500 MHz) are utilized for surveys on concrete slabs, to locate rebar, electrical conduits, or other pipes prior to core drilling or saw cutting.

Geo-Earth staffs skilled in digital signal-processing techniques that enhance GPR data interpretations. Signal processing can reduce background noise and identify weaker reflections (such as from fiberglass USTs, or subtle stratigraphic variations) that would remain undetected using analog GPR instrumentation.

The gravity method is a passive, non-destructive geophysical technique involving the precise measurement of the Earth's gravitational field at specific locations on the Earth's surface. Careful processing and imaging of these measurements provide for the detection of subtle gravity changes due to lateral variation in subsurface density. Earth scientists can therefore use gravity data to make inferences about Earth's density structure. The gravity method can be used to detect density variation on all scales; from microgravity surveying for natural or man-made voids, to prospect scale surveying for ore deposits, to space-borne surveying to characterise the shape of the Earth's core.

Geo-Earth specializes in ground based gravity surveying from microgravity (10s of m) to regional (100s of km) scales. Gravity is our bread and butter. It's what we are good at and accounts for most of our business activity. Our gravity survey capabilities include:

TypeSpacing

Microgravity0.5m – 10m

Detailed10m – 100m

Semi Regional100m – 1000m

Regional1000m – 10000m

Similarly to gravity survey, the magnetic survey method is also passive but involves the precise measurement of the Earth's magnetic field. Typically the total magnetic field and/or vertical magnetic gradient is measured. Magnetism is, just like gravity, a potential field. Anomalies in the earth's magnetic field are caused by induced or remanent magnetism. Induced magnetic anomalies are the result of secondary magnetization induced in a ferrous body by the earth's magnetic field. The shape, dimensions, and amplitude of an induced magnetic anomaly is a function of the orientation, geometry, size, depth, and magnetic susceptibility of the body as well as the intensity and inclination of the earth's magnetic field in the survey area.

Seismic techniques are useful for determining velocity contrasts in the subsurface. Seismic velocity is the speed at which a surface generated p-wave or s-wave travels through soil and rock. Seismic velocity correlates well with the rock hardness and density, and these in turn correlate with changes in lithology, fracturing, faulting, degree of weathering etc. Seismic techniques, when applied correctly, can image the subsurface where traditional geophysical techniques fall over and fail. The Refraction seismic technique is ideally suited for depth to bedrock determination e.g. finding palaeochannels and shallow environmental and engineering applications. It is best suited where slow velocity layers overlay faster velocity layers and depth of investigation is usually limited to 100-150m (or 4 x the Source-Receiver Offset distance). The method is based on the fact that when a wave reaches a boundary between two layers having different seismic velocities, that seismic wave will be refracted (or bent) either toward the normal to the interface or away from the normal to the interface, depending on whether the velocity increases or decreases at the boundary. In the special case where layer velocity increases with depth at the boundary, critical refraction occurs where seismic waves travel along the interface between the two materials. The angle at which the seismic waves are critically refracted (the critical angle) is uniquely determined by the ratio of the velocities of the two materials: $\theta c= \sin-1(V1/V2)$, and because the critical angle is uniquely determined, the depth at which the boundary between the layers occurs can be calculated using geometry and the measured first arrival travel times. For more complex geology, Reflection is superior, giving the ability to image subsurface layers and complex structures to significant depths (+500m). The seismic reflection method is based on the fact that when a wave reaches a boundary between two materials having different acoustic impedances (product of velocity and density) that wave will be reflected back to the surface. The angle at which the seismic waves are reflected is determined by the angle of incidence of the waves.

GEOEARTH uses a very low impact, skid steer operated accelerated drop hammer for a seismic source. the seismic refraction utilizes acoustic waves generated by an impact or small explosive source to measure depths to bedrock or overburden layers of sedimentary rock and to infer bedrock faults or fracture zones.

•Seismic response are plotted through distance along the geophone array to identify individual layers, and to compute layer thicknesses and seismic velocities.

•Specific geologic conditions, such as bedrock fractures or valleys, may be interpreted directly from these time-distance plots or by using several seismic modeling techniques.

•Low-velocity zones and thin strata may be undetected using older interpretive methods, such as the crossover distance technique.

Geophysical Applications can use SeisOpt2D velocity modeling to identify these "hidden layer" conditions. SeisOpt2D also provides a means of quantitatively evaluating lateral seismic velocity variations that can represent lithologic contacts or fracture zones. Geophysical Application's software can also perform forward modeling to design geophone and shotpoint spacings needed to achieve specific survey objectives.

- The EM method measures the conductivity of earth materials, buried objects, and backfill utilizing electromagnetic induction. Comparing in-phase and quadrature EM data, or EM and magnetic contour maps, can benefit a project by differentiating ferrous and non-ferrous sources of elevated conductivity (such as drums versus landfill leachate).

Electrical Resistivity Imaging, Soundings, and Profiling - Electrical resistivity methods can measure depths to groundwater and bedrock, and locate clay layers, sand and gravel deposits, and leachate plumes from lagoons or landfills.

Geophysical Applications utilizes digital resistivity instrumentation and the linear filter modeling technique to obtain accurate layer thickness interpretations during resistivity sounding surveys. Automated dipole-dipole profiling surveys are conducted using an ABEM resistivity system or Advanced Geosciences Sting resistivity meter and Swift electrode array, with inversion software to generate contoured resistivity cross sections.

Is an electromagnetic geophysical method for inferring the earth's subsurface electrical conductivity from measurements of natural geomagnetic and geoelectric field variation at the Earth's surface. Investigation depth ranges from 300 m below ground by recording higher frequencies down to 10,000 m or deeper with long-period soundings. Developed in the USSR and France during the 1950s, MT is now an international academic discipline and is used in exploration surveys around the world. Commercial uses include hydrocarbon (oil and gas) exploration, geothermalexploration, mining exploration, as well as hydrocarbon and groundwater monitoring. Research applications include experimentation to further develop the MT technique, long-period deep crustal exploration, and earthquake precursor prediction research

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An earthquake (also known as a quake, tremor or temblor) is the perceptible shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's crust that creates seismic waves. Earthquakes can be violent enough to toss people around and destroy whole cities. The seismicity or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter magnitude scale. These two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible or weak and magnitude 7 and over potentially cause serious damage over larger areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. Intensity of shaking is measured on the modified Mercalli scale. The shallower an earthquake, the more damage to structures it causes, all else being equal.[1]

At the Earth's surface, earthquakes manifest themselves by shaking and sometimes displacement of the ground. When the epicenter of a large earthquake is located offshore, the seabed may be displaced sufficiently to cause a tsunami. Earthquakes can also trigger landslides, and occasionally volcanic activity.

In its most general sense, the word earthquake is used to describe any seismic event — whether natural or caused by humans — that generates seismic waves. Earthquakes are caused mostly by rupture of geological faults, but also by other events such as volcanic activity, landslides, mine blasts, and nuclear tests. An earthquake's point of initial rupture is called its focus or hypocenter. The epicenter is the point at ground level directly above the hypocenter.

The vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The word comes from Latin vibrationem ("shaking, brandishing") The oscillations may be periodic, such as the motion of a pendulum—orrandom, such as the movement of a tire on a gravel road.

Vibration can be desirable: for example, the motion of a tuning fork, the reed in a woodwind instrument or harmonica, amobile phone, or the cone of a loudspeaker.

In many cases, however, vibration is undesirable, wasting energy and creating unwanted sound. For example, the vibrational motions of engines, electric motors, or any mechanical device in operation are typically unwanted. Such vibrations could be caused by imbalances in the rotating parts, uneven friction, or the meshing of gear teeth. Careful designs usually minimize unwanted vibrations.

The studies of sound and vibration are closely related. Sound, or pressure waves, are generated by vibrating structures (e.g. vocal cords); these pressure waves can also induce the vibration of structures (e.g. ear drum). Hence, attempts to reduce noise are often related to issues of vibration.

Vibration Analysis (VA), applied in an industrial or maintenance environment aims to reduce maintenance costs and equipment downtime by detecting equipment faults.[3][4] VA is a key component of a Condition Monitoring (CM) program, and is often referred to as Predictive Maintenance (PdM).[5] Most commonly VA is used to detect faults in rotating equipment (Fans, Motors, Pumps, and Gearboxes etc.) such as Unbalance, Misalignment, rolling element bearing faults and resonance conditions.

VA can use the units of Displacement, Velocity and Acceleration displayed as a Time Waveform (TWF), but most commonly the spectrum is used, derived from a Fast Fourier Transform of the TWF. The vibration spectrum provides important frequency information that can pinpoint the faulty component.

The fundamentals of vibration analysis can be understood by studying the simple mass–spring–damper model.