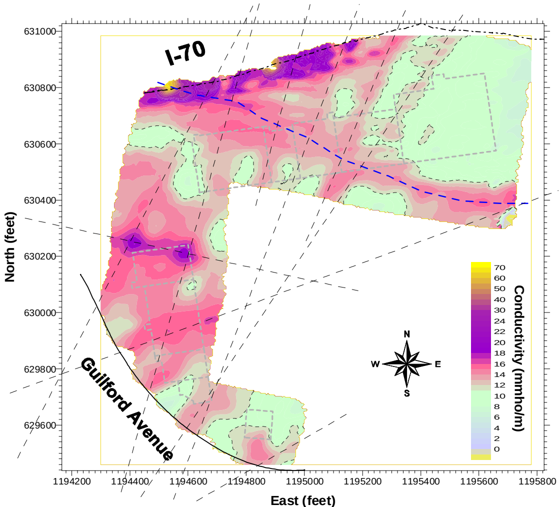
FRACTURES



EM fracture mapping

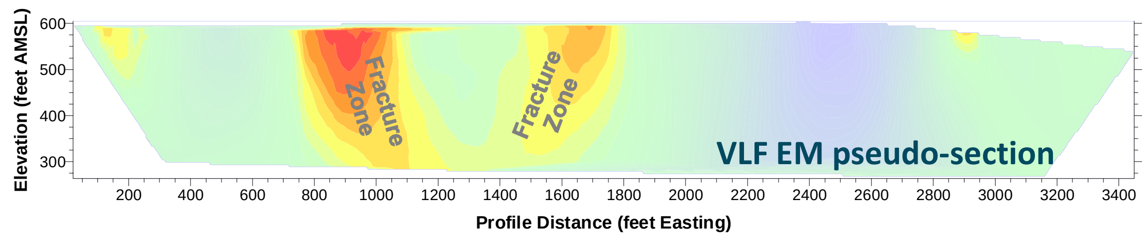
The word *fracture* is used to describe discontinuities in rock ranging from regional-scale faults, through outcrop-scale joints, down to sub-hand-sample-scale cracks. Fractures are typically tabular (i.e. thin relative to their height and width), and occur in sets with preferred orientations.

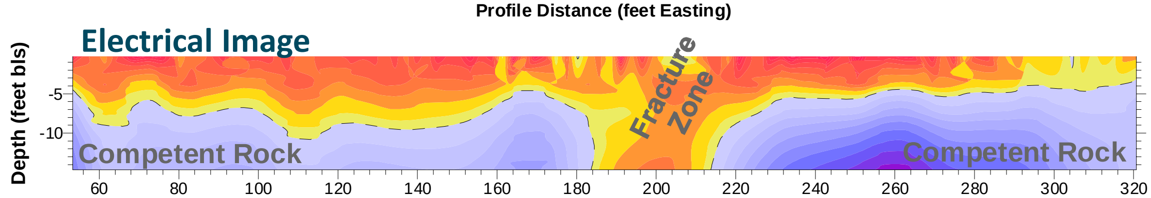
A fracture is a break in the rock. This implies a localized loss of strength, and increase in porosity. This in turn implies that fractures can be detected using **seismic** methods which are sensitive to rock mechanical properties, and/or **electrical** or **electromagnetic (EM)** methods which are sensitive to rock electrical properties. Electrical/EM methods are particularly useful when the fracture porosity is filled with a conductive material such as water, clay, weathering products, or mineralization.

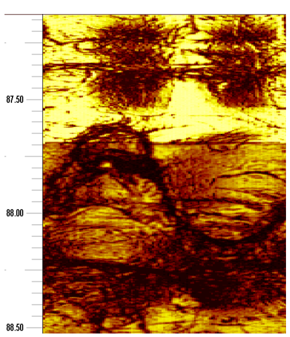
GPR scanning of an underground mine roof for hidden delaminations

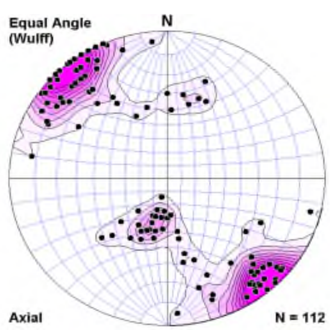
Knowledge of fracture locations, orientations, character, and density is often critical to hydrogeologists siting production wells or modeling contaminant transport; to engineers designing road cuts, bridge abutments, foundations, landfills, etc.; to miners stabilizing tunnel walls and ceilings; and many others.

RETTEW uses an array of geophysical techniques sensitive to detect and characterize fractures at many scales. Detection and mapping of steeply-dipping regional features is performed **very low frequency** (**VLF**) **EM**, **resistivity** or **EM profiling**, **electrical imaging (EI)**, **seismic refraction**, or **microgravity** (the latter, in particular, in karst terranes). Flat-lying fractures are best detected and characterized using **electrical** or **EM sounding**, **ground penetrating radar (GPR)**, or **seismic reflection** methods. Outcrop-scale fractures are detected using **tomographic EI**, **EM** or **seismic** methods between boreholes, or from tunnels to boreholes or the ground surface.









Acoustic televiewer image of dipping fractures (left) and stereogram of fracture orientations in a borehole (right)

Very small (hand-sample to nearly microscopic scale) fractures can be characterized qualitatively using geophysical logging methods (**caliper**, **fluid temperature**, or **conductivity**, **short- or long-normal resistivity**, **EM formation conductivity**, **full-waveform sonic**, **natural gamma**, etc.), or measured quantitatively using **borehole optical** or **acoustic televiewer** methods.

At all scales, **seismic** methods that measure secondary (S) or shear-wave velocity anisotropy are useful for estimating the orientation and spatial density of fracture sets – even where individual fractures are too small to resolve.