

## Locating the Play: The History of Visualization in Petroleum Exploration

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Although a visualization sequence in petroleum exploration is far from linear, several important milestones document a history of visualization techniques that proceeded from direct surface observation through subsurface imaging. Many newer methods typically complemented older ones, rather than replacing them. </P>

Early exploration for hydrocarbons proceeded through direct visualization: if a seep could be located, petroleum could be harvested. In 1859, Drake's pioneering well extended the seep into the subsurface realm by drilling. Likewise, direct visualization was extended when Logan recognized the importance of structural traps, and petroleum searches proceeded through seeps and antiformal structures after Spindletop (1901). The graphic vehicles that best supported data for early petroleum exploration were detailed, geological maps. By the 1920s, airplanes were able to facilitate mapping through aerial photography, and the resultant topographic maps helped to standardize the mapping process. </P>

Direct visualization carried petroleum exploration only so far, and geologists realized that to locate subsurface petroleum reservoirs, they had to "see" into the subsurface. An explosion of techniques, modified for the petroleum industry, resulted. Seismic reflection methods emerged from WWI technology, with acoustic data employed to image the subsurface. Mapped gravity measurements, first through the torsion balance, also allowed geologists to peer into the Earth. Well logging's resistivity data permitted subsurface mapping between two surface points. Seismic profiles, gravity surveys, and e-logs became supporting graphic tools for petroleum exploration in the late 1920s and 1930s.</P>

As technology advanced, exploration techniques evolved. Neutron logs enabled geologists to gauge porosity beginning in the 1940s, while NMR was hailed as a reliable visualization tool for permeability in the 1950s. The explosion of digital technology and computers resulted in efficient data filtering and analysis. Computers allowed for more thorough analyses of 3D seismic data (1970s) over 2D seismic data, and eventually 4D time-lapse seismic data (1990s-). However, subsurface visualization never replaced surface visualization. Detailed geologic maps maintained their importance within exploration, although additional data-gathering techniques were added over the years, including thermal, infrared, and remote sensing.