Reservoir Connectivity Analysis: Studies of the Hydrocarbon and Aquifer Pressure Systems of Hydrocarbon Fields

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My consulting work involves analysis of gas and oil accumulations and the pressures associated with them in an attempt to understand: (1) why hydrocarbons have filled a hydrocarbon trap the way they have, and (2) to predict what hydrocarbons might be discovered in untested parts of hydrocarbon fields. The work has many similarities to groundwater hydrology except that we have two or three phases (gas/oil/water) and data that cost hundreds of millions of dollars to acquire.

The first step in our analysis is to interpret the pressure data for evidence of how hydrocarbons or water are or are not communicating in the field across faults or between different reservoirs (usually sandstone). Depending on the stage of development in the field we can be working with 1-12 wells and up to hundreds of pressure measurements.

The next step is to define what I call the 3D connectivity framework. For this we rely heavily on logs in wells to indicate the characteristics of our sand and shale rocks, and 3D seismic to define the structural and stratigraphic geometry. In many cases we can image the geometry of sand channel belt systems, shorelines, or other environments in vivid detail. We make maps and 3D images of these. These are our reservoirs—the equivalent of aquifers in groundwater hydrology. We can commonly define where one reservoir incises into or laps onto another—one way different reservoirs can connect. These reservoirs intersect faults, where one reservoir may be juxtaposed against a different reservoir—this is the other primary way that two different reservoirs can communicate with each other.

Once we have this framework of sand geometries and fault connections established, we attempt to explain the patterns of communication defined by pressure measurements, and to predict what will be present in untested areas.

This work has revealed many surprising results and concepts that I will discuss. The impact this work can be considerable. For instance, if it means that one well does not have to be drilled, or prevents a poorly sited well, the savings are near $100 million. Some of these studies have led to new hydrocarbon discoveries with values on the order of billions or tens of billions of dollars at current prices.