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## Geology for the Layman

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"GEOLOGY FOR THE LAYMAN"

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The first thing that an individual must thoroughly understand, is that geology is not an exact science. This may be strange for a geologist to say, but it is very similar to the profession of law in that any set of data may be and is usually interpreted differently by individual lawyers. We geologist start with some known facts (sometime geological), make assumptions, and then intrepret into the unknown. It is this interpretation that separates a successful geologist from a geologist. A successful oil finding geologist is a geologist that has developed this interpretation of geological facts into an art. It is this state of art that separates a successful oil finding geologist from a successful geologist.

It would indeed be a dismal world if all geologists would be able to come to the same conclusion after starting with the same meager geological facts. Needless to say, all the oil would have now been found and none of us would be needed in the industry today. An example of this follow the leader geologist may be seen in south Arkansas:

Initially all Smackover production in south Arkansas was thought to be structurally controlled, that is until Walker Creek was discovered. Originally, the discovery was believed to be located on a "seismic" structure. Today we know this field to be one of the largest stratigraphic traps of Smackover oil in Arkansas. Now that we know Smackover oil can be produced from stratigraphic traps, the geologist is directing his attention to stratigraphic exploration with reasonable success.

Would you believe that you can find very few geologists that will now admit that they once believed all Smackover oil would be productive from structural traps. That shows flexibility, an important trait for a geologist.

### SEDIMENTARY GEOLOGY

How does the reservoir rock that produces oil occur in the subsurface? How was the rock deposited originally? Under what conditions? What are the distribution patterns of the reservoir rocks? These are the questions that a successful oil finding geologist must answer.

Assume for the sake of brevity, that sometime long ago in the geologic past a broad bulge developed in the earth's crust, and smaller wrinkles occurred in the bulge as the result of the crust's mobility under the influence of the earth's internal heat and pressure. As the wrinkles developed, great masses of material emerged as islands above sea level where they became exposed to the atmosphere and subject to weathering and erosion. The loosened particles of rock, now under the influence of gravity, wind and water, washed down the slopes. Some of the sediments were deposited at lower levels on the islands and along the shoreline; but with time, and the addition of more and more material, periferal blankets of sand, silt, and clay, were formed that extended well out to sea.

Assume further that the crustal movements within the earth changed from time to time, and that the size of the bulge and the shape and orientation of the wrinkles also changed. Old wrinkles sub-

merged and became basins of deposition and new wrinkles formed that created new islands, and consequently new patterns of sediment distribution. Again and again the bulging and wrinkling processes continued throughout millions of years. Great land masses emerged above sea level as other areas subsided and filled with layers of sediment.

Accumulations of mud and silt from nearby islands began to coalesce and overlap each other forming distinctive bedded layers of strata, and finally consolidated into a broad mass of land more recognizable today because of the position of sea level, as the continent of North America. Sand grains, silt and other debris are eroded from highlands into off-shore water. This material is usually laid down in layers. If the layers are predominately sand grains, we call the rock a sandstone, if predominately silt or mud, we call the rock a siltstone or shale. The sand may be formed as beach sands, off-shore bars or in flat sheets. The sheets of sand are usually widespread whereas the beach and bar sand deposits are more restricted in occurrence.

Where sand is deposited, the highland area is active in depositing materials into the adjacent water masses. The opposite is true for the deposition of limestone. The absence of or greatly reduced erosion aids conditions for the development of calcareous material in the adjacent water. This quiet or inactive period usually is accompanied by warm weather and warm water --- causing the maximum creation of calcium and carbonates in the water. Limestone may be formed as chalk, silt or mud, or with skeletal remains of plants and animals. The oolitic lime found in the Smackover of south Arkansas was formed by fine grained debris entering highly concentrated calcium enriched water causing calcium carbonate to solidify around the grains. Usually

the water was active enough to cause the accreted and enlarged grains to become more rounded by the rolling activity.

During the early sedimentary activity, primitive forms of life evolved; first in the sea and later in brackish water swamps and fresh water rivers, and finally on land. Great forests and deserts were formed, and later destroyed. It is this creation and devastation that the geologist studies today to record the history of the earth. Stratigraphy studies have evolved that permits geologists to interpret with some confidence the more important chapters in this history. Stratigraphy or stratigraphic geology is the study of the character and distribution of the layers of sedimentary rock with respect to well-defined periods of geologic time.

In the broadest sense, strata (deposits) are subdivided into three categories:

"Marine Strata" (deposited in the sea) - are typically siltstones, shales, or limestones having broad areal distribution over hundreds or thousands of square miles with relatively uniform composition and continuity.

"Marginal-Marine Strata" (shoreline deposits) - are typically conglomerates or gravel (large pebbles) and sandstones distributed in well defined sinuous patterns that represent ancient shorelines.

"Non-Marine Strata" (deposited on land or lakes and/or swamps) - are typically combinations of clayey sandstones and siltstones having heterogeneous composition and erratic distribution.

During burial, as new sediments accumulate over the top of other strata or sediments, the deposits readjust to the weight and the underlying sediments become more compact. Eventually, the physical structure of the sediments reach a more solidified state, normally referred to as rock, due in part to compaction and in part to mineral precipitation. From this point forward, the beds of rock material respond in a more rigid manner to physical and chemical changes by fracturing, jointing, folding, or faulting.

The ultimate goal of a stratigrapher is to be able to correlate individual rock units with contemporaneous geologic events in other nearby areas. For convenience and simplicity in visualizing the rock and time units, a geologic correlation chart is most often used.

There are two basic assumptions that are fundamental to all stratigraphic interpretations:

"Law of original horizontality" - the original beds of sediments were deposited as flat-lying beds, parallel to sea level.

"Law of superposition"-in undisturbed strata the oldest beds are on the bottom, and each overlying unit is progressively younger.

With these laws and concepts in mind, geologists have established two types of nomenclature in order to communicate their findings. They establish names for specific sets of strata that seem to have some commonality, and they utilize a world standard reference time scale. For example: A geologist in Arkansas, east Texas, and Oklahoma may refer to the Cretaceous Woodbine Sand, the Jurassic Smackover Lime, or the Pennsylvanian Springer of Oklahoma, and other geologists will understand the age and something of the character of the strata.

However, the nomenclature may change from area to area, therefore, a nomenclature chart may be helpful to sort out the formations.

All stratigraphic units have upper and lower contacts with other units above and below. Contacts are considered "conformable" if the sedimentation across the boundary appears to have taken place without a major interruption. Unconformable contacts indicate that there was a hiatus between the time the lower beds were deposited and the time the overlying beds were laid down over the top. In some cases, the hiatus may have been only a few hundreds or thousand years --- others may have been for millions of years.

Correlation in its simplest form is the matching up of information about the beds from one place to another. This is illustrated best by a cross-section that may show sand pinch-out, unconformities and lateral changes in strata under study.

Isopach mapping is one of the most common methods used in understanding and illustrating stratigraphic relationships. "Iso" means equal, the "pach" means thickness. This method of mapping has some interpretation that must be applied. The same set of data can usually be interpreted in at least two different manners. A general knowledge of the regional trends of similar features nearby and the nature of the features are essential.



## STRUCTURAL GEOLOGY

Geologists use the word structural geology to mean "disturbed geology". The term "structure" is used in a variety of ways. For example:

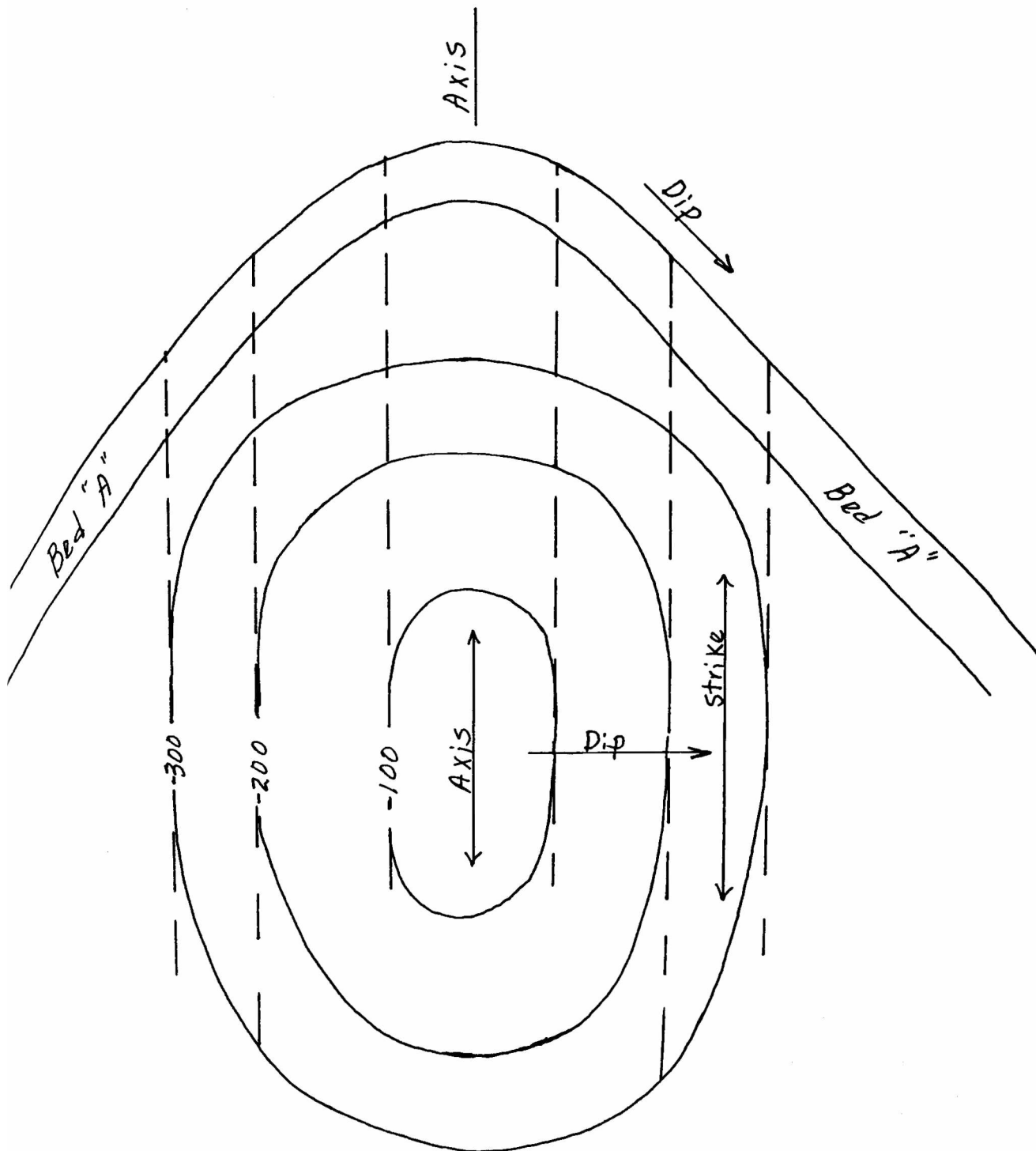
- a. Structure - to mean a particular fold, dome, faulted complex, or some other type of feature where the strata have been disturbed or broken.
- b. Structure map - Illustrates, through the use of contours, the position of a particular reference datum with respect to present day sea level.
- c. Structural cross-section - Illustrates a vertical view of the configuration of the strata with respect to present day sea level.

In other words, "structure" implies that compared to a flat surface, with sea level as a reference datum, the strata have developed a different configuration.

There are several structural terms in common usage by the petroleum industry that are worth note:

Axis (of a fold) shows the position and direction of a fold along its crest (if bowed upward), or along its trough (if bowed downward). (Fig. 1)

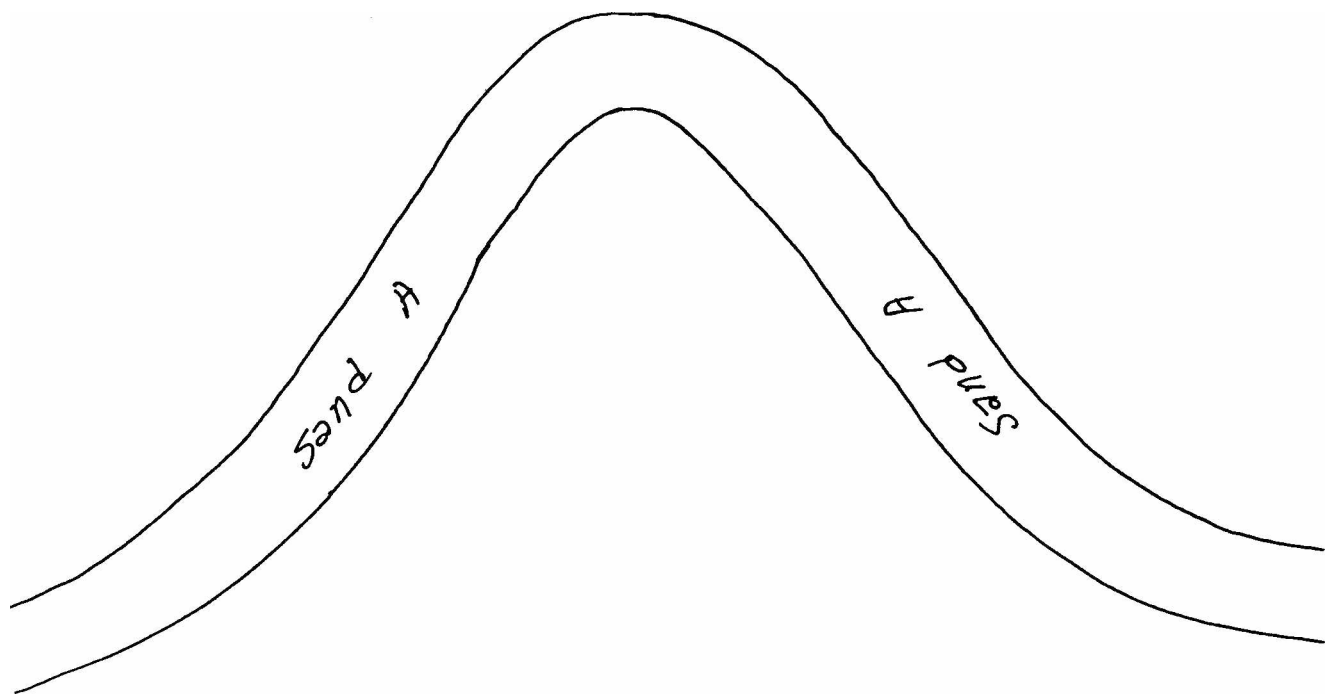
Dip is the direction and degree of inclination of strata. A dip of one degree equals an inclination of 92 feet per mile. (Fig. 1)



ANTICLINE WITH CONTOURS SHOWING STRUCTURE

FIGURE 1

ANTICLINE



SYNCLINE

FIGURE 2

Strike is the direction at right angles to the dip. In effect a structural contour of a bed defines the strike. (Fig. 1)

Depositional strike is the direction of greatest uniformity of a specifically defined stratigraphic interval.

Anticline is the name applied to a fold wherein the strata have been bowed upward. (Fig. 2)

Syncline is the name applied to a fold wherein the strata have been bowed downward. (Fig. 2)

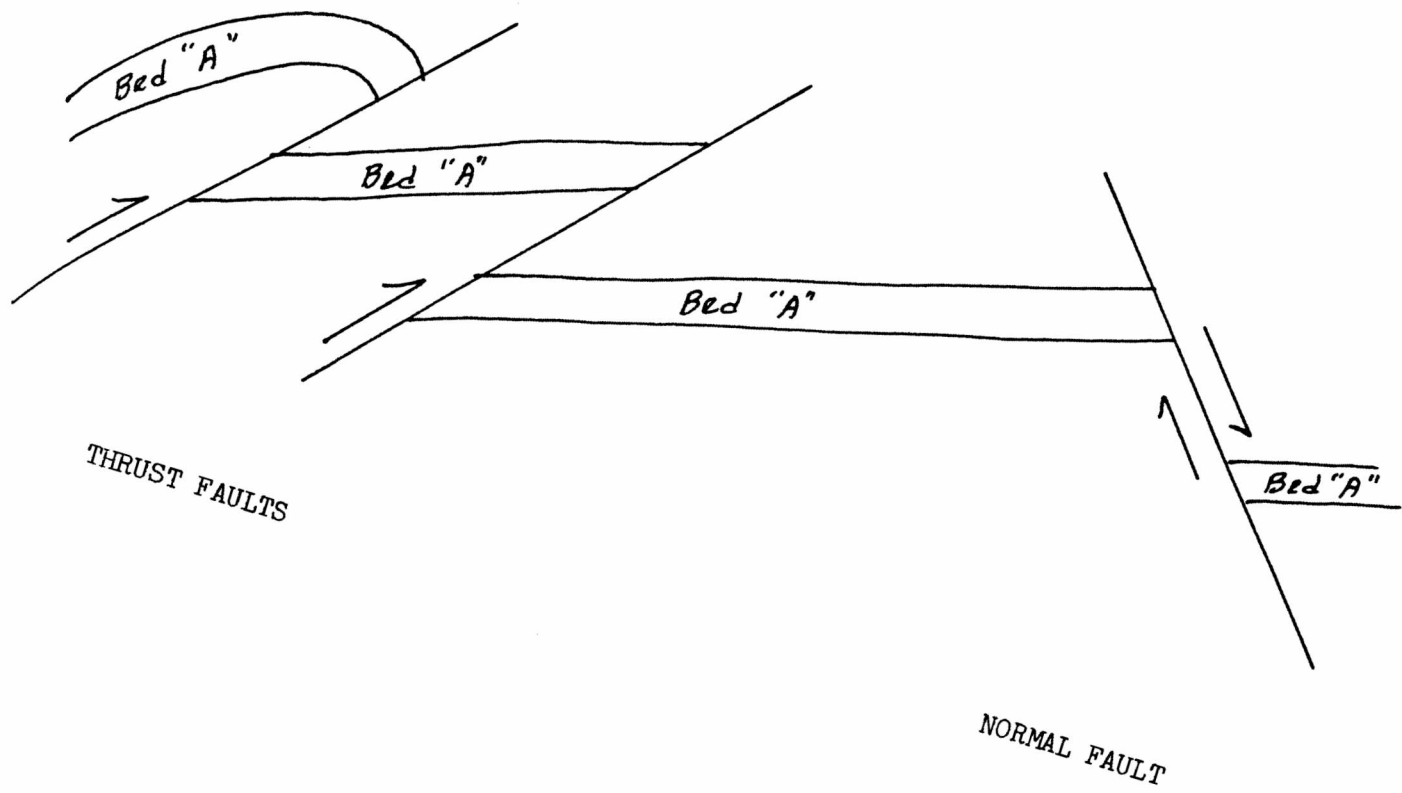
Fault is a rupture in the strata wherein the beds are displaced. The amount of movement is normally represented as "feet of vertical movement". (Fig. 3)

Structural reservoirs are those accumulations of oil and gas that are trapped because of structural deformation of the strata, either by folding or faulting.

Stratigraphic reservoirs or accumulations of oil and gas are created by stratigraphic conditions rather than structural deformation. The up-dip limit of porosity may be due to a variety of causes: It may be the depositional edge of the sandbody, or it may be due to increased cementation, or it may be due to erosional truncation.

With this basic information, a better understanding of geology and geological processes is available to the student. What you do

COMMON FAULTS



THRUST FAULTS

NORMAL FAULT

FIGURE 3

with this information to develop the art of petroleum geology is the challenge. In fact, if most geologist were honest with themselves, this brief study is about all they carry with them when they leave college. It is the development of the "art" as they practice their craft that brings them success or failure.