Importance And Applications Of Field Data

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Importance of Data

Information costs money! Is it worth it? For example some approximate costs of data are given below:

1. Reservoir fluid analysis—$1,000.
2. Bottom hole pressure measurements—$10 per hour.
3. Bottom hole samples—$200.
4. Core analysis—$500.
5. Well Logging—$700.

Whether or not the information is worth the expenditure depends on its reliability and its application.

It is the purpose of this paper to (1) present a partial list of the types of data required and indicate their sources and applications and (2) to impress all personnel concerned with obtaining data that their work is extremely valuable since most calculations made by engineers and many decisions made by management are based on the reliability of their work.

Information is obtained to answer these questions about a reservoir.

1. Is there any oil in this formation?
2. How much oil or gas will be recovered by natural depletion?
3. How much oil or gas is in the reservoir?
4. Is there any method available to increase total production above that which would be obtained by natural methods?
5. How fast can the oil be recovered?

In other words the engineer is interested in reserves, recovery factor (percent reserves recoverable), rate of recovery and riches (how much money can be made on the operations). These applications are referred to as the four Rs of reservoir engineering.

The answer to these questions can result in decisions such as, selling or buying production, obtaining a loan for development, investing money in a secondary recovery project, investing money in an injection program, abandoning a well or lease, unitizing, or obtaining special allowable treatment. Without the data necessary to answer the questions the decisions can only be based on guesses and such guesses are usually not adequate to convince anybody to invest money. This means that the obtaining of data should be planned for, and included in expenditure estimates at as early a date as possible in the development of a field.

Types of Data

This section is concerned with listing the properties which should be known in order to answer the questions posed above. For the purpose of simplification, properties can be classified as:

1. Rock properties.
2. Fluid properties.
3. Reservoir properties.

Several of these characteristics or properties will be defined, their applications to the four Rs indicated, and their sources listed. Table 1 is a summary of these properties.

Rock Properties

The important rock properties that will be discussed here are:

1. Porosity.
2. Permeability.
3. Connate water saturation.
4. Relative permeability.
5. Wettability.
6. Capillary pressure.
7. Floodability.

Figure 1 shows three grains of sand and the fluid distribution in the void space between the grains. The percent of the total volume (rock and liquid) occupied by fluids is called porosity. If the total or bulk volume occupies 1,000,000 barrels and the void space between the rock particles, 200,000 barrels, the porosity is 20 percent. Obviously the greater the porosity a given oil bearing rock has, the greater will be the amount of oil which the rock can contain. This property can be obtained by direct measurement on cores, or by calculations from electric logs such as the MicrolateroLog, MicroLog or Contact Log, and from the neutron log.

Permeability is a rock property which indicates how rapidly fluids such as oil or water or gas can flow through it. This, of course, is valuable information because it is of definite economic importance to know whether a well or reservoir will give up its reserves at a rate of ten barrels a day or a thousand barrels a day. The permeability is usually obtained from direct measurements on cores, but it can be estimated by observing the rate at which the bottom hole pressure increases after a well is shut in. Permeability depends on the sizes of the pore spaces or void spaces and how they are interconnected. Obviously the smaller the pore's diameter the lower will be the permeability.

Connate water saturation is defined as the volume of water in a given pore volume divided by the pore volume. For example, where the bulk volume was 1,000,000 barrels and the pore volume was 200,000, if the water volume contained in the pore space was 20,000 barrels, the connate water saturation would be 20,000 divided by 200,000, or 0.10 (or 10 percent). Thus means that the oil or gas must occupy the remainder of the pore space or the oil saturation equals 180,000 divided by 200,000, or 09 (or 90 percent).

This is very important property since the amount of connate water affects reserves. Connate water can be measured on cores or obtained by electric log interpretation.

Relative permeability is the permeability of a rock to a given fluid such as oil, gas, or water, compared to the permeability of the same rock if all the pore volume were occupied by one fluid. This is a most important property of rock since the flow rate of oil depends not only on the rock but also

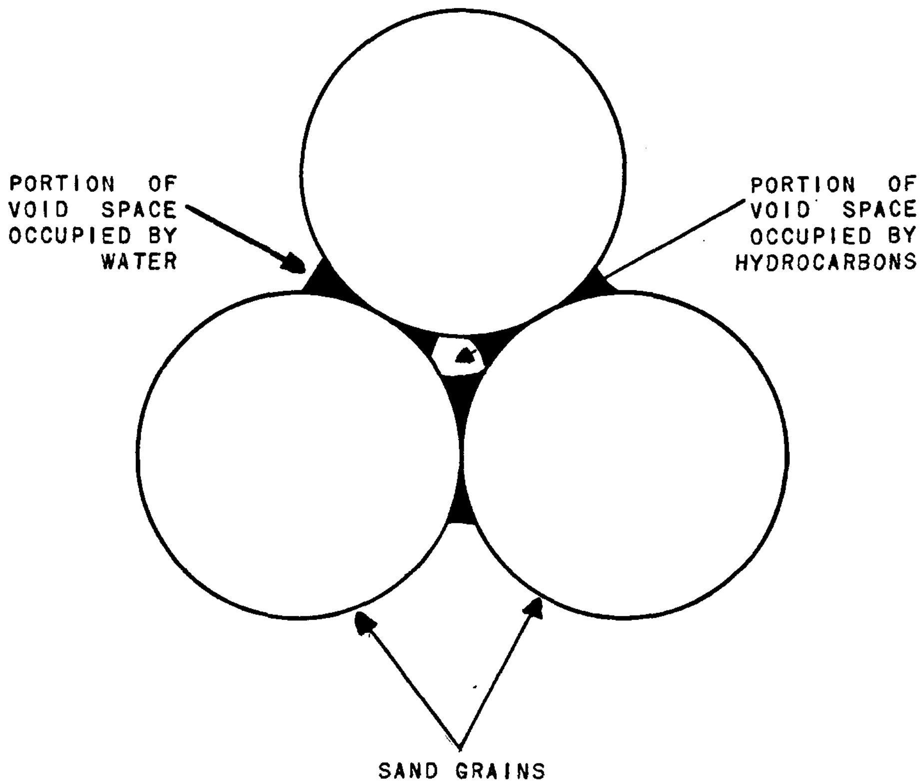

FIGURE 1

REPRESENTATION OF WATER AND OIL DISTRIBUTION IN THE VOID SPACE BETWEEN SAND GRAINS upon the saturation (percent pore volume occupied by oil) of the oil. It is just as if the pore size, as far as oil is concerned is either large or small. In discussing permeability, above, it was pointed out that the smaller the pore size the lower will be the permeability. The smaller percent of the pore space occupied by oil, the lower will be the permeability of the rock to it. Relative permeability can be obtained from studies on cores, or in some cases from production data. For example, if we know the producing gas to oil ratio and the properties of the fluids we can calculate the relative permeability in the reservoir. The accuracy of this calculation depends on the reliability of the sampling technique, analysis, and gas-oil ratio measurements.

Just as water or ink will be absorbed by a blotter due to capillaries, the distribution of water and oil in reservoirs is determined primarily by the size and distribution of the rock capilliaries. A measurement of this property in rocks is called capillary pressure. It helps describe the nature of the pore space and is important for reserve calculations since water-oil contacts can be determined from it. It is usually obtained from core data.

Floodability experiments on cores in which water drives or gas drives or other types of operations are carried out will frequently provide an effective comparison of the efficiencies of various processes. For example, it may be found that a water drive would produce 60 percent of the oil in place, while a gas drive might produce only 30 percent. This type of information combined with knowledge of relative costs of operation can help the management to make a decision concerning secondary recovery operations. Floodability is also determined by the pilot or small flood. This can be an expensive operation and the proper interpretation of results (i.e. to expand flood operations or discontinue them) will often depend on the reliability and completeness of the production and injection data.

Fluid Properties

Fluid samples are obtained by either collecting surface samples of gas and oil and recombining them in a laboratory, or by collecting a bottom hole sample which is used directly in analysis. Some of the important properties which are determined by the analysis are:

1. Density.
2. Formation volume factor.
3. Gas solubility.
4. Gas compressibility.
5. Composition.
6. Viscosity.

Density, measured in pounds per cubic foot or degrees API is the basic for the price of a barrel of crude oil. It is a useful property for pump calculations and is also necessary in capillary pressure applications.

Formation volume factor relates the volume of the reservoir oil to the volume at surface conditions. This is a property necessary for calculating reserves. We can, for example, estimate the volume of the reservoir and knowing the connate water saturation and the porosity can determine the volume of oil in the reservoir. In order to convert this volume into stock tank barrels, we must know the shrinkage or formation volume factor.

Gas solubility is another property of fluids or of oil that is very important in calculating reserves and in predicting reservoir performances.

Knowledge of composition of the oil and gas is very useful because it enables the engineer to prepare for problems which might be caused by undesirable chemicals and to evaluate the reservoir products for refining in the gasoline plant and the refinery.

Viscosity is a property of fluids which affects the ease of flow of the fluid thru rock or thru a pipe. The lower the viscosity the more easily the fluid flows through the porous media. Since it is a property which affects the rate of flow and the efficiency of production it is valuable for engineering calculations.

Reservoir Properties

As with the other types of information, reservoir properties are necessary for the evaluation of the four Rs. Those which will be described are:

TABLE 1—APPLICATIONS AND SOURCES OF RESERVOIR DATA

TYPE OF DATA	APPLICATIONS (reserves, recovery factor, or rate of recovery).	SOURCES
Rock Properties		
Perosity	Reserves,	Cores, MicrolaterLog, MicroLog or Contact Log, neutron log cores, pressure buildup
Permeability	Rate	
Connate Water saturation	Reserves, rate, recovery factor	Cores, conventional electric logs, Guard or Laterlog, and Induction log, and logs indicated for porosity
Relative permeability	Recovery factor, rate of recovery, secondary recovery	Cores, production data, and sample analysis
Wettability	Secondary recovery, recovery factor in natural water drives	Cores and reservoir performance
Floodability	Secondary recovery, maintenance operations	Cores and pilot operations
Capillary pressure	Reserves	Cores and electric logs
Fluid Properties		
Density	Basis for price, reservess (with capillary pressure data)	Recombined or bottom hole samples
Formation volume factor	Reserve recovery factor	Recombined or bottom hole samples
Gas solubility	Reserve recovery factor	Recombined or bottom hole samples
Gas compressibility	Reserve recovery factor	Recombined or bottom hole samples
Composition	Property estimation, processing problems	Recombined or bottom hole samples
Viscosity	Rate, recovery factor	Recombined or bottom hole samples
Reservoir Properties		
Size	Reserves	Logs, cores, geophysical data
Structure	Well location	Logs, cores, geophysical data
Pressure	Reserves, rate of production, recovery factor, well problem diagnosis	Direct measurement
Type of natural drive	Recovery factor, secondary recovery	GOR, pressure, fluids produced

1. Size.
2. Structure.
3. Pressure.
4. Type of natural drive.

The size of a reservoir is an obviously important property. It can be determined by drilling, sub-surface geology (log and sample studies), and by geophysics and other surface methods. Structure (e.g. anticline, dome) can also be ascertained by the above methods.

Pressure in combination with fluid analysis is a most valuable piece of information since it can indicate how far depletion has gone and how far it has to go. The change of pressure with time can show the type of natural drive which is predominant (e.g. solution gas, water, etc.) This is very useful since the type of natural drive affects directly the percent of the reserve in place which can be recovered. Pressure as a function of time is also helpful in diagnosing well problems such as blockage.

Summary

Seventeen types of data have been briefly described. For many of these, the reliability depends on good field practices. The information, obtained from the field, costs money and is worth it when it is obtained and applied properly.