Benha University
Faculty of Science
Geology Department
Petroleum Economics and evaluation course Code (453G)

4^{th} Year Exam (Geophysics)
Petroleum Geology
18 Jan. 2017
Time allowed: 2 hrs

****

Write on four of the following and illustrate your answer with drawing as possible

Each point with 12 mark

1- Definition and classification of porosity.

Porosity is the first of the two essential attributes of a reservoir. The pore spaces, or voids, within a rock are generally filled with connate water, but contain oil or gas within a field. Porosity is either expressed as the void ratio, which is the ratio of voids to solid rock, or, more frequently, as a percentage:

$$\text{Porosity } (\%) = \frac{\text{volume of voids}}{\text{total volume of rock}} \times 100 .$$

Porosity is conventionally symbolized by the Greek lowercase letter phi (Φ). Pores are of three morphological types: catenary, cul-de-sac, and closed
Catenary pores are those that communicate with others by more than one throat passage. Cul-de-sac, or dead-end, pores have only one throat passage'connecting with another pore. Closed pores have no communication with other pores.
Catenary and cul-de-sac pores constitute effective porosity, in that hydrocarbons can emerge from them. In catenary pores hydrocarbons, can be flushed out by a natural or artificial water drive. Cul-de-sac pores arc unaffected by flushing, but may yield some oil or gas by expansion as reservoir pressure drops. Closed pores are unable to yield hydrocarbons (such oil or gas having invaded an open pore subsequently closed by compaction or cementation). The ratio of total to effective porosity is extremely important, being directly related to the permeability of a rock.

2- Relationship between Porosity, Permeability, and Grain Shape.

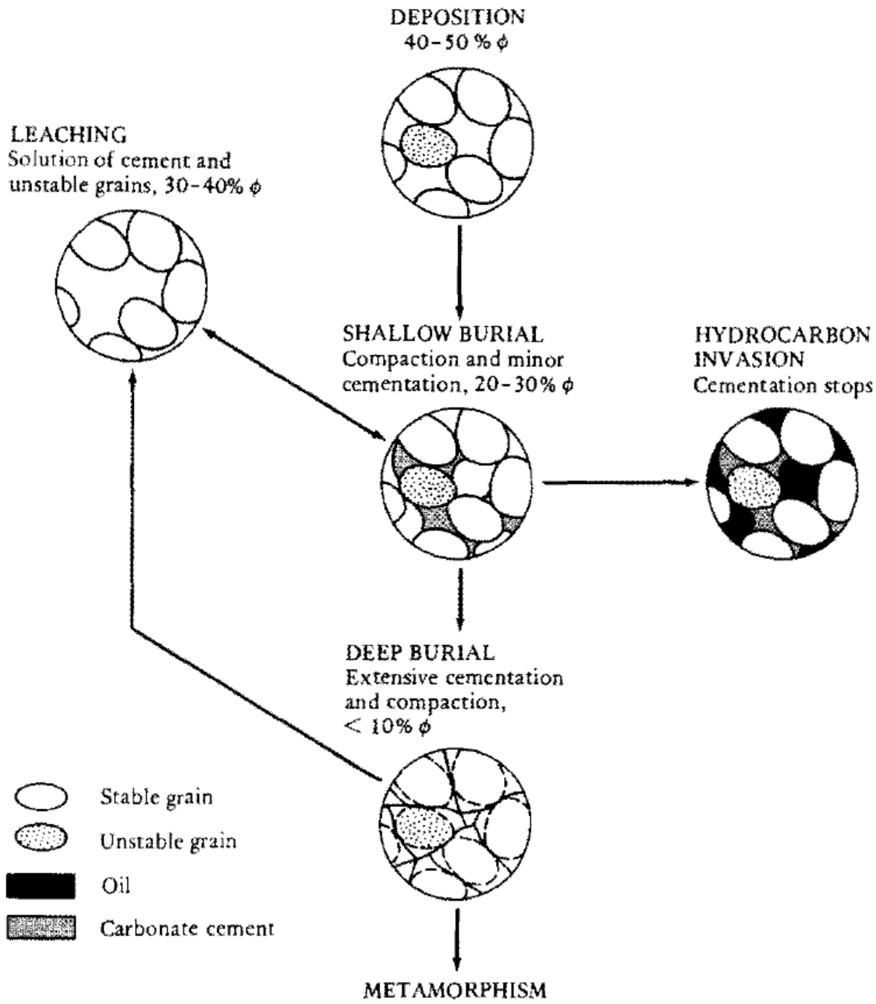
The two aspects of grain shape to consider are roundness and sphericity (Powers, 1953). As Fig. 6.19 shows, these two properties are quite distinct. Roundness describes the degree of angularity of the particle. Sphericity describes the degree to which the particle approaches a spherical shape. Mathematical methods of analyzing these variables are available.
Data on the effect of roundness and sphericity on porosity and permeability are sparse. Fraser (19 35) inferred that porosity might decrease with sphericity because spherical grains may be more tightly packed than subspherical ones.

3- Regional Variations on Sandstone Reservoir Quality.

Studies of Recent sands, such as those of Pryor (1973), show that they have porosities of some 40 to 50% and permeabilities of tens of darcies. Most sandstone reservoirs, however, have porosities in the range of 10 to 20% and permeabilities measurable in millidarcies. Although fluctuations do occur, the porosity and permeability of reservoirs decrease with depth. This relationship is of no consequence to the production geologist or reservoir engineer concerned with developing a field, but it is important for the explorationist who has to decide the greatest depth at which commercially viable reservoirs may occur. The porosity of a sandstone at a given depth can be determined if the porosity gradient and primary porosity are known (Selley, 1978):

where
$D = $P- GD ,
porosity at a given depth
primary porosity at the surface
porosity gradient(% Mkm)
burial depth Reviews of porosity gradients and the factors controlling them have been given by Selley (1978) and Magara (1980). The main variables that affect porosity gradients are the mineralogy and texture of the sediments and the geothermal and pressure regimes to which they are subjected. The more mineralogically mature a sand is, the better its ability to retain its porosity (Dodge and Loucks, 1979). Taking the two extreme cases, chemically unstable volcaniclastic sands tend to lose porosity fastest, and the more stable pure quartz sands tend to have the lowest gradients (Fig. 6.26). Texture also affects the gradient: Poorly sorted sands with abundant clay matrix compact more and lose porosity faster than do clean, well-sorted sands (Rittenhouse, 1971). A similar effect is noted in micaceous sand, as, for example, in the Jurassic of the North Sea (Hay, 1977). Geothermal gradients also affect the porosity gradient of sand, as shown in Fig. 6.27. Because the rate of a chemical reaction increases with temperature, the higher the geothermal Effects of Diagenesis on Carbonate Reservoirs. Post-discovery Reserve Calculations.

4- Effects of Diagenesis on Carbonate Reservoirs.



The carbonate rocks include the limestones, composed largely of calcite (CaC03), and the dolomites, composed largely of the mineral of the same name [CaMg(C03) 2]. As reservoirs, carbonates are as important as sandstones, but
their development and production present geologists and engineers with a different set of problems. Silica is chemically more stable than calcite. Thus the effects of diagenesis are more marked in limestones than in sandstones. With sandstone reservoirs the main problem is to establish the original sedimentary variations, working out the depositional environment and paleogeography, and using these to predict reservoir variation as the field is drilled. The effects of diagenesis are generally subordinate to primary porosity variations, which is seldom true of carbonate reservoirs. When first deposited, carbonate sediments are highly porous and permeable and are inherently unstable in the subsurface environment. Carbonate minerals are thus dissolved and reprecipitated to form limestones whose porosity and permeability distribution are largely secondary in origin and often unrelated to the primary porosity. Thus with carbonate reservoirs, facies analysis may only aid development and production in those

rare cases where the diagenetic overprint is minimal. Having discussed the general effects of diagenesis on carbonate reservoirs, it is now appropriate to consider them in more detail. Major texts covering this topic have been published by Reeckmann and Friedman (1982), Roehl and Choquette (1985), Tucker and Wright (1990), and Jordan and Wilson (1994) and Lucia (1999). Shorter accounts that specifically relate carbonate diagenesis to porosity evolution have been given by Purser (1978) and Longman (1980). The following description is based on these references, concentrating on those

5- Post-discovery Reserve Calculations.

Once a field has been discovered, accurate reservoir data become available and a more sophisticated formula may be applied:
where
V
7758
<I> SW
R
FVF
. 7758V<!J(l - *S*)R
Recoverable od (bbl) = FVF w , the volume (area X thickness); conversion factor from acre-feet to barrels;porosity (average);water saturation (average);recovery factor (estimated); andformation volume factor.These variables are now discussed in more detail. As wells are drilled on thefield, the seismic interpretation becomes refined so that an accurate structurecontour map can be drawn. Log and test data establish the oil:water contactand hence the thickness of the hydrocarbon column (Dahlberg, 1979).The porosity is calculated from wireline logs calibrated from core data, andthe water saturation is calculated from the resistivity logs. The recovery factoris hard to estimate even if the performances of similar reservoirs in adjacentfields are available. Approximate values have been given previously.The FVF converts a stock tank barrel of oil to its volume at reservoir temperaturesand pressures. It depends on oil composition, but this dependence cangenerally be approximated by calculating the FVF's dependence on the solutiongas:oil ratio (GOR) and oil density (API gravity). The FVF ranges from 1.08 flow GORs and heavy crudes to values of more than 2.0 for volatile oils and high GORs. The GORis defined as the volume ratio of gas and liquid phase obtained by taking petroleum from one equilibrium pressure and temperature, in the reservoir, to another, at the surface, via a precisely defined path. For a restrictive set of subsurface conditions it may be calculated from the following equation:
where
Ga s:OI· 1 rati·O ("m t h e reservOi.r) = -QQg = -J.LKoKg
0 I-Lg 0
Q = flow rate at reservoir temperatures and pressures;
J.L = viscosity at reservoir temperatures and pressures;
K = effective permeability;
g =gas; and

o = oil.

-With best wishes-

Dr. Mohamed Moustafa Afife

Afife, Mohamed

-With best wishes -