GEOL 452 - Mathematical Tools in Geology
Lab Assignment # 3 - Feb 4, 2010 (Due Feb 11) Name:

Oil Fields & Porosity of Sandstone

Algebra: Manipulation and Factoring

A. Gas, Oil, and Water Recovery

Look at the figures shown of the eroded anticline in Landers, Wyoming. This eroded anticline exposes an oil trap which formed within the folded structure which is known to facilitate the accumulation of gas, oil, and water beneath the anticline and impermeable layer shown. Drilling into these "traps" often produced the gushing oil wells seen in the 60's and 70's.

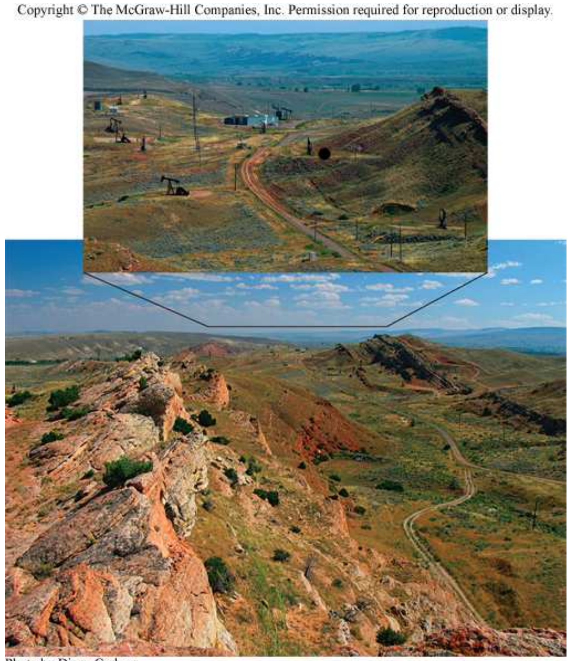

Photo by Diane Carlson

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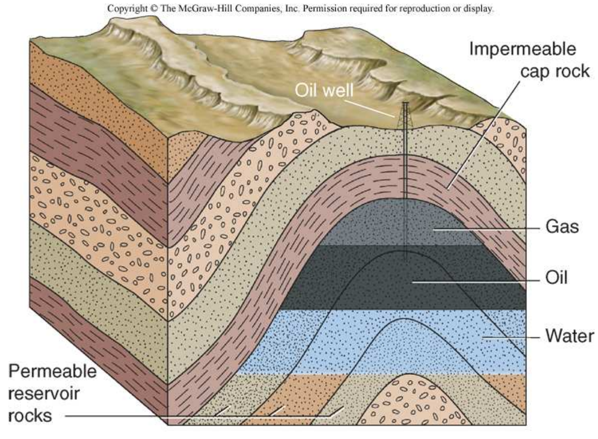
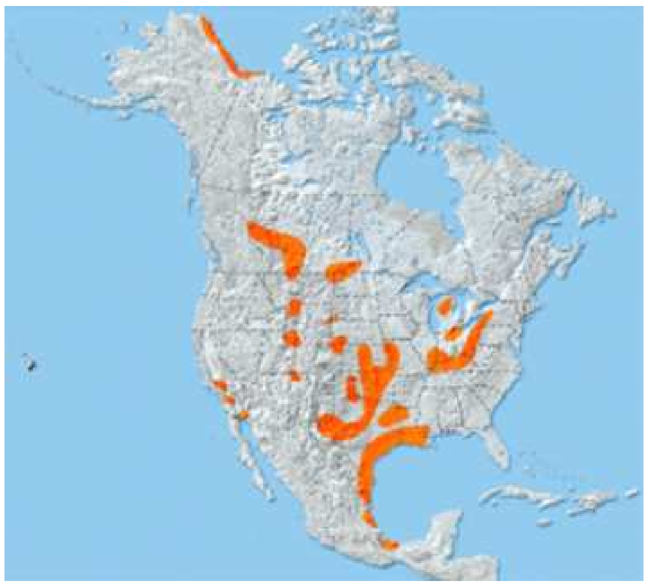


A

Photo by Diane Carlson

1. Let's say that you work for Chevron and need to assess (?) the volume of gas and oil which can be recovered for this oil field. Your geologists and engineers tell you that you can recover 2 gallons of oil per each square kilometer and 0.5 gallons of natural gas per square kilometer. You have funds to work on 3 square kilometers. Determine the volume of oil and volume of gas which can be recovered in this 3 km^2 area.



2. You have done such an excellent job with this first task that Chevron has asked you to work regionally and assess the volumes of gas and oil to be recovered in various oil fields throughout the country (see map of North America). To make your job easier, rewrite the above problem from #1 in a general form using a variable (letter at the end of the alphabet) for each substance and coefficients (letter at the beginning of the alphabet) for the known or measured volume ratios. This should make it easier for you to just plug in the new measured volume ratios for each new field site.

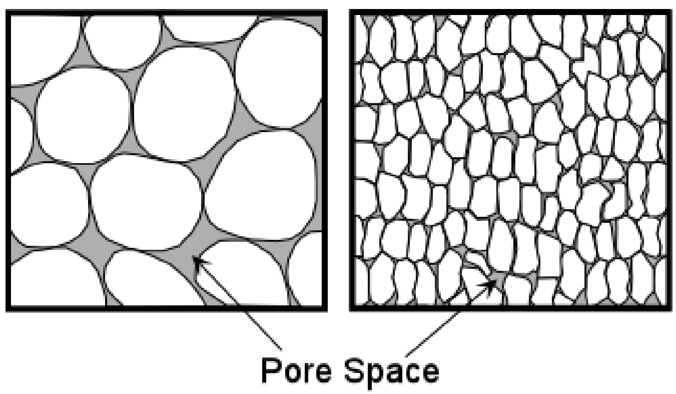
3. Now solve the problem in #1 again, by using your equation in general form and substitute your measurements for this particular site. Multiply out your equation through any brackets and show each step. Label and describe each step in words if necessary.

4. In a recent meeting, your supervisors have just notified you that a donor has offered a large amount of funds for your exploration endeavors. This will be enough to increase the area of each of your future work sites by 2 square kilometers for the next 10 years. Represent this new addition in your general equation.

5. Now apply your specific problem from #1 to the new updated equation and solve for your final answer.

B. Density and Porosity of Wet Sandstone

Determine the average density of a sample of wet sandstone. Mathematics can be used to derive equations for the density of wet, porous sandstone. A wet sandstone rock will be partially made of sand grains with a density of ρ_s, and partially made of water with a density of ρ_w. Hence, the average density of your sample will be somewhere between these values, right ?



1. If the porosity, n, is low, how will the density shift in relation to ρ_s and ρ_w ? Which will it be closer to ?

2. If the porosity, n, is high, how will the density shift in relation to ρ_s and ρ_w ?

3. Describe the total mass (m_{total}) of your sample in terms of the mass of the two substances. Explain what this means in words.

4. Now rewrite your mass balance equation (#3 for the total mass), in terms of volume and density of each substance. Write what each of these substitutions mean in words.

5. *Porosity* of a rock sample usually describes what percentage of the volume is "porous" or made up of "empty space". A typical value for porosity is given as a number in percentage and is unitless. For a rock that is 80 cm^3 sandstone and 20 cm^3 of pore space, what is its porosity ?

6. How can you describe the volume of water (V_w) in your original sandstone problem, by considering its porosity (n) in general?

7. Now describe the volume of sandstone only, by using your solution in #6.

8. Rewrite your original equation for mass (#4) and substitute your new derivation for the volume of water and the volume of sandstone. Use parantheses to mark each substitution.

9. Multiply out the expressions in the brackets.

10. Can you factor out any variables which are common to all 3 terms in your equation ? If yes, make it so.

11. Looking at your last derivation, is there any way that you can rearrange your equation, using your general knowledge about density and volumes, to decribe the average density of your sample ? Simplify your final equation by factoring if necessary.

12. Using your final derivation for average density of a porous rock, make a table, of how density varies with changes in porosity. Consider porosity from zero to one in one percent increments. The table should have 2 columns for average density, (ρ_{avg}) and porosity (n). Use a common density for water and sandstone.

13. Plot your equation (using your table values) on a graph (you may use Excel on the class computers - all computers should print except the middle table).

Laboratory Measurements: Use your equation to determine the porosity of the three samples you are given. You will be adding water to your sample and making a few measurements.

14. Rearrange your equation to solve for the variable you are interested in (Do this in steps and describe each step in words.). Be sure to label average density as ρ_{avg}.

15. Given the samples of sand in each beaker, measure 25 cm^3 of water at a time and pour this into your beaker until you begin to see water seeping at the surface. Note the volume of water you use and record errors in all measurements. When you have a saturated sample, measure your sample on the scale (use an empty beaker to subtract the mass of the container (tare) in your sample. Record all volumes and weights you measure with errors indicated by the accuracy of each apparatus.

16. How can you use your measured values in your equation ? Substitute these values into the new equation and determine the porosity of each sample. List them here in a table.

17. Plot your measured values of average density and porosity for each of your samples of wet sand on your graph. Include error bars for each measurement (in both density and porosity). Do your measurements fit the theoretical calculations ? Make speculations about any trends or discrepancies.