OIL SEARCH

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Purpose

All students are familiar with petroleum products from the point of view of putting gas in their cars. They may have heard of petroleum exploration especially since such environmentally critical areas as the North Slope petroleum resources in Alaska appear periodically in the news. An understanding of what is needed to find and produce petroleum is necessary to understand why the world's resources are restricted and non-renewable.

Definitions

Anticline - an up-fold or a fold shaped like an upside down U, see figure 1.
Cap rock - a rock that is not permeable that locks the petroleum in the reservoir rock.
Crack - changing organic material to petroleum. The reference is to catalytic cracking, the refinery process used for making the petroleum products we buy.
Cross-section - a picture of a vertical slice through a map, like looking at the wall of a quarry.
Dome - a circular up-fold, a circular anticline
Permeable - fluid can flow through the rock.
Petroleum - natural gas and oil.
Porosity - holes in the rock.
Reservoir rock - a rock in which the petroleum accumulates. It must be porous and permeable.
Source Rock - a rock that has organic matter accumulated in it and can release the material to a rock in which it will be stored.

Teacher Information

The picture of an oil pool in this exercise is a very simplified one involving a classical domed structure. Exploring for oil today involves much more complicated situations and the costs are much higher, but this makes a good starting exercise.

This exercise is simple, but requires some prior knowledge. An optional exercise is to make a structure contour map of the oil field. Either the students should know how to do contouring or they should do the Maps and Topography exercise first. However, Oil Search can be done without completing the contour map.

Geologists know that the organic material for petroleum accumulates in an area that is oceanic, warm, shallow, well oxygenated, has lots of food, and was buried quickly. It helps if the surface water fits all of these criteria and the bottom is an area where the organic material will be preserved - either a low oxygen area or one of rapid burial. The Gulf of Mexico coast and the adjacent areas of Texas and Oklahoma were

such areas in the past. Once the organic matter is accumulated, it needs to buried deeply enough that the temperature rises high enough to change, or crack, the organic material into petroleum. Once the petroleum is formed it is lighter than the water that is also in the rock and it will float upwards toward the surface of the earth. If it flows into a reservoir rock with a cap rock above it, an oil "pool" will form. An oil pool is a reservoir rock in which the porosity is oil saturated. Natural gas will be at the top of the pool, oil in the middle and water under it (see figure 1).

Limestone and shale are excellent source rocks. Sandstone and limestone are both excellent reservoir rocks. Shale makes the best cap rock.

In the search for petroleum, a geologist does not really look for a source rock. All one needs to find is an area that would have had the right rocks in the geologic past. A geologist will look at areas that are now shallow marine coastal areas, or had been in the past. The rocks should have been buried deeply for the organic matter to have been cracked. Then, a geologist hopes for structures such as anticlines and domes that will help the oil to accumulate and make it easy to find. There are lots of different types of petroleum traps, but this is the easiest to illustrate.

Once the right geological area is found, the geologist must find a potential reservoir rock with a cap rock on top of it. These rocks can be found by mapping the surface geology, but the surface and the subsurface may be different. They can be located by variety of sound wave (seismic), gravity, magnetic, electrical, and chemical techniques. This exercise uses the old way, drilling. The students will drill to see what the rocks in the subsurface look like and to determine the sequence of rocks.

Student Exercise

I would not give them any hint as to where to begin, where to drill, or how far to go to the next hole. Let them use whatever technique they want to. Some will approach the problem randomly. Some will be very systematic. Some will be too conservative, some too radical. The fun is in the search. If they hit oil on the first try, great! What they are doing is Wildcat Drilling, they do not know where the oil is and are drilling in hopes of finding some. Wildcatting in the real world has a chance of less than 1 in 20 of producing enough oil to pay for the well itself.

The student's objective is to find a reservoir rock and then find the high point in that rock because that is where the oil will be. This can be done in two ways. For a simple exercise, only have the students drill and locate the rock. They should write the elevation of the top of the reservoir rock on their map. If they hit oil or gas, great! If they do not hit oil, they should drill again. If they hit oil, great! If not, their two holes ought to show them which direction is up the structure. Their next hole should be looking for a higher elevation on the structure because that is where the oil will be.

If they are drawing the structural contour map, they should start to draw it as soon as they have two points and continue to draw it as they get more points.

You will give them the worksheet and $10,000,000. You will keep the well logs. The students will decide which hole they want to drill. They will then buy a well log from you for $1,000,000. If they hit oil, they can collect $2,000.000. For gas they get $1,000,000. Once they have found oil they can go into production drilling drilling more holes that produce petroleum on the basis of what they have already learned and the fact that they know what the structure ought to look like. This step is especially if you are making a structure contour map of the oil field.

You can modify our exercise all the way from giving them no clues to giving them lots of hints. For a hard exercise, have the students start with $5,000,000 and no clues.

WORKSHEET

Attached is a map of Slick, Texas. You as a geologist are going to explore this area for petroleum. You will be looking for the following rock types:

Reservoir rock - a rock in which the petroleum accumulates. It must be porous and permeable. In this area, the reservoir rock is a sandstone.

Cap rock - a rock that is not permeable that locks the petroleum in the reservoir rock. The cap rock is a shale.

You will also be looking for where the rocks are domed up, figure 1, thus providing a nice oil pool.

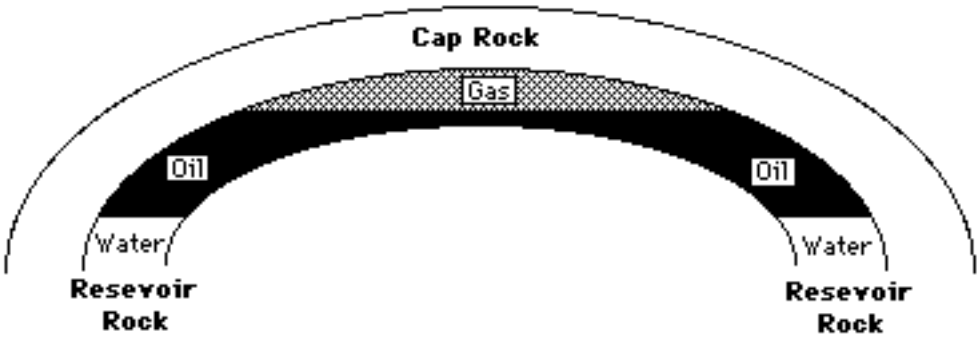


Figure 1. Cross-section of an oil field in a dome.

Oil is more valuable than gas. You would really like to find oil, but gas is all right. What you do not want to find is water. That is what is called a dry hole because it has no oil and is useless.
The search technique is to drill the rocks and see what is below the surface. You want to find a shale above a sandstone that is oil filled.

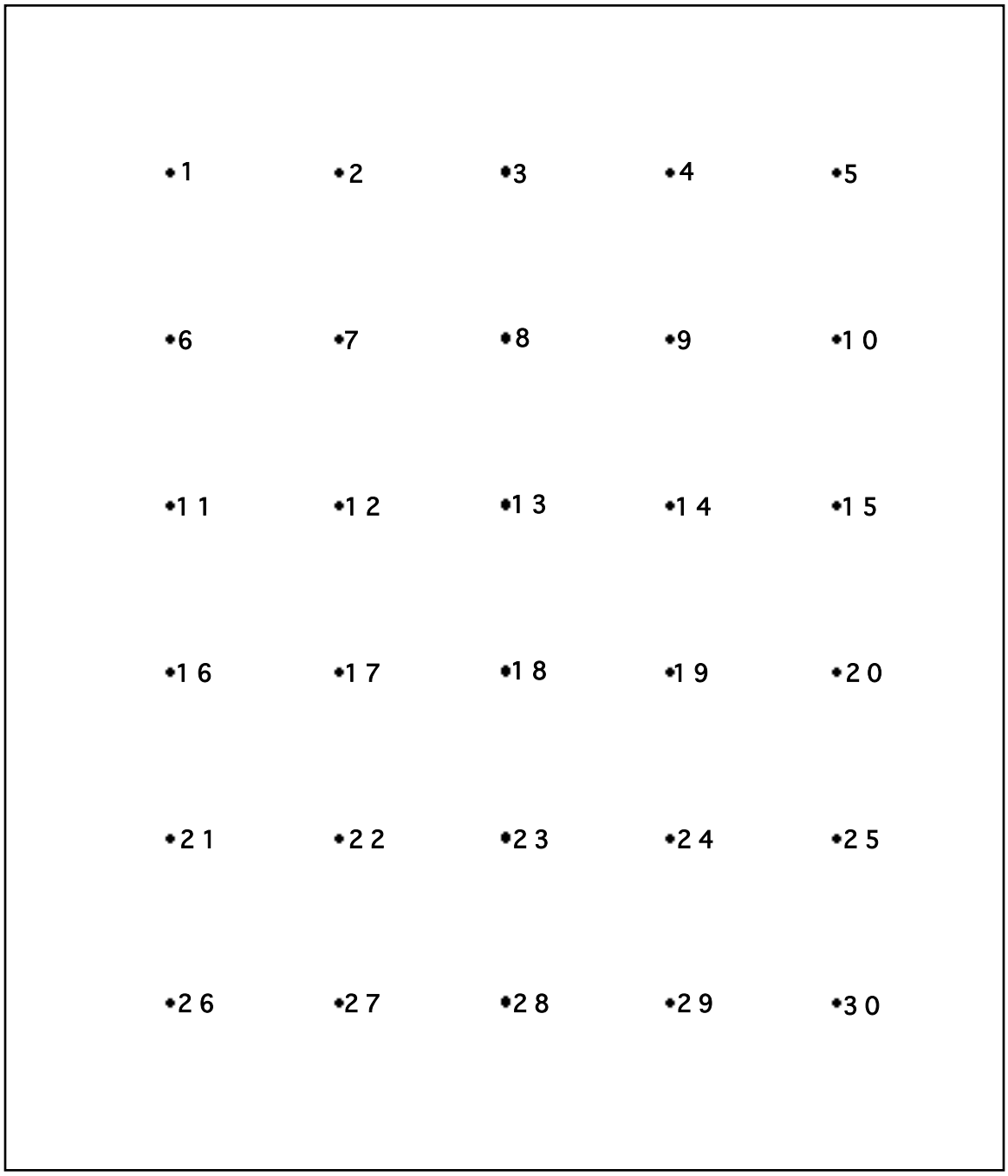
You start the search with $10,000,000. It costs you $1,000,000 to drill a hole. If you strike gas you will earn $1,000,000. If you strike oil, you will earn $2,000,000.

As you can see from figure 1, gas will occur at the top of the dome, so to find oil you must go out to the sides. If the reservoir rock is very deep, you may get water.

Each hole that you drill will give you a well log, or picture of the rocks that you find and the elevation of the rocks above sea level. To see the shape, or structure of the rocks, you want to contour the top surface of the reservoir rock. Each drill hole is numbered. Request a drill hole and pay your $1,000,000. If the record shows a potential reservoir rock record its depth on the map, and drill again. The shape of the structure will tell you where the oil ought to be. Go up slope from water to find oil. Go down slope from gas to find oil. If you produce petroleum, collect $2,000,000 for oil and $1,000,000 for gas. Once you have found oil, you start to step out. That means that you drill the adjacent areas because they should also have oil. If a well does not produce oil, go in a different

direction. If you run out of money, you may borrow from the bank, but when you borrow $10,000,000 you must declare bankruptcy and quit.

You start by drilling anywhere. You will get a well log that will tell you what rocks occur in you drill hole. Now you know the depth of the reservoir rock. Write it on your map. If you did not hit oil you have to pick another hole and drill it. You may not have hit oil this time, but now you have two holes. The third hole should be drilled in a direction that will be higher in the structure than the first two.



Slick, Texas

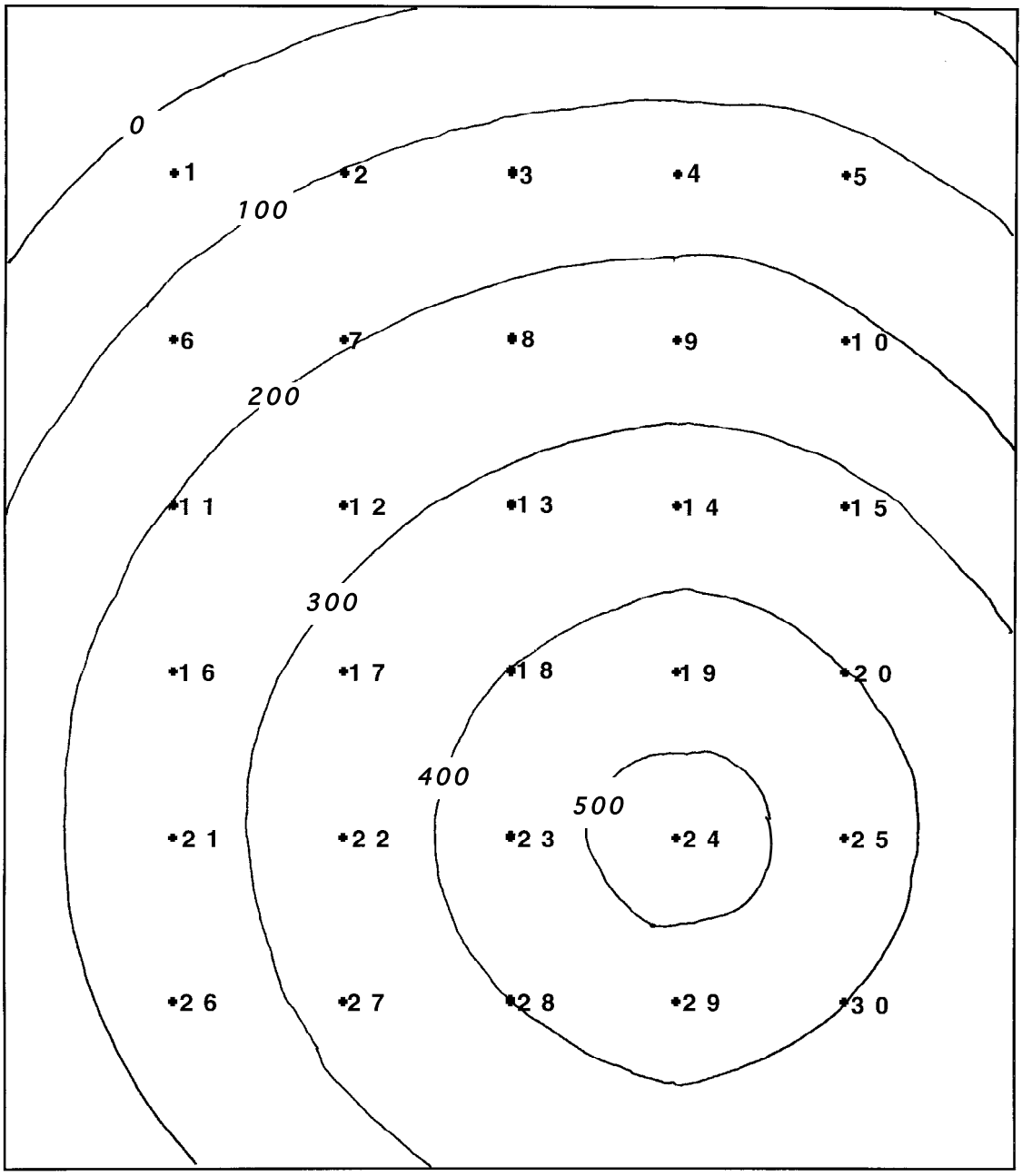
Structural Contour Interval = 100 feet

Sandstone

Shale

Limestone

Answer Sheet - Structure Contour Map



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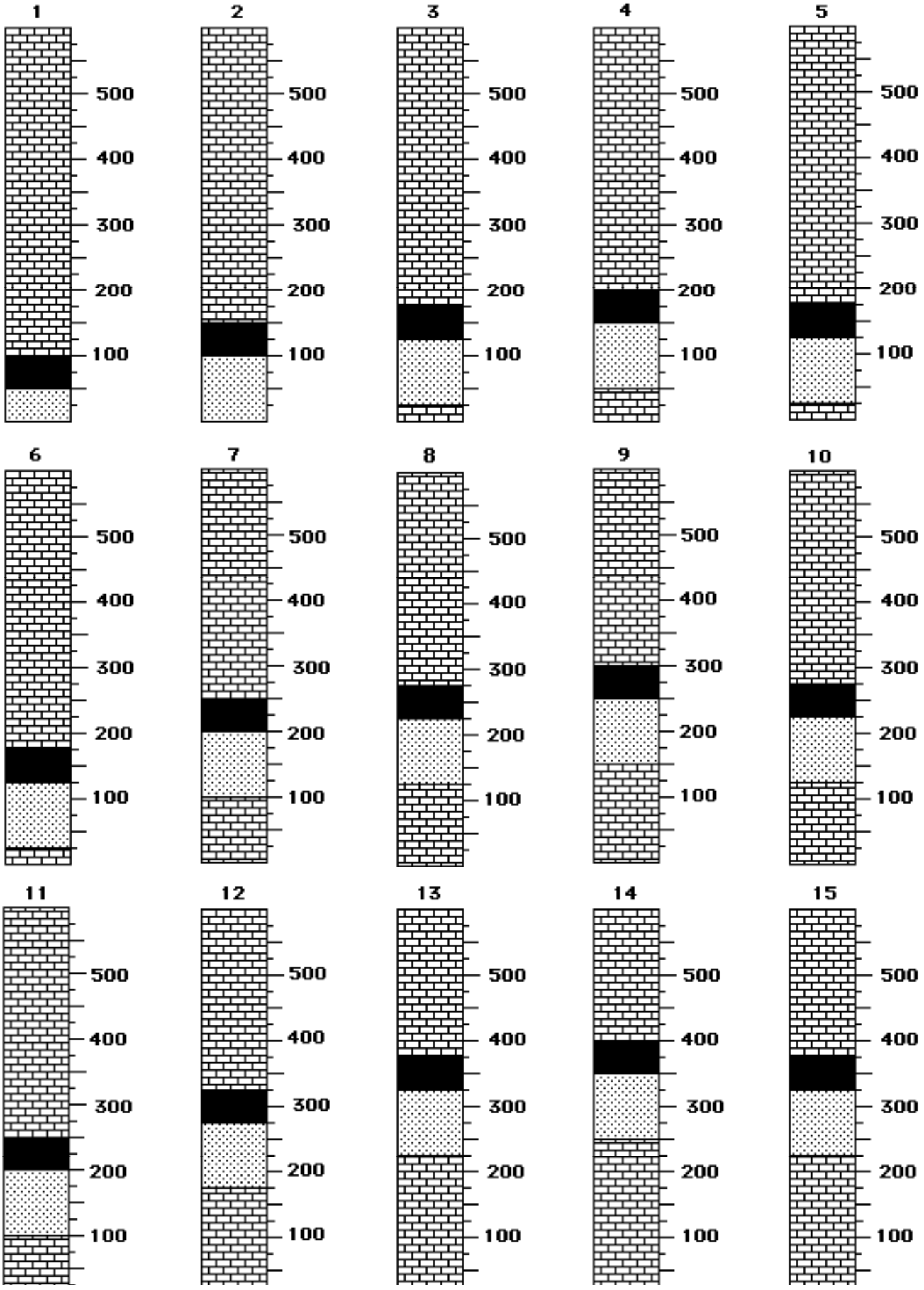
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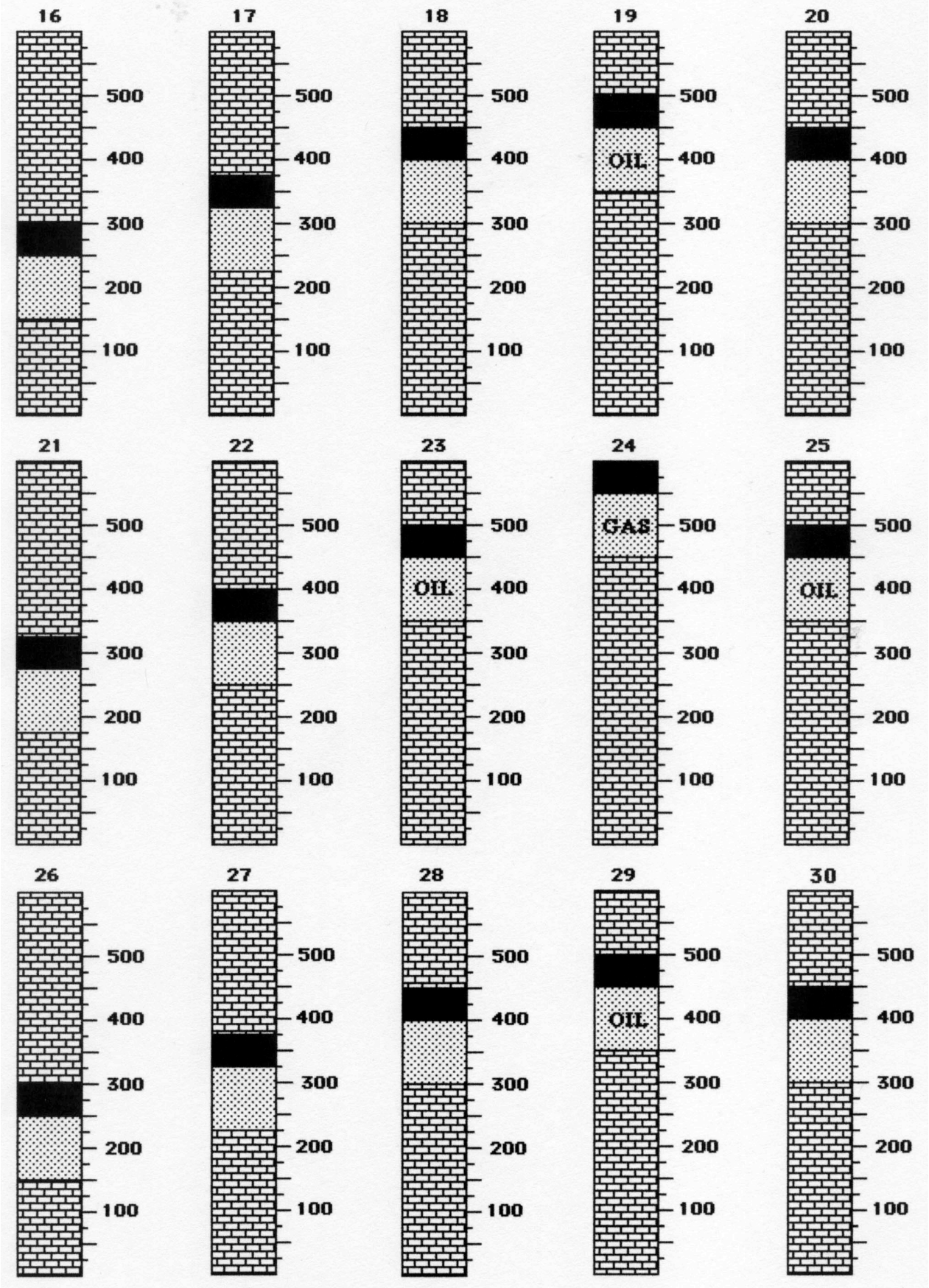
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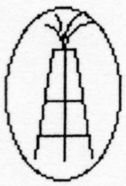
First National Bank of Slick, Texas



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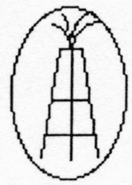

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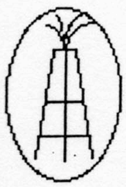

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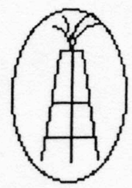

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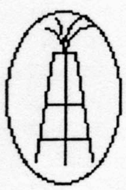

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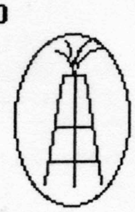

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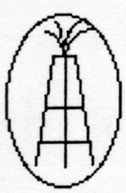

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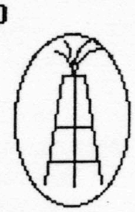

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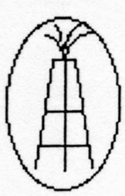

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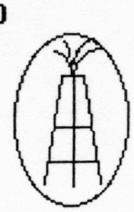

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