When completion is not the end

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Over time I will migrate the earlier parts of our techie Saturday's over to the new site, and with some patience, may learn to add pictures to them to make them a bit more understandable.

But for now I would like to return to our little drill, just as it drills down into the rock that is carrying the oil.

It would nice, once the drill hits the oil-bearing rock, to say that you were done. That having connected the feed line from the well through a choke valve (that controls the outflow from the well), we could proceed to tie the outflow into some kind of collection network, and then we could sit back and count the money as it flowed by.

Well not quite. There are a number of different steps that we have yet to go through before we can finish what is commonly called, the **completion**, of the well. At this point in the process the bottom of the well is still an open hole. That means that the rock wall is exposed, just as it was drilled. There are several issues that can come about as a result of this. The first is that the rock we have drilled into can be fairly weak. This is one of the peculiarities of geology. To a degree the richer in oil the rock is, the weaker the rock will be. (And that also holds true for oil shale - of which more at a later date). Why is that?

Well let's talk a little about the rock structure. There are two types of rock, that oil is usually found in and for now, to make a simple generalization, I am going to call them **sandstone** and **carbonate**. Sandstone rock is made up of relatively large grains that are glued together at the edges with various different types of natural cement. The grains do not fit that well together (think apples filling up a room, and connected where they touch). We call the gaps between the grains, the **pore space** of the rock, and it is these gaps that the oil fills up to form the reservoir. And so we can calculate the "free volume", as it were, of the rock as the (relative amount of free space in the rock, you can get this by subtracting the weight of the rock from the weight of the same sized piece cut from solid quartz and it will tell you how much empty space there is in the rock, and thus, how much oil there could be in that volume.

So say we had a core that weighed 144 lb/cu ft and the weight of solid quartz (flint) is 220 lb/cu ft. Then only 65% of the rock (144/220) is solid rock and the remainder is what is known as **pore space**. Now these holes can be connected or totally surrounded by rock. Normally the percentage given is reversed, i.e **porosity = proportion of void space to total volume**, or in this case 35% of the total volume is not rock. (A picture showing porosity of a sandstone can be found here. Now in the reservoir rock this space is going to be filled with a fluid, either gas, oil or water. For now let us assume that it is filled with oil.

What I have described so far is known as primary porosity,i.e. that which is created by this initial structure of the rock. With carbonates more than sandstone there is a secondary porosity, and this is the porosity induced by rock movement and the dissolving of channels and holes in the rock by the movement of fluid over the rock through the millennia. Again put simply the oil found in a sandstone will occur between the grains of the rock. In the case of the carbonates,which normally have a much smaller individual particle size, the oil is more often usefully found in the cracks and joints formed were the rock bedding planes were created (and which can be seen in exposed rock in a lot of road cuts along the highway). The voids and spaces in the rock are also formed from the spaces from what might have been old coral reefs, or where water dissolved holes through the rock. But sometimes the two methods of formation mix, and I would like to quote from Kenneth Deffeyes book "*Hubbert's Peak*" (my favorite text as an explanation of the geological case).

Fine grained calcium carbonate mud usually gets consolidated into massive limestones, usually with little or no porosity. . . . . . .About 10 percent of ancient limestones do have porosity. . . . . . .Most massive and nonporous limestones contain textures made by invertebrate animals that ingest sediment and turn out fecal pellets. Usually the pellets get squished into the mud. Rarely do the fecal pellets themselves form a porous sedimentary rock. . . .I twisted Aramco's collective arm for samples from the supergiant Ghawar field. . . . .Examining the reservoir rock of the world's biggest oil field . . .a small part of the reservoir was dolomite, but most of it turned out to be fecal pellet limestone. I had to go home that evening and explain to my family that the reservoir rock in the world's biggest oil field was made of shit.

So there you have it. And the reason for the quote is that the rock at the bottom of our well can be very weak, and may be left in poor shape by the oil drilling bit that just passed it by. Now remember it is this wall around the hole that is the barrier through which all the oil in that rock must pass to get into the well. So before we leave it we have to ensure that it is in as good a condition to allow that flow as possible.

One of the problems is that the drill bit may have overly crushed the rock, so that fine carbonate particles are pushed into the cracks and pores of the rock, right around the bore. These can block the passages that will allow the oil to enter the well. And so, in order to get rid of these particles, a strong acid can be poured into the bottom of the well. This **acidizing** dissolves these fine particles and opens up the cracks leading out into the surrounding rock, so that the oil can flow into the **well bore** more easily.

Another problem is that the rock may be very weak, since a lot of its strength comes from the oil that fills the holes within it. This oil only provides strength as long as the rock is totally confined on all sides, but when the pressure is removed on one side (think of popping a champagne cork) then the oil can flow away, taking the support for the surrounding rock with it. If the rock bridges that are left are weak then they can crush. This will cause the crushed rock (**sand**) to mix with the oil, which will require a **de-sanding process** at the surface, but it will also close some of the passages through which the oil is flowing to the well. A well operator that speeds the flow of oil out from the rock around the well, can reduce the support that the oil gives to the surrounding rock to the point that it crushes, and permanently reduces oil flow into the well. (This is the sort of damage that Matt Simmons writes about).

To stop that rock crushing from happening and to reinforce the rock , we can pour a layer of concrete into the bottom of the well, cementing a steel liner into the rock, just as we cased the well higher up the well. The steel liner, or **production casing**, has, however, one problem. Once it is cemented into place, there is this hollow tube all the way to the surface, but there is no way that the oil can get through the cement and the steel into that passage.

And this is where Her Majesty's Explosive comes in. Small, specially designed, explosive charges are now put together into specifically designed charge packages, and lowered down into the well into the completion zone. Here they are detonated, sending small jets of metal against the wall of the casing and **perforating** the steel and concrete into the surrounding rock (see information here) and a picture here. This gives the passage for the well to flow out of the rock and into the well bore. We have finally completed the first stage of our oil production.

Technorati Tags: peak oil, oil