The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

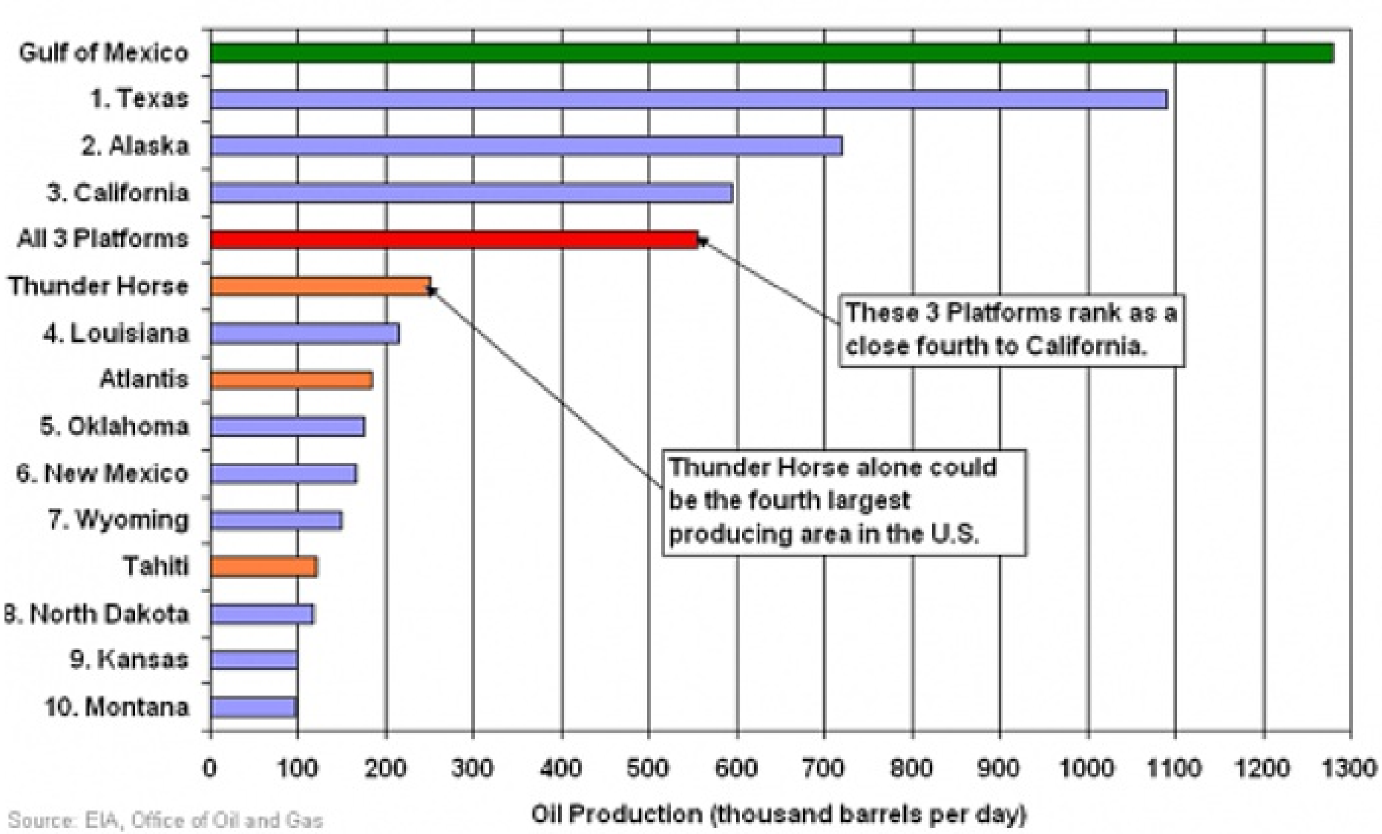
Tech Talk - The Deep Waters of the Gulf and Salt Domes

Posted by Heading Out on August 7, 2011 - 3:04am
Topic: Supply/Production
Tags: atlantis, deepwater, florida, gulf of mexico, salt, salt dome, tahiti, thunder horse [list all tags]

The deep waters of the world's oceans and seas are a frequent topic in discussions of the source of future production of oil. Having talked about the development of the offshore Gulf of Mexico oil and gas fields last time, in this post, I'm going to venture further away from the coast and look at the deeper wells that are now where the most promising discoveries and developments are made.

For the sake of reference, the U.S. Government has defined deepwater as being anything deeper than 1,000 ft. IHS (CERA) has defined it more recently as deeper than 2,000 ft, and in their projections last year suggested that deepwater fields had the potential to contribute up to 10 mbd to global supply by 2015. This would be up from 1.5 mbd in 2000 and 5 mbd in 2009. As a "region" that would put it at the top of the league in the company of Russia and Saudi Arabia.

Within the United States, deepwater production is currently focused in the Gulf of Mexico (GOM) with individual oil fields that compete with state production.



Production from the Gulf Of Mexico comparing some individual platform production. (Petro Views)

At present (August 2011), there are 27 rigs active in the Deepwater, in water depths ranging from 9,627 ft (Tobago) to one allowed at 922 ft (GC 50). Eight of the rigs are being run for Shell. In total there are about 90 prospects being considered, while 81% of current GOM production of oil and 47% of natural gas comes from the deep waters of the Gulf.

For the three largest fields cited in the plot, Tahiti is believed to hold 4-500 million barrels of oil (mb) started production in 2009 in 4,000 ft of water. Production is nominally some 125 kbd of oil and 70 mcf of natural gas. Atlantis lies under 7,100 ft of water and was set to nominally produce 200 kbd of oil and 180 mcf of natural gas. Thunder Horse lies in 6,050 ft of water, and even with delays due to having to do some re-engineering, is still not performing up to the anticipated 250 kbd of oil and appears to be declining in production at a higher than expected rate. And even when the North field has been added, as Darwinian has noted, production has not been sustained at target levels.

These fields are now generating new projects that lie close to the original discoveries - Thunder Hawk, for example, lies close to Thunder Horse, and is in 5,724 ft of water with total vertical depth (TVD) of the well being 25,885 ft. It is designed for 60 kbd of oil and 70 mcf of natural gas. Further discoveries continue to be made. In June, for example, Exxon announced a discovery in Keathley Canyon, so that even if the original potential is not achieved (and I have not even discussed fields such as Jack, which has been rated at perhaps 500 mboe) there will continue to be sustained production from the Gulf even if it is steadily moving further offshore.

This might be a good point to slip in a little comment about salt domes. When the original Spindletop well was drilled in Texas, it was not recognized at the time that the hill from which the well descended had been formed by a salt dome. Yet once this had been grasped, the slight hills that were the surface feature of these domes became a guiding marker for wildcatting across Texas.

John Bratton has provided a little explanation of the initial history of salt in the Gulf. Simplistically, as the global pull separated North from South America it first created a valley:

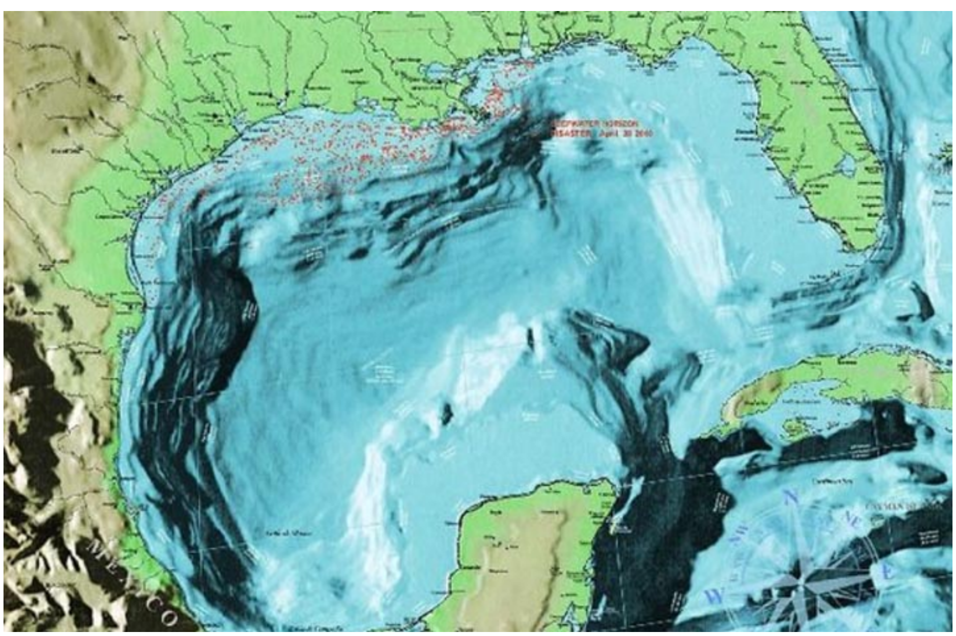
> The tearing apart of plates does not make an ocean right away. Usually, the big valleys first start to fill as salt deposits form, like those found in the Dead Sea in Israel and Jordan, or the Salton Sea in California. These deposits are called the Louann Salt in the Gulf of Mexico area. As the big crack at the bottom of North America widened, the ocean filled the big valley permanently, new ocean crust began to form, and sediment began washing into the widening hole from the Mississippi. Other rivers and reefs grew along the shore, burying a width of more than 500 km of salt and the edges of the new crust.
>
> Over millions of years, plumes of the light salt began to float up through the heavier sediment that covered it, like the colored liquid in a lava lamp. As the salt made it very close to the surface, sometimes having traveled through more than 10 km of rock and sediment, it pushed up the sea floor above it to form a mound or dome.

The driving force for the movement of the salt lies in the difference in specific gravity between the 2.19 SG of the salt and the typical 2.7 SG of the overlying sediments. As a result, due to the plasticity of the salt, it will flow under the differential pressure and due to its lighter density preferentially deform upwards. (This can be illustrated, for example, at the Wieliczka salt mine in Poland where miners have mined what they thought was virgin salt, only to find old mining equipment buried within the rock.) With time that upward movement pushed through and compresses overlying sediments.

Michel Halbouty has described how the Gulf salt, which can now lie some 30,000 ft below the surface, could then create the traps for oil.

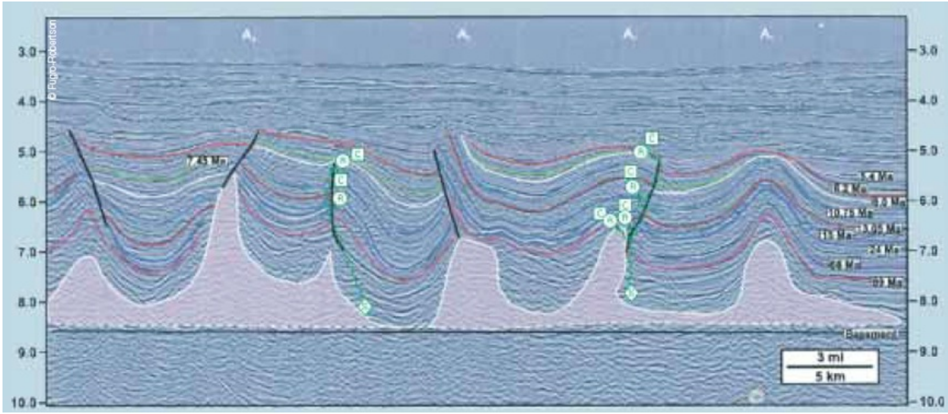
> Once the movement of salt begins, the forces of buoyancy are constantly at work, depending on the static weight of the sediments above the salt and on the flanks of the salt core. The main motive force of the uplift of the salt through the sediments is the static weight of these sediments, principally on the flanks of the salt core. The salt stock moves in stages through geologic time, depending on the thickness and the weight of the sediments above and around the salt mass . . .
>
> Cycle after cycle of this procedure took place until the domes gradually pierced their way through the overlying beds to their present positions under the surface of the earth . . . Some of these moved upward rather slowly, so that they could not keep pace with the rapid deposition of sediments and eventually became buried beneath many thousands of feet of overburden. These domes are referred to as "deep-seated," and gas and oil production is generally found in the arched, but unpierced, formations lying over the super-dome area. Other salt stocks, including the one at Spindletop, seem to have developed under conditions that resulted in the salt stocks remaining near the surface throughout their growth history . . . Gas and oil production at these domes is therefore likely to be important in the pierced formations that butt against the sides of the salt mass. It was one of these salt cores that finally settled under an area that is known as Spindletop.

It is difficult to see these deeply buried domes given the current geology of the undersea Gulf surface.



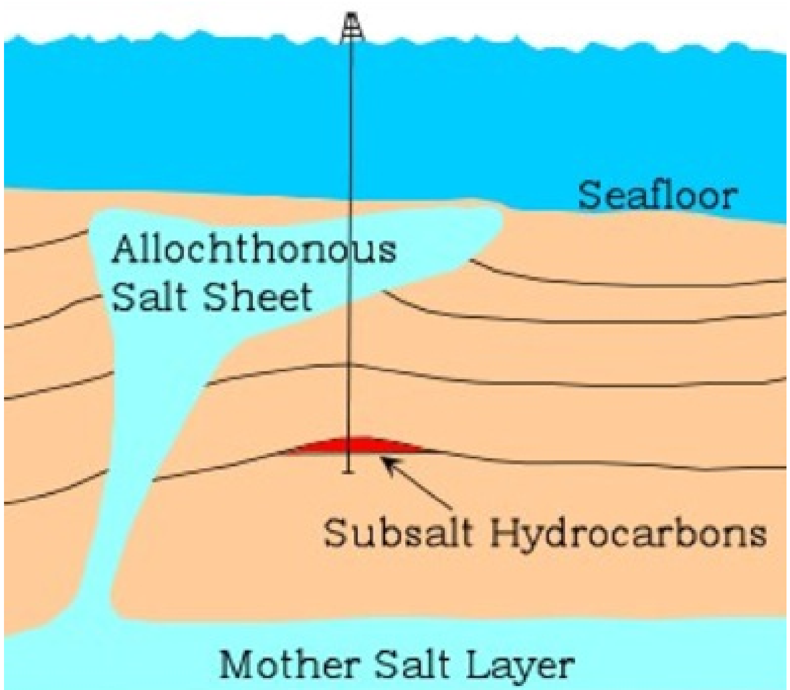
Gulf topography (Gulf Blue Plague)

Rather we have to rely on geophysical surveys where the subsea geology is plotted through the return of sound waves, allowing the rocks under the sea to be mapped in three dimensions. Using this technique it is easy to see (even in a simpler 2-D version) the presence of salt domes.



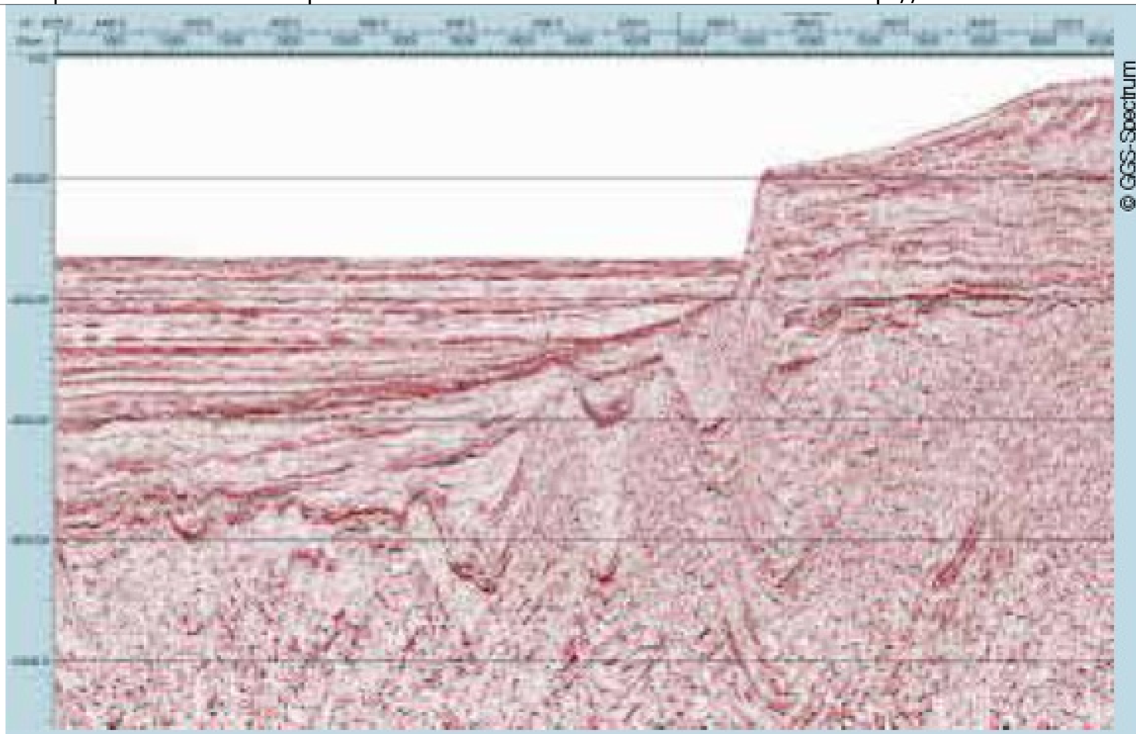
Salt migration and the effect on overlying Miocene deposits in the Gulf (after Morris via Geoexpro) The image has been colored to enhance the features.

Similar structures extend to the East and are projected to be potential areas for future production closer to Florida. The salt does not just move vertically upwards, but can also flow laterally. However, in earlier times the formations under the salt would not have been distinguishable because of the way that sound waves move through that rock. (The results have been compared with seeing through frosted glass). Thus hydrocarbons in beds below the salt would have been hidden.



Hydrocarbon reservoir that used to be hidden by overlying salt (BOEMRE)

More modern and advanced techniques have allowed formations to be seen both above and below the salt. (Or pre and post salt).



Depth section across the Florida Escarpment showing plays both above and below the salt Section width is 90 km, vertical magnification is 5:1 (Geoexpro)

As with the technology to find these deeper reservoirs so increasingly more complex drilling rigs have had to be developed to reach and develop the deposits. This included technology to drill through the salt, first carried out by Diamond Shamrock in 1983, although it was not until the Mahogany field was discovered by Philips Petroleum that commercial subsalt production began. Both Atlantis and Thunder Horse reservoirs lie sub salt.

Not all the equipment works as anticipated and this has been evident, not only with the Deepwater Horizon tragedy last year, but in other rigs and other locations.

Hopefully now, however, the industry has learned the lessons that needed to be learned, and the permitting of new drilling means the new discoveries that continue to be made can be developed without further loss of life.