

M. KING HUBBERT CENTER FOR PETROLEUM SUPPLY STUDIES

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DEEPWATER OIL – THE END OF THE END GAME

C. J. Campbell

Looking at the globe we can see that most of it is covered by water; and if we take a closer look, we can see that much of that is deep water. Reading of the remarkable feats of engineering that have opened the deep water to oil exploration may prompt us to wonder if vast new deposits of oil have been brought within our reach. Have we escaped forever from the fear that OPEC or the Middle East may again control the supply and hence the price? This fear in the back of our minds remains real enough, even as we fill up our gas-guzzling four-wheel drive vehicles from pumps that were just about giving the stuff away a few months ago.

If we pull back the veils of obfuscation that surround almost every aspect of the oil industry's resource base, we would realize just what dangers we face. As we come to think about it, it soon becomes obvious that no one would be looking for oil far offshore beneath 6000 feet of water if there was anywhere else left that was easier. We might also come to conclude that technology does not normally lead but rather follows. As viable prospects in the shallower seas were exhausted, the industry edged into deeper water following already established trends. "Necessity" they say "is the mother of invention".

There are 160 million Brazilians with such a thirst for fuel that they tried making it out of sugar cane. Onshore Brazil had little oil to offer, and even the shallow shelf was less than prolific although a number of useful small to medium sized fields have been found. Then, the explorers' eyes turned ocean-ward as they wondered if there could be some promising prospects in deep water. They plucked up courage to test them, even though they did not then have the facilities to produce what they found. They were rewarded when they fell into a cluster of giant fields, each bigger than anything found in the United States for more than 25 years.

So far, the world has provided only two major deep water geological domains: both due to special circumstances as tectonic plates moved apart. One results from the opening of the Caribbean; the other the South Atlantic.

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It is too much of a complicated story to repeat here in full, but suffice it to say that the oil, once generated in the stagnant troughs that marked the opening of the oceans, has found its way upward to collect in very unusual reservoirs. Off Africa, huge masses of limestone slipped down the ocean floor, locally to come to rest above the generating troughs to form huge fractured traps sealed by an envelope of clays which were laid down on top of them. Off both Brazil and Africa, long shore bars were occasionally destroyed by storms which released something like a submarine avalanche (called a turbidite). They generally form poor reservoirs containing too much clay to produce well, but remarkably enough, currents in some areas took the material back into suspension and removed the clay depositing beautiful dune-like sands forming excellent reservoirs. In the Gulf of Mexico oil was trapped in the outer parts of the ancestral delta of the Mississippi River, where salt movements played a part in forming the prospects. This is generally an extension of a conventional basin that runs into deep water, although it does contain some advantageous aspects that make it particularly prospective. It has to be distinguished from the very different truly oceanic domain where prospects depend on a remarkable combination of geological circumstances that only rarely come together in one place.

So, what has been the effort to find this oil ? and what has been the result ? Today, only Brazil and the Gulf of Mexico are actually on production. Worldwide roughly 500 wildcats have been drilled finding approximately 25 billion barrels – that is to say enough to supply the world for close to one year. How much remains to find? The prognosis is not great. Outside the two prime provinces, some 300 wildcats drilled over 25 years have yielded only about a billion barrels – enough to supply the world for two weeks. No one knows how much more the prime tracts can deliver, but looking into the crystal ball on the basis of current knowledge might suggest an ultimate recovery of approximately 60 billion barrels. Recognizing that we are still in the early days, we may expect some surprises, even good ones. Yet, we must not let our optimism run away with us, because experience everywhere shows that the biggest and best fields tend to be found first. Understandably, no oil company plans to start with the worst, but prefers to cream off the best fields ahead of its competitors. This suggests that the best may already be behind us, and also explains why, for example, the Brazilians are inviting in the foreign companies. Bearing these factors in mind suggests a world ultimate of 85 to 100 billion barrels, enough to meet demand for 3 to 4 years.

We should also be a bit concerned about production. The Brazilian fields seem to be underperforming and there is talk of difficulties in getting the deep Gulf of Mexico fields up to scratch. Deepwater operations, while now possible, remain difficult and expensive. Companies are under economic pressure to secure high flow rates and deplete their finds quickly. It is sometimes said that deep water fields have high flow rates as if it were a feature of deepwater fields: the reality of course is that it is only those with high flow rates that are viable. That in turn seriously limits the number of prospects that can be tackled. Furthermore, finding gas is not good news. It cannot be flared, for environmental reasons, and has to be reinjected into the reservoir or processed into sub-economic synthetic fuels in costly ship-mounted plants.

The price collapse of 1998 did not help, halting the industry's momentum, always one of its strongest drivers. But, with the recent upward price shock, deepwater exploration will no doubt recover. The International Energy Agency now confirms in its *World Energy Outlook* that

production outside the Middle East will peak next year, meaning that the Middle East share is set to rise. We don't know when that will translate into a further price shock, but we can expect one long before the Middle East share reaches 50 percent, which according to the IEA projection will be around 2010.

In short, deepwater oil is valuable, useful, and much needed, especially by the United States, which now imports more than half of its requirements; but it is not going to have much global impact, at best meeting a few years of world demand.

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After finishing a Ph.D. in geology at Oxford University, C. J. Campbell joined Texaco in 1958 as an exploration geologist in South America, later moving to BP with assignments in Colombia, Australia, and Papua. In 1968, he joined Amoco in New York as regional geologist for Latin America, becoming Chief Geologist in Ecuador in 1969. With the opening of the North Sea, he returned to England in 1972 as General Manager of the Texas independent Shenandoah Oil Corporation, before rejoining Amoco to become Exploration Manager in Norway in 1980. In 1985, he was appointed Executive Vice-President of Fina in Norway. He is now a petroleum consultant and has had commissions from the Norwegian Petroleum Directorate; Bulgarian government; European Commission; Amoco ShellEsso; Amerada; Mobil; and others. He specializes in oil resource assessment, having published and spoken widely. His book "The Golden Century of Oil" was published by Kluwer in 1991, and "The Coming Oil Crisis" by Multi-Science Publishing Co. in August 1997. He has co-authored several major studies on world reserves of oil and gas and their depletion for Petroconsultants as based on their authoritative data.

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*Do you know the difference between an optimist
and a pessimist? A pessimist is better informed.
--CLARE BOOTHE LUCE*

**OPERATOR BUDGETS LEAVING LITTLE FOR FRONTIER EXPLORATION:
ARE THE FRONTIERS DEAD?**

Marshall DeLuca

Is frontier exploration justifiable at \$12/bbl oil? The answer from operators around the world seems to be a resounding no. During this latest downturn, operators have been cutting budgets an average of 34 percent. Exploration in frontier regions seems to have been included in that cut, despite the fact that lease and licensing periods are running.

An area is deemed frontier when it meets two main criteria:

- The area has not been developed due to geographic challenges. This may be due to the relative location, lack of infrastructure, under a boundary dispute, or affected by some other factor that has left it relatively undeveloped.
- The area presents a technological challenge. This means special and advanced technologies are essential for operations.

However, when an area is classified as being "challenging" or necessitates major technological innovation, costs almost always go up - well above operating costs in more established areas.

Frontier costs, risks

The average development cost threshold an operator must meet when deciding the economic feasibility of a project is \$8/bbl, including deepwater. If costs exceed that mark, an operator will most likely cancel or postpone the project. Sometimes costs get below that mark in more established areas. In fact, Petrobras, the leader in deepwater technology, recently announced that it had pushed development costs in the Campos Basin down to \$6/bbl for deepwater.

This threshold figure fluctuates with the price of oil. If the price of oil is \$23/bbl, then \$10/bbl development costs are still justifiable, for the short term. And, likewise, if oil is at \$11/bbl, an \$8/bbl development cost does not give the operator much breathing room. The threshold must be lower.

For example, two of the more recent frontier developments in the Atlantic Margin frontier, BP's Schiehallion and Foinaven, were sanctioned during a time when oil was at \$21/bbl. If the oil price had been at current levels, the chances of their development would have been slim. Frontier exploration costs, with their added challenges, typically lie at the higher end of the cost threshold.

Another addition to the cost is the amount of relative risk that an operator faces coming into a new frontier. Although the old gambler's adage "the bigger the risk - the bigger the payoff" frequently applies, an operator must weigh the potential cost of this risk, such as a dry hole, compounded with increased operational costs of frontier areas. From an economic perspective,

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the only times this sort of operation would make sense would be when an operator could get costs equivalent to an established exploration area, or more importantly, when the commodity price is high enough to justify it.

While the advent of more sophisticated technology is making exploration and production more precise and results in lower overall costs, even in some frontier areas, from a commodity price standpoint, conditions now are bad for high cost projects. When an operator decides to cut the budget, the first to go are the high cost projects, of which frontier areas top the list.

In the past and in the future, frontier exploration will always be a mixed bag of risk and payoff. Many projects have been largely successful, but many have been utter disappointments. Others have been successful only after long exploration programs.

Falkland Islands

The most recent frontier project was the offshore Falkland Islands area. This exploration project has turned out to be a disappointment - thus far. The operators have tried six wells in the area on tranches A, B, C, D, and F, and have encountered some oil shows, but did not strike anything close to commercial levels. It has been estimated that the group will need a discovery with at least 140 million bbl of oil to justify development off the Falklands. With the harsh environment of the Falklands, well costs are currently estimated at between \$25 and 30 million per well. The FOSA drilling program is now complete, and the operators are evaluating well data. No plans for the future have been announced.

Britain's Atlantic Margin

The Atlantic Margin has long been one of the key frontier plays, but it also presents some of the harshest operating conditions in the world. The area is prone to extreme environmental conditions, such as wind speeds over 80 knots, currents as high as 4 knots, wave heights up to 80 to 90 ft, and water temperatures at the freezing mark near the seabed. These make activities a major operational challenge. Several equipment problems with production systems at the surface and on the seabed in the Atlantic Margin indicate that operators will have to design for conditions that are harsher than the North Sea.

Almost 100 wells were drilled in the region before two major commercial discoveries: the 500-million-bbl Schiehallion and Foinaven fields. Several more discoveries have followed, with most information on them being tighthead.

The government of Ireland recently held a South Porcupine Basin Frontier licensing round. Only two companies, Elf and Agip, bid for blocks. Exploration is planned in the area for the future, following award of the blocks.

The Faeroe Islands also have planned a licensing round offshore. A number of speculative seismic surveys have been performed over the Faeroe's prospective regions, particularly in the east and south. However, the challenge for this area is the thick layers of basalt covering the Faeroe's shelf.

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Southern Caspian Sea

Another area of significant frontier interest is the southern Caspian Sea, primarily in Iranian waters. The geological structures in that area reportedly are some of the largest in the Caspian. Historically, sheens of oil have been found floating over large areas indicating that the structures underneath are discharging oil. At the present, National Iranian Oil Corporation (NIOC), Shell, and Lasmco have an agreement to drill exploration wells in the region, although drilling is not expected to get underway until later next year or 2001. Water depths over the best prospects are estimated at 600 to 800 meters, which would require a deepwater drilling unit in the Caspian Sea. No such rig is working there now, and one would have to be brought in. Considering that the unit would have to be broken up and floated down several rivers from the Baltic Sea, no quick action is expected, although day rate prices on such rigs are becoming relatively attractive.

The final frontiers

The largest, most long-standing, and most sought after frontiers will always remain the ultra-ultra-deepwater, such as 12,000+ ft of water, and the deepwater arctic. These areas are often spoken of as the final frontier.

For the ultra-ultra-deepwater, many geologists believe that 10,000 to 15,000 ft of water is the limit of sedimentary deposition. However, sedimentation has a tendency to flow to the lowest level, and even the deepest basins should not be considered devoid of prospectivity before being drilled. But industry has a long way to go before it is technologically capable of drilling in such depths. Operators are now fringing on what is considered to be ultra-deepwater. The current world record water depth drilling record is 7,718 ft. New vessels floating out of the shipyards are equipped to drill in a water depth maximum of 10,000 to 2,000 ft. Before drillers can even think about going to 15,000 ft or greater, vessels must be designed to handle such depths, and new technologies - such as riserless drilling - must become reliable and economical.

Drilling in the ultra-ultra-deepwater probably will occur long before a way is discovered to drill and develop in the deeper waters of the Arctic Ocean. Shelf areas out to the 100-ft contour present little opportunity for drillers. Unless a drilling unit is firmly attached to the seafloor and has an ice sheet resistant hull, attempting to keep a vessel on station in anything other than open water is impossible at this time. Current conditions below the Arctic ice sheet also present a formidable challenge for drillers, as well as gas hydrate formation during both drilling and production operations.

The Arctic Ocean will remain a final global frontier long after development of the other frontier areas of the world.

Other frontiers

Other frontier areas exist off southern Greenland, the far-eastern reaches of the Eastern Canadian shelf, and East Africa, all of which have been gaining interest from oil companies.

- **Greenland:** Operations are now planned to begin in the summer of next year. Seismic surveys in the area have indicated that the area has sedimentary basins larger than the Viking-Central Graben area of the North Sea.
- **East Africa:** This area is also beginning to gain interest. Two development schemes by Canadian companies are under review off Tanzania to help alleviate local dependence on diesel fuel and hydro-electricity for power generation.

Lesser frontiers

Some other areas fall into the classification of lesser frontiers. These are areas that are not as remote, but have yet to be explored or developed, therefore allowing for less risk and potentially lower cost. These areas include new acreage that has been on offer in the past year and have been catching the eyes of the operators despite low oil prices and cut budgets.

- **Brazil:** The opening of Brazil to the international operators represents one of the most attractive areas for exploration. The area for the most part is frontier for everyone except Petrobras. The risk for operation in the area is relatively low and it has a strong infrastructure with vast proven reserves.
- **India and China:** Both countries have offered new, relatively unexplored acreage. Several discoveries have been made in both regions and they remain attractive to operators, despite the downturn.
- **Ultra-deepwater West Africa:** Next to Brazil, however, the most prolific of the lesser frontiers are those in the deepwaters off West Africa. Acreage has been snatched up all along the western coast line, especially in Angola where bid amounts are very high. This area is relatively unexplored, but the potential in the area is extremely high.

So is frontier exploration dead? For the time being, until prices stabilize at a consistent rate, frontier exploration will be put on hold. The massive potential for some of these areas will always keep frontier exploration alive and companies will keep investing when the timing is right.

Even when the oil price stays up, there will still be a lag time of approximately 6 to 12 months before frontier areas are placed back on producers' budgets. When prices go up, operators begin reviving projects in order of costs and relative economics. Frontier areas are more than likely far down the list.

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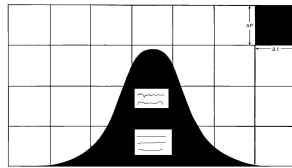
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H.C. NEWSLETTER



The M. KING HUBBERT CENTER FOR PETROLEUM SUPPLY STUDIES

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The Hubbert Center has been established as a non-profit organization for the purpose of assembling and studying data concerning global petroleum supplies and disseminating such information to the public.

The question of WHEN worldwide oil demand will exceed global oil supply is stubbornly ignored. The world's oil problems, timing and ramifications can be debated and realistic plans made only if the question is publicly addressed. A growing number of informed US and European evaluations put this crisis as close as the years 2000 - 2014. The formation of this center is to encourage a multi-field research approach to this subject.

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