The 'Abiotic Oil' Controversy

rense.com/general58/biot.htm

The debate over oil's origin has been going on since the 19th century. From the start, there were those who contended that oil is primordial - that it dates back to Earth's origin - or that it is made through an inorganic process, while others argued that it was produced from the decay of living organisms (primarily oceanic plankton) that proliferated millions of years ago during relatively brief periods of global warming and were buried under ocean sediment in fortuitous circumstances.

During the latter half of the 20th century, with advances in geophysics and geochemistry, the vast majority of scientists lined up on the side of the biotic theory. A small group of mostly Russian scientists - but including a tiny handful Western scientists, among them the late Cornell University physicist Thomas Gold - have held out for an abiotic (also called abiogenic or inorganic) theory. While some of the Russians appear to regard Gold as a plagiarist of their ideas, the latter's book The Deep Hot Biosphere (1998) stirred considerable controversy among the public on the questions of where oil comes from and how much of it there is. Gold argued that hydrocarbons existed at the time of the solar system's formation, and are known to be abundant on other planets (Jupiter, Saturn, Uranus, and some of their moons) where no life is presumed to have flourished in the past.

The abiotic theory holds that there must therefore be nearly limitless pools of liquid primordial hydrocarbons at great depths on Earth, pools that slowly replenish the reservoirs that conventional oil drillers tap.

Meanwhile, however, the oil companies have used the biotic theory as the practical basis for their successful exploration efforts over the past few decades. If there are in fact vast untapped deep pools of hydrocarbons refilling the reservoirs that oil producers drill into, it appears to make little difference to actual production, as tens of thousands of oil and gas fields around the world are observed to deplete, and refilling (which is indeed very rarely observed) is not occurring at a commercially significant scale or rate except in one minor and controversial instance discussed below.

The abiotic theorists also hold that conventional drillers, constrained by an incorrect theory, ignore many sites where deep, primordial pools of oil accumulate; if only they would drill in the right places, they would discover much more oil than they are finding now. However, the tests of this claim are so far inconclusive: the best-documented "abiotic" test well was a commercial failure.

Thus even if the abiotic theory does eventually prove to be partially or wholly scientifically valid (and that is a rather big "if"), it might have little or no practical consequence in terms of oil depletion and the imminent global oil production peak.

That is the situation in a nutshell, as I understand it, and it is probably as much information as most readers will need or want on this subject. However, as this summary contradicts some of the more ambitious claims of the abiotic theorists, it

may be helpful to present in more detail some of the evidence and arguments on both sides of the debate.

Oil at the Core?

Gold is right: there are hydrocarbons on other planets, even in deep space. Why shouldn't we expect to find primordial hydrocarbons on Earth?

This is a question whose answer is only partly understood, and it is a complicated one. The planets known to have primordial hydrocarbons (mostly in the form of methane, the simplest hydrocarbon) lie in the further reaches of the solar system; there is little evidence of primordial hydrocarbons on the rocky inner planets (Mercury, Venus, Earth, and Mars). On the latter, possibly the hydrocarbons either volatized and escaped into space early in the history of the solar system, or - as Gold theorizes - they migrated to the inner depths. (Note: very recent evidence of methane in the atmosphere of Mars is being viewed as evidence of biological activity, probably in the distant past. (1)) There is indeed evidence for deep methane on Earth: it vents from the mid-oceanic ridges, presumably arising from the mantle, though the amount vented is relatively small - less than the amount emitted annually in cow farts (incidentally, there are persuasive biotic explanations for the origin of this vented methane).

A new study by the US Department of Energy and Lawrence Livermore Lab suggests that there may be huge methane deposits in Earth's mantle, 60 to 120 miles deep. (2) But today oil companies are capable of drilling only as deep as six miles, and this in sedimentary rock; in igneous and metamorphic rock, drill bits have so far penetrated only two miles. (3) In any attempt to drill to a depth remotely approaching the mantle, well casings would be thoroughly crushed and melted by the pressures and temperatures encountered along the way. Moreover, the DOE study attributes the methane deposits it hypothesizes to an origin different from the one Gold described.

More to the point, Gold also claimed the existence of liquid hydrocarbons - oil - at great depths. But there is a problem with this: the temperatures at depths below about 15,000 feet are high enough (above 275 degrees F) to break hydrocarbon bonds. What remains after these molecular bonds are severed is methane, whose molecule contains only a single carbon atom. For petroleum geologists this is not just a matter of theory, but of repeated and sometimes costly experience: they speak of an oil "window" that exists from roughly 7,500 feet to 15,000 feet, within which temperatures are appropriate for oil formation; look far outside the window, and you will most likely come up with a dry hole or, at best, natural gas only. The rare exceptions serve to prove the rule: they are invariably associated with strata that are rapidly (in geological terms) migrating upward or downward. (4)

The conventional theory of petroleum formation connects oil with the process of sedimentation. And, indeed, nearly all of the oil that has been discovered over the past century-and-a-half is associated with sedimentary rocks. On the other hand, it isńt difficult to find rocks that once existed at great depths where, according the theories of Gold and the Russians, conditions should have been perfect for abiotic oil formation or the accumulation of primordial petroleum - but such rocks typically contain no traces of hydrocarbons. In the very rare instances where small amounts of hydrocarbons are seen in igneous or metamorphic rocks, the latter are invariably found near hydrocarbon-bearing sedimentary rocks, and the hydrocarbons in both types of rock contain identical biomarkers (more on that subject below); the simplest explanation in those cases is that the hydrocarbons migrated from the sedimentary rocks to the igneous-metamorphic rocks.

Years ago Thomas Gold recognized that the best test of the abiotic theory would be to drill into the crystalline basement rock underlying later sedimentary accumulations to see if there is indeed oil there. He persuaded the government of Sweden in 1988 to drill 4.5 miles down into granite that had been fractured by a meteorite strike (the fracturing is what permitted drillers to go so deep). The borehole, which cost millions to drill, yielded 80 barrels of oil. Even though the project (briefly re-started in 1991) was a commercial failure, Gold maintained that his ideas had been vindicated. Most geologists remained skeptical, however, suggesting that the recovered oil likely came from drilling mud.

The Russians (I must remind the reader that I am actually talking about a minority even with the community of Russian geologists) claim successes in drilling in basement rock in the Dneiper-Donets Basin in the Ukraine. Professor Vladilen A. Krayushkin, Chairman of the Department of Petroleum Exploration, Institute of Geological Sciences, Ukrainian Academy of Sciences, Kiev, and leader of the exploration project, wrote:

The eleven major and one giant oil and gas fields here described have been discovered in a region which had, forty years ago, been condemned as possessing no potential for petroleum production. The exploration for these fields was conducted entirely according to the perspective of the modern Russian-Ukrainian theory of abyssal, abiotic petroleum origins. The drilling which resulted in these discoveries was extended purposely deep into the crystalline basement rock, and it is in that basement where the greatest part of the reserves exist. These reserves amount to at least 8,200 M metric tons [65 billion barrels] of recoverable oil and 100 B cubic meters of recoverable gas, and are thereby comparable to those of the North Slope of Alaska. (5)

However, independent assessments of the situation do not support these claims. First, the US Geological Survey does not agree that the Dneiper-Donets reserves are that large (it cites 2.7 billion barrels for total oil endowment). Second, the appearance of oil in basement rocks is unusual but not unheard of, and there are various ways in which oil can appear in basement rock. In the process of drilling through overlying sedimentary rock, oil can be expelled downward so that it appears to come from below. Then there are situations where igneous or metamorphic rocks have migrated upward, or sedimentary rocks have migrated downward, so that basement rock covers sedimentary rock (in some cases, the overthrust may be hundreds of square kilometers in extent). In his paper "Oil Production from Basement ReservoirsóExamples from USA and Venezuela," Tako Koning of Texaco Angola, Inc., cites source rocks such as marine shales in nearly all instances. (6) More to the point, numerous studies cite the existence of sedimentary source rocks in the Dneiper-Donets region. (7)

Refilling Fields?

Abiotic theorists often point out evidence of fields refilling. The most-cited example is Eugene Island, the tip of a mostly submerged mountain that lies approximately 80 miles off of the coast of Louisiana. Here is the story as related by Chris Bennett in his article "Sustainable Oil?" on WorldNetDaily.com:

A significant reservoir of crude oil was discovered nearby in the late '60s, and by 1970, a platform named Eugene 330 was busily producing about 15,000 barrels a day of high-quality crude oil. By the late '80s, the platform's production had slipped to less than 4,000 barrels per day, and was considered pumped out. Done. Suddenly, in 1990, production soared back to 15,000 barrels a day, and the reserves which had been estimated at 60 million barrels in the '70s, were recalculated at 400 million barrels. Interestingly, the measured geological age of the new oil was quantifiably different than the oil pumped in the '70s. Analysis of seismic recordings revealed the presence of a "deep fault" at the base of the Eugene Island reservoir which was gushing up a river of oil from some deeper and previously unknown source. (8)

A "river of oil" from an unassociated deep source? This does sound promising. But closer examination yields more prosaic descriptions and explanations.

According to David S. Holland, et al., in Search and Discovery, the reservoir is characterized by

1. Structural features dominated by growth faults, salt domes, and salt-related faulting.

2. Thick accumulations of predominantly deltaic deposits of alternating sand and shale.

3. Young reservoirs (less than 2.5 m.y. old) with migrated hydrocarbons whose origins are in deeper, organic-rich marine shales.

4. Rapidly changing stratigraphy, due to deposition and subsequent reworking.

5. Numerous oil and gas fields with stacked reservoirs, long hydrocarbon columns, and high producing rates. (9)

While it is true that the estimated oil reserves of Eugene have increased, the numbers are not extraordinary. The authors note that "From 1978 to 1988, these operations, activities, and natural factors [including better exploration and recovery technology] have increased ultimate recoverable reserves from 225 million bbl to 307 million bbl of hydrocarbon liquids and from 950 bcf to 1.65 tcf of gas." Other estimates now put the estimate of total recoverable oil as high as 400 Mb.

None of this is especially unusual for a North American oil field: most fields report reserve growth over time as a consequence of Securities and Exchange Commission reporting rules that require reserves to be booked yearly according to what portion of the resource is actually able to be extracted with current equipment in place. As more wells are drilled into the same reservoir, the reserves "grow." Then, as they are pumped out, reserves decline and production rates dwindle. No magic there.

Production from Eugene Island had achieved 20,000 barrels per day by 1989; by 1992 it had slipped to 15,000 b/d, but recovered to reach a peak of 30,000 b/d in

1996. Production from the reservoir has dropped steadily since then.

The evidence at Eugene Island suggests the existence of deep source rocks from which the reservoir is indeed very slowly refilling - but geologists working there do not hypothesize a primordial origin for the oil. In "Oil and Gas - 'Renewable Resources'?" Kathy Blanchard of PNL writes, "Recent geochemical research at Woods Hole Oceanographic Institution has demonstrated that the wide range in composition of the oils in different reservoirs of the Eugene Island 330 field can be related to one another and to a deeper source rock of Jurassic-Early Cretaceous age." (10) Her article explains that this kind of migration from nearby source rocks is hardly unique, and discusses it in the context of conventional biotic theory. A technical paper by David S. Holland, et al., "Eugene Island Block 330 Field - U.S.A. Offshore Louisiana," published by AAPG, notes that the Eugene Island oils show

abundant evidence of long-distance vertical migration. Based on a variety of biomarker and gasoline-range maturity indicators, these oils are estimated to have been generated at depths of 4572 to 4877 m (15,000 to 16,000 ft) at vitrinite reflectance maturities of 0.08 to 1.0% and temperatures of 150 to 170C (300 to 340F). Their presence in shallow, thermally immature reservoirs requires significant vertical migration. This is illustrated on Figure 36, which represents a burial and maturation history for the field at the time of petroleum migration, that is, at the end of Trimosina "A" time approximately 500,000 years ago. A plot of the present measured maturity values versus depth is superimposed on the calculated maturity profile for Trimosina "A" time to illustrate the close agreement between measured and predicted maturity profiles. The clear discrepancy between reservoir maturity and oil maturity is striking and suggests that the oil migrated more than 3650 m (12,000 ft) from a deep, possibly upper Miocene, source facies. Petroleum migration along faults is indicated based on the observed temperature and hydrocarbon anomalies at the surface and the distribution of pay in the subsurface. These results are consistent with those of Young et al. (1977), who concluded that most Gulf of Mexico oils originated 2438 to 3350 m (8000 to 11,000 ft) deeper than their reservoirs, from source beds 5 to 9 million years older than the reservoirs. (11)

Biomarkers

The claims for the abiotic theory often seem overstated in other ways. J. F. Kenney of Gas Resources Corporations, Houston, Texas, who is one of the very few Western geologists to argue for the abiotic theory, writes, "competent physicists, chemists, chemical engineers and men knowledgeable of thermodynamics have known that natural petroleum does not evolve from biological materials since the last quarter of the 19th century." (12) Reading this sentence, one might assume that only a few isolated troglodyte pseudoscientists would still be living under the outworn and discredited misconception that oil can be formed from biological materials. However, in fact universities and oil companies are staffed with thousands of "competent physicists, chemists, chemical engineers and men [and women!] knowledgeable of thermodynamics" who not only subscribe to the biogenic theory, but use it every day as the basis for successful oil exploration. And laboratory experiments have shown repeatedly that petroleum is in fact produced from organic matter under the conditions to which it is assumed to have been subjected over geological time. The situation is actually the reverse of the one Kenny implies: most geologists assume that the Russian abiotic oil hypothesis, which dates to the era prior to the advent of modern plate tectonics theory, is an

anachronism. Tectonic movements are now known to be able to radically reshuffle rock strata, leaving younger sedimentary oil- or gas-bearing rock beneath basement rock, leading in some cases to the appearance that oil has its source in Precambrian crystalline basement, when this is not actually the case.

Geologists trace the source of the carbon in hydrocarbons through analysis of its isotopic balance. Natural carbon is nearly all isotope 12, with 1.11 percent being isotope 13. Organic material, however, usually contains less C-13, because photosynthesis in plants preferentially selects C-12 over C-13. Oil and natural gas typically show a C-12 to C-13 ratio similar to that of the biological materials from which they are assumed to have originated. The C-12 to C-13 ratio is a generally observed property of petroleum and is predicted by the biotic theory; it is not merely an occasional aberration. (13)

In addition, oil typically contains biomarkers - porphyrins, isoprenoids, pristane, phytane, cholestane, terpines, and clorins - which are related to biochemicals such as chlorophyll and hemoglobin. The chemical fingerprint of oil assumed to have been formed from, for example, algae is different from that of oil formed from plankton. Thus geochemists can (and routinely do) use biomarkers to trace oil samples to specific source rocks.

Abiotic theorists hypothesize that oil picks up its chemical biomarkers through contamination from bacteria living deep in the Earth's crust (Gold's "deep, hot biosphere") or from other buried bio-remnants. However, the observed correspondences between biomarkers and source materials are not haphazard, but instead systematic and predictable on the basis of the biotic theory. For example, biomarkers in source rock can be linked with the depositional environment; that is, source rocks with biomarkers characteristic of land plants are found only in terrestrial and shallow marine sediments, while petroleum biomarkers associated with marine organisms are found only in marine sediments.

The Bottom Line

The points discussed above represent a mere sampling of the issues; it would be difficult if not impossible for me to address all of the arguments put forward by the abiotic theorists in a brief essay of this nature. I circulated a draft of this essay on two energy-related email newsgroups and received about a dozen thoughtful comments, one defending the abiotic theory but most of the others critiquing it. About half of the comments were from physicists, geophysicists, or geologists. It quickly became apparent to me that a book-length treatment of the subject is called for.

J. F. Kenney has put forward a succinct and persuasive paper arguing for the abiotic theory (5), but there is no prominently published rebuttal piece that systematically discusses or attempts to refute his assertions. A reader of Kenney's web site might find fault with some of my statements in this essay (for example, as a counter to my description of the depth "window" of oil formation, a reader might refer to Kenneyís discussion of Russian experiments that have shown that oil can be formed at high temperatures and high pressures - conditions similar to those that must exist in the Earthís mantle). Yet among the draft comments I received from scientists were convincing criticisms of Kenney's claims (returning to my example: even if oil were formed in the mantle, as more than one commenter pointed out, abiotic theorists

have suggested no plausible means by which it could rise to the depths at which we find it without passing through intermediary regions in which the temperature would be too high and pressure too low for liquid hydrocarbons to survive). Many other assertions made by Kenney and critiqued by the experts are more technical in nature and more difficult to summarize.

So, rather than continuing along these lines, I would prefer now to pull back from a focus on details and again emphasize the bigger picture.

There is no way to conclusively prove that no petroleum is of abiotic origin. Science is an ongoing search for truth, and theories are continually being altered or scrapped as new evidence appears. However, the assertion that all oil is abiotic requires extraordinary support, because it must overcome abundant evidence, already cited, to tie specific oil accumulations to specific biological origins through a chain of well-understood processes that have been demonstrated, in principle, under laboratory conditions.

Now, I like scientific mavericks; I tend to cheer for the underdog. Peak oil is itself a maverick idea, and for the past several years I have been promoting a view that the Wall Street Journal recently described as "crackpot." (14) So I feel a bit unaccustomed and even uncomfortable now to be on the side of the scientific "establishment" in arguing against the abiotic oil theorists. The latter certainly deserve their day in the court of scientific debate.

Perhaps one day there will be general agreement that at least some oil is indeed abiotic. Maybe there are indeed deep methane belts twenty miles below the Earthís surface. But the important question to keep in mind is: What are the practical consequences of this discussion now for the problem of global oil depletion?

I have not personally inspected the oil wells in Saudi Arabia or even those in Texas. But nearly every credible report that I have seen - whether from the industry or from an independent scientist - describes essentially the same reality: discoveries are declining, and have been since the 1960s. Spare production capacity is practically gone. And the old, super-giant oil fields that the world depends upon for the majority of its production are nearing or past their all-time production peaks. Not even the Russian fields cited by the abiotic theorists as evidence for their views are immune: in June the head of Russia's Federal Energy Agency said that production for 2005 is likely to remain flat or even drop, while other officials in that country have said that growth in Russian production cannot be sustained for more than another few years. (15)

What if oil were in fact virtually inexhaustibleówould this be good news? Not in my view. It is my opinion that the discovery of oil was the greatest tragedy (in terms of its long-term consequences) in human history. Finding a limitless supply of oil might forestall nasty price increases and catastrophic withdrawal symptoms, but it would only exacerbate all of the other problems that flow from oil dependency - our use of it to accelerate the extraction of all other resources, the venting of CO_2 into the atmosphere, and related problems such as loss of biodiversity. Oil depletion is bad news, but it is no worse than that of oil abundance.

Given the ongoing runup in global petroleum prices, the notion of peak oil hardly needs defending these days. We are seeing the phenomenon unfold before our eyes as one nation after another moves from the column of "oil exporters" to that of "oil importers" (Great Britain made the leap this year). At some point in the very near future the remaining nations in column A will simply be unable to supply all of the nations in column B.

In short, the global energy crisis is coming upon us very quickly, so that more time spent debating highly speculative theories can only distract us from exploring, and applying ourselves to, the practical strategies that might preserve more of nature, culture, and human life under the conditions that are rapidly developing.

Footnotes

1. See New Scientist www.newscientist.com/news/news.jsp?id=ns99996425

2. www.eurekalert.org/pub_releases/2004-09/dlnl-mid091304.php

3. http://wow.osu.edu/Geology/ebmf.htm

4. See Kenneth Deffeyes, Hubbertís Peak, pp. 21-22, 171; Walter Youngquist, Geodestinies, p. 114.

5. www.gasresources.net/energy_resources.htm

6. www.dur.ac.uk/react.res/RRG_web/hydrocarbons_meet.htm

7. www.911-strike.com/pfeiffer.htm (link expired; click on "cached")

8. www.wnd.com/news/article.asp?ARTICLE_ID=38645

9. #20003, 1999, www.searchanddiscovery.com/documents/97015/eugene.htm

10. www.pnl.gov/er_news/08_95/er_news/oil1.kb.html

11. www.datapages.com/97015/eugene.htm

12. See footnote 9.

13. www.giss.nasa.gov/gpol/abstracts/1997/FungFieldB.html

14. "As Prices Soar, Doomsayers Provoke Debate on Oil's Future," 9/21/2004

15. www.mosnews.com/money/2004/06/17/oilproduction.shtml

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