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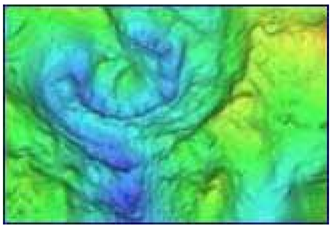

Prospecting for Oil? Look In an Asteroid Crater

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The Earth has suffered thousands of violent collisions with asteroids and comets over the last four billion years. The scars from these collisions are impact craters. But the Earth hides its wounds well -- less than two hundred impact craters have been discovered. Many are buried deep below the surface. They were only found by accident during geological surveys that were part of the massive, ongoing effort to find oil for an energy-dependent world.

Now it seems that the link between impact craters and oil is not accidental. Buried impact crater formations make excellent underground traps for oil, but these craters rarely seem to be above the types of rocks that are supposed to contain oil. New thinking changes all that. If Russian theories about the non-biological origin of much of our oil prove to be accurate, then there may be good reasons for oil prospectors to go searching for impact craters.

Where does oil come from?

"Rock oil originates as tiny bodies of animals buried in the sediments which, under the influence of increased temperature and pressure acting during an unimaginably long period of time transform into rock oil" -- M.V. Lomonosov 1757AD.

Maybe it's time to change the textbooks.

For two centuries Lomonosov's simple and compelling theory on the origin of oil went unchallenged. It meant, of course, that the world would run out of this fuel once the rare sedimentary rocks that contained the bodies of animals were drained of oil. It also meant that so-called basement rocks, which had never been near the surface of the Earth, would not bear oil.

The Russians decided to try something different. In the 1950s, perhaps due to the pressures of the Cold War, they started to hunt for oil according to a new theory -- most oil occurred naturally, deep within the Earth's crust, and had nothing to do with rotting organisms. That hunt has been highly successful, and the former Soviet states have many commercial oil wells apparently producing from deep basement rocks.

Tom Gold, Professor Emeritus of Astronomy at Cornell University, supports the Russian idea. In his book *The Deep, Hot Biosphere*, Gold discusses the discovery of life deep within the Earth' s crust. He argues that most oil and gas could only have come from non-biological sources much deeper underground.

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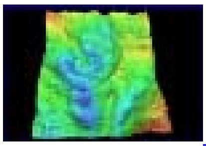

Computerized view of the Chicxulub impact crater (blue area is deepest) off Mexico's Yucatan Peninsula.

Map of the Chicxulub crater.

According to this theory, the natural traps formed by impact formations will be even more promising as places to look for oil because the "source rocks" containing the oil are everywhere.

Liquid gold in the rubble of an impact crater

Wham! 65 million years ago a huge asteroid hit the Earth in a shallow sea off the coast of Mexico. A crater perhaps 150 miles or more across was briefly formed in the seafloor and chunks of rock were scattered in mile-thick layers for hundreds of miles in all directions. Tsunami from the impact churned up more piles of broken rocks on coastlines thousands of miles away.

Over time, layers of sediment covered the impact scars and they lay undisturbed for millions of years. Then, only several decades ago, prospectors started looking for oil in the region, unaware that the Chicxulub crater lay buried deep beneath them. They were very successful, and commercial oil production began. But it was not until 1990 that the signs of a crater were recognized. The rubble from that impact is now thought to be the source of most of Mexico's vast oil reserves. Geologists are beginning to see that impact crater formations make good traps for oil.

How it gets there

Oil from deep underground gradually works its way upward through cracks and fissures in rocks. Oil prospectors get excited if the "reservoir rocks" that contain the oil are covered by a contorted layer of "cap rocks" because this can confine oil in natural reservoirs. An oil well is usually drilled until it breaks through the cap rocks and reaches the oil-saturated reservoir rocks below.

The rubble from an impact often forms a porous rock known as breccia that is full of cracks and fissures -- making it excellent for extracting oil through a well. Domes, basins, deep cracks, along with crumpled, folded landforms are other typical features of an impact crater that make them promising for oil prospectors.

There are hundreds of thousands of oil wells in the United States, but only a dozen or so are known to be associated with impact structures. Like Chicxulub, none of the craters were discovered until after commercial production of oil began. Geologist Richard Donofrio of Oklahoma City points out that drilling an impact structure is much more likely to be successful than drilling other types of formations.

Deep under the layers of sedimentary rocks that cover most of the United States there should be at least 20 undiscovered impact craters. Canada's geology is different and most craters are on or near the surface. Donofrio therefore went through the exercise of randomly superimposing the distribution of known Canadian impact craters on a map of the U.S. Using conservative assumptions he came up with an estimate of the oil-producing potential of undiscovered impact craters in the U.S. His conclusion is staggering -- 50 billion barrels -- double the current proven American reserves.

Geoscientist John Gorter from Perth, Western Australia has studied the petroleum potential of Australian impact structures. He also believes that impact craters make very promising sites for oil exploration. The most interesting, and speculative, of the Australian sites is the Bedout Structure some 200 miles off the coast of Broome. There are tentative signs that this was originally a crater 160 miles in diameter -- perhaps bigger than Chicxulub. If it does turn out to be a large impact crater, there could be huge reserves of oil in the region.

The Bedout Structure could also be of interest to paleontologists -- its possible age of 250 million years corresponds with the great mass extinction at the end of the Permian period.

Tar-coated comets and oily asteroids

The idea that complex hydrocarbons (the main components of petroleum oil) are a natural part of the Earth's crust should come as no surprise to scientists who study comets and asteroids. Some of the meteorites that fall to Earth are rich in tar-like hydrocarbons. Comets such as Halley and Hale-Bopp are thought to have a skin of tar-like material covering a "dirty snowball" -- like an ice cream dipped in chocolate.

The early Earth was made of the same stuff as comets and asteroids, so the presence of hydrocarbons deep within the Earth is to be expected. It used to be thought that the fierce heat deep underground was sufficient to break up any hydrocarbon molecules. However, Russian scientists have demonstrated that the enormous pressures prevent this.

Even if the Earth did not manage to retain its original supply of hydrocarbons it is likely that the rain of comets, space dust and asteroids over billions of years would have kept the crust of the Earth topped off with the raw ingredients for oil.

Could there be too much oil?

Oil is best found near impact structures. Oil forms deep underground from non-biological processes. If these ideas prove correct then Donofrio's estimates for the United States should apply to other parts of the world. For areas of similar size there are possibly 20 buried impact craters with perhaps half having commercial oil reserves. The search for these elusive craters could be very rewarding.

It may turn out that there is too much oil for our own good. A massive increase in known oil reserves could lower oil prices and drastically devalue existing reserves.

A longer-term problem is that an unchecked increase in oil consumption could place untenable strain on the global environment. Already human activities in our oil-dependent society have led to alarming species extinction rates. An oil glut could accelerate this problem.

It would be ironic if the Chicxulub impact event turned out to be a time bomb that was not only associated with the extinction of the dinosaurs and other species at the end of the Cretaceous Period, but also with another mass extinction resulting from human activities some 65 million years later.

Glossary

Basement rocks are rocks that have never been near the surface of the Earth. They lie under the top layer of rocks, most of which are sedimentary and have been recycled many times by erosion.

Cap rocks are rocks that are impervious -- they resist the flow of fluids such as water, oil and gas and trap these fluids in rocks below.

Organic molecules are simply molecules that contain carbon. This does not mean that they have anything to do with organisms or life. As Carl Sagan pointed out in his book "Comet," astronomers tend to be nervous about the word organic because of concern that it might be misunderstood as a token of life. So they use the term "carbonaceous" to describe meteorites that are rich in carbon compounds. Kerogen is a tar-like organic compound found in some meteorites (and in over-cooked hamburgers on Earth).

Reservoir rocks act as reservoirs for oil. They have sufficient cracks and fissures to allow the oil to flow into the well. Reservoir rocks must be covered by cap rocks to prevent the oil seeping up to the surface and escaping.

Source rocks are those in which oil is generated. The classical view is that source rocks must have layers containing the bodies of dead plants and animals and that these gradually change to oil. The controversial view is that all basement rocks have the potential to be source rocks because oil has non-biological origins deep within the Earth.

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