Nature's own way of getting lost

At least a third of all oil formed below ground escapes to the surface as natural seepage - also called natural oil pollution.

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Humans have been finding oil for many centuries without having to look particularly hard for it. Large lumps of floating tar prompted the Romans to call the Dead Sea *Mare Asphalticum*, for instance.

And asphalt was used as a building material as far back as 3000 BC in the Middle East, according to *Seabed Pockmarks and Seepages, Impact on Geology, Biology and the Marine Environment* by Martin Hovland and Alan Judd.

The Book of Genesis in the Bible records how Noah was commanded to build an ark of gopher wood, fitted with many rooms and pitched within and without.

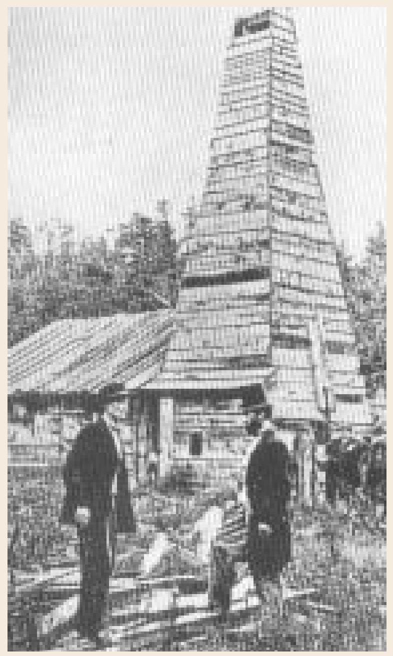
And the coast Indians in America used bitumen to seal their canoes, while Norwegian explorer Thor Heyerdahl found asphalt lumps floating in the sea on his voyages.

"He concluded that these lumps were pollution from ships, but that's by no means certain," says NPD geologist Harald Brekke. "Asphalt is formed naturally, and micro-organisms even feed on them."

Numerous cases of natural oil seepage exist, both in ancient times and more recently. Natural lakes of asphalt are found in Namibia and Trinidad, while Azerbaijan has lots of surface oil.

Gas actually flows to the surface around the Azeri capital of Baku and is ignited on the surface, which explains why this region was called the Land of Fire.

Early oil operations were often prompted by visible oil seepages. Edwin Drake initiated US oil history at Titusville in Pennsylvania by drilling near one of these leaks.



Edwin Drake launched the US oil industry at Titusville in Pennsylvania by drilling near a natural oil seepage. (Picture: The Prize, *Simon & Schuster)*

Confucius in China also mentions wells which were a few metres deep around 500 BC, while petroleum was part of the materials used to embalm Egyptian mummies from 1295-300 BC.

The question is why such oil seepages occur without any human intervention.

Density

Part of the answer is that all oil and gas "flow" up through the sub-surface because their density is lower than sedimentary rocks and water.

This upward motion can be stopped if the petroleum encounters an impermeable layer of rock, which also forms a trap capable of preventing hydrocarbons escaping around the edges. Such reservoirs can retain considerable volumes of oil and gas.

But more than simple uplift is required for natural seepage to take place, explains geologist Per Arne Bjørkum in Statoil, who researches this phenomenon.

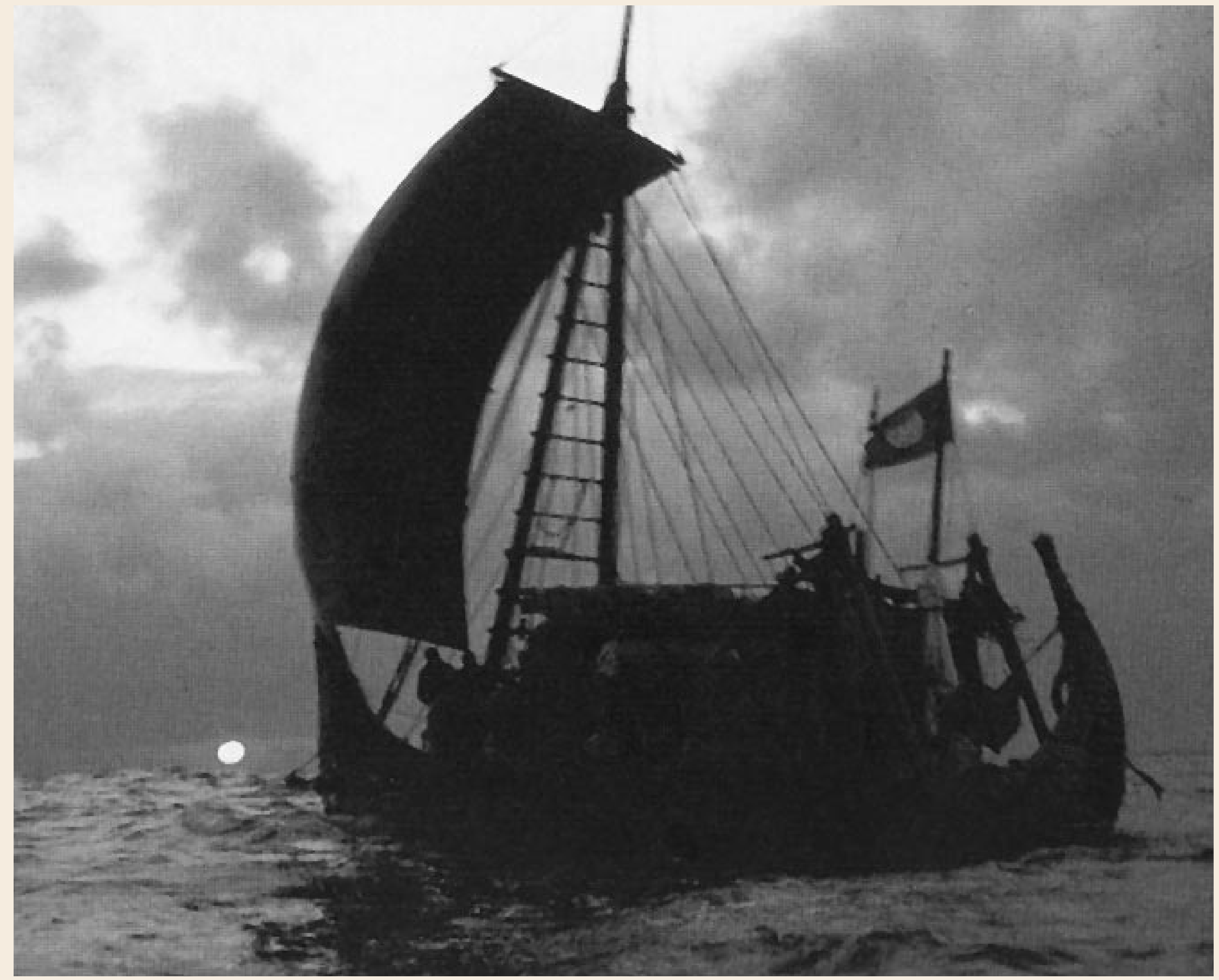
"The oil we recover from the Norwegian continental shelf is easy to produce because it has enough energy to reach the surface without the need for pumping.

"That means the pressure driving these hydrocarbons is enough to bring them up under their own steam - in other words, without drilling.

"For a long time, our understanding of how these high pore pressures build up under natural conditions was limited. A few years ago, however, it proved possible to detail the processes involved in a new and more effective manner."

Temperature

Together with Statoil colleagues Paul Nadau and Olav Walderhaug, he discovered that pore pressure is built up a couple of kilometres underground through chemical processes governed by temperature.



Thor Heyerdahl found lumps of asphalt floating in the ocean on his expeditions, and assumed they were evidence of pollution. Geologist Harald Brekke at the NPD believes they could just as easily have come from natural oil seepage. (Picture: Eventyret og livsverket, Gyldendal Norsk Forlag)

In other words, this development does not result from the pressure exerted by overlying sediments, as had previously been thought.

The build-up usually causes hydraulic fracturing of the impermeable shales which form the cap rock in hydrocarbon traps, and thereby allows the oil to escape.

If the fracturing extends to other sandstone layers, the oil or gas will collect there and - in the absence of another cap rock - can seep to the surface and be lost.

"When it reaches the seabed, such migrating oil floats to the surface and the lightest components vaporise," Mr Bjørkum explains.

"Some will also be biodegraded - consumed by micro-organisms - or oxidised by sunlight and oxygen. Whatever's left is dispersed by wind

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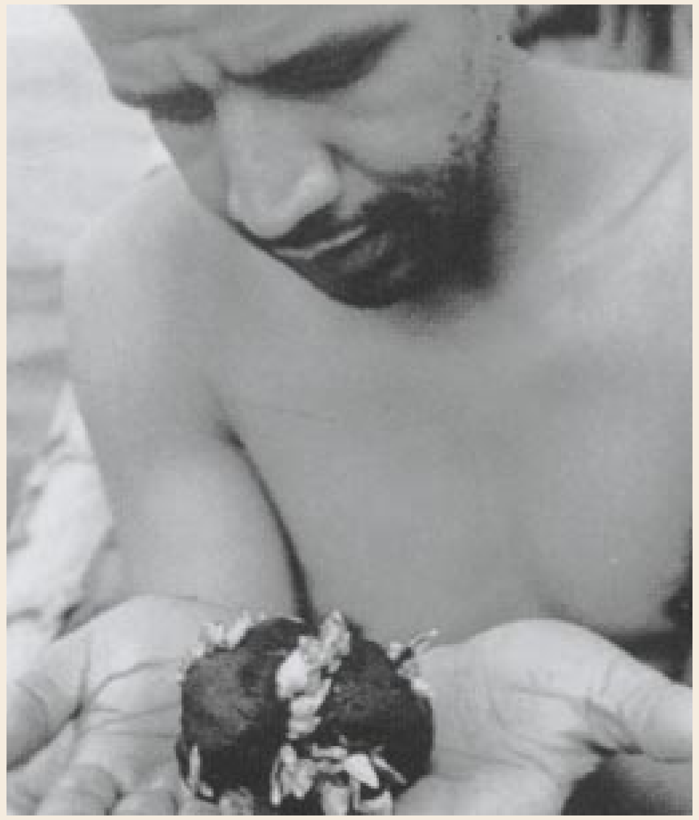
and current, so that any oil seepage will be lost for good.

"It's usually calculated that about a third of the oil formed in the Earth's crust dissipates by seeping to the surface. About a third remains in the source rocks, and the remaining third is found and produced - if we do a good job.

"We've so far discovered about a tenth of the hydrocarbons we think were formed off Norway, which means it should still be possible to find more."



A crew member studies an asphalt lump found during one of Thor Heyerdahl's expeditions. (Picture: Eventyret og livsverket, *Gyldendal Norsk Forlag)*

Lost

"If migrating oil reaches the surface on land, it will be partially lost through the same processes of vaporisation, biodegrading and oxidisation seen at sea.

"What's left will collect around the seepage site. Many such 'deposits' can be found around the world - in Venezuela, for instance. But it's not easy to convert this congealed 'crude' into saleable oil."

Asked whether it would ever be possible to exploit these "wasted" resources, Mr Bjørkum points out that innovative technology is needed to commercialise such residues.

"And a lot of the natural oil seepage at the surface has lain there so long that it can no longer be utilised."

Pollution

Marine geologist Martin Hovland in Statoil - co-author of the book cited above - prefers to describe such seepage as natural oil pollution.

"My job is to understand the processes which occur on the seabed, and seepages can be significant in that context.

"During the development of Norway's offshore industry, hydrocarbons have been viewed as the big, bad wolf in an environmental context.

"As we learn more about natural pollution, however, we see that such minor leaks do not cause the sort of damage one might expect. On the contrary, nature appears to cope well with these seepages.

"The environment only fails to tackle the big spills. It may be that we're too quick to level accusations of pollution when nature is also a polluter.

"And the planet has been familiar with natural oil seepages for a couple of hundred million years, after all.

It's capable of handling such spills by itself."

But Mr Hovland agrees that the environment can be overloaded even by natural sources of petroleum, and points to heavy seepage found in California's Santa Barbara basin. This has produced local changes in animal life and the marine environment.

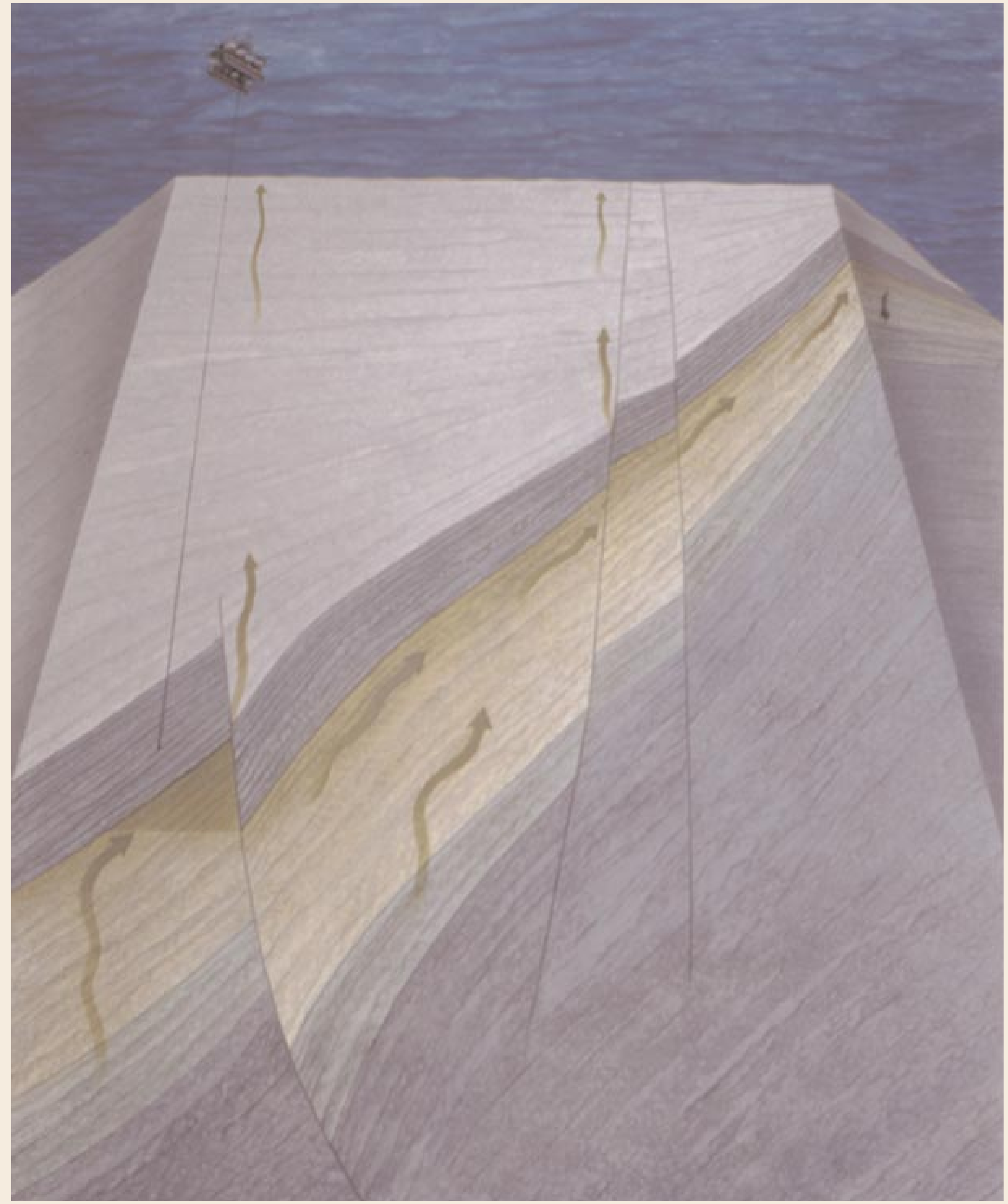
"And it's obviously important to establish how much is seeping up. Baku has 200 hundred mud volcanoes, for instance. We know far too little about atmospheric gases to be able to monitor the volume of petroleum escaping naturally."

NPD engineer Trond Brekke, who shares brother Harald's interest in seepage, also wonders how much carbon dioxide may escape to the air without human assistance.

He notes that this volume is excluded from calculations of atmospheric composition.

"Perhaps nature has built in its own comfortable tolerances. On the other hand, things may be finely balanced - and leaving variables out of the equation could have consequences.

"That's why it's important to know as much as possible about what's happening in the sub-surface."



How natural oil seepage occurs*: Oil forms in shales (green layers) with a high content of organic material, and migrates to permeable sandstones (yellow layers). It then continues to migrate upwards until it meets an impermeable cap rock which forms a trap or reservoir. Oil not captured in this way continues to the surface. If this occurs at the seabed, any petroleum not vaporised or biodegrated may form lumps or slicks.*