Looking for Cook Inlet hydrocarbon kitchen

Former Mobil Oil geologist Frank Banar explains how Escopeta's Kitchen prospects may contain large quantities of gas and light oil

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Only a drill bit is going to determine how much oil and gas lies deep beneath Alaska's upper Cook Inlet in Escopeta Oil and Gas's Kitchen prospects. But a multi-year effort by Escopeta to bring a jack-up rig to the inlet for drilling at Kitchen indicates sustained expectations of a significant find.

On March 21 Escopeta consultant Frank Banar told Petroleum News about his latest ideas on the upper Cook Inlet petroleum systems, and how the petroleum geology of the region leads to optimism about Kitchen. Banar used to work on Cook Inlet geology for Mobil Oil and has been working for Escopeta for the past three or four years.

The U.S. Geological Survey originally proposed the concept of a Kitchen prospect as an oil trap against a major thrust fault that demarks the eastern side of the Middle Ground Shoal oil field, Banar said. Subsequent analysis by Escopeta using enhanced resolution seismic data identified the prospect as a thick wedge of Tertiary strata with a trap formed against what geologists term a normal fault, a relatively steeply inclined fault that cuts through the wedge of sediments.

"In Kitchen prospect you've got this huge dipping wedge of sediments ... that dip from Middle Ground Shoal to the east," Banar said.

East Kitchen

A second prospect, called East Kitchen or South Cook Inlet, consists of a potential petroleum trap in Tertiary strata in a major anticline to the east of the Kitchen prospect.

The East Kitchen anticline consists of the southern extension of a north-northeasterly trending structure that also contains Forest Oil's Corsair prospect and ConocoPhillips' North Cook Inlet gas field. A similar trending anticline...
structure to the west forms the Middle Ground Shoal and Granite Point fields — the Kitchen prospect lies on the eastern flank of that more westerly anticline. All of the Cook Inlet oil fields have reservoirs in Tertiary sandstones.

But, although the Kitchen prospects consist primarily of structural traps, formed from folding and faulting of the strata, an analysis of enhanced resolution seismic data has also revealed the potential for stratigraphic traps in what appear to be ancient river channels cutting through the sedimentary layers in both Kitchen and East Kitchen, Banar said.

And what’s particularly intriguing about these river channels is that their locations seem to correspond to what geophysicists term “bright spots,” teased from the seismic data using a technique called wavelet energy absorption. Bright spots consist of anomalies in the amplitudes of the seismic signals and can indicate the presence of hydrocarbons, especially natural gas.

**Recent structures**

Geologists have determined that the major anticlines in Tertiary strata under the northern Cook Inlet formed in relatively recent geologic time, during the Pliocene and Pleistocene epochs (somewhere between 10,000 and 12 million years ago).

And Banar thinks that the more complex nature of the western anticline system, coupled with the removal by erosion of some of the stratigraphic sequence in the west, indicates that compression forces in the Earth’s crust pushed the Tertiary strata over a relatively rigid platform of older Mesozoic rocks.

“The compression, I think, pushed against the Mesozoic platform there (at Middle Ground Shoal) and that’s why you’re starting to get overturned beds and missing section,” Banar said. “Whereas when you go to North Cook Inlet, Corsair and East Kitchen it’s still folded, but it’s not as severe.”

But the mechanism by which oil migrated into the Tertiary reservoirs presents something of a puzzle, since geologists have established that the oil in the Cook Inlet Tertiary reservoirs originated from the Jurassic Tuxedni formation and that the oil started generating some time before some of the trap structures formed.

How did oil move from the source rocks into geologic structures that deformed the Tertiary strata after the oil started to form? And how did some of the oil become trapped in somewhat older structures in fields such as Swanson River and Trading Bay, on the east and west sides of the Cook Inlet?

**Two-stage vs. one-stage migration**

USGS geologist Les Magoon, in his seminal work on Cook Inlet petroleum geology, postulated that the oil migrated in two stages. In the first stage the oil would have flowed into a Tertiary stratigraphic trap. Then, during the upheavals associated with the folding of Tertiary strata the oil would have drained upwards from that trap into newly formed fold and fault structures.

But Banar thinks that variations in the API gravities of oil between different Cook Inlet fields point to a simpler single-stage oil migration model, similar to a model that he said Aurora Gas geologist Andy Clifford has proposed. In the single-stage model, oil would have been generated from the Tuxedni over an extended period of time and would have migrated directly into the current oil reservoirs.

Banar arrived at this idea by plotting on a map the API gravity data from one of Magoon’s 1970s reports and from some more recent oilfield data.
"I saw that there was some relationship between oil gravity and the location of the fields," Banar said. "... It appeared there were higher gravity crudes down the middle of the Cook Inlet basin."

There is 44 API oil in the Tyonek formation of the Granite Point field and oils of around 42 API in the higher oil sands of the Middle Ground Shoal field, Banar said. Shell found some 42 API oil when it drilled the Corsair prospect in 1965, and some 56 API condensate has been produced from the North Cook Inlet field, Banar said. Banar also said that one seismic section through the Corsair prospect appeared to show a gas chimney (vertical column of natural gas bubbling up through the rock strata) — a gas chimney suggests the presence of thermogenic gas that has formed by heating petroleum source material (most natural gas in the Cook Inlet area is biogenic and formed though bacterial action on coal seams).

By contrast, oils from the Trading Bay and McArthur River fields on the west side of the Cook Inlet, and from the Swanson River field on the Kenai Peninsula, have API values below 40, Banar said.

Magoon did recognize the variations in API gravity between different fields and had suggested that late oil generation, after the draining of the postulated intermediate stratigraphic trap, might have placed relatively high API gravity oil in fields such as Granite Point.

But Banar thinks that if the maturity of the source rock increased over an extended time period, a resulting transition from generating low API oils through higher API oil to condensate and natural gas would explain the current oil gravity distribution. With oil migrating into the reservoirs as the structures of those reservoirs formed, the older structures around the perimeter of the Inlet captured lower API oils than the younger structures along the central axis. Fields such as Trading Bay contain deep faults that could have provided migration routes for those lower API oils from the Jurassic source, Banar said.

"It looked to me like the first surge of source rocks produced the lower gravity crudes, say below 40 gravity, in Trading Bay, McArthur River, Swanson River and Beaver Creek, and then you had the late structures formed in the Granite Point, Middle Ground Shoal, North Cook Inlet and South Cook Inlet," Banar said. "That stopped any migration to the east and west and confined it to the center of the basin."

Compelling evidence

Banar said that the structure of the older Mesozoic strata that underlie the Tertiary rock sequence also provides compelling evidence for the petroleum system that he is proposing. A huge east-west oriented anticline in the Mesozoic strata predates the formation of the Tertiary rocks and plunges to the east from a point around the center of the Cook Inlet. As the major anticlines in the Tertiary strata formed, the older anticline would have formed a conduit, pumping the late-forming and high API oil and gas east to west into Tertiary reservoirs under the center of the Cook Inlet.

"That's what focused the oil to the west," Banar said.

Not only that. The Tuxedni source rocks in the core of the Mesozoic anticline come right up in contact with the base of the potential reservoirs of the Kitchen and East Kitchen prospects.

"That's what makes this whole thing so exciting because the source rock and the reservoir are so close," Banar said.

In addition, the Kitchen prospects are in some of the deepest parts of the Cook
Inlet Tertiary section — with 25,000 feet of Tertiary rocks loading down on them, the Tuxedni rocks should have been pushed into the temperatures and pressures required for oil.

And that possibility of the prospects sitting over the main cooking pot for Cook Inlet oil is what inspired the name of the Kitchen prospects, Banar said.

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