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Surface Exploration Successful in Finding Alberta Leduc Pinnacle Reefs

In Alberta, as elsewhere where coral pinnacle reef reservoirs are found, they are much prized. Reservoirs in pinnacle reefs are usually prolific and efficiently drained, often having substantial porosity and permeability. In Alberta, the large Devonian reef trends, e.g., Homeglen-Rimbey and Stettler-Fenn-Big Valley, were discovered over fifty years ago using conventional geology and seismic exploration. However, the much smaller pinnacle reefs that are typically associated with the larger reef trends have proven difficult to locate. But when they are found, they can be enormously profitable.

In 1982, Gulf Canada Resources discovered a small pinnacle, called the Rumsey Reef, just to leeward of the Stettler-Fenn-Big Valley reefs. It produced over 3.7 million barrels of high gravity oil from one well; 90% was recovered during the first three years. During that period it flowed 3,000-4,000 bbls/day. A decade later, Gulf explorers, Lemon and Taylor (1993) presented a paper with the wistful title, "The Rumsey Leduc Pinnacle Reef: Where are the Rest?" They lamented the lack of further success in discovering nearby Leduc targets, using a seismic template of the Rumsey reef as a guide. "Why?" they asked in their 1993 paper, after so many dry holes had been drilled using this guide.

The present authors believe they have the answer: Probably most of the remaining Leduc pinnacle reefs in central Alberta, and we have measured many of them, are physically too small to be adequately resolved by reconnaissance seismic exploration, whether 2D or 3D. Our measurements suggest pinnacle reefs, similar to Rumsey in size, are pillars of coral growing between 550' to 700' high from the Cooking Lake carbonate platform. They appear to range from 70' to 225' in diameter. These measurements were recorded using commercially available passive telluric technology discussed and referenced below. This range of dimensions suggests that, when using seismic exploration, only one or two traces, or one or two bins could possibly "see" a seismic anomaly over these pinnacle reefs. Such a small anomaly would likely go unnoticed or deemed not of interest by seismic interpreters.

Using high resolution ground magnetic (HRGM) surveys (LeSchack and Van Alstine, 2002), the present authors have consistently located pinnacle reefs within a horizontal distance of 150' to 250'. Such spatial accuracy is adequate for defining most hydrocarbon reservoirs, as attested to by the 85% success rate discussed in that LeSchack and Van Alstine paper. However, that accuracy is insufficient for consistently identifying drilling locations for pinnacle reefs with the observed diameters of between 70' to 225'. As a result, the present authors have followed the HRGM survey by using, consecutively, two independent and commercially available geophysical technologies based on measuring passive telluric currents.

Both passive telluric technologies permit estimates to be made of not only the depth to formation tops but of hydrocarbon content. The first, Jackson (1998), is a tool that is easy with which to make recordings and interpretations in the field. It verifies that the *fossil* magnetic anomaly identified by HRGM surveys reflects hydrocarbons *currently* in place, and provides real-time data so that, based on

each measurement result, modifications to the field data collection program can be made on-the-spot. The Jackson method is inexpensive to use, and is necessary for the effective use of the second, more accurate, but far more expensive and time-consuming passive telluric survey described by Kober and Procter-Gregg (1987). The present authors acknowledge that although the passive telluric technology is neither intuitive nor much used by explorationists, it is effective. The data recorded by these technologies can be mapped as subsurface geology, and used just as geologists would use classical subsurface geological maps. However, we recognize many telluric stations needed to be recorded by us, in a variety of geological settings, before we gained the confidence in the efficacy of these telluric tools.

Using these three technologies in sequence, we successively refined both the horizontal and vertical location of a reef reservoir 15 miles northeast of the giant Leduc reef Redwater Field in Alberta. We drilled the 14-29-59-19W4 well on this reef and it was discovered within 30' of the depth predicted. The down-hole logs for the 14-29 well display as much reef buildup as do the Rumsey Reef well logs. A comparison of the Kober-Procter-Gregg telluric log recorded at the drilling location several months prior to the actual drilling, shows a remarkable similarity to the down-hole log recorded after drilling. The formation tops and hydrocarbon content identified from the telluric log are consistent with the drill cuttings and down-hole logs after drilling. The cuttings in the Devonian Leduc reef exhibited oil shows and coral fragments at the Leduc reef- Ireton Shale interface, and oil shows in the overlying Devonian Nisku biostrome. Despite the accurate prediction of location and depths to the formation tops, and the accurate prediction of hydrocarbons within the reservoir formations, a series of engineering problems associated with the drilling rendered this well uneconomic. These various logs, along with typical HRGM and telluric maps of this and other reef areas in Alberta show the value of this combination of technologies.

"Where are all the rest?" asked Lemon and Taylor in their 1993 paper: Well, it appears from hundreds of dry holes drilled to the Leduc in search of lucrative pinnacle reef reservoirs, that we cannot find these small targets reliably by using the conventional exploration technology of the past 60 years. However, our current work suggests that by using the above-discussed non-seismic geophysical measurements, small reefs as well as large ones can be relatively inexpensive to locate. Already, we have identified many pinnacles ready to be drilled. Even more will surely be found using these technologies.

References

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