[GC]Seismic Attribute Analysis of Hydrothermal Dolomite*

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General Comments

To optimize subsurface geophysical interpretations, it is beneficial to place seismic attributes into the proper regional geological context; knowledge of regional geology may assist exploration/exploitation efforts in advance by high-grading attribute selection and attribute intersection for purposes of risk analysis.

The field-tested exploration strategy presented here seeks to encapsulate all pertinent play characteristics into a viable geological model, where each dominant reservoir property is expressed as a risk parameter that in turn can be resolved by a seismic attribute.

The play is Givetian (Devonian) biohermal build-ups and lagoonal deposits, which comprise prospective section within the Western Canadian Sedimentary Basin. This geologic basin hosts well known gas fields such as Ladyfern (> 1Tcf) (see Figure 1).

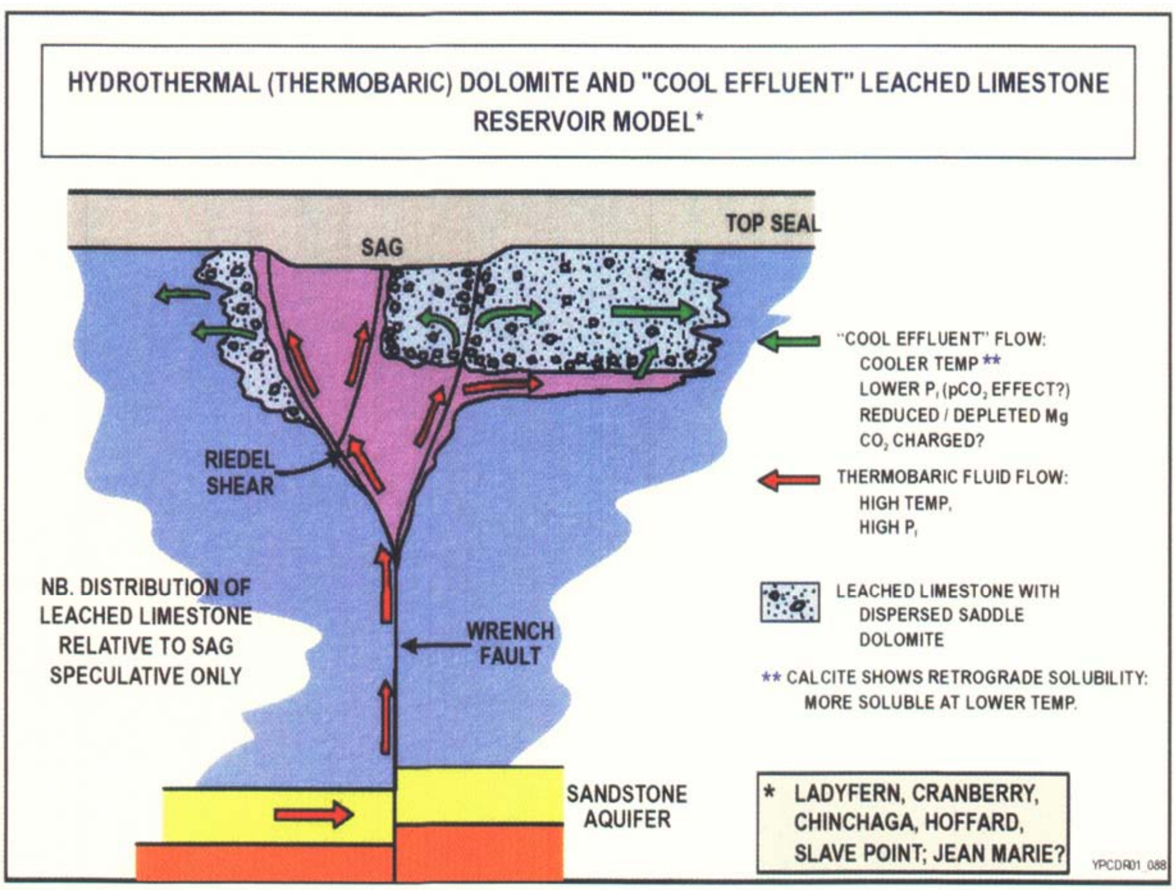

Figure 1 -- Hydrothermal dolomitization model (from Boreen and Davis, 2001)

Structure and Diagenesis

What structural and diagenetic changes caused this Canadian Paleozoic carbonate platform to become a world-class hydrothermal dolomite play?

The above model of hydrothermal dolomitization contends that Mg^{2+}-rich brines ascend along wrench-faults forcing a chemical phase transition from calcite to dolomite along favorable carbonate rock fabric/textures. Porosity development deteriorates away from faults, implying that -- in contrast to conventional wisdom -- highest reservoir quality rock may not always be encountered on structural crests, but instead on anticlinal flanks with a high wet risk (Table 1).

Risk Parameter	Seismic Attribute	Dominant Reservoir Property
Fracture	Similarity, Dip Azimuth	Hydrothermal conduit
Lithology	Waveshape KSOM	Limestone or Dolomite
Porosity	Bandlimited Impedance	Porous vs. tight
Structure	Dip Azimuth, Amplitude (TWT)	Gas / water contact

Table 1 -- Exploration strategy.

Seismic Attributes and Geologic Model

Using geological knowledge about the formation, seismic attributes can be employed to illuminate specific reservoir properties. For instance, fracturing/faulting can be detected via low similarity values (event terminations). Conversely, wells that tested tight are not situated close to or within fracture zones. This caveat has been confirmed since by several wells drilled that did not employ seismic attribute analysis. Lithologic change from tight limestone to porous dolomite is indicated by amplitude and waveform changes that can be catalogued using Kohonen self-organizing maps (artificial neural network topology).

Because of high compressional carbonate rock velocity, well-log impedances (AI) almost entirely respond to total porosity (PHIT) change instead of fluid type. Unfortunately, overlapping lithology fields in a petrophysical AI/PHIT crossplot suggest that no differentiation of shales from porous dolomites should be possible in the seismic domain.

The spatial distribution of relative acoustic impedance using geological knowledge about the formation, however, is employed to illuminate specific reservoir properties (Figure 2). In accord with the geological model, dolomitization (lowered relative acoustic impedance) occurs preferably at the base of the formation (phase reversal in relative AI). In contrast, high relative impedance values are associated with tight limestone (no polarity reversal). Intraformational shales, too, are associated with lowered values of relative acoustic impedance, but occur within the formation rather than at its base (Figure 3).

In accord with the geological model, this lowered relative acoustic impedance spot centered within the Slave Point Formation is incompatible with the geologic model, as hydrothermal dolomitization should occur at the base of the formation first. The well drilled on this anomaly encountered a shale plug.

Conclusion

Matching seismic attributes to a viable geological model can significantly reduce drilling risk.

Reference

Boreen, T., and G. Davies, 2004, Hydrothermal dolomite and leached limestones in a TCF gas play: the Ladyfern Slave Point reservoir, NEBC, *in* Dolomites—The spectrum: Mechanisms, models, reservoir development: CSPG Seminar and Core Conference, June 13-15, 2004, Calgary, Alberta, 17 p.

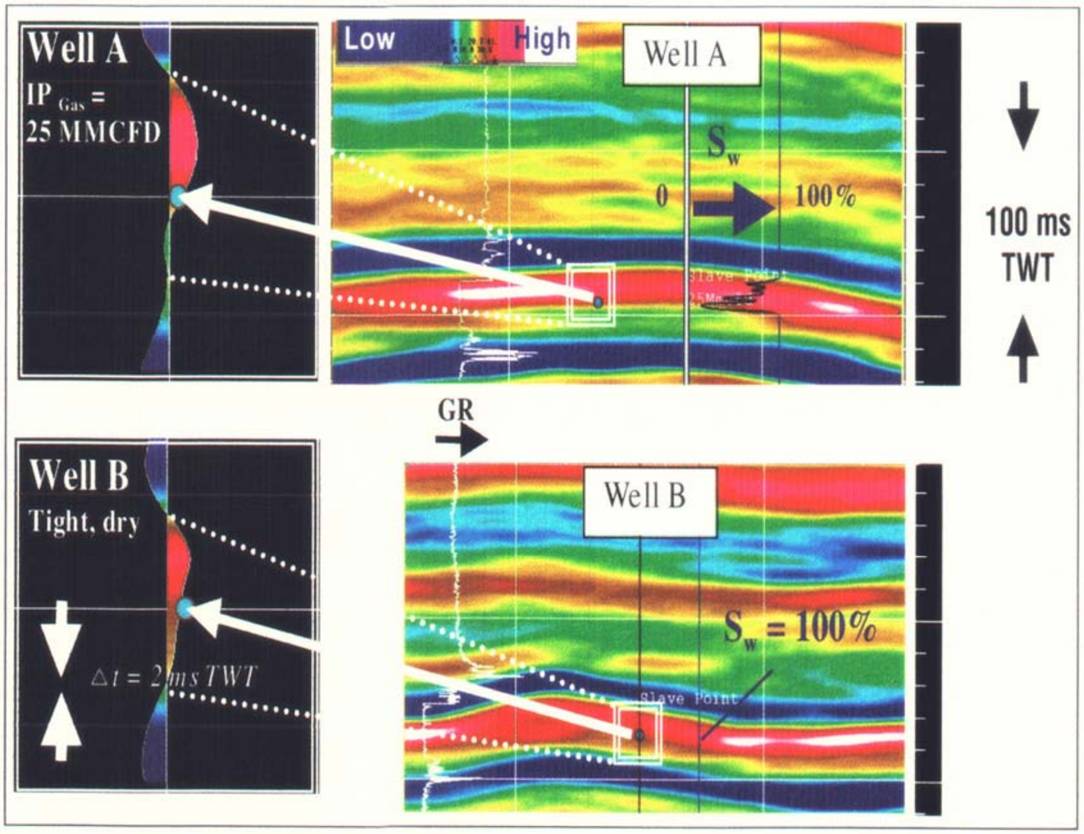

Figure 2 -- Hydrothermal dolomite versus tight limestone in relative acoustic impedance.

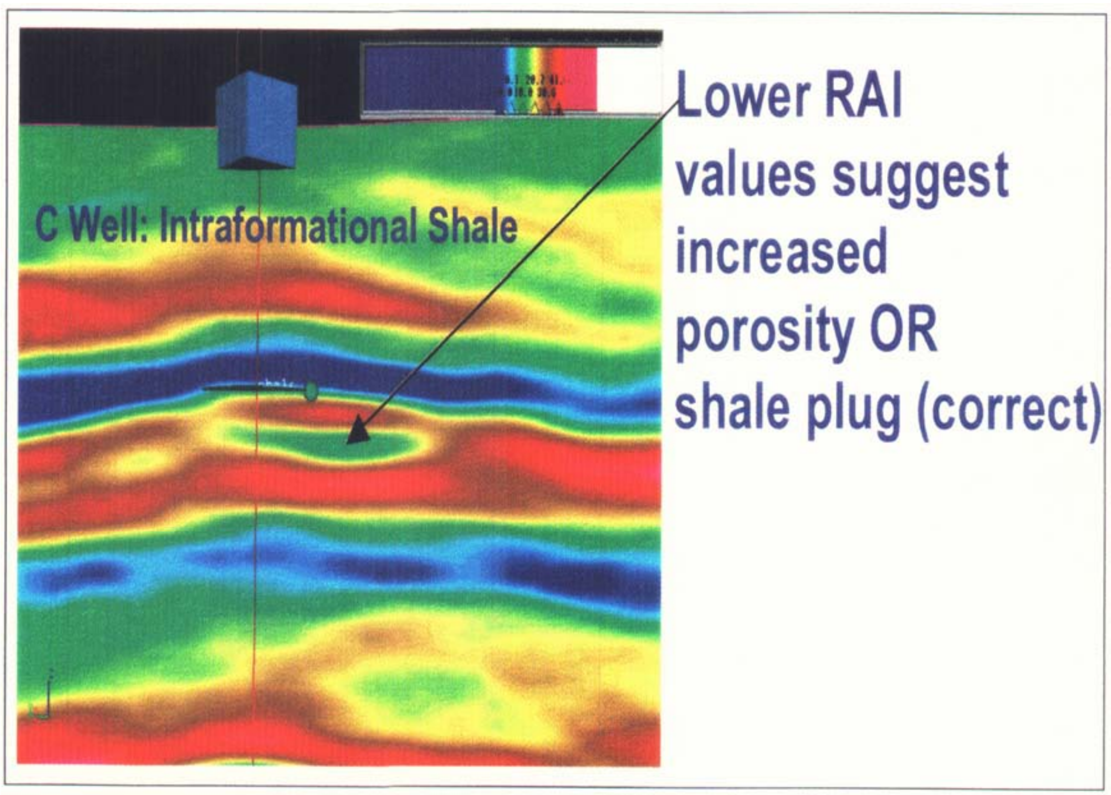

Figure 3 -- Relative acoustic impedance.