AAPG Datapages/Search and Discovery Article #90254 ©2016, GEO-2016, 12th Middle East Geosciences Conference & Exhibition, Manama, Bahrain, March 7-10, 2016

4D inversion in carbonate environments

Frédéric Cailly[1], Christian Hubans[1], Pierre Thore[1]

[1]Total SA, Pau, FRANCE

ABSTRACT

Some of the giant Middle-East carbonate oil fields are now mature and their depletion strategy is confronted to new problems as the mitigation of water breakthroughs, the identification of undepleted/unswept areas for infill wells location, the surveillance of EOR systems, etc. Although these questions are in other environments addressed by 4D seismic monitoring, this technique is still less ubiquitous in carbonates. Even if useful 4D signal can be extracted directly from seismic vintages differences, more robust and relevant attributes are generally estimated through a proper 4D seismic inversion.

The methodology we promote in this paper is to realize first an inversion of both Time-shift and amplitude differences simultaneously, as presented in Williamson et al (2007) and called "warping", taking advantage of the expected consistency between them. A large band frequency content "velocity change" attribute is estimated. This last makes the interpretation easier because of its volumetric nature, its petrophysical meaning and its natural low frequency content due to time-shift inversion.

The second step is to go to the calibration of this 4D signal to the well data. The CAL4D tool (Thore and Hubans, 2012) has been developed to use well information to define a locally-layered representation of the earth around the well, within which the inversion of the 4D seismic traces along the well trajectory is very stable and can be formulated to separate the 4D density and velocity responses (even with post-stack data). If the rationales of a 4D impedance inversion are highlighted, this will be the third step. A 4D impedance inversion can provide in addition a proper account of the density variations over the field and allow to increase the interpretability of the production fluid effect.

Other schemes of 4D inversion exist. In particular, the Cal4D layering and associated constraints can be propagated over the full field area (Thore and Blanchard, 2015). This methodology is still at the research step but could have a bright future in environments where the layering assumption does not vary too rapidly, such as carbonates systems. All these methodological steps will be detailed in the presentation through real carbonate fields examples.

If all this procedure is followed, there is no reason 4D seismic does not become the solution for Middle-East carbonate oil fields monitoring.