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Secondary Porosity and Permeability Calculation on Heterogeneous Carbonates of Eastern Mexico, Using Borehole Images*

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Abstract

In heterogeneous carbonates, the micro-electrical borehole images provide both high resolution measurement as well as azimuthal coverage of the borehole wall, and they can resolve quantitatively the heterogeneous components of the porosity. In this way it is posible to determine the amount of secondary porosity in a given interval, and by mapping the heterogeneities of the borehole wall, it is posible to obtain a connectivity factor of the conductive events that could be related directly with permeability.

In those wells where the coring is compromised due to low recovery percentage, mainly due to the presence of open natural fractures as well as karstification, the micro-electrical borehole images represent an alternative for the interpretation of such heterogeneities (fractures, vugs, caves, etc.), and for calculating secondary porosity and permeability of the borehole wall, with the calibration of this last measurement using core data, dynamic formation testers, and magnetic resonance outputs.

In this example of Cretaceous arbonates of eastern Mexico, the intervals with the presence of natural fractures and evidence of karstification show bimodal porosity histograms, indicating the respective secondary porosity (Figure 1). The mapping of heterogeneities gave as a result a connectivity index between conductive areas of the borehole wall, that was converted to permeability and calibrated with permeability data of other sources (in this specific case with a dynamic formation tester and a magnetic resonance tool logged in the same well). The advantage of having data from a micro-electrical borehole image resides on the azimuthal measurement of the borehole wall, compared with other unidirectional measurements.

It was posible to differentiate intervals with development of primary porosity (unimodal porosity histograms), intercalation between secondary porosity and compact intervals, and possible presence of stylolites that could act as local or regional seals for the movement of fluids (Figure 2).

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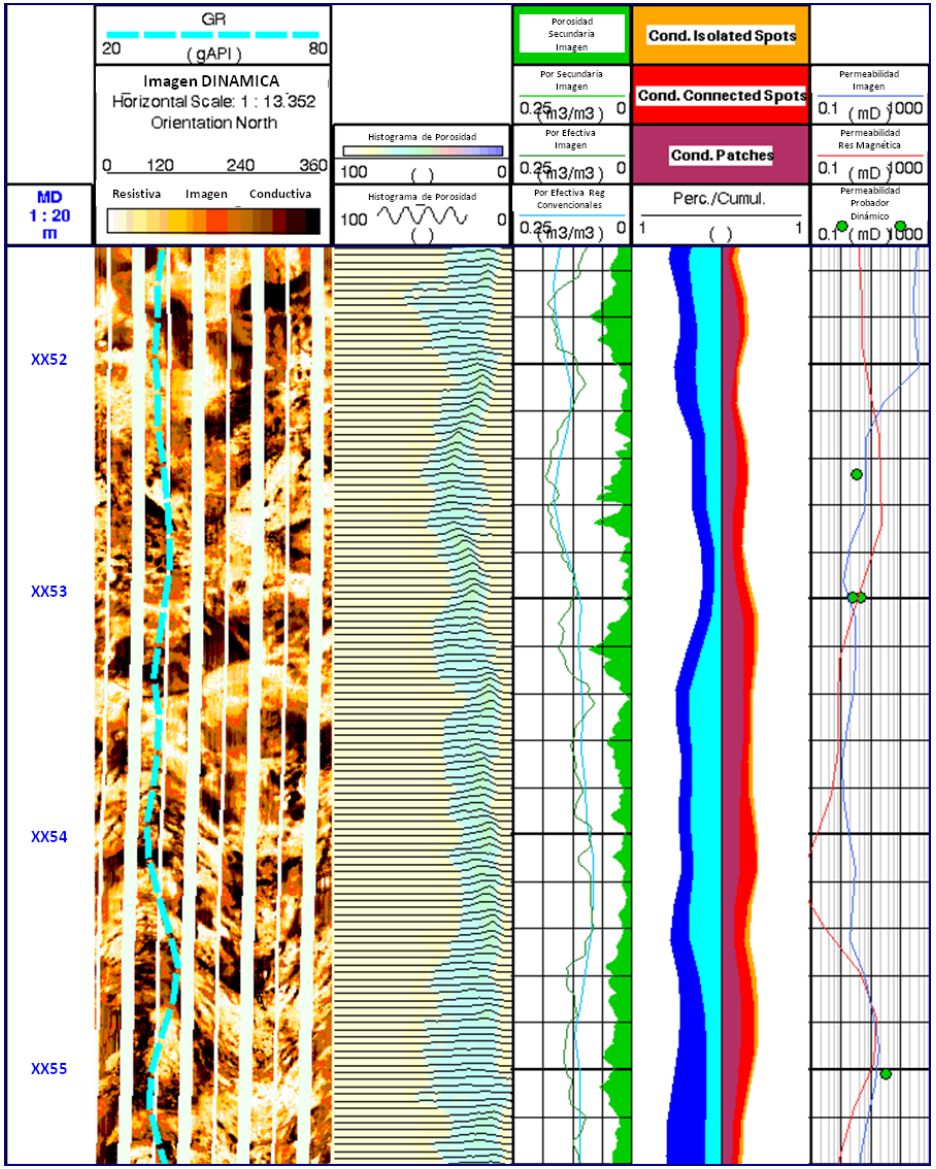

Figure 1. Interval with evidence of heterogeneities (caves, vugs and natural fractures) on the borehole wall (track 2). The porosity histograms are bimodal (track 3) because of the development of secondary porosity (in green, track 4). The mapping of conductive heterogeneities and its connectivity represent a permeability value that was calibrated with data of other sources in the same well (magnetic resonance tool and dynamic formation tester, plotted in track 6).

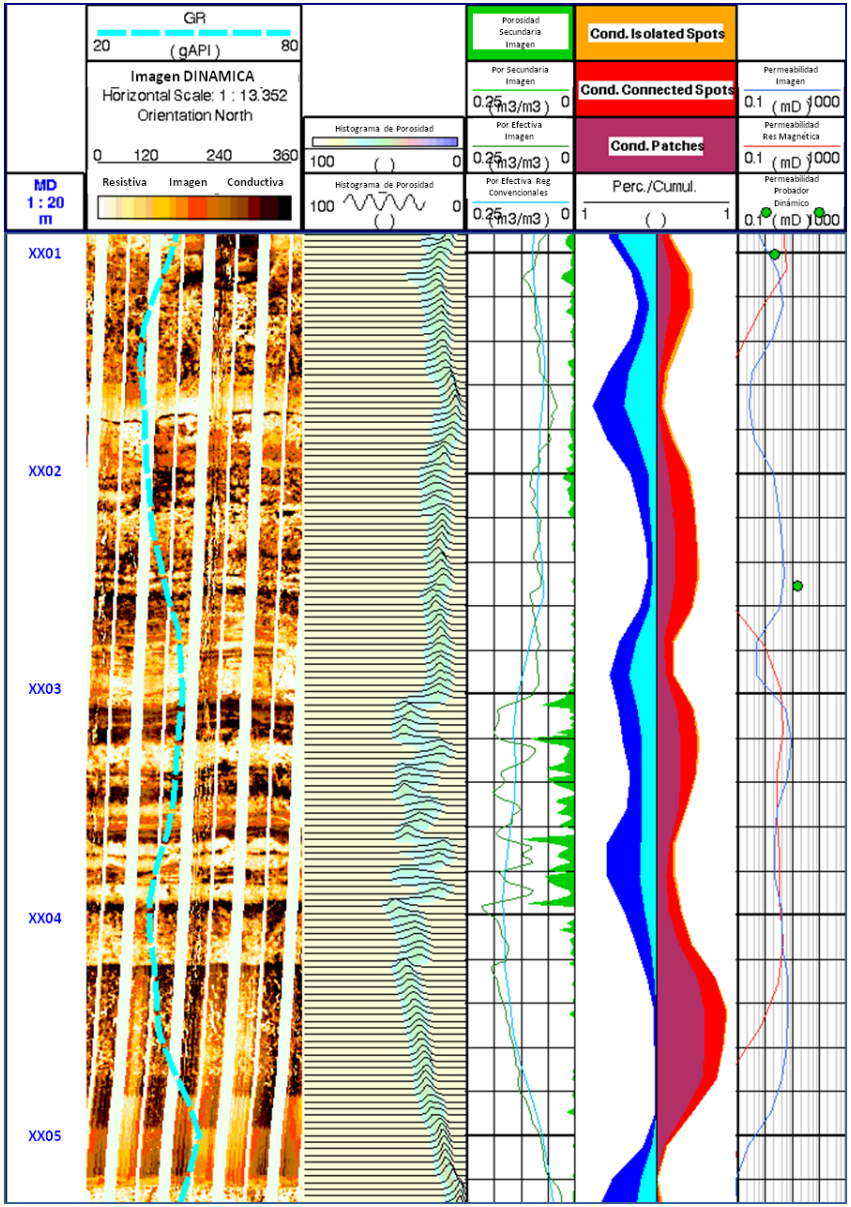

Figure 2. Compact zone near to the top of this interval, pointed by a stylolite (low values of porosity and permeability). Towards the bottom, a zone with good development of primary porosity (unimodal histograms), as well as an interval with intercalations between compact and development of secondary porosity zones.