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DIFFERENCES IN HYDROSTRATIGRAPHY OF NE AND NW YUCATAN REVEALED BY RESISTIVITY SOUNDINGS: A CONSEQUENCE OF TERTIARY TECTONICS?

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ABSTRACT

We used resistivity measurements to estimate interconnected porosity of saturated carbonates. Fourteen soundings were performed in the remote and understudied region of NE Yucatan. Resistivity soundings provide a quick and cheap alternative to drilling in regions where aquifer hydrostratigraphy is not well constrained by multiple boreholes. The relatively homogeneous lithological make up of the aquifer in N Yucatan offers also favorable conditions for resistivity soundings because it makes the subsurface resistivity dependent mainly on a combination of interconnected rock porosity and fluid resistivity. While the interior of NE Yucatan remains relatively undeveloped and protected by the El Eden Ecological Reserve, regional groundwater resources may come under an increasing stress due to the rapidly developing tourist zone centered on Cancun. The carbonate aquifer of Northern Yucatan is considered to be naturally fragile, because its freshwater is thought to be contained in a thin (dozens of meters) freshwater lens floating on top of a regional saltwater intrusion. For the purpose of comparison, we have completed also eighteen soundings in, and just outside of, the Cenote Ring in NW Yucatan. Hydrogeology of this area is better understood than that of NW Yucatan. All surveys were done in the Schlumberger arrangement, with half-spacing of electrodes ranging between 80 and 420 m. Geoelectric layered-earth models were produced from unfiltered data using two software packages (RESIXP and RESIST). Data collection and processing followed the procedures of Zohdy et al. (1984).

Comparison of results from NE and NW Yucatan reveals a distinct difference in the subsurface resistivity structure of the two regions. In NW Yucatan the structure is consistent with the accepted model of a dozens-of-meters thick freshwater lens overlying saltwater. The upper geoelectric layer, interpreted as the freshwater lens, has resistivities falling typically between ~30 and ~300 ohm-m and thickness between ~15 and ~70 m. The underlying low-resistivity layer, interpreted as the regional saltwater intrusion, has resistivities falling between ~1 and ~10 ohm-m. Best estimates of interconnected porosity for the freshwater lens fall within a reasonable range of ~15% to ~40%. In the NE part of the peninsula most surveys showed a transition from an upper layer, with thickness and resistivity similar to that of the NW Yucatan freshwater lens (~10 to ~100 m and ~20 to ~100 ohm-m), to a lower layer with even higher resistivities (~200 to ~650 ohm-m). Only two surveys performed relatively close to the coast yielded evidence consistent with presence of a freshwater-saltwater interface. Estimates of interconnected porosity for the upper NE Yucatan layer range between ~20% and ~40% and for the lower one between ~5% and 20% (assuming saturation with freshwater of similar conductivity as the one in the upper layer, ~6 ohm-m).

Existence of the high-resistivity (low-porosity) deeper layer in NE Yucatan may also help explain why we have not found geoelectric evidence for an inland saltwater intrusion in this region. The deep subsurface in this area may have simply too low hydraulic conductivity to permit such widespread penetration of saltwater as it is the case in NW Yucatan. If this is true,

the inland portion of the NE Yucatan aquifer may be less susceptible to depletion of groundwater resources and intrusion of saltwater into wells than it is the case in NW Yucatan. Based on our review of existing (sparse) stratigraphic and structural constraints from the region, we speculate that NE Yucatan may have very different geologic structure than NW Yucatan. Eastern margin of the Yucatan Peninsula was part of an early-mid Tertiary plate paleoboundary, which shutdown in the latest Eocene-early Oligocene. There is an extensive system of elongated karst depressions in NW Yucatan. These depressions parallel the coast as well as the well-studied offshore system of Tertiary faults, which formed while the plate boundary was still active.

Keywords: Rock Resistivity, Hydrostratigraphy, N Yucatan, Plate Tectonics

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