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Mapping the fresh-water aquifer structure of the Okavango Delta, Botswana, using seismic-reflection and seismic-refraction imaging

Fabienne Reiser (1), Cedric Schmelzbach (1), Joel E. Podgorski (1), Heinrich Horstmeyer (1), Alan G. Green (1), Thomas Kalscheuer (1), Hansruedi Maurer (1), and Wolfgang Kinzelbach (2)

(1) ETH Zurich, Institute of Geophysics, D-ERDW, Zurich, Switzerland (cedric.schmelzbach@erdw.ethz.ch), (2) ETH Zurich, Institute of Environmental Engineering, D-BAUG, Zurich, Switzerland

The Okavango Delta in Botswana is one of the world's great inland deltas. Situated within the semi-arid Kalahari Desert, it is one of the largest wetlands in Africa with an enormous biodiversity. Inversions of extensive airborne time-domain electromagnetic (TEM) data recorded across the Okavango Delta yield a general three-layer electrical resistivity model consisting of: (1) an upper resistive layer of dry and fresh-water saturated sands, (2) an intermediate conductive layer of clay or saline-water saturated sands and (3) a lower resistive layer of fresh-water saturated sands or crystalline basement. If the third layer comprises fresh water saturated sands, it would provide a new deep source of fresh water for the local population.

In an attempt to constrain the interpretations of the second and third layers, two high-resolution seismic-reflection and seismic-refraction data sets were acquired at each of two locations: (i) Jedibe Island (Jao) situated near the estuary of the Okavango River and (ii) an area located near the western border of the delta (HR2). High-quality seismic-reflection images and first-arrival traveltime tomography models suggest a basement depth at Jao of around 115 m. Except for a transition from dry to saturated sands in the uppermost part, the sedimentary section at shallow to intermediate depths is practically featureless in the seismic data. The featureless seismic response is not consistent with the presence of horizontal boundaries between sand and clay layers, but is compatible with depth variations in salt content, the second of the two possible interpretations for the conductive layer at intermediate depths in the TEM model.

The quality of the HR2 tomography models is somewhat inferior to the Jao models, with only poor constraints on the basement depth and velocities in the middle and lower parts of the sedimentary section. In contrast, the two HR2 seismic-reflection images appear to be of relatively high quality, revealing a number of undulating and subhorizontal reflections. The reflection most likely associated with the boundary between the unconsolidated sediments and basement occurs at around 145 m. This depth is consistent with a poorly defined basement depth in the tomography model for one of the HR2 lines. One or more reflections in the upper 50 ms of the HR2 reflection images are interpreted as lithological boundaries between layers of gravels, sands, silts and clays. Lithological layering does not exclude variations in salinity being the source of the observed resistivity variations.