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Consequences of the anthropogenic alterations along the Jordanian Dead Sea coast

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The Dead Sea is a terminal lake located over the Jordan - Dead Sea transform fault. At around 428 m bsl, it is the lowest emerged place on Earth. Since the 1960s, the over-exploitation of the water resources in the catchment area has lead to lower the level at an increasing pace. In 2014, it is upper than 1m/year. In the last 50 years, a 50 by 15 km slice of brine, around 33 m thick, has disappeared.

With a salinity ten times greater than the average ocean water, the lake and its underground lateral extensions act as a high density layer over which the fresh groundwater is in hydrostatic equilibrium. The slope of the interface between saline and fresh waters is ten times shallower than normally expected near the ocean. According to a number of wells, in some places, the water table does not drop at the same speed than the Dead Sea. There, the head difference is constantly increasing. The fresh groundwater moves rapidly towards the lake to compensate for the imbalance. The most conspicuous consequence is the proliferation of thousands of sinkholes and wide shallow subsidence.

In parallel, in the last two decades, industrial and touristic developments have taken place along the coast. Hence, such a dynamic environment provides a unique test bed to study Human-Earth interaction in the Anthropocene.

As an example, numerous ground collapses are distributed along lineaments whose orientations fit with the main structural directions. This observation highlights the role of conduit played by underground discontinuities, such as faults and fractures. Very rapid underground water circulation explains the appearance of vegetation (Tamarisk) in unexpected places such as the northern tip of the Lisan peninsula and an “aborted” hectometer-scale landslide.

The reactivation of a paleo-channel located below a 38 M$ salt evaporation pond of the Arab Potash Company, Lisan area, Jordan, provides an example for the implementation of an Early warning System. Time series analysis of high and very high resolution satellite images acquired from the 1970s (Corona, Landsat, Spot, and Worldview) indicate major changes in the landscape. An agreement is found between the limits of the paleo-channel revealed by 2011-2012 Worldview images and Corona photographs acquired in 1973. Landsat MSS data of the 1980s and early 1990s indicated that this channel was reactivated a few years after the emergence of the salt flat around the Lisan peninsula.

Radar images (ERS, Envisat, and COSMO-Skymed) acquired from the 1990s are used to map the evolution of the deformation fields associated to the reactivation phenomena.

This work shows the need of analyzing very carefully all available data sources acquired prior and during the recession of the lake level before the development of any kind of industrial activities over the recently emerged lands. This research also underlines the necessity to integrate surface and subsurface observations to develop an efficient Early Warning System to live with the Dead Sea geo-hazards.