

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

# DELINEATION OF SALTWATER INTRUSION IN AL MAKHA AREA, RED SEA COAST, YEMEN USING VES AND 2D-RESISTIVITY IMAGING

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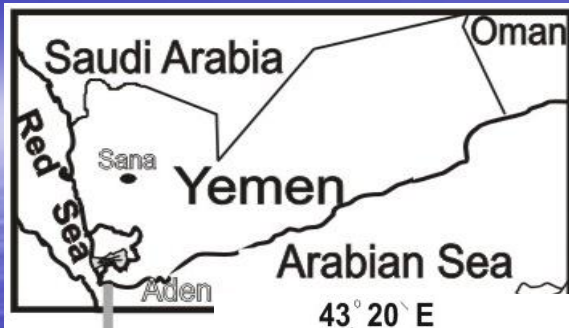
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**ISG-5**

**28 /11/2007**

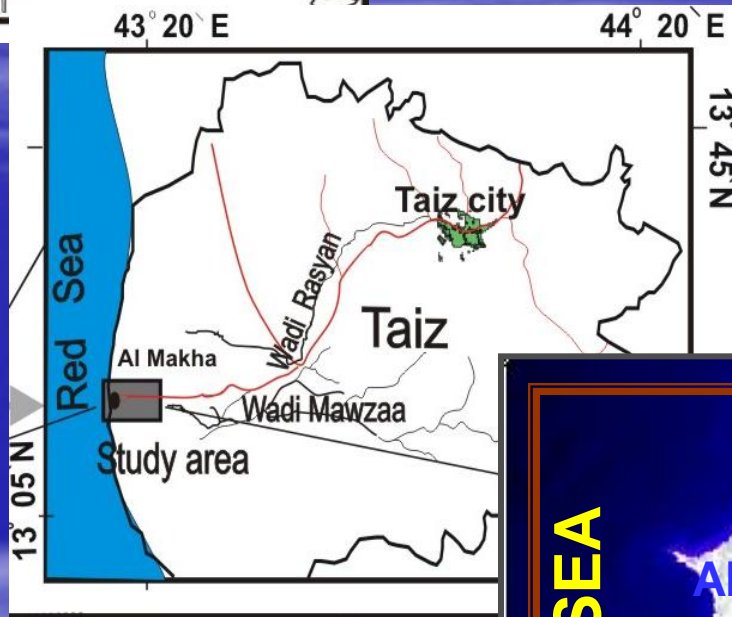
# THE STUDY AREA



The oldest port in Arabian Peninsula “Coffee port”  
In The south western corner of Yemen

AREA = 70 km<sup>2</sup>

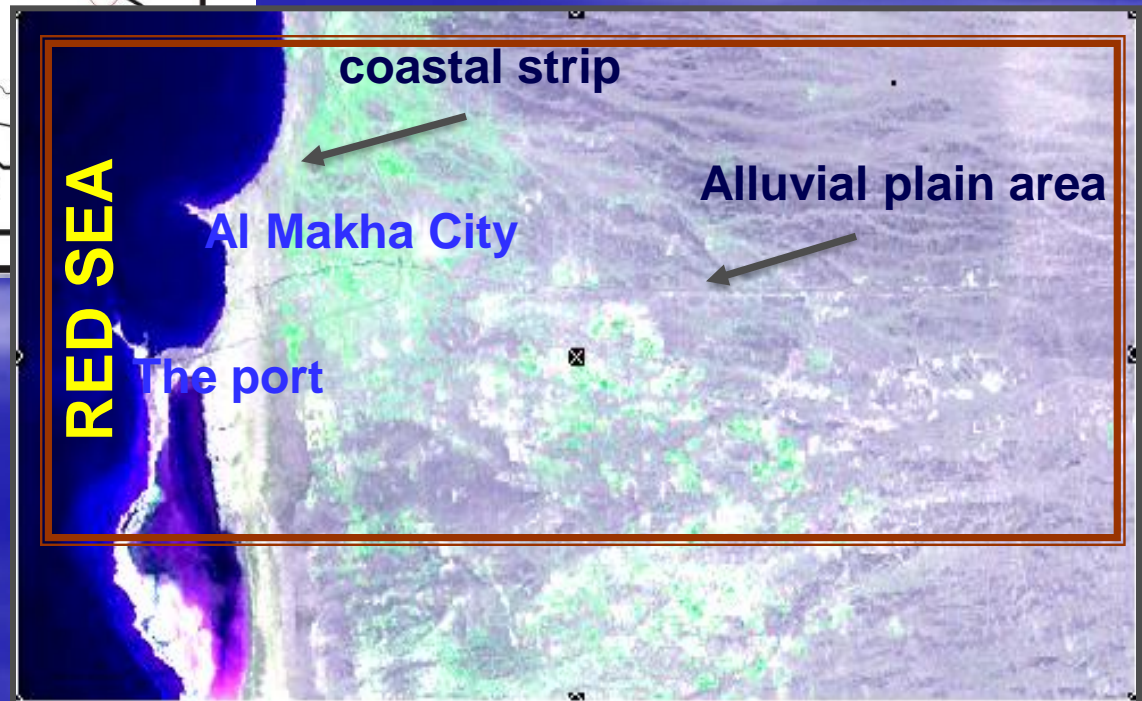
population = 20,000



It Suffers of :

Water supply shortage

Water salinity increase



# ➤ OBJECTIVES

1. To delineate the saline water intrusion
2. To identify the aquifers that may be affected by sea water geometries.

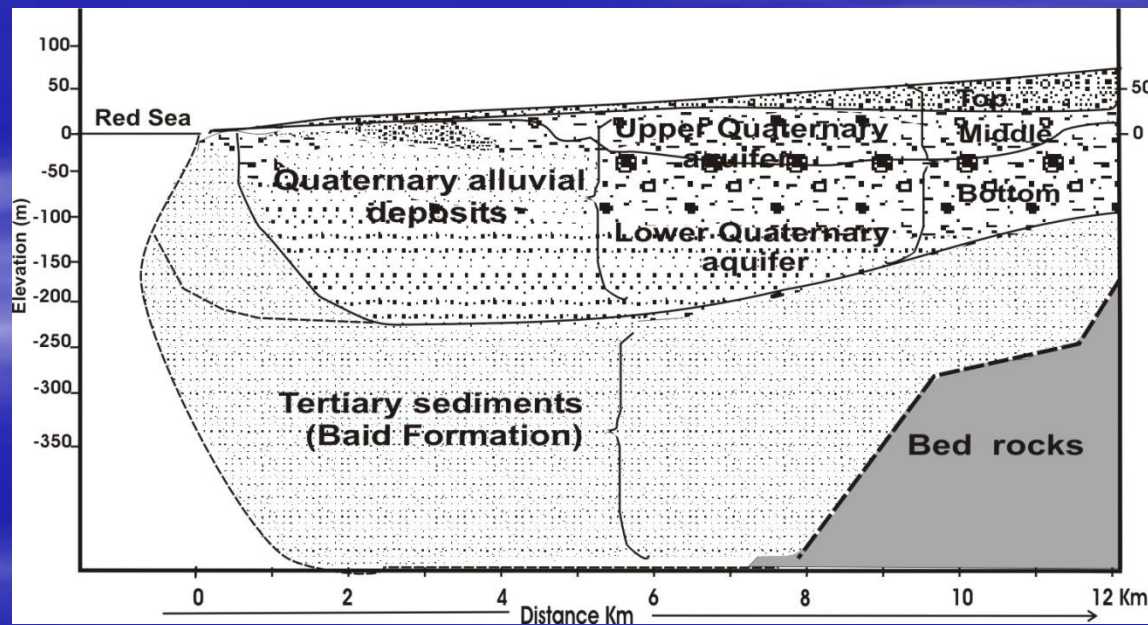
# ➤ GEOLOGY      The area belongs to Tihama coastal plain

**Bed rocks-** Tertiary volcanics

**Baid Formation-** clays, sands, evaporates, and weathered volcanic (to 3000 m thick)

**Quaternary Alluvial deposits -** clastic sediments clays-, sands and gravels (to 350

**Recent sediments-** coastal sands, aeolian alluvial deposits



*Fig. 2. Schematic lithostratigraphic cross section of Al Makha area, Tihama, Yemen.*

# METHODOLOGY

1. Geoelectrical survey
2. Well inventory
3. Hydrochemical analysis

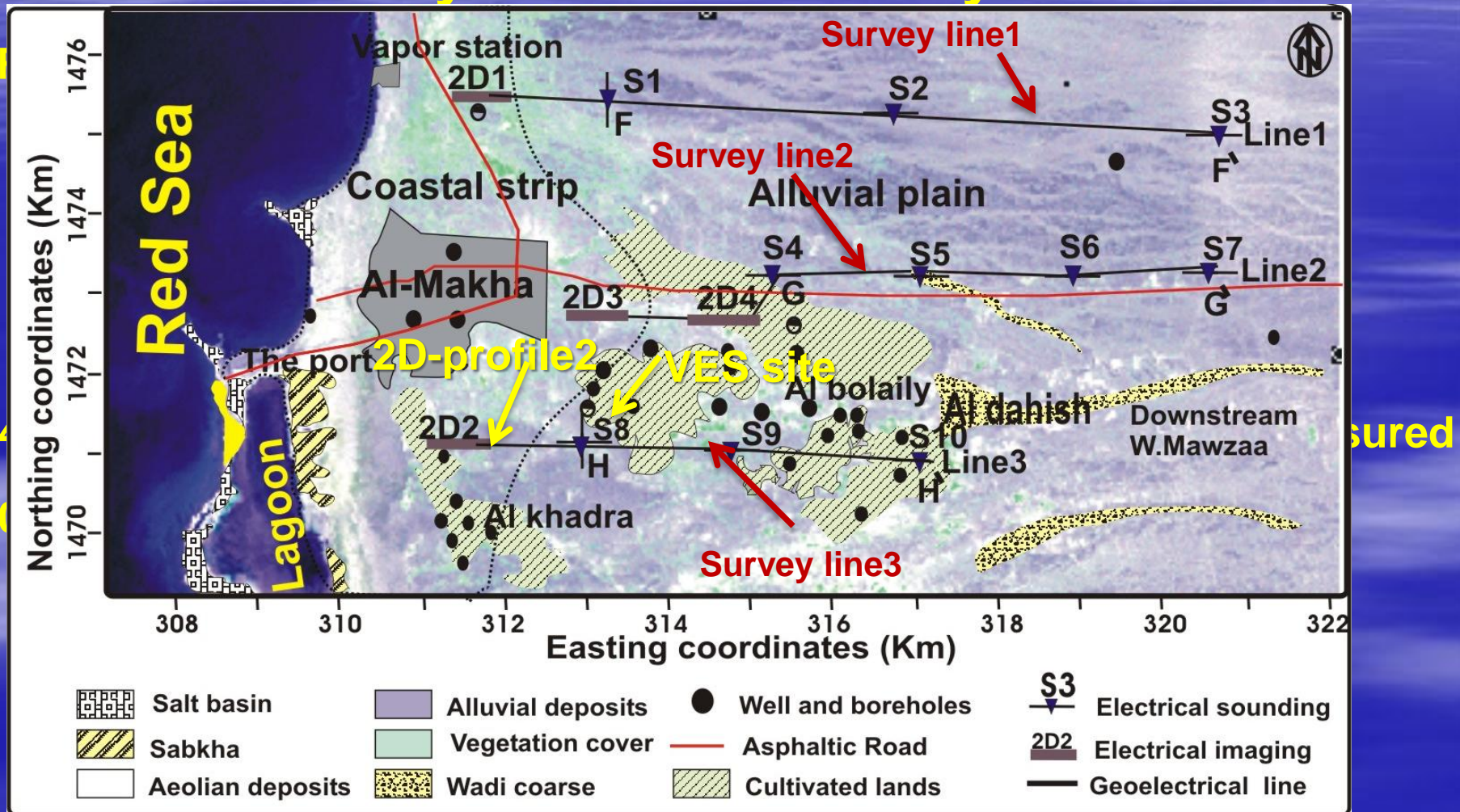


Fig. 2. Map showing locations of resistivity measurements (2D-profiles and VES sites), locations of wells and water samples.

# DATA PROCESSING

- ❖ The field geoelectric data were processed and interpreted automatically by using the IPI2-win and Zohdy, 1989 computer programs.
- ❖ Data were processed by using the Res2dinv resistivity inversion software (loke, 1996).

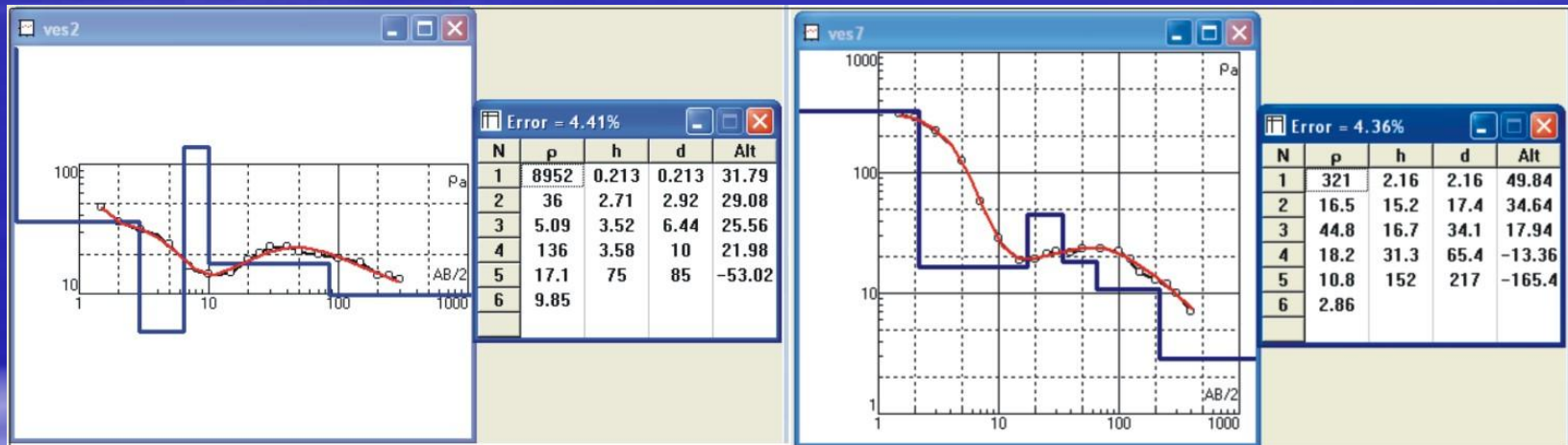


Fig. 2. An example of inversion results of IPI-2win for sounding S2, and S7

- ❖ The groundwater table with respect to mean sea level was contoured to construct water table map.
- ❖ The electrical conductivity EC values for the groundwater samples were converted to salinity values TDS and contoured ,

# RERSULTS AND DISCUSSIONS

- ❖ Groundwater level and flow direction
- ❖ Hydrochemistry of groundwater

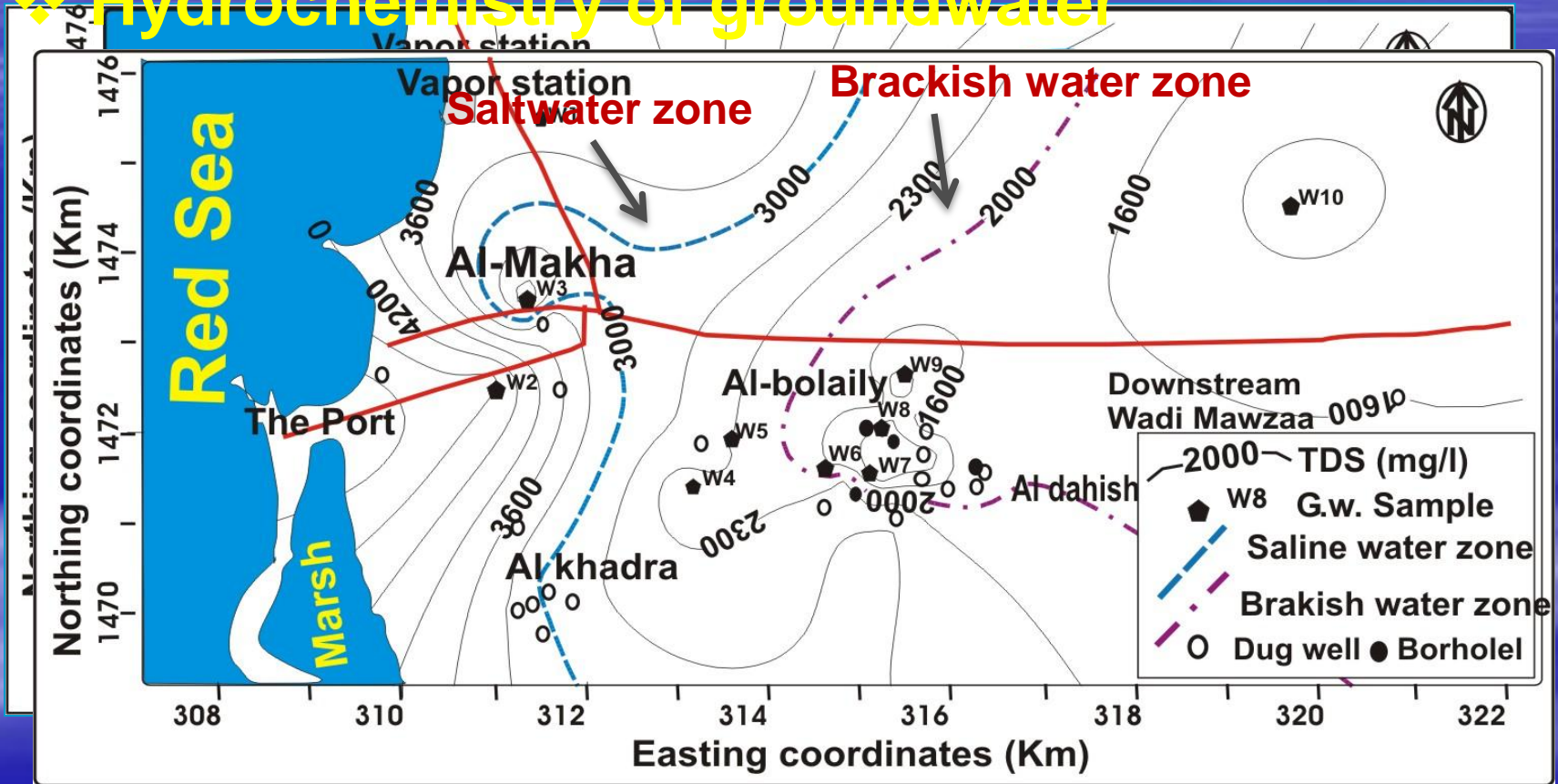
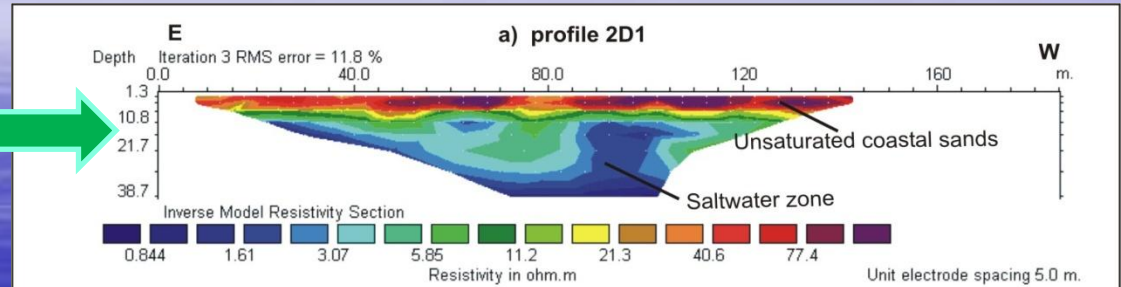


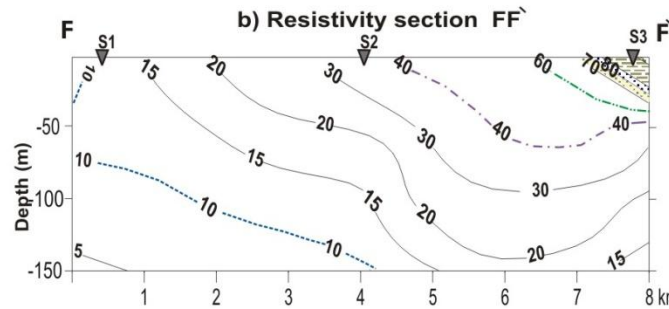
Fig. 4. Groundwater level map showing direction and sense of groundwater flow and well sites.  
Fig. 5. Distribution of total dissolved solids in the study area.

# RERSULTS AND DISCUSSIONS

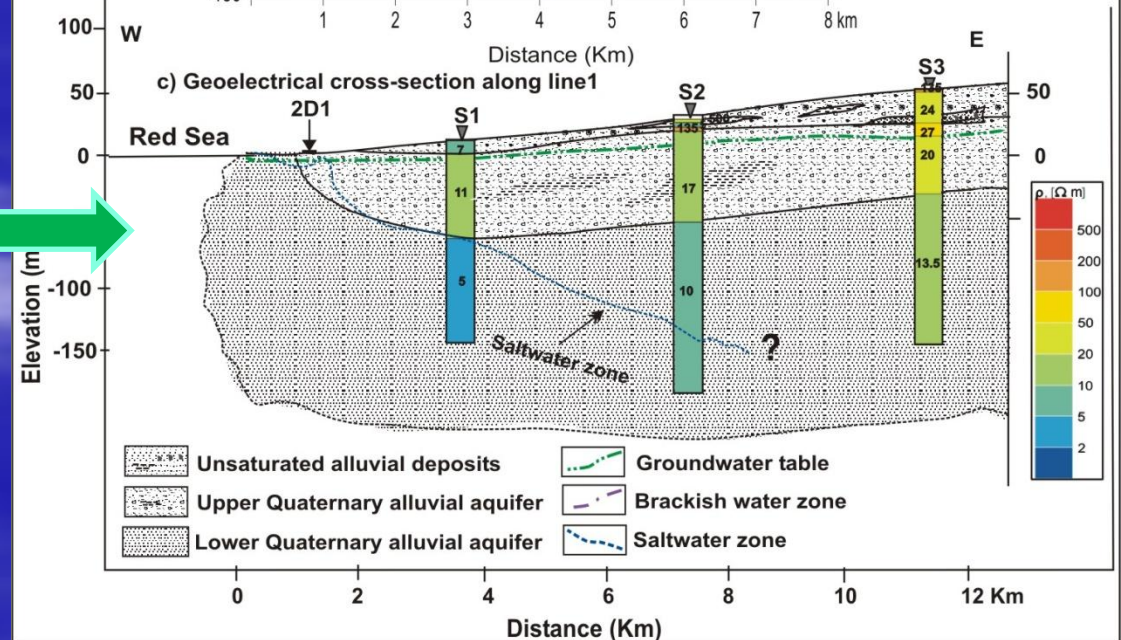
❖ 2D-resistivity section



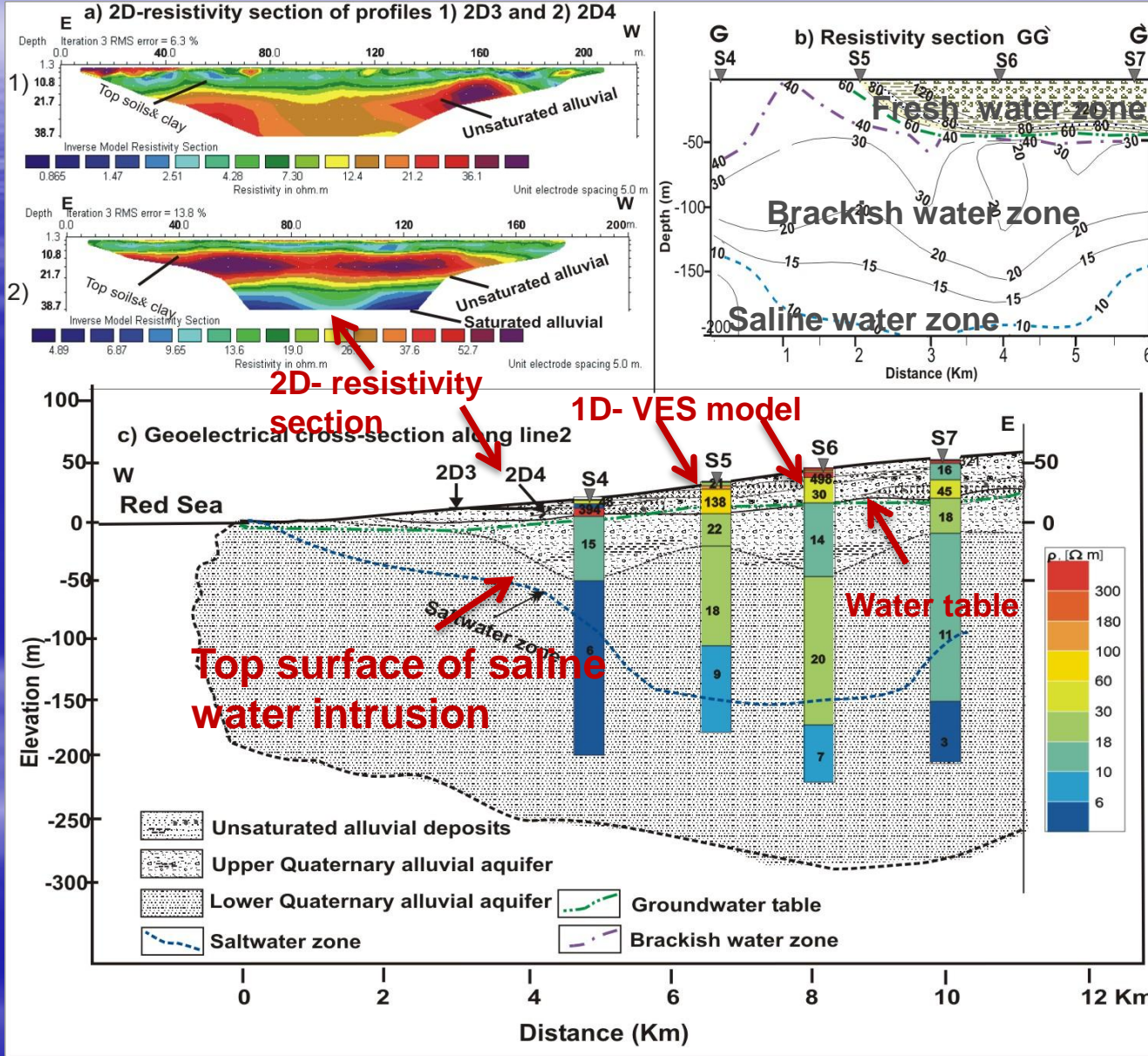
❖ True resistivity section along line FF across the northern part of the area



❖ Geoelectrical cross-section, indicating groundwater aquifers, and saline water interface. This resulting from integration of collected- measured and interpreted 2D-resistivity profile1, VES models for the VES1, 2, and 3. across the northern area (8-km long)



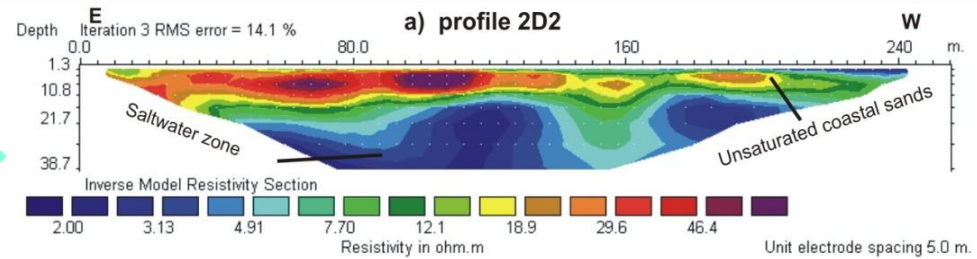
# RRESULTS AND DISCUSIONS



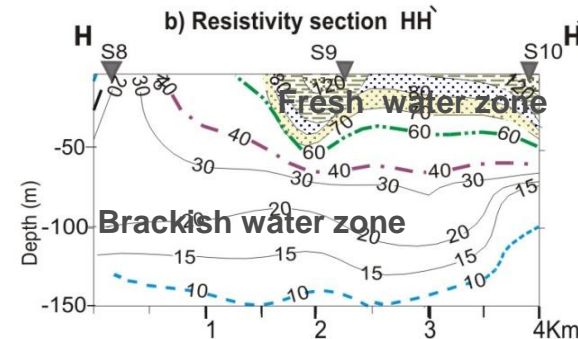


# RERSULTS AND DISCUSSIONS

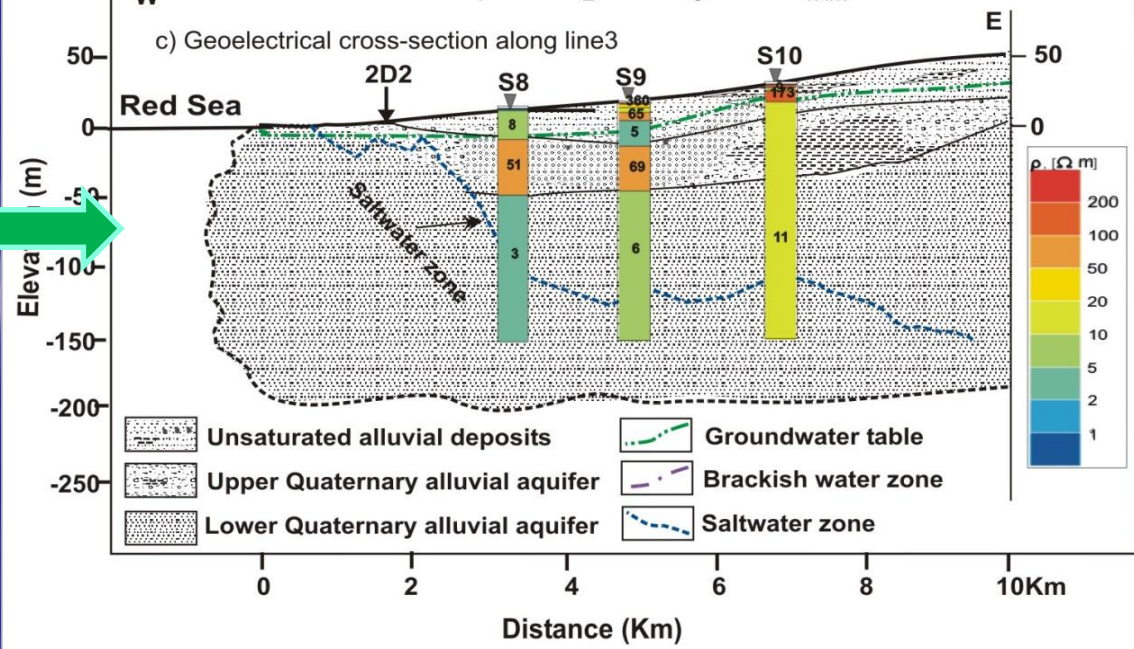
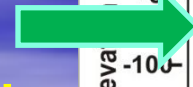
❖ 2D-resistivity section



❖ True resistivity section along line HH across the southern part of the area



❖ Geoelectrical cross-section, including all collected, measured and interpreted 2D-resistivity profile1, VES models for the VES8, 9, and 10. Located across the southern part (line3)



# CONCLUSIONS

- The groundwater in the study area is generally brackish (TDS >1500 mg/l)
- The free groundwater table is located about **30 m deep** in the eastern part, **20 m** in the middle and north parts of the area, **8 m** near in the coastal strip, and it is deeper than **40 m** in extensive agricultural area (Al Bolayli area).
- The results of this study indicate invasion of the Red Sea water into the lower alluvial aquifer. while, the upper alluvial aquifer is not affected by seawater.
- The top surface of saltwater intrusion is detected at **10 m to 50 m** in the coastal strip, and deepens to more **150 m** at 11-km distance from the shore line. In extensive agricultural areas (Al Bolaily area) the depth to saltwater zone is found at **~200 m**.

**Groundwater contamination by saline water from the sea is considered as a result of over pumping in the cultivated area.**

- Two aquifers have been delineated: **(i)** the Upper Quaternary Alluvial, coarse to fine-grained sediments intercalated with clay lenses, of 30 to 70 m thickness. **(ii)** The lower Quaternary Alluvial is medium to fine grain deposits, detected at depths ranging from 20 m in the coastal zone to more than 250 m from the surface in the eastern part

# TAIZ CITY

An aerial photograph of Taiz City, Yemen, showing a dense urban landscape with numerous multi-story buildings and a prominent mountain range in the background. The city is built on a hillside, and the buildings are mostly light-colored with arched windows. A large, modern, white building with a grid-like facade is visible on the right side. The mountain in the background is rugged and brown, with some structures visible on its slopes. The sky is clear and blue.

Thank You for your  
attention