UNDERSTANDING THE RELATIONSHIP BETWEEN CONTINENTAL AND MARINE GROUNDWATER IN YANTAI (CHINA) AND VENICE (ITALY) AREAS: PRELIMINARY RESULTS

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Introduction. The coastal areas are transition zones where land and ocean processes interact and play a critical role. Here, several factors may trigger environmental disasters or increases hydrogeological hazard. More than half of the global population lives in the 60 km wide coastal zone and the resources for populations, such as freshwater and food, depend on the critical relationships between land and sea and their variations due to both natural and anthropogenic causes. In particular, climate changes and stresses induced by human activities, e.g. pollution, engineering interventions for dams, flood control, canalization, deforestation, urbanization, agriculture and freshwater withdrawals, cause the degradation and the ravage of the habitat. In the new millennium the management of the use of coastal areas is focussed on the integration of the monitoring systems which

have to provide data and information for decision support system-based actions. In 2008 the project "An integrated monitoring and management approach of hydrologic processes in coastal ecosystems for the understanding of the relationship between continental and marine waters in the Yantai (China) and in Venice (Italy) areas" started under the umbrella of the bilateral scientific and technological agreement between the National Research Council of Italy and the Chinese Academy of Sciences. The project is carried out by the Institute of Marine Sciences of Venice and the Institute of Coastal Zone Research for Sustainable Development of Yantai. This project aims at understanding the complex relationship between continental and marine groundwater, i.e. the salt water intrusion, in two coastal areas, the Laizhou Bay (Shandong Province) in the southern Bohai Sea (China) and the Venice Lagoon (Italy).

In this work we report an overview of the salt water contamination process in the two study areas and some preliminary results on a survey carried out in the Venice Lagoon, which goal was to test seismic and geoelectrical surveys for the detection of buried morphological features, such as high-permeable sandy paleo-channels, that can enhance the flow of saline water from the lagoon-sea to the inland.

Background. The coastland surrounding the Venice Lagoon, Italy, is a precarious environment subject to both natural changes and anthropogenic pressure. A number of critical problems affect this lowlying area, i.e. relative land subsidence, periodic flooding during severe winter storms, and saltwater intrusion. The combined effect of sea level rise and land subsidence has enhanced the saltwater contamination and the related soil salinization with serious environmental and socio-economic impacts. The risk of soil desertification and the compromising of agricultural activities are major problems in the farmland bounding the southern Venice. In the Shandong Province, two major problems are related to the groundwater contamination by salt: a) effects on the human health due to fluorine excess in drinkable water induced by changed F release conditions and b) the reduction of agricultural productivity due to soil salinization. Past geomorphological studies evidenced the presence of exposed or buried geomorphological features filled by sandy deposits in the two study areas (Chen et al. 1995; Rizzetto et al., 2003; 2009). Hydrogeological studies pointed out that these geomorphologic features are one of the main components of the salt water contamination process in coastal aquifers (de Franco et al., 2009; Tosi et al., 2009). In particular, well developed sandy paleo-channels crossing the farmland with main directions from inland to the lagoon/sea boundary represent a preferred path for groundwater flow. For this reason the detection of buried geomorphological features and groundwater characteristic in the lagoon subsoil is the essential point to understand the salt water flow toward the inland.

Results of the VHRS and CERT surveys. We have experimented the coupled CERT-VHRS survey, i.e. the Continuous Marine Electrical Resistivity Tomography and the Very High Resolution Seismic survey in very shallow water, less than 1 m depth. VHRS system has been widely used in the Venice Lagoon (Zecchin et al., 2008; 2009). It consists of an impulsive energy source (boomer) and an electro-dynamic transducer UWAK05 mounted on a catamaran frame. A pre-amplified oil filled streamer composed of eight piezoelectric elements connected in series with a 2.8 m active array section were used to collect the signals. The geometry of the system was optimized to operate in water depths less than 1 m, i.e. the streamer was deployed parallel to the boomer and towed with a 2 m lateral offset as shallow as possible (about 0.3 m beneath the water surface).

CERTsurvey was carried out by means of a georesistivimeter configured to work in continuous survey acquisition, and using a floating marine multipolar cables with 16 graphite electrodes towed by a boat. We used the IRIS Syscal Pro 72 Switch georesistivimeter that is characterized a multichannel capability. The cable can be kept floating or submerged at constant depth using support devices. Positioning data of both surveys were collected using an integrated DGPS navigation system. The VHRS-CERT acquisition test was carried out in the shallows (about 1 m depth) of the Venice Lagoon in July 2009. VHRS pointed out the architecture of the subsoil while CERT shown the lateral and vertical variation of the deposits. The VHRS survey revealed the presence of numer-

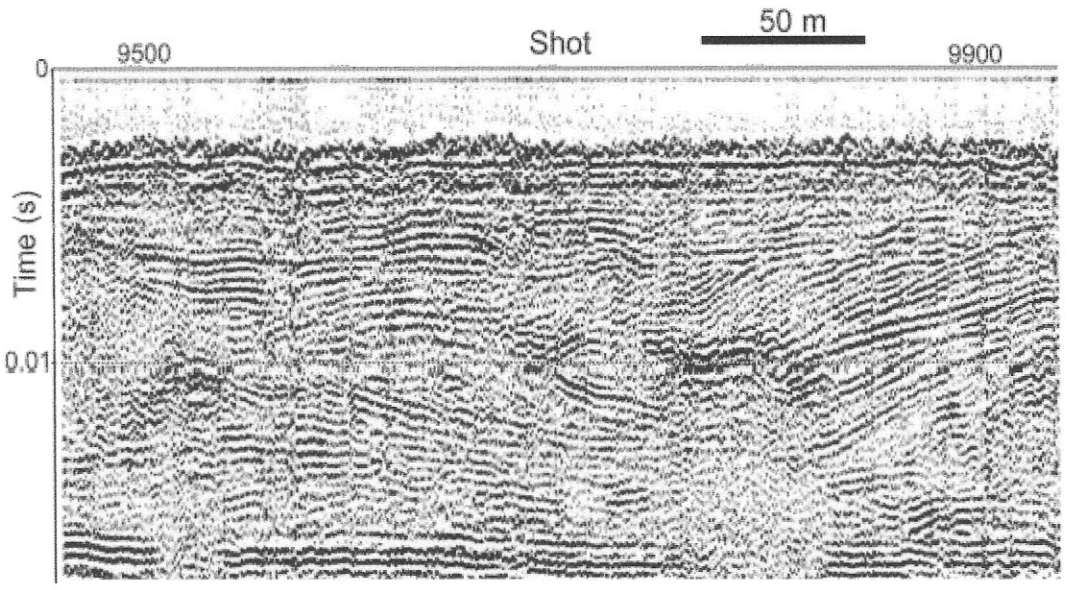

Fig. 1 – Example of VHRS section showing a buried paleo-channel in the Holocene deposits. Water depth is about 1 m.

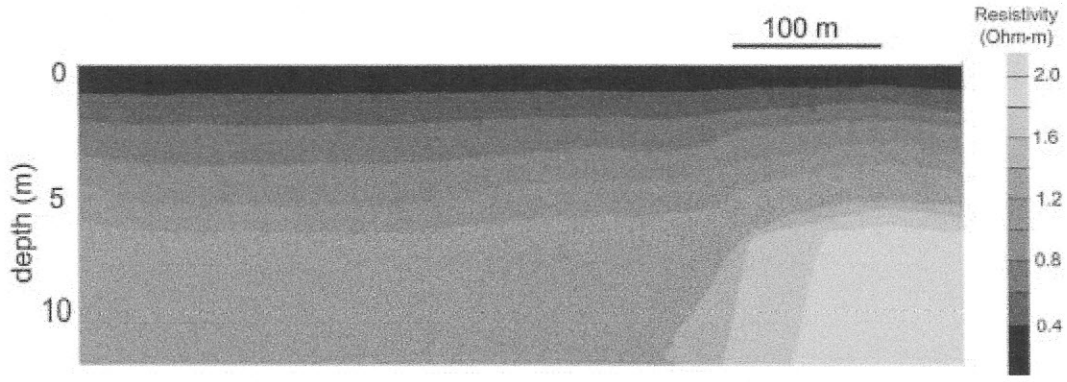

Fig. 2 – Example of ERT section showing electrical resistivity variations in the Holocene deposits. Water depth is about 1 m.

ous buried geomorphological features in the shallow subsoil. An example of ancient channel is shown in Fig. 1. Resistivity changes were detected in the close by geomorphological structures or gas occurrences as indicated by VHRS survey (Fig. 2).

Discussion and conclusion. The coastland surrounding the Venice Lagoon, Italy, and Yantai (Shandong Province), China, are precarious environments subject to both natural changes and anthropogenic pressure. One of the most important environmental problems is the saltwater intrusion process in shallow aquifers (Carbognin et al., 2006; Pousa et al., 2007; Qi and Luo, 2008). The salt contamination is generally the result of seawater encroachment, but significant contributions can also be due to the water exchange between the bed of the major rivers and the subsurface. In fact, the reduced freshwater discharges that occur during the dry periods allow the saltwater to flow up from the river mouths for several kilometres. Saltwater intrusion is enhanced by the presence of several ancient sandy fluvial ridges, crossing the farmland with a main direction from inland to the

lagoon boundary, that can act as preferential pathways for groundwater flow and solute transport.

The VHRS-CERT coupled survey was successfully tested in the Venice Lagoon and will be exported to the Laizou Bay a soon as possible. The most important outcomes of this work are the implementation of this technique in very shallow water (less than 1 m depth) and the detection of the subsoil architecture with the identification of geomorphological features and their vertical and lateral resistivity changes. At the moment only preliminary interpretation are available. Analysis of collected cores aimed at validating the VHRS-CERT records is in progress.

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