Geophysical techniques for investigating shallow and deep landslides: results in the framework of PREVIEW project (FP6 – UE)

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Geophysical Techniques for Investigating Shallow and Deep Landslides - Results in the Framework of Preview Project (FP6 - UE)

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SUMMARY

In the framework of the PREVIEW (Prevention Information and Early Warning) project, co-funded by the European Community within the Sixth Framework Programme, shallow rapid slope movements and deep-seated slow moving landslides have been investigated by using the integration of advanced technologies in the field of Earth Observation.
The activities of Institute of Methodologies for Environmental Analysis (IMAA) of CNR - Italy in the project have been to apply high resolution in-situ geophysical techniques for investigating some landslides located in Italian and Swedish territories. In particular, a shallow rapid slope movement, located in Liguria region (Italy), has been investigated by using electrical resistivity and self-potential maps; two deep-seated slow moving landslides, located respectively in Lombardia region (Italy) and in Sweden, have been studied by using electrical resistivity tomography technique.

Introduction

The aim of PREVIEW project is to develop, at the European scale (fig.1), new information services to support the management of risks, of significant added value, making the best use of the most advanced research and technology outcomes and validated under pre-operational conditions. In particular, for landslide risk, PREVIEW proposes to develop an innovative technological system based on two services: "Monitoring of slow-moving landslides" and "Prediction of shallow rapid slope movements". Aim of the system is to support end-user (e.g. National Civil Protections) decision during crisis management, with effective instruments for understanding landslides risk and for planning prevention and mitigation strategies and for managing warning systems.

Many in situ geophysical techniques (seismics, geoelectrics, magnetometry, gravimetry, thermometry, GPS, etc.) produced significant results and information in the investigation of landslide areas (Hack, 2000). In particular, the electrical resistivity and self-potential methods, characterized by a relatively fast field data acquisition and low costs and showing a notable spatial resolution, proved to be powerful tools for investigating complex geological and environmental phenomena such as landslides (Lapenna et al., 2005; Meric et al., 2005). Furthermore, the development of innovative and robust inversion methods (Loke and Barker, 1996; Patella, 1997) yielded more sophisticated and reliable data interpretation for the study of complex geological problems, such as the definition of the geometry of buried structures and the study of space-temporal evolution of phenomena connected with movements of fluids in areas affected by mass movements. This paper reports the results related to the application of the electrical resistivity and self-potential methods for investigating a shallow rapid slope movement and two deep-seated slow moving landslides located in the test sites of the project.

Figure 1 – Partners of PREVIEW project

Service 1: Monitoring of slow-moving landslides

The main aim of this service is monitoring deep-seated slow-moving landslides over large areas, applying interferometric techniques integrated with geomorphological methods, in situ electrical and electromagnetic applications.

The two test sites for this services were: the Ruinon landslide in Frodolfo River Basin (Lombardia, Italy) and the Trosa municipality (Vagnhärad, Sweden). In both the areas, 2D electrical resistivity tomography (ERT) technique has been applied to reconstruct the geometry of the investigated subsoil and to obtain information about the pattern of the groundwater flows.

In particular, on the Ruinon landslide two ERTs with direction transversal to the body, have been carried out by using a multielectrode system with 48 electrodes 20 m spacing and a

wenner-schlumberger array. Figure 2 shows the ERT carried out with direction transversal to the landslide body at a height of about 1900 m a.s.l.

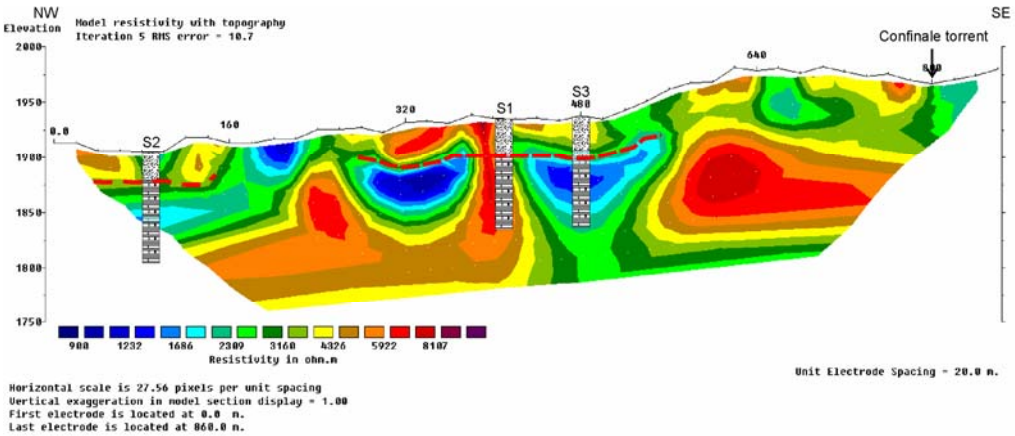

Figure 2 – ERT carried out with direction transversal to the Ruinon landslide (Lombardia, Italy)

It shows resistivity values (ρ) varying in the range 900-9000 Ω m. The first 25-30 m of the electrical image are characterized by a chaotic distribution of terrains with resistivity values included in the range 3000 – 8000 Ω m. These terrains could be associated with disarranged debris material as also reported by the stratigraphical data coming from S1, S2 and S3 soundings. The higher Resistive nuclei (ρ > 8000 Ω m) embedded in this material are associable to compact material. The deeper part of the image (depth > 80 m) is characterized by resistivity values higher than 4000 Ω m associable to the bedrock material not involved in the slide. The very high conductive nuclei (ρ < 2000 Ω m), located in the central part of the ERT, could be associable to fractures of the bedrock that encourage the water infiltration.
In the SE side of the tomography is located the Confinale torrent which represents the left lateral boundary of investigated body. Any information related to the right boundary is available.
In the Trosa municipality six 2D ERTs were carried out for investigating a hypothetical unstable area. The resistivity data were acquired by using a georesistivimeter Syscal R2 connected to a multielectrode cable with 32 electrodes. The electrodes were spaced 3 m and 5 m. Both dipole-dipole and wenner-schlumberger electrode configurations were applied. Figure 3 shows the ERT carried out along AA' profile by using the dipole-dipole array. It allowed us to discriminate 3 layers: the first one, characterized by very low resistivity values, is associated with the clay material; the second one, characterized by low resistivity values, with transitional soil; the last one, characterized by relatively high resistivity values is associated with sands and conglomerates.

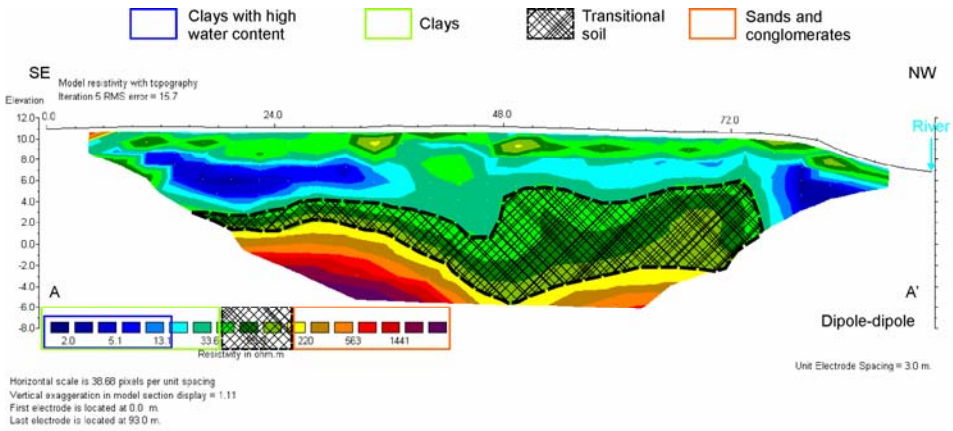

Figure 3 – One of the six ERTs carried out in Trosa municipilaty (Sweden).

Service 2: Prediction of shallow rapid slope movements

The main aim of this service is the prediction and early warning for local rapid slope movements, through hydro-meteo modeling, radar remote sensing and geophysical methods.
The test site for this service was the Armea river basin (Liguria, Italy). One of the shallow landslide occurred in the area has been studied by using electrical resistivity method and self-potential survey. In particular, an electrical resistivity and a self-potential (SP) map were performed.
The first one was carried out by using the Vertical Electrical Sounding (VES) technique. Twenty-two VES distributed on the whole landslide body were performed reaching a maximum investigation depth of about 2 m. The self-potential map was carried out to obtain information about the pattern of the groundwater flows. Sixty-two SP points were measured specifying the GPS coordinates.
SP map (fig.4) shows a spatial pattern characterized by positive self potential values in the source area and negative values in the accumulation zone. According to the electrokinetic effect, the accumulation of positive SP values in the source area could be associated with the presence of a high water content. This is proved by the presence of many cisterns for the rainwater collection. The high water content could be the main cause of the movement which involves the slope. The negative SP values in the accumulation zone could be associated with a dry terrain probably due to the water infiltration in the neighbouring areas. Finally, a strong SP gradient follows the accumulation zone outline perfectly, giving the possibility to better reconstruct the superficial geometry of the landslide body.

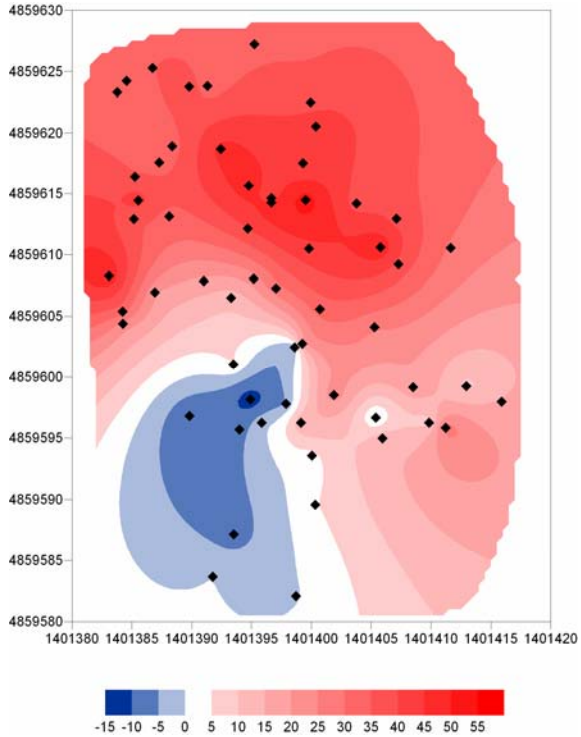

Figure 4 – Self-potential map carried out on a shallow landslide in the Armea basin (Liguria, Italy)

Conclusions

The paper reports the results obtained in the framework of PREVIEW project by the IMAA – CNR. Electrical resistivity and self-potential methods have been applied for investigating the test sites, allowing to reconstruct the geometry of investigated subsoil and to study the groundwater flow patterns.

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