



## **Integrated methodology in karst hazard assessments: aerial photography, geophysics and geotechnical approaches (Zaragoza, Central Ebro Basin, Spain)**

D. Anson López, Ó. Pueyo Anchuela, A. Casas Sainz, and A. Pocovi Juan  
Geotransfer. Universidad de Zaragoza. Zaragoza. Spain (anson.diego@gmail.com)

Karst hazards are an important subject of research in the surroundings of Zaragoza, with a very clear application to determination of geological risks. The developing of methodological approaches to the urban planning and construction has been one of the main objectives of the Geotransfer Research Group from the University of Zaragoza.

In this work, three different approaches were applied to urban planning in a zone in the proximities of Zaragoza. The studied zone covers 10000 square meters where 4 boreholes and 12 penetration tests have been realized. The geophysical approach consisted in magnetometry, GPR and EM radiation surveys. On the other hand, 12 different aerial photographies, ranging from the 1950' to present, were analyzed.

The availability of a large number of historical data and aerial photographies permitted to determine different karst hazards in the prospected area, in spite of karstic features not being evident at surface. The analysis from only geotechnical data does not show allow to infer karst activity because the geometry of the Quaternary cover-Tertiary substratum cannot clearly be linked to a subsidence doline. Conversely, the results obtained from geophysical techniques show a good coincidence of change of the measured properties with closed envelopes in map view: higher intensity of the magnetic field, higher apparent conductivity (wave in quadrature of EM data) linked to closed envelopes of adaptation features in the GPR profiles and higher attenuation of the waves. The results obtained indicate the presence of a sinkhole, filled with Quaternary gravels, below a flat area. The comparison between aerial photographs and geophysical data shows a direct correlation, whereas the geotechnical data are ambiguous and show contradictory results over the sinkhole, the penetration tests indicating higher strengths related to the historical filling of the subsident zone.

The existence of several series of aerial photographs permitted to correlate the different geophysical anomalies with geomorphological features, showing that the applied geophysical methodology can be applied in places where no previous knowledge about karst activity exists, or where the aerial photographs cannot be interpreted unequivocally. The independent planning of geotechnical tests shows on one hand ambiguous results or no evidences of karst activity, and on the other hand that the results obtained from isolated tests cannot be laterally correlated without the knowledge of the geometry of the subsoil. The geotechnical planning can be seriously improved if they are planned after the geophysical survey and where the lateral correlation of the discrete tests can be distributed in order to minimize ambiguity in interpretation.