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Integrated geophysical and building damages study of karst effects in the urban area of Alcalá de Ebro, Spain

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with 7 figures

Abstract. Karst hazards caused by sinkhole development in the surroundings of the city of Zaragoza (Central Ebro Basin, Spain) have been an increasingly important research subject related to the vulnerability of man-made constructions. Karstic processes have been active during most of the Quaternary, developing an important record of alluvial karst that represents a serious problem for building projects. Karstic problems have been mitigated in many cases by filling and waterproofing of sinkholes. In this work, a multidisciplinary survey is presented, applied to characterize and analyse karst hazards in Alcalá de Ebro (25 km upstream and to the West of Zaragoza) after a sudden collapse in the main street of the village in 2007. The map of damaged structures, GPR surveys, borehole data and microgravimetry survey demonstrated to be a good methodology to be applied in urban settings with karst hazards. The results obtained show that the increase in the activity of karstic processes may have been caused by concrete injection initially intended to reduce the karst hazards.

Keywords. Sinkhole, karst hazard, urban setting, geophysical prospecting

1. *Introduction*

On June, 22nd 2007 a sudden 1-m diameter collapse occurred in the main street pavement of the small village of Alcalá de Ebro (population 302, Zaragoza province, NE Spain). Direct observation showed a 15 m deep, 6 m wide open cavity underlying the collapsed pavement. During the following days, the affected area widened even as the void was filled with blocks and gravels with an approximate weight of $0.5 \cdot 10^6$ Kg. On July 8th the infilling materials collapsed again. In the intervening days, different controversial opinions from the local authorities on the origin of the collapse were published in the local newspapers. These news and discussion led us to carry out a multidisciplinary survey in Alcalá de Ebro.

Alcalá de Ebro is located in the Central Ebro Basin, close to the Ebro River. The stratigraphic succession consists of Miocene evaporites unconformably covered by the Quaternary fluvial deposits mainly related to the Ebro River and its tributaries.

Karst hazards are not a new phenomenon in this area. In a chapter of Don Quixote, Sancho Panza fell into a doline (sinkhole) *that was between the buildings,* during his trip between the Insula Barataria (Alcalá de Ebro) and Pedrola (some km to the Southeast). More recently, during the 1970´s, a house was destroyed by a sinkhole in Alcalá de Ebro and at the beginning of the 1980´s, a new collapse affected the main street of the village,

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