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# Natural and induced sinkholes of the Obruk Plateau and Karapınar-Hotamış Plain, Turkey

Uğur Doğan *, Mutlu Yılmaz

*Department of Geography, Ankara University, Sıhhıye, Ankara 06100, Turkey*

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ABSTRACT

The number of sinkholes (locally known as *obruks*) has increased rapidly in recent years near Karapınar, located in the semi-arid Konya Closed Basin in Central Anatolia. Nineteen sinkholes have formed in the last 33 years (1977–2009) as a result of the collapse of cavity roofs in the Neogene lacustrine limestone in the Obruk Plateau and beneath Quaternary lake sediments in the Karapınar-Hotamış Plain. Of these, 13 have formed within the past 4 years (2006–2009). The Obruk Plateau takes its name from the presence of several hundred paleo-sinkholes which formed as a result of natural processes during the Quaternary period. More recently, human activity has induced the formation of new sinkholes, which presents a hazard to life and property. Changing agricultural patterns have led to the opening of thousands of deep wells in recent years, and increased water pumping currently exceeds the sustainable yield of the aquifer. Thus the formation of sinkholes has been triggered by a combination of natural and human causes. The groundwater level has dropped almost 24 m in the vicinity of Karapınar during the last 26 years (1983–2008). Approximately 8 m of this drop occurred within the 4 years prior to the study (2005–2008). Legally-binding precautions must be taken to prevent further water table decline, in order to decrease sinkhole formation within the basin in the years to come.



## 1. Introduction

Carbonate karst is estimated to cover over 10–15% of the Earth's land surface and these karstic terrains provide essential ground water to supply roughly 20–25% of the global population (Ford and Williams, 2007). Within these karst areas, sinkholes are among the most significant natural hazards threatening human life and property and lead to increasing expenditure each year (White, 1988; Waltham, 1989; Waltham and Fookes, 2003; Waltham et al., 2005; Parise et al., 2008). The location and timing of sinkholes cannot generally be predicted and they usually occur abruptly (Newton, 1987; Waltham et al., 2005).

Sinkhole hazards increase in cohesive alluvial cover on karst rocks (Doğan and Çiçek, 2002; Waltham et al., 2005) and on evaporite karst, where dissolution is more rapid (Benito et al., 1995; Alberto et al., 2008; Gutiérrez et al., 2008a,b; Luzón et al., 2008; Galve et al., 2009) in comparison to carbonate karst (Bruno et al., 2008; Brinkmann et al., 2008) or caprock areas (Doğan, 2005). In Turkey, nearly one third of which is composed of karst terrains, most attention is focused on sinkholes formed in recent years on lacustrine limestone and consolidated non-karst caprocks overlying the limestones near Karapınar in the Konya Closed Basin (KCB) (Fig. 1), rather than on sinkhole hazards in evaporite karst, which are seen across a large area (Doğan and Yeşilyurt, 2004; Doğan and Özel, 2005). The KCB is comprised of the Konya Plain sub-basin in the south, the Tuz Lake sub-basins in the north and the Obruk Plateau, which is located between these two sub-basins (Fig. 1).

*Obruk* is the local name for sinkholes that may be of collapse or caprock type; there are many that have been formed within the Taurus karst and in the KCB, and reach their greatest density on Obruk Plateau, northwest of Karapınar.

In the Obruk Plateau, there are several hundreds of saucepan-like and cylindrical sinkholes, showing dimensions ranging from a few meters to tens of meters in width. Those which attract attention are "cenote" type (Ford and Williams, 2007) sinkholes at diameters of several hundred meters; depths can range from 10 m to more than 100 m. A lake is often observed at the bottom where the sinkhole reaches the depth of the water table (e.g. Kızören, Çıralı, Meyil, Timraş, Apa) (Figs. 1 and 2).

Many geomorphologic and hydrologic studies have been conducted on the subject of the KCB especially regarding the Obruk Plateau sinkholes, which have attracted the attention of researchers since the early 20th century (e.g. Erinç, 1960; Eroskay and Günay, 1980; Canik and Çörekçioğlu, 1986; Erol, 1986, 1990; Biricik, 1992; Bayarı et al., 2009a,b). However, the hazard to life

* Corresponding author. Tel.: +90 312 3103280/1248; fax: +90 312 3105713.
*E-mail address:* ugdogan@yahoo.com (U. Doğan).

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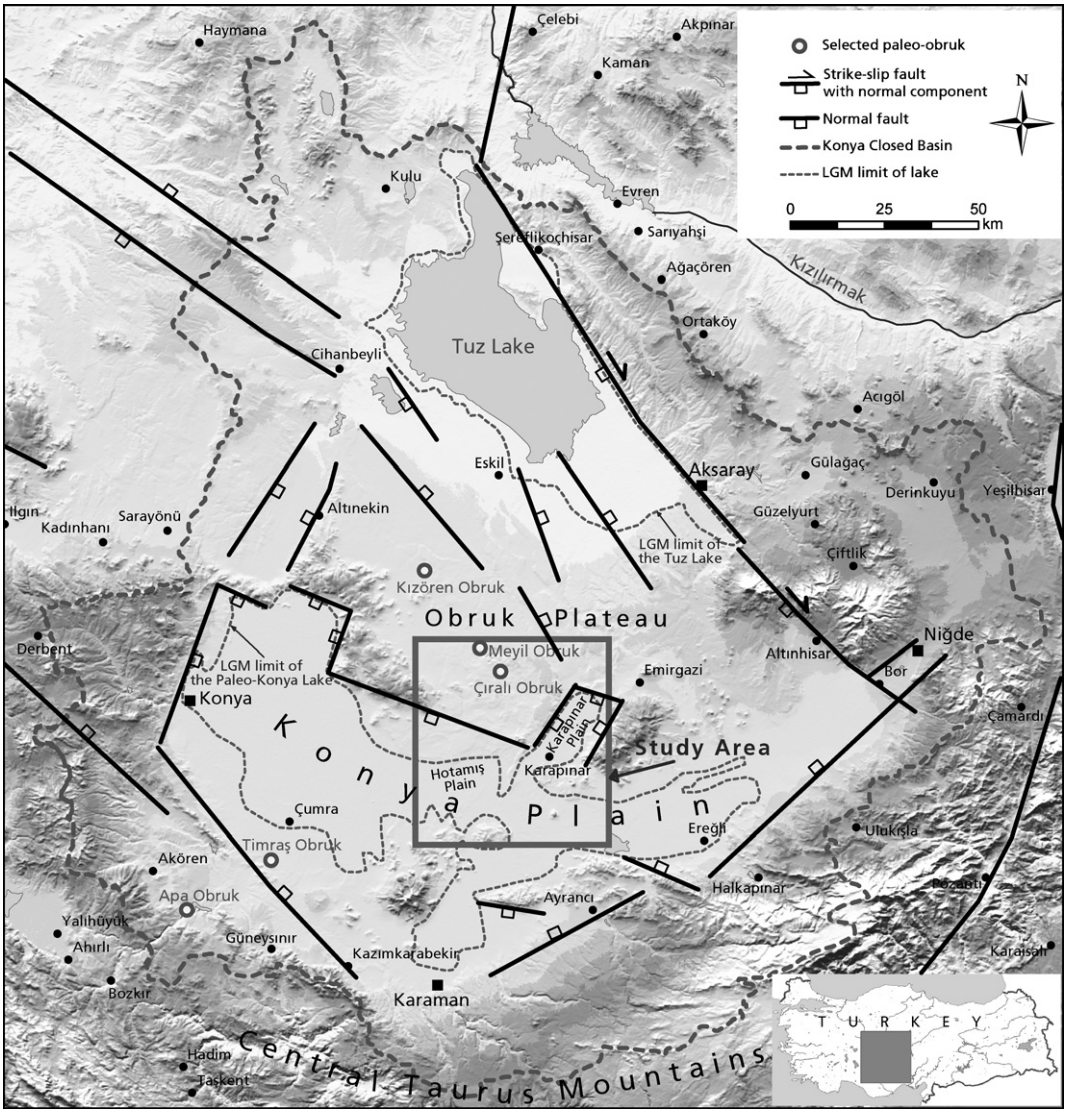


**Fig. 1.** Location map of the study area. Faults have been adapted from Koçyiğit (2005) and Özsayın and Dirik (2007). Last Glacial Maximum (LGM) lake limits have been adapted Fontugne et al. (1999) and Kashima (2002).

**Fig. 2.** The Çıralı Obruk, one of the giant paleo-collapse sinkhole located in the Obruk Plateau. There are many man-made ancient caves in the sinkhole slopes (photo taken in 2004).

and property posed by sinkholes, which continue to form rapidly at the present time, and which will continue to form in the future, has been widely ignored.

The purpose of the present study is to determine the role of human and natural causes relating to the formation of new sinkholes around Karapınar.

## 2. Regional setting

### 2.1. Geological setting

The formation and spatial distribution of sinkholes are closely related to the lacustrine İnsuyu Formation (Ulu, 2009a,b) and the aquifer in this formation (Figs. 3 and 4). The İnsuyu Formation was formed as a result of an extension regime during The Upper Miocene–Pliocene (Koçyiğit, 2005). It consists of thick limestone in the upper section, limestone, marl, clay, tuff and silt intercalation in the lower section (Ulu, 2009a,b). The thickness of fractured lacustrine limestone, suitable for karstification has been documented by boreholes to be over 200 m (Canik and Çörekçioğlu,