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Evolution of Çolpan barrier and lagoon complex (Lake Van-Turkey): Sedimentological and hydrological approach

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A B S T R A C T

The northeastern coast of the Lake Van (Eastern Anatolia-Turkey) is exposed to energetic waves, inducing large sediment transport rates. Intense wave activity on coastal environment shows the shaping impact on the shoreline either erosional or depositional processes. Sedimentation is characterized by gravelly beaches, spit formation, and barrier-lagoon complex. Çolpan barrier and lagoon complex forming the subject of this study occurred in these swashed environmental conditions. This study aims to introduce formation and evolution of the Çolpan barrier and lagoon complex and to assess the future development of the coastal area around the Lake Van.

Characteristics of barrier sediments as shape, size, provenance, sedimentary structures, and palaeocurrent directions are determined with field investigations. Smooth, flattened, and rounded polygenetic sediments compose the barrier drifted to the shoreline with coastal processes as wave and longshore currents. Çolpan barrier was created a lagoon completely isolated from Lake Van. This wetland constitutes a habitat for some animals and plants with relatively dilute water than sodic Lake Van's. Water level fluctuation is an important element for the constructive and destructive processes for the barrier and lagoon complex.

1. Introduction

Lacustrine basins are sensitive to climatic (global and local), tectonic, and sedimentological changes, providing clear sedimentary records about them (Van Houten, 1964; Picard and High, 1972; O'Sullivan, 1983; Anadón et al., 1991; Bradbury and Dean, 1993; Itkonen, 1997). Lake shore sub-environments like delta, lagoon, and beach are highly susceptible to coastal processes as waves, lake shore currents, and lake level fluctuations (Street-Perrott, 1980; Oviatt et al., 1994; Kaplin and Selivanov, 1995; List et al., 1997; Adams and Wesnousky, 1998; Zhang et al., 2011; Adlam, 2014; Haghani et al., 2016; Sato et al., 2016). Shore deposits are generally composed of loose, unconsolidated sediments, ranging from very fine sand up to pebbles and cobbles in terms of sediment size (Carter and Woodroffe, 1994; Storms et al., 2002; Moore et al., 2010; Monge-Ganuzas et al., 2015). They receive their sediments from rivers draining a catchment area and the erosion of nearby cliffs and foreshore outcrops. Fault activity in the hinterland increases fluvial sediment capacity transported to the coastal area.

Shore systems deal with the interactions between depositional and erosional processes as waves, currents, rivers, tides, and winds (Galloway and Hobday, 1996; Chempalayil et al., 2014; Wu and Lin, 2014; Lu et al., 2015). The shape of shore systems can change either rapidly or very slowly to prograding (favour to deposition or erosion) or cyclic (returning to the same arrangement over different periods) (Boyd et al., 1992; Bird, 1994). Barrier spits are one of the best examples found on the shores of seas and lakes where the predominant direction of longshore drifting by waves arriving obliquely to the shore. Barrier spits often form at the mouths of lagoons, estuaries, and other places where the coast orientation changes (Bird, 1994; McBride et al., 2013; Shan et al., 2015).

Lake Van is a closed-basin lake located in the southernmost part of the Eastern Anatolian Plateau (Fig. 1a). The shoreline of Lake Van has undergone significant modification associated with water level changes related to climatic conditions and tectonism since its formation (Valeton, 1978; Landmann et al., 1996a; Kuzucuoğlu et al., 2010; Görür et al., 2015). Numerous studies have been carried out in terms of formation and sedimentological evolution (Wong and Degens, 1978; Çukur et al., 2013; Sumita and Schmincke, 2013a, b; Baumgarten et al., 2014; Çağatay et al., 2014; Stockhecke et al., 2014a,b), palynology and geochemistry of ancient and modern lacustrine sediments (Degens et al., 1984; Wick et al., 2003; Huguet

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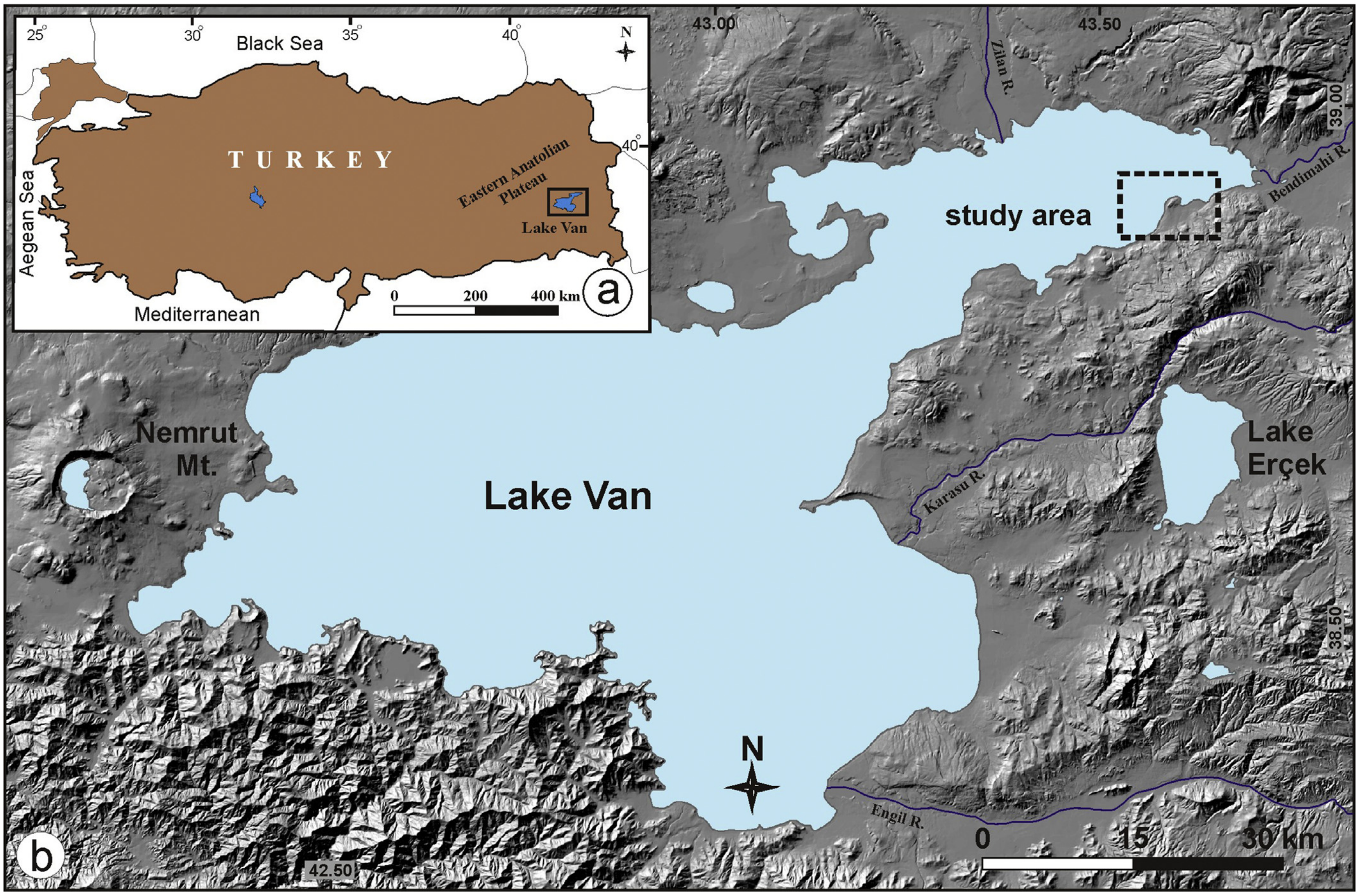

Fig. 1. Location maps of the study area; (a) Eastern Anatolian Plateau and (b) Lake Van Basin.

et al., 2011; Tomonaga et al., 2011, 2012; Kaplan, 2013; Litt et al., 2014; Randlett et al., 2014; Pickarski et al., 2015; Damcı and Çağatay, 2016; Makaroğlu et al., 2016), and hydrology of the Lake Van (Landmann et al., 1996a,b; Landmann and Kempe, 2005; Reimer et al., 2009; Kaden et al., 2010; Düzen and Aydın, 2012; Aydın and Karakuş, 2016), but none of them deals with the shore systems. Lack of the morphological and sedimentological studies about shore systems obstruct the remarking about coastal processes in the Lake Van region.

Çolpan lagoon is a wetland, located on the north-eastern part of the Lake Van (Fig. 1b), completely isolated from the Lake Van by a barrier (Üner, 2016). Vertical profile of the barrier is clearly observed by the water level drop after the barrier formation. This case study aims to describe the formation and evolution of the barrier and lagoon system with sedimentological and hydrological data at the northeastern coast of the Lake Van and assess the impact of water level changes on Çolpan lagoon. This study will also help to the understanding of similar areas both around the Lake Van and similar conditions around the World.

2. Geological setting

The East Anatolian Plateau emerges from the collision between the Eurasian and Arabian plates in the eastern Mediterranean region (Şengör and Yılmaz, 1981). Numerous basins were formed by this compressional tectonism, including the Pasinler, Muş, and Lake Van basins (Şaroğlu and Güner, 1979). The Lake Van basin is situated on basement rocks consisting of Mesozoic metamorphic rocks, Triassic limestones, Upper Cretaceous ophiolites, and Miocene turbidites. These rocks are unconformably overlain by Quaternary volcanics and coeval lacustrine sediments. The basin infilling ends with Late Quaternary travertines and recent unconsolidated fluvial sediments (Aksoy, 1988; Acarlar et al., 1991) (Fig. 2).

The Lake Van was formed c.a. 600 ka ago in the Lake Van basin (Stockhecke et al., 2014a,b). It is the largest soda lake in the world, with a surface area of around 3570 km^2, volume of 607 km^3, and depth of 451 m (Kempe et al., 1978). It has 9.8 pH and 22–23‰ salinity (Reimer et al., 2009; Kaden et al., 2010; Tomonaga et al., 2012). Ancient lacustrine and coastal deposits are situated at the east and north of the lake, indicating larger coverage area than today (Degens et al., 1978; Kuzucuoğlu et al., 2010; Görür et al., 2015).

Water budget of the Lake Van is related with surface waters (e.g. Engil, Karasu, Bendimahi, Zilan rivers), precipitation, groundwater recharge, snowmelt, and evaporations. Annual variation on these climatic elements may oscillate the lake level up to 90 cm (Degens and Kurtman, 1978; Kaden et al., 2010; Stockhecke et al., 2012). Freshwater input to lake changes the water chemistry especially in shallow coastal areas. Some plants and animals (e.g. reeds and turtles) can survive in alkaline lake water due to this freshwater feeding.

3. Material and methods

Geological part of the study is composed of mapping and sedimentological data collection while hydrological part forms the determination and correlation of physical properties of lagoon and lake waters.