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## Aeolian control on the deposition of high altitude lacustrine basins in the Middle East: The case of Lake Neor, NW Iran

Nizamettin Kazancı <sup>a,\*</sup>, Tirzad Gulbabazadeh <sup>b</sup>, Suzanne A.G. Leroy <sup>c</sup>, Zeynep Ataselim <sup>a</sup>, Alper Gürbüz <sup>d</sup>

<sup>a</sup> Ankara Üniversitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü, 06100 Tandoğan, Ankara, Turkey

<sup>b</sup> Department of Geology, Payame Noor University, PO BOX 19395-3697, Tehran, Iran

<sup>c</sup> Environmental Sciences, Brunel University London, Uxbridge UB8 3PH, UK

<sup>d</sup> Niğde Üniversitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü, 51240 Niğde, Turkey

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### ABSTRACT

Lake Neor is the largest lacustrine basin in the high mountains of the Middle East, at 2500 m altitude in the Alborz belt. This lake of Holocene age is a shallow, fresh water body of glacial origin with ca 4 km<sup>2</sup> surface area and a 40 km<sup>2</sup> drainage area. Its sedimentary sequence comprised of peat and gyttja consists of >10 m infill, which is fairly thick for such a lake. Autochthonous organic matter is limited in and around the lake except for small areas at the northern and southern ends. Inorganic constituents of the infill sediment include a significant amount of fine-grained calcite, dolomite and mica particles that are exotic to the catchment. They do not occur in the source rocks, as the drainage area of the lake is composed of only andesites and trachyandesites of Eocene age. In addition, the uppermost part of the infill includes abundant fine-grained charcoal particles derived from large forest fires perhaps derived as far as the Mediterranean region. As shown by the present meteorological records, the sediment of Lake Neor is under aeolian control during dust storms; this is leading to a considerable amount of deposition air-borne particles. The infill of some lakes, particularly those in highlands, may have contain an important aeolian component and thus they cannot be used directly for the interpretation of the evolution of the palaeogeography without taking into consideration the role of dust storms on deposition.

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### 1. Introduction

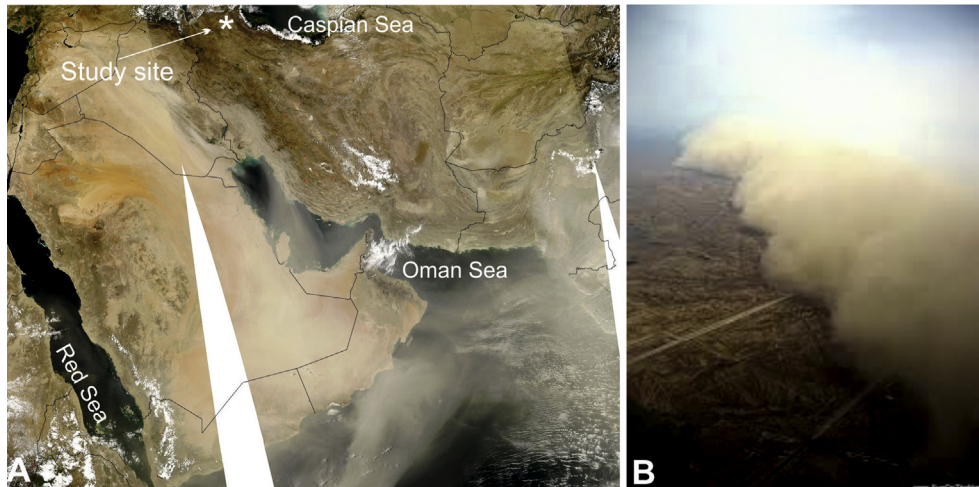
Aeolian impact and dust storms that are the results of strong winds are common earth-surface processes for both sediment transportation and deposition. Particles can be moved long distances by, for example, winds from central Africa to Arctic regions and they can be deposited either by trapping or settling in various places depending heavily on wind direction (Nickling, 1994; Sleewaegen et al., 2002). As a part of climate, particularly in dry periods, dust storms have modified environment and impacted civilisations (Roberts et al., 2011; Albani et al., 2015; Sharifi et al., 2015). At present, central Asia, the Sahara and the Middle East are the regions most affected by wind storms ([www.earthobservatory.nasa.gov/naturalhazards](http://www.earthobservatory.nasa.gov/naturalhazards)) (Fig. 1). When considering extensive sand dunes and loess deposits in the geological record, lakes should

include a considerable amount of aeolian deposits. However, their amount, particularly in large lakes located on lowlands, could be negligible as the drainage areas of such lacustrine basins are also large and can provide much alluvial sediment. In addition, distinguishing aeolian sediments in lakes from ordinary lacustrine sediments is extremely difficult as there are no strict criteria (An et al., 2012). On the other hand, aeolian effects on deposition in lakes with small drainage areas cannot be negligible as a major part of their infill could be provided by dust storms. Because high altitude or highland lakes are generally small, their drainage areas are often limited (Stoch, 2006). Lake Neor, to be introduced in this study, is a good example of a high altitude lake located in a dusty region of the Middle East (Figs. 1 and 2).

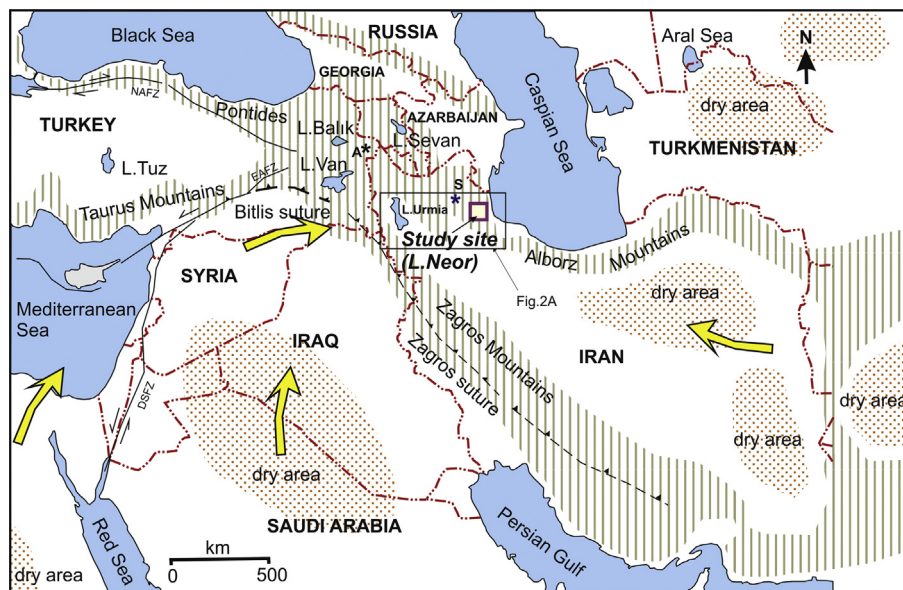
The term “high altitude lake” is widely used, but it is not well described. Here we use the lower boundary of the alpine zone as the limit for highland lakes for the Middle East region, as it corresponds to the timberline (Noroozi et al., 2008). The alpine zone, according to ecological variations, is generally over 2000 m a.s.l.

\* Corresponding author.

E-mail address: [nkazanci@ankara.edu.tr](mailto:nkazanci@ankara.edu.tr) (N. Kazancı).



**Fig. 1.** Dust plumes in southern part of the Middle East. A) a day with moderate dust (8 March 2008) at the Gulf of Aden ([www.earthobservatory.nasa.gov](http://www.earthobservatory.nasa.gov)), B) view from ground of a usual dust storm on 22 April 2014 in Qatar (QatarCare News letter, 23 April of 2014).



**Fig. 2.** Location of the study site and main tectonic elements of the region. Note that the each mountain belt represents more than one tectonic complex. Large arrows show dominant directions of dust storms (Kutiel and Furman, 2003; Anonymous, 2005). DSFZ Dead Sea Fault Zone, EAFZ East Anatolian Fault Zone, NAFZ North Anatolian Fault Zone, A Mount Ağrı, S Mount Sabalan.

with slight variations depending on latitude and humidity (Troll, 1973). With regard to high-altitude lakes, these conditions are mainly associated with glaciers, but flank collapses like landslides, alluvial deposits and debris cones may also play important roles. Although rare, lakes in karst or tectonic basins, and those associated with discontinuous tongues of permafrost, are not unusual. High altitude lakes are relatively small basins except for a few larger ones in the Andes (lakes Titicaca and Poopo), and in the Himalayas on the Tibetan plateau (lakes Pangons Tso, Bangong Co, Tsongmo and Aksayqin Hu). Such lakes in the alpine zone are proxies for the understanding of permafrost characteristics of the cold regions (e.g. Giralte et al., 2004; Liu et al., 2010) and for atmospheric depositions (e.g. Tait and Thaler, 2000; Rogora et al., 2001; Clow et al., 2002; Mosello et al., 2002). However, a large knowledge gap exists concerning sedimentation in high altitude lakes. The aim of this paper is to present sediment characteristics, particularly typical aeolian grains in the basin and the role of dust storms on deposition in high

altitude lakes, using Lake Neor as a case study located at ~2500 m on the Alborz Mountains in NW Iran (Figs. 2 and 3).

## 2. General setting

The northern part of the Middle East (including Eastern Turkey and northwest Iran) forms a crossing point of four major mountain belts called the Pontides, the Taurides, the Alborz and the Zagros (Fig. 2). This mountainous region includes large volcanic centres, high plateaus and well-studied large lakes such as L. Van, L. Urmia, L. Sevan (Kelts and Shahrabi, 1986; Mohajjel and Taghipour, 2014; Stockhecke et al., 2014 and references therein). Also, many small, high-altitude lakes occur here (name of a city in eastern Turkey is “Bingöl”, which means one thousand lakes), but only Lake Neor and Lake Balik amongst them include significant sediment infill. The latter (Fig. 2) is a relatively large fresh water body (54 km<sup>2</sup>) at

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