JOURNAL OF QUATERNARY SCIENCE (2021) 36(4) 598–610 ISSN 0267-8179. DOI: 10.1002/jqs.3310

JQS Journal of Quaternary Science QRA

Lake Neor reveals how mountain vegetation responded to 7000 years of hydroclimate variability in northwestern Iran

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Received 10 July 2020; Revised 9 March 2021; Accepted 10 March 2021

ABSTRACT: Palynological and geochemical analyses provide valuable information about modern and past climatic regimes and vegetation. The impact of climate and humans on past vegetation in the semi-arid areas of northwestern Iran has received increased interest in the wake of warming temperatures in the Middle East. Palynological and down-core XRF elemental abundances from a peat core from Lake Neor enabled a reconstruction of vegetational changes of the past 7000 years over the highlands of northwestern Iran. Periods of increased arboreal pollen (AP) types and high (*Artemisia*+Poaceae)/Chenopodiaceae ratios along with low titanium abundances, high percentages of total organic carbon, more negative δD values, and higher carbon accumulation rates suggest a relatively wet climate. These conditions have persisted during the periods 6700–6200, 5200–4450 and 3200–2200 cal a BP. The overall low AP values, substantial rise of Chenopodiaceae, high Ti abundances and low values of palaeo-redox proxies, are all evidences of a drier climate, as has been reconstructed for the periods 6200–5200 and 4030–3150 cal a BP and the last 2200 years. An important feature of the last centuries is the increase of anthropogenic and pastoral indicator pollen types. Our results may provide basic data to predict future trends in vegetation dynamics under future climate change in western Asia. Copyright © 2021 John Wiley & Sons, Ltd.

KEYWORDS: climate change; Holocene; Irano-Turanian vegetation; Peatland; PCA

Introduction

The area in west Asia that covers modern Turkey, the Caucasus and Iran is home to rich and highly diverse flora (Mittermeier *et al.*, 2011; Frey *et al.*, 1999; Zohary 1973). The Iranian northwest, in particular, has attracted the attention of a number of investigators who pursue the history of human activities in the region (van Zeist and Bottema 1977; Bottema 1986; Klein and Lacoste 1995; Djamali *et al.*, 2009; Ponel *et al.*, 2013; Ramezani *et al.*, 2020) and its floral diversity (Zohary 1973; Assadi 1998; Ghahremaninejad *et al.*, 2012). Understanding the relationship between climate, environmental and human factors that shaped the vegetation of the past is key to reconstructing the origin, history and trajectories of existing terrestrial ecosystems in this region (Birks 2012; Dearing 2006). Multiproxy palaeoecological studies are particularly helpful in developing a comprehensive framework of the forces and responses that drive environmental transformations over extended periods of time (Zachary*et al.*, 2010).

Among terrestrial environments, peatlands have shown great potential to preserve high-resolution archives of changes in palaeoecological conditions. They have been used to reconstruct abrupt changes in climatic and environmental conditions during the late Quaternary, particularly the Holocene, as well as the human impact on natural vegetation (Barber 1981; Martini *et al.*, 2006; Muller *et al.*, 2008; van Geel and Mauquoy 2010; Naafs *et al.*, 2017). Palaeoenvironmental investigations in peatlands using palynological and/or geochemical proxies have revealed the relationships between climate change, vegetation dynamics and human impact across western Asia, including the Iranian Plateau, during the Last Glacial period and the Holocene (Djamali *et al.*, 2008; Kuzucuoğlu *et al.*, 2011; Woodbridge and Roberts 2011; Ponel *et al.*, 2013; Ramezani *et al.*, 2020; Sharifi *et al.*, 2015; Talebi *et al.*, 2016).

A seminal palynological study based on the sediments of Lake Urmia in northwest Iran (Fig. 1a) was presented in Bottema (1986), in which the dominant vegetation and climate history of the area was reconstructed for the periods of the Late Glacial and the Holocene. The Lake Urmia pollen record from that study shows that the region was covered by steppe vegetation prior to 9000 BP, dominated by various *Artemisia* species. A relative increase in precipitation triggered forest-steppe development during the time interval of 9000–8000 BP. The present vegetation type in the area has been established since 7000 BP. Forest vegetation development in eastern Turkey and western Iran in the Early Holocene was partially delayed compared with the southwestern coastal areas of Asia (Wright *et al.*, 1967; Roberts *et al.*, 2001; Djamali *et al.*, 2010). The eastern Mediterranean region experienced stronger precipitation seasonality than eastern Turkey and western Iran

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