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Pleistocene terrace deposition related to tectonically controlled surface uplift: An example of the Kyrenia Range lineament in the northern part of Cyprus

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ABSTRACT

In this study, we consider how surface uplift of a narrow mountain range has interacted with glacial-related sea-level cyclicity and climatic change to produce a series of marine and non-marine terrace systems. The terrace deposits of the Kyrenia Range record rapid surface uplift of a long-lived tectonic lineament during the early Pleistocene, followed by continued surface uplift at a reduced rate during mid-late Pleistocene. Six terrace depositional systems are distinguished and correlated along the northern and southern flanks of the range, termed K0 to K5. The oldest and highest (K0 terrace system) is present only within the central part of the range. The K2–K5 terrace systems formed later, at sequentially lower levels away from the range. The earliest stage of surface uplift (K0 terrace system) comprises lacustrine carbonates interbedded with mass-flow facies (early Pleistocene?). The subsequent terrace system (K1) is made up of colluvial conglomerate and aeolian dune facies on both flanks of the range. The later terrace systems (K2 to K5) each begin with a basal marine deposit, interpreted as a marine transgression. Deltaic conglomerates prograded during inferred global interglacial stages. Overlying aeolian dune facies represent marine regressions, probably related to global glacial stages. Each terrace depositional system was uplifted and preserved, followed by subsequent deposits at progressively lower topographic levels. Climatic variation during interglacial–glacial cycles and autocyclic processes also exerted an influence on deposition, particularly on short-period fluvial and aeolian deposition.

1. Introduction

The combined study of shallow-marine, fluvial, and aeolian sediments can provide clear insights into the interplay of tectonics, eustatic sea-level change, and climatic change. Numerous studies have considered the allocyclic versus autocyclic controls of Pleistocene fluvial systems in the Mediterranean, for example, in southern Spain (Stokes and Mather, 2000). In addition, the tectonic versus climatic controls of Pleistocene coastal-marine and aeolian terrace deposits have been the focus of numerous studies, as in Rhodes (Titschack et al., 2005), Mallorca (Nielsen et al., 2004), and west Sardinia (Andreucci et al., 2009). However, few of these studies have shed much light on how shallow-marine, fluvial, and aeolian systems interact in response to tectonically controlled uplift during a period of eustatic sea-level change and associated climatic change.

The Pleistocene sedimentary geology of northern Cyprus provides an excellent example of how tectonically controlled surface uplift can exert a dominant control on sedimentation. Comparable studies, as in Spain (Zazo et al., 2003), west Sardinia (Andreucci et al., 2009), and Syria (Dodonov et al., 2008), have mostly focused on relatively short time periods, commonly the late Pleistocene (126 to 5 ka). However, this study provides an unusual opportunity to investigate the entire Pleistocene record in a single area of ongoing surface uplift.

The main aim of this paper is to present and discuss the results of an integrated study of successively raised marine and continental terraces, as exposed on both flanks of the Kyrenia Range in the north of Cyprus. Our specific objectives are (1) to explain the nature and distribution of the terrace deposits on the northern and southern flanks of the range based on sedimentary facies and petrographic evidence, (2) to describe and interpret the various marine and non-marine facies that are associated with each of the raised terrace deposits, (3) to evaluate different processes that have interacted to form each of the raised terrace deposits, and (4) to outline a depositional-tectonic model for terrace deposits in the light of tectonic, eustatic sea-level, and climate-related processes. Our results are potentially applicable to comparable regions of rapid surface uplift of near coastal areas elsewhere. Supporting information, including terrace correlation and geochronological data, are presented elsewhere (Palamakumbura et al., 2016a, 2016b). Specifically, field luminescence profiling has been used to help document sedimentary processes in the lowest and youngest terrace deposits (Palamakumbura et al., 2016a). Also, several types of dating have been undertaken to constrain the rate and timing of surface uplift of the Kyrenia Range (Palamakumbura et al., 2016b). The depositional

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age model produced by this companion study provides a framework to help understand the sedimentary development of the raised terrace systems.

2. Influences on sedimentary development

Regions that combine coastal and fluvial terraces and which span the Pleistocene as a whole are relatively rare, and the Kyrenia Range is exceptional in this regard. The Kyrenia Range is a narrow (ca. 5 km- wide), elongate mountainous lineament, which is ca. 160 km long and up to 1024 m high (Fig. 1b). Marine and non-marine Pleistocene facies interfinger on the northern flank of the range, whereas exclusively non-marine Pleistocene deposits occur on the southern flank. Pleistocene tectonic uplift has resulted in older deposits being preserved at progressively greater heights above mean sea level (AMSL), allowing facies of different age to be distinguished without overlap. The geology of the Kyrenia Range is well known (e.g., Ducloz, 1965; Baroz, 1979; Robertson and Woodcock, l986; McCay et al., 2012), allowing detrital sediment provenance to be easily identified. A range of depositional settings, including shallow-marine, aeolian, and fluvial, is preserved within the terraces flanking the Kyrenia Range (Ducloz, 1965; Baroz, 1979). The facies on the northern flank accumulated in a setting that was open to the sea to the north, whereas those on the southern flank form part of the intermontane (Mesaoria (Mesarya)) basin, which is itself bordered by the Troodos ophiolitic massif to the south (Fig. 1b). This allows terrace sedimentation in both marine and non-marine settings to be compared in a common tectonic setting.

Given that the terrace deposits accumulated during a period of surface uplift (Palamakumbura et al., 2016b), it is probable that tectonic processes significantly influenced their sedimentary development. In addition, the eastern Mediterranean is located at the intersection of several different climatic systems related, respectively, to continental Europe to the north (Mosbrugger et al., 2005), monsoon-influenced Asia to the east (Clift, 2006), continent-influenced North Africa to the south (Trauth et al., 2009), and the Atlantic Ocean-influenced region to the west (Ford and Golonka, 2003). The interaction of these climatic systems has had a strong influence on Pleistocene deposition in the eastern Mediterranean region (Kasse, 2002; Starkel, 2003; Cornée et al., 2012; Kober et al., 2013), including Cyprus (Waters et al., 2010; Main et al., 2016). Tectonic uplift, eustatic sea-level change, and climatic change, therefore, have to be taken into account in any interpretation of the terrace development.

3. Geological setting

The Pleistocene deposits discussed here occur extensively along both flanks of the Kyrenia Range and at its western and eastern extremities (Fig. 1b). An understanding of the pre-Pleistocene geology is critical to any interpretation of the provenance of the Pleistocene terrace deposits. The central segment of the Kyrenia Range (Fig. 1b) is dominated by Mesozoic metacarbonate rocks, whereas the eastern range is characterised by Cenozoic pelagic limestones, basic volcanic rocks, and large-scale debris-flow deposits (olistostromes). The outer flanks of the range are made up of late Eocene to late Miocene siliciclastic

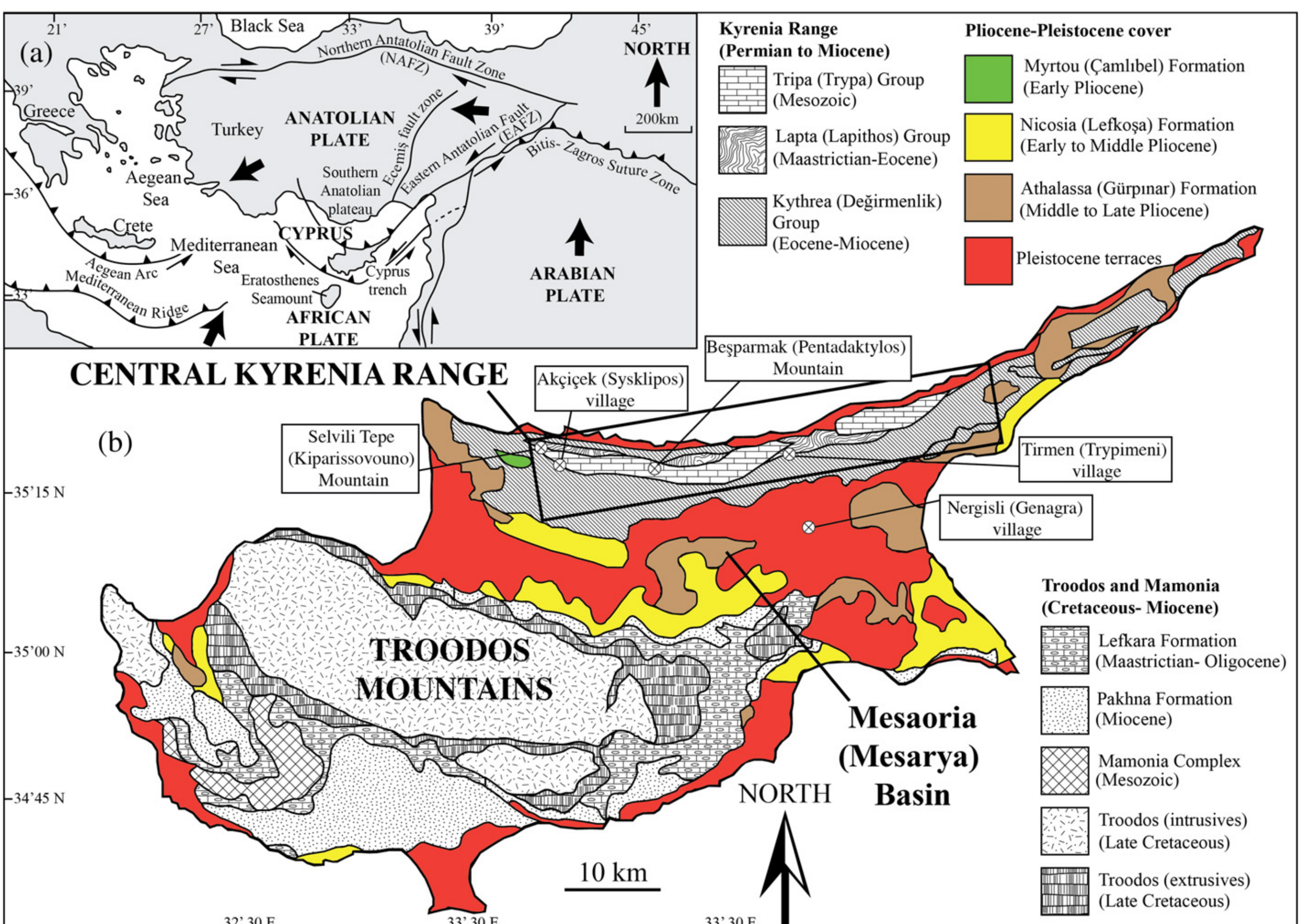

Fig. 1. (a) Summary tectonic map of the Eastern Mediterranean during the Pleistocene and (b) simplified geological map of Cyprus with emphasis on the distribution of Pliocene and Pleistocene deposits; modified after McCay et al. (2012) and McCay and Robertson (2012b).