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Stable isotope geochemistry of Quaternary calcretes in the Mersin area, southern Turkey – A comparison and implications for their origin

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ABSTRACT

In the Mersin area, Quaternary calcretes are widespread, and occurred in a variety of forms, as namely powdery, nodular, tubular, fracture-infill, laminar crust, hard laminated crust (hardpan), pisolithic crust. They are predominantly calcite, and small amount of palygorskite associated with them as a minor component. Calcite $\delta^{18}O$ and $\delta^{13}C$ values of the calcretes vary from −4.31 to −6.82 and from −6.03 to −9.65‰ PDB, respectively. These values are consistent with values of pedogenic calcretes reported in literature from worldwide sites. The oxygen isotope values indicate formation under the influence of meteoric water at estimated temperatures from 25 to 32 °C. The carbon isotope values are typical for pedogenic calcretes, reflecting development under the C3-dominated vegetation cover and semiarid or seasonally arid climatic conditions.

1. Introduction

Calcrete (syn. caliche) is defined as a product of terrestrial processes within the zone of weathering in which calcium carbonate ($CaCO_3$) has accumulated in and/or replaced a pre-existing soil, rock, sediment or weathered material to give a substance which may ultimately develop into an indurated mass (Goudie, 1973; Salomons et al., 1978; Wright and Tucker, 1991). It occurs in a variety of forms, and is characteristic of arid and semi-arid climates (James, 1972; Goudie, 1973, 1983; Tucker, 1991). There are two basic models to explain the calcrete formation. These are pedogenic calcretes forming in soil profiles, beneath soils in the vadose zone, and groundwater (or phreatic) calcretes developing around the water-table (Wright and Tucker, 1991). A huge amount of literature exists on various aspects of calcretes such as general reviews, calcrete profiles and their origin, biogenic features, geochemistry including stable isotopes, paleoclimate, associated authigenic clays and hardpan morphology. In contrast to the world, there is a little information available concerning calcretes in Turkey despite their extensive occurrence especially in the Adana and Mersin regions. The previous studies describe variations in calcretes with toposequences and their evolution in the Adana Basin (Kapur et al., 1990) and in southern Anatolia (Atalay, 1996; Kapur et al., 2000), calcretes in the Misis area of the Adana Basin (Kapur et al., 1993), in the Kırşehir region (Atabey et al., 1998), and in the Mersin area (Eren et al., 2008), micromorphology of calcrete column in the Adana Basin (Kapur et al., 1987), associated authigenic clays (Kadir and Eren, 2008), hardpan morphology (Eren, 2007) and hardpan karst surface features (Eren and Hatıpoğlu-Bağcı, 2010). For the first time, this study represents the stable isotope composition of calcretes in the Mersin area and also in Turkey, and interpretes the environmental conditions under which the calcretes formed. Moreover, the study attempts to compare the stable isotope values of calcretes in the Mersin area with those of calcretes worldwide. In the world, the comparative studies are very limited (Salomons et al., 1978; Talma and Netterberg, 1983).

2. Geological setting

The study area is located on the western flank of the Adana Basin (Fig. 1) which is one of the major Neogene basins next to the Tauride orogenic belt (Yalçın and Görür, 1983). In the basin, a thick sedimentary package ranging in age from Burdigalian to Recent unconformably overlies the Palaeozoic and Mesozoic basement rocks (Yetiş, 1988; Yetiş et al., 1995). In the study area, Tertiary and Quaternary units are present (Figs. 2 and 3). The Tertiary units are the Karaisalı Formation (Burdigalian-Early Serravalian), the Güvenç Formation (Burdigalian-Serravalian) and the Kuzgun

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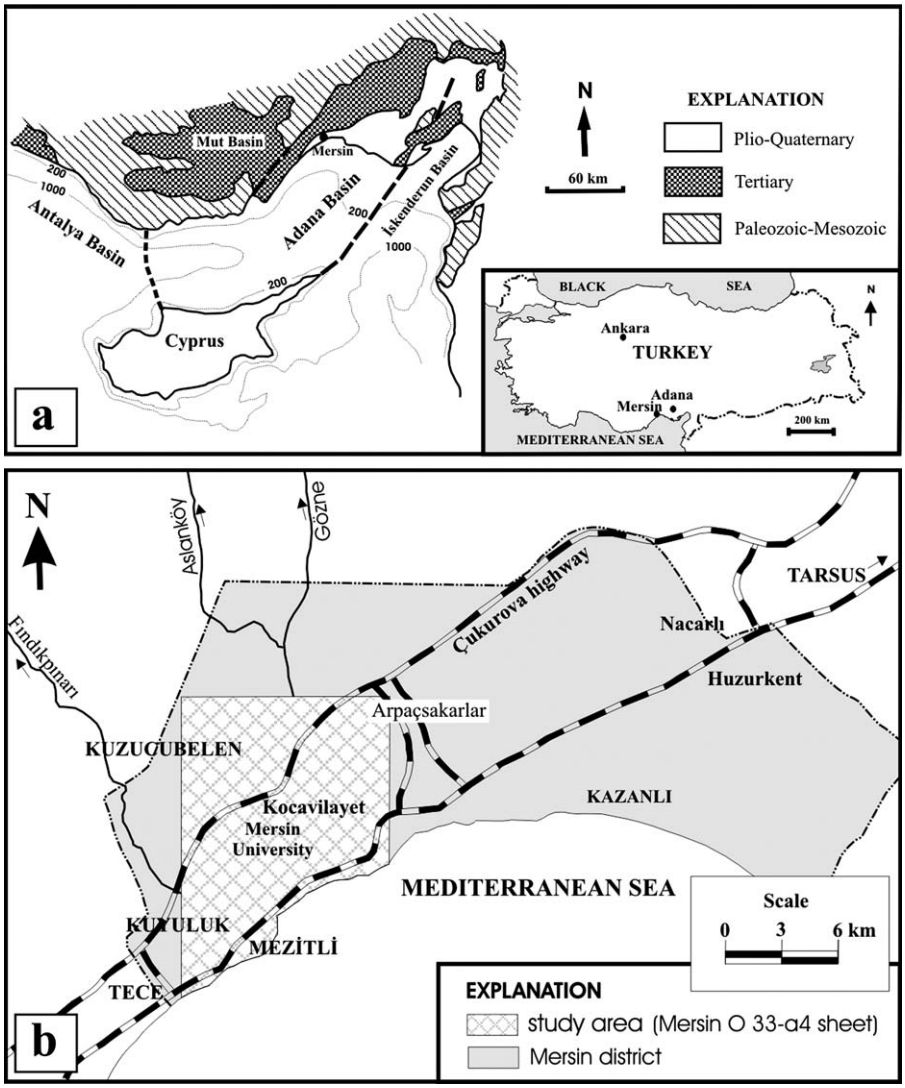

Fig. 1. Location maps showing (a) the Adana Basin and (b) the study area.

Formation (Tortonian). The Quaternary units involve a hard laminated crust (hardpan calcrete), deltaic deposits, pebbly alluvial red soils (colluvium) and recent alluvium/terrace.

Eren et al. (2004, 2008) provide detailed information on calcretes in the Mersin area where they are widespread and form in a variety of forms such as powdery, nodular, tubular, fracture-infill, laminar crust, hard laminated crust (hardpan), pisolithic crust. The hard laminated crust (calcrete hardpan) occupies large areas (Fig. 4) and appears as wavy crust on the small ridges and highs, forming a terrace-like morphology at topographics levels of 20–250 m. The calcrete hardpan covers the lithologically different beds of the Kuzgun Formation (Fig. 2) and also remains of alluvial materials in erosional troughs. It is typically cream coloured, evenly discontinuous laminated, indurated, wavy horizon of calcium carbonate with an average thickness of 1–1.5 m. The carbonate crust represents a sharp upper surface and gradational lower surface, passing into isolotaded calcrete horizon (softpan; Fig. 4), comprising white coloured powdery, nodule, tube, and fracture-infill. In the study area, the pisolithic crust is only found in one restricted place at the Taşlıseki site, and consists of pisolithes which are inversely graded, poorly sorted, brown in colour, and spherical to subspherical in shape with a size of 2 mm to 6 cm. The calcrete samples consist of mainly calcite associated with minor smectite and palygorskite and accessory quartz, feldspar, illite and dolomite.

The age of the calcretes in the Mersin area is based on the previous studies. ESR and TL dating methods by which calcretes in the Adana region were dated from 250 to 782 ka BP (Özer et al., 1989; Atalay, 1996), corresponding the middle Pleistocene time. This age is also accepted for the calcrete formation by Kapur et al. (1987, 1990, 1993, 2000) for the Adana region and Eren et al. (2008) for the Mersin area.

3. Materials and methods

A total of 24 samples were collected from different localities in plastic bags characterizing different calcrete forms such as hard laminated crust, nodule, tube, fracture-filling and pisolithic crust. For stable isotope analysis, outer parts of samples were scraped, and then washed 1 N HCl for very short time to remove any exterior detrital sediments. After cleaning process, small pieces were broken from the center of individual samples. Stable isotope measurements were performed on powdered samples using a Finnigan MAT 252 isotope ratio mass spectrometer at the isotope laboratory of the Southern Methodist University (SMU), Dallas, Texas, USA. Powdered samples of 5–10 mg were reacted with 100% phosphoric acid (H_3PO_4) at 50 °C to release CO_2 required for isotope analyses. Replicate analyses of the randomly selected samples provided a mean deviation of ±0.05‰ PDB for $\delta^{18}O$