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Geochemical monitoring of clays for diagenetic evolution of the Paleozoic–Lower Mesozoic sequence in the northern Arabian plate: Hazro and Amanos regions, Southeastern Turkey

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ABSTRACT

Clay minerals in the diagenetic/very low-grade metamorphic–sedimentary series from southeastern Anatolia in Turkey were analyzed to determine their mineralogical and chemical compositions. In the Amanos region, the lowermost unit is composed of metaclastics with primary clastic textures, as well as slaty cleavages and chlorite-mica stacks including volcanic rock intercalations. The Lower Cambrian is composed of mainly very low-grade metamorphic clastic rocks, while the Ordovician units have silicic-clastic and carbonate rocks. In the Hazro region, the Late Silurian–Lower Triassic units are represented by highly diagenetic carbonate and clastic rocks. All of the rock units include illite. In addition, chlorite, mixed-layered illite–chlorite and chlorite–vermiculite are present in the Amanos region, while calcite, dolomite, kaolinite, mixed-layered illite–smectite (I–S) and glauconite occur in the Hazro region. The illites are characterized by the dominance of $2M_1$ polytype in the Amanos samples; and $1M_d + 2M_1$ in the Hazro samples. The I–S, glauconite and kaolin have R1 and R3, $1M$ and kaolinite polytypes, respectively. The illites have greater tetrahedral and lower octahedral substitutions than the I–S. Total trace element contents, elemental substitutions and chondrite-normalized trace element and *REE* values decrease toward illite–I–S–kaolinite. There are obvious fractionations for some major – trace and rare earth elements with respect to each other and clear enrichment with respect to the chondrite, with strong anomalies of positive for Gd and negative for P, K and Eu in the clay minerals. The textural, morphological and geochemical data indicate that kaolinite and I–S in the Hazro area occur in supergene conditions with due to a full neoformation mechanism, whereas illites in the Amanos region represent the hypogene origin. In brief, the K_2O contents, ratios of Eu/Eu^* and La_N/Lu_N and $\delta^{18}O$ and δD values of I–S and illite exhibit notable relationships with increasing diagenetic/metamorphic grade.

1. Introduction

Diagenetic and very low-grade metamorphic processes such as re-crystallization, authigenesis, and transformation affect the texture, mineralogy, and geochemical characteristics of rocks. The interlayer and layer charges of clays increase due to substitutions in tetrahedral and octahedral sheets during the progressive ordering and conversion of clay minerals, together with increasing degree of diagenesis–very low-grade metamorphism (e.g., Lippmann, 1982; Peacor, 1992). Trace- and rare-earth-element (*REE*) compositions of clay minerals have been used in many studies to determinate provenance and sedimentary processes (Fleet, 1984; Mclennan, 1989; Condie, 1991) and to evaluate diagenetic/metamorphic grades (Milodowski and Zalasiewicz, 1991; Ohr et al., 1994). Moreover, stable-isotopic (O and H) compositions of smectitic, illitic and kaolinitic clays from sedimentary environments may reflect some thermal events during diagenetic/metamorphic processes (e.g., Savin and Lee, 1988; Sheppard and Gilg, 1996; Uysal et al., 2000, 2006).

Textural and mineralogical data from late-diagenetic-, low-grade metamorphic sedimentary sequences from southern Turkey provide important information on the diagenetic/metamorphic evolution and geotectonic setting of the sedimentary rocks in the region (e.g., Bozkaya et al., 2002, 2006; Bozkaya and Yalçın, 2000, 2004, 2010). Clay mineralogy characteristics of the Paleozoic–Lower Mesozoic sedimentary cover units of the pan-African basement in southeastern Anatolia have previously been studied (Bozkaya et al., 2009, 2011), but the geochemical properties of these clays have not previously been determined. This study was conducted to investigate the chemical compositions of clay minerals, e.g., diagenetic kaolinites, illite–smectites, and very low-grade metamorphic illites and to determine the relationship between their origin and diagenetic/metamorphic grade. Thus, this study

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will provide some additional information about the formation of clay minerals from the perspective of their origin/provenance and diagenetic evolution.

2. Geologic setting and stratigraphy

The study area is located in Southeastern Turkey, and represents the northern part of the Arabian Plate (Fig. 1a). In this region, several Alpine continental and oceanic terrains are outcropped: from north to south, the Sakarya Composite Belt, the North Anatolian Ophiolite Belt, the Tauride–Anatolide Platform (the Kütahya–Bolkardag Belt, the Central Anatolian Crystalline Complex and the Tauride Belt), the Southeastern Anatolian Ophiolite Belt, and the Southeastern Anatolian Belt (the Bitlis–Pötürge Crystalline Complex and Southeastern Anatolian Autochthon) encompassing the Arabian Plate (Göncüoğlu et al., 1997) (Fig. 1b). The main stratigraphic characteristics of the Southeastern Anatolian Autochthon (SAA) units have been described in previously published studies (e.g., Bozdoğan et al., 1987; Yılmaz and Duran, 1997; Bozkaya et al., 2009, 2011; Ghienne et al., 2011). In this study, the Paleozoic–Lower Mesozoic sedimentary units of the SAA in the Hazro and Amanos areas (MTA, 2002; Fig. 1c and d), which exhibit relatively well-preserved sequences, were investigated. As previously stated by the authors (e.g., Bozdoğan et al., 1987; Yılmaz and Duran, 1997), the lithostratigraphy and the formation names differ in Amanos and Hazro areas.

The Lower Cambrian units of the SAA was outcropped in the Amanos region (Fig. 1), which is formed by mainly very low-grade metamorphic clastic and carbonate rocks (Fig. 2). The lowermost unit (Late Cambrian, Sadan formation) is overlain by the Zabuk, Koruk and Sosink formations of Cambrian age. Ordovician thick siliciclastic sequences (the Seydişehir, Kızlaç and Bedinan formations) conformably overlay these units. The Sadan formation is made up of metasandstone, metasiltstone and slate. The Zabuk

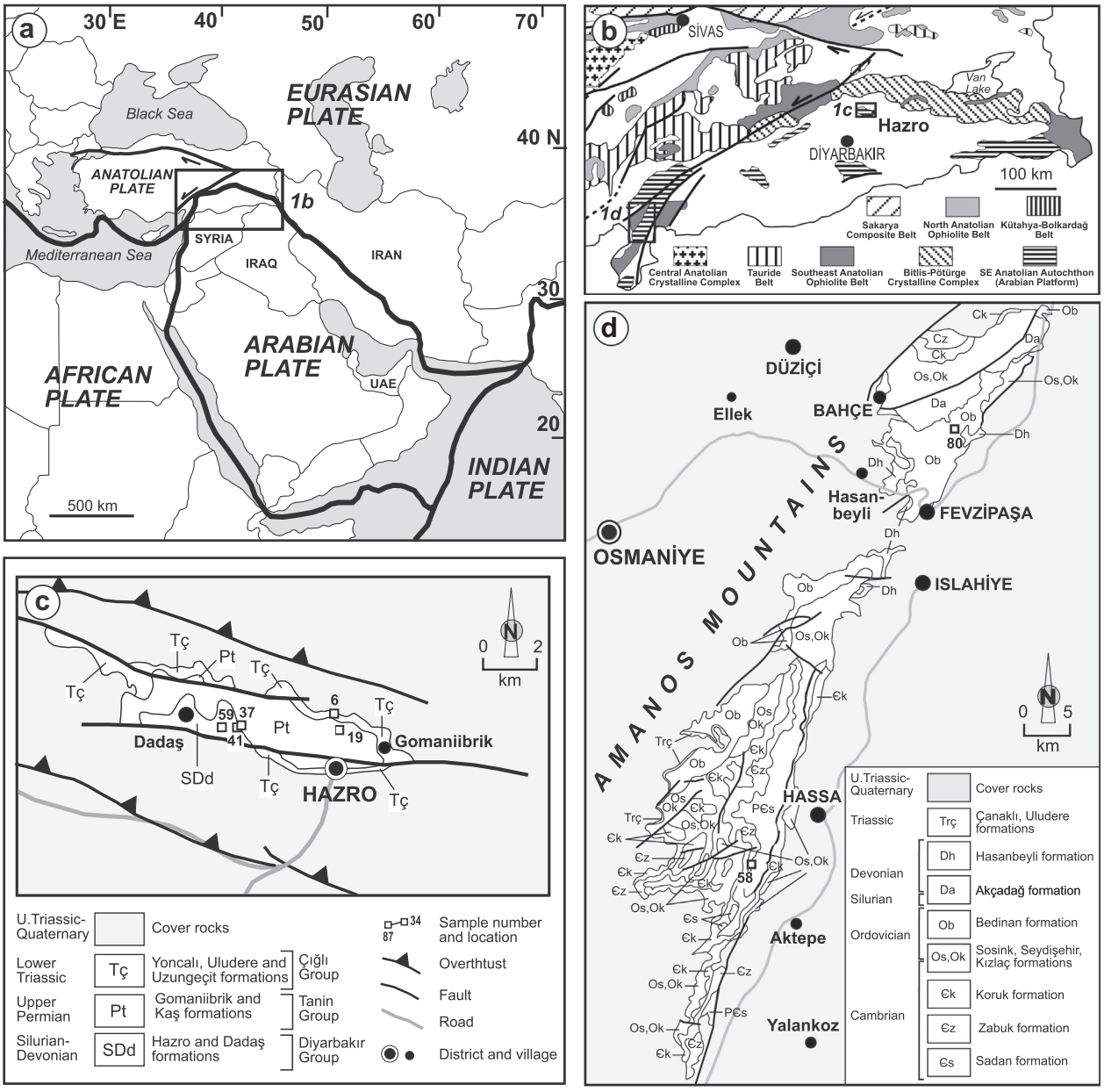

Fig. 1. (a) The geographic setting of Turkey and surrounding countries in terms of the global tectonic plate concept, (b) Tectonic units of Southeastern Turkey (Göncüoğlu et al., 1997), (c and d) Geologic maps of the Hazro and Amanos regions (MTA, 2002).