Diagenetic to very low-grade metamorphic evolution of Precambrian-Mesozoic units in the Sandikli area, Western Taurides, Turkey

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Introduction

Several mineralogical indicators such as mineral assemblages, illite crystallinity (KI), white K-mica *b* cell dimensions, phyllosilicate polytypes etc. have been used to understand the paleo-geographic and tectonic settings and tectono-thermal evolution of diagenetic to low-grade meta-clastic rocks (i.e., Merriman & Frey, 1999; Merriman & Peacor, 1999).

The study area is located in southwestern part of Sandikli area at the junction of western and Central Taurides and comprises the Precambrian basement, its Lower Paleozoic and Mesozoic cover, Hence, it is a key-area to study the metamorphic evolution of the Taurides. The Precam-brian Sandikli Basement Complex (SBC), consist of Güvercinoluk Formation and Kestel Cayi Porphyroid Suite (KCPS: Gürsu & Göncüoglu, 2001 a,b). Lower Paleozoic units (Gögebakan, Hüdai, Caltepe and Seydisehir formations) disconformably covering the SBC constitutes meta-clastic and metacarbonate rocks, which are unconformably overlain by Jurassic Ilyasli and De-realani formations (Figure 1).

The aim of the study is (1) to establish the P/T conditions of metamorphism in the Precambrian-Jurassic rock-units; and (2) to interpret the geological history of the study area by means of the diagenetic-metamorphic data.

Methodology

A total of 154 rock samples were collected from measured sections in the units and analyzed by optical and X-ray diffraction (XRD) methods. To check the possible effect of the late-Alpine thrust-ing on the diagenetic-metamorphic data, samples were collected both from the thrust zone and from the areas not influenced by this event. After sample preparation and clay separation proc-esses, the semi-quantitative percentages of the rock forming minerals and clay-size fractions were calculated. The widths of the 10-Å illite peaks at half-height (Kübler index: KI, $\Delta°2\theta$) were calibrated by using crystallinity index standards (CIS: Warr & Rice, 1994). $d_{(060,331)}$ reflections or *b* cell dimensions of illite/muscovites were measured by means of the (211) peak of quartz (2θ=59.982º, d=1.541 Å) as an internal standard. Illite polytypes determinations and their ratios were determined by the method of Grathoff & Moore (1996).

Results

Petrography

Fine-grained metamorphic biotites are typical in the phyllitic slates, phyllites, metasiltstones and highly deformed rhyolitic-dacitic metavolcanic rocks of the Güvercinoluk Formation and KCPS, respectively. Crenulation folds and cleavages are textural evidences for three distinct deformational phases for these formations. Metapelites of the Gögebakan Formation have partly preserved their primary clastic textures with respect to the Güvercinoluk Formation and are characterized by well developed crenulation type slaty cleavage indicating two deformational phases. Tremolite/actinolite, epidote and albite occur as metamorphic neoformations in the metadiabases. Metaclastic rocks of the Hüdai Formation with weakly developed cleavage mostly contain undulose quartz, sericitized plagioclase and microcline. Partly better preserved primary microlaminations are characteristic features of metaclastic rocks of this formation. Slates and metasiltstones of the Seydişehir Formation have poorly developed slaty cleavages. The amount of chlorite-mica stacks (CMS) anomalously increase with the increasing of volcanogenic material such as detrital biotite. In addition to detrital chlorites, authigenic or neoformed chlorites have also developed in the pores of the matrix. Clastic rocks of the Ilyasli and Derealani formations have weak orientation without any cleavages. However, well-developed cleavage and crenulations were observed locally along the thrust zones.

X-ray Mineralogy

Pre-Cambrian to Lower Paleozoic rocks in the study area contain phyllosilicates, quartz, feldspar, calcite and dolomite. The calcite content increases in the Güvercinoluk and Derealani formations, whereas dolomite occurs in the Caltepe Formation. The amount of feldspar increases in KCPS and diabase lenses.

Phyllosilicate minerals are represented by illite, chlorite, mixed-layered chlorite-vermiculite (C-V), chlorite-smectite (C-S) and smectite. Illite, C-V and C-S is found almost in all units, whereas chlorite is mostly detected in the Gögebakan and Seydisehir formations (Figure 1). KCPS is represented by illite±C-V paragenesis. On the basis of clay mineral associations, two major phyllosilicate zones are distinguished from Precambrian to Ordovician as: illite+C-V+C-S±chlorite (Güvercinoluk Formation-lower parts of the Gögebakan Formation) and illite+chlorite±C-V±C-S (middle-upper parts of the Gögebakan Formation-Seydisehir Formation). The clay fraction of the Jurassic Ilyasli and Derealani formations contain the assemblage illite+chlorite±C-V.

The KI values of the Precambrian-Lower Paleozoic units indicate high grade anchizonal to epizonal grades and slightly decrease from Ordovician to Pre-Cambrian formations. Jurassic Ilyasli and Derealani formations have late diagenetic KI values distinctly lower than the underlying formations (Figure 1). KI and *b* values of white K-micas of Ilyasli and Derealani formations in the thrust zones represent anomalously higher grade of diagenesis-metamorphism than in the undisturbed ones (Figure 2).

Güvercinoluk, KCPS, Hüdai and Caltepe formations have high $d_{(060)}$ or b_0 values than the overlying units. High $d_{(060)}$ values of the Hüdai formation are related to the presence of 1M celadonitic mica. Güvercinoluk, KCPS and Caltepe formations have phengitic, Gögebakan Formation has muscovitic-phengitic, Seydisehir, Ilyasli and Derealani formations have nearly muscovitic composition. There is a clear trend of the I(002) / I(001) ratio of illite/muscovites towards higher values with decreasing *b* values (Figure 2).

$1M_d$, 1M and $2M_1$ illite/muscovite polytypes were found in the Jurassic-Pre-Cambrian units showing combinations of $2M_1$, $2M_1$ + $1M_d$ and $2M_1$ + 1M. 1M and $1M_d$ polytypes are restricted to the Hüdai, and Ilyasli-Derealani formations, respectively (Figure 1). The presence of 1M polytype in the Hüdai Formation indicates the existence of celadonitic/phengitic micas with high *b* values. Chlorites have IIb polytypes in the all units.

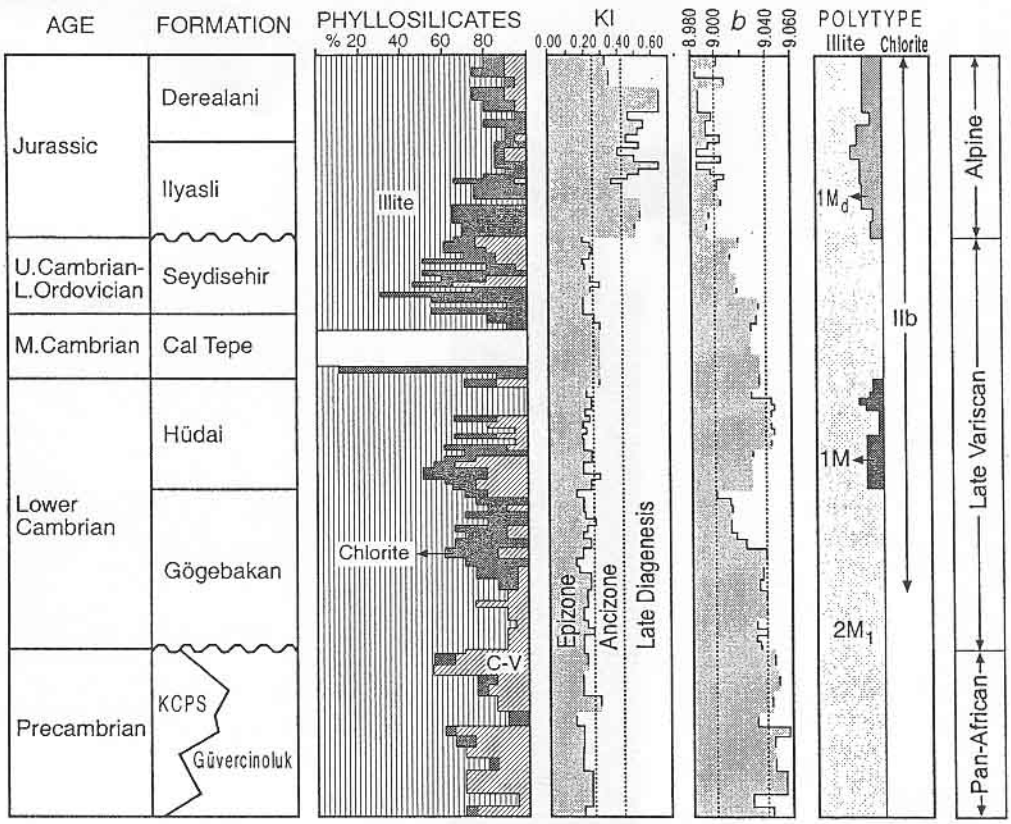

Figure 1. Vertical distribution of mineralogic data in the Sandikli area.

Conclusions

Lower Cambrian to Pre-Cambrian metapelites show well developed crenulation type of slaty and smooth cleavages, whereas Middle Cambrian to Ordovician units have poorly developed rough cleavage. Clastic rocks of Ilyasli and Derealani formations have no cleavages except in the local thrusting zones. Index mineral paragenesis of metabasic lenses in the Gögebakan formation indicates the sub-greenschist facies metamorphic conditions.

The KI values of Precambrian to Late Ordovician units are slightly increasing towards lower parts and have almost similar high grade anchi-epizonal grades. According to these data, these units were deformed and recrystallized at T ~ 300 °C. Similar KI values of Late Cambrian to Late Ordovician units indicate that the very low-grade metamorphism was developed in post-Ordovician to pre-Jurassic time interval, possibly during the Late Variscan orogeny.

In spite of the similar KI values, Ordovician-Precambrian units have different *b* values of illites/muscovites. The *b* values of Precambrian Güvercinoluk Formation and KCPS characterize the higher part of intermediate pressure facies series and high pressure facies series (Guidotti & Sassi, 1986). Lower Cambrian Gögebakan Formation has distinctly lower *b* values than Precambrian units and indicates conditions of typical intermediate-pressure facies series (Figure 2). The similar b_0 values of Güvercinoluk Formation and KCPS may be evaluated as either simultaneous deposition of sedimentary and volcanogenic components or similar diagenetic/metamorphic evolution at the same pressure conditions. Approximate burial pressures can be derived from P-T-b_0 grid of Guidotti and Sassi (1986) by extending the b_0 curves into the subgreenschist facies P-T space. Assuming a temperature of ~ 300 °C and average b_0 value of 9.043, a pressure of ~4.2 kb can be derived, which indicates a burial depth of ~15 km. The lower *b* value of the Gögebakan Formation with respect to the Güvercinoluk Formation may indicate lower pressure conditions corresponding to ~ 3.2 kb, indicating burial dept of ~10 km.

On the basis of KI and *b* values of illites/muscovites, there is a sudden transition between Lower Jurassic Ilyasli Formation and Ordovician-Upper Cambrian Seydisehir Formation (Figure 1). According to these data, Late Precambrian units reflect a different thermal history (Pan-African and Late Variscan) from the Jurassic units. Hence, the effect of the Alpine orogenesis is limited only to late diagenetic grades and has not completely erased the mineralogic fingerprints of the Late Precambrian and Late Variscan events.

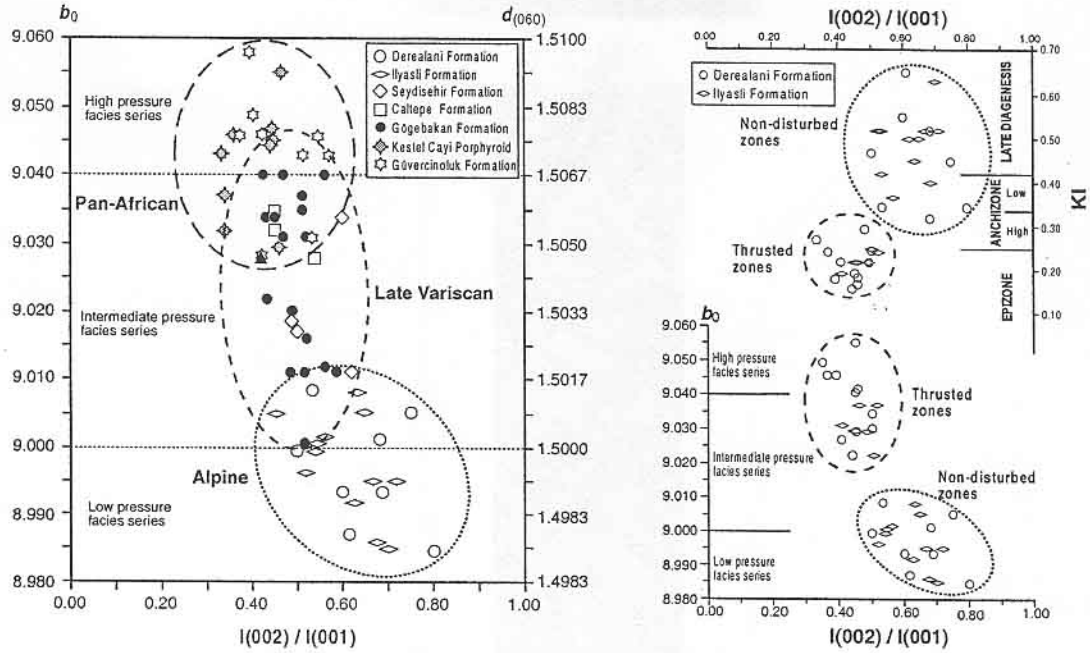

Figure 2. b_0 or $d_{(060)}$ versus I(002)/I(001) diagram of the illite/white K-micas of Jurassic-Precambrian units in the Sandikli area (left). b_0-I(002)/I(001) and KI diagrams related to local thrusting effect on the diagenetic illites of Ilyasli and Derealani formations (right).

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