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The Morphology, Mineralogy, Geochemistry and Physical Implications of Foid bearing Syenite and Syenite-Carbonate Rocks Contact Zone Soils: Kırşehir-Akpınar-Buzlukdağ, Turkey

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Abstract

The study area is located to the central part of Central Anatolian Crystalline Complex (CACC). The area mainly composed of Kırşehir metamorphic rocks as the basement units and intruded by syenite, foid syenite and foid diorite. The metamorphic rocks mainly represented by mica schist, chlorite schist, vollastonite marble and marble units. Calcsilicatic minerals and hornfels rocks are observed at the contact of intrusive and metamorphic basement in some parts of the study area. In order to determine morphology, mineralogy, geochemistry and physical properties of the soils two profiles were digged in the area. One of them is located in the foid bearing syenite and the other one is located in the syenite with carbonate rocks contact zone. The petrographical studies reveal that the foid bearing syenite characterised by the presence of nepheline, K-feldspar, plagioclases, Na-amphibole, pyroxene with rare amount of garnet (melanite), titanite and opaque minerals. The marble is mainly composed of calcite and rare amount of wollastonite and opaque minerals.

Contact of foid bearing syenite profile is lythic xerorthent, and the other one is described as a typical haploxeroll. They contain important morphological, mineralogical, geochemical and physical differences. It was found that these differences belong to the composition of the host rock of the region.

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Introduction

Central Anatolia Crystalline Complex (CACC), bounded by the İzmir-Ankara-Erzincan Suture Zone in the North, the Tuz Gölü Fault in the west and the Ecemiş Fault Zone in the South, are roughly triangular in shape and located in between the Ankara-Sivas-Niğde cities (Göncüoğlu et al., 1991; Akıman et al., 1993). Central Anatolia Crystalline Complex consist of metamorphic rocks as a basement units, ophiolitic units which are mainly crops at northern edge of CACC, magmatic units and cover units. Magmatic units are represented by felsic and mafic plutons. These felsic and mafic plutons are intruded into the metamorphic and ophiolitic units. Felsic plutons are composed mainly of granitoids, monzonites, and syenitoids, whereas mafic plutons

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comprise gabbros. The felsic intrusive rocks are calcalkaline, shoshonitic and alkaline in nature and divided into three groups as a granite, monzonite, and syenite. Granitic plutons are more abundant than syenitic rocks and mainly occur along the western edge of the complex, whereas syenitic plutons form in the inner part. The alkaline rocks are divided into two main groups as silica saturated and unsaturated units. The silica saturated alkaline rocks, which display gradational contacts with the monzonitic and granitic rocks, in the compositions of quartz syenite and syenite. Unsaturated silica rocks are foid syenite, foid monzosyenite, foid diorite and foid gabbro in composition. Gabbros are spatially associated and coeval with the felsic plutons. (Kadıoğlu et al., 2006).

Buzlukdağ syenitic rocks belong to the CACC's silica-undersaturated alkaline intrusive rocks. The rocks are located to the northwestern (NW) of the CACC, approximately 40 km west of Kırşehir. These syenitic rocks intruded into the Kırşehir metamorphic rocks which belong to the basement of the CACC. Kırşehir metamorphic rocks mainly represented by mica schist, chlorite schist, wollastonite marble and marble units. Calcsilicatic bearing minerals and hornfels rocks are observed at the contact of the intrusive and metamorphic basement in some parts of the study area. The dominant felsic lithologies are foid bearing syenites. Alkali feldspar foid bearing syenite, foid diorite porphry and foid gabbros are also can be observed in the study area (Deniz, 2010).

The Buzlukdağ pluton consists mainly of foid bearing syenite with minor lithology of foid bearing alkali-feldspar syenite, foid bearing diorite porphry and foid bearing gabbros. Foid bearing rocks have holocrystalline hipidiomorph granular texture in thin section. They are mainly composed of nepheline, K-feldspar, plagioclase, Na-pyroxene, biotite, phlogopite, Na-amphibole with rare amount of garnet, cancrinite, titanite and opaque minerals under the microscope (Fig. 1). Migmatite, hornfels and marble rock units are observed at the outer zone of syenites as a product of contact metamorphism (Fig. 1).

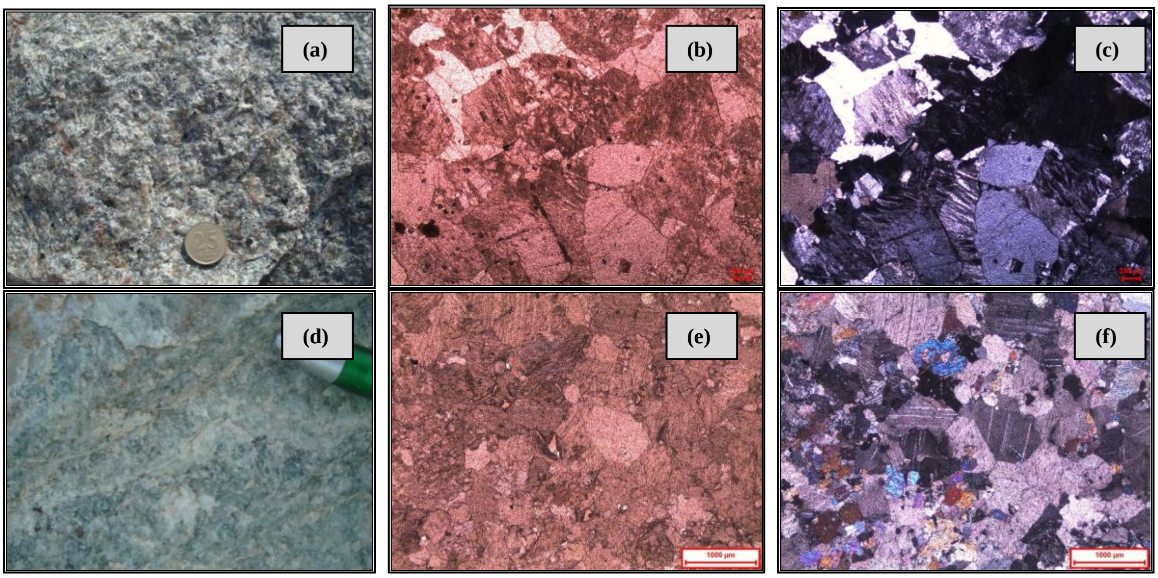

Figure 1. Photographs and photomicrographs from the foid bearing syenites and wollastonite marbles. (a) Photograph of foid bearing syenite, (b-c) photomicrographs of foid bearing syenite (parallel and cross nicol), (d) Photograph of wollastonite marble, (e-f) photomicrographs of wollastonite marble (parallel and cross nicol).

Detrital sedimatary rocks can be revealed the contact metamorphic products of the migmatites in the area. The migmatites have migmatitic texture under the microscope and they are composed of have quartz, feldspar and mica minerals. Quartz and feldspar minerals formed light colour levels which are named as a leucosom whereas biotites formed dark colour levels named as melanosom of the unit. Leucosoms have scalar granoblastik texture whereas melanosoms have slightly oriented texture. Quartz, plagioclase, scapolite, biotite, hydrobiotite and chlorite are forming the main mineral assemblages of the rock unit. Hornfels are found at the contacts of the syenites. Hornfels have granoblastic texture with smaller grains. Quartz, plagioclase, scapolite and pyroxene minerals are forming the main mineral composition. Marbles typically have granoblastic texture and they are composed of calcite, quartz and opaque minerals under the microscope. Wollastonite can be also observed within some parts of the marble level in the form of wollastonite (Deniz, 2010).

Material and Methods

Representative samples have been selected from each studied rocks and then prepared thin sections of these rock samples. After preparing thin sections, petrographic investigations are carried out in the polarizing microscope. Selected samples were crushed, ground and sieved, then pressed into thick pellets for XRF analysis in the laboratories of the Department of Geological Engineering and Earth Science Application and Research Center of Ankara University (YEBİM-Ankara, Turkey).

After taking soil samples, they were air dried, crushed and sieved using a 2 mm sieve. Particle size distribution was determined by the hydrometer method (Bouyoucos 1951), Organic matter in air-dried samples was determined by the Walkley-Black wet digestion method (Nelson and Sommers 1982). pH and EC-electrical conductivity were determined according to the methodology of the Soil Survey Laboratory (1992). Lime content was determined by Scheibler calsimeter (Soil Survey Staff, 1993). Exchangeable cations were measured by using the 1 N NH_4OAC (pH 7) method (Soil Survey Laboratory, 1992). In addition, morphological properties of the four profiles were determined by sampling genetic horizons in the field, and soils were classified according to the methodologies of the Soil Survey Staff (1993 and 1999) and FAO/ISRIC (2006).

Results

Buzlukdağ foid bearing syenitic rocks intruded into the mica schist, chlorite schist, wollastonite marble and marble metamorphic units. Migmatite, hornfels and marble which are the contact metamorphic rocks are observed at the contact of the intrusive and metamorphic basement in some parts of the study area (Fig. 2) (Deniz, 2010).

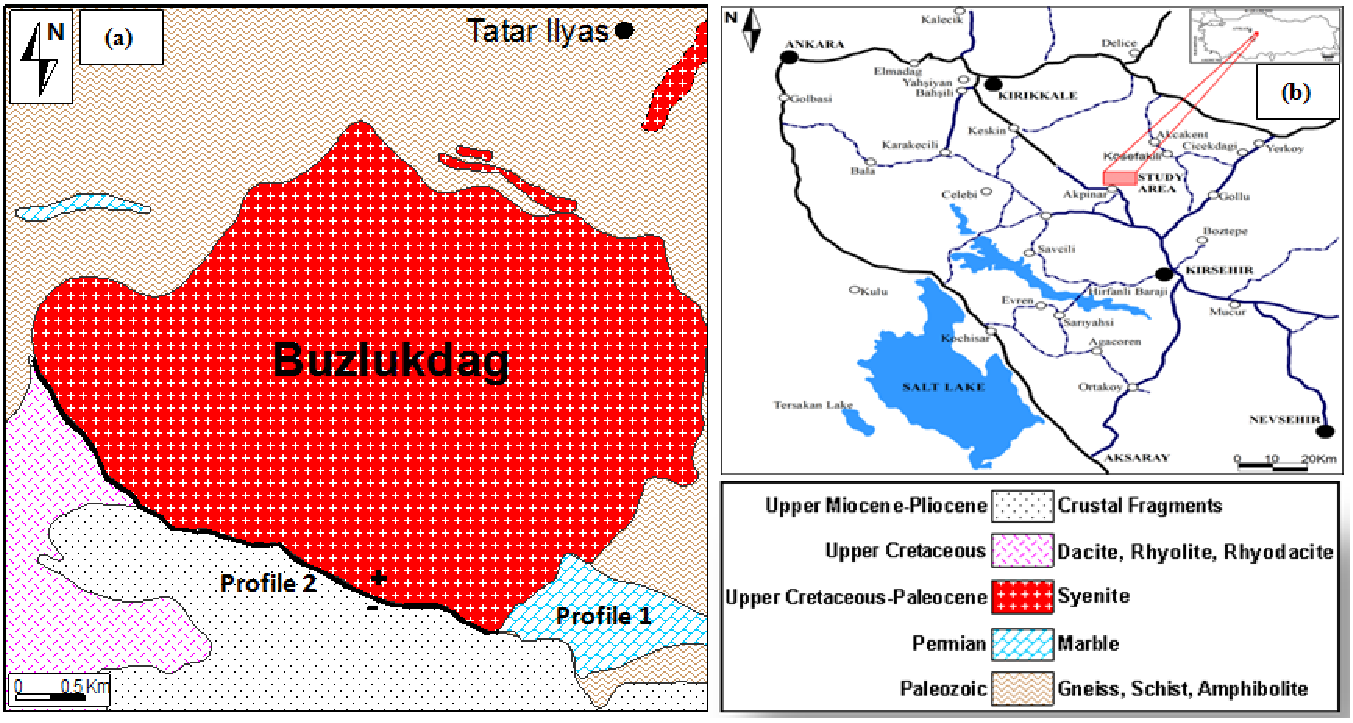

Figure 2. (a) The geological map and (b) location map of the study area.

According to Jenny (1980) natural soil bodies are the result of climate and living organisms acting on parent material with topography and with time required for soil forming processes. These soil forming factors determine soil properties by governing the type and intensity of the pedological processes involved. Because the variable of climate, parent material, relief and time also govern geomorphic processes, landscape evaluation is intimately related to soil development (McFadden and Knuepfer, 1990).

According to the meteorological data and soil water balance analysis it was found that the study area has Xeric soil moisture regime and Mesic temperature regime. Through Profile I formed on syenite, foid syenite and foid diorite parent material has light colour (7.5 YR 5/3), low organic matter and lower than 20 cm depth, it has only ochric epipedon. The horizon orders of the profile in the study area were defined to be A-C form and located on between high slope and slightly high slope. This means this soils has no diagnostic subsurface horizons and low pedogenetic development. It has only ochric epipedon overlying C or R horizon. Therefore, this soil can be defined as young soils. These pedons were classified as Lithic Xerorthent according to Soil Taxonomy (1999). Besides, it was classified as Lithic Leptosol FAO/ISRIC (2006).

The morphology of Profile II formed on foid siyenit and hornfels parent material and located on flat plateau was differently found from Profile I (Fig. 2). The horizon orders of this pedon are defined to be A/Bw/BC/C. Soil colour is 7.5 YR 3/4 in the Ap horizon, due to high organic matter. This soil has mollic epipedon on surface layer due to low value colour, high bas saturation, slightly hard structure. Main soil formation process in the differentiation of soil profile were structural formation, iron oxidation, clay formation and sericitization while, main subsurface diagnostic horizon is cambic horizon developed as a result of structural formation in this profile. Especially, structural development was observed after 20 cm depth. According to Soil Taxonomy (1999) and FAO/ISRIC (2006) this pedon was classified as Typic Haploxeroll and as Haplic Kastonozem (Table 1.).

Table 1. Morphological properties of profiles

Horizon	Depth (cm)	Colors	Structure	Consistence (Dry and Wet)	Boundary	Special features
			Profile I: Lithic Xerorthent / Lithic Leptosol			
A	0-10	7.5 YR 5/3	2mgr	sh fr ss ps	cw	
C1	10-22	7.5 YR 4/3	1fgr	sh vfr ss ps	cw	
C2k	22-33	7.5 YR 4/3	-	so vfr ss ps	-	$CaCO_3$ nodules
			Profile II: Typic Haploxeroll / Haplic Kastanozem			
A	0-10	7.5 YR 3/4	2mgr	h fr ss ps	cw	
Bw	10-20	7.5 YR 4/3	2msbk	h fr ss ps	cw	struc. dev.
BC	20-40	7.5 YR 3/2	1fsbk	sh fi ss ps	gw	
C	40-60	7.5 YR 3/2	-	h fi ss pt	-	

Boundary: a = abrupt; c = clear; g = gradual; d = diffuse; s = smooth; w = wavy; i = irregular
Structure: 1 = weak; 2 = moderate; 3= strong; vf = very fine; f = fine; m =medium; c = coarse; gr = granular; pr = prismatic; abk = angular blocky; sbk = subangular blocky; sg = single grain; m = massive;
Consistance: Dry : lo = loose; so = soft; sh = slightly hard; h = hard; Moist: lo = loose; vfr = very friable; fr = friable; fi = firm; et : so = nonsticky; ss = slightly sticky; st= sticky; po = nonplastic; ps = slightly plastic; pt= plastic; struc. dev. = structural development

Significant differences in soil chemical, physical and morphological properties in a small area are known to be related to landscape position and parent material (Ruhe, 1956, Dengiz et al., 2006). It was apparent, however, that while the regional controls of climate and vegetation were important at continental scales, "local" soil variability within smaller areas could often be attributed to changes in relief and topography and to local parent materials (Dahlgeren et al., 1997; Lark, 1999). The major physical and chemical properties of the soils are presented in Table 2. Soil texture is not significantly changing in top soil of all pedons defiened as silty clay loam. Typic Haploxeroll has the highest clay content while, Lithic Xerorthent has the highest silt content. The pH of the soils was moderately alkaline and there are no significant differences in the values of pH 7.1-8.1. In addition, both pedons have slightly soluble salt content. Calcium carbonate content of the pedons was found to be low. The calcium carbonate content was even much higher in the horizons with carbonate accumulation (i.e. calcic horizons). The low amount of $CaCO_3$ in Profile II can be explained by leaching of $CaCO_3$ in the profile. Exchangeable Ca and Mg cations were accounted for over 95% of the exchangeable complex as a result of dissolution of carbonates whereas, exchangeable K and Na levels were found rather low. In general expectation, lower landscape positions usually have higher organic matter contents than those upslope due to higher water content on low slope potions yields more biomass and more incorporation of organic matter into soil (Dengiz and Başkan, 2010). For all soils, the organic mater is highest in the surface horizon and decreases sharply to its lowest level in the subsoil. In the study area, the reasons of the low level organic matter are attributable to rapid decomposition and mineralization of organic matter. Soil organic matter ranged from 1.19 to 2.2% in Lithic Xerorthent, while Typic Haploxeroll has organic matter between 1.2-4.6% in h upper horizons of both profiles (Fig. 2).

Table 2. Some physical and chemical properties of soils

Horizon	Depth (cm)	pH	EC (dS.m1)	$CaCO_3$ (%)	O.M (%)	Exchangeable cations (cmol kg-1) Na+	K+	Ca++	Mg++	Texture (%) Clay	Silt	Sand	Class
Profil I: Lithic Xerorthent / Lithic Leptosol													
A	0-10	7,9	0,3	2,3	2,2	0,08	0,8	21,5	8,0	26	24	50	SCL
C1	10-22	7,8	0,3	3,7	1,9	0,07	0,4	26,4	11,1	34	21	45	SCL
C2k	22-33	8,1	0,3	16,7	1,9	0,12	0,2	30,5	5,3	25	21	54	SCL
R	33+												
Profil II: Typic Haploxeroll / Haplic Kastanozem													
A	0-10	7,3	0,4	2,0	4,6	0,03	1,4	12,1	5,7	24	21	55	SCL
Bw	10-20	7,1	0,3	1,9	2,9	0,03	1,3	12,9	4,8	31	12	57	SCL
BC	20-40	7,3	0,4	1,7	1,6	0,06	1,5	17,5	10,2	37	13	50	SCL
C	40-60	7,3	0,5	1,9	1,2	0,09	1,5	20,3	8,5	42	11	47	SC
R	60+												

O.M. = organic matter; EC = Electrical conductivity; SCL = Silt Clay Loam; SC = Silt Clay

Discussion

Soil properties data of these both profiles indicated significantly differences each other in terms of pedogenic processes which have been shaped by landscape position and parent material. Another way to view this concept that these factors are keys on soil forming processes especially at the local region. In the study area, the main negative impact of soil forming factor on profile development in high slope positions is soil erosion. Graham and Boul (1990) indicated that in mountainous terrain, soil erosion and mass movement or landslides are important geomorphic processes. While soil development proceeds on all parts of the regolith-covered landscape, it can be interrupted at any stage by mass movement event. This interruption is relatively common on high slope degree, so Entisol often predominant there. Therefore, these soils can be defined as young soils. Soils in lower slope position (Profile II) showed marked differences in terms of more development sub surface profile due to no interruption events. Main subsurface diagnostic horizons of this soil is mollic epipedon and cambic horizon. On the other hand, In the Profile I, detected $CaCO_3$ and pH values were rised up to 16,7% and 8,1, respectively in wollastonite marble rocks. According to our observations, it was concluded that these values must have resulted from of this rocks' (wollastonite) mineralogic and geochemical composition's; but, they were found at very low level in the Profile I. However, due to placed in an alluvial fan, Profile II has thicker (60 cm) than the another one (33 cm). As a result that, morphologic, genetic and chemical differencies which have seen between the Profiles I and II are resulted mainly from the main rock and topographical conditions.

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