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Research Article

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Clay Occurrences as Alteration Products in Volcanic Rocks and Marls around Ciftehan (Nigde/Turkey)

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Abstract The study area is located in the vicinity of Çiftehan in Ulukışla (Nigde) basin. Volcanic and sedimentary rocks in the vicinity of Çiftehan in Ulukışla basin have been subjected to the geothermal alteration. Clay minerals as alteration products were intense in volcanics and sedimentary units, along the fractures and cracks. Alterations are very rare or not present in areas where there are no fractures and cracks. As a result of alteration, smectite, illite, chlorite, sericite, kaolinite, zeolite occured in volcanic rocks and smectite, illite and kaolinite occurred in sedimentary rocks.

Keywords Ulukışla, Niğde, Geothermal, Alteration, Clay

Introduction

The investigation area is located in the Ciftehan district of Nigde province at the southern part of the Central Anatolia region (Figure 1). The Ulukışla Basin is situated at the southeastern edge of Central Anatolian Basins. The E-W-trending Ulukışla basin is restricted by the Niğde-Kırşehir Metamorphic Massif to the north; the Bolkar Carbonate Platform (formed the central part of Menderes-Taurides Platform) to the south; the sinistral Ecemiş Fault Zone to the east; and the Tuzgölü Basin to the west (Figure 2). Plutonic, subvolcanic and volcanic rocks and sedimentary rocks developed from the Upper Cretaceous to Middle Eocene in the study area.

There are many geological studies in Çiftehan (Niğde) and its surroundings. Demirtaşlı et al. (1973) [1], conducted research on the general geology of the Bolkar Mountains. Çalapkulu (1980) [2] studied Horoz granodiorite, which is located to the east of the Bolkar Mountains, and revealed that it is a shallow settlement granodiorite as a result of the delay tectonism. The age of the granodiorite was determined as post-Campanian (even Lower Paleocene) and pre-Lower Eocene. Oktay (1982) [3] determined the existence of the units formed in the age ranging from Paleocene to Quaternary. Işler (1988) [4] investigated the mineralogical, petrographic and geochemical features of volcanics in the Çiftehan (Niğde) region. Çevikbaş and Öztunalı (1992) [5] stated that the tectonic units forming the basin consist of Nigde group metamorphics, sedimentary rocks and granitoids.

Kozlu, (1994) [6] studied the origins of thermal waters by using natural isotopes Oxygen-18, deuterium and radioactive isotope tritium, found in thermal waters of Çiftehan (Niğde). Alpaslan et al. (2003) [7] determined the geological location of the volcanism observed in Çamardı-Ulukışla basin which is known as one of the post-collisional basins in Central Anatolia. Gedik (2005) [8] studied about exploration of ore deposits by using biogeochemical methods as well as normal geochemical methods for discovery and extent of covered mine ores.

There are also geothermal waters known as Çiftehan spas in the area. Çiftehan spas are known in the region since antiquity and are one of the places where people especially seek solutions for rheumatic diseases.

This study aimed to investigate the effects of the geothermal waters in the region on the volcanic and sedimentary rocks. For this purpose, samples were taken from the volcanics and marls in the region and investigations were carried out to determine the alteration products caused by the geothermal resources in rocks.

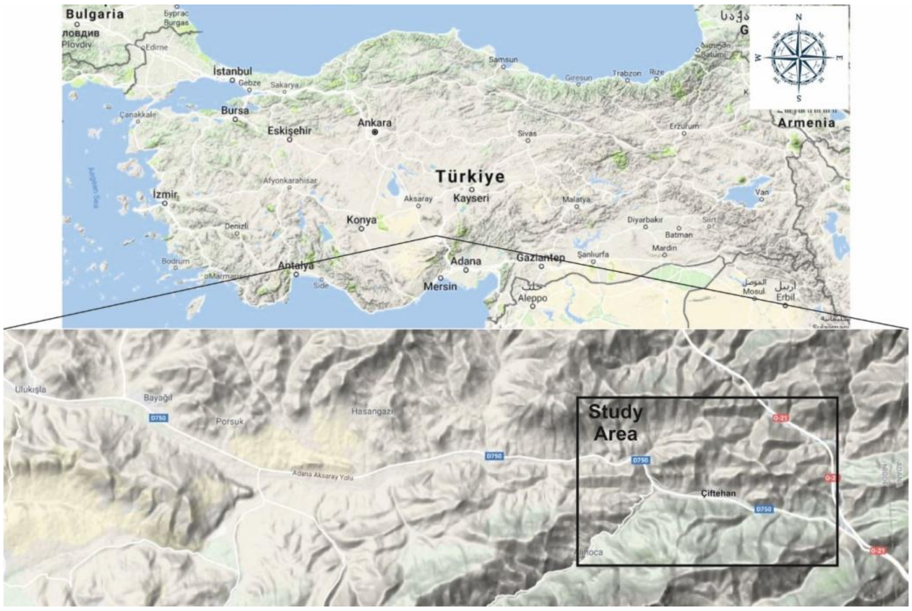


Figure 1: Location map of the study area

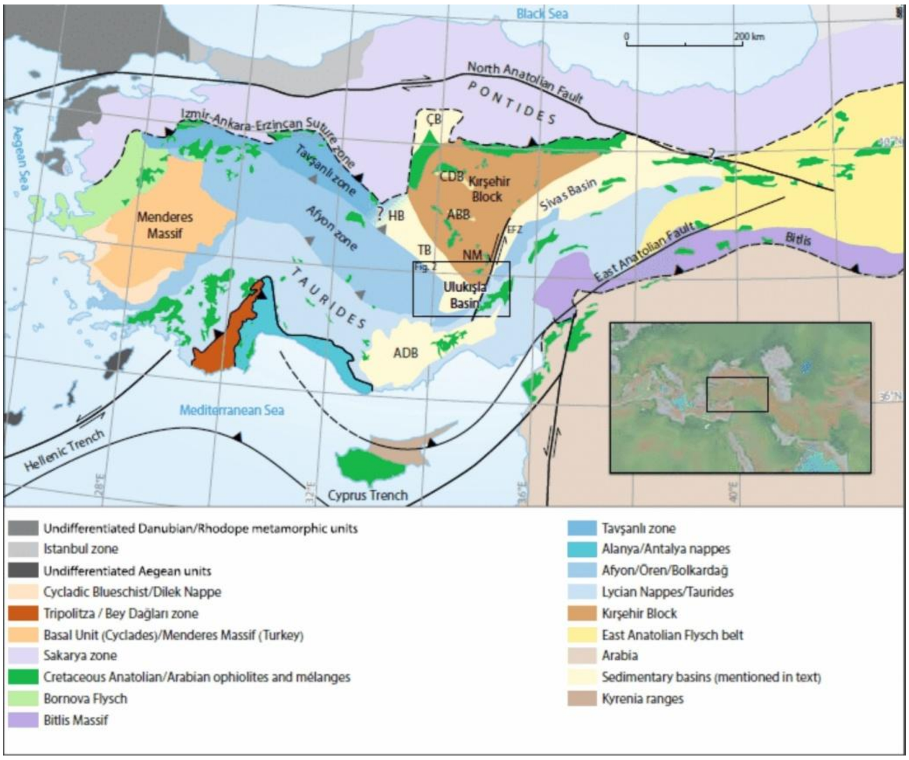


Figure 2: Map of Late Cretaceous to Miocene sedimentary basins of Central Anatolia in the framework of the tectono-metamorphic units of the Eastern Mediterranean, associated suture zones, ophiolites, and major faults (modified after Okay et al. (1996)[9], Pourteau et al. (2010)[10], and van Hinsbergen and Schmid (2012)[11]). The basement units are the Pontides, the HT-metamorphic Kırşehir block (with its southern tip the Niğde Massif (NM)), the Tavşanlı, and Afyon metamorphic HP-belts. Central Anatolian basins mentioned in the text: Ulukışla basin, ÇB = Çankırı basin, ÇDB = Çiçekdağı basin, ABB = Ayhan-Büyükkışla basin, HB = Haymana basin, TB = Tuzgölü basin, ADB = Adana basin, Sivas basin. Major faults marked include the North Anatolian fault and the Ecemiş Fault zone (EFZ), East Anatolian Fault (Gurer et al., 2016)[12].

Analytical Methods

In accordance with the purpose of the study, samples were taken from the volcanics and marls representing the sediments located in and near the Çiftehan spas in the Niğde province. Mineralogical and petrographic investigations were carried out at the laboratory of Niğde Ömer Halisdemir University Engineering Faculty Geological Engineering Department on thin sections of taken samples. In addition, XRD analysis were made in Erciyes University KOSGEB unit.XRD analyzes of the samples were performed with the Bruker AXS D8 Advance brand machine, Cu Tube / Wavelength 1.5406 Angstrom 40 kV, 40 mA values.

Geological Setting

Ulukışla-Çamardı Tertiary basin is located on different tectonic units.The part consisting of volcano-sedimanter and plutonic rocks in the north is over Niğde massif, the part consisting of sedimentary rocks in the south is over Bolkardağı marbles, and the part consisting of volcano-sedimentary rocks in the middle part is developed on the Alihoca ophiolite complex. All three units came side by side with Upper Eocene tectonics [5].

From bottom to top Madenköy Ophiolitic Melange, Ömerli Formation, Tabaklı Formation and Ardıçlı Formation units are located in the section called "middle section" by Çevikbaş and Öztunalı (1992) [5] in the study area where geothermal resources are present (Figure 3).

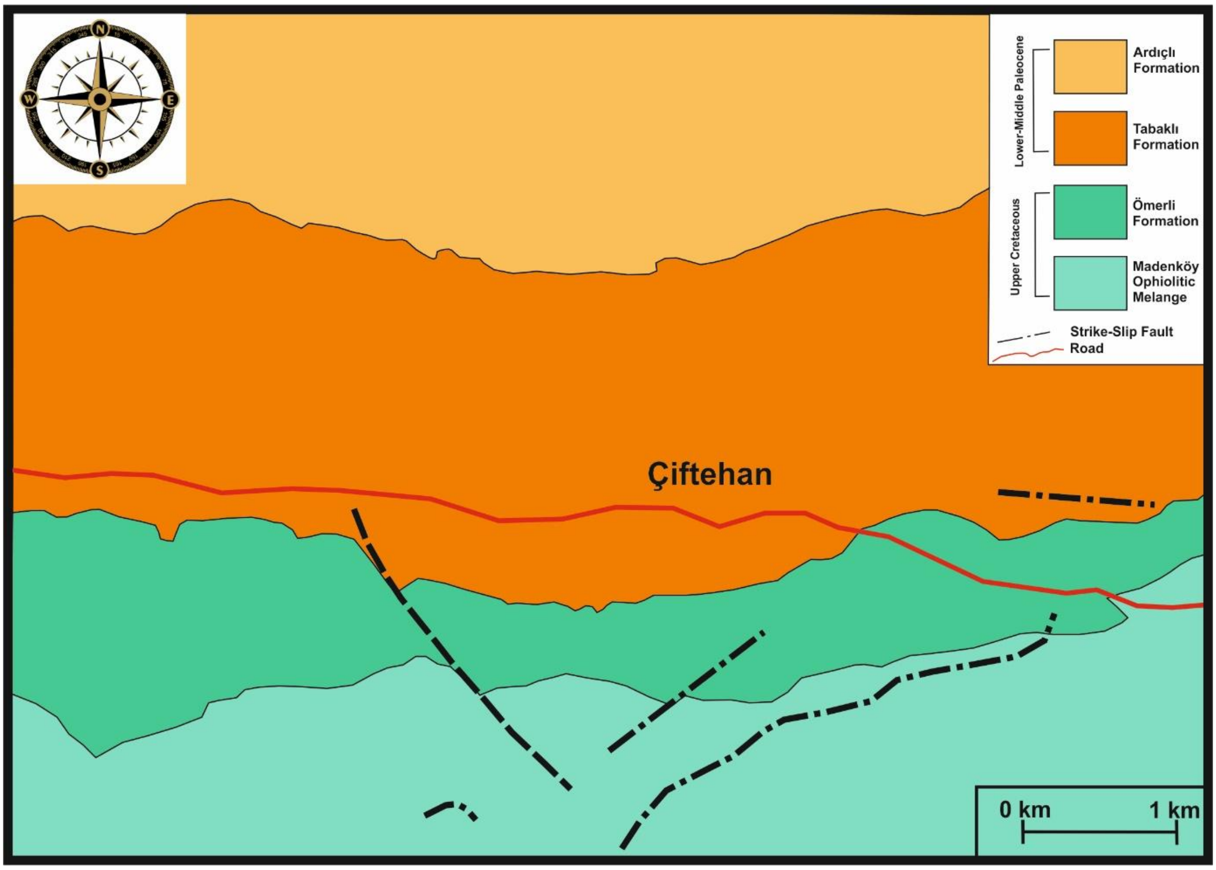


Figure 3: Geological map of the Çiftehan and surroundings (modified from Uçar, 1997, [13]).

Madenköy Ophiolitic Melange

The ophiolitic block unit consisting of a mixture of different lithologies is called Madenköy ophiolitic melange. Çevikbaş (1991) [14] determined that the formation age of Madenköy ophiolitic melange is Upper Cretaceous according to the obtained stratigraphic data. Demirtaşlı et al. (1975) [15], Çalapkulu (1980) [2], Şişman and Şenocak (1981) [16] suggested that the settlement of the ophiolitic melange in the region was before the Upper Cretaceous (Campanian).Madenköy ophiolitic melange consists of schist, peridotite, gabbro, serpantinite, diabase, metadiabase, silicified rock, marble and limestone blocks. The Alihoca ophiolite complex came tectonically contiguouson Madenköy ophiolitic melange. The schist and marble blocks in the ophiolitic melange are originally related to the Bolkar schists and marbles [16].

Ömerli Formation

The name of the formation was taken from Ömerli village. According to the Roslta fornicata, Ganserina sp., Globotruncana bulloides, Rosita cf. contusa (Cushman), Globotruncanita cf. Stuarti (de'Lapparent), Rugoglobigerina sp., Hetorohelix sp. foraminifera species found in the samples collected from the lower and central part of the unit, the age of the unit has been determined as Maastrichtian [5]. The unit was previously described as an olistolith in Ulukışla volcanics [15]. At the bottom, red colored and medium to thick bedded micritic limestones were observed., Bluish, gray, medium bedded turbiditic limestones came on this unit. The decomposition color of the sandstone-shale intercalation on this level is yellowish gray, cracked surface color is bluish gray and composed of very thick massive strata. In the middle of the level there are thick turbiditic sandstones indicating the Bouma sequence. At the top there is a medium-bedded micritic limestone level. The base of the unit is of tectonic contact and Ardıçlı and Ünlükaya formations conformably overlie this unit. The thickness is 230 m. According to all the above features, the formation was observed to be deposited in a deep environment under the wave base [5].

Tabaklı Formation

The name of the formation came from the Tabaklı village. According to Abathomphalusmayaroensis Boll (migrated), Globotruncanidae (migrated), Morozovellauncinata, Globorotalia sp., M. velascoensis (Cush), Globigerina triloculinoides Plummer planktonic foraminifera species which are determined on the sandstone and limestone layers, the age of the unit is Early-Middle Paleocene. It consists of basalt-andesite agglomerate and limestone interbedded sandstone and shale intercalations. It is observed that the unit is transitional with the Kırkgeçit formation and its limestone member below, but it has angular discordance on the Madenköy ophiolitic melange. It is transitional with the Ardıçlı formation and Karatepe limestone at the top. The thickness is about 800-1000 m. The unit was drawn back in the conditions under the wave base according to all of the above features. The Tabaklı formation was deposited in a non-deep shelf environment [8]. The member of the Delikkaya limestone extending towards it is dirty white, medium-thick bedded and has abundant fossils. At the lower levels, it was observed as sandstone-shale and marl levels (Figure 4 A,B).There are rare volcanic intercalations at the upper levels. The alterations in fractures and cracks are clearly distinguished in the marl member of Tabaklı formation. Along the fractures and cracks, 5-6 cm thick alterations are characterized by the domination of dark colors (Figure 4B).

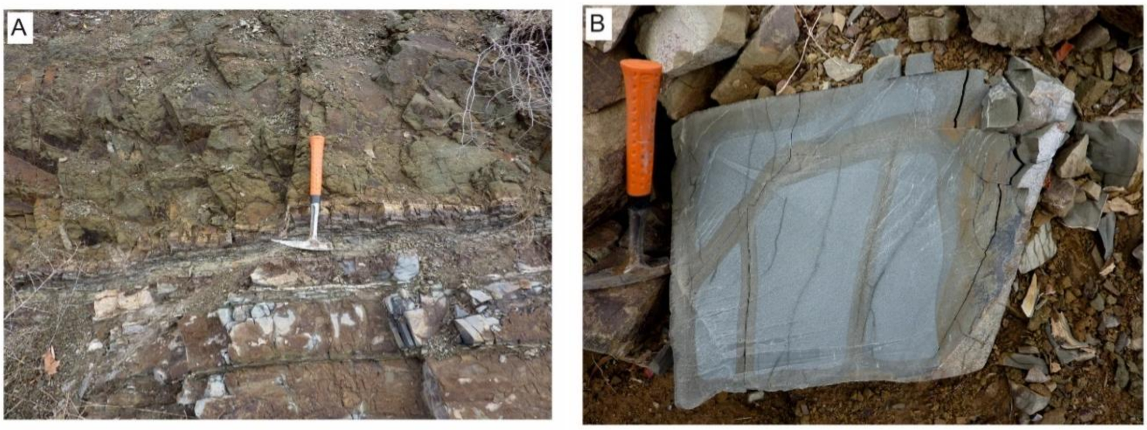


Figure 4 A-B: Delikkaya member of the Tabaklı formation (A: sandstone-shale and marl levels at the lower level of the Delikkaya limestone member, B: alterations observed in fractures and cracks).

Ardıçlı Formation

It consists of andesitic lava, agglomerate, tuff and sedimentary lithologies. Except members of the formation, lithology consists of andesitic rocks. It shows a smooth topography because it is usually altered. Lavas and agglomerates are pink and gray. Mostly has andesite and trachyandesite lithology and in some places, basic lavas and pillow lavas are observed. It is laterally and vertically transited with the other formations and it is 1000-1500 m thick [5].

Figure 5: Volcanics of Ardıçlı formation in the hot water source in Çiftehan geothermal field.

Geothermal Alteration

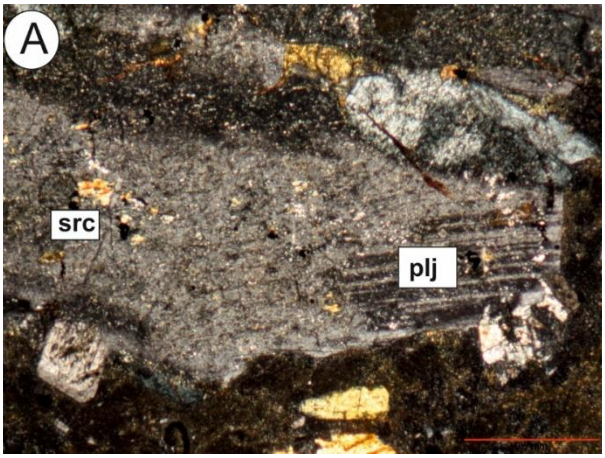
Geothermal waters cause alteration of rocks by passing hot water fluids through the rocks and changing their composition by adding or removing or redistributing components. In the study area, hydrothermal alteration minerals appear both as replacement of the primary minerals, as well as fillings in vesicles, vugs and fractures.

Sedimentary rocks

Significant alterations were observed in the marl samples of the study area. Macro color changes up to 5 cm in thickness are widely seen along the breaks occurred by tectonic activity (Figure 4B).In macro-alterations, the alteration areas are noticeably darker than other areas. The mineralogical-petrographic examination of the marl samples revealed no microscopic differences between the altered section and the non-altered section.

Volcanic rocks

In the volcanics taken from the Çiftehan geothermal field (Figure 5), significant alterations were observed along fractures and cracks. Alterations occurred notin the edge zones of the crystals, but in the structures occurred as a result of tectonics suggest that they occurred by the influence of the geothermal waters that have penetrated into the rock. The most prominent alteration products are sericitizations and zeolitizations (Figure 6A-B). Natural zeolites fill amygdales and veins in basaltic rocks. They were probably formed as a consequence of late-stage hydrothermal activity. Zeolites, as products of hydrothermal crystallisation, are generally known from active volcanic rock- associated geothermal systems. Clay minerals occurred in the discontinuities in the basalts as a result of the circulation of geothermal waters and atmospheric effects along the discontinuity zones contained in the basalt mass.



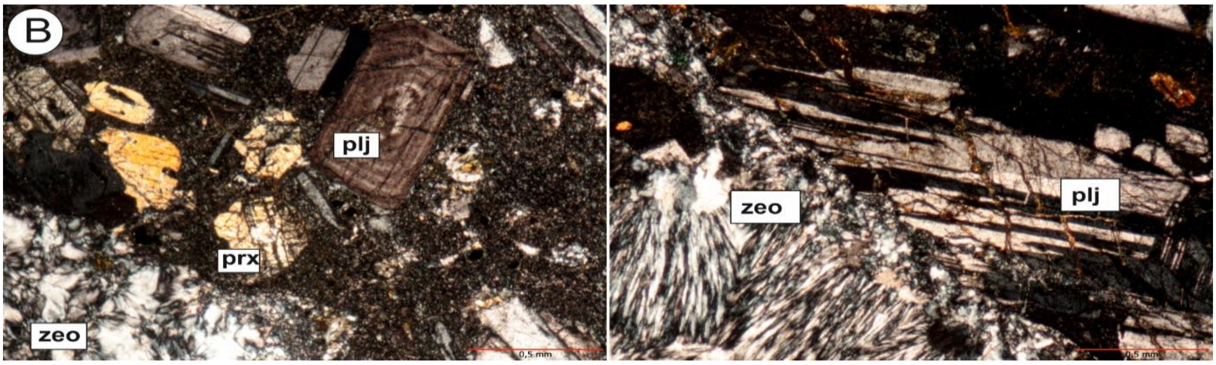


Figure 6: Alterations in basaltic rocks. (A: sericitization, B: zeolitization). src: sericite, plj: plagioclase, prx: pyroxene, zeo: zeolite.

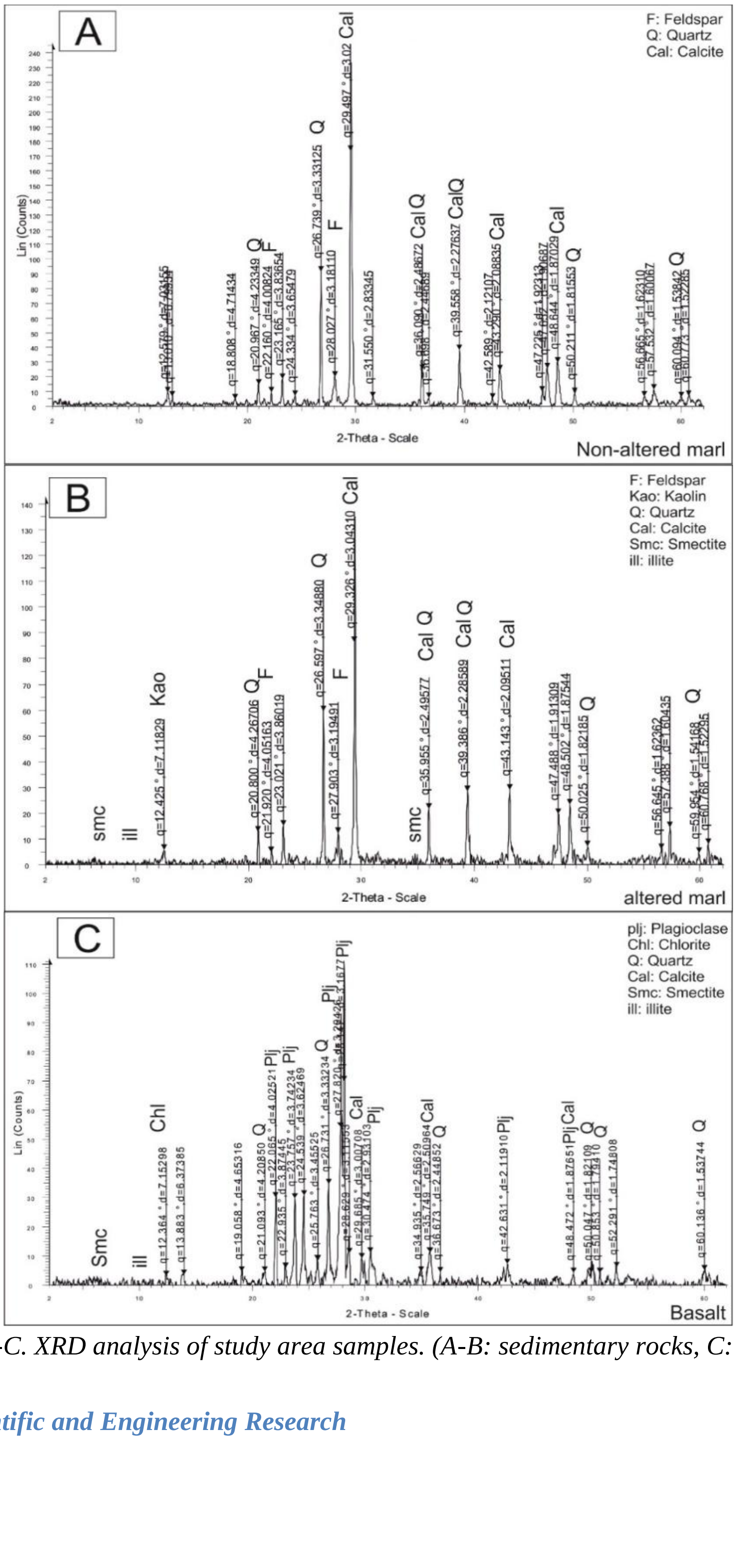


Figure 7: A-B-C. XRD analysis of study area samples. (A-B: sedimentary rocks, C: basaltic rock)

XRD Analysis

The X-ray Diffractometer (XRD) is used to identify individual minerals (e.g. clays and zeolites). XRD analysis was carried out on 3 samples in the study area. These samples were taken from marls as representatives of sedimentary units and from volcanics. XRD analysis was made from marl samples (from the rock where the alteration was observed, from the rock where alteration was not observed) and samples taken from basalts representing the volcanics in the region.

As a result of the XRD analysis, quartz, feldspar and calcite minerals were detected in the sample taken from the section where the alteration of the sedimentary rocks is not observed as a macro (Figure 7A).

Smectite, illite, kaolin, quartz, feldspar and calcite minerals were detected in the altered part of the sedimentary rock (Figure 7B). In basalts, smectite, illite, chlorite, quartz, feldspar and calcite minerals were detected (Figure 7C).

Conclusions

It was observed that the Çiftehan geothermal field in the Ulukışla basin developed a significant alteration on the rocks around it. It is observed that these alterations lead to the formation of smectite, illite and kaolin in the samples taken from the sedimentary rocks and smectite, illite, kaolin, chlorite and zeolite formation in the basalts.

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