Characterization of Clayey Soils and Physical Properties of Their Compressed Earth Blocks from Central Anatolia-A Case Study

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Abstract— **The world is losing its inhabitability because new technologies bring impurities and climate, soil and the weather is changing day by day. National and international organizations are founded in order to prevent the destruction of the environment. The expansive nature of soils containing high amounts of clay minerals can be altered through chemical stabilization, resulting in a material suitable for construction purposes. During past decade, depending on the nature and function of soil, many different chemical products have been proposed to stabilize the soil. Temperature as a soil-forming factor has long been neglected, but today its importance in the general scheme of soil genesis can no longer be denied. Soil scientists do not agree among themselves as to the exact place of organisms in the scheme of soil-forming factors. Mineralogical and geotechnical analysis revealed that the soil of Central Anatolia is mainly composed of kaolinite and mixture of smectite and illite. The qualitative determination of the mineral composition in major elements of the raw soils was performed by FTIR, XRD and SEM. Despite having shown very good results at plot level, their widespread adoption remains a challenge for Central Anatolia.**

Keywords—Clay Minerals; Soil; Kaolinite; Smectite; Soil-forming; Central Anatolia

I. INTRODUCTION

The soil is a natural body, differentiated into horizons of mineral and organic constituents, usually unconsolidated, of variable depth, which differs from the parent material below in morphology, physical properties and constitution, chemical properties and composition, and biological characteristics [1-3]. It is problematic whether any definition of soil could be formulated to which everyone would agree. Fortunately there is no urgent need for universal agreement. For the purpose of presentation and discussion of the subject matter it is necessary only that the reader know what the author has in mind when he uses the word "soil".

The vast importance of the soil in the development of various systems of agriculture and types of civilizations has long been recognized; but it is only within the last few decades that soils as such have been studied in a scientific manner. During thousands of years mankind has looked upon soils mainly from the utilitarian point of view. Today it is being realized more and more that the soil per se is worthy of scientific study, just as animals, plants, rocks, stars, etc., are subjects for theoretical research and thought [2]. There is every reason to believe that any advance in the fundamental knowledge of soils will immediately fertilize and stimulate practical phases of soil investigations.

In the early days of soil science, the geologic or petrographic nature of parent material was taken as the sole basis for soil classification. With the advent of the climatic concept in classification, the geological systems were discredited, especially in countries that span entire continents, such as the United States and Russia. However, even today, in regions of relatively uniform climates and vegetation, the geologic classification criteria continue to enjoy wide popularity. The terms "glacial soils", "limestone soils", "loessial soils", and "basaltic soils", are widely used. Probably no issue in soil science has been more disputed than the postulate of the dominance of climate in soil formation [4-6]. The arguments that have been advanced to prove or disprove the contention have been numerous, and even today opinion is divided.

As long as soil climate functions are studied within regions of uniform seasonal distribution patterns, the annual moisture values give satisfactory correlations. Parent material, climate, and organisms are commonly designated as soil formers or soil-forming factors. Since soils change with time and undergo a process of evolution, the factor time also is frequently given the status of a soil-forming factor. Topography, which modifies the water relationships in soils and to a considerable extent influences soil erosion, also is usually treated as a soil former. The emphasis placed on the nature of the colloid is in line with the present trend in pedology that considers the colloid fraction of the soil a relatively stable yet sensitive product of the interaction of soil-forming factors [7].

That defines a mature soil as one whose profile features are well developed. This definition is strictly morphological and may be applied directly in the field. Among students of soils, one frequently encounters a second definition that is enjoying increasing popularity. It rests on dynamic rather than morphological criteria and may be expressed as follows: mature soils are in equilibrium with the environment [8]. In this case,

emphasis is not placed on profile descriptions but on soil-forming processes. More specifically, the concept has some bearing on the factor time in soil development. It alludes to the familiar equilibrium idea employed by chemists and physicists. It will prove profitable to analyze the equilibrium concept of soil maturity in the light of time functions.

Naturally, every soil property has its own vertical distribution pattern or specific "depth function" (Fig.1). In practice, special emphasis is placed on substances that migrate easily within the soil, such as soluble salts and colloidal particles. The difficulty of horizon designation is accentuated in soils derived from anisotropic parent materials such as stratified sand and of fact, there exists great need for rigorous criteria of horizon identification, because all scientific clay deposits. As a matter systems of soil classification as well as the theories regarding soil development rest on horizon interpretations [9].
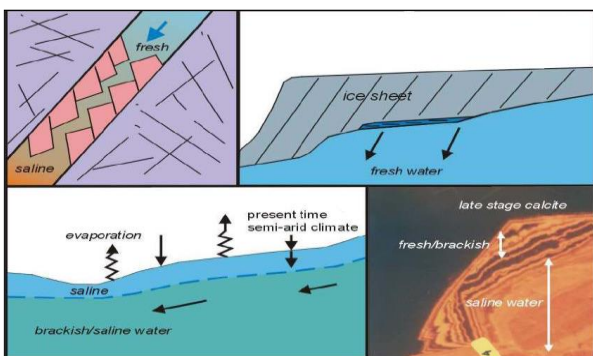

Fig. 1. The schematic of evaluate the response of deep groundwater systems to climatic change.

Since the beginning of the present century a great amount of work on soil identification and mapping has been carried out in all parts of the world. The detailed descriptions of the soil types investigated embrace hundreds of volumes, charts, and atlases. Attempts to coordinate the great mass of data frequently have been made, but almost exclusively along the lines of soil classification. The idea of classification has stood foremost in the minds of many great soil scientists of the past, and the present day leaders in field soil studies continue in this same direction.

It should be remembered, however, that classification is not the only way to systematize facts. Data can also be organized by means of laws and theories. This method is characteristic of physics, chemistry, and certain branches of biology, the amazing achievements of which can be directly attributed to a great store of well-established numerical laws and quantitative theories. The present treatise on soils attempts to assemble soil data into a comprehensive scheme based on numerical relationships. Soil properties are correlated with independent variables commonly called "soil-forming factors". It is believed that such a mode of approach will assist in the understanding of soil differentiations and will help to explain the geographical distribution of soil types [1, 9, 10]. The ultimate goal of functional analysis is the formulation of quantitative laws that permit

mathematical treatment. As yet, no correlation between soil properties and conditioning factors has been found under field conditions which satisfies the requirements of generality and rigidity of natural laws. For this reason, the less presumptuous name, "functional relationship", is chosen.

If we admit that soil formation consists of a series of chemical and biochemical processes, we may again resort to analogies with simpler systems. Dynamics of chemical reactions may be described accurately by indicating the initial state of the system, the reaction time, and conditioning variables. These considerations may be directly applied to the soil. During past decade, depending on the nature and function of soil, many different chemical products have been proposed to stabilize the soil [4].

This research concerns regional study of the Central Anatolia clay minerals of this area soils and aims to provide some insight into the range of clay mineral assemblages that may be encountered in this region and environment. The qualitative determination of the mineral composition in major elements of the raw soils of Central Anatolia region was performed by FTIR, XRD and SEM.

II. GEOLOGICAL SETTINGS

In this study area, the pre-Oligocene basement consists of Palaeozoic and Mesozoic metamorphic rocks, ophiolites, igneous rocks and Eocene units consisting of conglomerates, sandstones, claystones, tuffites and reef limestones deposited in various environments, turbiditic, tidal, shallow and deep marine (Fig. 2). The compressed Anatolian plate was transported westward along two large strike slip fault zones. In this way, the thickening in the crust in Anatolia migrated toward the east. Movement began in the late Miocene and continues today [11, 12].
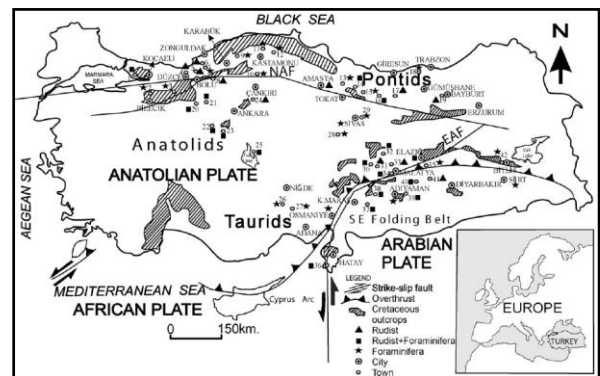

Fig. 2. Generalized geological map of the Central Anatolia of Turkey.

In late Eocene and Oligocene time, Anatolia was progressively uplifted and eroded (Fig. 3). This resulted in the development of a Himalayan type plateau [13]. In the early Miocene, most of western Anatolia was subjected to erosion and lacustrine environments occurred locally [14].
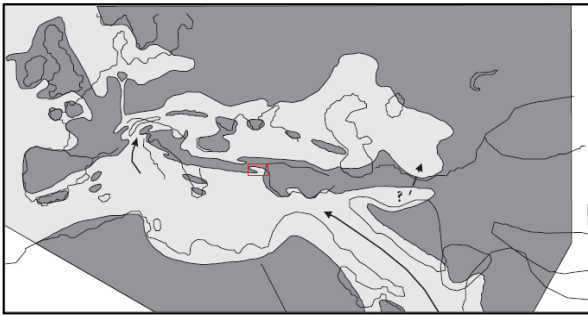
Fig. 3. Palaeogeographic scheme of the Central Anatolia region in the early Oligocene with ocean and land distribution and seaways (the location of the studied area is marked by a rectangle) [15].

A.   Weathering and Soil Formation

The passive soil formers are represented by the constituents that serve as the source of the mass only and by the conditions that affect the mass. They comprise the parent material, the topography, and the age of the land. The active soil formers are the agents that supply the energy that acts upon the mass furnishing reagents for the process of soil formation. The elements of the biosphere, the atmosphere, and partly the hydrosphere are representative of this class of soil formers. The Central Anatolia again offers an ideal territory for soil formation temperature investigations, since broad soil belts with comparable moisture conditions run from north to south through areas of varied temperatures. In certain areas, parent material, vegetation, and topography are sufficiently uniform to enable an approximate solution of the problem. A difficulty requiring some thought is the selection of suitable moisture criteria. Certain investigators are content with annual precipitation values, disregarding the fact that a given amount of rainfall is not so effective in the tropics as it is in the north temperate region, owing to a great difference in evaporation. The slopes of soil property-temperature functions will vary greatly according to the nature of the moisture index selected.

In reference to soils, two questions present themselves: what are the conditioning factors, and what is the minimum number necessary to define completely the soil system? A priori we do not know. Experience has shown, however, that some soil properties satisfy the requirements of an independent variable, whereas others do not. With reference to the latter, it is evident that the hydrogen ion concentration (acidity) and the hydroxyl ion concentration (basicity) cannot be selected as a pair of independent variables, because a change in one necessitates a change in the other. They cannot be made to vary independently of each other. Similarly, soil structure and organic matter or soil color and ferric oxide content are properties that often change simultaneously [16]. A different situation exists in the case of soil temperature and soil moisture. Soils may possess high temperatures and at the same time low moistures, and vice versa. One may change without altering the other. These two soil properties are independent variables. Likewise, the shape of the surface of the soil, the topography, belongs in this class,

as do certain aspects of the organisms. The hydrogen ion concentration and the depth of the carbonate horizon react most sensitively to rainfall; next come nitrogen and organic matter and finally clay and saturation capacity [17].

Weathering includes solution, hydrolysis, carbonization, oxidation, reduction, and clay formation. Among the soil-forming processes, the following are listed: calcification, podsolization, laterization, salinization, desalinization, alkalization and dealkalization, formation of peat and poorly drained soils, including gleization [18]. Since these are merely special types of chemical processes, their separation into geologic and pedologic groups appears neither convincing nor fruitful. The entire issue might be dismissed as being of purely academic interest, were it not for the fact that a practical consequence is involved, namely, the determination of parent material. At soil temperatures below 0°C, chemical reactions in the soil practically stop; therefore, only temperatures above freezing should be dealt with in soil formation studies [2]. Not only the absolute soil temperature but also the length of the annual weathering period have to be considered.

Since weathering is controlled by moisture and temperature, it follows that the formation of parent material also becomes a function of climate. Parent material could no longer be treated as an independent variable and therefore would cease to be a soil-forming factor. All soil property climate functions to be discussed in the following chapters become meaningless, because they would have to be considered as the result of complex combinations of soil-forming and parent-material-forming processes [9, 18]. Naturally, this observation presents an additional uncertainty in the evaluation of soil climate relationships from field studies. In any given instance, are the present soil climate relationships really expressions of the effects of today's climate upon the soil? Evidently climatic pulsation cannot be lightly passed over by the student of soil formation processes.

Generally speaking, all moisture indexes based on ratios suffer from their hyperbolic nature. Whenever the denominator is small, the ratio becomes excessively great, probably out of proportion to its physical or chemical significance. Correlations between soil properties and moisture, which are based exclusively on rainfall or humidity quotients without taking topography into consideration, neglect the role of runoff, which may reduce or enhance the effectiveness of precipitation in soil-forming processes. As a rule, runoff increases in an exponential fashion with increasing rainfall, but it is difficult to quote accurate figures having general significance. As rainfall becomes greater, weathering becomes more intense, clay formation increases, and aggregation is favored, particularly in the presence of abundant organic matter.

Organic matter and total nitrogen are high in the poorly drained soils, undoubtedly on account of anaerobic conditions developed during wet periods.

The base status of all profiles is very low, and, accordingly, the acidity is high, as revealed by the low pH values. Soils formed in the presence of high ground-water table tend to be more acid than the profiles of the well drained series. Whether this difference is due to variations in the base status or in the kinds of clay minerals cannot be elucidated from the data on hand. The latter possibility is suggested by the magnitudes of the silica-alumina ratio of the colloidal fraction. Assuming that the composition of the clay particles at the beginning of the cycle of soil formation was identical, it follows that the better drained soils suffered a relatively greater loss of silica than the poorly drained soils [19].

The humid soils present a somewhat different picture. The percentage aggregation varies from about 25% in the podsols to 95% in the true laterites. The cause associated with the small percentage aggregation of the silt and clay in the podsols has been discussed previously. Aggregation in the laterites is related in some way to the aluminum and iron present. Evidently when the hydrated oxides of these elements dehydrate they cause the formation of exceedingly stable secondary units. Thus, in lateritic soils, alumina and iron contribute to aggregation, while, in the podsol, any secondary particle formation is due to small amounts of organic matter [20].

Agriculturists have long realized that many important properties of soils are inherited from the underlying rocks. Technical expressions like limestone soils or granitic soils are encountered in the oldest textbooks on agricultural subjects. They clearly convey the importance of parent material in soil formation. Although the origin of loess is a geological rather than a problem, the question of its formation has occupied the minds of all researchers of loessial soils [21].

Some of the most carefully studied soil formation series deal with loess. In conformity with the evenness of loess deposits, the loessial soils are exceedingly homogeneous. Within a given locality, the variability of the soil characteristics is small, especially if contrasted with morainic soils. Loessial soils are predominantly fertile, partly because of favorable chemical properties, partly because of excellent structural features. They acquired and preserve these properties by virtue of a moderate climatic environment in which they escape the destructive influences of extreme podsolization and laterization [22]. Typical zonal soil types associated with loess are chestnut soils, chernozems, prairie soils, and to a lesser extent gray-brown podsolic soils, and yellow-red soils.

The procedure of deriving depth functions from moisture functions may be reversed. With the aid of a series of soil profile data, it is also possible to construct a family of nitrogen rainfall functions. This interdependency of the two types of functional relationships may be generalized to include any soil property and any soil-forming factor. In other words, the customary method of soil description by profiles and the new approach of functional analysis supplement one another. Expressed the opinion that climatic factors are responsible for the existence of different organic matter levels in soils; however, it is only within the last decade that the problem has been subjected to rigorous quantitative treatment [20, 23]. The difficulty lies in the fact that the amount of soil humus, or, more generally, soil organic matter, present depends upon all the soil-forming factors. Only by the method of separating and controlling the soil formers can the contribution of the individual factors that affect the distribution of organic matter be determined. When moisture and temperature functions are combined into general climate functions in such a form that the two individual variables are still recognizable, one can visualize much more clearly the variation of soil characteristics over large areas. Combinations of this kind have been constructed for the nitrogen and the clay contents of selected regions.

The most active agency in soil profile formation is percolating water. As long as water passes through the solum, substances are dissolved, translocated, precipitated, and flocculated, and the soil is not in a state of rest. This force, the penetrating rain water, is counteracted by evaporation, transpiration of vegetation, and by impenetrable horizons such as clay pans and hardpans, which are themselves the result of soil formation.

Now, we can learn with a reasonable degree of assurance whether or not water percolates a given horizon; and, although we cannot definitely prove maturity by the absence of percolation, its presence certainly precludes final equilibria. Most soils of humid regions are not impervious to water, and therefore they are not mature in the sense that they are in final equilibrium with the environment. All we can hope to do in soil classification is to arrange the soils in an ascending series of development, implying that the highest members in the series come closest to maturity.

Changes in soil properties are designated by agriculturists as alterations of soil productivity and soil fertility. It will prove of interest to examine these cardinal agronomic terms in their relationship to soil properties and soil-forming factors. When a farmer buys a tract of land, the surrounding climate is implicitly included in the transaction. In reality, he acquires a producing system of which it may become a part. The physical productivity of this producing system is measured in yields per unit area, be it tons of hay per acre, or bushels of oats per acre.

B. Facies and Depositional Environments

Sedimentary petrology already has benefited from the investigations of the nature and of the formation of colloidal clays. The explanations of the origin of geologic strata, such as laterite and ferruginous deposits in general, must be formulated in conjunction with pedological research [24]. Geomorphology, particularly its aspects relating to erosion and denudation, is paying increasing attention to the physical and chemical properties of the soil.

Karaman city (Turkey, Central Anatolia) has very important potential with clear air and soils for organic agriculture. Especially, the soil structure is most appropriate for medicinal and aromatic plant production in district and for grape production in central villages. In addition to plant production, natural flora is very favorable for apiculture applications. Organic production is undertaken and well developing with aid of government supports by local enterprising. However local organic products have not being marketed in real value prices. New marketing ways could be stepped in using last communication technologies to scale up organic agriculture and speed up rural development. In addition, local enterprising people should be encouraged to invest on processing of organic products [25].

III. MATERIALS AND METHOD

Descriptions of soils by observers in the field are primarily of a qualitative character. Functional analysis of soils requires quantitative data. At present, these are mainly available in the domain of soil physics and soil chemistry. It is hoped that, in the future, soil surveyors also will stress the accumulation of quantitative data such as measurements of variability of horizons, topography, etc. It is desirable that the information be arranged in a manner suitable for presentation, if possible, in graphic form.

The Central Anatolia region is one of the richest in occurrence of clay deposits in the world. Therefore, investigation of these deposits, their quantitative and qualitative characterization is highly important.

A. Presentation of Physical Analyses

The list of measurable physical soil properties includes the true and apparent densities, heat capacity and conductivity, plasticity, soil structure criteria, and a host of properties pertaining to water relationships, such as moisture equivalent, wilting percentage, water-holding capacity, vapor-pressure curves, etc.

The relationship between particle size (upper limit) and settling velocity in water at 18°C is calculated with the aid of Stokes' law ($\upsilon=34{,}760.r^2$). Here, υ denotes the settling velocity expressed in centimeters per second, and r the radius of the particle in centimeters. Many soil scientists express mechanical analyses exclusively in terms of settling velocities or their logarithms: others prefer to deal with diameters of hypothetical or effective spherical particles computed from Stokes' law.

In designation; fine gravel (2-1 mm), coarse sand (1-0,5 mm), fine sand (0,25-0,1 mm), very fine sand (0,1-0,05 mm), silt (0,05-0,002 mm), and also clay <0,002 mm. Being one of the most ancient and important raw materials benefited by humanity throughout the history, clay has never lost its significance. It is still the most important raw material for the industry today. Clay is a term used to describe a group of phyllosilicate minerals. The pure clay is rare in nature and usually mixed not only with other clays but with microscopic crystals of

carbonates, feldspar, micas and quartz. As a sedimentological term, it is typically less than 0,002 mm (2 µm) in diameter. Plasticity, sintering and absorption of water form the important characteristics of the clay minerals. A combined profile representing the constructed profiles chosen for this and nearby area was shown in Fig. 4.
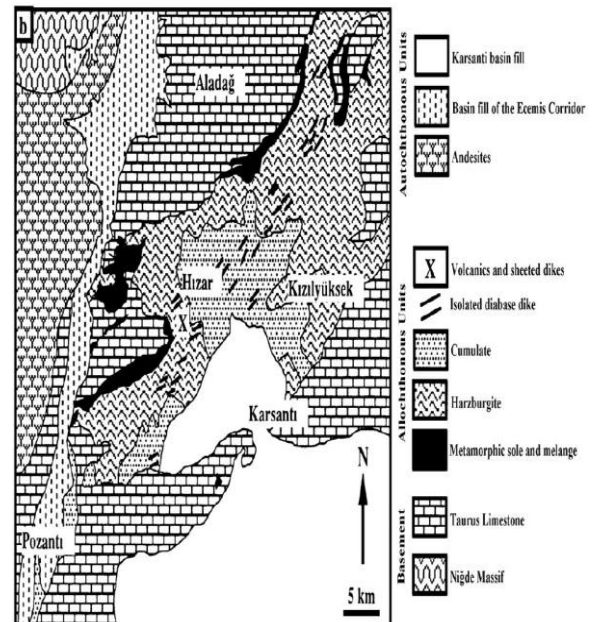

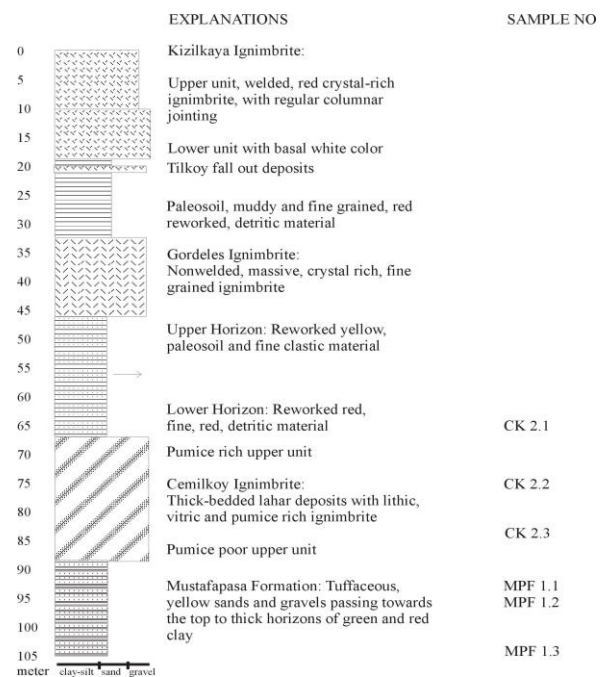**Fig. 4.** Simplified geology map of Central Anatolia and locations [26].

Fig. 5. Generalized litostratigraphic columnar section of the Arapli-Yesilhisar region, Central Anatolia-Turkey.

- The clay samples were taken from three different levels shown in the litostratigraphic columnar section of a selected locality in the Arapli-Yesilhisar region, Central Anatolia (Fig 5). The samples taken from lower level, middle level and upper level were labeled as MPF 1.2, MPF 1.1, and CK 2.3, and CK 2.2, CK 2.1, respectively. The following processes were applied to

prepare the samples for the FTIR (Fourier transform infrared) measurements (Fig. 6 and Fig. 7). Initially about 1 kg of samples was collected, and 20-40 g splits were prepared for further analyses. Samples were heated at 110°C for 24 hours and crushed to powder and screened using an 80 mesh sieve. Clay fractions were prepared following the procedure including removal of carbonates, sulfates and organic matter by dissolving, through washing to acquire stable suspension, and siphoning (to acquire the clay fraction - <2 micron).

Samples were ground into powder. Powdered samples were alternately washed with pure water, ethylealcohol, and ether. Then, they were dried in an oven at 110°C for 24 hours. These samples were prepared applying the disc technique (mixing ~1 mg clay sample with ~200 mg KBr) and put in molds. These intimate mixtures were then pressed at very high pressure (10 tons per cm^2) to obtain the transparent discs, which were then placed in the sample compartment. Bruken Equinox 55 FTIR spectrometer (Department of Physics, METU, Turkey) was used for the IR spectral measurements of these samples with standard natural clay and the spectra were recorded over the range of 5000-370 cm^{-1} (% transmission versus cm^{-1}). Before taking the spectra measurements of the samples, spectrometer was calibrated with polystryrene and silicateoxide of thicknes 0.05 nm.
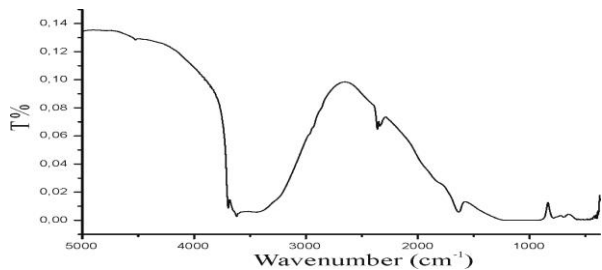

Fig. 6. FTIR spectrum of the clay sample taken from the lower level (MPF 1.2) of Arapli-Yesilhisar profile.
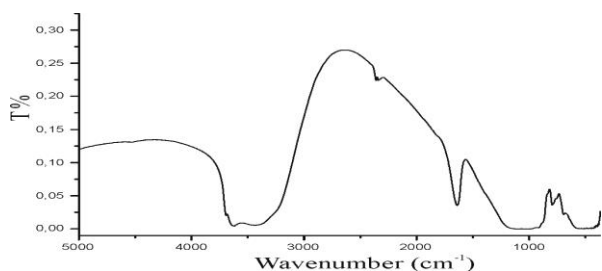

Fig. 7. FTIR spectrum of the clay sample taken from the upper level (CK 2.1) of Arapli-Yesilhisar profile.

FTIR spectrum of the clay sample taken from the lower level of Arapli-Yesilhisar (Fig. 6) was compared with the fundamental vibration frequencies of the clays known as standard natural clay and the assignments of the band components of the samples, minerals corresponding to each of the vibration bands in the spectra were determined and the results for each clay sample. There are 10 fundamental vibration frequencies of illite mineral in the spectrum of standard natural clay. But, there is only ν(OH) stretching vibration frequency of this sample at 3623 cm^{-1}. Although Si-O deformation of kaolinite in standard natural clay is seen at 754 cm^{-1}, it was observed at 755 cm^{-1} for the sample. There is a little shift. ν(Si-O) planar stretching vibration frequency, ν(H-O-H) stretching frequency, and Si-O-Mg deformation frequency are not observed at 1027 cm^{-1}, 3433 cm^{-1}, and 428 cm^{-1}, respectively. But, Si-O-Al and Si-O-Fe deformation bands are observed at 546 cm^{-1} and 470 cm^{-1}, respectively. The bands corresponding to 1010 cm^{-1} and 910 cm^{-1} are the vibration bands of kaolinite mineral. These are in a good agreement with the fundamental vibration frequencies of standard natural kaolinite clay. On the other hand, ν(OH) stretching vibrations of quartz were observed at 798 cm^{-1}, 788 cm^{-1}, and 697 cm^{-1} and ν(OH) stretching vibration of feldspar was observed at 800 cm^{-1}. These results show that the samples taken from the lower level include illite, kaolinite, feldspar, and quartz minerals.

The FTIR spectrum of the clay sample taken from the upper level of Arapli-Yesilhisar clays (Fig. 7) was compared with the fundamental vibration frequencies of the clays known as standard natural clay and the assignments of the band components of the samples were performed [27, 28]. Only one ν(OH) stretching vibration frequency band was observed for illite mineral at 3623 cm^{-1} as it was observed for the sample taken from lower level. Although Si-O deformation frequency of kaolinite was observed at 755 cm^{-1} for the lower level sample, it was observed at 750 cm^{-1} for the upper level sample being different from the lower level sample. In addition, the ν(Si-O) planar stretching vibration, ν(H-O-H) stretching, and Si-O-Mg deformation frequencies belonging to 1027 cm^{-1}, 3433 cm^{-1}, and 428 cm^{-1}, respectively, are not observed for this sample and also Si-O-Al and Si-O-Fe deformation bands have not been observed and at 546 cm^{-1} and 470 cm^{-1} in the spectrum of upper level sample. The assigned bands observed for lower level samples at 1010 cm^{-1} and 910 cm^{-1} were observed for the upper level samples. The observed vibration bands for both quartz and feldspar are the same for the upper level sample. Although, there are little shifts from the fundamental vibration frequencies, 11 of all the fundamental frequencies of the kaolinite mineral were observed. These very small frequency shifts are caused by the water going into among the layers of kaolinite mineral [29].

Since all the clay samples include illite, kaolinite, feldspar, and quartz minerals, it means that these clays have the framework of silicate structure, such as T-O (tetrahedral-octahedral) or O-T (octahedral-tetrahedral). On the other hand, it was observed O-H, Si-O, Si-O-Al and Si-O-Si groups in their FTIR spectra.

- XRD (X-ray powder diffraction) measurements were employed to determine the mineral phases included in the same samples (Siemens D-5000 Diffract AT V 3.1 diffractometer, CuKα radiation λ=1.54056 A˚ and 0.03 steps; General Directorate of Mineral Research and Exploration laboratories-MTA, Ankara-Turkey).
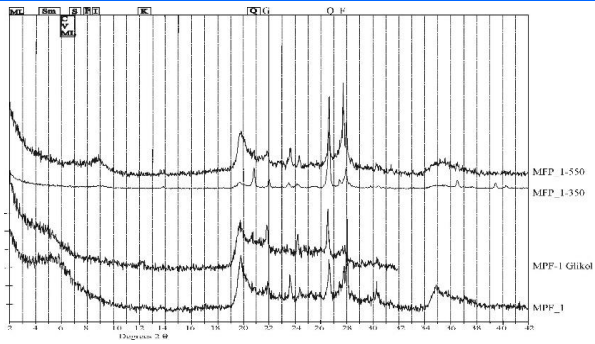
Fig. 8. XRD pattern of the clay samples from the lower level (MPF 1.2) of Arapli-Yesilhisar clays (Q=quartz, F=feldspar, I=illite, ML=mixed layer clay, C=chlorite, S=smectite).
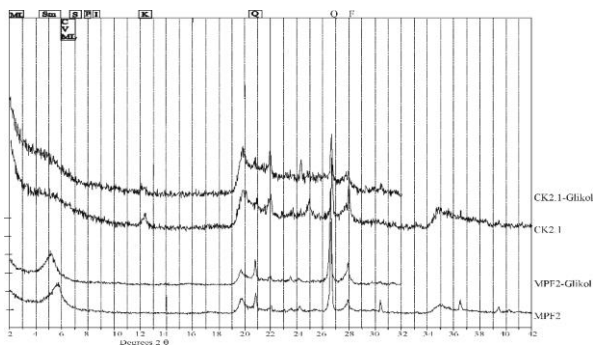

Fig. 9. XRD pattern of the clay samples from the middle level (MPF 1.1) and the upper level (CK 2.1) of Arapli-Yesilhisar clays (Q=quartz, F=feldspar, I=illite, ML=mixed layer clay, C=chlorite, S=smectite).

According to the XRD measurements (Fig. 8 and Fig. 9), subject clays are found to be composed of abundant 30% smectite, 30% feldspar, 20% quartz, 12% calcite, 3% illite marly limestone, 5% albite-muscovite and trace quantities of amorphous silica and Fe-oxide minerals, respectively. In the MPF 1.2 lower part of the clay profile (Fig. 5), amount of quartz tend to decrease while smectite, calcite and illite show significant increase. Whereas at the top of the Kk1, just opposite of this abundance trend was observed and palygorskite was totally absent.

B. Interpretation of Chemical Analyses

The chemical analyses of the Arapli-Yesilhisar, Central Anatolia-Turkey clay samples (dried in an oven at 110°C for 24 hours) were carried out at the ACME-Canada laboratories by means of XRF-ICP (X-ray fluorescence spectrometry-inductively coupled plasma) technique [30]. Major oxide composition of the samples representing the lower, middle and upper parts of the profile was as follows (these data suggest that the clays of the region are essentially rich in SiO_2 and Al_2O_3);

- for the lower part: 54.32% SiO_2, 0.57% TiO_2, 12.56% Al_2O_3, 6.70% Fe_2O_3, 0.07% MnO, 2.16% MgO, 1.44% CaO, 0.67% Na_2O, 1.08% K_2O, 0.105% Cr_2O_3, 0.03% P_2O_5;

- for the middle part: 55.69% SiO_2, 0.82% TiO_2, 16.72% Al_2O_3, 6.57% Fe_2O_3, 0.04% MnO, 1.80% MgO, 1.40% CaO, 0.34% Na_2O, 1.85% K_2O, 0.014% Cr_2O_3, 0.04% P_2O_5;

- and for the upper part: 55.71% SiO_2, 0.70% TiO_2, 16.81% Al_2O_3, 8.67% Fe_2O_3, 0.04% MnO, 1.21% MgO, 1.31% CaO, 0.69% Na_2O, 1.55% K_2O, 0.007% Cr_2O_3, 0.05% P_2O_5.

C. Soil-water Characteristics

Ten clay dominant samples were selected for SEM-EDX (Scanning electron microscope-Energy dispersive X-ray spectrometer) analysis of clay minerals (JEOL JED-2300). SEM studies were performed on 350 A° thick Au film-coated sample chips, using a Giko IB3 ion coater. SEM analysis is carried out on some samples, and the both results obtained from XRD analysis are confirmed by SEM (Fig. 10 and Fig. 11). On the basis of analytical methods, mineralogy of the region had been brought out. In the SEM investigations, smectites show honeycomb texture, which is characteristics of dioctahedral smectites. Besides, hexagonally packed smectites were observed.
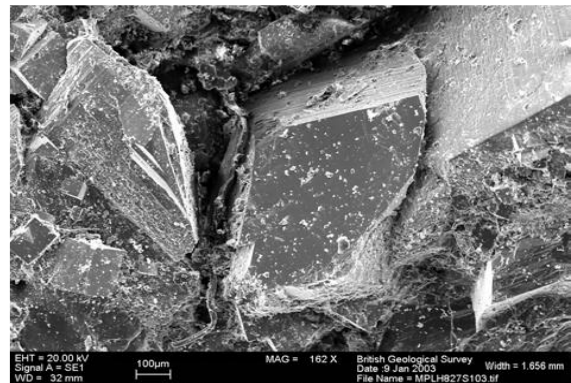

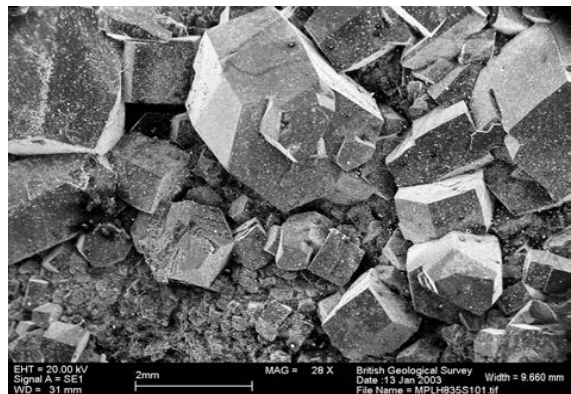**Fig. 10.** SEM micrograph of calcite showing morphology of the surface.

Fig. 11. SEM micrograph of carbonate showing morphology of the surface.

The exchangeable bases of the neutral clays are replaced by hydrogen ions of water and carbonic acid. This interchange of ions converts the neutral clay into a hydrogen clay or acid clay. The hydroxide and bicarbonates formed as a result of the reaction are leached out by percolating rain water, whereas the acid clay remains in the soil and gradually accumulates. Increasing amounts of rainfall progressively intensify these processes. Soils of arid regions are generally low in colloids and consequently possess low saturation capacities. The exchangeable cations are chiefly Ca, Mg, K, and Na. Depending on local ground-water

conditions, Mg and Na ions may predominate (alkali soils). Saturation capacities are high because the soils are rich in clay and humus colloids. Under still higher precipitation, the downward percolation of rain water becomes a dominant feature. The bases are for the most part leached out, and hydrogen ions constitute the bulk of the adsorbed cations [31, 32].

In arid regions, intensive agriculture must rely on irrigation. Where the irrigation water is pure and the ground-water table is low, the resulting changes are similar to those brought about by leaching in semihumid and humid regions. Frequently, however, the irrigation water contains considerable amounts of salt. In these cases, the crops remove the moisture of the soil, and the salts accumulate in the soil solution. This process may result in the formation of alkali soils.

IV. RESULTS AND DISCUSSIONS

Before the advent of the climatic theories of soil formation, parent material was considered the major soil-forming factor. In spite of a vast amount of work on the relationships between soil properties and underlying geological strata, relatively little information is at hand that can be interpreted in the light of functional analysis. As a rule, the correlations are suffering from lack of control of soil-forming factors, particularly climate. Regions with little or moderate seasonal variations of temperature and rainfall are said to have oceanic climates. Continental climates are characterized by very hot summers and extremely cold winters. In refining soil property climate correlations, the annual march of temperatures may prove of importance and could then be treated as a separate soil-forming factor.

Summarizing the influence of the plant cover on profile differentiation, the following two points stand out: (1) in the first place, the distribution of organic matter is conspicuously different for prairie and for timber, (2) the latter has a large proportion of its carbon content in the surface layer. In the second place, the translocation of mineral substances is greater under timber than under prairie. From the data at hand, one would conclude that under equal climatic circumstances a deciduous forest cover stimulates leaching and accelerates soil development [33, 34].

In Central Anatolia, these changes should lead to increased water stress, the extension of arid areas and, ultimately, lower crop yields. Cereal yields are expected to fall by 10 to 15% by 2025, while 20% of the population is already structurally vulnerable and food crises are regular [35, 36]. The situation is difficult, but simple and effective techniques can be implemented to adapt farming practices. This involves making the best use of agricultural water, using collection techniques that aim at maintaining as long as possible the water in the fields. It also means combatting erosion due to the wind or heavy rains, introducing physical barriers in the fields. Already handicapped by increasing land pressure and continued land degradation, Central Anatolia farmers face an additional challenge: to adapt their farming practices to climate changes. This mean that, with few resources, the farmer may be able to improve its yields,

while preserving its natural capital (the soil), and taking into account the future climate changes in Central Anatolia. Finally, this implies to better manage physical and chemical soils properties, in order to maintain or restore their fertility. These techniques must be implemented in a complementary manner.

In going from the humid temperate to the humid cold region in Central Anatolia, one passes from brown forest soils to podsols. Both are considered by many Central Anatolia investigators as climatic soil types that differ in general in the following features. By means of irrigation, it may change completely the climate of the soil. That also influences directly the properties of the soil. Cultivation and fertilization of soils and the removal of crops are widely practiced activities that stamp man as an outstanding biological soil-forming factor.

Likewise, in all studies of soil climate relationships, vegetation is treated as a dependent variable rather than as a soil-forming factor, because significant changes in climate are always accompanied by variations in kind and amount of plant life. It is a universally known truism that microorganisms, plants, and many higher animals affect and influence the properties of soil. But such action alone in no way establishes organisms as soil-forming factors [37, 38].

Uncertainty arises in comparisons of soils of different origins or different climatic regions, for the morphologic and the dynamic criteria may stand in contradistinction to each other. Theoretically, at least, soils may be in equilibrium with the environment without having marked profile features, and, vice versa, soils may have well developed profiles without being in equilibrium. The foregoing discussions represent but a fragmentary analysis of the nature of soil maturity. It has been the purpose to elucidate this cardinal concept of modern pedology rather than to pass dogmatic judgment on its practical utility.

The mineralogy of the fracture fillings comprises primary quartz, biotite, muscovite, alkali feldspar, plagioclase, accessory minerals, and secondary minerals consisting mainly of clay minerals (smectite, kaolinite and illite), Fe-oxyhydroxides, secondary sulphides, phosphates, sulphates, uranium minerals, and carbonates [39, 40]. Most of the fracture samples correspond to very fragile millimetre thick coatings. Only a few are of centimetre thickness-scale. Their mineralogy consists mainly of carbonates (dolomite-ankerite and siderite), apatite and quartz.

Carbonate vein mineralization was mainly selected for mineralogical and chemical analysis, and sample selection was based on various criteria, including: degree of sample consolidation; sufficiency of the mass of material available to meet the analytical requirements; and correlation with groundwater flowing through hydraulically active zones [41, 42]. This type of mineralization coincides with present groundwater flow paths, and it was hoped that it might contain neoformed minerals that record signatures of the most recent palaeohydrogeological events that have influenced the groundwater system.

Smectite is the most extensively developed clay mineral. Kaolinite is much more scarce, and generally occurs in fractures at a relatively shallow level (<82 m). The greater abundance of smectite relative to kaolinite is consistent with the saturation indices of both minerals with respect to the chemistry of the groundwaters, which indicate that most of the groundwater compositions lie in the field of the smectite stability.

The presence of smectites was confirmed by glycolation of XRD samples and by FTIR analyses that also enabled identification of individual smectites: montmorillonite (frequent, younger) and nontronite (sparse, older). Neither the microscopic techniques (binocular, optical microscope, cold-stage CL, SEM), nor the analytical techniques (XRD, FTIR) could detect the presence of any carbonate minerals [43].

Some fracture fillings yielded sums of the major oxides approaching 100 wt. % in a simple onestep procedure. However, in other cases, it was necessary to modify the calculations by attributing part of the content of K, Na, and Ca to primary magmatic phases (feldspars, muscovite).

Depositional characteristics and ages of evaporites differ in the basins in western and Central Anatolia. In western and Central Anatolia, lacustrine sediments include tuff and evaporite beds intercalated mainly with carbonates [44]. In Central Anatolia, halite and gypsum were deposited when short periods of marine transgression into the molasse basins combined with arid climatic conditions.

REFERENCES

[1] P.W. Birkeland, Soil and Geomorphology, 3rd ed., Oxford University Press: New York, 1999, pp. 10-430.

[2] E.E. Putri, N.S.V Kameswara Rao, and M.A. Mannan, "Threshold stress of the soil subgrade evaluation for highway formations," International Journal of Engineering and Applied Sciences, vol. 6, pp. 301-307, 2012.

[3] W. Hu, M.A. Shao, Q.J. Wang, and Y. Li, "Effects of sampling size on measurements of soil saturated hydraulic conductivity," Acta Pedologica Sinica, vol. 42, pp. 1040-1043, 2005.

[4] A. Eisazadeha, K.A. Kassima, and H. Nurb, "Molecular characteristics of phosphoric acid treated soils," World Academy of Science, Engineering and Technology, vol. 63, pp. 1-3, 2010.

[5] F.C. Ugbe, O. Odedede, J. Fayomi, and E.S. Elebe, "Appraisal of some sedimentary clays in parts of Western Delta, Nigeria," Achievers Journal of Scientific Research, vol. 1, pp. 55-64, April 2016.

[6] U.M. Uche, "Geochemical investigation of surface water from the effect of mining in the Arufu area, NE Nigeria," International Journal Geology and Mining, vol. 1, pp. 2-16, May 2014.

[7] I.I. Wakindiki, and M. Ben-Hur, "Soil mineralogy and texture effects on crust micromorphology, infiltration and erosion," Soil Science Society of America Journal, vol. 66, pp. 897-905, 2002.

[8] B.C. Schreiber, and M. El Tabakh, "Deposition and early alteration of evaporites," Sedimentology, vol. 47, pp. 215-238, 2000.

[9] D.Q. Lu, M.A. Shao, R. Horton, and C.P. Liu, "Effect of changing bulk density during water desorption measurement on soil hydraulic properties," Soil Science, vol. 169, pp. 319-329, 2004.

[10] T.U.S. Onyeobi, B.G. Imeokparia, O.A. Liegieuno, and I.G. Egbuniwe, "Compositional, geotechnical and industrial characteristics of some clay bodies in southern Nigeria," Journal of Geography and Geology, vol. 5, pp. 73-84, 2013.

[11] T. Wu, Y. Wang, J. Lv, and B. Zhang, "Soil water characteristics of Middle Pleistocene paleosol layers on the loess Plateau," African Journal of Biotechnology, vol. 10, pp. 10856-10863, September 2011.

[12] B. Davarcioglu, "The clays in the Messinian alluvial fan deposits of Ulukisla-Nigde basin, Central Anatolia-Turkey," Journal of Mineral, Metal and Material Engineering, vol. 1, pp. 65-72, 2015.

[13] M.F. Sener, M.Z. Ozturk, and M. Sener, "The Characteristics of Late Eocene Evaporites from Central Anatolia, A Case Study," 4th International Symposium on Development of Kop Region, Proceeding Book, pp. 158-161, Karaman-Turkey, October 21-23, 2016.

[14] K. Dirik, "Neotectonic evolution of the northweswward arched segment of the Central Anatolian fault zone, Central Anatolia, Turkey," Geodinamica Acta, vol. 14, pp. 147-158, 2001.

[15] O.F. Gurer, and A. Gurer, "Development of evaporites and the counterclockwise rotation of Anatolia, Turkey," International Geology Review, vol. 41, pp. 607-622, 1999.

[16] F.N. Dalton, "Development of time-domain-reflectometry for measuring soil water content and bulk soil electrical conductivity," in Advances in Measurement of Soil Physical Properties: Bringing Theory into Practice. Soil Science Society of America: Madison-USA, Special Publishing, 1992, pp. 143-167.

[17] P.A. Floyd, M.C. Goncuoglu, J.A. Winchester, and M.K. Yaliniz, "Geochemical character and tectonic environment of Neotethyan ophiolitic fragments and metabasites in the Central Anatolian crystalline

comples," in Tectonics and Magnatism in Turkey and the Surroundings Area, vol. 173, E. Bozkurt, E. Winchester, and J.D.A. Piper, Eds. Geological Society: London, Special Publishing, 2000, pp. 183-202.

[18] H.A. Wallace, Soils and Men-Yearbook of Agriculture, 1st ed., United States Published-Department of Agriculture: Washington DC USA, 1938, pp. 943-1232.

[19] K. Semhi, N. Clauer, S. Chaudhuri, R.Boutin, and M. Hassan, "Effect of a high silver stress on the element transfers from a smectite-type clay substrate to plants," Green and Sustainable Chemistry, vol. 2, pp. 76-89, 2012.

[20] O. Adegbuyi, B.O. Adeleye, and A.C. Ogunyele, "Evaluation of the physical and chemical properties of lateritic soils from Idoani area, Ondo State, southwestern Nigeria," Achievers Journal of Scientific Research, vol. 1, pp. 25-31, April 2016.

[21] T.W. Adejumo, "Installation techniques of pile foundation on some low bearing capacity soils in Nigeria", African Journal of Engineering Research, vol. 1, pp. 17-22, March 2013.

[22] A.S. Al-Farraj, "The mineralogy of clay fractions in the soils of the sourthern region of Jazan, Saudi Arabia," Journal of Agronomy, vol. 7, pp. 115-126, 2008.

[23] S. Dewaele, H. Goethals, and T. Thys, "Mineralogical characterization of cassiterite concentrates from quartz vein and pegmatite mineralization of the Karagwe-Ankole and Kibara Belts, Central Africa," Geologica Belgica, vol. 16, pp. 66-75, 2013.

[24] S. Ozer, E. Meric, M. Gormus, and S. Kanbur, "Biogeographic distribution of rudists and benthic foraminifera: An approach to Campanian-Maastrichtian palaeobiogeography of Turkey," Geobios, vol. 42, pp. 623-638, 2009.

[25] E. Akça, Determination of the Soil Development in Karapinar Erosion Control Station Fallowing Rehabilitation, University of Cukurova-Institute of Natural and Applied Sciences, Doctoral Thesis, Adana-Turkey, 2001, pp. 195.

[26] O. Parlak, V. Hock, and M. Delaloye, "The supra-subduction zone Pozanti-Karsanti ophiolite, southern Turkey: Evidence for high-pressure crystal fractionation of ultramafic cumulates," Lithos, vol. 65, pp. 205-224, 2002.

[27] V.C. Farmer, The Infrared Spectra of Minerals, 1st ed., Mineralogical Society: London, 1974, pp. 43-236.

[28] P.G. Nayak, and B.K. Singh, "Instrumental characterization of clay by XRF, XRD and FTIR," Bulletin Material Science, vol. 30, pp. 235-238, 2007.

[29] R.L. Frost, S.J. Van Der Gaast, M. Zbik, J.T. Kloprogge, and G.N. Paroz, "Birdwood kaolinite: a highly ordered kaolinite that is difficult to intercalate-an XRD, SEM and Raman spectroscopic study," Applied Clay Science, vol. 20, pp. 177-187, 2002.

[30] A.A. Elueze, C.A. Bakare, and A.T. Bolarinwa, "Mineralogical, chemical and industrial characteristics of residual clay occurrences in Iwo and Ijebu areas, southwestern Nigeria," Jornal of Mining and Geology, vol. 40, pp. 119-126, 2004.

[31] W. Durner, "Hydraulic conductivity estimation for soils with heterogeneous pore structure," Water Resources Research, vol. 30, pp. 211-223, 1994.

[32] K. Semhi, N. Clauer, and S. Chaudhuri, "Variable element transfers from an illite-rich substrate to a growing plant during a three-month experiment," Applied Clay Science, vol. 57, pp. 17-24, 2012.

[33] R. Prasad, M. Kumar, and A. Varma, "Role of PGPR in soil fertility and plant health," Soil Biology, vol. 42, pp. 247-260, December 2014.

[34] A.S. Al-Farraj, "Mineralogical composition of limestone rock and soil from Jubaila formation," Asian Journal of Earth Sciences, vol. 4, pp. 203-213, 2011.

[35] M.K. Yaliniz, P.A. Floyd, and M.C. Goncuoglu, "Supra-subduction zone ophiolites Central Anatolia: Geochemical evidence from the Sarikahraman ophiolite, Aksaray, Turkey," Mineralogical Magazine, vol. 173, pp. 697-710, 1996.

[36] M.K. Yaliniz, P.A. Floyd, and M.C. Goncuoglu, "Geochemistry of volcanic rocks from the Cicekdag ophiolite, Central Anatolia, Turkey, and their inferred tectonic setting within the nortern branch of the Neotethyan ocean" in Tectonics and Magnatism in Turkey and the Surroundings Area, vol. 173, E. Bozkurt, E. Winchester, and J.D.A. Piper, Eds. Geological Society: London, Special Publishing, 2000, pp. 203-218.

[37] A.H. Akhaveissy, "Implementation of generalized plasticity in load-deformation behavior of foundation with emphasis on localization problem," World Academy of Science, Engineering and Technology, vol. 39, pp. 4-9, 2010.

[38] R.G. Elenga, B. Mabiala, L. Ahouet, J. Goma-Maniongui, and G.F. Dirras, "Clayey soils from Congo and physical properties of their compressed earth blocks reinforced with post-consumer plastic wastes," Geomaterials, vol. 1, pp. 88-94, 2011.

[39] M.L. McKelvy, T.R. Britt, B.L. Davis, J.K. Gillie, L.A. Lentz, A. Leugers, R.A Nyquist, and C.L. Putzig, "Infrared spectroscopy," Analytical Chemistry, vol. 68, pp. 93-160, 1996.

[40] E. Demir, and H. Yalcin, "Adsorbents: Classification, properties, use and projections," Turkish Journal of Scientific Reviews, vol. 7, pp. 70-79, 2014.

[41] A. Polat, J.F. Caset, and R. Kerrich, "Geochemical characteristics of accreted material beneath the Pozanti-Karsanti ophiolite, Turkey: Intra-oceanic detachment, asembly and obduction," Tectonophysics, vol. 263, pp. 249-276, 1996.

[42] O. Parlak, "Geochemistry and significance of dyke swarms in the Pozanti-Karsanti ophiolite (Sourthern Turkey)," Turkish Journal of Earth Sciences, vol. 24, pp. 29-38. 2000.

[43] X. Guan, X. Chen, and J. Jiang, "Integration of modified uninformative variable elimination and successive projections algorithm for determination harvest time of laver by using visible and near infrared spectra," African Journal of Agricultural Research, vol. 6, pp. 5987-5991, November 2011.

[44] M.M.S. Rossi, G.C. Caterina, and R.L. Rossi, "Effects of soil water content in four soybean genotypes in different environments in the Central Area of the Argentine Pampean region," Open Access Library Journal, vol. 2, pp. e2034/1-9, 2015.