Arab Gulf J. Scient. Res., Agric. Biol. Sci., **B5** (3), pp. 321-337 (1987)

Soils of Qassem and Hail Regions of Central Saudi Arabia

H. Shadfan[1] and A.A.A Hussen

Soil Science Department, Faculty of Agriculture, King Saud University, Riyadh, Saudi Arabia

ABSTRACT. Nine soil profiles from Qassem and Hail regions of Central Saudi Arabia were investigated for their physical, chemical, and mineralogical properties. It was found that the soils of Qassem which were formed on Permain sediments were Gypsiorthids, highly saline, and contained high amounts of kaolinite in the clay fraction. Soils formed on Quaternary deposits were Calciorthids with high carbonate in the topsoil. Palygorskite was found in high amounts in the clay fraction of these soils. Soils of Hail region which were formed from granite were Torriorthents with small amount of salts and carbonate. Smectite dominated the clay fraction of these soils. Soil properties of both regions were mainly determined by the parent materials of the soils. Most soils contained low amounts of nitrogen, available phosphorus, and zinc.

Agriculture has become a major concern for the government of Saudi Arabia within the last 10 years. Wheat production in the country has increased from 4,000 tons in 1978 to over 1,000,000 tons in 1984. In spite of the great increase in the development of agriculture, little is known on the soils of the area. The Qassem region in the central part of the country is the major expansion area for wheat production due to the availability of ground water. Studying the soils of that region will help in the proper selection of these soils for agriculture in order to properly utilize the limited sources of available ground water.

The objectives of this work were to i) study some of the physical, chemical, and mineralogical properties of the major soils in that area, ii) evaluate genesis and formation of soils common to the region, and iii) evaluate the status of nutrients that limit agricultural production in that environment.

1 *Present address:* 3700 Fredericksburg Rd # 149, San Antonio, Texas 78201, USA.

General Nature of Study Area

The foundation for the sedimentary deposition in central Arabia is the Arabian Shield - a vast Precambrian complex of igneous and metamorphic rocks that occupies roughly one-third of the Arabian Peninsula in the west and crops out along the southern coast. Gneissic granite, andesite, and schist of Precambrian are exposed west of Qassem (Buraydah) and Hail aea (Fig. 1). Paleozoic, Mesozoic, and lower Tertiary sediments are exposed in central Arabia where they crop out in a great curved belt along the eastern margin of the Arabian shield. Sag and Tabuk sandstone formations are exposed in large areas east of Hail and west of Qassem (Buraydah). The Permian (Kuff Formation) and Triassic (Jilh Formation) rocks at the base are limestone and dolomite alternating with gypsiferous shale. Above the Triassic System are Lower and Middle Jurassic rocks which are interbedded marine shale and shelf limestone. Upper Cretaceous (Aruma Formation) and Eocene rocks, almost exclusively in limestone and dolomite facies, are extensively exposed along the eastern edge of the great curved belt. Some of these sediments are partially covered with Quaternary deposits of sand, silt, clay, and gravel sheets (Powers *et al.* 1966). Vast areas in central and eastern Arabia (Fig. 1) are coated by a cover of calcareous duricrust which is believed to be the result of certain climatic conditions mainly during the Upper Pliocene and Early Pleistocene. Its further development during the humid phases of the Pleistocene and Holocene may have been relatively slow, while the surface denudation has been quite considerable during the intermediate arid phases of Quaternary (Al-Sayari and Zotl 1978).

Soils in central Saudi Arabia are mainly Torriorthents, Gypsiorthents, Gypsiorthids, Torrifluvent, and Torripsamment (Mashhady *et al.* 1980, Bashour *et al.* 1983, Viani *et al.* 1983, Lee *et al.* 1983, Shadfan *et al.* 1984, Shadfan and Mashhady 1985).

The climate of the study area is arid with high temperature and low rainfall. The mean temperature during the summer ranges from 31-33 and in winter 12-15°C. The amount of rainfall ranges from 100-200 mm/year (Schyfsma 1978).

Materials and Methods

Nine soil profiles were sampled within the area between Buraydah (Qassem) and Hail to represent the different soils and geologic formations in the area (see Fig. 1). Profiles 1 and 2 were sampled within the Kuff Formation of Permian 20 to 50 km north of Buraydah. Profiles 3, 4, and 5 were sampled within soils formed on calcareous duricrust. Profiles 6 and 7 were sampled within soils formed on Quaternary sediments of quartz and limestone gravels. Profiles 8 and 9 were formed on geneissic granite of Precambrian about 60-90 km southeast of Hail.

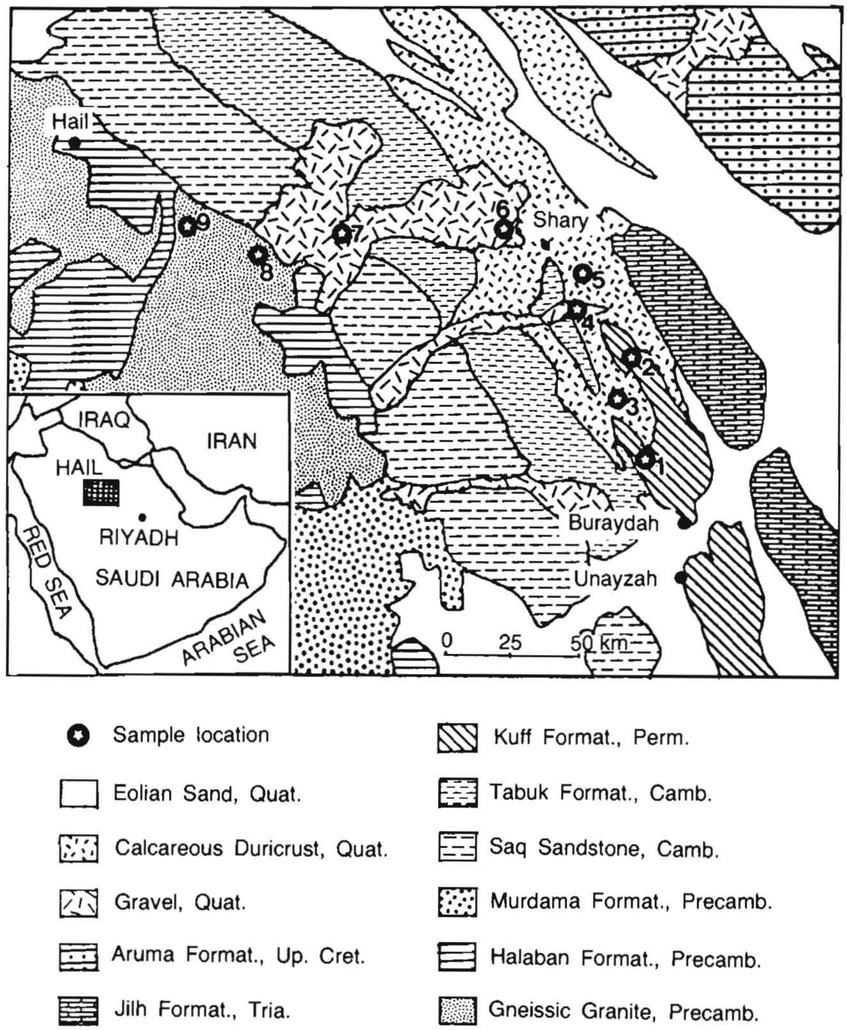

Fig. 1. Geological map of area studied with sampling sites (compiled by the U.S.G.S. and the Arabian American Oil Co., 1963).

Profiles were described and sampled and the following measurements were undertaken on the less than 2 mm fraction: pH (H_2O), carbonates (volumetric calcimeter method), electrical conductivity (in saturated paste extract), mechanical analysis (hydrometer method), and organic carbon (Walkely Black method). The procedures used for all the above analyses are described by Black (1965). Gypsum was determined using the precipitation method with acetone (Richards 1954). Soil samples were passed through a 50 μm sieve and treated with 1M NaOAc (pH 5) for carbonate removal (Jackson 1975). The treated samples were suspended with calgon and the < 2 μm clay fractions were separated by centrifuge. The clay fraction was Mg saturated and glycerated or K saturated prior to sedimentation on glass slides for XRD analysis. The K-saturated samples were x-rayed at 25°C and after heat treatments for 2 h at 300 and 550°C. XRD powder analysis for the sand and silt fractions was carried out on powder mounts by backfilling rectangular aluminium frames. Powder and clay samples were analyzed with a Philips X-ray diffractometer with a graphite monochromator and a Cu target X-ray tube operated at 35Kv and 15mA. The relative abundance of minerals in the samples was judged from XRD peak intensities. Transmission electron microscopy was used to examine the fibrous minerals in the clay fractions. Available phosphorus was extracted with 0.5M $NaHCO_3$ (OLsen *et al.* 1954) and phosphorus in the extract was determined by the method of Watanabe and Olsen (1965). Micronutrients (Fe, Zn, Mn, and Cu) were extracted with DTPA (Lindsay and Norvell 1978). Soil samples were extracted with 1N NH_4OAc, pH = 7 for exchangeable or available potassium (Black 1965).

Results and Discussion

General Soil Characteristics

Profiles 1 and 2 that are formed on Permian sediments of the Kuff Formation were typic Gypsiorthid ranging in texture from loamy sand to sandy clay loam (Table 1). They formed a gypsic horizon in the first 50 cm of the soil profile, which is probably originated from the parent material (Table 2). The presence of gypsum in the sediments of the Kuff Formation was indicated by Power *et al.* (1966). Carbonate content mostly in dolomite increased with depth within the soil profile. The high salinity in both profiles resulted from the long period of cultivation of these soils.

Soils formed on the Quaternary calcareous duricrust (Profiles 3, 4, and 5) were Calciorthids with coarse texture ranging from sandy loam to sandy clay loam (Table 1). Gypsum was absent in these soils while carbonate content mainly as calcite was high especially in the upper part of the soil profile (Table 2). The low salinity of these soils reflects their recent introduction to cultivation.

Table 1. Morphology of soil profiles

Horizon	Depth (cm)	Moist colors	Texture	Sand 2000-50	Silt −2 %	Clay <2 μm
Profile 1. Typic Gypsiorthid						
Ap	0-15	7.5YR 4/6	1s	79	9	12
IC_1	15-40	7.5YR 5/4	1	43	41	16
IC_2	40-90	7.5YR 5/4	1	51	35	14
IC_3	90-115	7.5YR 4/6	1	45	39	16
IIC_1	115-135	7.5YR 4/6	si1	25	53	22
Profile 2. Typic Gypsiorthid						
Ap	0-20	7.5YR 4/6	1s	79	9	12
C_1	20-50	7.5YR 4/6	s1	72	14	14
C_2	50-90	7.5YR 4/6	s1	74	12	14
C_3	95-120	7.5YR 4/6	s1	76	11	13
Profile 3. Typic Calciorthid						
Ap	0-10	5YR 4/4	s1	64	16	20
C_1	10-35	5YR 4/6	s1	64	16	20
C_2	35-85	5YR 4/6	sc1	67	10	23
C_3	85-120	5YR 6/6	s1	74	9	17
C_4	120-140	5YR 4/6	s1	69	14	17
Profile 4. Lithic Calciorthid						
Ap	0-15	5YR 4/4	1s	80	8	12
IC_1	15-35	5YR 4/4	s1	71	9	20
IC_2	35-55	5YR 4/4	sc1	69	9	22
Profile 5. Typic Calciorthid						
Ap	0-15	5YR 4/6	s1	80	10	10
C_1	15-40	5YR 4/6	s1	70	12	18
C_2	40-75	5YR 5/6	s1	71	11	18
C_3	75-100	7.5YR 6/6	s1	76	6	18
C_4	100-150	5YR 4/6	s1	75	10	15
Profile 6. Typic Calciorthid						
Ap	0-15	5YR 4/6	s1	68	13	18
C_1	15-40	5YR 4/6	sc1	62	17	21
C_2	40-75	5YR 4/6	sc1	68	11	21
C_3	75-110	5YR 5/6	s1	60	21	19
Profile 7. Typic Calciorthid						
Ap_1	0-15	5YR 4/4	s1	68	13	18
Ap_2	15-35	5YR 4/6	s1	68	18	14
IC_1	35-60	5YR 4/6	s1	75	10	15
IIC_1	60-100	5YR 4/6	1s	86	5	9
$IIIC_1$	100-135	5YR 4/6	s1	78	5	17
IVC_1	135-195	5YR 5/6	s	91	2	7
IVC_2	195-220	5YR 4/6	1s	85	6	9

Table 1. (contd.)

Horizon	Depth (cm)	Moist colors	Texture	Sand 2000-50	Silt -2	Clay <2 μm
				%		
Profile 8. Typic Torriorthent						
C_1	0-20	5YR 4/3	1s	85	7	8
C_2	20-35	5YR 4/3	s	92	1	7
C_3	35-49	5YR 4/3	s	89	2	9
C_4	49-80	5YR 4/3	1s	84	6	10
C_5	80-110	5YR 4/3	s	87	6	7
Profile 9. Typic Torriorthent						
C_1	0-15	7.5YR 4/4	s1	78	10	12
C_2	15-45	7.5YR 4/4	s1	75	11	14
C_3	45-70	10YR 6/5	1s	80	8	12

Table 2. Selected chemical properties of soils

Profile No.	Horizon	pH (H_2O)	EC mS/cm	Gypsum %	$CaCO_3$ %	Organic matter %	Available K	P	Fe	Mn	Zn	Cu
							ppm					
1	Ap	7.5	15.2	15.0	3.4	0.53	200	4.5	4.5	1.0	0.2	0.3
	IC_1	7.5	33.6	38.1	5.8	0.88	650	7.0	1.0	0.4	0.2	0.3
	IC_2	7.5	28.1	38.0	5.0	–*	–	–	–	–	–	–
	IC_3	7.5	29.9	8.3	5.9	–	–	–	–	–	–	–
	IIC_1	7.5	34.9	9.1	29.6	–	–	–	–	–	–	–
2	Ap	7.4	12.7	3.8	9.2	0.96	480	9.2	9.4	2.8	0.8	0.4
	C_1	7.6	4.6	3.0	9.9	0.74	230	2.2	0.9	1.1	0.4	0.5
	C_2	7.7	3.3	2.8	12.0	–	–	–	–	–	–	–
	C_3	7.6	0.8	0.3	9.6	–	–	–	–	–	–	–
3	Ap	7.5	8.2	0	23.0	0.66	650	7.3	6.1	4.2	0.6	0.9
	C_1	7.4	10.9	0	39.5	0.30	176	1.9	3.9	2.1	0.4	0.9
	C_2	7.4	12.7	0	11.2	–	–	–	–	–	–	–
	C_3	7.5	14.5	0	16.1	–	–	–	–	–	–	–
	C_4	7.4	12.7	0	16.4	–	–	–	–	–	–	–

Table 2. (Contd.)

Profile No.	Horizon	pH (H_2O)	EC mS/cm	Gypsum %	$CaCO_3$ %	Organic matter %	Available K	P	Fe	Mn	Zn	Cu
							ppm					
4	Ap	7.6	2.7	0	5.9	1.25	220	22.7	3.8	2.5	0.4	0.3
	IC_1	7.6	3.0	0	8.3	0.96	330	3.0	6.7	2.4	0.9	0.4
	IC_2	7.5	6.3	0	12.0	–	–	–	–	–	–	–
5	Ap	7.4	1.5	0	8.3	0.66	122	3.7	4.8	2.0	0.3	0.4
	C_1	7.5	0.5	0	15.4	0.53	145	0.5	1.1	0.4	0.2	0.3
	C_2	7.6	0.4	0	13.3	–	–	–	–	–	–	–
	C_3	7.5	0.9	0	4.9	–	–	–	–	–	–	–
	C_4	7.4	2.3	0	4.5	–	–	–	–	–	–	–
6	Ap	7.3	1.6	0	18.6	0.96	188	2.3	6.1	1.7	0.5	0.9
	C_1	7.7	0.5	0	27.0	0.44	140	1.8	1.5	0.4	0.5	0.4
	C_2	7.5	1.6	0	13.7	–	–	–	–	–	–	–
	C_3	7.5	2.3	0	24.2	–	–	–	–	–	–	–
7	Ap_1	7.3	1.9	0	16.5	0.66	250	3.2	1.7	1.5	0.4	0.9
	Ap_2	7.4	2.2	0	18.3	0.59	190	0.5	1.1	0.8	0.4	0.3
	IC_1	7.2	3.5	0	18.4	–	–	–	–	–	–	–
	IIC_1	7.2	2.8	0	24.5	–	–	–	–	–	–	–
	$IIIC_1$	7.3	2.8	0	4.4	–	–	–	–	–	–	–
	IVC_1	7.3	1.5	0	5.9	–	–	–	–	–	–	–
	IVC_2	7.2	3.7	0	3.4	–	–	–	–	–	–	–
8	C_1	7.5	0.9	0	5.3	1.25	196	2.8	2.9	1.4	0.3	0.2
	C_2	7.5	0.4	0	4.3	0.89	190	1.9	6.9	1.5	0.2	0.2
	C_3	7.4	0.5	0	4.9	–	–	–	–	–	–	–
	C_4	7.3	0.4	0	6.7	–	–	–	–	–	–	–
	C_5	7.7	0.5	0	3.6	–	–	–	–	–	–	–
9	C_1	7.4	1.0	0	3.8	0.81	120	3.5	5.2	2.6	0.2	0.4
	C_2	7.5	0.6	0	2.5	0.66	174	3.3	4.7	1.8	0.2	0.4
	C_3	7.5	0.4	0	2.0	–	–	–	–	–	–	–

* = not determined

Profiles 6 and 7 that have been derived from Quaternary deposits of sand and limestone gravels were typic Calciorthids. The wide variation in texture within the soil profile is due to the mode of sedimentation in the different layers. These soils have been introduced to wheat production in the recent years due to their low salinity and availability of ground water (Table 2).

Soils of Hail region (Profiles 8 and 9) showed very limited development on the granite parent materials and were classified as typic Torriorthents (Table 1). The effect of parent material on the soils is indicated by the low amount of carbonates, low salinity, and coarse texture. The mineral composition of the sand and silt fractions of these soils consisted mainly of feldspars and quartz (X-ray data for sand and silt fraction not shown).

Clay Mineral Composition

Kaolinite was dominant in the clay fraction of Profiles 1 and 2 that were formed on the Permianin sediments of the Kuff Formation (Table 3). The X-ray diffraction patterns of Profile 1 showed strong kaolinite peak at 0.72 nm especially in the lower part of the profile with small amounts of smectite, mica, and chlorite (Fig. 2). Kaolinite in these soils is probably originated from the sediments of Kuff Formation that contain mainly kaolinite in the clay fraction (Shadfan and Mashhady 1985). On the other hand, Mashhady *et al.* (1980) found mica to be the major mineral in a sample of Kuff limestone and proposed that mica alters to smectite-mica at an early stage of weathering. The clay fraction of Profile 2 also contained appreciable amounts of palygorskite (Table 3). The increase of palygorskite in the topsoil relative to subsoil might indicate the deposition of palygorskite from other sediments.

Soils of Profiles 3, 4, and 5 showed a predominance of palygorskite in the clay fraction (Table 3). The XRD-pattern of the clay fraction for Profile 5 showed a strong palygorskite peak at 1.05 nm (Fig. 3). Similar to the other soils, the amount of palygorskite decreased with depth within the profile. In addition to palygorskite, smectite, kaolinite, mica, and chlorite were found in the clay fraction of these soils. Viani *et al.* (1983) indicated that soil clays of the central basin of Saudi Arabia have greater smectite contents than those of the kaolinitic western highland soils and palygorskite-rich eastern-region soils.

The clay fraction of Profiles 6 and 7 contained a high amount of palygorskite, kaolinite, and smectite (Table 3). As with the other soils, the palygorskite content of Profile 6 decreased with depth (Fig. 4). The presence of palygorskite in the clay fraction of Profile 6 was also indicated by transmission electron microscopy (Fig. 5). The palygorskite fibers were heterogeneous in length and width and slightly weathered unlike those found in sediments (Shadfan and Mashhady 1985).

The clay fraction of Profiles 8 and 9 that are formed on granite were predominated by smectite with appreciable amounts of mica and chlorite (Table 3). A well crystallized smectite especially in the subsoil was identified in the clay fraction of Profile 9 (Fig. 6). Only traces of palygorskite could be found in Profile 9 and in the topsoil.

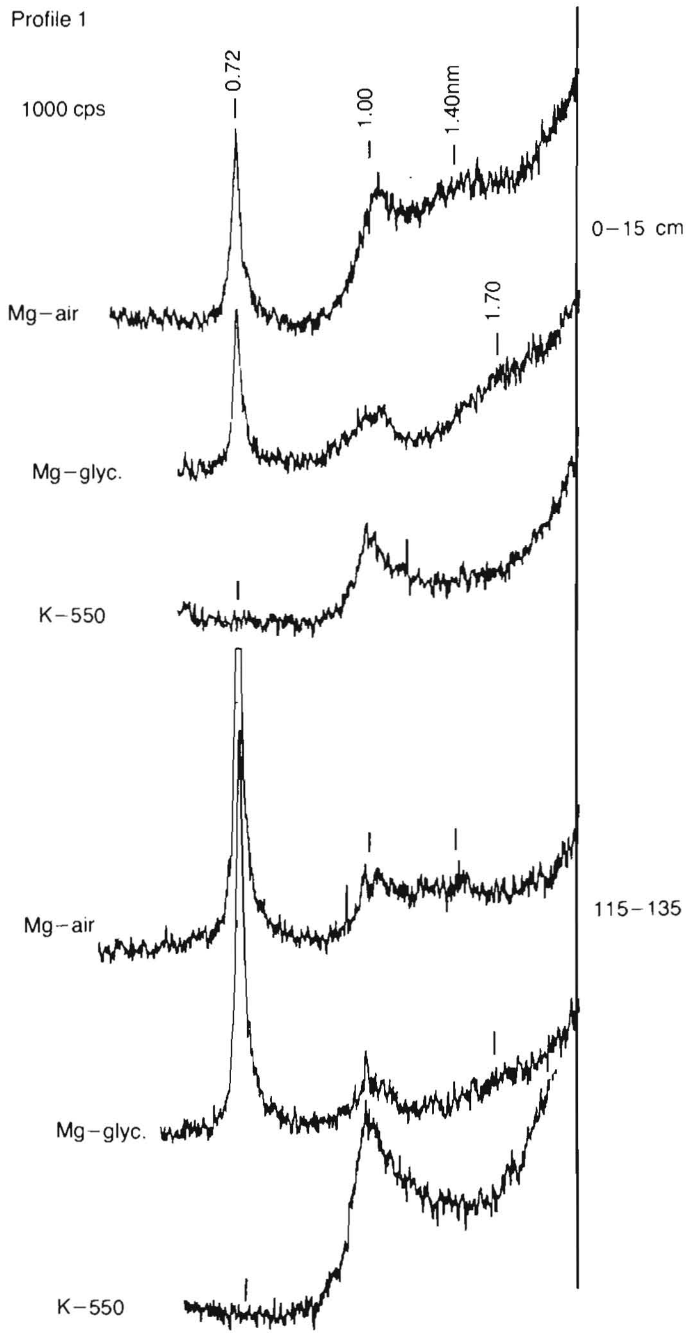

Fig. 2. X-ray diffraction patterns for the < 2μm clay from soils formed on Permian sediments.

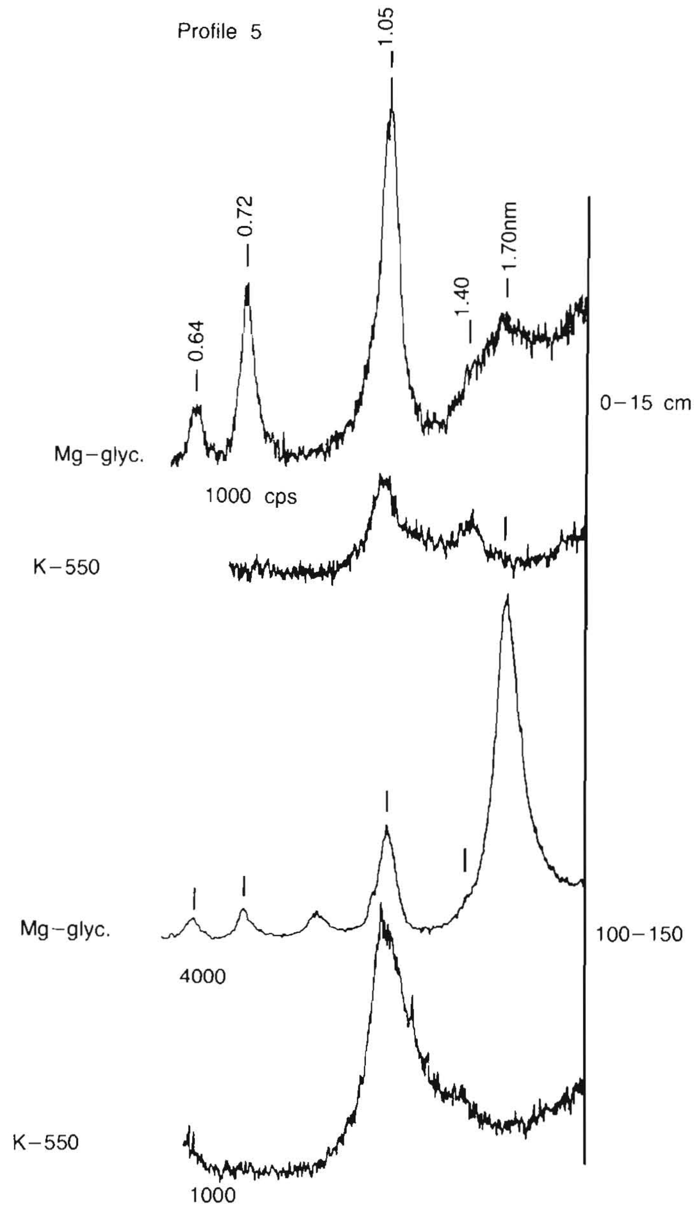

Fig. 3. X-ray diffraction patterns for the < 2μm clay from soils formed on calcareous duricrust.

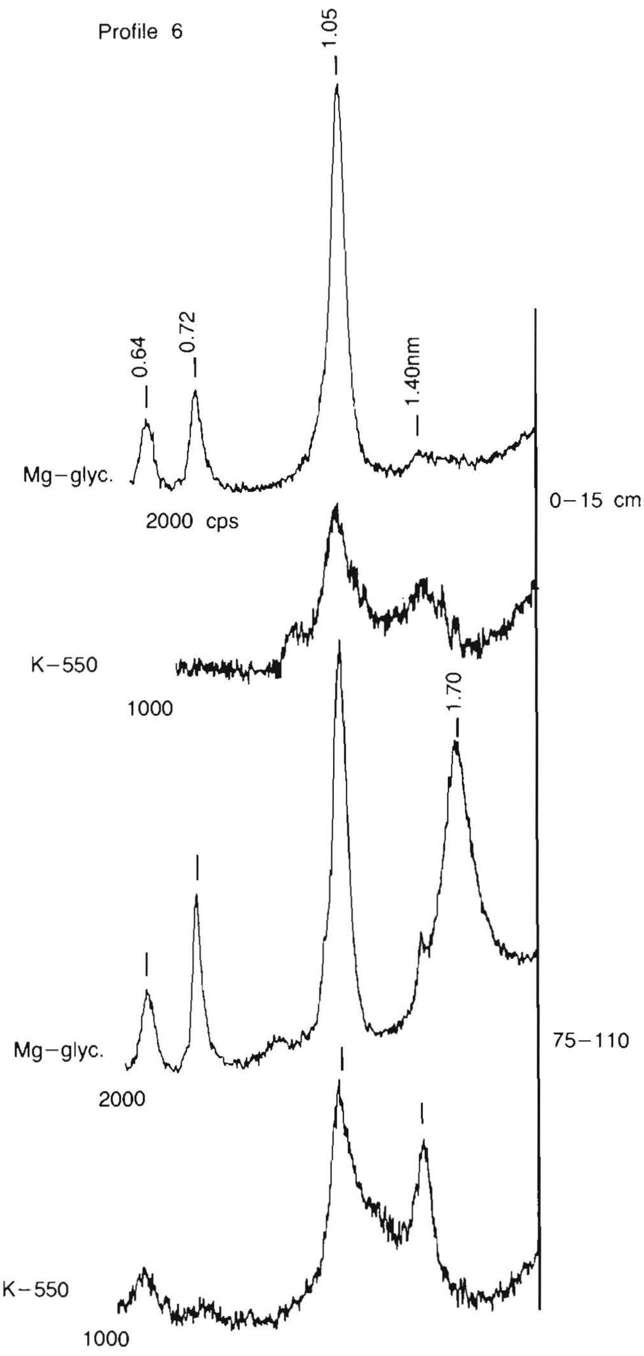

Fig. 4. X-ray diffraction patterns for the < 2μm clay from soils formed on Quaternary sediments.

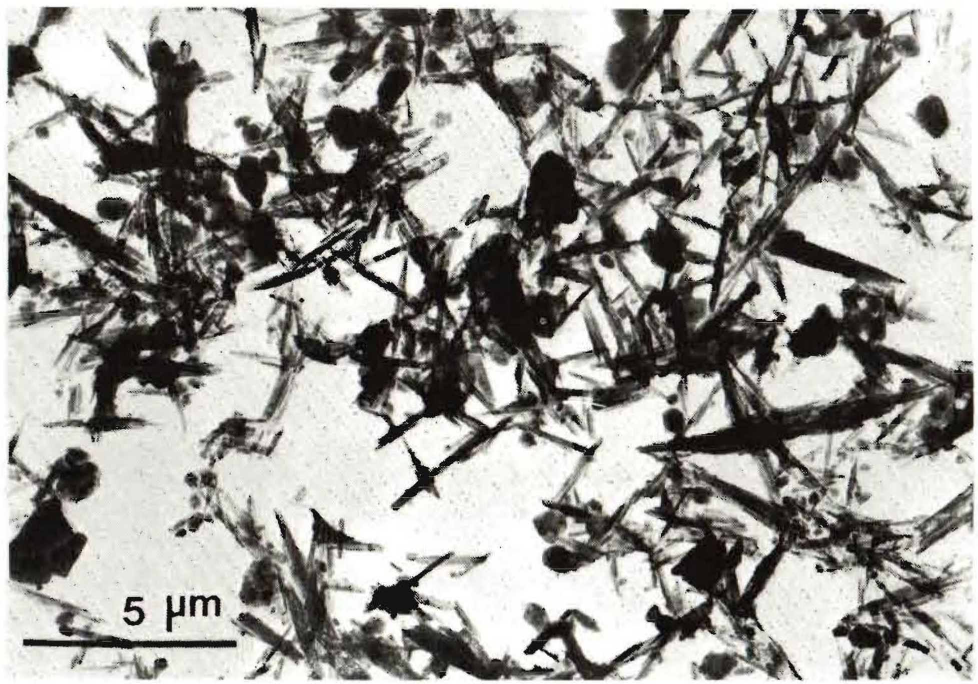

Fig. 5. Transmission electron micrographs for the < 2μm clay from soils formed on Quaternary sediments (Profile 6).

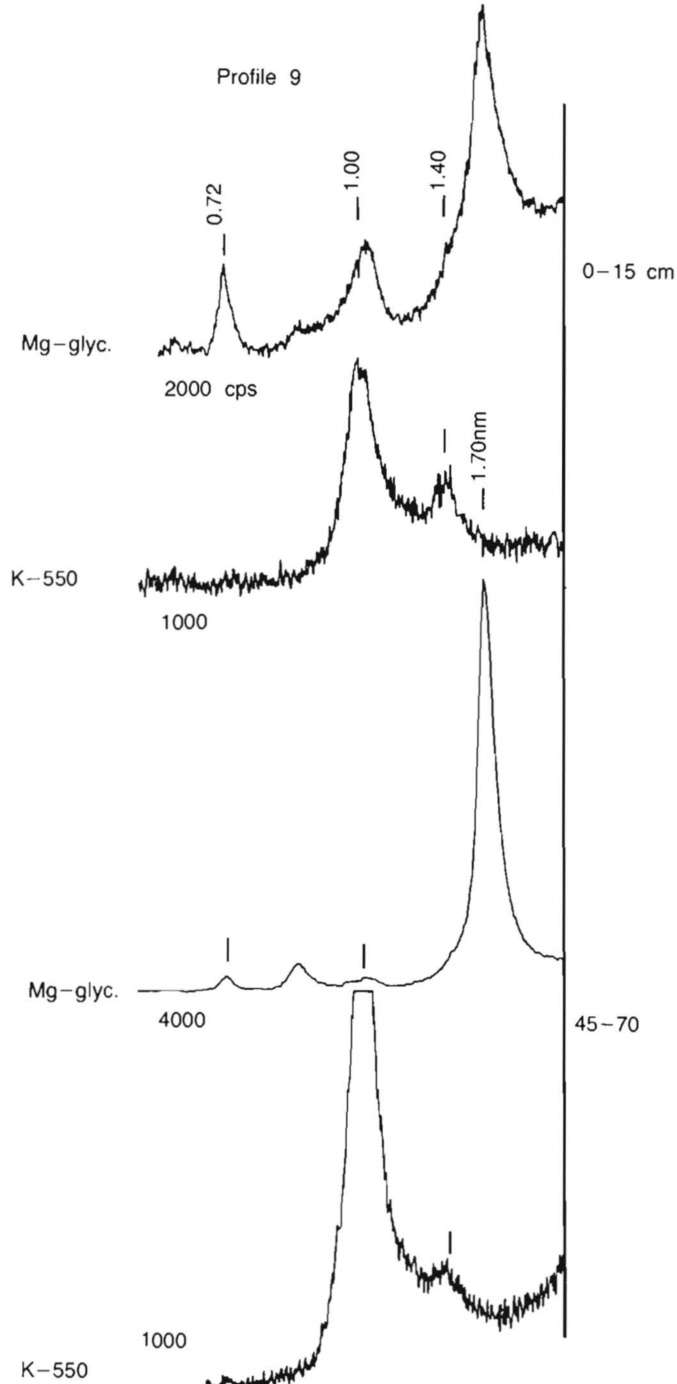

Fig. 6. X-ray diffraction patterns for the < 2μm clay from soils formed on Precambrian granite.

Table 3. The relative abundance of mica, smectite, chlorite, palygorskite, and kaolinite in the < 2 μm clay fraction of soils.

Profile No.	Horizon	Mica	Smectite	Chlorite	Palygorskite	Kaolinite
1	Ap	++	+++	+	--	++
	IIC_1	++	++	+	--	++++
2	Ap	+	++	+	++	++
	C_3	++	++	+	+	+++
3	Ap	+	+	+	+++	++
	C_4	++	+	+	+++	+
4	Ap	+	+	+	+++	++
	IIC_2	+	++	+	++	++
5	Ap	+	+	+	+++	++
	C_4	+	+++	+	+++	++
6	Ap	+	+	+	+++	++
	C_3	+	++	++	++	+
7	Ap_1	+	++	+	++	++
	IVC_2	+	+++	+	++	+
8	C_1	++	+++	+	--	+
	C_5	++	+++	+	--	+
9	C_1	++	++	++	+	+
	C_3	+	++++	+	--	+

It was obvious that the clay mineral composition was mainly affected by the parent materials of the soils. Soils formed on Permian sediments contained high amounts of kaolinite, while Palygorskite dominated the clay fraction of soils formed on Quaternary deposits. Smectite on the other hand was predominant in soils formed on granite. Palygorskite was found in higher amounts in the topsoil relative to the subsoil and therefore it could be originated from the palygorskite rich sediments. Shadfan and Mashhady (1985) reported the presence of high amounts of palygorskite in the calcareous sediments of the Aruma Formation of Upper Cretaceous. These sediments are exposed extensively in the eastern part of the study area (see map, Fig. 1). Palygorskite could be transported by wind and water from the Upper Cretaceous and Tertiary palygorskite-rich sediments in eastern Saudi Arabia to these soils. The possibility of pedogenic formation of palygorskite as suggested by Mashhady *et al.* (1980) and Elprince *et al.* (1979) could not contribute significantly to the occurrence of palygorskite in these soils.

Fertility Status of Soils

Using organic matter as a rough estimate of total nitrogen in the soils (about 10% of organic matter) soils of Qassem and Hail contained low amounts of nitrogen. The amount of organic matter ranged from 0.5 to 1.3% (Table 2), depending on the length of cultivation period for the different soils, thus growing plants in these soils will probably show high response to nitrogen fertilizers.

Considering 175 ppm NH_4OAc-extractable K as a critical level for K-availability (Doll and Lucas 1973), most soils with the exception of Profiles 5 and 9 showed adequate amounts of available potassium (Table 2). The obtained higher value of NH_4OAc extractable K in Profiles 1, 2, 3, and 4 are related to the high salinity of these soils.

The amount of $NaHCO_3$-extractable phosphorus in these soils ranged from 2.8 to 22.7 ppm in the topsoil(Table 2). All soils with the exception of Profile 4 considered to be low, if compared with a value of 10 ppm, the suggested level of available phosphorus in calcareous soils (Kamprath and Watson 1980). The high content of phosphorus in the topsoil of Profile 4 is due to P-fertilization. The low values of the indigenous P in the subsoil (less than 3 ppm) indicated the deficiency of these soils in phosphorus.

Trace elements like Fe, Mn, Zn, and Cu are generally problematic nutrients to plants in calcareous systems. Considering 4.5 ppm of DTPA-extractable Fe as suggested by Lindsay and Norvell (1978), most soils contained adequate amounts of available Fe. Considering critical values of 1.0, 0.8, and 0.2 ppm of DTPA-extractable Mn, Zn, and Cu, respectively for the availability of these nutrients (Lindsay and Norvell 1978) most soils showed adequate amounts of available Mn and Cu and low amounts of available Zn. Bashour *et al.* (1983) indicated that the amount of phosphorus, iron, and zinc in surface layers of studied soils in Saudi Arabia are below the minimum levels established for the availability of these nutrients.

References

Al-Sayari, S.S. and **Zotl, J.G.** (1978) *Quaternary Period in Saudi Arabia*, Vol. 1, Springer-Verlag, New York, pp. 4-15.

Bashour, I.I., Mashaddy, A.S., Prasad, J., Miller, T., and **Mazroa, M.** (1983) Morphology and composition of some soils under cultivation in Saudi Arabia, Geoderma, **29:** 327-340.

Black, C.A. (1965) Methods of Soil Analysis. Part 1 & 2. *Agronomy* **9:** 572, 917, 936, 1372, 1389.

Doll, E.C. and **Lucas, R.E.**, (1973) Testing soils for potassium, calcium, and magnesium. *In:* **Walsh, L.M.** and **Beaton, J.D.** (eds.) *Soil Testing and Plant Analysis*. Soil Sci. Soc. Am., Madison, WI, pp. 133-151.

Elprince, A.M., Mashhady, A.S., and Aba-Husayn, M.M., (1979) The occurrence of pedogenic palygorskite (attapulgite) in Saudi Arabia, *Soil Sci.* **128:** 211-218.

Jackson, M.L. (1975) *Soil Chemical Analysis: Advanced Course*, 2nd ed., Published by the author, Madison, WI pp. 31-34.

Kamprath, E.J. and **Watson, M.E.** (1980) Conventional soil and tissue tests for assessing the phosphorus status of soils. *In: The Role of Phosphorus in Agriculture*, Soil Sci. Soc. Am., Madison, WI, pp. 433-469.

Lee, S.Y., Dixon, J.B., and **Aba-Husayn, M.M.** (1983) Mineralogy of Saudi Arabian soil: Eastern Region, *Soil Sci. Soc. Am. J.* **47:** 321-326.

Lindsay, W.L. and **Norwell, W.A.** (1978) Development of a DTPA soil test for zinc, iron, manganese, and copper, *Soil Sci. Soc. Am. J.*, **42:** 421-428.

Mashhady, A.S., Reda, M., Wilson, M.J., and **Mackenzie, R.C.** (1980) Clay and silt mineralogy of some soils from Qasim, Saudi Arabia, *J. Soil Sci.* **31:** 101-115.

Olsen, S.R., Cole, C.V., Watanabe, F.S. and **Dean, L.A.** (1954) *Estimation of available phosphorus in soils by extraction with sodium bicarbonate.* U.S. Dept. of Agriculture Circ. 939.

Powers, R.W., Ramirez, L.F., Redmond, C.D., and **E.L. Elberg,** (1966) *Geology of the Arabian Peninsula: Sedimentary Geology of Saudi Arabia.* pp. 1-20. U.S.G.S. Prof. Paper 560-D. U.S. Government Printing Office, Washington, D.C.

Richards, L.A. (1954) *Diagnosis and Improvement of Saline and Alkali Soils*, pp. 102-104. Agric. Handb. 60. USDA. U.S. Government Printing Office, Washington, D.C.

Schyfsma, F. (1978) Climate. pp. 31-44. *In:* **Al-Sayari, S.S.** and **Zotl, J.G. (ed.)** *Quaternary Period in Saudi Arabia*. Springer-Verlag, New York.

Shadfan, H. and **Mashhady, A.S.** (1985) Distribution of palygorskite in sediments and soils of eastern Saudi Arabia, *Soil Sci. Soc. Am. J.* **49: 243-250.**

Shadfan, H., Mashhady, A.S., Eter, A. and **Hussen, A.A.** (1984) Mineral composition of selected soils in Saudi Arabia, *Z. Pflanzenernaehr. Bodenk.* **147:** 657-668.

Viani, B.E., Al-Mashhady, A.S., and **Dixon, J.B.** (1983) Mineralogy of Saudi Arabian soils: Central alluvial basins. *Soil Sci. Soc. Am. J.* **47:** 149-157.

Watanabe, F.S. and **Olsen, S.R.** (1965) Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. *Soil Sci. Soc. Am. Proc.* **29:** 677-678.

(Received 09/02/1986;
in revised form 10/01/1987)

أراضي حائل والقصيم بالمنطقة الوسطى بالمملكة العربية السعودية

حربي شدفان[1] و عاكف حسن

قسم علم التربة - كلية الزراعة - جامعة الملك سعود - الرياض - المملكة العربية السعودية

درست الصفات الفيزيائية والكيميائية والمعدنية لتسعة قطاعات من منطقة حائل والقصيم بالمنطقة الوسطى من المملكة العربية السعودية. وقد وجد أن ترب القصيم المتكونة على رواسب العصر Permian وهي من نوع Gypsiorthids ، عاليه الملوحة، وتحتوي على كميات كبيرة من معدن الكاؤلينيت في الجزء الطيني. كما وجد أن الترب المتكونة على رواسب الـ Quaternary كانت من نوع Calciorthid الغنى بالكربونات في الطبقة السطحية، مع وجود كميات كبيرة من معدن الباجورسكيت في الجزء الطيني من هذه الترب. ترب منطقة حائل المتكونة على صخور الجرانيت مجموعة Torriorthents والتي تتميز بقلة الأملاح والكربونات مع سيادة معدن السمكتيت في الجزء الطيني منها. وقد لوحظ تأثر صفات الترب في المنطقتين بمادة أصل التربة. وتحتوي أغلب الترب المدروسة على كميات قليلة من النتروجين والفوسفور والزنك الميسر.

(١) العنوان الحالي.

Dr. H. Shadfan
3700 Frederickeburg Rood # 149
Sanantonio, Texas 78201, USA