N. Alperovitch and J. Dan (1973) *Israel J. agric. Res.* 23(1): 13–19.

CHEMICAL AND GEOMORPHOLOGICAL COMPARISON OF TWO TYPES OF LOESSIAL CRUSTS IN THE CENTRAL NEGEV (ISRAEL)

By

N. ALPEROVITCH* AND J. DAN**

The chemical and geomorphological characteristics of a hard and a soft loessial crust found in the Sede Boqer plateau of the central Negev were investigated. The very hard crust, which showed high ESP and pH values, was found at the eroded site, whereas at the non-eroded site the crust was softer and had lower values of ESP and pH. The very hard crust consisted of the saline layer of loessial sierozem whose upper surface was partially leached of soluble salts. The exchangeable sodium, however, was not leached and it is suggested that the resultant clogging of the top soil may be the cause of the hard crust formation.

Hard, dry and smooth silt and clay crusts are widespread in arid areas (6, 11) and are characteristically found mainly in dry playas. Such soils are termed Takyrs by Russian soil scientists (4). The properties of these crusts are usually explained by reference to their silty-clay texture and high pH and ESP values (3, 6). Soluble salts are usually found in the deeper soil layers, having been partially leached from the crust. In areas where the upper crust is only partially leached the crusted areas are described as "slick spots" (10) because of their shiny surface and slickiness after wetting. Plant growth in such areas is either very poor or completely absent.

Most of the loessial crusts found in Israel, even in the driest playas, are not very hard (7), and playas with hard crust formations are found in the Sinai desert only. A typical hard crust polygon takyr found in such an area is illustrated in Plate 1 A. Hillel (5) has explained their formation as being due to the mechanical composition (high silt and fine sand fractions) and low organic matter content of loessial soils.

The crusts described in this note were found in the Sede Boqer plain of the central Negev, 1 km east of the settlement. The area consists of a flat loessial plain, mainly of loessial sierozems (2) on Neogene sediments, in the synclinal valley between the Boqer and Hathira anticlines, and represents the southern boundary of the aeolian loess distribution. The loessial sierozems are saline in their deeper layers (1), the depth of the saline layers depending on the amount of precipitation (2), which averages 100 mm yr^{-1} at Sede Boqer (9). The saline layer in the Sede Boqer plain begins at a depth of 10–30 cm. A description and chemical analysis of a typical soil profile are given in the Appendix.

The soil surface is characterized typically by a slightly undulating microrelief (Plate 1 B) with a horizontal distance between elevations and depressions of several meters and a vertical difference of 20–30 cm. The silt crust of the elevated areas (Plate 1 C) and of the depressions is not very hard. These areas have a sparse vegetation cover of *Ornithogalum trichophyllum*, *Erodium hirtum*,

Publication of the Agricultural Research Organization. No. 174-E, 1973 Series. Received Oct. 1972; accepted Jan. 1973.

* Div. of Physical Chemistry, ARO, The Volcani Center, Bet Dagan.
** Div. of Pedology, ARO, The Volcani Center, Bet Dagan.

Scorzonera judaica and *Plantago cornopus*. The crust of the transitional, sloping areas between the elevations and depressions (Plate 1 D) is by contrast very hard and without any vegetation cover.

Soil samples were taken from the crusts of both the elevated area (site 1) and the transitional zone (site 2) and from the soil immediately below the crusts. The soil samples were analyzed for pH, ESP, cation exchange characteristics, conductivity and soluble salt composition, using the standard methods recommended for saline soils (8).

The results (Table 1) show very high ESP values (38) in the very hard crust area (site 2) and even higher values (47) in the underlying layers. The high soluble salt content (EC of 25 mmhos) of this underlying layer results in a pH value of 8.0, lower than that found in the crust (8.45).

Much lower ESP values were found in the crust and underlying layer taken from the flat upper part of the microrelief (site 1), 8 and 28, respectively. Slightly higher pH values were found than at site 2, probably due to the lower EC values in the underlying horizon.

On the basis of these results, and other unpublished measurements from the Sede Boqer plain, it seems likely that the different structure of the crusts from the two sites can be explained by differential soil erosion. The hard crust at site 2 is a typical eroded area where the deep saline layers are exposed to the surface. Rainfall is sufficient to leach the soluble salts from the surface but the adsorbed Na^+ is not leached. As a result, the soil disperses and on drying forms a very hard crust. By contrast, at site 1, a typical non-eroded soil, the crust is soft and values of ESP and salinity increase with depth.

The chemical composition of the loessial crusts in the central Negev, and of the crusts of the typical takyr soils is identical; both soils are saline, and both crusts are the result of some leaching of salt from the upper soil layer.

In spite of the resemblance of the loessial crusts to those of the takyrs, their geomorphic formation is somewhat different. Takyrs characterize depositional surfaces of closed basins, where eroded material may collect. The floodwaters in such areas contain salts that may concentrate in the soils due to low permeability and restricted leaching. Some leaching of the uppermost layer leads eventually to the formation of the hard, sodium-saturated crust. The loessial sierozems, on the other hand, as a rule cover plateaus or slightly undulating areas that may undergo erosion. The formation of the hardest loessial crust is attributed in this case to the high salinity of the exposed deeper soil layers as a result of erosional process and some leaching which, here also, leaves a sodium-saturated crust. The formation of this crust is thus different from that of the Takyrs although the final features are similar.

ACKNOWLEDGMENT

The authors are indebted to Dr. Hanna Koyumdjisky for her comments, criticism and suggestions.

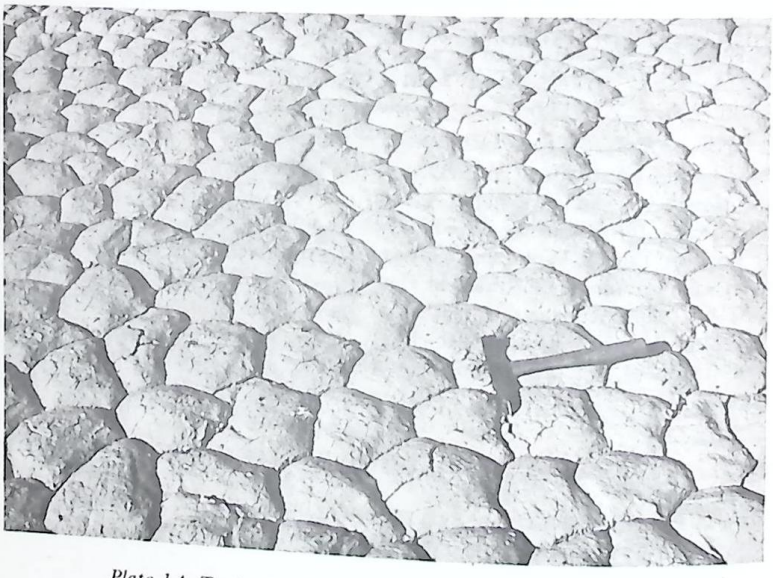

Plate 1A. Typical surface of takyr crust in Central Sinai.

Plate 1B. General view of the various crusts in the Sede Boqer plain.

Plate 1C. Loessial crust of the elevated area.

TABLE 1

CHEMICAL CHARACTERISTICS OF TWO TYPES OF LOESSIAL CRUSTS IN THE SEDE BOQER PLAIN

Soil sample	*CEC* (meq/100 g soil)	*ESP*	*EC* (mmhos)	*pH of saturation extract*	*Soluble salts* (meq/1) Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}
Site 1, Soft crust												
Elevated area, loessial crust (0 – 1.5 cm)	14.5	8.34	0.4	8.1	3.91	0.12	1.71	1.68	1.33	3.38	–	2.71
Soil underneath crust (1.5 – 10 cm)	13.95	27.60	0.55	8.7	7.67	0.077	1.14	1.12	1.09	4.68	0.52	3.71
Site 2, Hard crust												
Transitional area, loessial crust (0 – 1.5 cm)	14.81	37.95	2.50	8.45	39.13	0.17	1.71	1.68	30.3	3.12	0.30	8.97
Soil underneath crust (1.5 – 10 cm)	16.07	46.61	25.5	8.0	402.2	0.40	64.98	45.76	410.0	2.08	–	101.26

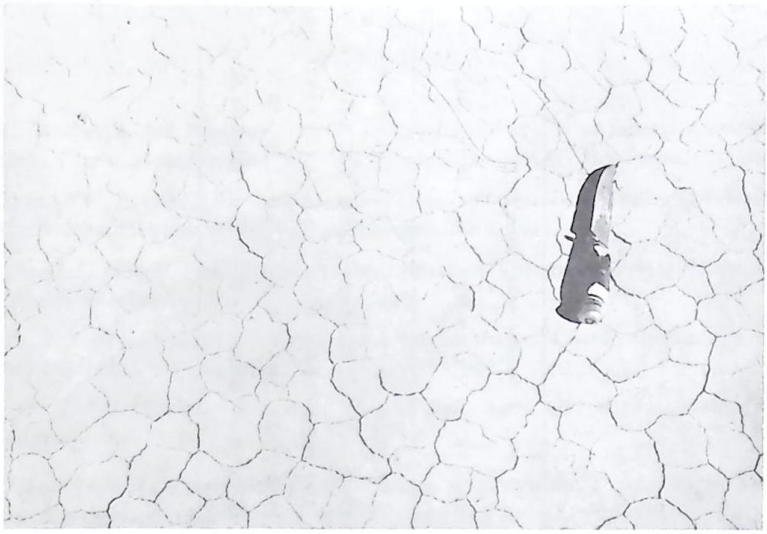

Plate 1D. Bare loessial crust from the eroded sloping area.

APPENDIX

Typical profile description from the Sede Boqer plain in the vicinity of the sites used for crust samplings.

Profile S.B. 3 – Sandy loam loessial sierozem.

Location: 1 km south of Sede Boqer, at co-ordinate 1306/0305.

Site: Broad plain covered by loessial sediments, with a very slight northwestern slope of 0–1%. The vegetation consists mainly of scattered *Hammada scoparia* shrubs, some scattered plants of *Erodium hirtum* and *Plantago cornopus,* and some small annuals. The vegetation in the depressions is more dense. The soil was sampled from a flat area, between the depressions. The whole soil is calcareous.

Profile Description

A 0–55 cm	Very pale brown (10 YR 7/3) dry, light yellowish brown (10 YR 6/4) moist, fine sandy loam; massive to weak subangular blocky structure; soft, non-sticky but slightly plastic; clear boundary.
B_{cs} 55–80 cm	Similar to above layer, with many salt and gypsum crystals mostly arranged vertically; weak medium blocky to subangular blocky structure; hard, under dry conditions; clear boundary.
C_{11} 80–130 cm	Very pale brown (10 YR 7/3) dry, light yellowish brown (10 YR 6/4) moist, fine sandy loam with very few salt and gypsum crystals; massive, soft, non-sticky but slightly plastic; gradual boundary.
C_{12} 130–160 cm	Similar layer without salt and gypsum crystals.

Analytical Results of Above Profile

Soil profile	*Depth* (cm)	*Soil size fractions* (%)				$CaCo_3$ (%)	$CaSO_4$ (%)	*CEC* (meq/100g soil)	*FSP*	*EC* (mmhos)	*Soluble salts* (meq/l)						
		clay	silt	fine sand	coarse sand						Na	K	Ca	Mg	Cl	HCO_3	SO_4
A_1	0–30	6.44	34.24	57.92	1.40	21.44	0.023	12.4	25.6	3.43	24.77	0.31	9.22	4.11	25.5	2.05	10.68
A_3	30–55	11.48	52.48	35.64	0.40	21.63	0.010	15.6	32.5	16.60	103.12	0.29	63.59	31.25	185.0	1.82	11.43
B_{cs}	55–80	14.88	60.24	24.88		21.83	1.29	18.7	30.4	22.60	152.94	0.26	89.40	46.68	245.0	1.71	42.57
C_{11}	80–130	11.16	48.36	40.48		22.88	0.30	16.1	32.0	21.27	177.94	0.23	54.37	42.76	215.0	1.59	58.71
C_{12}	130–160	10.68	46.80	41.56	0.96	22.42	0.43	13.4	31.0	23.46	218.33	0.24	50.69	46.05	225.0	1.71	88.60

REFERENCES

1. **Dan, J., Moshe, R.** and **Nissim, S.** (1972) [A typical soil profile of loessial sierozem near Be'er Sheva.] Internal Report No. 72/5, The Volcani Center, ARO, Bet Dagan. (in Hebrew)
2. **Dan, J.** and **Raz, L.** (1970) The Soil Association Map of Israel. Israel Ministry of Agriculture, and The Volcani Institute of Agricultural Research, Bet Dagan.
3. **Garkusha, J.T.** (1962) [Soil Science.] State Teachers College Publishing House, Ministry of Culture, Moscow. pp. 357–363. (in Russian)
4. **Genusov, A.Z.** (1964) [Soils of Central Asia.] Int. Seminar on Classification and Investigation of Soils, Tashkent. (in Russian)
5. **Hillel, D.** (1959) [Studies on Loessial Crusts.] *Bull. Agric. Res. Stn, Rehovot, Israel* **63.** (in Hebrew)
6. **Neal, J.T.** (1969) Playa variations. *In:* Arid Lands in Perspective. The American Association for the Advancement of Science, Wash., D.C.; and The University of Arizona, Tucson, Arizona. pp. 13–44.
7. **Ravikovitch, S., Pines, Fanya** and **Dan, J.** (1957) Soils of the Central and Southern Negev. Ford Foundation Research Projects. pp. 211–238. Israel Foundation Trustees, Jerusalem.
8. **Richards, L.A.** [Ed.] (1954) Diagnosis and Improvement of Saline and Alkali Soils. *Handbk U.S. Dep. Agric.* **60.**
9. **Rosenan, N.** (1970) Rainfall Maps of Israel. Climate IV/2. *In:* Atlas of Israel. Elsevier Publ. Co., Amsterdam, and Survey of Israel, Ministry of Labor, Jerusalem.
10. **SSSA Sub-Committee for Soil Terminology.** (1971) Glossary of Soil Science Terms. SSSA, Madison, Wisc.
11. **Vilensky, D.G.** (1954) [Soil Science.] State Teachers College Publishing House, Ministry of Culture, Moscow. pp. 375–382. (in Russian)