Colloque de la Sous-commission de Micromorphologie des Sols
de l'Association Internationale de la Science du Sol

MICROMORPHOLOGICAL STUDIES AS A PART OF SOIL SURFACE RESEARCH

An introduction

Christian VALENTIN

REUNION INTERNATIONALE DE MICROMORPHOLOGIE DES SOLS

PARIS FRANCE 8-12 JUILLET 1985

MICROMORPHOLOGICAL STUDIES AS A PART OF SOIL SURFACE RESEARCH. AN INTRODUCTION

Christian VALENTIN
ORSTOM, B.P. V-51, ABIDJAN, IVORY COAST.

The theme of structural alteration induced by cultural pr&tices must be seen as highly appropriate for inclusion in a meeting on soil micromorphology. Indeed, the impact of man as a soil-forming factor, has dramatically increased throughout the world in the last decades. This has resulted in the development of specific pedological features the characterization of which has been allowed mainly by micromorphological studies. Among the authors who contributed the most to draw the attention of agronomists and soil scientists to this topic, Dr. A. JONGERIUS is definitely the one who played the major role. That is why I wish to express the appreciation of all those who met this oustanding scientist for dedicating this session to him. His famous works led him to develop the concept of *regrouping phenomena* that he defined in 1970 as "all changes in the mutual arrangement of solid components in the pedon, caused by natural processes or by human activity, in so far that they - at least as concerns the mineral components - are not a consequence of enrichment from outside the pedon or of transformation in situ". Jongerius classified the regrouping phenomena into three groups, namely pedoturbations, pedocompactions and concentrations. Only few papers in this conference address the first group, i.e. the mixings of components caused by natural processes (such as faunal activity under broadleaved forest - BULLOCK and NYS, these proceedings) or by human activity (such as tillage action - BILLOT and MARIONNEAU, these proceedings). More numerous are the papers devoted to pedocompaction. These tillage-induced processes result in the development of plowpans, as studied under various circumstances and climatic conditions: temperate (COLLINS and LARNEY, these proceedings, KOOISTRA, these proceedings), mediterranean (OLMEDO PUJOL, these proceedings) and tropical (ALFONSO et al., these proceedings). Most of the contributions to this session may be grouped under the heading of concentrations. More precisely, most studies are dealing with diru-concentrations, i.e. surface slaking and subsequent crust formation.

The purpose of my comments is not to itemize in detail all the aspects os surface crusting. Rather, I would like to outline some works which could be achieved reliably only with the help of microscopy. Equally, I would attempt to point out some uncertainties and unknowns which require further investigation.

Morphology, genesis and properties of surface crusts

The use of thin sections provides a visual method for examining surface crusts at a wide magnification range. It helps characterize the layers building up the crusts. Emphasis has been given mainly to the morphology of crusts occurring in the fields under temperate conditions (DULEY, 1939; McIntyre, 1958; EVANS and BUOL, 1968). Several studies, however, have clearly shown that crusted soil surface was a common feature of most soils in the desert and arid environments as well (EVENARI et al. 1974; VALENTIN, 1981).

Micromorphology is often used to investigate the intrinsic factors of crustability such as high exchangeable sodium content (GAL et al., 1984) or low calcium carbonate content (HALL, these proceedings). As an attempt to combat surface crusting, extensive consideration has been given to the use of artificial treatments such as soil conditioners (PAGLIAI et al. 1978), gypsum (GREENE etal., these proceedings), phosphoric acid (SMILLIE etal., these proceedings), sewage sludge and pig slurry (PAGLIAI et al., 1983), or sewage sludge and sawdust (BARIL, these proceedings). Various studies combining soil microscopy and rainfall simulation have been also carried out (TACKETT and

PEARSON, 1965; EPSTEIN and GRANT, 1973; MUCHER and de PLOEY, 1977). Some attention have also been paid to the crusts formed under irrigation (MILLER, 1971; BISHAY and STOOPS, 1975; SIDIBE and BROWERS, these proceedings; VALENTIN and RUIZ FIGUEROA, these proceedings). The identification of such specific features allowed TRICHET and COURTY (these proceedings) to reveal the presence of similar crusts in buried ancient soils of Afghanistan.

Most significant insight into soil crusting processes has been allowed by collecting time sequence samples under natural rainfall (BOIFFIN and BRESSON, these proceedings) or simulated rainfall (FARRES, 1978; CHEN et al., 1980). Thus, several stages could be determined together with specific crust features (structural crust and depositional crust). Based on macro- and microscopic observations, crust genesis may be reconstructed both in space and time.

Since infiltration is severely reduced by the occurrence of surface crust, many attempts have been made to relate hydraulic parameters to the pore-size distribution as obtained by using planimetry on enlarged micrographs (OLESCHKO and ANAYA GARDUNO, these proceedings), more sophisticated opto-electronic device (OLMEDO PUJOL, these proceedings) or image analyser (BOUMA et al., 1977; PAGLIAI et al., 1983; in these proceedings: BOUMA and KOOISTRA; GREENE et al.; PAGLIAI; NORTON and SCHROEDER).

As shown by FARRES (1978) and BOIFFIN (1984), micromorphological studies may assist in unravelling the complex interactive relationships between soil erosion and surface crusting.

Some gaps to be filled

Despite these important contributions, it appears that some gaps in our knowledge need to be filled. First, it must be noted that contrary to other fields of micromorphology, crust studies do not commonly use the entire range of research possibilities afforded by new techniques. For instance, SEM crust observations have been initiated lately (CHEN et al., 1980; VALENTIN, 1981; PAGLIAI et al., 1983). Moreover, no work on capillary pores within compacted crust has been so far undertaken, although combining back scattered electron images (BESI) with image analysis, as already done on soil materials (BISDOM and THIEL, 1981; JONGERIUS and BISDOM, 1981), allow such studies.

Most workds have focused on the arrangements of mineral components. Abundant litterature exists also on the crust strength. Apparently, no much attempt was done to combine these crust resistance studies to the characterization of the bonding agents which could be assisted by using an electon microprobe analyser (EMA). Perhaps even more important is the absence of data on organic components. The complex interactions between living organisms (hyphae, algae, bacterial colonies, earthworms, ants, roots , vegetative cover,....) and surface crusts still need to be investigated.

Moreover, I should highlight how fragmentary most of the studies appear , especially in terms of scale:

- in space. As mentioned by ESCADAFAL and FEDOROF (these proceedings), it should be possible to relate the structure of surface crust as revealed by microscopy to radiometric measurements gained from satellites. In the meantime, we should be trained to use the binocular magnifier in the field as commonly as our microscope in the laboratory (CALLOT, these proceedings).

- in time. More attention should be paid to the evolution of surface crusts through time. As stressed out by BOIFFIN (1984), the history of soil surface needs to be taken into account. In order to be more efficient in the fields, micromorphologists have to study the medium and long terms evolutions: cultural cyles and seasonal changes.

I whish to conclude saying that the scope of the work required to fill existing gaps is so diverse that this task should be tackled not only by specialists of micromorphology but also by teams associating rearchers from a large range of scientific fields.

REFERENCES

BISDOM, E.B.A. and THIEL, F., 1981. Backscattered electron scanning images of porosities in thin sections of soils, weathered rocks and oil-gas reservoir rocks using SEM-EDXRA. In: E.B.A. BISDOM (editor), Submicorscopy of Soils and Weathered Rocks. 1st Workshop IWGSUM, 1980, WAGENINGEN, pp. 191-206.

BISHAY, B.G. and STOOP, G., 1975. Micromorphology of irrigation crusts formed on a calcareous soil of the mechanized farm, north-west Egypt. Pédologie, (2):143.

BOIFFIN, J., 1984. La dégradation structurale des couches superficielles du sol sous l'action des pluies. Thèse, Paris, 320 p.

BOUMA, J., JONGERIUS, A., BOERSMA, O., JAGER, A. and SCHOONDERBEK, D., 1977. The function of different types of macropores during saturated flow through four swelling soil horizons. Soil Sci. Soc. Am. J., 41 (5): 945-950.

CHEN, Y., TARCHITZKY, J., BROUWER, J., MORIN, J. and BANIN, A., 1980. Scanning electron microscope observations on soil crusts and their formation. Soil Sci., 130 (1): 49-55.

DULEY, F.L., 1939. Surface factors affecting the rate of intake of water by soils. Soil Sci. Soc. Amer. Proc., 4: 60-64.

EPSTEIN, E. and GRANT, W.J., 1973. Soil crust formation as affected by raindrop impact. in: HADAS (editor), Physical Aspects of Soil Water and Salts in Ecosystems. Ecological Studies N°4, Springer Verlag edit., Berlin: 195-201.

EVANS, D.D. and BUOL, S.W., 1968. Micromorphological study of soil crusts. Soil Sci. Soc. Amer. Proc., 32 (1): 19-22.

EVENARI, M., YAALON, D.H. and GUTTERMAN, Y., 1974. Note on soils with vesicular structure in deserts. Z. Geomorph. N.F., 18 (2): 163-172.

FARRES, P., 1978. The role of time and aggregate size in the crusting processes. Eart Surface Processes, 3: 243-254.

GAL, M., ARCAN, L. and SHAINBERG, I., 1984. The effect of exchangeable Na and phosphogypsum on the structure of soil crust. SEM observation. Soil Sci. Soc. Am. J. 48: 872-878.

JONGERIUS, A., 1970. Some morphological aspects of regrouping phenomena in Dutch soils. Geoderma, 4: 311-331.

JONGERIUS, A. and BISDOM, E.B.A., 1981. Porosity measurements using the Quantimet 720 on backscattered electron scanning images of thin sections of soils. In. E.B.A. BISDOM (editor), Submicroscopy of Soils and Weathered Rocks. 1st workshop IWGSUSM 190, Wageningen, pp. 207-216.

Mc INTYRE, D.S., 1958. Soil splash and the formation of surface crusts by raindrop impact. Soil Sci. 85: 261-266.

MILLER, D.E., 1971. Formation of vesicular structure in soil. Soil Sci. Soc. Amer. Proc., 35 (4): 635-637.

MUCHER, H.J. and de PLOEY, J., 1977. Experimental and micromorphological investigation of erosion and redeposition of loess by water. Earth Surface Processes, 2/ 117-124.

PAGLIAI, M., GUIDI, G. and PETRUZZELLI, G., 1978. Effect of molecular weight on Dextran-Soil Interactions. In: EMERSON, BOND a,d DEXTER editors, Modification of Soil Structure.John WILEY & Sons edit., pp. 175-180.

PAGLIAI, M. BISDOM, E.B.A. and LEDIN, S., 1983. Changes in surface structure (crusting) after application of sewage sludge and pig slurry to cultivated agricultural soils in norther Italy. Geoderma, 30: 35-53.

TACKET, J.L. and PEARSON, R.W., 1965. Some characteristics of soil crusts formed by simulated rainfall. Soil Sci. 99 (6): 407-413.

VALENTIN, C., 1981. Organisations pelliculaires superficielles de quelques sols de région subdésertique (Agadez-Niger). Dynamique de formaition et conséquences sur l'économie en eau. Thèse 3ème cycle, Paris, 259 p.