SUB-GROUP ON WEATHERING PHENOMENA - AND NEOFORMATIONS A PROGRESS REPORT *

G. Stoops, E. Bisdom, J. Delvigne, E. Fitzpatrick and G. Paneque

I. Introduction.

In 1973 the Working Group on Soil Micromorphology of the I.S.S.S. decided to set up a Subgroup on Weathering phenomena and neoformations, in order to investigate ways of describing and classifying weathering minerals and rocks. The following persons agreed to be members of the subgroup: Dr. E.B.A. Bisdom (The Netherlands), Prof. Dr. J. Cady (U.S.A.), Dr. J. Delvigne (Secretary) (Ivory Coast), Prof. Dr. V.V. Dobrovolsky (U.S.S.R.), Dr. E.A. Fitzpatrick (Great Britain), Prof. Dr. G. Paneque (Spain), Dr. J. Sleeman (Australia) and Prof. Dr. G. Stoops (Chairman) (Belgium). In 1975 Prof. Dr. J. Cady withdrew for personal reasons.

II. The First Meeting : Its Preparation and Results.

The subgroup did not meet during the first year, but a regular correspondence between the different members permitted the drawing up of a programme which was broadly to survey the needs for terminology, classification and information encountered when describing weathe

* The content of this paper is partly based on the two first working meetings of the Subgroup on "Weathering Phenomena" of the "Working Group on Soil Micromorphology of the International Society of Soil Science". Comments of non-participating members (Dr Cady, Prof. Dr. V. V. Dobrovolsky and Dr. Sleeman) are acknowledged.

ring materials. It included a survey of macromorphologycal andmacromorphological features as well as environmental factors (climate, geomorphological position). In situ weathering material and transported weathering residues or accumulations of secondary minerals (i. e. the total weathering crust of the Russian authors) were included.

During the first meeting held in Ghent in June 1975 the draft was discussed. It was decided to concentrate first on the microscopic features resulting from an in situ weathering of rocks and minerals. Macroscopic aspects of weathering were included insofar as they are perceptible in a hand specimen. Weathering products that were transported (e. g. absolute iron accumulations, colluvial deposits of weathering products) or reorganized (e. g. calcite or gibbsite nodules in a saprolite) were not considered since such features are part of the programme of the main group.

a) The concept of weathering.

As a first step towards the analysis of the problem, the concept of weathering and the difficulties of differentiating between weathering and alteration were discussed. The members present agreed that only true meteorological weathering should be the concern of the Sub-Group. In his report on the first meeting, Dr. Delvigne proposed the followingextensive definition of weathering : "Partial or complete transformation, isovolometric or otherwise, of rocks, soils or loose sediments, accompanied by changes in their colour, texture, hardness or shape. These changes occur by partial or complete disappearance of part or all of the original minerals and their possible replacement by a secondary, crystallized or amorphous, autochtonous or partially allochtonous material. The physico-chemical reactions responsible for the weathering occur between, on the one hand, percolating or underground waters, carbon dioxide, organic matter and various ions or colloids dissolved or transported by those waters, and, on the other hand, the crystal lattice of the transforming primary minerals and the ions released from it. These processes often towards an <u>in situ</u> accumulation of soft, porous and easily erodable material which is the main source of transported sediments. Although weathering may occur at greater depth due to important fracturing or high porosity of the rock, very often it occurs near the surface or at shallow depth under temperature and pressure conditions prevailing at the Earth's surface. There are thus, important variations in the intensity of processes related to the type of climate or palaeo-climate. The main factors controlling the intensity or the rate of reactions are: temperature, rainfall, drainage, topographic locations and also the petrographic and mineralogical composition of the parent material".

According to the Glossary of Geology (1973), the term alteration is defined as "Any change in mineralogical composition of a rock brought about by physical or chemical means, especially by the action of hydrothermal solutions; also a secondary, i.e. supergene, change in a rock or mineral. Alteration is sometimes considered as a phase of metamorphism, but it is usually distinguished from it in being milder and more localized than metamorphism is generally thought to be".

In fact, materials resulting from weathering and from alteration are in many cases morphologically identical, and thus cannot be distinguished; moreover, a gradual transition between both processes may occur.

b) <u>The description of weathering phenomena.</u>

For the description of weathering phenomena an open system without established hierarchy was proposed, having several aspects that could be used, including:

- degree of preservation of rock structure;
- degree of mineral weathering;
- location of the weathering in the minerals;
- arrangement of pores and secondary products;
- shape of pores, weathering products and weathering residues;
- nature of secondary products.

Some of these parameters are further discussed.

c) The secondary porosity pattern.

A first important parameter to be studied is the secondary porosity pattern of the weathered rock. Fracture of a rock generally precedes its chemical weathering, the latter proceeding mostly along pores and fractures in the rock and in the minerals. It is generally impossible to describe the chemical weathering in a rock or mineral without making reference to the porosity pattern. On the level of rock structure, three main related distribution types of pores and minerals were recognized:

- Transmineral : pores traversing the rock without following the grain boundaries. The transmineral pores are very often several cm. long.

- Intermineral : pores traversing through the rock following the grain boundaries. If the intermineral pores are very close-spaced, the rock is crumbly and is made up of loosened, isolated mineral grains, as for example in a granitic sand.

- Intramineral : pores or minute fissures within a mineral grain, limited to the inside of its boundaries and very often without connection with the pores in the neighbouring minerals.

(these three terms were introduced beforehand by Bisdom (1967)).

Patterns of pores may be indicated by the usual terms, such as anastomosed, crossed, concentric, radial etc. Orientation patterns may contain much precise information, especially the referred orientation pattern, which is described according to the terminology in use, i. e. parallel, normal, oblique, tangential, and random or unreferred.

The shape of the pores was only partly discussed. A selection of terms will be proposed later.

Dependence : the distribution and orientation patterns of the pores and secondary products may be dependent on various factors, which may be internal or external. They are mostly zones of physical or chemical weakness where fractures are more easily formed or where chemical weathering finds less resistance.

a. Internal factors (mainly important for intramineral pores and weathering products) may be subdivided into :
   - cleavage (e. g. in pyroxenes);
   - twinning (e. g. in plagioclases);
   - crystallography (e. g. oriented crystals of secondary minerals);.
   - chemical composition (e. g. zonation) ;
   - mixture of two or more of the above-mentioned types .

b) External factors (mainly important for trans-and intermineral pores but also for intramineral ones. Their subdivision has not yet been agreed.

Genesis and filling

Pores may be formed by fracture and separation of the walls, or by solution and disappearance of some material. The shape of these two kinds of pores is different and it is often easy to recognize the two types in thin section: if the pore is an open fracture the two opposite walls are strictly parallel, even on the finest scale, and may be brought together without overlap; if the pore is due to solution, the walls are less regular and the parallelism is not perfect.

The pores may be empty, or filled to varying degrees with autochtonous or allochtonous materials, or a combination of both. It is often possible to describe the nature of the filling material (kaolinite, goethite, calcite, etc.), its colour, fabric, optical characteristics etc.

All characteristics mentioned above for pores (patterns, shapes etc.) may also be applied to their infillings, or arrangements of secondary products that look like infillings.

d. Degree of weathering

To describe the degree of rock-weathering and of mineral-weathering, it was decided to set up a scale of five classes. Stage O is reserved for the unweathered (i.e. fresh) rock or mineral. An increasing number (from 1 to 4), corresponds to an increasing degree of weathering. Stage 4 represents the completely weathered rock or mineral. With respect to the degree of rock weathering several definitions for the different stages have been proposed, but no final decision has been taken. One of the reasons for this is that some of the characteristics to be considered have not been sufficiently discussed yet.

In the same way several proposals were made to define the degree of mineral weathering. Those were discussed on the basis of different weathering sequences of some minerals, illustrated by strips of drawings showing weathering stages of the same grain. A few of these strips are shown as an example in Fig. 1. It was decided to produce in the coming years a kind of atlas illustrating as completely as possible all different weathering sequences of the most common minerals.

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III. THE SECOND MEETING

During the second meeting, held in Wageningen in June 1976, mineral weathering in particular was discussed and a proposal for a descriptive scheme of mineral transformations worked out.

The aim of this proposal is to present a classification scheme that would allow the micromorphologist to describe in simple but precise terms the type and degree of chemical weathering of minerals, in cases in which physical agents had not changed their fabric or shape. This means that the scheme is restricted to mineral transformations where pseudomorphs are formed or the dissolution holes preserved.

As on this level the problem of differentiating between products of weathering and alteration is even more difficult to solve, the term alteration was used in its most general sense, covering mineralogical and chemical changes resulting from weathering and alteration sensu stricto, or even diagenesis. Two main topics from the description scheme on mineral alterations are presented here (in a summarized form), namely the degree of alteration and the alteration pattern.

a) The degree of alteration expresses the relative amount of original mineral replaced by a secondary mineral or pore space (in the case of solution). Five classes are proposed :

Class 0 ; fresh or nearly fresh : less than 2.5% of the mineral has been altered.

Class 1 : slightly altered : 2.5- 25 % of the mineral has been altered;

Class 2 : moderately altered : 25 - 75 % of the mineral has been altered;

Class 3 : strongly altered : 75 - 97.5 % of the mineral has been altered;

Class 4 : completely altered : more than 97.5 % of the original mineral has been altered, i.e. less than 2.5 % is conserved.

The above mentioned limits are expressed in area percent.

In reality however, one must be aware that the weathering of a mineral can take place in different successive steps, related to different physico-chemical conditions (e.g. biotite to vermiculite and later to kaolinite), or may succeed a mineral alteration (e.g. olivine to serpentine, later to nontronite). In these cases the first alteration (weathering or alteration) will be referred to the primary mineral i.e. stage 0 is the fresh primary mineral. Stage 0 of the second sequence will be the end product of the first cycle of alteration.

b) Alteration patterns

The initial alteration of a mineral can be localized at different places. A few simple distribution patterns of alteration products and/or pores and of relicts of the primary minerals can be distinguished. They are summarized in Table 1 and Fig. 2.

The alteration may be of a pellicular type, i.e. starting from the border and gradually invading the mineral; a diminishing core of original material is left (Table 1, first horizontal row). The alteration may also occur along cracks, fissures, cleavage planes and other surfaces of weakness in the mineral. These surfaces may form a regular or irregular network. In the first case the alteration forms a regular linear and regular banded pattern, and the residues are arranged according to a regular pattern (organized (minute) residues). In the second case alteration products or pores will form successively an irre

-gular linear and an irregular banded pattern, residues being randomly distributed (random (minute) residues) (Table 1, row 2 and 3).

A last type of alteration is that starting inside the mineral (apparently without reference to external or internal features). In early alteration stages the secondary products or pores appear as randomly distributed individual dots (dotted), later as islands (patchy). The residue has first a cavernous aspect, changing gradually to a pattern of dispersed minute residual particles (Table 1,).

Combination of the above-mentioned patterns are of course possible (and even very frequent), yielding a complex alteration pattern.

IV FUTURE WORK

As mentioned above, the description of the porosity pattern and the transformation of individual mineral grains were considered by the members of the subgroup as a first step towards the description of more complex phenomena such as the weathering of a rock as a whole, pure physical weathering, mechanically disturbed weathering products etc.. These will be discussed during the next meetings.

Table 1

1) 0	1	2	3	4
2) 0-2.5 %	2.5-25 %	25 - 75 %	75 - 97.5 %	97.5 - 100 %
ORIGINAL MINERAL	pellicular	thick pellicullar		COMPLETELY ALTERED
		large core	core	
	linear irregular	banded irregular		
		random residues	random minute residues	
	linear regular	banded regular		
		organized residues	organized minute residues	
	dotted	patchy		
		cavernous residue	dispersed minute residues	
	COMPLEX			

← ALTERATION ORIGINAL MINERAL →

Table 1. Terminology for different patterns and degrees of alteration (cf. fig.2)

1) degree of alteration (class)

2) degree of alteration expressed in %.

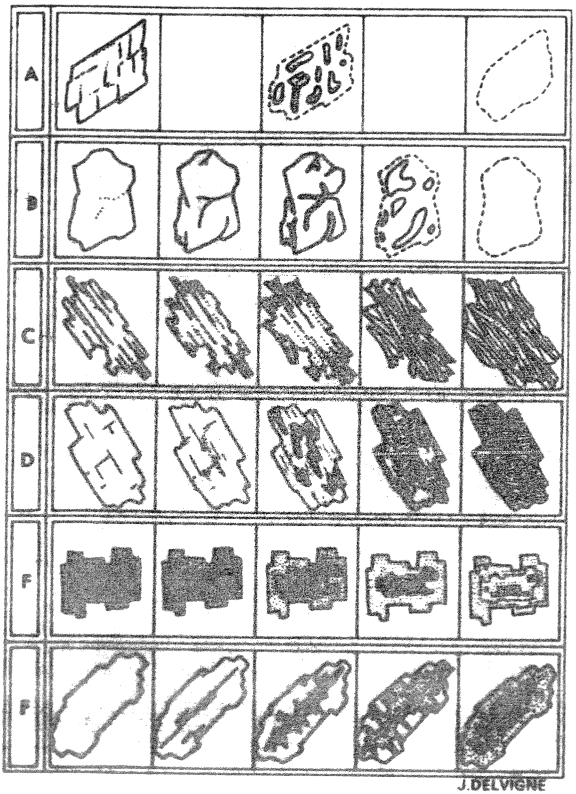

Fig. 1. Weathering Sequence of some Minerals
A) Calcite ; B) Quartz ; C) Biotite to vermiculite ;
D) Pyroxene or amphibole to vermiculite ;
E) Magnetite to hematite ;
F) Plagioclase to amorphous material and kaolinite.

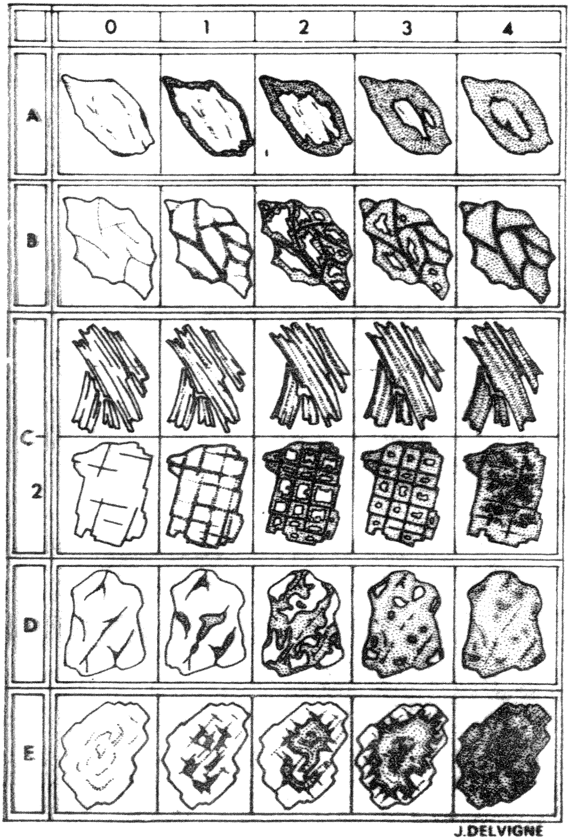

Fig. 2. Patterns and Degrees of Alteration.
A) Pellicular : Olivine to iddingsite ; B) Linear irregular : Olivine to nontronite ; C) (1) Linear regular (parallel) : Muscovite to kaolinite ; (2) Linear regular (crossed): Orthose to amorphous material and kaolinite ; D) Dotted : Feldspar to gels ;
E) Complex : Plagioclase to amorphous material and kaolinite.

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