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HEMATITE TO GOETHITE SURFACE WEATHERING

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ABSTRACT

The hematite to geothite transformation by weathering has been followed with X-ray and optical methods. Evidence is given of the influence of the hematite growth steps and dislocations in such a process.

Hematite crystals from Elba Island, developed as (0001) platelets, often show on their surfaces formations of a substance whose color varies from a bright red to a reddish brown. X-ray powder diffractometry and film methods have proved the substance to be FeO(OH), goethite, or hematite-goethite mixtures in various percentages (with a higher hematite percent when the colour is bright red). Although sometimes the red substance has appeared to be amorphous, it is our opinion that these samples are not different from the previous ones; in agreement with what has been stated by Holser (1953) and authors he cites.

The substance is usually concentrated along crystallographic directions (at angles of 60°, according to the face symmetry) which follow either growth layer steps or straight traces of dislocation movements caused by natural stresses the crystal has undergone during its history (Sunagawa, 1960; 1962).

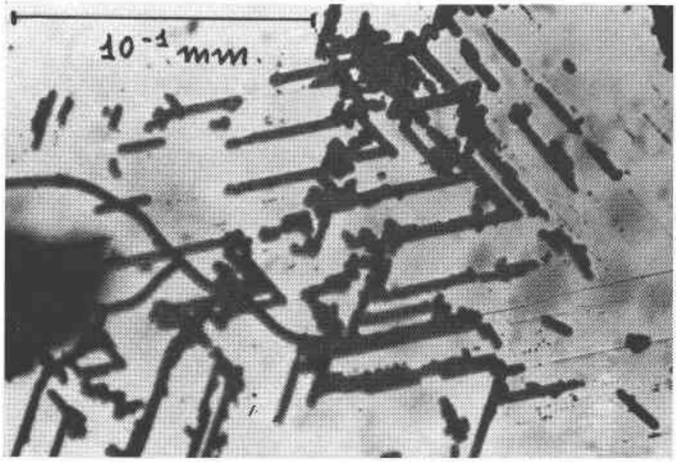

FIG. 1. Framework of goethite on hematite platelets.

The process by which geothite has formed on the hematite matrix has been directly followed in this laboratory by checking hematite platelets at intervals of about 12 hours during exposure to the atmosphere. X-ray and optical methods (phase-contrast, reflection microscopy, and interferometry) were used.

The hematite-to-goethite decay may be simplified according to the following scheme:

a) goethite formation along the lines described above, giving place to a framework like that of Figure 1.
b) filling up of the voids of the framework with formation of a crust, easily detachable, thinner than the branches of the framework (Figures 2 and 3).

Phase (a) of the process could take place in about one week when the room humidity, owing to local weather conditions, reached values higher than 90 percent, the temperature being about 20°C. Phase (b) that always followed phase (a) appeared to be even more rapid under the same conditions. No artificial laboratory conditions have been imposed.

The polarizing microscope in transmitted light showed that while very thin scales of hematite are uniaxial, the superimposed red substance is quite often biaxial, in agreement with the X-ray determinations of goethite.

On some hematite platelets that appeared to be more reactive to the weathering, the very beginning of the goethite formation was also characterized by condensation of water droplets arranged in "dendritic" formations, which can be roughly distinguished into three types.

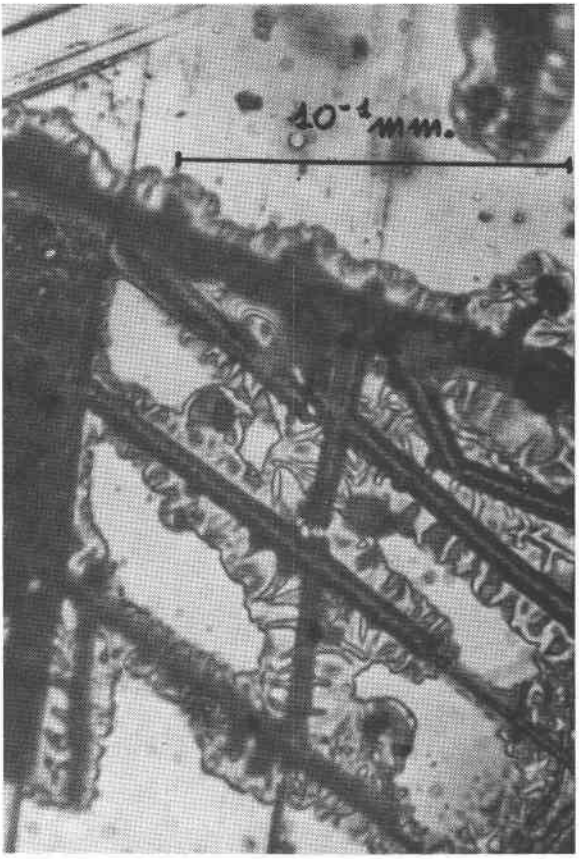

FIG. 2. Filling process of the goethite framework.

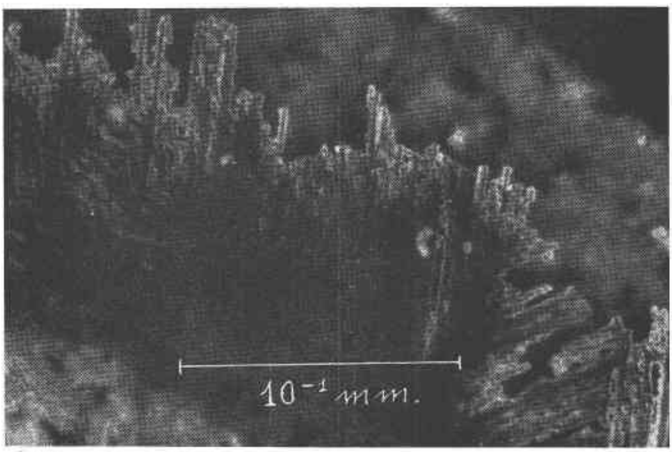

FIG. 3. Goethite crust detached from the matrix.

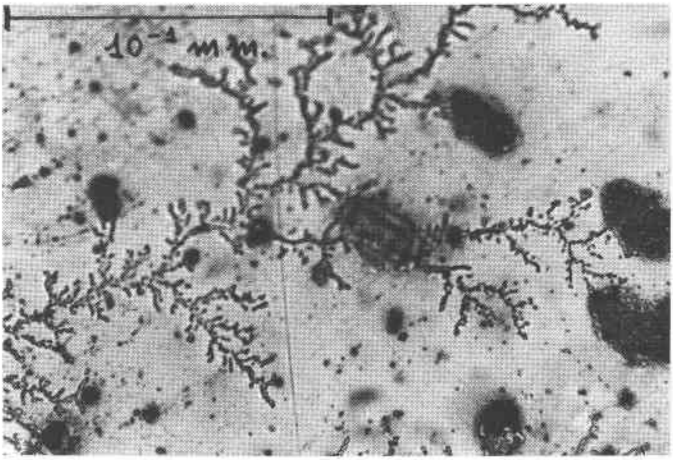

FIG. 4. Non-symmetrical water "dendrites".

Type 1: without any apparent symmetry (Figure 4).
Type 2: with a sort of hexagonal arrangement (Figure 5).
Type 3: with angles of 90° within the branches (Figure 6).
In any case the clustering of the droplets (though sometimes very puzzling as in the case of Fig. 6) seems to be linked to particular points of the surface, and we suggest that they may be regarded as a sort of "decoration".

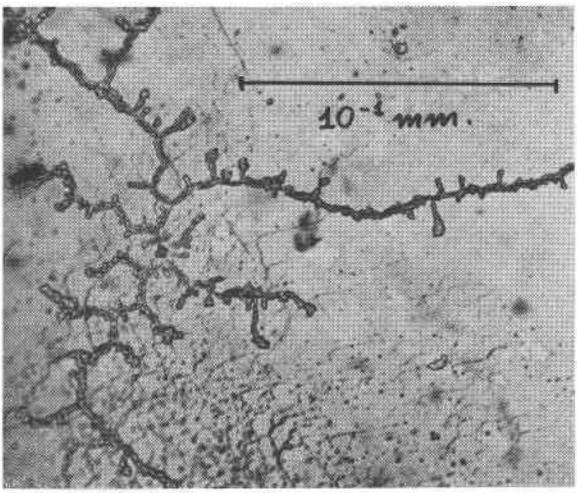

FIG. 5. Hexagonal water "dendrite"s.

FIG. 6. Orthogonal water "dendrites".

The hematite to goethite transformation has been observed:

1) at the points where the water "dendrites" cross the straight growth lines described above;
2) where the dendrites meet particles of pre-formed goethite, causing the goethite itself to grow at the expense of hematite;
3) at single points of the surface which may be sites where dislocations emerge (Thomas and Evans, 1967).

It is our opinion that the information given here may be useful to an understanding of the weathering mechanism of iron materials.

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