ALUMINIUM CONCENTRATION IN A BAUXITE DERIVED OF GRANITE (IVORY COAST): RELATIVE AND ABSOLUTE ACCUMULATIONS

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Two fundamental ways of iron and aluminium enrichment have been evidenced in Ivory Coast on a bauxitic profile derived from granite by petrographical and mineralogical analysis:

— the in situ evolutions bounded to the weathering which pseudo-morphose the parent minerals and produce an relative accumulation;
— the transfer of material in solution or in particle which produce absolute accumulation.

The historical succession of these two process give way to a progressive hardening of the original isalterite with preserved granitic texture. A relative quantification of the weathering and transfer plasmas is proposed according to the isovolumetric method.

So one can show:
— the importance of the absolute accumulation which appears as the first weathering stages and which at the end represents more than half of the indurated bauxitic material;
— that the hardening of these bauxites is caused by the multiplicacy of the transfers.
INTRODUCTION

In a recent study on the bauxite laterite formations of Ivory Coast, we described some mechanisms, which are common to lateritic profiles and occur during bauxitization [3].

These mechanisms, which are more particularly at the origin of iron and aluminium oxihydroxides accumulations are classed in two categories according to the terminology proposed by D’Hoore in 1954 [5]:

— mineralogical transformation mechanisms which, by associated losses of material, are at the origin of residual product accumulations, thus called «relative accumulations»;

— transfer and deposit mechanisms, at the origin of accumulations thus called «absolute» because they correspond to gains of material.

With structural, mineralogical and geochemical analysis, on all scales, one shows from an example on Ivory Coast’s granite, how these two types of mechanisms occur during the development of bauxitic isalteritic formation.

The example is taken from Mont Tato (384 m) in the Lakota region.

The bauxitic formation includes six successive unités (Table I). So as to

prove the facies relations, we have to distinguish perfectly both mechanisms of accumulation and so determine in the samples the weathering plasmas and the transfer and deposit plasmas.

<table>
<thead>
<tr>
<th>HORIZONS</th>
<th>Depth. in m.</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>SiO₂ quartz comb. in % of total weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardpan blocks</td>
<td>1</td>
<td>55</td>
<td>10</td>
<td>—</td>
</tr>
<tr>
<td>Upper aluminous hardpan</td>
<td>1</td>
<td>60</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>Lower aluminous isalterite hardpan</td>
<td>10 à 15</td>
<td>57</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Upper isalterite</td>
<td>3 à 5</td>
<td>43</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Lower isalterite</td>
<td>2</td>
<td>29</td>
<td>2</td>
<td>.24</td>
</tr>
<tr>
<td>Granite</td>
<td></td>
<td>17</td>
<td>2</td>
<td>29</td>
</tr>
</tbody>
</table>
I. WEATHERING PLASMAS

The orthose and albite feldspars are the first minerals to be weathered in the lower isalterite. Their pseudomorphic transformation into gibbsite is indirect: it is preceded by the transitory formation of metahalloysite. The microcline feldspars are weathered later; gibbsite septa formed delimit voids. With some microprobe analysis, we can follow this transformation (Fig. 1).

In the lower isalterite, the biotites exude their iron into interlamellar goethite and are weathered with formation of mixed interlayered bioti-

![Fig. 1: Geochemical ratio changes of feldspars, their weathering plasmas and transfer plasmas](image1)

![Fig. 2: Geochemical ratio changes of biotites, their weathering plasmas and transfer plasmas](image2)
te-vermiculite, next into kaolinite and gibbsite. Some microprobe analysis lets us follow this transformation (Fig. 2).

The quartz dissolution begins in the lower isalterite and is going on even in the hardpan. The muscovites are the last minerals to be weathered in the lower hardpan. Their transformation into gibbsite is direct. So, the parental minerals weathering is differential and always pseudomorphic. The weathering voids are as many reception sites for the transfer plasmas. There is relay between parental minerals and minerals of neoformation, which preserve the granitic textures and structures.

II. TRANSFER AND DEPOSIT PLASMAS

The eluviation of the profile leads to a redistribution of elements towards the inferior horizons. This migration develops in transfer plasmas either in particles or in solution. The accumulation occur in the form of cutanic deposits in all the illuvial microsystems. They lead to the increase of the iron and aluminium contents in the aluminous hardpan.

1) *Metahalloysite* neoformations

At the bottom of the profile, the granit presents transmineral fissures, crossing inaltered quartz and feldspars (ph. 1). These fissures contain aluminosilicated deposits which crystallize into metahalloysite (Ph. 2, 3, 4). This, which covers the unaltered quartz and feldspars surface, is independent of the bed rock and precedes the weathering of primary mineral.

Such metahalloysite neoformations can also overlay the gibbsite proceeding from the feldspars weathering, and are partly the reason why their volumes are filled (Ph. 5, 6).

Microprobe analysis lets us differentiate these transfer plasmas from the weathering plasmas (Fig. 1, 2).

2) *Kaolinite* vermiform neoformations

So in the lower isalterite, but in the superior part, kaolinite vermiforms neoformations occur in the zones of preferential circulations. These kaolinites also fill some fissures of weathering feldspars (Ph. 7, 8).

Later, from the top of the lower isalterite and in the upper isalterite, these kaolinites change into gibbsite and this transformation is direct (Ph. 9, 10).

3) *Ferrigibbsitans*

All accumulations, which have been described, are crystallizations caused by solution transfers and occur in the lower part of alterites. But in the upper isalterite these accumulations are overlayed then relayed by other accumulations caused by transfers of particles.
There are two deposit types:

- *amorphous alumino-ferruginous plasmas* which present in succession yellowbrown zones and yellow clear zones; in these cutanic deposits iron becomes displaced and is fixed into the internal position, the gibbsite cristallizes in the external position (Ph. 11, 12). So these amorphous plasmas change into ferrigibbsitans in which ferruginous dark zones and gibbsitic clear zones alternate (Fig. 3);

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**Fig. 3:** Microprobe analysis through a cutanic deposit of alumino — ferruginous plasma

- *argilo-ferruginous plasmas* superimpose the previous plasmas; these cutanic deposits, generally made up of kaolinite and ferric hydrates, present microlayers caused only by the preferential orientation of phyllite particles. Subsequently to the deposit these ferriargilans [4] are transformed into ferrigibbsitans (Ph. 13, 14). Microprobe analysis through zoned ferriargilans show that the more kaolinitic external rim undergoes a desilification. Aluminium accumulates relatively and precipitates as gibbsite (Fig. 4). This transformation can be also shown petrographically by lateral and continuous passage, in a same deposit, of kaolinite to gibbsite (Ph. 15, 16).
Fig. 4.: Microprobe analysis through a cutanic deposit of argillo — ferruginous plasma

4) Gibbsitans

A third type of plasmas corresponds to gibbsite neoformations which cross the previous cutanic plasmas. These plasmas fill some voids, and surround residual quartz. The contact surface are clear-cut. There is no continuity in the chemical compositions of these gibbsitans and their rim. The absence of iron in the structure of gibbsite, or of lateral transition to phyllite structures indicates that this gibbsite can only derive from a direct crystallization of a relatively pure solution of very strong aluminium concentration.

CONCLUSION

It can be possible to precise quantitatively how these two mechanisms of accumulation (relative by weathering and absolute by transfer) take place in the development of a lateritic profile.

This quantitative estimate has been made in this bauxitic profile developed on a granite, on the basis of isovolumetric method in the lower part of the profile where rock structure is unaltered, and selective collapsing factors in upper indurated horizons (Fig. 5).

It shows that the part of absolute accumulations increases notably from the lower part to the top of profile where it exceeds 50 %.
Boulangé: Aluminium concentration in a bauxite derived from granite

Fig. 5: Quantitative estimate of the weathering and transfer plasmas in a lateritic bauxite on Ivory Coast granite [3]

two chief stages of gibbsite formation, by weathering of primary minerals in the lower part of the alterite and by weathering of secondary minerals transferred or not, like kaolinite, from the top of the alterite.

REFERENCES

1. Bocquier, G., Boulangé, B., Ildefonse, P., Nahon, D., Muller, D.: Transfers, accumulation modes, mineralogical transformations and complexity of hi-


Boulengé: Aluminium concentration in a bauxite derived from granite
PLATE I

1. MP. Weathering of granite: from a transmineral fissure (ft), development of intramineral fissures (fi) in the feldspars
2. MP. In the unaltered microcline (mi) of the photo 1, detail of the transmineral fissure (ft) with metahalloysite (ha)
3. SEM. Transmineral fissure (ft) crossing feldspar and quartz with metahalloysite
4. SEM. Detail of fissure (ft) in a quartz with metahalloysite
5. SEM. Pseudomorphose of feldspar into gibbsite with volumes filled
6. SEM. Metahalloysite neoformation (ha) on the gibbsite (gi)
7. MP. Weathered microcline. Kaolinite neoformation (ka) in the gibbsitic septa
8. SEM. Idem photo 7
Boulange: Aluminium concentration in a bauxite derived from granite
9. MP. Transformation of kaolinite vermiform into gibbsite
10. MP. Gibbsite issued of the complete transformation of kaolinite vermiform
11. MP. Ferrigibbsite issued of the deposit and the transformation of a amorphous alumino-ferruginous plasma. On the right and on the left of the photo gibbsitic areas derived from the weathered feldspar
12. SEM. Idem photo 11. The crystals of gibbsite are smallest and disordered
13. MP. Ferrigibbsite issued of the transformation of an argiloferuginous plasma. On the right of the photo these deposits surround areas of amorphous aluminoferruginous plasmas at which so they are later
14. SEM. Idem photo 13. The crystals of gibbsite are perpendicular to the rim of void
15. MP. Ferrigibbsite. In the gibbsitic external zone, we observe the transition of phyllite structure, derived from original ferriargilan, to a prismatic structure
16. SEM. Idem photo 15. Transformation of kaolinite of ferriargilane into gibbsite
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