

## NOTE ON THE NATURE AND ORIGIN OF LATERITE.

BY

R. BELHOMME, B.A.—B.A.I.—ASSOC. MEM. INST. C.E.—  
VICE-PRESIDENT.

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To the Student of the Archaeology of the Indo-Chinese Peninsula the word "Laterite" is an ever-recurring one inasmuch as most of the magnificent old ruins which have, more or less resisted the ravages of climate and vegetation had been built with this material.

But while the name and the appearance of Laterite are familiar to the tourist and Archaeologist, the origin and structure of this stone seem to be little known to them and no wonder at this since Geologists, themselves, are far from having reached complete agreement thereanent!

At the President's request, the writer has undertaken to condense, for the benefit of the lay reader, the latest theories propounded by eminent Geologists on the formation of Laterite.

The writer lays no claim to originality; this work is merely one of compilation.

What is Laterite?

The Encyclopaedia Britannica describes the rock as being:—

"a red or brown superficial deposit of clay or earth  
"which gathers on the surface of rocks and has been  
"produced by their decomposition; it is very common  
"in tropical regions."

Morrow Campbell, a great authority on the subject, describes the rock and its formation as follows:—

"Laterization is the process by which the hydroxides  
"of ferric iron, aluminium and titanium are intro-  
"duced into the mass of any rock near the surface.  
"Laterization involves deposition only" .....

The careful reader will not fail to notice a discrepancy between these two statements, to wit:—

While both authorities agree that the process of Laterization is one of leaching followed by deposition, the Encyclopaedia Britannica tells us that the deposition takes place in "clay or earth"

while Morrow Campbell states that the deposition takes place "into the mass of any ROCK".

The point is of importance because, by the first theory, Laterite would be merely an indurated clay while, by the second, it would be a conglomerate.

Considering that soft Laterites, which harden by exposure, do exist, the writer is of opinion that deposition in clay or earth is the more common product to be called by that name.

How is Laterite formed?

The answer is implied in the two definitions already given but the process deserves lengthier and more detailed description:—

The rainwater which falls over a valley partly runs away on the surface and partly percolates slowly through the ground.

Such waters as slowly percolate through the ground travel over or through the different strata from a higher to a lower level until they reach a point of escape into a stream or a state of equilibrium.

These underground waters are commonly known as sub-soil or subterranean waters,

Suppose that a section be now cut across such a valley, we would find:—

At the bottom of the valley, a water course with its banks, then the two sloping sides which gradually rise to the top of the hills.

Since percolation takes place through the sloping strata of the valley these strata can be divided into three zones:—

- 1.—The zone of Non-Saturation—this zone includes all Strata through which the waters simply percolate without ever remaining in them;
- 2.—The zone of Intermittent Saturation—this zone includes all Strata in which the action of capillarity can temporarily hold the percolating waters down to the lowest point to which atmospheric oxygen can penetrate.
- 3.—The zone of Permanent Saturation—this zone clearly implies such waters as are imprisoned below the level of our stream.

Of these three zones the waters in the second, or zone of

Intermittent Saturation, are the ones active in the process of Laterization.

For the sake of brevity, modern Geologists have coined a new word for these waters which are called "VADOSE" waters.

In tropical countries, such "VADOSE" waters contain more carbonic acid, alkaline carbonates, organic matters, etc., than in colder climates; they are also at a higher temperature.

All these elements explain why rocks that are leached by such waters, in the tropics, are more rapidly altered and also why Laterite is much more commonly met with in tropical countries than in colder ones.

Some of the changes brought about in rocks subject to the action of "Vadose" waters may be described as follows:—siliceous rocks are changed into alkaline silicates with evolution of carbonic acid—ferric rocks give rise to ferrous bi-carbonates—lime and magnesia are removed—double silicates of magnesia and alumina break up, yielding hydrous silicates of magnesia (which disappear in the tropics) and of alumina (which remain)—even quartz is slowly dissolved—certain double silicates yield the beautiful rock known as Serpentine while, in certain cases, the result appears in the form of Talc—in the case of ferriferous minerals, the iron would be gradually reduced and appear on the Surface as ferric hydrates and oxides.

With these facts in mind, let us now return to the banks of the stream in our imaginary section through the valley.

The section of our imaginary stream bed in the tropics would usually be as follows:—

One bank is steep, composed of decomposed schist below and capped with laterite; the other bank has a gradual slope leading to a steep one, also capped with laterite. The "VADOSE" waters would reach the stream through the strata below this gradually sloping bank and here would occur the zone of laterization—it is in this zone that laterite would now be forming.

It should here be remembered that laterite is not derived from a rock but is the result of the removal of the greater part of the mineral matter originally in that rock and the substitution in

its place of other mineral matter held in solution by the "vadose waters :—" Leaching and Deposition."

The laterite mentioned as existing at the top of the steep banks would be dead laterite formed ages ago when the stream stood at a higher level.

The process of laterization cannot go on above the reach of "VADOSE" waters, but it also ceases if the thickness of the rock above becomes too great to allow of oxygen reaching the "VADOSE" waters.

From this imaginary section and the process above described we can now deduce the reasons why Laterite occurs in layers and why the thickness of these layers is generally limited to about less than 30 feet :—

It is in layers : because the process of laterization can only proceed in the zone of "VADOSE" waters ;

It is of fairly regular thicknesses ( about 20 feet ) : because, as Laterite beds thicken, their rate of formation diminishes rapidly owing to the obstacle the formation itself presents to the access of oxygen.

Returning once more to our imaginary Stream : sooner or later, the stream would be hemmed in by the newly formed Laterite escarpments and the resistance of the latter would prevent rapid widening of the stream.

As soon as the stream has dug down into its bed, widening would become much more rapid owing to undermining. The Laterite would break away, first on one bank and then on the other. The channel across the bed would gradually be widened and deepened, the zone of Intermittent Saturation would be lowered and the process of Laterization would start again at a deeper level.

The reader should remember that the process here so shortly described takes hundreds of years in its evolution and that the movements of our imaginary stream bed are much quicker than the phenomenon of laterization.

Water that leaches rocks and transports and deposits their contents into other rocks, such as shales and clays, in such a manner as to alter those latter into Laterite must be active for centuries.

A remark which is of importance and which will now be easily understood is that:—only porous rocks are capable of being laterized.

Clay is a substance receptive of water and so we come to conciliate the two definitions of Laterite given at the outset.

Many varieties of Laterite have been recognised:—the useful building material known in India as “kunkar” is a calcareous laterite and serves as a hydraulic cement; in Ceylon a kind of clay locally known as “cabook” is also a variety of laterite; in some districts of the West-Indies the name of “puzzolana” is wrongly given to a variety of calcareous laterite.

In Siam, the stone, although of frequent occurrence in the Northern valleys, does not appear to be used to any extent to-day; bricks seem to be more in favour and it is quite interesting to notice, when visiting the ruins of PHIMAI, the erection, now going on, of a Temple in brickwork and on modern lines by the side of the gorgeous old monuments. Doubtless, labour costs, the lack of roads and other economical questions, supply the explanation for the preference now enjoyed in the country by bricks.

The traveller that loiters about the magnificent ruins of Siam and Cambodia is struck by the almost universal presence of large basins dug, in symmetrical positions, around the monument, and popular tradition has it that these basins ( now ponds ) were the quarries from which the Laterite was obtained.

Four such basins are to be found at the four corners of the ruins at PHIMAI and no stone whatever can be seen for many miles around these wonderful monuments.

In the light of the explanations given above, the belief that the Laterite was obtained from these excavations is a most plausible one and the presence at Phimai of the river bed ( Semoun river ) close to the ruins adds weight to the assertion.

The Ancients apparently knew of old that if, within certain distances from their streams, they were to dig a hole into the ground, they would soon meet the zone ( present or past ) of Intermittent Saturation of their valley, and therein find the coveted Laterite for the erection of their Magnificent Monuments. They would, in the process of digging, probably first find a hard bed ( old Laterite ) and, after digging through it, find, lower down, a softer bed ( Laterite in formation ) which would harden in air. Tradition among the neighbouring inhabitants also asserts that the Laterite was soft when obtained hence the possibility of hewing it easily when building the Temples. Here again, Science tells us that the old tradition is within the limits of possibility.

#### LATERITE OR LIMONITE ?

Monsieur Commaile, in his fine work on Angkor Wat ( Guide aux Ruines d'Angkor, Paris 1912 ) states that only three materials entered into the construction of these Stupendous monuments, viz : Limonite, Sandstone and Wood. His statement is supplemented by the following details ( translated ) :—

“ The *limonite* and the sandstone which compose the edifices  
 “ of the two Angkors ( i.e. Angkor Wat and Angkor Thom )  
 “ and of the neighbouring temples came from the mountains  
 “ of Koulen, some 30 kilometres E. N. E. of the ruins.  
 “ ON THE SUMMIT and on THE SIDES of the mountains  
 “ are to be seen the quarries ( PUIITS D'EXTRACTION )  
 “ about three-quarters full of water, especially during the  
 “ rainy season, and forming regular cisterns ”.

This statement contains the fact that the limonite was extracted from the summit and the sides of the mountain.

If the reader would kindly remember the statements made above, when describing the Section across our imaginary Valley, he would find that Laterite was stated to “ Cap ” our cliffs and also be present on the banks of our stream.

Commandant Lunet de Lajonquière in “ Le Domaine Archéologique du Siam ” describing the ruins of :—PHANNIEP, SAXANA-

LAI, MUANG SING, PHANAT, MUANG PHRA ROT &c., &c., states that the stone used in these monuments was "Limonite". Other travellers who have visited the same ruins state them to be in "Laterite".

Is then Laterite the same thing as Limonite ?

The Encyclopaedia Britannica states that Limonite is

" a NATURAL FERRIC-HYDRATE named from " the Greek word " meadow " in allusion to its occurrence as " bog-ore " in marshes and meadows "—"it occurs in concretionary or in compact and earthy " masses"—" the colour presents various shades of " brown and yellow " ( not red or black ).

James Park, the New Zealand Geologist, describes limonite as being :—

" a superficial ore-body formed by the action of descending waters which act upon and concentrate " ORES disseminated in adjacent country rocks ".

The same Authority also tells us that, in Mexico :—

" valuable deposits of Limonite, resulting in a large " measure from the alteration of the carbonate ore " ( lead ) occur in shales and limestone in chemically " eroded hollows and caverns. . . .

also that :—

" The ores of iron of commercial value are siderite, " LIMONITE or brown Haematite," &c., &c.

Dana, the famous American Authority, describes Limonite as being :—

" Brown Haematite, Bog-iron ore, A common ORE " of IRON which is always secondary in its origin " formed through the alteration or solution of previous existing iron minerals." He further proceeds

to state that the alteration or solution is due to the action of percolating waters.

Professor Grenville Cole describes Limonite as being :

“ a common earthy brown product of the alteration  
“ of ferriferous minerals.”

From all these descriptions one might infer that Laterite is a rock whereas Limonite is an ore. This inference would find its justification in the following fact :—Geologists have observed that in certain Laterites a crystalline ferric hydrate often lines passages or cracks in the mass ; its colour is orange to bright red.

Professor Lacroix ( *Les Latérites de la Guinée et les produits d'altération qui leur sont associés.* Paris, 1913 ) considers this mineral to be Limonite. From this it might be inferred that Limonite may exist in Laterite and the statement of such a high Authority as Prof. Lacroix would tend to show that while Limonite can exist in Laterite, yet the two terms are not synonymous.

We know that Laterite exists in large masses whereas Limonite is comparatively rare, hence the conclusion could be upheld that what the French Archæologists have hitherto named Limonite is ( at least in the Indo-Chinese Peninsula ) a misnomer for Laterite.

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