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## LATERITE OF KERALA (INDIA)

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In the area where laterite was first described it consists of mottled saprolite, that is weathered rock in place. This material is widespread in southern India and is still actively quarried. It is hard when excavated, and there is only a slight increase in hardening on exposure. The common Indian laterite used for building is different from the concretionary ferricrete, often called laterite, which appears to be formed in soil or transported material above the saprolite.

KEY-WORDS: Laterite, Ferricrete, Saprolite, India.

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Nell'area ove la laterite fu descritta per la prima volta essa consiste di un saprolite maculato ed è roccia alterata in situ. Questo materiale è diffuso nell'India meridionale ed ancor oggi attivamente sfruttato. Appena scavata la laterite è dura e con l'esposizione si verifica soltanto un leggero aumento della durezza. La comune laterite indiana usata per le costruzioni è diversa dalla crosta ferrosa concrezionare ricca di ossidi di ferro spesso chiamata laterite. Questa appare essere costituita di suolo o di materiale trasportato sopra il saprolite stesso.

TERMINI CHIAVE: Laterite, Crosta ferrosa, Saprolite, India.

### INTRODUCTION

Laterite has long been a problem in geomorphology, soil science and geology. There are continuing controversies over its definition, genesis, and its place in landscape evolution. Discussion of these topics is not aided by the original definition of BUCHANAN in 1807, or secondary ideas based on it. The present paper records the findings of our own re-investigation of the type area in the light of modern concepts, and the significance of these findings in a wider context.

BUCHANAN described laterite as material which was initially soft enough to be cut into blocks by an iron instrument, but which became hard as brick on exposure to air (BUCHANAN, 1807, p. 440). Extensive quotations from BUCHANAN's journal are provided by FOX (1936), which

is more generally available than BUCHANAN's publication. BUCHANAN later found material which was hard while still in the ground, not exposed to air, but it is his first account of the change from soft to hard which captured the imagination of later writers, and which was given further emphasis, in phrases such as «soft as cheese» (RUSSELL, 1962, p. 560).

In a well-known review of BUCHANAN's classical laterite site, STEPHENS (1961) expressed great surprise at finding an existing laterite quarry where the laterite was hard, and quarried by picks. What had come to be called, «BUCHANAN's laterite» apparently did not exist even in the type locality.

It now transpires that BUCHANAN was not the first to describe the material but he coined the name, and earlier descriptions, though possibly accurate, cannot be taken as definitions. Many and varied definitions have been proposed by later writers. BUCHANAN investigated Malabar, which is now combined with Travancore and Cochin to make the modern State of Kerala. The individual town with the greatest claim to being the type area is Angadippuram, close to the larger town of Perintalmanna (fig. 1). Laterite of the type area has been re-described by LAKE (1933), FOX (1936) and STEPHENS (1961).

### LATERITE IN KERALA

The bedrock in the type area of Angadippuram is dominantly Precambrian gneiss. The area is one of extensive deep weathering, certainly to depths of tens of metres in places (indicated by wells that do not reach solid bedrock) and quite possibly to many tens of metres. As is typical in many areas of deep weathering there is commonly an abrupt junction between weathered rock and apparently fresh rock, either at the basal weathering front or around corestones.

Deep weathering followed by partial stripping of the weathered rock (saprolite) has given rise to a type of landscape, well known nowadays from many parts of the world, commonly referred to as an etchplain landscape (e.g. THOMAS, 1974). Many tropical landscapes of this kind are distinguished by accumulated corestones, tors and in-

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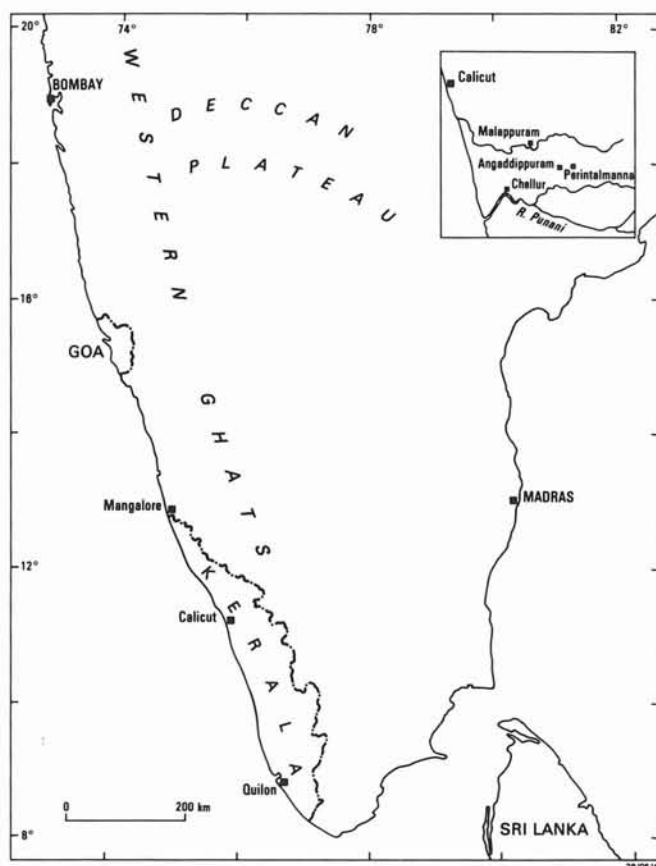


FIG. 1 - Locations mentioned in the text.

selbergs, but these features seem to be especially well developed on granite. On the gneisses of the Kerala region there are some hills of essentially bare rock, equivalent to inselbergs, but their relationship to lower slopes is obscure because of thick vegetation. Bare rock footslopes are rare.

Topography is also undulating to hilly, so domes do not rise abruptly from surrounding plains like typical inselbergs. Nevertheless the general process seems to be the same as that described from numerous places where inselbergs and etchplains have been described, such as Uganda (OLLIER, 1960), Nigeria (THOMAS, 1965) or Australia (FINKL, 1979). A hill a few kilometres south of Perintalmanna is an almost exhumed rock dome, but has retained a thin, flat-topped cap of saprolite surrounded by bare rock slopes. A small amount of excavation could produce an «inselberg» in the manner described by BOYE & FRITSCH (1973) in Cameroun, where a «crystalline dome» was exposed by hydraulic sluicing.

The weathered rock of Kerala retains original rock structure to varying extent, but wherever quartz veins are numerous it can be seen that the saprolite is weathered rock in place. The presence of pseudomorphs of original rock structure and of quartz veins in place makes it easy to distinguish the saprolite from materials such as disturbed soil, expanded saprolite, or colluvium. The laterite quarried in the area around Angeddippuram is a mottled and vesicular variety of saprolite.

A hard crust, about a metre thick, serves as a caprock that forms distinct breakaways at the edges of small plateaus. But although the crust may be indurated the underlying material is not really soft, and it can be cut only with a tool like an axe. Both the crust and the underlying material consist of red mottled saprolite, and the pallid zone is relatively rare. A rocky pavement that is formed after severe soil erosion appears black, but the blackness is only a paint-thin coat of micro-organisms, beneath which is the vesicular, red-mottled laterite of normal weathering profiles.

Other general accounts of the laterites of Kerala have been provided by LAKE (1933), FOX (1936) and STEPHENS (1961). GOPALASWAMY and NAIR (1975) worked on micro-morphology of the laterite. Mineralogy and geochemistry investigations of Kerala laterites are reported by NAIR & MATHAI (1981), NAMBIAR & alii (1981) and MALLIKARJUNA & alii (1981). Laterite profile development has been linked to supposed polycyclic erosion surfaces in Southern Kerala by KARUNAKARAN & ROY (1981), and in Central Kerala by SAMBANDAM & PRASAD (1981).

#### COMPLICATIONS IN THE STORY OF KERALA LATERITES

Several ideas, both old and new, have complicated the simple picture of Kerala laterites presented in this note. BRUCE FOOTE (1962) wrote: «The name "laterite" has unfortunately been extended to other rocks of somewhat similar aspect, but of very different origin from the truly sedimentary ferruginous clay of the western coast, to which the name was first applied by Dr Francis BUCHANAN». In this BRUCE FOOTE is wrong, for the material described by BUCHANAN is not sedimentary (We should remember that in BUCHANAN's time Wernerian ideas were still prevalent and modern ideas of the origin of rocks were not established. By the time BRUCE FOOTE was writing, concepts of rock formation were essentially modern). BRUCE FOOTE continues «Much confusion has arisen from this loose application of names, the true sedimentary laterite being frequently confounded with... a peculiar indurated ferruginous clay found chiefly on the summits of the highest mountains in Southern India... resulting from the decomposition of... ferruginous rocks in very damp climates... To avoid such confusion the term "laterite" is, in this report, applied only to a truly sedimentary rock».

There are laterites formed on sediments, notably in the Goa region, but these are not our concern in this note. Certainly the laterites in BUCHANAN's classical area are *not* sediments, but are weathered gneiss in place.

BRUCE FOOTE's comments lead to another confusion, the distinction between high-level and low-level laterites. Many workers in this century have written of high and low level laterites, meaning those on interfluves as contrasted with those of valley bottoms or lower slopes. BRUCE FOOTE's remarks contrast the «highest mountains» with the coastal plains. This idea has been followed up by PATON

& WILLIAMS (1972) in their valuable paper on the concept of laterite, and they contrast laterites of the coastal plain with those of the Deccan Plateau. Our own observations lead to the conclusion that laterite of saprolite origin, used for building, is found on both the plateau and much of the lowland. The classical site happens to be in the hilly lowlands well below the plateau and the Ghats, but it is not alluvial. There may well be catenary variation in laterite profiles, but there is no simple division into high-level and low-level laterite on the scale of major landforms like the Deccan Plateau and the coastal plain.

More recently several authors have related laterite to cyclic erosion surfaces. Having examined the area in the field we are not convinced that the erosion surfaces exist, and so cannot correlate them with laterite types.

Furthermore, the description are obscure. SAMBANDAM & PRASAD (1981) wrote «The remnants of the first (highest) two erosion surfaces form summits of ridges and contain detritus and boulders of primary laterite derived from the

above rocks». On the highest surface at least we must wonder what is meant by «above rocks». Then, despite the presence of this laterite detritus, we are told «Hence, it is evident that the laterite cover of the surfaces had been stripped off». It cannot simultaneously remain on the summit and be stripped. We are told that the lower surfaces are «covered by primary laterite (5-8 m thick), derived from the above rocks». What can primary mean in this sentence? The surfaces in south Kerala described by KARUNAKARAN & ROY (1981) appear to be stages in the formation and stripping of an etchplain, the basic model of landscape evolution which we also propose. Their basic description of laterite profiles is like our own, but with more emphasis on detrital laterites. In their interpretation the highest landforms are bare rock inselbergs and domes, rising above a surface with thick, mainly residual laterite. This is partially stripped to give a lower surface with both residual and detrital laterite, and in valleys cut below this surface there is alluvial fill.

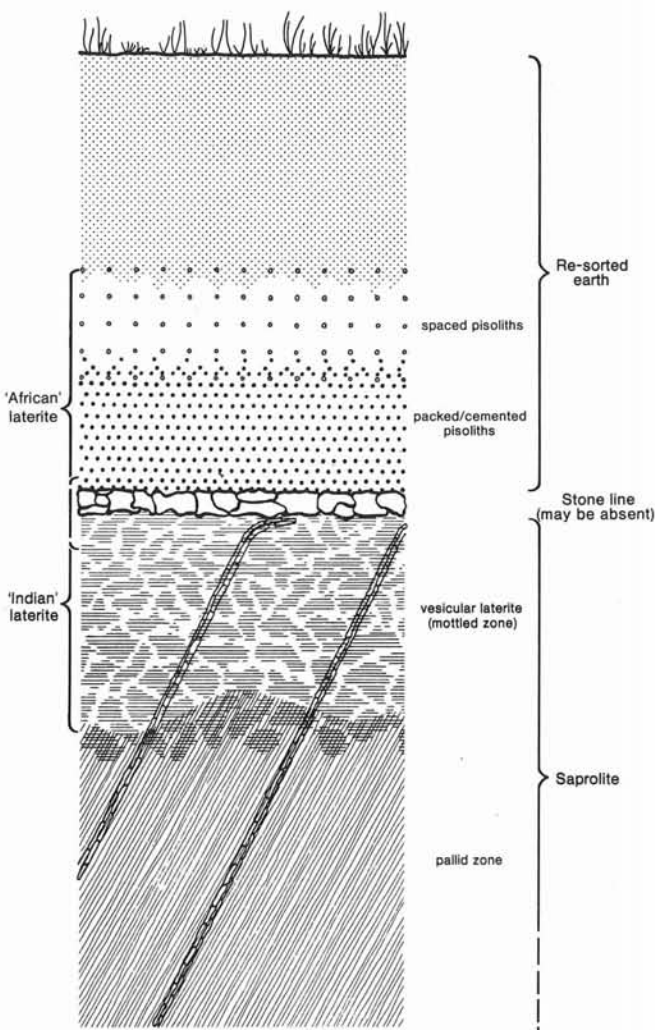


FIG. 2 - Zones in a profile with laterite in a two-cycle landscape (after OLLIER, 1959). The brackets on the left show the parts of the profile most often called «laterite» in Africa and in India.

#### THE MEANING OF THE WORD «LATERITE»

In a two-cycle landscape where earlier deep weathering is not related to the present erosional ground surface, a theoretical weathering profile consists of zones as shown in fig. 2. There are two basic divisions: an upper zone of re-sorted earth (disturbed by roots, organisms, creep or other processes), and a lower zone of saprolite. If there are quartz veins in the saprolite a stone line may be present between the two zones.

The upper, re-sorted zone is generally regarded as some sort of «soil» commonly a tropical red earth. Ferruginous concretions are generally separated by earth, as «spaced pisoliths». Lower down the profile the concretions may be in contact as «packed pisoliths», and these may be cemented together. This is the concretionary, nodular, or pisolithic horizon encountered in many descriptions of laterite. In East Africa the term «murrum» is often applied to friable material rich in pisoliths, but in India, where the word originated, it means «weathered rock», usually «friable saprolite» and more commonly described there as «friable lithomarge». (Outside India the term lithomarge is seldom heard nowadays. To early writers such as FERMOR (1911) lithomarge was synonymous with kaolin).

The re-sorted earth of fig. 2 may have been transported to some extent by creep or sedimentary transport, and if it is iron rich such material might be referred to as «detrital laterite». Unfortunately the term «detrital laterite» is ambiguous, and can refer to either (a) a deposit made of transported laterite fragments, or (b) a deposit of transported sediment such as pebbly colluvium, which was subsequently indurated by ferruginous cement to make a ferricrete. It is not always easy to distinguish rounded pisoliths that have grown in place from fragments of ferricrete that have been rounded by attrition. Modern work in Australia suggests that ferricrete is very commonly formed in transported material, and has little to do with under-

lying weathering profiles (e.g. BOURMAN & *alii*, 1987; OLLIER & GALLOWAY, 1989).

The division of laterite into residual and detrital has a long history. LAKE (1933) expressed the idea well: «Laterite is originally formed in place by the decomposition of the rocks on which it rests but this primary form is often broken up, redistributed in a detrital form, and reconsolidated». Even earlier, FERMOR (1911) provided a table of laterite classification that included True Laterite (formed in situ) and Detrital Laterite.

Our description of the Angaddippuram laterite shows clearly that it is part of the saprolite of the mottled zone, the vesicular laterite of fig. 2. This immediately gives rise to some problems of definition, well expressed by SCHELLMANN (1981) who wrote about the definition and classification of laterites: «The essential problem of a laterite definition is the exclusion of less weathered, non-lateritic materials, e.g. reddish, kaolinitic decomposed rock (saprolite)». He is clearly excluding the type laterite of Angaddippuram from his definition. Fig. 2 also indicates what we believe to be the greatest cause of confusion in the literature. The term «laterite» usually means different things in India and Africa. In India the term «laterite» usually refers to the indurated mottled zone of saprolite, and this is the laterite that is in widespread use as a building material. Similar laterite is also used for building in Cambodia, Thailand, Malaya and northern Nigeria (YOUNG, 1976). In most of Africa and Australia the term «laterite» usually refers to nodular, pisolitic or concretionary material, which may be used for road-making but not for building. However, Indian scientists also use the word «laterite» for concretionary horizons (although in both the type area and in the wider region of western India described in this paper concretionary «laterite» is rarer than the mottled zone laterite) and African scientists may use the term «laterite» for materials other than concretionary «laterite», including indurated saprolite.

## THE USE OF LATERITE

Just north of the town of Angaddippuram, near the P.W.D. offices, is a monument to BUCHANAN with plaques announcing his description of laterite in English, Hindi and Malayalam (the language of Kerala). The monument is built of the same sort of laterite that is exposed in road cuttings, railway cuttings and wells all around, and there can be no doubt that this is *the* type laterite. In a road cutting about 50 m east of the monument a dome of fresh gneiss is exposed beneath a thin cover of saprolite, from which it is separated by a typical sharp weathering front.

There were no active laterite quarries at Angaddippuram at the time of our visit, but we examined an extensive quarry at Pothkundu, about 5 km east of Malappuram. Several groups of people were digging and trimming laterite blocks. On a flat quarry floor a series of vertical grooves are cut at right angles to isolate blocks (fig. 3). The pick used for this work is called mazu. Then the blocks are

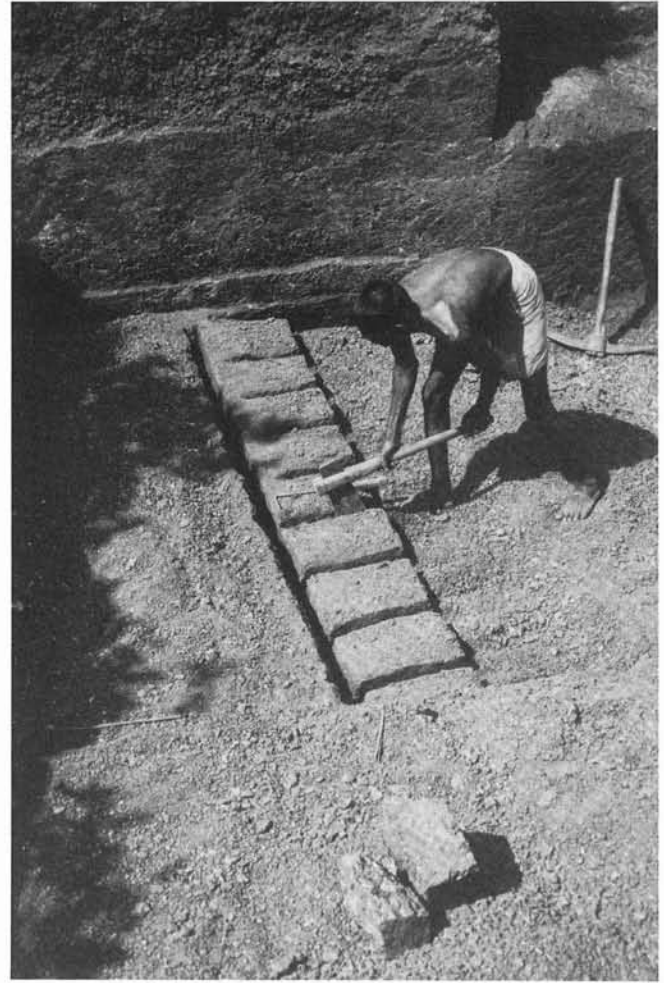


FIG. 3 - The excavation of laterite blocks, Pothukundu, Kerala. The worker is using an axe, and has a pick (background) and a hook (just behind the axe) for scraping dirt out of the cracks.

separated from the ground by an adze-like implement. Other tools include a hook-like implement to remove debris from the vertical grooves, and a small adze-like implement used for trimming the blocks. Isolated blocks are stacked for storage, but not for drying: they are hard and dry before they are removed, although the degree of hardness may possibly increase somewhat with future exposure. The quarry is worked in small areas, and each one is dug out in a series of steps. Various qualities are recognized, and poor quality material is left behind. Saprolite with many quartz veins is poor quality, but occasional quartz veins may be included in commercial blocks, although they are liable to crumble after a few years. The laterite with most red colouration is preferred to that with more yellow or grey. The vesicles are generally tubular, sometimes branching, and mainly roughly horizontal: they seem to have no role in the assessment of quality of the laterite.

Since laterite is so widespread it is sometimes possible to use the same site as house foundation and quarry. The quarrying may even be carried out so carefully that some

FIG. 4 - Excavation of laterite for a house, Chellur, Kerala. Part of the house is excavated, and the excavated blocks will be used for building walls. A well has been sunk on the left, and pallid zone material has been brought up.



of the house walls may be left standing. A well is frequently dug next to the home site, exposing the deeper parts of the lateritic profile. At Chellur, for example, there is a well 20 m deep and almost 4 m in diameter. The upper ten metres was dug in a red mottled zone with horizontal tubes (the laterite) and the lower ten metres in a paler material, roughly corresponding to the traditional pallid zone. In India pallid zones appear to be neither so common nor so pale as those of some other places (Australia and

Madagascar for example), but excavation for a well can often be spotted from a distance by the pile of paler coloured debris brought up from the base (fig. 4).

Possibly the first western reference to the building material now called laterite was by J.C. VISSCHER who worked for the Dutch East India Company between 1717 and 1723 (SARMA, 1982). VISSCHER described the Quilon district of southern Kerala and wrote «I must add that the local stone is very well adapted for building. There are quar-



FIG. 5 - A traditional two-storey house under construction in 1982. Chellur, Kerala.

ries here from which the stone is hewn; and I have seen a piece of this stone when being cut from the rock, split like wood under the stroke of the axe. The stone is reddish-yellow and spotted, very porous and full of holes, in which the lime used in building gets mixed up, and the whole gets so well consolidated that the old stone is often preferred to new. The East India Company finds this stone very serviceable for erecting their fortresses and factories, and the inhabitants use it for building their houses...» (English version of VISSCHER's letters edited by Major Heber DRURY, assistant to General E. CULLEN, British Resident in Travancore, published in 1862 and quoted by SARMA, 1982).

Laterite is the commonest building material over a wide area, stretching from about 100 km south of Bombay to somewhere south of Quillon, and extending a long distance inland. It is commonly used in two-storey traditional homes (fig. 5), sometimes in multi-storey buildings, temples and cathedrals, and in roads, paths and steps. Poor quality, rough laterite is used in drystone walls. We heard that some laterite might crumble after fifty years, but we have seen ordinary traditional homes that are over 200 years old, and showing no signs of decay.

The widespread use is reflected in local language, and each region has its own names for laterite, and for the tools used to extract it. In Malayalam (language of Kerala) it is called *vettu cullu* meaning «cut stone» (not *itica cullu*, «brick stone», as reported by BUCHANAN: this term refers to burnt bricks). In Goan the name is *chira*, which means «cracks» and refers to the way it is excavated. In Marathi it is called *jambha*, which means «violet coloured rock». Actually the most «violet» bits have a Munsell colour of 7.5R 5/3 (dull reddish brown) (dry) and 7.5R4/6 (red) (moist). A more usual colour is 10R 5/6 (red). FOX (1936, p. 421) lists further local names for laterite.

## CONCLUSIONS

Laterite is a very common building material in western India, and there is no disagreement amongst local practical people over what the term means. In scientific terms the traditional laterite is part of the mottled zone in saprolite.

The original definition of laterite by BUCHANAN gave rise to widespread difficulties because he suggested it was soft when cut and hardened on exposure. The word «cut» possibly suggests something soft like cheese, but it is cut only the sense of cutting with an axe. If the original BUCHANAN laterite which hardens on exposure exists at all it is extremely rare, whereas hard laterite is widespread.

The use of the term «laterite» for materials different from the standard Indian product presents problems. In Africa and Australia especially, the term laterite has generally been applied to concretionary, nodular or vesicular material, rich in iron oxides, which may or may not be underlain by a «mottled zone» equivalent to the Indian laterite. Although laterite presents some real scientific problems, it seems to us that a considerable part of the pro-

blem is semantic. Workers in different continents have been talking at cross-purposes for almost a hundred and eighty years. Apart from complications arising from using «laterite» for weathering profiles, soils (elementary text books talk of laterite being the commonest soil of the tropics), and several different kinds of earth material, confusion has arisen because the traditional Indian laterite does not correspond to the BUCHANAN laterite, or to the mainly concretionary material called laterite in other continents.

It will be difficult to rectify the situation of laterite nomenclature at this stage: nevertheless we suggest that «laterite» should mean the traditional Indian laterite used in building, that is a hard, mottled variety of saprolite. Concretionary ferruginous material could be called «ferricrete», «concretionary ferricrete», «pisolithic ferricrete», and so on. If it is accepted that laterite is a *material*, then the profile in which it is found may be called a «lateritic profile». Such a profile need not have an upper pisolithic horizon. Confusion results from using the single word «laterite» to describe the weathering profile, and at least two types of material within the profile.

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