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Origin of iron carbonate layers in Tertiary coastal sediments of Central Kalimantan Province (Borneo), Indonesia

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ABSTRACT

Siderite layers, brown coals and quartzitic sands are an important part of the Tertiary section of the Rungan River Basin in Central Kalimantan Province, Indonesia. The siderite layers consist of grey, fine-grained, indurated rocks.

The depositional setting in Borneo during the Upper Tertiary was that of a large coastal lowland area with peat swamps and tropical giant podzols, much like the modern landscape. This environment seems to have been favourable for the formation of siderite. A relationship can be suggested between iron carbonate sedimentation and deferrification of onshore sedimentary continental formations through a pedological podzolization process. The iron was probably removed from the soils by 'black' waters which were rich in iron-complexing organic compounds. The iron carbonate was probably formed in tidal lagoons, in a brackish environment under reducing conditions.

The depositional setting shows that the origin of the iron in siderite layers must be sought laterally, probably hundreds of kilometres away, in bleached siliceous formations, associated with coal beds which are the former peat deposits. This mode of occurrence may have application to other sequences where such distinct lateral relationships are less obvious.

INTRODUCTION

Since 1979, Indonesian and ORSTOM scientists, within the framework of scientific cooperation between Indonesia and France, have produced soil maps covering large parts of Central Kalimantan Province (Brabant & Muller, 1981; ORSTOM & Dept Transmigrasi, 1981). Numerous observations and analyses are available for the post-Miocene sediments of the Central Kalimantan Coastal Plain (Sumartadipura, 1976).

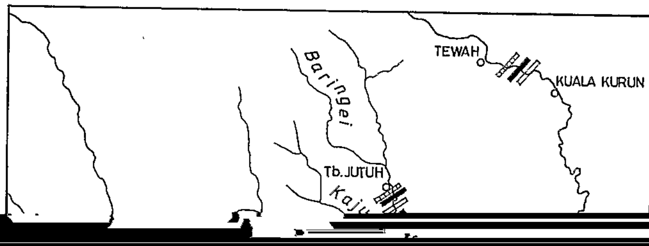
The outcrops of these sediments reveal sandy layers, sometimes intercalated with gravels and clayey horizons, siderite, and coal beds. An analysis of the modern depositional setting of the coastal plain was carried out as a basis for interpreting the nature and formation of these outcrops. This paper outlines the characteristics of the main outcrops along the Rungan River (Fig. 1) and describes the present coastal landscape and geochemistry of units within it.

DESCRIPTION OF THE OUTCROPS

Siderite

The most conspicuous outcrops of bedded siderite are located on the Rungan River, between its confluence with the Manuhing River and the town of Tumbang Jutuh (Fig. 1). On this stretch, the Rungan River cuts its valley through post-Miocene sediments. Three main siderite outcrops can be observed within the river channel between July and November, when the water level of the river is low.

The siderite consists of a very hard rock, forming nearly continuous layers between 200 and 300 mm in thickness. The layers are so hard that they form small rapids in the river (Fig. 2). The rock has a very pale yellowish-grey colour which changes gradually into dark reddish-violet, especially after a week of air exposure. This change in colour is not just super-


TEWAH
KUALA KURUN
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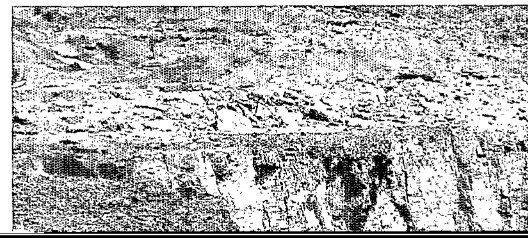
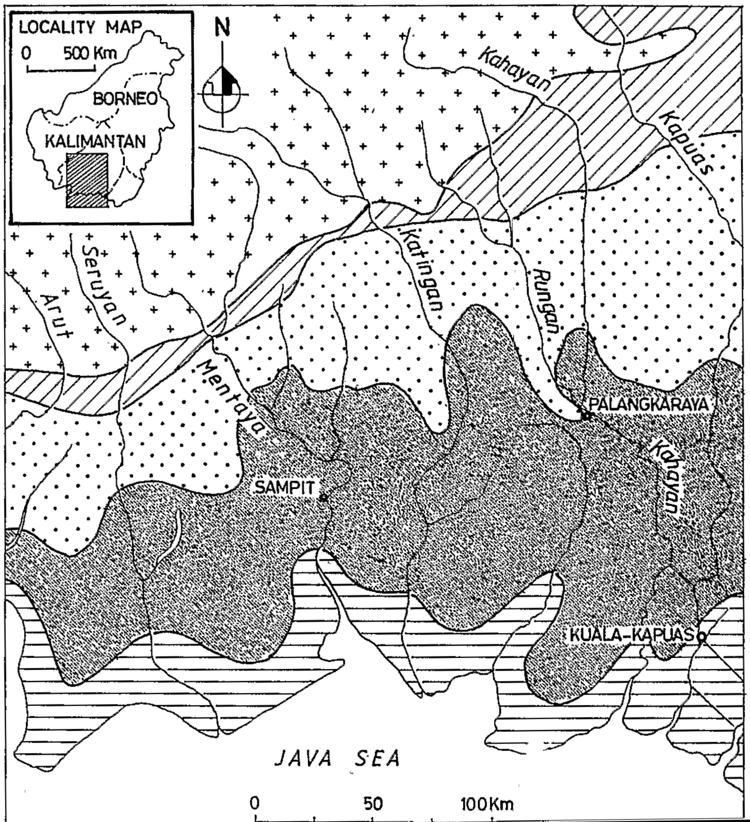
ficial; after two weeks a depth of 20 mm is affected, and after two months a 100 mm thick block becomes completely dark red up to the centre. This change in colour undoubtedly corresponds to an oxidation process. Submerged under the river water the siderite acquires only a very superficial yellow crust.




LOCALITY MAP
0 500 Km
BORNEO
KALIMANTAN
N
Kahayan
Kapuas
Katingan
Rungan
Seruyan
Arut
Mentaya
PALANGKARAYA
Kahayan
SAMPIT
KUALA-KAPUAS
JAVA SEA
0 50 100Km

during hydrolysis, nearly two-thirds of the weathered rock is removed in soluble, ionic form. It is easy to forget this because the process is invisible. The hydrolysis of 3 parts of andesite gives only 1 part of soil and the remaining 2 parts disappear. Half of the dissolved rock is silica. In other words, for each quantity of soil we can see in Borneo, on the Matto Grosso Shield in Brazil, or in the Congo Basin, an equal amount of silica has been transported to the coastal zone of sedimentation.

2 Erosion affects all soils and removes the soil minerals formed during the weathering process in the form of suspensions in the rivers. In equatorial regions, the soils represent an equilibrium between the weathering and the erosion processes. This removal of 'soil minerals' can be seen and measured: it is the solid transport. These two mechanisms are represented on the right-hand side of Fig. 5.

The giant podzols

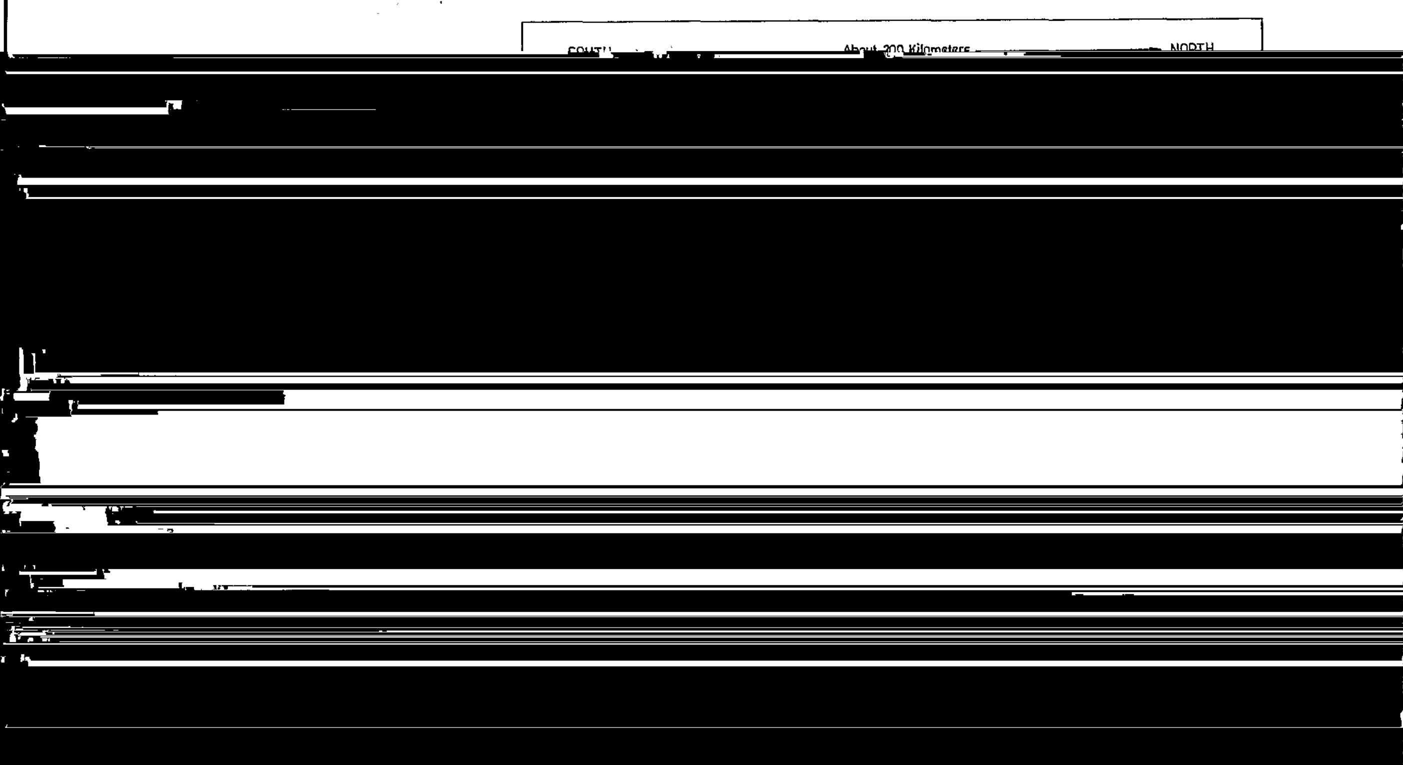
This unit occurs over thousands of square kilometres and forms a very flat landscape. The giant podzols can be morphologically compared with those of temperate climates, but differ from temperate podzols by the greater thickness of their horizons. They are characterized by a white quartz sand horizon, often more than 5 m thick, overlying an iron and aluminium hardpan, frequently more than 2 m thick. The hardpan forms a nearly permanent water table with only lateral outflow.

Such podzols have been extensively reported during the last 30 years by Viera & Oliveira-Filho (1962), Altenmuller & Klinge (1964), Klinge (1967, 1969), Andriesse (1969, 1970), Turenne (1970, 1975), Flexor *et al.* (1975) and Thompson (1986). The normal, undisturbed vegetation on such soils is forest.

At its southern limit, the giant podzols are overlain by ombrogenous thick peats as represented in Fig. 5. The great contrast in these soils, between the white quartz sand horizon and the iron and organic hardpan, is not caused by a change in depositional source materials or by facies changes resulting in different parent materials, but by thousands of years of clay mineral breakdown through rainwater percolation

The giant podzols have been formed from fluviatile sedimentary clayey sands, similar to those deposited by modern rivers, and composed mainly of quartz gravels and sands, kaolinites and iron hydroxides. The percolation of the equatorial rainwater through such sediments created the bleached horizon in which only quartz remains. If the past rainfall was comparable to the modern rainfall, a column of 50 km of rainwater has percolated slowly through these soils during the last 30 000 years.

The removal of the iron and aluminium through organic compounds has been described by Bruckert



(1970), Razzaghe-Karimi (1974), and Turenne

to the genesis of the siderite and pyrite. Siderite

REFERENCES

ALTENMULLER, H.J. & KLINGE, H. (1964) Micromorphological investigations on the development of podzols in the Amazon Basin. Soil micromorphology *Proc. 2nd. Int. Wk. Mtg. Soil Micromorph. Arnhem*, pp. 295–305.

ANDRIESSE, J.P. (1969) A study of the environment and characteristic of tropical podzols in Sarawak. *Geoderma* **2**, 201–207.

ANDRIESSE, J.P. (1970) The development of podzol morphology in the Tropical Lowlands of Sarawak (Malaysia). *Geoderma* **3**, 261–279.

BONIFAS, M. (1959) *Contribution à l'étude géochimique de l'altération latérique*. Thèse Doc. ès Sciences, Strasbourg. *Mém. Serv. Carte Géol. Als. Lorr.* **17**, 159pp.

BRABANT, P. & MULLER, D. (1981) *Reconnaissance Survey in Central Kalimantan. Soil and Land Suitability.* Indonesia–ORSTOM Transmigration Project PTA-44, 136pp. Dept of Transmigration, Jakarta.

BRUCKERT, S. (1970) *Influence des composés organiques solubles sur la pédogenèse en milieu acide*. Thèse Sci. Univ. Nancy, 250pp.

BUBENICEK, L. (1970) *Géologie des gisements de fer de Lorraine*. Thèse Sci. Univ. Nancy. Publ. *IRSID* **48**, 146pp.

CASAGRANDE, D.J., SIEFFERT, K., BERSCHINSKI, C. & SULTON, N. (1977) Sulfur in peat forming systems of the Okefenokee Swamp and Florida Everglades: origin of sulfur in coal. *Geochim. Cosmochim. Acta* **41**, 161–167.

CECIL, C.B., STANTON, R.W., NEUZIL, S.G., DULONG, F.T., RUPPERT, L.F. & PIERCE, B.S. (1985) Paleoclimate controls on late Paleozoic sedimentation and peat formation in the Central Appalachian Basin (USA). *Int. J. Coal Geol.* **5**, 195–230.

DELVIGNE, J. (1965) Pédogenèse en zone tropicale. La formation des minéraux secondaires en milieu ferrallitique. *Mém. ORSTOM* **13**, 177pp.

DIETZ, R.S. (1941) *Clay minerals in recent marine sediments*. Thesis, Univ. Illinois. Summary in *Am. Min.* **27**.

FLEXOR, J.M., OLIVEIRA, J.J., RAPAIRE, J.L. & SIEFFERMANN, G. (1975) La dégradation des illites en montmorillonite dans l'Alios de podzols tropicaux humo-ferrugineux du Reconcavo Bahianais et du Para (Brésil). *Cah. ORSTOM* (ser. Pédol.) **XIII**, 41–48.

GIBBS, R.J. (1967) Geochemistry of the Amazon River system. *Geol. Soc. Am. Bull.* **78**, 1203–1232.

GIRESSE, P. (1987) Les dépôts Quaternaires du lac Barombi-Mbo (Ouest Cameroun). *Géodynamique* **2**, 132–133.

GRIM, R.E., DIETZ, R.S. & BRADLEY, W.F. (1949) Clay mineral composition of some sediments from the Pacific Ocean of the California Coast and the Gulf of California. *Bull. Géol. Soc. Am.* **60**, 1785–1808.

GRIM, R.E. & JOHNS, W.D. (1954) Clay mineral investigations of sediments in the Northern Gulf of Mexico. *Clays Clay Min.* (2nd Natl. Conf. 1953), 81–103.

KLINGE, H. (1967) Podzol soils: a source of blackwater rivers in Amazonia. In: Atas do Simposio sôbre a biota amazonica. *Limnologia*, 117–125.

KLINGE, H. (1969) Climatic conditions in lowland tropical podzol areas. *Trop. Ecol.* **10**, 222–239.

LELONG, G.F. (1967) *Nature et genèse des produits d'altération de roches cristallines sous climat tropical humide (Guyane Française)*. Thèse Sci. Univ. Nancy, 182pp.

MILLOT, G. (1964) *Géologie des Argiles*. Masson, Paris, 499pp.

NELSON, B.W. (1960) Clay mineralogy of the bottom sediments, Rappahannock River, Virginia. *Clays Clay Min.* (7th Natl. Conf. 1958), 135–148.

ORSTOM & DEPT. TRANSMIGRASI (1981) *Reconnaissance survey in Central Kalimantan*. Phase I Maps. 21 maps 1/250 000. ORSTOM-Transmigrasi Project PTA-44. Dept of Transmigration, Jakarta.

PINSAK, A.P. & MURRAY, H.H. (1960) Regional clay mineral patterns in the Gulf of Mexico. *Clays Clay Min.* (7th Natl Conf. 1958), 162–178.

POSTMA, D. (1982) Pyrite and siderite formation in brackish and fresh water swamp sediments. *Am. J. Sci.* **282**, 1151–1183.

POWERS, M.C. (1957) Adjustment of land derived clays to the environment. *J. Sedim. Petrol.* **27**, 355–372.

POWERS, M.C. (1959) Adjustment of clays to chemical change and the concept of the equivalence level. *Clays Clay Min.* (6th Natl. Conf. 1957), 309–326.

RAZZAGHE-KARIMI, M. (1974) *Evolution géochimique et minéralogique des micas et phyllosilicates en présence d'acides organiques*. Thèse Univ. Paris VI, 96pp.

SIEFFERMANN, G. (1973) *Les sols de quelques regions volcaniques du Cameroun*. Thèse Sci, Strasbourg. *Mém. ORSTOM* **66**, 183pp.

SUMARTADIPURA, A.S. (1976) *Geologic map of Tewah quadrangle, Central Kalimantan*, 1 : 100 000 scale. Geol. Survey of Indonesia, Bandung.

TANCREDI, A., SIEFFERMANN, G., BESNUS, Y., FUSIL, G. & DELIBRIAS, G. (1975) Présence et formation de niveaux de sidérite dans les sédiments récents du delta Amazonien. *Bull. Groupe franç. Argiles* **XXVII**, 13–29.

TARDY, Y. (1969) *Géochimie des altérations. Etudes des arènes et des eaux de quelques massifs cristallins d'Europe et d'Afrique*. Thèse Sci. Strasbourg. *Mém. Serv. Carte. Géol. Als. Lorr.*, 270pp.

THOMPSON, C.H. (1986) Giant podzols on Pleistocene dunes in eastern Australia. *XIII Congr. Int. Soc. Soil Science, Hamburg* **III**, 1295–1296.

TURENNE, J.F. (1970) Influence de la saison des pluies sur la dynamique des acides humiques dans les profils ferrallitiques et podzoliques sous savane en Guyane Française. *Cah. ORSTOM*, Pédol. **VIII**, 419–450.

TURENNE, J.F. (1975) *Mode d'humification et différentiation podzolique dans deux toposéquences guyanaises*. Thèse, Univ. Nancy, 175pp.

VIERA, L.S. & OLIVEIRA-FILHO, J.P.S. (1962) As caatingas do Rio Negro. *Bol. Tec. Inst. Agron. Norte* **42**, 1–42.