GEOSEA V Proceedings Vol. I, Geol. Soc. Malaysia, Bulletin 19, April 1986; pp. 315–325

Bauxite in the Kuantan area, Peninsular Malaysia

S. SENATHI RAJAH
Geological Survey of Malaysia, Ipoh

Abstract: An account is given on the search for bauxite in the Kuantan area, Peninsular Malaysia. Results of the reconnaissance survey indicate significant reserves of ferruginous bauxite in the area that may be of commercial interest. The bauxite belongs to the tropical lateritic type. It has formed *in situ* by decomposition of the underlying basalt of probable Tertiary age, and occurs as blanket deposits and lenses in the residual rock mantle. Further detailed prospecting is warranted to confirm whether the bauxite deposit is viable for exploitation.

INTRODUCTION

General.—The existence of bauxite in the Kuantan area, Peninsular Malaysia was first recognized by the Geological Survey in 1937 (Fitch, 1952). Subsequently, preliminary investigations by Fitch (1952) have shown that its occurrence is confined to areas underlain by the Kuantan basalt. This paper is based on the results of the bauxite investigation undertaken by the Geological Survey in 1979 (Rajah 1980) by reconnaissance auger prospecting, over the general area following the recommendation of Robertson Research International Ltd. (1976).

Location and Access.—The area of interest lies in the neighbourhood of Kuantan in the states of Pahang and Terengganu (Fig. 1). It is easily accessible via the highway to Kuala Terengganu, the new Kuantan bypass, and roads to Sungai Lembing, Bukit Goh Estate and Jabor Valley Estate.

Topography and Vegetation.—The area is flat to undulating. Hills with flat tops and low ridges between 100 and 200 ft (30–60 m) in altitude constitute the main topography. The highest point, which is a basalt outcrop, in the general area is at Bukit Tinggi (136m; 454 ft.). About 40% of the area is below 50 ft (15m) and swampy. The main streams draining the area are Sungai Mabok, Sungai Pinang, Sungai Jabor, Sungai Nyior and their tributaries.

A large part of the area under investigation is cultivated with oil palm and rubber, in particular the former. Primary and secondary jungles occur in the northern sectors of the area.

GENERAL GEOLOGY

The geology of the Kuantan area has been described in detail by Fitch (1952) and it is depicted in Figure 2. Essentially, the area is underlain by basalt and associated dolerite dykes, which cut the underlying rocks. The basaltic eruption was of the fissure type. The basalt forms a distinctive topography characterized by hills. It overlies and

Paper previously presented at CCOP, 20th Session, 1–18 Nov. 1983, Kuala Lumpur.

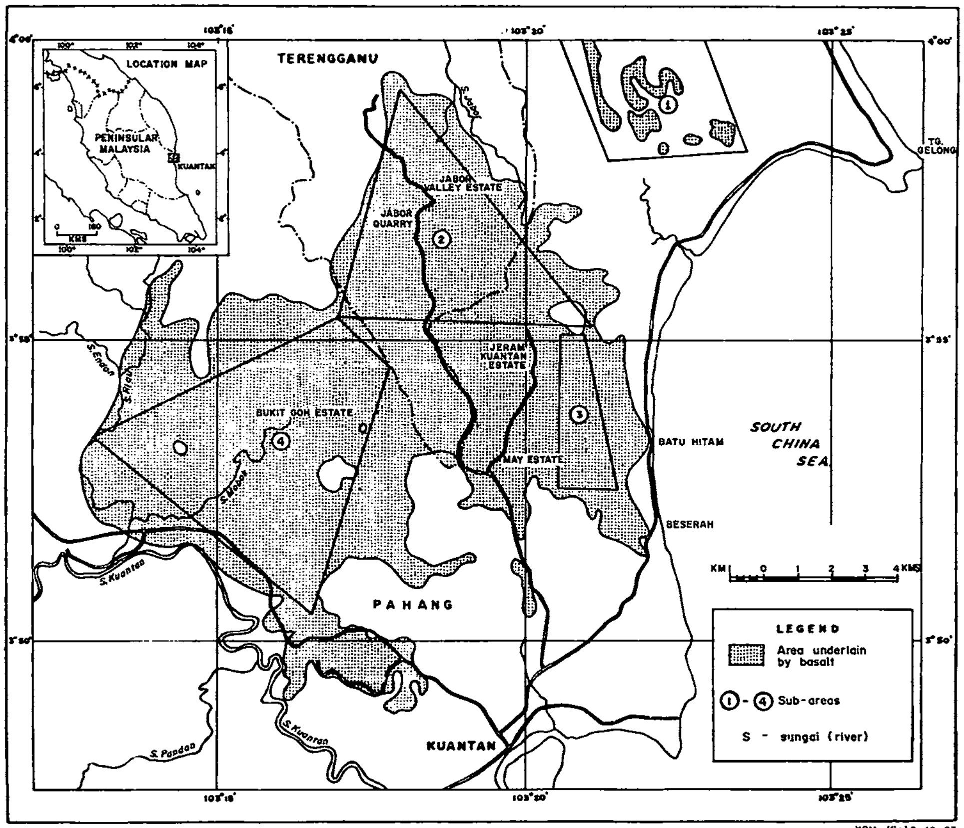

Fig. 1. Map of the Kuantan area, Peninsular Malaysia

surrounds the granitic hills north and northwest of Kuantan and extends over a sequence of Late Palaeozoic sedimentary-volcanic rocks. The basalt is generally a black to greenish-black, vesicular, olivine-bearing rocks with columnar jointing. Fitch (1952) believed the Kuantan basalt to be of Lower Tertiary (Miocene) age. According to J.D. Bignell (in Hutchison, 1970), however, potassium-argon radiometric determination suggests that it may be Quaternary, with an age less than 2 m.y.

Granitoids, comprising grey porphyritic and non-porphyritic granite, outcrop in areas underlain by basalt.

Recent alluvium is widespread and covers the basalt along the coastal areas and towards the south in the environs of Sungai Kuantan.

METHOD OF INVESTIGATION

For the purpose of this exploratory investigation of bauxite the Kuantan area was subdivided into four sub-areas, numbered 1–4, as shown in Figure 1. The programmes

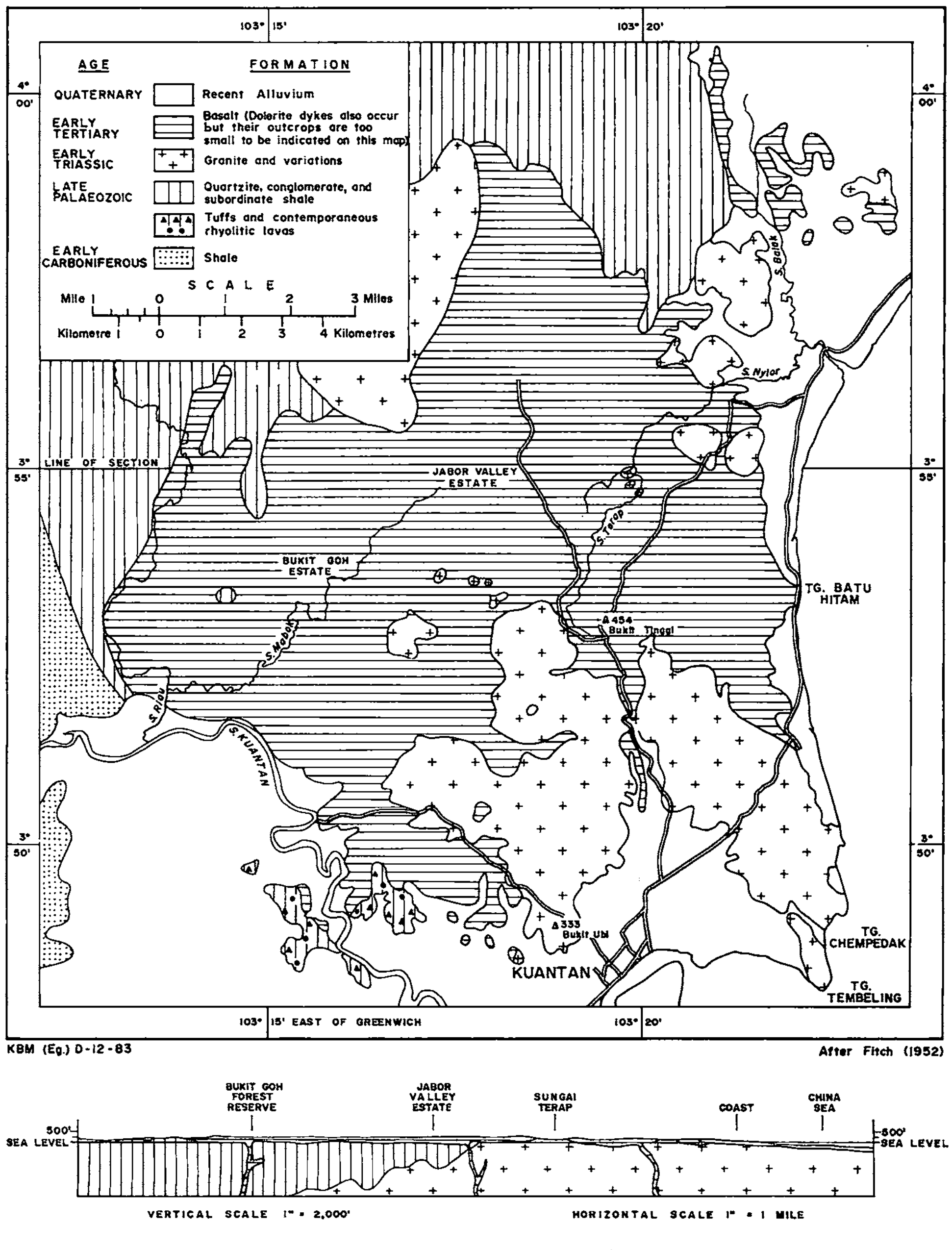

Fig. 2. Geological map of the Kuantan area, and cross-setion of the Kuantan basalt and associated (dolerite) dykes.

set out consisted of auger drilling and, where possible, pitting, examination of (lateritic) quarry faces and road-cuts. Samples were collected at 5 ft (1.6 m) intervals and logged. Those containing bauxitic material were screened and the loss on ignition (L.O.I.) was determined on the plus 12 mesh fraction. Samples having values of loss on ignition (water of hydration) greater than 20% were analysed for Al_2O_3, Fe_2O_3, SiO_2, and TiO_2.

RESULTS OF INVESTIGATIONS

Area 1.— This area is centred around Bukit Tanah Merah and located about 4 miles west of Kuantan port at Tanjong Gelang. More than 70% of the area is low-lying, below 50 ft(15m) above mean sea-level (a.m.s.l) and swampy. 10 auger holes were drilled over the area with depths ranging from 15 to 30 ft (5 to 10 m). 19 samples were collected for analysis. Analytical results indicate alumina content varies from about 33% to 44% with fairly high iron oxide content ranging from 21% to 30%. The silica content of most of the samples is generally low, varying from less than 1% to as high as about 17%. The titanium content ranges from 3% to 4.6%.

Area 2.—This area lies largely in the Jabor Valley Estate, in the Kemaman district of Terengganu; a large proportion of it is cultivated with oil palm and occasionally rubber. More than 40% of the area is of low relief, below 50 ft (15m) and swampy, particularly in the northeast. During the investigation 46 sites were tested, 44 of them by drilling to depths varying from 15–30 ft (5–10 m) and at a spacing of about 3000 ft (1000 m) or more. The total footage drilled was 1021 ft (309 m). Of the various samples collected, 90 had LOI values greater than 20% and were therefore subjected to complete analysis. Majority of the samples (56) have alumina content ranging from about 30% to 39%. 19 of them have fairly high alumina values ranging from about 40% to 48%, and the remaining 5 samples yield low values of alumina from about 24% to 29%. All the samples had high iron content; Fe_2O_3 values were between 23% to 27%. Silica values were generally low, but ranged from about 2% to as high as 24%. TiO_2 content varied from 2% to 5%.

Area 3.—This encompasses several small rubber estates, notably Jeram, Jeram Kuantan, Nachappa and May Estates, together with the settlements lying west of the coast road. More than 20% of the area lies below 50 ft (15 m) or in swamps. 13 boreholes were augered with depths ranging from 15 to 30 ft (5–10 m). Total footage drilled was 295 ft (89 m). A large number of samples was examined but only 22 samples were analysed. Of these, 8 had alumina content ranging from 34% to 39%, 9 samples from 27% to 33%, and 5 samples 21% to 28%. All the samples had high iron oxides varying from 25% to 40%. Silica values were generally low, ranging from 1.96% to 2.8%. TiO_2 content varied from about 3% to 6%.

Area 4.—This area includes a major part of Bukit Goh Estate. Much of the area towards the south is below 50 ft (15 m) in height. The area is almost exclusively planted with oil palm. 48 boreholes were augered with a total footage of 1139 ft (357 m) and giving an average of 25 ft (8 m) per bore. A large number of samples were examined. 106 samples which had LOI values greater than 20% were analysed. Of these 30 gave fairly high alumina values ranging from 40% to 48%. The bulk of the samples (68) had alumina content from about 30% to 39%, and the remaining 8 samples had low values of alumina from 26% to 29%. A large proportion of the samples had Fe_2O_3 values from about 22% to 26%. Silica values range from as low as 1.44% to as high as 25%. TiO_2 content varied from 2% to 5%.

Mode of Occurrence of Bauxite and Relation to Bedrock.—Of the large number of holes augered, only four bottomed on decomposed granitic rock. The rest of the boreholes including soil profiles in road cuts and qurries confirm the presence of weathered basalt.

Topography governs the vertical extent of the Kuantan bauxite. The basalt surface has been subjected to long and fairly intensive lateritic type weathering which resulted in the development of a soil blanket and bauxitic material. The basalt in low-lying areas has been decomposed to a depth of about 15 ft (5 m), while in the low hills and ridge tops to a depth of 30 ft (10 m). Laterite is invariably present throughout the sequence from the underlying residual clay (basaltic clay) or decomposed basalt to the surface, but more commonly in the upper section. Bauxite occurs mainly as somewhat horizontal beds (blanket deposits) and lenses in the residual lateritic mantle (between the soil overburden and underlying residual clay). The topography is characterized by low, flat-topped hills or gentle slopes with elevation ranging from about 50 to 200 feet above mean sea-level. Thickness of the bauxite range from 2 to 20 feet.

Morphology.—Typical section through a bauxitic profile in the Kuantan area is shown in Figure 3. The profile shows that the thickness of the upper horizon (overburden) commonly varies up to a depth of 5 ft (1.6 m) and rarely in excess of 10 ft (3 m), and consists of dark brown clayey soil with humus. The middle horizon ranges from about 5 to 20 ft (1.6 to 7 m), and consists of various shades of red to chocolate brown lateritic clayey material. Bauxite is also is commonly present in this horizon but is confined mainly to the upper half of the horizon, commonly forming a zone of concretions which can vary in thickness up to 6 ft (2 m). The lower section of this horizon is granular to earthy. The basal part of the middle horizon gives way gradually to a reddish brown and in places grey to olive brown residual clay (saprolites). This underclay becomes slimy with depth and overlies partially decomposed basalt. The clay generally is kaolinitic.

The middle (lateritic) horizon or bauxitic zone is never continuous laterally over the entire area but is generally restricted as hill cappings. The upper portion of this horizon in places may contain a layer of lateritic (iron) crust. In the low hills, bauxite also commonly occurs in association with the laterite, generally at a depth of 2 ft (1 m) or more and forms a layer of earthy concretionary mass.

Definition and Characteristics of Bauxite.—Although bauxite has been variously defined by different authorities, the definition proposed by Valeton (1972) has been widely adapted. Valeton's definition is as follows:

> The term *bauxite ore* is applied to *bauxites* which are economically mineable at present or in the foreseeable future, containing not less than 40–50% Al_2O_3, and not more than 20% Fe_2O_3 and 3–5% combined silica.

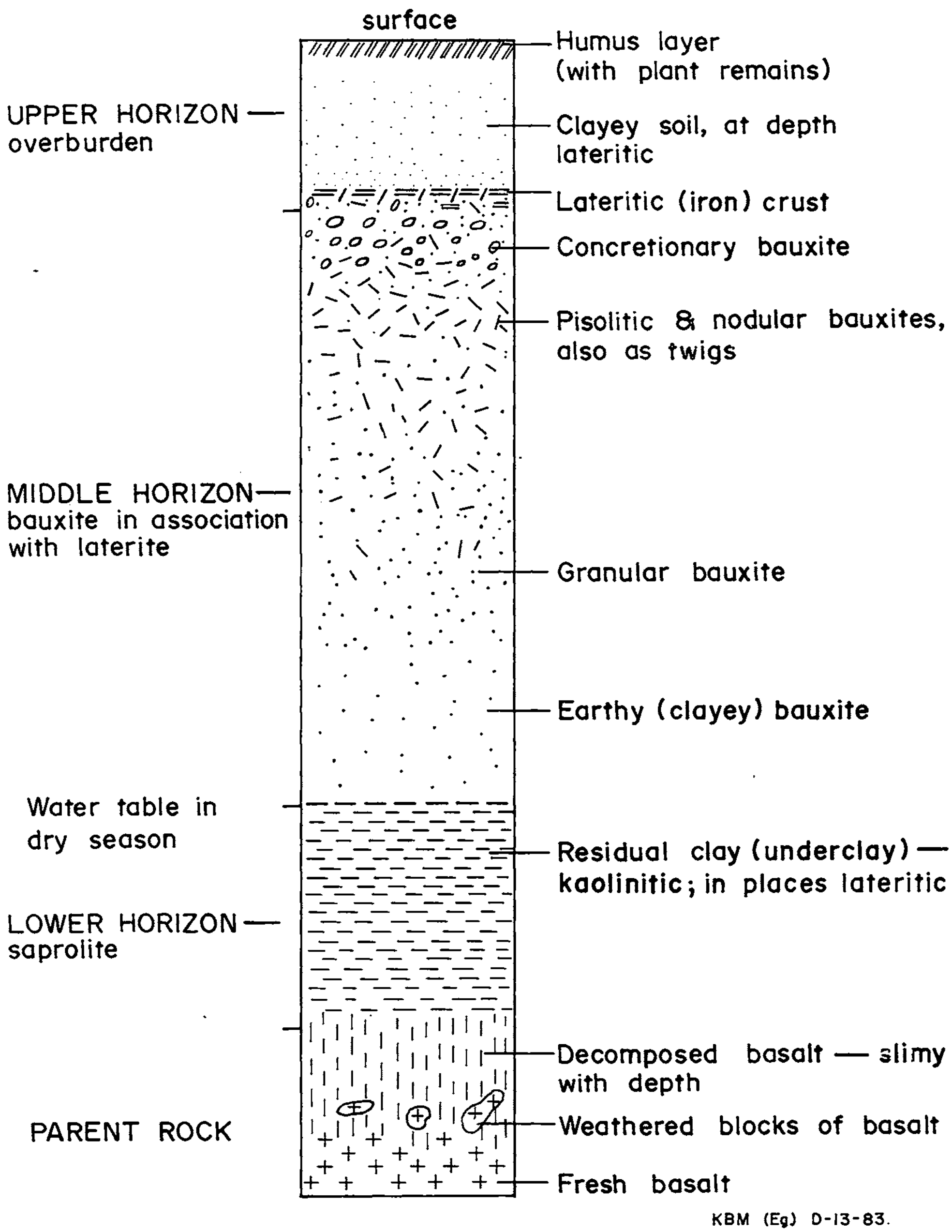

Fig. 3. Typical section through a bauxitic profile in Kuantan area.

Chemical analyses of the bauxitic samples collected from the sub-areas 1–4 of Kuantan generally show a wide range of composition corresponding to low or medium grade bauxite. Some of the samples are typically lateritic with very high iron and silica contents, others are high in iron only. A fairly large number of them, however, are of commercial grade according to the definition of Valeton (1972). Washing of raw bauxite material from the areas would upgrade the alumina content by reducing the silica and other impurities. Most of the bauxite, however, tends to be 'sticky' and may pose beneficiation problems during the washing.

The most promising localities for bauxite in Area 1 are centered around Bukit Tanah Merah, in Area 2 towards the south-western sector and in Area 3 in the vicinity of Jeram Kuantan Estate. Although Area 4 has widespread occurrence of marginal grade bauxite, only the environs of Sungai Rembahan-Sungai Patong towards Sungai Kuantan as well as Sungai Mabok have good development potential for bauxites of economic significance.

Analyses of representative selection of Kuantan bauxite are given in Table 1. The variation with depth in chemical composition of the bauxitic material and underlying clay is shown in Figures 4 & 5.

As the Kuantan bauxite is characterized by high ferric oxide content it may be

TABLE 1

COMPOSITE ANALYSES OF BAUXITIC MATERIAL FROM THE KUANTAN AREA

Sub-Area	Sample No.	Depth (ft)		Analyses (percent)				
		From	To	LOI	Al_2O_3	Fe_2O_3	SiO_2	TiO_2
Area 1	1K6a	7	17	23.8	39.9	30.7	0.90	3.72
Area 1	1K8a	7	14	23.8	41.1	14.4	17.9	2.56
Area 1	1K1a	10	15	26.4	44.4	21.2	4.52	3.38
Area 2	2K1a	2	10	25.7	41.3	19.3	9.30	2.92
Area 2	2K16a	10	15	20.0	31.8	23.9	20.3	3.92
Area 2	2K32b	15	30	26.5	43.7	23.0	2.96	3.84
Area 2	2K42d	20	25	25.8	46.3	20.1	5.28	2.80
Area 2	2K43a	6	10	28.4	44.1	20.8	3.12	2.48
Area 2	2K46a	8	15	26.2	43.5	19.2	7.56	3.20
Area 3	3K1a	9	15	26.3	39.8	25.9	3.20	4.00
Area 3	3K8a	10	16	23.1	23.6	40.6	6.28	5.12
Area 3	3K7c	15	30	22.8	38.4	23.6	11.0	4.00
Area 4	4K44a	5	10	28.3	48.6	18.2	2.40	2.62
Area 4	4K27a	10	15	29.2	48.2	15.6	3.84	3.60
Area 4	4K42b	10	15	26.7	46.3	21.1	1.48	4.08
Area 4	4K43c	15	20	25.6	42.5	19.7	9.20	2.94
Area 4	4K15c	20	25	25.0	40.4	28.1	1.68	4.24
Area 4	4K11d	25	30	24.6	40.1	20.8	11.3	3.28
Area 4	4K48a	5	10	21.2	35.2	15.3	25.2	2.43
Area 4	4K26b	10	20	25.6	41.9	26.7	1.40	4.32

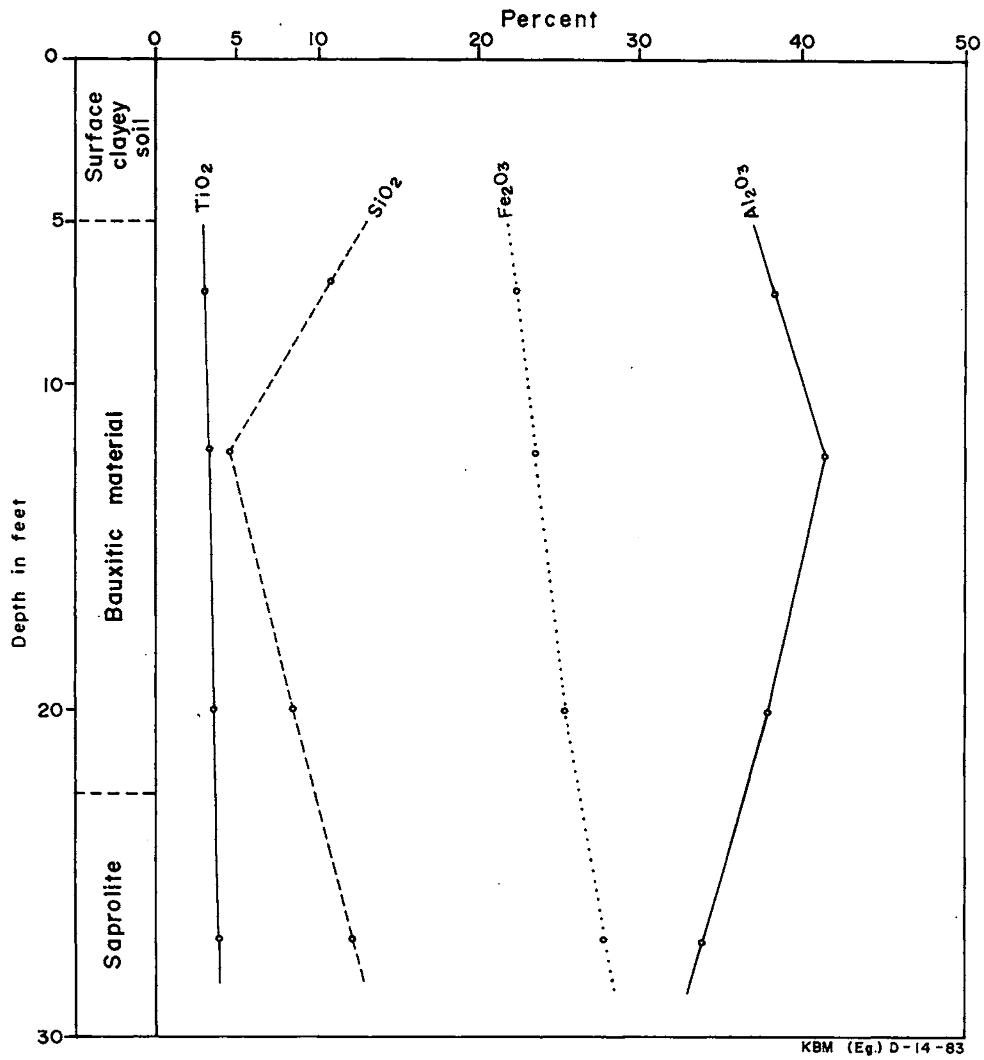

Fig. 4. Variation with depth in composition of bauxite material and underlying clay at Area 1 (Hole 1K4).

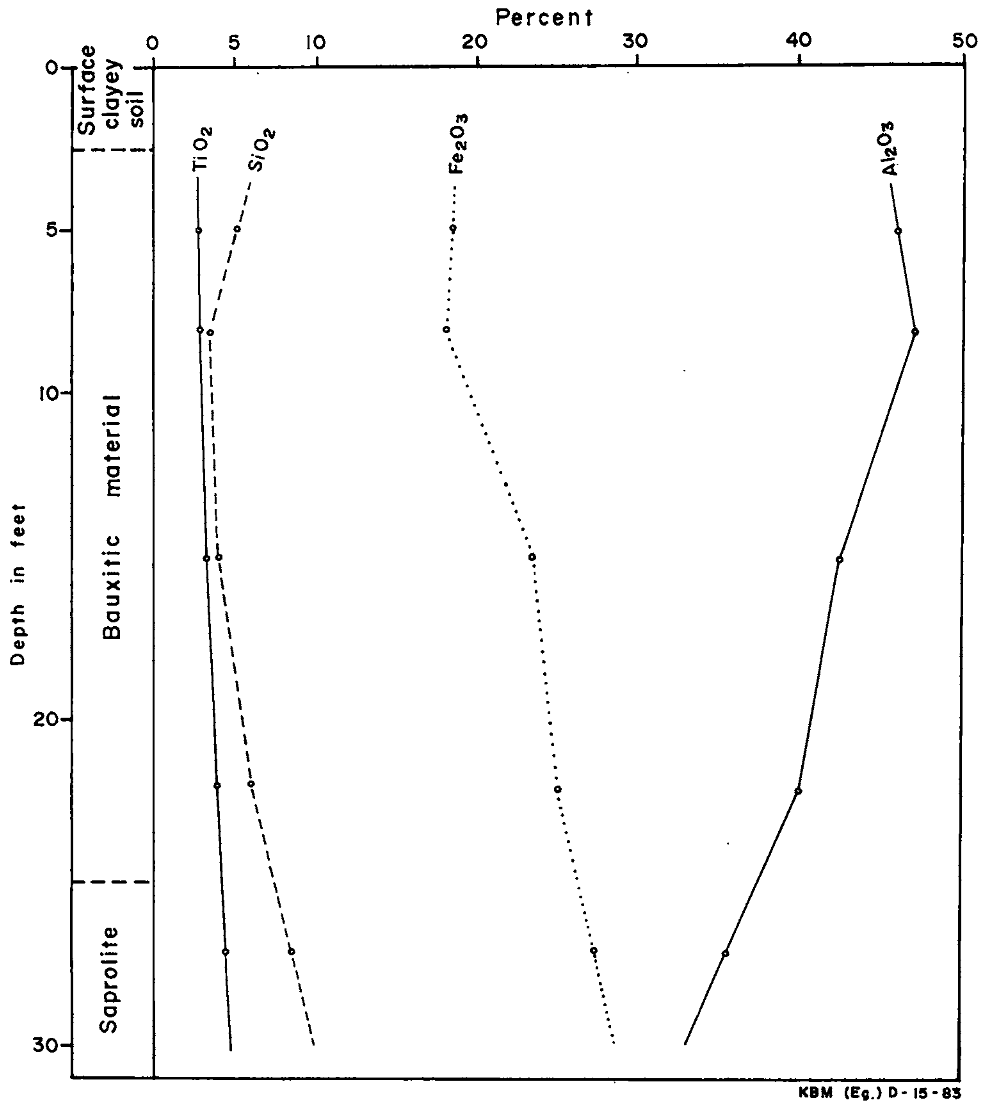

Fig. 5. Variation with depth in composition of bauxite material and underlying clay at Area 4 (Hole 4K1).

termed as ferruginous bauxite. It exhibits a variety of textures. Commonly it occurs as granule-size particles or as amorphous ore. In the upper portion of the middle or bauxite horizon there is a marked tendency for the bauxite to be in the form of twigs, pisolites, nodules or concretions varying from $\frac{1}{4}$ to 4 inches (0.64–10.2 cm); the bulk of it however is less than $1\frac{1}{4}$ inches (3.2 cm).

Close to the surface of the ground the bauxite forms moderately hard, porous masses and is generally brick-red in colour. At depth, towards the lower portion of the middle horizon it becomes soft and earthy ('clayey' bauxite) usually yellow, buff or red brown in colour.

Mineralogically, X-ray studies of Kuantan bauxite indicate that it consists principally of gibbsite, with minor amounts of goethite, hematite, kaolin, illite, quartz and feldspar.

MODE OF FORMATION

Ferruginous bauxite in the Kuantan area shows a definite relationship to the nature of the bedrock and has formed *in situ* by lateritization of the basalt.

The following tentative hypothesis is suggested for the origin of the bauxite. The basalt was exposed to weathering after its extrusion. Lateritization or bauxitization processes probably commenced during late Tertiary or early Pleistocene, and are still continuing at present. The formation of bauxite was a result of the humid tropical, monsoonal conditions coupled by the low relief of the land and good drainage. To a large extent its formation was probably controlled, along with other processes, by repeated saturation and desiccation due to the fluctuation of the water table during dry and wet seasons. Basalt is altered to bauxite above the water table below the water table the basalt is altered to a kaolinite clay.

ESTIMATION OF BAUXITE AVAILABLE

Because of its varying thickness and sometimes discontinuous nature the volume of the Kuantan bauxite deposit is still undetermined. A systematic programme of drilling and pitting is recommended in order to arrive at an accurate evaluation of the available resources.

The most promising areas for finding bauxite are generally confined to areas between the 50 and 200 foot contour elevations. Over much of the area, the bauxite deposit has varying thickness ranging commonly from 2 to 20 ft (1–7 m). It is reasonable to assume that an average thickness of 6 ft (2 m) would be present over considerable parts of the Kuantan area. Based on this assumption the Kuantan deposit, for sub-areas 1–4, may contain approximately 70 million tonnes of crude, mainly low to medium grade, ferruginous bauxite (natural basis). This estimate is at best conservative.

The possibility of further discoveries of ferruginous bauxite is good in other areas underlain by the Kuantan basalt. Johore Mining & Stevedoring Co. carried out prospecting in localities close to Area 3 (Jeram Kuantan Estate) and to the south of Area 4 (in the environs of Lian Hup Estate) in early 1980 and estimated the presence of about 10 million tonnes of bauxite around these localities (S.M. Yip, Mines Dept., written communication). Scout prospecting by the Malaysia Mining Corp. in the environs of Jabor Valley Estate (Area 2) in 1981 noted the presence of a substantial volume of ferruginous bauxite.

CONCLUDING REMARKS

The reconnaissance investigation carried out in the Kuantan area has added greatly to the knowledge of bauxite deposits in the area. There is a good development of largely low to medium grade ferruginous bauxite, in association with laterite. Bauxite occurs as 'blanket' deposits and lenses over the area. Although bauxite is widely distributed, its best development is in the higher grounds commonly associated with lateritic capping of low hills. Bauxite is generally present in a lateritic layer varying from 2 to 20 ft (1–7 m) thick and is overlain by a soil overburden which may have a thickness of 5 ft (1.5 m) or more. The lateritic (bauxite) horizon is associated with an underclay (saprolite) derived from the basalt.

The bauxite is formed as a result of weathering of the basalt. Reserves of largely low to medium grade ferruginous bauxite, which may be of commercial potential, are substantial. The likelihood of finding more bauxite over the basalt outside the study area is good.

The existence of the Kuantan port enhances the economic importance of its bauxite reserves. However exploitation of the bauxite in the area is not presently feasible because a large proportion of the area is currently under the cultivation of high-yielding oil palm and rubber. Also some sectors of the area have been earmarked for industrial and housing development. Despite these constraints more detailed prospecting and evaluation are warranted over the area to determine whether the Kuantan bauxite deposit is viable for exploitation.

REFERENCES

FITCH, F.H., (1952). The geology and mineral resources of the neighbourhood of Kuantan. *Geological Survey Federation of Malaya Memoir* 6.

HUTCHISON, C.S., (1970). Volcanic activity. *In* Gobbett, D.J., and Hutchison, C.S. (eds.) *Geology of the Malay Peninsula:* Wiley-Interscience, New York, p. 177–214.

RAJAH, S.S., (1980). Reconnaissance bauxite investigation in Johore and Pahang. *Geological Survey of Malaysia Report MX(G) 1/1980* (unpublished).

ROBERTSON RESEARCH INTERNATIONAL LTD., (1976). *Feasibility study to establish an alumina/aluminium industry in Malaysia.*

VALETON, I., (1972). *Bauxites.* Elsevier Publishing House, Amsterdam, 226. p.

Manuscript received 6th August 1984