Finally an important monoclinal flexure, which appears about Point Noir, has been traced west and west-south-west for upwards of six miles.

These flexuring movements brought up ridges of tertiary rocks into the zone of denudation, and one accordingly finds near La Brea and Oropuche the youngest tertiaries lying unconformably on the denuded edges of the older. The irregularities of their folding are due to a compromise between the post-cretaceous and subsequent movements, the underlying ridges of cretaceous strata causing divergences from the general direction of the latter flexures. The north and south movement abutting on north-east and south-west barriers caused lateral stresses and occasional fractures, which occur almost invariably in the neighbourhood of outcrops of cretaceous strata. Thus there are a series of step faults in the Cunapo coal field, which are largely lateral displacements along more or less vertical planes. They die out when traced northward.

There is evidence that the movements that gave rise to those flexures are still continuing, the anticlines being marked by recently elevated beaches or alluvial tracts and the synclines by swamps.

The geology of Trinidad is characterised by marked lateral variations in the character of the beds, such as are to be expected on the margin of a continent. In one place the strata indicate the occurrence of estuarine conditions with lagoons and perhaps even land surfaces, while elsewhere there is evidence of deep clear water with small islands. In some localities there were coral reefs, in others deposits characteristic of shallow muddy water; and there are even indications of oceanic conditions. All of these deposits appear to be of more or less the same age. The Moruga series of Wall and Sawkins represents, chiefly in estuarine phase, the whole of the tertiary strata, 6,000 to 6,500 feet in thickness. The Caroni series of the same authors corresponds to the upper part of the Moruga, while the Tamana represents its lower portion, but possibly reaches down to a slightly lower horizon. Their Nariva series includes a number of clays of different ages, while the Naparima marl, which was believed to be low in the tertiary is really fairly high and never approaches within 2,500 of the lowest tertiaries seen in

the island. These conclusions obtained by stratigraphical work are confirmed by fossil evidence.

On the crests of the anticlines the oil-bearing beds approach or even reach the surface; the centre lines of the anticlines are therefore marked almost everywhere by indications of oil, which does not occur sporadically or in pockets, as some have supposed.

From Guayaguayare to Cedros, from Mayaro Bay to Point Fortin, and from Mayaro Point to the mouth of Vance River the petroleum of the lower beds makes its presence evident by pitch deposits and seepings of oil or mud volcanoes, while there are higher oil horizons, which have a less extended distribution. More detailed information regarding the petroleums and pitch deposits of Trinidad is given in this *Bulletin*, 1903, **1**. 177, 180; 1904, **2**. 175, 19; 1905, **3**. 32; 1907, **5**. 198, 199.

The author believes that the districts of Chatham and Irois may in time furnish sufficient lignitic fuel for all local purposes, and support a patent fuel industry. Manjak may be worked throughout the length and breadth of the Guaracara Valley and oil will probably be struck some day near the line of the northern range, most likely in the ground between Arima and Matura.

ALLUVIAL TINSTONE DEPOSITS OF NORTHERN NIGERIA.

THE alluvial tinstone (cassiterite) deposits of Northern Nigeria occur in the south-west part of the province of Bauchi, in the neighbourhood of the river Delime, the water of which flows north-east towards Lake Tchad. This tinstone-bearing district is some 220 miles north-east of the town of Lokoja, which is situated at the confluence of the rivers Niger and Benue.

The land of the Bauchi province, and also in part that of the surrounding provinces, comprises the most elevated portion of the Protectorate. The town of Bauchi, which is itself about 3,000 feet above sea level, is practically at the centre of the province. It is also approximately the centre of a mountainous district which covers altogether an area of about 50,000 square miles. This elevated tract of country consists for the most part of a gneissic plateau, which is freely cut by dykes of dolerite and basalt, while extensive intrusions of granite form the more conspicuous hills.

The tinstone alluvium, as far as is at present known, is restricted to the comparatively small area comprised by the plateaux of Tilde, Rukuba, Jos and Ngell. The gravel of Tilde is fine grained, while that of Jos and Ngell is coarse. The rocks of the Tilde and Rukuba plateaux consist of soft felspathic gneisses, which are often garnetiferous, and are cut by veins of muscovite-pegmatite. Dykes of basalt and dolerite are also of frequent occurrence. The rock composing the plateaux of Jos and Ngell is a reddish biotite-granite, passing into a quartz-porphyry on the margin.

Tinstone has hitherto been found only in the gravels, and its mode of occurrence in the rocks from which it has been derived has not yet been definitely determined. Lumps of tinstone, more or less angular in shape and having a granitic matrix, have been found in the neighbourhood of Jos. This fact has led the engineers who have prospected the country to infer that the tinstone is probably disseminated in the red granites, with lodes in the neighbourhood of the coarse material.

The tinstone is very irregularly distributed in the gravel. Adjoining pits differ considerably in their yield, which varies from 10 lb., or less, up to 400 lb. per ton. The gravels have hitherto been worked principally in the neighbourhood of the river Delime, but they appear to be more or less rich in tinstone over the whole surface of the plateaux.

Metallic tin is frequently found in small quantity in the sands and gravels of the river Delime. It has been described as being native tin of natural origin, but this is probably not the case. Its general appearance, and the fact that it is usually found only in the vicinity of native smelting works, justifies the view that it is of artificial origin. It probably represents material smelted by the natives and subsequently thrown into the gravel with rejected slags.

The "black tin" obtained by washing the gravels is seldom pure tinstone; it usually contains a considerable amount of

impurity such as ilmenite and zircon, and monazite is sometimes present. The following table shows the approximate mineral composition of a fairly typical sample of "black tin" from the Tilde plateau, which has been examined recently at the Imperial Institute (see also this *Bulletin*, 1903, 1. 21). The separation of the various minerals was made by an electromagnet.

Ilmenite, Garnet	about 20 *per cent.*
Monazite	about 5 *per cent.*
Tinstone with some zircon rutile, quartz	about 74 *per cent.*

A chemical analysis of a Tilde sample gave the following results :—

		Per cent.
Stannic oxide	SnO_2	67·96
Silica	SiO_2	2·94
Thorium oxide	ThO_2	0·20
Titanium dioxide	TiO_2	6·71
Cerium oxide	Ce_2O_3	2·20
Ferric oxide	Fe_2O_3	2·33
Alumina	Al_2O_3	8·07
Lead oxide	PbO	0·60
Ferrous oxide	FeO	5·38
Manganous oxide	MnO	0·47
Lime	CaO	1·10
Magnesia	MgO	0·56
Phosphoric acid	P_2O_5	1·06

Previous to the location of these deposits by the officials of the Niger Company during the latter part of 1902, tinstone had been smelted by the natives, and tin was sold in the local markets in the form of thin rods of very pure metal. Mr. Nicolaus gives the following description of the procedure adopted by the Hausa natives in washing and smelting the tinstone :—

"The washers, usually working in gangs of three or four, wade into the river, tributary, creeks or gullies, generally at or near some shallow rapids, and loosen the gravel under water with a short hoe-like implement and scoop it into large calabashes about 18 to 24 inches in diameter; as soon as sufficient gravel is collected (about 30 lb.) it is washed and the resulting rough concentrate placed in a smaller calabash, 6 to 8 inches in diameter, and thoroughly cleaned (nearly all the fine tinstone being lost). The resulting 'black tin' containing the equivalent of from 60 to 65 per cent. metal, is sun dried and packed in bags and skins for transport to the smelting furnaces. A gang of four natives will produce on the average in an ordinary day's work 80 lb. to 1 cwt. of clean 'black tin.'

"The 'black tin' is usually smelted in various parcels on a royalty basis exclusively by members of one family, who hold the process a great secret. Only three smelting furnaces are in use, and these are each capable of turning out about 2 cwt. of metal per day. They are built of well-puddled clay, and are 3 feet 6 inches in diameter, and have at the back four tuyere holes conducting the blast from primitive sheepskin bellows to the hearth. The tin is reduced by means of charcoal, and runs through a channel 2 feet 6 inches long and 4 inches broad into a catch pot, whence it is ladled by small gourds or calabashes and poured.

"The tin is cast in the form of thin bars of about one-eighth inch diameter and 12 inches long, which are produced by pouring the molten metal on semicircular banks of clay, 18 inches high, perforated by dry guinea corn halms."

Until recently, prospecting was made practically impossible owing to the hostility of the native tribes, and when in 1902, the Niger Company's engineers visited the tinstone district, they were only able to work under the protection of an escort. Even as recently as 1904, the hostility of the natives of Jos rendered development difficult and the High Commissioner ordered troops to march from Loko (on the Benue) viâ Keffi, in order to open up a direct route to the tin field. The establishment of this route is now in progress, and is described as follows by the High Commissioner in his report for 1905–6:—"The new route to Western Bauchi and the tin mines was opened up during the year. It starts from Loko, on the Benue, which is only 110 miles from Lokoja, and is therefore much more accessible than Ibi (300 miles) or Amar (390 miles), which were the former ports for the route viâ Wase, viz. 14 days instead of 27. It traverses the Nassarawa province, passing through the head-quarters at Keffi to Darroro; thence it ascends the Assab, Sura or Kibyen plateau. . . . The next step will be to bridge some of the streams or to reconstruct a cart road for at least a part of the distance, and I hope during 1906 to commence this work."

Having held prospecting licences in the Bauchi province for some time, the Niger Company in 1905 applied for mining licences in certain selected areas. In spite of some difficulty due to lack of water supply in the dry season, the company secured an output of one ton per day of "black tin," and thus proved conclusively that the gravels could be worked profitably.

The present head-quarters of the prospecting party are at Jos, where large stores, offices and native houses have been erected. The staff includes four Europeans, and some 200 native labourers are constantly employed at the works. In addition to these, many natives are engaged in the work of transport and gravel-washing. At one period during the latter part of 1906, smelting was carried on day and night in four shifts. The fuel used is entirely wood charcoal, in the making of which many natives are constantly employed.

With tin at its present high price, the alluvial tinstone deposits of Bauchi province promise a fruitful field of work for some time to come, although the absence of transport facilities is a serious drawback. During 1904–5 a preliminary survey of the tin-bearing areas of Bauchi was made by the officers of the Mineral Survey, which is now being conducted in Northern Nigeria in connection with the Imperial Institute. The samples of tin-bearing gravels and tinstone concentrates thus collected have been examined at the Imperial Institute, and the results will probably be published shortly.

It is possible that further tinstone deposits will be found in other districts as the result of the work of the Mineral Survey, which is still in progress. So far only a small portion of the Protectorate has been examined. The geological structure of the country gives every reason to believe that, as the work proceeds, further deposits of commercial importance as a source of tin will be discovered.

GENERAL NOTES.

Annatto Seed from Southern Nigeria.—A sample of annatto seed (*Bixa orellana*) was sent for examination and valuation to the Imperial Institute by the Conservator of Forests for Lagos and Southern Nigeria, with the information that it was obtained from a few plants grown experimentally in the Onitsha Plantations.

The sample weighed about 1 lb., and consisted of clean seeds of good colour and free from any trace of mouldiness. The seeds were classed by brokers as "fair, bright and fresh," and were valued at about 5*d.* per lb.

Recently annatto seed has been scarce in the London market, and as much as 6*d.* and 7*d.* per lb. has been obtained for it, but when normal supplies are available, the price obtainable is from 3*d.* to 4*d.* per lb., though within the last few years it has been sold as low as 1*d.* per lb.

The planting of annatto on a small scale promises under present market conditions to be a profitable enterprise. It is obvious, however, from what has been stated above, that any large increase in the production would diminish considerably the present high price.

Sesamé Seed from Southern Rhodesia.—This sample of sesamé seed, known locally as "Lugonca" or "Ndongca" seed, from Southern Rhodesia, was sent to the Imperial Institute for examination by the British South Africa Company. The seed is said to be cultivated by the natives, who use it in small quantities for food and also anoint their bodies with the oily pulp obtained on pounding the seed.

The sample consisted of 2 oz. of seed, which varied in colour from pale buff to dark brown; it was clean and free from dirt and foreign seeds.

The sample was submitted for valuation to brokers, who stated that it was equal in quality to Coromandel Bigaree Sesamé seed, January crop, the current value of which is £12 7*s.* 6*d.* per ton c.i.f. delivered in London. They added that large quantities of the seed could be disposed of at this price.

Cinnamon Bark from the Gold Coast.—A sample of this bark, prepared from plants grown in the Botanic Gardens at Aburi, was included in a collection of products forwarded recently for examination to the Imperial Institute by the Director of Agriculture in the Gold Coast.

The sample weighed about 1 lb., and consisted of quills of bark rolled upon each other. The quills were not well prepared, as, in some cases, the outer bark had not been carefully and completely removed, whilst in others the quills had been scraped too thin and had become broken in consequence.

The sample was submitted for valuation to two commercial experts, one of whom described the cinnamon as stout and coarse, but of good flavour, and worth about 5*d.* to 6*d.* per lb. in London.