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Economic geology of northern Angola

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ECONOMIC GEOLOGY OF NORTHERN ANGOLA.

by

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FOREWORD.

The material for this thesis was gathered while in the employ of the Companhia de Pesquisas Mineiras de Angola and the Companhia de Diamantes de Angola from August 1920 to date. An opportunity was afforded to visit all the known mineral prospects in northern Angola during two years of exploration work. A year on exploitation in the Lunda made it possible to make observations and deductions regarding the diamondiferous gravels.

Literature regarding Angola is rare and if this thesis has helped to partially fill this void it will have more than fulfilled its mission.

Luaco, Lunda, Angola,
December 15, 1923.

ECONOMIC GEOLOGY OF NORTHERN ANGOLA.

INTRODUCTION.

History:

Angola was discovered in 1476 by a Portuguese navigator and has been occupied almost continuously by that nation ever since. For many years it was a penal settlement. As there is no capital punishment in Portugal, this colony has absorbed most of its desperate criminals. Owing to this, the tropical climate, the hostile attitude of the natives and the absence of any outstanding mineral occurrences, progress has been very slow and most of the serious and successful attempts to develop the mineral resources of the province have been confined to the last decade

Location:

Angola proper lies just south of the Congo River on the west coast of Africa, bounded on the north and east by the Belgian Congo and Rhodesia and on the south by Bothland. It has an area of more than a million and a quarter square kilometers, equal to the area of Kansas, Missouri, Minnesota, Iowa and the Dakotas combined. The colony is composed of

eleven districts; Cabinda, Congo, Quanza-Norte and Sul, Loanda, Lunda, Benguela, Mossamedes, Cubango, Huila and Moxico. Cabinda is separated from the main part of Angola by a narrow strip of territory belonging to the Belgian Congo. Loanda is the capital and principal seaport. Portuguese and German Steamers ply between it, South African and European ports on a regular schedule.

Climate:

As in other tropical countries, with the exception of the littoral zone and in the extreme southern part where desert conditions prevail, there are two seasons of nearly equal duration; one of rainfall and one of drought. The rainy season is also one of intense heat while the dry season is comparatively cool. The heat is alleviated by the frequent showers which come, generally, at certain hours of the day. Altitude greatly affects temperature. In the mountains of the interior, the climate is delightful. The nights are always cool and sometimes actually cold.

Flora and Fauna:

Unlike the country to the north of the Congo

River, there is very little exploitable timber to the south. Vegetation is always heavy along rivers and streams, but elsewhere is savanna. In the wet season, gigantic grass grows to the incredible height of sixteen feet and covers the entire country. Travel during this period is as difficult as going through a tropical jungle. As the trails are choked with grass, it is possible to see for only short distances and the difficulty one experiences in forcing a path thru the thick, sharp blades defies all description. After the rains cease, usually in May, the grass dry rapidly and is burned by the natives. These fires present a magnificent spectacle at night.

Game is plentiful and the Portuguese are such indifferent sportsmen, that it is truly a hunter's paradise. Elephant are rare but buffalo, which are conceded to be the most vindicative and dangerous animals in Africa, are just as exciting to hunt. Monkeys and leopards are found in the heavily wooded areas. On the plains are antelope of all descriptions, ranging from the size of a fox terrier to great beasts, the size of a horse. In the southern part of the province are said

to be maneless lions.

Agriculture:

Along the Malange Railroad are many plantations. They are for the most part going rapidly to decay. Rubber is no longer exploited, as it is said that it can not be done at a profit. Coffee brings a good price but only limited amounts can be transported by the railroad. In the vicinity of Novo Redondo and Loanda are several large sugar plantations with modern refining apparatus. The Malange plateau has all the criteria of a good wheat country, and cattle thrive, sleeping sickness being unknown. With improved transportation facilities, Angola promises to become an important agricultural country.

Inhabitants:

Although there are many different native tribes, they are closely related by speech and customs. They are a happy-go-lucky lot. Most of the hostile tribes have been subdued, but it is still necessary in isolated sections of the country to travel under military protection. The native population has been estimated to be about six million. Their

predominating characteristic is laziness, or perhaps it might be regarded as contentment with their present condition. Missionaries have accomplished wonderful results but, unfortunately, their efforts reach only a very few people.

As is the case with most non-Christion people, polygamy is permitted but not generally practiced. The average man does not take advantage of the priviledge, preferring to live in more or less peace with only one wife than in an incessant volcano, as do his bigamist friends. Women are regarded as chattel and are bought and sold as dumb animals and inanimate objects. They do most of the work around the village. The men do the sewing, look after the children and move only to keep in the shade.

Government:

The Colonial Secretary of Portugal appoints a High Commissioner of the colony for a term of five years. He, in turn, names the Governors of the eleven districts. They then choose Administrators and Commandants for each civil and military area in their jurisdictions. A census of the native population is

taken each year. Every male of working age, unattached female and wife, when more than one, is required to pay a head tax. This system, although characteristic of perhaps all African colonies, has been the source of a great deal of misunderstanding. Many tribes, thinking the tax unjust or exorbitant, have rebelled or fled to other parts, leaving the country almost depopulated in some areas. It is doubtful if any method of taxation could be devised that would prove satisfactory to all concerned and still furnish an inperative incentive for all the natives to contribute a certain amount of productive labor.

Transportation:

The water ways of the country, because of numerous rapids are rarely navigable, but for this very reason, afford many excellent power sites. There are three narrow gauge, single track, railroad lines in operation; The Malange Railroad, the Benguela or Williams Railroad and the Mossamedes Railroad. They have a combined length of one thousand and two hundred kilometers. The Mossamedes and the Malange Railroads are owned and operated by the Government and are

not an exception to the rule which applies to this class of control. The Benguela Railroad is operated by private British interests. It has not yet reached its objective, the Katanga of the Belgian Congo, where it will join a branch line of the proposed Cape to Cairo Railroad. When completed, it will afford an outlet for the copper output of the Katanga Mines on the Atlantic seaboard and reduce transportation costs considerably. Construction has been at a standstill for several years because of financial and political difficulties but it is rumored that work will soon be resumed. All the lines burn wood. Lack of fuel is a serious handicap in Angola but the discovery of oil in commercial quantities would go far in alleviating this obstacle and will offer encouragement for the extension of old lines and the construction of new ones.

The past ten years has seen an active road building campaign which resulted in twelve thousand kilometers of fair highways. Road building and maintenance methods are primitive but with the increasing demands of traffic they will naturally become better.

Contrary to expectations, the local traders have not taken advantage of these improvements; preferring native carriers for transport, which is seemingly cheaper, to a large initial investment in a truck.

Domestic animals can not be used with any degree of success in much of the country because of the prevalence of sleeping sickness. But in some parts, not yet cursed with the tsetse fly, the recognized carrier of the disease, oxen and burros are used extensively. Natives, who fortunately have been trained from earliest childhood to carry heavy loads for great distances, are relied upon almost entirely for transportation. It is customary for white men to travel in a tepoi, which is a hammock slung on a long pole, carried by two husky natives, who move at a dog trot and are relieved from time to time by fresh carriers.

Labor:

Formerly, native labor was secured through government bureaus. This labor was theoretically voluntary. The local Administrator or Commandant requested the native chiefs under his jurisdiction to bring in a

specified number of men. On arrival, they were bound into service for a period ~~of~~ from six months to two years either in or out of their district. Now this work is done by licensed recruiting agents. Service is voluntary, in fact and must be confined to the natives' district and for only a period of six months. This sudden change of system has caused many difficulties. The average native prefers to lie under a shade tree in his own village and supervise the labor of his wife or wives than to move himself to great exertion for the white man, who pays him little and does not always deal fairly. Consequently, most of the native population have gone on a vacation. The ~~average salary~~ official wage is Esc. 0,40 about five cents a day, exclusive of board, lodging and a certain amount of clothing which must be furnished by the employer but in Angola as in other countries where there is so-called cheap labor, it does not really prove economical. Transportation costs by native labor are enormous.

Mineral Concessions:

The mining laws compare favorably with those of other countries. Prospecting, declaration of discovery and ownership is allowed any person or company, providing; first, if foreign, he or they terminate

the special rights of home citizenship with everything concerned with mining; and second, that all regulations and provisions of the law are complied with. Special mining and prospecting licenses can be secured under specified conditions. A discoverer may stake out twice the number of claims allowed by one prospecting permit. Vertical planes passed through the end and side lines of the claim are the limiting boundaries.

Practically the entire area of the country is divided among six concessionnaires: The Companhia de Diamantes de Angola and the Companhia de Pesquisas Mineiras de Angola, sister companies of the Societe Internationale Forestiere et Miniere du Congo; the Companhia de Petroleo de Angola, a subsidiary of the Sinclair Consolidated Oil Corporation; the Angola Oil Company, Ltd., a dormant British company; the Empresa de Mineira de Sul de Angola, a Portuguese firm which recently received its concession; and the Companhia de Mossamedes, controlled by British interests. The rights of these concessionaires are not retro-active, so that there are several independent companies hold-

ing mining claims within other concessions as well as in the limited free area. With but one or two exceptions, none of these independent companies are operating their properties.

PHYSIOGRAPHY.

There are two systems of hills or mountains which trend more or less parallel to the coast. The first uplift is known as the Crystal Mountains and the second is a great plateau. The highest elevation on the plateau is about fourteen hundred meters. The only prominent break in the topography is the sudden transition from the hills of the Crystal Mountains to the table land above to the east. The topography is usually typically tropical, that is to say, the streams are entrenched deeply in V shaped valleys and the country is reduced to low rollong hills. All the streams drain ultimately into the Atlantic. Most of them find their source in the sedimentary rock to the east of the eruptive.

After becoming familiar with the rock formations and their relation to the topography, it is easy to classify the rock in an area from the study of the

physiography alone. The regions where conglomerates prevail are very precipitous. In an area of metamorphosed limestone, there are heavily wooded hills and monoliths. Where eruptives predominate, the projections, taking the form of cones, mounds and ridges, are barren of vegetation and the skyline has a jagged appearance. Sandstone is uniformily eroded, while quartzites have a distinctive unevenly eroded aspect. The prsence of dikes are frequently betrayed by isolated, sharp prominent ridges. Rivers and streams often follow the contact between plutonic and sedimentary rock. Simple observations such as these are of a great help in making a hurried reconnaissance.

DESCRIPTIVE GEOLOGY.

Petrography:

The coastal plain is underlain by marine sediments. The writer had an opportunity to study these formations at Binga on the Cuvo River near Novo Redondo. The oldest stratified formation is a coarse basal conglomerate which rests on the basement complex. It cohsists of coulders of crystalline rock

in a matrix of ferruginous cement, averaging ninety meters in thickness. This conglomerate is thought to have been deposited in the earlier part of the Permian Age. Overlying this formation, conformably, is a series of marine conglomerate, sandstone and shale, rich in fossil remains which have been identified as belonging to the Cretaceous Age. In places, it is totally absent and in others twenty meters thick. It has a wide distribution along the coast and is frequently cupriferous. Resting unconformably over this series is a dolomitic limestone, presumably of Tertiary Age, more than one hundred and fifty meters thick which has at its base lenses of barite and gypsum. This formation evidently has a wider distribution than any of the others mentioned as it was encountered in the Portuguese Congo and the districts of Quanza-Norte and Sul on the coastal plain and very probably extends for a considerable distance to the north and south.

Igneous rocks predominate in the range of hills, called the Crystal Mountains, which extend at a distance of several hundred kilometers from and

parallel to the coast for the entire length of Angola. There are also isolated outcrops in the hinterland. These rocks are thought to represent at least three different geologic ages but are often so similar in character that their differentiation in the field is exceedingly uncertain. The oldest formation is a pre-Cambrian granitic gneiss. Of a later date is an intrusion of acidic igneous rock that took the form of a batholith and is for the most part a granite. Because of the absence of fossils in the sedimentary rocks which were distorted and metamorphosed by the intrusive, the age of the igneous activity is doubtful. Boulders of this formation are found in the basal conglomerate on the coast and it is, therefore, of Permian or an earlier age. Numerous basaltic dikes which traverse both the igneous and sedimentary formations are slightly younger.

Going north from Calulo, south of the Quanza Rive in Quanza-Sul, to the Malange Railroad, the youngest series in contact with plutonic rock are metamorphosed marine snadstone and shale and litho-

graphic limestone. The contact is most irregular. Underlying these is a conglomerate, more than three hundred and fifty meters thick, the coarser aggregate of which are pebbles of quartzite, sandstone and conglomerate bound together with a sandy ferruginous cement. The conglomerate is derived mostly from the iron formation, which has as members, quartzite, ferruginous sandstone and shale. This is the most conspicuous formation on the plateau and corresponds closely to the Kundulungu (Permo-Carboniferous) beds of the Belgian Congo. Underlying these are a series of thin interlying beds of sandstone and shale with thicker isolated beds of limestone as found at Bembe and are probably of Devonian Age. The rarity of fossils make geologic classification almost impossible. Perhaps the youngest formation, other than recent gravel deposits, is the Lubilashe (Jura-Triassic age) of the Lunda district.

Structural Geology:

The strata of the coast are gently rolling with a slight general dip to the west. Faulting is negligible. As they were deposited after the igneous

activity, they were of course not disturbed by the intrusion. The sedimentary formations in the interior, however, have been subjected to two periods of deformation. The intrusion was preceded, perhaps induced, by a period of folding which caused the strata to take the form of a geoanticline, the plateau of the hinterland becoming the crest and the western flank dipping toward the Atlantic. Later, the upward force of the intrusion caused doming on the eastern contact thus reversing the dip and forming a stratigraphical trough or syncline, more pronounced in some localities than in others. On the plateau proper, the strata are for the most part flat-lying and normal in appearance. At the contact, they are highly metamorphosed and for some seventy miles to the east, badly folded and faulted. Although there are some zones of fracturing in the massive formation, there does not seem to have been any appreciable earth movement after the consolidation of the magma. Joint planes are frequently well developed but are considered as cracks resulting from contraction during cooling. They are filled not uncommonly

with quartz, pegmatite and basalt. The quartz veins are small and unimportant. Some are very feebly mineralized but most of them are barren. Basaltic dikes are confined largely to the north of the Quanza River. They vary is size and composition and are found most commonly intruding the iron formation. The pegmatites are sometimes ten or more meters wide and were observed only on the west side of the amogene formations.

ECONOMIC GEOLOGY.

Oil Possibilities:

Asphalt has been known to exist in Angola for several hundred years. The natives used it to calk their canoes and as a medicine. Seeps are found scattered along the entire length of the coast from Cabinda to Mossamedes. In 1757, several hundred tons were exported to Portugal and Brazil. The government of Angola took the initiative of prospecting and drilling for oil in 1900. The results from the analysis of a crude asphaltic oil extracted from a well 100 meters deep at Katunbo were very encouraging. In 1913, the Companhia de Petroleo de Angola

was formed to work the area reserved. In spite of the difficulties engendered by the World War, wells were bored at Benguella Velha, N'Gondo, Ambrizete and Dande. The Sinclair Consolidated Oil Corporation purchased a half interest in the Company and took over the work in 1920. It is anticipated that this company will carry on the work to a field final result. ~~ish.~~

The oil sands are found in the mid-Cretaceous of the coastal plain, the strata of which have been subjected to some folding, resulting in structures favorable for the accumulation of oil. Some faulting is suspected. Overlying these beds, conformably, are Tertiary formations which have been only slightly disturbed. Drilling operations have proven the existence of a small amount of thick sands saturated where penetrated by drilling with an oil of 10.6° Beaume. The base of the oil is paraffin, which is another encouraging factor.

Asphaltic Coals:

The occurrence of asphaltic coals at Dondo, Quilongo and Calucala is extremely interesting and may in the future prove of economic importance. It is an intermediate product between bituminous coal

and a pure asphalt that is chemically analogous to cannel coal. It is such a rare species that the term "libollite" has been accepted by authorities.

The most promising of these beds are at Quilongo, twelve kilometers due east of Zenza do Itombe, a station on the Malange Railroad. The mines are on the concession of Messrs. Camara & Co., Ltd., covering an area of 5000 hectares.

Mr. J. Bacellar Bebiano, (1), describes the geology. The formations in the vicinity are presumably of the Cretaceous Age. The oldest is a yellow calcareous snadstone, muscovitic in appearance and often bituminous, dipping generally to the N. W., with inclinations varying from 7° to 40°and reaching 100 meters in thickness. Underlying the formation is the carboniferous asphalt seam. This overlies an argillaceous calcareous sandstone of varying thickness. These formations are contorted by phonolitic eruptions which took place very likely in the Tertiary Age.

The roof of the seam is asphaltic calcareous sandstone more than two meters thick. The libollite

(1) BEBIANO, J. B., Catalogo descriptivo da coleçao de minerais enviados a Exposicao de Londres.

bed is from one half to one and one half meters in thickness. The floor or hanging wall is argillaceous sandstone impregnated with asphalt. It has a thickness exceeding one half a meter. There is no great differentiation between the libollite bed and the hanging or foot walls.

Chemical Analysis of the Quilongo libollite:

Density	1.16%
Moisture	1.80
Volatile hydrocarbon matter	47.70
Ash	18.30
Fixed carbon (coke less ash)	22.20
Coke	50.50

Calorific value - 7.200 calories.

Coke Analysis:

Fixed carbon	56.00%

Calorific value - 6,600 calories.

Dry Distillation:

Crude oil	36.40%
Water	33.10
Coke residue	15.50

Dry Distillation of Crude Oil:

Light oils (gasoline and petroleum)	30.00%
Medium oils (for internal combustion)	40.00
Lubricating oils	22.00
Wax and vaseline	2.10
Asphalt	6.00

	Sample of Hanging Wall:	Foot Wall:
Solid and liquid asphalt	18.6%	14.1%
Moisture	7.1	2.6
Mineral matter	77.0	83.6

The Diamond Fields:

The diamondiferous gravels of the Kasai River basin in the Belgian Congo were proven to extend into Angola in 1912. Concessions were granted and are being exploited by the Companhia de Diamantes de Angola. There are great reserves and a very extensive area practically unexplored. Transportation difficulties are being rapidly overcome and mechanically driven rotary pans are being introduced for concentration. At present, four deposits are being exploited. The average production is about one hundred thousand carats per annum.

The oldest rocks are ancient hornblende schists, chloritic micaceous schists, quartzites and a basement complex, usually a granitic gneiss. Overlying these, presumably unconformably, is a siliceous limestone having a wide distribution. This formation was observed in situ in Xa Tuka Creek in contact with the granitic gneiss. Unconformably overlying the siliceous limestone is a series of gray and red sandstone and shale, also widely distributed, locally known as the Lubilashe formation (Jura-Triassic age)

The alluvial deposits consist of detrital products of all these rocks. The diamonds are associated with certain heavy minerals, among which are, andalusite, garnet, epidote, staurolite, tourmaline, corundum, chrysoberl, cyanite, rutile, ziron, spinel and magnetite. These result largely from the decomposition of the igneous and metamorphic rocks.

There is considerable evidence of contact metamorphism; metasomatism resulting in the abundant developement of chlorite and epidote,and silicification of the limestone beds. This writer beleives that the igneous rocks are the primary source of the diamonds. The earlier geologic events are rather obscure but it is not improbable that an exchange of materials might have taken place by means of gases between a hot intrusive, whether just consolidated or molten, and adjacent carboniferous sediments, perhaps what is now the silicified limestone. No doubt, most of the changes took place on the cooler side but the intrusive might also have received material, mainly carbon dioxide. Thus epi-

dote and garnet and probably diamonds were developed by replacement in the igneous rock.

The Bembe Mines:

The mines are situated near the administrative post of Bembe in the district of the Congo, two hundred kilometers due east of the seaport of Ambrizete by a well graded automobile road. A proposed railroad extension from Gulungo Alto, the terminal of a branch of the Malange Railroad, to Porto Rico, near the mouth of the Congo River, which will pass through Bembe, is now being surveyed. The road to Ambrizete can only be used for a few months in the dry season. The harbor at Ambrizete is not well protected and loading must be done in surf boats.

Attention was first called to the deposit by copper trinkets worn by the natives of the Bembe region. They were worked by a Brazilian slave trader in 1857 who later transferred his concession to the West African Malachite Mining Company. This company mined and shipped several hundred tons of ore but because of the high death rate among their white employees, due to malaria, they were forced to abandon

the project. In 1911, the Portuguese goverhment made another attempt to develope the property but after spending several thousand escudas became discouraged. The property remained idle until 1918 when it was manifested again by the Empresa das Minas do Bembe, Ltd., who still hold the title. Their concession consists of five lode claims of one hundred hectares each and include all the mineral in the vicinity.

The nearest igneous rock is over eighty kilometers away. The rocks present are a series of thin interbedded layers of ferruginous sandstone and shale with thicker isolated areas of limestone. These strata stike N 45°E and dip 45°S. W. There is no appreciable metamorphism except along pressure planes. Cutting the series is a sheeted zone, consisting of many parallel planes along which there has been considerable movement. They stike N 19° W and dip 49° S.E.

The ore occurs in the sheeted zone and outcrops over a length of 1200 meters. Bembe Creek flows along this zone, very near and roughly parallel to the deposit. Reaching the limit of mineralization,

it swerves suddenly at right angles to its previous course. Copper minerals present are malachite and azurite with subordinate amounts of tenorite and chrysacolla. The latter replaces quartzite. The ore is found for the most part as almost solid crustations of malachite in smooth water-worn limestone cavities surrounded by clay gouge impregnated with small pieces of malachite. Between the gouge and the hanging and footwalls is usually bog manganese. The strike and dip of the ore and vein filling seem to coincide roughly with those of the strata.

Hardly enough evidence is available to determine whether the deposit was formed by hot ascending solutions or cold descending solutions. In spite of the fact that there is no igneous rock in the vicinity, this writer is inclined to favor, the former theory of origin because; (1) The deposit occurs in a sheeted zone, the planes of which would have afforded better channels for solutions under pressure, (2) it has no similarity with sedimentary types of copper deposits elsewhere examined in Angola, and (3) there are no other mineral occurrences any-

where in the vicinity. A satisfactory theory must be decided upon before drilling could commence for although the ore seems to conform with the strata of the surrounding rock, it is very probable that at depth it will be found to conform with the fault planes of the sheeted zone.

An attempt is being made to develop the property by four adits located at irregular intervals along the outcrop. The work is practically useless and it is only with great difficulty that the workings are kept open, because of heavy rains. The ore is not persistently followed. The only partially proved ore body is a shoot of almost solid malachite, 10 x 10 x 15 meters, surrounded by gouge impregnated with malachite, 20 x 20 x 15 meters, all above the water table. But as has been said before, there are indications of mineralization and remains of old workings over a length of 1200 meters.

Ancient Mine Workings at Dala Tuto and Gombi Andoi:

In the vicinity of Dala Tuto and Gombi Andoi between the Malange Railroad and the Quanza River are several ancient prospecting pits and mine workings.

Nothing is known of their history. In order to make an examination, it was necessary to sink test pits into the debris of the caved workings and in other favorable localities.

The geology of the region is simple but unusual. A stratified and a crystalline formation are present. Most of the sedimentary rock has been removed by erosion. Only small areas of metamorphosed ferruginous sandstone, quartzite and a light colored shale remain. At Gombi Andoi, the intrusive is a basaltic rock approaching a peridotite in composition. It is a basic segregation in a granitic magma. At Dala Tuto light colored minerals are in excess. Metasomatic alteration, especially that of propylitization, has been intense and makes the determination of the feldspars uncertain.

Chalcopyrite occurs in a gangue of quartz and calcite in narrow stringers. Malachite and azurite occur along joint and pressure planes as a stain or thin film. Minerals of alteration are chlorite, sericite (sometimes altered to kaolin near the water table) and epidote. There is considerable bag man

ganese and some tenorite. High temperature minerals are absent. The minerals are confined, in all cases, to zones of shearing.

These are typical deposits formed at a moderate depth by hot ascending magmatic solutions. Whether or not, the overlying formations acted as a dam is a matter for conjecture. But if a commercial deposit was formed it has long since been eroded away. There is not a hand specimen to be found that will run as much as 0.5% Cu.

Sedimentary Copper Occurrences:

Of no economic importance but of considerable geologic interest is the sedimentary occurrence of copper minerals on the Cuvo River, thirty five kilometers north east of Novo Redondo, in the district of Quanza-Sul. There is a similar deposit at Zenza do Itombe, a station on the Malange Railroad, but it was not examined.

The oldest rock in the vicinity is a granite. The oldest stratified formation is a conglomerate over ninety meters thick, consisting of boulders of igneous rock in a matrix of ferruginous, sandy, calcareous material. Overlying this is the cupriferous

formation, varying in thickness up to twenty meters, of calcareous conglomerate, sandstone, shale and marl. The youngest formation is a dolomitic limestone of great thickness. Fossil remains found in the cupriferous formation have been identified as belonging to the Cretaceous Age. All these strata have been maderately folded and slightly fractured.

The cupriferous beds cover a great area. The outcrops are brilliantly colored. The shale and marl members are rich in plant remains and fossil wood which have usually been converted to chalcocite. Malachite and azurite occur as impregnations in the conglomerate and sandstone members. At the base of the dolomitic limestone are lenses of barite and gypsum.

The entire dependence of the occurrence of igneous rock is marked. The epigenetic character of the deposit is proved beyond reasonable doubt. The dolomitic limestone must have contained finely divided copper mineral derived from such deposits as at Dala Tuto and Gombi Andoi on the older continental area. When atmospheric waters charged with gypsum searched these beds, they might have taken the cop-

per into solution as a sulphate and concentrated it at the horizon of vegetable (reducing) matter.

The Quicuinhe Manganese Deposit:

A deposit of manganese was recently discovered and manifested by the Companhia de Pesquisas Mineiras de Angola. It is located on Quicuinhe Creek near Ambaca, a station on the Malange Railroad, some three hundred kilometers from Loanda.

The ore is found associated with deformed, shattered and altered ferruginous sandstones and shales. The presence of the ore was revealed by large boulders of pyrolusite resting loosely on a great thickness of residual clay. A vein of low grade ore was encountered in trenching operations and there are numerous outcrops of iron-manganese veins in the creek beds. Mineralization is confined to a certain series of joint planes, the walls of which have been replaced and near a thick bed of ferruginous shale, the probable source of the ore. There are indications of mineralization over an area of one thousand hectares.

The high grade character of the ore and the

mode of its occurrence together with the nearness of transportation facilities give promise of a future for the property.

Muscovite near Loanda.

An occurrence of muscovite at the head of navigation on the Dande River, near Sassa, was recently staked by the Companhia de Pesquisas Mineiras de Angola. It is only a few hours by a good automobile road from Loanda and near the railroad.

The mica occurs in a pegmatite dike surrounded by a country rock of gneiss. Two grades of muscovite were observed; a dark greenish variety and a white variety. The white mica occurs in "books" segregated in irregular clusters or pockets along one side of the dike. Dark colored sheets and some white mica are dispersed through the pegmatite as lenticular aggregates. The mine run would probably be of Nos. 5 and 6 grade.

There is nothing extraordinary about the deposit and it could never have more than a very modest future.

Miscellaneous Occurrences:

Gold has been known to exist along the tributaries of the Lombige River, approximately 50 kilometers north of Golungo Alto, for many years but repeated efforts to expoit the deposits have met with failure.

In the valley of the Caxibo River, about 50 kilometers S. E. of Zenza do Itombe is an occurrence of galena. The deposit consists of veinlets, 1 to 2 centimeters thick, in a gangue of calcite traversing the ancient basement complex. The claim consists of 500 hectares and is the property of Camara & Co.,Ltd.

Occurrences of iron are common. The most important are a deposit of magnetite near Zenza do Itombe, owned by the Empresa das Minas do Bembe, Ltd., and a deposit of specular hematite south of Dala Tando on the Lucala River.

The evaporation of seawater for salt is a rather important industry. The average production is about 10,000 tons perannum. Some 100 kilometers N. E. of Malange, on the Lui River, is a deposit of rock salt that is being worked by natives.

Antimonite samples have being brought in

from Malange and rubies from Alto Dande but the exact location of these occurrences are not known.

SUMMARY.

Most of the mineral deposits have been known to exist for over a generation but efforts to mine them usually met with failure. The most signal discovery, that of diamonds, was made only in recent years. They are the only substance coming under the category of mineral which are being exploited on a large scale. Energetic efforts are being made to find petroleum in commercial quantities. There are still vast areas practically unexplored which if thoroughly prospected might lead to more discoveries. It is difficulty, however, for one who has prospected for two years in Angola without any particular success to be optimistic about the possibilities.

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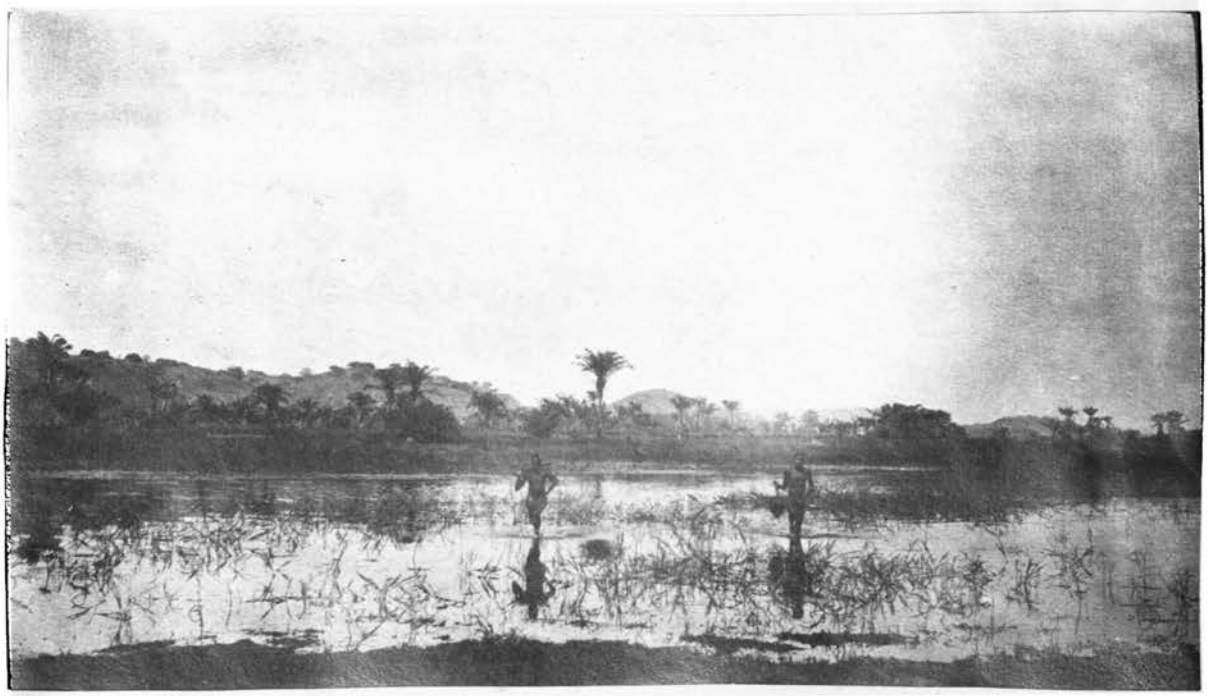
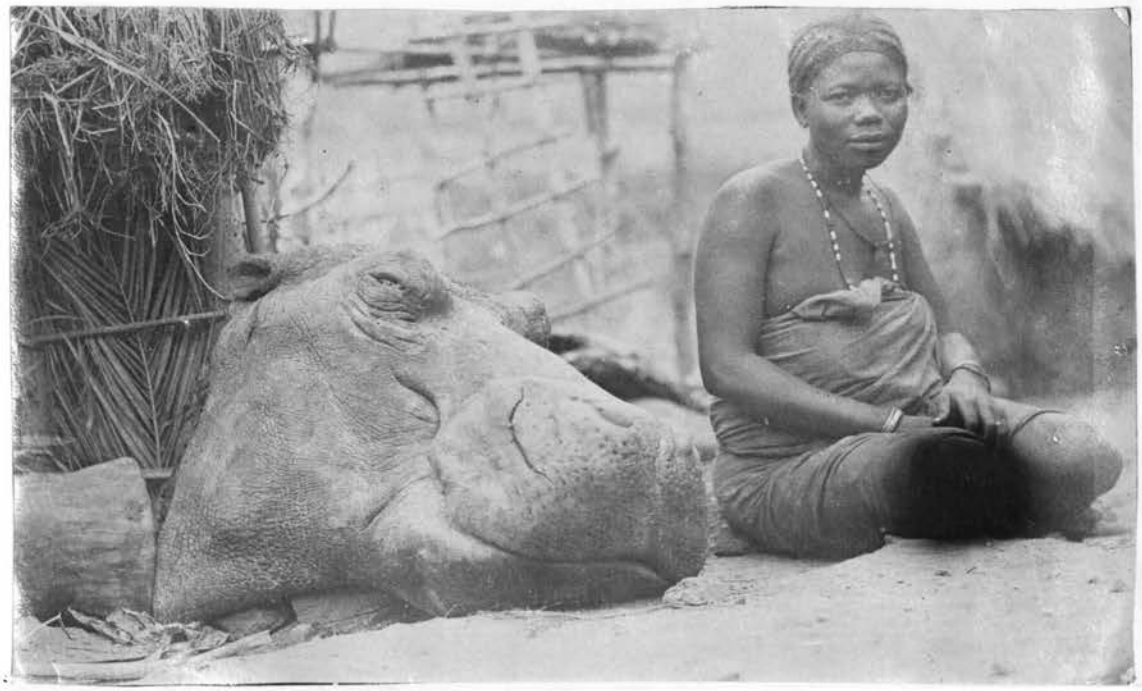
African Grass.

Below - Swamps of the Coast Country.



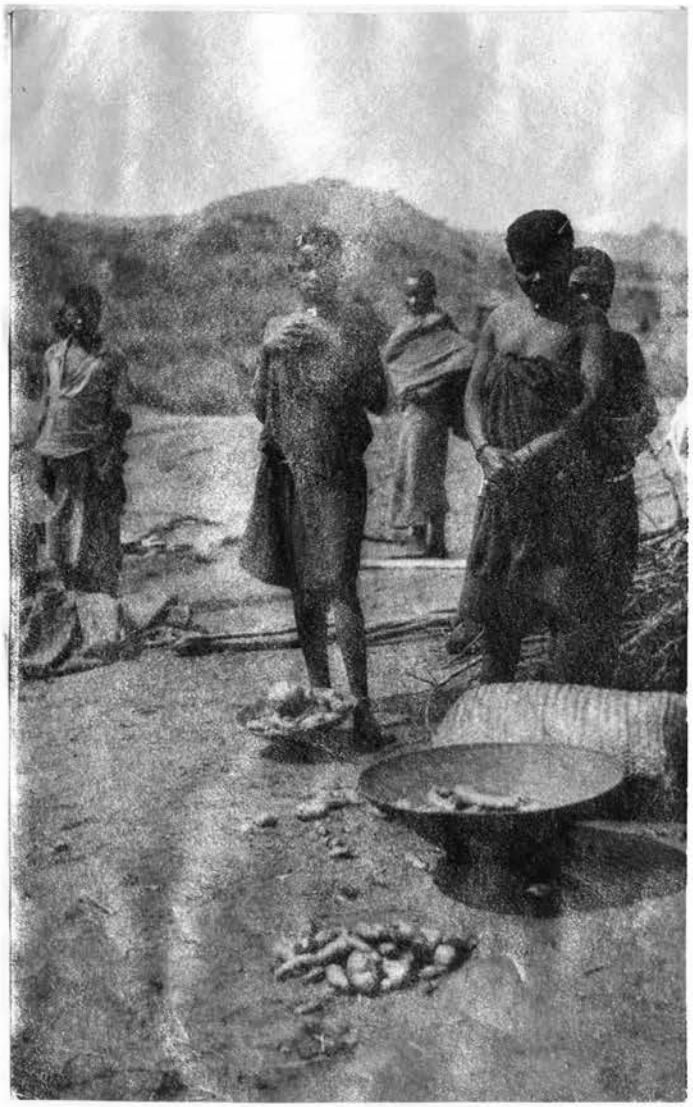
A Specie of Antelope found in Benguela District.



A Hippo Kill.

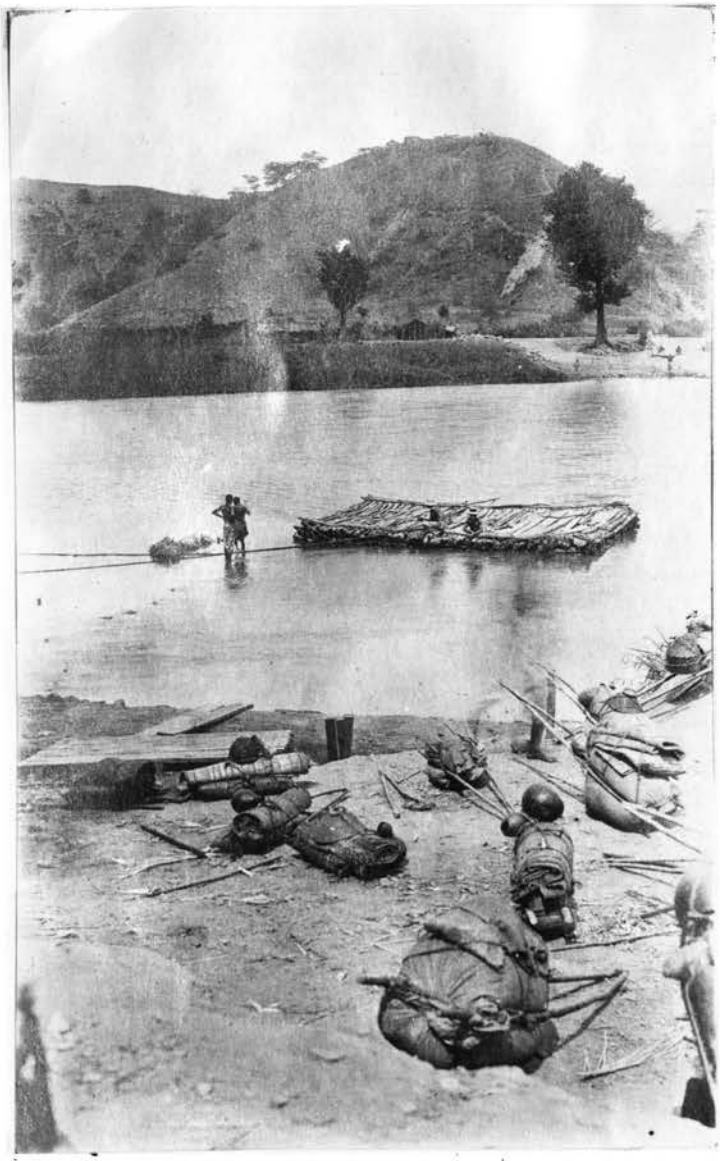
A Coffee Plantation.

Prospectors Lunching on the Trail.



A Village in the Mountains of Quanza-Sul.

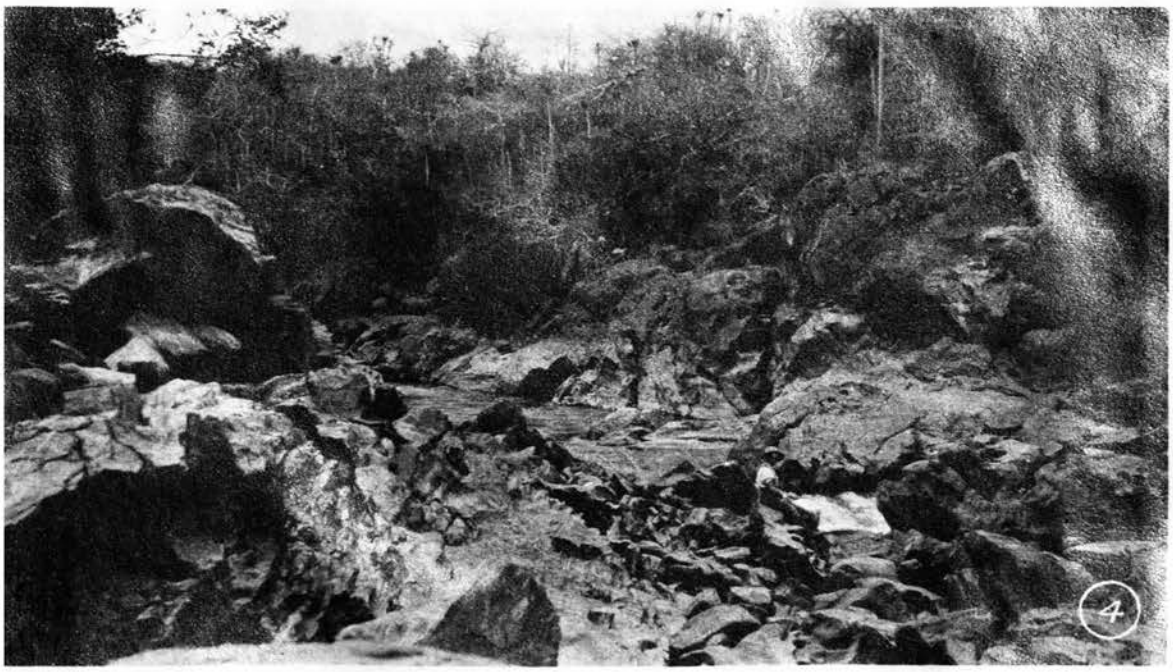
Native Women of Quanza-Sul.



A Native Ferry.

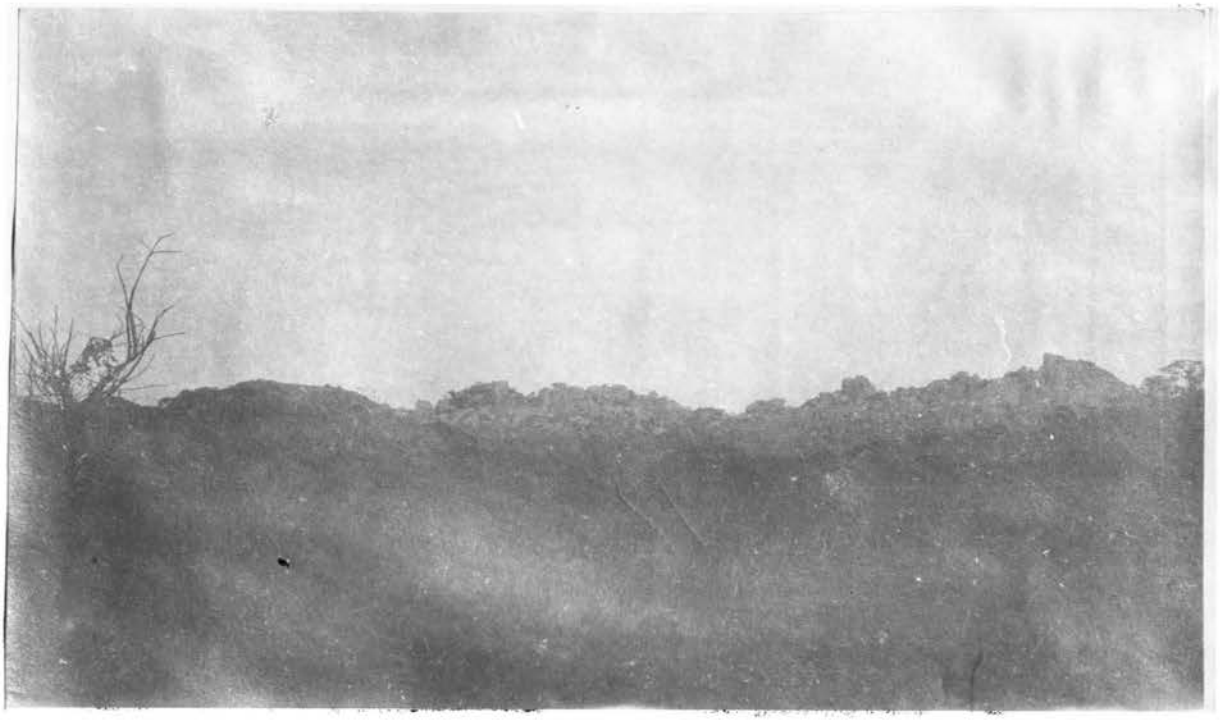
A Prospector's Caravan.

In the Foothills.



Subterranean Passage of the Dande River

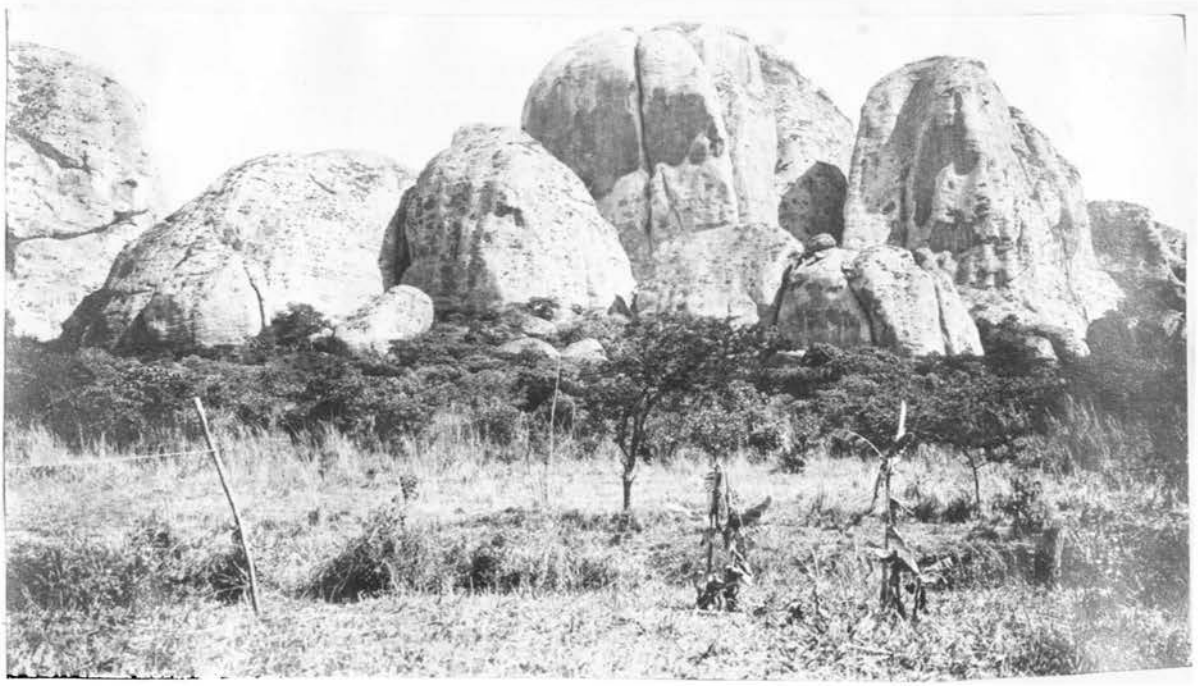
Cuvo River Falls.



Jagged Appearance of Skyline on Plateau.

Basaltic Dike in Quartzite.

Outcrops of Conglomerates.



Classifying Gravel.

Maludi "O" Mine in Lunda Diamond Fields.

Outcrop of Cupriferous Stratum on Cliff near Cuvo River.

Boulders of Sandstone Impregnated with Malachite found near Outcrop above.

Prospecting Trench
at Gombi Andoi.

Pyrolusite Boulders
at Quicuinhe.

Discovery Notice Posted on Muscovite Occurrence near Sassa.

A Cluster of Muscovite "Books".