British Geological Survey

Natural Environment Research Council

WF/AG/51/107C

THE OCCURENCE OF URANIUM AT KILEMBE MINE, UGANDA

by

C B CAMPBELL

Report No 107 February, 1951

SECRET

GEOLOGICAL SURVEY AND MUSEUM

ATOMIC ENERGY DIVISION

Report No. 107

S E C R E T

REPORT ON THE OCCURRENCE OF URANIUM AT KILEMBE MINE, UGANDA

by

C.B. Campbell

February, 1951.

SECRET

C O N T E N T S

~~SECRET~~ OFFICIAL USE ONLY

GEOLOGICAL SURVEY AND MUSEUM,

Exhibition Road,

South Kensington,

London, S.W. 7.

February, 1951.

Dear Thompson,

I submit herewith a brief report by Mr. Campbell on the occurrence of uranium at Kilembe mine, Uganda, based on a recent visit to this property.

We received some samples from Kilembe in October, 1949, which assayed from 0.05 to 0.25 per cent U_3O_8 and which, since Kilembe is potentially a large-tonnage copper-cobalt mine, led us to hope that there might be important possibilities of acquiring by-product uranium from this source. It was later found that the uraniferous mineral submitted to us was derived from ore-shoots of unique mineralogy and insignificant size, the potentialities of the property for uranium production apparently being non-existent.

Campbell's inspection has confirmed this last conclusion. The uranium-bearing pockets are quite minute, and a radiometric examination of the mine workings and mine waters has shown that no recoverable uranium is present. General interest in the possibilities of radioactive ore being found in this general region should not, however, be allowed to drop, since the copper-cobalt mineralization is one in which locally workable developments of uranium may yet be found.

Yours sincerely,

C.F. Davidson

C.F. Davidson
Chief Geologist,
Atomic Energy Division.

R.A. Thompson, Esq.,
Atomic Energy Secretariat,
Ministry of Supply,
4th Floor, Shell Mex House,
Strand, W.C.2.

Distribution:
1. R.A. Thompson, Esq.,
2. G.S.M. Files
3-6. Through P.J. Eaton, Esq.,
7. Dr. K.A. Davies (G.S. of Uganda)
8. C.B. Campbell, Esq., (field)
9. Dr. F. Dixey
10. Colonial Office
11-12. G.S.M. files

Spare copy for Mr. Bowie

~~SECRET~~

SUMMARY

Kilembe mine is situated on the lower eastern slopes of Mt. Ruwenzori, which forms the borderland between Uganda and the Belgian Congo. The property is in a fairly advanced stage of development, the enterprise being capitalized jointly by Probisher Ltd. and Rio Tinto Ltd.

The ore-bodies occupy thin-banded, usually crushed, horizons in a series of folded fine-grained metamorphic rocks (granulites and amphibolites), probably of Pre-Cambrian age. Mineralization is believed to be related to a prolific series of alaskite dykes which intrude the granulites, usually along their banding. Extensive faulting, as well as the emplacement of basic dykes, has taken place following mineralization.

The ore-bodies have been developed by means of a number of adits at various levels, running into the hillsides on both flanks of a valley. So far over 11,000 feet of underground development has taken place, as well as over 40,000 feet of diamond drilling.

The ores contain about 2% copper and 0.18% cobalt, as well as a little gold, silver and nickel. The occurrences of uranium so far found have been confined to one or two very local patches, usually in the form of torbernite (copper uranium phosphate), lining cracks either as small individual crystals or, in association with other copper minerals, as narrow fissure fillings. Radiometric examination of these uraniferous concentrations shows that radioactivity diminishes very markedly over a small distance, both horizontally and vertically. Elsewhere, the background readings underground are generally extremely low and tests of mine adit drainage water and diamond drill cores have so far yielded no encouraging results whatever.

On present evidence this uranium occurrence is regarded as of academic interest only. It is recommended that, as development continues, further routine radiometric tests should be made from time to time, covering both new extensions of the workings and new sections of drill core.

ACKNOWLEDGEMENTS

The writer is indebted to the management of Kilembe mine for access to those records, plans and reports which are relevant to this investigation and from which the following account has been freely borrowed. In addition, thanks are due to Dr. Rex Davies and Messrs. Bruce Gordon and W. Matheson, of the Company's geological staff, for stimulating discussions of their structural problems and for facilitating the writer's inspection of the underground workings.

INTRODUCTION

The examination of Kilembe copper-cobalt mine from the aspect of its potentiality as a producer of uranium ore was stimulated by the discovery, using a G.M. Counter, of certain radioactive anomalies in some of the underground workings. Specimens of ore and rock fragments giving high radiometric readings were submitted by the Geological Survey of Uganda to the Atomic Energy Division, Geological Survey and Museum, in October, 1949, for assaying and mineralogical examination.

In the absence of sufficient background data concerning these field occurrences, the initial specimen assay results (0.05-0.2% equ. U_3O_8) seemed encouraging, especially in the light of known associations of uranium with copper and cobalt minerals in other parts of the world. The writer was therefore deputed to investigate the occurrence of uranium-bearing minerals in this property, during the course of a visit to Uganda to evaluate other known radioactive occurrences.

/LOCATION

L O C A T I O N

Kilembe mine is situated in Toro district of Western Uganda on the eastern slopes of Mt. Ruwenzori. Fort Portal, the administrative centre of Toro district and nearest town, lies about 57 miles to the N.E. Kampala, the capital and railhead, is 203 miles by road to the east of Fort Portal.

The mine is connected by road to the main highway from Fort Portal to Mbarara. A projected extension of the railway line westward from Kampala to the vicinity of Kilembe has been approved and this will greatly facilitate transport of goods to and from the coast.

TOPOGRAPHY, VEGETATION, ETC.

The eastern slopes of the Ruwenzori range are cut up into a series of narrow ridges separated by deep V-shaped valleys, the sides of which slope at about 30°. Flat areas, are practically non-existent except for a few relatively narrow banks bordering the larger streams.

The elevation of the camp site at Kilembe is 4,500 feet, whilst the ore-bodies extend up to elevations of nearly 5,500 feet. The crests of the adjacent ridges are even higher, rising to 7,000 feet.

A dense growth of elephant grass covers the hillsides round the mine workings, forming an almost impenetrable barrierto progress on foot except along the numerous native paths which have been cut through it. It has been found however that this type of vegetation does not grow where the cupriferous gossan outcrops; in such places it is sometimes replaced by a comparatively short grass of different type.

H I S T O R Y

The Kilembe copper deposits were discovered about 1927 by Tanganyika Concession Ltd. (T.C.L.), within a concession covering an area of approximately 250 square miles. Following the conclusion of prospecting, T.C.L. reduced their original holding to an area of about 3.5 square miles which contained all the known copper deposits of the region. This smaller area is identical with that now held by the present owners under their exclusive prospecting licence ('E.P.L.').

T.C.L. carried out entensive development of the property between the discovery date and 1933. During this period about 10,000 feet of trenches were dug and about 9,000 feet of underground work was accomplished. Between 1933 and 1936, most of the concession area was mapped topographically, a geophysical survey made, diamond drill holes were bored, and the underground workings were resampled.

Subsequently, in 1937 or 1938, Tanganyika Concessions did not continue with their development of the deposits and, in consequence, they forfeited their E.P.L. This discontinuance of exploration was due to a number of adverse conditions, including transport difficulties and the low price of copper at that period. The property thereupon reverted to the Government and the Commissioner of Mines closed the area to prospecting. This state of affairs continued until 1st February, 1947, when the present E.P.L. was granted to Frobisher Exploration Co.

During the last three years, the new company has reopened all the main T.C.L. adits and most of the underground workings, although many are still inaccessible due to caving. Surface trenches have been cleaned out, new ones have been dug and several new adits have been driven. Re-mapping and re-sampling has been done, both at surface and underground, and roads and buildings have been constructed. Hydro-electric power possibilities also have been studied.

/The results

The results of this new phase of prospecting activities have been plotted and are being interpreted by a very competent resident staff of four geologists. A short while ago, a Ratemeter 1011 was loaned to the company for routine investigation of radioactive occurrences. Periodic visits to the property have also been made by Messrs. Johnson and Gerrard of the Geological Survey of Uganda for this and other inspection purposes.

G E O L O G Y

(a) General

The principal rocks in the vicinity of the Kilembe ore deposits are, in order of age -

(i) Granulites and amphibolites.

(ii) Alaskite and pegmatite dykes.

(iii) Basic dykes (diabase, etc.).

The oldest rocks (i) comprise the greater part of the rocks in the neighbourhood of the mine and they are considered to be Pre-Cambrian in age.

The granulites which are the host rocks of the principal ore-bodies are fine- to medium-grained metamorphic rocks, believed to be dominantly of sedimentary origin. Called amphibole-biotite-hornfels by A.D. Combe (who mapped the area, including the workings, in 1936), they vary considerably in composition but consist essentially of quartz, felspar, sericite, biotite, and amphibole, in varying proportions. They vary from massive to well-banded in structure, the banding strongly suggesting original bedding. In places they are schistose. Nearly all the ore-bodies occur in and along thinly banded horizons in the granulite.

While no positive markers have been recognized in the granulite series, the banding and general characteristics of the host rocks are so similar that it is suspected that all the ore-bodies occur within the same stratigraphic horizon and may thus be segments of a single bedded deposit. The areal distribution of the deposits in relation to recognized folded structures is also compatible with this hypothesis.

The amphibolites are somewhat different in character to the granulites. Also banded, they are composed essentially of amphiboles, tremolite, biotite, and plagioclase felspar, and sometimes a little quartz. Some exposures suggest a tuffaceous origin.

Both granulites and amphibolites are cut by prolific alaskite dykes which are often pegmatitic. They are composed of coarse, uneven-grained aggregates of quartz and alkali felspars. Biotite, tourmaline, garnet, microcline, and chalcopyrite, sometimes occur as accessory minerals. In places usually near their margins, they contain sufficient chalcopyrite to constitute ore. Most commonly the alaskites follow the banding of the granulites but sometimes they cut across it. They are, in every case, closely associated with the known ore-bodies and often form one, or sometimes both walls. In size and habit they range from very small lenses to large continuous dykes, having lengths of up to 700 feet and widths up to 60 feet. Even larger dykes probably occur.

The alaskites appear to have been emplaced in a highly aqueous condition and have not appreciably disturbed the invaded rocks. In many cases, contacts fade imperceptibly from alaskite into granulite. They are regarded as pre-mineralization in age but are probably genetically related to the mineralization.

/Three

Three late post-mineralisation basic dykes have been recognized. Locally called diabase, they cut across all the above formations and the ore-bodies. They range in width from a few feet to perhaps as much as 200 feet.

(b) Structure

The granulites and amphibolites have been subjected to major folding along N.E.-S.W. trending axes. Cross folding and secondary drag folding is also suggested. Several anticlinal and synclinal axes have been recognized but their mutual relationship is still being determined in the light of accumulating borehole data and structural mapping.

Faulting has been observed in a number of the underground workings. The trend of movement is north-easterly, making a small angle with the strike direction of the country rocks. All the faults dip nearly vertically and, of the three in the northern part of the deposits, two displace the ore-body. These faults are undoubtedly of post-mineralization age but whether movement continued along them after the intrusion of the diabase dykes, is not known. Where the faults cross the rocks bounding the ore-bodies much crushing and gouge is developed over widths of 10 to 20 feet or even more, but in the more competent ore zone the faults are tighter and contract to widths of from 2 to 4 feet.

Strong shearing and crushing occurs in all the ore-bodies that occupy thinly bedded granulite horizons. This shearing is not to be confused with the faulting described above. It is essentially pre-mineralin age and the affected zones are commonly impregnated by heavy sulphide mineralization. Often, where this shearing has been particularly intense, replacement by sulphides is almost complete. It is suggested that the crushing occurred contemporaneously with regional folding and it selected the thin-bedded granulite horizon because of its relative incompetence as compared with the more massive beds which surrounded it. This crushing and shearing is regarded as having been an extremely important factor in providing channel-ways for the access of mineralizing solutions.

M I N E R A L I Z A T I O N

(a) Copper and Cobalt

At surface, the ore-bodies are marked by gossan float or by outcrops of isolated occurrence, since a very large proportion of the area is covered by overburden, sometimes to a depth of 20 feet or more. Oxidation is most variable in depth but does not appear to extend to levels more than 125 to 200 feet below outcrop, although malachite (the dominant oxidized mineral), chrysocolla and other oxidized copper minerals occur sporadically in channels open to percolating waters. Outcrops of the ore-bodies vary from masses of red or yellow ochre to granulites containing disseminated or massive aggregates of malachite.

Mineralization in the sulphide zone consists essentially of chalcopyrite, pyrite and, subordinately, the cobalt mineral, linnaeite. The sulphides occur within the granulite horizon as massive impregnations, lenses, veins, stringers,and disseminations. Along zones of heavy crushing, impregnation and replacement by sulphides is often nearly complete, resulting in the development of massive sulphide ores, ranging in width from 5 to more than 30 feet. The intensity of mineralization decreases as crushing and shattering diminish, so that outward from the main crush zone it is common to pass through first, a zone containing lenses and seams of sulphides, and then into uncrushed banded granulites in which the sulphides are more evenly disseminated.

No well-defined zone of secondary enrichment has been recognized in any of the Kilembe ore-bodies. Chalcocite occurs, but it is not abundant in the oxidized and partially oxidized horizons. On the levels where pre-dominant sulphide ore occurs, the dominant copper mineral is chalcopyrite.

Chalcocite and native copper have been recognized on some of these levels but only in very small amounts and in isolated occurrences.

So far four, and possibly five, major ore occurrences have been discovered and partially developed at Kilembe, all within a radius of half a mile. These are referred to as the Northern, Stream, Southern, and Eastern deposits. The orebodies have been developed by means of 14 adits as well as minor prospecting trenches. The drives extend intermittently over about 3,400 feet along the direction of strike and, in them, underground chambers have been constructed for diamond drilling. In the vertical direction, the orebodies have been developed underground over a range of 600 feet on both sides of the Nyalusegi Creek.

The results obtained from this extensive development work and from surface and underground drilling up to September, 1950, are summarized as follows:-

Ore Reserves

	Classification	Tonnage	% Cu.	% Co.
Class A	Partially developed	6,080,000	2.3	0.18
Class B	Strongly indicated	1,180,000	2.0	0.17
Class C	Indicated by drilling	2,510,000		
Class D	Possible, projected	4,260,000		
Class E	Theoretical or geological	11,000,000		

In the developed parts, the overall average grades of about 2% Copper and 0.18% cobalt extend over an average horizontal width of 45-50 feet and over a total length of about 2,700 feet.

(b) Uranium

By comparison with the tonnages of copper and cobalt present in the orebodies, the occurrence of uranium appears to be merely of academic interest. So far only two recognizable and isolated localities have been found where uranium minerals, in the form of torbernite or metatorbernite, are visible. One is in "M" level, the uppermost working in the Northern deposit (elev. 5,167 ft.), and the other is in "A3" level in the Eastern deposit (elev. 4,482 ft.), these two places lie on opposite sides of the Nyalusegi Creek, about 3,000 feet horizontally and nearly 700 feet vertically apart.

The "M" level occurrence is the richer. The uranium is here confined to a selvage of supergene mineral and oxidized copper ore lining a fissure at a point where a strike fault zone approaches a very wide diabase dyke. The superficial area of this thin film, or what remains of it on the side of the crosscut, appears to be no more than two square feet.

The other occurrence in the crosscut from the entrance to "A3" level, is of similar type but even more restricted in extent.

Other parts of the workings seem to be virtually barren of these local supergene occurrences, although a few patches having a slightly higher degree of radioactivity than average were encountered in "39" level (this working lies on the same side of the Nyalusegi Creek as "M" level, but at an elevation of about 4,820 feet). These occurrences do not show any visible uranium minerals and they appear, from their wider areal extent, to be associated with percolation channels in or adjoining fault zones. Their disposition is along the same fault zone as that associated with the richest pocket in "M" level, and below it, in the dip direction of the fault.

/RADIOMETRIC

RADIOMETRIC INVESTIGATIONS

A Ratemeter 1011 was used to investigate the degree of radioactivity in underground workings and of the diamond drill cores stored in the core shed at the mine. In general, the background readings obtained in most parts of the workings were about 5 to 9 on C range, using sensitive 5B tubes. Drainage leats at the entrance to adits also gave similar low readings.

In the immediate neighbourhood of the rich pocket in "M" level, readings rose rapidly from 11-13 (C) to a maximum of 15 on A range, when the probe was placed in the centre of the pocket. On either side and above and below, a marked fall-off in degree of radioactivity was observed over distances of a few feet. In "A3" adit, a small patch on the wall of the entrance crosscut gave a maximum reading of 25 on B range; in "39" level (below end to the N.E. of "M" level) local maximum readings of 32(C), 26(C) and 18(C) were found at different intersections of the same fault zone. The results of drill core investigations were of a similar low order as the rest of the underground workings.

C O N C L U S I O N S

The few patches of supergene uranium minerals found in the fairly extensive workings of this mine are, if anything, of smaller and less frequent occurrence than might be expected in a Copper-Cobalt-Nickel/Sulphide mineralization having such a dislocated structure. Those occurrences that have so far been encountered appear to be associated with fault zones trending almost parallel to the strike of the folds and orebodies and, perhaps, they are of greater frequency near the margin of a transverse basic dyke. Such apparent associations between uranium mineralization and dyke or fault structure follow a pattern which is frequently observed in other fields.

Present prospects of obtaining any appreciable quantities of uranium ore as by-production from this copper-cobalt mine are negligible. However, it is recommended that routine checks should be made from time to time to discover the extent and grade of possible uranium occurrences in newly developed ground and from the evidence of diamond drill cores.