Bulletin No. 32

MALAŴI
MINISTRY OF AGRICULTURE
AND
NATURAL RESOURCES

GEOLOGICAL SURVEY DEPARTMENT

THE GEOLOGY OF THE NKHOTAKOTA-BENGA AREA

by
D. R. HARRISON, B.Sc.
and
F. W. P. CHAPUSA, B.Sc., M.Sc.

PRICE K5.00

1975
PUBLISHED BY THE GOVERNMENT PRINTER, ZOMBA, MALAŴI

II. PHYSIOGRAPHY

(a) Topography and erosion surfaces

The Nkhotakota–Benga area is situated along the western boundary of the Malaŵi Rift Valley and much of the topography reflects the faulting which has affected the area. Elevations range from 474 m (1555 ft) above mean sea level at Lake Malaŵi to 170 m* (5595 ft) at the highest point of the Ntchisi Mountains.

Two major physiographic units (Fig. 2) are recognized: the Rift Valley fault scarp zone, including the Ntchisi Mountains in the extreme southwest of the area, and the Lakeshore Plain. The Ntchisi Mountains are dominated by the prominent ridge to the west of Mwansambo, underlain by perthitic gneisses, but to the north and south of the topography consists of closely spaced, rounded hills between 850 and 1370 m (2800 and 4500 ft) above sea level which reflect the local geology (pelitic schists). The topography of the remainder of the fault scarp zone is a consequence of the underlying geology and the Rift Valley faulting. In the north a distinctive shelf and scarp topography is developed, comparable with, but less pronounced that that noted further south in Malaŵi (e.g. Walshaw 1965; Dawson and Kirkpatrick 1968). The fault scarps lie *en echelon* and vary in height from about 6 to 140 m. The major features are often continuous over several kilometres. The surfaces or 'step' above each escarpment is strongly dissected but slopes gradually upwards to the next escarpment. Differential weathering of surfaces has resulted in the development of prominent ridges such as Nyenje, Kampande, Vundikira, Chisoti, and Chuwi. In the south, where no recognizable fault scarps are present, the boundary between the zone and the Lakeshore Plain is gradational and poorly defined. In favourable circumstances it is marked by a significant break of slope and an increased degree of dissection to the west.

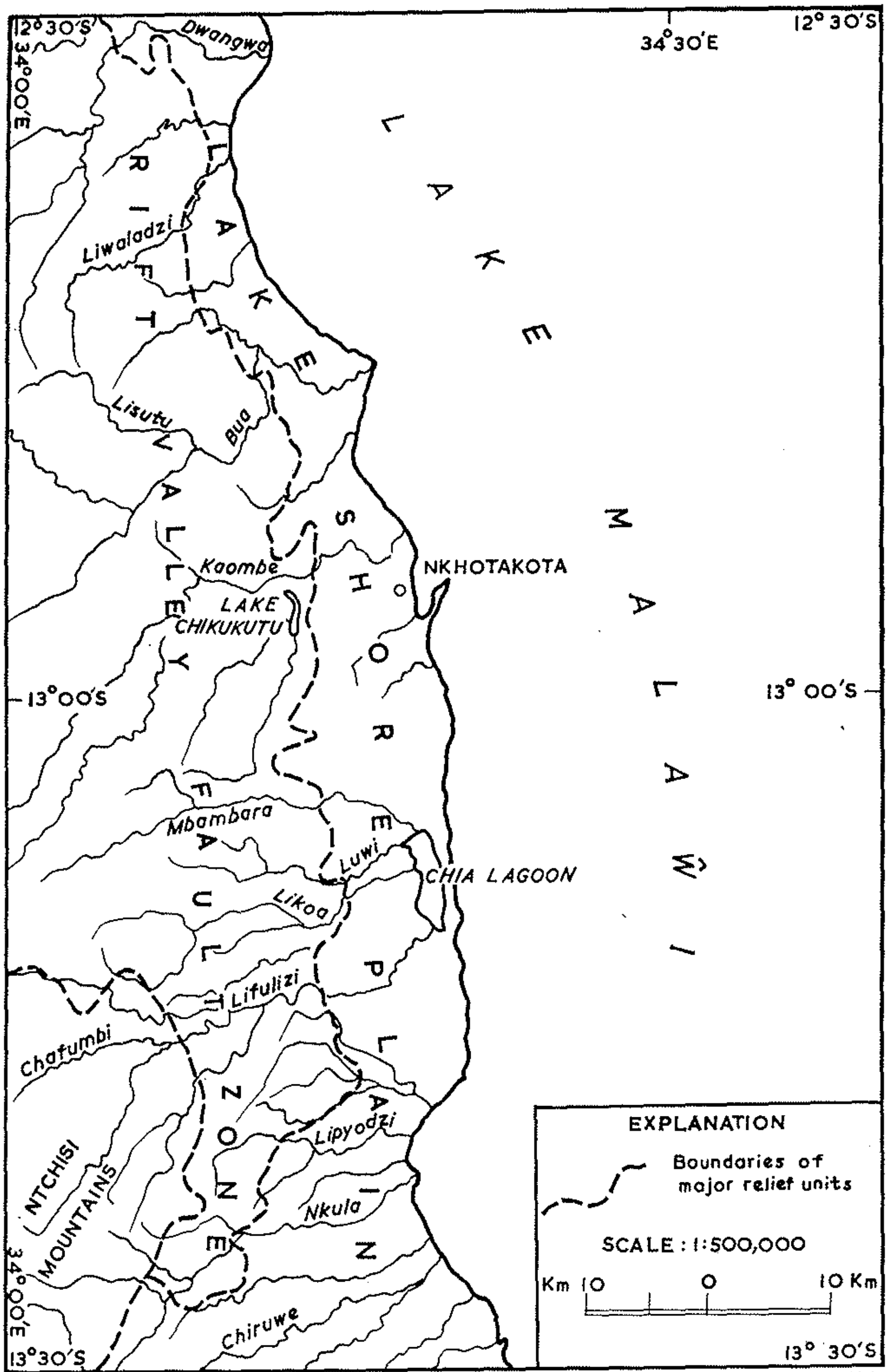
The Lakeshore Plain extends the length of the area in a southerly direction. It varies in width from about 13 km near the Dwangwa river to about 2 km near Liwaladzi. From the mouth of the Kaombe river southwards to Kirambu Point, a distance of some 45 km, the continuity of the plain is interrupted by a series of *en echelon* fault ridges, facing to the west; the most extensive of these features is caused by the Sani fault. Elsewhere, the surface of the plain is flat and little dissected and it slopes gently towards Lake Malaŵi at an angle of less than one degree. The plain is a composite feature resulting from both subaerial weathering and lake and river deposition.

The prevailing southeasterly winds have caused longshore drift to the north and the formation of sandspits and bars along the present shoreline (e.g. Sungu Spit, opposite Nkhotakota) and inland (e.g. in the Dzadza and Dwangwa Marshes).

Following Lister (1967), the effects of two major erosion cycles can be recognized (Fig. 3). Dissection and erosion within the fault scarp zone is correlated with the late Miocene and Pliocene 'post-African' cycle and with Quaternary erosion along the valleys. Four erosion surfaces are present within the zone, standing at approximately 950 m (3100 ft), 840 m (2750 ft), 690 m (2250 ft) and 560 m (1850 ft). The 560 m surface is the most extensive and it slopes gently eastwards to the Lakeshore Plain. It represents a peneplain graded to a lake level some 90 m (300 ft) above the present level and the gravel sheets now found on the surface are regarded as former beach deposits. Both the surface and the Lakeshore Plain are correlated with Lister's (*op. cit.*) Quaternary cycle which is of both erosional and depositional nature; it is largely confined to the floor and sides of the Rift Valley.

In the extreme west dissected remnants occur of the upwarped eastern edge of the late Cretaceous to early Miocene 'African' erosion surface. This surface gives

*Value shown on 1:100 000 physical map of Malaŵi, 2nd edition 1973.



GSN.967A. *Geological Survey Dept. Malaŵi 1975* MM.

Fig. 2. Topographical units in the Nkhotakota–Benga area.

rise further west to the extensive plains of the Central Region (e.g. Bellingham and Bromley 1973).

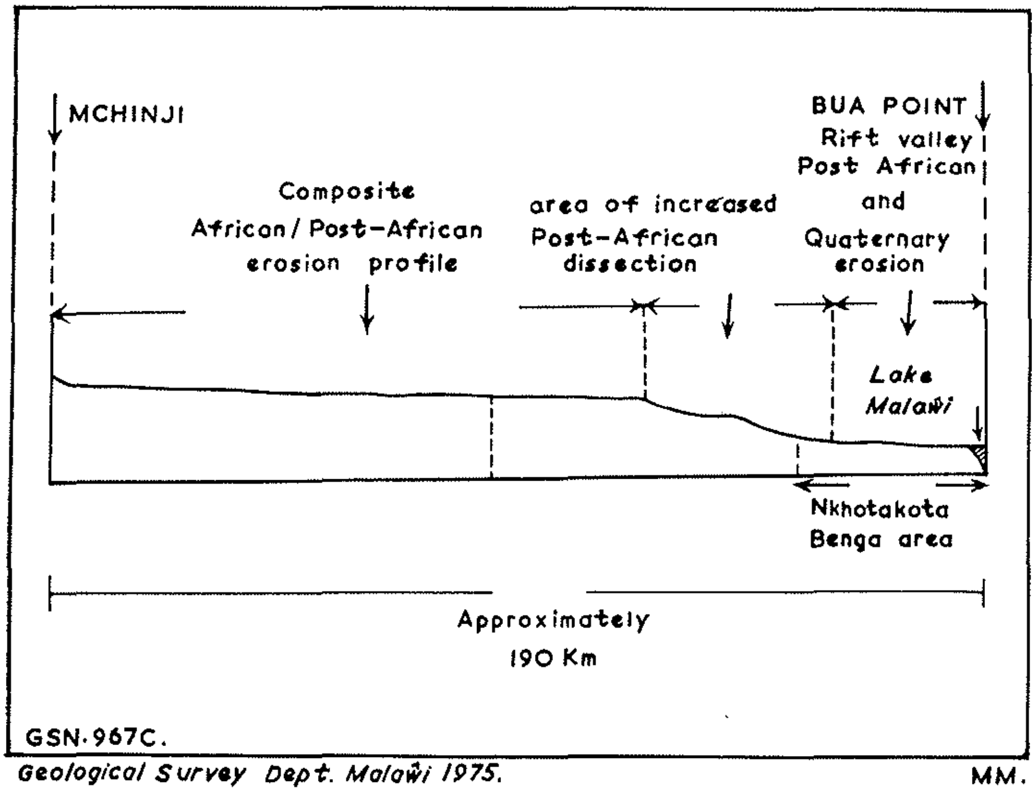


Fig. 3. Diagrammatic section showing the nature of the Bua profile.

(b) Drainage

The area is drained by rivers and streams flowing off and across the Rift Valley escarpment in an easterly and east-northeasterly direction into Lake Malaŵi. The more important drainages are shown on Plate I.

The Kasungu Plain to the west of the area is drained by rivers, such as the Bua river, which had reached a mature stage of development prior to the rift faulting. Rejuvenation occurred where these rivers crossed the Rift Valley escarpment. The rivers maintained their original courses by rapid downcutting during the periods of differential uplift associated with the faulting, and now flow through deeply incised gorges and valleys. Smaller rivers (e.g. Lilavwe, Lifumbidzi, Msupadzi, Lifulizi, Chiruwe) which rise in the fault scarp zone were presumably initiated at the time of faulting and uplift and in many instances they follow older lines of structural weakness rather than the overall direction of slope. They display vigorous headward erosion, cutting back into the escarpment.

In the west of the area, therefore, the drainage pattern comprises deep major river gorges and short tributaries flowing down steep-sided gullies (e.g. Lifumbidzi and Chiruwe rivers). Further east, where slopes are more moderate, the pattern is increasingly dendritic and the drainage is less deeply incised (e.g. Mikongwe and

Chizeu Rivers in the north and the Nkumbaleza, Lipyodzi and Nkula rivers in the south).

On the Lakeshore Plain, the drainage reverts to a mature or senile stage of development. Deposition rather than erosion, and meandering and braided channels are the norm. The rivers flow sluggishly across the plain, either on the same level as the plain (e.g. Nkumbaleza river) or in shallow trenches (e.g. Kaombe river) but terrace development indicates repeated base level adjustment. Four terraces are recognizable in the Nkula river which flows into Lake Malaŵi south of Benga. They average about 80 m in width and indicate valley deepening amounting to 15 m on the first occasion, 8 m on the second, 2 m on the third and about 600 mm along the present watercourse.

In addition to causing downcutting and terrace development, recent faulting on the Lakeshore Plain has diverted certain rivers and impeded others. Thus, the Bua river swings through almost 180° to the west of Bua point as it is diverted around and locally controlled by the northern end of the Mphalanyongo fault. The westward facing *en echelon* fault scarps to the west and south of Nkhotakota have impeded the drainage, causing rivers and streams to form small lakes (e.g. Lakes Chilingali and Chikukutu) and marshy tracts (e.g. along the Sani fault scarp).

serpentinites. These anomalies were further prospected between 1970 and 1972 by International Nickel Company (Pty) Limited as part of a more extensive mineral exploration programme in the Central Region. An area north of Ngombe Hill and east of the Camsani stream was drilled, but with disappointing results. The following summarizes the main points of interest from the reconnaissance survey.

Low copper, nickel and chromium anomalies were found to coincide with known ultramafic rocks to the south of Kute Mountain and a grouping of higher than normal nickel and chromium values in the area to the northeast of Njongombe Hill may be similarly associated, although it may also relate to the large discordant amphibolite body which crops out in the area. The metapyroxenite due south of Kute Mountain gives rise to anomalous copper values, whilst the anomalous nickel and chromium values are linked with the small serpentinite intrusions.

Further south, between the Kaombe river and Ngombe Hill, similar anomalous values for these elements form groups which reflect the presence of ultramafic rocks not discovered during the regional mapping, but which were recorded during the follow-up investigations by E. R. Peters, as noted above.

To the south of approximately 13°15'S no results of interest were obtained, despite the dense sampling pattern. The secondary copper mineralization is not reflected in the stream sediment analyses.

Low anomalous values for tin, lead and niobium are reported for stream sediments in the vicinity of the Sani granite hills. The values are not significant and owe their origin solely to the presence of the granite.

(e) Building materials

There has been little development of the building material resources of the area and the only specific assessment made of them was carried out by K. E. Wilderspin (1965, unpublished report) during the course of a rapid survey for sources of aggregate along the line of the proposed Lakeshore road. Small roadside outcrops have in general provided the materials necessary for road construction and maintenance and a small quarry was opened for this purpose a few hundred metres south of the Bua river bridge.

The Sani granite is the only rock type which could provide large quantities of road aggregate and building materials of suitable quality on the Lakeshore Plain. Accessible developments of quartzo-feldspathic gneisses and mafic rocks which might prove suitable are limited. Wilderspin (1965, unpublished report) noted possible sites at Bowa, about 1,6 km south of the Dwangwa crossing, and again at a similar distance north of Mpikapika. The quartzo-feldspathic gneisses between Benga and Mwansambo might merit further consideration should the need arise.

Gravel deposits occur sporadically throughout the Lakeshore Plain and the adjacent hinterland to the west. Despite their extensive spread, they are surface deposits and the clearance of large areas of land would be required to obtain a substantial volume of gravel. Potentially the best gravel deposits occur along the major rivers (e.g. Dwangwa, Liwaladzi, Bua), both upstream and downstream of the main road crossings.

(f) Groundwater

Surface water supplies which, with the obvious exception of Lake Malaŵi, become unreliable during the latter part of the dry season, have been augmented by the development of the groundwater resources. This development has concentrated along the Lakeshore Plain, where reliable supplies are to be found. The Plain is also both the most densely populated part of the area and the part with the greatest agricultural potential. Few boreholes have been drilled in the Rift Valley

TABLE I

BOREHOLES DRILLED FOR WATER SUPPLY IN THE NKHOTAKOTA–BENGA AREA TO 1974

Ref. No.	Location	Depth (m)	(ft)	Yield (gph)	Rocks penetrated	Year drilled
L344	Mtambo	31	102	350	Weathered gneiss	1956
E54	Mteya	33	109	240	Terrace sands	1960
E55	Nkhongo	30	100	600	Weathered gneiss	1957
E56	Thandwe	31	103	700	Weathered gneiss	1957
E57	Chimbuta	37	120	720	Terrace sands	1957
E58	Mtachi	31	102	720	Terrace sands	1960
E59	Kalowiro Mission	31	101	576	Terrace gravels	1960
E61	Chakaka	31	101	400	Terrace sands	1960
E62	Kasanja	28	93	480	Colluvium, gneiss	1960
W321	Nkhotakota township	49	162	2000	Terrace gravels	1965
Q39	Kanyembo	23	75	250+	Terrace sands	1966
Q265	Liwaladzi Camp	44	145	450	Weathered gneiss	1968
Q266	Usufa Radio Stn.	20	66	720	Terrace sands	1968
Q346	Tavita Clinic	42	137	720	Weathered gneiss	1969
Q347	Garnett	49	160	760	Weathered gneiss	1969
Q348	Laston Saidi	49	162	480	Weathered gneiss	1969
Q349	Chiwalanga	42	138	360	Weathered gneiss	1969
Q350	Chiunjeza	48	158	720	Weathered gneiss	1969
Q351	Chamatumbi	52	170	576	Weathered gneiss	1969
R43	Aroni	40	130	900	Terrace sands, gneiss	1969
R44	Nkhotakota School	43	140	650	Clay, gneiss	1969
R47	Mwansambo	24	80	900	Weathered gneiss	1969
R100	Mtambalika	38	125	500	Weathered gneiss	1970
R101	Mkhungwa	28	90	620	Weathered gneiss	1970
R102	Mgundana	43	140	1000	Weathered gneiss	1970
R104	Khango	37	120	330	Weathered gneiss	1970
R105	Nkhala	37	120	950	Weathered gneiss	1970
R106	Nkongolo	43	140	750	Weathered gneiss	1970
R107	Chomveka	46	150	300	Weathered gneiss	1970
X100	Kamuona	49	160	1800	Terrace gravels, gneiss	1970
X101	Nkanje	46	150	1800	Terrace gravels	1970
X102	Chiunjiza School	43	140	150	Terrace sands, gneiss	1970
X103	Makho	40	130	1125	Terrace gravels	1970
X104	Kulein	46	150	780	Terrace gravels	1970
X111	Mcholi	41	135	240	Colluvium, gneiss	1970
X112	Kajaliza	46	150	1500	Colluvium, gneiss	1970
X192	Msumbu School	52	170	1000	Weathered gneiss	1971
Y83	Msemanjira	41	135	330	Terrace sands, gneiss	1970
Y84	Manjawira	40	130	1200	Terrace sands, gneiss	1970
Y85	Aruni Haridi	40	130	2570	Terrace sands, gneiss	1970
Y86	Kamkonke	49	160	400	Terrace sands, gneiss	1970
Y87	Kanzanga	46	150	690	Terrace sands, gneiss	1970
Y88	Phaphala	46	150	640	Terrace sands, gneiss	1970
Y89	Funsani No. 1	46	150	360	Terrace sands, gneiss	1970
Y90	Chigwe	44	145	800	Terrace sands, gneiss	1970
Y99	Emu	46	150	450	Terrace sands, gneiss	1970
Y100	Liwera	46	150	600	Terrace sands, gneiss	1970
Y101	Mkhalandani	41	135	150	Colluvium, gneiss	1970
Y111	John Nyoni	43	140	600	Colluvium, gneiss	1970
Y112	Mtaponga	37	120	360	Colluvium, gneiss	1970
Y113	Kapili Hospital	46	150	1000	Colluvium, gneiss	1970
Y114	Chilenga	46	150	150	Colluvium, gneiss	1970
Y185	Kalimanjira	37	120	480	Colluvium, gneiss	1971
Y186	Chombo School	46	152	480	Colluvium ,gneiss	1971
Y187	Nkhotakota Church	46	150	300	Colluvium, gneiss	1971
Y189	Kaombe Settlement	43	140	480	Colluvium, gneiss	1971
DP85	Peg No. C 192	44	145	515	Fractured gneiss	1971
DP86	Peg. No. C 184 (extension gate)	49	160	1125	Fractured gneiss	1971

TABLE 1—*cont.*

Ref. No.	Location	Depth (m)	(ft)	Yield (gph)	Rocks penetrated	Year drilled
DP87	Kamponja	43	140	1285	Weathered gneiss	1971
DP88	Mwachipita	52	170	360	Weathered gneiss	1971
DP89	Mpondelo	46	150	150	Weathered gneiss	1971
FC56	Kayoyo School	46	150	150	Fractured gneiss	1972
FC151	Mvula	46	150	485	Colluvium, gneiss	1972
FC152	Kasakala	46	150	600	Colluvium, gneiss	1972
FC153	Chazama	46	150	330	Colluvium, gneiss	1972
FC154	Chikunumba	46	150	1500	Colluvium, gneiss	1972
FC156	Malembo	61	200	900	Colluvium, gneiss	1972
FC157	Thanga	62	200	225	Colluvium, gneiss	1972
FC158	Kajaliza	46	150	950	Colluvium, gneiss	1972
FC159	Damba	46	150	300	Colluvium, gneiss	1972
RB57	Sasani	43	140	450	Terrace sands	1972
RB58	Zunga School	43	140	750	Terrace sands	1972
RB61	Dwangwa Project	46	150	1220	Terrace sands	1972
RB134	Benga New Hospital	41	135	450	Fractured quartzite	1972
CM14	Mwansambo	35	105	600	Weathered gneiss	1973
FP39	Mphakwe School	46	150	1200	Quartzite, gneiss	1973
FP41	Matalezi	61	200	300	Quartzite, gneiss	1973
GK81	Dwangwa Farm	76	250	280	Gneiss	1973
GK84	Bua Irrigation Scheme	43	142	516	Terrace sands, gneiss	1973

Metric depths converted and rounded to nearest whole metre.

fault scarp zone where the potential for groundwater and agricultural development is low.

Details of the boreholes drilled are given in Table I and the distribution of the boreholes is shown on the geological map.

In the Mwansambo–Benga and Chia Lagoon areas there are nearly 70 drilled wells. Over half of them are in the Lakeshore–Plain area. Contours of depth to the bedrock show that in Mwansambo the Basement slopes in the north-easterly direction towards Chia Lagoon. This direction is roughly parallel to Lifulizi stream valley. Contours showing depth to first water and depth to main supply coincide closely indicating that water-table conditions exist. Water level contours show a slope towards Chia Lagoon indicating that groundwater in this area discharges into the lagoon.

Borehole data from the Benga area indicate that nonflowing leaky artesian conditions may exist and that the bedrock here slopes towards Lake Malaŵi into which groundwater discharges. Contours showing depth to bedrock indicate the existence of buried valleys and spurs.

(g) Hot Springs

Eleven natural thermal springs are present in the area. The main grouping of ten springs occurs just south of Nkhotakota and these springs are probably the best known in the country (see also Dixey 1927; Kirkpatrick 1969). They flow out into the bottom and sides of the small valley of the Mawiri stream, and several of the springs have been tapped for the township water supply. However, the excessive fluorine content of the water has to be reduced before it is suitable for human consumption. The water temperature of the hottest of these springs at the point of issue is 65 °C (Kirkpatrick, op. cit.). Four of the springs flow directly into the stream and at one locality a cold spring flows out only 14 m from a hot one.

The other recorded spring is situated about 90 m west of the bridge over the Chikwidzi river, about 9 km south-southwest of Benga. It issues from the banks of the river at a temperature of 52,4 °C.

Chemical data of the spring waters are given in Table II.

The thermal springs are generally considered to represent the warning phases of vulcanicity associated with the East African Rift System. In the present area the springs are broadly associated with the Rift Valley faulting although they cannot be related to specific fractures. In Tanzania, James (1967) has related hot springs occurring in a similar environment to the outcrop of antithetic faults associated with the main rift faults.

TABLE II

CHEMICAL ANALYSES OF SPRING WATERS

	Nkhotakota	Chikwidzi
Total solids (mg/l)	388	376
Total hardness (mg $CaCO_3/l$)	14	8
Total alkalinity (mg $CaCO_3/l$)	84	56
Non-carbonate hardness (mg $CaCO_3/l$)	nil	nil
Bicarbonate alkalinity (mg $CaCO_3/l$)	68	28
Carbonate alkalinity (mg $CaCO_3/l$)	16	28
Hydroxide alkalinity (mg $CaCO_3/l$)	nil	nil
Ca^{2+}	4,4	2,4
Mg^{2+}	0,7	0,5
Na^+	282	270
K^+	3,0	2,2
Fe^{2+}	n.d.	n.d.
Mn^{2+}	n.d.	n.d.
Cu	n.d.	n.d.
SiO_2	90	80
P_2O_5	tr	tr
Cl^-	18	30
F^-	17	8
Nitrate nitrogen (mg N/l)	n.d.	n.d.
Nitrate nitrogen (mg N/l)	n.d.	n.d.
SO_4^{2-}	20	20
Electrical conductivity (RM/cm³ — 20 °C)	505	485
pH	8,7	9,5

Data from Kirkpatrick (1969, Table 1), chemical values in mg/l