CONTINUED FROM PREVIOUS FILM

found that slow changes of level are apt to precede an earth ake, and therefore in some sense to predict it. The information available on this point is as yet meagre, but earnest attention is being paid to it in Japan; and possibly something of the same kind might receive attention in Kenya. If further information on this subject of levelling is desired, Professor Imamura of the Seismological Institute, Tokyo Imperial University, would probably send copies of his papers. But I have just looked again at a few of them, and I feel a little afraid that such work may prove ~~barrickitis productive~~ rather unproductive in proportion to the probable cost. We are in fact at present much in the dark on such matters, though it may be urged of course that this is an excellent reason for working at them.

I am,
Yours obediently,

H. H. Turner

The maps & photographs are returned herewith, as requested

The Under Secretary of State.
Colonial Office,
London, S.W.1.

British Association Seismological Committee.

A[illegible] inquiries and correspond[illegible]
Prof. H. H. TURNER
University Observatory
OXFORD

1928 Aug 10

Sir

I have the honour to acknowledge (gratefully) your letter of 7 August [illegible] 15165/28 with enclosures referring to the Kenya Earthquake of January last.

[illegible] I have ~~[illegible]~~ compared the [illegible] rapidly with what are already [illegible] of [illegible] Kenya [illegible] that [illegible] further [illegible] after which [illegible] comments [illegible] the kind [illegible] of the Government of Kenya [illegible] logical information from [illegible] that [illegible] not [illegible] [illegible] & is naturally specially welcome.

[illegible]
[illegible] obedient servant
H H Turner

The [illegible] of State
for the [illegible]

11 4

British Association Seismological Committee.

Prof. H. H. TURNER
University Observatory
OXFORD

1928 Aug 10

Sir

I have the honour to acknowledge
(gratefully) your letter of 1 August
1516/28, with enclosures referring to
the Kansu Earthquake of January last.
I have already transferred the
[illegible] with that on cloudy
[illegible] of Australia & New
[illegible]
[illegible]
[illegible] the Government of
[illegible]
[illegible] from
[illegible]
[illegible]

The Entomological Club
[illegible]

KENYA.

No. 320

GOVERNMENT HOUSE,
NAIROBI
KENYA

22nd JUNE, 1928.

Sir,

I have the honour to state that on the 6th January, and succeeding days, a series of earth tremors took place in various parts of the Colony and more particularly in the vicinity of the Laikipia Escarpment.

2. Damage was caused to the houses of settlers in the Subukia and Solai Valleys, these houses were, however, mainly constructed of temporary materials. Adequate assistance was rendered by the District Officer, Nakuru and tents were lent by Government where necessary.

In addition various cracks appeared in, nd damage was caused to, structures elsewhere in the Colony and generally where mud had been used as a mortar.

No reports have been received that native huts were affected.

3. A circular was issued to Administrative Officers, of which I enclose a copy, calling for reports and the Governor of Uganda kindly rendered assistance by allowing Mr. W. C. Simmons, Government Petrologist, to visit the affected area whither two Surveyors had been despatched to examine the terrain. The Director of Public Works/

THE RIGHT HONOURABLE
LIEUTENANT COLONEL L.C.M.S.AMERY, P.C., M.P.,
SECRETARY OF STATE FOR THE COLONIES,
DOWNING STREET,
LONDON S.W.

Works, Mr. H. L. Sikes also visited [illegible] Solai and Subukia Valleys.

I enclose an illustrated copy of Mr. Sikes' notes dated the 10th February together with three copies of Mr. Simmons' report of the 16th March. The reports of the Director of Public Works, of the Surveyors and the Administrative Officers were supplied to Mr. Simmons.

I understand that the Uganda Geological Department does not associate itself with the views expressed by the Director of Public Works.

4. I observe that Professor H.H.Turner, Savilian Professor of Astronomy at Oxford University, in a letter to the "Times" newspaper on the 10th January, is of opinion that the epicentre of this earthquake was in the neighbourhood of Lake Victoria Nyanza, the meizoseismic area appears now to have been at the foot of the Laikipia Escarpment, and in view of the interest which he has taken in the matter I should be obliged if the enclosures to this despatch might be communicated to him and if his advice could be obtained upon the seismological considerations raised.

I have the honour to be,

Sir,

Your most obedient, humble servant,

GOVERNOR.

14

CIRCULAR No. 5

G 4
A—1
D—

THE SECRETARIAT
NAIROBI,
19th January, 1928

EARTHQUAKE—JANUARY, 1928.

In view of the report on the recent earthquake referred to in Reuter's telegram of the 10th instant (reproduced below), it is desired *immediately* to collect all possible information concerning the effects produced in the various districts

2 District and Resident Commissioners are requested to forward as early as possible a full report including, amongst other details

(a) A sketch map of the district shewing the localities where material damage was caused

(b) The nature and construction materials of the buildings damaged and the extent of damage

(c) The dates and times as accurately as possible of the shocks felt,

(d) The extent and direction of any land fissures which may have occurred

(e) Notes on any marked changes in the water level of the lakes, rivers etc.

(f) Notes on any other interesting reports of phenomena accompanying the tremors

3 The reports should classify the intensity of the shocks on the scales indicated below:—

Technical classification	*Explanation of the effects for guidance*
I. Microseismic shock	I. Felt by delicate instruments only
II. Extremely feeble shock	II. Felt by a few persons at rest
III. Very feeble shock	III. Felt by several persons at rest
IV. Feeble shock	IV. Felt by many persons at rest. Disturbance of movable objects
V. Shock of moderate intensity	V. Felt by almost everybody. Disturbance of movable objects
VI. Fairly strong shock	VI. Felt by all. Many frightened and run out of doors
VII. Strong shock	VII. Difficulty in standing. Noticed by persons driving motor cars
VIII. Very strong shock	VIII. Trees shaken. Damage slight
IX. Extremely strong shock	IX. Partial destruction of buildings
X. Shock of extreme severity	X. Total destruction of buildings

If possible please state the direction from which the shocks appeared to come and the exact or approximate latitude and longitude from the map recorded.

4 The reports should be made direct to this office in triplicate, two copies being sent to the Senior Commissioner of the Province

HUXON ARTCO
for Colonial Secretary

Reuter's Telegram—London, 9th January, 1928.

"In a letter to the 'Times' on the earthquake in Kenya, Professor of H. H. Turner, Professor of Astronomy at Oxford University, fixes the epicentre of the shock of earthquake in the neighbourhood of Victoria Nyanza, a decision which is supported by the Hawaiian Observatory. Professor Turner is hoping to obtain information which he states will be of great interest from Entebbe, where a seismograph was installed a year or two ago."

All Heads of Departments,
All Senior Commissioners, with copies for District Commissioners
All Resident Commissioners,

COPY.

NOTES ON EARTHQUAKE OF 6-1-28.

On Saturday, 4-2-28, I proceeded by car to Farm No. 3230 (Major Boyce) for the purpose of making a reconnaissance during the week-end of the movements which gave rise to the earthquake at about 10 hrs.3 mins. p.m. on 6-1-28. Reports from the Ag. Executive Engineer, Nakuru, dated 18-1-28, 27-1-28 and 31-1-28 had already demonstrated the existence in the Sabukia Valley of a crack of the nature of a gravity fault running for some miles along the Laikipia Escarpment near its base and of small r cracks on the floor of the valley on and in the neighbourhood of Farm 3230. The damage done to buildings had also been shown to be greater in the Sabukia and Solai Valleys than elsewhere in the Colony. Disturbances of various descriptions had also been reported [illegible] from Lake Hannington. On Saturday afternoon I started for that locality on foot. On th[illegible], natives who lived in the region of Lake Hannington assured me that there was no visible evidence of the effect of the earthquake other than landslides, the chief one being the falling of a large quantity of boulders from the steep escarp overlooking Lake Hannington. Nothing of the nature of cracks had been seen, and the lake had not been disturbed. This information was subsequently confirmed by other natives. I, therefore, did not visit Lake Hannington but diverged towards the lower part of the Sabukia Valley as all the evidence pointed to the epicentral area being situated along the Laikipia Escarpment overlooking that

valley. The ensuing day (Sunday 5-2-28) was spent in examining the cleft which was found to extend along the Laikipia Escarpment for 10 miles, approximately from long. 36°- 12' E, lat. 0°- 17' N, to long. 36°-16' E, lat. 0°-10' N as shown roughly on the accompanying map as indicated by the line AD. At the former point (A on the map) the cleft was found to have become so small in magnitude that it was difficult to follow, and at the latter point (D on map) it was lost in the steep south-western slope of Marmanet to which it had diverged. Between B and C it showed the maximum movement. The confirmed native reports allege that it continues northward along the Laikipia Escarpment past Lake Baringo, and it is also stated on reliable authority that it reappears on the escarpment south-east of Marmanet and continues for [illegible] miles in that direction. It is also stated [illegible] similar cleft appears on the flank of a valley [illegible]lel to the Sabukia valley a few miles north-eastward of it. Time was not available to investigate [illegible] Nakuru on Sunday night.

[illegible] Laikipia escarpment may be regarded as forming the chief eastern wall of the Rift Valley in this area. The Sabukia River, which was [illegible] about ½ cusec at the lowest point reached by me, flows parellel to its foot in a gorge cut by it through the valley. The scarp is much denuded and dissected by dry ravines which carry the flood drainage from it to the Sabukia River. In height it varies from 2000 to 2500 feet and has an average

slope of 10° to 25°. It is an old fault scarp which is now much worn away, the lower part of the slope being formed mostly of screes, clays and decomposed volcanic rocks. It has been regarded as Pliocene in age, but the evidence is not conclusive. Its formation was probably very slow and proceeded by a series of jolts occurring at intervals. Evidence exists at one locality of vulcanicity after the scarp had assumed a form approximating to its present outlines but probably not in recent times.

3. On the lower slopes of this scarp there has been a recurrence of gravity faulting along a plane which is so situated that one would expect it to be in the locality of one of the original main planes of faulting. Along this plane the strata has fractured and has subsided on the south-west or down-hill side. The cracking of the underlying strata doubtless produced the earthquake. This crack was probably caused primarily by the tension in the mass of volcanic rock below resulting from the loss of heat over a long period. The tension in the rock again reached the intensity of breaking point and caused adjustment of stresses by fracture and subsidence. It has manifested itself at the surface in a crack or cleft or series of adjacent ones following an average bearing of 138° along the slope of the Laikipia Escarpment for a distance of about 10 miles, or possibly much more. It varies a good deal from this average direction, bearings of 106° and 168° being noted at particular points. Transverse valleys are generally crossed by it at right angles, but the presence of hills in its course appears to have caused it to diverge round their flanks in some

cases. Normally the down-throw is to the south-west, the south-western side having sunk, so forming a s[illegible] in the hill slope and the ground having opened in a trench. Occasionally, however, where the plane of movement diverges considerably from its average direction, the movement has been of the nature of reversed faulting, one side having been slightly thrust up and often overlapping the surface of the other side. The movement in those parts appears to have been due to pressure or shear through conjugate stresses being set up in particular directions as a result of the dominant tensional stress. The line of the fault appears to follow, on the average, the 6,000 ft. contour along the flank of the escarpment, but, owing to the presence of ravines and hills on the flank, its level varies in elevation by some 500 feet in different parts. The amount of movement, both vertical and horizontal, which is registered by surface movement varies [illegible]atly and the form which it takes is also various. It increases gradually in magnitude from A to B; from B to C it is at its maximum, and from C to D it gradually becomes reduced. Ordinarily it takes the form of a cleft varying from a few inches in width to a maximum of 10 feet with one or more small trenches roughly parallel to it within 50 feet on either side. The width at the surface is generally much greater than at depth owing to disturbance of the soil and screes which have fallen into the cleft. Usually the north-eastern or uphill edge of the cleft is higher than the south-western or down-hill side by an amount which varies from a few inches to a maximum of 11 feet and shows the amount of vertical displacement

at that particular point of the cleft. The small subsidiary clefts show similar but smaller differences of level between the two edges. In other cases, though rarely, the subsidence at the surface takes the form of a small trough fault, a strip of ground having subsided between parallel planes to a depth of 3 or 4 feet below the former surface of the ground. As previously mentioned when the line diverges much from its average direction, the fracture sometimes takes the form of a reversed fault, the soil of one side with trees and other vegetation having sometimes been thrust over the other side to distances varying from a few inches to a few feet.

4. Small clefts showing vertical and horizontal displacement up to 1 foot in each direction are met with at intervals on the foot-hills below the main cleft and on the valley floor within a couple of miles of the cleft. These minor clefts vary greatly in direction, some being roughly parallel to the general direction of the main cleft on the flank of the escarpment, others are almost at right angles to it, while others again are intermediate in direction. As one would expect, the north-eastern side of the valley below the main cleft seems to have subsided, the maximum movement being along the plane of the main cleft, but causing subsidiary fractures in other parts as the subjacent strata subsided and adjusted itself.

5. The earth tremors resulting from the fracture of the strata have produced landslides on steep slopes,

especially in the region of the Sabukia and Solai Valleys. Many large boulders have collected at the feet of such slopes, often overturning trees in their courses down the hillsides.

6. Damage has been done to many houses and other structures in the Sabukia and Solai Valleys and to a lesser degree in other parts, especially at Ravine, Fort Hall and Nyeri. A statement of the damage done to property in the Sabukia and Solai Valleys, as noted by the Ag. Executive Engineer, Nakuru, is attached to these notes with a rough estimate of the damage.

7. After-shocks which are common after an earthquake and sometimes last for months at frequent intervals, have been occurring since the main shock of January 6th. They were still noticeable in the Sabukia Valley last week. These are due to the strata continuing to adjust itself locally by fracture or other movement to the altered stresses in the effort to achieve equilibrium. It is to be observed that the c[illegible] intercepts all the drainage from the upper part of the Laikipia Escarpment for a distance of at least 10 miles, and it is not improbable that during the rains water in quantity will find its way into the cleft and may cause further adjusting movements. Such movements may be considerable or trivial, but their possibility should not be disregarded. One small stream, known as the Little Sabukia, has been intercepted by one of the clefts and will have to be flumed across it. It has been noted in many cases that streams former / clear have become turbid. This is due to earth tremors disintegrating the

soil so that particles formerly adherent to adjacent particles have become disconnected from them and easily removable by water. It is stated that some streams have become reduced in flow and others have increased. This cannot be determined quantitatively owing to the absence of measurements. It is reasonable to suppose that it has taken place. Reduction of flow would obviously be due to fracture or greater absorption owing to disintegration. Temporary increase of flow would be caused by disintegration on account of the earth tremors of water-bearing strata from which the stream is fed, so enabling that strata to discharge its water more rapidly than before.

8. It is to be observed that the earth movements which have taken place are not inconsiderable and are not disproportionate to some of those which have caused very destructive earthquakes. If a town had been situated in the Sa a or Solai Valleys, the loss of life and property would have been likely to be considerable. The absence of earthquakes of importance in recent times in the Rift Valleys is remarkable, for one would expect it to be a seismic zone where earth movements causing rejuvenation of fault scraps, as in this case, continued to occur at intervals.

9. It was intended to place a cement tie between the sides of the cleft to show any further movement. In no place could there be found sufficiently sound rock in the sides of the cleft to render this possible.

22

Arrangements were therefore made for concrete pegs to be established at certain spots and their relative levels ascertained with precision. It can subsequently be determined by levelling whether relative movement has taken place or not.

10. It seems very desirable that 3 seismological stations should be established in Kenya. It is suggested that they might be at Nairobi, Nakuru and Nyeri. An estimate of the cost and advice regarding the type could be obtained from the Director of Geological Survey, Uganda.

(Sd) H. L. SIKES.

DIRECTOR OF PUBLIC WORKS.
10th February, 1928.

DAMAGE TO PROPERTY, SABUKIA AND SOLAI VALLEYS.

ESTIMATES BY AG. EXECUTIVE ENGINEER, NAKURU.

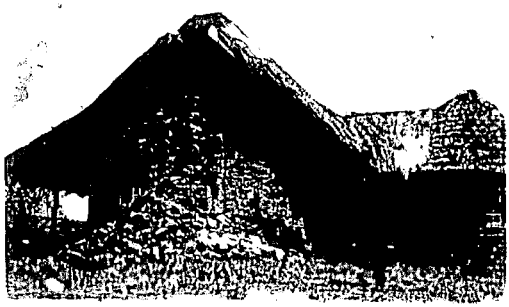
Farm No.	Description.	Cost of Repair or Replacement. £	Remarks.
Hopley	2 chimneys knocked down.	20	
Lean.	Stone in cement walls badly cracked. Maize crib and dip cracked.	250	Repairs.
Smith Bros.	Stone house destroyed.	400	New house.
Allison, Sen.	Mud brick house damaged and not worth repair.	200	New house.
Allison. Jn.	Wattle and daub house destroyed.	100	New house.
Jackson.	House of C.I., upper storey on rubble and mud walls, requires rebuilding.	300	New house.
Aubrey (Sabukia).	Chimney of log cabin knocked down.	20	
Aubrey (Solai)	Stone walls of house destroyed.	300	New house.
Weir.	Wattle and daub house requires rebuilding.	200	
Rutherford.	House of part stone, part mud brick. New [illegible] required.	200	
Ney.	Stone house in mud mortar, chimneys fell down.	200	Repairs.
Stringer.	House mud brick on daub ruined. Stone in cement house practically undamaged.	200	New house.
Rose.	Stone house badly cracked, requires partial rebuilding.	80	Repairs.
Markwell.	Wattle and daub house badly cracked.	10	Repairs.
Laurie.	House of mud brick practically wrecked.	200	New house.
Boyce.	House of mud and poles badly cracked and unsafe.	200	New house.
Williamson.	House badly damaged.	200	New house.
Blunt.	Mud brick house badly cracked cow house destroyed.	200	
Kirby.	Stone house destroyed.	300	New house.
		£ 3710	
	Sundry damage, say,	290	
	Total, say	£. 4000	

GEOLOGICAL SURVEY OF UGANDA.

REPORT ON THE SUBUKIA VALLEY EARTHQUAKE OF 1928 JANUARY 6.

by

W. C. SIMMONS, PETROLOGIST.



Stone house east of Lake Solai viewed from the South and after the earthquake of January 6th. The log hut attached was comparatively little damaged.

26

REPORT ON THE SUBUKIA VALLEY EARTHQUAKE OF 1928 JANUARY 6.

---oooOooo---

INTRODUCTION.

This earthquake was felt over a wide area in East Africa extending from Mombasa in the east, to Mubendi in the west, and the district in which most damage occurred was the Subukia Valley, and neighbouring hills. This area begins about 20 miles North of Nakuru, and lies between Lake Hannington and the Laikipia Escarpment. It forms a part of the Great Rift Valley, the rocks being all volcanic, usually much faulted, and covered in places by Tertiary and newer lacustrine and alluvial deposits.

The time at which the earthquake started at the origin from observations at the Entebbe Observatory was 10-01-37 (or approximately 1½ minutes past 10 p.m. local mean Nairobi time). Unfortunately there is no proper synchronisation of clocks in East Africa, and the records of the times of arrival of the earthquake waves at the different district headquarters from which reports have been received, are very inaccurate.

One of the best means of studying the effects of an earthquake on the ground is to note the effects on buildings and the ideal would be if there were an equally spaced, similarly oriented, number of buildings of similar shape and strength of materials, over the country. As it is, in this area there were a few far-scattered houses of various and generally indifferent architectural strength, which occur mostly to the south of the earthquake centre.

There are in the district east of Lake Hannington many slopes which are of a steepness up to 45° and which as well as showing outcrops of volcanic rocks, often in almost vertical cliffs, have many loose boulders

and stones scattered over them. Some of these slopes are at near the maximum angle of rest for scree slopes, and here the effects of the earthquake in causing landslips of parts of the hillsides, and the falls of many boulders, can be well seen.

The fault feature, which has been traced for some miles near the foot of the Laikipia Escarpment east of the Subukia Valley, and shows in places a wide deep crack with an apparent downthrow to the west of as much as 10 feet is a very characteristic phenomenon.

In this report descriptions of some of the effects of the earthquake, a map showing the fault crack, a plan to show the areas most affected, notes on alterations of the flows of the streams, a summary of the reports from the various districts, together with a review of the available evidence as to the causes of the earthquake, and likelihood of further activity, will be g[illegible] below.

(1). The Meizoseismal Area.

This area of maximum disturbance is indicated on Map I herewith as the inner area east of Lake Hannington, including the Subukia Valley and the Laikipia Escarpment, and extending not far south of Lake Solai. It will be seen on Map II showing the earthquake fault that the escarpment has a bend in it at the south end, and that the fault also turns with the escarpment.

All the bigger buildings in this central area have suffered considerable damage, but at the time of my visit some had been completely demolished, and some had been temporarily repaired, so that it was not possible to judge in all cases what the actual effects of the earthquake were. Major Boyce's house is the

farthest north of the farmsteds and is of wattle and daub strengthened with a system of steel wire. It was very badly shaken, and the building now leans to the southwest, and has been propped up. The plaster of the walls shows a network of cracks. The kitchen was a separate building not so substantially built as the house, and the chimney fell. It and there are several cracks in the soil round the house. Another farm house of stone to the southeast suffered much damage. Many grain stores round here, which consist of grass-roofed buildings with wire netting sides on poles, were damaged, but none actually fell, (1) I believe.

There is a stone building east of Lake Solai, which was fortunately not inhabited, where the effects of the shock are very well seen, as it seems to have been left as it was. This house stands on a small rocky hill which is one of the foothills of an escarpment, and is ~~at~~ 1 mile east of the swamp which now occupies one site of Lake Solai. This house had its longer axis north and south, which is about parallel with the escarpment on the foot hills of which it stands. The house was of the usual volcanic rock used to build so many of the houses in the district. In fact so many of them the mortar between the stones was mud, with cement pointing on the outside. There are two partition walls and two end walls at right angles to the main axis, and all four of these east and west running walls have partly fallen down, while the longer outside north to south walls running (facing east to west) are badly cracked, but still standing. (See photograph).

(1). There is often difficulty now in getting accurate information as to the effects of the earthquake, owing it appears to an idea that being in a bad ~~earthquake~~ centre depreciates the value of the

Further southeast in the upper Subukia Valley, near the Subukia Valley Club, which is itself a wattle and daub building and was said to have suffered little, there was a badly built stone house which was much cracked and has since been dismantled. The upper Subukia Valley round the Club shows some damage to old and badly constructed buildings, and evidence that the waves have come from North to South, but I have put this outside the meizoseismal area because the damage is on the whole much less and by no means so general as in the Lower Subukia Valley. It was noticeable that a nicely built house, the walls of which consisted of upright cedar poles closely set together, had suffered little damage beyond the fall of a stone chimney. It is clear that the houses of stone have suffered most, that wattle and daub houses were badly shaken and sections of the plaster fell from the walls and they afterwards often leaned away from the earthquake centre and had to be propped up, that the better square mud and grass buildings were a little damaged and also caused to lean over, but that small grass huts, and especially round grass huts took but little harm. At Capt. H.A. Stirling's farm (L.O.8477) which lies about 5 miles north-west by west of Lake Solai, and 8 miles south-west of Nakuru, well in the meizoseismic area, the wattle and daub dwelling house was so damaged as to have to be dismantled. The shock here was from North to South and knocked the south end of the house mostly fell out. A herd of cattle were said to be shaken off their feet, and some damage was done to outbuildings. There is on this estate a galvanised iron store, and I was told that though the structure suffered little damage all the stores were precipitated from the shelves and all the bottles were broken. It appears that well built stores of galvanised iron on good wooden structures generally stood the shock well.

30

(1)a. The Subukia Valley Fault.

All along the foot of the Laikipia Escarpment from five miles south of Marmanet hill and from there running NNW. for a distance of at least fifteen miles there is a fault feature which can be seen from Major Boyce's farm, running along the foothills. From a distance it looks like a line of grey soil, and it can be followed apparently going up and down hill, and often disappearing behind some of the nearer foothills. When examined at close quarters it is seen to be a wide crack in the soil of the slopes, the bottom or west side of which is, as much as six feet away from the top side, and appears to be up to as much as ten feet below the top.

The fault has been partly described by Mr.H.L. Sykes, the Director of Public Works in an interview given to the "East African Standard" (Feb.18th.), and in a report which I understand is to go with this, with also some photographs. I do not wish to repeat what he has done. It is clear that this fault is a slight re-opening of, or rather evidence of renewed activity, along an old fault. This Laikipia escarpment is about on the same strike line as the Aberdare Range which may be taken as the eastern side of the Great Rift Valley. Until an accurate re-survey of the whole area is made it is not possible to take it as obvious that the area to the west of the fault has fallen in by gravity faulting. It may be that the Laikipia Escarpment has on the whole been elevated. In the Californian Earthquake (1906) which was due to renewed activity along the old San Andreas fault, in which, however, the horizontal movement was more than the vertical displacement, it was not possible to say which sides had moved till a new trigonometrical survey was made. In

the Subulia earthquake there is very little evidence of horizontal movement except that at right angles to the fault, and even the vertical movement is smaller than appears at first sight. The displacement is mo. to the east, and north-east of Major Boyce's farm, and has been put at as much as 10 feet, though I examined it at many places I could not find more than 8 feet, and in that place the slope of the hill was nearly 45°. The lower side had moved outwards from the upper so that, looked at from above, there is a chasm 6 feet wide which tapers downwards till the two sides nearly meet below and the crack continues on. Because of the steepness of the hillslope and the wideness of the gap the fault looked at from the lower side appears to have a downthrow or upthrow of 8 feet, but this is partly due to the angle at which it is viewed as on a 45° slope it would be exaggerated in amount, and largely due to the movement of the soil on the slope down hill. Where the fault is traced over level ground on one of the side hills it becomes either a crack or several anastomosing cracks with litt[illegible] apparent downthrow, or is represented by a long mound of broken earth running in the same direction. Where the fault crosses one of the gullies at right angles to the main scarp, the movement again appears small, and nowhere could the fault be found in solid rock. These points are important and I was particularly grateful to Mr. Ballenden of the Survey party for looking for them also. The fault is persistent for a distance of 15 miles, [illegible]ng along the foothills of the Laikipia Escarpment, where the old slopes of weathered rock rubble and soil have masked the original rock surface. This is of importance in connection with rift faults generally, and I am in agreement with Mr. Sikes that this Subukia earthquake is due to a re-opening of one of the rift faults, but with a vertical displacement

now which is probably small, and is trifling compared with the total amount of movement which has taken place in the past. I regard the movement as relatively deep-seated, that is to say that the epicentre of the earthquake lies at some depth along this fault, the surface expression of which, owing to the varied nature of the ground and to the masking by old screes, does not indicate the precise movement at depth. I have prepared a map (Map 2) to show as near as possible on such a small scale the line of the fault, and have indicated also all the known positions of the subsidiary cracks, some of which I saw on the ground, and several more of which were mapped by the survey party.

(2). Alterations in rivers and streams.

In the main close small area many of the small side-streams coming down from the Laikipia Escarpment to join the Subukia River are dry now because the time of my visit was near the end of what has been an unusually dry season, but several which were still flowing, though only with a small volume of water, now only flow as far as the [illegible] line, and there soak into the ground, and do not flow past it.

It has been noted that near its southern extremity the fault crack turns with the escarpment, and at the [illegible] one of the larger tributaries of the Subukia River comes down the scarp in a deep gorge. This stream now flows to near the site of the crack, which cannot be traced in the alluvium of the valley, and then soaks into the ground so that the river course is dry from there to the main Subukia Valley. Were these cases of cutting off of rivers due to a tilt up of the valley floor, so that water could not flow in them, it would be expected that there would be a lake just below the fault where the streams were dammed up. In no case is that so, and it appears that the cessation of flow is simply due to soakage down the crack owing to the prevailing dry climatic conditions, and I should expect

that when the next rains have well soaked the ground that the streams will flow again where they did, with, however, minor variations due to slight alterations of the levels of the beds. I do not believe that if there is a renewed activity of earthquake phenomena when the next rains come, that it should be ascribed to new subsidence along the fault line due to the percolating water, because it appears that the epicentral zone is deeper than the depth likely to be reached by a season's rain.

The Molo River is said to be running less since the earthquake, but the season being so dry it is difficult to [illegible] due to the seismic disturbance. All the other cases I have heard of are of springs being augmented, which is the more usual thing to happen. The Narusaru River near Eldama Ravine has risen, and a small hot spring near Mile 18 on the Solai road also flows in greater volume than it did before. I heard of several cases of [illegible] the water of which was stained red after the [illegible], particularly one near Njoro.

(3) Causes of the Earthquake and likelihood of further Seismic activity.

It has been sufficiently emphasised above that this earthquake was due to the reopening of a fault line, and the existance of a long fault feature on the surface of the ground shows where the centre was located. I was not able to get down to Lake Hannington, and there is only native evidence that there was no other crack along the Hannington Escarpment, though there were big falls of rock and sliding down of scree slopes. There are many small vibrations recorded by the seismograph at Entebbe, most of which when the record is clear enough to show the arrival of the P and S waves fit in as subsidiary movements from the known epicentre, (see table attached hereto), but I am disposed to think, on

what may be too scanty evidence, that the bigger shock which took place at about 5 a.m. on February 10th. (2 h. 26 m. 30 s. G.M.T.), and was only second in magnitude to the main shock, may have had another epicentre. This point will be discussed when the reports from the Districts are considered below, but Major Boyce who lives very close to (two miles from) the fault had no recollection of a tremor at 5 a.m. on February 10th, of larger effect that many others which he noted for days after the main shock.

The country here in the Rift Valley has been very much faulted, and it is clear on the ground that the long straight, or slightly curved, escarpments are all due to faulting. (See J W.Gregory, Rift Valleys and Geology of East Africa for descriptions of them). Whether this faulting be explained as due to "gravity faulting" owing to tension, or the arching up of the continent of Africa and the formation of faults ~~xxxxxxxxxxx~~ in an area under a state of compression, which is at times relieved by volcanic extrusions, is a matter of great importance in studying tec s, but does not alter the view that the present seismic activity is due to a continuation of old faulting. It is clear that there is no reason to suppose that there will not be further earthquakes, and it would be well to regard the Rift Valley as a Seismic Zone.

I put on record here all the known factors which are considered as those which may have decided the outbreak of this present seismic activity. It is generally recognised that the stresses that are set up in the earth's crust before an earthquake, may take a long time in reaching a culminating point, and then at the end what appears as some slight factor such as a sudden drop or rise in the barometer, change of temperature, unusually high tide, or heavy rainfall or some other unknown factor, will cause the final breaking.

In this case of the Subukia earthquake the season was unusually dry. The barometer usually stands at about 24½ inches at the altitude of this area (5000 ft.), and weather conditions make surprisingly little difference to it.

In the "News and Views" column in "Nature" of January 14th., there is a comment on the Thames floods of January 7th, with the following note:- "The night tides at winter full moons are helped by the north declination of the moon at such times. On Saturday morning January 7th, the moons north declination was 25°.....The sun was near the earth, having passed perihelion on January 4th. The moon was in perigee late on January 3rd, and was considerably nearer the earth than its average distance". I suggest that the fact that the sun and moon were nearer at that time than is usual and were therefore exerting a slightly bigger tidal pull may as well have been one of the contributory causes of the Subukia earthquake, as of the ...es floods. But until some records of the occurrence of earth tremors in Kenya are kept, it is not possible to begin to theorise. Sufficient to say that in my opinion there is every reason to apprehend a possibility of further seismic activity, and that it is time that a Seismological Observatory be set up. I was not asked to advise as to the site for an observatory, but for reasons given below under district reports I advise that Nakuru be not a site for an observatory, though I would certainly advise the erection of one at Nairobi.

(4). District Reports.

It has already been hinted that because there is no method of accurate, or even approximate, synchronisation of clocks in Kenya, the reports of times of arrival of the seismic waves at the different stations are of no value

The usefulness of these reports lies in the observations of the intensity of the effects. Map 1. shows the middle Kainozoic area where the disturbance was strongest, and it is clear that had there been a town anywhere in this area and particularly in the lower Subukia Valley that it would have been ruined, but this earthquake did not reach the magnitude of some of the most disastrous shocks, though in parts of the central area it was probably within (10) of the Rossi-Forel scale, but mostly fell within the limits of (9), which is partial or total destruction of some buildings. There are not enough buildings to f define the incidence or limits of 9 and 10 clearly.

Outside this central area I have drawn a larger one which roughly shows the limits of 7 and 8 on the same scale.(1) It is seen at once that this curved area has its greatest elongation along the eastern side of the rift valley. It appears that the waves travelled more easily along, th ney did transversely to, the direction of the rift faults. Cracks appeared in buildings at Fort Hall and at Kabete, but none were reported from Nairobi. At Eldama Ravine several buildings were badly cracked, but mostly they were old and in bad repair. The closing of the curve before it reaches Lake Baringo is a little uncertain. It will be noticed at once that Nakuru, Elmenteita, Gilgil and Naivasha lie outside that area. I regard this as due in all cases, except the first, to the fact that these

(1) Rossi-Forel Scale (7). Overthrow of movable objects, fall of plaster, ringing of church-bells, general panic, without damage to buildings. (8) Fall of chimneys, cracks in the walls of buildings.

places are on the flatter area at the bottom of the Rift Valley where there are thick tertiary and alluvial deposits. Nakuru, however, stands so much nearer to the centre that it would have been expected that there should have been greater effects. There are several buildings with quite large rooms, and many stone buildings houses, and yet I did not hear of any serious damage to any structure. I suggest that there may be two explanations either or both of which may have caused a damping of the earthquake waves (1) the plug of volcanic rock in the huge volcanic sink or caldera of Menengai which lies close to the north of Nakuru may have acted as a buffer; (2) the thick mantle of volcanic tuffs and flows from the volcano on which the town is built may have functioned as a blanket. From the fact that the seismic waves have not much disturbed Nakuru, I do not advise the erection of a seismological observatory there, but if one is wanted in this area, would suggest the choice of a site to the north east away from Menengai.

The earth tremor of 5 a.m. January 10 (local mean time, or more accurately at Entebbe at 2 h. 26 m. 30 s. G.M.T.), is reported as felt as a tremor of less severity than the main one, but of more than the other subsidiary ones, from the following stations:- Kabarnet, Eldama Ravine, Kisumu, at near Kisumu, and Kabete, and was probably felt at other places and not reported. Because this shock when it reached Entebbe was recorded as much bigger than the others except the main one, and of much longer duration, and was not very noticeable, so far as reports go in the Bukukia Valley, I am disposed to think that it may have been a sympathetic shock in another near epicentre, for instance Lake Hannington to the west of Bukukia, but I admit that as the Entebbe record shows a sudden oncoming with no distinguishable P and S waves that I cannot prove this.

(5). Recommendations as to future buildings and sites.

As we have seen that the Rift Valley is to be regarded as a seismic area, the following brief notes as to precautions to be taken are given. It has been stated that houses built on a thick soil foundation suffered much less than those on rock, and the choice of a site on flat ground not near the rock and not too near a range of hills or escarpment is indicated. Stone houses built of dressed lava blocks with bad mortar and cement pointing have been most damaged, and this type of building is to be avoided. Wattle and daub houses which have been able to oscillate as a whole in the passage of the earthquake waves, have been subjected to strong vibration, which has caused much cracking, and made sections of the plaster fall out, have on the whole stood fairly well. Galvanised iron buildings on good wooden structures have been little hurt, and it appears that wooden buildings would have stood as well. Probably houses of uforced concrete are to be preferred, and the choice of a site on which to put such a structure is important. This is a case where the advice of Mr Sikes, the Director of Public Works would be most valuable.

(6). Conclusion.

I have tried to make the most of the facilities which were given me in carrying out of this investigation, which has been undertaken at the expense of my own work in Entebbe, and wish to express my thanks to those who were so good as to give me their assistance, and especially to those named herein, and to Dr.Parkinson and Major Deacon of the British Museum Expedition.

William C. Simmons.

16th. March, 1928.

PETROLOGIST.

TREMORS RECORDED AT ENTEBBE IN CONNECTION WITH THE SUBUKIA EARTHQUAKE.

of 1928 January 6.

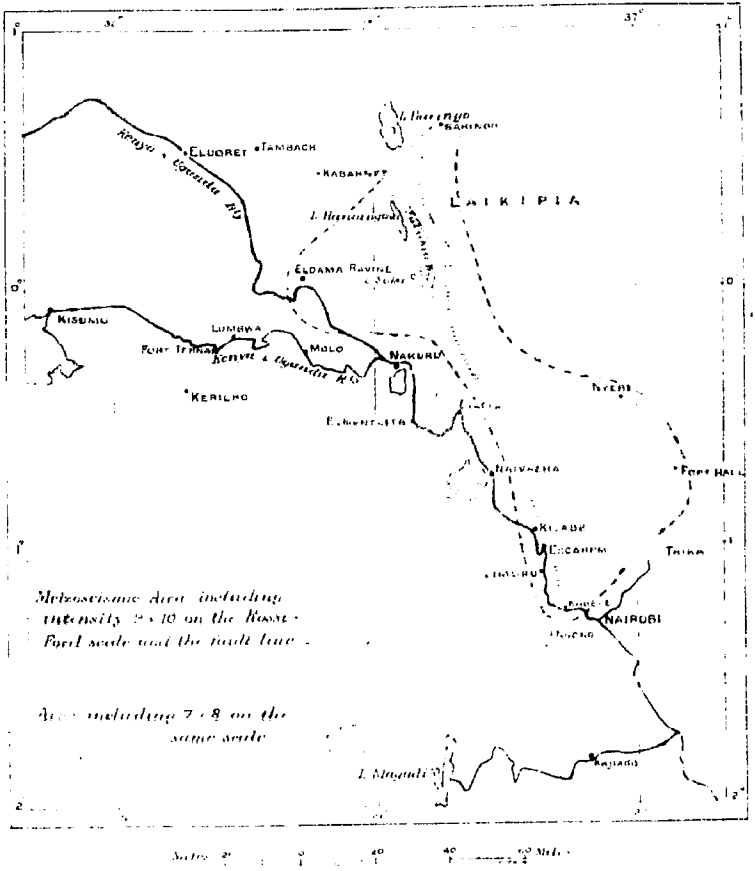
Date.	Time of arrival of P. Waves. Greenwich Mean Times.	Time of arrival of S. Waves.	Measurement S-P in seconds.	Δ from tables in Degrees.	Distance from the formula $x = 7.27y - 38$ for preliminary tremor duration (y) in kilometers.	Remarks.
January 6	19. 32. 42	-	-	-	-	The main shock. Mirror connection knocked off no records till mirror connection replaced at 5.30 pm 7/1/28.
January 7	7. 55. 20					
" 7	8. 27. 52					
" 7	9. 31. 29					
" 7	10. 18. 22	10.19.12	50	4.2	400	
" 7	11. 11. 52		40	3.4	330	
" 7	11. 50. 40		60	5.0	470	
" 7	13. 43. 20		50	4.2	400	
" 7	13. 53. 35	13.54.20	45	3.8	365	Maximum at 13.55.00 12 minutes duration in al
" 7	18. 11. 00	18.11.50	50	4.2	400	6 minutes duration
" 7	18. 34. 43		50	4.2	400	13 " "
" 7	19. 43. 20					
" 7	20. 16. 55	20.17.53	58	4.9	460	
" 7	22. 52. 50		50	4.2	400	10 minutes duration
" 7	23. 52. 50					
" 7	23. 58. 52					
" 8	5 and 7.	Tilt overlaps and obscures times.				
" 8	14. 31. 40	? 14. 32. 20	40?	3.4 ?	330 ?	
" 8	21. 05. 00					Small tremors.
" 8	21. 10. 00					
" 8	22. 12. 20					
" 8	22. 35. 05		55	4.6	440	very clea
" 8	23. 0. 00	23. 1. 00	60	5	470	Good vibration 12 minutes duration but S. not
" 9	3. 20. 22					
" 9	6. 20. 52					
		Several tremors of which hour doubtful owing to tilt (np of record.				
9	8. 45. 20					Small
" 10	2. 26. 30	?	?	?	?	Sudden rapid big vibration felt over a wide area and total record over one hour.
" 11	9. 43. 20					Small
" 11	21. 6. 40					"
" 12	13. 13. 07					
" 12						Big distant earthquake.
" 12	20. 23. 20					Small.

Note. 1. Where the time of arrival of the S waves is given the record is fairly clear, where that column is not filled in but (s-p) is given the record is not so clear.

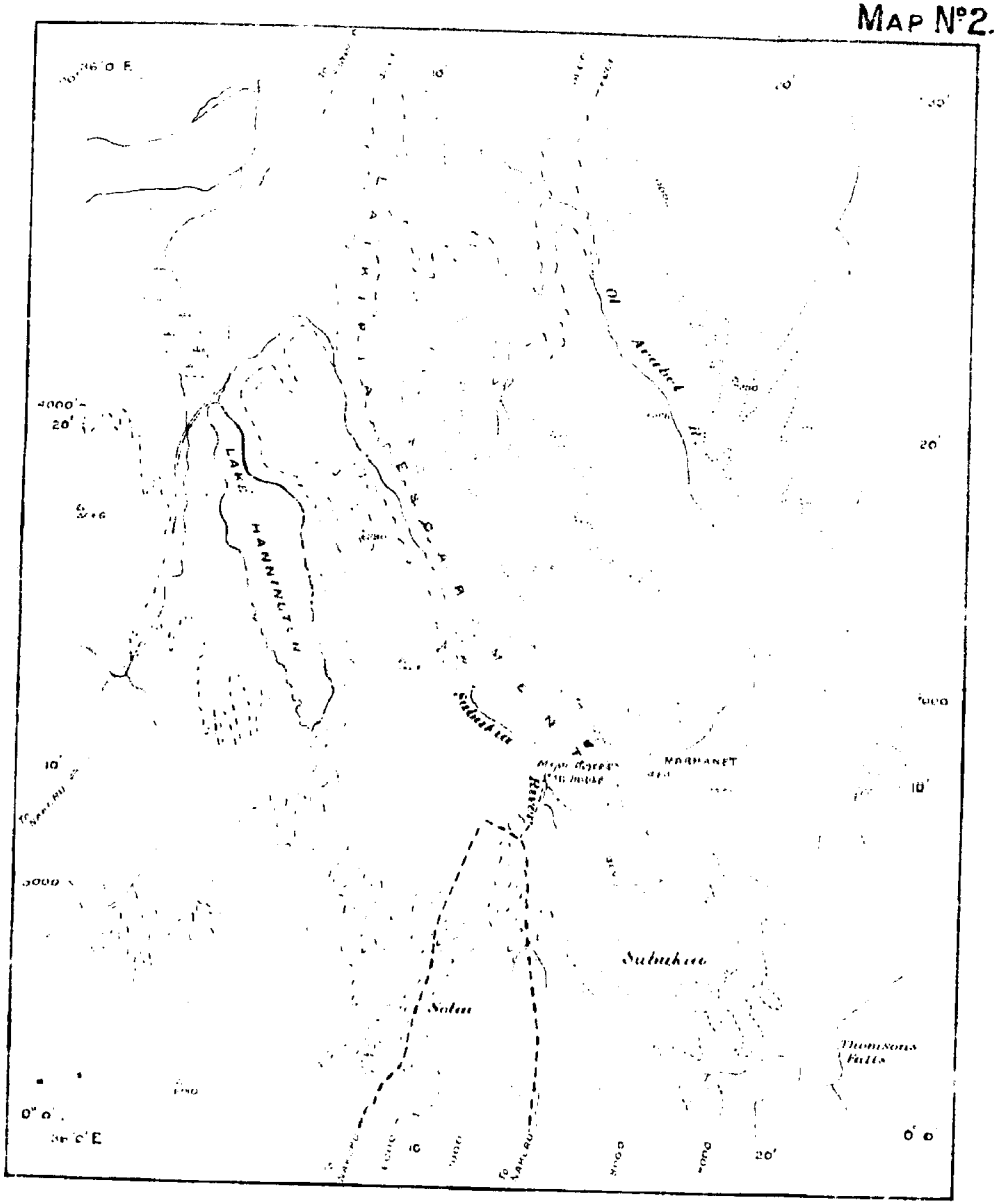
Note. 2. It will be noted that the records mostly show Δ as 4°.2 which is 470 kilometers or by the formula 400 kilometers. The actual distance from Entebbe to Subukia is 420 kilometers or about 260 miles. For short rapid vibrations the calculations are not so accurate as for distant shocks.

Note. 3. To get local mean Nairobi time add 2 hours 30 minutes to the Greenwich mean time.

MAP N° I


L. Baringo
ELDORET
TAMBACH
KABARNET
LAIKIPIA
L. Hannington
ELDAMA RAVINE
KISUMU
LUMBWA
MOLO
NAKURU
KERICHO
NYERI
NAIROBI
L. Magadi
Meteoseismic area including intensity 9 × 10 on the Rossi-Forel scale and the fault line
Area including 7 - 8 on the same scale

MAP N°2.


LAKE HANNINGTON
Subukia
Mau Narok
MARIANET
Subukia
Salan
Thomsons Falls
To Nakuru
To Lake Rd
Kabazi
Kabazi
Kabazi
Kabazi

COLONY AND PROTECTORATE OF KENYA

THE SECRETARIAT,
NAIROBI,
19th January, 1928

CIRCULAR No. 5
G—4
A—1
D—

EARTHQUAKE—JANUARY, 1928.

In view of the report on the recent earthquake referred to in Reuter's telegram of the 10th instant (reproduced below), it is desired *immediately* to collect all possible information concerning the effects produced in the various districts.

2. District and Resident Commissioners are requested to forward as early as possible a full report including, amongst other details:—

(*a*) A sketch map of the district shewing the localities where material damage was caused.

(*b*) The nature and construction materials of the buildings damaged and the extent of damage.

(*c*) The dates and times as accurately as possible of the shocks felt.

(*d*) The extent and direction of any land fissures which may have occurred.

(*e*) Notes on any marked changes in the water level of the lakes, rivers etc.

(*f*) Notes on any other authentic reports of phenomena accompanying the tremors.

3. The report furnished should classify the intensity of the shock in the scales indicated below:

Technical classification.		*Explanation of the effects for guidance*	
1.	Minute shock.	1.	Felt by delicate instruments only.
2.	Extremely feeble shock.	2.	Just perceptible.
3.	Very feeble shock.	3.	Distinct movement, no objects shifted.
4.	Feeble.	4.	Loose crockery rattles.
5.	Shock of moderate intensity.	5.	Lamps and pictures swing markedly.
6.	Fairly strong shock.	6.	Doors and windows rattle strongly.
7.	Strong shock.	7.	Loose crockery broken.
8.	Very strong shock.	8.	Walls crack and gape.
9.	Extremely strong shock.	9.	Stone walls broken.
10.	Shock of extreme intensity.	10.	Houses overturned.

If possible photographs should be obtained and the exact (or at least approximate latitude and longitude from the map) recorded.

4. The reports required should be made direct to this office in triplicate a copy being sent to the Senior Commissioner of the Province.

JUXON BARTON
for Colonial Secretary.

Reuter's Telegram—London, 10th January, 1928.

"In a letter to the "Times" on the earthquake in Kenya, Professor H H Turner Professor of Astronomy at Oxford University, fixes the epicentre of the world earthquake in the neighbourhood of Victoria Nyanza, a decision which is supported by the Helouan Observatory. Professor Turner is hoping to obtain information which he states will be of great interest from Entebbe, where a seismograph was installed a year or two ago."

All Heads of Departments,
All Senior Commissioners, with copies for District Commissioners.

Enclosures of

EAST AFRICA PROTECTORATE

BARINGO

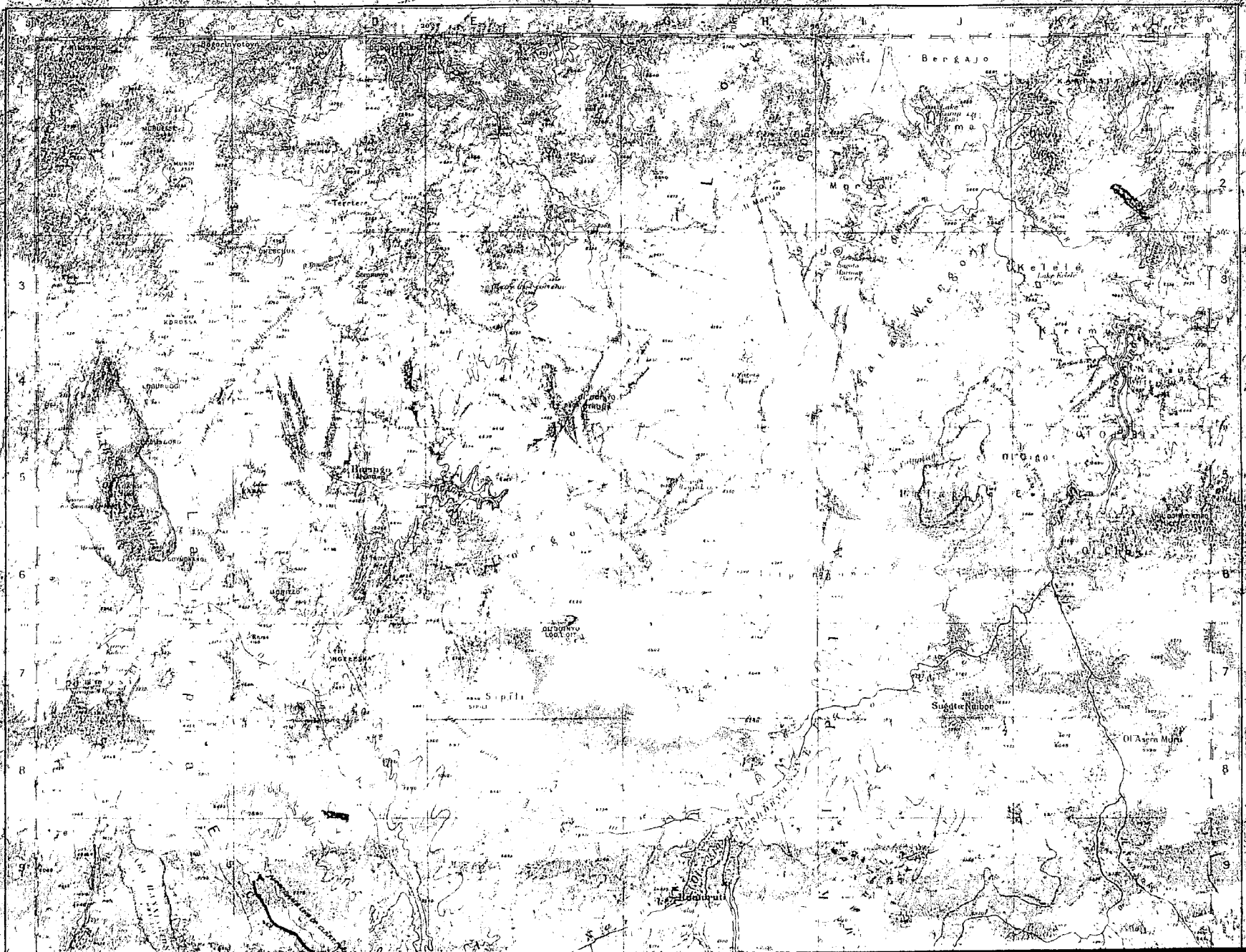
A 1 250 000

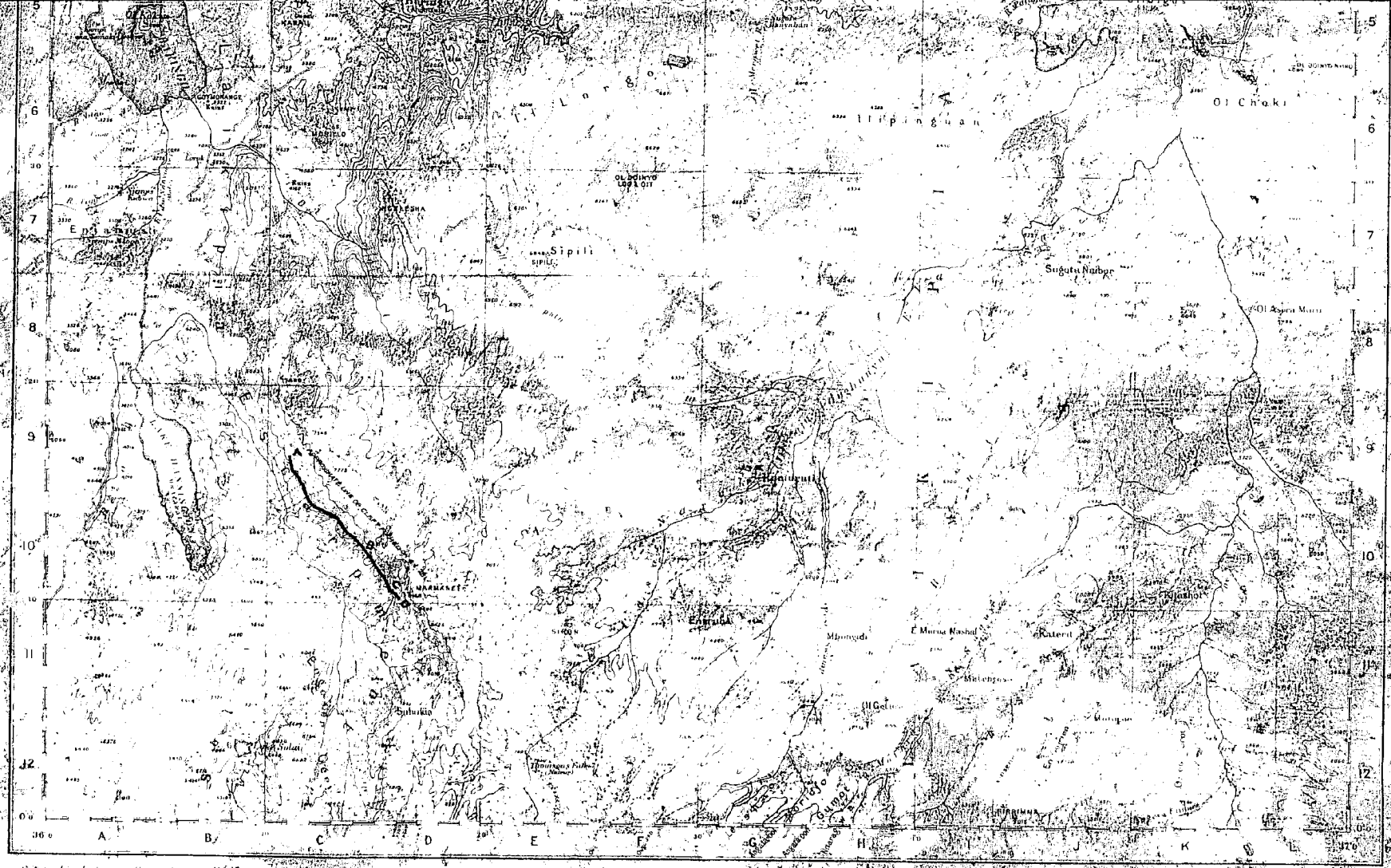
SHEET

EAST AFRICA PROTECTORATE

BARINGO

AFRICA 1:250,000 SHEET NORTH A 37





Scale 1 Inch to 3·85 Miles
or 1·014 Inches to 4 Miles

Miles 5 4 3 2 1 0 5 10 15 Miles

Kilometres 5 4 3 2 1 0 5 10 15 20 25 Kilometres

1 Centimetre to 2·5 Kilometres

Form lines at approximately 200 feet V.I.

REFERENCE

INDEX TO ADJOINING SHEETS

When demanding quote Africa, Sheet 500,000 N

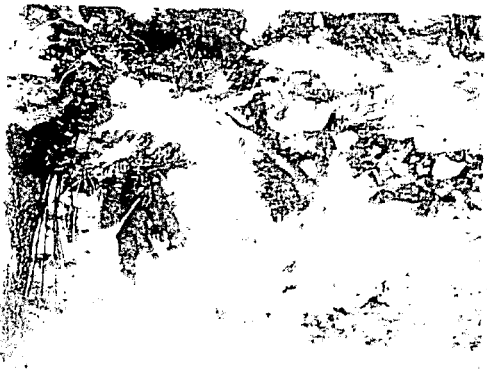
REFERENCE

EAST AFRICA.

BARINGO.

SHEET $\frac{\text{NORTH A-37.}}{\text{S}}$

SCALE 1 : 250,000.



Stone house east of Lake Solai viewed from the South end after the earthquake of January 6th. The log hut attached was comparatively little damaged.