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## REPORT ON ACTIVITY IN THE NORTHERN CRATER OF OL DOINYO LENGAI, 24TH JUNE TO 1ST JULY 1988

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### INTRODUCTION

Ol Doinyo Lengai, the only active volcano in the Gregory Rift Valley of East Africa, is also the only active carbonatite volcano in the world. Several times this century it has erupted lava and ash composed largely of sodium carbonate minerals. Early accounts of its eruptive activity were given by Hopley (1918) and by Reck and Schulze (1921); later accounts were provided by Richard (1942), Guest, (1956), Dawson (1962) and Dawson, Bowden and Clark (1968). The most recent widely known eruption was the explosive eruption that occurred between August and October 1966. Few people, whether in East Africa or elsewhere, are aware that the volcano erupted in early 1983, and that small scale activity in the northern crater has continued since then. A report on the activity from 1983 to 1987 has been published by the present author (Nyamweru 1988), and several short accounts have appeared in the Scientific Event Alert Network Bulletin between 1983 and 1988. The account that follows is the record of activity between 24th June and 1st July 1988, during which period the author was a member of a party that camped in the inactive (southern) corner of the north crater (area S in figures 1, 2 and 3).

### DIARY OF ERUPTIVE ACTIVITY

**24-06-88, 1630 hours:** First view into the crater when party members arrived on the crater rim. No lava flowing out on crater floor. Liquid lava present in two (connected) small lava lakes in the area T4T7 (see figures 1, 2 and 3). The larger lake lies to the east, and is about 8 to 10 metres in diameter, with overhanging sides 2 to 3 metres high. The liquid lava is black, with very low viscosity and bubbling actively, breaking in bubbles over 50 cm in diameter which throw 'spray' over 4 metres high. Small drops of lava fall outside the vent and form lapilli on the surrounding slopes. Plate I is of this lava lake and shows two bubbles of lava breaking on the lake surface, below the overhanging north wall of the vent. The second lava lake lies about 20 metres to the west, and is also active; a vertical fan-shaped spray of lava is rising from a narrow pinnacle in the centre of the lake, building it up. At

1630 hours there is no other activity visible in the crater, although steam and sulphurous fumes are emitted from a number of vents on the crater floor, its walls and its rim (see figure 1).

**24-06-88**, circa 1800 hours: lava begins to overflow from the southern side of the eastern lava lake of T4T7, and flows rapidly southwards; Flow 1 in figure 4.

**24-06-88**, between 1900 and 2000 hours: The flow (mainly of a lava) reaches the southern wall of the crater and is stationary but still hot at 2000 hours. During this period lava probably also flows eastwards, where it reaches the base of the crater wall. After dark there is an intermittent orange-yellow flare of burning gas from the top of the western vent of T4T7, and a dull red glow of lava from the eastern lava lake and its outflow.

**25-06-88**, 0700 hours: no new flows during the night: whitening of rock by chemical change beginning to occur around the margins of Flow 1. Lava is bubbling gently in the eastern lake of T4T7 but not splashing high or flowing out. The western lake is quiet, with little or no bubbling sound.

**25-06-88**, circa 1200 hours: lava begins to spill over the lip of the eastern lake, rapid flow begins towards the south, very liquid black lava flowing in a stream about 1 to 1.5 metres wide, spreading out and slowing down as it flows (Flow 2 in figure 4).

**25-06-88**, 1345 hours: liquid lava overflowing to the east in a very narrow layer, probably less than 5 cm thick but several metres wide; this 'sheetflow' lasts only for a few minutes (Flow 2 in figure 4).

**25-06-88**, 1400 hours: active outflow has largely ceased.

**25-06-88**, 1630 hours: lava moving in the lava lakes on T4T7 but not flowing out or bubbling over the edges of the lakes.

**26-06-88**, 0730 hours: small outflow of lava from the southeast side of T4T7, escaping from a little crack below the rim of the lava lake. This has ceased before 1000 hours, when the lava is solid but still very hot (Flow 3 in figure 4).

**26-06-88**, 1000 hours: lava bubbling actively in both lava lakes, but not spattering out or overflowing.

**26-06-88**, 1030 hours: small tricklings of fluid lava emerging from within the edge of Flow 2, near the northeast crater wall. Thickness of edge of flow is 50 to 60 cm; surface is solid but still warm.

**26-06-88**, 1600 to 1730 hours: no flowing lava on crater floor but lava bubbling at a relatively low level in T4T7 east. During this period, the noise of moving lava is heard from the open holes on the upper slopes of T5, from which shimmering heat and steam are rising; looking deep into the holes, it is possible to see liquid lava moving around below. At 1630 hours a small patch of pahoehoe lava is still warm on the north slope of T5 and probably formed within the last one or two days, though it was not observed flowing; this little flow appears to have originated from a crack low down on the slope of T5.

**27-06-88**, 0800 hours: lava is bubbling at a very high level in the lava lake T4T7 east.

**27-06-88**, circa 0900 hours: a crack opens on the lower southwest side of the T4T7 ridge and very fluid lava flows out in a narrow stream; Flow 4 in figure 4.

**27-06-88**, 0940 hours: lava has spread along a bearing of about 210 degrees from its source, towards the southwest corner of the crater. Black, smoothly flowing lava is in a stream about 50 cm wide, spreading out into tongues with a small-scale surface; it cools to a dark chocolate brown colour.

**27-06-88**, 1000 hours; flow is about 112 metres long and reaches to within 27 metres of the southern crater wall at the western end of the saddle. Its thickness is about 20 to 30 cm on the lobes at its lower end. During this period the lava remains bubbling actively at a high level in T4T7 east.

**27-06-88**, 1115 hours: flow is continuing, spreading out between T1 and T2 but not extending further south.

**27-06-88**, 1145 to 1200 hours: flow continuing, lava lake in T4T7 east bubbling actively.

**27-06-88**, 1300 hours: lava bubbling actively in T4T7 east. At the head of the new flow (F4) a hornito (H1) about 50 to 70 cm high has formed within about the last hour, by bubbling of highly gaseous lava from a narrow slit near its top. The hornito (see Plate II) is being built up by wrinkled cords and tiny lobes of smooth lava, while below it lava is still flowing out rapidly in streams 30 to 60 cm wide. In places the liquid lava disappears into a tunnel and then emerges further downstream; at this stage steady movement over quite a wide front is continuing towards the lower end of the flow. Slabs of pahoehoe form on top of the flowing lava, then are carried on by the moving rock, broken and tilted; lines of tilted slabs mark the flow lines (see Plate III).

**27-06-88**, 1340 to 1350 hours: hornito still bubbling; volume of lava escaping from beneath it is gradually decreasing, as the flow is contained within the limits of the earlier flows.

**27-06-88**, 1430 hours: hornito no longer bubbling but flow continues.

**27-06-88**, 1515 hours: flow continuing in a narrow (20 to 30 cm wide) channel within the earlier channels. Flow is on surface near source, then goes into a tunnel.

**27-06-88**, 1615 hours: source of flow has moved a few metres downstream, bubbling out under a narrow corded skin of lava that is few hours older. There is a gentle spattering in the west side of T4T7, and more active bubbling in T4T7 east.

**27-06-88**, 1700 hours: flow is continuing; there is active bubbling in T4T7 east and a gentle noise of moving lava deep below T5.

**27-06-88**, later that night: flow ceases along F4; bubbling continues in T4T7 east. The central pinnacle in T4T7 west, which was emitting a spray of lava on the evening of 24-06-88, collapses.

**28-06-88**, 0800 hours: no new flows on crater floor, no outflow of lava, but lava bubbling actively in T4T7 east.

**28-06-88**, 1630 hours: active continuous bubbling from T4T7 east, little or no sound from any other vent.

**29-06-88**, 0750 hours: a new large flow has formed in the night, overflowing from a groove cut in the lip around the lava lake, T4T7 east; this is Flow 5 which has gone mostly towards the south and southwest (Figure 5).

**29-06-88**, 0810 hours: flow very active from the vent, with overflow from two places on the rim of the lava lake; lava has also flowed round to the east and northeast and has reached the north wall of the crater below the rim cone C1. On the northwest side of T4T7 there is spattering of very gas-rich lava from the top of one of the little cones that border the vent; new trails of dark lava are forming down the pale grey slopes of the cone.

**29-06-88**, 1010 hours: lava bubbling in both the eastern and western lakes of T4T7; overflow still continuing from the south side of T4T7 east.

**29-06-88**, 1100 hours: lava bubbling in both lakes; occasional spattering from the top of the western cone.

**29-06-88**, 1230 hours: active bubbling and overflowing from T4T7 east; line of small hornitos building up along the line of flow where liquid lava is breaking out of tunnels below the older surface.

**29-06-88**, 1400 hours: lava bubbling and overflowing; southwestern corner of flow has reached within 16 metres of the southeast corner of T2.

**29-06-88**, 1430 to 1530 hours: spray of highly gaseous lava from the top of a hornito, the highest of a line of about 7 hornitos that lie along the axis of Flow 5; the spray from the hornitos has stopped by about 1530 hours but extension of the lava flow further downstream continues until later in the day.

**29-06-88**, 2000 hours: surface outflow of lava has ceased before this, but the lava lake on both sides of T4T7 is bubbling actively, with a dull orange glow and an occasional pale orange flare of gas. When the molten lava spatters on the rim of the vent, it glows dull red for some seconds before it cools.

**30-06-88:** active bubbling and splashing of lava from both the eastern and western sides of T4T7 continues throughout the day, but there is no surface overflow during daylight hours.

**30-06-88,** approx. 1949 hours: a new vent opens on the east side of T4T7 and lava begins to flow rapidly to the east and southeast, quickly reaching the east wall of the crater (figure 5).

**30-06-88,** 2030 hours: the lava has spread to the east of T5, covering the earlier (Flow 1) lava in this area. A lava cone is soon built up at the source of the lava (T8) which at this time appears to be 2 or 3 metres high and about 10 metres in diameter. A spray of dull red lava is thrown a further 3 metres above the top of the cone. At this time the level of lava in T4T7 has fallen by as much as 10 metres and it is possible to see a large hollow below the arch that joins the two lava lakes (east and west sides of T4T7).

**30-06-88,** 2200 hours: lava from T8 fountaining from the cone and flowing actively.

**01-17-88,** 0230 hours: occasional spattering from the top of T8.

**01-07-88,** 0630 hours: occasional spattering from the top of T8. The cone is now about 10 to 12 metres high, with a smooth slope to the southeast, a break in slope on its northwest side. The lava below T4T7 can be heard moving around, though at some depth. The last members of the party left the crater rim at about 0700 hours.

#### LIST OF LAVA FLOWS (see figures 4 and 5)

**Flow 0:** This was not observed actually flowing but at noon on 25-06-88 was still warm and had undergone very little whitening; it had originated from the northwest slope of T4T7 and had flowed to within a metre of the north crater wall; see figure 4. This flow probably formed on 24-06-88; according to M. Krafft it was already in existence when he visited that part of the crater late that day. The flow was about 35 metres long, width at downstream end (across 3 lobes) circa 30 metres, width near base of cone circa 14 metres. Thickness between 30 to 50 cm. It was largely composed of a lava, but it was overlain with little lobes of pahoehoe that seem to have resulted from the closing stage of the eruption.

**Flow 1:** This flow came from the eastern lava lake of T4T7 and formed between about 1800 to 1900 hours on 24-06-88. Its dimensions were as follows: from the vent to the east-northeast crater wall, about 50 metres long; from the vent to the southern crater wall, about 180 metres long; maximum thickness 50 to 70 cm (see figure 4; this flow is also visible in the centre of Plate IV).

**Flow 2:** This flow formed between about 1200 and 1400 hours on 25-06-88, by overflow of very liquid lava from the rim of the eastern lava lake. Its dimensions were not measured but it was a much smaller flow than Flow 1 and only covered parts of it, within a few tens of metres of the vent (see figure 4).

**Flow 3:** This formed between about 0730 and 1000 hours on 26-06-88, it was another very small flow which escaped from a crack on the southeast side of T4T7, below the rim of the lava lake (dimensions not measured, but see figure 4).

**Flow 4:** This flow started at about 0900 hours on 27-06-88 from a crack that opened low on the southwest slope of T4T7. It continued to flow in gradually narrower channels until after 1700 hours on the same date; between about 1200 and 1430 hours a small hornito formed at its upper limit, by effusion of highly gaseous lava. The final dimensions of the flow were: length about 120 metres; width ranging from 1 metre close to its source to about 40 metres at its downstream end; thickness maximum 50 cm. At its final extent, the toe of the flow reached to within 12 metres of the south wall of the crater (see figure 4; this flow is also visible in Plate IV, where it is the narrow, dark flow on the left side of the crater floor).

**Flow 5:** This flow probably started during the early hours of 29-06-88; by our first visit to the crater at 0750 hours that day, the flow had extended far to the south of its source; it was overflowing actively from a notch cut in the southern rim of the eastern lava lake of T4T7. The flow also extended to the east and northeast of its source, covering a distance of about 80 metres from the vent to reach the crater wall (see figure 5). Flow continued until about 1600 hours and at its final extent the flow was over 150 metres long and had reached to within 20 metres of the south crater wall at the saddle, and to within 6 metres of the north side of T1.

**Flow 6:** This flow began to form at about 1940 hours on 30-06-88, from a new vent low on the east side of T4T7. Movement was very rapid in the early stages and by 2033 hours the new flow had extended round the slopes of T5 and reached the eastern crater wall (see figure 5). The thickness of the flow ranged from 20-30 cm to a maximum of about 50 cm. At the source of the flow, lava fountaining built up a new cone (T8; see figure 5) which by 0630 hours on 01-07-88 was about 10 to 12 metres high. The flow of lava probably ceased soon after 2200 hours, but spattering from the top of the cone continued throughout the night and was still taking place at a reduced level the following morning.

#### DIMENSIONS OF CRATER

Pacing from west to east on a diameter just to the north of T2, between T4T7 and T5: 244 metres.

Pacing from north to south on a diameter to the west of T4T7, past the eastern corner of T1: 222 metres (average of 2 pacings).

Pacing on a diameter at bearing 136 degrees, from the base of D, passing just to the south of T5: 253 metres.

Height of northeast wall (estimated) 40 to 50 metres. Northwest wall could be slightly higher (but not more than 60 metres). East wall is slightly lower (30 to 40 metres).

The level of the crater floor around T5 and T4T7 is markedly higher than the level to the south, at the base of the saddle, and may even be higher than the lowest point of the saddle.

#### DESCRIPTION OF THE CRATER; THE ERUPTIVE CENTRES (see figures 1 to 3).

**Southern crater:** this feature, to the south of the central summit, was a shallow, gently sloping depression floored by rather coarse grey ash, with patches of green vegetation on its floor and sides.

**T1:** (the 'igloo') inactive and largely unchanged since April 1988 and even December 1987; rounded pale grey slope (length about 45 metres around base of slope) facing southwards towards the saddle. Overhang facing northwards into the crater; distance across base of overhang was about 10 metres. Occasional slight emission of steam from base of its inner slopes.

**T2:** this collapsed centre also largely unchanged since April 1988; in plan it was approximately circular, about 33 metres in diameter, with inward facing walls (best preserved on its north and south sides) and a central cone with an open hole on its south side. This hole was more than 6 metres deep and inside it was a jumble of blocks of rock; some warm fumes were rising from it. Considerable sulphur staining was visible on its inner slopes and fumes were emitted from the central holes from the base of the outer walls. There were 'stalactites' along the base of the inner walls.

**T5:** little change in this group of pinnacles since April 1988. When first seen at 1630 hours on 24-06-88 there was no steam visible, no sound of molten rock at depth, but later during the week there

was emission of steam, and shimmering heat rising from the holes that were still open towards the top of the pinnacles.

At 1630 hours on 26-06-88 a member of the party heard and saw liquid lava moving around deep below T5, and at mid-day on 30-06-88 it was possible to hear moving lava below this feature. A small flow of pahoehoe lava was still hot on the north slope of T5 at circa 1600 hours on 26-06-88, and may have formed within the last 24 to 48 hours, though it was not actually observed flowing. T5 is visible on the right of the crater floor in Plate IV.

**T4T7:** this was the centre of activity throughout our stay. It changed greatly after December 1987 (when there were two quite small separate vents, T4 and T7) and according to D. Peterson also changed noticeably between his visit on 27-05-88 and the end of June 1988. By then it had developed into a continuous ridge, broadly aligned east-west, with an uneven crestline rising to a series of grey lava pinnacles; its length (parallel to its long axis) was about 80 metres. The two lava lakes (eastern and western) were connected under an arch of older lava, which supported a lava pinnacle over 3 metres high. When the level of lava was low (as it was late on 30-06-88) it was possible to look through and under the arch from one lake to the other. The lava pinnacle in the centre of the western lava lake that was emitting a spray of lava on 24-06-88 collapsed on 27-06-88. T4T7 can be seen on the far (north) side of the crater floor in Plate IV.

**A3:** these inactive vents, small cones and lava flows were still clearly visible on the crater wall, though rather paler in colour than they had been in late 1987; largely grey or white, with a crumbled, rather powdery surface; erosion by running water had begun to cut little gullies down parts of this slope. There were at least 5 small vents on the northern slope, as well as others to the west and (possibly) the east. The cones were of basically the same form and dimensions as comparable features on the crater floor; the three larger ones stood between 3 to 6 metres above the crater wall and there were two smaller ones. The largest cone lay to the west of the cluster, and had a steep top with an open vent, though the bottom of the hole was not visible.

**A4:** on the northern wall of the lowest part of the saddle, just behind T1, there was an area of soft, powdery pale grey/brown material, with two or three small, partly in filled pits which appear to be heavily weathered small vents comparable to those on the north wall of the crater, opposite them. The top of the saddle for several metres was made of soft powdery pale grey/brown material rather than of the mid-grey, harder and coarser material (which includes pieces of rock up to 10 cm long) that made up the rest of the saddle and much of the upper rim and summit of the volcano.

**D:** this inactive vent, with a small lava flow below it, was still clearly visible on the crater wall, though pale brown and heavily weathered. There was possibly an equally old, smaller vent to the south of D, close to the top of the western crater wall.

**C1:** when first seen at 1630 hours on 24-06-88, was not emitting steam. The cone rose over 4 metres above the crater rim and had steep slopes of soft, crumbly grey material. An estimate of its dimensions was 10 metres long and 8 metres high. Later during the week occasional emission of steam from this cone was observed. C1 lies at about 1 o'clock on the crater rim in Plate IV.

**Crater floor:** the areas not covered by very recent flows were various shades of pale grey, pale brown and white; different generations of flows could be distinguished by overlapping lobes and tongues of weathered lava. Despite the intensive weathering of the lava surfaces, the pahoehoe and aa structures, as well as some lines of small hornitos, were clearly distinguishable. For example the tilted slabs of pahoehoe and the small hornito observed forming on Flow 4 on 27-06-88 could be recognized in a weathered state on nearby older flows. Figures 1 and 2 show FF, two medium grey

flows which had longitudinal blackened fissures following their long axes. The blackening marked a line of fumaroles and was due to chemical activity of the fumes. Viewed from the summit on 28-06-88, the oldest parts of the crater floor appeared to be on its southeast side (beyond T5; here there was a small alluvial fan of material brought down from the slopes above, overlying the weathered lava) and on the southwest side beyond T1.

**M:** the saddle was very low on its north side; its height there was about 4 metres. To the south, towards the inactive southern section of the crater, there was a drop of about 12 metres; thus the floor of the southern section was at a lower elevation than that of the active northern part of the crater.

**DESCRIPTION OF THE CRATER; THE FUMAROLES** (marked xxx on figure 1; not marked on the other figures)

**East rim:** Strong sulphurous smell, fumes and yellow staining along cracks on rim.

**West and northwest rim:** deeply cracked in many places, both parallel to the rim and across it. Some cracks emit mainly steam and support local patches of vegetation, including mosses and lichens; others emit sulphurous fumes and the surrounding areas are largely bare of vegetation.

**T1:** occasional gentle emission of steam and slight smell of sulphur.

**T2:** sulphurous smell, yellow staining, fumes from inner slopes on both sides.

**T5:** occasional emission of steam (see notes above).

**Northeast wall:** patches of bright yellow sulphur, local gentle emission of steam.

**M:** the saddle; the east side of the saddle, where it begins to rise steeply, is heavily altered and there is emission of sulphurous fumes. On the west side of the saddle, at a rather lower elevation, there is an open crack (less than 5cm wide) that crosses the saddle, with active emission of fumes and some sulphur staining (see note b. below).

**Southern section of the crater:** the crack referred to above crosses the saddle and extends into the southern 'inactive' section of the crater. Occasional emission of steam was also observed from a spot near the centre of the southern section of the crater.

#### GENERAL OBSERVATIONS AND CONCLUSIONS

- a. Over the period that we observed the crater, activity was concentrated in the area T4T7, where there was a lake of liquid lava over 40 metres long (including the eastern and western lakes and the connection between them). However liquid lava was also seen and heard moving around deep below T5 and there was evidence of recent small flows from the northern slope of T5, so this centre is not entirely extinct. Broadly, however, it appears that most activity is concentrated towards the northeastern and eastern sides of the crater.
- b. A line of weakness seems to cross the whole crater, on a bearing about 42 degrees to 222 degrees. On the northeast wall it is marked by a small grey vent near the top of the wall, with grey material below it. On the crater floor it is marked by fumaroles that have formed long lines of black staining that run to the west of T1. On the saddle it is marked by the big crack which emits sulphurous fumes. The new cone (T8) that formed the night of 30-06-88 lay very slightly to the northwest of this line. This line of weakness could well form the site of future eruptive vents.

- c. Eruptions have taken place at several locations on the crater walls, in particular on the north wall (A3 and C1), but also apparently along the saddle (A4). Considering the fumaroles that extend across the saddle, and the high level of the floor of the northern section, it seems quite possible that lava could in the future reach the surface in the 'inactive' southern section of the north crater. Equally, it is quite possible that future eruptions could occur on the crater walls or even on its rim.
- d. The newly erupted lava weathers extremely rapidly, changing colour almost completely; the surface goes from dark grey or dark chocolate brown on newly cooled lava to pale grey within less than 48 hours. This makes it virtually impossible to recognize a 'new' lava flow unless one observes it within one or two days of its formation and thus creates serious limitations to the detailed picture of changes in the crater that may be drawn. The rate of change of the lava may depend to some extent on the weather conditions; when the atmosphere is very moist (and windy) one might expect the change to be more rapid than when it is still, hot and dry. However even the flows that erupted on the sunny days that we were in the crater (e.g. Flow 4) changed colour very rapidly.
- e. During the seven days during which observations were made, liquid lava was always present close below the surface; at least 4 quite substantial flows were produced and a cone over 10 metres high was built up. It is not possible to tell whether this represents the general level of activity over the last five years or not, since no other continuous observations over seven days have been made. However the intermittent observations made over the years since 1983 indicate that liquid lava was frequently present, bubbling close below the surface if not actually flowing out. The topography of the crater floor and walls has changed strikingly over this period, evidence of the emission of quite a large volume of lava.
- f. In particular the northern 'pit-crater' that existed in the late 1960's and during the 1970's has become much shallower; shallower even than it was before the explosive eruption of 1966. One may ask how much shallower it will get before another major explosive eruption occurs and recreates a deep, vertical walled pit crater at the summit of Ol Doinyo Lengai?

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#### GLOSSARY

**AA** a lava flow with a rough, jagged, clinkery surface. (A term of Hawaiian origin). See the lava in the foreground of Plate III.

**HORNITO** a small mound built up on top of a lava flow by clots of very fluid rock escaping from openings in the roof of an underlying lava tube. Two hornitos are shown to the right of the standing figure in Plate II.

**PAHOEHOE** a lava flow with a smooth, billowy or ropy surface. (A term of Hawaiian origin). See the lava in the foreground of Plate II.



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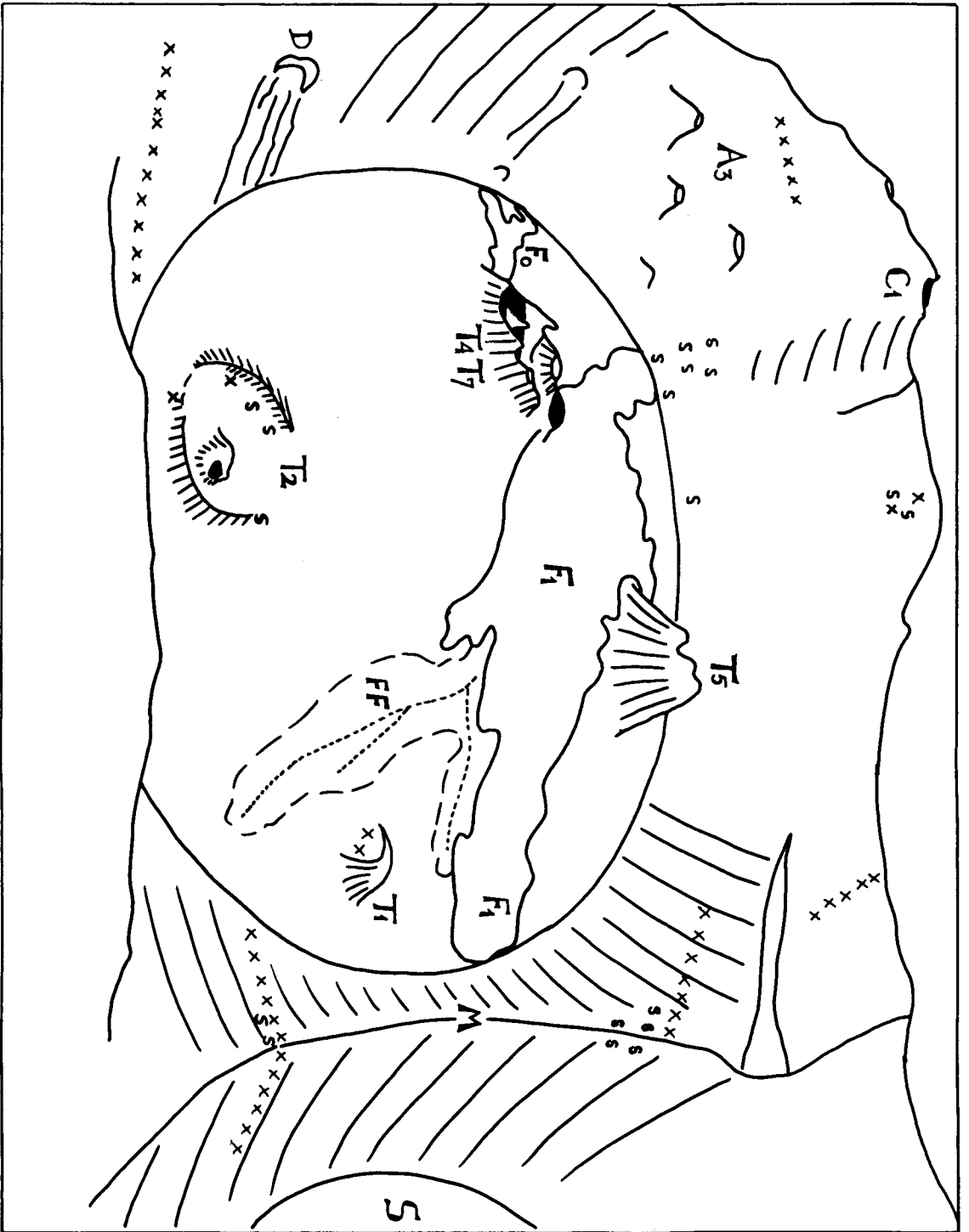


Figure 1: The crater of Ol Doiyo Lengai sketched from a point on its southwest rim at 1520 hours on 25th June 1988. xxx: fumaroles, sss: Sulphur. For other letters and numbers, see text.

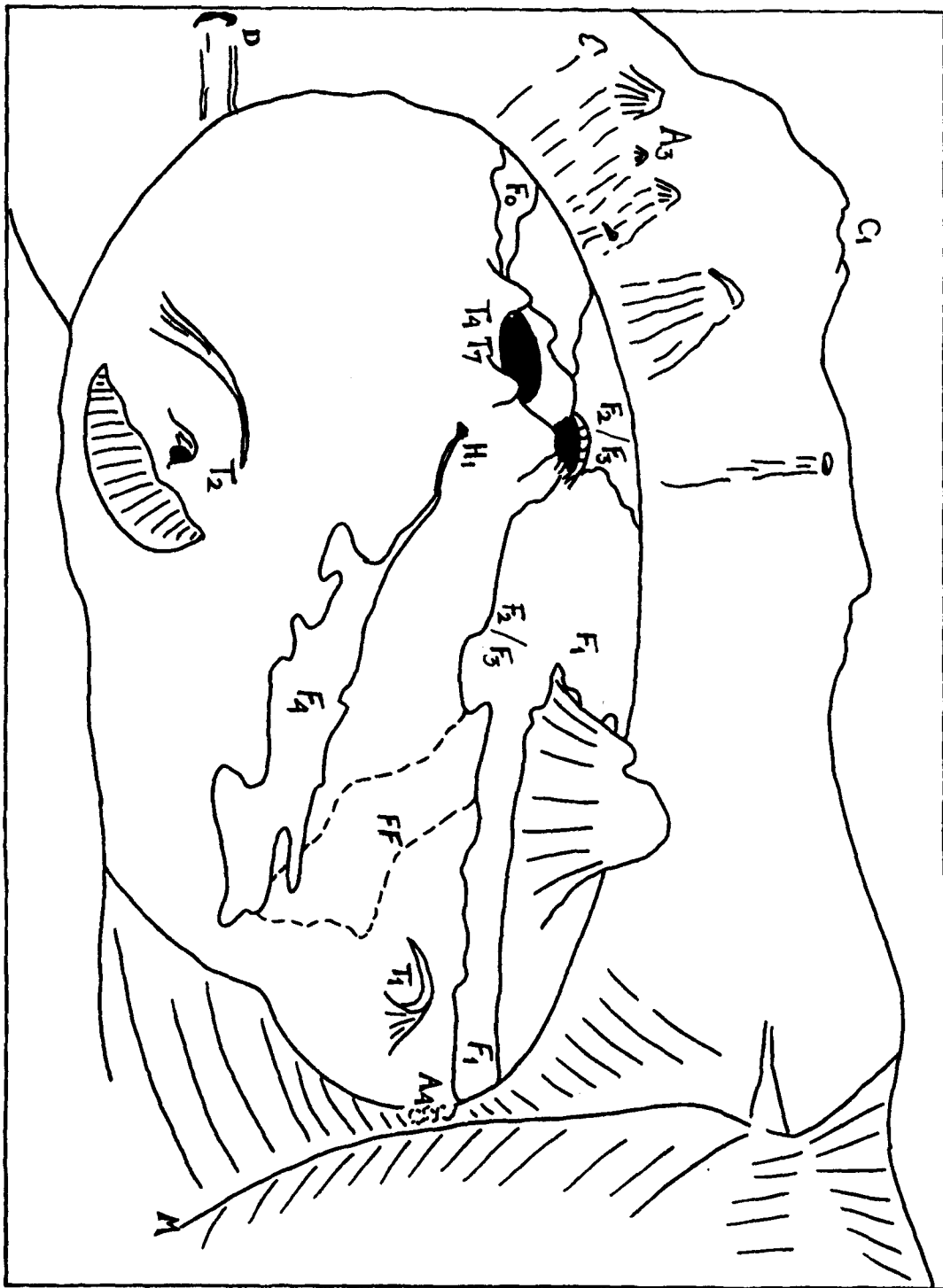


Figure 2: The crater sketched from the same point as figure 1 at 1600 hours on 28th June 1988.

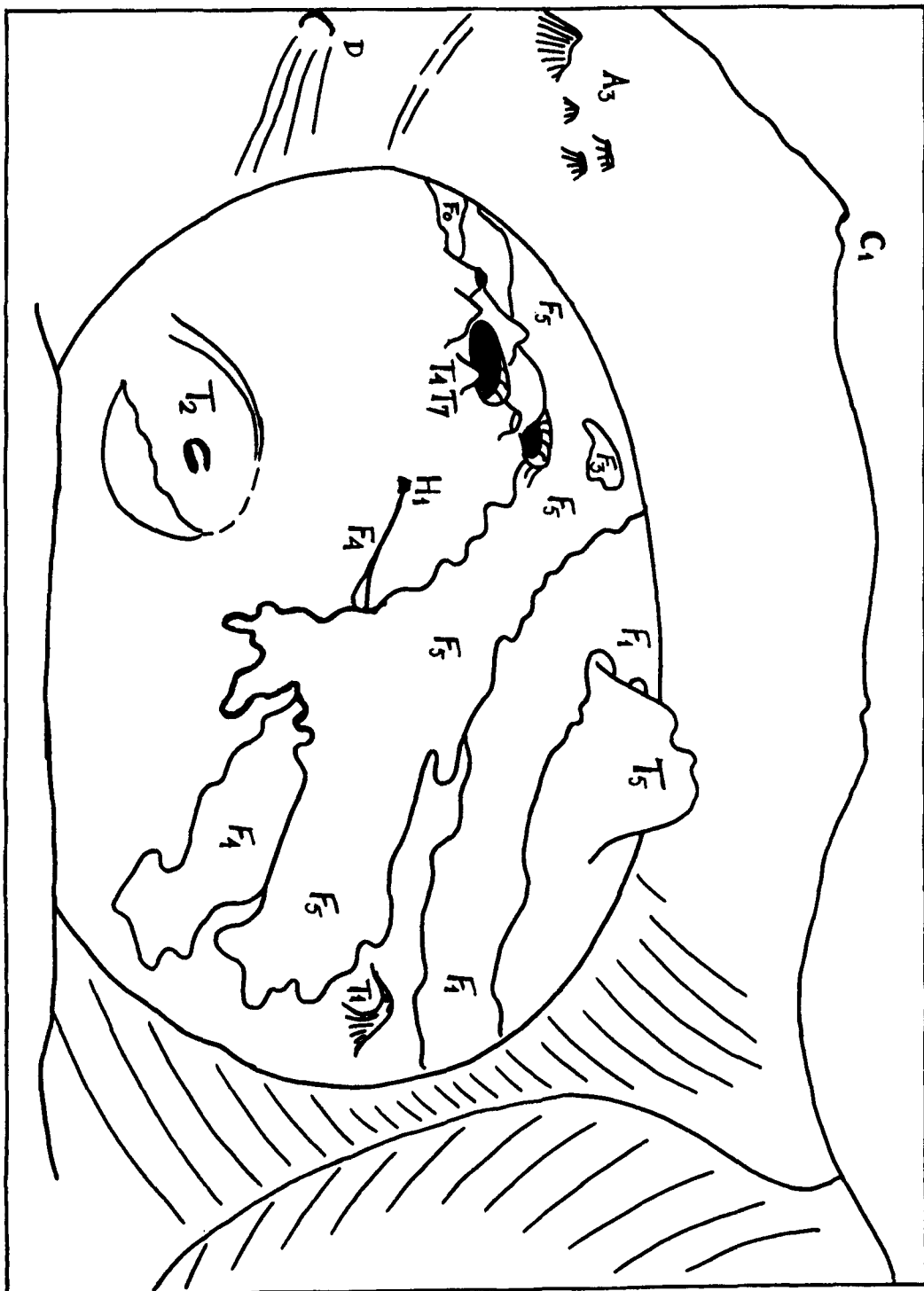


Figure 3: The crater sketched from the same point as figures 1 and 2 at 1545 hours on 29th June 1988.

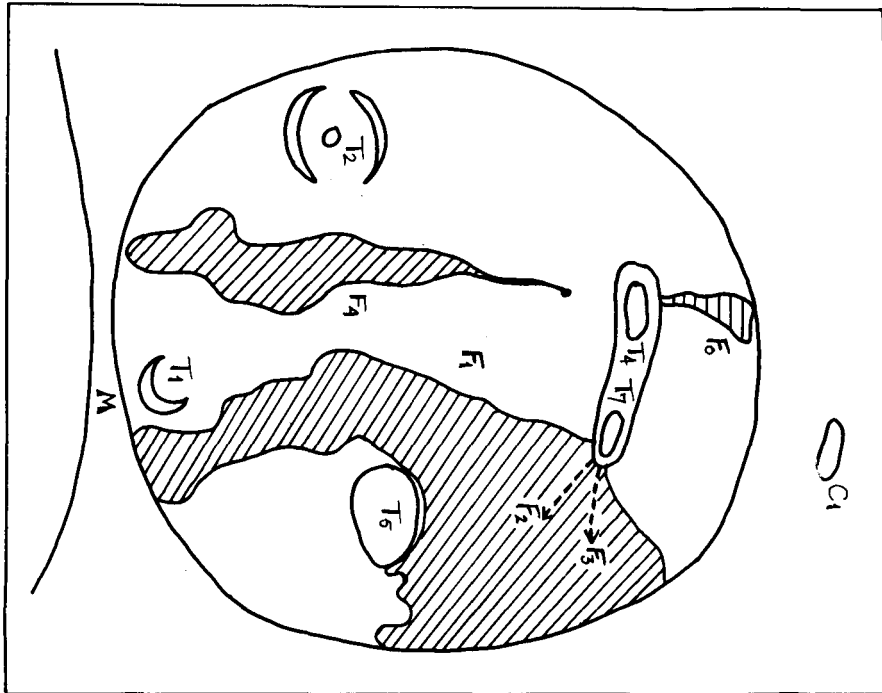


Figure 4: Plan of the crater of Ol Doinyo Lengai showing the approximate positions of flows F0, F1, F2/F3 and F4. Approximate diameter of crater is 240 metres.

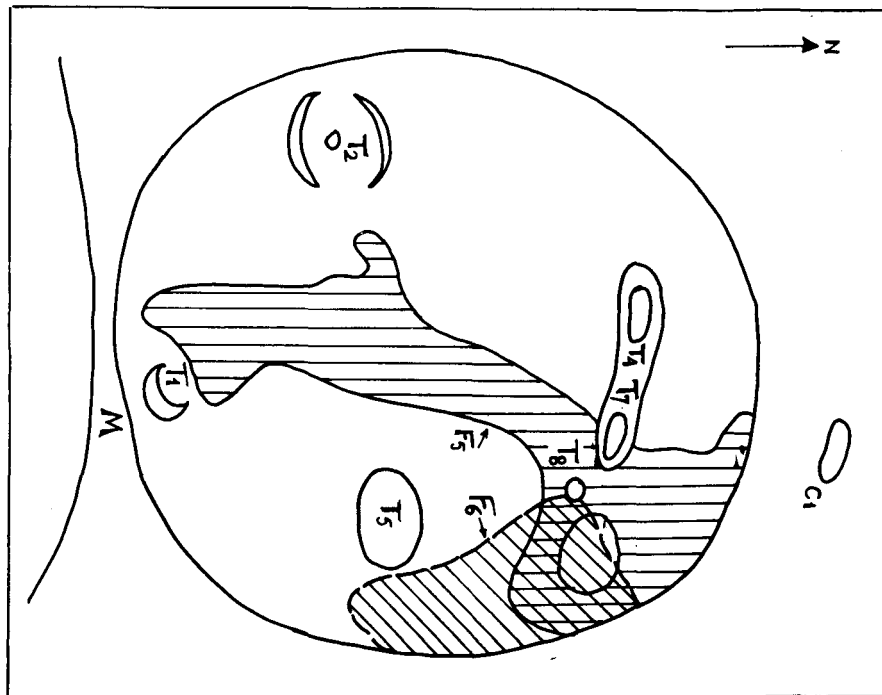
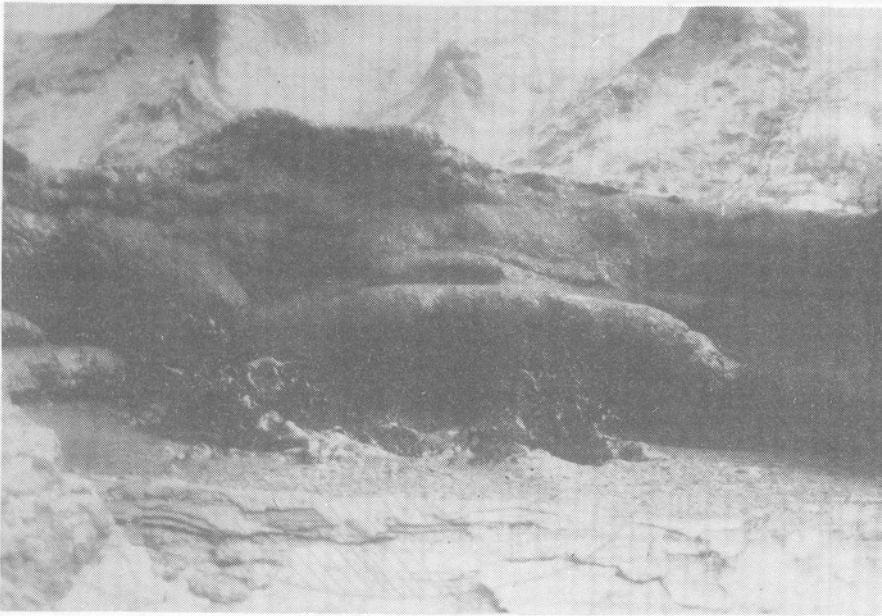


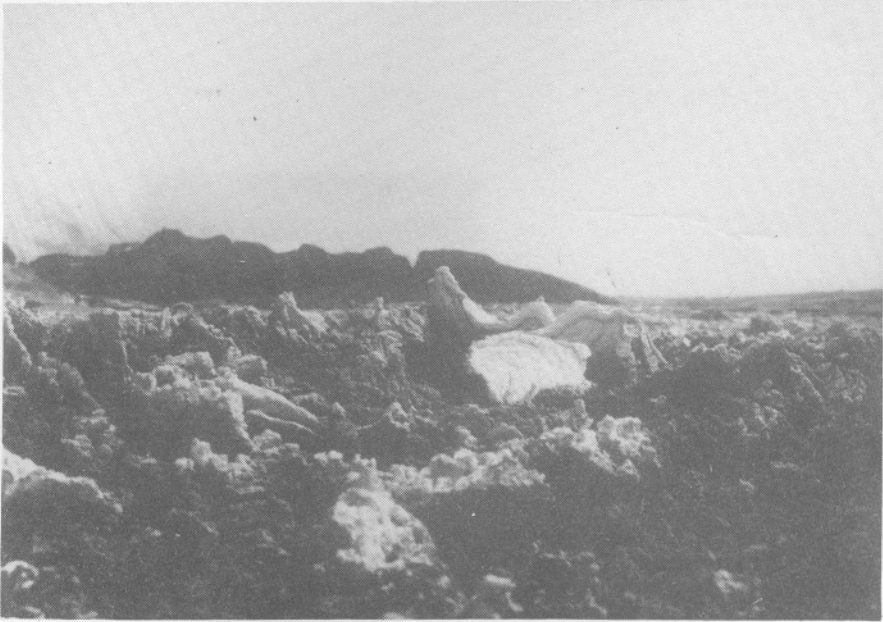
Figure 5: Plan of the crater of Ol Doinyo Lengai showing the approximate position of flows F5 and F6.



*Plate I:* Lava bubbles breaking in the eastern lava lake of T4T7. In the background is the crater wall with the cones labelled A3 in figures 1 to 3.



*Plate II:* The source of Flow 4 at 1615 hours on 27th June 1988; two hornitos and several small channels of pahoehoe lava. Behind the standing figure are the pinnacles forming T4T7 and in the background stands the crater rim with the rim-cone C1.



*Plate III.* Surface of Flow 4 on 30th June 1988; tilted slabs of lava already turning white. The broken wall of the old vent T2 is in the background.



*Plate IV:* View of crater from the southeast on 28th June 1988, showing the saddle to the left, the rim-cone slightly east of north and the eruptive vents T1, T2, T4T7 and T5 on the crater floor.  
*(all photographs taken by the author)*