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Ash deposits from the new explosion crater, Etna 1971

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The weakly explosive activity in May to June 1971 from the new explosion crater high on the eastern side of Etna produced a pyroclastic fall deposit which is very poorly sorted on the crater rim, but is well sorted farther away. Grain-size parameters are given for 47 sieved samples, seven of which were collected from the ash-fall during the eruption. The initial strombolian-type activity soon changed as pre-existing pyroclastic debris slid into the crater, and thereafter the ejecta included much non-juvenile material derived from this debris. The ash fell in the form of small damp flocculated clumps, but as it dried out much of the dust-grade material was blown away by the wind. Such dust may account for much of the loess-like soil found on the vegetated lower slopes of Etna.

One feature of the 1971 eruption of Etna was the formation of a new explosion crater 100 to 200 m in diameter at the foot of the steep summit cone high on the eastern slope of the mountain. This crater developed on an E–W fracture which opened on 4 May. Gases were emitted from the upper part of this fracture, and lava from the lower part, but the outpouring of lava ceased two days later and the activity then migrated to fissures lower down on Etna.

Regarding the new crater, Romano & Giudice recorded (Smithsonian event card no. 1213) that: 'In the early morning of 18 May, strong explosions started to open a new sub-terminal crater which at 10 o'clock was already more than 150 m wide and violently emitting dark clouds charged with ashes and white vapour. The new crater is situated at the place where on 4 May a small eruption center had opened on the eastern slope of Mt Etna at about 2900 m altitude'.

When the authors visited Etna between 21 and 27 May, explosive activity was still taking place at this new crater while lava was issuing quietly from the Citelli boccas 5 km to the east and 1100 m lower down on the slope of the mountain: presumably the juvenile magma supplying the Citelli boccas was being degassed largely through the new crater. On 26 May, dark-coloured ash-rich cauliflower clouds were observed coming out almost continuously from the eastern of two vents located in the bottom of the new crater, many of the eruptive bursts beginning with 'cockscomb' plumes of ash. Much of the coarser debris thrown up fell back into the crater, and most of the noise was caused by its fall. The eruption was relatively quiet, however, and little could be heard outside a radius of 200 m apart from occasional thunder-claps. At night some of the ejecta were visibly incandescent. The eruptive cloud rose for the most part not more than 200 or 300 m above the crater, and drifted rapidly NE in the strong wind.

Above the new crater, the steep slope of the terminal cone of Etna, largely made of older pyroclastic deposits, was cracked (with steam issuing from the cracks) and in a very unstable condition. From time to time portions of this material slid into the crater, and much of the debris thrown out by the explosive activity was undoubtedly thus derived.

Fall-out from the ash cloud was measured on the afternoon of 26 May at a point (near c, figure 1) about 400 m down-wind of the crater. It amounted to between 30 and 70 g m^{-2} min^{-1} over collecting periods of up to 20 min duration, corresponding to a thickness increment of 0.02 to 0.03 mm/min. It rose to a peak rate of more than 400 g m^{-2} min^{-1} over 10 s periods, a thickness increment of 0.25 mm/min. The total thickness of 25 cm at this station had

10-2

accumulated over the preceding $8\frac{1}{2}$-day period at an average rate of 0.02 mm/min. The maximum grain-size of the ash-fall material was 1 mm, and the median diameter between 0.12 and 0.06 mm, although the ash when it fell was damp and fell mostly as flocculated snow-flake-like clumps about 1 to 2 mm in size. A slight ash-fall was experienced at the Citelli boccas on the evening of 23 May, at times accompanied by slight rain, but no samples were collected.

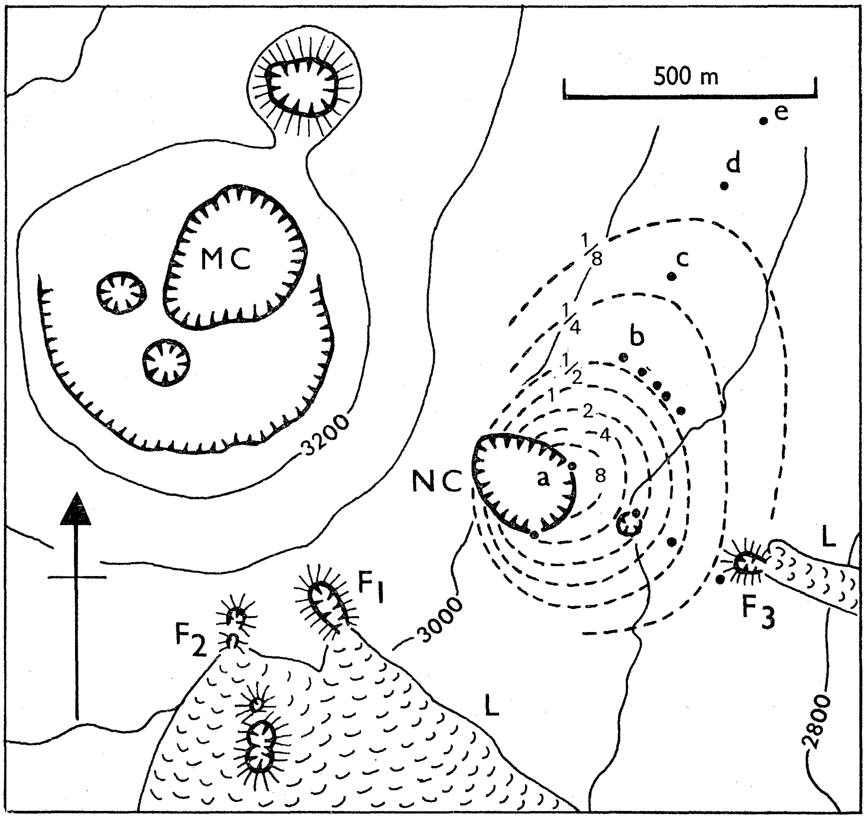

FIGURE 1. Sketch map of the summit area of Etna showing the location of the new explosion crater, NC, and the distribution of ash from it. The isopachs (thicknesses in metres) are based upon measurements at the points marked by black dots, and samples were collected from points a to e. MC, main summit crater of Etna; F_1, F_2 and F_3, eruptive vents from which lava (L) was emitted during the first month of the 1971 eruption. Contours in metres.

Practically the entire deposit had accumulated by 26 May, and on the following day the activity had noticeably declined and was interrupted by periods of an hour or more when only steam drifted out. Some relatively coarse-grained ash (layer 5, figure 2) at the top of the deposit formed as a result of strong explosions a few days later, however.

Eruptive activity had ceased when we returned in mid-July, apart from occasional rumbles in the new crater which were without any surface manifestation. The crater was by then only 40 m deep and was being filled in by the almost continuous sliding of loose debris from the terminal cone of Etna. Weak fumaroles in the bottom of the crater were depositing pale green, yellow and brown MgFe chlorides (analyses by J. Angus) as flower-like, stalactitic and stalagmitic encrustations.

The pyroclastic deposits attained a maximum thickness of 12 to 13 m on the crater rim, thinning rapidly to 3 cm at a distance of 850 m. The deposit was well stratified, the lower part

(1, figure 2) made largely of juvenile basaltic scoria typical of a strombolian deposit and the remainder (2 to 5, figure 2) containing a large proportion of lithic debris, with occasional spindle bombs among the juvenile ejecta. In the middle of this part (3, figure 2) the deposit contained abundant fine-grained red debris, probably derived from pre-existing reddened ashes constituting part of the terminal cone of Etna. This red part may mark a particularly large collapse of such debris into the crater. During the eruption we observed several such collapses taking place.

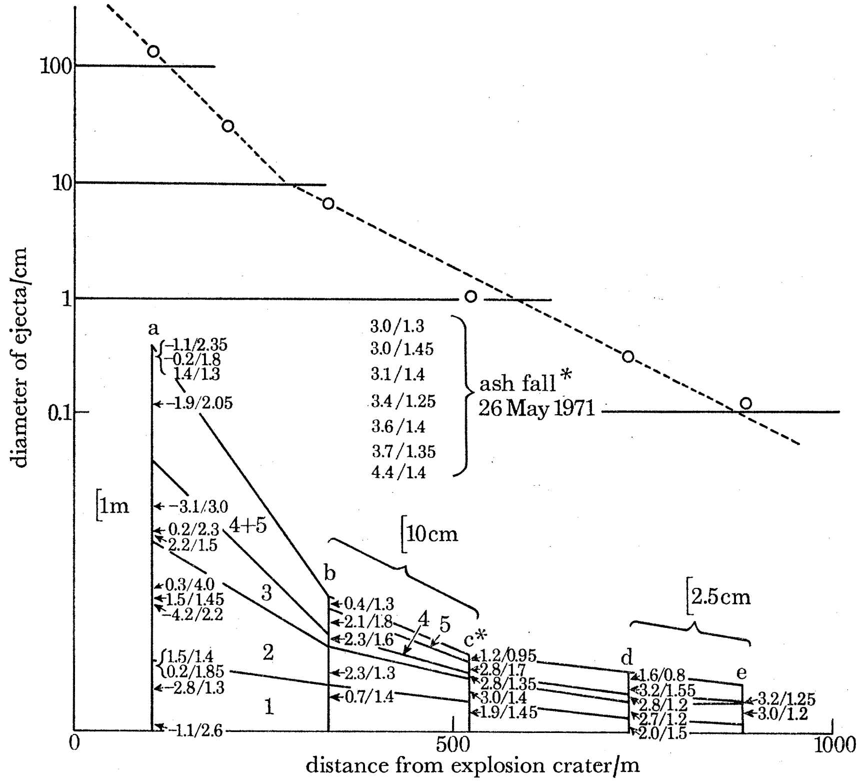

FIGURE 2. Graphically derived parameters, Md_ϕ and σ_ϕ, from sieve analyses of samples of 1971 ash collected from 5 points (a to e, figure 1) and from the ash-fall of 26 May 1971. Above: plot ○ of the maximum diameter of ejecta as a function of distance from the centre of the new explosion crater.

The largest ejected block seen measured 1.7 m in diameter and the maximum throw of 30 cm blocks was 200 m, although many which fell on the slope below the crater rolled much farther than this. Forty representative ash samples collected from five sections (a to e, figure 1), together with seven samples collected from the fall-out on 26 May have been sieved, and their graphically derived Md_ϕ and σ_ϕ values (Inman 1952) are inserted on figure 2 and plotted on figure 3.

Two features are shown by these sieve analyses. One is the remarkably poor sorting of the crater rim samples, for which σ_ϕ ranges from 1.3 to 4.0 and averages 2.1. Some of these values lie outside the normal field of pyroclastic fall deposits as summarized by the contoured field on figure 3 (from Walker 1971). These high values are attributed largely to fine-grained debris filling in the interstices between coarser (cf. Tsuya, Murai & Hosoya 1958). The other feature is the very rapid improvement in sorting with distance from the vent: at 600 m or more the value of σ_ϕ has decreased to an average of 1.25. Such a decrease is believed to be common, and may be normal, though it has not often been demonstrated (Fisher 1964; Walker 1971).

The high degree of fragmentation is partly an original character which predates the 1971 activity, though further comminution must be attributed to ball-mill action taking place in the 1971 crater. The fine grain of the deposit 100 m or more from the crater rim and the short distance that the coarser debris has been thrown reflects the weakness of the explosions.

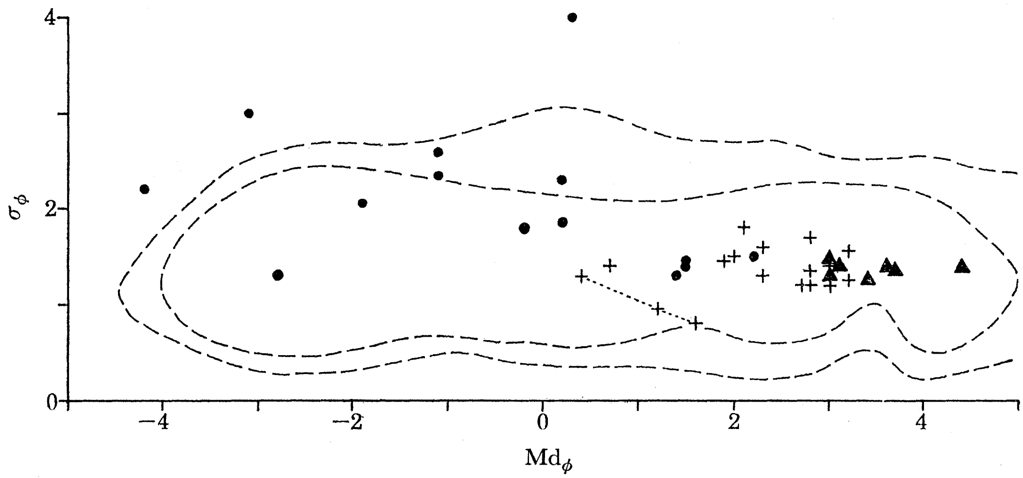

FIGURE 3. Plot of σ_ϕ against Md_ϕ for sieved samples of the Etna 1971 ash from the new explosion crater on Etna. Crater rim samples (●) are distinguished from samples collected farther from the vent (+) and from the ash-fall of 26 May (▲), and a tie-line is drawn (dotted) for three samples collected from the top of the deposit at points b, c and d of figure 1, showing the fall in Md_ϕ and σ_ϕ with increasing distance from the vent. The dashed lines are the 1 and 2 % contours taken from the pyroclastic fall field of Walker (1971).

The samples collected from the ash-fall are consistently finer-grained than samples of the accumulated deposit later collected from the same site. As previously mentioned the ash when it fell was damp and had flocculated. All the time we were observing the eruption a strong wind (the Sirocco) was blowing and deflation was removing much of the fine dust as it dried out. The remaining ash is a form of lag deposit. Of the three finer-grained samples from site c, on average 26 % is coarser than 0.25 mm; in contrast, of the seven ash-fall samples collected near the same site during the eruption, on average only 11 % is coarser than 0.25 mm. These figures suggest that more than half of the deposited ash was removed by the wind during the eruption and carried lower down the mountainside. Such may be the origin of some of the very fine, loess-like soil prevalent in the vegetated lower slopes.

The conclusion to be drawn from the study of the ash deposit is that the eruption from the new crater was at first of strombolian type (though the deposit in part has a higher σ_ϕ value, up to 2.6, than is normal for strombolian activity (Walker & Croasdale 1972)), ejecting predominantly juvenile scoria including achneliths. The eruption then changed character because of the insliding of pre-existing pyroclastic debris in large amounts, and the remainder of the deposit is rich in this non-juvenile material. The style of eruption changed from one dominated by the escape of gases through relatively fluid lava to one dominated by the passage of gases through loose solid debris. Although the eruption at times superficially resembled a surtseyan one (Walker & Croasdale 1972), the drastic chilling of ash particles in surtseyan ashes is not found.

The ash deposit is small – the volume is estimated at 0.65×10^6 m^3, or 0.4×10^6 m^3 dense rock equivalent, of which perhaps 50 % is juvenile. While the actual volume may have been twice as large due to deflation by wind, it is still small in comparison even with the 1971 lava from the Citelli boccas. Pyroclastic deposits are, however, formed almost every year on Etna and must contribute significantly to its total volume, and no previous studies have been made of them. Most of these deposits very soon lose their individuality: within one month of the end of the eruption in 1971 the deposit had already been largely removed outside the 25 cm isopach, some washed down into the interstices of the underlying aa lavas, though most had been eroded away and presumably transported to lower down on Etna. By the time this paper is published little of the primary deposit will remain recognizable. Prompt examination of such deposits is therefore very desirable.

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