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PRELIMINARY REPORT ON THE PYROCLASTIC PRODUCTS OF VULCANO

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OBJECTIVES

Field work was undertaken in 1980 to examine the recent products of Vulcano in order to evaluate their eruptive and emplacement mechanism. This study, supported by the International Institute of Vulcanology at Catania and NSF Grant INT-7823984, was restricted to the unconsolidated products lying on top of the "Tuffi Rossi" tuff cone of the "Fossa" volcano. By identifying the products as pyroclastic fall, flow, or surge, or as lahar a number of eruptive patterns can be recognized. Stratigraphic marker beds such as pumice fall layers or phreatic breccias signify specific phases of different eruptive cycles and allow correlation of sections. The deposit patterns could then be evaluated in terms of eruption phenomenology, crater morphology, and hydrologic models in order to postulate possible models of renewed activity.

FOSSA III DEPOSIT

The first step toward understanding the products of the Fossa vent was to examine the Fossa III deposit of Keller (1970). To this end fifty-six (56) sections were measured through the Fossa III deposits at representative places around the cone. At many places the distinctive Tuffi Rossi deposit can be recognized at the base of the section. However, in some places the transition between Tuffi Rossi beds and Fossa III deposits is not clear. In a few sections a thin layer of reddish altered ashes that appear similar to the Tuffi Rossi is interbedded with fresh black deposits that could be either Fossa I or Fossa III beds. Because of possible confusion, radiometric dating is needed to clarify some stratigraphic and age relationships.

ERUPTION CYCLES

An eruption cycle is here meant to be an active period lasting from days to years that has produced a significant deposit on the Fossa cone. The eruption cycles described in this section have produced deposits ranging from one to a few meters in thickness. Our statement concerning eruption cycles must be considered preliminary and subject to future reinterpretation as more data are developed. The actual number of eruption cycles associated with the

Fossa III deposits is not yet known, although as many as five cycles are superimposed at a single locality.

The start of an eruption cycle is marked by a sharp break in the pattern of the deposits. This is noted in some places by an erosional uncomformity, a basal explosion breccia, a phreatic horizon, or a pumice bed. A cycle may be characterized by a dominant type of activity, a peculiar inclusion type, or a recognizable type of pumice lapilli. It is felt that each of the five exposed lava flows (two rhyolites and three trachytes) may be recorded by a corresponding cycle of pyroclastic deposits.

1888-90 cycle. The products of this cycle are the dark black capping beds that form approximately the upper meter of the Fossa III deposits. Erosion has stripped these beds from the upper slopes of the cone and slope wash or lahar beds overlie these deposits on the flanks. The base of this cycle is marked by either a thin orange phreatic breccia or an uncomformity related to the stripping of the underlying deposits. On the caldera floor where both of these features may be missing there is no distinctive marker to note the base of the cycle.

This cycle consists of at least three types of depositional units. On the steep north flank it is composed of a series of lahars with a total thickness between 1 and 3 meters. Between the lahar beds are thin discontinuous lenses of cross-stratified slope wash deposits. At the top of the Fossa tuff cone this cycle is characterized by thin beds of alternating coarse air-fall lapilli and fine ash. These beds are thought to result from a combination of ballistic emplacement for the lapilli and collapse with density flowage (surge?) for the fine ash. Blocks and bombs in this sequence reach a maximum diameter of a few meters near the vent. At the rim sections and on the southern slopes of the cone this cycle also contains typical surge beds. However, surge does not appear to have been a major component of this cycle of activity.

Forgia Vecchia (1739) cycle. These products are best seen on the north flanks of Fossa, where this cycle began with a phreatic explosion breccia, similar to that at the start of the 1888-90 cycle. This was followed by a dry hot surge sequence and ended with the extrusion of the rhyolitic lava of 1739. An important part of this cycle was the formation of the Forgia Veccia tuff cone complex. An understanding of this type of cycle has an important bearing on the volcanic risk related to future eruptions. This cycle seems to be the typical pattern within the Fossa III deposits.

Other cycles. On the northern slopes of Fossa at least five cycles are noted in Figure 1A. The main marker beds that separate or characterize the eruptive cycles include the orange phreatic breccia (O.Ph.B.), yellow phreatic breccia (Y.Ph.B.), trachytic pumice (T.Pu.), and red vesiculated tuff (R.Vt). The trachytic pumice is probably related to a nearby lava flow of the same composition. The cycles in this diagram are given the suffix N, indicating the northern slope, because they may be of only local extent.

Several eruptive cycles have also been noted on the southern slopes of Fossa as shown in Figure 1B. The rhyolitic pumice bed is probably related to the adjacent lava of similar composition. A period of surge emplacement and erosion separates this level from the cycle 4S, a trachytic pumice bed. This 2 m thick pumice horizon is cogenetic with the trachytic lava flow upon which it rests. The rhyolitic pumice (R.Pu) and the trachytic pumice (T.Pu) are widespread marker beds on the southern part of the tuff cone.

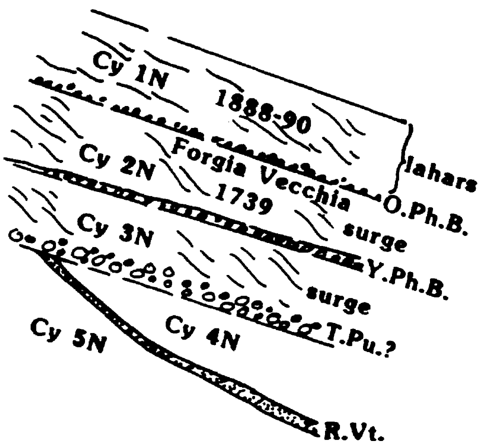

Figure 1A - North Slope

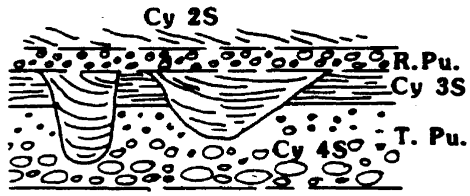

Figure 1B - South Slope

ERUPTION CYCLES

Although the 1888-90 eruption may not be typical of the period that produced the Fossa III deposits, it is the best documented of the historic eruptions (Mercalli, 1891). The active period was characterized by a rapid succession of explosions of various intensity, each separated by a few minutes pause. The rising ash clouds attained a maximum height of only 2 to 3 km, while lapilli, blocks, and bombs were projected out along ballistic paths. The fine ash cloud then either collapsed as a density flow (surge?), or the fine particles settled out as a thin air fall bed. In either case, the resulting deposit has thin beds of alternating coarse and fine products. The largest explosions threw out the large blocks and bombs that are now scattered over the present surface of the tuff cone.

A more common type of eruption cycle would be that of the Forgia Vecchia tuff cones. In this case the eruption began with small phreatic explosions that produced wet ashes building up the tuff cone complex. Construction of a cone followed by collapse and construction of another cone produced the quaquaversal dips common in these cones. As the explosive energy increased, hydromagmatic bursts sent dry hot surges throughout the main caldera. Intermittent surges and lahars then gave way to a final magmatic stage that produced a short stubby lava flow. In some of the cycles a pumice fall is produced at this stage.

There seem to be several factors that influence the type and distribution of pyroclastic products. First, the rate of water/magma mixing is critical (Sheridan & Wohletz, 1981). If the ratio of water to magma is high at the start, phreatic tuff rings of limited extent would be favored. An increase in the rate of magma supply or a decrease in the available water could drive the eruptions to a more violent hydromagmatic stage producing large explosion craters and powerful surge blasts. If the rate of water input becomes very low, but the magma continues to rise, purely magmatic eruptions would produce pumice fall beds and lava domes. If ratios of water to magma were reversed with time, the products could develop in the opposite order.

For any ratio of water/magma input, the morphology of the volcanic edifice plays an important role. There is no evidence for a persistent eruptive column in the products of Fossa III. Repeated eruptions that produce low intermittent bursts are the typical phenomenon. Therefore, the distribution of products is related to the depth of the crater and the energy of the burst. In a deep crater only the larger ballistic clasts and the fine dust will be transported beyond the crater rim. Surge blasts and fine grained ashes that are unable to surmount the crater wall will gradually fill up the crater. If the crater is nearly full of debris, surges are much more likely to travel outward.

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