DISCUSION*

(Deruelle y Brousse, 1984, Rev. Geol. Chile, No. 22, p. 345)

"NUEE ARDENTE" DEPOSITS AT TATA SABAYA VOLCANO: A RE-INTERPRETATION

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ABSTRACT

The "nuée ardente" deposits at Tata Sabaya volcano are re-interpreted on morphological evidence as being those of a large volcanic debris avalanche, similar to that experienced by Mt. St. Helens, May 1980. The prismatic jointed blocks and pumice deposits described by Deruelle and Brousse (1984) are clear evidence of magmatic activity, but the stratigraphic relations between these deposits and those of the debris avalanche are not clear.

RESUMEN

En base a evidencias morfológicas, se interpretan los depósitos de "nube ardiente" del volcán Tata Sabaya (oeste de Bolivia), como depósitos de una gran avalancha volcánica de detritos, similar a la ocurrida en el volcán Saint Helens (noroeste de EE.UU.), en Mayo de 1980. Los bloques con diaclasamiento prismático y los depósitos de pómez descritos por Deruelle y Brousse (1984), son evidencias de actividad magmática, pero las relaciones estratigráficas entre estos depósitos y aquéllos de la avalancha de detritos no son claras.

Deruelle and Brousse (1984) discussed the very interesting deposits of the Tata Sabaya volcano, Bolivia. While their contribution is very useful in drawing attention to what is clearly a remarkably impressive deposit, we feel that their interpretations are incomplete and misleading, particularly their emphasis on "nuée ardente" deposits. It is matter of regret that Deruelle and Brousse provided few details of the physical characteristics of this important deposit, and concentrated instead on petrological aspects. We have not yet had the benefit of field studies at Tata Sabaya, but as the result of studies of Socompa volcano, north Chile, which experienced a similar type of eruption (Francis *et al.*, 1985) and remote sensing study of Tata Sabaya using Landsat Thematic Mapper imagery (Fig. 1), we feel that we are in position to offer a fuller interpretation.

The key to understanding the Tata Sabaya deposits lies in the eruption of Mount St. Helens of May 1980. At 08:32 on the morning of May 18, the northern flank of the volcano collapsed, forming a mejor debris avalanche with a volume of 2.8 km^3, and leaving a large "collapse caldera" or amphitheatre. Failure of the flank of the volcano exposed a "cryptodome" of hot dacitic magma in the core of the volcano, triggering a violent laterally directed blast, which devastated an area of some 500 km^2. Subsequently, a sustained plinian eruption column became established, causing ash fall out over a large area. Intermittent collapse of the eruption column caused the emplacement of a series of pumiceous pyroclastic flows (ignimbrites) which accumulated to form a pumice plain, overlying the debris avalanche deposits. These details have been fully documented in a publication of the United States Geological Survey (Hoblitt *et al.*, 1981).

Although similar eruptions have been described

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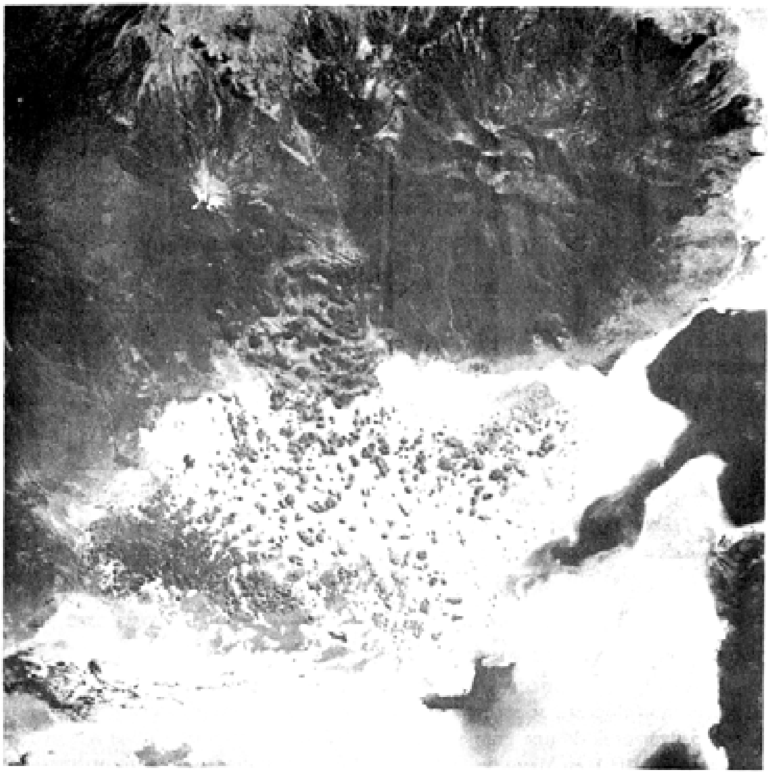

FIG. 1. Landsat Thematic Mapper image (band 4) of Tata Sabaya volcano and its debris avalanche deposit, Bolivia. Large hummocks southeast of volcano are slumped blocks. Amphitheatre left by collapse has been largely filled by younger lavas, though traces of scarp are visible on east flank of the volcano.

previously (for example, the eruption of Shiveluch; Gorshkov and Dubik, 1970) the eruption of Mt. St. Helens focussed attention on this kind of eruption, which is now seen as a relatively common, almost normal, stage in the evolution of a large volcano (Kerr, 1984), and a number of other major volcanic debris avalanche deposits have been recognized: Mt. Shasta, USA (Crandell *et al.*, 1984); Colima, Mexico (Luhr and Prestegaard, 1985); Popocatepetl, Mexico (Robin and Boudal, 1984); and Socompa, Chile (Francis *et al.*, 1985). Siebert (1984) has catalogues approximately 100 other examples in the geological literature. Some of these catastrophic collapse events appear to have also involved a violent blast and magmatic eruption (for example, Socompa), some involved only phreatic eruptions (*e.g.* Bandai-San, 1888), while others may have been simply "cold" collapses or large landslides.

The morphology of the Tata Sabaya deposits, which cover nearly 200 km^2 are unequivocally those of a large debris avalanche deposit (Fig. 1). Amongst the chief diagnostic features are the extensive tracts of hummocky topography with numerous small hills and closed depressions, longitudinal and transverse ridges, and a systematic decrease in hummock size away from the source volcano (Siebert,1984; Ui,1983; Voight *et al.*,1981). The largest hummocks at Tata Sabaya are about 100 m high. Taking an average thickness of 20 m gives a very conservative estimate for the volume of the whole deposit of 4 km^3. The amphitheater left by the collapse event has been largely obscured by post-collapse extrusion of lava flows (such as is currently under way at Mount St. Helens), but parts of the bounding scarps can be seen in places, particularly on the lower eastern flank of the volcano.

Thus, we conclude that Tata Sabaya represents a further example of large scale volcano collapse and debris avalanche formation. But was the eruption magmatic, phreatic or "cold"? Here the field evidence of Deruelle and Brousse (1984) for a "nuée ardente" must be examined. The prismatic jointed blocks that they describe and illustrate are typical of so called "hot avalanche" deposits (Francis *et al.*, 1974; Wright *et al.*, 1980), and clearly indicate some post-collapse magmatic activity. The pumice deposits briefly mentioned are further evidence for this. Unfortunately, however, Deruelle and Brousse do not present sufficient field evidence to determine whether the prismatic blocks and pumice deposits were related to the emplacement of the debris avalanche, in a "Mt. St. Helens" type of eruption, or whether they were emplaced at some later stage, associated with the extrusion of the lava flows and domes that have filled the amphitheater. Our observations of the field relations at Socompa show that prismatic jointed blocks were emplaced both during the catastrophic collapse-related eruption, and also later (over a much smaller area), during the emplacement of the dacitic domes in the amphitheater. The same situation may be true at Tata Sabaya.

Finally, we emphasize the need for use of appropriate terminology. While the deposits described by Deruelle and Brousse clearly include prismatic jointed blocks similar to those found in "nuée ardente" deposits, this does not mean that the whole deposit should be so described. Typical "nuée ardente" deposits have small volumes, usually much less than 0.1 km^3 (Wright *et al.*, 1980), which is trivial compared to the volume of the Tata Sabaya deposits. While "nuée ardente" deposits may sometimes be formed by "hot avalanches" from a growing dacitic dome or plug, these avalanches are also small, and result from the mechanical instability of a growing dome, and not from the collapse of a large sector of the entire volcano. The Tata Sabaya deposits may include features reminiscent of "nuée ardente" deposits, but these are merely one aspect of the phenomena resulting from the initial mejor collapse event.

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