Forum

Friction marks on blocks from pyroclastic flows at the Soufriere Hills volcano, Montserrat: Implications for flow mechanisms: Comment

COMMENT

Lothar M. Schwarzkopf*
Hans-Ulrich Schmincke
Valentin R. Troll
Abteilung Vulkanologie und Petrologie, GEOMAR FZ, Wischhofstrasse 1-3, D-24148 Kiel, Germany

We congratulate Grunewald et al. (2000) on their very detailed study of pseudotachylite-bearing friction marks on andesitic blocks from block-and-ash flow deposits of Soufriere Hills volcano, Montserrat. Their observations contribute substantially to the current discussion on flow models of block-and-ash flows. In a contemporaneous study at Merapi volcano, we (Schwarzkopf and Schmincke, 2000; Schwarzkopf et al., 2001) observed the same type of structures on block surfaces of the 1998 block-and-ash flow deposits and came to similar conclusions with respect to flow mechanisms. Two aspects concerning the formation of pseudotachylites from Merapi volcano are, however, not fully in accordance with the model presented by Grunewald et al. (2000).

Grunewald et al. argued that the compositions of lava blocks, flow matrix, and pseudotachylites indicate that the latter had been generated by flash melting of flow matrix trapped between shearing large blocks, rather than by melting of the blocks themselves. Their interpretation is based on lower SiO_2 and higher Al_2O_3 and CaO in pseudotachylites and the flow matrix compared to bulk rocks, showing no compositional overlap of pseudotachylite glasses with whole rock data. Our results from Merapi clearly indicate bulk melting of the blocks on impact, however. All major elements listed above were found to show a striking overlap of pseudotachylites and whole rock compositional fields for Merapi andesites (Fig. 1).

In addition to the chemical similarities, we observed a gradual decrease in grain size within cataclastic layers toward the glassy pseudotachylite in the friction marks from Merapi (Fig. 2A). We interpreted this gradation to reflect increasing fragmentation or comminution from the host rock toward the pseudotachylite; this allows the inference that deformation rates were at a maximum at the very outer layer, merging into a zone of bulk rock remelting. This grading clearly resembles the marks from the Soufriere Hills (Grunewald et al., 2000, their Fig. 4). Assuming the Grunewald et al. model of matrix melting to be correct (Fig. 2B), the observed grain-size grading is not consistent with experiments by Morrow and Byerlee (1989). These authors performed frictional sliding experiments on granite samples with a 3-mm-thick layer of artificial fault gouge in between and observed that uncrushed particles are concentrated near the center of the gouge zone with finely fractured particles aligned at the sides adjacent to the granite interfaces (Fig. 2C). Such textures were not observed in marks either at Soufriere Hills (Grunewald et al., 2000) or at Merapi.

Combining the chemical and textural evidence, we suggest that pseudotachylites in block-and-ash flows are more likely to form by bulk melting of blocks on impact than by flash melting of flow matrix trapped between blocks. Although the latter mechanism may contribute to the produced pseudotachylite melt, we do not consider flow matrix melting as the major mechanism.

ACKNOWLEDGMENTS

Our work was funded by the Deutsche Forschungsgemeinschaft (grants Schm 250/62-1 to -3).

*E-mail: lschwarzkopf@geomar.de.

REFERENCES CITED

Grunewald, U., Sparks, R.S.J., Kearns, S., and Komorowski, J.C., 2000, Friction marks on blocks from pyroclastic flows at the Soufriere Hills volcano, Montserrat: Implications for flow mechanisms: Geology, v. 28, p. 827–830.

Morrow, C.A., and Byerlee, J.D., 1989, Experimental studies of compaction and dilatancy during frictional sliding on faults containing gouge: Journal of Structural Geology, v. 11, p. 815–825.

Schwarzkopf, L., and Schmincke, H.-U., 2000, The 1998 eruption of Merapi volcano, Central Java, Indonesia: Volumes and structure of the deposits and implications for flow mechanisms: IAVCEI general assembly, Bali, Indonesia, Abstract vol., p. 166.

Schwarzkopf, L.M., Schmincke, H.-U., and Troll, V.R., 2001, Pseudotachylite on impact marks of block surfaces in block-and-ash flows at Merapi volcano, Central Java, Indonesia: International Journal of Earth Sciences, v. 90, p. 769–775.

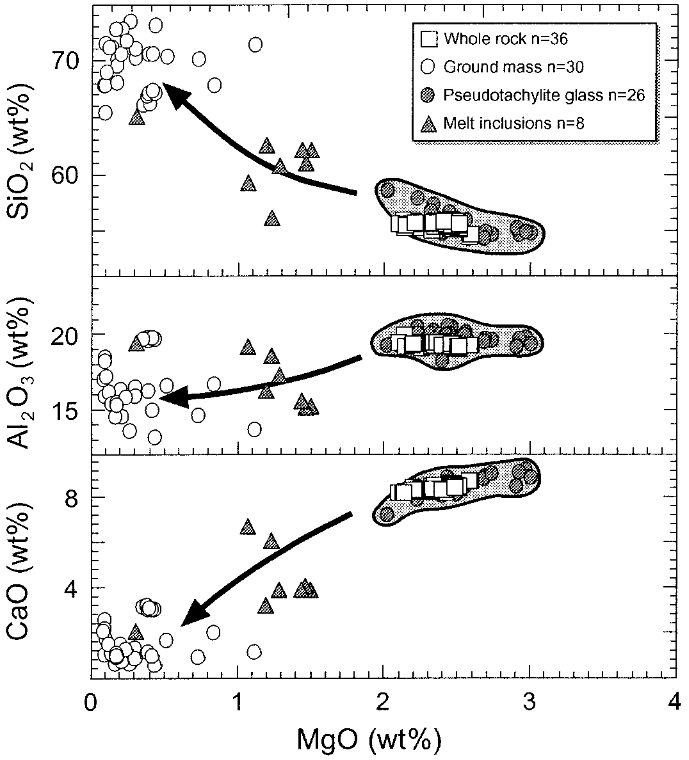

Figure 1. MgO vs. SiO_2, Al_2O_3 and CaO of whole rocks, melt inclusions and ground mass. Arrows indicate trends of magmatic evolution. Compositional fields of pseudotachylites overlap for all elements with the whole rock samples, indicating pseudotachylite formation by bulk melting.

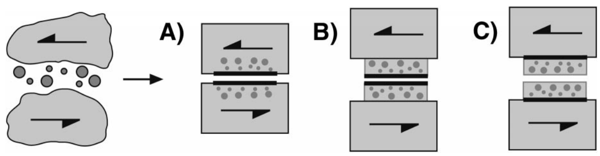

Figure 2. Schematic drawing of blocks moving in a flow prior to collision (left). Resulting friction marks: (A) as observed at Merapi, (B) as suggested by Grunewald et al. (2000), and (C) as expected for the Grunewald et al. model and observations by Morrow and Byerlee (1989). Note different grain-size grading in (B) and (C); thick black lines represent pseudotachylite.