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Interactive comment on "Fall-experiments on Merapi basaltic andesite and constraints on the generation of pyroclastic surges" *by* L. M. Schwarzkopf et al.

L. M. Schwarzkopf et al.

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We thank the anonymous referee #1 for his comments on our manuscript and hope to have correctly understood his remarks in the following responses.

Reviewer comment 1. The presentation of experimental set-up is not very clearness, we can get neither the panorama nor the details. There is a lack of an overview of the whole apparatus, and some details can describe on the side. The tube with pressure transducer is the same diameter (62mm) with the impact chamber, but in the Fig.1 the former looks like situated in the side of the chamber, and the relation between steel rod and pipe, rock sample and furnace, are both unclear.

Author Response Fig.1 clearly shows the desired overview of the whole experimental set-up, and details such as used materials and precise lenghts/diameters are described in section 2.1 of the manuscript. On page 84, lines 14 to 17, we give details of the impact chamber including the part containing the pressure transducer. The pressure transducer is situated in an uptake in the side wall of a steel tube, as shown in fig.1 and correctly noticed by the reviewer. At his place, the pressure transducer does not affect the chamber geometry and generated pressure waves, and is not destroyed in every single experiment. The relation of steel rod and pipe and the relation of rock sample and furnace are described in fig.1 and section 2.1 of the manuscript. There, we precisely describe the experimental procedure and where and how the sample is heated.

Reviewer comment 2. There is a lack of comparison between laboratory and actual condition: The sample of basaltic andesite was taken from Merapi volcano, the paper did not mention where the sample was taken from? The sample is taken from which layer of the deposite, how far it is from the crater, and the author did not depict it. The sample is the deposite of pyroclastic flow, and some different from the material of pyroclastic flow before the generation of cliff-triggered surges.

Author response All details of the used experimental materials that we consider as relevant for the mechanisms and processes are given in section 2.2 of the manuscript. The used rock samples were taken from the 1998 block-and-ash flow deposits as stated in the text; more precisely, they were taken from the central part of unit 4 basal avalanche deposits in the southern part of Kali Putih at a horicontal distance of 4.7 km from the source of the 1998 pyroclastic flows. This unit was not affected by any cliffs in the flow path of the parental block-and-ash flow. But, of course, such precise information is absolutely irrelevant for the understanding of our experiments and their meaning. Cliffs do occur at volcanoes in proximal areas as well as at distal reaches several kilometers away from the flow source. The transport distance of the volcanic material has no influence of its ability to generate cliff-triggered surges - if it still has a temperature of some 400° C as shown by our work. Much more relevant than the travel distance for the studied processes may be the material itself. At Merapi, the juvenile material can be divided into 6 rock types, mainly differing in vesicularity. As stated in the manuscript, we performed our experiments using the most common rock type. To study the influence of the rock material, additional experiments may be run in a future project.

Reviewer comment 3. The impact pressure waves (1) It is very clear from the Fig.2, that the measured pressures are increased with increasing temperature, and are mostly generated by the sudden heating of air after the impact, I would like to suggest the author measure the temperature inside of the impact chamber, and to show the temperature curves with the pressure data in Fig.2 to prove their conclusion of the pressure was generated by the sudden heating of air.

Author response We are grateful for this remark. In the Munich lab, only thermocouples are available to measure temperatures as those in our experiments. These thermocouples have a response time that is much too long for the few tens of milliseconds of our impact experiments.

Reviewer comment (2) I would like to suggest the author make some spectrum or time-frequency analysis on the pressure waves, the results can give some hints with the mechanism of the pressure waves.

Author response To the best of our knowledge and experience, time-frequency analyses may be useful to recognize fragmentation or fracture processes that occur over longer times (seconds, tens of seconds and longer). In our experiments, we have studied processes that last for milliseconds only. Moreover, we regard the use of a high-speed camera, as we have done it, to be much more useful in studying single impact fragmentation processes than any spectrum analysis.

Reviewer comment (3) As mentioned above, the measured pressure are mostly induced by the heating of air, but the major mechanism of fragmentation is the impact, did the author measure the pressure purely come from the impact? Is the impact pressure comparable with that at cliffs in the flow path of block-and-ash flows? I would like

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to point out the induced pressure at cliffs of block-and-ash flows is different with the dynamic pressures of pyroclastic density currents.

Author response The pure impact pressures can be seen in room temperature experiments, confer fig.2. In our view, the “impact pressures” of our experiments are comparable with those occurring at cliffs in nature. Considering the real rock block weights and fall heights in nature, the impact pressures may even be much higher in the real case, i.e. the generation of severe pressure waves is even more likely in nature. We do not exactly understand the last remark of the referee - induced pressures at cliffs are of course different from dynamic pressures of pyroclastic density currents. What we have shown is that pressure waves were generated following the impact and fragmentation of hot volcanic rock material which are in the range of dynamic pressures of pyroclastic density currents.

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