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***Interactive comment on* “Quantification of magma ascent rate through rockfall monitoring at the growing/collapsing lava dome of Volcán de Colima, Mexico” by S. B. Mueller et al.**

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Many volcanoes are located in developing countries. New developments in, for example, seismic tomography provide increasingly robust and complex methods of volcano monitoring. However, due to a lack of resources, monitoring at many volcanoes is limited to only a few stations and, as a result, such state-of-the-art monitoring is not a viable method. This paper presents a method by which the extrusion rate (at volcanoes that continually shed their lava dome through rockfall) can be estimated using a digital camera. The authors show results that demonstrate that their method provides a convincing proxy for the magma extrusion rate. However, I feel that the manuscript

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could benefit from some reorganisation (in the introduction and the discussion section) and clarification. Based on my review, and the comments of the two reviewers, I recommend that your paper can be published in Solid Earth, providing that all of the comments (that sum to a moderate revision) are addressed.

Stylistic comments:

1. Prior to acceptance in Solid Earth Discussions, I asked the corresponding author to change the references in accordance to the Solid Earth format. I see that this was not done. This should be changed.

2. The paper is littered with small English mistakes. I find this surprising since I know at least two of the co-authors are native English speakers. I have corrected some of the grammatical errors in my comments below.

3. The figures look like they have been exported directly from Microsoft Excel (and have fuzzy jpeg edges). I suggest that the authors use a vector graphics editor. I recommend the excellent open source program called Inkscape.

Line 26: “As a consequence of this. . .”

Line 32: After “infrared” I would add “temperature” in parentheses.

Line 33: I would be more specific with “larger events”. Are you talking about rockfalls or eruptions?

Line 37: I prefer “newly-exposed lava dome” to “newly formed cliff”.

Line 38: I would mention that it is only a proxy for the seismic energy.

Line 52: Do you mean 3850 m? Or 3.850 m?

Lines 66-74: This paragraph explains that other lava domes around the world are also cyclic. Is this needed? Can it not be summarised in a sentence? The introduction consistently refers, in great detail, to other volcanoes. I would focus it a little better.

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Line 87: “Varley et al. (2010) studied the events that occurred between February and September 2005 in detail. . .”

Line 99: A recent paper in Solid Earth showed that rocks from Volcán de Colima can quickly regain their permeability following an explosive event. This should be cited here. Kolzenburg, S., M.J. Heap, Y. Lavallée, J.K. Russell, P.G. Meredith, and D.B. Dingwell, 2012. Strength and permeability recovery of tuffisite-bearing andesite. Solid Earth, 3, 191–198.

Line 102: “occurs when magma intrudes into. . .”

Line 111: I dislike the word “done” in a scientific paper. There are many instances of this. I would prefer “performed”, “undertaken”, “implemented”. . .anything but “done”.

Line 121: Remove “itself”.

Line 125: “The dome category can be classified as between. . .”

Line 127: Change “what” to “that”.

Line 132: “Lose” not “loose”.

Line 133: “Obviously one can trigger the other.”

Line 133: Change “at” to “which”.

Line 136: Change “slowly growing” to “slow-growing”.

Line 137: I would remove “Larger volumina or if larger portions. . .” and replace with “If larger volumes. . .”

Line 139: I was under the impression that a BAF is a type of pyroclastic flow. This sentence implies that this may not be the case. I would be more specific here.

Line 139: “Speaking”, not “spoken”.

Line 143: Change “this” with “it”.

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Line 145: This is a bold statement. Is there not a reference for this?

Line 153-161: This is another large paragraph describing monitoring at a different volcano. While I think that such discussion is important, perhaps not in so much detail. This paragraph begs the question “Can this system work at Colima?” Are the resources in place for this?

Line 164: Can you be more specific about what “cigar-shaped” means? What is cigar-shaped exactly?

Line 167: By “centred” do you mean “average”?

Line 168: Change “distant” to “from”.

Line 170: More detailed discussion describing monitoring at another volcano. I think this type of discussion should be set in the context of Colima. Can this also be performed at Colima? If not, why not? I feel that the introduction would benefit from a bit of an overhaul. It lacks focus.

Line 176: It might be useful to mention that these are in North America.

Line 180: Another instance of “done”. Also, do you mean “authors”, not “others”?

Line 192: Another instance of “done”.

Line 200: Change “larger” to “higher”.

Line 205: Change “being” to “was”.

Line 217: You have a paragraph in the previous section that starts with “Several studies have recently investigated the characteristics of seismicity generated by rockfalls.” I’m confused as to the organisation of the introduction. Why not group this together?

Line 218: Another instance of “done”. Also, I would add “. . .at Volcán de Colima” to the end of this sentence.

Line 219: Hang on. The first sentence says “. . .limited work on rockfall seismicity has

been done”. The second sentence says “. . .Much of the previous work deals mainly with the seismic analysis of rockfall or block and ash flow events”. For me, this is an oxymoron. Later you add “Rockfalls at Volcán de Colima can be readily identified by their seismic signal”. Do we know? Or don’t we know?

Line 222: “. . .frequency of rockfalls” can also mean their number. Can you reword this to be more specific please?

Line 224: Why?

Line 241: Change “is using” to “uses”.

Line 251: Between 1 and 15 what?

Line 253: No need for a capital “V” in volcano.

Line 271: What percentage of the total number of rockfalls does this represent? If I look at Figure 10 I see that there were about 12000 rockfall events at Volcán de Colima between that time. I think it would be useful to mention this here. And perhaps include Figure 10 a little earlier in the paper. You should also comment on whether 86 out of 12000 rockfall events is an appropriate number to sample. How were these 86 chosen exactly?

Line 276: Before and after what? The rockfall event? Be specific.

Line 284: How were they “digitally sharpened”?

Lines 293-294: What are the errors on “2300 m” and “1050 m”? What impact does this have on the volume estimate? Doesn’t this also assume that all the rocks are in exactly the same place on the volcano?

Line 299: Remove “itself”.

Line 301: Change “supposed to be” to “approximated to”.

Line 301: Change “show” to “share”.

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Line 304: How exactly is “h” measured? How accurate is this?

Line 307: Sigma is usually used to denote stress. I would use something else.

Line 307: Please comment as to the extent that beta and delta are approximately equal. “a” and “b” are not parallel. So, the bigger the rock, the larger the error.

Line 309: Helicopter flights are required to assess the geometry of the blocks? This is not such a cheap method. Since the method is very approximate, is there not an easier solution? What are the errors if you assume they are spheres? Or cubes?

Lines 287-323: I would actually remove the geometrical method to find the real length of the rock. I’m unconvinced that it’s more accurate, given the assumptions and errors, than just measuring the length of the rocks from the photographs. The key point here is the average geometry of the blocks. It would be interesting to see a table with the volume estimates using your 1:2:3 geometry, a sphere, and a cube.

Line 328: Do you mean 28000 m²? Or 28 m²?

Line 329: The resolution is 20.25 m²? Your photographs can identify rocks that are 20 cm in diameter. Will you not miss most of the smaller rockfall activity if you use the thermal camera?

Line 342: Hang on. “. . .in the case of very small rockfalls (volume of only a few cubic meters) it was not always possible. . .” The resolution on your thermal images is 20.25 m², I would suspect that it’s difficult to identify a rock smaller than 100 m in diameter.

Line 349: Remove “in the end”.

Lines 359-363: I read through this text and looked at the pictures numerous times, and I still can’t figure out what’s going on. Firstly, are you sure that you’re following the correct rock? The rock in C1 is at 106 °C. As it rolls down the slope (since there is no time difference between the pictures we will have to take your word that it is “during” the rockfall event) it is now 402 °C (even though this temperature does not appear on the

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scale). How did it get hotter? Following the rockfall event the temperature in C1 is now 305 °C. However, could this not be the very hot rock next to C1 in panel “b”? Perhaps this is the one that fell? Panel “c”, for me, shows that the rock broke into many pieces during its descent. However, there is no discussion of this in the paper. Did you observe the rocks breaking? How would this impact your volume estimates? In conclusion, I’m not convinced of the worth of the thermal imagery. First, this is a specialist tool. Second, the resolution isn’t as high as the photography. Third, it seems difficult to be sure what’s going on (unless you have corresponding photographs). Further, in Figures 5 and 6 you have temperature data for suspiciously low volume rocks. How accurate is this?

Lines 375-380: Please discuss this method in more detail. This energy is the energy of the received waveform and assumes that attenuation is equal for each event (big ones, small ones, near ones, far ones).

Line 389: So, the bigger the rock, the larger the temperature difference between the external surface and the surface in contact with the dome? Nowhere is this simple relationship described. Does it make sense?

Line 426: Why March?

Line 428: I would describe this as a “proxy for the energy of the received signal”.

Line 441: “20 °C”.

Line 448: Change “can” to “could”.

Line 459: I thought this was the discussion. I think this section on extrusion rate should form the first subsection of the discussion section.

Line 472: I would reword the start of this sentence.

Line 474: What is “D”? The duration?

Lines 480-481: “21,000 m³”, 20.000 m³”. I assume the authors mean “20 000 m³”.

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Can this be corrected?

Line 487: I can't see how this method is more accurate. Can the authors elaborate?

Line 494: Can you add a sentence describing whether this small subset of the total number of rockfall events is representative?

Line 502: You mean 1 mm on the picture?

Line 517: How exactly was 35% calculated?

Line 526: What estimate did Lavallée et al. (2012) provide?

Line 531: The authors should comment on whether this method can be applied to other volcanoes worldwide.

Line 566: I feel that the end of the discussion requires a sentence akin to "While we appreciate these obvious flaws, we contend that our practical and simple method provides a reliable approximation for the magma extrusion rate at volcanoes that continuously shed their lava dome through rockfall. . ."

Figure 6: By "Cut Off Temperature" do you mean ΔT ?

Figure 8: What is the scale on the y-axis of "a"? Amplitude?

Figure 11: Remove the commas in the y-axis. And in the figure caption.

Figure 12: The energy proxy is now called "Es". And the units are different. Remove the commas in the y-axis.

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