

## **Response to the Referee 2's comments**

**Manuscript ID: EGUSPHERE-2022-268**

**Title: An experimental perspective on the effects of initial structures on rock avalanches' propagation and sedimentary characteristics**

**Authors: Zhao Duan, Yan-Bin Wu, Qing Zhang, Zhen-Yan Li, Lin Yuan, Kai Wang, and Yang Liu**

Dear Andrew Mitchell:

On behalf of my co-authors, we would like to express our sincere gratitude for your comments. We have considered your comments very carefully and made corresponding revisions. The revisions are highlighted in red in the manuscript. The responses to your comments are detailed as follows, in which the paragraphs in **normal fonts** are the comments and the authors' responses are in *italic*.

Yours sincerely,

Yan-Bin Wu

Corresponding author: Yan-Bin Wu

E-mail: 19209071021@stu.xust.edu.cn

### **Response to the comments:**

#### **General comments**

**Comment 1:** The paper does a good job of showing how this work builds on previous physical modelling studies that examined the effect of large particles. However, there are some general comments that should be addressed or expanded upon.

1. In the title and through out the paper, the authors refer to “deposit architecture”. I would replace architecture with “morphology”, “structure”, or something similar, as “architecture” implies human design.

*Answer: Thank you very much for your comments. We have replaced “architecture” with “morphology” throughout the manuscript. Please check.*

**Comment 2:** The authors refer to “rock masses disaggregated by discontinuous sets” throughout the manuscript. I recommend the authors use more standard and descriptive terminology for the description of rock masses, particularly when describing actual events, and the description/classification system should be referenced. For example, many of the references used by the authors use the GSI system to describe the in - place source rock masses (Hoek and Brown, 1997). I associate disaggregation with the process where the rock mass goes from its intact state in the source pre - failure, to the final, fragmented deposit, not a as a characteristic of the source area. Throughout “discontinuous sets” should be replaced by “discontinuity sets”.

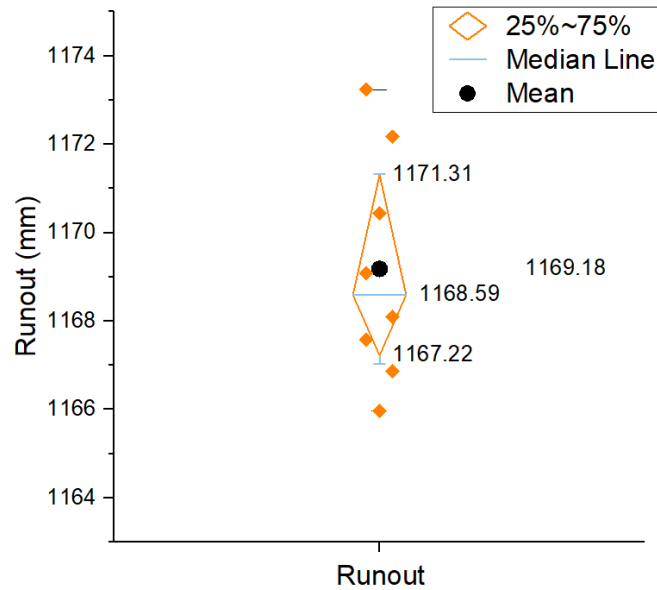
*Answer: Thank you very much for your suggestions. We have replaced “discontinuous sets” with “discontinuity sets” throughout the manuscript after referring the GSI systems. Please check.*

**Comment 3:** The experimental procedure has a variety of initial block configurations that have been systematically tested. However, as I understand it, only one run was completed with each block configuration, so the repeatability of the experiments cannot be quantitatively assessed. The variation between many of the experiments is rather small, so it is hard to assess whether these differences in runout and deposit area are the result of the changes in block configuration, or the result of natural variability within the experiments. I think this should be addressed in the discussion when interpreting the results.

*Answer: Thank you very much for your comments. In fact, we did a serious of pre-experiments for quantifying the experimental error. The pre-experiments were carried out at a slope angle of 50°, centre gravity height of 0.7 m, and sandbox volume of  $3.6 \times 10^{-3}m^3$ . The experimental condition is same with that in this manuscript. The material was just sand. We did repeated experiments of total 8 times, and obtained the mean value of the runouts of the repeated experiments and corresponding standard deviation (figure 1). The mean runout is 1169.18 mm, and the standard deviation is 2.41 mm.*

*The variation of runout at different experimental conditions in the manuscript is larger than the standard deviation, and larger than 3 times standard deviation. Therefore, it is plausible to consider the difference of experimental results is caused by the experimental variables.*

*We have supplemented related descriptions in the manuscript. please see line 301-305.*



**Figure 1: error quantification of runout for repeated experiments**

**Comment 4:** I do not agree with referring the cause of the rotation resulting in the zig zag pattern of the large blocks in the deposits as a “bending moment”, as that is generally used to refer to a moment that would cause a deflection within the block, as opposed to something that would cause a rotation of the entire block.

**Answer:** *Thank you very much for your comments. We have replaced “bending moment” with “moment” throughout the manuscript.*

**Comment 5:** The limitations of the experiments should be more clearly stated throughout the manuscript. One factor of note is the “excess mobility” of rock avalanches, with travel angles less than what is expected on the basis of friction (following the definition of Hsü, 1975). The experimental results presented in this study all have a travel angle of approximately 30 degrees, which is within the range that would be expected for a sandy material. At some point within the paper it should also be stated there is significant scientific debate regarding the physical processes that result in the enhanced mobility of rock avalanches. Given the limited mobility of the laboratory flows, it is likely the experiments are not capturing the mechanisms leading to the mobility of natural events. There was a review paper published recently that addresses some of the potential effects of discontinuities on rock avalanches (Lan et al., 2022) which could help to provide context.

**Answer:** *Thank you very much for your comments. We have added descriptions in “4.1 runout of rock avalanches” on the discussion of limitation. Please see line 333-339.*

*The paper of Lan et al., (2022) is really helpful for our study, especially for the research*

*background. We have supplemented related descriptions. Please see line 38-41.*

### **Specific comments**

**Comment 6:** Line 10: I'm not sure what is meant by "direct threads", I would recommend "methods" or some similar wording.

*Answer: Thank you very much for your comments. We have replaced "direct threads" by "methods". Please see line 10.*

**Comment 7:** Line 11: The phrase "geologic setting" is used here and throughout the paper, which is very broad, it could refer to the lithology, tectonics, etc. As the authors seem to be discussing the structural geology in particular, I would make that clear throughout.

*Answer: Thank you very much for your suggestions. We have replaced "geologic setting" with a more specific word "characteristics of structural geology" throughout the manuscript according to your suggestions.*

**Comment 8:** Line 11: When I think of the "structures of the disaggregated rock mass", I interpret that as the deposit structure, however; I think the authors are referring to the in-place rock mass structure.

*Answer: Thank you very much for your comments. We have substituted "in-place rock mass structure" for "structures of the disaggregated rock mass". Please see line 11.*

**Comment 9:** Line 19-20: This sentence is unclear, I think the authors are saying a zigzag structure is created in the blocks resulting from the lateral spreading of the deposits causing the blocks to rotate.

*Answer: Thank you very much for your comments. We reorganized the sentence, and replaced it with "a zigzag structure is created in the blocks resulting from the lateral spreading of the deposits causing the blocks to rotate" according to your suggestions. Please see line 20.*

**Comment 10:** Line 26: You could say that rock avalanches are a "ubiquitous geological phenomenon in mountainous regions", but there are many places on the earth's surface in general where they are not found.

*Answer: Thank you very much for your comments. We have replaced “Rock avalanches are a type of ubiquitous geological phenomenon on the earth’s surface” with “Rock avalanches are a type of ubiquitous geological phenomenon in mountainous regions”. Please see line 26.*

**Comment 11:** Line 32-33: What was unique about the block orientation and distribution in the referenced studies?

*Answer: Thank you very much for your comments. In the referenced studies, what the arrangement of blocks’ long axis is parallel or perpendicular to the motion direction of rock avalanches is the unique about the block orientation and distribution. We have supplemented related statement in the revised manuscript. Please see line 33.*

**Comment 12:** Line 39: Remove the phrase “In addition”, as no other methods of examining rock avalanches have been introduced, missing “the” between “of” and “fundamental”.

*Answer: Thank you very much for your comments. We removed the phrase “In addition”, and added a “the” between “of” and “fundamental”. Please see line 42.*

**Comment 13:** Line 40-44: References should be provided to support the statements made in these sentences.

*Answer: Thank you very much for your suggestions. We have provided references to support the statements. Please see line 44-46 and 49-50.*

**Comment 14:** Line 43: Be more specific as the initial structures within the rock mass, as all rock masses have some sort of structure.

*Answer: Thank you very much for your comments. We have specified the initial structures within the rock mass. please see line 47-48.*

**Comment 15:** Line 61-63: Following general comment 5, the previous work referenced has looked at the effect of the movement of the material, particularly areas of extension and compression within the sliding mass as it comes to rest, and that effects the orientation of the blocks within the deposit. With the limited runout of the lab cases there is still significant uncertainty surrounding the effect of the source zone geologic structures, and if that affects the deposit morphology after a long runout event, or if at longer runouts the effects of source geologic structures are of less importance than the movement processes for the final deposit.

*Answer: Thank you very much for your comments. After a careful consideration, we agree with your perspective. We have added limitation in “4.1 runout of rock avalanches”. Please see line 333-339.*

**Comment 16:** Line 70: It is unclear what the authors mean by “differences in geological environments”, or how the geology relates to a systematic field investigation of the source structures and deposit characteristics.

*Answer: Thank you very much for your comments. We apologize for not clearly describing the sentence and making you confusing. We reorganized the sentence as “In rock avalanches, it is hard to know whether the characteristics of structural geology of the source volume are related to the orientation of large blocks in the deposits by field investigation due to what a role the motion process of rock avalanches played was unknown.” Please see line 75-77.*

**Comment 17:** Line 70-71: Please elaborate on the motion processes, what are the specific challenges with obtaining this information?

*Answer: Thank you very much for your comments. We apologize for not clearly describing the sentence and making you confusing. We mean it is hard to obtain the motion process of rock avalanches due to we do not know when and where they will occur. We have reorganized the sentence. Please see line 75-77.*

**Comment 18:** Line 75: Replace “parallelly” with “parallel”.

*Answer: Thank you very much for your suggestions. We have replaced “parallelly” with “parallel”. Please see line 81.*

**Comment 19:** Line 84-85: State what the interpretations from these experiments were.

*Answer: Thank you very much for your suggestions. We have supplemented statements on what the interpretations from these experiments were. Please see line 91.*

**Comment 20:** Line 85-86: Delete the words “Nonetheless” and “about”, state the main findings regarding the deposit morphologies and sedimentary characteristics.

*Answer: Thank you very much for your comments. We have deleted words “nonetheless” and “about”, and supplemented statements on the main findings regarding the deposit morphologies and sedimentary characteristics. Please see line 92-93.*

**Comment 21:** Line 94: Missing the word “the” before “resulting”.

*Answer: Thank you very much for your comments. We have added the word “the” before “resulting”. Please see line 101.*

**Comment 22:** Line 120: Recommend changing “bird view” to “overhead view”, as some readers may not be familiar with the phrase “birds - eye view” .

*Answer: Thank you very much for your comments. We have replaced “bird view” with “overhead view”. Please see line 127.*

**Comment 23:** Lines 127 – 128: I find this sentence difficult to follow, I recommend rephrasing as: “A layer of quartz sand was attached to the surface of the cuboid blocks using epoxy glue to produce a rough surface.”

*Answer: Thank you very much for your suggestions. We have rephrased the sentence as “A layer of quartz sand was attached to the surface of the cuboid blocks using epoxy glue to produce a rough surface” according to your suggestions. Please see line 133-134.*

**Comment 24:** Line 130: Replace “uneven coefficient” with “uniformity coefficient”, I would recommend including a reference for the Cc and Cu for readers who may not be familiar with particle size distribution metrics.

*Answer: Thank you very much for your comments. We have replaced “uneven coefficient” with “uniformity coefficient”. Please see line 136. In addition, we have given more information on Cc and Cu. Please see line 136-139.*

**Comment 25:** Lines 131 – 132: What is the significance of the proportion of particles in the 0.075 mm to 0.42 mm range? The upper bound of 0.42 mm does not correspond to a particle size class in the MIT system shown in Figure 4. On line 132 it states the average particle size is 0.18 mm, while on line 130, it states 0.2 mm, this only needs to be stated once, and a consistent number of significant figures should be used.

*Answer: Thank you very much for your comments. In fact, it is meaningless so that we removed the sentence on the proportion of particles in the 0.075 mm to 0.42 mm range. We only left the average particle size of 0.18mm.*

**Comment 26:** Lines 132 – 133: As written it is not clear if the interface values between the plexiglass and the sand were from lab testing or assumed values. The information included in

lines 158 – 162 as well as Figure 7 should be a paragraph within the Materials section.

*Answer: Thank you very much for your comments. The interface values between the plexiglass and the sand were from lab testing. We have moved the information included in lines 158 – 162 as well as Figure 7 within the Materials section. Please see line 144-148 and 154.*

**Comment 27:** Line 136: The ratio of glue to sand was already stated in line 126.

*Answer: Thank you very much for your comments. We have removed the sentence.*

**Comment 28:** Line 151: The volume of the sand was stated already on line 111.

*Answer: Thank you very much for your comments. We have deleted the sentence.*

**Comment 29:** Line 153: Rephrase “the sand of 150 g” as “150 g of sand”.

Table 1: The center of gravity height and matrix density could be pulled out of the table as they have the same values for all experiments.

Figure 9: I think it would be helpful to show where the slope break is on the displacement plots, that is an important control on the pattern of acceleration and deceleration and will help readers to interpret the results shown.

*Answer: Thank you very much for your suggestions. We have rephrased “the sand of 150 g” as “150 g of sand”. Please see line 167 and 168.*

*We have removed the center of gravity height and matrix density from Table 1. We have marked the time the front of the mass flow reached to the slope break in Figure 9.*

**Comment 30:** Lines 192 – 193: As you say below, the time to the peak velocity just the time to reach the bottom of the steep incline, which implies this finding is related to the experimental apparatus, not the effect of the slope angle per se. If the steep slope were longer, it would be expected that the material would continue to accelerate, and the steeper slopes would attain higher velocities until a terminal velocity was reached.

*Answer: Thank you very much for your comments. You are absolutely right, that is due to the set of slope angle is always larger than the internal friction angle of the experimental*

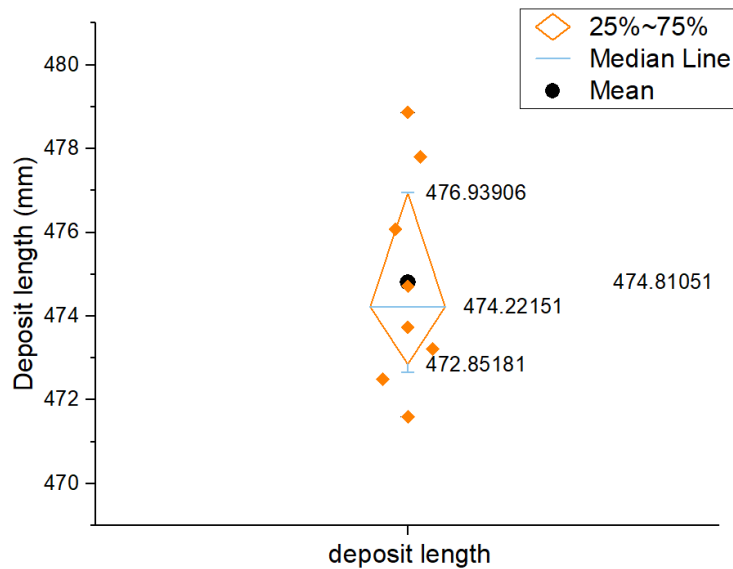


material. We added related descriptions in this part. Please see line 203-205.

**Comment 31:** Lines 219 – 220: It should be noted the difference in the results for the different configurations is quite small, a rough comparison of the plots indicates a relative difference from the LV50 case well under 20% in most cases. With the relatively small difference between the cases, how robust are the trends discussed further in the paper?

*Answer: Thank you very much for your comments. In fact, we did a serious of pre-experiments for quantifying the experimental error. The pre-experiments were carried out at a slope angle of 50°, centre gravity height of 0.7 m, and sandbox volume of  $3.6 \times 10^{-3} m^3$ . The experimental condition is same with that in this manuscript. The material was just sand. We did repeated experiments of total 8 times, and obtained the mean value of the deposit lengths of the repeated experiments and corresponding standard deviation (figure 2). The mean deposit length is 474.81 mm, and the standard deviation is 2.41 mm. please see line 299-301.*

*The variation of deposit length at different experimental conditions in the manuscript is larger than the standard deviation, and larger than 3 times standard deviation. Therefore, it is plausible to consider the difference of experimental results is caused by the experimental variables.*



**Figure 2:** error quantification of repeated experiments.

**Comment 32:** Line 230: Replace “data” with “digital”.

*Answer: Thank you very much for your comments. We have replaced “data” with “digital”.*

*Please see line 239.*

**Comment 33:** Line 231: Replace “under the impact of” with “resulting from”.

*Answer: Thank you very much for your comments. We have replaced “under the impact of” with “resulting from”. Please see line 240.*

**Comment 34:** Line 234: I’m confused by the statement that “no apparent protrusion of the blocks was visible”, to me it seems that raised areas are visible in the deposits for the EP, LP, and R configurations, albeit less pronounced than is seen for the LV tests.

*Answer: Thank you very much for your suggestions. We have rewritten the sentence as “the protrusion of blocks was less obvious than that seen for the LV experiments (Figure 11(a))”. Please see line 243-244.*

**Comment 35:** Line 235: Is “separation of the blocks and granular matrix” referring to blocks that run out further than the main deposit, such as the LV - 40 and LV - 50 results? Please make this clearer, and ideally highlight the behaviour you are referring to in the figure.

Figure 11: The x and axis on the one panel of 11b is quite small, I recommend more clearly labelling the x and y directions for these figures to make the following discussion easier to follow. In the legend I would also recommend replacing “arrangement of zigzag - like” with “zigzag - like structures” for consistency with how it is referred to in the main text.

*Answer: Thank you very much for your suggestions. We mean that most part of the blocks’ body immersed in the granular matrixes, and have rewritten this sentence. Please see line 243-244.*

*We have given a clearer x and coordinate axis in Figure 11. And we have replaced the “arrangement of zigzag-like” with “zigzag-like structure” in the legend.*

**Comment 36:** Line 242: Replace “present” with “presents”.

*Answer: Thank you very much for your comments. We have replaced “present” with “presents”. Please see line 251.*

**Comment 37:** Line 244: It seems strange to refer to “contact by matrices” as a contact type, since the matrix is between the blocks and preventing them being in direct contact. I would

suggest referring to what are currently called contact types more generally “deposit characteristics”, and coming up with different terminology to describe the blocks having a consistent orientation, but separated by matrix material.

*Answer: Thank you very much for your comments. In fact, here we mean the contact ways of blocks. In the deposit, there are direct contact and non-direct contact (the blocks are separated by the matrix), and in most cases they are non-direct contact. Therefore, we changed the phrase “contact by matrices” to “non-direct contact”. Please see line 255 and 257.*

**Comment 38:** Line 246: What is meant by the R - 50 deposit exhibiting “no symmetry” , to me the large blocks are approximately evenly distributed throughout the deposit Is the sentence “Direct contact and contact by matrixes were just two kinds of contact ways” meant to say the those were the only two contact types observed in the R - 50 test? As written, it is not clear.

*Answer: Thank you very much for your comments. The orientation of blocks’ long axis is not symmetry according to the y-axis. The sentence “Direct contact and contact by matrixes were just two kinds of contact ways” indeed means there are only two contact types observed in the R-50 test. We have rewritten the sentence as “There were only direct contact and non-direct contact observed in the deposit”. Please see line 257.*

**Comment 39:** Line 247: The sentence “The blocks in the deposit showed a good sequence” is unclear, please be more descriptive about what the sequence of the blocks was, and how it differs from any other tests. Replace “up” with “upper”.

*Answer: Thank you very much for your comments. We have supplemented descriptions on the sequence of blocks. The sequence is the position relationship of the blocks, and it inherited the initial position sequence in the sand container. In fact, we mean that the blocks in all of these experiments showed good sequence, so that there is no difference from any other tests. We are sorrow for our unclear descriptions. We have reorganized the sentence. Please see line 262-263. We have replaced “up” with “upper”. Please see line 264.*

**Comment 40:** Lines 248 – 251: Was the colour pattern for the blocks the same for each experiment, or is this information only applicable to the LV experiments? It would be helpful to refer back to the schematic in Figure 6.

*Answer: Thank you very much for your comments. The colour pattern for the blocks is not always the same for the experiments, but we show the colour pattern in Figure 7. The information is applicable to all of the experiments with blocks, and we just take LV experiment as an example to describe.*

**Comment 41:** Line 252: By “farther distribution of the blocks”, do you mean the blocks are more spread out? Please clarify this point.

*Answer: Thank you very much for your comments. Yes, we mean the blocks are more spread out. And we have rewritten the sentence. Please see line 268.*

**Comment 42:** Lines 253 – 254: The EP cases have very similar deposits to the NB cases, is the general statement that the blocks control mobility supported for all cases?

*Answer: Thank you very much for your suggestions. In order to more preciseness, we rewritten the sentence as “In most cases, the blocks played an important role in controlling the mobility of rock avalanches”. Please see line 269.*

**Comment 43:** Line 259: Replace “counted” with “measured”.

*Answer: Thank you very much for your suggestions. We have replaced “counted” with “measured”. Please see line 271.*

**Comment 44:** Lines 262 – 263: It seems to me that the scatter in the EP case is quite random, with no dominant direction.

*Answer: Thank you very much for your comments. We have rewritten the sentence as “The orientation distribution was scatter at the condition of EP-50, and hence there was no dominant orientation of the blocks”. Please see line 274-275.*

**Comment 45:** Line 267: Are the orientations to 40 and 120 degrees significant? Visually the pattern looks very consistent for all of the LV results.

*Answer: Thank you very much for your comments. There is no significant and we just to show the changes in orientation of blocks. Yes, you are right, the orientation of bocks is very consistent for all of the LV results.*

**Comment 46:** Line 277: I would add “is thought to be” before “decreased”, as this is an inference and not something directly measured in the experiments.

*Answer: Thank you very much for your comments. We have added “is thought to be” before “decreased”. Please see line 289.*

**Comment 47:** Line 278: Is the “high level of the center of gravity” referring to the deposit thickness? Please clarify.

*Answer: Thank you very much for your suggestions. Yes, we mean the deposit thickness. We have rewritten this sentence. Please see line 290-291.*

**Comment 48:** Lines 279 – 280: With the variation in deposit thickness being on the order of millimeters between the various tests with a fall height of 0.7 m, is the variation in the final potential energy significant?

*Answer: Thank you very much for your comments. You are right, the variation in deposit thickness is on the order of millimeters, which is smaller comparing with the fall height of 0.7 m. Therefore, we have rewritten the sentence. Please see line 290-291.*

**Comment 49:** Line 281: Replace “present” with “aligned”.

*Answer: Thank you very much for your comments. We have replaced “present” with “aligned”. Please see line 292.*

**Comment 50:** Lines 286 – 287: Make it clear that statements related to collisions and frictional losses are inferences.

*Answer: Thank you very much for your comments. We have added descriptions in the sentence to indicate that the statements related to collisions and frictional losses are inferences. Please see line 298-299.*

**Comment 51:** Lines 296 & 297: Replace “interlock” with “interlocked”.

*Answer: Thank you very much for your comments. We have replaced “interlock” with “interlocked”. Please see line 312 and 313.*

**Comment 52:** Lines 300 – 302: Is this referring to the present study, or that of Manzella and Labiouse?

*Answer: Thank you very much for your comments. The sentences refer to the present study. We have indicated that is in present study. Please see line 317-318.*

**Comment 53:** Lines 307 – 311: Following general comment 2, please be more descriptive

and provide details on the specific rock mass structures and orientation of discontinuity sets for both cases discussed.

***Answer: Thank you very much for your suggestions. We have provided specific rock mass structures and orientation of discontinuity sets for both cases. Please see line 327-330.***

**Comment 54:** Lines 314 – 315: The influence of topography has been shown to have a strong influence on the runout distance of rock avalanches using analysis of much larger datasets of different cases (Nicoletti and Sorisso - Valvo, 1991; Strom et al., 2019; Mitchell et al. 2020; Liu et al., 2021). The effect of volume on runout is also very well established, going back to Heim (1932). The volumes of the two cases mentioned are radically different, with the Ganlou event having a volume of  $5.2 \times 10^4 \text{ m}^3$ , while the Sierre rock avalanche has an estimated volume of  $1.6 \times 10^9 \text{ m}^3$ , according to the studies referenced by the authors. Using these two events as test cases for the effect of discontinuity orientation is a poor comparison, because the mobility difference expected based on the difference in volume is so great. Any comparison to infer the effect of the rock mass structure on observed runout would have to control for the effects of volume and topography.

***Answer: Thank you very much for your comments. We have removed related deduction due to the volume and topography of these two rock avalanches are also different. We added this as a limitation of this study. Please see line 331-337.***

**Comment 55:** Lines 319 & 321: Do you mean “beneath the blocks” as opposed to “somewhere between the deposits”? It is not clear as written.

***Answer: Thank you very much for your comments. We mean underlying the blocks. We have reorganized the sentence clear. Please see line 341 and 342.***

**Comment 56:** Line 322 – 324: Please clarify this sentence and check the grammar.

***Answer: Thank you very much for your comments. We have reorganized the sentence to make it clear. Please see line 344-346.***

**Comment 57:** Lines 326 – 327: By “initial discontinuous structures”, do you mean the blocks remain separated by matrix material at deposition, or that the arrangement of the blocks in the source area is preserved in the deposit? Please clarify.

***Answer: Thank you very much for your comments. We mean that the arrangement of the blocks in the source area is preserved in the deposit and have rewritten the sentence. Please see line 346-347.***

**Comment 58:** Line 329: Delete “a” between “to” and “less”.

*Answer: Thank you very much for your suggestions. We have deleted the “a”.*

**Comment 59:** Line 337: It is not clear what is meant by the blocks “immersing into the area”, please be more specific.

*Answer: Thank you very much for your suggestions. We mean that the matrixes surrounding the blocks to be pushed aside and leaving space to allow the blocks immersing into. We have rewritten the sentence. Please see line 358-359.*

**Comment 60:** Lines 346 – 348: Following general comment 4., remove “bending”. Replace the period between “clockwise” and “the” with “and”.

*Answer: Thank you very much for your comments. We have replaced the period with “and”. Please see line 368.*

**Comment 61:** Lines 385 – 387: I think this is all referring to the matrix promoting rolling contacts between the blocks, but this should be stated more directly, for example, the statement “the contact of the blocks flexible, and hence, easily have rotation and variation in position” is not clear.

Figure 14: Provide a more descriptive caption that refers to all four panels.

*Answer: Thank you very much for your comments. We have reorganized the sentences as “The presence of the matrixes promoted rolling contact between blocks” to make it directly. Please see line 407-408.*

*We have provided a more descriptive caption referring to all the four panels. Please see line 419-420.*

**Comment 62:** Lines 411 to 413: Is this sentence referring to the current study, or describing characteristics of natural rock avalanches?

*Answer: Thank you very much for your comments. In this sentence, we mean the natural rock avalanches. We have indicated that in line 433. Please check.*

**Comment 63:** Line 416: Replace “actual” with “realistic”.

*Answer: Thank you very much for your comments. We have replaced “actual” with “realistic”. Please see line 437.*

**Comment 64:** Line 429: Specify the relationship with slope angle was only tested for the LV configuration.

*Answer: Thank you very much for your comments. We have specified the relationship with slope angle was only tested for the LV configuration. Please see line 450.*

**Comment 65:** Lines 435 – 436: Contradicts line 364 which stated that the block structure went from disorderly to orderly. Given there was only one test of the random configuration, how much confidence is there that a different random arrangement of blocks would not lead to a different result?

*Answer: Thank you very much for your comments. We have removed this conclusion in case of any misleading due to the deduction.*