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Earth Surface Dynamics Discussions

Interactive comment on "Groundwater seepage landscapes from local or distal sources in experiments and on Mars" *by* W. A. Marra et al.

Anonymous Referee #2

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General The manuscript deals with the formation of theater-head hydrological channels by analogical sandy box experiments, testing different water supply processes (groundwater or association of precipitation and groundwater) and different locations of water sources (local water table or distant water table). My general point of view concerning this part of manuscript is quite positive, even if some clarifications must be done. Indeed, authors used "seepage" word in the title and used "sapping" word in the text. These are two different processes. At the manuscript reading, authors seem themselves unclear on what process(es) they modeled. It is quite confusing. Therefore, it is necessary to add the definition of these processes, list parameters that they differentiate and determine which process they model. Minor points must be added concerning the experimental design and parameters to help readers. In my point of view, they modeled seepage process in no cohesive material forming fluvial channels.

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Interactive Discussion
Discussion Paper

They do not find channel bifurcations. How could they explain that ?

Different Martian fluvial valley analogs have been explored in regards to the experiment results. Although this approach seems interesting and promising, the choice of examples is not relevant and has no direct relationships with parameters tested in analogical experiment. Indeed, they studied Martian valley networks (not channel networks) with theater-heads showing a lowly branching pattern. This 2D channel/valley organization is not observed in their experiments. Therefore, this part must be either removed from the part dealing with analogical experiment in other manuscript or try to find good Martian analogs without channel/valley bifurcations. The second point concerns the valley formation in relation with the channel formation on Earth and Mars. How do they explain the formation processes in regards to their experiment? The third point is the origin of distant water table? How do they supply the distant water table, on Earth and on Mars? What are the climatic implications? The fourth point and the more critical is the lithology. Is it possible to compare a no cohesive material like sand to Martian lithology (expected to be volcanic rocks (from lava to volcanic ash) and locally sedimentary rocks not sediments)? This point is not discussed.

The manuscript is well enough written, but requires typewriting corrections.

For these reasons, I recommend the authors to revise their manuscript to be in order for publication with MAJOR REVISIONS. ———————————————————————- The following lists some specific remarks and comments: Abstract Rewrite abstract in regards to seepage vs sapping to be in line with the main manuscript outline or title. Line 5. “but the climate implications are quite different”. Remove or explain why. Line 12. “ We study sapping. . .” seepage or sapping ? Line 14. Use another word than “piracy” or explain the physical process. Lines 19-21. You mention only two Martian examples whereas you present other examples in the part 4. Be coherent.

1. Introduction p.2. Lines 23-25. It will be good that you describe geometrically

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the theater-head channels or valleys before listing terrestrial and Martian examples. In addition, it is necessary to discriminate formation processes between valleys and channels. p.3. lines 5-15. Be clearer between processes and observed objects. For example, Laity and Malin (1985) explained the sapping process and not the seepage process. You mentioned that the "head-wall retreat is due to undercutting by water fall erosion of a hard cap rocks (lamb et al. 2006) would be the best explanation for Snake river and Chilean valleys formation (Fig. 1 d and e). You ignore the contribution of runoff, overflow effect at local scale and infiltration forming temporary water table at regional scale. Lines 16-17. "the main argument against a groundwater origin of the Martian valleys is the limited erodibility by the low seepage discharge (Lamb et al.,2006). It is quite surprising, isn't it? How do you form valleys on Mars? Could you explain this point. p.3.Lines 19-21. No, there are Martian examples showing these morphological relationships (e.g., Mangold et al., 2004; Mangold et al., 2008, Ansan et al. 2008, Lucas et al., 2009).

Lucas, A., V. Ansan, N. Mangold, 2009. New insight on genetic links between outflows and chasmata on Valles Marineris plateau, Mars. Géomorphologie: relief, processus, environnement, n° 1, p. 32-35. Mangold. N., V. Ansan, Ph. Masson, C. Quantin, G. Neukum, 2008. Geomorphic study of fluvial landforms of northern Valles Marineris plateau, Mars, using HRSC/MEX images and topography. J. Geophys. Res., vol. 113, E08009,doi:10.1029/2007JE002985. Ansan ,V., N. Mangold, Ph. Masson, E. Gailhardis, G. Neukum, 2008. Topography of valley networks on Mars from the Mars Express High Resolution Stereo Camera Digital Elevation Models. J. Geophys Res., vol. 113, E07006, doi:10.1029/2007JE002986. Mangold, N., C. Quantin, V. Ansan, C. Delacourt, P. Allemand, 2004. Evidence for precipitation on Mars from dendritic valleys in the Valles Marineris area. Science, vol. 305, (5680), 78-81.

p.3.Lines 22-24. I do not understand your arguments about climatic implications. How do you supply your groundwater table ?

p.4. Line 1. Could you explain "ground water piracy" in terms of physical process.

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P.4 Lines 24-25. Could add references as Schumm (1986), Dunne et al. (1980)

p.4. Lines 5-23. Once again, sapping or seepage ? Flow piracy ?

p.4. Lines 24-30. Remove valley formation because you model only channel formation. Choose definitely what you model: Seepage or sapping ?

p.5. Lines 1-7. “shows the arrangement of multiple valleys” Is it really your main objective? In your experiment you do not obtain multiple valleys with bifurcation. Do you really constrain the climate conditions with your experiment? Give arguments.

2. Methods

p.5. Lines 21-26. Could you justify your choices about sand granulometry, topographic slope of sandy surface (0.22 mm-1) which is quite high for granular material. Why do you choose a partially sloping impermeable floor with a decreasing in slope value by a factor 2? This leads to a wedge of sandy layer from top to bottom of your experiment box, why this choice? How do justify the horizontal offset in slopes between the sandy surface and the impermeable surface? Which implications do you expect? p.6. Lines 9-11. Could you explain clearer how does work your head tank? At which depth does water flow: on entire tank height or at different heights? It is not clear in text and in Figure 2. p.6. Lines 20-28.Could you justify and explain your different mean discharges in local and distal experiments (cf. table1): one order of magnitude?

2.3 Valley development and eroded volume Change valley word by channel p.8. Line 25. Could you explain why you use SLc (shape index of channel cross-section) and 0.5 coefficient in your formula of channel volume. You obtain for each channel the DEM by stereogrammetry, so you can extract directly volume without this correction. In addition, this formula is not appropriate because you want to calculate channel V-shape whereas you obtain wide rectangular shape. p.9. Line 5. Once again, I do not understand your calculation strategy in erosion rate. Why do use the density of sand? Why the high density value of your sand (2300 kg.m-3 and not 2300 kg.m-1)? How do you measure

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the porosity of sediment at the begin of experiment and during the experiment?

2.4 Martian landscape metrics In this part, change the word channel by valley because you analyze valleys at the surface of Mars. p.9. Line 24. How do you analyze Nirgal valley whereas you do not have accurate DEM? Here we present the morphological analyze of valley bifurcations but you do not write about that in experiment methodology. It is incoherent.

3.1. Distal groundwater source Here change the word “valley” by channel. p.11 Lines 13-15. Could you explain the physical process of “groundwater piracy? Why is typical of groundwater sapping? Sapping, why? You model seepage. p.11. Line 17. “the valleys did not bifurcate, which is the result of the high initial slope” where ? at the top or the bottom of sand layer ? Do you test for small slope? In this case, do you observe bifurcations? p.11 Line 23. Change the word “mud flow”. It is not appropriate here, it would correspond to concentrate flow but not mudflow. Idem p.12 line 13. p.11 Lines 5-14. I do not understand where you measured channel width (Fig. 6 and 7). Is it at the head? At outlet? A mean value? Could you clarify this.

I suggest to permute §3.2 with §3.3 because it is easier to understand the influence of local topography on distal groundwater table.

3.2. Effect of initial morphology on distal experiment. In this experiment you have channel widening and deepening without increase in headward erosion. It is interesting but you do not analyze what experiment parameters could influence this process. You remain evasive suggesting that only groundwater piracy would be the main parameters and the channel geometry develops independently from the initial topography. It is not really the case, because they do not crosscut previous channels. Could you investigate which parameters (geometry of water table, slopes etc. . .) in your experiment could explain this final morphology?

3.3. Local groundwater source Why do you model a discharge with a higher factor of 5 than that in distal groundwater source? It could have to misinterpretation when

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we compare experiment results. This water comes from local precipitation in your experiment. What was the precipitation rate? In which terrestrial climatic conditions? p.13. Line 13. “valley heads with a v-shaped planform (Fig. 3b-ii)” It is not clear on your figure. However this paragraph is quite convincing. But you have no channel bifurcation.

3.4. Effect of initial morphology on local groundwater table. This part is interesting but authors do not analyze completely the experiment result. It is pity. Channels widen and stretch out by headward erosion up to flat surface where a feather morphology develops. You observe channel bifurcation ! Which is process at the origin of that? Which parameters control that because you have not overpression? Could you explain.

4. Examples of Martian valley system. This part is not convincing in relation with the experimental results. Valley vs channel? Could you explain? Examples are not well chosen. This part must be reworked.

5. Discussion. Once again, you model channels not valleys !

p. 17. Line 16. It is very ambiguous “The general morphology of our experimental channels (by seepage) agrees well with studies on sapping” Could you clarify. You discuss the nature of material as major parameter in experiment result (sand). You do not discuss the geometry of your experimental model on channel formation (thickness of sand, variation in slope between the upper and bottom surface, etc. . .)

5.4. Headward channel bifurcation You conclude that the lack of bifurcation is due to the high slope in your experiment. Is it the only parameter? Others experiments obtain bifurcation with a horizontal surface. It is the only geometric parameter (topographic surface?)?

5.5.Origin of Martian examples This part must be reworked, examples are not in correlation with your experiment results. You wrote sapping and seepage, which is very confusing. You do not discuss the scaling between your channels and Martian valley,

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the lithology on Mars. . .The analogy is quite limited.

Table1. Could you add the signification of each term in legend, for example d=day etc. . .

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