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Interactive comment on "Experiments on patterns of alluvial cover and bedrock erosion in a meandering channel" *by* Roberto Fernández et al.

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Thanks for your comment to our paper. Answers/comments to the issues you have brought up are included below:

I. Paper structure: We will work on the paper structure to improve its readability. Both your comments and those of Jens Turowski point in the same direction on this regard. II. Transient cover zone: We discuss this in some sections (e.g. 4.3, 4.4 and 4.5) but perhaps the current structure of the paper is not the best way of conveying the message. We will make sure to highlight the issue better in the revised manuscript. III. Slab experiment: We will make sure to mention this second experiment earlier and highlight its importance. Initial thoughts are that we might add a figure to the main

document and extend the supplemental material to thoroughly describe the approach and show images of it. Regarding your specific questions, here are our thoughts: 1. What is the settling velocity of the particles (calculated or measured). How does that influence the observations?

Using D = 1.5mm, R = 0.35, and v = 1.02e-6m/s^2, C1 = 18, C2 = 1 vs $\sim$ 8.9cm/s (Dietrich) and $\sim$6.9 cm/s (Ferguson and Church). Both values are roughly 2.5 times smaller than those obtained with R = 1.65 (22.6cm/s and 16.5cm/s respectively)

I'm not sure what the effect of heavier sediment would be. My first thought is that it would be harder to push up against the point bar, thus making the permanent cover deposits wider. What do you think?

2. The Shields stress is relatively high (âĹij0.18) does that have an impact on the hop length of the particles, and the locations where impacts are expected? Does the density of the particles affect the hop length?

Shear stress and particle density definitely affect hop lengths. Similar sand grain would hop less... But we are not focusing on this scale. We cannot see this scale. We can only see sediment patches with our technique. I can't say anything specific about the impacts but our conclusions would still hold with other shear stresses and sediment. The regions of transient alluvial cover will continue to be at the edge of permanent alluvial deposits.

3. The width depth ratio is relatively narrow (âĹij5.5), yet migrating bars are described in the paper. IS there any data on the width depth ratio of bedrock meanders? Are the bars forced bars or free bars (or some other bedform)?, and would the results in a wider channel differ?

I am not aware of a set of W/H values specific to bedrock meanders but Wohl and David (2008) and Yanites (2010) show W/H values for bedrock rivers. Both include many W/H < 10. Values reported by Wohl and David (2008) have a mean W/H value of 7.7 and a standard deviation of 6.4. The experiment shows forced bars (point bars) and free bars migrating over them. I guess it depends on how wide you make the channel. At the apices I think, sediment will continue to travel along the toe of the point bar. At the crossings, however, a wider channel might show other kinds of bars depending on sediment supply.

4. I would be interested to hear more description of the channel morphology including how deep were the pools and how much did the lateral slope of the bar vary. To some degree, experiments are their own self-contained system, but I couldn't help asking myself how the results would differ if sand or gravel were used rather than walnut shells. Presumably the area of transient cover might be closer to the inner bank with heavier sediment?

We measured bathymetry for three cover conditions but haven't processed the data to quantify the issues you are interested in. In terms of heavier grains, I think we might see more persistent cover for the same shear conditions. At the apices, the secondary flow will be less successful at pushing grains up against the point bar. Would this actually lead to wider/shallower point bars?

Questions about experimental procedure: 1. Approximately how thick was the pea gravel?

It varied from one cross section to another. The mean gravel elevation, measured from the bottom of the channel, was 0.10m. Left and right bank elevations varied following the bathymetry measured in experiments conducted in the same flume using crushed walnut shells in a purely alluvial configuration (Czapiga 2013). The transverse slopes of the bed at streamwise locations were extracted from those experiments and those were used to cut the foam. See Fig. 1 (of this comment). We built a foam 'skeleton' and then filled the channel with pea gravel following the profile defined by the foam cross sections. We then covered everything with a thin layer of concrete.

2. Was the bed cleaned out between runs? Is the adjustment between runs reflected

in any of the results (i.e., how long did it take to adjust the channel morphology)?

Bed was not cleaned. We started with high volume of sediment (pc79) and removed sediment to conduct runs with lower pc values. Values obtained were not really planned. We just removed enough sediment to achieve a different condition. This lead to pc72 first and pc54 afterwards. After this runs we removed it completely and measured the bare bedrock case (pc00). Following this case we started adding sediment and did the other four conditions (pc19, pc27, pc38 and pc46). We allowed the bed to adjust for at least 8 hours between runs. The 60 minutes we report in the manuscript is after the bed had adapted the new condition. We computed the alluvial cover statistics throughout the transition from one state to another and once it had reached equilibrium we continued measuring. We report only the values once the system had reached equilibrium for each condition.

3. My memory of walnut shells is that they are pretty angular. Does that affect the experiments at all?

Yes they are angular and maybe the slab experiments would lead to slightly different results if rounder grains were used (maybe more sediment will be needed to fill the voids in the bedrock bed). Otherwise, our measurements in the Kinoshita flume do not allow focusing on this smaller scale. Figure 3b in the manuscript shows a close up view of the grains for reference.

Other specific comments Page 5. Lines 10-21. I found the intermingling of "bed material", "alluvium", "bedrock", and "bedrock basement" confusing. Bed material could either refer to the bedrock or alluvium. I think sticking to bedrock or alluvium would be helpful. I also got confused by the way the description of the artificial bedrock was built starting with the bottom. It might be helpful to start by describing what each component is used for (walnut shells to give the basic channel shape (pools and bars), pea gravel to provide roughness, and concrete to provide strength), then describe how it was built. How thick was the pea gravel?

See Figure 1 (in this comment) for a better description of the bed construction. We will improve the description in the manuscript and incorporate more details to supplement material to thoroughly describe it.

Page 5. Line 19. Is there anything special about the cement mix? What was the ratio of water to sediment (could be useful to future experiments).

No it's just a pre mixed bag (Quickcrete in the US). We followed the bag's instructions for water content. See link: https://www.quikrete.com/pdfs/data_sheet-concrete%20mix%201101.pdf

Section 2.3. What was the scanning interval of the bed, and was the scanner measuring a grid or cross sections (from later in the paper I gathered it was cross sections but I am not sure) ?

We did scan cross sections. The laser was attached to a stepper motor that moved in 0.42 mm displacements along the cross section.

The slope was measured with point gages from 9 m to 21 m. These spots are just before the apex of one bend and after the apex of another bend. Often the water surface elevation can vary based on position in the bend as water backs up behind the bend apex. Did this occur in these experiments? If so, are these slope measurements representative of the overall slope.

Figure 4 (in the manuscript) shows how different the overall slope (measured between upstream and downstream tanks) was with respect to the slope measured in the middle portion of the flume. We decided to measure close to our region of interest but do not know if the measurements were affected by backwater effects as you suggest.

Page 10, lines 5-15. Does the thickness of the alluvial cover depend on the shape of the particles?

Perhaps rounder particles would build slightly shallower deposits but the areal alluvial cover trends we focus in would tend to be similar.

Figure 10. Please define area ratio in the figure legend.

Ok. We will do this.

Figure 11. Can we quantify the variability of cross sectional alluvial cover relative to reach average cover using standard deviation, or just a range?

Figure 13 shows box plots of local pc (normalized with reach-averaged values). This shows the ranges observed locally.

Figure 13. I found myself curious how symmetrical the results were and wondered why the cover was higher upstream than downstream. How did cover vary as a function of the absolute value of curvature? Presumably the curvature upstream and downstream matters as well as local curvature.

To see how the trend in Figure 13 looks with respect to absolute curvature use both the true and negative curvature signals. Follow the true signal from CS10 to CS 12.8. Then 'hop on' the negative signal and follow it until CS 17.8. At this point, 'jump back' onto the true curvature signal. We decided to include true and negative curvature signals because the sharp changes in the absolute curvature signal at the crossings did not look great. We believe that using both signals seems to better show the trend.

As for more cover upstream than downstream it might suggest that the curvature sign also has an influence, and as you suggest, the curvature leading to a given point. One way to know would be to run the experiments and focus on more than one bend and see if the trends repeat themselves one bend after another. This of course can't be done now but is an interesting thing to try to answer with

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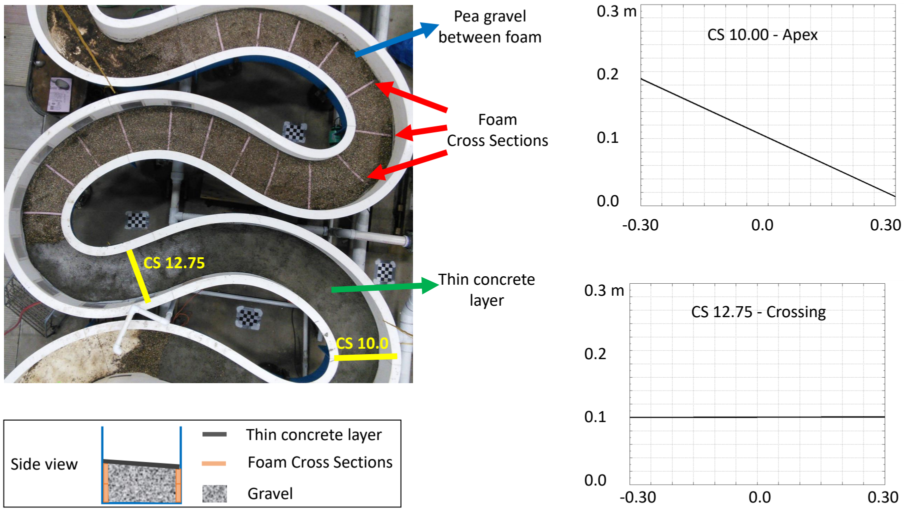

Fig. 1. Description of bed construction