Review of Zhu et al. Modeling 3D permeability distribution in alluvial fans using facies architecture and geophysical acquisitions.

In the full review and interactive discussion, the referees and other interested members of the scientific community are asked to take into account all of the following aspects:

1. Does the paper address relevant scientific questions within the scope of HESS? Yes. This manuscript presents use of multiple forms of data to address estimation of the distribution of hydraulic properties in an alluvial aquifer. Due to the highly heterogeneous nature of such aquifers, modeling these distributions is difficult.

2. Does the paper present novel concepts, ideas, tools, or data? In part, the combination of tools and geological and hydrogeological ideas makes this paper novel. Though others model heterogeneity in alluvial systems, these authors present a nice example of such work.

3. Are substantial conclusions reached? Nothing earth shaking, but still good results are presented, and others may be able to apply similar techniques to understanding heterogeneity in alluvial aquifers.

4. Are the scientific methods and assumptions valid and clearly outlined? Yes. This paper is well written and presented.

5. Are the results sufficient to support the interpretations and conclusions? Yes, generally. Some expansion on how lithofacies are simulated would be helpful.

6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? Yes. Though expansion on how lithofacies were defined would be helpful.

7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution? Yes.

8. Does the title clearly reflect the contents of the paper? Yes, though you could specify that the geophysics is borehole geophysics. One may think that high-resolution seismic or other surface methods were used.

9. Does the abstract provide a concise and complete summary? Yes.

10. Is the overall presentation well structured and clear? Yes.

11. Is the language fluent and precise? Yes.

12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? Yes

13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Yes. See comments below.

14. Are the number and quality of references appropriate? Mostly yes.

15. Is the amount and quality of supplementary material appropriate? None seen.

General comments:

The manuscript is well written and conceived. The authors use an interesting mix of data sources (well logs, geophysical logs, and vertical electric soundings. The manuscript offers interesting analyses and results, and with minor revisions would be a nice publication. Below, I outline general comments and specific comments on the manuscript.

1. The authors call this an "alluvial fan", which in the current sedimentology/geomorphology literature this may not be strictly considered an alluvial fan. Since it is longer than 30 km, this would be called a 'fluvial megafan' (e.g., Leier et al., 2005, Geology, v. 33, p. 289-292) or a "large distributive fluvial system (DFS)" (Hartley et al. 2010, Journal of Sedimentary Research, v. 80, p. 167-183).
2. In using the borehole geophysical tools (resistivity), the authors report resistivity values measured across the units. Were these logs calibrated? Are these values accurate given the calibration? If they were not calibrated, the relative values between muds and sands would be important but the actual values are not significant. If the logs were calibrated, some discussion of calibration procedures is important. Also, these values are strongly influenced by the fluid conductivity. Some discussion of fluid resistivity should be included. The depth of water table is also important to note unless all data come from below the water table (resistivity properties in the vadose zone are different). Line 161, where resistivity values are used in Archie's Law, makes it important that the logs were calibrated. If the logs are not calibrated, Archie's Law is not appropriate to use. Clarify this point.
3. The use of zones for modeling the system is appropriate and interesting. However, progradation of fans often leads to these zones shifting position upward, where the coarser facies shown in Zone 1 overlie finer facies that you describe in Zone 2 (see Weissmann et al 2013, SEPM Special Publication 104, p. 131-147, for a discussion on this). Do you see this pattern in the logs? The abrupt boundary seen

between zones 1 and 2 in Figure 7 probably does not exist. This sharp transition could have been softened by using the results from the zone 1 simulation as conditioning for the zone 2 simulation. Likewise, the zone 2 simulation results could have been used as conditioning for the zone 3 simulation.

4. It isn't entirely clear how the lithofacies were placed into the variograms or modeled. Were lithofacies distributions modeled first, then variability added using variograms? Or, were K values assigned to the various lithofacies observed in well logs and lithologic logs, and then the variograms created from these K values? This must be clarified so others can apply your techniques. Looking at Figure 7, it appears as if you modeled lithofacies distributions first….how did you do this?
5. Additionally, your horizontal variograms don't show very much character. The fit is somewhat arbitrary. This is very common since the spacing between wells is often greater than the average widths/lengths of lithofacies, especially since strictly horizontal measures from logs may not indicate the actual paleo-horizontal. It's fine to show these models, but how sensitive were the results to these variograms (probably not very sensitive, but maybe).
6. Figure 7 indicates that the facies were modeled with dip direction in one orientation, thus facies near the apex area will not include a radiating pattern that emanates from the fan apex. This should be noted somewhere. Also, the authors could note that *a priori* orientation information from surface mapping of the fans could be used to create a model with channel orientations aimed at the apex (See work by Carle et al., where they are able to put varying orientations into the resulting models).
7. It is unclear how the vertical electric soundings were used, or what these data look like or what they show. This should be clarified.

Specific Comments:

1. Line 12: "heterogeneous" Heterogeneous in what? Hydraulic conductivity? Hydraulic properties?
2. Line 12, change "…which make difficult …" to "which make *it* difficult…"
3. Line 23: Change "bad" to "poor"
4. Line 35: Change "Conductivity distributions…" to "Hydraulic conductivity distributions…"
5. Line 36: Papers by Weissmann and Fogg (1999) and Weissmann et al (2002, 2004) also use conditional indicator geostatistical methods to model alluvial aquifers.
6. Line 90: Change "…exploration…" to "…exploitation…"
7. Line 100: remove the word "through"
8. Line 135: Change "…700 borehole lithostratigraphies were…" to "…700 borehole lithologic logs were…" My understanding is that these are the lithologic logs written by the drillers or well site geologists at time of drilling and are based on cuttings. Is that correct?
9. Line 141: "surrounding" Do you mean "in the area surrounding the sites of geophysical acquisitions."?
10. Line 156: What is the "representative" grain diameter"? D50? D10? How was this measured or estimated?

11. Line 192: "…vertical and dip directions…" What was used in the strike direction (perpendicular to dip)? Expected length scales would be expected to be less than what is used in the dip direction.
12. Line 248: Change "…bad…" to "…poor…" Grains are poorly sorted, not 'badly' sorted.
13. Line 254: Change "…have a good sorting." to "…are well sorted."
14. Line 260: Change "…alike…" to "…similar…"
15. Lines 265-268: This discussion of zone 2 does not make sense. All of the zones have multiple flooding events depositing the sediments. This medial zone does allow for greater preservation potential of finer sediments than the more proximal zone, where channel switching from the apex in the proximal zone tends to fill accommodation quickly and amalgamated channel belts are most likely preserved (see Weissmann et al. 2013, SEPM Special Publication 104, p. 131-147 for more details on structure of megafans and development of this structure through time). A different explanation for the distributions of sediments and processes to develop these distributions is needed.
16. Line 293: Change "…our average K values is gently…" to "…our average K values are gently…"
17. Line 293: Change" …than these latter is likely…" to "…than these latter values are likely…"
18. Line 309: "lithostratigraphies" Do you mean "lithologic logs"?
19. Line 311: "…are built-up…" Do you mean "…were constructed…"?
20. Line 320: Change "..a bad sediment sorting" to " …a poor sediment sorting"
21. Line 321: Change "…relatively good sorted" to "…relatively well sorted."
22.