Extent of Armor Layer Development in the Sand-dominated San Antonio River

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1. Introduction

In rivers with mixed-sized sediment, low sediment input relative to transport capacity can cause armor development (Dietrich et al., 1989). Defined by a surface layer that is one or two coarser particles in thickness (Melville and Chin, 1986), armoring is developed by two winnowing processes (fig. 1).

The vertical winnowing process can be visualized by grain replacement. For example, when a large grain is removed, it leaves an opening in the bed where smaller grains may move below the surface (Parker and Klingeman, 1982).

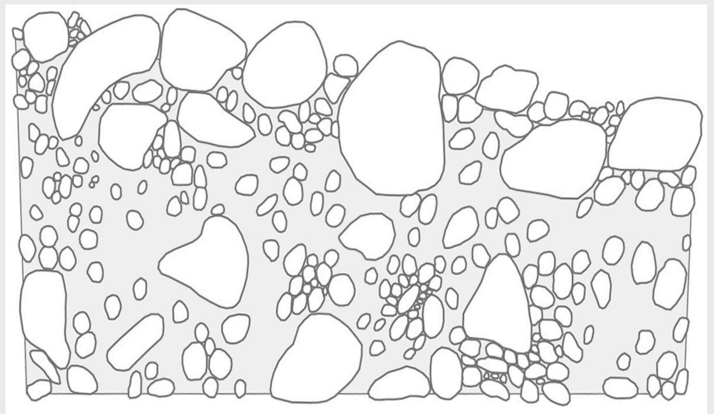

Fig. 1 - Modified from Church, M. and J.K. Haschenburger (2017)

Additionally, when there is a poorly sorted bed surface deprived of sediment, those surfaces typically coarsen due to size-selective winnowing of the fine grains (Buffington and Montgomery, 1999), known as horizontal winnowing. In a sediment mixture dominated by sand, it is expected that armoring may become 'patchy' as shear stress declines to values that prevent sand fractions from continued suspension (Church and Venditti, 2014).

2. Objective

This poster presents initial results from a field study investigating the sediment characteristics of channel bars in the poorly sorted sand-dominated San Antonio River. The specific objectives were to (1) establish whether armor development occurs and (2) quantify how variable the development is when present.

3. Methods

The study reach is the lower section of the San Antonio River, located south of the city of San Antonio, Texas (fig. 2).

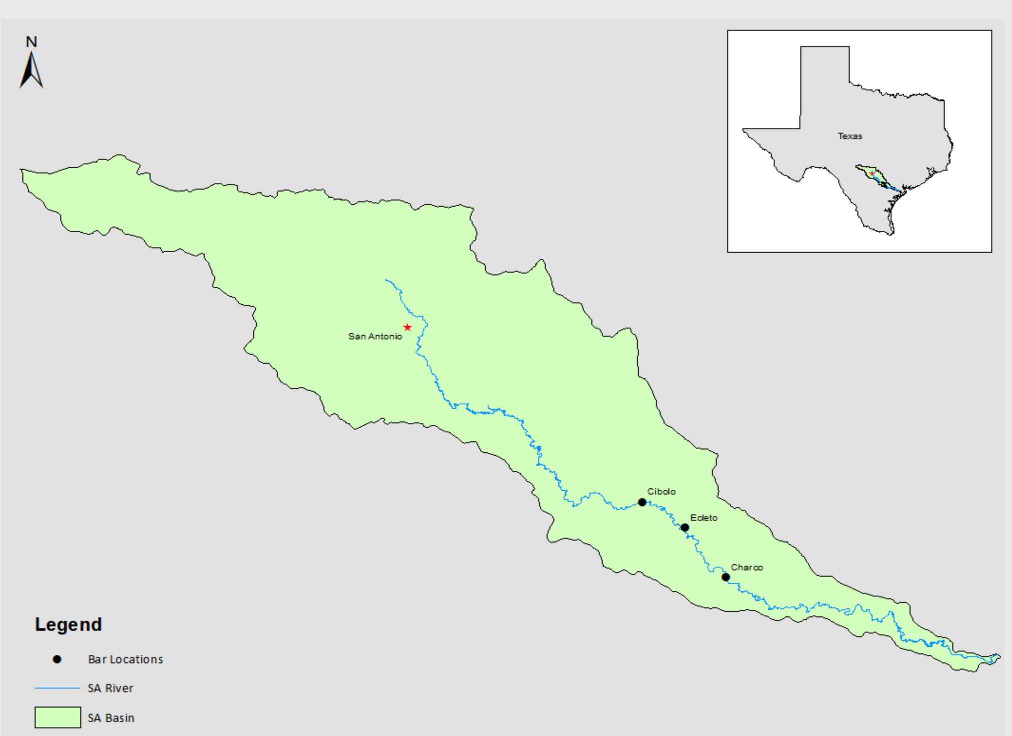

Fig. 2 - The location of the San Antonio River and channel bars.

The surface and subsurface sediments were sampled independently, as recommended by Kellerhals and Bray (1971). The sampling technique used was the volumetric method, where bulk samples of both the surface and subsurface were collected.

The data collected in the field consisted of 72 bed material samples obtained from 3 channel bars in spring of 2017 (fig. 3). To characterize whether armor layers were present, 12 paired surface and subsurface samples were collected from each bar head.

Fig. 3 - Channel bar locations with respect to river channel morphology. (A) Cibolo, (B) Ecleto, and (C) Charco. Map scale is 1:2,600. Flow is from top to bottom in each photograph. Left photograph is most upstream which progresses to downstream in the last photograph.

For each bar head, sample sites followed a 2 x 3 m grid oriented along the water edge. At each site, samples were removed from a 57 x 57 cm area defined by a wooden frame. The surface sediment was removed to a 2-cm depth and the immediate subsurface sample was collected typically to a depth of 10 cm. Characteristics of the bar sediment ranged from mud drapes to well exposed gravel up to 45 mm in size (fig. 4). Some areas were well covered by grasses.

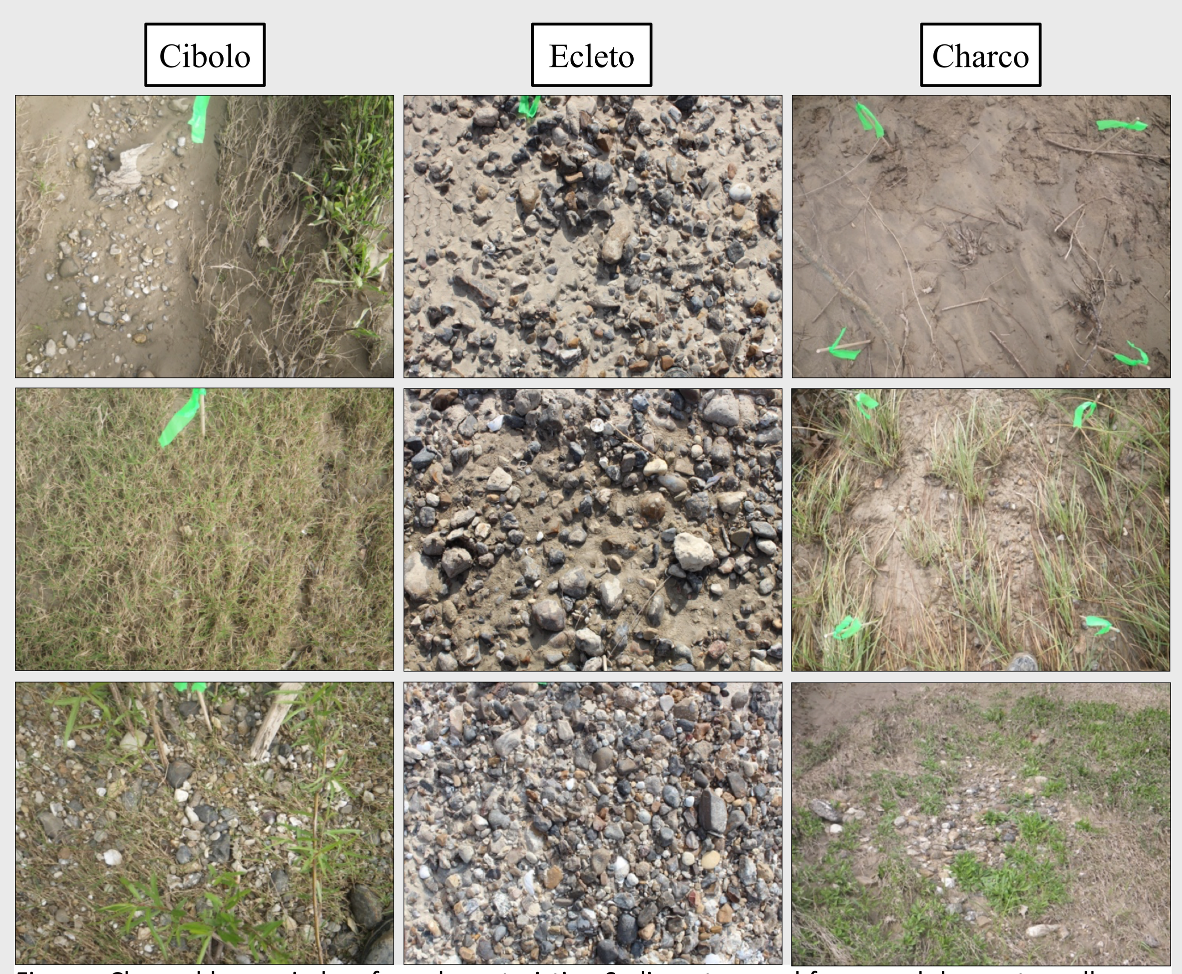

Fig. 4 - Channel bar varied surface characteristics. Sediment ranged from mud drapes to well exposed gravel up to 45 mm in size. Some areas were well covered by grasses.

To characterize the amount of armoring, the ratio between D_{50s} and D_{50b} was computed (Hassan et al. 2006), where D_{50s} is the surface median diameter and D_{50b} is the subsurface median diameter. A lack of armor development is indicated by a ratio of 1, whereas a well-developed armor will have a ratio of 2 or more (Hassan et al. 2006). Armor ratio values that are below 1 may indicate that fine sediment covers the surface (Bunte et al. 2001).

4. Results

On the Cibolo bar the D_{50s} range from 0.15 to 16 mm, whereas the D_{50b} range from 0.15 to 4.8 mm. Armor ratios average 9.8 ± 2.9, where 58% have a ratio of 2 or larger. Five significant outliers with ratio values of 16, 16.4, 20, 23, and 27 are found at positions 9, 4, 5, 7, and 6, respectively (fig. 5).

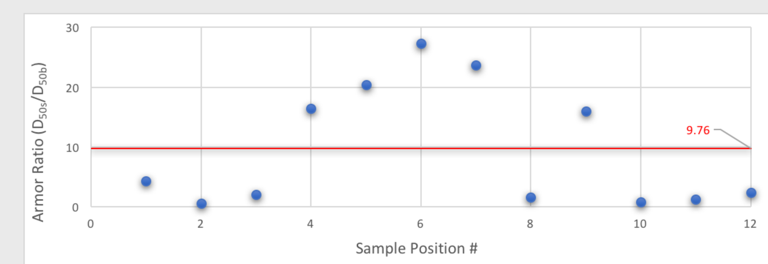

Fig. 5 - Armor ratios with respect to sampling position at Cibolo. The solid red line indicates the mean armor ratio.

On the Ecleto bar D_{50s} are more similar, ranging from 18.0 to 31.5 mm, whereas the D_{50b} span a wider range of 0.77 to 13.3 mm. Armor ratios average 8.6 ± 3.3, where 100% have a ratio of 2 or higher. Four significant outliers are at position 7, 8, 2, and 3 with ratio values of 6.8, 10, 27, and 36, respectively (fig. 6).

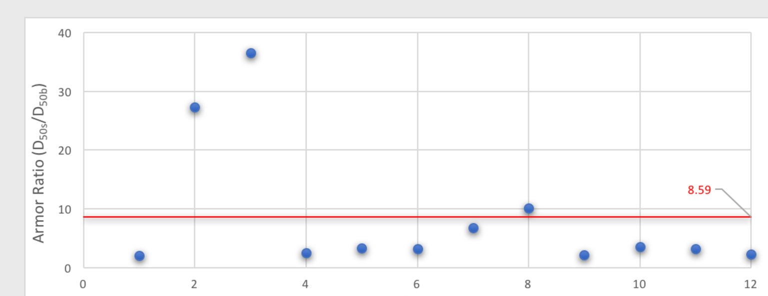

Fig. 6 - Armor ratios with respect to sampling position at Ecleto. The solid red line indicates the mean armor ratio.

On the Charco bar D_{50s} range from 0.12 to 12 mm, whereas the D_{50b} are more similar and range from 0.13 to 0.25 mm. Armor ratios average 11.2 ± 6.6, where 25% have a ratio of 2 or higher. Three significant outliers are at position 7, 10, and 4 with ratio values of 7.7, 53, and 66, respectively (fig. 7).

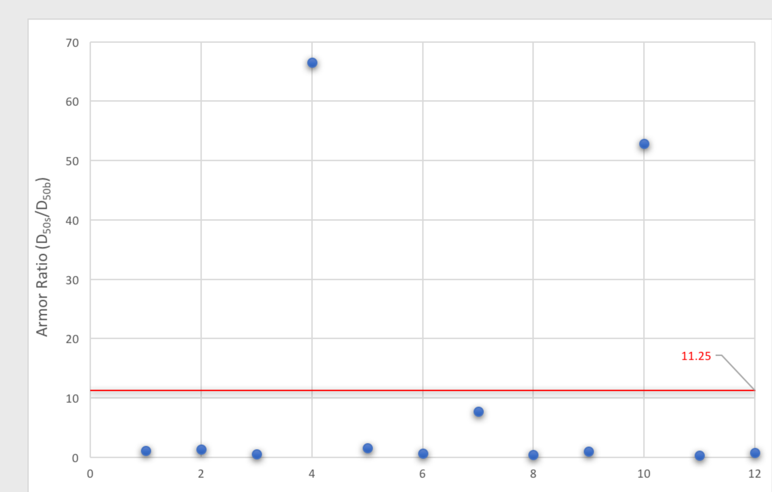

Fig. 7 - Armor ratios with respect to sampling position at Charco. The solid red line indicates the mean armor ratio.

5. Conclusions

The main conclusions of this study are:

1) Armor layer development is documented on all three channel bars. However, the frequency of development ranges from only 25% to the maximum possible of 100%. This suggests that local controls on sediment supply and transport are especially important in the process of armor development when gravel content in the bed material is low.
2) When armor is present, the armor ratios indicate that the surface layer can be more than 20 times the thickness of the characteristic size of subsurface sediment. This is best explained by the vertical segregation of sizes; gravel generally resides only on the surface and overlies nearly pure sand.

Further study is needed to improve understanding of armor layer development in poorly sorted sand-dominated rivers like the San Antonio River.

6. References

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7. Acknowledgements

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