

# KECK GEOLOGY CONSORTIUM

## PROCEEDINGS OF THE TWENTY-FOURTH ANNUAL KECK RESEARCH SYMPOSIUM IN GEOLOGY

April 2011  
Union College, Schenectady, NY

Dr. Robert J. Varga, Editor  
Director, Keck Geology Consortium  
Pomona College

Dr. Holli Frey  
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Union College

Carol Morgan  
Keck Geology Consortium Administrative Assistant

Diane Kadyk  
Symposium Proceedings Layout & Design  
Department of Earth & Environment  
Franklin & Marshall College

*Keck Geology Consortium*  
*Geology Department, Pomona College*  
*185 E. 6<sup>th</sup> St., Claremont, CA 91711*  
*(909) 607-0651, keckgeology@pomona.edu, keckgeology.org*

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Robert J. Varga  
Editor and Keck Director  
Pomona College

Keck Geology Consortium  
Pomona College  
185 E 6<sup>th</sup> St., Claremont, CA  
91711

Diane Kadyk  
Proceedings Layout & Design  
Franklin & Marshall College

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**2010-2011 PROJECTS**

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Faculty: *SUZANNE O'CONNELL*, Wesleyan University

Students: *LYNN M. GEIGER*, Wellesley College, *KARA JACOBACCI*, University of Massachusetts (Amherst), *GABRIEL ROMERO*, Pomona College.

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**GEOLOGIC, GEOMORPHIC, AND ENVIRONMENTAL CHANGE AT THE NORTHERN TERMINATION OF THE LAKE HÖVSGÖL RIFT, MONGOLIA**

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**LATE PLEISTOCENE EDIFICE FAILURE AND SECTOR COLLAPSE OF VOLCÁN BARÚ, PANAMA**

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**EOCENE TECTONIC EVOLUTION OF THE TETONS-ABSAROKA RANGES, WYOMING**

Faculty: *JOHN CRADDOCK*, Macalester College, *DAVE MALONE*, Illinois State University

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**Short Contributions— Connecticut River**

**SEDIMENT DYNAMICS & ENVIRONMENTS IN THE LOWER CONNECTICUT RIVER**

Project Faculty: SUZANNE O'CONNELL, Wesleyan University

**INVESTIGATION ON TROUGH CREST RELATIONSHIP OF BEDFORMS IN THE CONNECTICUT RIVER**

LYNN M. GEIGER, Wellesley College  
Research Advisor: Dr. Brittina A. Argow

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GABRIEL ROMERO, Pomona College  
Research Advisor: Robert Gaines

Keck Geology Consortium  
Pomona College  
185 E. 6<sup>th</sup> St., Claremont, CA 91711  
[Keckgeology.org](http://Keckgeology.org)

# INVESTIGATION ON TROUGH CREST RELATIONSHIP OF BEDFORMS IN THE CONNECTICUT RIVER

LYNN M. GEIGER, Wellesley College  
 Research Advisor: Dr. Brittina A. Argow

## INTRODUCTION

The Connecticut River is a major tributary of the Long Island Sound. The flow of water in the river creates structures in the substrate on the river floor, such as sand ripples and subaqueous dunes. These are called bedforms. The velocity of the river water and the grain size of the sediment dictate the size of these bedforms. It is theorized that the sediment grain size in fluvial sand waves is a gradient with finer grains in the troughs and the coarser sand on the crests. It is also thought that the trough sediment will be more poorly sorted than crestal sediment. Using samples collected from several bedforms in the Connecticut River during the summer of 2010, this study will compare how grain size differs from crest to trough in sand waves varying in height from 0.2 m to 1.3 m.

## METHODS

Scuba divers collected sand samples from 6 different bedform fields in the Connecticut River, CT. In each bedform field, they sampled 3 consecutive waveforms, taking two samples from each crest and trough. The bedform fields were numbered 1, 2, 7, 8, 15, and 19. In bedform field 8, sandwave C, no crest samples were collected, making the total number of samples 70. The heights of sand waves in each field were 1.2 m, 0.5 m, 0.37 m, 0.3 m, 0.2 m, 1.3 m respectively. The samples were dried for 72 hours at 50 degrees C in a drying oven. Many of the samples contained clams and after the drying process, all clams were removed. Bulk density was measured for each sample by measuring volume of the sample in a conical graduated cylinder and mass on a precision balance. Gross grain size distribution for each sample was determined by sieving at 2 mm and 1 mm. The grain size distribution of the subset finer than 1 mm of each sample was further analyzed using a Beckmann-Coulter Laser Diffraction Particle Size Analyzer

(LDPSA) LS 13 320 with the Universal Liquid Module (ULM). The data collected from the LDPSA were reconvolved with sieve data and statistically analyzed using Microsoft Excel.

## ANALYSIS AND RESULTS

Through extensive analysis of grain size of the samples, it has become apparent that the results of this study are not clear; many of the trends found are weak at best, and more data are needed to prove these conclusions. Figure 1 is a composite of all the data collected, showing the raw grain size distribution of every sample, created by using the LDPSA data with a lower limit binning system. The LDPSA returns a much finer resolution of grain size data than sieving, by having much smaller bins. Not much can be determined by this graph alone; to understand the working of the bedforms deeper examination is needed. These

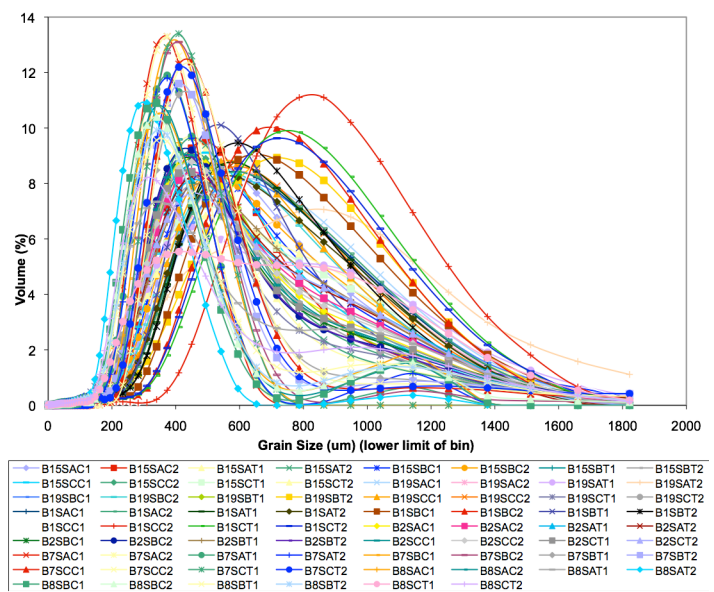


Figure 1: An overview graph containing grain size data of all the samples from the LDPSA. The LDPSA system uses lower limit bins to create data.

data are used to calculate the following statistics and analysis.

The first analysis is to compare the bedforms to their placement in the river. The bedfields are numbered so the higher the number, the further away from the river mouth the field is. Comparing distance from the sea and sand wave height yields no correlation. The height of the sand waves steadily decreases through the meanders, then suddenly jumps at bed field 19. There is a bridge at sample site 19, which may be affecting the height, in which case the last data point may be an anomaly, giving rise to a negative correlation, but this is speculative. Distance from the sea was also compared to the mean grain size of the bedforms, but again no correlation could be found.

The next approach was designed to see if crest and trough could be separated out and analyzed, to see if any difference in trends between them exist. Figure 2 illustrates the lack of differentiation found between crest and trough. No strong trends are inherently visible, except that the poorly sorted, platykurtic (unpeaked) samples are only present in the troughs. Comparing different statistics will show any trends that separate the crests from the troughs. The first comparison is sand wave height versus mean grain size. There is no strong correlation between the two, although the troughs seem to have smaller grain sizes than crests as the bedform height increases. Comparing mean grain size and median grain size shows no substantial difference between crests and troughs;

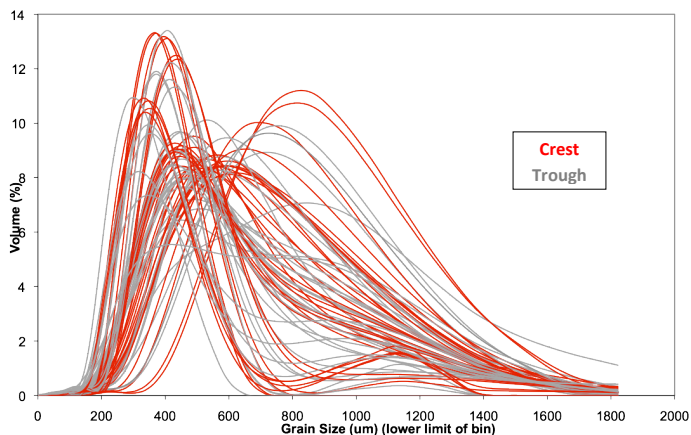


Figure 2: The LDPSA graph with the samples split into crests and troughs. There is no apparent trend in differentiation between crest and trough grain size.

they have virtually the same slope and very similar correlations.

Three graphs did split the data set into crests and troughs though. The graphs depicted in figure 3 are mean versus mode, graphic mean against mode, and mode against median. The graphic mean shows the average of the graph itself, representing the average of the curve; it is a preferred method of calculating mean amongst sedimentologists. Graphic mean is calculated by taking the average of the 50th, 16th and 84th phi percentile (16 is 1/3 of 50 and 84 is 5/3). The graphic mean was translated from phi back into um for ease of understanding. When graphed against the arithmetic mean, there is no difference between crest and trough, so the graph was omitted. Figure 3a shows mean grain size graphed against mode modal grain size. In almost every sample the mean is higher than the mode. The higher the mean, the more substantial the coarse tail is, pulling the mean up. The coarse tail is a larger factor than the fine tail, and the graph is coarsely skewed. The trough trend line has a slope very close to 1, showing that mode and mean scale similarly for bedforms. For a slope less than one, like in the crests, as the bedform gets coarser the graph is increasingly more skewed. The crests have a very high correlation, where as the trough's correlation is less strong.

Median graphed as a function of mode, figure 3b, show the crest mode and median scale in almost perfect 1:1 ratio and with a very strong correlation. The troughs are very different, with a slope of 0.8. As the modal grain size increases, as the sand wave gets coarser, either the trough is becoming more well sorted or the fine tail is becoming more prominent. The correlation for this relationship is pretty strong, but there are many more data points at lower grain sizes and more data at higher grain sizes would be needed before this hypothesis can be proven. Graphic mean verses mode, illustrated in figure 3c, is another way to show how skewed the graph is. If the graphic mean and the mode are the same then the graph will resemble a bell curve, the same amount of graph on either side of the peak. When graphic mean is larger than the mode, the graph is heavier on the coarse side, positively skewed when using micrometers. The crest trend line has a slope slightly below

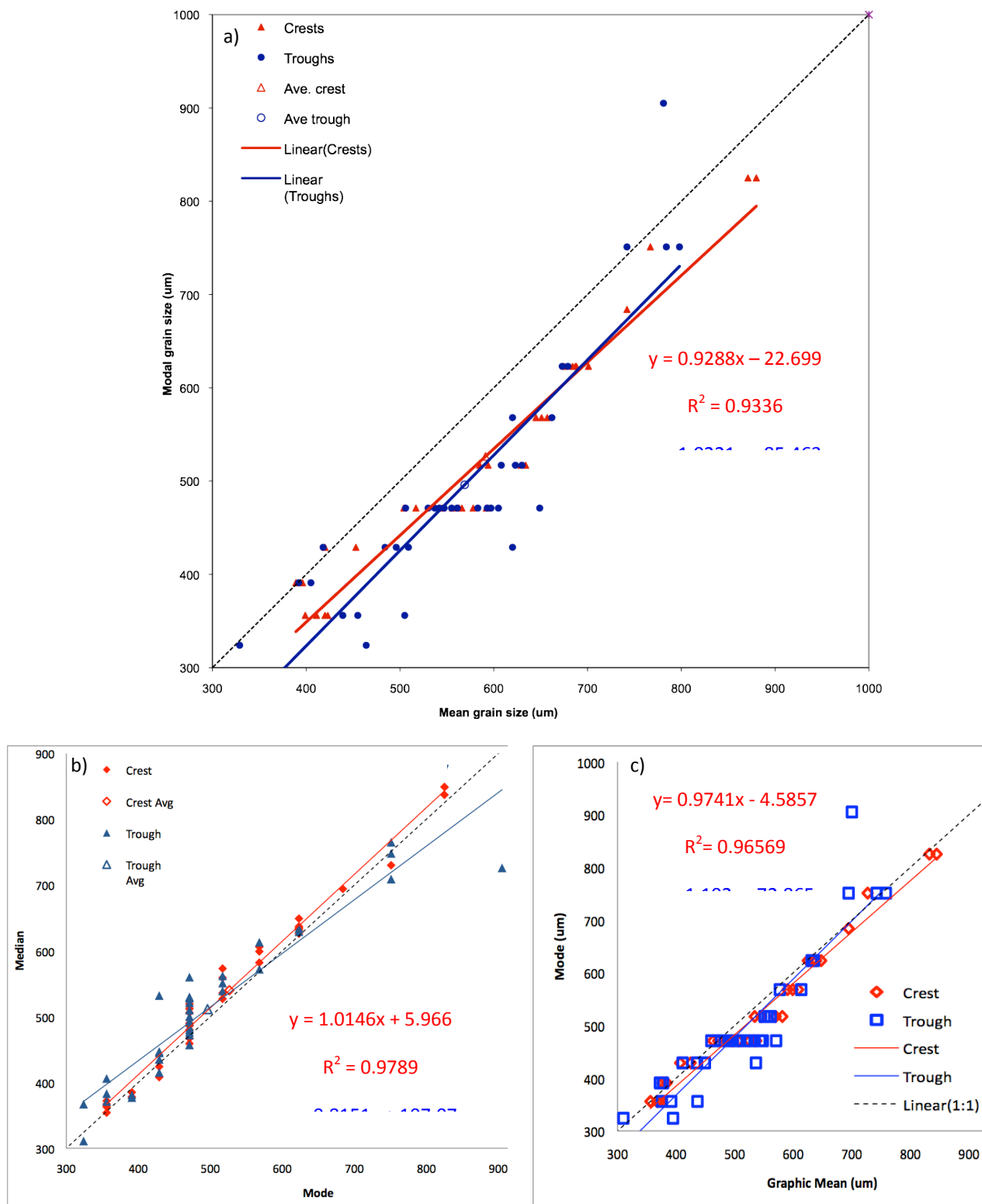


Figure 3: The three statistical graphs of most significance. Mean Grain size versus Modal Grain size (a) The trough trend line has a slope very close to 1, showing that mode and mean scale similarly for bedforms. Crest slope is less than one, meaning as the bedform gets coarser the graph is increasingly more skewed. Mode versus Median (b) The crests scale in almost perfect 1:1 ratio, with a very strong correlation. The troughs are very different, with a slope of 0.8. As the modal grain size increases, as the sand wave gets coarser, the trough becomes more well sorted. Graphic Mean versus Mode (c) As the crests get coarser the graph becomes more coarsely skewed, the correlation of this relationship is very strong. The troughs follow the opposite trend, because the slope is greater than one. When the troughs get coarser the sample will become less coarsely skewed. This means the negative, fine, tail is becoming greater.



one. As the crests get coarser the graph becomes more coarsely skewed, the correlation of this relationship is very strong. The troughs follow the opposite trend, because the slope is greater than one. When the troughs get coarser the sample will become less positively skewed. This means the negative tail is becoming greater and if the trough continues to increase in coarseness it will eventually become negatively skewed.

An alternate way to categorize the samples is by bedform field first and then to look at the variance between crest and trough within the bedform. Figure 4 shows each field graphed individually, and going through each bedform, different trends become apparent. In bedform field 1 (Fig. 4a), the crests increase in coarseness going downstream, which suggests a winnowing of crestal fines progressing downstream. This could be caused by increasing water velocity creating increased interaction with the crests and

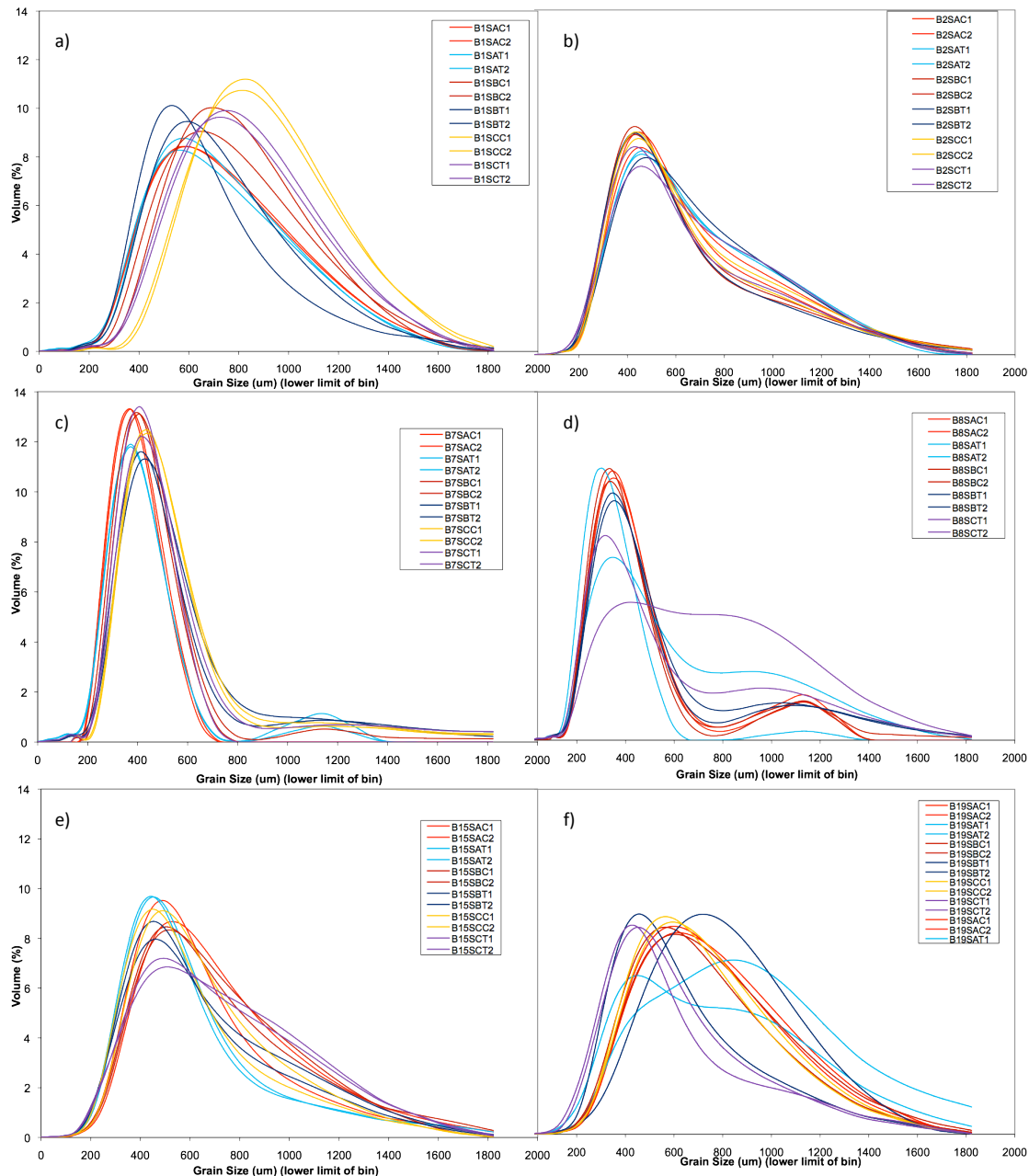


Figure 4: The samples are grouped by the bedform field from which they were sampled, with each graph illustrating variations in a single field. Each group is comprised of three individual sand waves from the field, A, B, and C, with two samples from each crest and two from each trough. The troughs are represented by cool colors, blues, and the crests are warm colors, reds. Each sand wave is given a unique color, to highlight differences between individual waves within the bedform field.



removal of fine sands. In bedform 7 (Fig. 4c), there is the same increasing crest coarseness as in Figure 4a, but in field 7 the samples were collected in the reverse order, going upstream. Which nullifies any hypothesis on those grounds. Another trend is found in bedform 15 (Fig. 4e), where the troughs become less and less sorted as they go down stream, but as before this trend is also contradicted. In figure 4f, bedform 19's troughs become more sorted traveling downstream. No universal trend was found in these bedforms. Looking at grain size and sorting of crest and troughs also shows differences vary by bedform. In bedform 1, the modal grain size for each crest is coarser than their respective trough, but in bedform 2 there is less variation and the crests and troughs have similar modal grain sizes. Bedform 7 has the most peaked graph; the sand waves are the more sorted and finer than any other field. All the crest samples, in bedform 8, are very similar in both modal peak and tail, but the troughs show a large variance; trough A peaks finer than its crest and trough B peaks coarser, and one of wave C's troughs has no definitive peak at all. Bedform 15's sand waves A and B both have crests peaking coarser than their respective trough, but trough C's modal grain size is equal to crest C. Finally, sand waves A and B, in bedform 19, both have one sample coarser than the crest and one sample finer, exposing a lack of continuity within the troughs. In trough A, both samples have small secondary bumps underneath the modal peak of the other sample. These bumps could signify that the trough has bimodal sediment. More sampling of the trough would be needed for confirmation. Wave A also went through varve clay and had debris in the trough, which could also explain the unconformity of the trough samples. Over all 52.9% of the crests are coarser than their respective trough, and 29.4% are equal in coarseness. 44.2% of the crests are better sorted than their trough and 35.3% have a comparable degree sorting.

When all of these bedform graphs are compiled into one, it is very easy to see that the data separate into bedforms easily. Figure 5 shows this composite graph, each field is a different color, the crests are represented by solid lines and troughs are dashed lines. The bedforms themselves can be paired up into three distinct groups. Bedforms 7 and 8 are both steeply peaked in the fines with a course tail that has

a bump around 1200um. Bedforms 2 and 15 are the most similar, with a same modal peak and a large coarse tail. Bedforms 1 and 19 are both coarser and spread out, with the most variation within the bed field. Bedform 15 is the smallest, at 0.2 m, and is poorly sorted. As height increases to bedform 8, 0.3 m, the crests become well sorted but the troughs are still unsorted. Next is bed field 7, 0.37 m, which is similar, but better sorted as a whole. Bed 2 is larger, 0.5 m. The distribution moves back to resemble bedform 15, with a coarse tail. Beds 1 and 19 are the largest, 1.2 and 1.3 meters respectively. These two bedforms have the broadest and coarsest grains sizes. The distribution trend starts with small, poorly sorted waves, becoming increasingly sorted until reaching a maximum around .4 meters, then start to become less sorted again.

## CONCLUSIONS

In summary, crests and troughs separate by bed field first and foremost, and only separate into crest and troughs within these groups. The bedform field is more influential to grain size than the location, crest

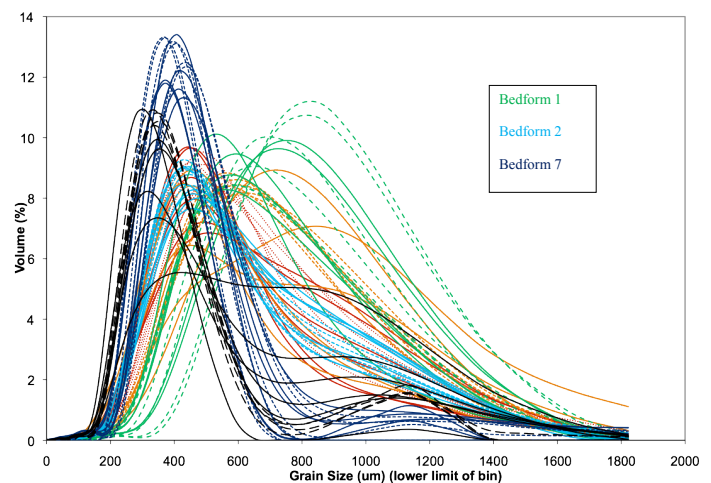


Figure 5: Overview graph split into bedforms by color; dashed lines are crests and solid lines are troughs. The data groups by bedform first and crest/trough second. The bedforms themselves can be paired up into three distinct groups. Bedforms 7 and 8 are both steeply peaked in the fines with a course tail that has a bump around 1200um. Bedforms 2 and 15 are the most similar, with a same modal peak and a large coarse tail. Bedforms 1 and 19 are both coarser and spread out, with the most variation within the bed field.

or trough, within a sand wave, and intermediate sized sand wave are best sorted. Crests of sand waves are equivalent to or coarser than the troughs 82.3% of the time and equivalently or better sorted than troughs 79.5%. As grain size increases a crest will become more coarsely skewed and a trough will become more finely skewed. All of the trough correlations are lower than the corresponding crest correlations. This is evidence that troughs will be consistently less reliable. They are the low spot and debris will collect in them, tarnishing the sample's purity. It is the nature of a trough.

There is significant future work that can be done to improve the data's reliability. Sampling more bed-forms, within the current sample height and exceeding it, could improve correlations and strengthen the hypothesis. Using ARC GIS to map out the samples would be beneficial in seeing if the graphs correlate with placement within the river channel and depth.