Unit 2: Geodetic survey of stratigraphic section – Student exercise

Assignment design by Bruce Douglas (Indiana University) and Chris Crosby (UNAVCO). Contextualization by Katherine Shervais (UNAVCO).

One of the more recent ways of describing and interpreting the sedimentary sequences found in some packages of sedimentary rocks is sequence stratigraphy. Sequence stratigraphy is based on the assumption that there should be a fundamental arrangement of sedimentary packages such that each is related to units below and above in a conformable succession that is bounded by unconformities. The concepts embedded in sequence stratigraphy are tied to the volume of accommodation space available to collect and preserve sediment and the rate of sediment supply. Accommodation space is linked to cycles in sea level; each sequence reflects a rise and fall in sea level. It should be noted that it is the relative rates of change in sea level and sedimentation that are important; knowledge of absolute sea level is not necessary or required. Sediment supply and accumulation are controlled primarily by eustatic sea level changes, tectonic subsidence rates, and climatic effects on sediment production.

At the scale of an outcrop what is most readily visible are parasequences. A parasequence is a sequence of beds that form conformable sequences representing a systematic shallowing-upwards sedimentary cycle. This coherent package is marked by marine flooding surfaces at the base and top and a progression of increasing shallow depositional environments over time. A typical parasequence for a clastic-dominated depositional sequence is attached. Walther's Law is inherent to understanding the arrangement of sedimentary environments. After the initial flooding event, deep-water facies are succeeded by a series of units that reflect an offshore-to-onshore progression as outlined in Walther's Law. While the diagram shows a siliciclastic sequence, a carbonate-dominated sequence will follow a similar pattern with lime mudstones and wackestones dominating the distal sediments and pelodal skeletal wackestones and packstones found near the top of the sequence. Individual beds are often the result of "events" that reflect periodic rapid perturbations in conditions within the shallowing water column over time.

Introduction:

In this unit, apply the skills of survey design from Unit 1 (TLS and/or SfM) to design a survey to characterize the parasequences of this particular sedimentary succession. Keep in mind all skills learned previously, such as taking extensive notes about metadata, sketching both the outcrop and the survey setup, and considering the ultimate research question while designing the survey. Once the survey is complete, use the *Data Processing and Exploration Manual* to construct a depositional history of the formation, based on the measured thicknesses of beds from the point cloud.

Project Description:

Below is a description of the workflow to follow when working on this project. This exercise is expected to take eight to ten hours, including some classroom time to analyze the parasequences found in the outcrop on individual or group workstations.

NOTE: *All survey instruments should be treated with care. These instruments are used by many scientific researchers and may be on loan from a community pool maintained by UNAVCO or your institution. These instruments are in high demand, so careful and cautious handling of the equipment is essential, both for the success of the immediate project but also for others who depend on the equipment being in excellent working condition at the end of the day.*

Field Notes and Metadata Collection:

While in the field, record field notes as you would on any other field day (weather, rock type[s], measurements of strike and dip or other features, a sketch of the outcrop) as well as detailed metadata related to the scans. Metadata includes a sketch of the survey design, including camera locations / collection path or scanner locations, target locations, and study area; justification (including the limitations) of the selection of these locations; file naming conventions and locations; the surface texture, color, and condition; who is present; and the object of the project (as well as anything else that seems important to recall about the survey when no longer in the field). If doing a TLS survey, comment on how the reflectance may affect the scan.

Data Exploration and Analysis:

You have been given both a *Field Methods Manual* and *Data Processing and Exploration Manual* for the method/s you will be using. The method of rotating, measuring, and exporting the data was covered in Unit 1, so this will be a review.

Write-up:

After collecting and exploring the geodetic survey data, create a write-up detailed below about the specifics of survey design and results of parasequence analysis.

Project Report:

Part A: Survey Design Description

1. How did you design this survey to highlight the area of interest?
2. Provide a map of the camera locations / collection path or scan positions, target locations, and GPS locations, with annotations justifying and explaining why those locations were chosen. Include any limitations on camera locations / collection path or scanner, target or GPS positions.
3. If doing a TLS survey: describe the target tie-point verification process, including a plot of the tie-points from RiScan and the degree of correlation of the points. Use this information to discuss the goodness of fit of the merged data sets and what could have been done to increase the goodness of fit.
4. If doing an SfM survey: provide a map of camera locations. Based on the calculated camera locations from the software, how could you have designed the survey better to highlight the feature of interest? Are any important portions missing or blurry? Use the function in the SfM software to generate a map of photo density. Does this map show you successfully surveyed the feature of interest? Why or why not?

Part B: Parasequence Analysis

This section of the report is an analysis of one parasequence.

1. Include a figure of the parasequence and a justification of why this selection is a parasequence.

2. Justify the data rotation you chose to use to make your bed thickness measurements.
3. Label this figure with the defining surfaces of the parasequence.
4. Report bed thicknesses for the lower and upper portions of the sequence.

Milankovitch-type sea-level fluctuations with cycles of the order of 23 and 100 ka (fifth order) are superimposed on third- and fourth-order sea-level fluctuations.

1. Calculate the sedimentation rate for the entire sequence and consider whether the depositional rates might differ for the units in the lower and upper portion of the parasequence.
2. Calculate the length of time required to accumulate the material within the parasequence assuming a subsidence rate of 0.007–0.11 m/ka (this can change).
3. Use these calculations to write a brief description (1–2 paragraphs) of the time interval represented by the parasequence, including references to the water depth as a function of time and how well the two methods for determining rates or intervals agree.

After completing these portions of the write-up, answer the following questions:

1. What is the societal impetus to study sequence stratigraphy and why use geodetic techniques?
2. What are the most useful components of Unit 1 that you used for Unit 2? What did you need to change from what you did in Unit 1?

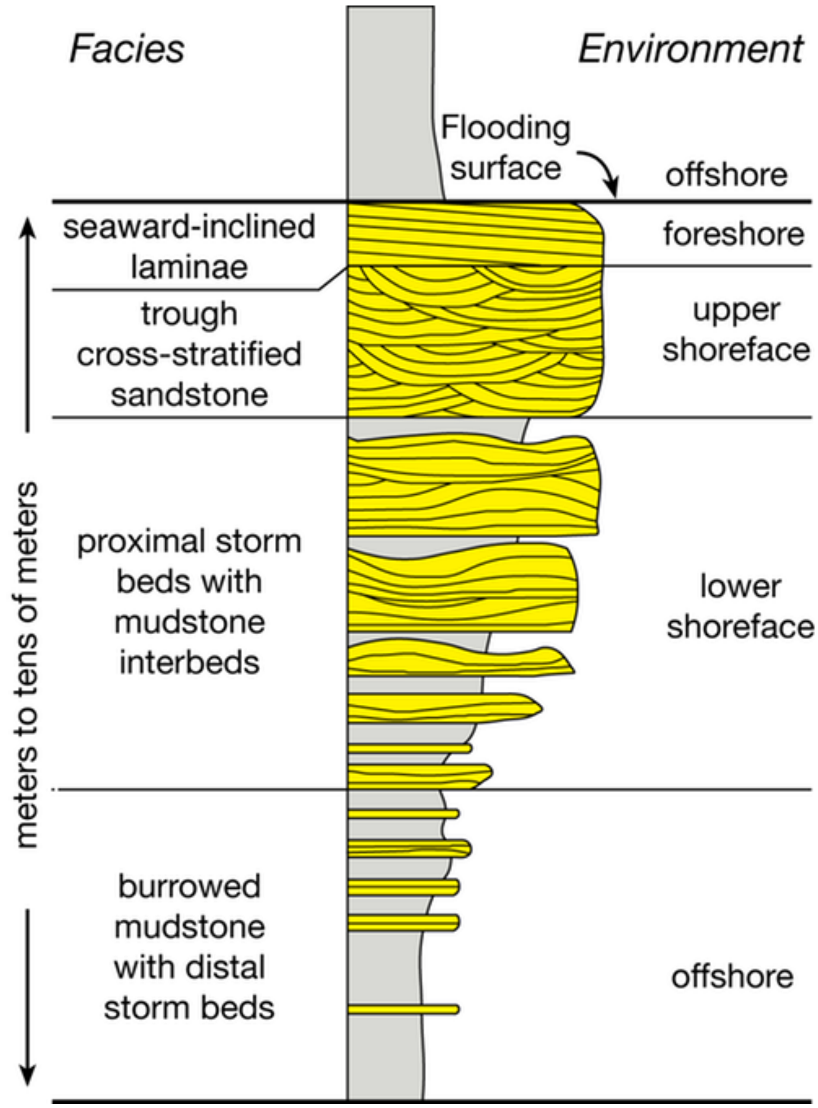

Figure 1. Siliciclastic parasequence. Courtesy Steve Holland, UGA.

Scan Resolution Parameter Worksheet

Use this worksheet to determine the optimal and realistic scan times based on desired scan resolution.

Beam diameter at instrument: __________m (RieglZ620 = 0.014; RieglVZ400 = 0.007)

Beam divergence: ___________radians (RieglZ620 = 0.00015; RieglVZ400 = 0.0003)

Constants for a given scanner

Table 1. Scan spacing

Scan site and scan number	Distance to target (m)	Spot size (m) [Dist*Diverg]+Diameter	Angle of Incidence to target	Ellipse max diameter (m): Spotsize/sine[Angle]	Optimal measurement spacing (m)	Actual spacing used (m)	Comments
	Min						
	Max						
	Mean						
	Min						
	Max						
	Mean						
	Min						
	Max						
	Mean						
	Min						
	Max						
	Mean						

Table 2. Scan time

Scan site and scan number	Horiz scan dist (m)	Optimal # horiz measurements	Vert scan dist (m)	Optimal # vert measurements	Time for optimal scan [#horiz * #vert * time/measurement]	Time for actual scan

Unit 2 Rubric - Geodetic survey of stratigraphic section

This rubric covers the material handed in for Unit 2 student exercise and is the summative assessment for the unit.

Component	Exemplary	Basic	Nonperformance
General Considerations	Exemplary work will not just answer all components of the given question but also answer correctly, completely, and thoughtfully. Attention to detail—as well as answers that are logical and make sense—is an important piece of this.	Basic work may answer all components of the given question, but answers are incorrect, ill-considered, or difficult to interpret given the context of the question. Basic work may also be missing components of a given question.	Nonperformance occurs when students are missing large portions of the assignment, or when the answers simply do not make sense and are incorrect.
Part A: Survey Design Description **(10 points)**	9–10 points: Research question and why geodesy (3 points) Map with scanner or collection path, target and GPS locations with justifications (3 points) Target tie-point verification, including a figure, degree of correlation, and explanation of the goodness of fit and how it may improve (3 points) OR reflection on collection path / camera locations with figure showing photo overlap and some discussion of how survey design may improve If all of the above in included and the material is presented in a clear, concise and well-written fashion (1 point)	5–8 points: Missing 1–2 of the listed characteristics for an exemplary report and may be poorly written/unclear; AND/OR All characteristics are present but lack detail or are incorrect, showing a lack of comprehension	0–4 points: Missing 2–4 of the characteristics, maybe poorly written and unclear; AND/OR Most characteristics are present (1–2 missing) but are incorrect, showing a lack of comprehension

Part B: Parase-quence Analysis **(10 points)**	9–10 points: Figure of parasequence with a logical choice for data projection (1 point) Justification of parasequence selection and rotation (1 points) Bed thicknesses (1 point) Calculations and description of deposition history (4 points) Detailed and thoughtful answer to reflection question about learning experience and societal impetus (2 points) If all of the above is included and the material is presented in a clear, concise and well-written fashion (1 point)	5–8 points: Missing 1–3 (depending on which ones) of the characteristics for an exemplary report and may be poorly written or unclear; AND/OR All characteristics are present but lack detail or are incorrect, showing a lack of comprehension. In addition, answer to reflection question is not thoughtful/considered.	0–4 points: Missing 3–5 of the characteristics, may be poorly written and unclear; AND/OR Most characteristics are present (1–2 missing) but are incorrect, showing a lack of comprehension. In addition, reflection question is not answered.