Why are there trillions of sea shells in the Colorado River Delta?

(*Parts in red are for teachers.*)

The Colorado River delta VFE can help you teach about rivers and sediments using a real-world example of how changing the flow and course of a river can greatly change the distribution of ecosystems and where sediments are deposited. It was designed with **high school Earth and environmental science** and **introductory college geoscience and environmental science** classes in mind. The learning objectives focus on Earth processes, human impacts, and potential policies; explaining the formation of cheniers is the vehicle for these explorations, rather than the primary goal.

Undertaking every component (all seven question sets) of the VFE may take about a week or more. It is not necessary, however, to use every component of the VFE, and we encourage you to look through it and choose the parts most relevant to your class. The VFE could also be revisited across a school year or across grade levels.

Some middle school teachers may find components suitable for **middle school** physical science classes, and the VFE could be adapted to other contexts. Because the VFE incorporates a range of topics, including freshwater, climate, organisms, sedimentation, and human impacts such as dams, it is an excellent example of *systems*.

***Essential Questions:***

* *Why are there trillions of shells in the Colorado River delta?*
* *Why does the Colorado River delta look the way it does?*

***Objectives specific to the Colorado River delta VFE:***

1. *Explain generally the influence of moving water in a variety of environments upon the deposition of sedimentary particles;*
	* *Describe how changes in moving water over short and long time scales can influence erosion, deposition, and environments;*
	* *Define chenier and explain specifically how cheniers form, including description of how the processes of erosion and deposition contribute to chenier formation;*
2. *Describe several ways human activities have changed the Colorado River Delta over the last century.*
3. *Propose policy initiatives to appropriately protect, restore, or, if appropriate, leave be, the Colorado River Delta ecosystem and explain the rationale for these initiatives drawing from the available evidence.*

You can, of course, specify the number of activities required to satisfy the second objective and the level of detail required in the third to suit their curricular needs. See also the general objectives for VFEs.[[1]](#footnote-1)

Using VFEs to reach the **Next Generation Science Standards** is discussed further in the [introduction to the VFE](http://virtualfieldwork.org/CRD/Colorado-Delta-VFE1.html#Using%20Virtual%20Fieldwork%20Experiences%20in%20the%20classroom). High school level **Performance Expectation** standards well represented in the Colorado River Delta VFE include:

* Performance Expectation HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
* Performance Expectation HS-ESS2-7**.** Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.

The VFE connects to the **Science & Engineering Practices** *Engaging in Argument from Evidence*, and to *Connections to Nature of Science:* *Scientific Knowledge is Based on Empirical Evidence*, specifically:

* Science knowledge is based on empirical evidence.
* Science disciplines share common rules of evidence used to evaluate explanations about natural systems.
* Science includes the process of coordinating patterns of evidence with current theory.

The VFE connects to the **Disciplinary Core Idea**

* *Biogeology*: The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth’s surface and the life that exists on it.

And the VFE relates to the **Crosscutting Concepts**:

* *Stability and Change*: Much of science deals with constructing explanations of how things change and how they remain stable.
* *Cause and Effect*: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

*This version of the worksheet contains answers (in red/italics) to the questions from the Colorado River delta VFE. In several cases, responses will depend on student opinions and on education level/background. Please add or remove questions as appropriate for your students. We have also bolded the questions we believe are most important for solving the mystery of chenier formation.*

***Background:***

The Colorado River delta covers more than 65 km2and is situated just south of the US-Mexico border at the head of the Gulf of California. The delta environment can be harsh due to the hot, dry climate, but life nonetheless thrives in a variety of habitats, from cottonwood groves to saltmarshes and tidal flats. Here in this virtual field experience (we’ll abbreviate it “VFE”) we will take a closer look at one of the most prominent features in the delta, accumulations of trillions of sea shells in formations called cheniers, and you will explore how they formed. These cheniers are unique and such formations only occur in a few places around the world. It took experts several decades to understand the mystery of how they formed, and now it’s your turn to solve the mystery of chenier formation in the Colorado River delta. Just like a scientist conducting research, you may not be able to answer all of your questions on your first pass and you may need to change your answers as you learn more about the Colorado River delta.

1. To begin, go through the introductory slides to familiarize yourself with where the Colorado River delta is located and how it looks today.

 **Question Set 1: How does a typical river delta form?**

1. The different colored sediments, which in this video are plastic beads of different sizes, represent different sediment grain sizes. Why do you think the sediments end up sorted by color even though they didn’t start that way?

*Larger grains require more water energy to move them, so the grains become sorted by different amounts of water flow.*

1. What happens to the sediments as the video progresses?

*Sediments move from the top of the table to the bottom*.

1. What do you think would happen if a dam were built halfway up the stream in the video?

*Movement of sediments would stop. The delta would not form.*

1. **The grand challenge: Make a prediction about how you think these cheniers formed?**
2. Go through the VFE and answer the questions in it to help you solve the mystery of the formation of the shell accumulations.

 **Question Set 2:** **Geology in the Colorado River delta: The big picture**

1. How do you think the mountains near the Colorado River delta formed?

*Uplift and plate collisions in the past. The San Andreas Fault forms the boundary between the Pacific Plate and North American Plate. This is a complex fault with portions that are divergent, convergent, and transform.*

1. What role did the tectonic history of the Gulf of California play in the development of the Colorado River delta?

*Tectonics in the region led to the opening of the Gulf of California and subsequently created the outlet area where the Colorado River reaches the Gulf.*

1. Do you think tectonic history of this area has influenced chenier formation? Why?

*Answers will vary. In a broad sense, the answer should be Yes because tectonic history controls the river’s path and the depositional and erosional processes.*

**Question Set 3: Digging Deeper: Human Impact (*Include or skip at teacher’s discretion; the digging deeper is not essential for answering the chenier formation question*)**

1. How has the delta ecosystem changed in the last several decades?

*Delivery of freshwater (and sediments) has stopped. Marshes and green areas have disappeared and the desert has expanded.*

1. In what ways are people responsible for the changing ecosystem?

*The river was dammed.*

1. What actions have been taken to restore the Colorado River delta ecosystem?

*Minute 319 restoration flows.*

1. What do you think happened to the delta after the water was released?

*Answers will vary.*

1. Do you think the release of water influenced chenier formation in the delta?

*Answers will vary. (Ultimately, very little sediment came with the water because dams are still in place along the Colorado River and its tributaries and they trap the sediments.)*

 **Question Set 4: A history of diversions**

1. **How do you think diversion of the Colorado River to the Salton Sea may have influenced life in the Colorado River delta?**

***Sediment delivery to the Gulf of California stopped.*** *Limited freshwater input means reduced breeding areas for animals. Marsh grasses, cottonwood trees, and other plants don’t grow as well.*

1. In the time lapse, how did the color of the delta change?

*Becomes less green over time.*

1. What human activities does this correspond to?

*Damming of the Colorado River and increased water consumption in the southwestern United States and northwestern Mexico*.

1. What is similar about these past diversions and conditions in the Colorado River basin today?

*Similar in that there is no water being delivered from the river*.

1. How do the two sets of conditions differ?

 *Diversions were natural in the past and relatively short. Today the diversion is entirely human induced and is indefinite.*

1. **How might these diversions of the river have affected the formation of cheniers in the delta?**

 ***By stopping the delivery of sediments, the delta goes into a reworking phase. This removes fine grain sediments and leads to the accumulation of larger sediments, like seashells.***

 **Question Set 5: How does water shape a delta?**

1. What factors determine how far a river will transport any given sediment particle?

*Particle size and water velocity (energy).*

1. In the video the Colorado River delta is identified as an “outie.” Based on what you have learned so far, do you agree with this assessment?

*Hopefully students will say “No” because the delta has entered an erosional stage but if not, will have an opportunity to reevaluate later in the VFE after learning more about the delta.*

1. What might lead to changes in the shape of the Colorado River delta?

 *Erosion of existing sediments.*

1. **Do you think the water is currently depositing sediments, eroding sediments, or both?**

***It is eroding sediments for the most part, however, larger sediments, like seashells, tend to persist and accumulate.***

1. How have dams changed the impact of water in the downstream delta? Would this affect chenier formation?

 *The dams stop sediments from reaching the delta. Now erosion is the dominant process and very little or no deposition occurs.*

*Erosion removes fine grain sediments, leaving behind larger particles like seashells. Seashells accumulate to form cheniers.*

 **Question Set 6: Geology at a finer scale**

1. What is the grain size of the clasts on the tidal flat?

 *Muds and clays.*

1. How do the clasts in the chenier differ?

*They are primarily clam and snail shells that are much larger in size.*

1. **What types of processes might lead to this difference?**

***Shells move shoreward with wave action at low tide but are too heavy to re-suspend at high tide. However, muds and clays re-suspend at high tide, redistributing them and leading to their erosion.***

1. **Reconsidering the grand challenge: Revisit your prediction about chenier formation. Revise your prediction to incorporate the new information you learned.**
2. Now that you have written an answer based on the contents of the VFE, compare your answer to the information on chenier formation in the “Chenier Formation” and answer the following questions.

 **Question Set 7: Chenier formation**

1. Which set of conditions (progradation or reworking) is currently dominant in the Colorado River delta?

 *Reworking*

1. What processes in the Colorado River delta have led to the development of cheniers?

 *Dams and water diversions in the US (and Mexico to a lesser degree); erosion via tidal reworking and longshore currents; Alternated with times of sediment delivery when the Colorado River flows undammed*

1. How have humans influenced chenier formation in the Colorado River delta?

*Damming along the Colorado River has led to the shut off of the sediment supply and allowed for reworking to occur.*

 **Question Set 8: A final thought: Water in the future**

1. Keeping the potential drought in mind, what do you think the cheniers will look like in 50 years? 100 years?

*Responses will vary. The older cheniers will remain unchanged because they have been stranded from the shoreline. The active chenier will continue to accumulate more shells as they are swept shoreward by the tides. Unless dams are removed, they will continue to trap sediment upstream and tidal forces will continue to erode fine grade sediments in the delta.*

1. Return to the graphic organizer and reflect on what information was useful for solving the mystery of the chenier formation. Provide three examples of information that helped you solve the mystery. Be specific.
	* + 1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
			2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
			3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

We would like to continue to improve our VFE and enhance the development of new VFEs. Please help us to do so by filling out a short survey on your experience with our VFE. You can find the survey [**HERE**](http://bit.ly/CRD_VFE_survey) and it will probably not take more than 10 minutes.

1. See the introductory materials at <http://virtualfieldwork.org/CRD/Colorado-Delta-VFE1.html>. [↑](#footnote-ref-1)