LESSON PLAN – LONG VERSION
(Also see Short Version below)

CRISSY FIELD RIP RAP ROCKS: A FIELD TRIP
How do I recognize evidence of geological change in my environment?

Course:
Middle or High School Earth Science

Larger Unit of Instruction:
Plate Tectonics. A one-week unit (middle school) or three-week unit (high school) preceded by study of other evidence of plate tectonics, e.g., earthquakes and volcanoes. Field trip would occur early in unit.

Science Content:
The theory of plate tectonics explains many geological phenomena, such as continental drift, earthquakes, volcanoes, the rock cycle, and mountain building. The lithospheric (solid/rocky) tectonic plates of the Earth's crust form the continents and ocean basins; there are about 15 large plates. These plates float on a semi-molten layer (asthenosphere) and move in response to convection currents in this layer. At the boundaries between plates, these movements can be convergent, divergent or transform (plates slide past each other). At convergent boundaries between continents and oceanic plates, such as happened in the past along the coast of California, the denser oceanic plate moved under the continental plate. As this happened, the upper layers of the oceanic plate were scraped off onto the continental plate. Thus, we now have local rocks that were formed underwater in the mid-Pacific. Geologists used the composition of these rocks and their fossils to determine the conditions (underwater) and locations (Pacific Ocean) of their formation to help them piece together this history of our local rocks. Many of the riprap rocks at Crissy Field are from local outcroppings of these rocks. (Less depth of understanding would be expected for middle school students.)

Based on Concepts from CSS, NSES, and BSL:
(Lesson contributes to achievement of the following standards; other lessons in unit would be needed to develop full understanding.)

Plate tectonics accounts for important features of Earth's surface and major geologic events. *CSS*, Plate Tectonics and Earth's Structure, grade 6, p. 18. (Or, CSS, grades 9-12, 3-C)

Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions. *NSES*, Structure of the Earth System, 5-8, p. 160 (Or, BSL, grades 9-12, 4-C)

Think critically and logically to make the relationships between evidence and explanations. *NSES*, Abilities Necessary To Do Inquiry, grades 5-8, p. 145. (Or, CSS I & E, NSES 9-12)

Assessment Outcomes:
As a result of this field-based inquiry, students will be able to -

1. - write a 50 word explanation of the sources of the riprap rocks at Crissy Field in the conclusions section of the laboratory report.
2. - connect the results of the field inquiry to plate tectonics in short answer questions on the unit test.

Materials and References: (*provided by campus instructor)
Pre-field experience
Presidio Geology ppt, computer, LED projector*
Describing Rocks (transparency)*
Riprap Rocks – Field Observations (worksheet, one per participant)*
List of team members (transparency)*
(Pre-assessment and Human Subjects and Field Trip permission forms if not previously done)*

Field experience- outside
Quadrats
Magic Windows of Marin Headlands (transparencies)
Describing Rocks (information sheet, one per team)
Riprap Rocks - Field Observations (worksheets previously distributed)

Field/lab experience - inside
Rock samples – 6 sets of 6 each (one per team), plus extra samples
Numbered grids for matching samples to riprap descriptions (one per team)
Geologist loupes
Crissy Center Observations and Notes (worksheet, one per participant)*
Information sheets for basalt, chert, sandstone, serpentinite, andesite/dacite, and granite (one of each per team)
Information sheet – Around The World (one per team)
Geologic maps (2) of Marin and Presidio Headlands (information sheets, one of each per team)
Map of Pacific Ocean, showing surrounding countries (posted on wall)

Post-field experience
What We Have Determined transparency*
Inquiry Spectrum transparency*
Globe showing plate boundaries
Transparencies of plates, Earth layers, boundary types, etc.
Oreo cookies

Teaching Sequence

Pre-field experience(Campus, 45-60 minutes)

Time	Teacher	Students
End of class the week before	(Do pre assessment and permissions if not already done.)	
	Have first ppt slide up and ask students what they know of geological changes and evidence for geological change.	Respond to questions posed during showing of slides
	Show ppt of site (slides), orienting students to essential question of geologic change, location of field trip and surroundings, and riprap rocks to be examined. Riprap refers to an unordered wall of stones on a slope intended to control erosion.	
	(With slide of riprap) We are going to be investigating the sources of the riprap rocks that you've seen in these images.	
	What are the possible sources of the rocks? Remember, our essential question has to do with evidence of geologic change.	Placed by people, transported by water

	At Crissy Field, we will start by examining the rocks in the riprap. Then we'll move inside to examine specimens (previously and legally collected) more closely. You'll be using geologist loupes; show ppt slide of loupe.	Listen and look
	You will be identifying the most prevalent kinds of rock in the riprap and describing them. What observable characteristics of rocks can be used to differentiate them? Work through ppt slides illustrating characteristics. Time at beach: ~ 30 minutes.	Respond, listen and look at example rocks
	Show Describing Rocks transparency and go over briefly. Note there'll be one per team on site.	
	Distribute Riprap Field Observations worksheet and go over directions.	
	After observing the riprap rocks we'll move into the Crissy Field Center where you'll work with the samples, photographic information, and maps. The time indoors will be ~ 45 minutes.	Listen
	Remind students that the observations will be used to make inferences about the sources of the rocks and that we're looking for evidence of geologic change.	
	Go over appropriate dress, including shoes for moving about on the rocks and a jacket. Assign groups of 3-4; isolate any geology students in a group and ask them not to "give away any answers."	Ask questions

Field experience (Crissy Field, ~ 105 minutes)

4:10 ~ 45 min.	At Warming Hut pier: Reorient students to site and use Magic Window transparency to look over at the Marin Headlands. Introduce the term Franciscan Rocks, noting that geologists have long been interested in the unusual combination of local rocks.	Listen
Will and Roxie do this	Like geologists do, you will be carefully describing the riprap rocks. Distribute Describing Rocks information sheet to each team and have them get out their worksheets. Go over briefly: explain quadrats and ignoring concrete and asphalt. Reiterate being careful moving about on the rocks.	Listen and get out worksheet
	Assist students and move them along to finish by 1:45.	Observe rocks
~5:00	Move to Crissy Field Center.	
~5:15 ~45 min.	If time allows, have each team give a brief description/commercial for one riprap rock and pose a question that has occurred to them. Jot on transparency for later use.	Describe rocks and pose questions
Will does most	Distribute Field Center Observations and Notes and go over directions. As teams complete matching of riprap rocks with samples, distribute information sheets and map.	Follow worksheet directions

Post-field experience (Crissy Field, ~ 50 minutes)

6:00 10 min.	What have we been trying to determine from our examination of the rocks?	Their sources, evidence of change
You do	What all have you examined?	Describe briefly
	What was your inference about the source of the riprap rocks? What evidence did you examine that led you to this inference? Record responses on discussion transparency.	Headlands; picture match
	What was your inference about the conditions under which the rocks might have formed? What evidence did you examine that supports your inference? Record.	Underwater; fossils, layers, pillow shape
	What was your inference about the geologic process that could account for such rocks in their present location? What evidence do you have that supports your inference? Record.	Uplift, plate tectonics; to get from ocean bottom to seal level
	What you've been working with today is some of the evidence that geologists have used to explain how the unusual combination of rocks in the area came to be. .	Listen
25 min. Roxie	To explain how these local and other rock formations came to be: Introduce Roxi Farwell and her supersonic presentation on plate tectonics at work locally. Presentation with transparencies.	Listen, look, take notes
	Students ask questions of Roxie and Will. Revisit initial questions about geological changes and evidence for them by having students respond on reverse side of original cards.	Ask questions, respond to questions on cards
5 min.	Put up Inquiry Spectrum transparency discuss where this experience falls on the spectrum and compare it to other experiences in class.	Discuss
10 min.	Susan - post-assessment; Lynn – Field trips and National Parks.	Complete, listen

LESSON PLAN – SHORT VERSION

ROCKIN' IN THE RIPRAP: A FIELD TRIP
How do I recognize evidence of geologic change in my environment?

Course: Middle or High School Earth Science

Larger Unit of Instruction: Plate Tectonics.

Science Content: The theory of plate tectonics explains many geological phenomena. Plate movements can be convergent, divergent or transform. At convergent boundaries between continents and oceanic plates, such as happened in the past along the coast of California, the denser oceanic plate moved under the continental plate. As this happened, the upper layers of the oceanic plate were scraped off onto the continental plate. Thus, we now have local rocks that were formed underwater in the mid-Pacific. Geologists used the composition of these rocks and their fossils to determine the conditions (underwater) and locations (Pacific Ocean) of their formation to help them piece together this history of our local rocks. Many of the riprap rocks at Crissy Field are from local outcroppings of these rocks.

Based on Concepts from CSS, NSES, and BSL:
Plate tectonics accounts for important features of Earth's surface and major geologic events. *CSS,* Plate Tectonics and Earth's Structure, grade 6, p. 18. (Or, CSS, grades 9-12, 3-C)

Lithospheric plates on the scales of continents and oceans constantly move at rates of centimeters per year in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions, and mountain building, result from these plate motions. *NSES,* Structure of the Earth System, 5-8, p. 160 (Or, BSL, grades 9-12, 4-C)

Assessment Outcomes:
As a result of this field-based inquiry, students will be able to -

3. - write a 50 word explanation of the sources of the riprap rocks at Crissy Field in the conclusions section of the laboratory report.
4. - connect the results of the field inquiry to plate tectonics in short answer questions on the unit test.

Materials and References:
Pre-field experience
Introduction to site and questions to be investigated, as a PowerPoint presentation
Describing Rocks transparency and Riprap Rocks – Field Observations worksheets
Liability Forms
Field and lab experience
Magic Windows of Marin and San Francisco Headlands, quadrats for riprap
Describing Rocks data sheets and Riprap Rocks - Field Observations worksheets
Rock samples – 6 sets of 6 each (one per team), geologist loupes
Numbered grids for matching samples to riprap descriptions (one per team)
Crissy Center Observations and Notes worksheets
Data sheets for basalt, chert, sandstone, serpentinite, andesite/dacite, and granite
Data sheets – Cherts and Basalts Around The World
Geologic maps of Marin and Presidio Headlands
Map of Pacific Ocean, showing bordering countries
Post-field experience
What We Have Determined transparency (as per questions on Center worksheet)
Globe showing plate boundaries
I Have, Who Has pictures with definitions of plates, Earth layers, boundary types, etc.

Oreo cookies

Teaching Sequence

Pre-field experience (on campus)

Time	Teacher	Students
~ 30 min.	Show ppt of site, orienting students to essential question of geologic change, location of field trip and surroundings, and riprap rocks to be examined.	Respond to questions posed during showing of slides
	What are the possible sources of the rocks? Remember, our essential question has to do with evidence of geologic change.	Placed by people, transported by water
	Describe activities at site: observe headlands with magic windows, examine riprap rocks, and use samples and data sheets to gather additional information about rocks.	Listen and look
	Go over Riprap Rocks worksheet and Describing Rocks data sheet,	Listen, ask questions
	Go over appropriate dress, including shoes and a jacket. Assign groups of 4. Complete field trip liability forms	Ask questions, complete forms

Field experience (Crissy Field and Crissy Field Center)

~ 50 min.	At Warming Hut pier: Use magic window transparencies to examine headlands and introduce the term Franciscan Rocks.	Listen
+ 15 min. trav.	Distribute Describing Rocks data sheet to teams, explain ignoring concrete and asphalt, reiterate safety, and direct students to complete Riprap Rocks worksheet.	Listen then do observations and worksheet
~ 50 min.	At Crissy Field Center: have teams give brief descriptions/ commercials for riprap rocks and pose questions; record latter.	Describe rocks and pose questions
	Distribute Center Observations and Notes and explain loupes and directions; distribute data sheets and maps as teams are ready for them.	Listen, then do observations and worksheet

Post-field experience (Crissy Field Center)

40 min.	Ask teams to reiterate overall purpose/question and to recap what they've observed.	Evidence of change; rocks, print info
	Use center worksheet to go over observations and inferences, record responses on What We Have Determined transparency.	Names, Marin, underwater, uplift
	Introduce Roxi Farwell, do presentation with I Have Who Has cards and oreo cookies. Respond to previously posed and new questions.	Listen, participate, ask questions
	[Discuss elements of inquiry in this investigation.]	[Participate]