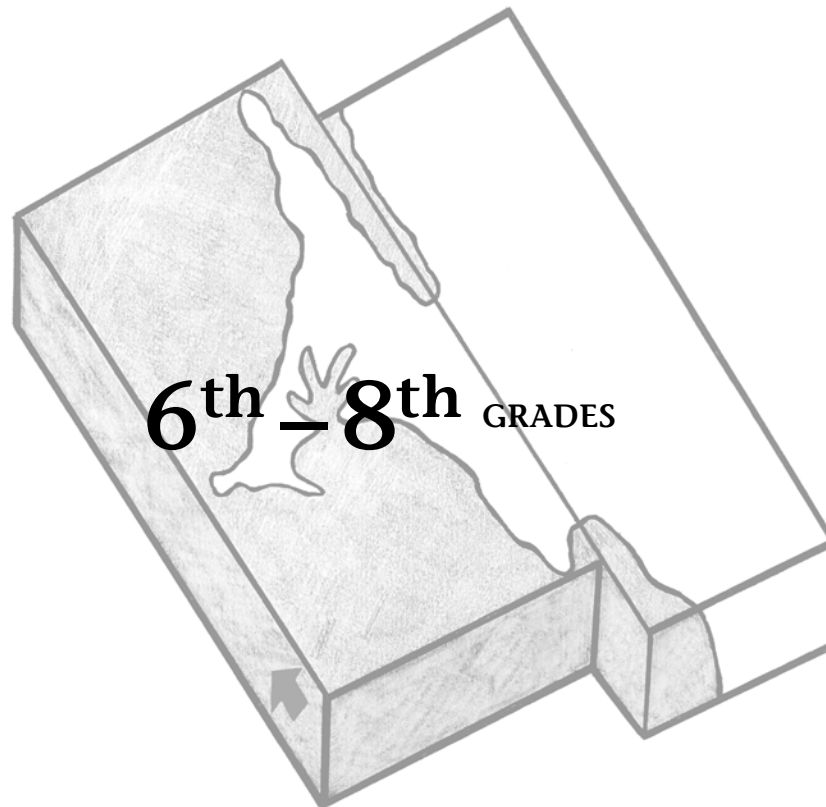


Creating
**COASTAL
STEWARDSHIP**
through Science

Uncovering the San Andreas Fault

at Point Reyes National Seashore



This project was made possible by funding from:



Publishing Information

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The listing of a resource in this curriculum does not presume its endorsement by the National Park Service.

This guide may be obtained by participating in a teacher workshop at Point Reyes National Seashore or through a teacher in-service training at your school.

Teachers are encouraged to offer their feedback by filling out the enclosed evaluation form or contacting Point Reyes National Seashore directly.



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Preface

The intent of these guides is to provide middle school students with the opportunity to observe natural processes at Point Reyes National Seashore so they might take a greater interest in environmental stewardship and science. Teachers from 15 area schools developed and field-tested 7 “Creating Coastal Stewardship through Science” guides for classroom and field trip use. Each guide is carefully designed to facilitate a hands-on learning experience using science and the environment. Natural resources such as Pacific gray whales, northern elephant seals, tule elk, California quail, Douglas iris, and the San Andreas Fault are highlighted because they are easy to identify and to observe. All activities are linked to the California State Science Standards (2000) and the National Science Standards.

You may use this guide alone or in conjunction with other guides. We highly recommend that whenever you use a guide, you use the pre-visit activities to fully prepare the students for the field trip. These activities address student safety, wildlife observation techniques, equipment use, field journal development, and concepts that need to be taught prior to the Park visit. Use of the post-visit activities is also critical to the learning process because they guide the students in making scientific deductions and in developing their environmental stewardship ethics.

Following this preface, you will find background information on the National Park Service and an overview of Point Reyes National Seashore. To provide your students with a better understanding of the place they will be visiting, we recommend you share this information with them. For an in-depth overview of the National Park Service, visit our website at www.nps.gov.

Point Reyes National Seashore provides outstanding opportunities for learning about natural and cultural resources. There are also exceptional educational opportunities provided by Park partners such as the Point Reyes Bird Observatory, Audubon Canyon Ranch, and Point Reyes National Seashore Association. To learn more about the Park and our partners, visit our website at www.nps.gov/pore.



THE NATIONAL PARK SERVICE

The National Park Service cares for special places saved by the American people so that all may experience our heritage.

Experience Your America

On August 25, 1916, President Woodrow Wilson signed the act creating the National Park Service, a new federal bureau in the Department of the Interior responsible for protecting the 40 national parks and monuments then in existence and those yet to be established.

This “Organic Act” of 1916 states that “the Service thus established shall promote and regulate the use of Federal areas known as national parks, monuments and reservations ... by such means and measures as conform to the fundamental purpose of the said parks, monuments and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations.”



Clyde R. National Park



Golden Gate National Recreation Area

The National Park Service still strives to meet these original goals, while filling many other roles as well: guardian of our diverse cultural and recreational resources; environmental advocate; world leader in the parks and preservation community; and pioneer in the drive to protect America’s open space.

The National Park System of the United States comprises over 379 areas covering more than 83 million acres in 49 states, the District of Columbia, American Samoa, Guam, Puerto Rico, Saipan, and the Virgin Islands. Although not all parks are as well known as the Grand Canyon and Yellowstone, all are areas of such national significance that they have been included in the National Park Service — ancient ruins, battlefields, birthplaces, memorials, recreation areas, and countless other wonders. Point Reyes National Seashore is one of ten national seashores.



Mesa Verde National Park



Grand Canyon National Park

The future of the National Park System lies in understanding and protecting its meanings, values, and resources. Each part of the system represents the United States and a part of our heritage. Preservation of individual sites and the entire system will ensure the essence of quality remains in our lives and the lives of all future generations.



POINT REYES NATIONAL SEASHORE

Point Reyes National Seashore was established to preserve and protect the natural and cultural features and natural ecosystems along the diminishing undeveloped coastline of the western United States. Located just an hour's drive from a densely populated metropolitan area, the Seashore is a sanctuary for countless plant and animal species. With half of Point Reyes National Seashore designated as wilderness, it provides a sanctuary for the human spirit—for discovery, inspiration, solitude, and recreation—and a reminder of the human connection to the land.



Bruce Farnsworth

Point Reyes National Seashore comprises over 71,000 acres, including 32,000 acres of wilderness area. Estuaries, windswept beaches, coastal scrub, coastal grasslands, salt marshes, and coniferous forests create a haven of 80 miles of unspoiled and undeveloped coastline located just an hour's drive from an urban area populated by seven million people. Abundant recreational opportunities include 140 miles of hiking trails, backcountry campgrounds, and numerous beaches.



Sue Van Der Walle

The San Andreas Fault separates the Point Reyes Peninsula from the rest of the North American continent. Granite bedrock found here and not found again until the Sierra Nevada range suggests that the Peninsula is geologically dynamic. According to geologists, the land that is now called Point Reyes has moved some 300 miles northwest over a period of 100 million years and is still moving.

As wildland habitat is developed elsewhere in California, the relevance of Point Reyes as a protected area with a notably rich biological diversity increases. Over 45% of North American avian species and nearly 18% of California's plant species are found here. Point Reyes also contains some examples of the world's major ecosystem types. For this reason, and because Point Reyes is dedicated to the conservation of nature and scientific research, it was recognized in 1988 by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Man and the Biosphere program and named as part of the Central California Coast Biosphere Reserve.



Rich Walkrup



Bruce Farnsworth

The cultural history of Point Reyes spans many lives and ways of living with the land. The Coast Miwok people are the first known residents of this peninsula. Archeologists have identified over 100 village sites in the Seashore and cultural traditions are still celebrated in the Park annually. Overlapping the Coast Miwok were Mexican land grantees, lighthouse keepers, and lifesaving station crews. To this day, agricultural operations that were built near the turn of the twentieth century continue within the Seashore's pastoral zone.



NPS Collection



Educational Opportunities at POINT REYES NATIONAL SEASHORE

Point Reyes National Seashore provides an outdoor classroom and learning laboratory for the study of geological and ecological processes and changing land-use values in which a greater understanding of and caring for public lands can be fostered.

Ranger-led Curriculum-based Education Programs

Reservations for Ranger-led programs are requested in writing and assigned on a first-come, first-served basis. Visit nps.gov/pore for the reservation form and calendar.

K-2 Students explore the natural resources of the Seashore with Park Rangers in the Bear Valley area or in their classroom.



NPS Collection

3-4 Students immerse themselves in the Coast Miwok culture by completing a comprehensive curriculum and visiting the Coast Miwok cultural exhibit, Kule Loklo.



NPS Collection

4 Students revisit the days of early lighthouse keepers while operating the original Point Reyes Lighthouse clockwork with Park Rangers.



NPS Collection



NPS Collection

5 Students study the oceanic influences on the Point Reyes Peninsula by completing a classroom curriculum and viewing gray whales and elephant seals with Park Rangers.

6-8 Students participate in Ranger-led stewardship activities such as habitat restoration, water quality monitoring, and beach cleanups.

Ranger-led Training Programs

9-12 Students become DOCENTS to assist middle school teachers with classroom teaching and use of scientific research tools on Seashore field trips (service learning credits earned).



NPS Collection

Students become RESEARCH ASSISTANTS at the Pacific Coast Learning Center by participating in the inventorying and monitoring of Seashore resources.

Teachers Teacher workshops are offered throughout the year for existing Park curricula and for field trip planning. Visit the Seashore's website at www.nps.gov/pore for a calendar of workshops.



NPS Collection

Classroom and Field Trip Curriculum

Based on the National and State Science and Social Science Standards

3-4



Teacher packets are available for field trips to the recreated Coast Miwok village, Kule Loklo, located near the Bear Valley Visitor Center.

The “Creating Coastal Stewardship through Science” middle school curricula are available to teachers who attend a one-day workshop at Point Reyes or a teacher in-service training.

6-8



Completion of the *Identifying Resident Birds Curriculum*, as a companion to a birdwatching field trip, will enable students to observe and identify different bird species, their habitats, and their behaviors. A visit to Point Reyes Bird Observatory will also enable students to observe bird banding and netting and to understand the most common threats to bird survival.



Completion of the *Monitoring Creek Health Curriculum*, as a companion to a Ranger-led creek program, will enable students to observe and understand the complexity and sensitivity of creek habitats and their role in protecting them.



Completion of the *Discovering Northern Elephant Seals Curriculum*, as a companion to an elephant seal viewing field trip, will enable students to observe and understand the amazing adaptations and behaviors of Northern elephant seals.



Completion of the *Defining Habitats Curriculum*, as a companion to a Park field trip, will enable students to observe and understand the complex land and ocean habitats of the Point Reyes Peninsula and their roles in habitat protection.



Completion of the *Uncovering the San Andreas Fault Curriculum*, as a companion to a geology field trip, will enable students to observe and understand the existence of the San Andreas Fault and the implications it has for area residents.



Completion of the *Investigating Tule Elk Curriculum*, as a companion to an elk viewing field trip, will enable students to observe and understand elk behaviors and the issues that surround their management.



Completion of the *Observing Pacific Gray Whales Curriculum*, as a companion to a whale watching field trip, will enable students to observe and understand gray whale adaptations and behaviors, and the factors that influence their survival.

Educational Facilities



The **Historic Lifeboat Station** is available to educational groups for overnight use. Nightly fees are charged. Group size must be under 25 (including chaperones). Reservations are made on a first-come, first-served basis by completing the boathouse form on our website at www.nps.gov/pore.



The **Clem Miller Environmental Education Center** is an overnight facility available by lottery to school groups visiting for multiple-night stays September through May. The facility is used for summer camps during the summer months. Fees are charged. For information, contact Point Reyes National Seashore Association at (415) 663-1200, website www.ptreyes.org.



The **Pacific Coast Learning Center** is a day-use facility located on Highway 1. This facility is used by researchers and students to study the natural and cultural resources of the Seashore.



The **Bear Valley Visitor Center** is a day-use facility open to school groups Monday through Friday from 9 A.M. to 5 P.M. Exhibits on natural and cultural resources are found here. Books, brochures, and other educational materials are available.



The **Ken Patrick Visitor Center** is located on Drakes Beach, approximately 30 minutes from the Bear Valley Visitor Center. This facility is open year-round on weekends and holidays from 10 A.M. until 5 P.M. Ranger-led elephant seal programs meet at this Visitor Center. Exhibits and a 150-gallon saltwater tank are located here. Books, brochures, and other educational materials are available.



The **Lighthouse Visitor Center** is located on the outermost tip of the Peninsula, approximately 45 minutes from the Bear Valley Visitor Center. This facility is open Thursday through Monday from 10 A.M. until 4:30 P.M. (closed Tuesdays and Wednesdays). Ranger-led whale programs and lighthouse tours meet at this Visitor Center. Exhibits on maritime history and whale biology are located here. Books, brochures, and other educational materials are available.



The **Lighthouse** is located below the Lighthouse Visitor Center at the bottom of a 308-step staircase. The lens room is usually open from 2:30 P.M. until 4 P.M. Thursday through Monday or as weather and staffing permit. High winds always close the lens room. Space in the lens room is limited so reservations are required for groups. Call (415) 464-5100 to confirm existing weather conditions.

Group Camping/Overnight Opportunities

* This listing is provided for your convenience and does not constitute a recommendation or endorsement of any of these facilities.



All overnight camping in **Point Reyes National Seashore** requires a permit and advance reservations. Group sites are very limited and in high demand. Sky, Coast, and Wildcat Camps are all backcountry campgrounds that require hiking to access them. A fee is charged. For more information, visit the Seashore's website at www.nps.gov/pore.

The **Point Reyes Hostel** offers a dormitory-style group cabin with a fully equipped kitchen and showers. For additional information and reservations, call (415) 663-8811 during office hours, 7:30 to 9:30 A.M. and 4:30 to 9:30 P.M.

Samuel P. Taylor State Park, located 6 miles east of the Seashore on Sir Francis Drake Boulevard, offers campsites for groups. A fee is charged. Reservations are highly recommended. For more information, visit the reservations website at www.reserveamerica.com.

Olema Ranch Campground is located half a mile from Seashore headquarters on Highway 1. It is privately owned. Several large group sites are available. Fees are charged. For more information, call (415) 663-8001.

The **Marconi Center** is located 8 miles north of Seashore headquarters on Highway 1. This facility is operated by California State Parks. Lodging, conference rooms, and catered meals are provided for a fee. For more information, call 1 (800) 970-6644 or visit the website at www.marconiconfctr.org.



National Park
FOUNDATION

Creating
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EXON



Uncovering the San Andreas Fault

Teacher Preparation1

Pre-Visit Activities 25

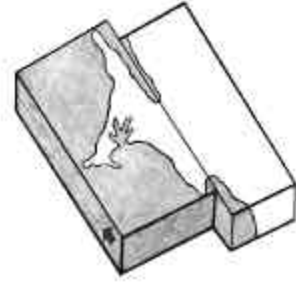
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Creating
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Uncovering the San Andreas Fault

Teacher Preparation

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Uncovering the San Andreas Fault



The San Andreas Fault System has moved the Point Reyes Peninsula to its present location and created many of the unique landforms in the Olema Valley.

Geologists estimate this peninsula has travelled about 280 miles from Southern California. It was brought here by the movement of the North American and Pacific Plates grinding and pulverizing rock and soil within its zone, creating narrow inlets and long, straight valleys. The Pacific Plate is still traveling northwestward, changing the landscape and creating occasional earthquakes. This unique geology has formed the basis of life at Point Reyes National Seashore, contributing to our current climate, soils, waterways, and ecology.

Completion of this unit, as a companion to your Park field trip, will allow your students to observe a portion of the San Andreas Fault. They will observe its effects on the land, and how everyone along the Fault must learn to live with its unpredictability.

Considerations

When: Year-round.

Where: The Earthquake Trail is located a short walk from the Bear Valley Visitor Center parking lot. This 1/2-mile loop trail is level and paved. The optional Mount Vision activity can be completed by driving up the Mount Vision road, located approximately 20 minutes from Bear Valley.

How: This unit may be used independently of all other guides. If you want to use an additional guide we suggest scheduling another field visit. The “Defining Habitats” guide is available from Point Reyes National Seashore and can give students a more complete understanding of how geology and the resulting topography and soils influence ecology.

Teacher Preparation

Creating
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through Science





Weather: The chart below lists average climate expectations based on previous years' data. The weather is subject to change quickly and can vary dramatically from different locations within the Seashore on the same day.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature												
Normal Daily Maximum	53	55	55	57	60	62	64	64	65	62	58	54
Normal Daily Minimum	41	42	42	43	47	50	51	52	51	48	45	42
Extreme High	78	85	80	92	94	99	96	96	103	96	81	79
Extreme Low	21	26	29	32	32	39	39	42	39	32	29	18
Precipitation												
Normal	12.0	9.0	8.0	4.0	3.0	1.0	0.3	0.8	2.0	4.0	9.0	12.0
Maximum	20.0	16.0	15.0	11.5	8.0	4.0	2.5	6.0	7.0	13.0	18.0	19.0

Seasonal Events: Consult the chart below to assess which months may be best for a class visit to Point Reyes National Seashore.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Gray Whale Migration	✓		✓	✓								
Elephant Seal Breeding	✓	✓	✓									
Bird Migration									✓	✓	✓	✓
Coho Spawning	✓											✓
Steelhead Trout Spawning		✓										✓
Tule Elk Rut Season							✓	✓	✓			
Peak Flower Blooms				✓	✓							
Tidepooling	✓	✓	✓									
Geology	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ocean and Land Habitats	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Resident Birds	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Chaperone Preparedness and Assistance

The success of your field trip will depend on your ability to actively prepare and involve your parent chaperones in the field trip activities. Without adult guidance, many of the students will not complete their field journals. It is essential that your field trip have as much structure as your classroom lessons. To accomplish this, we recommend that you assign each parent to a small group of students. Inform each parent that they are responsible for assisting their students with the field observations and with the completion of journal questions. Provide each chaperone with their own copy of the student journals and encourage them to complete it with the students. Also, have each chaperone carry a pair of binoculars and assist students with their use.





Suggested Lesson Plan

Total time needed: 12+ hours

Teacher Preparation

PRE-VISIT		Time Needed: 3+ hours
Activity #1	What Questions Do Geologists Answer? <i>Students investigate questions geologists can answer through research.</i>	2 hours
Activity #2	How Can We Prepare for Our Visit to Point Reyes National Seashore? <i>Students will prepare for upcoming field visit by constructing field journals.</i>	1 hour
Activity #3	Safety and Stewardship Challenge <i>Proper behaviors around National Park resources are examined in a game format.</i>	1 hour
ON-SITE		
ON-SITE		Time Needed: 2-6 hrs
Field Journal #1	What Makes the Geology of Point Reyes National Seashore So Special? <i>Students complete their field journals while hiking the Earthquake Trail.</i>	2 hours
Field Journal #2	What Does a Fault Zone Look Like? <i>Classes with more time may choose to visit the top of Mount Vision for an amazing view of the geology.</i>	4-6 hrs
POST-VISIT		
POST-VISIT		Time Needed: 5+hours
Activity #1	What Else Can We Learn About Information in Our Field Journals? <i>Multiple lesson ideas help students reinforce lessons learned on field trip.</i>	2 hours
Activity #2	What Is the Nature and History of the San Andreas Fault Zone? <i>Multiple activity sheets encourage students to think of the San Andreas in terms of the entire state and the world.</i>	30 min
Activity #3	What Is It Like to Be in an Earthquake? <i>Students take this opportunity to reflect on the human side of earthquakes.</i>	1 hour
Activity #4	What Earthquake Information Is Available on the World Wide Web, and Why Is It Important? <i>Students investigate real-time data on earthquakes around the world.</i>	1 hour
Activity #5	What Is Our Earthquake Safety Plan? <i>Students create an earthquake safety plan for home and school.</i>	1 hour



Field Trip Logistics

Teacher Preparation

<i>Things To Remember</i>		
<i>Students need:</i>	<i>Teachers need:</i>	<i>Chaperones need:</i>
<input type="checkbox"/> rain gear	<input type="checkbox"/> rain gear	<input type="checkbox"/> rain gear
<input type="checkbox"/> warm, layered clothes	<input type="checkbox"/> warm, layered clothes	<input type="checkbox"/> warm, layered clothes
<input type="checkbox"/> gloves and hat	<input type="checkbox"/> gloves and hat	<input type="checkbox"/> gloves and hat
<input type="checkbox"/> sunscreen and sunglasses	<input type="checkbox"/> sunscreen and sunglasses	<input type="checkbox"/> sunscreen and sunglasses
<input type="checkbox"/> bag lunch with drink	<input type="checkbox"/> bag lunch with drink	<input type="checkbox"/> bag lunch with drink
<input type="checkbox"/> water	<input type="checkbox"/> water	<input type="checkbox"/> water
<input type="checkbox"/> waterproof boots or tennis shoes	<input type="checkbox"/> waterproof boots or tennis shoes	<input type="checkbox"/> waterproof boots or tennis shoes
<input type="checkbox"/> clipboard with field journal and pencil	<input type="checkbox"/> map with directions	<input type="checkbox"/> map with directions
<input type="checkbox"/> permission slip	<input type="checkbox"/> pencil sharpeners and extra pencils	
	<input type="checkbox"/> teacher backpack and field trip kits from Bear Valley Visitor Center	
	<input type="checkbox"/> first aid kit	
<i>Optional:</i>		
<input type="checkbox"/> small backpack	<input type="checkbox"/> small backpack	<input type="checkbox"/> small backpack
<input type="checkbox"/> binoculars	<input type="checkbox"/> binoculars	<input type="checkbox"/> binoculars
	<input type="checkbox"/> camcorder/ camera	<input type="checkbox"/> camcorder/ camera

Other Things to Remember:

- Have students bring a bag lunch if you will be visiting during lunch time.
- If you have a student with accessibility concerns, please call the Park for suggestions.
- Students need warm, waterproof clothing most of the year. Sunscreen is needed on most days. Students should always be prepared for all types of weather.
- Have the students wear long pants and closed-toe shoes, preferably tennis shoes.
- Bathrooms, drinking water, and teaching materials (Geology Backpack, binoculars, clipboards etc.) are available at the Bear Valley Visitor Center. This should be your first stop when visiting Point Reyes National Seashore.





Evaluation Process

We need your help! Since this guide was designed for your use, only your feedback will make it work. There is an Evaluation Form located in this Teacher Preparation section, right before the Vocabulary list.

If you prefer to be interviewed over the phone about your experience, please phone (415) 464-5139 and request to speak with the project coordinator.

In addition to the evaluation form, we encourage other types of feedback. Please send any of the following items from your students:

1. Videotape or photos of Park field trip
2. Completed student journals
3. Any completed stewardship activities, including posters, murals, newsletters, etc.
4. A class portfolio illustrating various pre-visit activities, photographs, or drawings
5. Completed classroom projects or photographs of projects

Please indicate if these items need to be returned. We will use them to create a project library, highlight classroom efforts on our website and in Park publications, and complete evaluations of student outcomes.

Reservations

To avoid scheduling conflicts with other groups and to be notified about any unusual closures, please call the Park to notify us about your field trip date and time. See the Reservation Form following this unit overview.

Geology Backpack Contents

A Geology Backpack is available for use at the Bear Valley Visitor Center. These are available on a first-come, first-served basis.

- Visual Aid Binder with raised topography map and historic 1906 earthquake photos
- compass
- small first aid kit
- Bird Identification Guide

also available:

- 40 binoculars
- 40 clipboards
- spotting scopes

NOTE: Binoculars and spotting scopes are very useful if you plan to use the on-site lesson plan **What Does a Fault Zone Look Like?**





California Science Standard Links

Teacher Preparation

"Uncovering the San Andreas Fault" Unit										
Pre-Visit			On-Site		Post-Visit					
#1	#2	#3	Field Journal #1	Field Journal #2	#1	#2	#3	#4	#5	
Sixth Grade										
1	a,b,- d,f		a,b,c,d,e,f,- g	a,d,e,f		a,c,- d,e,- f,g		a,c,- d,e,- f,g		
2										
3										
4						c				
5										
6										
7	b,d	b,h	b,h	b,f,g,h	d,e	b,e		d		
Seventh Grade										
1										
2										
3										
4										
5										
6										
7	a,b,- c,e	a	a	a,e	c	a,b,- d	b,c			
Eighth Grade										
1										
2										
3										
4										
5										
6										
7										
8										
9	b	b	b	b		b		b		





Acknowledgments

This unit was written by area teachers, Park Rangers, scientists, and area naturalists. Special thanks to the following people:

Workshop Participants

Terry Wright, Geologist, Sonoma State University
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Special Thanks

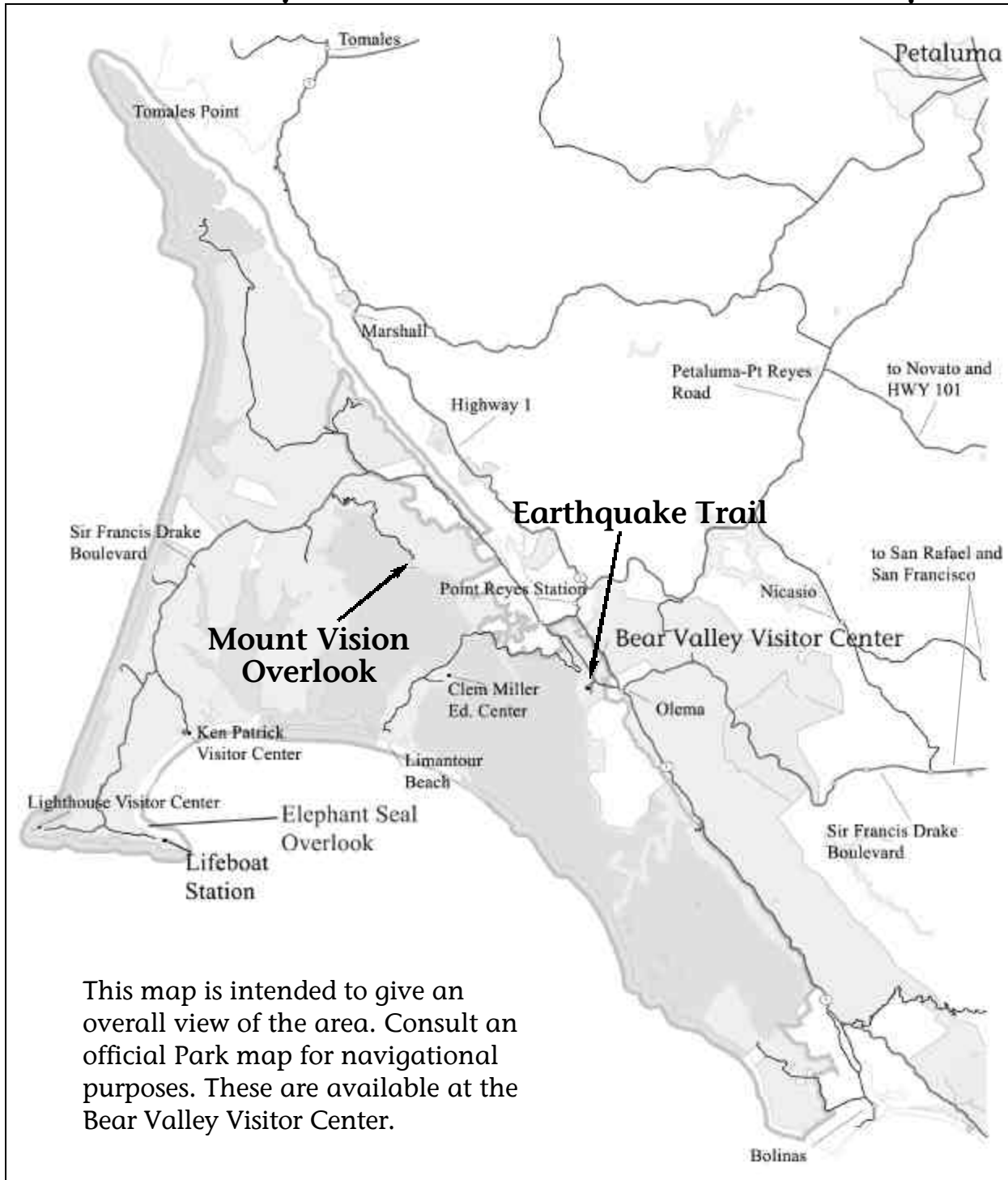
Kathleen Abbott, Geomorphologist/ Education Specialist,
GeoCorp America Participant at Point Reyes National Seashore
Thomas Wood Parsons, Cartographer
Rahel Fischer, Editor



Point Reyes National Seashore Map



Attachment



Approximate Driving Times/Distances

Petaluma to Bear Valley VC	40 min./19 miles
Novato to Bear Valley VC	40 min./19 miles
San Anselmo to Bear Valley VC	30 min./20 miles
Bear Valley VC to Limantour Beach	20 min./9 miles
Bear Valley VC to Tomales Point	30 min./19 miles
Bear Valley VC to Ken Patrick VC	30 min./15 miles
Bear Valley VC to Elephant Seal Overlook	45 min./22 miles

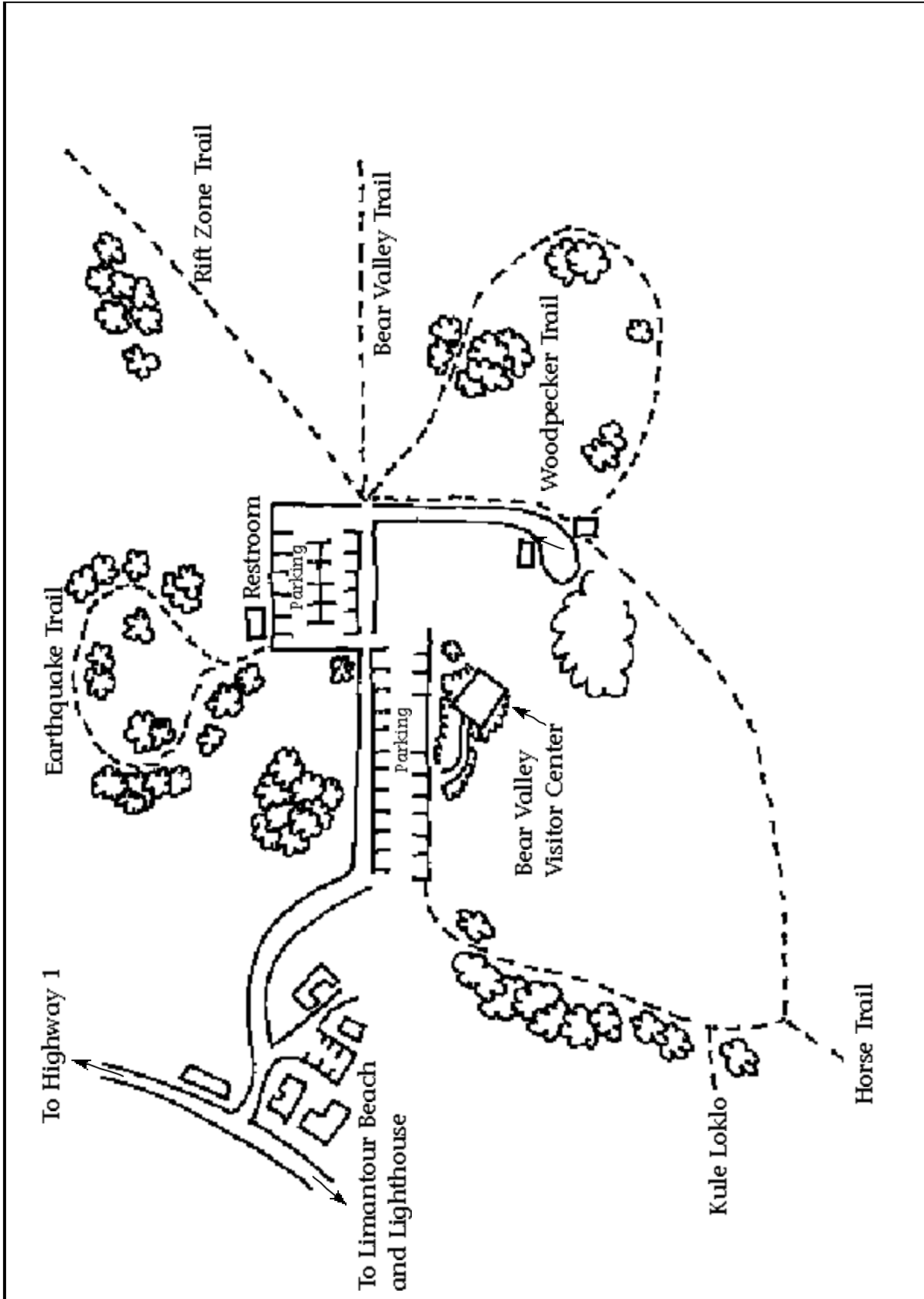
POINT REYES NATIONAL SEASHORE



Bear Valley Visitor Center Area Map



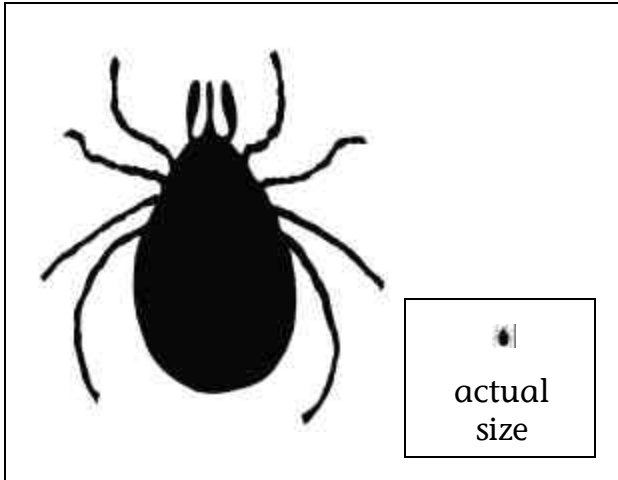
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Lyme Disease, Stinging Nettle, and Poison Oak

Lyme disease is an illness caused by bacteria transmitted to people by tick bites. Not all ticks carry the disease. Field studies in Marin County show that 1–2% of the western black-legged ticks carry Lyme disease. Since there are several other species of ticks in Marin, the odds of a tick bite producing Lyme disease is less than 1 in 100. Even so, Lyme disease can be severe; it is important to understand the prevention and symptoms.



Symptoms:

- arthritis and joint pain
- lethargy
- heart problems
- pain/limping
- fever
- kidney problems
- depression
- bull's-eye rash (50% of victims)

Tick species in California include:

Western black-legged tick and Pacific coast tick (West Coast)
Lone star tick and American dog tick (throughout U.S.)

How to avoid tick bites:

- Wear light-colored, long-sleeved clothes so you can more easily see the ticks.
- Tuck shirt into pants and pants into socks to keep ticks away from your skin.
- Stay on trails.
- Apply an insect repellent, labeled for ticks, to shoes, socks, and pants.
- Check yourself completely after a hike. Closely check any skin irritation. Ticks anesthetize the skin before biting so you'll seldom feel the original bite.

What to do if bitten:

- Use tweezers to grasp tick at point of attachment, as close to skin as possible. Gently pull tick straight out.
- Save tick, notify your doctor.
- Don't panic—ticks need to be embedded from 24 to 48 hours to transmit bacteria. The ticks that transmit Lyme disease are usually in a developmental phase in which they are smaller than the head of a pin.

References:

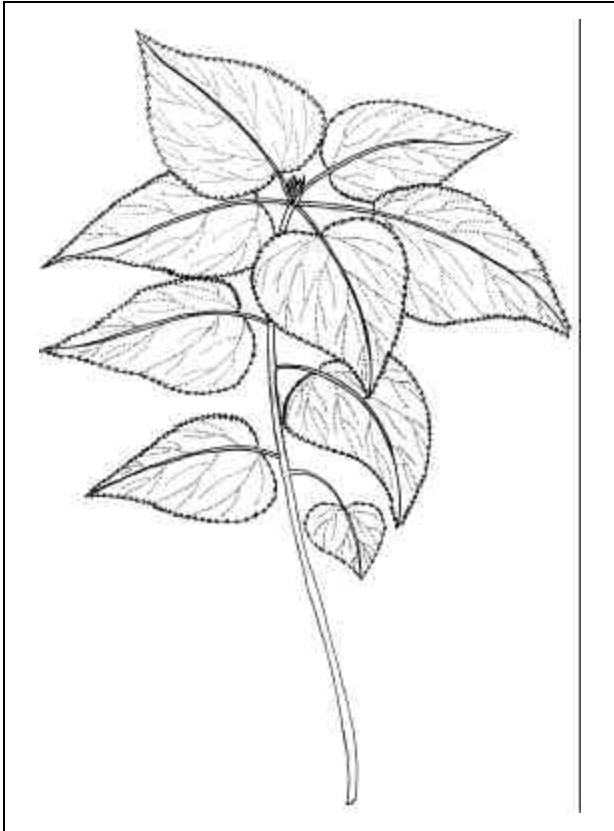
Ticks and Lyme Disease in the National Parks
Lyme Disease Foundation/www.lyme.org





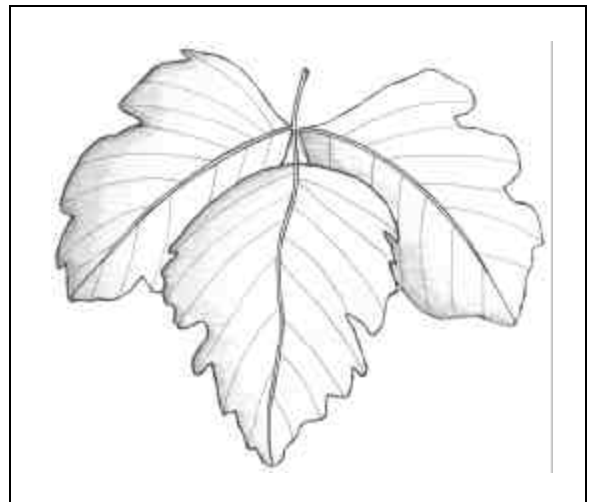
Lyme Disease, Stinging Nettle, and Poison Oak

Attachment



Stinging nettle is native to Europe, but grows at Point Reyes National Seashore. It can cause a painful rash that stings for up to 12 hours after brushing up against the plant. A topical analgesic (used to treat poison ivy or bug bites) can be applied to help alleviate the sting. Study the picture and have someone point out the plant in the Seashore to aid in its identification.

Poison oak usually causes an itchy rash if you are sensitive to it. You can get a rash by touching the plant, its leaves, or its roots. You can also contract poison oak by petting your dog (if the oils are on its coat) or by touching clothing that has touched poison oak. Rashes may occur several days after the initial contact with the plant. Severe rashes may affect the lungs. If you have difficulty breathing, call 911 or go to the nearest emergency room immediately. Preventive topical ointments are available to help avoid reactions to poison oak. Learn to recognize the compound leaves with a shiny appearance.



Creating Coastal Stewardship through Science



If you are planning a trip to Point Reyes National Seashore to use this curriculum, please notify the Park to avoid conflicts with other groups and to be notified about any unusual closures. Mail this form at least 2 weeks in advance (fold in thirds and affix postage) or call (415) 464-5139, to leave a message.

Teacher Name: _____
School Name: _____
School Address: _____
City/State: _____ Zip Code: _____
School Phone: _____ School Fax: _____
Email: _____
Grade: _____ Class Size: _____
Home Phone: _____

Reservation

Field Trip Options

- Monitoring Creek Health
- Observing Pacific Gray Whales
- Discovering Northern Elephant Seals
- Defining Habitats
- Investigating Tule Elk
- Uncovering the San Andreas Fault
- Identifying Resident Birds

Field Trip Preferences

Field Trip Topic	Dates (list three in order of preference)	Time
1. _____	_____	_____
	_____	_____
	_____	_____
2. _____	_____	_____
	_____	_____
	_____	_____

Comments

_____ Confirmation Letter
_____ Materials Sent

National Park Service
Point Reyes National Seashore
Division of Interpretation
attn: Education Program Coordinator
Point Reyes Station, California 94956



Creating Coastal Stewardship through Science



Evaluation

Please help us develop and improve our programs by taking a few minutes to complete this form. This evaluation form is preaddressed, but needs to be folded in thirds and provided with postage. If you prefer, E-mail comments to: PORE_Education@nps.gov

Name: _____ School Name: _____

School Address: _____

City/State/Zip Code: _____

School Phone: _____ School Fax: _____

Email: _____

Class Size/Grade: _____

Date of Visit: _____ Program/Location: _____

Getting Your Visit Set Up

Do you have any suggestions to make logistics easier? (maps, directions, reserving programs)

Curriculum Materials

Which lessons were the most effective?

Relevance of content to my students and curriculum:

Grade appropriateness?

Program Assessment

How does this program fit into California/National Standards and your personal education program?

Strengths/weaknesses of program?

Best part of experience?

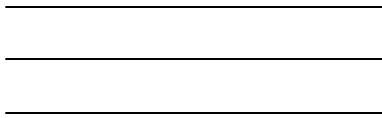
What is the level of support at your school for this program?

What could the National Park Service do to improve your education program?

Overall, how would you respond if a colleague asked about this program?

Highly recommended Recommended Recommended with some qualifications
Not recommended





National Park Service
Point Reyes National Seashore
Division of Interpretation
attn: Education Program Coordinator
Point Reyes Station, California 94956





Basalt	a fine-grained igneous rock with composition of a gabbro. Basalt makes up most of the ocean floor and is the most abundant volcanic rock in the earth's crust. Generally occurs in lava flows, but also as dikes.
Chert	a very fine-grained sedimentary rock made of quartz. Usually made of millions of globular skeletons (containing silica) from tiny marine plankton called radiolarians. Black chert is called flint.
Epicenter	that point on the earth's surface that lies vertically above the focus of an earthquake
Erosion	the complex group of related processes by which rock is broken down physically and chemically and the products moved
Estero	a semi-enclosed body of coastal water within which seawater is diluted with freshwater (estero: Spanish for estuary)
Fault Zone	faults generally consist of a zone, sometimes thousands of feet wide, composed of many small faults with brecciated rocks (rock composed of angular fragments of older rocks melded together). The San Andreas Fault Zone is more than 800 miles long and extends to depths of at least 10 miles within the earth. It varies in width from a few hundred feet to a mile wide.
Franciscan Complex	a common sedimentary rock(of the coastal range) which is a melange of chert, graywacke, blueschist, pillow lavas, and serpentine in a shale matrix
Gabbro	a coarse grained igneous rock in which olivine and pyroxene are the predominant minerals and plagioclase is the feldspar present (quartz is absent)
Gneiss	a coarse-grained, light and dark colored metamorphic rock that commonly has alternating bands of light and dark-colored minerals
Granite	a coarse-grained intrusive igneous rock with at least 65% silica. Quartz, plagioclase feldspar and potassium feldspar make up most of the rock and give it a fairly light color.
Greenstone	a metamorphic rock derived from basalt or chemically equivalent rock such as gabbro. Greenstones contain sodium-rich plagioclase feldspar, chlorite, and epidote, as well as quartz. The chlorite and epidote make greenstones green.



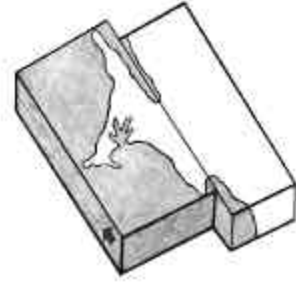
Vocabulary

Igneous Rocks	rock formed when molten rock (magma) has cooled and solidified (crystallized).
Lithosphere	the outer 100km of the solid earth, where rocks are harder and more rigid than the layer below the lithosphere (known as the asthenosphere)
Marble	a metamorphic rock made of calcium carbonate. Marble forms from limestone by metamorphic recrystallization.
Metamorphic Rocks	a rock that has undergone chemical or structural changes produced by increase in heat or pressure, or by replacement of elements by hot, chemically active fluids.
Offset Stream Course	a stream whose drainage pattern is altered or offset as it crosses an active fault
Plate Tectonics	the theory that the Earth's outer shell is made up of about a dozen lithospheric plates that move about and interact at their boundaries.
Sag Pond	a low spot formed adjacent to the fault which can fill with water.
San Andreas Fault	an active strike-slip fault in Western United States, forming the on-land portion of the western margin of the North American Plate.
Sedimentary Rocks	sedimentary rocks are formed from pre-existing rocks or pieces of once-living organisms. They form from deposits that accumulate on the Earth's surface. Sedimentary rocks often have distinctive layering or bedding.
Serpentine	serpentine minerals are light to dark green, commonly varied in hue, and greasy looking; the mineral feels slippery. Rocks made up of serpentine minerals are called serpentinite.
Serpentinite	produced when hot sea-water circulates through the lithosphere at ocean ridges; it is usually found in regions where mountain-building events have occurred in response to the closing of an ocean basin; also California state rock
Shutteridge	a ridge which is moved by the fault and blocks or shuts off the drainage of a creek.
Stewardship	choices and actions that protect our environment





Subduction	the process of one crustal plate sliding down and below another as the two converge; the subduction zone is the area between these two plates
Syncline	a downfold with a trough-like form
Topography	the shape of the land surface, including differences in elevation such as mountains, valleys, and rivers
Transform Fault	a strike-slip fault that offsets a midocean ridge in opposing directions on either side of an axis of seafloor spreading
Tsunami	an unusually large sea wave most often produced by an earthquake, volcanic eruption, or landslide out at sea.
Uplift	the raising up or displacement of surface features that occurs as a result of seismic activity. Mountain ranges are formed from uplift.
Weathering	the chemical alteration and mechanical breakdown of rock and sediment when exposed to air, moisture, and organic matter. The principal agent of chemical weathering is water solutions that behave as acids. Mechanical weathering involves physically breaking rock into fragments without changing the chemical makeup of the minerals within (example: water in cracks freezing and expanding, or changes in temperature that expand and shrink individual minerals enough to break them apart).



Uncovering the San Andreas Fault

Pre-Visit Activities

What Questions Do Geologists Answer?	25
How Can We Prepare for Our Visit to Point Reyes	
National Seashore?	35
Safety and Stewardship Challenge	39

What Questions Do Geologists Answer?



Pre-Visit LESSON PLAN

Students will prepare each other for their upcoming field trip by developing presentations, activity sheets, and vocabulary lists on geologic topics. Presentation topics are derived from questions geologists can answer through research. These questions cover the range of the earth's structure, plate tectonics, and earthquakes as they relate to the San Andreas Fault. This pre-visit lesson plan forms a foundation and imparts critical knowledge to prepare students for field visit.

Time required: 2 hours and independent research time

Location: classroom

Suggested group size: entire class organized into teams

Subjects: science, physics, mathematics

Concepts covered: natural history, observational techniques, earth science

Written by: Lynne Dominy and Christie Denzel Anastasia,
National Park Service

Last updated: 04/02/00

Student Outcomes

At the end of this activity, the students will be able to:

- Effectively locate and share information gained through research
- Prepare for upcoming field trip

California Science Standard Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

- 6th grade
- 1a - the fit of the continents, location of earthquakes, etc., provide evidence for plate tectonics
 - 1b - the solid earth has three layers
 - 1d - earthquakes are sudden motions along breaks in the crust called faults
 - 1f - explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes)
 - 7b - select and use appropriate tools and technology to perform tests, collect and display data
 - 7d - communicate the steps and results from an investigation

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- 7th grade 7a - select and use appropriate tools and technology to perform tests, collect and display data
7b - utilize a variety of print and electronic resources, including the World Wide Web, to collect information
7c - communicate logical connections among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence
7e - communicate the steps and results from an investigation
- 8th grade 9b - evaluate the accuracy and reproducibility of data

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; Develop descriptions, explanations, predictions, and models using evidence; Think critically and logically to make the relationships between evidence and explanations; Communicate scientific procedures and explanations.
- Content Standard B - Motions and forces; Transfer of energy.
- Content Standard D - Structure of the earth system; Earth's history.
- Content Standard F - Personal health; Natural hazards; Risks and benefits.
- Content Standard G - History of Science.

Materials

To be provided by the teacher:

- Research materials such as field guides, relevant books, access to Internet.
- Possible free materials from "Resources" list at end of guide
- Art supplies for students to prepare presentations

To be photocopied from this guide:

- **Responsibilities for Team Presentations** Activity Sheet; one per team
- **Focus Questions** Activity Sheet; one topic per team

Vocabulary

Students will provide vocabulary lists with their presentations.

Procedures

1. Explain assignment to students

Student teams will research topics relevant to their upcoming field trip to Point Reyes National Seashore. They will be responsible for preparing each other through a series of presentations. This will be run as a "scientific symposium" where brief presentations are given and time is allowed for clarifying questions.



2. **Create seven student teams**
Designate teams and assign topics, or allow students to group themselves according to interest.
3. **Provide photocopies to teams**
Each team should receive at least one copy of the **Responsibilities for Team Presentations** and **Focus Questions** Activity Sheets.
4. **Explain team responsibilities**
Reviews **Responsibilities for Team Presentations** and allow for questions. Designate amount of time for research and presentations. Let students know when you expect to receive their activity sheets and vocabulary lists (so you can make photocopies), and what day the presentations will occur.
5. **Allow time for independent team study and preparation**
Decide whether there is time for students to conduct research during class time or as homework assignments. Encourage the teams to use visual aids and activities to illustrate their geologic concepts.
6. **Collect student-generated materials prior to presentations**
Each team should turn in an activity sheet and a vocabulary list that will be photocopied for each student.
7. **Presentations**
These should occur in their numbered order for logical sequencing. Allow time for students to ask questions and complete their worksheets. Challenge the class to come up with at least three questions to pose to the presenting team.
8. **Reinforce concepts**
Summarize student presentations to provide foundational knowledge for upcoming field trip. The more students understand about plate tectonics, the more their visit to the Earthquake Trail or Mount Vision Overlook will be.

Extension Ideas

1. Divide vocabulary terms among students. Which ones could be better understood through illustrations or further detail? Develop a "Geologic Dictionary" that can be brought on field trip.
2. Investigate geologic research in the National Park System. If you navigate to **www.nps.gov** and select the following topics (Nature Net, Geology, Hot Topics in Geologic Resources) you will arrive at a chronological list of relevant issues and events. Have students pick one of interest and write a brief report summarizing information and pertinence to their lives.



Name _____ Date _____

Responsibilities for Team Presentations



YOUR CHALLENGE IS TO
PREPARE A PRESENTATION
DESIGN AN ACTIVITY SHEET
and PROVIDE VOCABULARY
FOR A GEOLOGIC TOPIC

1. Use your focus questions to begin research for your geologic topic.
2. As you work on the organization of your presentation, develop a one-page activity sheet that other students in the class will complete during your discussion. Make them think! If you make the questions too hard or too easy, you may lose their interest.
3. Prepare a vocabulary sheet for any words you will mention in your presentation that require an explanation.
4. Prior to your presentation, your teacher will need from you the following to provide copies to other students: activity sheet, answer key for activity sheet, vocabulary list.
5. When you prepare your presentation use visual aids, skits, or models that will help get your concepts across. Make learning your information fun and interesting!
6. Help the team following yours by providing a transition or bridge into their presentation.

Responsibilities for Team Presentations

YOUR CHALLENGE IS TO
PREPARE A PRESENTATION
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6. Help the team following yours by providing a transition or bridge into their presentation.





FOCUS QUESTIONS FOR TEAM 1

Topic: What Is the Structure of the Earth?

- How old is the earth?
- How many layers make up the earth, and what is their composition and thickness?
- Did the earth always have the same number of layers, or did it form in stages?
- What studies have geologists conducted to learn the structure of the earth?
- How does the structure of the earth contribute to earthquakes?

Presentation following yours will be "What Is Plate Tectonics?"

FOCUS QUESTIONS FOR TEAM 2

Topic: What Is Plate Tectonics?

- What is the definition for plate tectonics?
- What causes these plates to move?
- Are there ways to categorize how the plates meet and what directions they move?
- Is there a difference between plate movements whether they occur on land or in water?
- What plates immediately influence California and Point Reyes National Seashore?
- If you were looking at a map of the earth showing its plate tectonics, what relationship would that have to a map showing earthquake occurrences?

Presentation following yours will be "What Is an Earthquake?"

FOCUS QUESTIONS FOR TEAM 3

Topic: What Is an Earthquake?

- What is the definition of an earthquake?
- What are P and S waves, and what part of the earth's structure do they affect?
- How do scientists use these two types of waves to discover an epicenter?
- Why is it important to know the epicenter?
- What are some visual examples on the landscape of an earthquake having happened?
- What instrument is used to determine if an earthquake happened?

Presentation following yours will be "How Are Earthquakes Detected?"





Activity Sheet

Name _____ Date _____

FOCUS QUESTIONS FOR TEAM 4

Topic: How Are Earthquakes Detected?

- How does a seismograph work?
- If you had a seismograph reading that displayed a zigzag pattern, how would that information correlate to the two types of waves (P and S)?
- Is it important to have more than one seismograph in an active area?
- Once you know an earthquake occurred, what "scales" are used to measure it?

Presentation following yours will be "How Are Earthquakes Measured?"

FOCUS QUESTIONS FOR TEAM 5

Topic: How Are Earthquakes Measured?

- What is the Richter scale?
- What is the Mercalli Intensity scale?
- What are the similarities and differences between these two systems of comparison?
- What is the difference between magnitude and intensity?
- What fault moved on April 18, 1906, in San Francisco, and what was its measurement?

Presentation following yours will be "What Is a Fault?"

FOCUS QUESTIONS FOR TEAM 6

Topic: What Is a Fault?

- In geology what is the difference between a joint and a fault?
- List three types of faulting.
- What are the three major types of plate boundaries?
- In which part (or layer) of the earth does faulting occur?
- What is the relationship between plate tectonics and major faults?
- What type of fault is the San Andreas Fault?

Presentation following yours will be "What Is the San Andreas Fault?"



Name _____ Date _____



FOCUS QUESTIONS FOR TEAM 7

Topic: What Is the San Andreas Fault?

- Where does the San Andreas Fault lie in the state of California?
- What other places in the National Park Service does this fault travel through?
- What other major cities in California does this fault travel through?
- What is the history of movement along this fault in recorded history?
- Is there evidence that this fault moved before recorded history?
- When could the next large earthquake occur along the San Andreas Fault?

Activity Sheet





How Can We Prepare for Our Visit to Point Reyes National Seashore?

Students will prepare for upcoming field visit by constructing and reviewing their personal field journals.

Time required: 1 hour

Location: classroom

Group size: all

Subjects: science, math, writing

Concept covered: preparation for geology field trip

Written by: Christie Denzel Anastasia and Lynne Dominy,
National Park Service

Last updated: 04/10/00

Student Outcomes:

At the end of this activity, the students will be able to:

- Utilize field journals while visiting Point Reyes National Seashore

California Science Standards Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

- 6th grade 7b - select and use appropriate tools and technology to perform tests, collect and display data
 7h - identify natural changes in natural phenomena over time without manipulating the phenomena
- 7th grade 7a - select and use appropriate tools and technology to perform tests, collect and display data
- 8th grade 9b - evaluate the accuracy and reproducibility of data

National Science Standard Links (Grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; understanding about scientific inquiry.
- Content Standard G - Science as a human endeavor; Nature of science: students formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.



Materials

To be photocopied from this guide:

- Field Journal Sheets for each student (these sheets are located with the on-site lesson)

Vocabulary

generated by student inquiry

Procedures

1. Construct field journals

See the attached sheet for **Tips for Constructing Field Journals**. Hand out photocopies of the unit worksheets and have students assemble their field journals. Most groups will use **What Makes the Geology of Point Reyes National Seashore So Special?** field journal (page 53). Groups with more time and experience should consider using **What Does a Fault Zone Look Like?** field journal (page 93).

2. Review field trip logistics

Students will break into two groups. Both groups will begin at the Bear Valley Visitor Center to use restrooms and get drinking water. One group will remain at the Bear Valley Visitor Center to complete the activity in their journal labeled **Bear Valley Visitor Center Activity**. The other group will begin the Earthquake Trail. When the group on the Trail finishes, may go to the Bear Valley Visitor Center to complete their worksheets. Staggering the groups in this manner prevents large groups of students all trying to read one sign at the same time.

3. Important note

The **What Makes the Geology of Point Reyes National Seashore So Special?** field journal is based on signs installed in 1976. These signs will be updated and replaced by September 2003. If you are planning a field trip after that date, contact the Education Specialist at (415-464-5219) for an updated field journal based on the new signs.

Tips for Creating Field Journals



Materials

- Field Journal Sheets for each student, teacher, and chaperone
- One package blank paper and one package lined paper
- Colored paper, cardstock, or cardboard for journal covers
- Markers or colored pencils for decorating covers
- three-hole punch
- String, binding tape or twigs and rubber bands for binding
- Pencil on a string for each student
- Two plastic pencil sharpeners and extra pencils for field trip
- One box of large ziplock bags to rainproof journals

Procedures

1. Photocopy all of the unit handouts and provide each student with double-sided copies. Use recycled paper if it is available.
2. Provide five additional sheets of blank paper and five sheets lined paper to each student.
3. Have students create front and back covers for their journals using blank sheets of paper.
4. Have students bind their journals using binding tape, hole punches and string, cardboard, or a twig bound by rubber bands threaded through holes.
5. Once journals are bound, have students decorate the covers.
6. Have each student attach a sharpened pencil on a long string through a hole in the journal binding.
7. Have each student use a magic marker to write their name on the front cover of their journal.
8. Students will need a sturdy writing surface behind their field journals. Incorporate cardboard as the last page or have clipboards available for each student.

Extension ideas

1. Create a journal that is used throughout the year.
2. Share student journals with parents at open houses.
3. Students may choose to use their journals to create a class newsletter, resource newspaper, or a class website.

Safety and Stewardship Challenge



Students will learn how to protect themselves and the resources in a National Park. This will be accomplished by simulating a group "game show" and completing the first page of their field journals.

Time required: 1 hour

Location: classroom

Suggested group size: any

Subject: science

Concepts covered: low-impact use of natural areas, behaviors in a National Park, safety

Written by: Christie Denzel Anastasia and Lynne Dominy,
National Park Service

Last updated: 06/20/00

Pre-
Visit

LESSON PLAN

Student Outcomes

At the end of this activity, the students will be able to:

- List three safety precautions for upcoming field trip
- List three proper behaviors for geology field visits
- Understand the role of the National Park System and stewardship

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard F - Personal health: Injury prevention; Populations, resources, and environment.

Materials

To be provided by the teacher:

- Desk bell (or other device to indicate which team has the first answer)

To be photocopied from this guide:

- **Safety and Stewardship Challenge Questions Teacher Information Sheet** (one set)

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through Science

Vocabulary

stewardship





Procedures

1. Divide class into teams

Option A: If class can work as large teams, divide the class into two teams. Each team will need a spokesperson and team name. Answers will come from the entire group. Spokesperson can change throughout the game.

Option B: If class may get too loud, students can still be divided into teams, but answers will come from individuals on each team. One person from each team will be assigned a number. Team A and Team B will each have a #1, #2, etc. Randomly choose a number from hat. The student with that specific number from each team will be responsible for answering the question. Random choice of numbers will help students pay attention if they aren't quite sure when their turn will occur.

2. Draw challenge grid and scorecard on blackboard

There are four categories with questions of varying value. As a finale, there is a final jeopardy question. Draw this grid on the chalkboard:

Safety and Stewardship Challenge			
Category #1 Take Care of Yourself	Category #2 Minimize Your Impact	Category #3 Geology Etiquette	Category #4 The National Park Service
1 point	1 point	1 point	1 point
2 points	2 points	2 points	2 points
3 points		3 points	
4 points	3 points	4 points	3 points
		5 points	
Final Challenge			

3. Choose game show hosts

Option A: Teacher is responsible for asking all of the questions.

Option B: Four students will become "Challenge Hosts". Each student receives questions for a specific category and will ask appropriate questions according to point value.





4. Rules of the game

- A coin flip will determine which team goes first.
- The game will end when a predetermined time runs out or when all questions have been answered.
- Team will decide which category and value of question will be asked.
- Spokespersons or individuals will poise themselves on either side of the desk bell with one hand behind their backs.
- After the question is asked, the first team to have an answer will ring the bell and respond. If they are correct, the team receives the full point value.
- If they are incorrect, the other team gets a chance. If they also get it wrong, the first team can try again for one less point.
- When brainstorming answers, students should whisper, or the other team may hear their answer.
- When all of the categories are complete (or 5 minutes before a predetermined "game-over" time), class will go into "Final Challenge". Each team decides on amount of wager, listens to question, and writes down answer on a sheet of paper. Each team reveals answer.
- At the end of the game, the team with the most points "wins", but everyone wins if your visit to Point Reyes National Seashore is safe for themselves and the resources.

5. Complete first page of field journal.

Using the information gained in this "game show", have students list at least three items under each category on the first page of their journal (**Things to Remember While on Geology Field Trip**).

Safety and Stewardship Challenge Questions



CATEGORY #1: Take Care of Yourself

1 point

Bring a water bottle and drink plenty of water because...

- A you will not be able to speak well with a dry throat.
- B not drinking enough water can give you a headache and cause you to make bad decisions.**
- C a heavy water bottle will slow you down as you are walking.
- D all of the above

2 points

If the sun feels warm, you should...

- A try to get a tan.
- B use sunglasses, sunscreen, and/or a hat.**
- C take off your shoes and walk barefoot.
- D all of the above

3 points

Cliff edges in Point Reyes National Seashore are...

- A made of granite and safe as long as you have one foot flat on the ground at all times.
- B sandy, loose, and slippery; be careful at all times.**
- C safe if you have good balance.
- D the best places for a good view.

4 points

The best way to dress for a field trip:

- A comfortable, closed-toe shoes.
- B a T-shirt and a heavy, waterproof jacket.
- C "like an onion," many thin layers with a waterproof one on the outside.**
- D A and C



Safety and Stewardship Challenge Questions

CATEGORY #2: Minimize Your Impact

1 point

When visiting Point Reyes National Seashore, you should stay on trails because...

- A you are more likely to pick up a tick in grassy areas.
- B when you travel off-trail you can damage plants.
- C you are speeding up erosion.
- D **all of the above**

2 points

It's okay to take home just one rock from Point Reyes National Seashore.

- A Sure, it's just one, but let your teacher know.
- B No; every rock is home to many bugs and plants.
- C **No, with 2.5 million visitors, the Seashore would be rock-less if every visitor collected just one.**
- D B and C

3 points

Trash is....

- A okay to hide behind bushes in a National Park because it will eventually break down.
- B not a good source of food for hungry animals.
- C **not a part of the Point Reyes National Seashore ecosystem and should be properly disposed of whether it's your trash, or trash that someone else accidentally dropped.**
- D only the responsibility of the maintenance staff, wherever it is.



Safety and Stewardship Challenge Questions



CATEGORY #3: Geology Etiquette

1 point (Note: there are two answers for each question in Category #3)

If you found a whale fossil at one of the beaches in Point Reyes National Seashore, you could legally:

- A take it home to decorate your bedroom.
- B sell it to the highest bidder.
- C **notify a Park Ranger.**
- D **leave it where you found it because every fossil and its location are irreplaceable clues to our ecological history.**

2 points

What can a rock "tell you"?

- A **Depending on the rock type, it can tell you about the conditions where it was formed, where it has moved, and what processes have occurred.**
- B **Depending on the rock type, it may tell you about plants that were around because of the pollen fossils located inside.**
- C How much longer it has until it becomes sand or part of another rock.
- D If and when you are destined to win the lottery.

3 points

The best way to observe a rock in a National Park is to...

- A break it apart to see what's inside.
- B collect several samples to bring back home for your collection
- C **take a close-up picture.**
- D **carry a geologic map of the Park to determine which rock unit corresponds to your rock.**

4 points

All of the rock ledges in Point Reyes National Seashore are...

- A safe.
- B **subject to crumble while you are standing on them.**
- C **slippery when wet.**
- D not very high up from softer ground if you fall.

5 points

Some rocks in Point Reyes National Seashore could be...

- A insignificant in any way.
- B **tools the Coast Miwok Indians used when they lived within the Park's boundaries.**
- C fake to make it look prettier.
- D **tools from settlers, whalers, and gold hunters.**



Safety and Stewardship Challenge Questions

CATEGORY #4: The National Park Service

1 point

Which of the following is not in the National Park Service?

- A Grand Canyon National Park, AZ
- B Keweenaw National Historical Park, MI
- C **Monterey Bay Aquarium, CA**
- D Golden Gate National Recreation Area, CA
- E Yosemite National Park, CA

2 points

I should treat Point Reyes National Seashore with respect because...

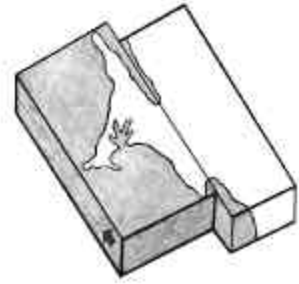
- A it belongs to everyone in the entire United States.
- B it preserves a part of the ecosystem you live in and depend on.
- C it's one of the few places natural processes can happen with little intervention from human society.
- D **all of the above**

3 points

Which of the following is the mission of the National Park Service?

- A Preserve natural and cultural resources.
- B Provide for the enjoyment, education, and inspiration of this generation.
- C To care for special places saved by the American people so that all may experience our heritage.
- D Cooperate with other resource-conservation and outdoor-recreation organizations in our country and the world.
- E **all of the above**





Uncovering the San Andreas Fault

On-Site Activities

What Makes the Geology of Point Reyes National
Seashore So Special?49

What Does a Fault Zone Look Like?87



What Makes the Geology of Point Reyes National Seashore So Special?

Students will walk the Earthquake Trail which is near what was once believed to be the epicenter of the 1906 earthquake. This trail has interpretive signs describing the geologic significance of the area. Students will answer questions in their field journals so they may gain the greatest appreciation of how clues on the land can tell a geologic story.

Time required: 2 hours

Location: Earthquake Trail (near Bear Valley Visitor Center)

Suggested group size: up to 50 walking on trail

Subjects: earth science, math, writing

Concepts covered: transform faults, plate tectonics, earthquake processes, earthquake preparation, rocks of Marin County

Written by: Mike Schulist

Last updated: 04/10/00

Student Outcomes

At the end of this activity, the students will be able to:

- Explain the major forces that create earthquakes
- Explain the role of plate tectonics in Point Reyes geology
- Name some of the local rock types in Marin County

California Science Standards Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

- 6th grade
- 1a - the fit of the continents, location of earthquakes, etc., provide evidence for plate tectonics
 - 1b - the solid earth has three layers
 - 1c - lithospheric plates that are the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle
 - 1d - earthquakes are sudden motions along breaks in the crust called faults
 - 1e - major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate tectonics



1f - explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes)

1g - how to determine the epicenter of an earthquake and that the effects of an earthquake vary with its size, distance from the epicenter, local geology, and the type of construction involved

7b - select and use appropriate tools and technology to perform tests, collect and display data

7h - identify natural changes in natural phenomena over time without manipulating the phenomena

7th grade 7a - select and use appropriate tools and technology to perform tests, collect and display data

8th grade 9b - evaluate the accuracy and reproducibility of data

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; understanding about scientific inquiry.
- Content Standard G - Science as a human endeavor; Nature of science: students formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.

Materials

To be provided by the student:

- comfortable shoes
- pen/pencil
- flat surface to write on (clipboard/binder)

To be photocopied from this guide:

- Field journals for each student, teacher, and chaperone

Vocabulary

earthquake, epicenter, fault zone, Franciscan sandstone, granite, greenstone, lithosphere, serpentine, topography, transform fault

Procedures

1. Bear Valley Visitor Center

Start your field trip at the Bear Valley Visitor Center which is within walking distance of the Earthquake Trail. The Visitor Center contains displays on the National Seashore, a video program, public restrooms, and drinking water. You may want to especially call attention to the working seismograph which students can watch in operation.

You may borrow the following teaching materials from the Visitor Center: Geology Backpack, binoculars, spotting scope, and/or clipboards. Remember to have one group start on the Trail and finish with the Visitor Center activity and the other group do the reverse. This frees up space on the trail and prevents crowding in front of the trail signs.





2. Earthquake Trail

Students walk the Earthquake Trail, stopping to read each informational sign and answering related questions on their worksheet. It is important for students to answer these questions while they are on the trail rather than waiting until they are back in class. **The most important display on the trail is the displaced fence.** This is visible evidence of the San Andreas Fault, of plate tectonics, and one of the best places in the surrounding area for students to truly understand the relationship between their surroundings and earthquakes.



Things to Remember While on Geology Field Trip

Three safety precautions:

1. _____

2. _____

3. _____

Field Journal Sheet

Four resource protection behaviors:

1. _____

2. _____

3. _____

4. _____

Watch Out for These Three Things...

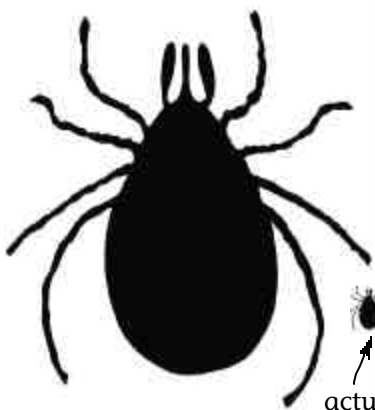
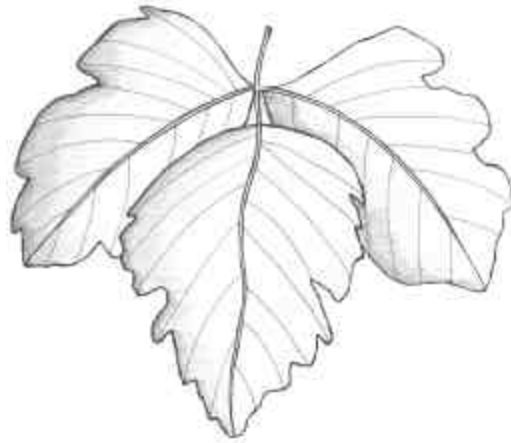


Stinging nettle

Stinging nettle is a tall plant with needlelike hairs, which can create a burning or stinging sensation for up to 24 hours. If you see this plant, do not touch it.

Poison oak

Poison oak has three smooth, shiny leaflets which are bright green or reddish. It can grow up trees as a vine, as a small bush, or as a small ground cover plant. Poison oak causes an itchy, blistering irritation which can last for one to two weeks. Even when leaves are not present, it is possible to get poison oak. Wash all skin and clothing that may have come in contact with poison oak with cool water and a grease-cutting soap.



Ticks

Ticks carrying Lyme disease are found at Point Reyes National Seashore. Check your body after a hike. Wear light-colored long pants and shirts to help find ticks. Tuck your pant legs into your socks.



Bear Valley Visitor Center Activity

Using the three-dimensional relief map in the Visitor Center and the official Park brochure located at the information desk, label the following topographical features on the map below:

San Andreas Fault

Tomales Bay

Bolinas Lagoon

Inverness Ridge

Mount Vision

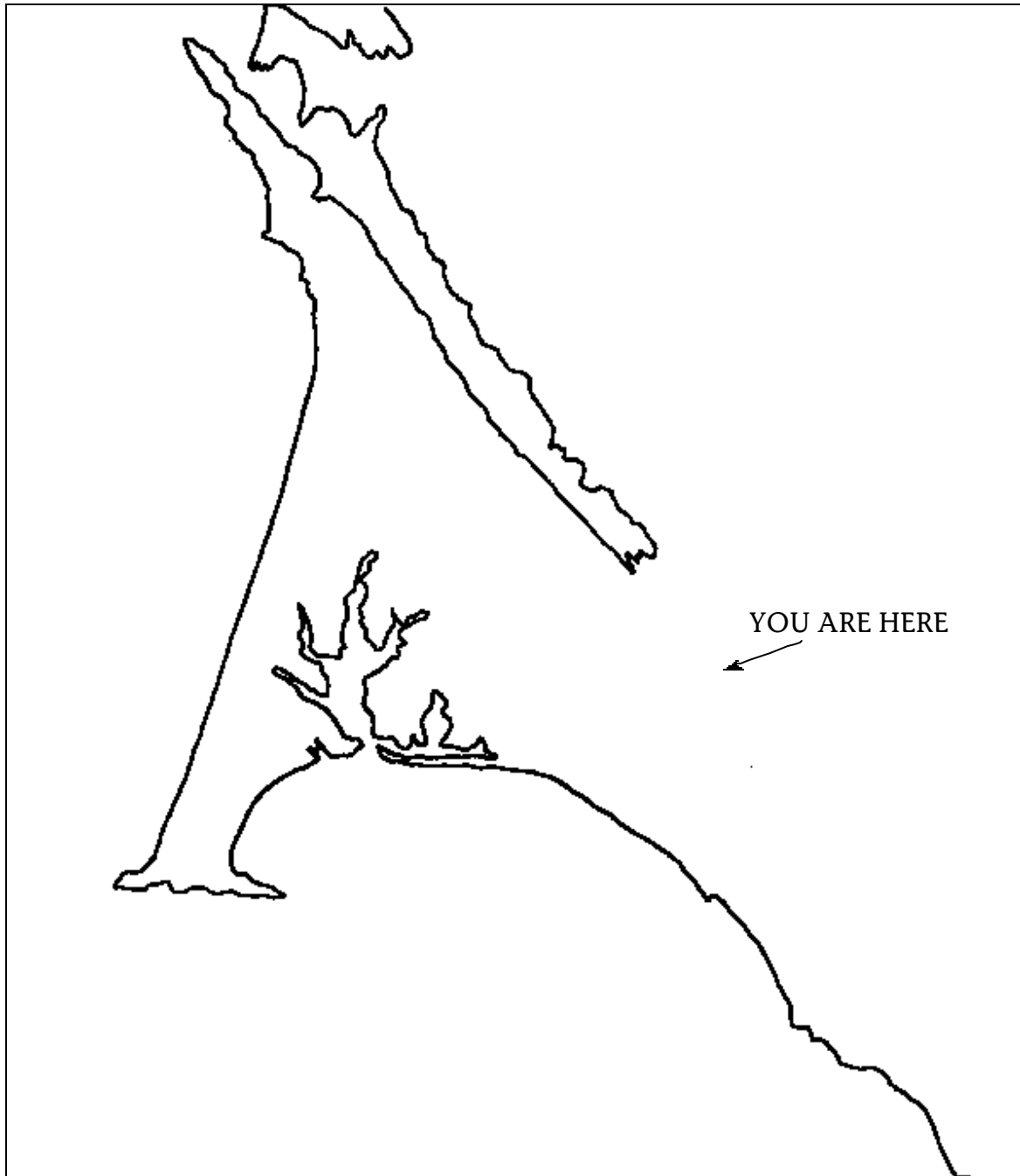
Drakes Estero

Mount Wittenberg

Pacific Plate (west of the San Andreas Fault)

North American Plate (east of the San Andreas Fault)

Field Journal Sheet



POINT REYES NATIONAL SEASHORE



Bear Valley Visitor Center Activity

Briefly write down some ideas as to how you think the San Andreas Fault has influenced the landforms across the Point Reyes Peninsula.

In one column, list ideas for how it has influenced landforms in the past and in the other, list how the fault may influence landforms in the future. Use your best guesses and creativity for answers.

	In the Past	In the Future
Ridges and Mountains	Example: <ul style="list-style-type: none"> • previously flat areas became raised as the fault moved 	<ul style="list-style-type: none"> • ridges and mountains may continue to get higher
Valleys		
Bays and Lagoons		
Esteros		

Earthquake Trail
Introduction Sign



What are two questions you have about the San Andreas Fault or the 1906 earthquake? Write these below:

1.

answers will vary

2.

Look closely at the three-dimensional map.
List two noticeable landforms that you think are caused by the San Andreas Fault. HINT: Look closely at the map's outline and elevations.

1.

Examples of landforms caused by fault:

- ***valley surrounding fault formed***
 - ***peninsula formed along fault line***
 - ***Tomales Bay formed along fault line***
 - ***Bolinas Lagoon formed along fault line***
- 2.

Note:

The eastern boundary of Tomales Point is parallel to the San Andreas Fault.

Bolinas Lagoon and Tomales Bay represent submerged blocks of the fault.

Mountain ridges are located on either side of the San Andreas Fault.



What happened during the 1906 earthquake?

Choose one photograph from this board to answer the following questions:

Briefly describe the photo:

Display has various photos of a toppled train, offset road, destroyed entrance gates to Stanford University, destroyed homes, fires.

Answers below will vary.

How were people affected in this photo?

Can you think of anything that could be done to prevent this situation from happening in the future?

The San Andreas Fault



The fault zone creates a depression surrounded by hills on both sides. How do you think this fault zone affects the strength of rocks making up the hills on both sides?

Rocks surrounding a fault zone can crack and form joints. This type of cracking can lead to a type of erosional feature called “melted ice cream topography.”

How does the fault zone affect the strength of rocks within the zone?

The fact that the fault zone is a depressed valley suggests that the rocks are weaker in this area. Rocks in the fault zone are weakened by the grinding of the North American Plate and the Pacific Plate.





Can the San Andreas Fault swallow cities?

How has this land healed since the last big earthquake? Compare the photos of the past with what you see before you on the landscape?

The crack has been filled in by erosion and deposition. Loose soil from surrounding areas was transported during heavy rains and deposited in the crack.

Erosion has smoothed the surface and there has been deposition of sediment into the cracks. In this area erosion occurs rapidly due to the weather (moist climate and vegetation). In the desert features like the crack formed by faulting would remain intact much longer.

How might the land have been different if the surface were solid granite?

Answers will vary.

The surface might have

- *split leaving a jagged cliff along the crack.*
- *increase the area effected by the earthquake, the granite would cause the waves to travel further.*

What are some ways that media (newspapers, television, etc.) affect stories being told about earthquakes?

Answers will vary.

The media may

- *help people prepare for aftershocks or avoid areas of heavy damage.*
- *help mobilize people such as doctors, firefighters, Red Cross workers etc., to assist with emergency situations.*
- *sensationalize stories of people and things that happen during earthquakes - such as the "cow in the crack" story at Point Reyes.*



Earthquake Trail Displaced Fence

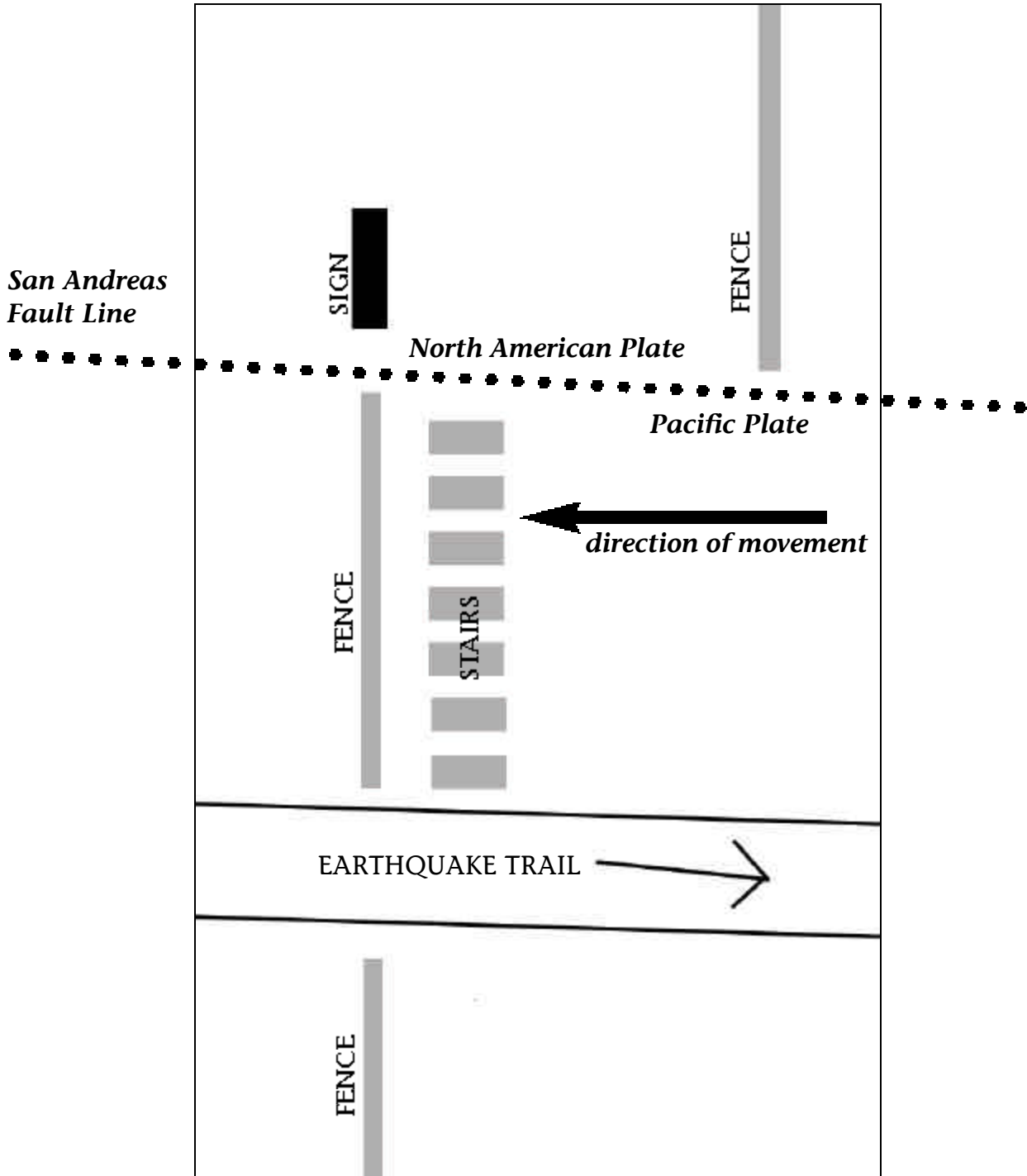
Orient yourself to the map below. Look for the trail, the fence, and the stairs.
Draw and label on the map:

San Andreas Fault Line

Pacific Plate

North American Plate

Also, draw arrows to indicate which direction each plate is moving.

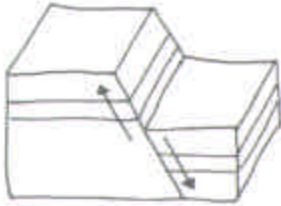


POINT REYES NATIONAL SEASHORE

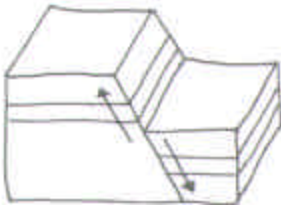


Earthquake Trail Displaced Fence

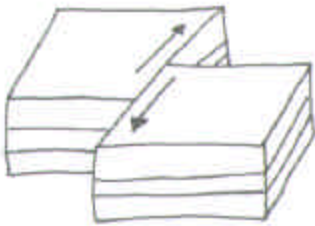
Based on your observations of this area, what type of fault is the San Andreas?
Circle your answer below:



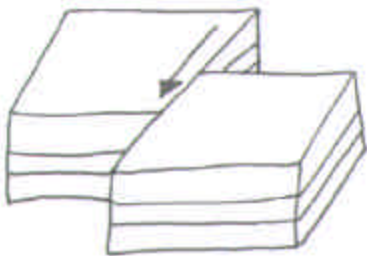
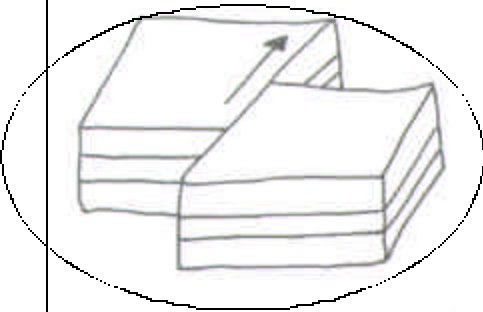
Normal Fault: One block will drop or rise against the other block as a result of stretching that breaks rocks along a steep fault plane.



Reverse Fault: One block is forced up and the other block is forced down.



The San Andreas Fault is a transform, right lateral strike-slip fault. If you were standing on the North American Plate facing the Pacific Plate (for millions of years), you would see a horizontal shearing with the Pacific Plate moving northwest along the North American Plate.



Left Strike-Slip: Same as Right Strike-Slip, but to the left.



Earthquake Trail

Why are the rocks different on either side of the fault?

What kinds of rocks are on the eastern side of the fault?

Mostly Franciscan rocks: the Franciscan Complex is a series of rocks that were formed in the DEEP ocean then jumbled, altered, shoved up, and attached to the North American plate.

What kinds of rocks are on the western side of the fault?

Mostly granitic rocks and some sedimentary rocks (such as the Lighthouse conglomerate and Drakes Beach cliffs.)

Why are these two different rock types next to one another at Point Reyes National Seashore?

Because there are two different plates which meet here and at this boundary the rock types are different.

In addition, the San Andreas Fault is the active boundary between these two different plates. The rocks on each side of the fault were formed at different places under different conditions and movement along the fault has brought the Point Reyes Peninsula to this position adjacent to the coastal ranges.



Earthquake Trail Franciscan Rocks

Choose one rock to observe on each side of the path. What is the grain size, texture, coloration? How do the two rocks that you choose to observe compare to each other? Are they more alike or more different? List one difference between the rocks on either side of the path.

Descriptions of FRANCISCAN rock
soft, flaky, layered, green, ocean origin

Serpentininite

Greenstone

Sandstone

Earthquake Trail



Marble

Granite

Schist

Descriptions of GRANITIC rock

hard, crystalline, speckled, compact



Continents drift because of moving plates

What are the names of the two lithospheric plates that form the San Andreas Fault?

North American Plate

Pacific Plate

List three geologic processes that happen on plate boundaries.

1.

2.

Examples:

*rising mountain ranges
subsiding ocean trenches
active volcanoes
earthquakes*

3.

How do you think the climate and ecology on the Point Reyes Peninsula will change in 50 million years?

It will most likely get colder from moving north, daylight/darkness cycles will change, hills may become eroded to flatlands, individual plants will either survive or die in the changes (creating new habitats).



Continental Drift Timetable

Where will Point Reyes National Seashore be in 40 million years?

Point Reyes will eventually become an island, isolating the plants and animals from the continent. As the climate changes, many of the plants and animals may die unless they can adapt to the changes. New plants and animals may appear if they are better adapted to the new climate.

If Point Reyes National Seashore and the land containing Los Angeles and Baja California are separated by water, why are they moving together?

Because they are on the same plate which encompasses both land and water between Point Reyes, Los Angeles, and Baja California.

How will Point Reyes National Seashore change as a result of plate tectonics? What do you think will happen to the plants and animals of the Peninsula as these changes happen?

Answers will vary.

Moving plates cause earthquakes...a continuing process



How are earthquakes created?

Earthquakes are the result of sudden movements along a fault.

Why are there so many earthquakes in California?

Because the San Andreas Fault SYSTEM trends in a northwesterly direction through much of western California. The fault system is the active boundary between the Pacific and North American plate and the faults that make it up (primarily the San Andreas Fault) collectively accommodate the relative motion between the two plates.

Write a definition of the San Andreas Fault.

An active transform fault, the active boundary between the Pacific and North American plates.



Occasional small quakes won't prevent big ones!

How many 5.3 magnitude earthquakes does it take to equal the power of the 1906 earthquake?

30,000

Why don't occasional small earthquakes prevent BIG ONES from happening?

Smaller earthquakes release only a fraction of the energy of large earthquakes, therefore it would take an excess of many small earthquakes to equal the energy that is being released in one large one.

How the geology performed during the 1906 earthquake



Locate your home on the “Active Faults of the San Francisco Bay Area” map.” What kind of land is it built on?

Answers will vary.

Is this type of land resistant to earthquakes or easily damaged during earthquakes?

Answers will vary.

Based on this map, would it be safe to build a home on the immediate banks of the San Francisco Bay? Why or why not?

No, the soil is unstable.





Earthquake Trail

Are you prepared for the next earthquake?

Field Journal Master

Circle the correct answer.

True False After an earthquake, immediately go outside to take photos.

True False You should prepare an Earthquake Kit with a first aid kit, food, water, and a portable radio.

True False When you are outside, be aware of your surroundings and avoid falling objects and live electrical wires.

True False During an earthquake, seek shelter under a window so that you can monitor damage in your area.

Earthquake Trail
Introduction Sign



What are two questions you have about the San Andreas Fault or the 1906 earthquake? Write these below:

1.

2.

Look closely at the three-dimensional map.
List two noticeable landforms that you think are caused by the San Andreas Fault. HINT: Look closely at the map's outline and elevations.

1.

2.



What happened during the 1906 earthquake?

Field Journal Sheet

Choose one photograph from this board to answer the following questions:

Briefly describe the photo:

How were people affected in this photo?

Can you think of anything that could be done to prevent this situation from happening in the future?



Earthquake Trail
The San Andreas Fault



Field Journal Sheet

The fault zone creates a depression surrounded by hills on both sides. How do you think this fault zone affects the strength of rocks making up the hills on either side of the fault?

How does the fault zone affect the strength of rocks within the zone?





Can the San Andreas Fault swallow cities?

How has this land healed since the last big earthquake? Compare the photos of the past with what you see before you on the landscape.

How might the land have been different if the surface were solid granite?

What are some ways that media (newspapers, television, etc.) affect stories being told about earthquakes?

Earthquake Trail
Displaced Fence



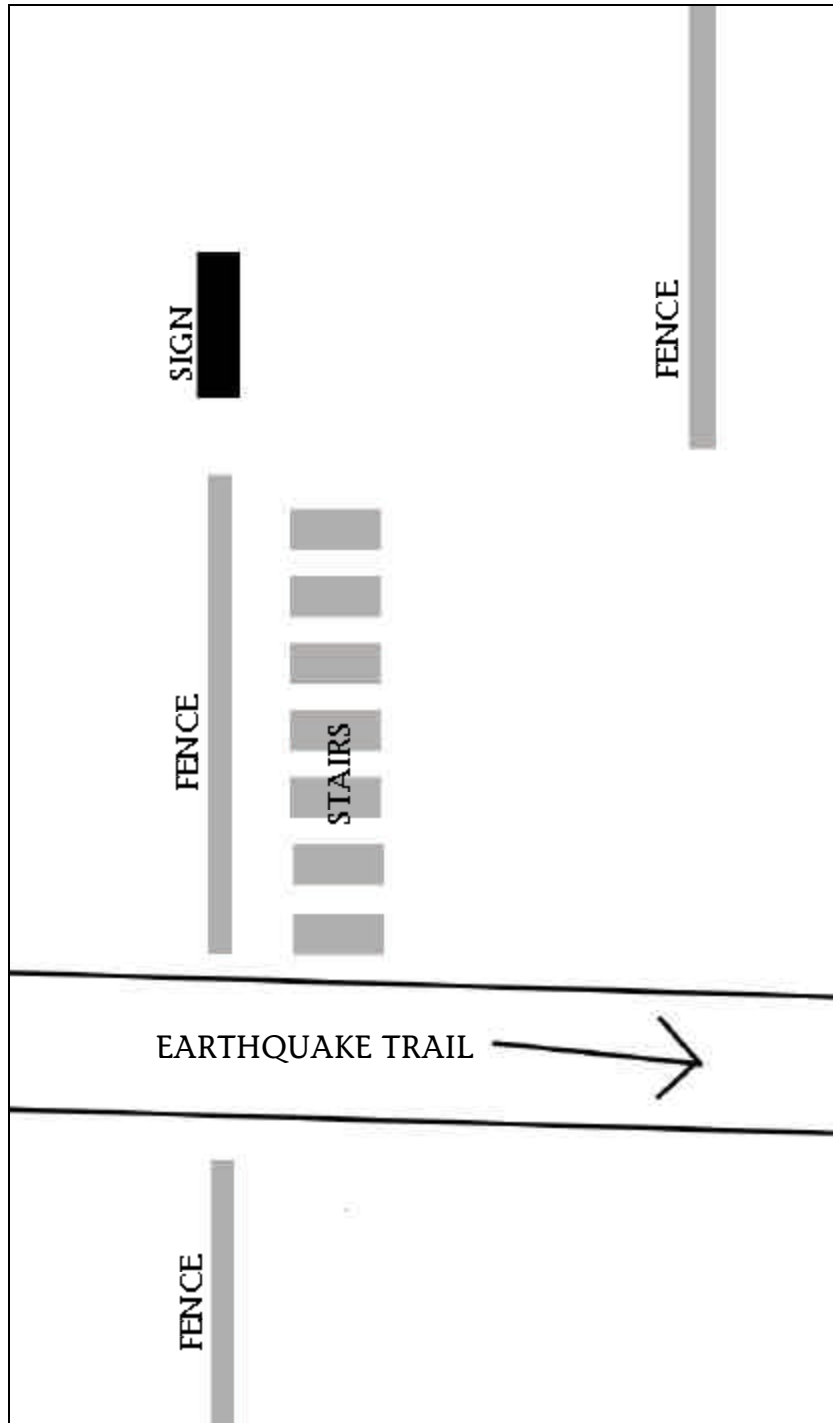
Orient yourself to the map below. Look for the trail, the fence, and the stairs.
Draw and label on the map:

San Andreas Fault Line

Pacific Plate

North American Plate

Also, draw arrows to indicate which direction each plate is moving.



POINT REYES NATIONAL SEASHORE

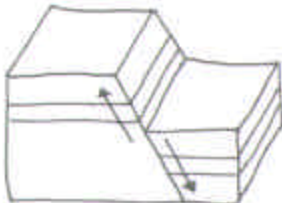


Earthquake Trail Displaced Fence

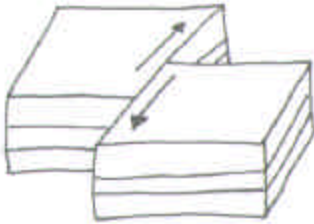
Based on your observations of this area, what type of fault is the San Andreas?
Circle your answer below:



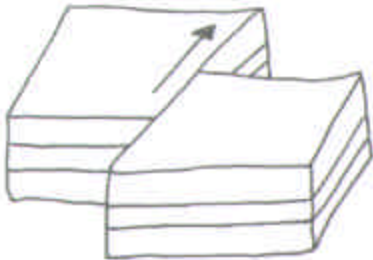
Normal Fault: One block will drop or rise against the other block as a result of stretching that breaks rocks along a steep fault plane.



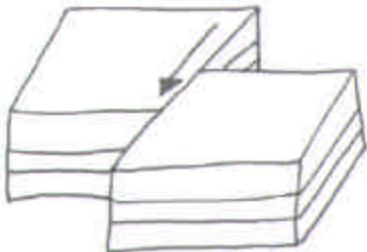
Reverse Fault: One block is forced up and the other block is forced down.



Strike-Slip or Slip-Strike: Horizontal shearing along a vertical plane (also known as Tear Fault, Transform Fault, Transcurrent Fault, or Wrench Fault).



Right Slip-Strike: Horizontal shearing along a vertical plane in which one plate moves to the right (if you were standing on the plate with no movement, the other plate would move to your right).



Left Slip-Strike: Same as Right Slip-Strike, but to the left.



Earthquake Trail

Why are the rocks different on either side of the fault?

What kinds of rocks are on the eastern side of the fault?

What kinds of rocks are on the western side of the fault?

Why are these two different rock types next to one another at Point Reyes National Seashore?





Earthquake Trail Franciscan Rocks

Choose one rock to observe on each side of the path. What is the grain size, texture, coloration? How do the two rocks that you choose to observe compare to each other? Are they more alike or more different? List one difference between the rocks on either side of the path.

Descriptions of FRANCISCAN rock

Serpentinite



Greenstone



Sandstone



Earthquake Trail



Marble



Granite



Schist

Descriptions of GRANITIC rock

Continents drift because of moving plates



What are the names of the two lithospheric plates that form the San Andreas Fault?

List three geologic processes that happen on plate boundaries.

- 1.
- 2.
- 3.

How do you think the climate and ecology in California will change in 50 million years?





Continental Drift Timetable

Where will Point Reyes National Seashore be in 40 million years?

If Point Reyes National Seashore and the land containing Los Angeles and Baja California are separated by water, why are they moving together?

How will Point Reyes National Seashore change as a result of plate tectonics?
What do you think will happen to the plants and animals of the Peninsula as these changes happen?



Moving plates cause earthquakes...a continuing process



How are earthquakes created?

Why are there so many earthquakes in California?

Write a definition of the San Andreas Fault.



Occasional small quakes won't prevent big ones!

How many 5.3 magnitude earthquakes does it take to equal the power of the 1906 earthquake?

Why don't occasional small earthquakes prevent BIG ONES from happening?



Earthquake Trail

How the geology performed during the 1906 earthquake

Locate your home on the “Active Faults of the San Francisco Bay Area” map.” What kind of land is it built on?

Is this type of land resistant to earthquakes or easily damaged during earthquakes?

Based on this map, would it be safe to build a home on the immediate banks of the San Francisco Bay? Why or why not?



Earthquake Trail

Are you prepared for the next earthquake?

Circle the correct answer.

True False

After an earthquake, immediately go outside to take photos.

True False

Prepare an Earthquake Kit with a first aid kit, food, water, and a portable radio.

True False

When you are outside, be aware of your surroundings and avoid falling objects and live electrical wires.

True False

During an earthquake, seek shelter under a window so that you can monitor damage in your area.

What Does a Fault Zone Look Like?



Students visit the top of Mount Vision, where it is possible to see the San Andreas Fault zone along Tomales Bay. From this overlook it is also possible to see the mountains of the Coast Range as well as see a good overview of the Point Reyes Peninsula. Guided activity sheets help students understand how the San Andreas Fault Zone and Marin County's rock types shape the local topography.

On-Site Lesson Plan

Special note: Call ahead for weather. This lesson is impossible if fog or low clouds obscure the view from the top of Mount Vision. September and October generally have the least fog.

Hiking option: Use Limantour Road to access Bayview Trailhead. Follow the Inverness Ridge Trail to the Mount Vision Overlook. It is about 3 miles (one-way) and 4-6 hours (round-trip) from the trailhead depending on the pace of walking.

Driving option: Take Sir Francis Drake Boulevard to Mount Vision Road. It is about a 30-minute drive from the Bear Valley Visitor Center (cars only)

Suggested group size: Individual hiking groups should not exceed 50 people.

Subjects: earth science, art

Concepts covered: faults, rock types of Marin County, interpretive geology

Written by: Don Jolley, Teacher, Bolinas School, Bolinas

Last updated: 04/02/00

Student Outcomes

At the end of this activity, students will be able to:

- Identify the geologic features of the San Andreas fault zone
- Explain how underlying rock types create different land formations
- Explain the basic geologic history of local landforms

California Science Standard Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

6th grade: 1a - the fit of the continents, location of earthquakes, etc., provide evidence for plate tectonics





1d - earthquakes are sudden motions along breaks in the crust called faults

1e - major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate tectonics

1f - explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes)

7b - select and use appropriate tools and technology to perform tests, collect and display data

7f - read a topographic map and a geologic map for evidence provided on the maps, and construct and interpret a simple map

7g - interpret events by sequence and time from natural phenomena

7h - identify natural changes in natural phenomena over time without manipulating the phenomena

7th grade: 7a - select and use appropriate tools and technology to perform tests, collect and display data

7e - communicate the steps and results from an investigation

8th grade: 9b - evaluate the accuracy and reproducibility of data

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; Think critically and logically to make the relationships between evidence and explanations.
- Content Standard B - Motions and forces; Transfer of energy.
- Content Standard D - Earth's history.

Materials

To be provided by the student:

- hiking shoes, lunch, water

To be photocopied from this guide:

- **What Does a Fault Zone Look Like?** Field Journal Sheets
- **The San Andreas Fault-Point Reyes** Teacher Information Sheet

To be picked up at the Bear Valley Visitor Center:

- Point Reyes National Seashore map (free at desk)
- Geology Backpack, binoculars, spotting scope, clipboards

Vocabulary

basalt, chert, erosion, fault zone, Franciscan Complex, topography, transform fault, uplift, weathering

Procedures

1. Teacher review and preparation

Review **The San Andreas Fault-Point Reyes** Teacher Information Sheet to prepare for your field trip.



2. At the Mount Vision Overlook

Drive or hike to the Mount Vision Overlook. Allow time for students to observe the topography. Designate a timeframe to complete the **What Does a Fault Zone Look Like?** Field Journal Sheet. They should be able to identify the major features shown on the map by using the Point Reyes brochure.

3. Summary

There are four major geologic features that students should locate:

- A. East of the Fault Zone is the **coast range mountains**. From the top of Mount Vision, one can see Mount Barnaby, Mount Black, Bolinas Ridge and Mount Tamalpais. Mountains in this range are underlaid by basalt and chert. These mountains have been pushed up, or uplifted, by forces from the San Andreas Fault. The hardness and resistance (to weathering and erosion) of these rocks also help to account for their relatively high elevations.
- B. Interspersed in the Coast Range are the rolling hills of the **Franciscan Complex**. These hills are underlaid by a mixture of deep-sea sediments, primarily sandstone. The high permeability of these rocks weakens them and makes them highly susceptible to erosion and land slides. Sometimes the many chunks of land that have slid down create a look known as "melted ice cream topography."
- C. East of Point Reyes is the **San Andreas Fault Zone**. This can be seen as a low-lying valley which includes Tomales Bay, Bolinas Lagoon, and much of San Francisco Bay. The grinding of the Pacific and North American Plates weakens the rocks in this area, making them susceptible to erosion and creating a depression in the topography.
- D. The **mountains of Point Reyes** are shaped from granite, which has been displaced to the north by the motion of the Pacific Plate. The hardness and resistance to erosion of granite make these mountains (including Mount Vision) relatively high.

Extension Ideas

1. Drive south on Highway 1 along the fault zone. This parallels the Rift Zone and Olema Valley trails in the park. Look for sag ponds along the road. Past Five Brooks on the south side of the road there are two creeks that flow in different directions parallel to each other. Pine Gulch Creek flows south and Olema Creek flows north. At Bolinas Lagoon the fault runs under the water. Along the cliffs of Highway 1 overlooking Stinson Beach there are many outcrops of serpentine, which is a dominant rock type in the Franciscan Complex. Serpentine is a greenish blue mineral that has a "waxy" appearance, this mineral is abundant in the rocks because they were formed in the deep ocean



the altered as they were brought to the surface and attached to the North American plate.

On-Site Lesson Plan

2. Find pictures of other areas of the San Andreas Fault Zone and compare them to the area around Point Reyes. In southern California there are desert areas where the fault is seen clearly by offset mountains and streams.



The San Andreas Fault-Point Reyes



The world-famous San Andreas Fault separates the Point Reyes peninsula from the main land of California. The fault is much more than a simple boundary. It has created the landscape of this area with its long bays and lagoons and the narrow Olema Valley. It looms and promises to change the landscape again with the next big earthquake. Will the “Big One” be today, next week, or five years from now? It’s a hard question to answer because there is so much that is still not known about earthquakes and seismic activity. However, it is known that the earthquakes we experience are caused by the shifting and movements of the vast plates that cover the earth some of which we live on.

Think Big, Think Plate Tectonics

To understand the San Andreas Fault, we must leave the Olema Valley to examine the larger global theory Plate Tectonics. Geologists believe that the outer layer of the earth is segmented into about a dozen rigid plates. These plates which are up to 62 miles thick, float on a fluid layer of molten earth. Currents within this layer slowly move and shift the surface plates that we live on. This movement causes plates to collide in convergent plate boundaries, to separate in divergent plate boundaries or slide past one another in transform plate boundaries. Where these plates meet, boundaries are the site where mountains are created, volcanoes erupt, and earthquakes occur.

The San Andreas Fault is a transform plate boundary that separates the two largest plates in the world, the Pacific and North American plates. The oceanic Pacific plate, which includes Point Reyes, is slowly grinding to the northwest at about two inches per year

in relation to the North American plate. This movement is responsible for the topography of the area as well as the frequent earthquakes of varying magnitude.

Hop a Ride on the Pacific Plate

Visitors to Point Reyes National Seashore will enter the San Andreas Fault zone and cross from the North American to the Pacific plate. Even though the Point Reyes peninsula is currently attached to the mainland, in many ways you have set foot onto a land in motion. The peninsula is thought to have traveled 280 miles over the last 30 million years from its origins near Los Angeles.

Not Soon Forgotten

During the brief presence of humans along the fault, the San Andreas has played a significant role in human history. Perhaps the most famous earthquake in the western world occurred the San Francisco Bay Area on



Teacher Information

April 18, 1906. When the earthquake struck, the Point Reyes Peninsula jolted northwest about 20 feet (6 meters). In nearby San Francisco, fires resulting from the earthquake crippled the city causing millions of dollars of damage and hundreds of deaths.

On October 17, 1989, San Francisco Bay Area residents were again reminded of the power of the San Andreas and its adjacent faults. The Loma Prieta Earthquake, whose epicenter was in the Santa Cruz Mountains, caused the collapse of a portion of the Bay Bridge, a freeway overpass in Oakland and many other structures.





What Does a Fault Zone Look Like?

From the top of Mount Vision you can see the coast, Inverness Ridge, the San Andreas Fault Zone, and the mountains of the Coast Range. Pick a spot where you have a great view, and make two separate drawing of what you see - one with the view to the east, and one with the view to the west. Identify each of these features on your drawing by writing the names next to the corresponding feature on your map. Use the Point Reyes map to help you.

The Pacific Ocean
Mount Barnaby
Mount Tamalpais
San Andreas Fault Zone

Mount Vision
Mount Black
Bolinás Ridge

Tomales Bay
Bolinás Lagoon
Drakes Estero

After sketching and labeling the two views on the blank sheets following these instructions, answer the following questions.

1. Why is Tomales Bay so straight? Compare it with the shape of Drakes Estero (estero is the Spanish word for estuary). What could account for their different shapes, in terms of their origin?

Tomales Bay lies directly in the San Andreas Fault Zone. Its straight shape mirrors the shape of the fault. Drakes Estero does not lie on the fault. Its branching shape forms as the water in the estuary seeks natural, randomly spaced weakness in the rocks. The area forming Drakes Estero has also been pushed below sea level by forces from the San Andreas Fault. The area is part of the Point Reyes Syncline.

2. Why are the Olema Valley and Tomales Bay topographically so low? What important feature runs through this area? What does this depression suggest about the strength of the rocks in this area? Why is the rock strength different in this area?

The Olema Valley and Tomales Bay are located on the San Andreas Fault Zone. The fault zone depresses the valley in two major ways. One, pressure from fault motion pushes blocks of rock upward, resulting in the mountains on either side of the fault zone. The actual process that causes the uplift is complex. In simple terms, slight bends in the direction of the fault line result in compression instead of strike slip motion. The compression squeezes rock against rock until it is finally forced upward. Two, the grinding of the North American and Pacific Plates weakens the rocks in the fault zone, making them more susceptible to erosion. The weakening of rock due to motion along the fault is easier to understand - this is the point that should be stressed for most students.



3. Notice the shape of the rolling hills to the east in the Roast range. The rocks under these hills are known as the Franciscan Melange). Their rounded, bulging shape is sometimes referred to as “wet ice cream topogaphy” because their shape resembles that of melting ice cream. What does this shape suggest about the Franciscan rock’s resistance to weathering and erosion?

The bulges in the hills are the result of landslides. A close look at the bulges reveals how various segments of the hillsides have slipped down over time. This is because the Franciscan melange is a relatively weak rock that has a high porosity and weathers easily. The bulges are from resistant blocks in the Franciscan Melange that stay together during landslides. Before a landslide, the ground becomes saturated with water. If excess water cannot be absorbed in the soil and rock, it creates smooth surfaces for chunks of land to slip over. (Students who live in Marin will probably be familiar with the many landslides that occur in this area).

4. What might account for the fact that certain features (i.e., Mount Black, Mount Tamalpais, Bolinas Ridge, Mount Vision you’re standing on) rise above the Franciscan Melange? Consider the differences between hard and soft rock, and how this affects erosion.

The raised topography of certain features shows that they contain harder, more resistant rocks. In the Coast Range, chert and greenstone tend to underlie the highest peaks, and on Point Reyes, granite underlies these features. The mountains themselves have been uplifted by pressure from the San Andreas Fault as explained in Question 2.



Field Journal Sheet

3. Notice the shape of the rolling hills to the east in the Coast Range. The rocks under these hills are known as the Franciscan Melange.) Their rounded, bulging shape is sometimes referred to as “wet ice cream topogaphy” because their shape resembles that of melting ice cream. What does this shape suggest about the Franciscan rock’s resistance to weathering and erosion?

4. What might account for the fact that certain features (i.e., Mount Black, Mount Tamalpais, Bolinas Ridge, Mount Vision you’re standing on) rise above the Franciscan Melange? Consider the differences between hard and soft rock, and how this affects erosion.





Field Journal Sheet

My View Looking East

Draw the prominent features of the topography and identify the symbols in your map key.

Map Key



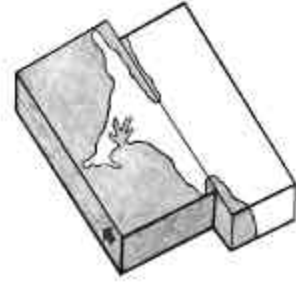
Field Journal Sheet



My View Looking West

Draw the prominent features of the topography and identify the symbols in your map key.

Map Key



Uncovering the San Andreas Fault

Post-Visit Activities

What Else Can We Learn About Information in Our Field Journals?	103
What Is the Nature and History of the San Andreas Fault Zone?	109
What Is It Like to Be in an Earthquake?	125
What Earthquake Information Is Available on the World Wide Web, and Why Is It Important?	129
What is Our Earthquake Safety Plan?	133

What Else Can We Learn About Information in Our Field Journals?



Post-Visit

LESSON PLAN

By conducting at least one extension idea, teachers can help students reinforce lessons learned on field trip. Students can also build on these concepts for a "big picture" understanding of plate tectonic, and geologic processes.

Time required: 2 hours

Location: classroom or homework

Suggested group size: independent or student teams

Subjects: earth science, math, physics,

Concepts covered: fault types, rock composition, scientific method

Written by: Christie Denzel Anastasia, National Park Service

Last updated: 04/09/00

Student Outcomes

At the end of this activity, the students will be able to:

- Understand topics covered on field trip in more depth
- Extend lessons learned on field trip to personal interests

California Science Standard Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

- 6th grade 7d - communicate the steps and results from an investigation
 7e - recognize whether evidence is consistent with a proposed explanation
- 7th grade 7c - communicate logical connections among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; Think critically and logically to make the relationships between evidence and explanations;





Recognize and analyze alternative explanations and predictions; Use mathematics in all aspects of scientific inquiry.

- Content Standard B - Motions and forces
- Content Standard D - Earth's history
- Content Standard F - Natural hazards; Risks and benefits.

Procedures

1. Review the list of **Extension Ideas** below. Choose at least one of the activities as a learning continuation of student's Field Journals.

Extension Ideas

PERSPECTIVE

Use the post-visit lesson **What Is the Nature and History of the San Andreas Fault Zone?** (page 109) to put the Earthquake Trail into a regional, national, and international perspective. Students should understand how the displaced fence at Point Reyes National Seashore fits into the movement of the San Andreas Fault and worldwide plate tectonics.

SCIENCE IS NOT SET IN STONE

According to the signs on the Earthquake Trail, the epicenter of the 1906 San Francisco earthquake was Olema Valley, very near to the Trail. Is that true? How and why did the scientific community change their information?

Why do the signs on the Earthquake Trail refer to "continental drift"? What is the difference between continental drift and plate tectonics? Why has the theory changed? What new evidence was presented to convince the scientific community this was necessary?

WHAT CAN YOU TELL ABOUT A ROCK'S HISTORY BASED ON ITS PHYSICAL FEATURES?

Students observed a variety of rocks on their field trip (serpentine, greenstone, marble, schist, etc.). How do their origins contribute to the observations made? For example: does the temperature that the rock cooled at affect its grain size or mineral distribution?

Coordinate information from all of the students to create a chart listing rock types, observable characteristics, and how they were created. Instruct students to bring a rock to class the next day. Using the chart created by their research, what conclusions may they come to about the formation and history of their rock?



SHOE-LENGTH MATH

The Pacific Plate is moving north in relation to the North American Plate. Using your answer to #5 in your journal, calculate how many years it takes for the plates to slide the length of your shoe. (Math hint: divide 220 years by the number of shoe - lengths between the two fences)

$$220 / \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ years.}$$

(shoe lengths)

How far, in shoe lengths, will the plates have moved one million years from now? (Math hint: divide 1,000,000 by your answer to Question three, the number of years it takes the plates to move one shoe length).

$$1,000,000 / \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ shoe lengths in 1,000,000 years}$$

years/ shoe length

In 1,000,000 years the plates will move shoe lengths.

It takes approximately 6000 shoe lengths to equal one mile. Where will Point Reyes National Seashore be located in one million years? In what direction will it be moving?

Over the past 30 million years, major earthquakes have occurred approximately once every 220 years. The last major earthquake on the San Andreas Fault was in 1906. This suggests that we will experience another major earthquake in the Bay Area by what date? (The Loma Prieta Earthquake of 1989 did not release any of the tension building up on this section of the San Andreas Fault.)

If this is true, a major earthquake should occur along the San Andreas Fault by: .

Answers:

It will take 8-14 years for the plates to slide the length of your shoe.
The plates move 68,000-113,000 shoe lengths.
In one million years Point Reyes will be 11.3 to 18.9 miles to the north.
Next major earthquake 2126

GEOLOGIC RESOURCES

Assign students various areas in the National Park System to understand in terms of the role of the San Andreas Fault in California or the role of geology in cultures. All of the following information can be found at www2.nature.nps.gov/grd ("Visit the National Parks Geology Tour")

Role of the San Andreas Fault in California

- Channel Islands National Park, California
- Cabrillo National Monument, California
- Golden Gate National Recreation Area, California



Joshua Tree National Park, California
Muir Woods National Monument, California
Pinnacles National Monument, California
Point Reyes National Seashore, California
Santa Monica Mountains National Recreation Area, California

Role of Geology in Cultures

Alibates Flint Quarries National Monument, Texas
Bering Land Bridge National Park, Alaska
Gila Cliff Dwellings National Monument, New Mexico
Keweenaw National Historic Park, Michigan
Klondike Gold Rush National Historic Park, Alaska and Washington
Mesa Verde National Park, Colorado
Mount Rushmore National Monument, New Mexico
Pipestone National Monument, Minnesota
Russell Cave National Monument, Alabama
Wright Brothers National Memorial, North Carolina
Yukon-Charley River National Preserve, Alaska

DIFFERENT FAULT TYPES CAUSE DIFFERENT LAND FEATURES

Have student refer to question #5 in their journals. Divide students into research teams. Each team is assigned a type of fault. Their challenge is to: illustrate their fault with a skit while the rest of the class attempts to guess which specific fault they are imitating.

Examples of faults in the world:

normal faults:

Tetons, Sierra Nevadas, Basin and Range,
Rhine Valley, East Africa

reverse/thrust faults

Northern Rockies, Alps, Himalayas, and Appalachians

SO WHAT?

Assign students to write an essay outlining the relevance of geology to their lives. There are no right or wrong answers; the only requirement is that students think critically and can logically support their reasoning process.



CRITICAL CONCEPTS

The following information is from the American Association for the Advancement of Science's publication, "Benchmarks for Scientific Literacy," 1993, section 10E, Moving the Continents (9-12 grade).

- The story of why science accepted the idea of moving continents only after the long resistance illuminates the conservatism of the scientific enterprise. Contrary to the popular public image of scientists as radicals ready to discard their beliefs instantly in the face of contrary "facts," the plate tectonics episode shows that it sometimes takes a large accumulation of evidence over an extended period of time to provoke a dramatic shift in what most scientists in a discipline accept as true.
- The history of the rise of the theory of plate tectonics shows that the acceptance of a theory depends on its explanatory power as well as on the evidence that supports it. As it has turned out, the modern theory of plate tectonics makes sense out of such a large and diverse array of phenomena related to the earth's surface that it now serves as a unifying principle in geology. In a sense, plate tectonics does for geology what evolution does for biology.
- The idea of continental drift was suggested by the matching shapes of the Atlantic coasts of Africa and South America, but rejected for lack of other evidence. It just seemed absurd that anything as massive as a continent could move around.
- Early in the 20th century, Alfred Wegener, a German scientist, reintroduced the idea of moving continents, adding such evidence as the underwater shapes of the continents, the similarity of plants and animals in corresponding parts of Africa and South America, and the increasing separation of Greenland and Europe. Still, very few contemporary scientists adopted his theory.
- The theory of plate tectonics was finally accepted by the scientific community in the 1960's, when future evidence had accumulated in support of it. The theory was seen to provide an explanation for a diverse array of seemingly unrelated phenomena, and there was a scientifically sound physical explanation of how such movement could occur.

What Is the Nature and History of the San Andreas Fault Zone?



Post-
Visit

Lesson Plan

Students investigate the San Andreas Fault in terms of earthquakes, visible evidence, and its relationship to the world and California. This lesson will also assist students to synthesize pre-visit and on-site activities and experiences.

Time required: 30 minutes in class and homework assignment

Location: classroom

Group size: independent

Subject: science

Concepts covered: plate tectonics, earthquakes, topography

Written by: Christie Denzel Anastasia and Lynne Dominy,
National Park Service

Last updated: 04/03/00

Student Outcomes

At the end of this activity, the students will be able to:

- Complete their understanding of the San Andreas Fault Zone
- Draw the San Andreas Fault on maps of the world and California
- Be aware of the San Andreas Fault Zone's contribution to California topography
- Synthesize information from other activities in this guide

California Science Standards Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

- 6th grade
- 1a - the fit of the continents, location of earthquakes, etc., provide evidence for plate tectonics
 - 1c - lithospheric plates that are the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle
 - 1d - earthquakes are sudden motions along breaks in the crust called faults
 - 1e - major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate tectonics
 - 1f - explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes)

Creating
COASTAL
STEWARDSHIP
through Science





1g - how to determine the epicenter of an earthquake and that the effects of an earthquake vary with its size, distance from the epicenter, local geology, and the type of construction involved
4c - heat from the earth's interior reaches the surface primarily through convection

7b - select and use appropriate tools and technology to perform tests, collect and display data

7e - recognize whether evidence is consistent with a proposed explanation

7th grade 7a - select and use appropriate tools and technology to perform tests, collect and display data

7b - utilize a variety of print and electronic resources, including the World Wide Web, to collect information

7d - construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge (e.g., motion of earth's plates and cell structures)

8th grade 9b - evaluate the accuracy and reproducibility of data

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; Think critically and logically to make the relationships between evidence and explanations; Understanding about scientific inquiry.
- Content Standard B - Motions and forces; Transfer of energy.
- Content Standard D - Earth's history.
- Content Standard F - Natural hazards; Risks and benefits.

Materials

To be photocopied from this guide:

- **Where is the San Andreas Fault Zone Found in Relation to World-Wide Tectonic Plates?** Activity Sheet
- **Where is the San Andreas Fault Zone Found in Relation to Earthquakes in California?** Activity Sheet
- **What Visible Evidence Exists of the San Andreas Fault Zone?** Activity Sheet

To be supplied by teacher:

- California atlas or access to Internet programs such as "Mapquest" for **Where Is the San Andreas Fault Zone Found in Relation to Earthquakes in California?** Activity Sheet

Vocabulary

sag pond, shutteridge, subduction, tsunami



Procedures

1. Free information

Consider ordering some of the free information listed in the “Resources” section of this guide. This information will help students with the activity sheets.

2. Brainstorm "known and unknown" of the San Andreas Fault

Using the blackboard or a large piece of paper, divide the space into two columns. One section will be space for students to brainstorm what they already know about the San Andreas Fault Zone while the other section will be what they do not know.

Examples: Width: few hundred feet to a mile wide
 Depth: 10 miles deep
 Length: 800 miles
 Age: 15-20 million years
 Length through Point Reyes Peninsula: 30 miles
 How does it move?
 When was the last time it moved?
 What is the average displacement?

3. Investigate “unknowns”

Students or groups of students can be challenged to discover the answers to some of their “unknowns.”

4. Assignment (in class or homework)

Distribute relevant activity sheets to students or teams.

5. Review

Use the review of the activity sheets and the experience of seeing the displaced fence on the Earthquake Trail to communicate the importance of visible earthquake evidence and the role of plate tectonics.

Extension Idea

1. Gather aerial views of the San Andreas Fault Zone from various sources. Students can use these views to illustrate "Visible Evidence" from activity sheets.



Where Is the San Andreas Fault Zone Found in Relation to World-Wide Tectonic Plates?



Locate a map of the world that illustrates major tectonic plates. Specifically draw (on the map below) where at least eight major plates are located. Finally, mark where the San Andreas Fault is found.

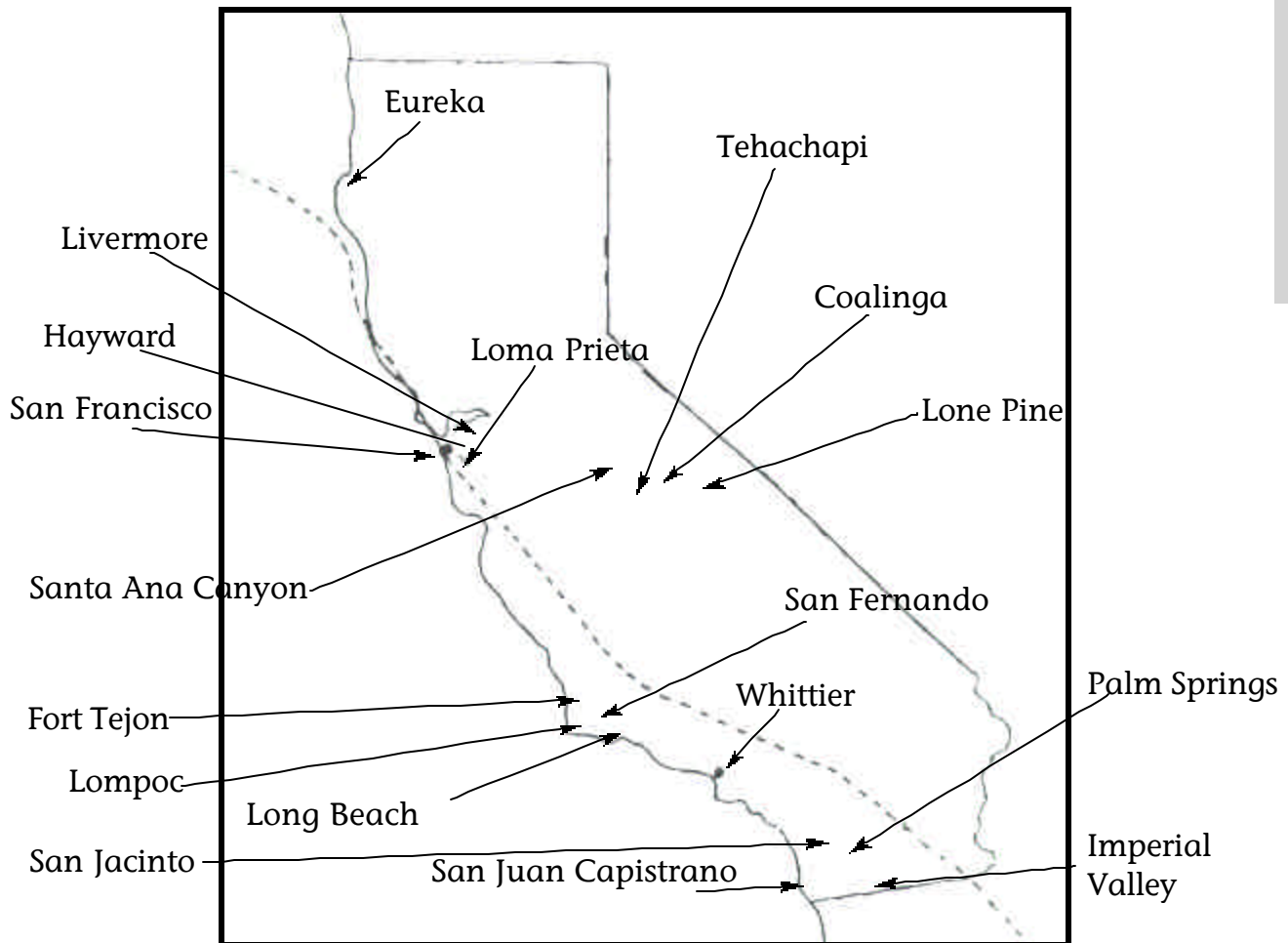
Activity Master



Where Is the San Andreas Fault Zone Found in Relation to Earthquakes in California?



Find a map showing where the San Andreas Fault Zone lies in California. Draw and label this zone on the map below. Then, using a detailed map of California and the list of major California earthquakes below, indicate which of these earthquakes the San Andreas Fault caused. (Hint: locate the town and determine if it's close enough to have been affected by the fault).



California Earthquakes							
date	location	magnitude	intensity	date	location	magnitude	intensity
1769	Santa Ana Canyon	8.0	XI	1933	Long Beach	6.3	IX
1812	San Juan Capistrano	7.0	X	1940	Imperial Valley	7.1	X
1836	Hayward	7.0	X	1952	Tehachapi	7.7	XI
1838	San Francisco	7.0	X	1971	San Fernando	6.6	XI
1857	Fort Tejon	7.7	X	1979	Imperial Valley	6.4	IX
1861	Livermore	7.0	VII	1980	Eureka	7.0	VII
1872	Lone Pine	8.3	XI	1983	Coalinga	6.7	VIII
1906	San Francisco	8.3	X	1986	Palm Springs	6.0	VII
1918	San Jacinto	6.8	IX	1987	Whittier	5.9	VIII
1925	Lompoc	7.5	X	1987	Imperial Valley	6.3	IX
1929	Whittier	6.8	XI	1989	Loma Prieta	7.1	X



What Visible Evidence Exists of the San Andreas Fault Zone?

Circle the visible evidence directly related to movements of the San Andreas Fault Zone. If you are unsure, note the reason why you think it may be evidence. Use the geology vocabulary list provided by your teacher and other sources to assist with this activity sheet.

Mountain-building zones

New river valleys formed

Oceanic trenches

Fossils

Cambrian rock forms

Valleys without streams

Streams with sudden bends

Volcanoes

Tomales Bay

Subduction zones

River valleys drained

Underground rivers

Offset stream course

Coastal erosion

Cave creation

Sandy shores

Dunes

Rock joints

Shutteridge

Drowned coastlines

Tsunamis

Asteroids

Sag pond

Altered slope of hills

Weathered rocks

Creation of coral reefs

Side-hill bench

Linear trough or valley

Bolinas Lagoon

Creation of glaciers

Creeks close together flowing in opposite directions

Wind-caused erosion

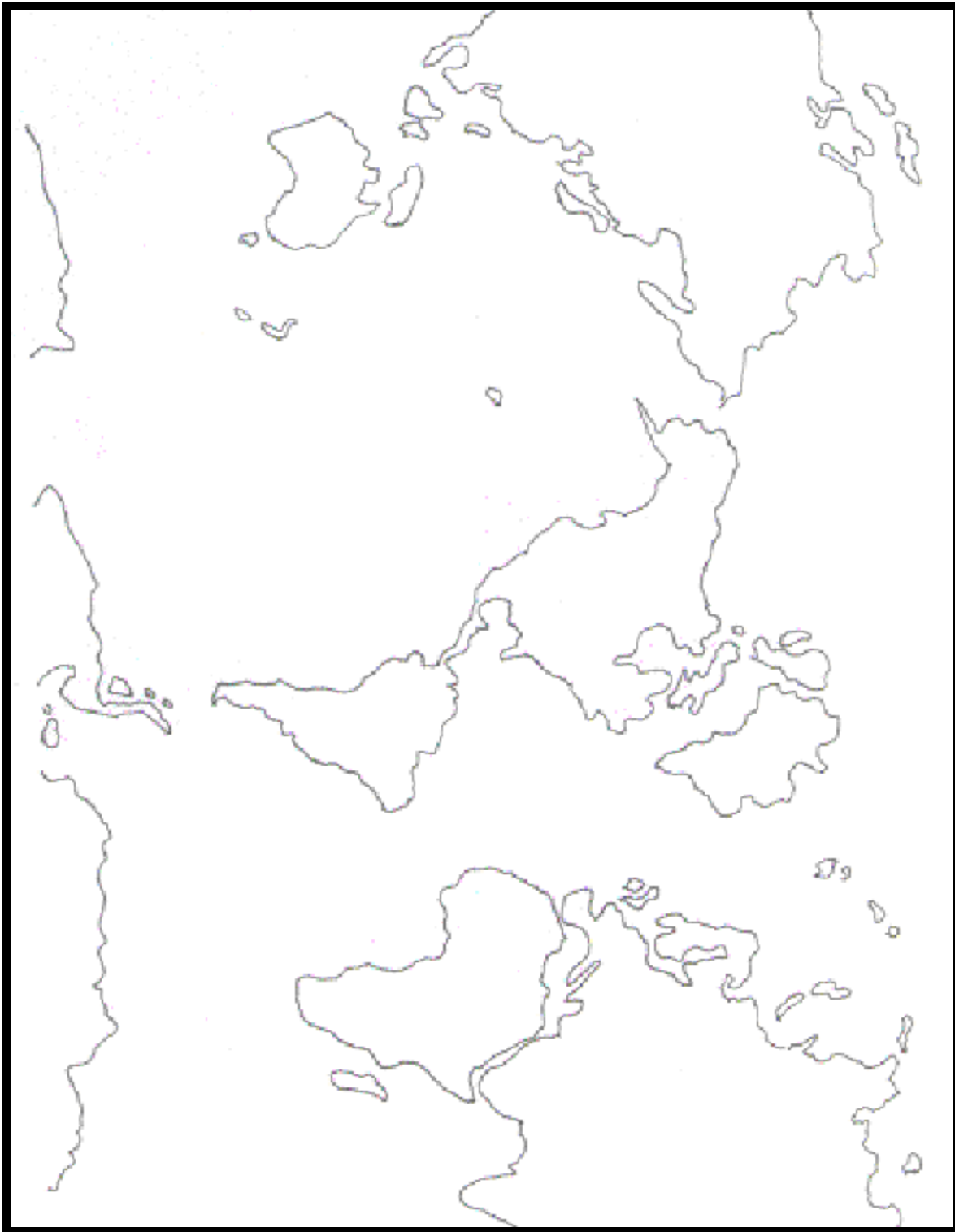
Name _____ Date _____



Where Is the San Andreas Fault Zone Found in Relation to World-Wide Tectonic Plates?

Locate a map of the world that illustrates major tectonic plates. Specifically draw (on the map below) where at least eight major plates are located. Finally, mark where the San Andreas Fault is found.

Activity Sheet





Where Is the San Andreas Fault Zone Found in Relation to Earthquakes in California?

Find a map showing where the San Andreas Fault Zone lies in California. Draw and label this zone on the map below. Then, using a detailed map of California and the list of major California earthquakes below, indicate which of these earthquakes the San Andreas Fault caused. (Hint: locate the town and determine if it's close enough to have been affected by the fault).



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1857	Fort Tejon	7.7	X	1979	Imperial Valley	6.4	IX
1861	Livermore	7.0	VII	1980	Eureka	7.0	VII
1872	Lone Pine	8.3	XI	1983	Coalinga	6.7	VIII
1906	San Francisco	8.3	X	1986	Palm Springs	6.0	VII
1918	San Jacinto	6.8	IX	1987	Whittier	5.9	VIII
1925	Lompoc	7.5	X	1987	Imperial Valley	6.3	IX
1929	Whittier	6.8	XI	1989	Loma Prieta	7.1	X

Name _____ Date _____



What Visible Evidence Exists of the San Andreas Fault Zone?

Circle the visible evidence directly related to movements of the San Andreas Fault Zone. If you are unsure, note the reason why you think it may be evidence. Use the geology vocabulary list provided by your teacher and other sources to assist with this activity sheet.

Activity Sheet

- | | |
|--|--------------------------|
| Mountain-building zones | New river valleys formed |
| Oceanic trenches | Fossils |
| Cambrian rock forms | Valleys without streams |
| Streams with sudden bends | Volcanoes |
| Tomales Bay | Subduction zones |
| River valleys drained | Underground rivers |
| Offset stream course | Coastal erosion |
| Cave creation | Sandy shores |
| Dunes | Rock joints |
| Shuttridge | Drowned coastlines |
| Tsunamis | Asteroids |
| Sag pond | Altered slope of hills |
| Weathered rocks | Creation of coral reefs |
| Side-hill bench | Linear trough or valley |
| Bolinas Lagoon | Creation of glaciers |
| Creeks close together flowing in opposite directions | |
| Wind-caused erosion | |

What Is It Like to Be in an Earthquake?



Students will share human experiences of earthquakes. This may be done through their own experiences, oral history interviews, or magazine articles. Implications and safety procedures of living near the San Andreas Fault will be discussed.

Time required: 1 hour homework interview or research

Location: varies

Suggested group size: independent work

Subjects: earth science, social science

Concept covered: earthquakes

Written by: Mike Schulist

Last updated: 04/02/00

Student Outcomes

At the end of this activity, students will be able to:

- Understand the experience of a major earthquake
- Appreciate the implications of living near a major fault line
- Relate earthquake studies at Point Reyes National Seashore to events closely affecting their lives

National Science Standard Links (grades 5 - 8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard F - Natural hazards; Risks and benefits.

Materials

To be photocopied from this guide:

- What Is It Like to Be in an Earthquake? Activity Sheet

Procedures

1. Assist students to choose one of the methods below (Oral Interviews or Research) for understanding the experience of an earthquake

Oral Interviews:

- Do you know someone who was in the Loma Prieta Earthquake of 1989?



- Do you know someone who was in another major earthquake?
- Have you ever been in a major earthquake?

If students answer yes to any of these questions, they will conduct an oral interview using the attached activity sheets.

Research:

- If you do not know anyone personally, you may need to locate information which depicts the human side of earthquakes. Many magazines (such as Time or Newsweek) published after the Loma Prieta Earthquake have articles. Students may also use the Internet to locate stories. These students may also use the **What Is It Like to Be in an Earthquake?** Activity Sheets, but will modify the answers according to the information provided.

2. Students summarize research in reports

Instruct students to use their completed activity sheets to write a one-page report according to the following outline:

What was remembered most about the earthquake?

Did the person change behaviors as a result of the experience?

What advice would you give this person for the next potential earthquake?

3. Have students hand in activity sheets and reports

Display reports on a bulletin board in the hallway or cafeteria where other students may contemplate implications and precautions for living next to the San Andreas Fault.

Extension Ideas

1. Students research articles about California earthquakes and report on their findings.
2. Find pictures of the devastation caused by earthquakes in the Bay Area and have students make a photo collage.
3. Students create poster boards or pamphlets teaching about earthquake safety procedure.
4. Students film and edit an interview of someone with a particularly moving story of earthquake survival to share with other students.
5. Students organize and practice an earthquake safety drill for their school.



What Is It Like to Be in an Earthquake?

Living in California, most of us have experienced the rumblings of an earthquake. Some of us have had our lives changed by earthquakes - the loss of a friend or loved one, of personal property, or perhaps just the memory of feeling the earth sway beneath us.

Your job is to find someone whose life has been touched powerfully by an earthquake. Start with your parents, and if they can't help you, ask them to lead you to someone who can. Friend's parents, relatives, older brothers or sisters all probably have good memories of what they were doing on October 17, 1989, when the Loma Prieta Earthquake struck.

Find someone with an interesting story and conduct an interview. You might bring a tape recorder so you can keep the flow of conversation going and copy your answers down later. Listen politely to the experiences of others - chances are you will someday have a story to tell about earthquakes, if you don't have one already...

1. What is the name of the person you will interview?

2. Why did you choose to interview this person?

TYPES OF QUESTIONS TO ASK:

3. What earthquake were you in?

4. Where were you when the earthquake hit?





Name _____ Date _____

Activity Sheet

5. What did it feel like to experience an earthquake?

6. What damage was done to the area around you as a result of the earthquake?

7. What did you do while the ground was shaking to make yourself safe?

8. How much earthquake safety preparation did you have before the earthquake?

9. If you had earthquake safety preparation, how did it help you during the earthquake?

10. What do you remember most about this earthquake?



What Earthquake Information Is Available on the World Wide Web, and Why Is It Important?



Post-
Visit

Lesson Plan

Students will research an earthquake of their choice based on a list of most recent earthquakes in the world. A worksheet will guide this process and prompt students to realize the importance of seismic research.

Time required: 1 hour

Location: classroom or homework assignment (requires Internet access)

Suggested group size: individual or student teams

Subjects: science, physics, math, computer literacy

Concepts covered: earth science, hazard prevention, earthquakes

Written by: Christie Denzel Anastasia, National Park Service

Last updated: 04/09/00

Student Outcomes

At the end of this activity, the students will be able to:

- Utilize on-line earthquake information
- Make the connection between seismic research and relevance to their lives

California Science Standard Links (grades 6-8)

This activity is linked to the California Science Standards in the following areas:

- 6th grade
- 1a - the fit of the continents, location of earthquakes, etc., provide evidence for plate tectonics
 - 1c - lithospheric plates that are the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle
 - 1d - earthquakes are sudden motions along breaks in the crust called faults
 - 1e - major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate tectonics
 - 1f - explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes)
 - 1g - how to determine the epicenter of an earthquake and that the effects of an earthquake vary with its conditions

Creating
COASTAL
STEWARDSHIP
through Science





- 7th grade 7d - communicate the steps and results from an investigation
7b - utilize a variety of print and electronic resources, including the World Wide Web, to collect information
7c - communicate logical connections among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence
- 8th grade 9b - evaluate the accuracy and reproducibility of data

National Science Standard Links (grades 5-8)

This activity is linked to the National Science Standards in the following areas:

- Content Standard A - Use appropriate tools and techniques to gather, analyze, and interpret data; Develop descriptions, explanations, predictions, and models using evidence; Think critically and logically to make the relationships between evidence and explanations.
- Content Standard B - Motions and forces.
- Content Standard D - Earth's history.
- Content Standard F - Personal health; Natural hazards; Risks and benefits.

Materials

To be provided by the teacher:

- Access to Internet (if not available at home/public library)

To be photocopied from this guide:

- **What Earthquake Information Is Available on the World Wide Web, and Why is it Important** Activity Sheet, one per student or team

Vocabulary

generated by student inquiry

Procedures

1. Review assignment

Distribute activity sheets to be completed (using information available on the Internet). Students may work independently or in teams.

2. Generate class discussion

Use Question #4 on the activity sheet to discuss the relevance of current earthquake information to various professions, agencies, and individuals. Do students think tax dollars should be spent on this type of research? Why or why not?

Extension Idea

1. What information is missing from the Internet? Were students looking for information they could not locate? Ask students to plan and create a website.



What Earthquake Information Is Available on the World Wide Web, and Why Is It Important?

You will need a computer with Internet Access for about 30 minutes to complete the following exercise.

1. Navigate to United States Geologic Society at www.usgs.gov.
 - Select "Earthquake Information" from list of options.
 - Choose one earthquake from "List of Most Recent Earthquakes" for this assignment.
 - You may want to search for the closest, most recent, or an international earthquake.
 - After completing the following information, double click on the title of the earthquake you have chosen to view its location.

Earthquake:

Day:

Time:

Latitude:

Longitude:

Depth:

Magnitude:

Real time conversion (click on "UTC" for instruction):

2. Select "Historical Seismicity," located under the earthquake map.

What has been the earthquake activity of this area in the past?



Name _____ Date _____

Activity Sheet

3. Select "P-Wave Travel Times;" located under earthquake map.

How much time would it take the waves to reach New York City?

4. Go to www.usgs.gov; in the Search Option type "Hazard Maps Help Save Lives and Property"; select "Hazard Maps Fact Sheet." Read the article "Hazard Maps Help Save Lives and Property" and answer the following questions.

Why could an earthquake in the central or eastern United States cause as many casualties and as much damage as several earthquakes of similar magnitude in California?

List four reasons that up-to-date earthquake maps can save lives and property.

5. Do you have any questions about earthquakes? You can send your question to Ask-A-Geologist@usgs.gov. Share your answers from the geologist with the rest of your class.



What Is Our Earthquake Safety Plan?



Given the real probability of an earthquake occurring in Northern California in the next 30 years, students will create an earthquake safety plan for home and school.

Time required: 1 hour

Location: classroom

Suggested group size: entire class

Subject: science

Concepts covered: natural disasters, hazards, and prevention

Adapted from: various United States Geologic Survey sources

Written by: Christie Denzel Anastasia, National Park Service

Last updated: 04/07/02

Student Outcomes

At the end of this activity, the students will be able to:

- Create an Earthquake Safety Plan and Earthquake Kit

National Science Standard Links (grades 5-8)

This activity is linked to the national science standards in the following areas:

- Content Standard F - Natural Hazards, Risks and Benefits

Materials

To be provided by the teacher:

- Books, pamphlets, or other sources of information regarding earthquake safety
- Many on-line materials regarding earthquake could be made available to students as reading material

Vocabulary

generated by student inquiry

Procedures

1. Introduction to earthquakes in California

As of yet, there is no scientifically verifiable way to predict earthquakes. We can only determine when they are likely to occur, what the shaking will be like, and what the result of that shaking will



be on certain types of engineering. The geologic record of fault movement in California tells us to expect an average of approximately seven earthquakes of magnitude seven or greater every century. With this in mind, we cannot prevent earthquakes, but we can be prepared with the right tools and mental attitudes.

2. What would you expect to happen?

Discuss expectations of earthquakes. Create a list on the blackboard of various situations created by earthquakes. (Example: houses shift, roads crack, electricity is lost.)

3. What are the hazards?

Based on their list of situations, what would be the disasters and possible results of those disasters? If students listed "large cracks are created in the ground", a result of that may be a dangerous hole is created and buildings slide into the cracks. Other situations may include falling buildings, power lines tilt or break, tsunamis, dam breaks, or landslides. Once these hazards and results are identified, group them according to major, moderate, or minor hazards.

4. What would you do if you were in a _____?

Discuss how students' reactions and responses to an earthquake may vary based on their location at the time. List the following situations and have students discuss what they would do if they found themselves in these situations during an earthquake.

indoors	beach
outside	shopping mall
driving	sidewalk near building
mountainous area	stadium
wheelchair (or with someone in a wheelchair)	
library	

5. What would you do after an earthquake?

What are the proper behaviors and actions after an earthquake? Have students brainstorm and prioritize their answers to this question.

- use flashlights or battery-powered lanterns (lighters or candles should not be used until you are sure there are no gas leaks)
- use telephones only for life-threatening emergencies
- listen to battery-powered radios
- watch out for existing hazards and aftershocks
- help those who are injured



6. Planning

Based on students' list of behaviors and actions after an earthquake, what are some planning actions that could make this time a little easier?

Create an Earthquake Kit

What should be in this kit? Do we have one? Where is it? (radio, flashlight, extra batteries, nonperishable food, first aid kit, wrench to turn off gas/water, alternate cooking source, essential medication)

Create an Earthquake Safety Plan

Investigate existing hazards at home/in the neighborhood/at school. Where should you be during the earthquake? Where will you meet others after the shaking? Where is the Earthquake Kit located?

7. Practice an earthquake drill

Create a scenario of an earthquake. The ground starts shaking during class. What should students do first? How long should they stay like that? What should they expect when they go home? Based on this practice session, would they have done anything differently?

Extension Ideas

1. What are existing building codes for school buildings? Is your school up to code? Who is responsible for ensuring earthquake safety? As of 1985, building codes have been based on different types of soil (hard rock, firm (sandy) soil, and soft (clay soil). What is the predominant soil type under your school? What does that mean in terms of earthquakes?
2. Investigate the current seismic retrofit of the San Francisco Bay Bridge. What are they doing, and how will that help during an earthquake? What would be possible results if they did not retrofit the bridge?

The following list is incomplete, but is meant to provide ideas for additional teaching resources.



Education and Reference Materials

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Field, Nancy and Adele Schepige. **Nature Activity Book: Discovering Earthquakes.** Middletown, WI: Dog-Eared Publications. 1995.

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Schulz, Sandra S. and Robert E. Wallace. **The San Andreas Fault.** Washington, D.C.: Government Printing Office. 1990.

Internet Addresses

National Park Service Geology Site
www2.nature.nps.gov/grd

United States Geologic Survey
www.usgs.gov

The Community Preparedness Website Project
www.preparenow.org

Northern California Earthquake Data Center



<http://quake.geo.berkeley.edu/>
California Department of Conservation
www.consrv.ca.gov/

FREE! Online Publications

Earthquakes

<http://pubs.usgs.gov/gip/earthq1/>

The Interior of the Earth

<http://pubs.usgs.gov/gip/interior/>

The San Andreas Fault

<http://pubs.usgs.gov/gip/earth3/>

The Severity of an Earthquake

<http://pubs.usgs.gov/gip/earthq4/severitygip.html>

United States Geological Survey Publications

<http://www.usgs.gov>

Bibliographical Sources

<http://www.calacademy.org/research/library/biodiv/biblio/quake.htm>

<http://www-geology.ucdavis.edu/~GEL115/quakes.html>

<http://www.fema.gov/emi/edu/biblo15.htm>