"What Happened Here Before"

Creating a Bay Timeline

TEACHER'S PAGES

Overview

In this activity students will begin by reading a poem by Gary Snyder and completing a homework assignment to learn about his presentation of the history of California. Students will then read about the geological history of the San Francisco Bay and will work in groups to create an artistic representation of a timeline of the Bay.

Central Questions

What were some of the major events in the history of California that affected its natural resources and physical characteristics? What is the geological history of the San Francisco Bay and its watershed? What role have plate tectonics, sedimentation, volcanoes, and climate change played in the formation of the Bay?

Estimated Time

Part I: Poetic Review
1 homework assignment
Part II: Artistic Interpretation
1 reading assignment, 1-2 class periods to create mural

Objectives

Students will be able to:

- Interpret a poem, identifying and defining key words and phrases, describing a theme, and linking the structure to the content.
- Describe the history of California and its wealth of natural resources.
- Comprehend that geology is a dynamic process.
- Understand how plate tectonics, sedimentation, climate change, and volcanic activity have shaped the Bay.
- Explain the formation of specific landscapes around the Bay.

Materials

Part I: Poetic Review
For each student:

- 1 copy of student worksheet with Gary Snyder's poem "What Happened Here Before"

Part II: Artistic Interpretation
For each student (for reading assignment):

- 1 copy of "Bay Today, Gone Tomorrow"

For each group (for mural):

- 1 blown-up copy of picture of the Bay
- Ruler
- Pencils
- Art supplies (crayons, color pencils, paints, etc.)

California Science Content Standards

Grade 6

Standard Set 1.e: major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate motions.

Standard Set 1.f: how to explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes).

Standard Set 2.a: water running downhill is the dominant process in shaping the landscape, including California's landscape.

Standard Set 2.b: rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.

Standard Set 2.d: earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

Grade 7

Earth and Life History (Earth Science)

Standard Set 4.a: Earth processes today are similar to those that occurred in the past and slow geologic processes have large

cumulative effects over long periods of time.
Standard Set 4.b: the history of life on Earth has been disrupted by major catastrophic events, such as major volcanic eruptions or the impact of an asteroid.
Standard Set 4.c: the rock cycle includes the formation of new sediment and rocks. Rocks are often found in layers with the oldest generally on the bottom.

Grades 9 - 12

Earth Sciences Standard 9.a: the resources of major economic importance in California and their relation to California's geology.

Language Arts

Grades 6 - 12

Reading

Students read and understand grade-level-appropriate material. *(See Standards for details)*

Teacher Procedure

Part I: Poetic Review

1. Pass out copies of Gary Snyder's poem "What Happened Here Before" and worksheets as a homework assignment.

2. Tell students that they are to read the poem carefully at least two times through before beginning the assignment. Then they should fill out the worksheet accompanying the poem. The worksheet requires the students to find one key word from each time frame in the poem and do a little research in the library or on the internet to define their key word.

3. Give the your class some examples of appropriate key words, citing a few words from the vocabulary list. The key words should be words describing the Earth's physical characteristics or natural resources (examples: slate, schist, manzanita, blacktail hare, etc.).

4. Each student should answer the following questions about the poem regarding its meaning and the meaning of the key phrase "WE SHALL SEE/WHO KNOWS/HOW TO BE."

Questions:

- What did you think of the poem?
- How did the poem make you feel?
- What are some of the key words you found and what are their definitions?
- Which key words did you not know before the presentations and how do they play a part in the poem?
- What specific images from the poem teach us about the history of California?
- What do you think is the poet's message?
- What does the poet seem to think about how we treat the Earth today?
- What do you predict California will look like in the future and how would you write a verse of the poem for the future time period? (Have the students read some verses aloud.)

5. The next day in class, lead a discussion about the poem before collecting the students' homework assignments.

Part II: Artistic Interpretation

Teacher Procedure

1. Pass out "Bay Today, Gone Tomorrow" article to students the day before and tell them to read it for homework.

2. Tell the students to pay special attention to the geologic processes that shaped today's Bay and to create a list of geologic processes mentioned in the article that have shaped the Bay.

3. In class the next day, divide class into 4 groups.

4. Pass out art materials to groups.

5. Explain that they are to read the article and create a free-form artistic mural detailing the history of the formation of today's San Francisco Bay. Their pictures should show the changes in their time period.

6. Assign each group to a specific time period/ era in the formation of the Bay and have the

group brainstorm the most important parts of their time period. Then each group will design and create their mural on the blown-up picture of the Bay.
   - Group 1: volcanic eruption and plate tectonics, Bay Block
   - Group 2: river systems, siltation, and sedimentation process
   - Group 3: glaciation and end of ice age processes, sea level rise and drop
   - Group 4: predictions of future changes….

7. Tell the groups that each group should create their mural to explain visually the processes they are assigned. They may use specific words, phrases, and quotes from the article. Also, ask them to label their time period on their mural.

8. When students are ready, have them display their murals in the room so they can see the other groups' work. Ask them what order the murals should go in to create a timeline for the history of the formation of today's Bay.

9. Have each group present their murals to the class, explaining what geologic processes occurred during their time period, etc.

Class Discussion/ Wrap-Up

1. Relate the article by Glen Martin to the poem by Gary Snyder. Each deals with almost incomprehensible amounts of time. How does each writer give us perspective on our place in geologic time? What are the similarities and differences between the poem and the article?

2. Ask the students to make predictions of what the Bay may look like thousands of years from now.
   - What changes may take place?
   - What geologic processes might cause these changes?
   - What are some things that we humans are doing that are affecting the Bay and its natural resources? (bay fill, wetland development, water diversion from the Delta, water pollution)
   - What are some things that we can do to protect our resources and prevent the types of changes we have caused?

Additional Resources

Geologic Bay History
http://squall.sfsu.edu/courses/geol103/labs/estuaries/partII.html

"What Happened Here Before"

Part I: Literary Comprehension

1. Read the poem "What Happened Here Before" by Gary Snyder carefully at least two times before beginning the assignment. On a separate sheet of paper write out one key word from each time period within the poem. Do a little research either in the library, on the internet, or in encyclopedias or dictionaries to define the terms you selected. The terms selected should be key words within that section of the poem, describing the Earth's physical characteristics, natural resources, or wildlife. (examples: schist, manzanita, blacktail hare, etc.)

Part II: Literary Analysis

Answer the following questions on a separate sheet of paper.

1. What do you think is(are) the overall theme(s)/message(s) of this poem?

2. What do you think the poet was trying to achieve by separating the poem into segments of time?

3. What are the Feather, Bear, and Yuba?

4. What historical event do you think the phrase "tossed up trees and boulders with big hoses" is referring to?

5. What could "sunlight grown heavy and tasty/ while moving up food-chains/ in search of a body with eyes and a fairly large/ brain" mean?

6. What do you think the phrase "the land belongs to itself./'no self in self: no self in things'" means?

7. Interpret the phrase "WE SHALL SEE/ WHO KNOWS/ HOW TO BE."

8. How did the timeline presented in this poem make you feel?

9. Did you like or dislike the poem? Why?

WHAT HAPPENED HERE BEFORE

by Gary Snyder

—300,000,000—
First a sea: soft sands, muds, and marls
— loading, compressing, heating, crumpling,
crushing, recrystallizing, infiltrating,
several times lifted and submerged,
intruding molten granite magma
deep-cooled and speckling,
gold quartz fills the cracks—

—80,000,000—
sea-bed strata raised and folded,
granite far below.
warm quiet centuries of rains
(make dark red tropic soils)
wear down two miles of surface,
lay bare the veins and tumble heavy gold
in streambeds
slate and schist rock-riffles catch it -
volcanic ash floats down and dams the streams,
piles up the gold and gravel—

—3,000,000—
flowing north, two rivers joined,
to make a wide long lake.
and then it tilted and rivers fell apart
all running west
to cut the gorges of the Feather
Bear, and Yuba.

Ponderosa pine, manzanita, black oak, mountain yew,
deer, coyote, bluejay, gray squirrel,
ground squirrel, fox, blacktail hare,
ringtail, bobcat, bear,
all came to live here.

—40,000—
And human people came with basket hats and nets
winter-houses and underground
yew bows painted green,
feasts and dances for the boys and girls
songs and stories in the smoky dark.

—150—
Then came the white man: tossed up trees and
boulders with big hoses,
going after that old gravel and gold.
horses, apple-orchards, card-games,
pistol-shooting, churches, county jail.

We asked, who the land belongs to.
And where one pays the tax.
(two gents who never used it twenty years,
and before them the widow
of the son of the man
who got him a patented deed
on a worked-out mining claim,)
laid hasty on the land that was deed and acorn
grounds of the Nisenan?
Branch of the Maidu?

(they never had a chance to speak, even,
their name.)
(and who remembers the Treaty of Guadalupe Hidalgo.)

the land belongs to itself.
"no self in self: no self in things"
Turtle Island swims
in the ocean-sky swirl-void
biting its tail while the worlds go
on-and-off
winking

& Mr. Tobiassen, a Cousin Jack,
assesses the county tax.
(the tax is our body-mind, guest at the banquet
Memorial and Annual, in honor
of sunlight grown heavy and tasty
while moving up food-chains
in search of a body with eyes and a fairly large
brain—
to look back at itself
on high.)

now,

we sit here near the diggings
in the forest, by our fire, and watch
the moon and planets and the shooting stars—

my sons ask, who are we?
drying apples picked from homestead trees
drying berries, curing meat,
shooting arrows at bales of straw.

military jets head northeast, roaring, every dawn.
my sons ask, who are they?

WE SHALL SEE
WHO KNOWS
HOW TO BE

Bluejay screeches from a pine.

BAY TODAY, GONE TOMORROW

S.F. region's defining feature is just a transitory puddle in geologic time

by Glen Martin, San Francisco Chronicle Staff Writer
Monday, December 20, 1999

If you had planned to stroll to Ocean Beach 17,000 years ago, you would have been well advised to pack a lunch. And maybe dinner and the next day's breakfast, too.

That's because the coast was very far away. From where San Francisco sits, the beach was 26 miles west, about six miles past today's Farallon Islands.

The islands themselves, of course, were not islands at all — they were peaks.

And San Francisco Bay? Well, there was no bay. And that would remain the case for several thousand years.

The site of the present bay was a series of broad valleys, each with a tributary stream that poured into a mighty, sediment-swollen river that originated in the Sierra Nevada. This river drained through the Central Valley, the Carquinez Strait, Raccoon Strait and the stony ramparts that are now the Golden Gate.

A bay, in fact, is something of an anomaly for the San Francisco region.

"During the past 600,000 years, the bay has only existed during three brief periods totaling about 15,000 years," observes Ken Lajoie, a senior geologist with the U.S. Geological Survey in Menlo Park who counts the Bay Area's geology among his specialties.

"The present bay has existed near its (current) size only for the last 4,000 years," he says. And if the past is any indication, it will be around for only another 1,000 years or so.

5,000-YEAR LIFE-SPAN

The geological history of San Francisco Bay is really the story of several bays — each of which lasted only about 5,000 years — and of the tens of thousands of years between, when the land supported big rivers and lovely valleys.

It is a story that involves the cataclysmic raising and lowering of the Pacific Ocean, stupendous volcanic eruptions, the creation of mountains through the grinding, compressing and upheaval of tectonic plates and the inundation of entire landscapes by vast floods.

It is also a story of life — of primeval forests of cedar and pine, of great Pleistocene mammals such as mammoths and giant ground sloths, and of the people who hunted them with nothing more than flint-pointed spears.

The very dimensions of the story can't help but give one a certain perspective, observes Lajoie, who notes that even the most dramatic of the Earth's features — bays, rivers, mountains — are ephemeral in the context of geologic time.

'NOTHING IS PERMANENT'

"We tend to think that the Earth's features don't change, but geologically speaking, the fact is that nothing is permanent, or even around very long," he says.

Today's bay formed when the last ice age waned. At the height of the last glaciation about 17,000 years ago, large amounts of water evaporated from the oceans and fell as snow, not rain, compacting into huge continental glaciers. Sea level lowered by about 300 feet, and big expanses of the present continental shelf were exposed.

As the glaciers retreated, sea levels began rising, with rates ranging from three feet per century to 15 feet per century. About 10,000 years ago, the ocean began sneaking through the Golden Gate, forming the nascent San Francisco Bay.

"The bay only reached its present size within the last few hundred years," says Lajoie.

Even while the melting glaciers worked to form a large bay, other factors conspired to restrict its size. "The bay would be about twice its present size if sediments hadn't partially filled the subsiding basin it now occupies," Lajoie observes.

But to understand the forces that shaped the bay, you have to go further back in time — close to a million years further.

The sedimentary record indicates that the interior of California didn't always drain through the bay basin, as is now the case. Minerals from the Sierra Nevada began appearing in the basin somewhat less than 600,000 years ago — a blink in the context of geological time.

Prior to that, a vast inland sea called Corcoran Lake occupied much of the Central Valley, draining through the Salinas River into Monterey Bay.

VOLCANIC ERUPTION

About 760,000 years ago, a tremendous volcanic eruption occurred in what is now the Bishop area. A great caldera was created, and massive amounts of volcanic ejecta were deposited in the lake.

But this ash didn't make it into the bay until tectonic shifting in the Earth's crust caused the Bay Area to subside and the south end of the lake to rise about 560,000 years ago.

This caused the lake to spill over the ridge that separated it from the bay basin. The flow carved the Carquinez Strait and drained the lake. It could have happened so fast that it would have been a single, catastrophic event, says Lajoie — a great gush of water roaring to the sea.

Since then, tectonic activity — upthrusting of the Earth's crust — has plugged the Central Valley's outlet through the Salinas River. Now, everything that flows into the Sacramento and San Joaquin valleys ultimately pours out the bay.

Another eruption, this from Mount Lassen and much smaller than the Long Valley Caldera near Bishop, also contributed sediments to the bay.

"This occurred about 435,000 years ago," says Lajoie. "Sediments from the event are called the Rockland Ash, and can be seen clearly in the sea cliffs at Fort Funston on the San Francisco coast."

As the ice from the last glaciation melted, the Sacramento and San Joaquin rivers became great, braided streams choked with sediment.

"All that glacial outwash was dumped in the Central Valley and the Delta," says Lajoie. "There was so much sediment that huge dune fields blew out of the river near Antioch about 15,000 years ago. The same thing happened where Oakland now sits."

Oakland, in fact, is built over a deposit of dune sand known as the Merritt Sand. There was no bay at that time, but those sediments ultimately covered much of the bay basin.

SOURCES OF SILT

A good deal of fine silt and clay still comes into the bay from the Sacramento-San Joaquin river system. But the lion's share of sediment — mostly sand and gravel — issues from Alameda Creek, which drains Livermore Valley through Niles Canyon.

"Many people find that surprising," says Lajoie, "because the biggest source of ongoing bay sedimentation isn't even directly adjacent to the bay — it's Livermore Valley. There's a huge alluvial fan of sediment deposited by Alameda Creek that spreads out beneath the bay from the Coyote Hills to the shore of Palo Alto."

Other things have helped the bay become a prime sediment trap — things of a tectonic nature. Mountains have built on both the San Andreas and Hayward faults, sharply defining the limits of the estuary. The process continues today, with the continuing uplifting of the Santa Cruz Mountains, which straddle the San Andreas Fault.

Simultaneously, the land just west of the Hayward Fault is subsiding; meanwhile, structural rock underlying the South Bay is slowly sinking and gradually tilting eastward.

As the Santa Cruz Mountains and the Berkeley Hills ascend, they are squeezing the zone of bedrock between them, known as the Bay Block.

"The interesting thing about the Bay Block is that it is basically free of faults at this point," observes Lajoie. "But as it continues to be compressed, it might eventually develop new fault lines."

CHANGES CONTINUE

The change has been dizzying — and it won't abate. It will continue, regardless of the level of human activity. Erosion and plate tectonics will grind on inexorably. And another ice age is not merely likely, Lajoie observes — it is inevitable.

Lajoie says there is increasing evidence to indicate that ice ages are triggered by perturbations in the Earth's orbit, subtle movements caused by the gravitational effects of Jupiter and our moon.

MASSIVE AMOUNTS OF DUST

"The planets formed by sweeping up massive

amounts of dust and debris when the solar system formed, but a lot was left over," says Lajoie. "It appears concentrated in a disk around the sun."

The Earth's orbital plane tips through this debris disk every 100,000 years or so, Lajoie observes. The dust occludes sunlight, reducing the amount of thermal energy that reaches the planet's surface.

That probably isn't enough to start an ice age by itself, he says.

"The oceans distribute solar energy globally, but the margins are very fine," he said. "The orbital parameters can't do it by themselves — but they're triggers. When the balance is finally thrown off in the oceans, glaciation can occur very quickly."

But what about global warming? Couldn't the ongoing atmospheric loading of heat-trapping gases like carbon dioxide forestall another ice age and guarantee the longevity of the bay, orbital wobbles notwithstanding?

Lajoie doesn't think so.

"I'd prefer that we maintain a cautious attitude about releasing greenhouse gases, but I don't think they could overcome the orbital signal," he says. "I think it's just too strong."

Our distant descendants, then, might well have to forgo bay views if they plan to live in San Francisco.

"When glaciation occurs, the bay drains, and everybody ends up walking to the Farallones," Lajoie says.

THE MAKING OF A BAY

Three geological processes have shaped San Francisco Bay: the rise and fall of sea level, the shifting of tectonic plates and the deposition of sediment from rivers. All work in concert to form an estuary that is in constant flux — and that periodically disappears for tens of thousands of years.

— Sea Level Rise

During the height of the last Ice Age 17,000 years ago, sea level dropped by 300 feet, and there was dry land west of what is now the Farallon Islands.

Melting glaciers caused sea levels to rise, and the current bay began to form around 10,000 years ago. It has existed near its current size only for the the last 4,000 years.

—The Bay Block

Shifting tectonic blocks continue to shape the bay. The rising Santa Cruz Mountains and Berkeley Hills are compressing the Bay Block, a vast slab of Franciscan rock underlying the south bay and its sediments. Though the Bay Block is essentially free of faults, it is expected that this compression will ultimately cause new faults to form.

CORCORAN LAKE

About 760,000 years ago, much of California's Central Valley was a great freshwater inland sea known as Corcoran Lake. The lake's outlet was the Salinas River, ultimately draining to Monterey Bay.

Then about 560,000 years ago, tectonic uplifting allowed the lake to rise sufficiently to cut through the soft soils of what is now the Bay Area. The Carquinez Strait was rapidly carved.

The uplifting also plugged the Salinas Valley outlet, leaving San Francisco Bay as the Central Valley's only outlet. Sediment deposited by Central Valley rivers limits the size of the bay.