Integrate Biology and Geology:
1883 News Report—Krakatoa Erupts!

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A Few Krakatoa Facts

- The volcano Krakatoa’s biggest day of eruption was on August 27th, 1883.
- This explosion was equal to 200 megatons of TNT.
- The tsunami produced by Krakatoa's eruption killed about 34,000 people.
- The “first internet” (wired telegraphy) told the world the news.
Scale of this Cataclysm

• On the morning of August 27, 1883, the rumbling volcano of Krakatoa stood more an 6,000 feet high, with a diameter of approximately 10 miles. Later that day, this giant cone exploded so violently it was literally blown away.

• The effects of the volcanic explosion caused a tsunami more than 140 feet high; one ship was carried more than 3 miles inland. Hail-sized stones fell as far as 100 miles away, and the city of Jakarta fell into total darkness.

• The noise of the eruption was unprecedented--it was heard as far away as Alice Springs, Australia and on the island of Madagascar near East Africa. Countries all over the globe were affected by the volcano's devastating after-effects. Heavy rains fell for the next three years. In the year following the eruption, average global temperatures fell by 2.2 °F.
Misleading Volcanic Eruption Teaching Strategies

- Vinegar and Baking Soda Volcano
  - Double replacement + decomposition reaction → CO2

- Ammonium Dichromate Volcano
  - Decomposition reaction → carcinogen “ash” + N2
Volcano Misconceptions

- Volcanoes are found only on land.
- Volcanoes are found only in hot climates.
- All volcanoes erupt violently.
- If it hasn’t erupted in 100 years, it’s extinct.
- Volcanoes are located randomly on Earth.
- Volcanoes only erupt straight up through the top vent.
Sensory Priming™ of our Inquiry

- TOUCH Volcanic Pumice (sharp glass)
- SEE Volcanic Pumice Float
- TASTE/FEEL Trapped Gas Bubbles (Pop Rocks®)
- SMELL Volcanic Gas (sulfur dioxide)
- HEAR Volcano Sounds (Audio Recording)
Our 1-Week Unit on Krakatoa

Features:
• Pre-Inquiry Bio-Geo priming
• Begins with Curiosity-Starter readings
• Includes an actual NY Times newspaper story published in 1883
• Involves the 5 Human Senses as Bio-Geo stimuli
• Includes an acclaimed PBS Documentary/Re-enactment DVD
• Calls for individual Bio-Geo Student Inquiry (Scientific Wondering) Projects that are to be shared
Step: Geographical Context

CREDITS: http://www.seismicity.see.uwa.edu.au/seismicity/?f=61307
http://www.abovetopsecret.com/forum/staff/sanctum/Krakatoa.jpg
<table>
<thead>
<tr>
<th><strong>Best Book for the Teacher</strong></th>
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<tr>
<td><strong>Paperback:</strong> 464 pages</td>
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<tr>
<td><strong>Publisher:</strong> Harper Perennial</td>
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<tr>
<td><strong>Date:</strong> 2005; $10</td>
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<tr>
<td><strong>Author:</strong> Former Field Geologist</td>
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<tr>
<td><strong>Text:</strong> Rich and rigorous in its historical and scientific details</td>
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<tr>
<td><strong>Includes:</strong> “The curious case of the terrified elephant!”</td>
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Zimmerman has successfully adapted Simon Winchester's *Krakatoa* (2003) for young people.
For the Younger Reader

Reading level: Ages 4-8
Length: 24 pages
Publisher: PowerKids Press
Date: 2001; $21
Author: Kathy Furgang

Status: Full-time freelance author. Has written children’s books about other famous volcanoes too.
THE KRAKATOA ERUPTION

First Sings of the Great Volcanic Disturbance

Cities obscured by “a cloud of darkness which might be felt.”

- The black dust was so fine that a mosquito net could not capture it.
- In Java itself, the tokens of evil were even more awfully manifest.
- In Batavia, the streets were heaped with volcanic-ashes and lava-dust...
- A piled-up wall of water sufficed to lay ruins to the village

(C) The New York Times
On Pumice (Winchester)

- “All three vessels were deluged with pumice: dangerous, heavy, sharp, fast moving masses of rock, the larger pieces still warm to the touch.” p. 218
- “…a hail of pumice-stone fell on us….we were obliged to cover up the skylights to protect the glass…." p. 220
- “Pieces of pumice hurled down from the sky, burning fiercely like jagged meteorites.” p. 228
- “The cloud of gas and white-hot pumice…” p. 234
Pumice Floats!

- Pumice is basically lava froth.
- It’s an extrusive rock “frozen” as its dissolved gases come out of solution.
- The bubbles (vesicles) in pumice are small and regular.
- Pumice is a kind of glass.

Our Pumice Source: [http://www.mineralminers.com](http://www.mineralminers.com) $5
Pop Rocks

• Analogous to pumice, tiny air pockets of gas (CO2) within its structure are released when this candy melts in your mouth. It has a mild "crackling" sensation and "popping" noise.

• Pop Rocks were developed in 1956 by General Foods research scientist William A. Mitchel.

• Our source: *Pop Rocks Extreme Sour Candy* (48 count) $11—Amazon.com
“Pumice the size of pumpkins…”

After Krakatoa’s main eruption…

• Human skeletons, animals, and plants floated across the Indian Ocean on rafts of volcanic pumice and washed up on the east coast of Africa.

• The volcano injected large amounts of sulfur dioxide (SO2) into the stratosphere.

• 5 cubic miles of rock, ash, and pumice were ejected!

• Ash shot up 50 miles high.
Volcanic Gases

- Volcanic gas can be harmful to humans, other animals, plants, agricultural crops, and property.
- Magma contains abundant gases that are released in a volcanic eruption, in order of amount → water, CO₂, SO₂, H₂S, HCL, H₂, CO
- Sadeo Matsuo says, “Volcanic gas is a telegram from the Earth’s interior [to us].”
- Pumice traps volcanic gases.
- Volcanic gases can severely damage vegetation.
Our “Volcano Gas” Sulfur Jar

\[ S + O_2 \rightarrow SO_2 \]

\[ S_8 + 8 O_2 \rightarrow 8 SO_2 \]

You want a very faint smell. Humans can smell SO2 at 1 ppm.
Why Use Safety Matches?

• Safety Matches: These matches are designed so they will only combust when struck against the right type of surface. The match heads are composed of sulfur (this is what you smell!) mixed with oxidizing agents like potassium chlorate, colorants (dyes), fillers, glue (binders), starch, and powdered glass. The glass in the match creates friction with the glass in the safety paper which ignites the head and then the wood.
Volcanic Plume: CO$_2$ Dispersal
History’s Loudest Volcano

• When it exploded in August, 1883, the noise was distinctly heard as far away as Perth, West Australia (~1,930 miles away) and in the Mauritius (~3,000 miles away).

• We use the recreated sound-track from the PBS DVD with a quality speaker system and without the projector turned-on to help students focus on the sounds Krakatoa made.
Acclaimed PBS Video

Studio: PBS Home Video

Length: 90 minutes

Type: Documentary with re-enactments

Date: 2005; $27

Features: Nice “nature of Bio-Geo inquiry” content
Step: Find a Scientific Inquiry Opportunity


CREDIT: http://ohiorc.org/pm/images/focus_chart.gif
Possible Student Questions

• How did the nearby animals sense that Krakatoa was about to erupt?
• How are Pop Rocks® like pumice, and not like pumice?
• What commercial uses are there for pumice?
• What happened under ground to cause Krakatoa’s massive 1883 explosion?

• How can plant life survive when a volcano erupts on an island? Insect life?
• How did the 1883 Krakatoa eruption affect the world’s sunsets?
• How are volcanoes and tsunamis connected?
• Why did the explosion’s sound travel so far?
• Why were no color photos of the eruption taken?
• What are the clues that a certain volcano will soon erupt?
Scientific terms learned spontaneously

- Animal Detection
- Ash Cloud
- Caldera
- Fumerole
- Lava
- Tectonic Plate Boundaries
- Magma
- Mudflows
- Pumice
- Pyroclastic Flow
- “Ring of Fire”
- Subduction
- Sulfur
- Tsunami
- Vulcanologist
Dispersal by Rafting

- Pumice rafting was an important process in the geologic past, and will continue to be in the future. It can serve as a natural dispersal mechanism for ecosystems damaged by human activity to recover species and biodiversity.
- See study: *Pumice rafting and biota dispersal across the Southwest Pacific following the 8-11 August 2006 Home Reef submarine volcanic eruption, Tonga*
Coconut Dispersal by Seawater
Drift Seeds & Drift Fruit
Seeds & Currents

2 = coconut
Image of 4 km$^2$ Pumice Raft
The eruption of Krakatoa was one of the first well-documented natural events in history. With it began the science of volcanology!

Most students have never seen a volcano, much less an active one. There, geology meets biology!