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ABSTRACT

Crustal Evolution Education Project (CEEP) modules were designed to: (1) provide students with the methods and results of continuing investigations into the composition, history, and processes of the earth's crust and the application of this knowledge to man's activities and (2) to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift, and plate tectonics. Each module consists of two booklets: a teacher's guide and student investigation. The teacher's guide contains all of the information present in the student investigation booklet as well as: (1) a general introduction; (2) prerequisite student background; (3) objectives; (4) list of required materials; (5) background information; (6) suggested approach; (7) procedure, recommending two 45-minute class periods; (8) summary questions (with answers); (9) extension activities; and (10) list of references. In these activities, students find differences in the chemical compounds that make up various rocks, plot a number of volcano sites in and around the Pacific, and relate their observations to plate boundaries and motions. In addition, students tell how volcanoes are different and classify them into certain groups. (Author/JN)

CRUSTAL EVOLUTION EDUCATION PROJECT™

Volcanoes: Where And Why?

TEACHER'S GUIDE

Catalog No. 34W1029

For use with Student Investigation 34W1129
Class time: two 45-minute periods

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Produced and Distributed by
Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

Volcanoes: Where And Why?

NAGT Crustal Evolution Education Project

Edward C. Stoever, Jr., Project Director

Welcome to the exciting world of current research into the composition, history and processes of the earth's crust and the application of this knowledge to man's activities. The earth sciences are currently experiencing a dramatic revolution in our understanding of the way in which the earth works CEEP modules are designed to bring into the classroom the methods and results of these continuing investigations. The Crustal Evolution Education Project began work in 1974 under the auspices of the National Association of Geology Teachers CEEP materials have been developed by teams of science educators, classroom teachers, and scientists Prior to publication, the materials were field tested by more than 200 teachers and over 12,000 students.

Current crustal evolution research is a breaking story that students are living through today. Teachers and students alike have a unique opportunity through CEEP modules to share in the unfolding of these educationally important and exciting advances CEEP modules are designed to provide students with appealing firsthand investigative experiences with concepts which are at or close to the frontiers of scientific inquiry into plate tectonics Furthermore, the CEEP modules are designed to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift and plate tectonics.

We know that you will enjoy using CEEP modules in your classroom. Read on, and be prepared to experience a renewed enthusiasm for teaching as you learn more about the living earth in this and other CEEP modules.

About CEEP Modules...

Most CEEP modules consist of two booklets. a Teacher's Guide and a Student Investigation. The Teacher's Guide contains all the information and illustrations in the Student Investigation, plus sections printed in color, intended only for the teacher, as well as answers to the questions that are included in the Student Investigation In some modules, there are illustrations that appear only in the Teacher's Guide, and these are designated by figure letters instead of the number sequence used in the Student Investigation.

For some modules, maps, rulers and other common classroom materials are needed, and in varying quantities according to the method of presentation. Read over the module before scheduling its use in class and refer to the list of MATERIALS in the module.

Each module is individual and self-contained in content, but some are divided into two or more parts for convenience. The recommended length of time for each module is indicated Some modules require prerequisite knowledge of some aspects of basic earth science, this is noted in the Teacher's Guide.

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Volcanoes: Where And Why?

INTRODUCTION

In these activities, the students find the differences in the chemical compounds that make up various rocks, plot a number of volcano sites in and around the Pacific and relate their observations to plate boundaries and motions.

Geologists group volcanoes by the different kinds of rocks they produce. Some ways in which volcanic rocks differ are in color, texture (size of crystals), mineral composition and chemical composition. Let's look at volcanoes and their rocks in one of these ways.

PREREQUISITE STUDENT BACKGROUND

In order to do these activities the students should have a basic knowledge of chemical compounds, igneous rocks, plate motions (including subduction zones) and use of latitude and longitude to plot locations.

OBJECTIVES

After you have completed these activities, you should be able to:

1. Tell one way in which volcanoes differ, and use this difference to classify them into certain groups.
2. Explain why groups of volcanoes are different.
3. Show on a map where groups of volcanoes of different kinds are located.

MATERIALS

Black, red and blue pencils for each student

BACKGROUND INFORMATION

Volcanic rocks are formed by molten rock that originates within the earth's crust and solidifies by cooling on the earth's surface, either on land or underwater. Most volcanic rocks are erupted through volcanoes, but some may come up through fissures and other types of vents.

There are many different kinds of volcanic rocks, and almost as many ways of classifying them. Some of the properties that have been found useful for classification are color, texture (e.g., size of crystals), mineral composition and chemical composition. Chemical composition is probably the most reliable property, but it is also the most difficult and expensive to determine.

Basalt, andesite and rhyolite are names given to three of the most common types of volcanic rocks in practically all classifications. These rocks differ significantly in their mineral and chemical compositions. Basalt is dark-colored because it contains dark-colored minerals in abundance. Rhyolites are lighter in color because they contain light-colored minerals. The color of andesite is usually in between basalt and rhyolite.

Differences in color and in mineral composition reflect differences in chemical composition. Basalts contain the greater amounts of iron, calcium and magnesium and the least amount of silica. Rhyolite contains lots of silica—enough, in fact, that quartz (SiO_2) crystals can form. The amount of silica in volcanic rocks is used in this activity to classify them as basalt, andesite or rhyolite.

The students can learn some important characteristics about the earth's crust by determining the chemical composition of volcanic rocks and then classifying them. Representative chemical analyses, for example, indicate that basalt is the only type of volcanic rock to occur in the deep ocean; rhyolite occurs only on continental areas and andesite is typically found along the margins of continents. There are exceptions to this simple scheme (basalt, for example, is not restricted to the ocean), but it is generally true.

Generally, then, the earth's crust beneath the ocean is of basaltic composition, whereas the crust beneath the continents tends to be rhyolitic. Andesite, which is part way between basalt and rhyolite in its silica content, characterizes the

areas where oceanic and continental crustal material tends to overlap.

This can best be explained by plate tectonics. Molten rock that comes to the surface in the Pacific and other ocean areas, flows out as basaltic lava. This will be low in silica. The same basalt, coming from the subduction zone up through the edge of the continent, is mixed with continental rock material, so the silica content of the andesitic lava will be somewhat higher. The highest silica content is found farther into the continent where the rhyolite lava is continental rock rather than ocean-bottom rock.

SUGGESTED APPROACH

Basically, these activities should be carried out by the students as independent inquiry. The students can work through the various steps at their own pace. At the end of the activities encourage the students to discuss their conclusions. You may wish to contribute some additional information on the subject.

PROCEDURE

PART A: Where are most volcanoes located?

In this activity the students plot the location of volcanoes and relate them to plate boundaries.

Key words: none

Time required: one 45-minute period

Materials: black pencil

1. Write down the names of all the volcanoes you can think of that are in or around the Pacific Ocean.

Give students some time to do this.

2. Compare your list with the rest of the class.

Let them expand their lists by comparing with others in the class.

3. Table 1 lists the locations of 30 volcanoes. You or others in your class may have named some of these. Plot the location of all the volcanoes in Table 1 on the map on the Worksheet. (Use latitude and longitude to find the places.) Write the name of the volcano next to each location.

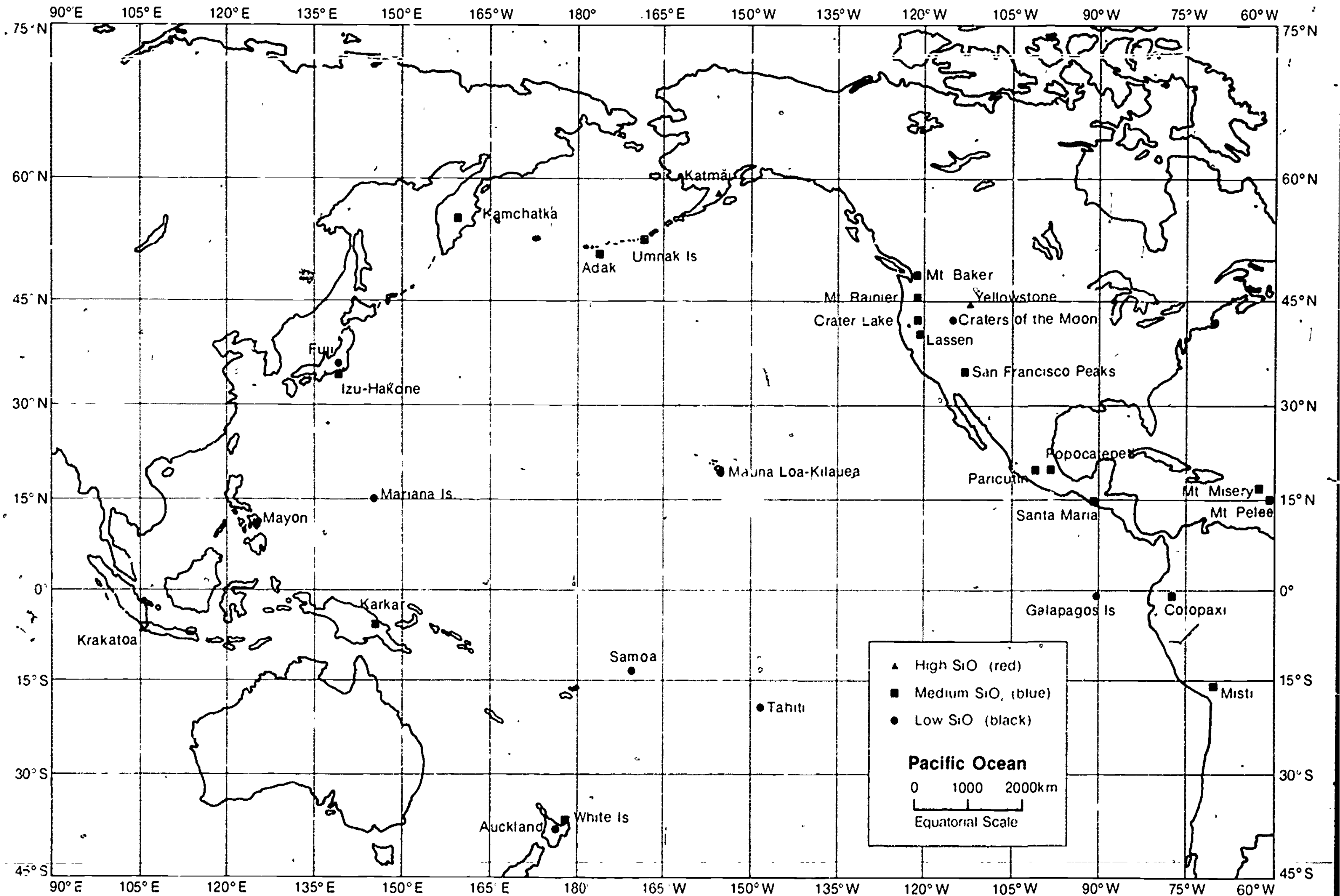
See Answer Sheet.

4. Where are most of these volcanoes located?

Most are around the edge of the Pacific Ocean. Some are farther inland, and some are in the ocean far from continents.

Table 1.
Locations of volcanoes

	Latitude	*Longitude*
	(approximate)	
Western United States, Pacific Border		
Lassen, California	40° N	121°W
Crater Lake, Oregon	43° N	122°W
Mt. Rainier, Washington	47° N	122°W
Mt. Baker, Washington	49° N	122°W
Western United States, Western Interior		
Yellowstone Park, Wyoming	45° N	111°W
Craters of the Moon, Idaho	43° N	114°W
San Francisco Peaks, Arizona	35° N	112°W
Central America and West Indies		
Paricutin, Mexico	19° N	102°W
Popocatepetl, Mexico	19° N	98°W
Mt. Pelee, Martinique	15° N	61°W
Santa Maria, Guatemala	15° N	92°W
Mt. Misery, St. Kitts	17° N	63°W
South America		
Cotopaxi, Ecuador	1° S	78°W
Misti, Peru	16° S	71°W
Alaska and Aleutian Islands Area		
Katmai, Alaska	58° N	155°W
Adak, Aleutians	52° N	177°W
Umnak Island, Aleutians	53° N	169°W
Kamchatka, USSR	57° N	160° E
Japan		
Fuji, Honshu	35° N	139° E
Izu-Hakone, Honshu	35° N	139° E
East Indies		
Mayon, Philippines	13° N	124° E
Krakatoa (between Java & Sumatra)	6° S	105° E
Karkar, New Guinea	5° S	146° E
Central Pacific		
Mauna Loa or Kilauea, Hawaii	19° N	[illegible]°W
Galapagos Islands	1° S	91°W
Mariana Islands	16° N	145° E
South Pacific		
White Island, New Zealand	37° S	177° E
Auckland, New Zealand	38° S	176° E
Tahiti	18° S	149°W
Samoa	13° S	172°W



Answer Sheet (PARTS A and B)

5. Look at the map of crustal plates in Figure 1. Where on the plates are most of these volcanoes located?

Most of them seem to be on the edge of the crustal plates where the plates are moving toward or past one another.

6. How can you explain this?

The bumping and rubbing of plates causes the friction and heat that make volcanoes. (Note that most of them are over subduction zones. Some students may make this observation.)

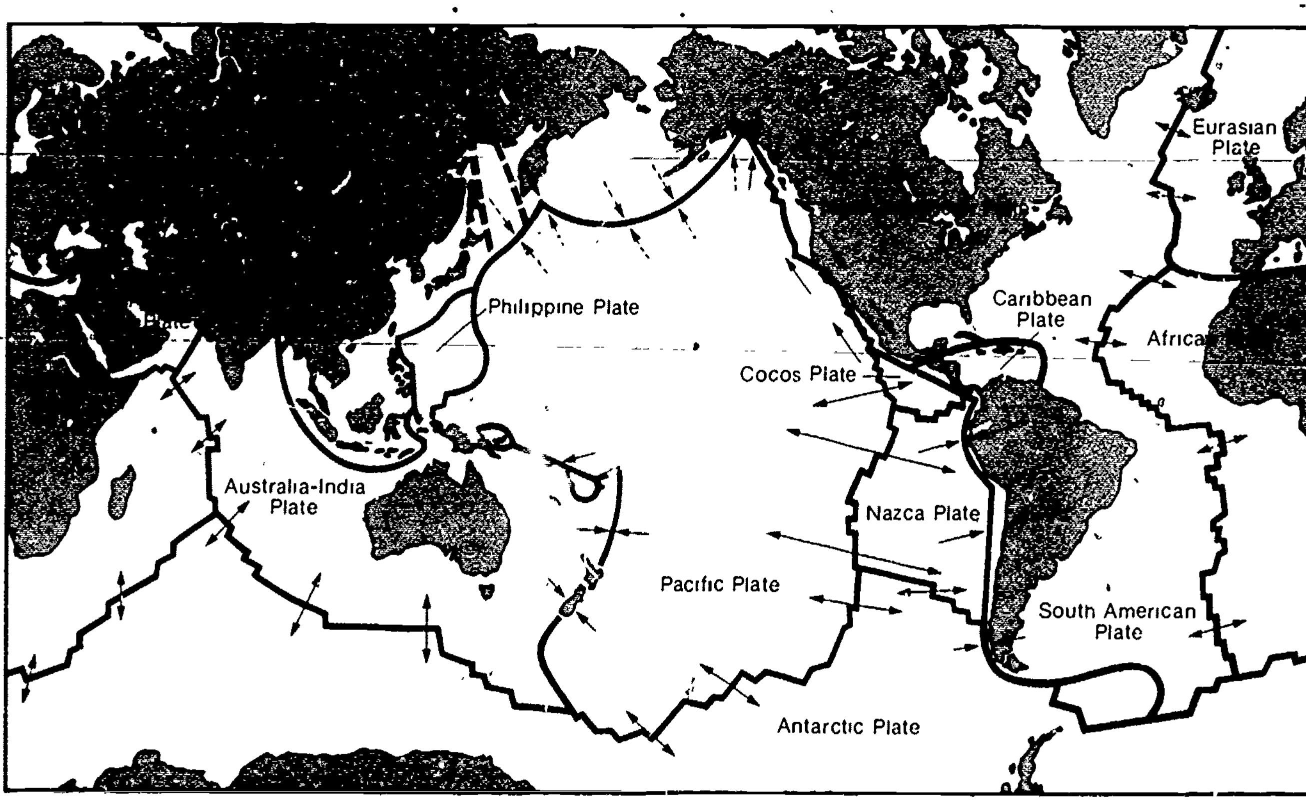


Figure 1. Map of crustal plates. Arrows indicate direction of plate movement.

PROCEDURE

PART B: What makes volcanic rocks different from each other?

The students identify the SiO_2 differences among rocks, plot SiO_2 groups and relate these to plate boundaries and motions.

Key words: none

Time required: one 45-minute period

Materials: Three pencils (red, black, and blue).

1. List all the ways in which you think volcanic rocks can be different from each other.

Color, texture (crystal size), mineral content and chemical composition.

2. From your list and the lists of other students, which characteristics of a volcano depend on where the rocks come from more than how the rock material was erupted? When a volcano erupts, rock material may either be exploded out or poured out.

Composition and mineral content depend on where the rocks came from, i.e., geography. Texture relates to the way they were erupted, which to some extent depends on composition. Color depends on composition and other factors like weathering.

3. Listed below are the complete chemical analyses (by percent) of two volcanic rocks that came from different volcanoes. Look at the information and tell which of the chemical compounds differs by the largest amount.

	Obsidian Cliff, Yellowstone National Park	*Basalt, Hawaiian Islands (average)*
SiO_2	75.50	49.58
Al_2O_3	13.25	13.19
Fe_2O_3	1.02	2.40
FeO	0.91	9.49
MgO	0.07	8.30
CaO	0.90	10.69
Na_2O	4.76	2.25
K_2O	2.85	0.55
H_2O+	0.41	-
TiO_2	-	3.17
P_2O_5	-	.26
	100.05	100.00

The SiO_2 differs between these two rocks by about 26 percent.

When the chemical composition of many volcanic rocks is studied, it is found that silicon dioxide (SiO_2) varies the most. The minerals in the rock, and many of the other things about volcanic rocks, can be related to the SiO_2 content.

For these reasons, one simple classification system for volcanic rocks is based on whether the rock has a high, medium or low amount of SiO_2. This classification system is given below. Examples are listed in parentheses.

High SiO_2 — more than 66 percent SiO_2 (rhyolite, obsidian, pumice)

Medium SiO_2 — between 66 percent and 52 percent SiO_2 (andesite)

Low SiO_2 — less than 52 percent SiO_2 (basalt)

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4. Table 2 gives the chemical compositions for the volcanoes listed in Table 1. On the Worksheet enlarge each volcano spot you plotted, with color, to show if it has a high, medium or low amount of SiO_2. So that everyone in the class can compare their maps, use these colors:

RED for high SiO_2 (more than 66 percent).

BLUE for medium SiO_2 (between 66 percent and 52 percent)

BLACK for low SiO_2 (less than 52 percent)

5. After coloring all of your locations, answer these questions:

See Answer Sheet.

a. Where are most of the red dots (high SiO_2) located?

Near the edge of the continent or inland.

b. Where are most of the blue dots (medium SiO_2) located?

Near the edge of the continent.

c. Where are most of the black dots (low SiO_2) located?

Most are in the Pacific Ocean, but some are on the continents.

6. Geologists have found that "low SiO_2" rocks underlie most of the oceans, and that most of the continents are made up of "high SiO_2." Why do you think the different kinds of volcanoes are located where they are? List the reasons. (Here is a hint: think about what happens at subduction zones.)

Ocean volcanoes are more uniform in composition because they can only originate by the melting of low SiO_2 rock of the ocean basins or the low SiO_2 rock from greater depths.

Volcanoes associated with subduction zones are varied for several reasons:

a. A greater variety of materials may be melted, such as ocean rock or sediments being carried down the subduction zone. High SiO_2 rocks related to the substructure of the continents may also be melted.

b. After rock has melted, it may be mixed with other materials as it moves upward. A low SiO_2 melt may reach the surface as low SiO_2 lava or it may be mixed with other material so that it is a medium SiO_2 or even a high SiO_2 lava by the time it reaches the surface.

All reasonable ideas by the students should be accepted and encouraged. Through a class discussion perhaps the whole concept can be fairly well developed by the students.

Table 2.
Chemical compositions

	SiO_2	Al_2O_3	$FeO+Fe_2O_3$	$MgO+CaO$	Na_2O+K_2O
Western United States, Pacific Border					
Lassen, California	57.3	18.3	6.2	12.7	11.0
Crater Lake, Oregon	55.1	18.0	7.1	13.2	4.5
Mt. Rainier, Washington	62.2	17.1	5.1	8.1	5.8
Mt. Baker, Washington	57.4	16.6	8.1	10.6	5.8
Western United States, Western Interior					
Yellowstone Park, Wyoming	75.5	13.3	1.9	1.0	7.6
Craters of the Moon, Idaho	51.5	14.0	15.2	8.8	5.9
San Francisco Peaks, Arizona	61.2	17.0	5.7	6.9	7.0
Central America and West Indies					
Paricutin, Mexico	55.1	19.0	7.3	11.9	4.9
Popocatepetl, Mexico	62.5	16.6	4.9	8.4	6.1
Mt. Pelee, Martinique	65.0	17.8	4.5	7.5	4.7
Santa Maria, Guatemala	59.4	19.9	5.9	7.0	5.1
Mt. Misery, St. Kitts	59.8	18.3	7.3	9.2	4.5
South America					
Cotopaxi, Ecuador	56.2	15.3	9.7	12.7	6.7
Misti, Peru	60.1	19.0	5.0	7.1	7.2
Alaska and Aleutian Islands Area					
Katmai, Alaska	76.9	12.2	1.4	0.9	7.3
Adak, Aleutians	60.0	17.0	6.9	10.4	4.8
Umnak Island, Aleutians	52.5	15.1	12.8	12.7	4.7
Kamchatka, USSR	60.6	16.4	7.9	8.9	5.0
Japan					
Fuji, Honshu	49.8	20 6	11.2	15.4	1.9
Izu-Hakone, Honshu	53.8	14.8	13.0	13.5	2.7
East-Indies					
Mayon, Philippines	53.1	20.0	8.2	13.1	4.2
Krakatoa	67.3	15.6	4.3	4.0	7.0
Karkar, New Guinea	60.1	16.4	9.6	10.4	2.6
Central Pacific					
Mauna Loa or Kilauea (average), Hawaii	49.6	13.2	11.9	19.0	2.8
Galapagos Islands	48.4	15.4	11.8	18.1	3.2
Mariana Islands	51 2	17.3	10.9	15.9	3.3
South Pacific					
White Island, New Zealand	62.2	14.3	6.0	9.8	4.9
Auckland, New Zealand	49.3	15.6	11.9	18.0	4.1
Tahiti (average)	44.3	14.3	12.4	19.6	5.1
Samoa (average of 5 flows)	48.4	13.3	12.3	15.9	5.0

SUMMARY QUESTIONS

1. How do volcanic rocks differ in composition?

Mainly in the amount of SiO_2 that they contain.

2. How is the composition of volcanic rocks related to their location on crustal plates?

Low silica volcanic rocks are found mostly well in the interior of ocean basin plates, medium silica rocks are at the edge of plates above subduction zones, and high silica rocks are located mostly in the continental parts of plates.

EXTENSION

Find the location of volcanoes in other parts of the world. Using the plate boundary map in Figure 1, tell whether each of those volcanoes should be high, medium or low in SiO_2.

Without chemical analysis reports you cannot be sure how the students are doing on this EXTENSION, but you can judge their methods, logic and probability of being correct for the places they choose.

HELPFUL BACKGROUND MATERIAL FOR CLASSROOM PRESENTATION

Films:

Heartbeat of a volcano **(20 min.), AGI-EBE, 425 N. Michigan Ave., Chicago, Ill. 60611**

Volcano: the birth of a mountain **(24 min.), AGI-EBE, 425 N. Michigan Ave., Chicago, Ill. 60611**

REFERENCES

Bullard, F.M., 1976, *Volcanoes of the earth.* Austin, University of Texas Press, 579 p.

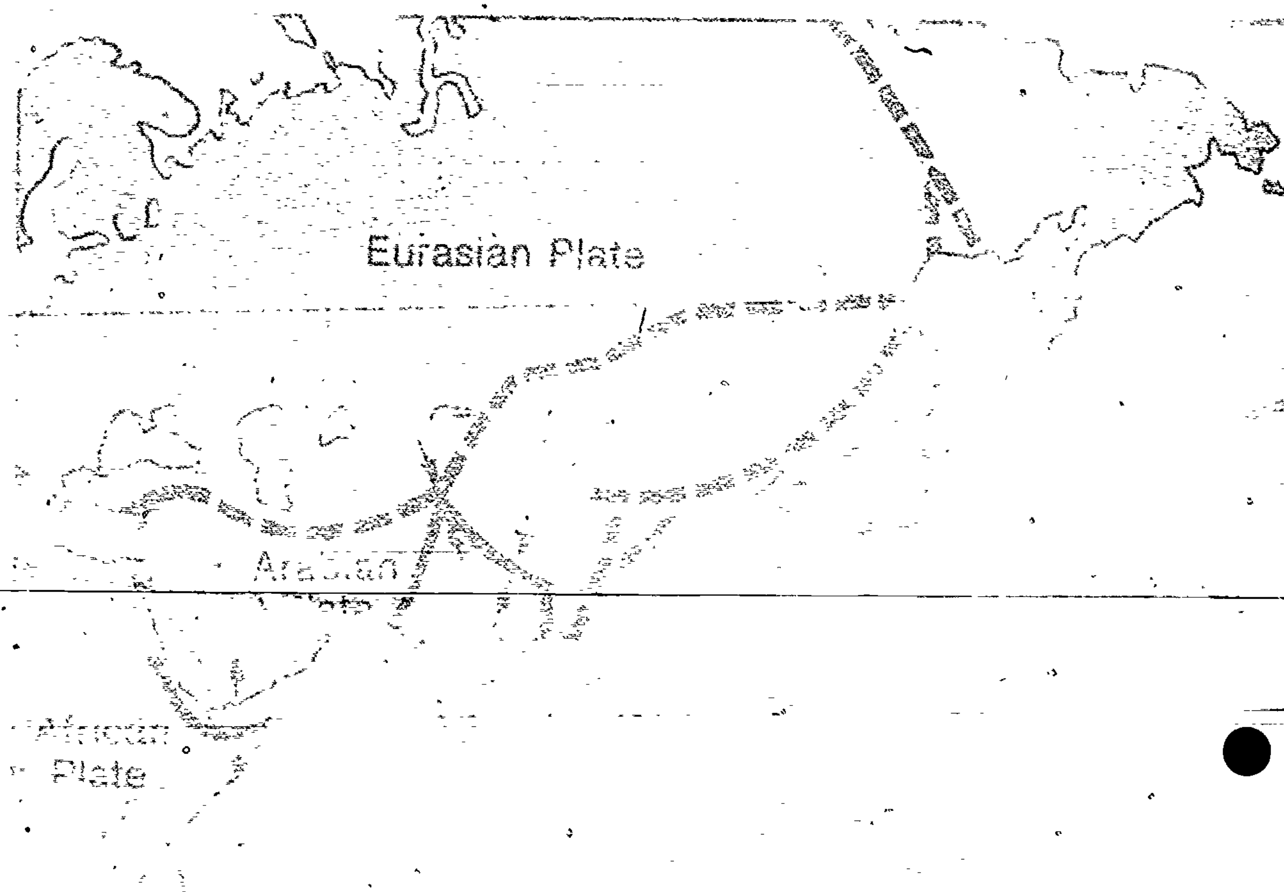
Grove, N., 1977, Vestmannaeyjar, up from the ashes. *National Geographic,* v. 151, no. 5 (May), p. 691-701.

Hamilton, W., 1976, Plate tectonics and man, in *Geological Survey Annual Report, Fiscal Year 1976.* Washington, U.S. Government Printing Office, p. 39-57.

NAGT Crustal Evolution Education Project Modules

CEEP Modules are listed here in alphabetical order. Each Module is designed for use in the number of class periods indicated. For suggested sequences of CEEP Modules to cover specific topics and for correlation of CEEP Modules to standard earth science textbooks, consult Ward's descriptive literature on CEEP. The Catalog Numbers shown here refer to the CLASS PACK of each Module consisting of a Teacher's Guide and 30 copies of the Student Investigation. See Ward's descriptive literature for alternate order quantities.

CEEP Module	Class Period	CLASS PACK Catalog No.
• A Sea-floor Mystery: Mapping Polarity Reversals	3	34 W 1201
• Continents And Ocean Basins: Floaters And Sinkers	3-5	34 W 1202
• Crustal Movement: A Major Force In Evolution	2-3	34 W 1203
• Deep Sea Trenches And Radioactive Waste	1	34 W 1204
• Drifting Continents And Magnetic Fields	3	34 W 1205
• Drifting Continents And Wandering Poles	4	34 W 1206
• Earthquakes And Plate Boundaries	2	34 W 1207
• Fossils As Clues To Ancient Continents	2-3	34 W 1208
• Hot Spots In The Earth's Crust	3	34 W 1209
• How Do Continents Split Apart?	2	34 W 1210
• How Do Scientists Decide Which Is The Better Theory?	2	34 W 1211
• How Does Heat Flow Vary In The Ocean Floor?	2	34 W 1212
• How Fast Is The Ocean Floor Moving?	2	34 W 1213
• Iceland: The Case Of The Splitting Personality	3	34 W 1214
• Imaginary Continents: A Geological Puzzle	2	34 W 1215
• Introduction To Lithospheric Plate Boundaries	1-2	34 W 1216
• Lithospheric Plates And Ocean Basin Topography	2	34 W 1217
• Locating Active Plate Boundaries By Earthquake Data	2-3	34 W 1218
• Measuring Continental Drift: The Laser Ranging Experiment	2	34 W 1219
• Microfossils, Sediments And Sea-floor Spreading	4	34 W 1220
• Movement Of The Pacific Ocean Floor	2	34 W 1221
• Plate Boundaries And Earthquake Predictions	2	34 W 1222
• Plotting The Shape Of The Ocean Floor	2-3	34 W 1223
• Quake Estate (board game)	3	34 W 1224
• Spreading Sea Floors And Fractured Ridges	2	34 W 1225
• The Rise And Fall Of The Bering Land Bridge	2	34 W 1227
• Tropics In Antarctica?	2	34 W 1228
• Volcanoes: Where And Why?	2	34 W 1229
• What Happens When Continents Collide?	2	34 W 1230
• When A Piece Of A Continent Breaks Off	2	34 W 1231
• Which Way Is North?	3	34 W 1232
• Why Does Sea Level Change?	2-3	34 W 1233



WARD'S
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CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

Student Investigation

Catalog No. 34W1129

Volcanoes: Where And Why?

INTRODUCTION

Geologists group volcanoes by the different kinds of rocks they produce. Some ways in which volcanic rocks differ are in color, texture (size of crystals), mineral composition and chemical composition. Let's look at volcanoes and their rocks in one of these ways.

OBJECTIVES

After you have completed these activities, you should be able to:

1. Tell one way in which volcanoes differ, and use this difference to classify them into certain groups.
2. Explain why groups of volcanoes are different.
3. Show on a map where groups of volcanoes of different kinds are located.

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PROCEDURE

PART A: Where are most volcanoes located?

Materials: black pencil

1. Write down the names of all the volcanoes you can think of that are in or around the Pacific Ocean.

2. Compare your list with the rest of the class.

3. Table 1 lists the locations of 30 volcanoes. You or others in your class may have named some of these. Plot the location of all the volcanoes in Table 1 on the map on the Worksheet. (Use latitude and longitude to find the places.) Write the name of the volcano next to each location.

4. Where are most of these volcanoes located?

Table 1.
Locations of volcanoes

	Latitude (approximate)	Longitude (approximate)
Western United States, Pacific Border		
Lassen, California	40°N	121°W
Crater Lake, Oregon	43°N	122°W
Mt. Rainier, Washington	47°N	122°W
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San Francisco Peaks, Arizona	35°N	112°W
Central America and West Indies		
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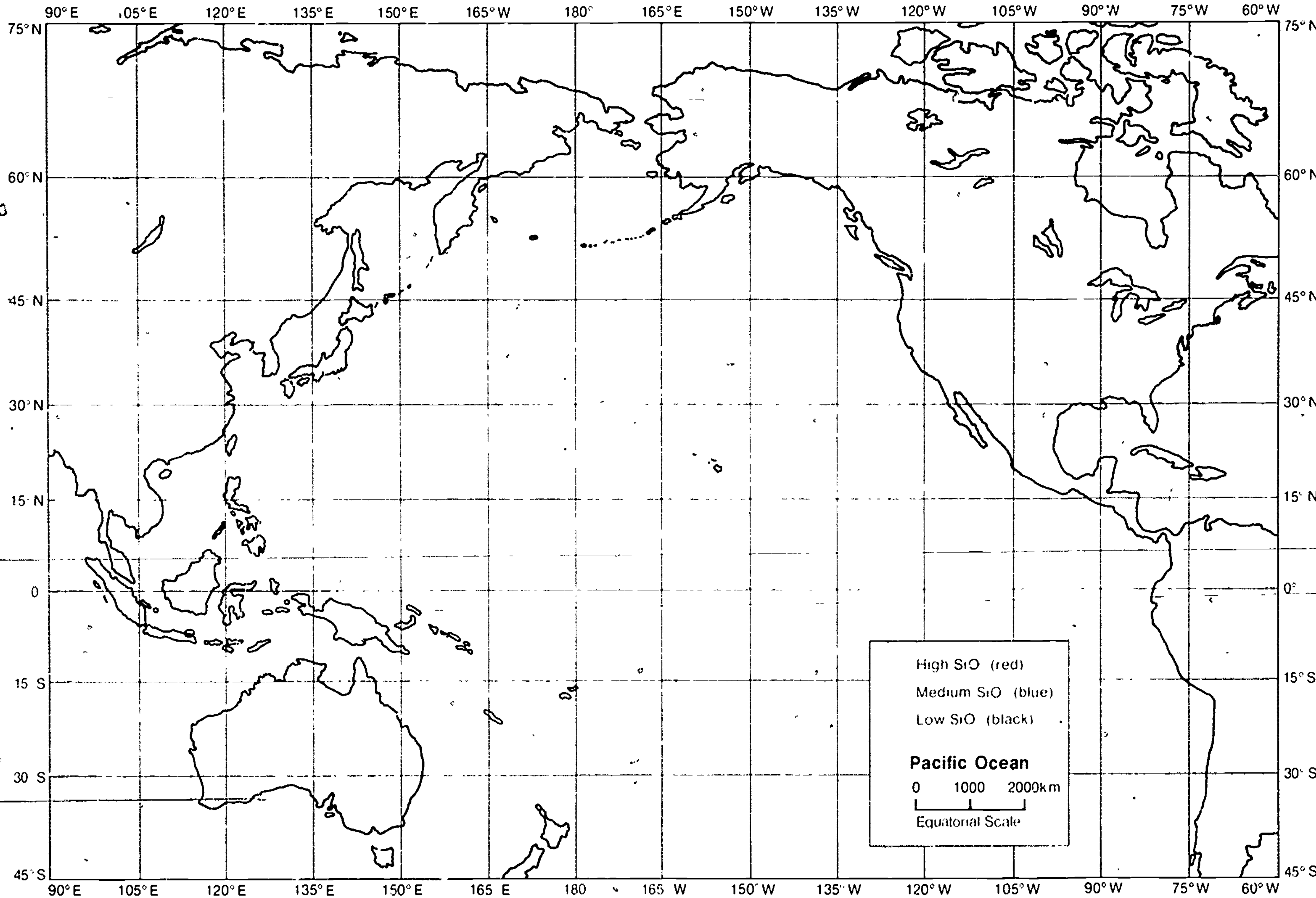
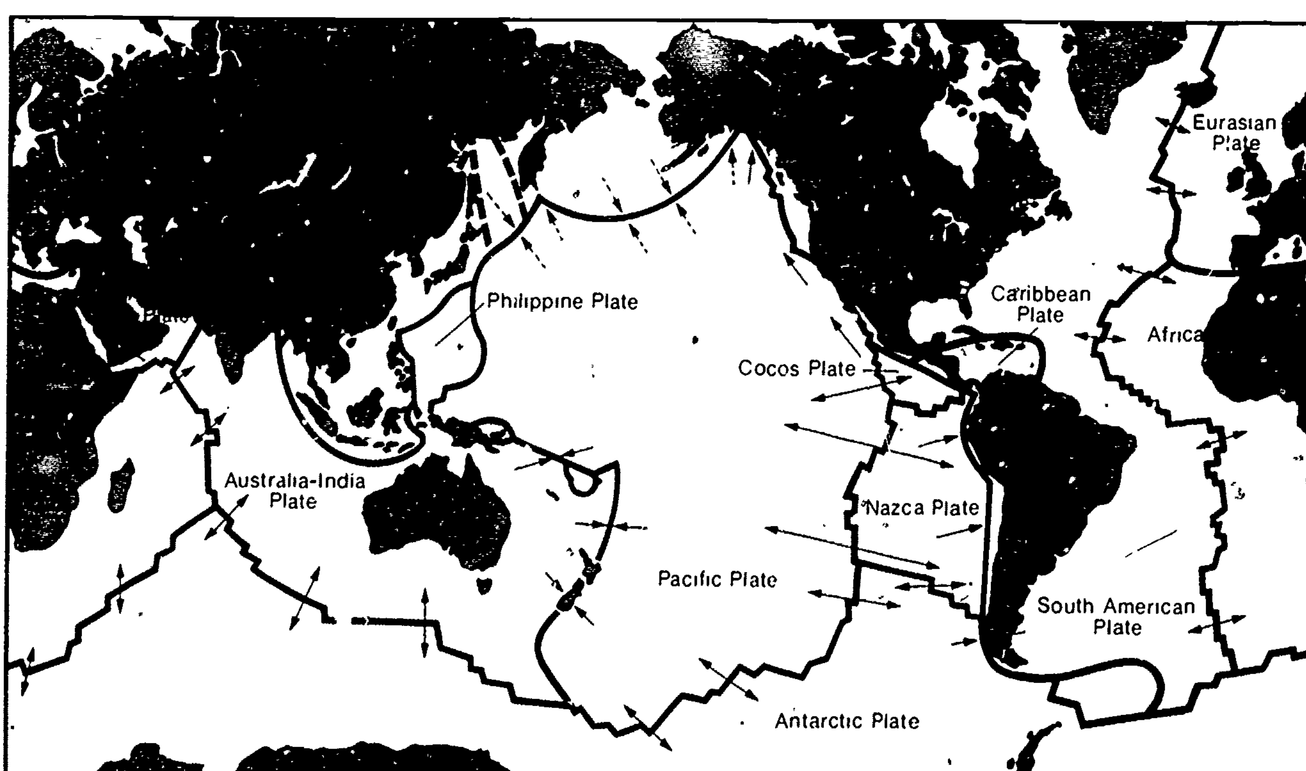
Popocatepetl, Mexico	19°N	98°W
Mt. Pelee, Martinique	15°N	61°W
Santa Maria, Guatemala	15°N	92°W
Mt. Misery, St. Kitts	17°N	63°W
South America		
Cotopaxi, Ecuador	1°S	78°W
Misti, Peru	16°S	71°W
Alaska and Aleutian Islands Area		
Katmai, Alaska	58°N	155°W
Adak, Aleutians	52°N	177°W
Umnak Island, Aleutians	53°N	169°W
Kamchatka, USSR	57°N	160°E
Japan		
Fuji, Honshu	35°N	139°E
Izu-Hakone, Honshu	35°N	139°E
East Indies		
Mayon, Philippines	13°N	124°E
Krakatoa (between Java & Sumatra)	6°S	105°E
Karkar, New Guinea	5°S	146°E
Central Pacific		
Mauna Loa or Kilauea, Hawaii	19°N	156°W
Galapagos Islands	1°S	91°W
Mariana Islands	16°N	145°E
South Pacific		
White Island, New Zealand	37°S	177°E
Auckland, New Zealand	38°S	176°E
Tahiti	18°S	149°W
Samoa	13°S	172°W



Worksheet (PARTS A and B)

5. Look at the map of crustal plates in Figure 1. Where on the plates are most of these volcanoes located?

6. How can you explain this?



gure 1. Map of crustal plates. Arrows indicate direction of plate movement.

PROCEDURE

PART B: What makes volcanic rocks different from each other?

Materials: Three pencils (red, black, and blue).

1. List all the ways in which you think volcanic rocks can be different from each other.

2. From your list and the lists of other students, which characteristics of a volcano depend on where the rocks come from more than how the rock material was erupted? When a volcano erupts, rock material may either be exploded out or poured out.

3. Listed below are the complete chemical analyses (by percent) of two volcanic rocks that came from different volcanoes. Look at the information and tell which of the chemical compounds differs by the largest amount.

	Obsidian Cliff, Yellowstone National Park	*Basalt, Hawaiian Islands (average)*
SiO_2	75.50	49.58
Al_2O_3	13.25	13.19
Fe_2O_3	1.02	2.40
FeO	0.91	9.49
MgO	0.07	8.30
CaO	0.90	10.69
Na_2O	4.76	2.25
K_2O	2.85	0.55
H_2O+	0.41	-
TiO_2	-	3.17
P_2O_5	-	.26
	100.05	100.00

When the chemical composition of many volcanic rocks is studied, it is found that silicon dioxide (SiO_2) varies the most. The minerals in the rock, and many of the other things about volcanic rocks, can be related to the SiO_2 content.

For these reasons, one simple classification system for volcanic rocks is based on whether the rock has a high, medium or low amount of SiO_2. This classification system is given below. Examples are listed in parentheses.

High SiO_2 — more than 66 percent SiO_2 (rhyolite, obsidian, pumice)

Medium SiO_2 — between 66 percent and 52 percent SiO_2 (andesite)

Low SiO_2 — less than 52 percent SiO_2 (basalt)

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4. Table 2 gives the chemical compositions for the volcanoes listed in Table 1. On the Worksheet enlarge each volcano spot you plotted, with color, to show if it has a high, medium or low amount of SiO_2. So that everyone in the class can compare their maps, use these colors:

RED for high SiO_2 (more than 66 percent)

BLUE for medium SiO_2 (between 66 percent and 52 percent)

BLACK for low SiO_2 (less than 52 percent)

5. After coloring all of your locations, answer these questions:

a. Where are most of the red dots (high SiO_2) located?

b. Where are most of the blue dots (medium SiO_2) located?

c. Where are most of the black dots (low SiO_2) located?

6. Geologists have found that "low SiO_2" rocks underlie most of the oceans, and that most of the continents are made up of "high SiO_2." Why do you think the different kinds of volcanoes are located where they are? List the reasons. (Here is a hint: think about what happens at subduction zones.)

Table 2.
Chemical compositions

	SiO_2	Al_2O_3	$FeO+$ Fe_2O_3	$MgO+$ CaO	Na_2O+ K_2O
Western United States, Pacific Border					
Lassen, California	57.3	18.3	6.2	12.7	11.0
Crater Lake, Oregon	55.1	18.0	7.1	13.2	4.5
Mt. Rainier, Washington	62.2	17.1	5.1	8.1	5.8
Mt. Baker, Washington	57.4	16.6	8.1	10.6	5.8
Western United States, Western Interior					
Yellowstone Park, Wyoming	75.5	13.3	1.9	1.0	7.6
Craters of the Moon, Idaho	51.5	14.0	15.2	8.8	5.9
San Francisco Peaks, Arizona	61.2	17.0	5.7	6.9	7.0
Central America and West Indies					
Paricutin, Mexico	55.1	19.0	7.3	11.9	4.9
Popocatepetl, Mexico	62.5	16.6	4.9	8.4	6.1
Mt. Pelee, Martinique	65.0	17.8	4.5	7.5	4.7
Santa Maria, Guatemala	59.4	19.9	5.9	7.0	5.1
Mt. Misery, St. Kitts	59.8	18.3	7.3	9.2	4.5
South America					
Cotopaxi, Ecuador	56.2	15.3	9.7	12.7	6.7
Misti, Peru	60.1	19.0	5.0	7.1	7.2
Alaska and Aleutian Islands Area					
Katmai, Alaska	76.9	12.2	1.4	0.9	7.3
Adak, Aleutians	60.0	17.0	6.9	10.4	4.8
Umnak Island, Aleutians	52.5	15.1	12.8	12.7	4.7
Kamchatka, USSR	60.6	16.4	7.9	8.9	5.0
Japan					
Fuji, Honshu	49.8	20.6	11.2	15.4	1.9
Izu-Hakone, Honshu	53.8	14.8	13.0	13.5	2.7
East Indies					
Mayon, Philippines	53.1	20.0	8.2	13.1	4.2
Krakatoa	67.3	15.6	4.3	4.0	7.0
Karkar, New Guinea	60.1	16.4	9.6	10.4	2.6
Central Pacific					
Mauna Loa or Kilauea (average), Hawaii	49.6	13.2	11.9	19.0	2.8
Galapagos Islands	48.4	15.4	11.8	18.1	3.2
Mariana Islands	51.2	17.3	10.9	15.9	3.3
South Pacific					
White Island, New Zealand	62.2	14.3	6.0	9.8	4.9
Auckland, New Zealand	49.3	15.6	11.9	18.0	4.1
Tahiti (average)	44.3	14.3	12.4	19.6	5.1
Samoa (average of 5 flows)	48.4	13.3	12.3	15.9	5.0

SUMMARY QUESTIONS

1. How do volcanic rocks differ in composition?

2. How is the composition of volcanic rocks related to their location on crustal plates?

EXTENSION

Find the location of volcanoes in other parts of the world. Using the plate boundary map in Figure 1, tell whether each of those volcanoes should be high, medium or low in SiO_2.

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