1999

Teachers' resource guide to the geology of Alum Rock Park

Carolyn H. Flanagan
San Jose State University

TEACHERS' RESOURCE GUIDE
TO THE GEOLOGY OF ALUM ROCK PARK

A Project

Presented to

The Faculty of Interdisciplinary Studies

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

By

Carolyn H. Flanagan

December, 1999

UMI Number: 1397722

Bell & Howell Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

APPROVED FOR INTERDISCIPLINARY STUDIES

Dr. Ellen Metzger

Dr. Leon Dorosz

Dr. Sharon Parsons

APPROVED FOR THE UNIVERSITY

ABSTRACT

TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK

by Carolyn H. Flanagan

This project developed resources for elementary and middle school teachers to utilize in leading geology field trips to Alum Rock Park in San Jose, California. The guide is divided into four independent modules: Geologic Characteristics of Penitencia Creek, Mineral Springs, Water Quality of Penitencia Creek, Rocks of Alum Rock Park. Each module consists of background information, preparatory classroom lessons with student worksheets, and a field trip plan accompanied by student data sheets, trip maps, and charts.

Additionally, the guide contains an introduction to the geologic history of the Earth and of the Alum Rock Park area. A schematic stratigraphic column depicting the general relationships of rock units found in the park is included. Auxiliary features provide a chart correlating the lessons with the National Science Education Standards (1996) and the California Science Content Standards (1998), as well as, an annotated list of additional resources and an extensive glossary.

ACKNOWLEDGMENTS

This project would not have been completed without the help and support of a number of people. The first group I would like to thank are my San Jose State University professors. I am grateful to the late Dr. Joseph Young and his wife, Edy, for first encouraging me to pursue a master's degree. Dr. Deborah Harden's book, *California Geology* was indispensable to me in writing the background section of this project. Thanks also goes to Dr. Harden for taking time to discuss ideas about the origin of various California rock formations. I am grateful to Dr. Richard Sedlock for accompaning me to Alum Rock Park to look at the supposed "Alum Rock Fault" and for advising me on the various ideas about the Hayward fault. Dr. June Oberdorfer kindly worked on site with me testing the water quality of the mineral springs. Dr. Patricia Grilione helped me examine my samples of microbial life from the mineral springs and provided information about them which was extremely useful to me in my project work. Thanks to Stan Vaughn, curator of the entymology collection for confirming my identifications of park insects. I appreciate Dr. Leon Dorosz and Dr. Sharon Parsons for taking their time to serve on my committee. I would particularly like to thank my advisor, Dr. Ellen Metzger, who provided inspiration, expertise, insight, encouragement, editorial help, a great deal of time, friendship, and almost endless patience.

I am grateful to a number of geologists from the United States Geologic Survey who were willing to discuss the Alum Rock Park area with no advance notice. Particular thanks are due to Dr. Russell Graymer and Dr. James J. Lienkaemper with whom I discussed possible faults in Alum Rock Park and the stratigraphy of the area and to Dr. Earl Brabb who provided information about landslides.

I would like to thank geologist, John M. Coyle, who met with me at Alum Rock Park to share his ideas and whose thesis, *Bedrock and Surficial Geology of the San Jose - Milpitas Foothills Area, Santa Clara County, California*, was invaluable to me in my work.

Alum Rock Park personnel were always interested in my project and willing to share their information and archives with me. Thanks goes to Youth Science Institute staff, Bonnie Spacek, Sue Van Stee, and Suzanne Lowd for their insights and to Sue and Suzanne for spending time at the park helping with the field trip plans. Additionally, I appreciate Suzanne's help with researching the park history. Without the aid of the park facility supervisors, Todd Capurso and Mike Will, I would not have had access to the park when it was closed to the public for many months because of water-related road damage. All the rangers I dealt with were helpful; Pam Helmke and Joe Van Sambeeck, in particular, provided useful information.

I am grateful to the following individuals and organizations that kindly allowed me to use their graphics: Tamara R. Sayre for both her previously published invertebrate drawings and particularly for providing three additional illustrations specifically for this work; *California Geology* magazine for the map of the San Francisco Bay Area faults; the San Jose Historical Museum for the photo of the "Alum Rock Meteorite".

Thanks goes to all the people who tried to assist me with my frustrating computer problems: Mike Bachman, Kim Brown, Steven Buckley, Larry Hayes, Dayle Moore, and Gus Misherghi.

The staff of the Hacienda Environmental Science Magnet Elementary School, where I teach, was very supportive during this time. I particularly want to thank Marcus Clark, Joseph Demers, and Connie Pranger who picked up all the pieces I couldn't hold while working on this project.

Thanks to my friends who are still my friends even though I have not been available for a long time.

Thanks especially to my long-suffering family, who had to do without much attention for several years (not a decade, Sean). My most grateful thanks go to my husband Daniel, who drew many of the computer graphics, but more importantly provided love, support, and encouragement.

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PURPOSE

As emphasized by the *National Science Education Standards*, "Learning science is something students do, not something that is done to them." (National Research Council, 1996, p. 2; emphasis mine). When hands-on and minds-on experiences are combined, students have the greatest opportunity to construct for themselves understandings of ideas, to discover the relationships between ideas and to develop the ability to apply these ideas to other events and phenomena. *Teachers' Resource Guide to the Geology of Alum Rock Park* is designed to further this philosophy. It provides elementary and middle school teachers with the means to lead significant, activity-based, hands-on geology field trips to Alum Rock Park in San Jose, California. The guide consists of field activities, preparatory classroom lessons, and teacher background information, as well as a chart (Appendix A) correlating the lessons with the *National Science Education Standards*, the *California Science Content Standards--Grades K-12*, and the *Science Framework for California Public Schools, Kindergarten Through Grade Twelve.*

HOW TO USE THIS GUIDE

"Teachers' Resource Guide to the Geology of Alum Rock Park" is a unit of study for teachers and their upper elementary and middle school students. The guide uses simulated geological events experienced in the classroom to connect with field experiences in San Jose, California's geologic treasure, Alum Rock Park (see maps in Appendices B and C). Emphasis is on guiding the students to make careful observations of events, so that they may draw their own conclusions about what occurred (although possible outcomes are suggested to the teacher). The classroom experiences will lead to more in-depth observations and understandings of what is seen at the park.

The main feature of the resource book is four modules, each dealing with a different aspect of the park's geology. The non-sequential modules are designed to stand alone, thereby necessitating repetition of some material among them. Within each module, the teacher will find these three sections: 1) background information, 2) classroom activities, and 3) a field trip plan.

1) The extensive background information is designed to give the teacher specific information about the topic being emphasized as well as geologic, historical, biological, and geographical background about the park. Also included are detailed descriptions of the trip and pre-trip preparations, including a list of materials to take on the trip. This information is presented at the beginning of the module to allow the teacher time to make advance arrangements, to obtain supplies, and to have a complete picture of where the module is leading.

2) The second section is comprised of classroom activities designed to give students the necessary background to prepare them for a successful field trip

experience. Student worksheets are provided with many of the lessons. Notes to the teacher summarize pertinent concepts and relate what has been simulated in the classroom lessons to what can be seen at Alum Rock Park.

3) Section three is the field trip plan. It contains information on safety, lunch stops, bathroom facilities, and distances, as well as specific activities for each stop on the trip. Also provided are questions and possible answers for the teacher and recording worksheets for the students. The data-gathering modules contain recording sheets and suggested topics for discussion of the data.

Features which will facilitate use of the modules include:

- Boldface type for words defined in the glossary, the first time they appear in each section of each module.
- Italic type in the teacher sections for questions that are on the student worksheets.
- Abbreviated vendor names and catalog numbers for specialized science supplies on the materials lists for each lesson. The full vendor names and phone numbers are given in Appendix E. The listing of a particular vendor in no way implies a recommendation for that company, but is evidence that the vendor is familiar to the author; information is provided for the convenience of the user. Many materials are available locally in supermarkets, pharmacies, and hardware stores.
- Measurements are generally given using the metric system. Distances between many field stops are in meters. A trundle wheel would prove helpful here.

In addition to the four teaching modules, this guide features brief summaries of the geologic histories of the Earth and of the Alum Rock area. At the back of the guide, the teacher will find additional information in "Frequently Asked Questions About the Geololgy of Alum Rock Park" (Appendix D), a glossary, and extensive lists of references and resources (Appendix F).

INTRODUCTION

A mystery is something that is not known or understood. The geologic history of the Earth has been a mystery to people for several reasons: 1) the Earth is thought to be 4.5 billion years old, while people have only been on Earth for 2 to 3 million years, so there are people-produced records of what has happened in the past on Earth for only a relatively short time; 2) most geologic events (except for sudden occurrences such as floods, earthquakes, and volcanic eruptions) are not observed because they take millions of years to effect changes--the uplifting of rocks to form mountains, the erosion of mountains to produce sediments, the movement of plates (which on the average move at about the rate that fingernails grow); and 3) many geologic processes and the results of those processes are hidden from our view because they occur deep within the Earth, under the oceans, or are covered by the surface rocks and sediments.

But as in the case of most mysteries, clues to what has happened and is continuing to happen are left behind. Just as criminologists put clues together to solve criminal mysteries, geologists have learned to read the clues left in rocks and put them together to solve parts of the mystery of Earth's history. Much remains for the "detective geologists" of the future to discover, particularly in the Coast Range area of California and especially here in the Alum Rock Park region.

GEOLOGIC HISTORY OF THE EARTH

Part I: Earth Layers

Advances in technology have enabled scientists to use indirect evidence to learn more about what was previously unknown. This is important because it is not always possible for those seeking information to be in the exact place at the right time to witness events or in some cases to ever reach the unknown place. In the late 1800's, the technology to locate, preserve and match fingerprints to individuals enabled criminologists to identify those present at a crime scene, even after they were no longer there (The World Book Encyclopedia, "Fingerprinting" 1983). The understanding of x-rays led to the development in the 1890's of the fluoroscope, a machine which made it possible for physicians to look inside the body to see the outline of the patient's bones and the body organs in operation (World Book Encyclopedia, "X-rays" 1983). In the early 1900's the technological development of sensitive instruments enabled geologists to measure how the velocity of **seismic** (earthquake) waves changes as the waves pass through the Earth (Tarbuck and Lutgens, 1988).

The velocity of seismic waves is calculated by measuring the time it takes a wave to travel from the **focus** of an earthquake to a seismic station. When there is a difference in the travel time that cannot be accounted for by the distance the wave traveled, it must be caused by a change in the rock material the wave is moving through. Using this indirect seismic evidence, geologists have learned about the nature of the unseen layers inside the Earth (Fig. 1). What they have discovered follows:

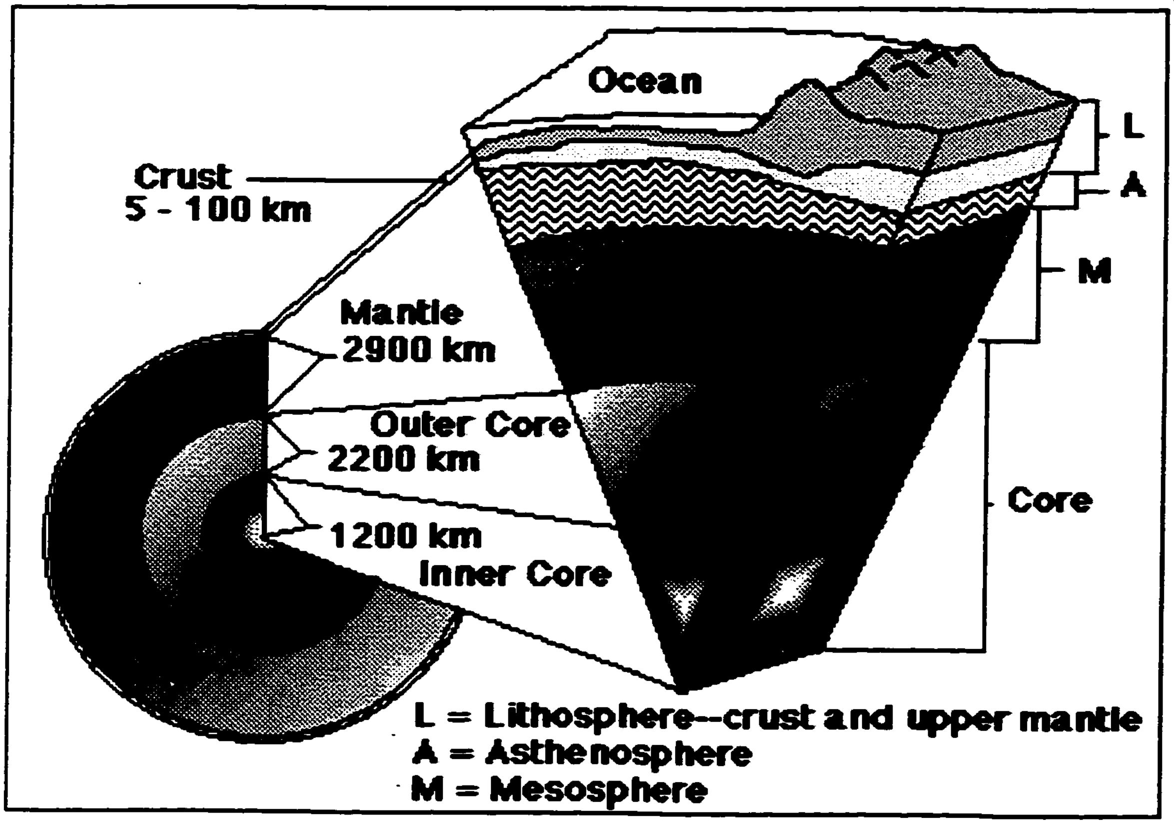

Figure 1. Cutaway views of the Earth's interior layers. (Source: Kious and Tilling, 1996.)

Crust: This thin outermost layer is like the skin on apple "Earth". There are two kinds of crust--thick (up to 100 km), less dense continental crust made of granite-like rocks, and thinner (about 5 km), more dense, basaltic ocean crust.

Mantle: Overall the mantle is about 2,900 km thick. This hot dense layer corresponding to the edible part of the apple is made up of several zones. The top zone of the mantle, cooler and somewhat rigid, combines with the overlying crust to form the **lithosphere**. The **asthenosphere**, also considered part of the upper mantle but just below the lithosphere, is less dense and behaves in a plastic fashion due to heat and a small percentage of melted material. It is thought that the lithosphere, which is broken into plates, moves about on the asthenosphere. Below them is the **mesosphere**, a zone of even higher temperature than the asthenosphere, composed of rocks made denser by the greater compression at greater depth (Skinner and Porter, 1989).

Core: Unlike the apple core, Earth's core is extremely dense (almost twice as dense as the mantle) and is made up of two parts. The 2,200 km-thick, molten outer section is thought to be responsible for the Earth's magnetic field. The 1,200 km-thick (radius) inner section is solid. Both are composed of iron and nickel (Kious and Tilling, 1996).

Part II: Plate Tectonics

Just as the use of technology led to greater knowledge about Earth's layers, increased use of other technologies as well as the development of new devices in the 1940's, 1950's and 1960's, permitted scientists to understand how these layers are related to each other and how they move. The following information in this remarkable story is summarized from *This Dynamic Earth* by Kious and Tilling (1996). Expanded data collection using sonar and deep-diving submersible vehicles like *Alvin* resulted in more detailed mapping of the ocean floor. A submarine chain of mountains was discovered in the central Atlantic Ocean (later called the Mid-Atlantic Ridge). Other submarine mid-ocean ridges were found nearly encircling the globe.

Using **magnetometers** (instruments that measure magnetism) developed during World War II to detect submarines, scientists learned that the magnetic alignment of rocks on either side of these ridges was arranged in alternating bands of **normal** and **reverse polarity** (Fig. 2). The term normal polarity refers to the magnetic orientation of rocks that formed when the Earth's magnetic field was aligned as it is at present; reverse polarity refers to rocks that cooled when the north and south magnetic poles were reversed. When magma reaches the earth's surface and becomes solid rock, it records the polarity of the Earth at that time. Throughout Earth's history its magnetic field has periodically reversed polarity.

The development by the petroleum industry of special drilling equipment led to the collection of ocean floor drill-core samples, which when dated showed that young crust was located near the ridges, while progressively older crust occurred on either side. All of this evidence supported the idea that new ocean crust is being created by melting of mantle material that rises to the surface at the mid-ocean ridges. The magnetically reversed and progressively older "stripes" are the result of the new ocean floor rising and spliting the previous deposit in two. Because the crust on either side of the ridge is moving away from it, the ridge is called a **spreading center** or a **divergent plate boundary** (Fig. 2).

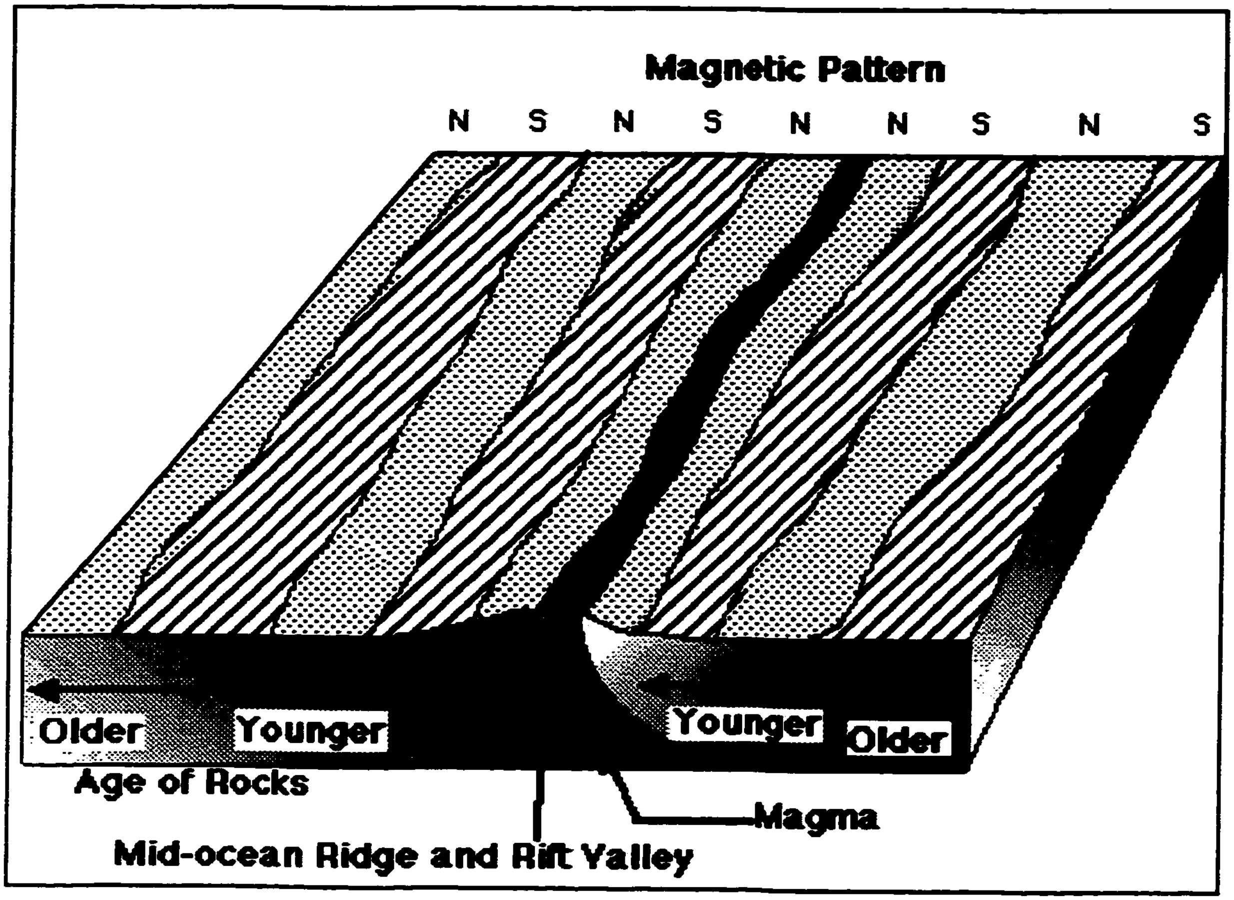

Figure 2. Divergent plate boundary or spreading center.

Because the Earth's surface is a finite size, if new crust is being formed, then older crust must be being destroyed. Scientists discovered that this is happening at plate boundaries where converging plates meet. The heavier of the plates sinks under the lighter plate in a process called **subduction**, and its material becomes part of the mantle once more (Fig. 3). The movement from ridge to trench is like a conveyer belt carrying crust to be recycled in the mantle below. If both converging plates are made of buoyant continental lithosphere, neither plate subducts. The continental plates are folded and faulted and pushed up into mountain ranges, such as the Himalayas, the Appalachians, the Urals, and the Alps (Fig. 4).

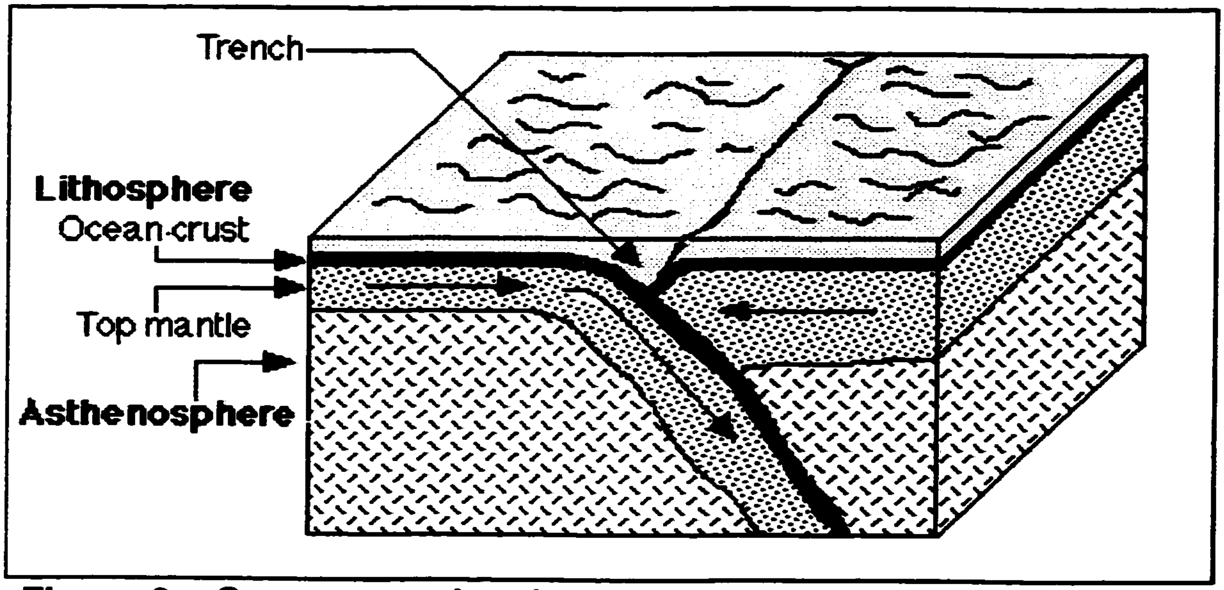

Figure 3. Convergent plate boundary or subduction zone. (Modified from Kious and Tilling, 1996.)

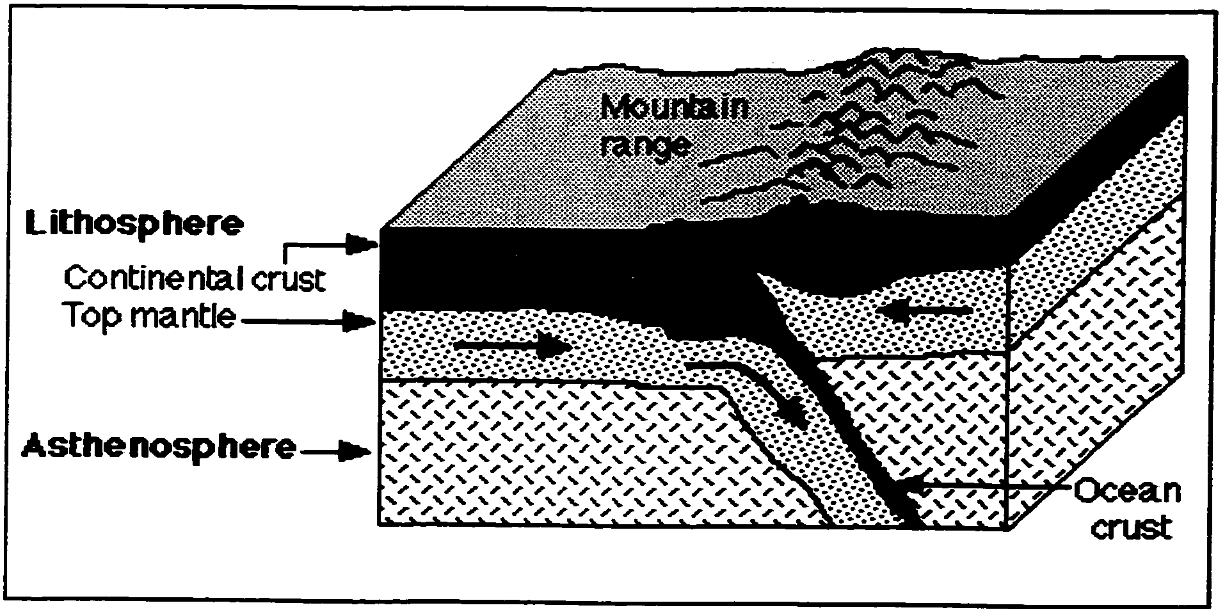

Figure 4. Convergent continental plate boundary. (Modified from Kious and Tilling, 1996.)

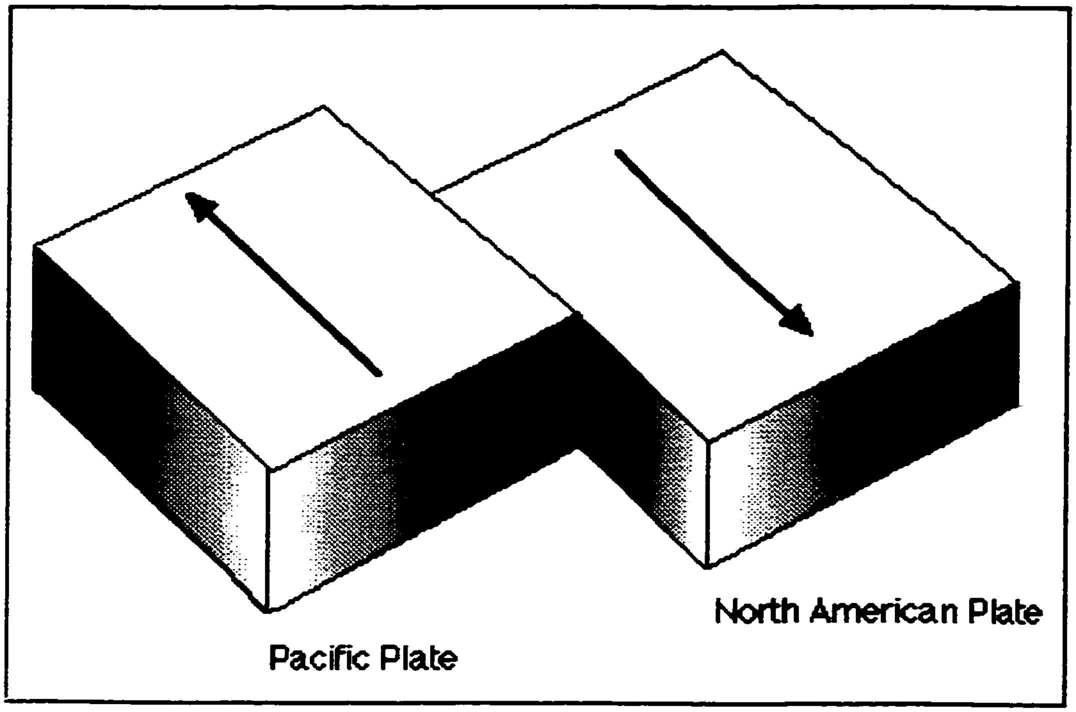

Figure 5. The San Andrea fault, a famous transform boundary.

In addition to **convergent** and divergent **plate boundaries** there is a third kind of boundary where the plates just slide past each other without producing or destroying crust. This is called a **transform** boundary because the relative motion of the plates can be changed or transformed along it. Probably the most famous transform plate boundary is the San Andreas fault system where the Pacific Plate and North American Plates meet (Fig.5).

The lithospheric plates have, since their formation, been on quite a ride! If people could have witnessed plate movements through Earth's history, they would have seen all the continents join together in one super landmass and then break apart into a number of separate plates. Both these events happened more than once. In the future the configuration will change again.

Plate tectonics tells us how the lithospheric plates move. Why they move is not fully known. It is thought that slow convection currents in the mantle relate to the plate movements. Differences in density, caused perhaps by differences in the temperature in various parts of the mantle or perhaps by different mantle materials, could lead to convection currents in the mantle, but this mechanism is not fully understood (Moores, 1996). Maybe new technologies of the future will help people solve this remaining mystery.

BRIEF GEOLOGIC HISTORY OF THE ALUM ROCK PARK AREA

PART I: PLATE TECTONIC HISTORY

Rumors were rampant in the 1970's that California was going to fall off of North America into the Pacific Ocean. How ironic that the opposite is true. The western boundary of the ancient North American Plate was once in Nevada and much of California has, in fact, been "stuck onto" North America. This did not happen in one simple addition, but in many pieces from many places over a long period of time. Just how this occurred and where these pieces (known as **terranes**) came from are the subjects of current geologic debate.

At least 200 million years ago, subduction zones began forming along the western edge of North America (Sedlock et al., 1993). Eastwardly moving plates subducting under the North American Plate were partially melted and the magma produced, being less dense than the surrounding mantle, rose to form a volcanic arc of mountains, the ancestral Sierra Nevada (Fig. 1).

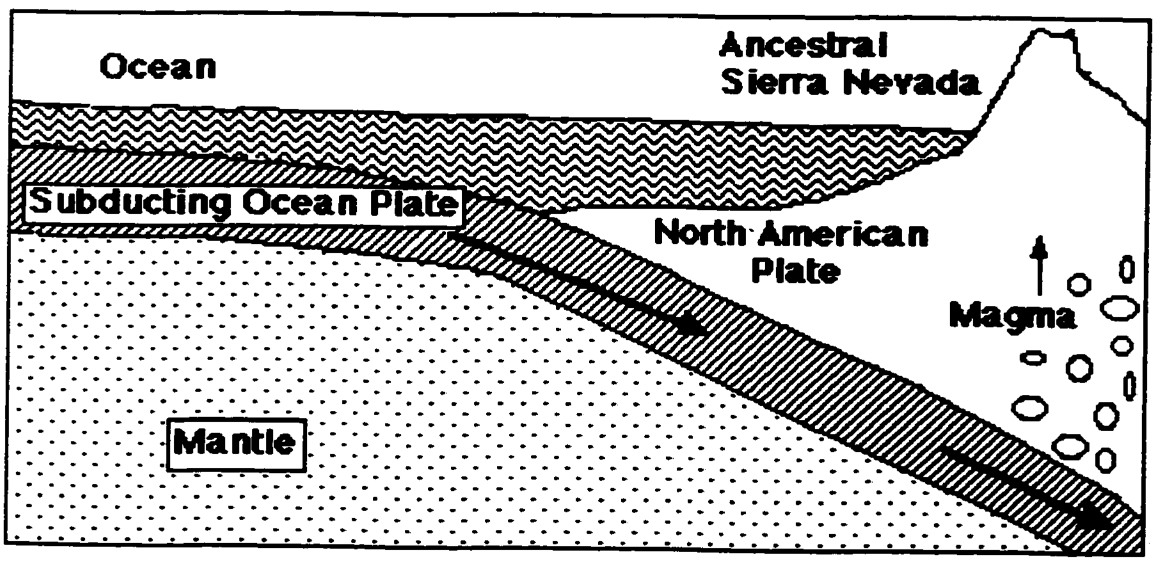

Figure 1. Formation of the ancestral Sierra Nevada.

By 140 million years ago at the end of the **Jurassic** period when *Tyrannosaurus rex* was the dominant predator, the **Farallon Plate** was being subducted under the North American Plate (Harden, 1998). As it moved under the continent, ocean crust from this plate along with sediments deposited on it were scraped off and stuck (**accreted**) to the western edge of the North American Plate. These are the rocks of the present day Coast Ranges (Fig. 2).

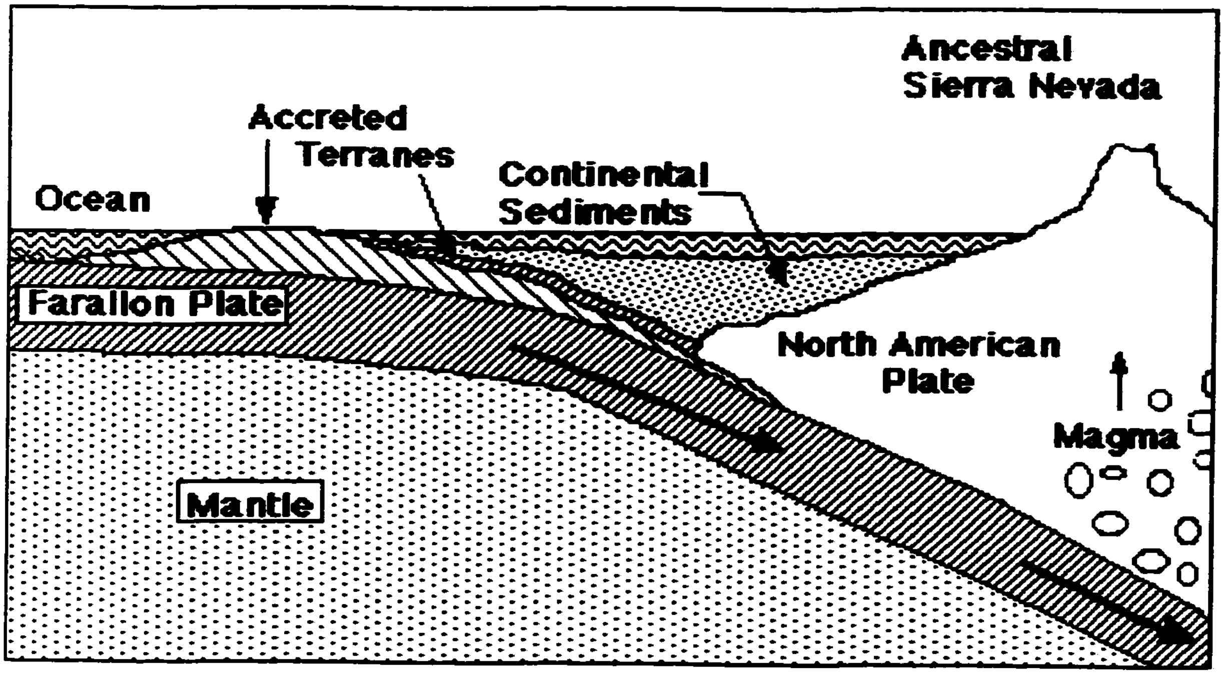

Figure 2. Sources of present day rocks of the Coast Ranges.

By about 28 million years ago, most of the Farallon Plate had been completely subducted, and the Pacific Plate met the North American Plate (Harden, 1998). This boundary, now known as the San Andreas fault zone, became a transform boundary as the Pacific Plate began to slide past the North American Plate in a northwesterly direction (Fig. 3).

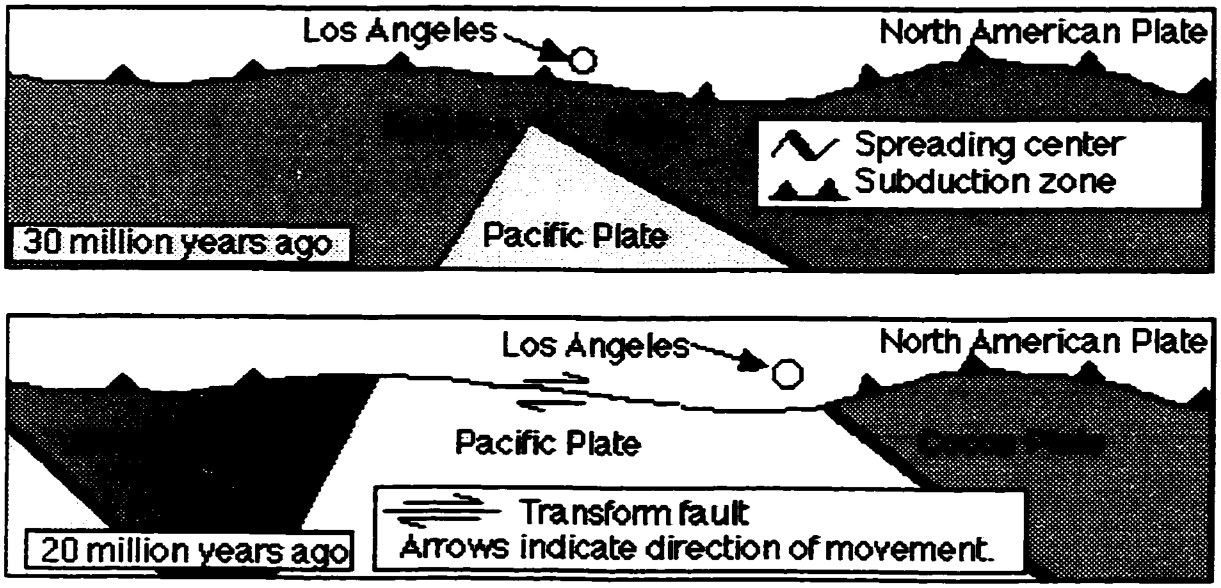

Figure 3. Pacific Plate meets the North American Plate and the boundary changes from a subduction zone to a transform boundary. (Modified from Kious and Tilling, 1996.)

About 3 to 4 million years ago, the plate movement shifted slightly, and the plates squeezed together somewhat (compressed) causing the Coast Ranges to begin rising (Fig. 4); they are still rising today (Page, 1992).

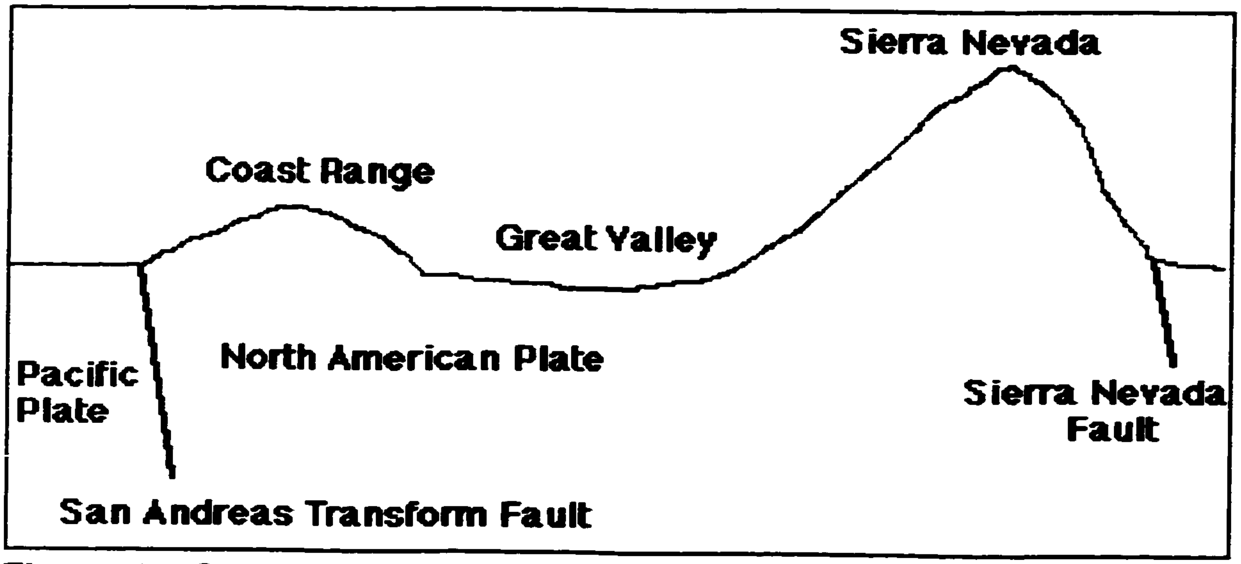

Figure 4. Cross section of present day central California. (Modified from Harden, 1998.)

PART II: ROCKS OF ALUM ROCK PARK

What pieces of this Coast Range puzzle can be seen today in Alum Rock Park? Basically there are two ages of rocks located in the park: the **Mesozoic** basement rocks and the overlying **Cenozoic** sedimentary layers (see **Stratographic Column**, Fig. 5). Unfortunately for the lay person, there is not total agreement about the relationships among these rocks. Further study by geologists is needed to find all of the pieces and to complete the puzzle.

Mesozoic Rocks (235-66 mya)

Ophiolite Suite (Jurassic Period)

The oldest rocks in the park and some of the most puzzling are the massive pinnacles known as Alum Rock, Eagle Rock, and Inspiration Point. Originally named the "Alum Rock rhyolite" by Crittenden (1951), these volcanic rocks are now thought to have erupted on the ocean floor during Jurassic times (Coyle, 1984) and to have been changed by interaction with hot ocean water from rhyolite to a sodium-rich rock known as **quartz keratophyre.** Recent evidence shows it likely to be part of a Jurassic **ophiolite suite** (Coyle, 1984; Jones and Curtis, 1991).

An ophiolite suite is a special group of rocks composed of upper mantle, ocean crust, and sediments deposited on the ocean floor. Raised onto the continent by tectonic forces, ophiolites are often broken apart, and all members of the suite are not always present. In Alum Rock Park the components appear to be **serpentinite**, **greenstone**, quartz keratophyre, and possibly **chert** (Fig. 6).

AGE: ERA	AGE: Period	AGE: Epoch	FORMATION	KIND OF ROCK
CENOZOIC	**Quaternary**		Santa Clara Formation	unconsolidated gravel, sand, and clay
				unconformity (a break in the geologic record)
	Tertiary		Orinda Formation	maroon, green, and gray conglomerate and sandstone
		Pliocene Miocene		**conformable contact** (unbroken sequence)
			Briones Formation	gray to white sandstone siltstone, and shell beds
		Miocene	Claremont Formation (part of the Monterey Group)	interbedded siltstone, chert,cherty shale, and sandstone
				faulted in part
MESOZOIC	**Cretaceous**		Berryessa Formation (part of the Great Valley Group)	conglomerate (formerly called "Oakland Conglomerate") micaceous sandstone, siltstone, and shale
	Jurassic			**fault**
			Ophiolite	sea floor sediments greenstone quartz keratophyre serpentinite (changed mantle)

Figure 5. Schematic stratigraphic column depicting the general relationships of the rock units found in Alum Rock Park. (Sources: Graymer, oral communication, July 30, 1996 and Graymer, 1995.)

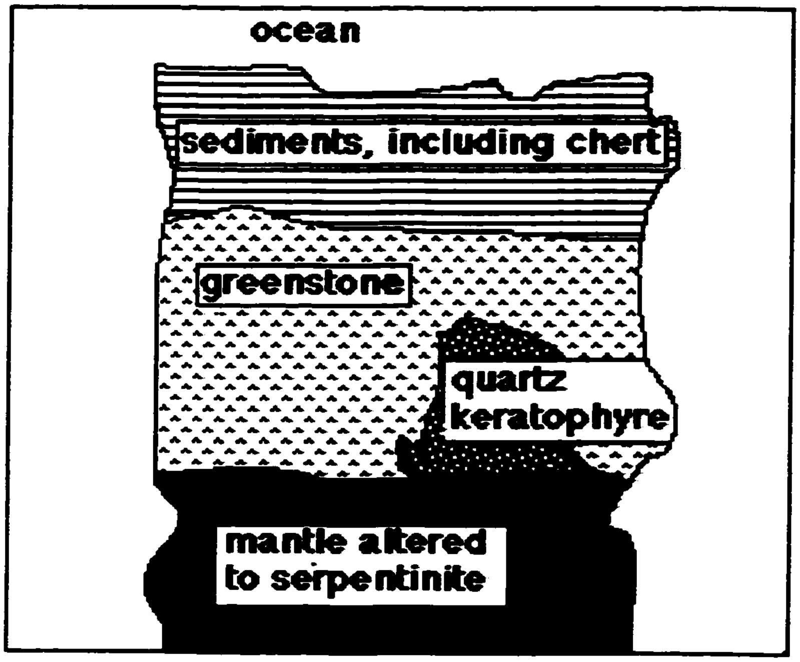

Figure 6. Ophiolite suite in Alum Rock Park.

Located near the keratophyre is serpentinite. This mostly green rock, the state rock of California, was originally part of Earth's mantle and has also been changed by hot fluid. Pieces of the serpentinite from the higher reaches of the park may be seen in Penitencia Creek, their current resting place.

Greenstone was once basalt which erupted on the ocean floor. Heat and interaction with sea water changed the basalt into a rock made of dark green minerals; hence the name greenstone. In Alum Rock Park, several outcroppings of greenstone are located below Eagle Rock along Penitencia Creek Road.

Sediments of silica from the skeletons of marine protozoa (**radiolaria**) may have become the final ophiolite member, chert. Pieces of chert, a hard, even-textured rock of red, green, black or white coloring, can be found in Penitencia Creek. Some or all of these chert pieces, however, may have come from the **Franciscan Assemblage** described below. If radiolaria are preserved, they can help geologists determine the source of the chert.

Franciscan Assemblage (Jurassic and Cretaceous Periods)

This confusing unit of rocks made up partly of coherent rock and partly of **melánges** (French for mixtures) containing broken pieces of the puzzle is thought to underlie much of the Coast Ranges. Made up of fragments of ocean crust from several ocean plates, including the Farallon Plate (Harden, 1998), as well as **turbidity current**-deposited sediments from the continent, this group of rocks was plastered onto the North American continent as the plate was subducted beneath the ophiolite (Fig. 7). Some of the sedimentary layers were deposited in water near the equator and must have moved thousands of kilometers north along transform faults before becoming part of this assemblage (Blake, 1991). Although the Franciscan Assemblage underlies the Great Valley Group and the ophiolite, it is not visible in the park itself, but can be seen nearby to the east. Perhaps because both the ophiolite and the Franciscan Assemblage contain serpentinite, greenstone, and chert, this unit was previously identified as being within the park (Crittenden, 1951). However, other rock types that characterize the Franciscan Assemblage, such as **blueschist** and **greywacke sandstone,** are not seen in Alum Rock Park. Ideas about the Franciscan Assemblage will most likely continue to evolve as geologists learn more about this complicated group of rocks.

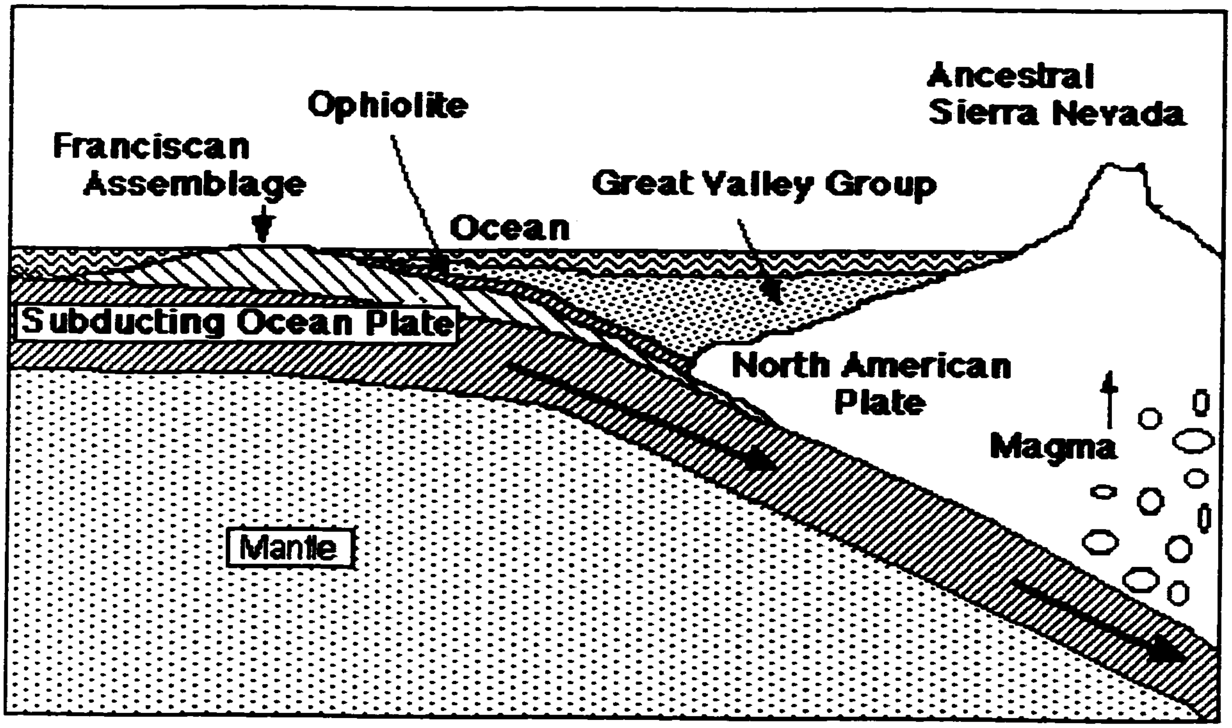

Figure 7. Diagram showing the location of the ophiolite, the Franciscan Assemblage, and the Great Valley Group.

Great Valley Group (Upper Jurassic and Cretaceous)

Between the subduction boundary and the ancestral Sierras, a marine basin formed next to the continent (Fig. 7). Sediments washed down off the continent and collected in this basin on top of the ophiolite. These sediments became the **sedimentary** rocks now called the Great Valley Group because most of the deposit lies under what is today the Central (Great) Valley of California. In Alum Rock Park, the Great Valley Group, is represented by the **Berryessa Formation** (Fig.5). The **shales** and **sandstones** of this formation are composed of sediments carried into the ocean by turbidity currents, which can be likened to undersea landslides moving down steep slopes (Harden, 1998). The rocks that form the Berryessa **conglomerates** were deposited by streams in undersea channels, closer to shore (Coyle, 1984). This formation, although often covered by landslides, can be seen in some places between the park entrance and the mineral spring area.

Cenozoic Rocks (66 mya to present)

Claremont Formation (Tertiary)

After the basement rocks discussed above were formed, but before the Coast Ranges were pushed up, ocean water still covered the future Alum Rock Park. Alternating layers of shale (from clay) and chert (from radiolaria skeletons) were deposited to form the Clarement Formation (part of the **Monterey Group**, Fig. 5). At the mineral springs area, observe how these layers have been greatly folded and even turned on edge. Because they are made of a harder material, the chert layers have not been eroded as much as those made of shale; you can see this uneven weathering. Radiolaria in these rocks are much younger than those in the ophiolite or Franciscan chert, and help geologists distinguish the various cherts.

Briones Formation (Tertiary)

The Briones Formation (Fig.5) is exposed upstream from the mineral springs area. The presence in this unit of fossils clams, scallops and oysters shows that these layers were deposited in a shallow sea, near the shore (Coyle, 1984). It is easy to spot the large fossil-containing boulders from this formation in the creek. These rocks are found in place near the north falls of Penitencia Creek in an area not open to the public and also can be seen near roads which cross over the range above the park.

Recent Units

Finally, during recent times (geologically speaking) all these layers and some that were deposited on top of them (the **Orinda** and **Santa Clara Formations** [Fig. 5] which are not encountered on field trips inside the park) were folded and faulted into the Coast Ranges. Of course, as soon as mountains are lifted up, erosion begins to tear them down. Many slopes within the park have been changed by landslides, which occur when steep slopes containing weak rock experience heavy rainfall or are subjected to seismic activity. Penitencia Creek, the main stream in the park, has cut through the layers and is slowly carrying the puzzle pieces west to San Francisco Bay.

GEOLOGIC CHARACTERISTICS OF PENITENCIA CREEK IN ALUM ROCK PARK

Using Penitencia Creek as a model, this module is designed to help students observe the geologic features of a stream in a field setting.

The BACKGROUND INFORMATION section provides material for the teacher about the geologic features and processes of the creek including its rocks and sediments.

The CLASSROOM ACTIVITIES section is comprised of two simulation lessons. In "Water Moving Downstream" students use a stream table and various sediments to learn about erosional and depositional patterns of real streams. In "Sediments to Sedimentary Rocks" students erode sediments from rocks and reconfigure those real sediments into sedimentary rocks. Having actually participated in these processes makes the observations at the park much more engaging and meaningful to students.

The FIELD TRIP PLAN encourages students to make continual observations as they move from the lower part of Penitencia Creek to the middle section of the creek. Emphasis is on how geologic features were formed and what these features and the kinds of rocks present indicate about the past. Students will identify the rocks and geologic features as they encounter them.

Background Information

GEOLOGIC CHARACTERISTICS OF PENITENCIA CREEK IN ALUM ROCK PARK

PRE-TRIP ARRANGEMENTS

1. There is no bathroom at the lower western end of the park where the morning will be spent, so students must use the bathroom before leaving school.
2. Arrange to have the bus let you out at the Penitencia Creek entrance and meet you at Quail Hollow Picnic Area (Fig. 1) in about 2 1/2 hours.
3. Arrange to have the Quail Hollow bathroom opened if your trip is on a weekday. Arrange a time near the end of your trip to have the Visitors' Center open. Phone number: (408) 277-4539.

PURPOSE

1. Observe the erosional patterns of Penitencia Creek and compare them to those formed in a stream table.
2. Look for various geologic features caused by moving water.
3. Look for various sizes of sediments.
4. Observe that the Penitencia Creek canyon width varies as the creek cuts through different types of rocks.
5. Observe the effects of human-made structures on a stream.

CONNECTIONS TO THE CALIFORNIA SCIENCE FRAMEWORK:

Themes: Systems and Interactions, Patterns of Change

Process Skills: observing, measuring, communicating, comparing and contrasting, inferring

Integration With Other Areas: math, drawing, creative writing

GRADE LEVEL: upper elementary, middle school

TIME: 4 hours

GROUPING: some whole group activities, some for individuals; some for groups of six

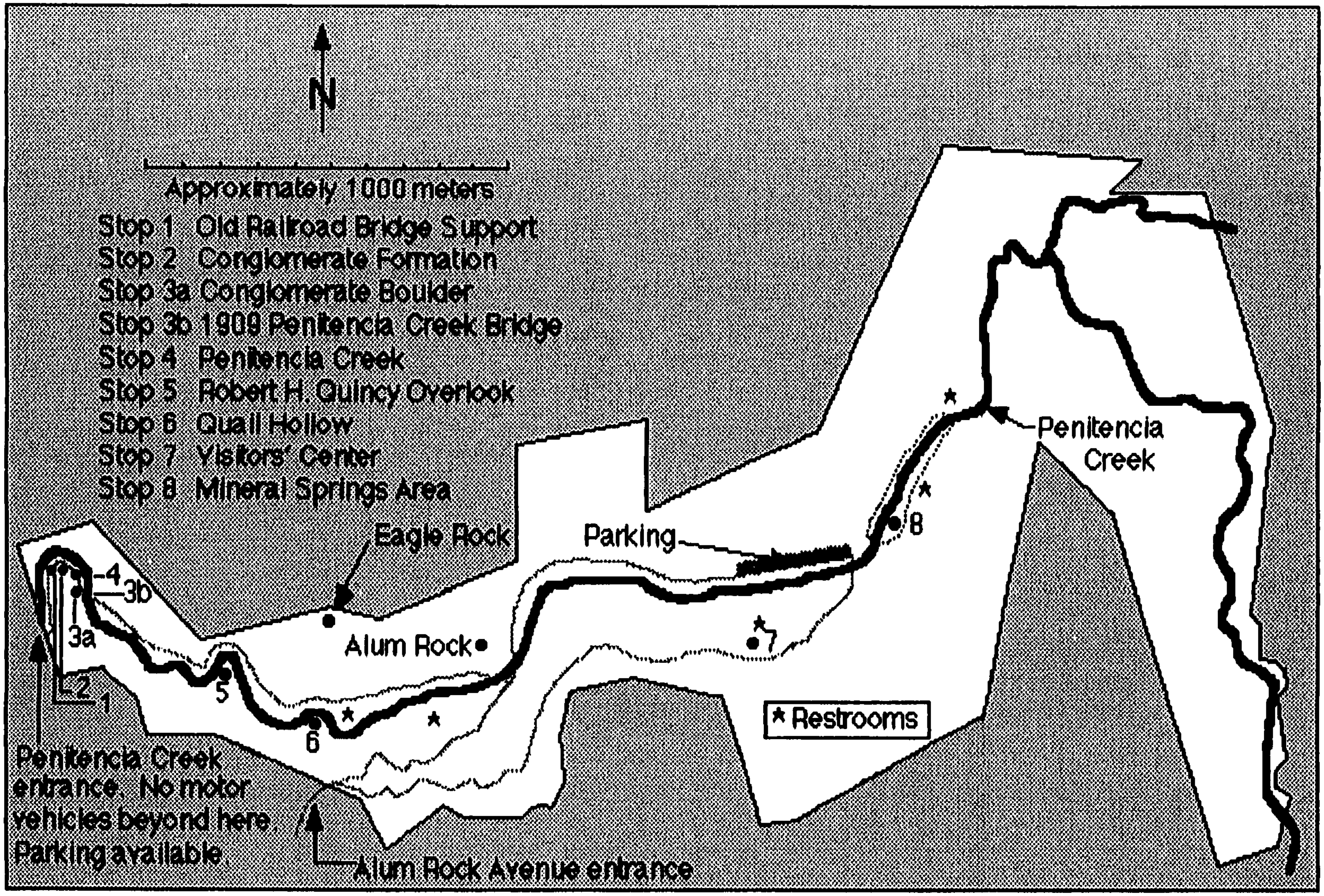

Figure 1. Map for Geologic Characteristics of Penitencia Creek in Alum Rock Park field trip. (Modified from San Jose Regional Parks, no date, Alum Rock brochure.)

MATERIALS

For the teacher

To prepare a 3% N solution of HCL, you will need 12N concentrated HCl. Add 1 part acid to 3 parts water, pouring the acid into the water.

- 12N concentrated HCl (Sc. Kit 82240-03) or obtain from a high school science department
- 1 dropping bottle (Sc.Kit 68593-02) of dilute HCl
- spray bottle of water
- copy of the old photo of the "Alum Rock Meteorite" (Figure 5 in Field Trip Plan section)
- *Pacific Coast Tree Finder* (Acorn FG-658) or other riparian plant identification guide
- white board, pen, and eraser
- Field Trip Map (photocopy Figure1)

For the class

- rope to aid in descent/ascent to and from the creek bed (optional)
- one soft pencil or crayon for rubbing of bench mark (optional)

For each student

- drawing materials
- cardboard or clipboards for support while drawing
- ruler (metric if possible)
- magnifiers--10x recommended--(Sc.Kit 62367)

For groups of six

- 3 cups for gathering sediments
- 6 signs with the sediment size names printed, worn around neck

LESSONS TO DO BEFORE YOU COME: "Water Moving Downstream", and "Sediments to Sedimentary Rocks"

GEOLOGIC BACKGROUND

Penitencia Creek is an excellent place to observe geologic characteristics of a stream. This background information describes features and rocks that may be seen along the stream channel beginning as you drive up Penitencia Creek Road to the park entrance and continuing through the mineral springs area. The upper reaches of Penitencia Creek are not accessible to the public and so are not included.

Where the Stream Ends

Many streams flow directly into bodies of water. Some streams, such as those that once flowed out of the steep **Diablo Range** here in the Alum Rock Park area, suddenly entered the gently sloping Santa Clara Valley and were abruptly slowed down. These streams dropped their sediment load in fan-shaped patterns. Because sediment deposited by flowing water is called **alluvium,** these fans are called **alluvial fans** (Fig. 2). These fans are often difficult to see because they are covered with vegetation and structures, but may be observed as you approach the park from the West. As you drive to the park entrance, you are driving up an alluvial fan; this is most obvious when driving up Alum Rock Avenue.

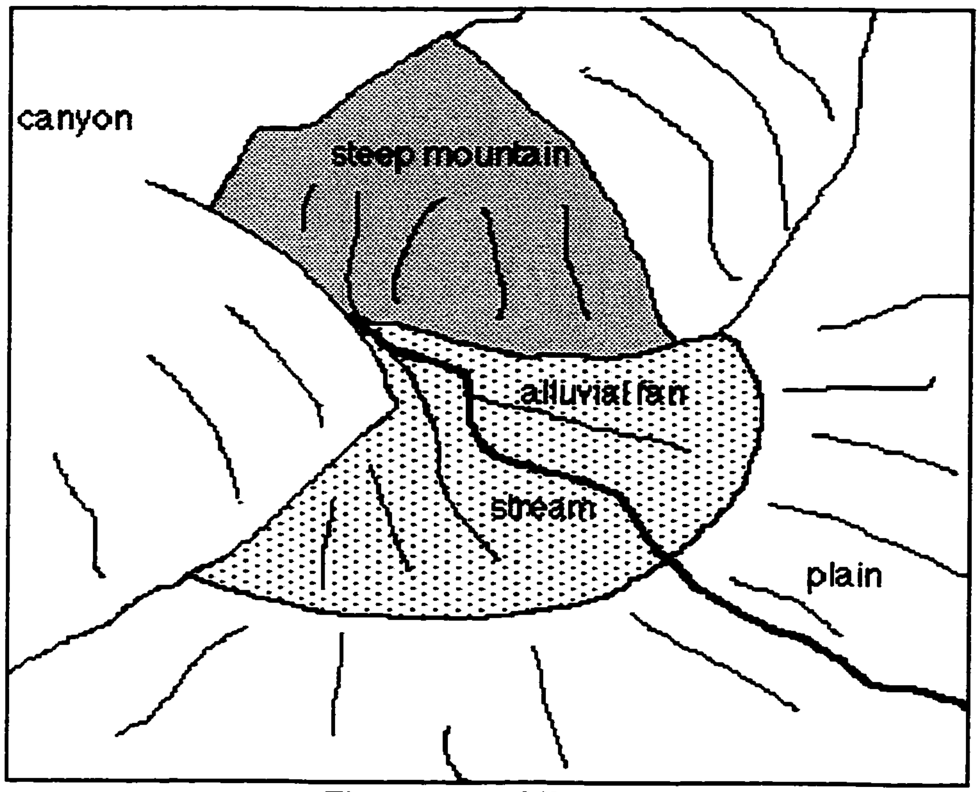

Figure 2. Alluvial fan.

Upper Penitencia Creek flows out of Alum Rock Canyon, down the alluvial fan at the edge of the Santa Clara Valley, and joins Coyote Creek, which empties into San Francisco Bay. Lower Penitencia Creek, which is not currently connected to the upper section, also drains into Coyote Creek just before it reaches the Bay (Appendix B).

Erosion and Deposition

Naturally occurring straight stream channels are not common and usually occur only for short stretches. Most streams form bends called **meanders**. Exactly why meanders form is not currently agreed upon; their formation seems to be a result of interactions between the water, the sediment load, the streambed and the stream banks. (Farndon, 1992) As a stream moves through a meander, inertia forces the water to the outside of the curve removing sediment from (**eroding**) the bank there. Long, curved **pools** develop along the outside curve. On the inside of the curve, the water moves more slowly, so the heavier sediments are dropped (**deposited**) forming **bars** (Fig. 3). Sometimes sediments are dropped in the middle of the stream, and the water goes around both sides of the bar or island. Over time, meanders tend to develop in a consistent pattern. Bends usually form every five to seven channel widths (Yates, 1988).

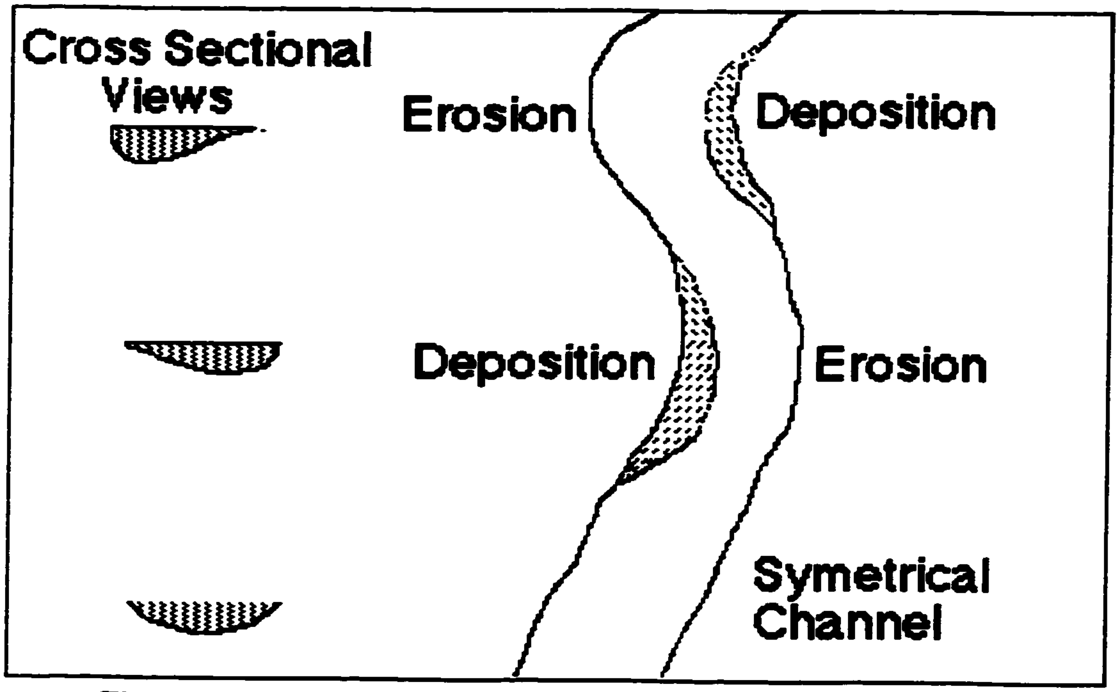

Figure 3. Stream channel erosion and deposition.

Instream features

Within the stream itself various features form depending on the depth and the velocity of the water and on the stream bottom materials. Besides forming on the outside of meanders, small pools, deep areas in a stream where the current is usually slow, are caused by other conditions. Obstructions such as boulders, logs, or wads of roots contribute to the formation of two kinds of pools: one forms when the water piles up behind the obstructions and the second when water cascading over and around obstructions scours out **plunge pools** below them (Yates, 1988). **Riffles**, shallow places where water moving quickly over gravel and cobbles causes ripples to be seen, develop where the gravel from the bar deposits washes downstream to a straight area. When the streamflow is high, riffles become **runs,** which are fast flowing-areas less shallow than riffles, so no ripples show (Fig. 4). Riffles or runs and pools develop in the same pattern as meanders, alternating every five to seven stream widths (Farndon, 1992).

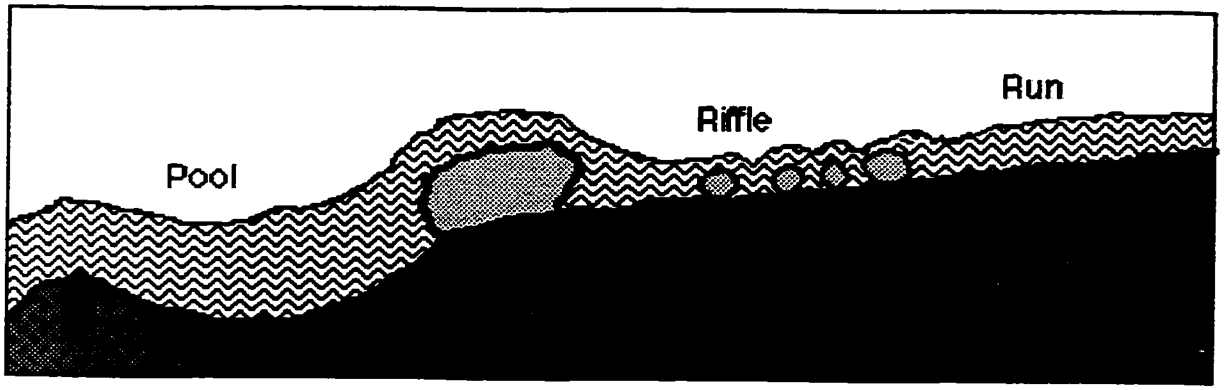

Figure 4. Instream features.

Stream Volume

The volume of Penitencia Creek naturally varies annually because of wet winter and dry summer seasons characteristic of San Jose's climate. In late summer of dry years, part of the creek does not flow above ground. During the rainy season, the volume is often greatly increased. The San Jose city-owned Cherry Flat Reservoir tends to even out the seasonal flow for the most part by holding back winter flood waters and releasing them during the dry season (Ranger Pam Helmke, oral communication, April 9, 1999). During the winter of 1998-1999, however, abnormally heavy rains exceeded the capacity of the 1930's flood control reservoir and so greatly increased the Penitencia Creek flow that decades-old creek retaining walls, creekside trails and bridges were damaged or destroyed. Boulders in the creek as large as two meters in diameter were moved downstream by the force of the water. Look along the creek banks in the dry season and notice the accumulation of tree trunks and branches washed up on the banks in periods of high water.

Substrate Material

The stream bottom (**substrate**) is made up of rock pieces and organic debris. Its composition depends upon a number of factors: the geology of the headwaters of the stream, the materials that the stream is moving through, and the force of the water. The sediments that are eroded have different names according to their sizes (Table 1). Streams with greater speed can move more sediment and larger size sediments than streams of the same volumes but less velocity. When the velocity of the stream decreases, it begins to drop its load. The boulders, being the heaviest, drop out first, followed by the cobbles, pebbles, sand, and finally the silt and clay. Large boulders may appear fixed in position in a stream, only to move later when velocity and volume of the water increase during floods.

If the same size pieces drop out together, the sediments are said to be **well-sorted.** If the sediments are mixed by size, they are **poorly-sorted.** The latter situation occurs when a stream slows abruptly and drops its mixed load of sediments. In Alum Rock Park the **conglomerate formation** visible immediately to the right of the Penitencia Creek entrance is an example of rock formed from poorly-sorted sediments.

MODIFIED WENTWORTH SCALE

NAME	**SIZE (diameter)**
Boulder	Above 256 mm (basketball or larger)
Cobble	64-256 mm (tennis ball to basketball)
Pebble	4-64 mm (BB to tennis ball)
Gravel	2-4 mm (BB)
Sand	2-0.062 mm (salt granules)
Silt/Clay	Less than 0.062 mm (flour)

Table 1. Sediment size: Sediments are named according to their sizes.

Boulders in Penitencia Creek

The large conglomerate formation visible near the Penitencia Creek park entrance is a **sedimentary** rock formed of large, water-rounded pieces cemented together in a **groundmass** of finer material. Many large boulders from this formation are found in the creek. Some of the rounded pieces in these conglomerate boulders were formed by volcanoes, perhaps even from the ancestral Sierras. The pieces then washed down rivers and were deposited under the ocean that was here before the Coast Ranges rose (Coyle,1984).

Probably the most distinctive type of boulder in Penitencia Creek is the sandstone from the **Briones Formation** (see Stratigraphic Column, Fig. 5)

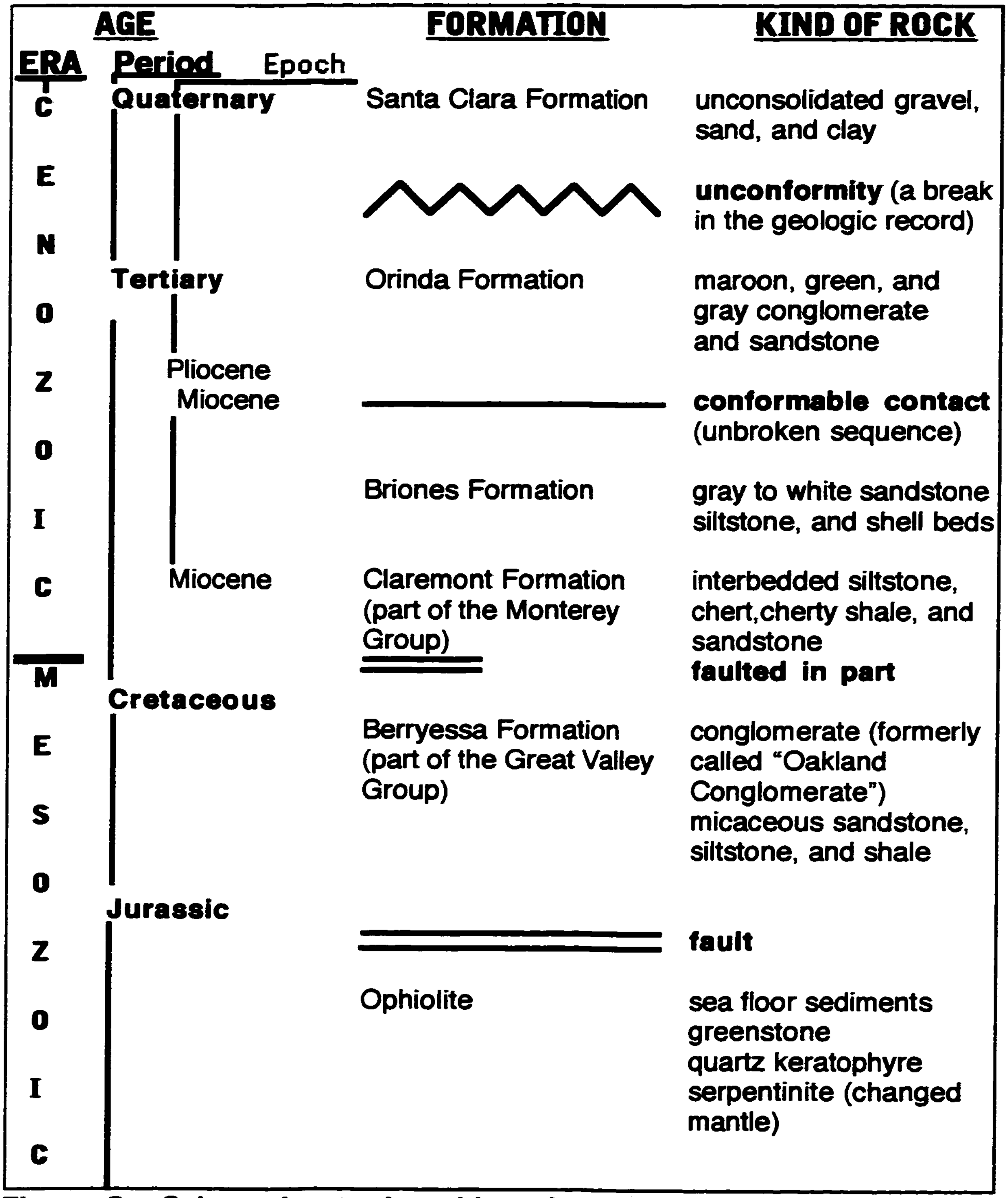

Figure 5. Schematic stratigraphic column depicting the general relationships of the rock units found in Alum Rock Park. (Sources: Graymer, oral communication, July 30, 1996 and Graymer, 1995.)

containing **pelecypod** (clam) fossils. This sandstone was formed when part of California was under a shallow sea. (Coyle, 1984).

Some of the large boulders that can be observed in Penitencia Creek, as well as some of the outcroppings that appear nearby, belong to a group with an interesting history. Tectonic forces sometimes lift a whole sequence of rocks from the ocean floor and the underlying mantle onto land. There are several ways that this spectacular event could occur, but no one agrees on a single mechanism. The whole group of rocks that moved as a unit, the **ophiolite suite**, (Fig. 6) is named for the appearance of one suite member, the **serpentinite.** Looking as though it is covered in snake skin with patterns of green, black, blue, and gray, serpentinite was once a mantle rock, **peridotite**. Hot water changed it to serpentinite. Subsequently, the Greek word,"ophis", meaning snake (McPhee, 1993) was applied in the form, "ophiolite", to the suite. Serpentinite, which may be difficult for a beginner to recognize by color, can be identified by its slippery soap-like texture. At the park you will see large boulders of serpentinite some of which have quartz veins running through them Quartz or silica (SiO_2) dissolved in hot water and moved through the cracks in the serpentinite, hardening as **opalized quartz** (non-crystalline quartz containing water molecules). Another interesting fact that is fun for students to know is that serpentinite is the state rock of California. (Serpentine is the name of the mineral in the rock).

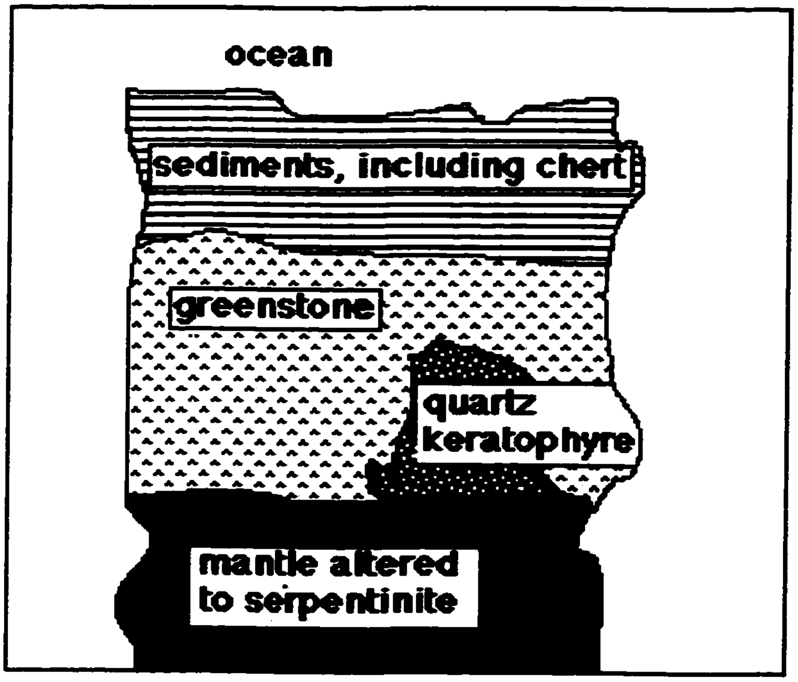

Figure 6. Ophiolite suite in Alum Rock Park.

Not found in the creek but nearby along the Penitencia Creek Road, several outcroppings of **greenstone** may be seen. This suite member was formerly , an **igneous** rock, **basalt.** After the basalt erupted on the ocean floor, heat and the addition of water changed it to the **metamorphic** rock called greenstone.

Another igneous rock from the ocean floor and also altered by interaction with ocean water is **quartz keratophyre**. It comprises the the three monoliths of the park, the Alum Rock, Eagle Rock, and Inspiration Point. Large blocks of quartz keratophyre, varying from pinkish to orange to brown to gray, have fallen into Penitencia Creek.

Chert, although not part of the ocean crust itself, is formed from skeletons of **radiolaria** (singled-celled marine protozoa) that were deposited on the crust. These silica skeletons become a very hard, even-textured rock made up of microscopic quartz crystals. The first chert you will most likely notice are the large red boulders, but further investigation of the stream will reveal samples of green, black or white chert as well. One identifying feature of chert is that it naturally breaks with a curving or **concholdal** fracture. The red color of the large chert boulders here is from iron oxide. The cracks could be filled with quartz or calcite. When you visit the park, test the white material in both the chert and the serpentinite with a dilute acid and look at the results through a magnifier. If it fizzes the white material is calcite; if not, it is probably quartz. Use your spray water bottle to wash off the rock.

Badlands Topography

In addition to rocks, soils may be observed on this trip. When weakly cemented clay or silt has little or no plant cover, small amounts of water easily erode the surface, forming many tiny, interweaving channels. This type of **"Badlands" topography** may be seen on the surface of the conglomerate formation that you pass as you go along the Creek Trail. The name "Badlands" was given to areas with this type of topography because they were poor farmland and difficult to travel across (Harris and Tuttle, 1990).

Mineral Springs

A number of warm mineral springs seep between the shale and chert layers of the Claremont Formation (Fig. 5). Minerals such as sulfur and calcium carbonate are present in the water and form interesting new rock deposits around the springs. For more about the mineral springs see the module entitled "Mineral Springs of Alum Rock Park".

CLASSROOM ACTIVITIES

GEOLOGIC CHARACTERISTICS OF PENITENCIA CREEK IN ALUM ROCK PARK

ACTIVITY 1: WATER MOVING DOWNSTREAM

This works best as an outside activity.

Objective

Observe simulated stream processes as demonstrated on a stream table.

Materials

- water in a 5-gal bucket
- stream table (Wards 36H4211) or plastic tub (at least 15" x 20"--dish pans are too small)
- about 2 lbs. of sand or diatomaceous earth (available at plant nurseries and pool supply stores) A mixture of both is best, combined in equal weights.
- ruler or strip of wood that is the width of the stream table
- 1/4 to 1/2 liter container with a hole in the bottom
- tongue depressors
- 1 cc colored sand
- blocks of wood or bricks
- bucket (if stream table has a hole in it)

Procedure

1. Mix equal weights of sand and diatomaceous earth and enough water so that they hold together, but so that water poured over them will make a gully as it runs off.
2 Push the sand and diatomaceous earth mixture to one end of the stream table away from the hole if it has a hole.
3. If the stream table has a hole, position the hole end over the edge of a table with the bucket underneath; otherwise it may be set on the ground (Fig. 1).

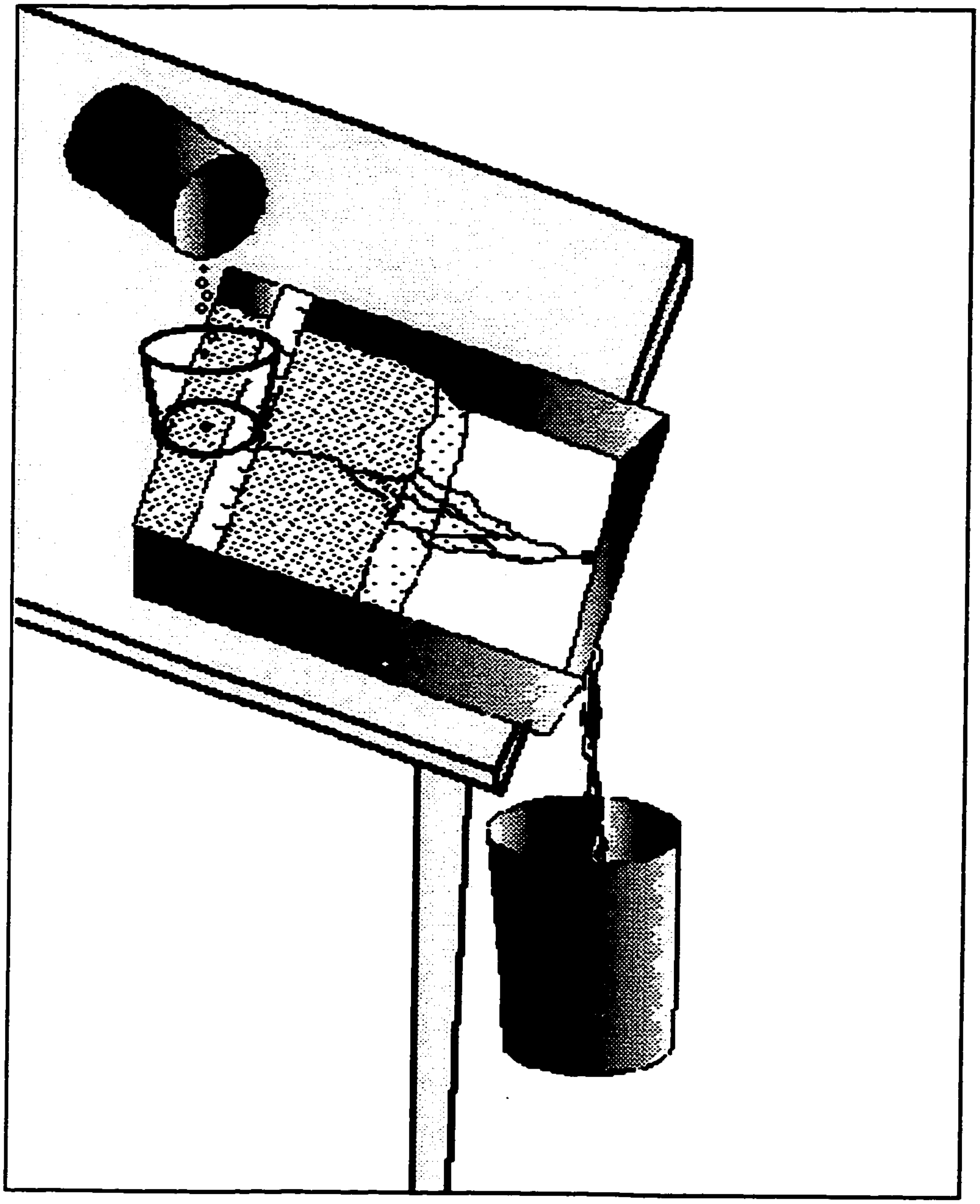

Figure 1. Stream table set-up.

4. Tape the ruler or wood strip across the tray over the sand mixture.
5. Balance the water container with the hole in it so that it rests partially on the ruler (strip) and partially on the edge of the stream table.
6. Fill the water container and let the water flow; refill if necessary.

7. Observe the gully that formed and the deposit at the opposite end from the water source. *On your worksheet draw the appearance of the stream table after your first experiment. Show how the gully is cut. Label the sediment deposit as a delta or an alluvial fan. Show where the sand was deposited and where the diatomaceous earth was deposited.*
8. Reform the sand mixture and use first one block and then two to raise the end with the sand/diatomaceous earth mixture, changing the slope of the table. *With the stream table set-up positioned with a steeper slope, what differences do you think there will be in the gully and in the deposits?* Fill the water container and perform the experiment. *Draw your observations of the results with the steeper slope set-up.*
9. Spread the sand mixture out into a less steep slope. Carve some meanders (S-shaped) grooves lightly into the sand. *How will the water flow and where will it erode and where will it deposit the sand mixture?* Adding a little colored sand to the water will make the results more visible. Perform the experiment. *Draw your observations showing where the sediments were eroded and where they were deposited on the meanders.*
10. Reform the sand mixture and carve a straight channel. Place several tongue depressors to simulate reinforcement walls along the channel. They may or may not extend above the top surface, but should not reach the bottom of the pan. *Predict what will happen when the water flows through the artificial channel.* Perform the experiment. *Draw the results of the artificial channel experiment. Why do you think these results occurred?*

Teacher Notes

At the far end of the stream table, material will be dropped as the water slows down; if your table has no hole and the water collects, this triangular shaped formation is called a **delta**; if the water has drained out through a hole, it is an **alluvial fan**. The diatomaceous earth is carried farther than the sand because it is lighter.

As the slope is increased, the water flows faster and cuts a deeper channel.

Water moves faster on the outside of the meanders and erodes the bank there. It slows down on the inside and deposits material downstream on the opposite bank, forming a bar.

Water flowing through an artificial channel tends to meander. When it cannot cut through the channel walls, it erodes the stream bed more deeply and then undercuts the walls. Eventually they will fall into the stream.

Relationship to Alum Rock Park

Look along Penitencia Creek for the processes that you have just observed.

As you drive up Penitencia Creek Road to enter the park, you are driving up the alluvial fan formed by deposits dropped by streams flowing from the Diablo Range to the Santa Clara Valley.

When you travel up Alum Rock Canyon, you can see that the largest boulders have been dropped farther up the canyon. They were dropped first because they are heavier. Farther down the canyon the slope decreases, so the water slows down and cannot carry the heaviest material.

Walking along Penitencia Creek, you are able to see meanders and bars.

Look for undercutting of many of the artificial walls along Penitencia Creek.

Additional Resources

For a more extensive treatment of these ideas see--

1) Full Options Science System (FOSS), 1993 *Landforms* (Grades 4-6): Lawrence Hall of Science and Regents, University of California, Berkeley, CA.
   Students simulate the creation of landforms by using stream tables.

2) Kaufmann, Jefferey S. and others, 1989, *River Cutters* (Grades 6-9): Great Explorations in Math and Science (GEMS), Lawrence Hall of Science and Regents, University of California, Berkeley, CA.
   Stream table activities include explorations of erosion, the order of geological events, pollution, and human manipulation of rivers.

NAME____________________
DATE________PERIOD______

STUDENT WORKSHEET FOR ACTIVITY 1: WATER MOVING DOWNSTREAM

1. Draw the appearance of the stream table after your first experiment. Show how the gully is cut. Label the sediment deposit as a delta or an alluvial fan. Show where the sand was deposited and where the diatomaceous earth was deposited.

2. With the stream table set up with a steeper slope, what differences do you think there will be in the gully and in the deposits?

____

____

3. Draw your observations of the results with the steeper slope set-up.

4. How will the water flow and where will it erode and where will it deposit the sand mixture?

____

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5. Draw your observations showing where sediments were eroded and where they were deposited on the meanders.

6. Predict what will happen when the water flows through the artificial channel.

____

____

7. Draw the results of the artificial channel experiment.

8. Why do you think these results occurred?

____

____

ACTIVITY 2: SEDIMENTS TO SEDIMENTARY ROCKS

Objectives

Observe how sediments are made and form simulated sedimentary rocks from different sizes of sediment.

Materials

- overhead projector or paper
- rounded river rocks
- pointed piece of brick (about the size of a golf ball)
- coffee can
- magnifiers (Sc.Kit 62367)
- water (60 mL/student)
- sand (30 mL/student)
- gravel (20 mL/student)
- ceramic clay powder (30 mL/student)
- plaster of Paris (60 mL/student)
- paper cup (5 oz.) for each student
- plastic mixing container for each student
- plastic spoon for each student
- Several drops of food coloring/student (optional)
- shells or gummy animals such as dinosaurs or fish to represent fossils or *Dem Bones® Tart and Tangy Candies* (optional)
- dishpan with water for washing the mixing cups and plastic spoons

Procedure

1. Show rounded river rocks and ask students how they became so round.
2. To simulate the wearing caused by tumbling in a river, tumble a pointed piece of brick in a coffee can. Before tumbling it, *trace around the brick* on an overhead projector or on a piece of paper to make a record of its shape.
3. Put the brick in the can with some other rocks and a little water.
4. Have the students pass the can around, shaking it about 50 times each.
5. Open the can and examine the brick; *trace around its new shape and compare it to its previous one.*
6. Observe the sediments of clay at the bottom of the container and save them.
7. Note the color of the water; set it aside for the suspended sediments to settle out. Ask students, *After the brick was tumbled, what was in the bottom of the container? What color was the water?*
8. Have students brainstorm other ways to erode sediments from rocks; try the feasible suggestions, saving the sediments.

9. To make simulated sedimentary rocks, you will need to provide more sediments than the students are able to produce.
10. In the mixing containers have each student combine 5 drops to 2 mL of food coloring and approximately 18 mL of water with 30 mL of sand and add 30 mL of plaster of Paris. (Wetter is better than drier.) Be sure to mix completely. Pour this mixture into the paper cup.
11. In the mixing containers now combine 20 mL of gravel and 10 mL of sand with 20 mL of plaster of Paris and beginning with 9 mL of water keep mixing very thoroughly and adding water until the mixture looks like a very thick milkshake. Then add this mixture carefully to the paper cup forming a "conglomerate" layer on top of your "sandstone". Push this layer down with the plastic spoon.
12. A layer of "shale" from 30 mL of ceramic clay powder and 2 mL of water could be added to the top. Try various colors and student ideas as well.
13. If you like, add the shells, gummy candy, or bones candy to each layer as you go along. Adding the candy or shells to the outside of the layers makes it easy to locate and remove later, revealing the "fossils" and upon their removal the" fossil molds".
14. Wait for a few days. Peel the paper cup to uncover the layered "rocks" Have students *draw their simulated sedimentary rock. Label the different layers.* Rub them on the pavement to better see the interior layering. *Which "fossils" are the oldest if the layers have not been disturbed?*

Teacher Notes

The clay layer represents **shale**, the gravel rock stands for **conglomerate**, and the sand represents **sandstone**.

Sediments are commonly held together by calcite or quartz which precipitates between the grains of sediment, acting as a cement. The cementing agent in our model rocks is the plaster of Paris.

The shells, bones candy, or gummy animals are the **casts** (replicas) of fossils and the impressions made by them are the **molds.**

In nature the formation of sedimentary rocks would take hundreds of thousands to millions of years.

Relationship to Alum Rock Park

At the park you can see shale, sandstone, and conglomerate.

The formation called the "**Oakland Conglomerate**" (see Stratigraphic Column, Fig. 5 in the Background Information section) is easily viewed at the

Penitencia Creek entrance and just south of the Inspiration Point summit. Notice also the human-made conglomerate (the old railroad bridge supports) and compare this to the natural form.

The **Claremont Formation**, where the mineral springs are, is made up of alternate layers of shale and and another sedimentary rock, **chert**. The chert layers, being made of fine-grained quartz, are less easily eroded and therefore, stand out more than the shale.

Sandstone is easily found as the rocks containing the **fossil** clams from the **Briones Formation**. Feel the sand and look at the grains with magnifying glasses.

Notice that the stream-tumbled rocks are rounded.

NAME________________________
DATE______________PERIOD_____

STUDENT WORKSHEET FOR ACTIVITY 2: SEDIMENTS TO SEDIMENTARY ROCKS

1. Draw the shape of the brick before and after tumbling.

2. After the brick was tumbled, what was in the bottom of the container? What color was the water?

____

____

3. What other methods could be used to "erode" sediments from rocks?

____

____

4. Draw your simulated sedimentary rock. Label the different layers. Which "fossils" are the oldest if the layers have not been disturbed?

FIELD TRIP PLAN

GEOLOGIC CHARACTERISTICS OF PENITENCIA CREEK IN ALUM ROCK PARK

DRIVING TO THE PARK

a. *As you drive up Penitencia Creek Road, notice the gradual rise. What do you think this landform is?* (an alluvial fan)

b. *Why did it form here?* (Because the water slowed suddenly upon reaching the floor of the Santa Clara Valley and dropped much of its **sediment load**. Recall the lesson, "Water Moving Downstream".)

LOWER CREEK (2 hours)

a. Drive in the Penitencia Creek entrance to Alum Rock Park and park the bus. Have an adult carry the box of drawing materials (pencils, paper and boards) and place it by the metal post on the stream side of the road across from the entrance to the conglomerate and just before the 1909 bridge (see Fig. 1, in the Background Information section). Keep several large sheets of paper and the soft pencils or crayons with the group for making rubbings of the bridge date and the bench mark.

b. Walk up the road 70 m beyond the gate to the former railroad bridge observing the rock **formation** (defined as a mappable body of rock) to your right.

Stop 1--Railroad Bridge Support

a *Of what materials is the concrete railroad bridge support made?* (You can feel and see sand, gravel, pebbles, and cement, so it is actually a human-made conglomerate.) This would be a good place to teach the sizes of **sand, gravel**, and **pebbles,** if you have not already done so.

b. *Because wet concrete flows, how did people get it to hold the needed shape until it hardened?* (It was held in shape by a framework of boards, the wood grain print of which is visible still.)

c. *To make the support strong, what was added to the concrete?* (iron bars some are visible)

d. Walk across the road and look at the creek bed on either side of the sycamore tree (the tree with the light-colored, peeling bark). The tree leaf is shown in Fig. 1.

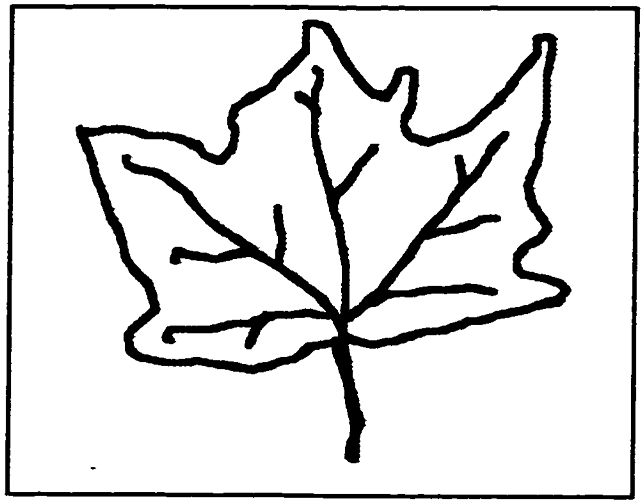

Figure 1. Sycamore leaf.

e. *Can you see the railroad bridge supports in the middle of the creek and on the other side? Why do you think they have the shape and the orientation in the stream that they do?* (wider at the base would be more stable, oriented with the longer axis in line with the stream flow to present a narrower profile and edges facing upstream to deflect the water) (Fig.2). *How heavy do you think the train was? As heavy as a car? A school bus?* (heavier than both)

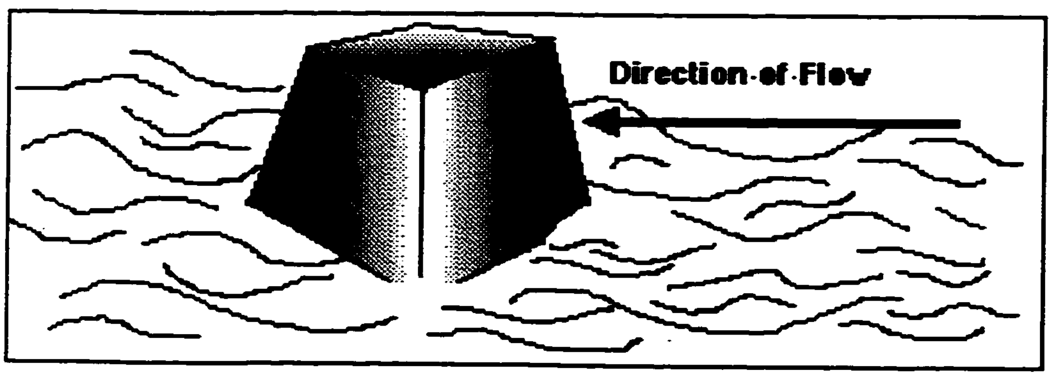

Figure 2. Instream railroad bridge support.

Stop 2--Conglomerate (Sometimes called Oakland Conglomerate)

a. Walk about 20-40 m past the railroad bridge support. This is a good location for a large group to view the conglomerate closely without climbing the unstable western and southern slopes of the formation. The best viewing spot depends on the time of year, time of day and vegetation barriers, so you may need to choose another area.

b. *A nickname for this kind of rock is pudding stone. Can you think of a reason why?* (People used to eat puddings with lots of lumpy ingredients such as raisins.) The actual name for this kind of rock is **conglomerate**.

c. *How do you imagine this big formation of rocks got here? Were the rock pieces brought here by Penitencia Creek?* (Many of the rock pieces in this conglomerate were formed by volcanoes some distance from here. Washed down by streams with very fast currents, they were deposited at the edge of the North American continent, once located here. That means that San Jose would have been under the ocean.)

d. *By looking carefully at the formation you can figure out something about its history. Which is older, the conglomerate or the rocks within it?* (the rocks within it) *How can you tell that the rocks that make up the conglomerate have been moved by water?* (their rounded shape) *Are the sediments well-sorted or poorly-sorted by size?* (They are poorly-sorted, meaning that the conglomerate contains rocks of various sizes mixed together.) *What does this kind of sorting tell you about how the sediments were deposited?* (When the fast moving current carrying these rocks reached the ocean, it lost speed abruptly and dropped the rocks without sorting them.) Remind students of the stream table activity where the sand was dropped first and the lighter diatomaceous earth was carried farther. This sorting didn't have time to occur because of the abrupt stop.)

e. After the conglomerate was formed, under water, it was uplifted and we can see it here. *Can you see evidence of what has happened to the formation on its journey? Which of the following clues can you pick out: fractures within the formation, individual rocks that have been fractured, a rock that has been fractured and recemented? (Circle on your paper.)*

f. *In what way is this conglomerate formation like the bridge support?* (Both are made up of different kinds of rocks of different sizes "glued" together.)

g. Continue along Penitencia Creek Road toward the 1909 bridge. Can the students find an outcrop of rock that is not conglomerate? (On the right there is a large outcropping of **greenstone** 120 m from the conglomerate observation location; this rock was formerly **basalt**, and has been changed from an **igneous** rock by heat and the addition of water to a **metamorphic** rock. Greenstone is part of an **ophiolite suite**).

h. As you continue past the conglomerate, notice that a large chunk was removed to make a flat bed for the railroad.

i. At this point if there are two leaders, divide the group in half and have one half move to Stop 3a and the other half to Stop 3b; then reverse positions (Fig. 3).

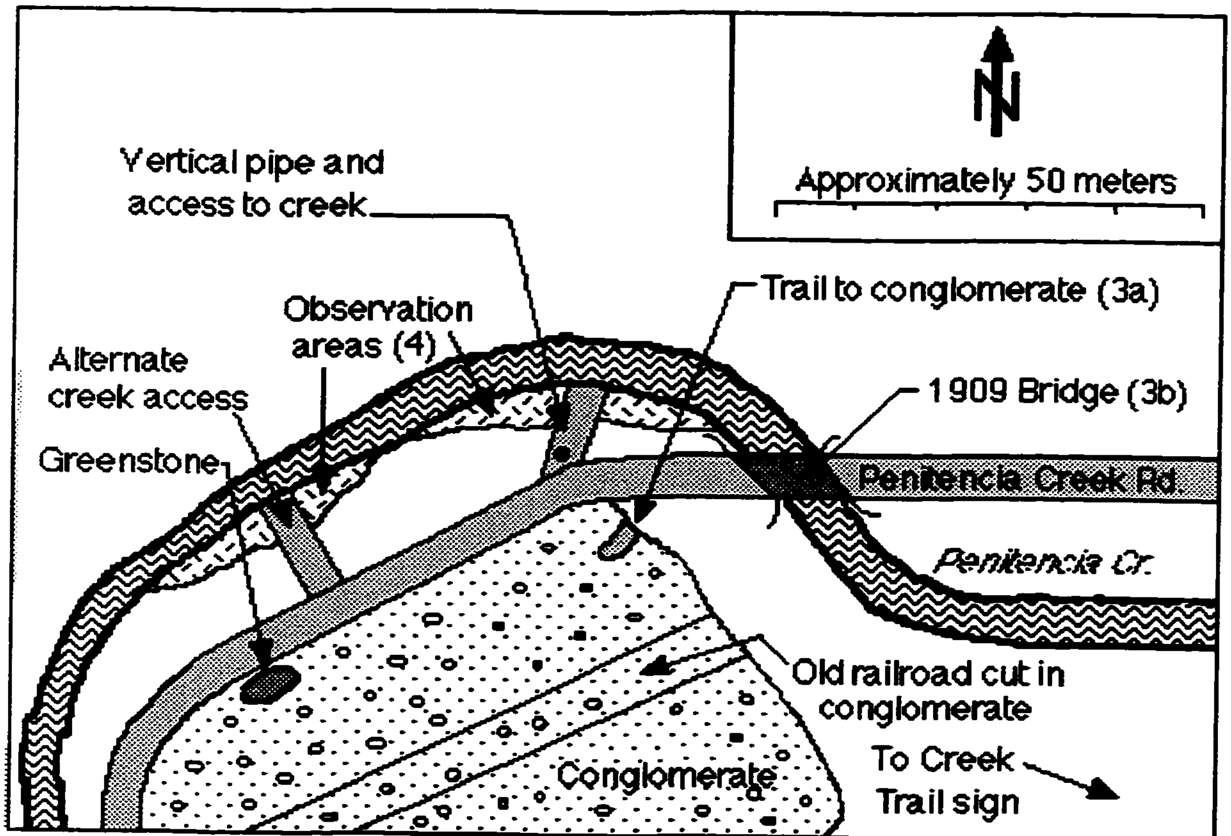

Figure 3. Enlarged map showing the area of lower Penitencia Creek with numbered trip stops.

Stop 3a--Conglomerate Boulder

a. Continue up Penitencia Creek road and turn right onto the service road that meets the main road 50 m uphill from the greenstone. Just as you start up the service road, look to the right. You will see a narrow trail that leads you into the conglomerate formation. Take this trail; do not continue on the service road. Almost immediately you will reach a large conglomerate boulder. Have half of the remaining group search for five different loose pieces that were part of the conglomerate, while the rest examine the boulder to locate five different rocks within it. Then have them switch places. This would be a good time to mention the term, **boulder.**

b. *Can everyone find the following rocks within the conglomerate?*
   1) ***Cobbles** and **pebbles** in the conglomerate boulder*
   2) *Granite-like rocks*
   3) *Quartz (grayish white with visible crystals)*
   4) *Different colors of chert (chemically the same as quartz, but with microscopic crystals)*
   5) *Dark volcanic rocks (with large crystals in a **groundmass** of small crystals--**porphyry***

c. *How many different kinds of loose rock from the ground can you match with a rock in the conglomerate boulder?*

d. *What is the material surrounding the small rocks in the conglomerate? Use a magnifier and your fingers to find out.* (sandstone)

e. *Why do some of the rocks have a rust coloring?* (The iron in the rocks is reacting with the oxygen in the air.)

Stop 3b--1909 Penitencia Creek Bridge (Fig. 4)

a. *Examine the rocks that make up the bridge. Can you find two rocks that are the same? Do you recognize any of the rocks?* (Wetting the rocks with water from the spray bottle makes their colors more visible.)

b. *Touch a rock with fossils in it. Of what animal do the fossils appear to be?* (clams)

c. *What rocks were used for the capstones of the corner posts?* (red and green chert and sandstone containing clam fossils) *Why?* (because they are decorative and were probably nearby)

d. *How many different colors of lichen can you find growing on the bridge? Are they affecting the rocks in any way?* (Lichen, a fungus and an alga living together, is probably helping to decompose the bridge rocks.)

e. Perhaps the students would like to make rubbings of the bridge date.

f. Look for the USGS bench mark (BM) on the uphill corner of the horizontal bridge foundation to the right of the railing and the post (Fig.4). Sometimes the marker is covered by the tree branches or debris and can be difficult to find. If you are successful, have someone make a rubbing of it, so all can read the information given. *When was the bench mark installed? What is the elevation above sea level? What do you think bench marks are for?* (1949, 332 feet, Bench marks are placed to locate points of elevation.)

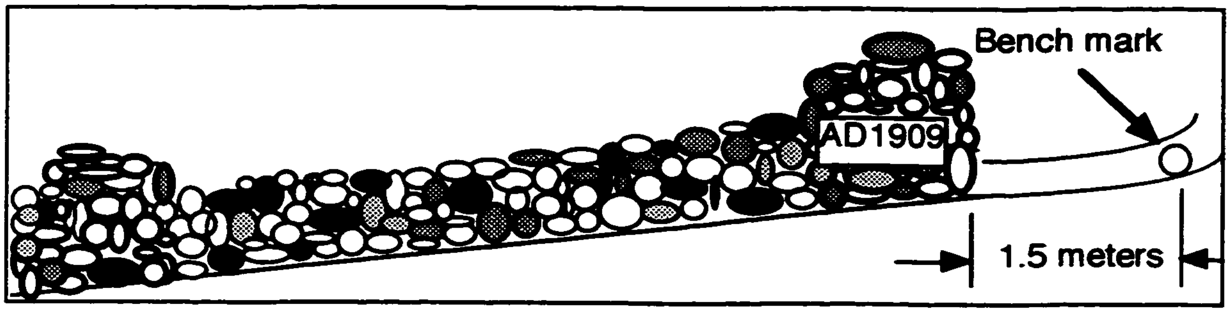

Figure 4. The 1909 Penitencia Creek Bridge with a USGS bench mark.

g. *Look over the bridge railing to the downstream side.* On the bank to your right the "Alum Rock **Meteorite**" was once present. Show the copy of the old photo (Fig. 5). Notice the person in the foreground who can assist you in estimating its size. The remaining piece of this large boulder of manganese ore is now displayed in the Visitors' Center. Initially thought to be a meteorite, the boulder remained labeled as such, because it was a tourist attraction even though scientists knew it was not one (Hartesveldt and Harvey, 1972). During World War I, the manganese was donated to the war effort to be used to harden and toughen steel needed for manufacturing ammunition and guns (Chivers, 1984). Be sure that the students understand that the boulder was never a meteorite.

h. *What else do you notice?* (conglomerate, human-made conglomerate, erosion around tree roots, undercutting of the bridge foundation, deposition of sediments, unstable slope)

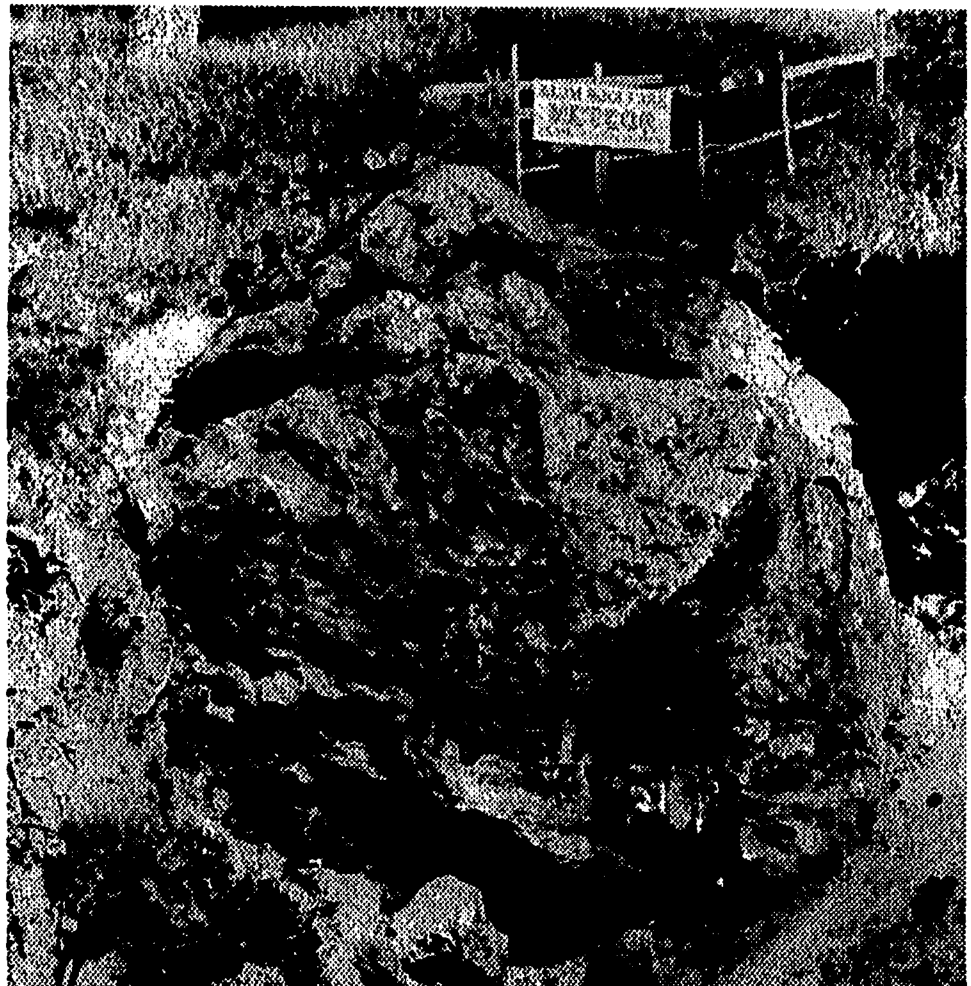

Figure 5. The sign says ":Alum rock Park METEOR", Note the person standing at the bottom of the "meteor". Photographed by Alice Hare, c. 1901. Courtesy of History Museums of San Jose.

Stop 4--Penitencia Creek

a. Have the two groups rejoin at this time and go back down Penitencia Creek Road to the trail leading down to the creek (where the drawing materials were left). This is the area where you are going to do your main observations (Fig. 3).

b. **Be careful not to touch the poison oak.** In spring and summer poison oak has shiny, green leaves that grow in threes. "Leaves of three, let them be." In the fall they turn red, and in the winter only the stems and branches remain. Many people get a rash from touching any part of this plant (Fig. 6).

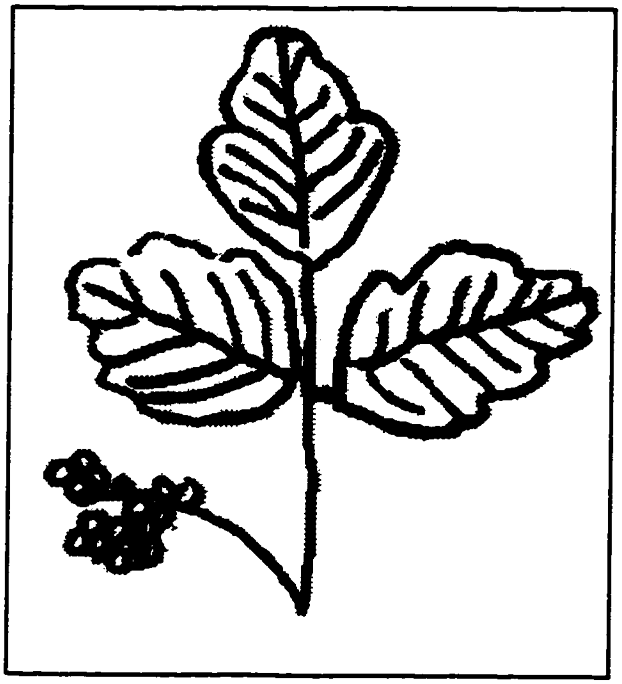

Figure 6. Poison oak. "Leaves of three let them be."

c. Before the students go down to the creek, explain that they are going to do the first activity without talking, so they can concentrate more intently on observing the creek. Explain that you will place them in a spot where they are to sit or stand with their eyes closed to see what they can notice with their other senses.

d. After a couple of minutes, they are to open their eyes and look carefully at the creek to notice as much as they can. They are then going to sketch what they see. Have students suggest what things they might include in their drawings. Be sure sediments, meanders, bars, debris, vegetation, and animals are mentioned.

e. Have students pick up a clipboard with paper and a pencil before they go to the creek. Have them walk down without talking and silently direct each one to a spot.

f. After the closed eyes activity, direct them to draw what they see without talking. After five or ten minutes let students share their observations with those near them, then gather at the widest area to do some sharing as a whole group.

g. *Were there some features of this place that you became aware of by their sound?* (If animals only are mentioned, ask students what water/rock/air interactions could be heard. If none were noticed, do this activity as a group now. Have them point to the loudest place and the next loudest. *Why did the water sound louder in some places?)*

h. *What does the channel look like? How does it compare to the ones you formed on your stream tables? Is the* ***channel*** *narrow and steep? Do you see* ***meanders****? Does the slope appear to be steep, flat, or moderate? Does it look like a little Grand Canyon, miniature lower Mississippi River, or neither one?*

i. Have students point out the location of meanders. You may have to look up or down the stream as the positions of meanders in a stream change through time. *Where on the bank is erosion going on?* (on the outside of a meander) *What is happening to some tree roots?* (Soil is being eroded away from them.) *Where are* ***sediments*** *being deposited?* (on the inside of a meander at a bar)

j. *Notice the large boulders in the stream. Could a person easily move these boulders?* (No.) *How could a little stream like Penitencia Creek move such large boulders?* (Sometimes there is much more water in the creek, such as during the winter of 1997-98 when a large opalized serpentinite boulder was moved from near the bridge to an area 30 meters downstream from here. Also gravity moves things downhill.) *Can you find boulders of conglomerate, chert, sandstone with clam fossils, and one of opalized serpentinite? Test the white veins in the serpentinite and the chert with dilute acid to see if they are quartz or calcite. Which are they?*

k. This is a good place to teach the terms **pool, riffle**, and **run**. *What caused the pools to form? Increased velocity of the water on the outside of curves? The piling up of water behind boulders, logs, or wads of roots? The scouring action of water cascading over obstacles? Can you see the gravel beneath the riffles? Can you tell where any of the features are by the sound? Which ones? Where does the water run faster?* (narrower channels) *Where does it run slower?* (wider channels)

l. The following activity could be done at this site; an even better spot is located about 30 meters downstream. (Sometimes this area is accessible by walking on the rocks in the creek; sometimes it would be necessary to go down the bank, using the safety rope tied around a tree to assist with both the descent and the ascent. (see Fig. 3 for location.)
   1) Divide the students into groups of six
   2) Materials
      a) six sediment signs--a different category sign for each group member
      b) several metric rulers showing mm for each group
      c) three cups for each group for collecting gravel, sand and clay/silt
   3) Challenge each group to find an example of each category of sediment. (boulder, cobble, pebble, gravel, sand, silt/clay)
   4) Give each group the six sediment signs, one for each member to wear, showing which sediment that student collects.
   5) The clay/silt, sand and gravel should be gathered in the cups, the pebbles and cobbles gathered by hand, and the boulders pointed out or sat upon.
   6) Have the students switch signs within their group and repeat the activity until they know each term, or you tire of the game.
   7) *Can you guess why the different sizes of sediment were dropped where they are found?* (Silt/clay, sand and gravel are often dropped behind large boulders that slowed the stream's velocity.)

m. This is a good place and time to have a snack. Use the trash can or even better, carry your trash out.

CREEK TRAIL (1/2 HOUR)

a. Continue up the canyon along the Creek Trail by crossing the paved Penitencia Creek Road and traveling along the service road, past Stop 3a; stay close to the creek and at the far end of the open area or the former conglomerate quarry you will see a sign for the Creek Trail (Fig. 3).

b. As you walk along the trail, ask the students to point out the various stream features that they have learned about--this could be an informal assessment. *On your worksheet circle the stream features we have learned about as you pass them on the creek trail: meanders, bank erosion, streamside tree root erosion, bars on the inside of meanders, island bars, pools, riffles, runs, boulders, cobbles, pebbles, gravel, sand, silt/clay.*

c. Help students to see that people have built walls to keep the river from eroding the banks, but that the walls are being undercut and in some cases even eroded from behind.

d. *Observe the large pieces of concrete in the stream. Where are they from? Did the creek erode them? Can you locate the route of the railroad?*

e. *Are you able to find other erosional features such as exposed tree roots and* ***"Badlands topography"*** *on the surface of the conglomerate to your right.? What observations can you make about these features?* Sometimes you can see erosion with deposits that look like alluvial fans at the bottom where the material met the flat land. Notice that the leaves, when present, being lighter than the soil, are at the outer edges of the fans.

f. This trail is an excellent place to see **riparian** (streamside) vegetation. If you know native plants or have a guide book, some to look for are California buckeye, wild rose, California bay, big leaf maple, valley oak, horsetails, cattails, and western sycamore. *What native plants do you see along this trail?*

STOP 5--Robert H. Quincy Overlook (5 min.)

a. Look across the creek and see the path that the railroad has been following. The sign gives a brief history of the railroads in the park. The defacing of the sign could prompt a discussion of good citizenship and what people can can do to change problem situations.

b. Notice that this overlook is still next to the conglomerate formation.

STOP 6--QUAIL HOLLOW (1/2 HOUR)

a. *As you enter this picnic area you will see that trees not native to San Jose, such as the Coast redwood and various fruit trees have been* *planted here. Why might people plant them?* (Possible reasons are to remind them of home, for their fruit, or because they like them.)

b. *Examine the bridge here. How has the bridge been built to protect it from floods?* (It was built to allow water to go over it and and also to pass through pipes under the bridge.) *What is a problem with this design?* (When there is a heavy flow of water, boulders could be moved by the water and plug up the pipes under the bridge--this happened in February of 1998.)

c. Look up at the formation known as Eagle Rock. The people-made structure on top is a radio relay antenna. This **quartz keratophyre,** formerly known as rhyolite, erupted on the ocean floor and may have been placed here by faulting More research is needed to be sure of how it got here Notice the large joints in the rocks and that many pieces have fallen down the slope.

d. The bus should be here with your lunches. After lunch, board the bus to ride farther up the canyon.

THE ALUM ROCK (VIEW FROM THE BUS)

a. *Why does the canyon narrow at the Alum Rock?* (The rock of Alum Rock, like that of Eagle Rock, is the **igneous** rock, quartz keratophyre [formerly called Alum Rock Rhyolite] Because this rock is harder than the rock farther up and down the canyon, the river could not erode it as easily).

b. Past Alum Rock notice that *the canyon widens again Why?* (The rock here known as the Berryessa Formation [Fig. 5 in the Background Information section] is made of more easily eroded **sedimentary** rocks.)

c. *About 0.1 mile up the road going in an upstream direction from the Alum Rock, notice a more modern attempt than concrete walls to control erosion of the creek bank. Why might this structure of wire cages containing rocks built in a step-like configuration (a* **gabion**; Fig. 7*) work better than the concrete walls?*

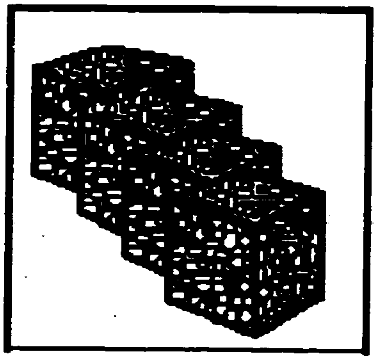

Figure 7. Gabion

(Water can move through the structure and vegetation can grow on it as sediment fills in the spaces between the rocks.)

If Stop 7 is to be done first, park by the Visitors Center; if Stop 8 is first, park at the far end of the parking lot (Fig.1, Background Information).

STOP 7--VISITORS' CENTER (45 MINUTES)

Be sure to see the remains of the manganese boulder (the "Alum Rock Meteorite"), the model of the park, and the historical photos of the park including those of the old electric train cars, as well as the insect collection and any live animals that might be on display.

STOP 8--MINERAL SPRINGS TRAIL (1/2 HOUR)

a. *What do you notice about the width of the canyon here?* (It is narrower again.) *What does this mean?* (This is a different formation of rock, the Claremont Formation, which is made of shale and chert and is more difficult for the river to erode.)

b. *What else is different about this formation?* (You can see the various layers of rock with mineral springs flowing out through spaces between the layers.)

c. *What unusual feature do you notice about many of the boulders in the* *creek and in the walls and bridges?* (They have fossils of marine clams, oysters, and scallops in them. This is called the Briones Formation. *Where have you seen rocks like these already?* (in the creek and bridge farther down the canyon) *From where might these rocks have come* ? (farther up the creek) *Where were they formed originally?* (at a shoreline)

d. *Observe the concrete walls that line the creek. What is happening to the bottom of the walls? Why?* (They are eroding away because the position of the creek is always moving, and it is cutting at the sides of the channel.) *Why did people build these walls?* (They thought they could control the creek this way. Recall the stream table experiment with the walls on the sides--the same thing happened.)

e. *What are the large, lumpy formations along the stream bank? How did they form?* (They are deposits from the mineral springs. These lumps are made of **travertine**, which is calcium carbonate that was dissolved in the water and is currently being deposited to from new rock.)

After viewing as many springs as time allows, return to the Visitors' Center to see the displays, if you have not already done so.

NAME______________________
DATE__________PERIOD______

STUDENT WORKSHEET FOR GEOLOGIC CHARACTERISTICS OF PENITENCIA CREEK IN ALUM ROCK PARK

DRIVING TO THE PARK

1. As you drive up Penitencia Creek Road, notice the gradual rise. What do you think this landform is? Why did it form here?

____

____

LOWER CREEK

STOP 1 Railroad Bridge Support

2. Of what materials is the concrete railroad bridge support made? Because wet concrete flows, how did people get it to hold the needed shape until it hardened? To make the support strong, what was added to the concrete?

____

____

____

3. Can you see the railroad bridge supports in the middle of the creek and on the other side? Why do you think they have the shape and orientation in the stream that they do? How heavy do you think the train was? As heavy as a car? A school bus?

____

STOP 2--Conglomerate

4. A nickname for this kind of rock is pudding stone. Can you think of a reason why?

5. How do you imagine this big formation of rocks got here? Were the rock pieces brought here by Penitencia Creek?

6. By looking carefully at the formation you can figure out something about its history.

    a. Which is older, the conglomerate or the rocks within it?

    b. How can you tell that the rocks that make up the conglomerate have been moved by water?

    c. Are the sediments well-sorted or poorly-sorted by size? What does the kind of sorting tell you about how the sediments were deposited?

7. Can you see evidence of what has happened to the formation on its journey? Which of the following clues can you pick out: fractures within the formation, individual rocks that have been fractured, a rock that has been fractured and recemented? Circle the ones you were able to find.

8. In what ways is this conglomerate formation like the bridge support?

____

STOP 3a--Conglomerate Boulder

9. Circle the sizes and types of rocks you were able to find within the conglomerate: cobbles, pebbles, granite-like rocks, quartz (grayish white with visible crystals), different colors of chert (chemically the same as quartz but with microscopic crystals), dark volcanic rocks (with large crystals in a groundmass of small crystals--porphyry).

10. How many different kinds of loose rock from the ground can you match with a rock in the conglomerate boulder?

____

11. What is the material surrounding the small rocks in the conglomerate? Use a magnifier and your fingers to find out.

____

12. Why do some of the rocks have a rust coloring?

____

STOP 3b--1909 PENITENCIA CREEK BRIDGE

13. Examine the rocks that make up the bridge. Can you find two rocks that are the same? Do you recognize any of the rocks?

____

14. Touch a rock with fossils in it. Of what animal do the fossils appear to be?

____

15. What rocks were used for the capstones of the corner posts? Why?

____

____

16. How many different colors of lichen can you find growing on the bridge? Are they affecting the rocks in any way?

____

17. When was the United States Geologic Survey (USGS) bench mark installed? What is the elevation above sea level? What do you think bench marks are for?

____

____

18. Look over the bridge railing to the downstream side. What do you notice?

____

____

STOP 4--PENITENCIA CREEK

19. Were there some features of this place that you became aware of by their sound? Why did the water sound louder at some places?

____

____

20. What does the channel look like?

    a. How does it compare to the ones you formed on your stream tables?

    ____

    b. Is the channel narrow and steep?______________________

    c. Do you see meanders?______________________________

    d. Does the slope appear to be steep, flat, or moderate? (Circle one)

    e. Does it look like a little Grand Canyon, a miniature lower Mississippi River, or neither one? (Circle one.)

21. Where on the bank is erosion occurring? What is happening to some tree roots? Where are sediments being deposited?

____

____

____

22. Notice the large boulders in the stream:

a. Could a person easily move these boulders? ______________

b. How could a little stream like Penitencia Creek move such large boulders?

____

c. Circle the names of the rock types that you see: conglomerate, chert, sandstone with clam fossils, opalized serpentinite.

d. Test the white veins in the serpentinite and the chert with dilute acid to see if they are quartz or calcite. Which are they?

____

23. Locate a pool, a riffle, and a run.

a.. What caused the pools to form?
Increased velocity of the water on the outside of curves?__________

The piling up of water behind boulders, logs, or wads of roots?

____

The scouring action of water cascading over obstacles? __________

b Can you see the gravel beneath the riffles? ______________

c. Can you tell where any of the features are by the sound? Which ones?

____

d. Where does the water run faster? Where does it run slower?

____

24. Can you guess why the different sizes of sediment were dropped in the places they are found?

____

CREEK TRAIL

25. As you walk along the creek trail look for the stream features you have learned about. Circle the ones you see as you pass them on the Creek Trail: meanders, bank erosion, streamside tree root erosion, bars on the inside of meanders, island bars, pools, riffles, runs, boulders, cobbles, pebbles, gravel, sand, silt/clay.

26. Observe the large pieces of concrete in the stream. Where are they from? Did the creek erode them? Can you locate the route of the railroad?

____

27. Are you able to find other erosional features such as exposed tree roots and "Badlands topography" on the surface of the conglomerate to your right? What observations can you make about these features?

____

____

28. What native plants do you see along this trail?

____

STOP 6--QUAIL HOLLOW

29. As you enter this picnic area you will see that trees not native to San Jose such as the Coast redwood and various fruit trees have been planted here. Why might people plant them?

____

30. Examine the bridge here. How has the bridge been built to protect it from floods? What is the problem with this design?

____

THE ALUM ROCK

31. Why does the canyon narrow at the Alum Rock?

32. Why does the canyon widen again above the Alum Rock?

33. About 0.1 mile up the road going in an upstream direction from the Alum Rock notice a more modern attempt than concrete walls to control erosion of the creek bank. Why might this structure of wire cages containing rocks built in a step-like configuration (a gabion) work better than the concrete walls?

STOP 8--MINERAL SPRINGS TRAIL

34. What do you notice about the width of the canyon here? What does this mean? What else is different about this formation of rock?

35. What unusual feature do you notice about many of the boulders in the creek and in the walls and bridges? Where have you seen rocks like these already? From where might these rocks have come? Where were they formed originally?

36. Observe the concrete walls that line the creek. What is happening to the bottom of the walls? Why? Why did people build these walls?

____

____

37. What are the large lumpy formations along the stream bank? How did they form?

____

MINERAL SPRINGS OF ALUM ROCK PARK

This module is designed to help students compare and contrast the mineral springs in Alum Rock Park based on their water characteristics, minerals deposits, and the forms of life found in and around them.

The BACKGROUND INFORMATION section contains material on the geologic nature of the mineral springs, their history, and the life forms associated with the springs, as well as the causes of folding and faulting of the land in this area.

The CLASSROOM ACTIVITIES section contains seven lessons, the completion of which will make the park visit much more meaningful. "Layers in the Earth", "Why do the Plates Move?", "Folded Layers", and "Faulted Layers" provide a foundation for understanding plate tectonics and its impact on the Alum Rock Park area. "Mineral Water" and "Mineral Deposits" make the basic observations of mineral springs understandable. "The pH of Common Substances" provides needed experiences for comparison with the measurements to be taken of the park springs

The FIELD TRIP PLAN guides students to make observations of and collect data on water characteristics, mineral deposits, and life forms of the springs. They are then asked to look for patterns in their data that might reflect the interaction of these various aspects of the mineral springs.

BACKGROUND INFORMATION

MINERAL SPRINGS OF ALUM ROCK PARK

PRE-TRIP ARRANGEMENT

Arrange to have the Visitors' Center open. Phone number: (408) 277-4539

PURPOSE

1. Observe and gain an appreciation for an unusual geologic mineral deposit.
2. Compare and contrast the variations in the springs and the life forms that exist in and around them (Fig. 1).

CONNECTIONS TO THE SCIENCE FRAMEWORK:

Themes: Systems and Interactions; Scale and Structure

Process Skills: observing; communicating, comparing and contrasting; inferring

Integration With Other Areas: creative writing (imagining what it would be like to be a small creature living among the spring deposits), math

GRADE LEVEL: upper elementary, middle school

TIME: 2 hours

GROUPING

Divide the class into groups of five for younger students and six for older students. The jobs should rotate among the students so that everyone does each job. These roles could be modified to fit the needs of the class.

1. Observer of colors, odors, and mineral deposits
2. Temperature taker
3. pH measurer
4. Conductivity tester
5. Living things observer
6. Recorder (For younger students, an adult needs to record)

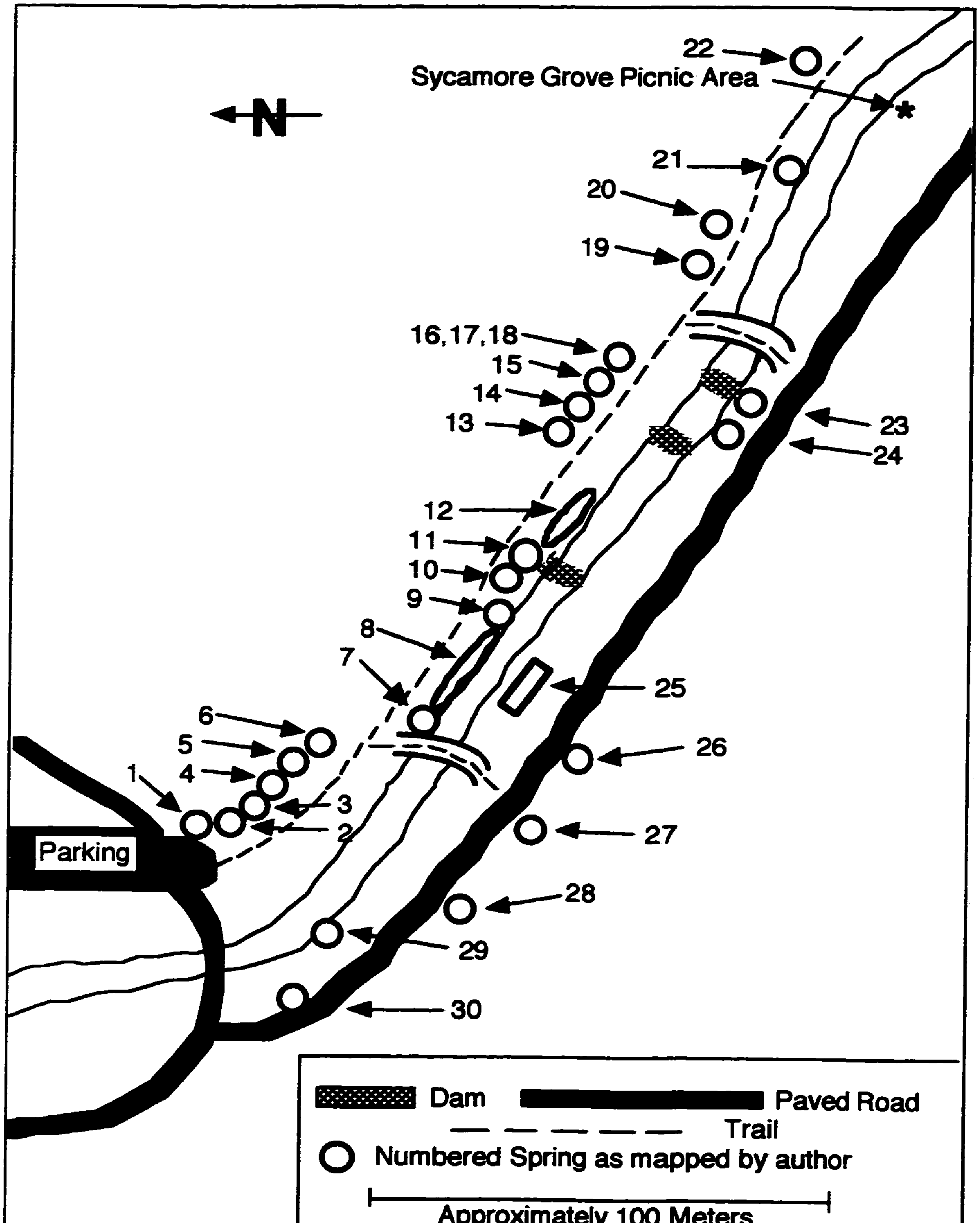

Figure 1. Map of Alum Rock Park Mineral Springs

MATERIALS

For teacher

To prepare a 3% N solution of HCL, you will need 12N concentrated HCl. Add 1 part acid to 3 parts water, pouring the acid into the water.

- 12N concentrated HCl (Sc. Kit 82240-03) or obtain from a high school science department
- 1 dropping bottle (Sc. Kit 68593-02)
- at least 3 pieces of felt or paper of 2 colors--to demonstrate folded layers
- paper model of bend in the San Andreas fault (photocopy Figure 1, Field Trip Plan section)
- scissors to cut paper model
- 1 spray bottle of water
- Mineral Springs Map (photocopy Figure. 1)

For Class

- watch or stop watch
- soft pencil and paper for rubbing of bench mark
- pH test kit (Hach 1470-11) or pH meter (Sc.Kit 46124-0, Forestry 76235) or borrow from BAESI (see Appendix E) to be rotated among the groups unless students will be using pH test paper
- conductivity meter (Forestry 76079) or borrow from BAESI (see Appendix E) to be rotated among the groups
- microscope with mirror with 400x magnification for viewing filamentous bacteria (optional) (Carolina D8-59-1176).

For Groups of five or six

- magnifiers--10x recommended--(Sc.Kit 62367)
- insect boxes or small plastic containers (Acorn T-111)
- pipettes for putting aquatic life into viewers (Acorn T-6247)
- narrow range pH paper (Forestry 78105 or Sc.Kit 66627)
- immersible thermometers (Forestry 77141)
- clipboard
- recording sheet and pencil
- Copies of Chart 1, Chart 2, Chart 3 (Field Trip Plan section) photocopy ahead

LESSONS TO DO BEFORE YOU COME: "Layers of the Earth", "Why Do the Plates Move?", "Folded Layers", "Faulted Layers", "Mineral Water", "Mineral Deposits"

OTHER STUDENT PREPARATION: If you plan to have students take the temperature, pH, and conductivity of the springs, have them practice doing these tasks beforehand.

GEOLOGIC BACKGROUND

Mineral Springs

As rain water falls and moves along the ground surface or underground, it comes into contact with carbon dioxide and dissolves it, forming weak solutions of carbonic acid. This acid then dissolves minerals in the rocks, and they become part of the water too. As the rotten egg smell will tell you, the mineral sulfur is present in the water of many of the springs. Other minerals and elements that have been detected include calcium carbonate, sodium chloride, magnesium, and iron (Berkstresser, 1968).

When water evaporates, mineral deposits are left behind. Calcium carbonate (calcite), a mineral often present in rocks, is easily dissolved by carbonic acid. Underground, where the pressure is greater, more carbon dioxide dissolves in the water, so the calcium carbonate in the rocks dissolves faster than at the surface. When the water emerges from the ground at a spring, it is under less pressure and some of the carbon dioxide goes back into the atmosphere leaving deposits of calcium carbonate behind. If the deposits are massive, layered, and finely crystalline, they are called **travertine**; if spongy and porous, **tufa**. Sometimes the formations produced are like those formed in limestone caves except they are on a miniature scale. When water runs over a wall, a drapery-like **flowstone** formation forms. If water drips from the top of a spring, icicle-like pendants, called **stalactites**, are slowly created. Hollow at first , they are nick-named "soda straws"; subsequently the hollow parts fill in and the stalactites grow outward. Evaporation of water from the puddles below the dripping stalactites leaves behind mound-like deposits called **stalagmites**. If the two formations connect, they make **columns** (Fig. 2). Two mnemonic devices can be used to help the learner differentiate between these dripstone formations: 1) stalac**tites** must hold "tite" to the ceiling so they don't fall, and stalag**mites** "mite" grow up from the ground if they try; 2) stala**c**tite contains a "c" for ceiling and stala**g**mite contains a "g" for **g**round.

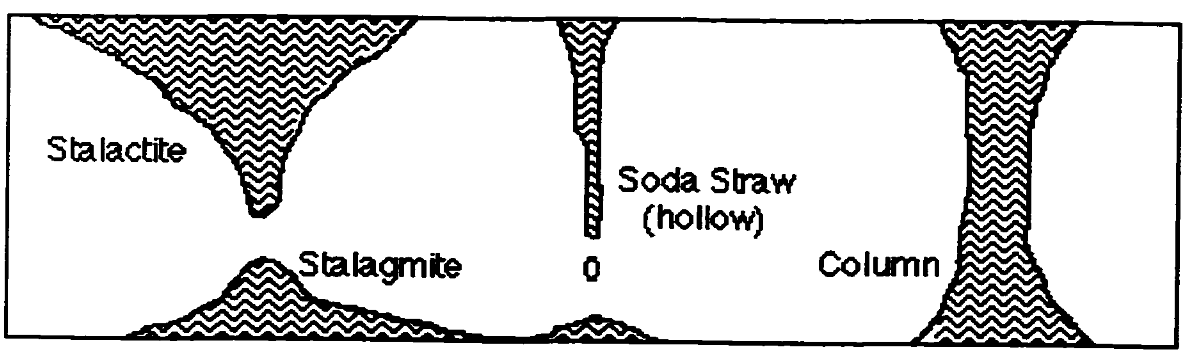

Figure 2. Cave deposits.

The water in the springs is warm, from 20°-30°C. (70°-80°F.), although one spring has been reported to be 98°F. (San Jose Mercury, 1896) **Hot springs** are those with temperatures over that of the human body (37°C/98° F.). The water is most likely heated when it travels deep in the earth through the greatly folded layers (Fig. 3). Another possibility is the presence of magma at depth (Hartesveldt and Harvey, 1972).

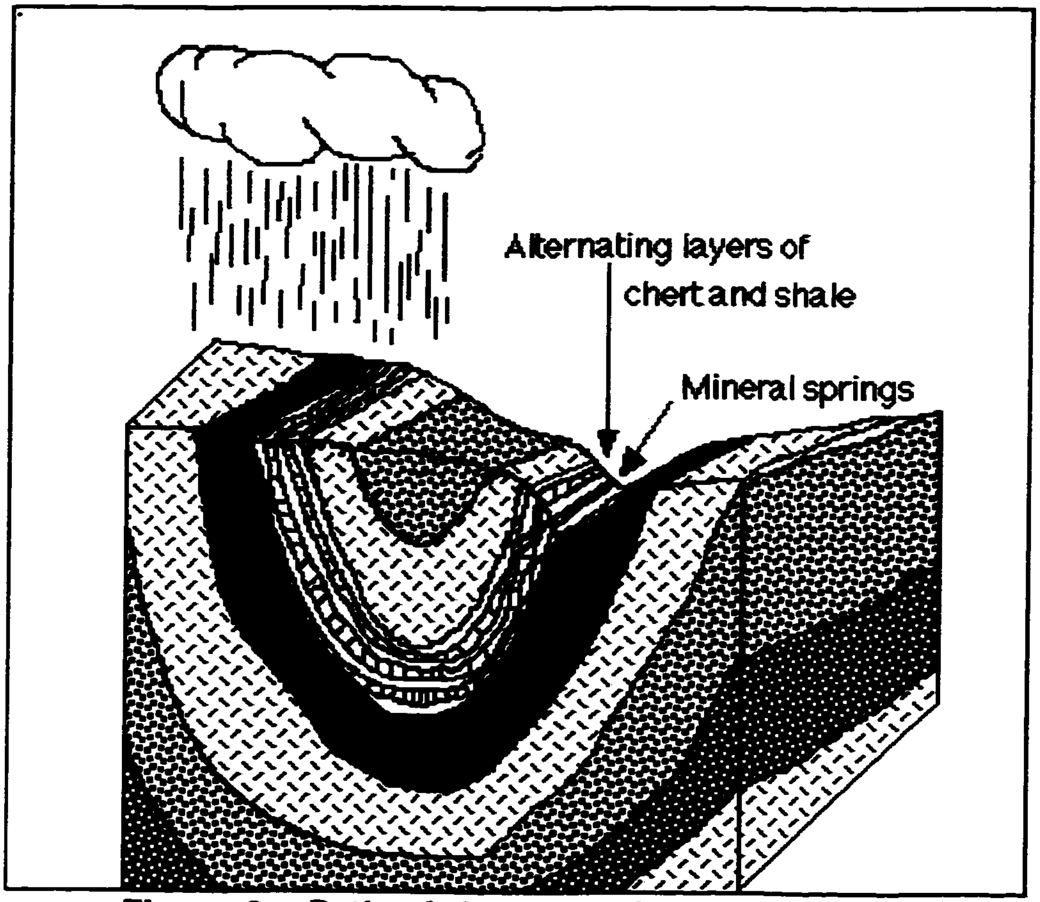

Figure 3. Path of the mineral springs water.

Plate Tectonics

The Coast Ranges, which began to rise 3 to 4 million years ago, are the product of the interaction of the Pacific Plate with the North American Plate. The **transform** boundary where the plates meet has a world famous name: the San Andreas fault. For the most part these two parallel plates slide past each other in opposite directions, in a **right lateral motion**; horizontal faults like this are called **lateral** or **strike-slip** faults Where bends occur in this type of plate boundary, however, the motion becomes more complicated. The motion along the San Andreas fault is right-lateral in some places; in other places the two plates push into each other, causing folding and uplift. The result is the Coast Ranges (Harden,1998).

Fault boundaries are not narrow lines as they appear to be on maps; they are really zones of faulting. The San Andreas fault is a fault system made up of many fault zones, including the **Hayward fault zone** and the **Calaveras fault zone**, which run close to or within Alum Rock Park (Fig. 4). It is natural then that people say, "Where is the 'Alum Rock Fault'? Show me!"

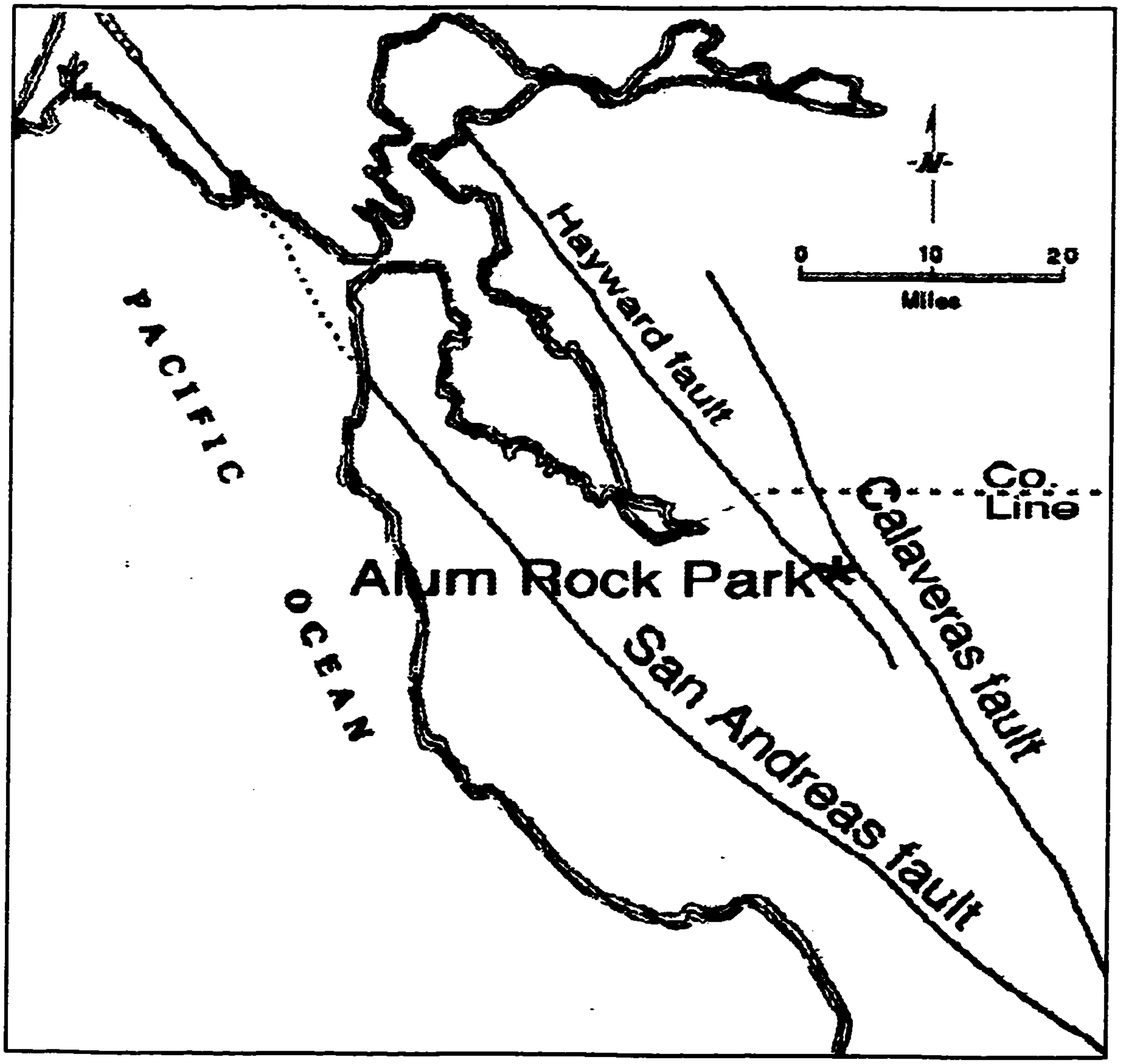

Figure 4. Map of the San Francisco Bay area showing faults that make up the San Andreas fault system. (Modified from Wagner, CALIFORNIA GEOLOGY, November, 1990, page 243, California Department of Conservation.)

There is no "Alum Rock fault" as such, so you will not see it in Alum Rock Park. Features that people have labeled "the fault" over the years are actually erosional ones. There is evidence, however, that geologists have used to delineate fault traces in and around the park (Fig. 5 and Fig. 6).

Since 1950, three geologists have made extensive geologic studies in the areas that included Alum Rock Park: Max Crittenden in 1951, Thomas Dibblee in 1973, and John Coyle in 1984. Crittenden, whose doctoral thesis research was published as the *Division of Mines Bulletin 157*, observed the Hayward fault zone north of the Santa Clara County line (Fig. 4); south of the line, Crittenden's view was that the fault died out or disappeared under the Santa Clara Valley sediments.

Dibblee, who mapped dozens of quadrangles for the United States Geologic Survey (USGS),depicted Alum Rock Park on his Calaveras Reservoir Quadrangle. He showed the Hayward fault trace, although uncertain and partially hidden, running through Alum Rock Park in a northwesterly trend one hundred meters west of the mineral springs area and ending at Penitencia Creek (Fig. 5).

Coyle, partially in an effort to resolve this and other conflicting geologic information, reviewed many of the previous studies and conducted his own field investigations for his San Jose State University master's thesis. Although he used Dibblee's fault trace on his thesis map, he concluded that because of the lack of visible surface features and low seismiscity, the Hayward fault dies out in Alum Rock Park (1984). Although a revised Calaveras Reservoir Quadrangle Special Zone Map (1982) showing the Hayward fault trace crossing Penitencia Creek and turning south was issued before Coyle completed his work, Coyle's view was that the fault does not cross Penitencia Creek (oral communication, November 26, 1996).

In the 1990's geologist, Russell Graymer of the USGS, has continued researching faults in the Bay Area. He believes that this fault does continue through the park, however, he calls it the Warm Springs fault, not the Hayward fault.

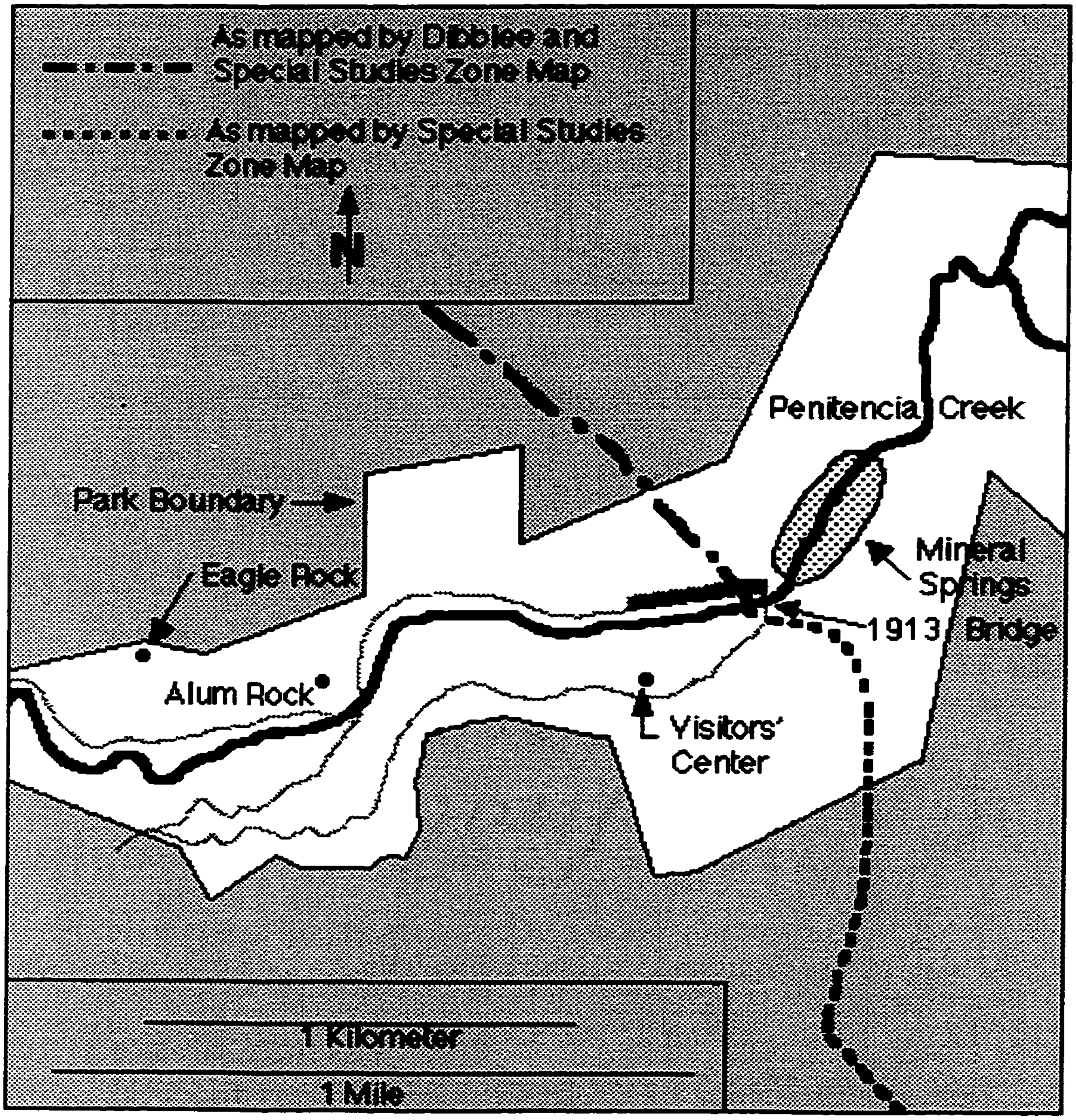

Figure 5. Possible traces of the Hayward fault in Alum Rock Park as mapped by Dibble and as shown on the Special Studies Zone Map. (Sources: Dibblee, 1973; State of California 1982; San Jose Regional Parks, no date, Alum Rock brochure.)

Other geologists think that the story is more complicated in that motion on the Hayward fault is transferred east to the Calaveras fault zone by some linking fault. Bennison and others (1991) suggest that the slip on the Hayward fault is transferred to the Calaveras by a complex system of faults including the Silver Creek fault (Fig 6.). However, most geologists consider the Silver Creek fault to be a **thrust fault** and an unlikely candidate to carry the Hayward fault motion. A more likely possibility as a linking fault, is the Mission fault located northeast of San Jose (Andrews et al., 1992) (Fig. 6). No wonder that there are so many versions of the "Alum Rock" fault!

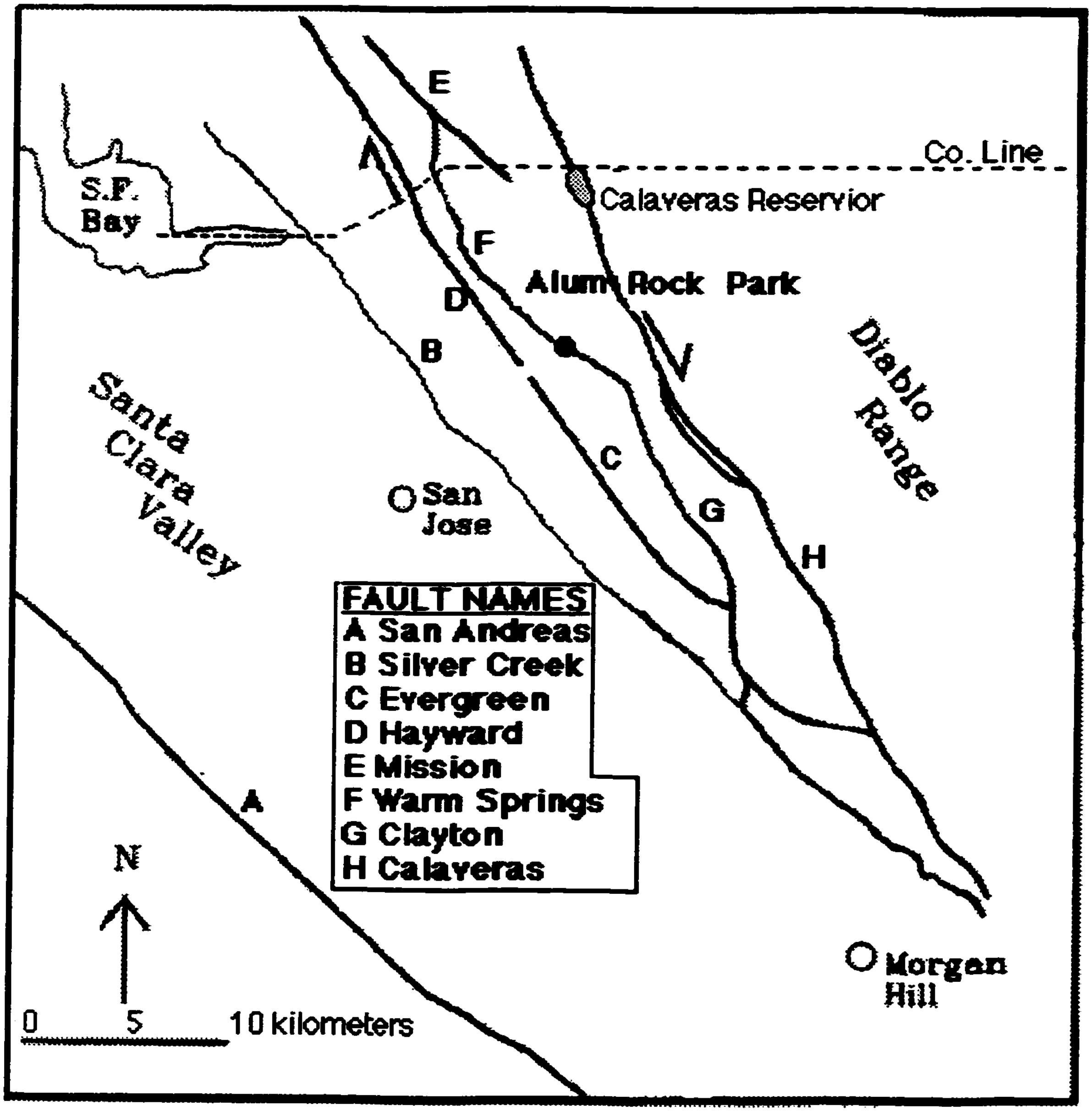

Figure 6. Generalized fault map of the Alum Rock Park area including the fault traces mentioned in the text as possible continuations of the Hayward fault. (Modified from Graymer, 1995.)

Other faults, also part of this large fault system and about which there is little agreement, may be located in the park as well. Much of the evidence showing where the faults lie has been covered by debris from many landslides in this region. Trenching, so as to look at the underlying rocks, is probably the only way to resolve this difficult puzzle.

Although there is currently no agreement on the exact location of the faults within Alum Rock Park, the compression caused by the meeting of the Pacific and North American Plates can easily be seen. The folding of sedimentary layers is visible at the east end of the parking lot located at the start of the Mineral Springs Walk. These shale and chert layers of the rock group known as the Claremont **Formation** (Fig. 7) appear to be greatly compressed, stressed, and tortured indicating the great force of tectonic activity.

HISTORIC BACKGROUND

Although Alum Rock Park was founded in 1872, its greatest popularity was from 1890 to 1932 when it was known nationally as a health spa with over 20 mineral springs (Douglas, 1993). Many of the springs were enclosed by stone grottoes and fonts where visitors could obtain water to drink, for medicinal reasons, or for pleasure. Water was also piped to the-no-longer-existing bath houses. The natatorium (indoor swimming pool) featured a warm sulfur bath. Until fairly recently visitors could still sample the sulfur and soda waters at the fountain across from the Youth Science Institute. Since the water is not being tested for coliform bacteria or harmful elements, drinking the spring water is no longer recommended.

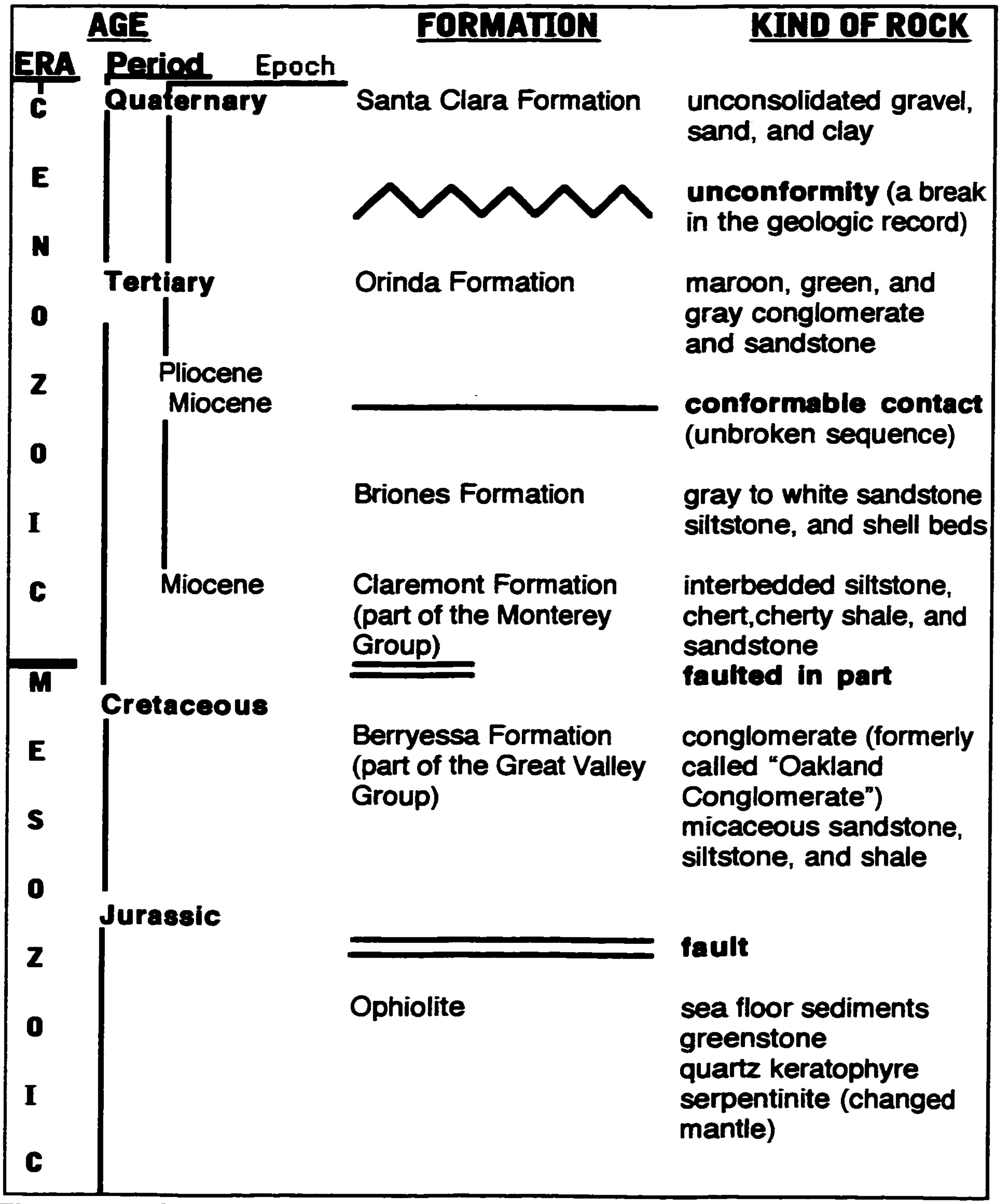

Figure 7. Schematic stratigraphic column depicting the general relationships of the rock units found in Alum Rock Park. (Sources: Graymer, oral communication, July 30, 1996 and Graymer, 1995.)

BIOLOGIC BACKGROUND

Bacteria

Strange as it may seem, some forms of life thrive in these mineral springs. Students have perhaps heard of recently-discovered bacteria that live near deep ocean thermal vents and are able to obtain energy from inorganic materials, such as sulfur. These bacteria are the basis for the deep ocean food chains where light-dependent organisms cannot live. A metabolically similar bacterium, a white filamentous form called ***Beggiatoa***, occurs here in the sulfur springs. Beggiatoa convert hydrogen sulfide in the water into energy and use carbon dioxide to make cell mass. Resultant sulfur is stored inside the bacteria in the form of granules which can be seen with a 400x microscope (Fig. 8). These life forms are able to move by gliding, but how they do so is not known. (Brock and Madigan, 1991).

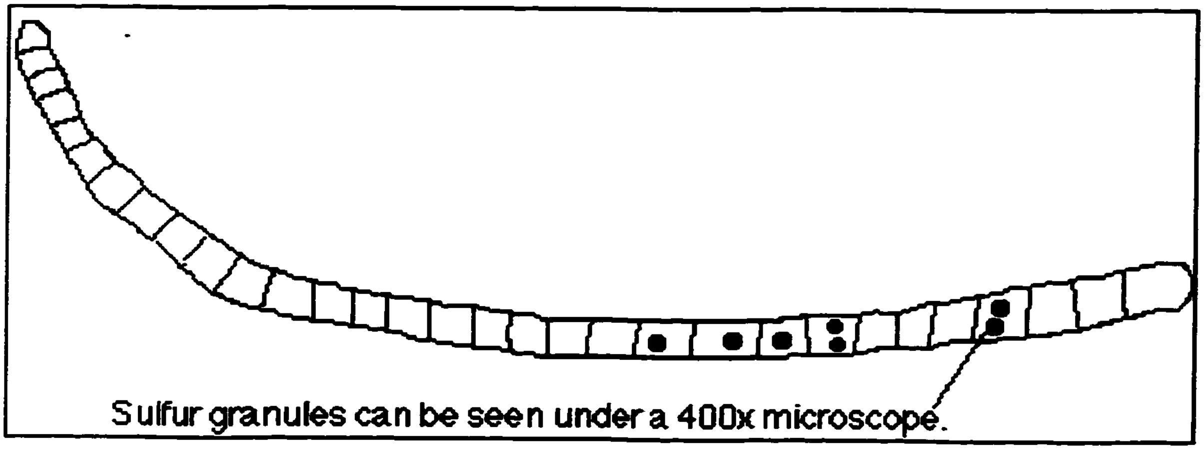

Figure 8. *Beggiatoa*, white filamentous bacteria, live on sulfur.

Students are likely to notice the filamentous, photosynthetic **cyanobacteria** (blue-green algae). These organisms have more primitive cell-structures than do the more commonly-observed green algae. Although not often familiar to students, cyanobacteria were responsible for a profound change on Earth two billion years ago. The oxygen-rich atmosphere that their photosynthetic activities created, made it possible for the evolution of today's oxygen-dependent life forms (Margulis and Schwartz, 1998). A common example here is **Oscillatoria**. This microbe derives its name from its fascinating movement (oscillation) that it can use to climb up the side of a container. (When you visit the park, use a plastic spoon to put a small sample in a plastic cup and watch it slowly creep up the side; then return the sample to the spring.)

Several other types of bacteria also reside in the vicinity of the springs. Look for purple **anaerobic** (not needing oxygen), photosynthetic bacteria. The rust-colored areas where iron is apparently being oxidized, could result from the action of bacteria that use iron to make energy or perhaps is caused by a chemical reaction between the iron in the rocks and the air. Microscopic observation of the rust-like material did not reveal the presence of cells, only amorphous masses, so microbial oxidation as a source of the "rust" is speculative at this time (Patricia Grilione, oral communication, January 8, 1999).

Scientists are becoming increasingly interested in studying places like the mineral springs area in Alum Rock Park, where conditions are analogous to those that might once have existed on Mars. The forms of life that occur in the springs are similar to early organisms on Earth and perhaps to those on other planets.

Besides bacteria, other forms of life flourish in this seemingly inhospitable environment. Small crustaceans called **ostracods** speed about like little motor boats in some mineral spring pools. Mosquito larvae and some **syrphid fly** larvae are able to survive in the mineral waters as both are equipped with siphons to obtain oxygen from the air. These syrphid fly larvae are called **rattailed maggots** because their siphons look like rat tails. **Black fly** larvae that inch along like measuring worms can be found in some springs. Yellow jackets, black flies, crane flies, and mosquitoes hover close to the spring water, while spiders prey upon all. These invertebrates are pictured on Chart 1 in the Field Trip Plan.

WATER QUALITY BACKGROUND

pH

A pH test is a measure of how **acidic** or **basic** a substance is. The term pH comes from the French phrase "puissance' Hydrogen", the potential of hydrogen. The test actually measures the concentration of hydrogen ions in a substance on a scale from 0 to 14. Distilled water, which is considered to be **neutral**, has a pH of 7. Acidic substances have pH values from 0 to 6.9; lemon juice, for example, has a pH of 2. Basic materials have pH values between 7.1 and 14; ammonia has a pH around 11. The farther from neutral the reading, the stronger the acidic or basic quality is. Because the pH scale is logarithmic, each whole number increase is a ten-fold change. Therefore, a lake with a pH of 4 is ten times as acidic as one with a pH of 5.

Water in the environment comes into contact with many things that cause its pH to change from a neutral 7. Water in the San Francisco Bay Area tends to be basic because the cementing material in the underlying sandstone is lime, a basic substance (Jerry Smith, oral communication, September 18, 1995). Additionally, contact with plants and animals, as well as artificial substances can cause pH levels to change. Maple leaves, for example, are basic, while conifer needles are acidic. Bacteria, breaking down plant matter such as fallen leaves, produce acids in the process. Most life forms have adapted to a narrow range of pH and will die if this changes even slightly. (see Chart 2 in Field Trip Plan for pH tolerance levels)) The concentrations of other substances in water may change to a more toxic form if the pH changes. Fish gills, especially in young fish, are very susceptible to damage from heavy metals released by acidic water.

Measuring pH with test paper is easy and inexpensive to do. For the activities presented here, narrow range papers that measure pH to the nearest .5 or a pH meter is needed. Test kits (available from aquarium, pool or scientific supply companies) work well for most uses but do not show the slight variations occurring at the mineral springs.

Temperature

Temperature is the average energy of motion of the molecules of a substance. It is measured in degrees **Celsius** (C) or degrees **Fahrenheit** (F) Water freezes at 0°C and boils at 100°C; it freezes at 32°F and boils at 212°F. (see Table 1 to convert from one scale to the other.)

$$°C = \frac{(°F - 32.0)}{1.80}$$

$$°F = (°C \times 1.80) + 32.0)$$

Table 1. Temperature conversion equations.

Water temperature depends on many factors: the amount of sunlight with daily and seasonal variations, the air temperature, the amount of shade, the velocity of the water (faster is cooler), the depth of the water (deeper is cooler), the inflow of both ground and surface water and the turbidity because suspended particles absorb heat.

Water temperature is extremely important to aquatic life (see Chart 3 in the Field Trip Plan). It affects characteristics of the water and the functions of the organisms. Colder water is able to dissolve more oxygen than warmer water. An increase in temperature means an increase in the rate of photosynthesis in aquatic plants. As more plants grow, more plants die as well, and their decomposition by bacteria uses up oxygen in the water. Metabolic rates in aquatic life increase as the temperature increases; their life cycles occur more quickly. Activities such as reproduction and migration often depend on the water being a certain temperature. Higher temperatures can cause organisms to become more susceptible to diseases, parasites, and pollution effects.

To maintain consistency, use the same thermometer at each study site. If a small plastic-backed thermometer is used, glue it ahead of time to a tongue depressor for strength. Temperature probes and meters are expensive and not needed for these activities.

Conductivity

The ability of water to conduct electricity is called its conductivity. Dissolved solids in the water are the conductors. The **ions** often found in water include sodium (Na^{+}), calcium (Ca^{+2}), potassium (K^{+}), magnesium (Mg^{+2}), chloride (Cl^{-}), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO_3^{-}). These ions are derived by weathering of rocks and minerals and are able to conduct electricity because they are positively or negatively charged.

Most aquatic life can tolerate a range of conductivity, but sometimes the concentration of particular ions is critical. Dissolved solids regulate the flow of water into and out of the cells of organisms. If the conductivity level is too high, imbalances can occur with this water flow. Dissolved solid particles are also essential nutrients needed for aquatic organisms to grow and reproduce.

The conductivity of water depends partially on the rocks and soils it runs over in the watershed. Clay soils contain water soluble particles and so cause conductivity levels to be high. Increased temperatures causing evaporation of fresh water increase the concentration of ions, and thus the conductivity. Human activities raise conductivity levels when chemicals are spilled or dumped into bodies of water, fertilizers and runoff from urban streets enter storm drains, and when sewage systems fail allowing sewage water to enter streams.

Conductivity levels are measured with an electronic meter. This can perhaps be borrowed from a high school, especially if high school students are helping with your trip or from the Bay Area Earth Science Institute (BAESI) at San Jose State University (See Appendix E). Meters measure in millisiemens (mS) or in microsiemens (μS). Generally streams have conductivity levels that are fairly consistent with some seasonal change. Monitoring of a stream might be done to note unusual conductivity levels which could indicate a pollution problem. It is interesting to compare the various conductivity levels in the mineral springs. The typical conductivity level in the Guadalupe River during the 1996-1997 school year was .8-.9 millisiemens as measured by the Biosite Project at the Children's Discovery Museum in San Jose (Amity Sandage, oral communication, July,1997). Compare this number with the data you obtain from Penitencia Creek.

CLASSROOM ACTIVITIES

MINERAL SPRINGS OF ALUM ROCK PARK

ACTIVITY 1: LAYERS OF THE EARTH

Adapted From

NSTA/FEMA, 1988, "Plates Going Places" in *Earthquakes: A Teacher's Package for K-6*: National Science Teachers Association, Washington, D.C.

Objectives

Observe a model that depicts the layers of the Earth and its plates and evaluate how the model is like and how it is unlike the Earth.

Materials

For the teacher

- several hard boiled eggs
- small knife
- two markers, one broad and one narrow tipped

For each student

- student worksheet
- pencil
- colored markers, crayons or colored pencils

Procedure

1. Hard boil several eggs ahead of time. Color the outer shells with a broad marker.
2. Have students *draw a diagram of the Earth's layers and label them.*
3. Have the students predict what will happen when you tap the egg on a hard surface. Tap the egg until cracks are produced. Outline these cracks with the narrow tip marker to make them more visible.
4. Explain that students are going to look at the layers in the egg and compare them to layers in the Earth. *What in this model represents the* ***crust?*** (The crust, the relatively thin layer on which we live, is represented by the color of the shell.)
5. *What represents the* ***lithosphere****?* (The shell, which is now divided into plates, represents the lithosphere [the crust and the uppermost part of the **mantle**].) The lithosphere, being brittle, also cracks into plates; the cracks stand for the plate boundaries (Fig. 1).

6. Now wet the knife and cut the egg in half lengthwise. Use the broad marker to make a colored circle in the center of the yolk (Fig.1).
7. Discuss the layers now made visible. *What represents the rest of the mantle?* (the egg white)
8. *What respresents the **outer core** and the **inner core**?* (The yolk is the outer core; the colored circle is the inner core. Both are believed to be made of iron and nickel. The outer core is molten, while the inner core is solid.)

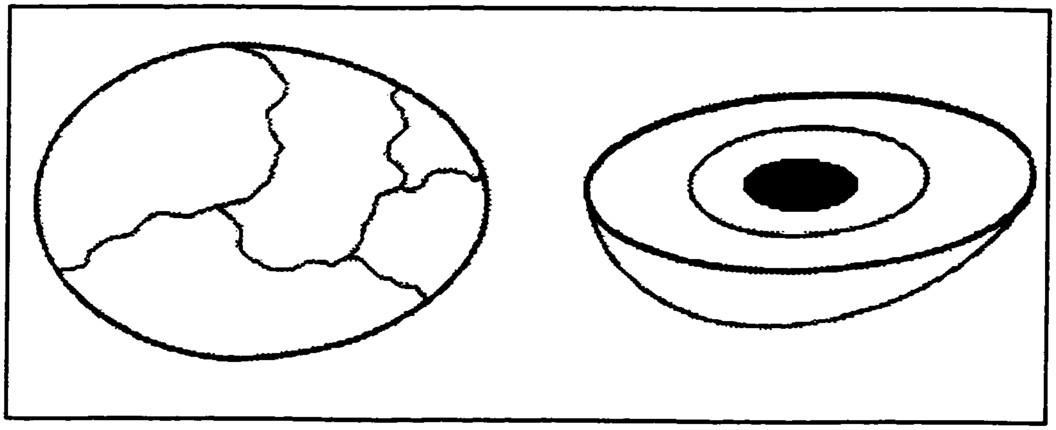

Figure 1. The cracked egg shell representing lithospheric plates and the hard boiled egg cross section representing the internal layers of the Earth.

9. *How is the egg model really like the Earth and how is it different?*

Ways the model is like the Earth:

a. The egg and the Earth are both composed of different layers.
b. The outer layers of both are brittle.
c. The layers under the brittle layers flow instead of break.

Ways the model is different from the Earth:

a. The plates of the Earth move slowly a few centimeters a year causing geologic events such as earthquakes and features like mountains; the eggs "plates" do not move.
b. The Earth has a solid inner core and a molten outer core: the egg has only one "core".
c. The relative thicknesses of the Earth's layers and the egg layers are different.
d. The Earth and the egg are made of different materials.
e. The Earth is not egg-shaped.

Teacher Notes

The radius of the Earth is 6370 kilometers (km). The thickness of the various layers (Fig. 2) is as follows:

Crust: oceanic 5-10 km; continental up to 100 km
Mantle: 2900 km
Outer core: 2200 km
Inner core: 1200 km (radius)

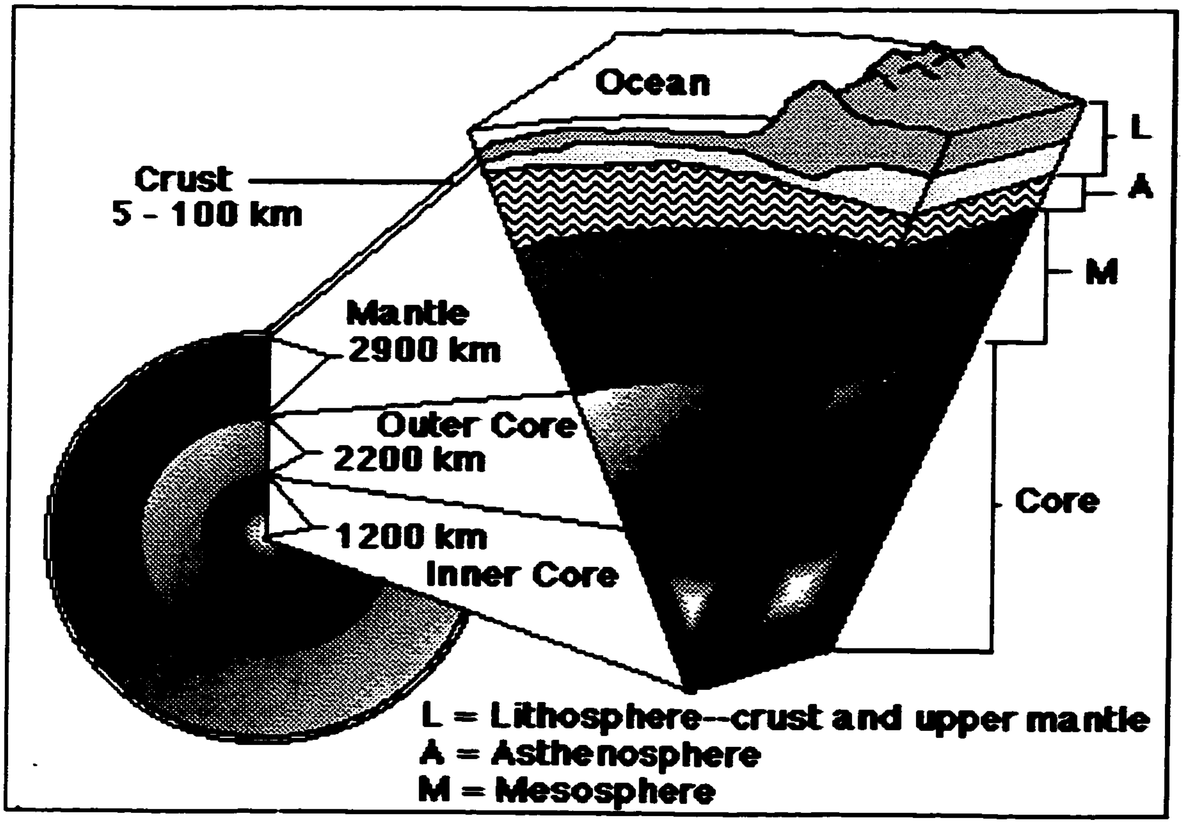

Figure 2. Cutaway view of the Earth's interior layers. (Source: Kious and Tilling, 1996.)

Relationship to Alum Rock Park

Alum Rock Park is located in the San Andreas fault zone along the boundary between the North American Plate and the Pacific Plate. Some of the park features exist because of its location in such a tectonically active area.

NAME________________________
DATE____________PERIOD_____

STUDENT WORKSHEET FOR ACTIVITY 1: LAYERS OF THE EARTH

1. Draw a diagram of the Earth's layers and label them.

2. In the egg model of the Earth, what part of the egg represents each Earth layer?

   the crust ____

   the lithosphere____

   the middle and lower mantle________________________________

   the outer core____

   the inner core____

3. How is the egg model really like the Earth and how is it different?

Ways the model is like the Earth:

1. ______________________________

2. ______________________________

3. ______________________________

Ways the model is different from the Earth:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

ACTIVITY 2: WHY DO THE PLATES MOVE?

Objectives

1. Investigate and observe how hot fluids rise and cold fluids sink, forming **convection currents.**
2. Demonstrate a possible cause for plate motion.

Materials

For the class

- hot plate or stove
- pan to heat water (water bath)
- 2 L container of crushed ice
- red food coloring

For groups of four or six

- colorless transparent vial, 30 X 50 mm (Sc.Kit 66879-05) fitted with a size 6 1/2 two-hole rubber stopper (Sc.Kit 62857-65)
- one 5 cm long, 6 mm diameter glass tube fitted in one of the stopper holes (Sc.Kit 61972-15)
- small plastic or paper cup
- scissors to make holes in the cup
- two piece spring clothes pin or clip to fasten cup to the large plastic container
- clear, rectangular container about 20 cm high and wide and 30 cm long (Sc.Kit 65777-03) or a 5 gal. aquarium
- blue food coloring
- student worksheets for each group member
- red and blue crayons, markers, or colored pencils

Procedure

1. Before class, fill one clear plastic vial for each group with red colored water. Stopper the vials and heat them.
2. Review the concept that the Earth's lithospheric plates are continually moving.
3. Have students fill their rectangular container with cool water (or have this done ahead of time).
4. Explain that they will be introducing a colored hot water source to the bottom of their large container and a different colored cold water source to the top. Ask them to predict how the water will move.
5. Have one student from each group get a small cup, make a few holes in the cup, and fill it with the crushed ice.
6. When they return to their group, they should clip the ice cup to one end of

the large container, so that the bottom of the cup is under the surface of the water.

7. As the teacher places a clear plastic vial with heated red-colored water at the opposite end of each large container, have a student add blue food coloring to the cup of ice (Fig. 1).

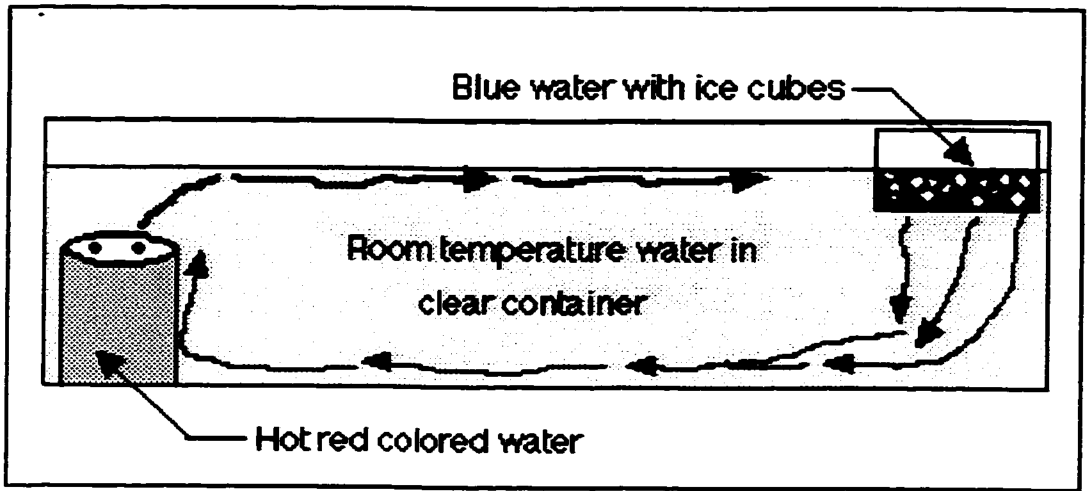

Figure 1. Convection cell set-up.

8. Students should immediately observe what is occurring and make their first drawings on the student worksheet. Drawings of the changes occurring should be made after one minute, two minutes, and five minutes.
9. This movement of material and heat energy is called a **convection current.** Ask students why the water moves the way it does.
10. Add some small pieces of paper to represent the lithospheric plates at the hot end. How are these like the Earth's plates? (They are moved by the circulation of material in the layer below.)

Teacher Notes

A convection current is formed because the hot water is less dense than the room temperature water around it and therefore rises. The ice water is more dense than the room temperature water in the container and sinks. As the cooler water reaches the vial, it is heated by the remaining hot water inside; it rises, pushing the previously heated water farther from the heat source. After a time the heated water, now away from the heat source, cools and becomes more dense, so it sinks. This heating and cooling causes a convection current to form. After a few minutes, the action stops as the whole system reaches the same temperature and the source of the hot water has been exhausted.

Most geologists think that convection currents in the mantle cause the plates to move.

Relationship to Alum Rock Park

To understand the features seen in Alum Rock Park such as the folded and tilted layers visible near the mineral springs and the uplifted keratophyres (Eagle Rock, Inspiration Point, and Alum Rock) the students need to be aware that the Earth is covered with lithospheric plates whose movement causes the geologic features we see.

NAME______________________
DATE___________PERIOD_____

STUDENT WORKSHEET FOR ACTIVITY 2: WHY DO THE PLATES MOVE?

Observe the convection current model and make four drawings of your observations.

Immediately

After one minute

After two minutes

After five minutes

ACTIVITY 3: FOLDED LAYERS

Adapted From

AIMS Education Foundation, 1987, "Peanut Butter and Jelly Geology" in *Overhead and Underfoot*, Fresno, CA.

Objectives

Observe models of sedimentary rock layers. Note that the oldest layer is on the bottom and that the layers which are originally horizontal may be folded and disrupted by natural forces.

Materials

For each group or pair of students:

- three slices of different kinds of bread, i.e. white, whole wheat, dark rye
- two things to spread on the bread, i.e. jelly, chunky peanut butter--two tablespoons of each
- several kinds of edible animals, i.e. gummy worms, fish, dinosaurs, etc. or *Dem Bones® Tart and Tangy Candies*
- a plastic knife
- a paper plate
- a worksheet for each student in the group
- pencil for each student

For the teacher:

- three or four strips of modeling clay, each a different color
- two wooden blocks

Procedure

1. If you are planning to have the students eat their experiment at the end, they should wash their hands before they touch the materials. There is a possibility that some students may be allergic to peanuts. Be sure that such students are clear about their allergic restrictions.
2. Have all of the groups place the same kind of bread on the paper plate, i.e., the dark rye and name it for a sedimentary rock that you may have studied, such as sandstone.
3. As the students continue to add layers, keep track of the order by recording on a diagram that all can see, so that they all build identical "sandwiches". Include the edible animals and bones, placing those that first appeared longer ago, such as the worms and fish in the lower layers, with the dinosaurs and mammals in the layers above (see Geologic Time Scale, Fig. 1).

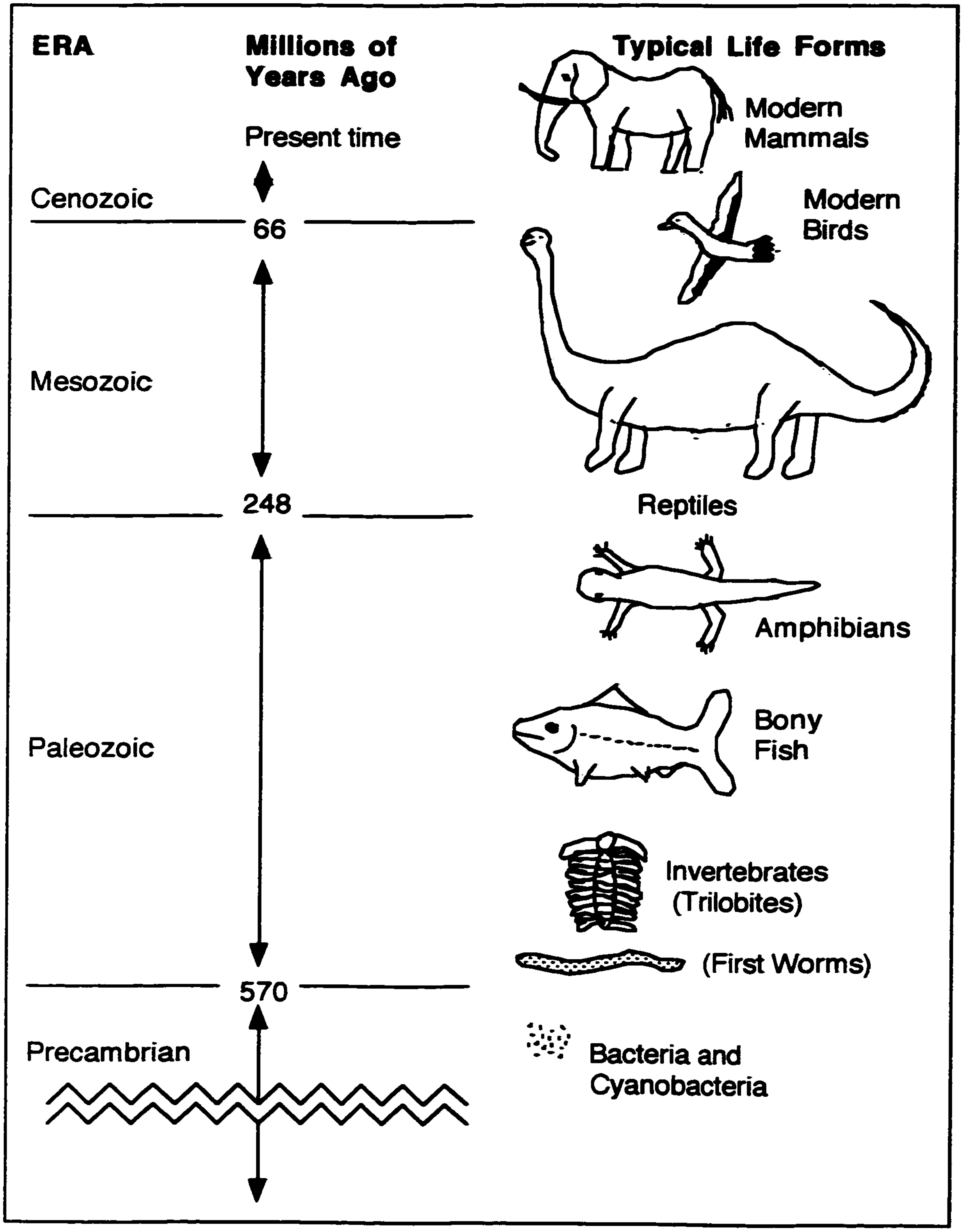

Figure 1. Simplified Geologic Time Scale. (Source: Pearse et al., 1987; Bailey and Seddon, 1995.)

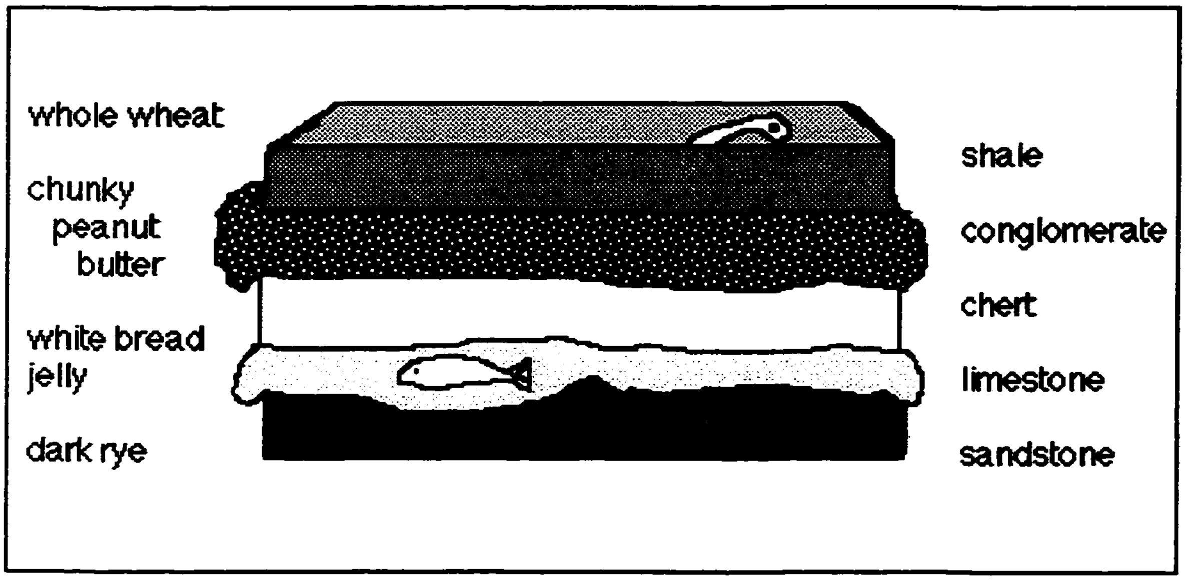

Figure 2. Sandwich model of sedimentary layers.

4. Students can continue naming the layers for rocks that they have studied. For example, the jelly could be limestone containing fossil worms, followed by the white bread (chert), then chunky peanut butter (conglomerate), with fish fossils, and the whole wheat bread containing dinosaur fossils (Fig. 2). *Draw a diagram of your model and label the layers.*
5. *Label the layers from the oldest one to the youngest one. How do you know which one is the oldest and which the youngest? Which "animals" must be the oldest then? Which must be the youngest?)*
6. Remind students of the "Why Do the Plates Move?" lesson and how forces within the Earth cause the plates to move. This movement may cause the layers to be pushed into folds. Have one partner bend the sandwich to form a hill; the other partner could then *draw and label the new position of the layers.* Next, have the partner who drew bend the sandwich layers to form a valley and the other partner *draw the layers.*
7. Finally, have the students tilt the entire sandwich on end to see how such a disruption would appear. *Draw how these layers appear when tilted on end. Can you find any of the fossils? Why is it difficult to tell the age of the fossils when the layers are in this position?*

8. The teacher could next explain that the following demonstration is more like the real process forming folded layers than bending them with hands. Have two students lay several strips of modeling clay of different colors on top of each other to represent various layers of rock. Instruct them to set a wooden block at each end, to represent colliding plates. When they push on the blocks to show two plates coming together, the clay folds into mountains and valleys (Fig. 3).

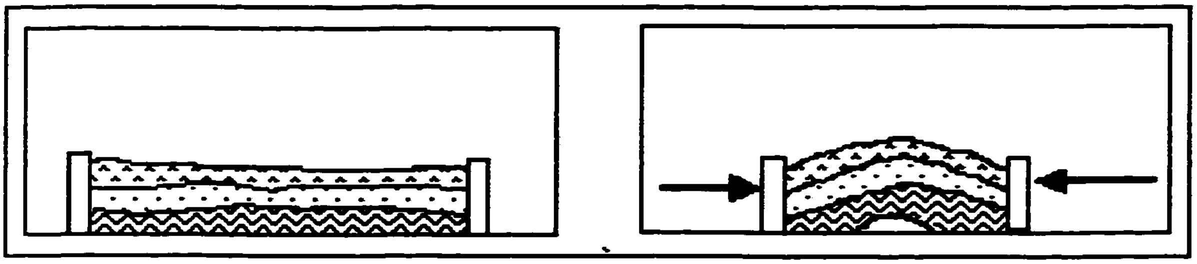

Figure 3. Compression causing rock layers to bend.

Teacher Notes

These activities demonstrate one of the oldest laws of geology, the **law of superposition,** which states that in an undeformed sequence of sedimentary rocks, each layer is older than the one above it and younger than the one below it. The bread that was laid down first is the oldest layer and the layers added above it are younger.

Sometimes layers are found in a horizontal position just as they were formed, but often they have been bent upward to form an upside down U shape (**anticline**) or downward to form a regular U shape (**syncline**) (Fig. 4). Be sure that students understand that <u>an anticline is not always a mountain and that a syncline is not always a valley</u> (Fig. 5).

Relationship to Alum Rock Park

On the north side of the mineral springs trail, folded layers are visible above the trail.

Look into Penitencia Creek in the mineral springs area to see layers that been tilted on end like the sandwich on its end. This is further evidence of rock influenced by natural forces.

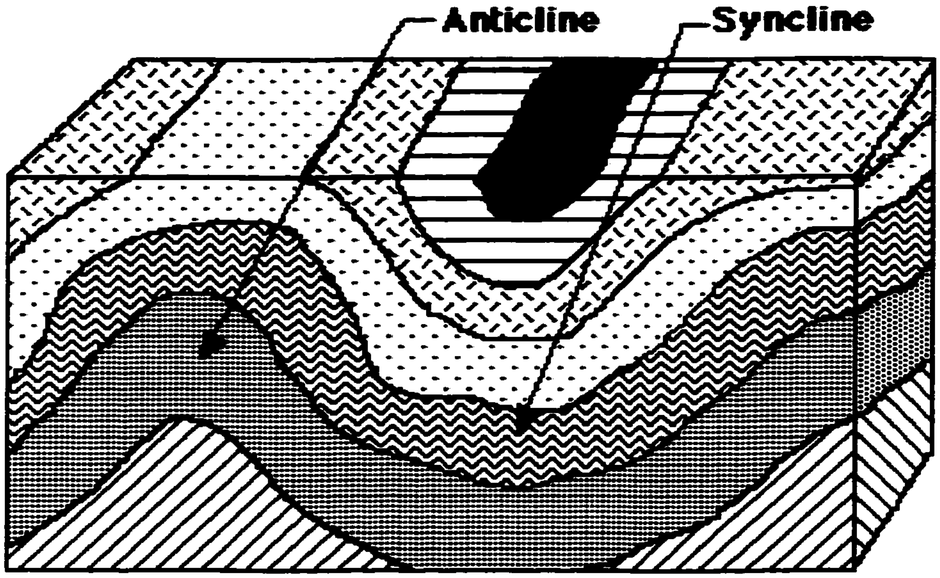

Figure 4. Anticlines and synclines are formed by the folding of horizontal layers.

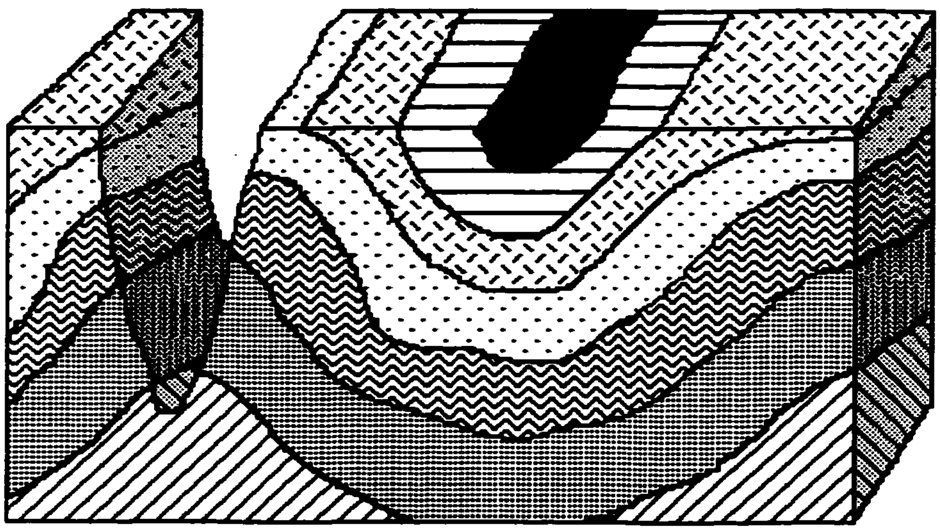

Figure 5. Erosion and deposition can cause anticlines to form valleys and synclines to form mountains.

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STUDENT WORKSHEET FOR ACTIVITY 3: FOLDED LAYERS

1. Draw a diagram of your model and label the layers.

2 Label the layers from the oldest one to the youngest one. How do you know which one is the oldest and which the youngest?

____

3. Which animals must be the oldest then? Which must be the youngest?

____

4. Draw your sandwich model in the "hill" position.

5. Draw your model in the "valley" position.

6. Draw the model when it is tilted on end. Can you find any of your "fossils"? Why is it difficult to tell the age of the fossils when the layers are in this position?

____

____

ACTIVITY 4: FAULTED LAYERS

This lesson could easily be done in conjunction with the "Folding Layers" lesson, as they both use the same materials. The folding activities should come before the faulting ones.

Objectives

Observe models of rock layers and see how they move in relation to each other when depicting the three main types of **faults**.

Materials

For each group or pair of students:

- material listed in Activity 3: "Folded Layers", with the exception of the candy

For the teacher:

- strip of wood about 30 cm long, 2 cm wide and up to 1 cm thick
- sink or basin large enough to hold the wood
- water to fill the basin
- two Big Hunk™ candy bars: one in freezer, one at room temperature
- wooden box of any size with thin base, cut into two pieces
- flour to fill the box
- flashlight

Procedure

1. Explain to students that under some conditions when rocks are being pushed together or pulled apart, they will break instead of bend. Gather the students around the basin which is filled almost to the top with water. Hold the strip of wood with one hand on each end, bending it until it breaks (Fig 1.).
2. Have the students describe the movement of the water. (jerky movement and waves moving out from where the wood broke)
3. This sudden, rapid movement of the water is caused by the release of energy that built up in the stick as it was bent. Energy similarly builds up in rocks when they are bent. When the rocks break and this energy is suddenly released, the Earth shakes like the water in the basin. This shaking is called an **earthquake**. The crack in the rock or soil along which movement has occurred is called a fault.
4. One factor that controls whether rocks bend or break is temperature. Demonstrate that when compressed, the warm candy bends. Remove the other bar from the freezer and apply the same force; it breaks.

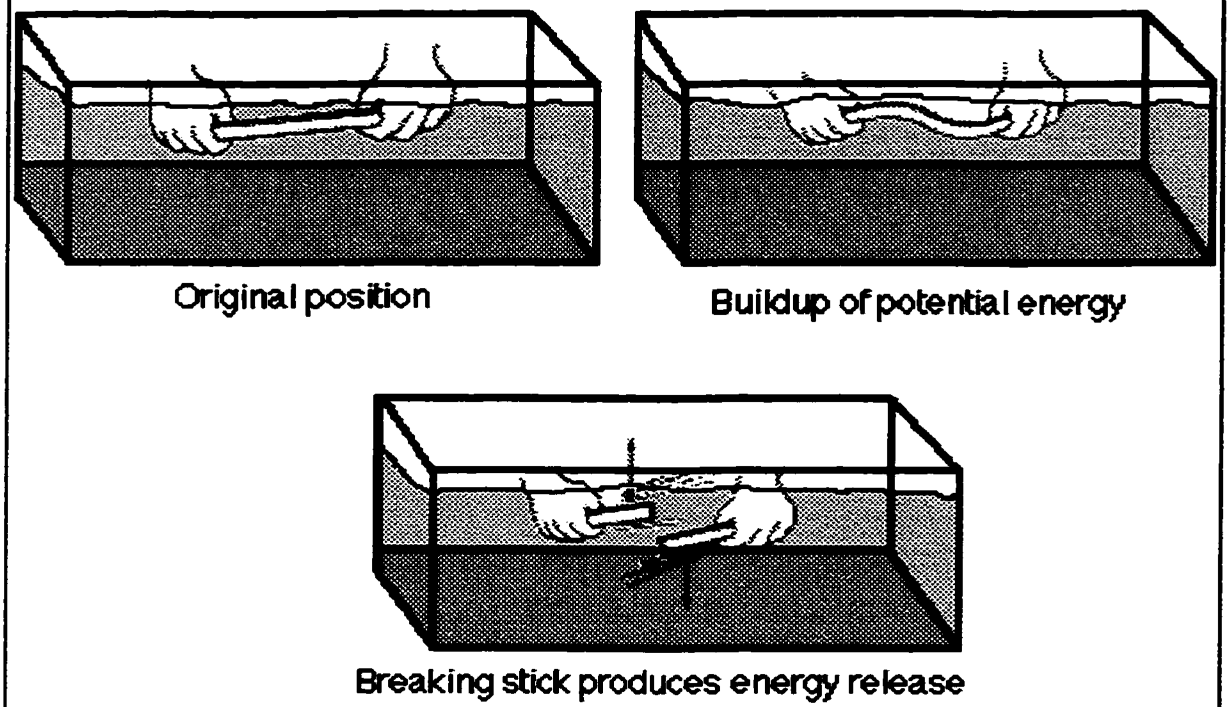

Figure 1. Model of the build up and transference of energy. (Modified from NSTA/FEMA, 1988.)

5. Have students make their hands into fists and press the flat edges of their fingers together. If they release the pressure and let one hand drop slightly, they are modeling a type of vertical fault that usually occurs where rocks are being pulled apart, a **normal fault** (Fig. 2). If they press more and force one hand to move up, they are showing a different type of vertical fault that happens where rocks are being compressed, a **reverse fault**.

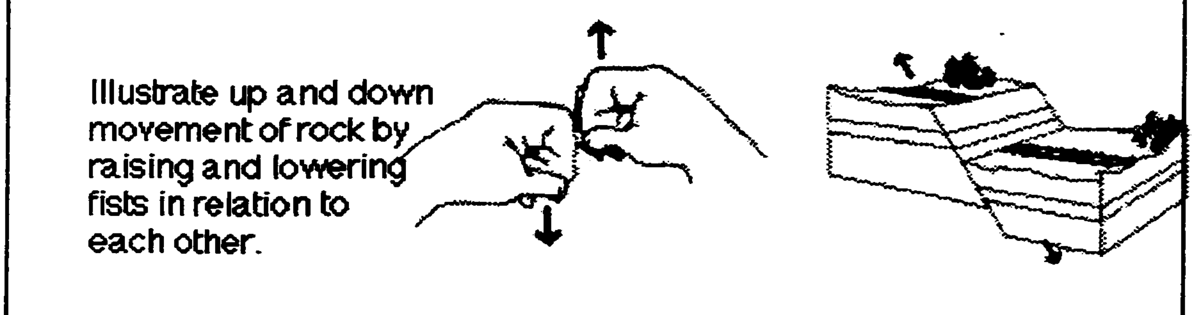

Figure 2. Vertical fault movement. (Source: NSTA/FEMA, 1988.)

Illustrate lateral sideways movement by sliding one hand next to the other.

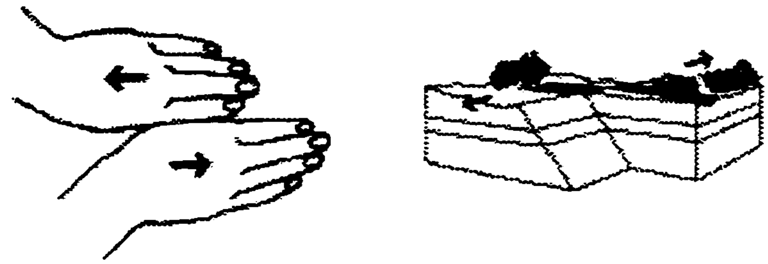

Figure 3. Lateral or strike-slip fault movement. (Source: NSTA/FEMA, 1988.)

6 Now, using open hands, have them press the edges of their hands together and slide one hand past the other; this is a **lateral** or **strike-slip fault** (Fig. 3).

7. Using the sandwich materials, have each group make a new sandwich and slice a fracture at about a 45° angle. Now they can move the **fault blocks** to show the three main types of faults mentioned above. *Draw and label the sandwich layers as they appear in a vertical and in a lateral fault. Use arrows to show which way the "rocks" are moving.*

8. The flour box provides a more realistic demonstration, as the flour acts somewhat like soil would. Fill the box with flour, smooth the surface and holding the box firmly use a quick sideways motion to move the fault blocks. Shine a flashlight across the surface of the flour to highlight the "soil" movement. Smooth the surface and try an up and down motion. Little buildings, fences and other features could be added to show how earthquakes affect things on the surface (Fig. 4).

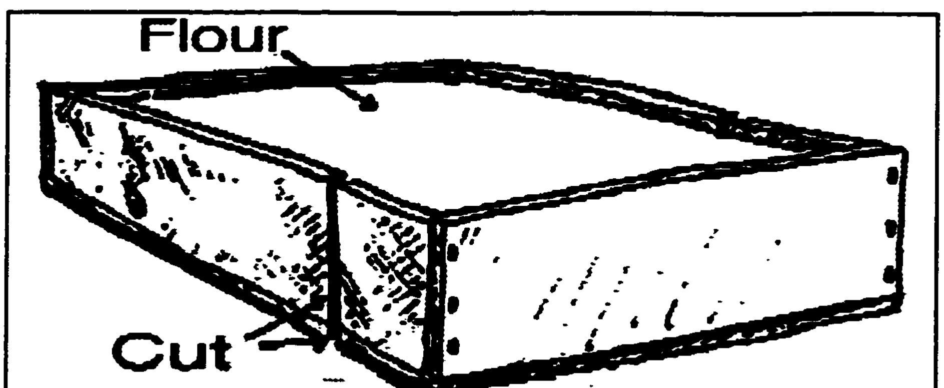

Figure 4. Flour Box. (Source: UCI/CSIN, 1989.)

Teacher Notes

Make sure that students understand that a **fault** is usually not a simple break in the rocks, but is a zone of fractures where movement occurs along various strands of the fault.

The motion of a lateral fault is described as though the viewer were standing on one side of the fault, looking across the break; if the other side has moved to the right, the fault is a **right-lateral** one; if it has moved to the left, it is a **left-lateral** fault (Fig. 5).

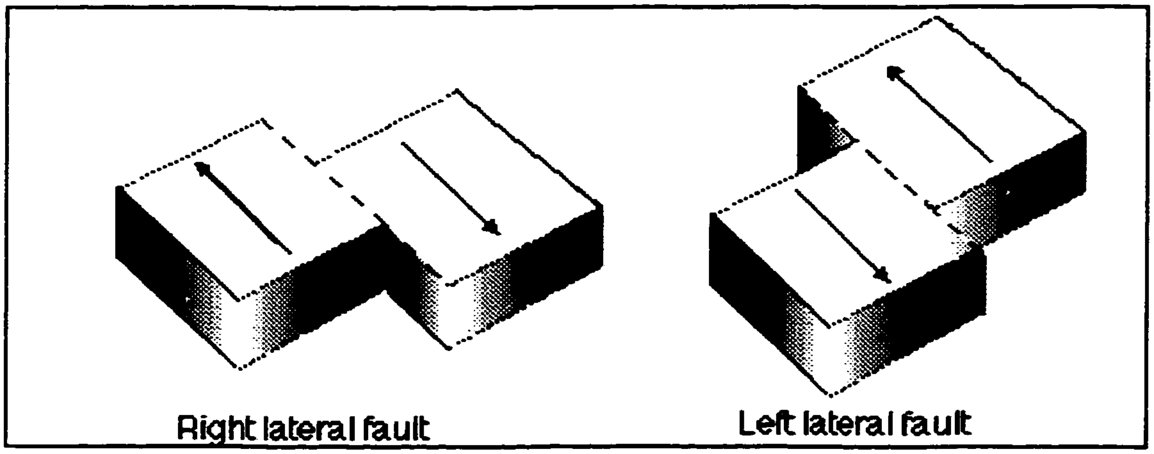

Figure 5. Lateral or strike-slip faults.

The **transform** boundary between the North American Plate and the Pacific Plate contains the San Andreas fault system, usually described as a **right-lateral** or **strike-slip** fault. Movement along this fault system is not simply right-lateral slipping, but also involves rocks being pushed together and pulled apart.

Relationship to Alum Rock Park

Alum Rock Park, like all of San Jose, is within the San Andreas fault zone. The location of the active trace of the Hayward fault is currently not agreed upon. The area around the mineral springs is where the Hayward fault was once thought to pass through the park. Compressed rock layers and upturned beds are indications of tectonic forces, but there is no surface rupture or other surface evidence of the Hayward fault in the park, so that one could point to a place and say, "There is the fault!"

Some geologists think that the monolithic structures, Eagle Rock, Inspiration Point, and the Alum Rock were moved from the ocean floor to their present locations along faults.

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STUDENT WORKSHEET FOR ACTIVITY 4: FAULTED LAYERS

Draw and label the sandwich layers as they appear in a vertical and in a lateral fault. Use arrows to show which way the "rocks" are moving.

Vertical Fault

Lateral Fault

ACTIVITY 5: MINERAL WATER

Objectives

1. Observe that substances that cannot be seen can be detected by taste.
2. Observe that substances that cannot be seen in a liquid can be seen when the liquid evaporates, leaving a deposit behind.

Materials

- paper cups for each student
- water for drinking
- Kosher salt (a food item, so it is safe to taste)
- pie pans
- magnifiers--10x--(Sc.Kit 62367)

Procedure

1. Pour drinking water in each student's paper cup and have them taste it.
2. Place a few pieces of Kosher salt (representing rocks) in each cup. Have the students shake the cup of water and salt simulating water running over rock for a long time. Taste it to verify that minerals do dissolve from rocks and can be tasted in the water even when not visible.
3. Pour the remaining water into pie pans; place these containers in a place where they will not be disturbed for a few days.
4. After the water evaporates, the crystals of salt will again be visible; students can use magnifying glasses to see the cubic shape of the salt crystals.

Teacher Notes

Most domestic water supplies contain dissolved minerals because at one time these waters flowed over or through the ground. Distilled water has been demineralized.

Relationship to Alum Rock Park

The flowstone and dripstone deposits around the mineral springs were formed when minerals that had been dissolved in the water were left behind as the water evaporated. Yellow sulfur deposits are easily identified.

The various elements and minerals such as sulfur, sodium chloride, carbonates and magnesium that dissolved in the springs were considered to be of medicinal value in the late 19th and early 20th centuries. Doctors of that time prescribed the mineral water for drinking and for bathing to treat "anemia, chlorosis, and chronic malaria, nervous prostration, debility, hemorrhagic diathesis, (and) menorrhagia" (Anderson and Eng, 1889, p.80).

ACTIVITY 6: MINERAL DEPOSITS

Objectives

Observe how materials that dissolve in water can be deposited in various ways when they come out of solution in simulated cave situations.

Materials

- 1 cup (250 mL) Epsom salts (Sc. Kit 83575-03) or from a pharmacy
- two 5 oz. (150 mL) jars or beakers (Sc.Kit 45111-02G)
- warm water
- spoon or stir stick
- wool yarn about 25 cm long
- two paper clips
- paper plate, saucer, piece of foil (something to drip onto)

Procedure

1. Put 125 mL of Epsom salts into each jar.
2. Add warm water to cover the Epson salts and stir until as much as possible is dissolved.
3. Attach a paper clip to each end of the wool yarn that has been thoroughly wetted and put the ends into the jars. Place the jars about 10 cm apart so that the center of the yarn is about 2.5 cm above the surface it is to drip on--paper plate, saucer, foil, etc. (Fig.1).
4. Put the jars in a place free from drafts where they will not be disturbed for several days.
5. Observe and draw what you see after 5 minutes, 30 minutes and then once a day for a week.

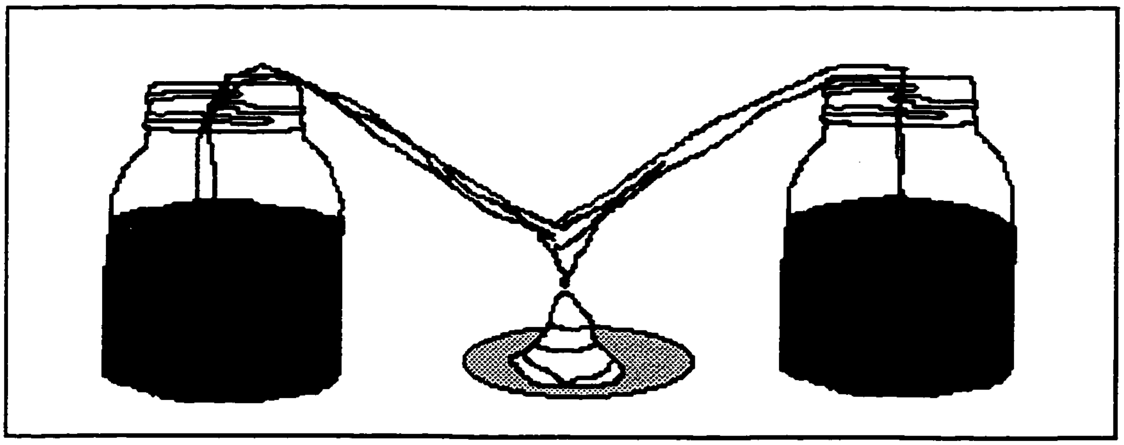

Figure 1. Mineral deposit demonstration.

Teacher Notes:

The liquid solution moves along the string because of capillary action.

Rainwater containing carbon dioxide forms a weak carbonic acid solution. As the rainwater moves through cracks in limestone, it is able to dissolve the limestone (calcium carbonate) eventually forming spaces or caves.

The deposit hanging from the string represents a **stalactite** that forms when water dripping from the ceiling of a cave evaporates leaving a tiny amount of calcium carbonate **dripstone** behind. The mound on the drip surface represents a **stalagmite**, the deposit that builds up on the cave floor. If they meet, they form a **column.** It takes many years for these deposits to become sizable.

These dripstone and **flowstone** deposits that are made up of calcium carbonate (limestone) are called **travertine** if they are massive and finely crystalline, and **tufa** if they are spongy and porous.

Relationship to Alum Rock Park

Many dripstone and flowstone deposits have accumulated around the mineral springs in small cave-like grottoes. Note the particularly interesting formations near Springs #4 and #8 (see Mineral Springs Map in Background Information section).

Travertine lumps are visible on the bank opposite Spring #4.

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STUDENT WORKSHEET FOR ACTIVITY 6: MINERAL DEPOSITS

Make periodic drawings of your simulated cave deposits.

5 minutes later

30 minutes later

1 day later

2 days later

3 days later

4 days later

5 days later

6 days later

7 days later

ACTIVITY 7: THE pH OF COMMON SUBSTANCES

Objectives

1. Gain background for measuring pH in a stream environment.
2. Observe that common substances may be acids, bases, or neutral and thus have different pH levels.

Materials

For the class

- 0.5 L of each test liquid
  neutral substances to test, such as--distilled water, isopropyl alcohol, salt water
  acidic substances to test, such as lemon juice, white vinegar, cola, 10 aspirin tablets dissolved in 0.5 L of water
  basic substances to test, such as 4 T baking soda, 20 antacid tablets, liquid soap (dissolve the solids in water and <u>let sit overnight</u>)
- 100 mLs of Universal Indicator Solution (Sc.Kit 87762) or wide range pH test paper (Sc.Kit 66627)
- a rinse station with water bottles and a catch bucket or access to a sink
- pH Tolerance Chart (see Chart 2 found with park field trip materials)
- marking pen
- masking tape
- chalkboard, chart paper or overhead transparency for recording class results

For each group of 4 students

- 1 tray
- baby food jars, wide-mouthed cups, or beakers for test substances
- a dropper (Sc.Kit 68593-02) for each substance to be tested
- 2 very small dropping bottles (Sc.Kit 68593-02) for the Universal Indicator solution or strips of test paper stored in 2 small vials (If paper strips are used, forceps are needed to handle them.)
- 1 Universal Indicator Color Chart (comes with the indicator solution or test paper)
- 2 mixing trays (white styrofoam egg cartons, white plastic ice cube trays)
- 4 paper towels
- 4 pencils
- 4 data sheets
- 4 safety goggles (Sc. Kit child size 68637-00, adult size 62011-01)

Procedure

1. In discussions leading up to your trip to Alum Rock Park, you may have mentioned the needs of terrestrial wildlife for certain food, cover, space, etc. The aquatic life has requirements as well. One is a certain range in the acidity level of the water. Explain to students that if their stream measurements are to have meaning for them, they need to be familiar with the pH of common substances.
2. Have students brainstorm acids and bases that they have heard of and list them so all can see. Explain that **acids** and **bases** are names of groups of chemicals that act in similar ways to other members of their group, but acids and bases act differently from each other. Chemicals that are not acids or bases are called neutral.
3. Introduce the pH scale as a number line that goes from 0 to 14. (The acids have a pH below 7 and bases a pH above 7; neutral substances have a pH of 7.)
4. Explain to the students that they will be testing some common substances to see if they are acids, bases, or neutral. They will be using strips of paper coated with a substance that will show the pH level or a liquid indicator solution.
5. Have students put on the safety goggles. Remind them that if they get any chemical on themselves, to rinse the site repeatedly with water at the sink or rinse station.
6. Demonstrate how to test a substance:
   a. *List each substance to be tested and record your prediction of its group (acid, base, or neutral) on the data table.*
   b. *Add a small amount of the substance from the container on the group tray into a section of your tray with the dropper.*
   c. *Using the forceps to hold the test paper, dip it into the solution for a few seconds and lay it on your paper towel or add two drops of Universal Indicator Solution to the test solution and gently swirl the mixture.*
   d. *Use the pH color chart to compare your solution or test strip and decide on the pH of the test substance.*
   e. *Record the pH numerical reading on your data sheet and label it as an acid, base, or neutral substance.*
   f. *Show where each substance falls on the pH scale at the bottom of the page.*
7. Have the students test the substances and record their results. If the color seems to be in between two numbers, such as 3 and 4, have students use 3.5 to indicate the result.
8. Record the data of each group where all can see (chalkboard, overhead, etc.). Discuss why different students got different results. How should the results be combined? By averaging? Other ideas?

9. Note which substances were in each category. Was the class surprised at any results?
10. Look at the pH Tolerance Chart (see Chart 2, Field Trip Plan) and note which organisms would have difficulty living in the various test substances. Notice what small range some organisms can tolerate. Acidic substances corrode metal. Why might this be a problem in a stream? (At levels of 5.0 -5.5 metals such as lead and aluminum that are often trapped in sediments are released into water and may be toxic to aquatic life.)

Teacher Notes

The pH scale is a logarithmic one. The lower the pH is below 7 the stronger the acid; a substance with a pH of 4 is ten times as acidic as one with a pH of 5. The higher the pH is above 7, the stronger the base; a substance with a pH of 9 is ten times more basic than one with a pH of 8.

Relationship to Alum Rock Park

The mineral springs in the park vary in their pH levels and also in the life forms that live in their waters. Can the students find any correlation between the pH and what lives in the spring?

Students can also test the Penitencia Creek water to see if the spring water emptying into the creek affects the pH of the larger body of water and what organisms can live there.

Additional Resources:

For a more extensive treatment of these ideas see:

1) Barber, Jacqueline. 1989, *Cabbages and Chemistry* (Grades 4-8): Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, U.C. Berkeley, CA.
   Students use red cabbage juice as an indicator to classify common liquids into groups with similar reactions.

2) Hocking, Colin and others, 1990, *Acid Rain* (Grades 6-10): Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, U.C. Berkeley, CA.
   After becoming familiar with acids and bases, students learn about the effects of acid rain on the environment and experience controversy in science, including the relationship between scientific and social issues.

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STUDENT WORKSHEET FOR ACTIVITY 7: THE pH OF COMMON SUBSTANCES

1. Test the pH of the substances provided using the following procedure:
   a. List each substance to be tested and record your prediction of its group (acid, base, or neutral) on the data table.
   b. Add a small amount of the substance from the container on the group tray into a section of your tray with the dropper.
   c. Using the forceps to hold the test paper, dip it into the solution for a few seconds and lay it on your paper towel or add two drops of Universal Indicator Solution to the test solution and gently swirl the mixture.
   d. Use the pH color chart to compare your solution or test strip and decide on the pH of the test substance.
   e. Record the pH numerical reading on your data sheet and label it as an acid, base, or neutral substance.
2. Show where each substance falls on the pH scale at the bottom of the page.

DATA TABLE

Test Substance	Prediction	Numerical Result	Acid, Base, or Neutral

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

most acidic — neutral (7) — most basic

FIELD TRIP PLAN

MINERAL SPRINGS OF ALUM ROCK PARK

STOP 1--PARKING LOT (see Field Trip Map in Background Information section)

a. Look up at the hill directly above the parking lot. *What signs can you see indicating that this hill is not stable?* (Some trees are leaning toward us, the hillside is moving downward.)
b. Enter the gate by the parking lot and stay to the left.

STOP 2--FOLDED OUTCROP OF ROCK TO THE LEFT OF THE CREEK

a. *What did these layers look like when they were deposited?* (horizontal layers with the oldest layer on the bottom) *How do you suppose they came to look as they do now?* (If necessary, remind students of the "Folded Layers" lesson.)
   1) Demonstrate with the felt or paper pieces how pushing on the layers causes them to bend up and down in folds.) *What pushed on these layers of rock?* (The Pacific Plate pushed up against the North American Plate, causing folding and uplift. This area is in the Hayward fault zone, which is actually part of the San Andreas fault zone, so many signs of tectonic activity are visible.)
   2) Use the paper model of the bend in the San Andreas fault (Fig. 1) to demonstrate why folding may occur along a fault. First, cut the paper along the fault trace. Next, lay the pieces side by side and slide the left-hand piece forward until the x's and y"s are opposite each other. Note the gaps and the overlaps that are produced, just as they are along the actual San Andreas fault.

b. Look closely at the folded layers. They are made up of **shale** (sedimentary rock formed from clay-sized particles) and **chert** (sedimentary rock made of the silica skeletons of **radiolaria**.) *Which rock layer do you think would erode more easily, the shale or the chert? Why?* (The shale, because it is softer. The chert, made of silica, is quite hard. Observe the chert layers sticking up higher than the shale layers.)

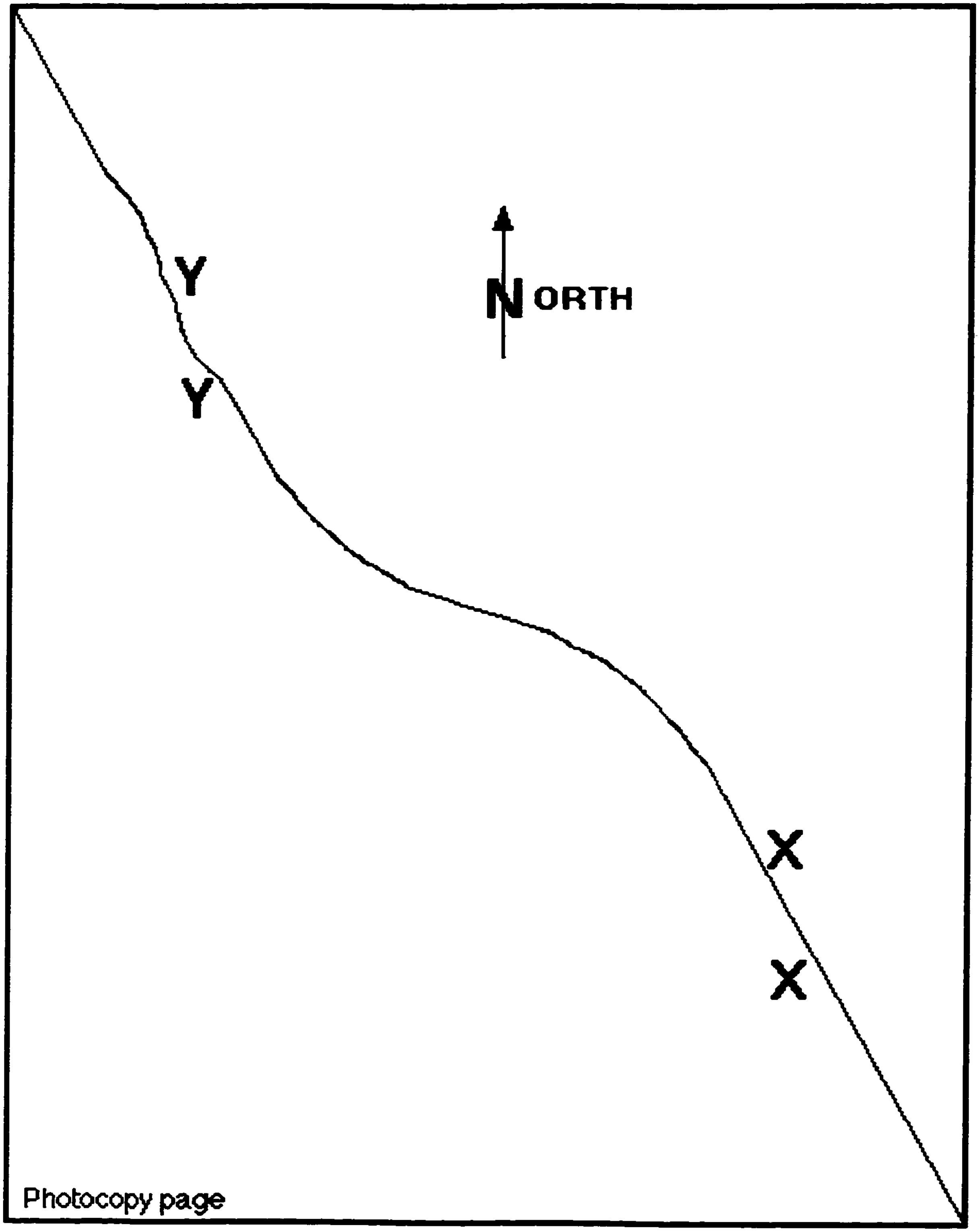


Figure 1: Paper model of a bend in the San Andreas fault.

c. As water moves through the rocks, it dissolves minerals from them. Even if the minerals cannot be seen in the water, sometimes they can be tasted. In the late 1800's and early 1900's, many people thought that drinking or bathing in mineral water was good for your health. Many people today enjoy drinking mineral water.

STOP 3--SPRINGS #1-6 (See Mineral Springs Map [Background Information section] and Chart 1 [Field Trip Plan section].)

a. Have the students look at Springs #1-6. Before they begin doing their assigned jobs, students should do this activity together, so they can concentrate on the unusual landscape they are viewing. *Can they find the formations they have studied--**stalactites, stalagmites, columns**? Can they find **travertine** and **tufa**?* They can look with their magnifying glasses, but remind them NOT TO TOUCH the deposits as it takes years to form their interesting shapes. Maybe the students would like to make up stories about adventures in these miniature landscapes and share them with a partner, with their group, or with the whole class.

b. Have students observe different dripping stalactites and answer the following questions:
   1) *Choose one stalactite to time. How long is it between drips?*
   2) *Compare several. Do they drip at a regular rates?*
   3) *What was the rate for the slowest dripper?*
   4) *What was the rate for the fastest dripper?*
   5) *Calculate how many drops per year one dripper would produce if the rate is constant.*

c. Now have the students examine Springs # 1-6. Use Spring # 1 or the first suitable spring as a place to demonstrate how to do and record each task. They will be recording on the Mineral Springs Data Sheet (included with the student worksheet). See the example below (Table 1). Tables 2-5 are blank so that the adults or older students may also record as they read the questions to younger students.

Spring#	Odor	Color	Deposits	Life	pH	Conduct.	Temp.	Time
1	none	brown	stalactites	cyano-	8.5	9.7	16° C	10 am
		dry white	flowstone	bacteria				
		dry black		yellow				
				jackets				

Table 1. Sample data on the mineral springs.

Spring #	Odor	Color	Deposits	Life	pH	Con.	Temp.	Time
1								
2								
3								
4								
5								
6								

Table 2. Table to record mineral spring data for Springs #1-6.

d. As the students are making their observations, question them to sharpen those observations.

1) *Can you tell which springs contain a lot of sulfur even before you see the yellow deposits? How could you tell?* (by the sulfur odor)
2) *Can you identify any other minerals present?* (Iron can be told by its reddish brown color.)
3) *What invertebrates have you observed so far?* (These will vary from spring to spring, from season to season, and also with the amount of rain. If life forms are put into containers or magnifiers for better viewing, be sure students return them to the places where they got them without injury. Spring #6 often contains mosquito larvae, pupae, and ostracods.)
4) *What colors of bacteria can you see?* (white, green, black, brown and purple are possibilities)
5) *Near what springs is moss growing?* (It is often near Springs #5 and #6.) *Will the moss affect the deposits? How?* (Over a long time tiny moss rootlets can break off small bits of rock until the whole rock is broken down into small particles.)
6) *By which spring is the United States Coast and Geodetic Survey (USCGS) bench mark?* (It is by Spring #4. Bench marks are placed to permanently [relatively] locate points of elevation.) *What is the elevation here?* (459') *When was this benchmark placed?* (1969) *What changes have occurred to it since then?* (It has been partially covered by mineral deposits.)

e. Look across the creek at the interesting features along the opposite bank. *What has happened to the retaining wall?* (It has been undercut by erosion.) *What is unusual about the large travertine lump opposite Spring #4?* (A tree is growing from it.) Look at the layers of rock in the stream. *How is their position different from those above the trail?* (They have been moved to a vertical position.)

STOP 4--FIRST BRIDGE

a. *What rocks were used to build the bridge and why?* (Travertine. Perhaps because it was plentiful around the springs.)

b. Travertine is the deposit of calcium carbonate left behind when water which dissolved the mineral from rocks evaporates. When a weak acid, such as dilute hydrochloric acid, is combined with calcium carbonate, carbon dioxide is released and you can see the bubbles. Put a few drops of acid on the travertine (the rocks on the sides of the bridge) and let students look with their magnifiers at the bubbles. Test other bridge rocks (most of the top ones) to see ones that do not contain calcium carbonate. *Can you explain why rocks not containing calcium carbonate were used on top?* (Probably so that they wouldn't deteriorate as quickly as travertine would, and thus protect the sides). Use the water spray bottle to wash off any possible remaining acid.

IMPORTANT! Do not let students make measurements at the following springs: Springs #7-12, Spring #21, Spring #29. These springs are on the stream side of the railing or wall. They are too dangerous to reach.

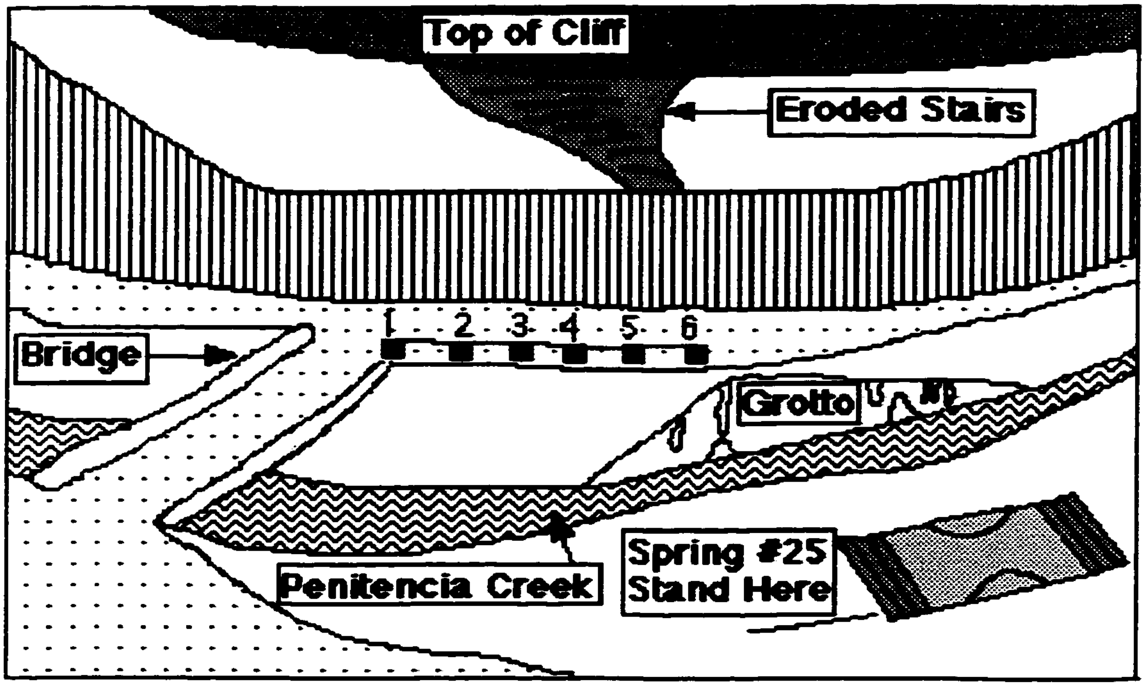


Figure 2. Diagram of how the old eroded steps to the gazebo appear.

STOP 5--ANOTHER SEARCH

a. The trail is often slippery here.

b. About eight feet above the trail between Springs #7 and #8 (see Mineral Springs Map, Fig. 1, Background Information Section) the remains of an old staircase that led to a gazebo can be faintly seen. Count the railing supports after the bridge; it is above the sixth one. See if students can find the steps because they look more human-made than natural (Fig. 2). Another viewpoint is next to Spring #25 on the other side of Penitencia Creek, *Were you able to see the eroded stairs?*

STOP 6--SPRINGS #13-14 (Springs #7-12 are too dangerous to reach).

a. Spring #9 is actually flowing beneath the trail.

b. As you head up the hill caution students to move in a single file and be careful on the uneven trail here. Notice the angular pieces of shale on the trail. The steps going down the hill are slippery too.

Spring #	Odor	Color	Deposits	Life	pH	Con.	Temp.	Time
13								
14								

Table 3. Table to record data for Springs #13 and #14.

c. Gather the group by Spring #14 to share their information. *Looking at the data that you have gathered so far, can you make any observations connecting colors or life forms and smells? Give examples of possible connections.* (Do not tell the students what connections to make, but question them to see if anything goes together or if they can come up with some ideas that they would like to check out at the next group of springs.)

STOP 7--SPRINGS #15-20 AND #22 (Spring #21 is too dangerous to reach.)

Spring #	Odor	Color	Deposits	Life	pH	Con.	Temp.	Time
15								
16								
17								
18								
19								
20								
22								

Table 4. Table to record data for Springs #15-20 and #22.

a. Challenge students to find the spring that surges (in which the flow increases suddenly)

b *Do you think Spring #15 with two openings should be numbered as two different springs? Why or why not?*

c. *What are some unusual features of the triple springs (Spring #16, #17 and #18)?* (They are all different colors. The color in Spring #16 comes from iron. Spring #17 is the one that surges or pulsates. Note that this "bath" is very ornate. Have the students discover that one spring is decorated with rounded shapes and the other with pointed ones.)

d. *What do you observe at Spring #19?* (It has an unusually large flow of water, abundant yellow deposits of sulfur, and much filamentous bacteria.) <u>This is a great place to look at the filamentous bacteria through the field microscope</u>. You can use the bridge to set up a viewing station. Perhaps you will be able to see the sulfur inside the organisms.. Notice the large stalactites deep inside the spring. This is also a good place to collect data on the spring water flowing into Penitencia Creek. If the creek is not too high, the creek pH, conductivity, and temperature could be measured in clear water areas and in places where the spring water has mixed with the creek water. Students could also try to locate a scallop fossil. (It is in a sandstone boulder located 2 m from the rock retaining wall, upstream from where Spring #19 drains into Penitencia Creek.) While some groups test the creek water, one group at a time should proceed to Spring #22 because the trail is narrow and is also a dead end.

e. At Spring #22 black fly larvae may be found during the spring, summer and fall. Look in the creek on your way back to the bridge for carbon dioxide gas bubbling up through the water.

f. If the group needs a break, gather at the Sycamore Grove area for a snack or lunch and compare data. (If they want to keep going you could stop later on the wall by Spring #26.) *What patterns can you see in the data that you have collected so far?* **Stress to students that their data is important, that by observing and recording data and looking for patterns, people make discoveries.** (Some possible patterns that were observed during July, 1997 were the following: 1) the white filamentous bacteria were only in the sulfur springs; 2) the pH readings were lower in the sulfur springs (between 6 and 7); and 3) the mosquito larvae and ostracods were not in the sulfur springs.) *Using your pH and temperature data and looking at Charts 2 and 3, what life forms* *do you think could and could not survive in the mineral springs? Do you think the springs would affect life in Penitencia Creek? In what ways?*

STOP 8--SPRINGS #23-28 AND #30 (Spring #29 is too dangerous to reach.)

Spring #	Odor	Color	Deposits	Life	pH	Conduct.	Temp.	Time
23								
24								
25								
26								
27								
28								
30								

Table 5. Table to record data for Springs #23-28 and #30.

g. Spring #24 is another good place to measure the spring water as it mixes with the Penitencia Creek water.

h. When standing by the walk-in Spring #25 and looking across the creek, you can see a log that has become incorporated into Spring #9.

i. If the teacher and the group are agile and the water is not too high, they might climb down by Spring #25 and cross the creek to the remarkable display of stalactites and stalagmites deposited by Spring #8. If you prefer, view this from the bank.

j. Gather by Spring #26. Share data if you have not done so. Tell what is known about the closed arsenic spring. This spring has been walled up because personnel in the park noted dead birds around it and thought they might have been killed by arsenic in the water of this spring. Although the arsenic was not supposed to be at a level high enough to harm people, the spring was blocked off to insure safety (Hardesvelt and Harvey, 1972). <u>This is a good place to note the folded layers of shale</u>.

k. Spring #27 usually has a strong flow.

l. As you leave, note Spring #30 bubbling up in the road. The springs have a way of coming out in new places as well as drying up, so the number of springs is something that changes.

STOP 6--VISITORS' CENTER

Be sure to see the old photos of the park including those of the mineral springs, the rock specimens, and the model of the park, as well as the insect collection and any live animals that might be on display.

NAME______________________
DATE___________PERIOD_____

STUDENT WORKSHEET FOR MINERAL SPRINGS OF ALUM ROCK PARK FIELD TRIP

STOP 1--PARKING LOT

1. What signs can you see indicating that this hill is not stable?

____

____

STOP 2--FOLDED OUTCROP OF ROCK TO THE LEFT OF THE CREEK

2. What did these layers look like when they were deposited?

____

3. How do you suppose they came to look as they do now? What pushed on these layers of rock?

____

____

4. Which rock layer do you think would erode more easily, the shale or the chert? Why?

____

STOP 3--SPRINGS #1-#6

5. Circle the following deposits if you observe them: **stalactites, stalagmites, columns, travertine, tufa.**

6. Observe some dripping stalactites.

   a. Choose one stalactite to time. How long is it between drips?________

   b. Compare several. Do they drip at a regular rates?________________

   c. What was the rate for the slowest dripper?______________________

   d. What was the rate for the fastest dripper?_______________________

   e. Calculate how many drops per year one dripper would produce if the rate is constant.____

7. With your group make your observations about Springs #1-6 and record the information on your group Mineral Springs Data Sheet.

8. Can you tell which springs contain a lot of sulfur before you even look at them? How can you tell?

   ____

9. Can you identify any other minerals present?

   ____

10. What invertebrates have you observed so far?

    ____

    ____

11. What colors of bacteria can you see?

    ____

12. Near what springs is moss growing? Will the moss affect the deposits? How?

    ____

    ____

13. By what spring is the USCGS bench mark? What is the elevation here? When was this bench mark placed? What changes have occurred since then?

____

14. Look across the creek at the opposite bank. What has happened to the retaining wall?

____

15. What is unusual about the large travertine lump opposite Spring #4?

____

16. Look at the layers of rock in the stream. How is their position different from those above the trail?

____

STOP 4--THE FIRST BRIDGE

17. What rocks were used to build the bridge and why?

____

18. After testing rocks on both the sides and the top of the bridge, can you explain why rocks not containing calcium carbonate were used on top?

____

____

STOP 5--ANOTHER SEARCH

19. Were you able to see the eroded stairs? ______________________

20. Looking at the data that you have gathered so far, can you make any observations connecting colors or life forms and smell? Give examples of possible connections.

____

____

21. Do you think Spring #15 with two openings should be numbered as two different springs? Why or why not?

____

22. What are some unusual features of the triple springs (Springs #16, #17, and #18)?

____

____

____

23. What do you observe at Spring #19?

____

____

24. What patterns can you see in the data you have collected so far?

____

____

25. Using your pH and temperature data and looking at Charts 2 and 3, what life forms do you think could and could not survive in the mineral springs? Do you think the springs could affect life in Penitencia Creek? In what ways?

____

____

____

Name/# ____________________

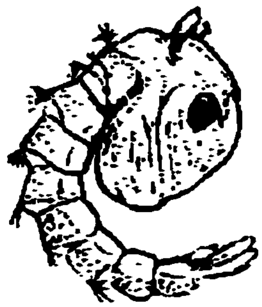
Date ____________________

MINERAL SPRINGS DATA SHEET
ALUM ROCK PARK, SAN JOSE, CALIFORNIA

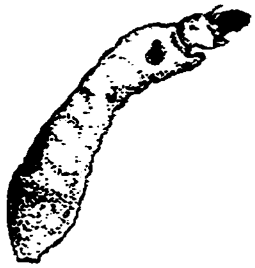
Spring #	Odor	Color	Deposits	Life	pH	Conductivity	Water Temp.	Time

CHART 1
INVERTEBRATES OF THE MINERAL SPRINGS


Mosquito larva

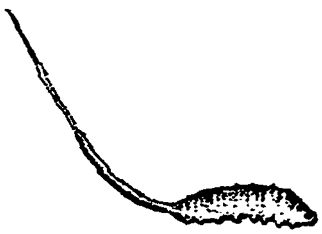

Mosquito pupa


Mosquito adult


Black fly larva

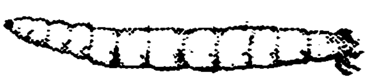

Black fly adult


Yellow jacket adult


Syrphid fly larva
(Rattailed maggot)


Syrphid fly adult


Ostracod


Crane fly larva


Crane fly adult

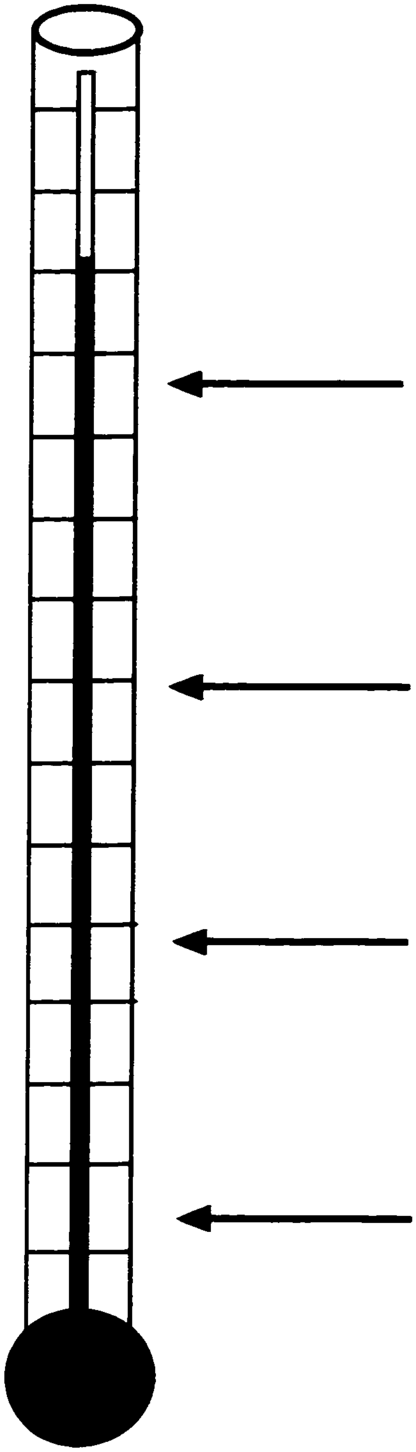

Aquatic soldier fly larva

CHART 2
pH TOLERANCE LEVELS

```
most acidic                          neutral (7)                        most basic

0    1    2    3    4    5    6    7    8    9    10   11   12   13   14
|    |    |    |    |    |    |    |    |    |    |    |    |    |    |
______________________________________________________________________

Bacteria           xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Plants                                   xxxxxxxxxxxxxxxxxxxxxxxxx

Carp, suckers, catfish,             xxxxxxxxxxxxxxxx
some insects

Bass, bluegill                        xxxxxxxxxxxxx

Snails, clams                              xxxxxxxxxxx

Trout, salmon, mayfly nymphs,            xxxxxxx
stonefly nymphs, caddis fly larvae--
Largest variety of animals
```

(Source: Mitchell and Stapp, 1997.)

CHART 3
TEMPERATURE TOLERANCES OF SOME AQUATIC LIFE



Above 20° C (68° F)
Bass, blue gill, carp, catfish,
California roach (a native fish)

16° C (61° F)
Upper limit for salmon, trout

13° C (55° F) to 16° C (61° F)
Mayfly nymphs, caddisfly larvae,
water beetles, water striders

Below 13° C (55° F)
Trout and salmon spawn, riffle
sculpins, stonefly nymphs

(Source: Mitchell and Stapp, 1997.)

WATER QUALITY OF PENITENCIA CREEK IN ALUM ROCK PARK

The water quality module provides a plan for measuring water quality characteristics of Penitencia Creek above, at, and below the mineral springs area and for comparing and contrasting these measurements to each other and to measurements taken in several mineral springs.

The BACKGROUND INFORMATION includes material on the significance of the water quality characteristics for aquatic life, as well as information on the equipment needed to make water quality measurements.

The two CLASSROOM ACTIVITIES, "How Does Water Gain and Lose Oxygen?" and "The pH of Common Substances", provide students with opportunities to practice making water quality measurements and to compare them with the test results they obtain at the park. Thinking about factors that change water quality characteristics ahead of time will make the field trip more meaningful.

The FIELD TRIP PLAN points out the best areas for access to the creek to take the measurements. The plan calls for students to make predictions of water quality levels before they measure them and for students to use their results to suggest which life forms could survive under the various environmental conditions.

Background Information

WATER QUALITY OF PENITENCIA CREEK IN ALUM ROCK PARK

PRE-TRIP ARRANGEMENT

If you plan to visit the Visitors' Center, phone ahead (408) 277-4539 to arrange for a ranger to be on duty.

PURPOSE

1. Become familiar with some ways water quality can be observed and measured.
2. Compare the characteristics of the water in the creek above, near to and below the mineral springs area. (Fig. 1)
3. Compare the creek water characteristics to those of a mineral spring.
4. Study what implications the results of these tests could have for life in Penitencia Creek.

CONNECTION TO THE CALIFORNIA SCIENCE FRAMEWORK:

Themes: Scale and Structure, Systems and Interactions

Process Skills: observing, measuring, communication, comparing and contrasting, inferring

Integration with other Areas: math, life science

GRADE LEVEL: upper elementary, middle school

TIME: 2 hours

GROUPING

Divide the class into five groups. Within each group have the following tasks: direction reader, experimenter, data reader, recorder/checker. Two students could share a job when needed. Devise a system ahead of time for rotating the jobs among the group members.

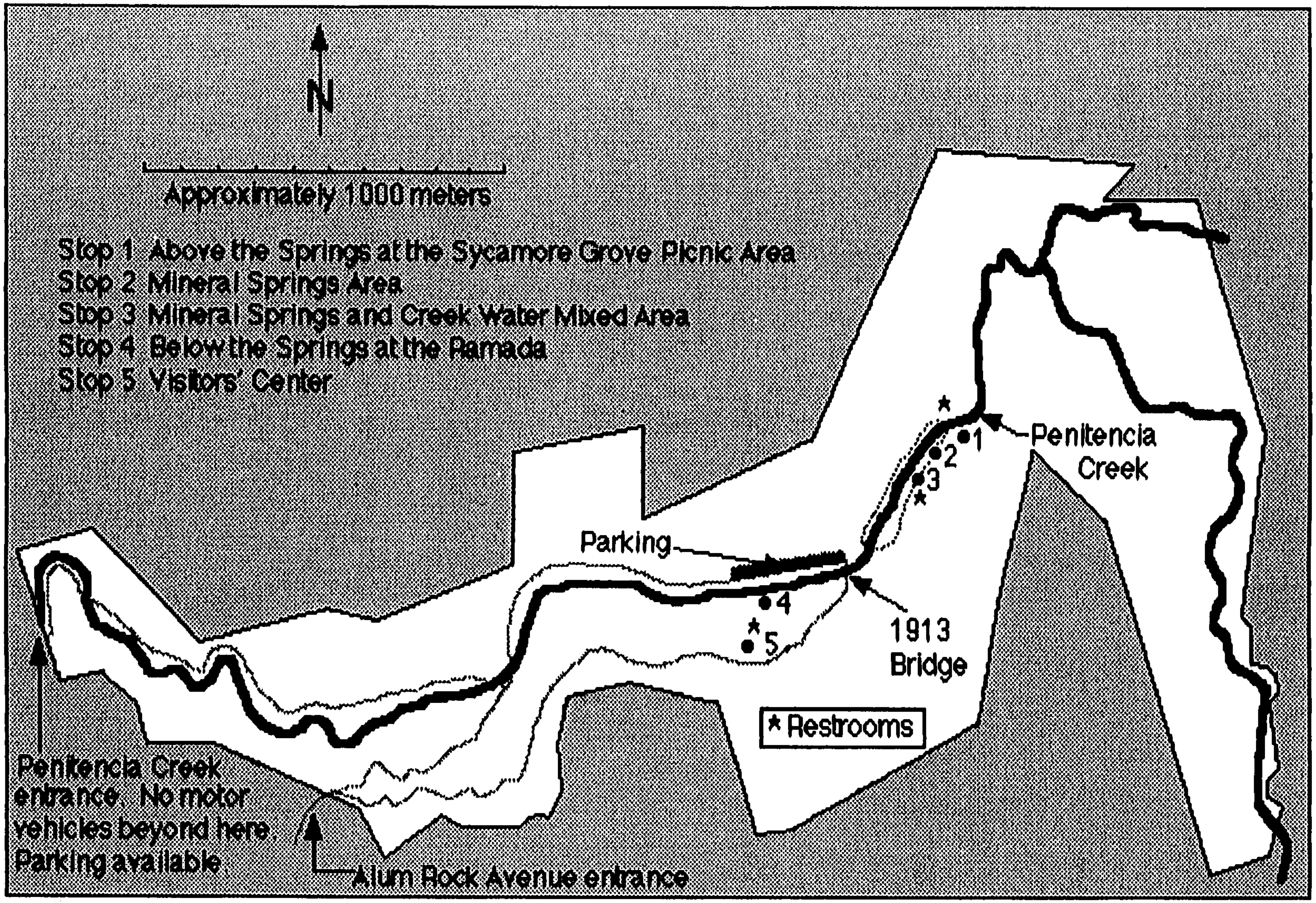


Figure 1. Map for Water Quality of Penitencia Creek in Alum Rock Park field trip. (Modified from San Jose Regional Parks, no date, Alum Rock brochure.)

MATERIALS

Station 1--Dissolved Oxygen

- dissolved oxygen test kit (Forestry [CHEMets] 78502--ampules --easier with younger students)
- or dissolved oxygen test kit (LaMotte) 77152--Winkler method--more accurate. Get several sample bottles and syringes, so that one kit could be used with several groups.

Station 2--pH

- pH meter (Sc.Kit 46124 or Forestry 76235) or borrow from BAESI (Appendix E)
- or narrow range pH paper (Forestry 781095 or Sc. Kit 66627)

Station 3--Temperature, Color, and Odor

- immersible thermometer (Forestry 77141)
- sheet of white paper
- 1 clear plastic cup for examining the water color and odor
- paper or cloth to wipe thermometer

Station 4--Turbidity

- turbidity test kit (Forestry 77164) or borrow form BAESI (Appendix E)

Station 5--Conductivity

- conductivity meter (Forestry 76079)

Stations 1 and 2

- dry waste container for empty powder pillows, wrappers, and/or ampules

Stations 1 and 4

- goggles (Sc.Kit [child size] 68637-00, [adult size] 62011-01)
- latex gloves

Stations 1-5

- liquid waste container with a lid, labeled "waste".
- container of distilled water for rinsing test equipment

For each group

- 1 data sheet
- 1 clipboard
- 1 calculator for averaging results (optional)
- Charts 1,2, 3, and 4 (in Field Trip Plan section), photocopy ahead of time
- Field Trip Map (Fig. 1), photocopy ahead of time

For the teacher

- white board, pens, eraser (for compiling data)
- Mineral Springs Map (in Field Trip Plan section), photocopy ahead of time

LESSONS TO DO BEFORE YOU COME: "How Does Water Gain and Lose Oxygen?" and "The pH of Common Substances"

OTHER PRE-TRIP ACTIVITIES

1. Have students practice using the water quality testing materials, including the thermometers before coming to the park; it is difficult to do tests for the first time in the field. Some possible test water to compare might be your classroom aquarium water, chlorinated water, and distilled water.
2. If you measure a different body of water, keep the results to compare with those you get at Penitencia Creek.
3. If possible, arrange for four adults or older students to accompany the class to help with water tests. For younger students, this would be necessary. Arrange for these people to become familiar with their assigned test prior to the trip.
4. If meters are being used for any of the tests, calibrate them beforehand.

BIOLOGIC BACKGROUND

Several types of filamentous bacteria thrive in the mineral springs. The white, filamentous form called ***Beggiatoa*** occurs in the sulfur springs. Beggiatoa convert hydrogen sulfide in the water into energy and use carbon dioxide to make cell mass. The green filamentous photosynthetic cyanobacteria, ***Oscillatoria,*** derives its name from its oscillating movement that enables it to climb up the side of a container.

WATER QUALITY BACKGROUND

Dissolved Oxygen

The amount of oxygen dissolved in water is often measured in parts per million (ppm). A reading of 10 ppm indicates that there are 10 parts of oxygen for every million parts of water. The level of oxygen dissolved in water depends on the temperature. When water holds all the oxygen it can at a given temperature, it is saturated (Table 1). Cold water is able to dissolve more oxygen than warm water. For example, at 0°C water is saturated with 14.6 ppm of oxygen, while at 31°C, it is saturated with 7.5 ppm (Mitchell and Stapp, 1997).

What makes the dissolved oxygen level change besides changes in temperature? Aeration by tumbling over rocks and photosynthesis of aquatic plants during daylight hours increase the amount of dissolved oxygen. Nighttime respiration of aquatic plants, respiration of bacteria decomposing dead material and biodegrable wastes, and **turbidity** of the water decrease the dissolved oxygen level.

Most aquatic organisms need oxygen to live and grow. Early life stages of animals usually require a higher oxygen level than adults. With very low oxygen levels only a few species of life can survive (see Chart 1, Field Trip Plan section for oxygen tolerance levels.) Dissolved oxygen meters are very accurate but expensive to buy. There are several inexpensive test kits that provide accurate readings under most conditions. In the mineral spring water, however, the chemical tests may react with chemicals in the springs and not provide accurate dissolved oxygen data. Kits using the Winkler method are considered to be very accurate, but the method needs to be practiced ahead of time as it is fairly complicated. Self-filling ampule methods are easier for younger students to use and fit more conveniently into a rotating station situation like this field trip.

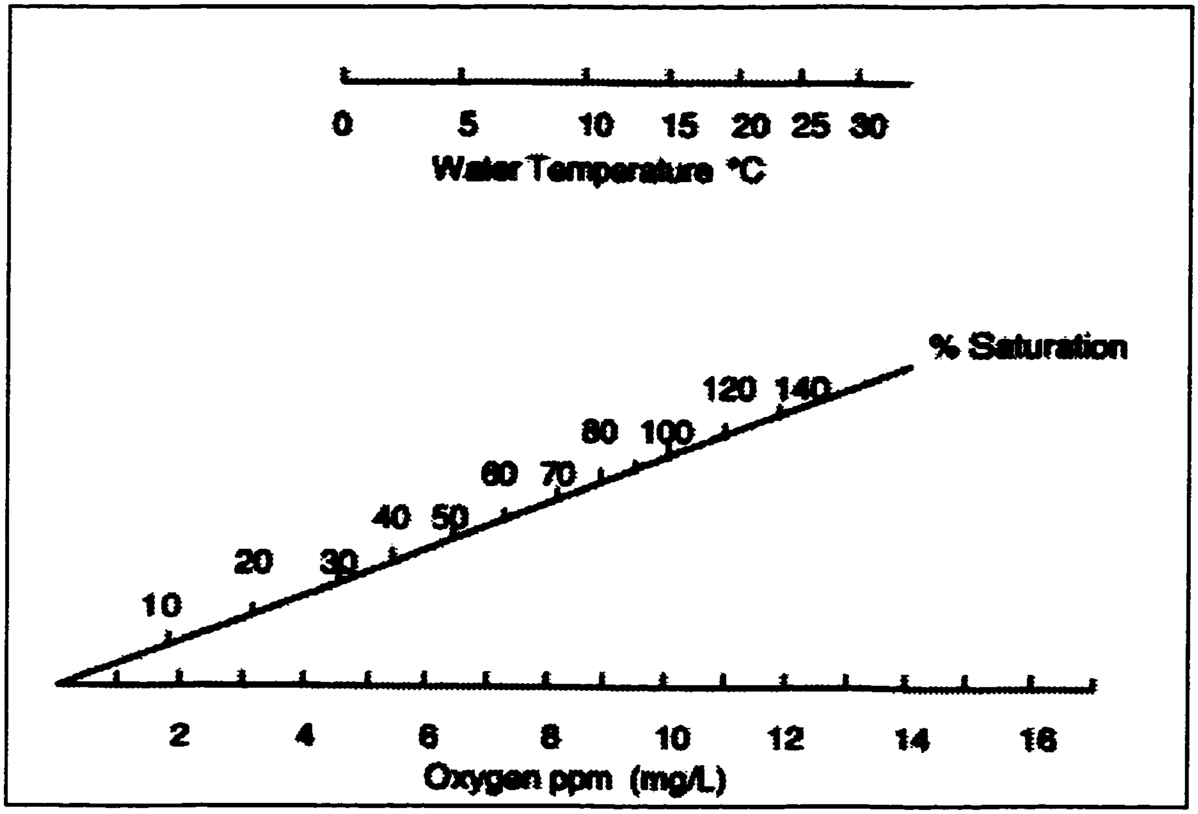


Table 1. Level of oxygen saturation chart. (Source: Mitchell and Stapp, 1997.)

pH

A pH test is a measure of how **acidic** or **basic** a substance is. The term pH comes from the French phrase "puissance' Hydrogen", the potential of hydrogen. The test actually measures the concentration of hydrogen ions in a substance on a scale from 0 to 14. Distilled water, which is considered to be **neutral**, has a pH of 7. Acidic substances have pH values from 0 to 6.9; lemon juice, for example, has a pH of 2. Basic materials have pH values between 7.1 and 14; ammonia has a pH around 11. The farther from neutral the reading, the stronger the acidic or basic quality is. Because the pH scale is logarithmic, each whole number increase is a ten-fold change. Therefore, a lake with a pH of 4 is ten times as acidic as one with a pH of 5.

Water in the environment comes into contact with many things that cause its pH to change from a neutral 7. Water in the San Francisco Bay Area tends to be basic because the cementing material in the underlying sandstone is lime, a basic substance (Jerry Smith, oral communication, September 18, 1995). Additionally, contact with plants and animals, as well as artificial substances can cause pH levels to change. Maple leaves, for example, are basic, while conifer needles are acidic. Bacteria, breaking down plant matter such as fallen leaves, produce acids in the process. Most life forms have adapted to a narrow range of pH and will die if this changes even slightly. (see Chart 2 in Field Trip Plan section for pH tolerance levels). The concentrations of other substances in water may change to a more toxic form if the pH changes. Fish gills, especially in young fish, are very susceptible to damage from heavy metals released by acidic water.

Measuring pH with test paper is easy and inexpensive to do. For the activities presented here, narrow range papers that measure pH to the nearest .5 or a pH meter is needed. Test kits (available from aquarium, pool or scientific supply companies) work well for most uses but do not show the slight variations occurring at the mineral springs.

Temperature

Temperature is the average energy of motion of the molecules of a substance. It is measured in degrees **Celsius** (C) or degrees **Fahrenheit** (F) Water freezes at 0°C and boils at 100°C; it freezes at 32°F and boils at 212°F. (see Table 2 to convert from one scale to the other.)

$$°C = \frac{(°F - 32.0)}{1.80}$$

$$°F = (°C \times 1.80) + 32.0)$$

Table 2. Temperature conversion equations.

Water temperature depends on many factors: the amount of sunlight with daily and seasonal variations, the air temperature, the amount of shade, the velocity of the water (faster is cooler), the depth of the water (deeper is cooler), the inflow of both ground and surface water, and the turbidity because suspended particles absorb heat.

Water temperature is extremely important to aquatic life (see Chart 3, located with the field trip materials). It affects characteristics of the water and the functions of the organisms. Colder water is able to dissolve more oxygen than warmer water. An increase in temperature means an increase in the rate of photosynthesis in aquatic plants. As more plants grow, more plants die as well, and their decomposition by bacteria uses up oxygen in the water. Metabolic rates in aquatic life increase as the temperature increases; their life cycles occur more quickly. Activities such as reproduction and migration often depend on the water being a certain temperature. Higher temperatures can cause organisms to become more susceptible to diseases, parasites, and pollution effects.

To maintain consistency, use the same thermometer at each study site. If a small plastic-backed thermometer is used, glue it ahead of time to a tongue depressor for strength. Temperature probes and meters are expensive and not needed for these activities.

Turbidity

Turbidity is the measure of the amount of suspended particles in the water (how cloudy it is). Using a turbidity tube, the observer views a black dot through a tube of water and compares it to a standard. The results can be converted to Jackson Turbidity units (JTU's) (Table 3). Turbidity meters are very expensive and not needed here.

JTU's	Rating
0-10	Excellent
10.1-40	Good
40.1-150	Fair
>150	Poor

Table 3: Jackson Turbidity Unit Ratings. (Source: Mitchell and Strapp, 1997.)

Increased algae growth, soil erosion, storms, waste discharge, stirring of sediment by bottom feeding animals like carp and crayfish, and urban and agricultural run-off all increase turbidity.

Why does turbidity matter? Greater turbidity results in less diversity of life. Solids absorb light and heat, causing the water temperature to rise and the dissolved oxygen level to fall. With increased turbidity, photosynthesis is reduced, lowering the oxygen level even more. Suspended solids may clog fish gills and reduce growth rates. Settling particles suffocate eggs and small aquatic insects.

Conductivity

The ability of water to conduct electricity is called its conductivity. Dissolved solids in the water are the conductors. The **ions** often found in water include sodium (Na^{+}), calcium (Ca^{+2}), potassium (K^{+}), magnesium (Mg^{+2}), chloride (Cl^{-}), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO_3^{-}). These ions are derived by weathering of rocks and minerals and are able to conduct electricity because they are positively or negatively charged.

Most aquatic life can tolerate a range of conductivity, but sometimes the concentration of particular ions is critical. Dissolved solids regulate the flow of water into and out of the cells of organisms. If the conductivity level is too high, imbalances can occur with this water flow. Dissolved solid particles are also essential nutrients needed for aquatic organisms to grow and reproduce.

The conductivity of water depends partially on the rocks and soils it runs over in the watershed. Clay soils contain water soluble particles and so cause conductivity levels to be high. Increased temperatures causing evaporation of fresh water increase the concentration of ions, and thus the conductivity. Human activities raise conductivity levels when chemicals are spilled or dumped into bodies of water, fertilizers and runoff from urban streets enter storm drains, and when sewage systems fail allowing sewage water to enter streams.

Conductivity levels are measured with an electronic meter. This can perhaps be borrowed from a high school, especially if high school students are helping with your trip or from the Bay Area Earth Science Institute (BAESI) at San Jose State University (See Appendix E). Meters measure in millisiemens (mS) or in microsiemens (μS). Generally streams have conductivity levels that are fairly consistent with perhaps, some seasonal change. Monitoring of a stream might be done to note unusual conductivity levels which could indicate a pollution problem. It is interesting to compare the various conductivity levels in the mineral springs. The typical conductivity level in the Guadalupe River during the 1996-1997 school year was .8-.9 millisiemens as measured by the Biosite Project at the Children's Discovery Museum in San Jose (Amity Sandage, oral communication, July,1997). Compare this number with the data you obtain from Penitencia Creek.

CLASSROOM ACTIVITIES

WATER QUALITY OF PENITENCIA CREEK IN ALUM ROCK PARK

ACTIVITY 1, PARTS A AND B: HOW DOES WATER GAIN AND LOSE OXYGEN?

Adapted From

National Aquarium in Baltimore, 1987, "Oxygen for Life" and "Plants Use Oxygen?" in *Living in Water*. Baltimore, MD

Objectives

1. Follow the dissolved oxygen testing instructions.
2. Observe that water may gain oxygen from the air.
3. Observe that water may gain oxygen from plants.
4. Observe that aquatic plants and animals remove oxygen from the water they live in.

Time Requirement

Part A--Several hours are needed for the plants to be in the sun. In a departamentalized situation, early classes could begin the experiment and later classes could finish it. The classes could then share their results.
Part B--Part of the experiment needs to be left in a dark place overnight. Water for this experiment need to be aged two days ahead of time.

Materials

For the class:

- parts per million chart (Fig. 1)
- a dissolved oxygen test kit to be shared (Winkler method--most accurate; if several sample bottles and syringes are obtained, one kit could be used with several groups [Forestry 77152, LaMotte]. Kits with self-filling ampules are easier for younger students [Forestry 78502, CHEMets]).

For each student:

- safety goggles (Sc.Kit, child size 68637-00, adult size 620II-01)
- data sheet
- pencil

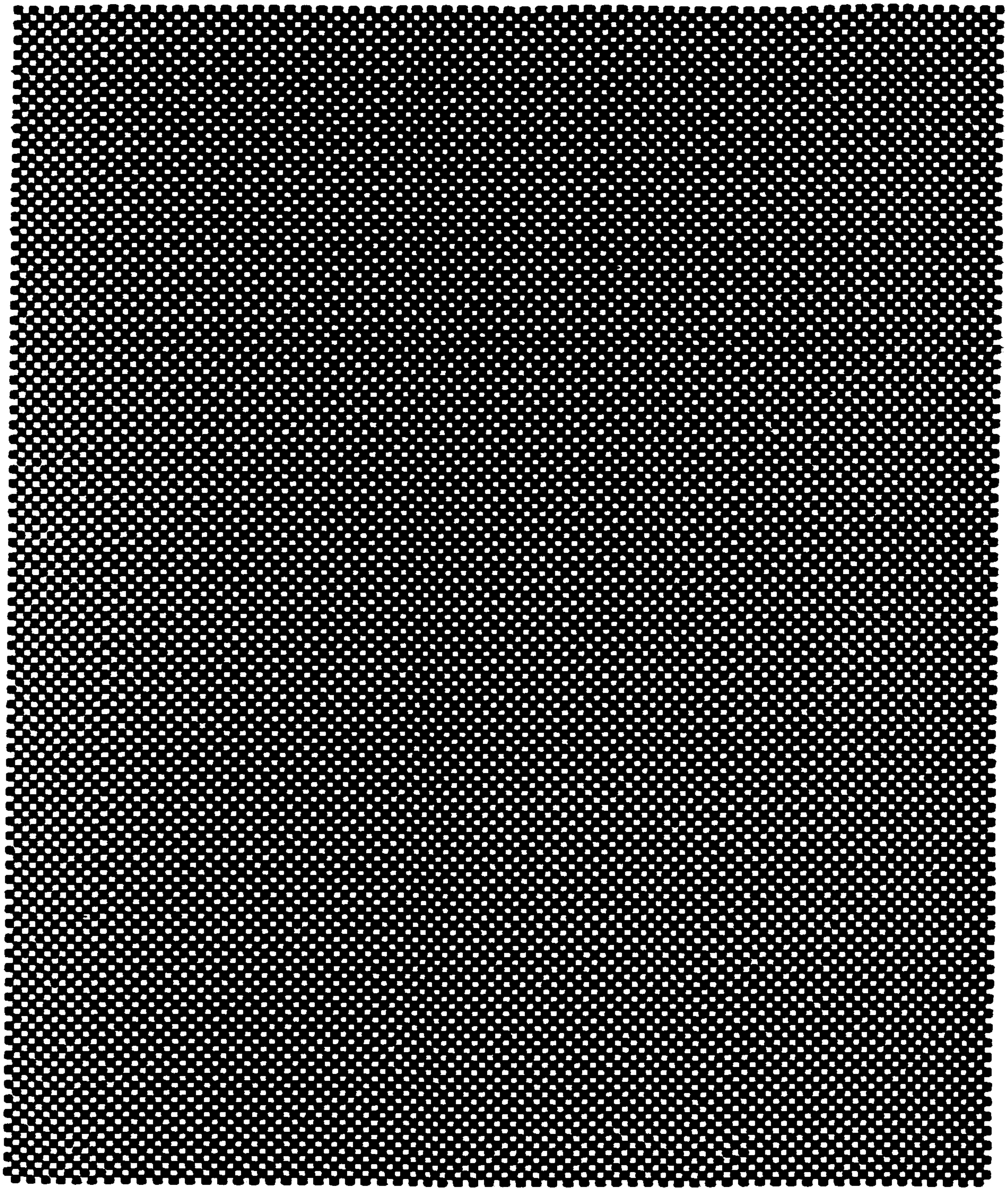


Figure 1. Sheet with 20,000 squares (representing parts). Make 50 copies to combine into a chart showing what a million parts looks like, so that students can understand ppm.

PART A: HOW DOES WATER GAIN OXYGEN?

Additional materials for Part A

For each group

- 2 sealed canning jars filled to the top with boiled water. Prepare ahead of time by boiling water vigorously for 10 minutes, pouring it into canning jars, and sealing them immediately. Do not use until they have reached room temperature.
- large open container to pour water into
- implements to agitate water

For half the groups

- 6 strands of *Elodea* (*Anacharis*) an aquarium plant easily obtained from pet stores or science supply companies (Sc.Kit 67440)

Procedure

Before class

1. Before having the students perform the dissolved oxygen test, the teacher must practice to learn how to do it.
2. If you are using the Winkler method, allow time (perhaps the day before) for the whole class to practice using the test materials with the teacher directing and discussing each step.
3. Prepare the "canned" water as explained above.

During class

1. Using the parts per million chart (Fig. 1), demonstrate how small a ppm is and have students research how many ppm of oxygen water usually holds.
2. Distribute the sealed jars explaining that you treated the water to remove the oxygen. Have students working in groups test the water for dissolved oxygen (DO). What was the *amount of dissolved oxygen when the jar was first opened?*
3. *How does air gets into water in a natural setting?* (from the atmosphere, waterfalls, rapids, waves). *How could these be simulated using the equipment at hand?* (Shake the water. Pour off part of the water into the large open container and recap the jar before shaking. Agitate the water. Pour all the water into the large container and use the implements to agitate it.)
4. Have students return the water to the jar and again measure the DO. What was *the amount of dissolved oxygen after the water was agitated? How much change in dissolved oxygen did you measure?*
5. Using the chalkboard, large chart, or overhead projector consolidate the class data and average the results. *Record the results for the*

class. What was the average difference in ppm? Why did dissolved oxygen levels change? (The agitation caused an increase in contact between the air and the water, so more oxygen could dissolve in the water.)

6. Discuss why different groups got different results and mention that scientists repeat tests many times for accuracy.
7. Now have each group unseal their remaining jar and test the DO level. What was *the amount of DO when the jar was first opened?* Have half the groups reseal their jars and half add 6 strands of *Elodea* to their jars before resealing; set all jars out in the sunshine for several hours. Then test the DO level in all the jars. What was the *amount of DO after the jar sat in the sunlight (with or without plants)? How much change in DO did you measure?*
8. *Record the results for the class.* What was *the average difference for jars with no plants?* What was the *average difference for the jars with plants? Why are the results different for the two sets of jars?* (Plants add oxygen to the water when they photosynthesize.)
9. *What are some ways that oxygen gets into water?* (Oxygen gets into water from the air, especially when water is agitated and from plants during photosynthesis.)

PART B: HOW DOES WATER LOSE OXYGEN?

Additional Materials for Part B

For the class

- opaque bag or dark place

For each group

- 4 qt. jars with screw tops
- 6 strands of *Elodea*
- 1 small guppy (Sc.Kit 67230-03), goldfish (Sc.Kit 67039-12), or crayfish (Sc.Kit 67020-01) or obtain locally

Procedure

Before class

Set out all the jars filled with water with their tops removed to age two days ahead.

During class

1. You know that aquatic animals use oxygen from the water. *How much oxygen do you predict a small aquatic animal will use in one hour?* (Substitute 45 minutes if necessary.) *Record your predictions.*
2. Have students measure the DO in two of their open jars.

3. Next have students place a small animal, i.e., goldfish, in one jar, label the other jar as the control, and seal both jars for about one hour. Caution the students to do this carefully and not to tap on the jar.
4. While waiting for the animal to spend time in the sealed jar, set up the plant experiment. *Do you think plants use up oxygen in the water too?* (Most students will think that plants add oxygen to water but do not use any.) *Predict which jar, the one with the plants or the control, will contain the most oxygen after 24 hours.*
5. Use the other open jars to test if plants use oxygen. Either measure the dissolved oxygen before beginning or assume they will be the same as the first two jars measured.
6. Put 6 strands of *Elodea* in one quart jar.
7. Refill the two jars to the brim with water and screw the tops on tightly.
8. Label the jar without the plants as the control.
9. Place all the jars in the opaque bag or in a dark closet and leave overnight. Best results will be obtained if the temperature does not go below 70° F.
10. After one hour, return to the animal experiment. *How much oxygen did your group's animal use in one hour as indicated by a change in the ppm of oxygen? Did different kinds of animals use different amounts of oxygen? Did animals of the same kind all use the same amount of oxygen? If there were differences, why might these have occurred?* (Different kinds of animals and different sized animals would use different amounts.)
11. The next day test the jars that were in the dark.
12. *Which changed more, the water with the plants or the control?* (the water with the plants) *What can you conclude about plants and oxygen?* (Plants use oxygen in respiration in both the dark and the light, but in light when they also photosynthesize, they add oxygen too; having the plants in the dark removed the effect of photosynthesis so their oxygen use could be observed.)
13. *What are some ways oxygen gets removed from water?* (plant and animal respiration)

Teacher Notes

Oxygen levels in water naturally vary from 0 to 14.5 ppm (Mitchell and Stapp, 1997).

The dissolved oxygen capacity of the water depends on the temperature and salinity of the water and on the atmospheric pressure.

See the Dissolved Oxygen Tolerance Chart (Chart 1, Field Trip Plan Section) to learn the effects on aquatic life of different oxygen levels.

Relationship to Alum Rock Park

Measuring the dissolved oxygen above, at, and below the springs will show if the mineral springs have any effect on this water characteristic and subsequently on the kind of life that could survive in different parts of Penitencia Creek. It is only possible to measure the dissolved oxygen in the springs with a meter as the chemical tests react to the chemicals in the springs and do not indicate the oxygen levels accurately. Omit this test in the springs unless you have a meter.

NAME________________________
DATE___________PERIOD_____

STUDENT WORKSHEET FOR ACTIVITY 1, PART A: HOW DOES WATER GAIN OXYGEN?

1. Record the results of your group's dissolved oxygen tests.

   a. Amount of dissolved oxygen when the jar was first opened: ________ppm

   b. How does air get into water in a natural setting, and how can we simulate these processes with the equipment at hand?

   ____

   ____

   c. Amount of dissolved oxygen after the water was agitated: _________ppm

   d. How much change in dissolved oxygen did you measure? ________ppm

2. Record the results for the class on this table:

DISSOLVED OXYGEN (DO) IN PPM

Group Number	1	2	3	4	5	6	average
DO--jar first opened							
DO--after agitation							

   a. What was the average difference in ppm? _________

   b. Why did the dissolved oxygen levels change?

   ____

   ____

3. Record the results for the dissolved oxygen in the second jar.

   a. Amount of DO when the jar was first opened: ____________ppm

   b. Amount of DO after jar sat in sunlight (with or without plants):_______ ppm

   c. How much change in DO did you measure? ____________________ ppm

4. Record the results for the class on this table:

DISSOLVED OXYGEN IN PPM

Group Number	1	2	3	4	5	6	average
DO--jar first opened							
DO--in sun, no plants							
DO--in sun, plants							

   a. Average difference for jars with no plants: ______________ppm

   b. Average difference for jars with plants: _______________ppm

   c. Why are the results different for the two sets of jars?

____

____

5. What are some ways water gains oxygen?

____

____

____

NAME________________________
DATE___________PERIOD_____

STUDENT WORKSHEET FOR ACTIVITY 1, PART B: HOW DOES WATER LOSE OXYGEN?

ANIMALS

1. How much oxygen do you predict a small aquatic animal will use in one hour? Record your predictions and results:

DISSOLVED OXYGEN IN PPM

	start	prediction	after 1 hour	difference
control				
animal				

a. How much oxygen did your group's animal use in one hour, as indicated by a change in the ppm of oxygen?___________

b. Did different kinds of animals use different amounts of oxygen? ________

c. Did animals of the same kind all use the same amount of oxygen? _____

d. If there were differences, why might these have occurred?

____

____

PLANTS

2. Do you think plants use up oxygen in the water? ________________

3. Predict which jar, the one with plants or the control, will contain the most oxygen after 24 hours.

____

4. Record the results of your group's plant test on this table:

DISSOLVED OXYGEN IN PPM

	start	after 24 hours	difference
control			
plants			

5. Record the class results on this table:

DISSOLVED OXYGEN IN PPM

group	1	2	3	4	5	6	total	average
control								
plants								

a. Which changed more, the water with the plants or the control?

____

b. What can you conclude about plants and oxygen?

____

____

____

6. What are some ways oxygen gets removed from water?

____

____

ACTIVITY 2: THE pH OF COMMON SUBSTANCES

Objectives

1. Gain background for measuring pH in a stream environment.
2. Observe that common substances may be acids, bases, or neutral and thus have different pH levels.

Materials

For the class

- 0.5 L of each test liquid
  neutral substances to test, such as--distilled water, isopropyl alcohol, salt water
  acidic substances to test, such as lemon juice, white vinegar, cola, 10 aspirin tablets dissolved in 0.5 L of water
  basic substances to test, such as 4 T baking soda, 20 antacid tablets, liquid soap (dissolve the solids in water and let sit overnight)
- 100 mLs of Universal Indicator Solution (Sc.Kit 87762) or wide range pH test paper (Sc.Kit 66627)
- a rinse station with water bottles and a catch bucket or access to a sink
- pH Tolerance Chart (Chart 2, Field Trip Section)
- marking pen
- masking tape
- chalkboard, chart paper or overhead transparency for recording class results

For each group of 4 students

- 1 tray
- baby food jars, wide-mouthed cups, or beakers for test substances
- a dropper (Sc.Kit 68593-02) for each substance to be tested
- 2 very small dropping bottles (Sc.Kit 68593-02) for the Universal Indicator solution or strips of test paper stored in 2 small vials (If paper strips are used, forceps are needed to handle them.)
- 1 Universal Indicator Color Chart (comes with the indicator solution or test paper)
- 2 mixing trays (white styrofoam egg cartons, white plastic ice cube trays)
- 4 paper towels
- 4 pencils
- 4 data sheets
- 4 safety goggles (Sc. Kit child size 68637-00, adult size 62011-01)

Procedure

1. In discussions leading up to your trip to Alum Rock Park, you may have mentioned the needs of terrestrial wildlife for certaiin food, cover, space, etc. The aquatic life has requirements as well. One is a certain range in the acidity level of the water. Explain to students that if their stream measurements are to have meaning for them, they need to be familiar with the pH of common substances.
2. Have students brainstorm acids and bases that they have heard of and list them so all can see. Explain that **acids** and **bases** are names of groups of chemicals that act in similar ways as other members of their group, but acids and bases act differently from each other. Chemicals that are not acids or bases are called neutral.
3. Introduce the pH scale as a number line that goes from 0 to 14. (The acids have a pH below 7 and bases a pH above 7; neutral substances have a pH of 7.)
4. Explain to the students that they will be testing some common substances to see if they are acids, bases, or neutral. They will be using strips of paper coated with a substance that will show the pH level or a liquid indicator solution.
5. Have students put on the safety goggles. Remind them that if they get any chemical on themselves, to rinse the site repeatedly with water at the sink or rinse station.
6. Demonstrate how to test a substance:
   a. *List each substance to be tested and record your prediction of its group (acid, base, or neutral) on the data table.*
   b. *Add a small amount of the substance from the container on the group tray into a section of your tray with the dropper.*
   c. *Using the forceps to hold the test paper, dip it into the solution for a few seconds and lay it on your paper towel or add two drops of Universal Indicator Solution to the test solution and gently swirl the mixture.*
   d. *Use the pH color chart to compare your solution or test strip and decide on the pH of the test substance.*
   e. *Record the pH numerical reading on your data sheet and label it as an acid, base, or neutral substance.*
   f. *Show where each substance falls on the pH scale at the bottom of the page.*
7. Have the students test the substances and record their results. If the color seems to be in between two numbers, such as 3 and 4, have students use 3.5 to indicate the result.
8. Record the data of each group where all can see (chalkboard, overhead, etc.). Discuss why different students got different results. How should the results be combined? By averaging? Other ideas?

9. Note which substances were in each category. Was the class surprised at any results?
10. Look at the pH Tolerance Chart (Chart 2, Field Trip Plan) and note which organisms would have difficulty living in the various test substances. Notice what a small range some organisms can tolerate. Acidic substances corrode metal. Why might this be a problem in a stream? (At levels of 5.0 -5.5 metals such as lead and aluminum that are often trapped in sediments are released into water and may be toxic to aquatic life.)

Teacher Notes

The pH scale is a logarithmic one. The lower the pH is below 7, the stronger the acid; a substance with a pH of 4 is ten times as acidic as one with a pH of 5. The higher the pH is above 7, the stronger the base; a substance with a pH of 9 is ten times more basic than one with a pH of 8.

Relationship to Alum Rock Park

The mineral springs in the park vary in their pH levels and also in the life forms that live in their waters. Can the students find any correlation between the pH and what lives in the spring?

Students can also test the Penitencia Creek water to see if the spring water emptying into the creek affects the pH of the larger body of water and what organisms can live there.

Additional Resources:

For a more extensive treatment of these ideas see:

1) Barber, Jacqueline. 1989, *Cabbages and Chemistry* (Grades 4-8): Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, U.C Berkeley, CA.
   Students use red cabbage juice as an indicator to classify common liquids into groups with similar reactions.

2) Hocking, Colin and others, 1990, *Acid Rain* (Grades 6-10): Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, U.C. Berkeley, CA.
   After becoming familiar with acids and bases, students learn about the effects of acid rain on the environment and experience controversy in science, including the relationship between scientific and social issues.

NAME________________________
DATE___________PERIOD______

STUDENT WORKSHEET FOR ACTIVITY 2:
THE pH OF COMMON SUBSTANCES

1. Test the pH of the substances provided using the following procedure:
   a. List each substance to be tested and record your prediction of its group (acid, base, or neutral) on the data table.
   b. Add a small amount of the substance from the container on the group tray into a section of your tray with the dropper.
   c. Using the forceps to hold the test paper, dip it into the solution for a few seconds and lay it on your paper towel or add two drops of Universal Indicator Solution to the test solution and gently swirl the mixture.
   d. Use the pH color chart to compare your solution or test strip and decide on the pH of the test substance.
   e. Record the pH numerical reading on your data sheet and label it as an acid, base, or neutral substance.
2. Show where each substance falls on the pH scale at the bottom of the page.

DATA TABLE

Test Substance	Prediction	Numerical Result	Acid, Base, or Neutral

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

most acidic — neutral (7) — most basic

FIELD TRIP PLAN

WATER QUALITY OF PENITENCIA CREEK

Enter Alum Rock Park by the main entrance on Alum Rock Avenue. Park at the east end of the parking lot. (see Field Trip Map [Fig. 1] in Background Information section and Mineral Springs Map [Fig. 1] in Field Trip Plan section).

STOP 1--ABOVE THE SPRINGS

a. Walk to the Sycamore Grove Picnic Area 300 m above the 1913 bridge.
   1) The water is most easily reached at the far end of this picnic area.
   2) You could use both sides of the creek, if conditions allow. Where you have students work will depend on the creek conditions.
   3) Decide on five stations where the adults or older students can safely take a water sample.

b. Have the groups rotate through all the stations and do all the tests.

c. In all cases that involve swirling chemicals such as in the La Motte or Hach kits, have the testers wear latex gloves and goggles.

d. Rinse all equipment between tests at different sites. Collect all liquid chemical wastes and rinse water in a liquid waste container that you empty in a sink or toilet connected to a sewage treatment plant. (Alum Rock Park's bathrooms are connected to septic tanks.)

e. Collect all solid wastes connected with the tests and dispose of them safely.

f. Record the agreed upon measurements.

g. **Station 1--Dissolved oxygen (DO)**
   1) Follow the directions given with the kit.
   2) Allowing an air bubble to be in the test sample when using the Winkler method will invalidate this test.
   3) Dissolved oxygen readings vary with the time of day and the temperature.
   4) Take the water for the dissolved oxygen test under as similar conditions as possible at each stop--i.e., still water each time,

tumbling water each time, etc.

h. **Station 2--pH:**
   1) Follow the directions given with the meter or kit or dip pH paper directly in the water.
   2) Collect used pH paper in the dry waste container.

i. **Station 3--Temperature, Color and Odor:**
   1) Lower the thermometer 10 cm into the water.
   2) Read the thermometer with the bulb in the water if you can.
   3) Have at least two people verify the temperature.
   4) To record the air temperature, remove the thermometer from the water, rinse it, wipe it dry and place it in the shade for one minute before recording the air temperature.
   5) Fill the clear plastic cup with water. One student should hold the cup up to the light while another holds a white paper behind the cup. Note the color.
   6) Note the odor if any.

j. **Station 4--Turbidity**
   Follow the directions for your measuring equipment.

k. **Station 5--Conductivity**
   1) Be sure the meter is calibrated before using it.
   2) If you are able to move upstream in the creek bed, you may be able to discover where a spring bubbles up through the creek by a change in the conductivity readings.

l. Gather at the picnic tables at the Sycamore Grove area
   1) Discuss test results. Average group results.
   2) *Why did different groups obtain different readings of water quality?* (different experimenters, different test equipmement, different techniques)
   3) *Which qualities will be different in the mineral springs versus the stream?*. (Possibly all of them. Unless you have an oxygen meter, you will not be able to measure the dissolved oxygen level of the mineral springs.)

STOP 2--MINERAL SPRINGS

a. Choose several distinctive springs to sample. Springs #17 and #19 are good possibilities (see Mineral Springs Map).
b. Set up the testing stations and have groups run the tests. Because

chemical tests will not provide accurate DO data,observation of life forms in the springs could be substituted here. A DO meter, however, will provide usable data.

c.. *What life forms are found in the mineral springs?* (Some possibilities are filamentous bacteria, mosquito larvae and pupae, and blackfly larvae.) (Chart 4).

d. *Were any of the water quality measurements very different for the spring or springs measured than for the creek? Which ones?*

e. Before you move on to Stop 3 discuss the following questions: *Which water qualities in the mixed spring and creek water areas will be the most like those in the creek at Stop 1 above the springs? Which water qualities will be the most affected by the mixing of the spring water with the creek water?*
(Not enough data has been collected to give a definite answer to these questions. The object is for the students to give reasons for their answers.)

STOP 3--MINERAL SPRING AND CREEK WATER MIXED

a. There are three easily accessible places where the mineral springs water can be seen to mix with the creek water. Choose the area that is best for the current conditions (see Mineral Springs Map).
   1) On the north side of the bridge just below Stop 1--either upstream or downstream from the bridge.
   2) On the north side of the bridge just below Spring #17.
   3) On the south side of the bridge along the stone wall where the water from Spring #24 mixes with the creek (close to tree #16)

b. Have each group repeat each test, if possible, or have them become specialists in one test after they have had an opportunity to do each test at least once.

c. Gather on the bridge just below the Sycamore Grove area or on the stone wall bordering the creek on the south side.
   1) Again compare and average results.
   2) *What water qualities were most and least affected by the mixing of the spring water with the creek water? Were you surprised by any of the results? Why or why not?*
   3) Look at the invertebrate chart and the tolerance charts (Charts 1, 2, 3, and 4). *What living things would have difficulty surviving in the*

mineral water according to the qualities we measured? (steelhead, salmon, riffle sculpins, stonefly nymphs, cadisfly larvae, mayfly nymphs, water beetles, water striders) *What would you expect to find living there?* (Rat-tailed maggots, mosquito larvae, and mosquito pupae that can obtain oxygen through tubes that they extend above the water)

4) *Do you think these measurements will be the same downstream from the springs,? Why or why not?*

STOP 4--BELOW THE MINERAL SPRINGS

a. Have the bus drive you to the parking area close to the Visitors' Center. Cross the bridge and walk upstream. Just above the bridge near the Ramada (covered picnic area), it is fairly easy to reach the stream. Again measure the water quality, compare and average the results.

b. Gather at the Ramada to compile data.

c. *Did the effects of the mineral springs reach this far downstream?* (Most water quality readings will probably be unaffected by the addition of spring water because it is so diluted by the much larger amount of creek water. Turbidity readings and conductivity readings, however, may be slightly higher (see Table 1 for some sample results).

d. *What life forms would be able to survive in this water compared to what could live close to the springs?* (Trout, salmon, snails, clams and immature mayflies, caddisflies, and stoneflies could survive above and below the springs. Carp, suckers, catfish, California roach, *Beggiatoa, Oscillatoria,* and immature mosquitoes, black flies, craneflies, and syrphid flies could probably survive near the springs.)

e. Have students share what they learned about doing the water tests, what they enjoyed and did not enjoy.

f. This would be a good place to eat a snack or lunch. Students could play on the playground too.

STOP 5--VISITORS' CENTER

Be sure to see the old photos of the park including the mineral springs and the model of the park, as well as the insect collection and any live animals that might be on display.

Table 1

Sample Water Quality Data from Penitencia Creek and Mineral Springs: Temperature, Odor, Color, Turbidity, Dissolved Oxygen, pH, Conductivity

Date	Time	Air Temp. °C	Water Temp. °C.	Odor	Color	Turbidity in JTU's	DO in ppm (Chemetrics)	pH (meter)	Conductivity (meter)
Above the spring (Sycamore picnic area)									
10/98	12:15 PM	18	13	none	colorless	0	11	8.2	0.6
Spring #19									
10/98	11:30 AM	19	27	sulfur	white	150	no data	7.2	4.6
Middle of springs (below Spring 19)									
10/98	12 noon	22	26	slightly sulfur	white	100	6	7.9	4.2
Spring #17									
10/98	12:30 PM	29	23	slightly sulfur	slightly orange	>5	no data	6.6	8.1

Sample Data (Continued)

Date	Time	Air Temp. °C	Water Temp. °C.	Odor	Color	Turbidity in JTU's	DO in ppm (Chemetrics)	pH (meter)	Conductivity (meter)
Middle of springs (below Spring 17)									
10/98	1 PM	29	23	slightly sulfur	slightly orange	>5	7	7.8	3.8
Middle of springs (below bathroom)									
10/98	1:15 PM	28	21	slightly sulfur	yellow	>5	7	7.6	3.2
Below springs (next to Ramada)									
10/98	1:30 PM	14	12	none	colorless	>5	11	8.2	1.3

NAME________________________
DATE____________PERIOD_____

STUDENT WORKSHEET FOR WATER QUALITY OF PENITENCIA CREEK IN ALUM ROCK PARK FIELD TRIP

STOP 1--ABOVE THE SPRINGS

1. Why did different groups obtain different readings of water quality?

____

____

2. Which qualities will be different in the mineral springs versus the stream?

____

STOP 2--MINERAL SPRINGS

3. What life forms are found in the mineral springs? Some possibilities are filamentous bacteria, mosquito larvae and pupae and blackfly larvae.

____

4. Were any of the water quality measurements very different for the spring or springs measured than for the creek? Which ones?

____

5. Which water qualities in the mixed spring and creek water areas will be the <u>least</u> affected by the mixing of the waters and will be most <u>like</u> those in the creek at Stop 1 above the springs?

____

____

6. Which water qualities will be the <u>most</u> affected by the mixing of the spring water with the creek water?

____

____

STOP 3--MINERAL SPRING AND CREEK WATER MIXED

7. What water qualities were most and least affected by the mixing of the spring water with the creek water? Were you surprised by any of the results? Why or why not?

____

____

8. What living things would have difficulty surviving in the mineral water according to the qualities we measured? What would you expect to find living there?

____

____

9. Do you think these measurements will be similar downstream from the springs? Why or why not?

____

____

STOP 4--BELOW THE MINERAL SPRINGS

10. Did the effects of the mineral springs reach this far downstream?

____

11. What life forms would be able to survive in this water compared to what could live close to the springs?

____

Name/#__________
Date__________

WATER QUALITY DATA ALUM ROCK PARK
SAN JOSE, CALIFORNIA

Location	Time	Air °C	H2O °C	Odor	Color	Turbidity	D.O.	pH	Conduct.
Above									
Mineral									
Springs									
Spring #									
Spring #									
Mineral Springs									
and Creek									
Mixed									
Below									
Mineral Springs									

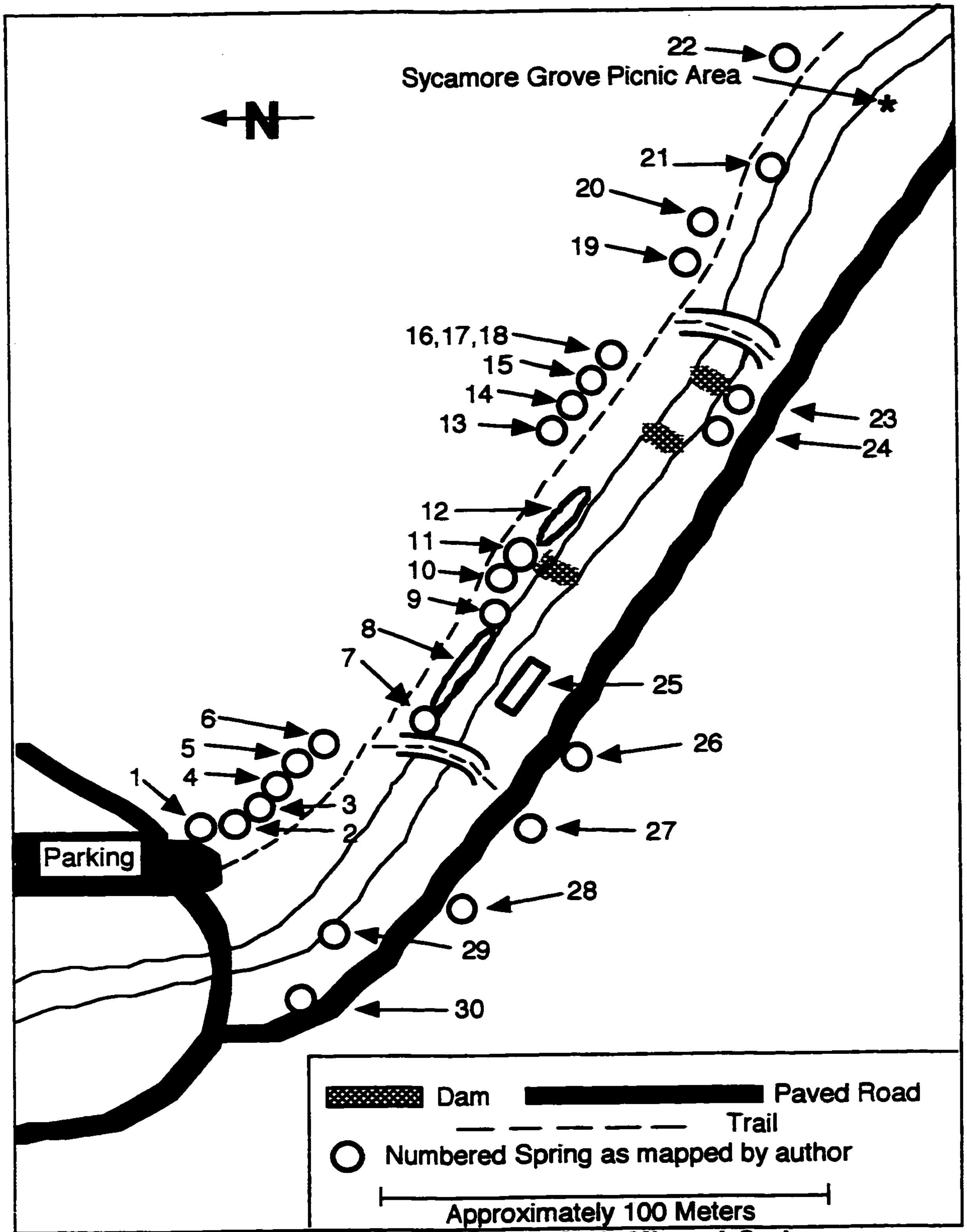


Figure 1. Map of Alum Rock Park Mineral Springs.

CHART 1: DISSOLVED OXYGEN (DO) TOLERANCES

	A	B	C
1	Biologic Effects on Aquatic Life	DO mg/L Instream	DO mg/L Intergravel
2	I. Salmonid waters		
3	A. Embryo and larva		
4	No production impairment	11	8
5	Slight effect	9	6
6	Moderate impairment	8	5
7	Severe impairment	7	4
8	Limit	6	3
10	B. Other life stages		
11	No production impairment	8	
12	Slight effect	6	
13	Moderate impairment	5	
14	Severe impairment	4	
15	Limit	3	
17	II. Non-salmonid waters		
18	A. Early life stages		
19	No production impairment	6.5	
20	Slight effect	5.5	
21	Moderate impairment	5	
22	Severe impairment	4.5	
23	Limit	4	
25	B. Other life stages		
26	No production impairment	6	
27	Slight effect	5	
28	Moderate impairment	4	
29	Severe Impairment	3.5	
30	Limit	3	
32	III Invertebrates		
33	No production impairment	8	
34	Some effect	5	
35	Limit	4	

(Modified from Rigney and Katznelson,1996.)

CHART 2
pH TOLERANCE LEVELS

most acidic							neutral (7)							most basic
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Bacteria xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Plants xxxxxxxxxxxxxxxxxxxxxxxxxxx

Carp, suckers, catfish, some insects xxxxxxxxxxxxxxxxx

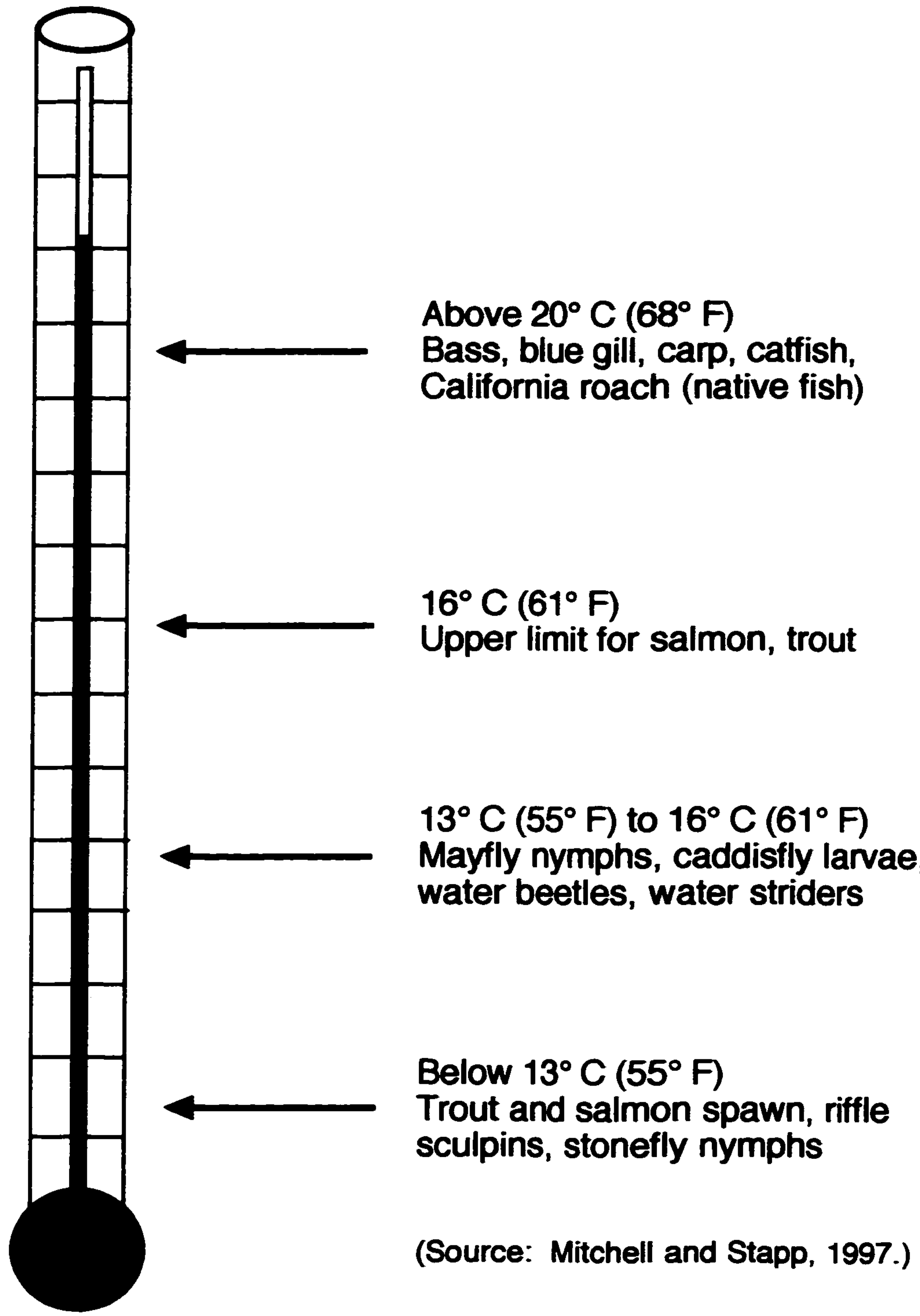
Bass, bluegill xxxxxxxxxxxxxx

Snails, clams xxxxxxxxxxxx

Trout, salmon, mayfly nymphs, stonefly nymphs, caddis fly larvae-- Largest variety of animals xxxxxxx

(Source: Mitchell and Stapp, 1997.)

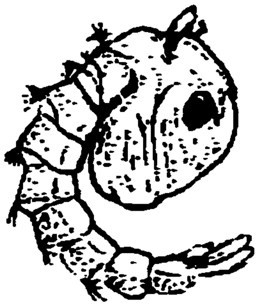
CHART 3
TEMPERATURE TOLERANCES OF SOME AQUATIC LIFE



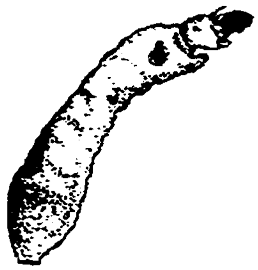
(Source: Mitchell and Stapp, 1997.)

CHART 4
INVERTEBRATES OF THE MINERAL SPRINGS


Mosquito larva

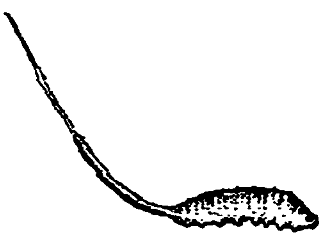

Mosquito pupa


Mosquito adult


Black fly larva


Black fly adult


Yellow jacket adult


Syrphid fly larva
(Rattailed maggot)


Syrphid fly adult


Ostracod


Crane fly larva


Crane fly adult


Aquatic soldier fly larva

ROCKS OF ALUM ROCK PARK

The "Rocks of Alum Rock Park" module makes students aware of the various processes by which rocks are formed and helps them locate examples of igneous, sedimentary and metamorphic rocks in Alum Rock Park.

The BACKGROUND INFORMATION material is concerned with how the various categories of rocks are formed and provides details on local examples.

The six CLASSROOM ACTIVITIES are all simulation experiences. In "Magma to Igneous Rocks","Sediments to Sedimentary Rock", "Metamorphic Rocks" and "The Rock Cycle" students experience the rock producing processes. By participating in the "Folded Rocks" and "Faulted Rocks" activities, students will be able to see how these phenomena caused by plate tectonics, so visible in this area, relate to the landscape in Alum Rock Park.

The FIELD TRIP PLAN provides an opportunity to see local examples from the rock formation categories: a few igneous rocks, many sedimentary rocks, and perhaps the hard-to-find metamorphic rocks. It allows for an overall view of Alum Rock Canyon from the Alum Rock itself, to the mineral springs, and to the top of Inspiration Point. This field trip is designed to increase understanding of this active geologic area.

BACKGROUND INFORMATION

ROCKS OF ALUM ROCK PARK

PRE-TRIP ARRANGEMENT

Arrange a time for the Visitors' Center (Fig. 1) to be open. Phone Number: (408) 277-4539

PURPOSES

1. See examples of local igneous, sedimentary, and perhaps metamorphic rocks.
2. Become aware of the processes by which these rocks were formed.

CONNECTIONS TO THE CALIFORNIA SCIENCE FRAMEWORK

Themes: Patterns of Change, Scale and Structure, Energy, Evolution

Process Skills: observing, communicating, comparing, ordering, categorizing, relating, inferring

Integration with Other Areas: botany, drawing, creative writing

GRADE LEVEL: upper elementary, middle school

TIME: 3 hours

GROUPING: entire class

MATERIALS:

To prepare a 3% N solution of HCL, you will need 12N concentrated HCl. Add 1 part acid to 3 parts water, pouring the acid into the water.

- 12N concentrated HCl (Sc. Kit 82240-03) or obtain from a high school science department
- 1 dropping bottle (Sc. Kit 68593-02)
- magnifiers--10x--(Sc.Kit 62367)
- plant key, such as *Pacific Coast Tree Finder* (Acorn FG-658)
- clip boards, worksheets, writing and drawing paper and pencils (if students will be writing)
- pieces of different colored felt (or paper) to show folding of layers
- spray bottle of water

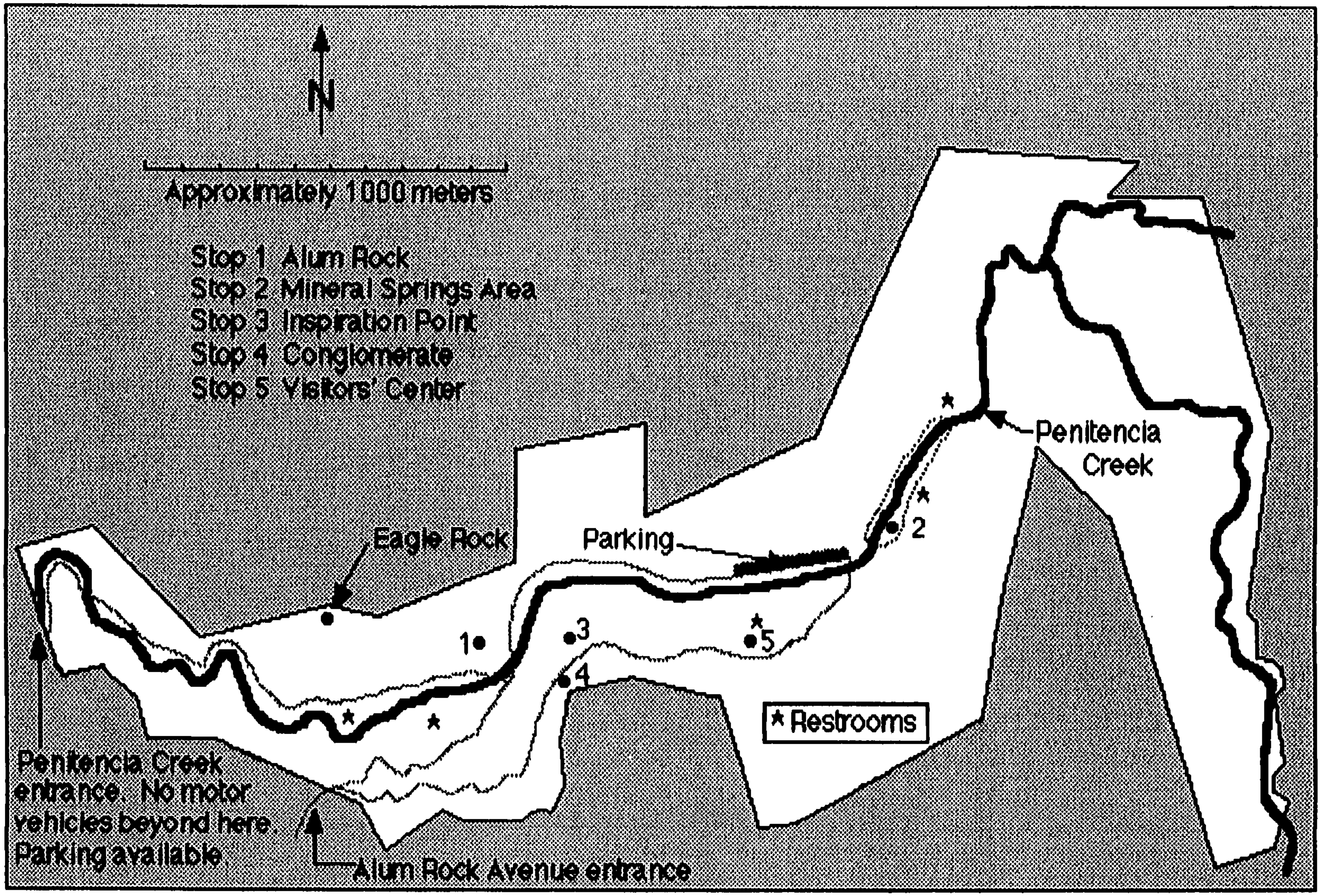


Figure 1. Map for Rocks of Alum Rock Park field trip. (Modified from San Jose Regional Parks, no date, Alum Rock brochure.)

- compass (Acorn T-3037 or Sc.Kit 61190)
- topographic map--Calaveras Reservoir (USGS 7 1/2 minute Quadrangle). (REI or USGS, Menlo Park)
- meter trundle wheel (Sc. Kit 68936)--optional but useful for locating field trip stops
- Field Trip Map (Figure 1) photocopy

LESSONS TO DO BEFORE YOU COME: "Magma to Igneous Rocks", "Sediments to Sedimentary Rocks", "Metamorphic Rocks", "Rock Cycle", "Faulted Layers", and "Folded Layers"

GEOLOGIC BACKGROUND

Rock Categories

Rocks are categorized according to the process by which they were formed. **Igneous** rocks are those formed from molten rock. If the rocks cooled underground from **magma**, they will have coarse (large) grains and are called **intrusive** igneous rocks. If the rocks formed above ground from **lava** and have fine (small) grains, they are labeled as **extrusive** igneous rocks. Both the formation environment and the mineral content of the rocks are used to classify igneous rocks (Table 1). **Sedimentary** rocks are those that formed on the Earth's surface from sediment fragments. **Clastic** sedimentary rocks are made from eroded sediments (**clasts**) of other rocks, while those described as **chemical/biogenic** are formed from sediments that precipitated from water. Biogenic rocks are made from microscopic plant and animal skeletons. **Metamorphic** rocks are made from igneous, sedimentary, or other metamorphic rocks whose texture and make-up have been changed (without melting) by increased temperature and/or pressure and the action of fluids.

Rocks of Alum Rock Park

The most familiar igneous rocks are not present in Alum Rock Park. **Granite**, one of the most abundant intrusive igneous rocks in the continental crust, only appears in the park as small pieces within a sedimentary rock called conglomerate. **Basalt**, the fine-grained igneous rock that makes up most of the oceanic crust, appears only as greenstone, a metamorphosed basalt. **Rhyolite**, chemically similar to granite but formed in an extrusive environment, is the parent rock of the three monoliths, Alum Rock, Inspiration Point, and Eagle Rock (Table 1). Geologists now call this a **quartz keratophyre** (ker rat' o fere) because when it erupted under the ocean, the lava reacted with ocean water and was altered.

	Felsic	**Intermediate**	**Mafic**	**Ultramafic**
	Light minerals	Medium colored 50% light 50% dark	Dark minerals and plag.	Almost all dark minerals
Coarse-grained	granite	diorite	gabbro	Peridotite (ol., px., ± garnet)
Fine-grained	rhyolite	andesite	basalt	———
SiO_2 Content	70%	60%	50%	45%
Minerals Present	qtz., Kspar., Na-rich plag., micas, hb.	Ca-Na plag., hb., px.	Ca-rich plag., ol., px., hb.	ol., px., ± garnet micas

Mineral abbreviations: qtz.: quartz; Kspar.: potassium feldspar; plag: plagioclase feldspar; hb.: hornblende; px.: pyroxene; ol.: olivine.

Table 1: Rocks formed by crystallization of magma or lava. (Modified from Metzger et al., 1994).

Sedimentary rocks are particularly well represented in Alum Rock Park. **Sandstone**, a common clastic sedimentary rock made of medium size grains and often composed of feldspar and rock fragments as well as quartz, is found in different deposits along Penitencia Creek. Those rocks containing fossils are most easily spotted. **Shale** is a fine-grained clastic rock made of particles too small to be seen without a microscope; shale is composed mainly of clay minerals with some feldspar, quartz and mica. Found in many places along Penitencia Creek, shale can be recognized by its tendency to break into thin sheets. **Conglomerate** is a coarse-grained rock composed of large rounded fragments or clasts cemented together. The large conglomerate formation in Alum Rock Park was quarried at one time. **Chert**, hard for a sedimentary rock, is made of silica (as is quartz) but with much smaller crystals; it may be deposited chemically from sea water or biogenically from the silica skeletons of small sea plants and animals. In the mineral springs area, chert forms layered beds between shale deposits. Black, red, green, brown and white chert may also be found as sediments in the creek. Because it is very hard, native people used chert for implements and weapons. **Travertine**, a finely crystalline, layered form of limestone (calcium carbonate), precipitates out of spring water and is deposited around the mineral springs. **Tufa** is the spongy, porous variety of calcium carbonate deposit that forms when spring water evaporates. (Zim and Shaffer, 1962)

In Alum Rock Park metamorphic rocks can be difficult to locate. **Serpentinite** (serpentine is the mineral name), the state rock of California, is named for its greenish-blackish-bluish-grayish serpent-skin appearance. Serpentine began as an upper mantle rock called **peridotite**. After the peridotite moved up from the mantle, hot fluids changed it to serpentinite. In the park serpentinite occurs where the quartz keratophyre meets other rocks. It is difficult to see serpentinite in place, but samples may be found in lower Penitencia Creek and on the trail by the Alum Rock. **Greenstone**, a greenish-black altered basalt formed by interaction with sea water, is located in several places near the Penitencia Creek park entrance along Penitencia Creek Road. It will not be seen on this walk.

Plate Tectonics

The Coast Ranges, which began rising 3 to 4 million years ago, are the product of the interaction of the Pacific Plate with the North American Plate. The boundary where the plates meet has a world famous name--the **San Andreas fault**. (Fig. 2). For the most part, these two plates slide past each other in opposite directions, parallel to each other in a **right lateral** motion; faults like this are called **lateral** or **strike-slip** faults. Where bends occur in this type of plate boundary, however, the motion changes slightly. The motion along the San Andreas Fault is right lateral in some places; in other places the two plates push into each other, causing folding, and uplift. The result is the Coast Ranges (Harden, 1998).

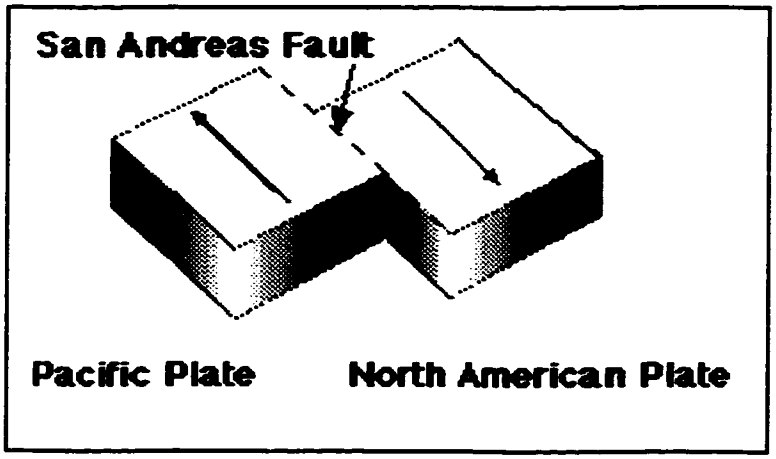


Figure 2. Right lateral motion along the San Andreas fault.

Fault boundaries are not narrow lines as they appear to be on maps; they are really zones of faulting. The San Andreas fault is a fault system made up of many fault zones, including the **Hayward fault zone** and the **Calaveras fault zone**, which run close to or within Alum Rock Park (Fig. 3). It is natural then that people say, "Where is the 'Alum Rock Fault'? Show me!"

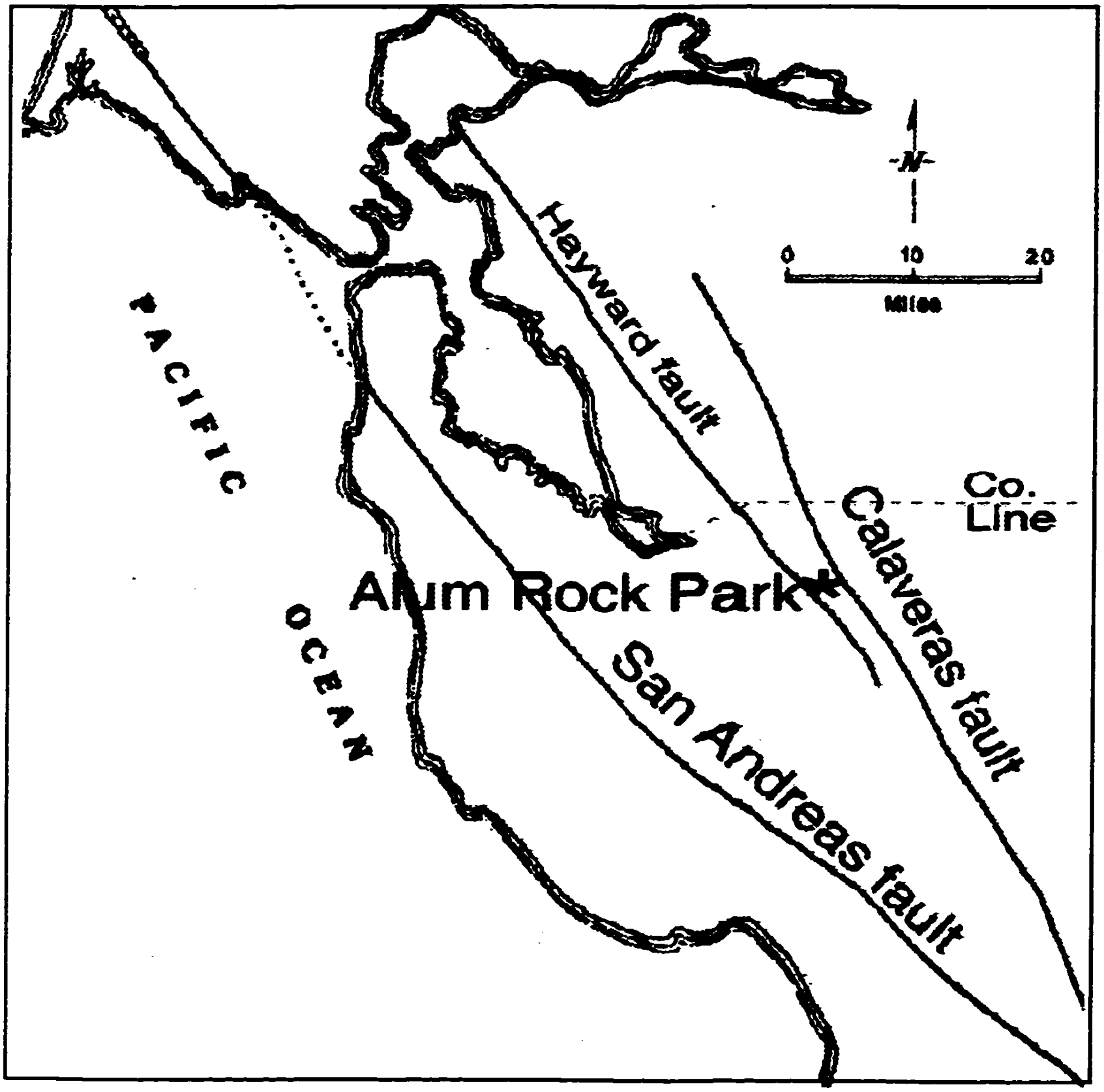


Figure 3. Map of the San Francisco Bay area showing faults that make up the San Andreas fault system. (Modified from Wagner, CALIFORNIA GEOLOGY, November, 1990, page 243, California Department of Conservation.)

There is no "Alum Rock fault" as such, so you will not see it in Alum Rock Park. Features that people have labeled "the fault" over the years are actually erosional ones. There is evidence, however, that geologists have used to delineate fault traces in and around the park (Fig. 4 and Fig. 5).

Since 1950, three geologists have made extensive geologic studies in the areas that included Alum Rock Park: Max Crittenden in 1951, Thomas Dibblee in 1973, and John Coyle in 1984. Crittenden, whose doctoral thesis research was published as the *Division of Mines Bulletin 157*, observed the Hayward fault zone north of the Santa Clara County line (Fig. 4); south of the line, Crittenden's view was that the fault died out or disappeared under the Santa Clara Valley sediments.

Dibblee, who mapped dozens of quadrangles for the United States Geologic Survey (USGS), depicted Alum Rock Park on his Calaveras Reservoir Quadrangle. He showed the Hayward fault trace, although uncertain and partially hidden, running through Alum Rock Park in a northwesterly trend one hundred meters west of the mineral springs area and ending at Penitencia Creek (Fig. 4).

Coyle, partially in an effort to resolve this and other conflicting geologic information, reviewed many of the previous studies and conducted his own field investigations for his San Jose State University master's thesis. Although he used Dibblee's fault trace on his thesis map, he concluded that because of the lack of visible surface features and low seismiscity, the Hayward fault dies out in Alum Rock Park (1984). Although a revised Calaveras Reservoir Quadrangle Special Zone Map (1982) showing the Hayward fault trace crossing Penitencia Creek and turning south was issued before Coyle completed his work, Coyle's view was that the fault does not cross Penitencia Creek (oral communication, November 26, 1996).

In the 1990's geologist, Russell Graymer of the USGS, has continued researching faults in the Bay Area. He believes that this fault does continue through the park, however, he calls it the Warm Springs fault, not the Hayward fault.

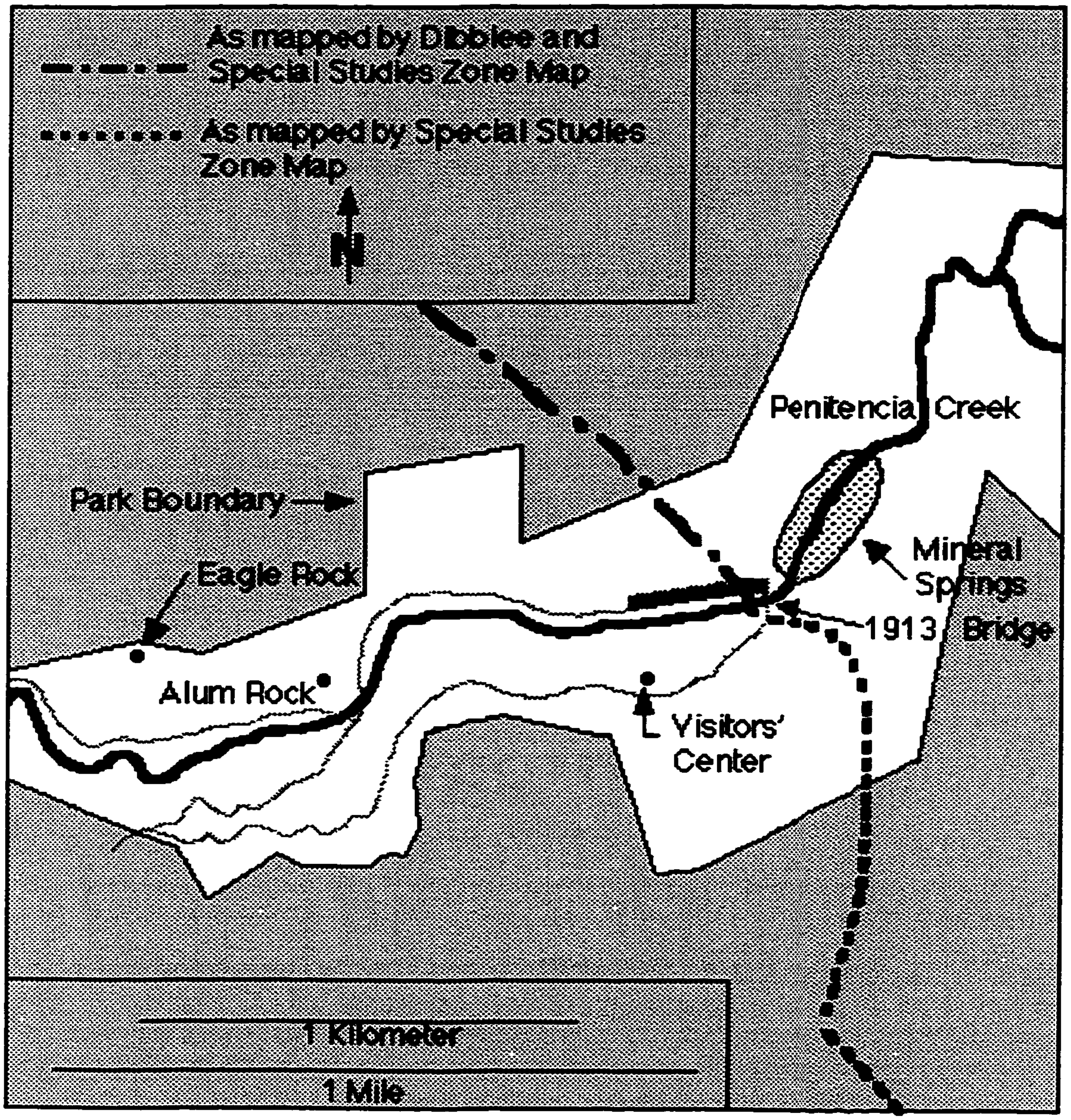


Figure 4. Possible traces of the Hayward fault in Alum Rock Park as mapped by Dibble and as shown on the Special Studies Zone Map. (Sources: Dibble,1973; State of California, 1982; San Jose Regional Parks, no date, Alum Rock brochure.)

Other geologists think that the story is more complicated in that motion on the Hayward fault is transferred east to the Calaveras fault zone by some linking fault. Bennison and others (1991) suggest that the slip on the Hayward fault is transferred to the Calaveras by a complex system of faults including the Silver

Creek fault (Fig 5). However, most geologists consider the Silver Creek fault to be a **thrust fault** and an unlikely candidate to carry the Hayward fault motion. A more likely possibility as a linking fault, is the Mission fault located northeast of San Jose (Andrews et al., 1992) (Fig. 5). No wonder that there are so many versions of the "Alum Rock" fault!

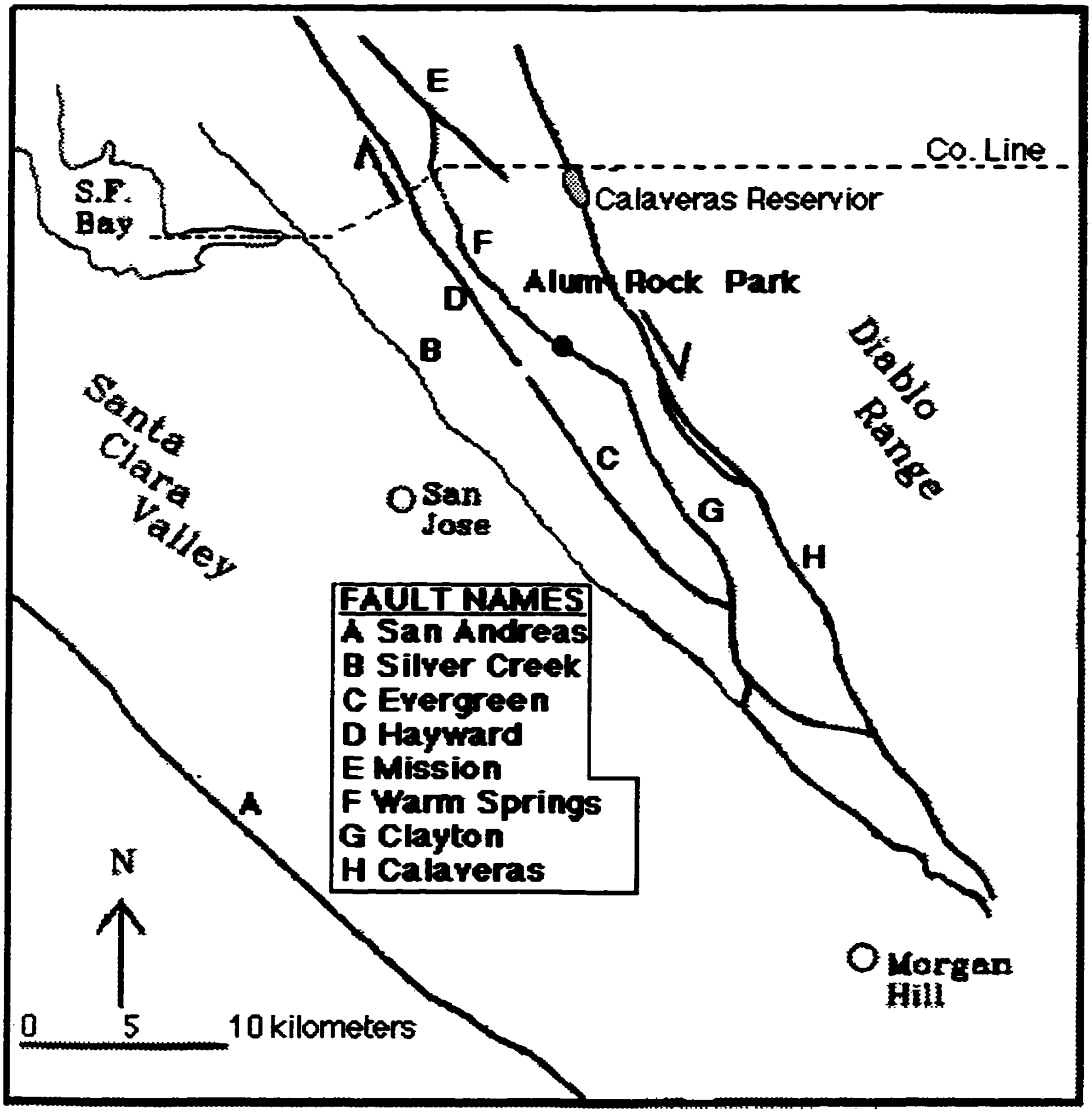


Figure 5. Generalized fault map of the Alum Rock Park area including the fault traces mentioned in the text as possible continuations of the Hayward fault. (Modified from Graymer, 1995.)

Other faults, also part of this large fault system and about which there is little agreement, may be located in the park as well. Much of the evidence showing region. Trenching, so as to look at the underlying rocks, is probably the only way to resolve this difficult puzzle.

Although there is currently no agreement on the exact location of the faults within Alum Rock Park, the compression caused by the meeting of the Pacific and North American Plates can easily be seen. The folding of sedimentary layers is visible at the east end of the parking lot located at the start of the Mineral Springs Walk. These shale and chert layers of the rock group known as the Claremont **Formation** (Fig. 6) appear to be greatly compressed, stressed, and tortured indicating the great force of tectonic activity.

ERA	AGE: Period	Epoch	FORMATION	KIND OF ROCK
CENOZOIC	Quaternary		Santa Clara Formation	unconsolidated gravel, sand, and clay
				unconformity (a break in the geologic record)
	Tertiary		Orinda Formation	maroon, green, and gray conglomerate and sandstone
		Pliocene Miocene		**conformable contact** (unbroken sequence)
			Briones Formation	gray to white sandstone siltstone, and shell beds
		Miocene	Claremont Formation (part of the Monterey Group)	Interbedded siltstone, chert,cherty shale, and sandstone **faulted in part**
MESOZOIC	Cretaceous		Berryessa Formation (part of the Great Valley Group)	conglomerate (formerly called "Oakland Conglomerate") micaceous sandstone, siltstone, and shale
	Jurassic			**fault**
			Ophiolite	sea floor sediments greenstone quartz keratophyre serpentinite (changed mantle)

Figure 6. Schematic stratigraphic column depicting the general relationships of the rock units found in Alum Rock Park. (Sources: Graymer, oral communication, July 30, 1996 and Graymer, 1995.)

CLASSROOM ACTIVITIES

ROCKS OF ALUM ROCK PARK

ACTIVITY 1: MAGMA TO IGNEOUS ROCKS

Adapted From

Cuff et al 1995, *Stories in Stone* : Great Explorations in Math and Science (GEMS) Lawrence Hall of Science, Berkeley, CA.

Objectives

1. Observe how simulated melted rock forms crystals of different sizes when cooled at two different temperatures.
2. Apply what has been observed to actual igneous rocks to infer the relative rates at which they cooled.

Materials

For the class

- two **igneous** rocks of the same composition but formed at different temperatures, such as **granite** (Wards 47H3639) and **rhyolite** (Wards 47H6909) or **gabbro** (Wards 47H3309) and **basalt** (Wards 47H1044)
- cup of hot tap water
- metal spoon for candy demonstration
- small square of chocolate candy
- photos of volcanoes erupting
- salol crystals (phenyl salicylate)--2 oz. class (Sc.Kit 86516-02)
- matches
- flashlight or seating near natural light
- a quarter teaspoon measuring spoon
- ice cubes

For each pair of students

- 2 pairs of safety goggles (Sc. Kit child size 68637-00, adult size 62011-01)
- 2 magnifiers (Sc.Kit 62367)--10x
- 1 tray
- 1 small paper cup (with a quarter teaspoon of salol crystals in it)
- 1 votive candle with holder
- 2 metal spoons
- lump of clay (optional)
- 1 paper towel

- 2 pencils
- 2 data sheets
- 1 ice cube

Procedure

1. Show students the chocolate and one of the rocks; have them list similarities and differences. Make sure that they mention that both are solids at room temperature.
2. Place the spoon in the cup of hot water for 30 seconds, then put the chocolate on the spoon and observe. (It melts.)
3. Do students think that all solids could melt? Could solid rock melt? Show pictures of volcanoes and explain that if heated deep within the earth, solid rock could melt, forming **magma**.
4. Show the two igneous rocks you are comparing and explain that they both were made from the same chemical composition of magma. Have students observe their differences, particularly the crystal size. What could have caused these differences? Have students brainstorm ideas. If no one suggests differences in cooling rate, mention it .
5. Explain that you have a way for them to observe crystal formation at different temperatures, not using rock, but an organic material called **salol** to simulate magma.
6. Demonstrate the procedures that the students will be using, but do not light the candle and actually perform the experiment.
7. Remind students of safety rules using candles: tie hair back, push up long sleeves, wear goggles, never reach across the flame.
8. Have one of each pair conduct the room temperature cooling and the other conduct the over-ice cooling; the less active partner in each experiment should help observe and assist as needed.
9. From the salol crystals in the paper cup have students add <u>less than half</u> to a metal spoon, heat the crystals by holding the spoon at least 3 cm above the lighted votive candle, removing it from the flame just before the melting is complete. Add a few "seed crystals", position the spoon with the handle supported by a lump of clay or, a pencil or the edge of the tray and observe the cooling salol with a magnifying lens in <u>good light</u>. *Draw and describe the the crystals as they form .*
10. The second student repeats the process, but holds the spoon on top of an ice cube on the paper towel. *Draw and describe the crystals. Compare the sizes and shapes of the crystals formed under the two different conditions. What can you conclude about the effect of cooling rate on crystal size?* (Hopefully, the students saw that in the colder situation the crystals formed more quickly and were not able to grow as large as those in the hotter enviironment.
11. Now upon comparing rhyolite with granite and basalt with gabbro,

students should be able to apply what they have learned. The desired outcome is for students to realize that the two rocks with smaller crystals (rhyolite and basalt) cooled quickly above ground in what is called an **extrusive** or **volcanic** situation, while granite and gabbro with larger crystals cooled more slowly under **intrusive** or **plutonic** conditions (Fig.1).

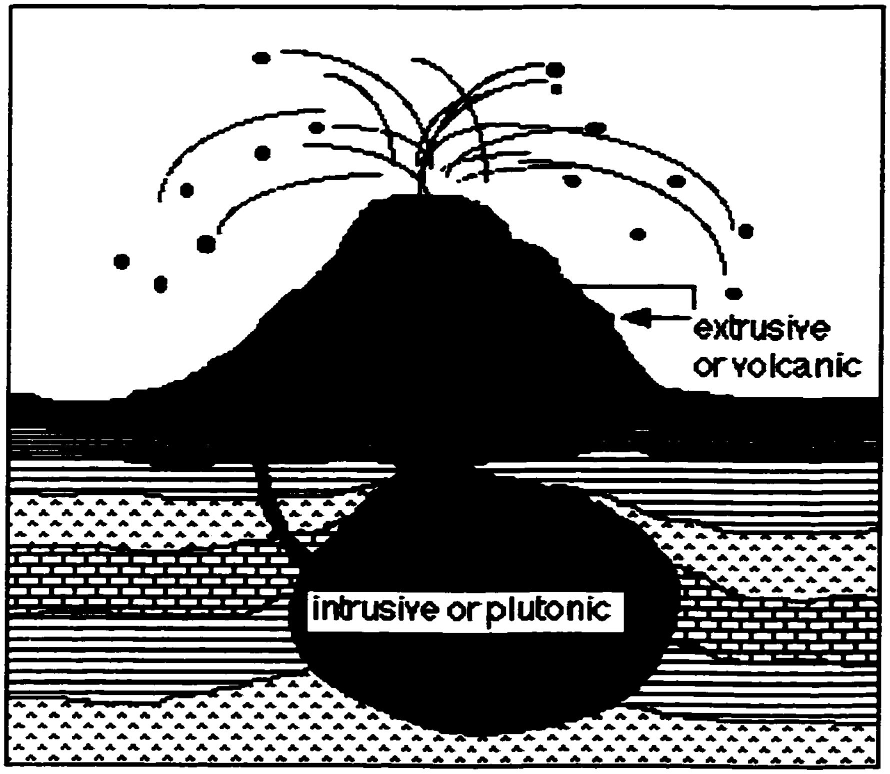


Figure 1. Igneous environments.

Teacher Notes

Salol is not a mineral, but an organic compound; however, like a mineral, it has a crystalline structure.

Relationship to Alum Rock Park

The three monoliths in the park (the Alum Rock, Eagle Rock, and Inspiration Point) are made of **quartz keratophyre**, which is a slightly modified form of rhyolite or **andesite.**

Some small rocks within the **conglomerate** formation are igneous. Students can compare the crystal size of the dark volcanic rocks with the granite-like pieces and draw conclusions about their environments of formation.

NAME____________________
DATE__________PERIOD______

STUDENT WORKSHEET FOR ACTIVITY 1: IGNEOUS ROCKS

1. Draw and describe the crystals as they form in the salol cooled at room temperature.

2. Draw and describe the crystals as they form in the salol cooled over ice.

3. Compare the sizes and shapes of the crystals formed under the two different conditions.

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4. What can you conclude about the effect of cooling rate on crystal size?

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ACTIVITY 2: SEDIMENTS TO SEDIMENTARY ROCKS

Objectives

Observe how sediments are made and form simulated sedimentary rocks from different sizes of sediment.

Materials

- overhead projector or paper
- rounded river rocks
- pointed piece of brick (about the size of a golf ball)
- coffee can
- magnifiers (Sc.Kit 62367)
- water (60 mL/student)
- sand (30 mL/student)
- gravel (20 mL/student)
- ceramic clay powder (30 mL/student)
- plaster of Paris (60 mL/student)
- paper cup (5 oz.) for each student
- plastic mixing container for each student
- plastic spoon for each student
- Several drops of food coloring/student (optional)
- shells or gummy animals such as dinosaurs or fish to represent fossils or *Dem Bones® Tart and Tangy Candies* (optional)
- dishpan with water for washing the mixing cups and plastic spoons

Procedure

1. Show rounded river rocks and ask students how they became so round.
2. To simulate the wearing caused by tumbling in a river, tumble a pointed piece of brick in a coffee can. Before tumbling it, *trace around the brick* on an overhead projector or on a piece of paper to make a record of its shape.
3. Put the brick in the can with some other rocks and a little water.
4. Have the students pass the can around, shaking it about 50 times each.
5. Open the can and examine the brick; *trace around its new shape and compare it to its previous one.*
6. Observe the sediments of clay at the bottom of the container and save them.
7. Note the color of the water; set it aside for the suspended sediments to settle out. Ask students, *After the brick was tumbled, what was in the bottom of the container: What color was the water?*
8. Have students brainstorm other ways to erode sediments from rocks; try the feasible suggestions, saving the sediments.

9. To make simulated sedimentary rocks, you will need to provide more sediments than the students are able to produce.
10. In the mixing containers have each student combine 5 drops to 2 mL of food coloring and approximately 18 mL of water with 30 mL of sand and add 30 mL of plaster of Paris. (Wetter is better than drier.) Be sure to mix completely. Pour this mixture into the paper cup.
11. In the mixing containers now combine 20 mL of gravel and 10 mL of sand with 20 mL of plaster of Paris and beginning with 9 mL of water keep mixing <u>very thoroughly</u> and adding water until the mixture looks like a very thick milkshake. Then add this mixture carefully to the paper cup forming a "conglomerate" layer on top of your "sandstone". Push this layer down with the plastic spoon.
12. A layer of "shale" from 30 mL of ceramic clay powder and 2 mL of water could be added to the top. Try various colors and student ideas as well.
13. If you like, add the shells, gummy candy, or bones candy to each layer as you go along. Adding the candy or shells to the outside of the layers makes it easy to locate and remove later, revealing the "fossils" and upon their removal the" fossil molds".
14. Wait for a few days. Peel the paper cup to uncover the layered "rocks" Have students *draw their simulated sedimentary rock. Label the different layers.* Rub them on the pavement to better see the interior layering. *Which "fossils" are the oldest if the layers have not been disturbed?*

Teacher Notes

The clay layer represents **shale**, the gravel rock stands for **conglomerate**, and the sand represents **sandstone**.

Sediments are commonly held together by calcite or quartz which precipitates between the grains of sediment, acting as a cement. The cementing agent in our model rocks is the plaster of Paris.

The shells, bones candy, or gummy animals are the **casts** (replicas) of fossils and the impressions made by them are the **molds.**

In nature the formation of sedimentary rocks would take hundreds of thousands to millions of years.

Relationship to Alum Rock Park

At the park you can see shale, sandstone, and conglomerate.

The formation called the "**Oakland Conglomerate**" (see Stratigraphic Column in Background Information section) is easily viewed at the Penitencia Creek entrance and just south of the Inspiration Point summit. Notice also the human-made conglomerate (the train bridge supports) and compare this to the natural form.

The **Claremont Formation**, where the mineral springs are, is made up of alternate layers of shale and another sedimentary rock, **chert**. The chert layers, being made of fine-grained quartz, are less easily eroded and therefore, stand out more than the shale.

Sandstone is easily found as the rocks containing the **fossil** clams from the **Briones Formation**. Feel the sand and look at the grains with magnifying glasses.

Notice that the stream-tumbled rocks are rounded.

NAME________________________
DATE___________PERIOD_____

STUDENT WORKSHEET FOR ACTIVITY 2: SEDIMENTS TO SEDIMENTARY ROCKS

1. Draw the shape of the brick before and after tumbling.

2. After the brick was tumbled, what was in the bottom of the container? What color was the water?

____

____

3. What other methods could be used to "erode" sediments from rocks?

____

____

4. Draw your simulated sedimentary rock. Label the different layers. Which "fossils" are the oldest if the layers have not been disturbed?

ACTIVITY 3: METAMORPHIC ROCKS

Objective

Observe that mineral grains in a simulated rock subjected to pressure line up parallel to one another in a plane as they do in some **metamorphic** rocks.

Materials

- playdough or modeling clay for each student
- lentils or washers
- examples of **foliated** and **non-foliated** metamorphic rocks (Wards, Introductory Rock Collection, 45 D 3120)

Procedure

1. Have students divide the rocks into groups with similar characteristics.
2. One group will likely be the foliated texture (layered or banded) rocks and one the non-foliated rocks.
3. Have students mix the lentils or the washers into the clay or dough in a randomly oriented way and form it into a ball. This model represents an igneous or sedimentary rock.
4. Now have students represent **directional stress** (pressure that is greater in one direction than in others) by pressing down on the ball. This represents part of the process of changing the rock to form a metamorphic rock.
5. Pull the flattened clay apart; the lentils or washers will be lined up parallel to one another in a plane perpendicular to the direction of the pressure, as the mineral grains are in the foliated metamorphic rocks. The presence of foliation is one way to recognize metamorphic rocks, as it shows that they have been subjected to directional pressure.

Teacher Notes

Meta comes from the Greek word for "change" and **morph** from "form".

Metamorphism is the changing of the texture or composition or both of pre-existing igneous, sedimentary, or other metamorphic rocks. This happens in the solid state; if rocks are melted and cooled, they are igneous rocks. Heat, pressure and chemically active fluids change the original rocks.

The layered alignment of mineral grains (foliation) does not always take place during metamorphism. Slate, schist, and gneiss ("nice") are examples of foliated rocks; marble, **serpentinite**, and **greenstone** are example of non-foliated rocks.

Relationship to Alum Rock Park:

At the park you can see serpentinite and greenstone. Serpentinite, the state rock of California, is mantle rock that has been altered by hot fluids. Greenstone is metamorphosed basalt. Both are found in the vicinity of the igneous formations (Alum Rock; Eagle Rock; Inspiration Point).

ACTIVITY 4: THE ROCK CYCLE

Objectives

1. Model the processes by which igneous, sedimentary and metamorphic rocks form.
2. Observe that rock materials are constantly changing and being reconfigured in the rock cycle.

Materials:

For the teacher

- hot plate
- large clear Pyrex container of boiling water
- large clear Pyrex container of cold water
- smaller Pyrex container to hold simulated magma
- crayons
- goggles (Sc.Kit, adult size 62011-01)
- lab apron

For each student

- lumps of crayons previously melted and cooled, representing **igneous** rocks
- food graters
- 30 cm squares of heavy duty aluminum foil
- goggles (Sc.Kit child size 68637-00) to be worn when using the hammers and the hot plate
- paper to cover work area

For groups of students to share

- hammers
- vise (optional)
- two boards (optional)

Procedure

1. Have students recall what they have learned about how rocks form and change into different types.
2. Demonstrate that melted crayon could be used to represent magma and lava by heating crayons in the smaller Pyrex container within a larger Pyrex container of water on a hot plate. While in the smaller container the melted crayon is a model for magma; after it melts, and you pour it out into the Pyrex container containing cold water, it becomes lava flowing Into the cold ocean. (Explain that in reality the lava would flow from underground.) It cools at once resulting in pillow-like forms somewhat analogous to the formation of "**pillow basalt**" on the sea floor.

3 Have students simulate mechanical weathering by grating the "igneous rocks" (previously hardened melted crayon lumps) onto 30 cm foil squares folded in half. Shavings should be about one cm deep. Students can trade "rocks" of different colors to obtain a variety of sediments and can spread each color of shavings on top of the one below to form layers.
4. Next, the students should fold the foil to make a packet, put it between two boards and press it with their hands or hammer it lightly.They should then open the packet and examine the "sedimentary rock", which is easily broken like some real sedimentary rocks.
5. To simulate metamorphic pressure, have students refold the foil and apply as much pressure as they can by using the vise, standing on the foil or hammering it harder. They should examine their "metamorphic rock"' to see how it differs from the "sedimentary" one.
6. The teacher could then take fragments from some sedimentary and some metamorphic and some ungrated igneous rocks and remelt them in the Pyrex container over water on the hot plate to show that all three types melt to become magma. Let the magma cool again to form an igneous rock.

Teacher Notes

Students need to understand that unlike many cycles, the rock cycle does not always go around in a circle. All three categories of rocks can be weathered, can be metamorphosed, and can melt.

The metamorphic simulation here only uses the agent of pressure, not heating or the chemical action of fluids which should be mentioned as well.

Students should be made aware that these processes take a great deal of time to occur.

Relationship to Alum Rock Park

Some smaller rocks within the conglomerate (a sedimentary rock) are igneous rocks formed in volcanoes a great distance away. Through weathering and erosion these rocks became sediments that washed down to the edge of the continent and, through cementation and pressure, became part of a sedimentary rock that has been uplifted here.

Rhyolitic volcanic rocks that formed on the ocean floor were modified by ocean water by the addition of sodium from the salt ocean water. They became quartz keratophyres (altered igneous rocks) before they were uplifted to form the cliffs of the Alum Rock, Eagle Rock, and Inspiration Point.

ACTIVITY 5: FOLDED LAYERS

Adapted From

AIMS Education Foundation, 1987, "Peanut Butter and Jelly Geology" in *Overhead and Underfoot*: Fresno, CA.

Objectives

Observe models of sedimentary rock layers. Note that the oldest layer is on the bottom and that the layers which are originally horizontal may be folded and disrupted by natural forces.

Materials

For each group or pair of students:

- three slices of different kinds of bread, i.e. white, whole wheat, dark rye
- two things to spread on the bread, i.e. jelly, chunky peanut butter--two tablespoons of each
- several kinds of edible animals, i.e. gummy worms, fish, dinosaurs, etc. or *Dem Bones® Tart and Tangy Candies*
- a plastic knife
- a paper plate
- a worksheet for each student in the group
- pencil for each student

For the teacher:

- three or four strips of modeling clay, each a different color
- two wooden blocks

Procedure

1. If you are planning to have the students eat their experiment at the end, they should wash their hands before they touch the materials. There is a possibility that some students may be allergic to peanuts. Be sure that such students are clear about their allergic restrictions.
2. Have all of the groups place the same kind of bread on the paper plate, i.e., the dark rye and name it for a sedimentary rock that you may have studied, such as sandstone.
3. As the students continue to add layers, keep track of the order by recording on a diagram that all can see, so that they all build identical "sandwiches". Include the edible animals and bones, placing those that first appeared longer ago, such as the worms and fish in the lower layers, with the dinosaurs and mammals in the layers above (see Geologic Time Scale, Fig. 1). Students can continue naming the layers for rocks that they have studied. For example, the jelly could be

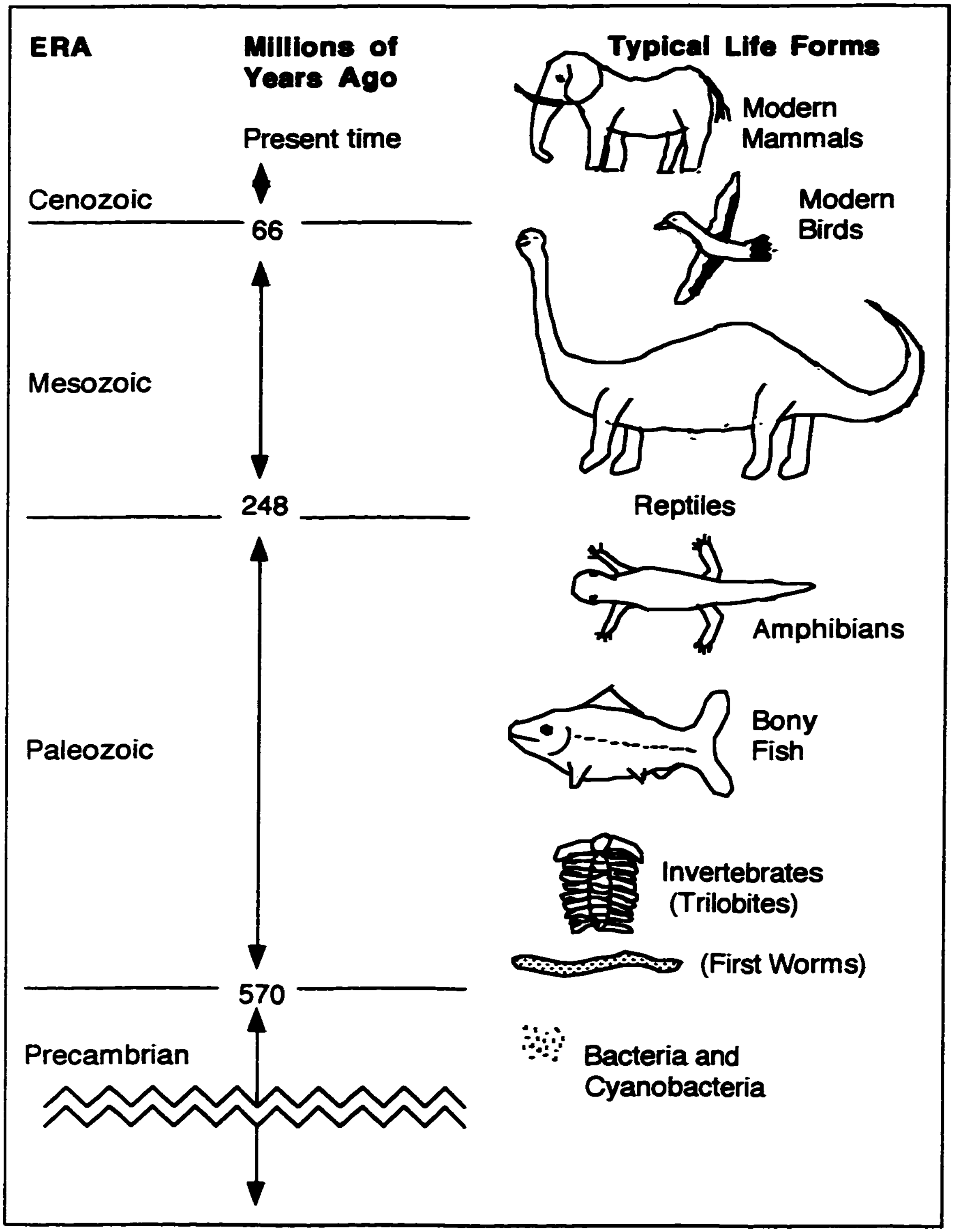

Figure 1. Simplified Geologic Time Scale. (Source: Pearse et al., 1987; Bailey and Seddon, 1995.)

limestone containing fossil worms, followed by the white bread (chert), then chunky peanut butter (conglomerate), with fish fossils, and the whole wheat bread containing dinosaur fossils (Fig. 2).

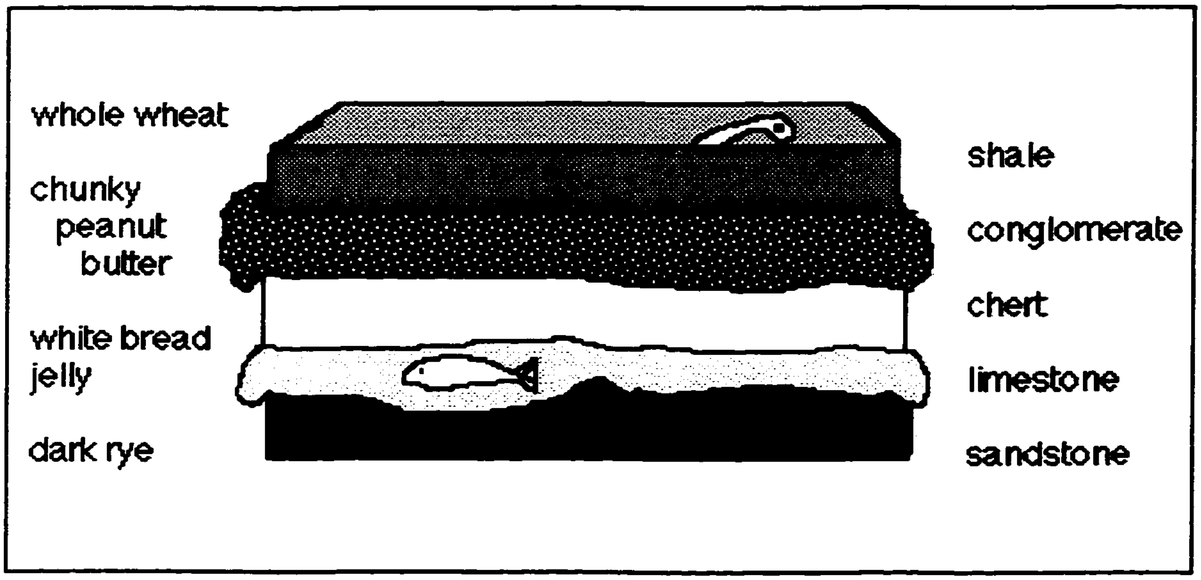

Figure 2. Sandwich model of sedimentary layers.

4. *Draw a diagram of your model and label the layers.*
5. *Label the layers from the oldest one to the youngest one. How do you know which one is the oldest and which the youngest? Which "animals "must be the oldest then? Which must be the youngest?)*
6. Remind students of the "Why Do the Plates Move?" lesson and how forces within the Earth cause the plates to move. This movement may cause the layers to be pushed into folds. Have one partner bend the sandwich to form a hill; the other partner could then *draw and label the new position of the layers.* Next, have the partner that drew bend the sandwich layers to form a valley and the other partner *draw the layers.*
7. Finally, have the students tilt the entire sandwich on end to see how such a disruption would appear. *Draw how these layers appear when tilted on end. Can you find any of the fossils? Why is it difficult to tell the age of the fossils when the layers are in this position?*

8. The teacher could next explain that the following demonstration is more like the real process forming folded layers than bending them with hands. Have two students lay several strips of modeling clay of different colors on top of each other to represent various layers of rock. Instruct them to set a wooden block at each end, to represent colliding plates. When they push on the blocks to show two plates coming together, the clay folds into mountains and valleys (Fig. 3).

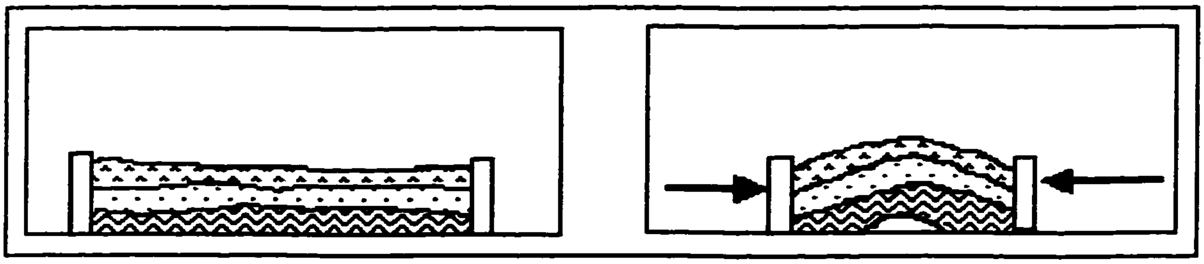

Figure 3. Compression causing rock layers to bend.

Teacher Notes

These activities demonstrate one of the oldest laws of geology, the **law of superposition,** which states that in an undeformed sequence of sedimentary rocks, each layer is older than the one above it and younger than the one below it. The bread that was laid down first is the oldest layer, and the layers added above it are younger.

Sometimes layers are found in a horizontal position just as they were formed, but often they have been bent upward to form an upside down U shape (**anticline**) or downward to form a regular U shape (**syncline**) (Fig. 4). Be sure that students understand that an anticline is not always a mountain and that a syncline is not always a valley (Fig. 5).

Relationship to Alum Rock Park

On the north side of the mineral springs trail, folded layers are visible above the trail.

Look into Penitencia Creek in the mineral springs area to see layers that been tilted on end like the sandwich on its end. This is further evidence of rock influenced by natural forces.

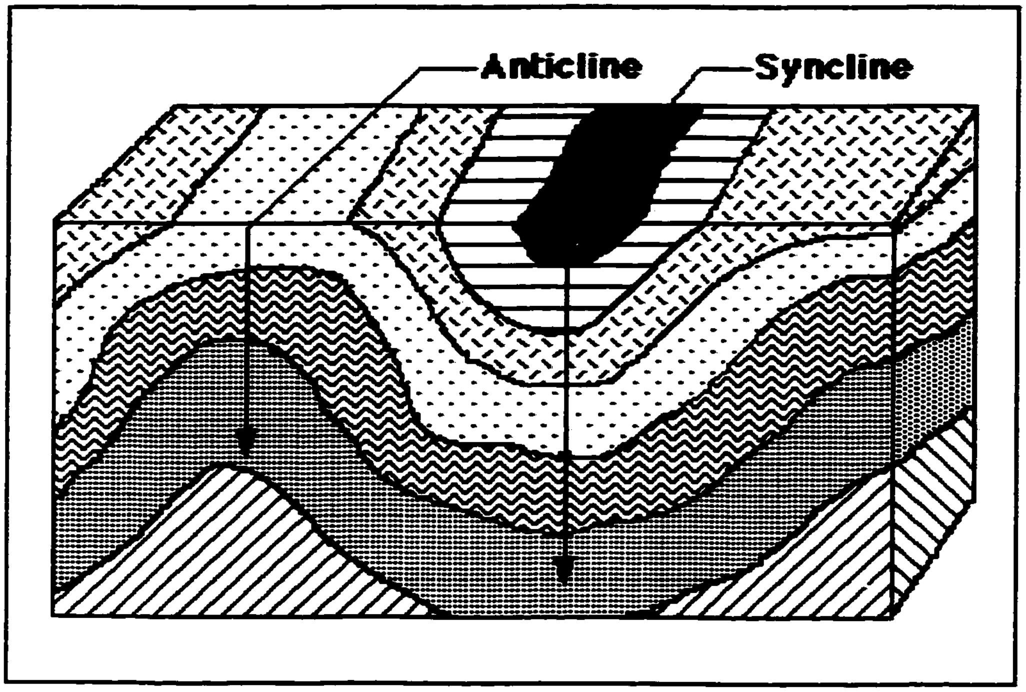

Figure 4. Anticlines and synclines are formed by the folding of horizontal layers.

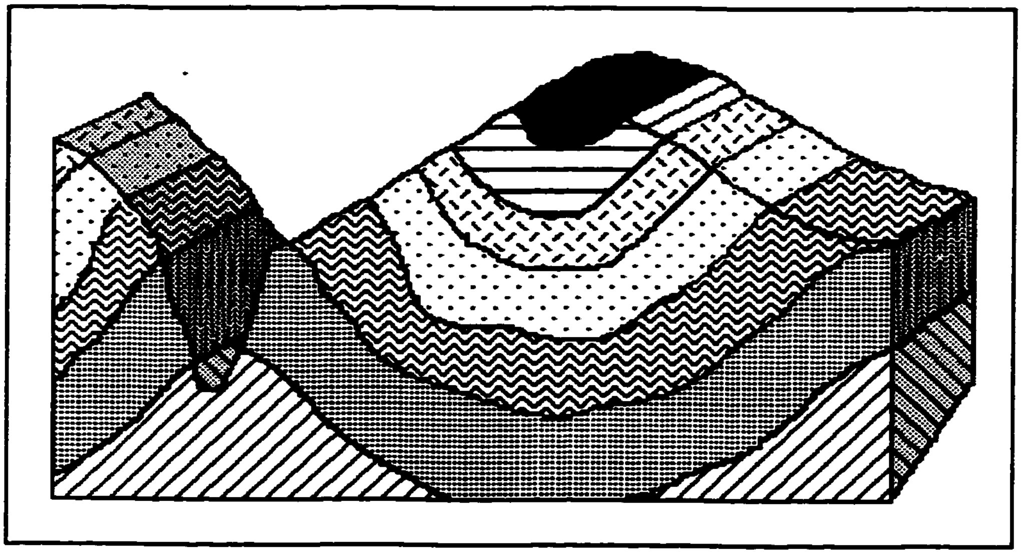

Figure 5. Erosion can cause anticlines and synclines to form valleys and mountains.

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STUDENT WORKSHEET FOR ACTIVITY 5: FOLDED LAYERS

1. Draw a diagram of your model and label the layers.

2. Label the layers from the oldest one to the youngest one. How do you know which one is the oldest and which one is the youngest?

____

3. Which animals must be the oldest then? Which ones the youngest?

____

4. Draw your sandwich model in the "hill" position.

5. Draw your model in the "valley" position.

6. Draw the model when it is tilted on end. Can you find any of your "fossils"? Why is it difficult to tell the age of the fossils when the layers are in this position?

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ACTIVITY 6: FAULTED LAYERS

This lesson could easily be done in conjunction with the "Folding Layers" lesson, as they both use the same materials. The folding activities should come before the faulting ones.

Objectives

Observe models of rock layers and see how they move in relation to each other when depicting the three main types of **faults**.

Materials

For each group or pair of students:

- material listed in Activity 3: "Folded Layers" with the exception of the candy

For the teacher:

- strip of wood about 30 cm long, 2 cm wide and up to 1 cm thick
- sink or basin large enough to hold the wood
- water to fill the basin
- two Big Hunk™ candy bars: one in freezer, one at room temperature
- wooden box of any size with thin base, cut into two pieces
- flour to fill the box
- flashlight

Procedure

1. Explain to students that under some conditions when rocks are being pushed together or pulled apart, they will break instead of bend. Gather the students around the basin which is filled almost to the top with water. Hold the strip of wood with one hand on each end, bending it until it breaks (Fig 1.).
2. Have the students describe the movement of the water. (jerky movement and waves moving out from where the wood broke)
3. This sudden, rapid movement of the water is caused by the release of energy that built up in the stick as it was bent. Energy similarly builds up in rocks when they are bent. When the rocks break and this energy is suddenly released, the Earth shakes like the water in the basin. The shaking is called an **earthquake**. The crack in the rock or soil along which movement has occurred is called a fault.
4. One factor that controls whether rocks bend or break is temperature. Demonstrate that when compressed, the warm candy bends. Remove the other bar from the freezer and apply the same force; it breaks.

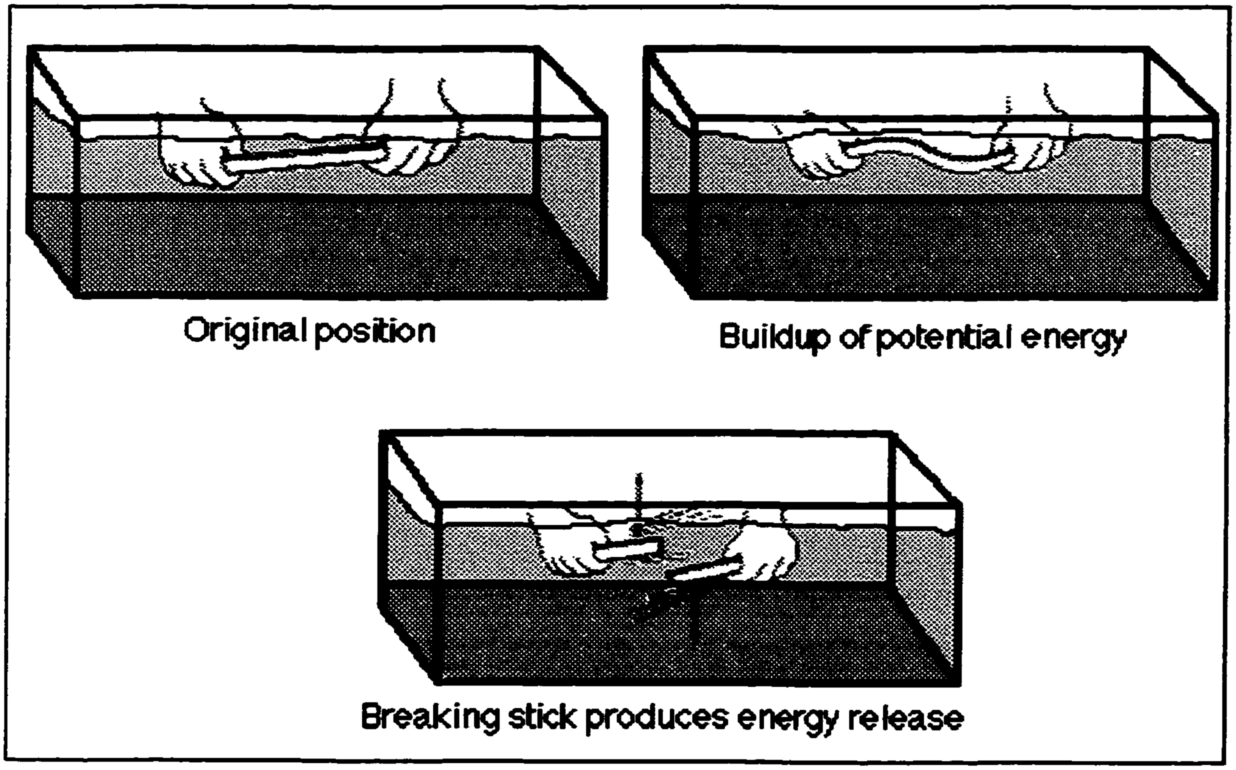

Figure 1. Model of the build up and transference of energy. (Modified from NSTA/FEMA, 1988.)

5. Have students make their hands into fists and press the flat edges of their fingers together. If they release the pressure and let one hand drop slightly, they are modeling a type of vertical fault that usually occurs where rocks are being pulled apart, a **normal fault** (Fig. 2). If they press more and force one hand to move up, they are showing a different type of vertical fault that happens where rocks are being compressed, a **reverse fault**.

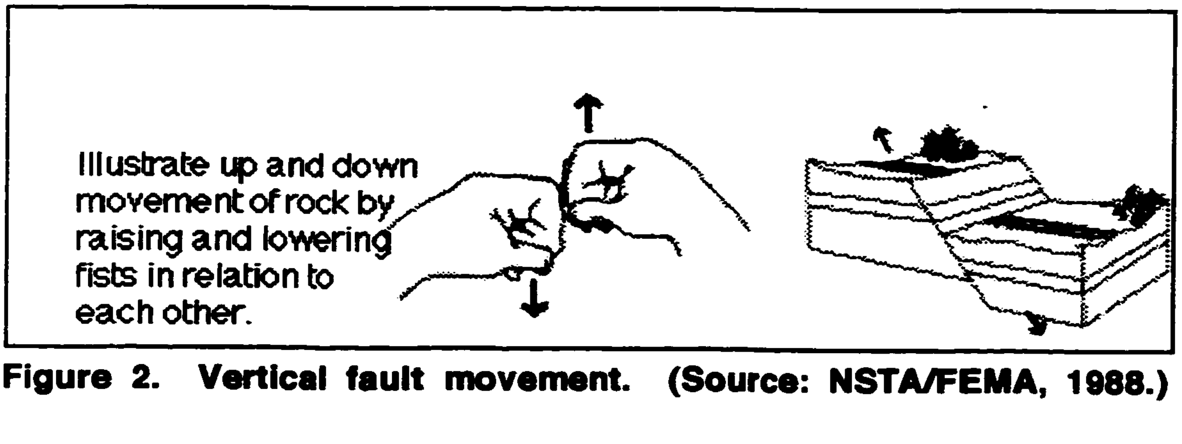

Figure 2. Vertical fault movement. (Source: NSTA/FEMA, 1988.)

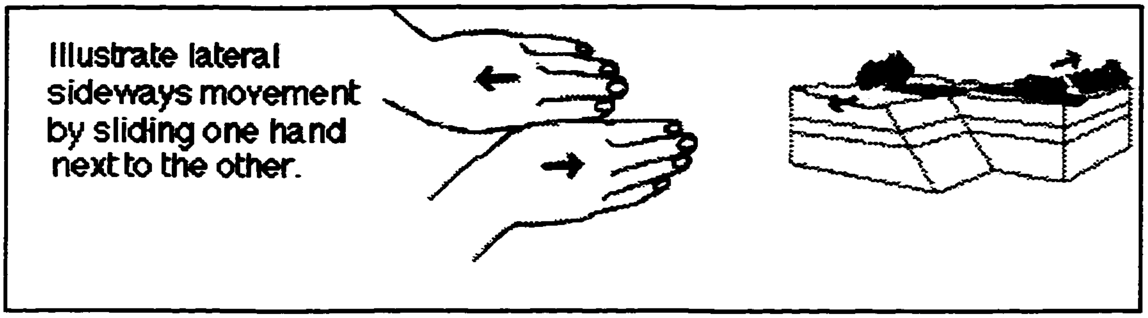

Figure 3. Lateral or strike-slip fault movement. (Source: NSTA/FEMA, 1988.)

6 Now, using open hands, have them press the edges of their hands together and slide one hand past the other; this is a **lateral** or **strike-slip fault** (Fig. 3).

7. Using the sandwich materials, have each group make a new sandwich and slice a fracture at about a 45° angle. Now they can move the **fault blocks** to show the three main types of faults mentioned above. *Draw and label the sandwich layers as they appear in a vertical and in a lateral fault. Use arrows to show which way the "rocks" are moving.*

8. The flour box provides a more realistic demonstration, as the flour acts somewhat like soil would. Fill the box with flour, smooth the surface and holding the box firmly use a quick sideways motion to move the fault blocks. Shine a flashlight across the surface of the flour to highlight the "soil" movement. Smooth the surface and try an up and down motion. Little buildings, fences and other features could be added to show how earthquakes affect things on the surface (Fig. 4)

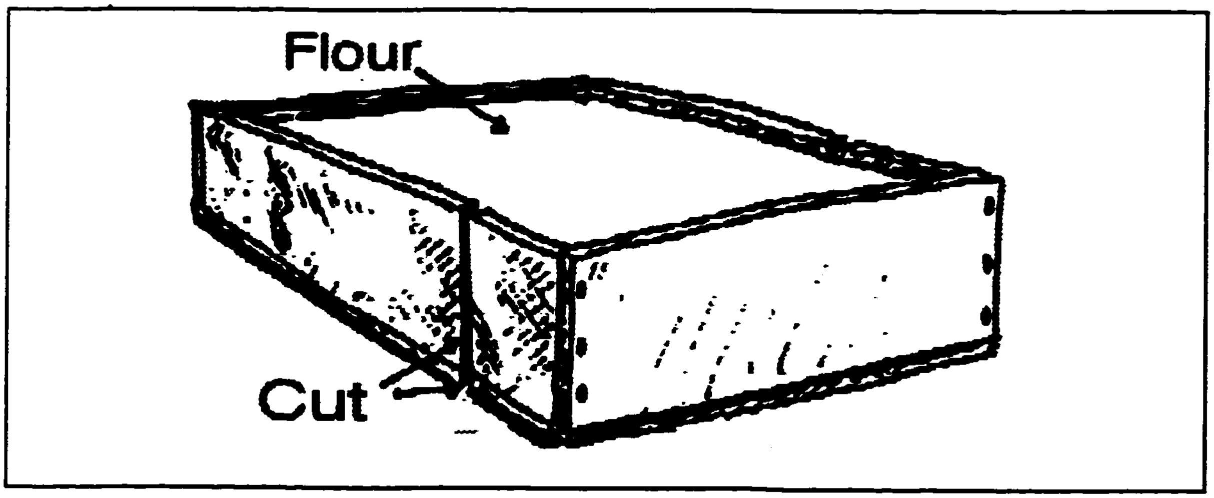

Figure 4. Flour Box fault model. (Source: UCI/CSIN, 1989.)

Teacher Notes

Make sure that students understand that a **fault** is usually not a simple break in the rocks, but is a zone of fractures where movement occurs along various strands of the fault.

The motion of a lateral fault is described as though the viewer were standing on one side of the fault, looking across the break; if the other side has moved to the right, the fault is a **right-lateral** one; if it has moved to the left, it is a **left-lateral** fault (Fig. 5).

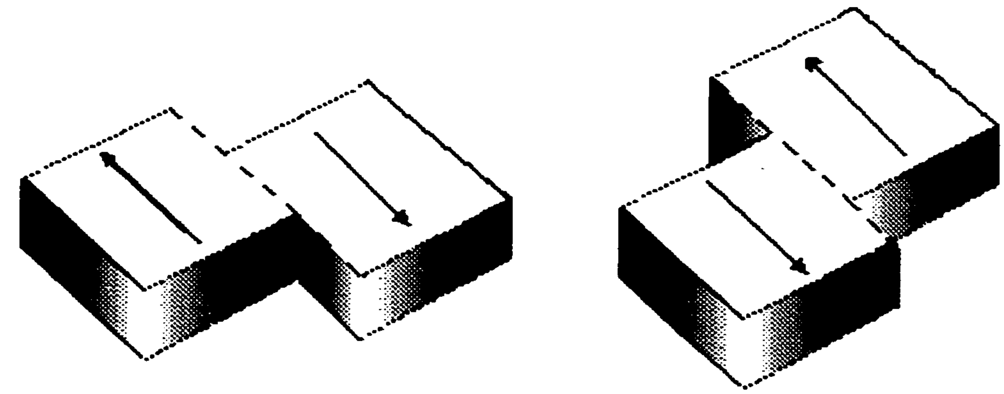

Figure 5. Lateral or strike-slip faults

The **transform** boundary between the North American Plate and the Pacific Plate contains the San Andreas fault system, usually described as a **right-lateral** or **strike-slip** fault. Movement along this fault system is not simply right-lateral slipping, but also involves rocks being pushed together and pulled apart.

Relationship to Alum Rock Park

Alum Rock Park, like all of San Jose, is within the San Andreas fault zone. The location of the active trace of the Hayward fault is currently not agreed upon. The area around the mineral springs is where the Hayward fault was once thought to pass through the park. Compressed rock layers and upturned beds are indications of tectonic forces, but there is no surface rupture or other surface evidence so that one could point to a place and say, "There is the fault!"

Some geologists think that the monolithic structures, Eagle Rock, Inspiration Point, and the Alum Rock were moved from the ocean floor to their present locations along faults.

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STUDENT WORKSHEET FOR ACTIVITY 6: FAULTED LAYERS

Draw and label the sandwich layers as they appear in a vertical and in a lateral fault. Use arrows to show which way the "rocks" are moving.

Vertical Fault

Lateral Fault

FIELD TRIP PLAN

THE ROCKS OF ALUM ROCK PARK TRIP

EAGLE ROCK

a. As you drive in the Alum Rock Avenue entrance, look across Alum Rock Canyon at Eagle Rock. This striking igneous structure probably erupted under the ocean and was uplifted by the faulting that formed the Coast Ranges. Notice the joints in the rock and how blocks have fallen off and are piled up down the slope.

b. This **outcrop** was once said to be **rhyolite**, an **extrusive igneous** rock, but now is labeled a **quartz keratophyre** because it was changed chemically by the ocean water.

STOP 1--ALUM ROCK (1/2 hr.)

a. When you arrive at the toll booth notice the igneous cliff rising before you. This is the Alum Rock, also a quartz keratophyre. Turn left on Penitencia Creek Road and have the bus park at the Eagle Rock Picnic Area.

b. Cross the road and take the trail that leads across the railroad bridge. While standing on the trestle look down the canyon. *What caused this canyon to develop?* (Penitencia Creek cut down through the rocks as tectonic forces pushed the rocks up, forming these mountains which are part of the Coast Ranges).

c. *Why does the canyon narrow when it reaches the Alum Rock?* (The rock that the Alum Rock is made of is harder than the rock farther down the canyon, so the creek could not cut though it so easily.

d. Continue across the bridge and use the magnifiers to examine the mineral deposits on the surface of the keratophyre. There are white ones and green ones.
   1) The white one, once thought to be **alum** (potassium aluminum sulfate), is actually **thenardite** which is sodium sulfate (Hartesveldt and Harvey, 1972). Early settlers mistook it because the two compounds have similar qualities, and they would have been familiar with alum because it was used as an astringent. (Besides

"Thenardite Rock Park" just doesn't have the same ring to it as "Alum Rock Park".)

2) The green deposits are clay minerals (determined using x-ray diffraction at SJSU).
3) If surface deposits are difficult to locate (dry conditions), continue past the keratophyre and follow the path down to the bottom where shady conditions allow for longer lasting deposits. Be careful of vehicles passing on the road.

e. Sometimes along this trail you can find **serpentinite** that has moved downhill from its original location This is one of the few places you might see metamorphic rocks in Alum Rock Park It is thought that the serpentinite was formed from mantle rock and was moved upward with the keratophyre when faulting occurred (Coyle, 1984). Outcrops of serpentinite are difficult to observe from the park trails. Loose pieces of serpentinite may also be found in Penitencia Creek near the Penitencia Creek park entrance.

STOP 2--MINERAL SPRINGS AREA (1/2 HR.)

a. **Folded outcrop of rock to the left of the creek**

1) This tortured section of layered rocks is a most striking example of earth forces. *What did these layers look like when they were laid down? How do you suppose they came to look like they do now?* If necessary, remind students of the" Folded Layers" lesson. Demonstrate with the felt or paper how pushing on the layers causes them to bend up and down in folds. *What pushed on these layers of rock?* Remind students of the "Why Do the Plates Move?" lesson. (The Pacific Plate pushed up against the North American Plate causing folding and faulting. This area is in the Hayward fault zone, which is actually part of the San Andreas fault zone, so many signs of tectonic activity are visible.)
2) These rock layers, called the Claremont Formation (see Stratigraphic Column, Fig. 6., in Background Information) are made up of **shale** (sedimentary rock formed from silt and clay) and **chert** (sedimentary rock made of the silica skeletons of microscopic plant and animals.) *In what kind of environment would shale and chert be deposited?* (These layers were laid down about 15 million years ago when San Jose would have been under the ocean. In the shallow sea, fine-grained sediments and skeletons of radiolaria and **diatoms** would fall over time to the sea floor, become cemented into rocks and eventually be lifted here by the plates pushing against each other.)
3) Look closely at the layers using the magnifiers. *Which do you think*

would erode more easily, the shale or the chert? Why? (The shale, because it is softer. The chert, made of silica, is quite hard.) Help students observe the chert layers protruding above the shale layers.

4) As you walk along the Mineral Springs Trail, look in the creek bed and notice how the position of these rock layers changes.

b. **Fossil sandstone**

Notice the boulders containing clam fossils scattered about. Some are in the creek as well. *Do you think the boulder containing clam fossils came from here or from upstream? Why?* (They came from upstream because you cannot see this sandstone formation called the "Briones" in place here (see Stratigraphic Column Fig. 6 in Background Information). This sandstone was formed about 6 million years ago in a shallow sea environment (Coyle, 1984).

c. **Travertine and tufa**

1) Look for these chemical sedimentary rocks formed as deposits from the mineral springs. The **travertine** is dense and layered, while the **tufa** is spongy. Both are made of calcium carbonate. Be careful not to touch or in any way disturb the deposits, which take a long time to form.
2) You could test the rocks on the bridge for calcium carbonate using the dilute HCl, which will bubble when carbon dioxide gas is released. Have the students look with the magnifiers to see the bubbles. After using the acid on the rocks wash it off with your spray bottle of water. *Where were the rocks made of calcium carbonate used? On the sides of the bridge or on the top? Why?* (On the sides because the top of the bridge would be more exposed to rain which would dissolve the calcium carbonate and erode the bridge away. Even natural [unpolluted] rain is slightly acidic.)
3) Cross the bridge and return to the Big Bear Picnic Area where the trail to Inspiration Point begins.

INSPIRATION POINT HIKE (1 1/2 HRS.) (Fig. 1)

a. You will be hiking 897 m (.5 mi.) up to the top of a hill called Inspiration Point. Using a trundle wheel would make it easier to locate the field trip stops, but distances could also be estimated.

b. *As you climb up the hill, what evidence do you see that the rocks and soil are moving down the slope?*

1) 110 m from the trail junction you come to a concrete catch-basin on your left and the steps to the Youth Science Institute on your right.

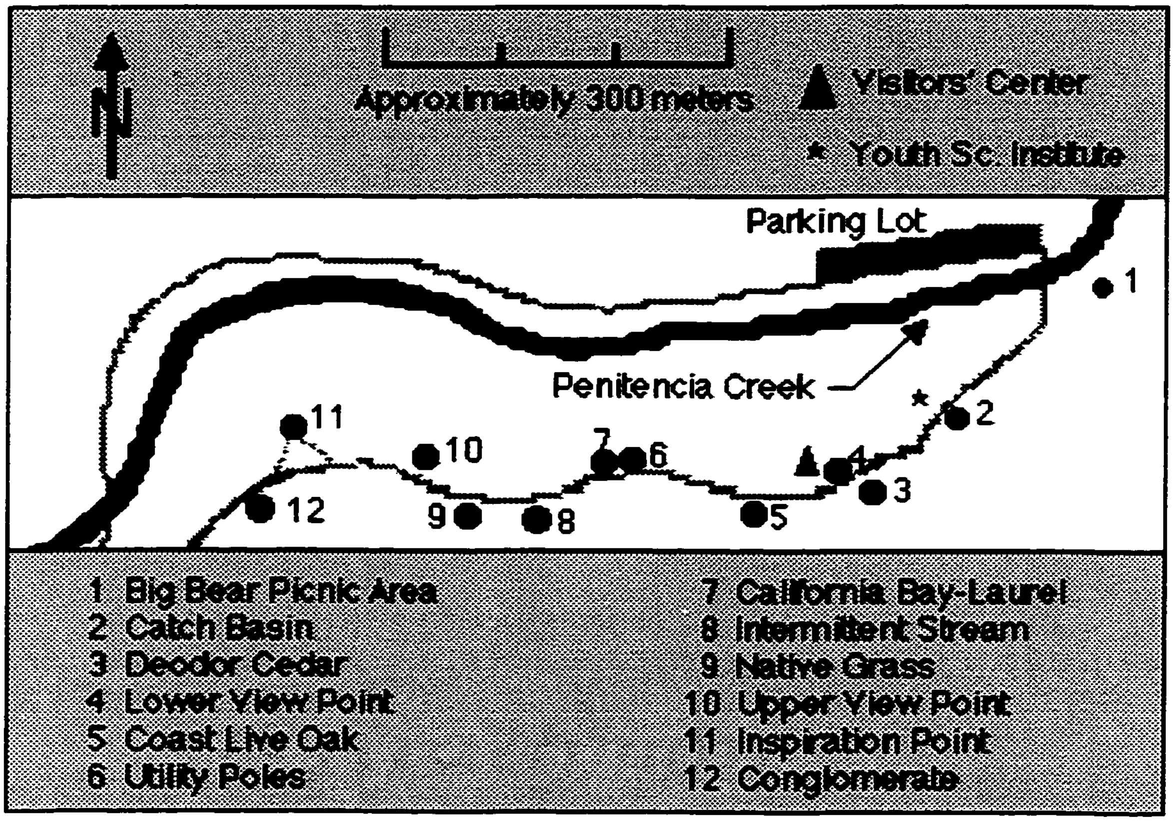

Figure 1. Inspiration Point Hike. (Modified from San Jose Regional Parks brochure, no date, Alum Rock.)

Notice the large erosional ditch caused by water running off the steep slope. This is NOT A FAULT, but this hillside is unstable. *Why do you think the concrete catch-basin was built here?* (to slow down the water movement and subsequent erosion and to keep water off the road) *What problems might occur in this area if there is a lot of rain?* (The water might overflow the basin and erode the hill below the road.)

2) It is 117 m more to the steps to the South Rim Trail where the sign indicates the distance to Inspiration Point is 0.4 mi. (667 m).
3) *Can you find places where water has eroded the soil away from tree roots on the hill?* (25 m past the trail sign is a large Deodar cedar with many roots exposed. This tree is native to the Himalayas.)

c.. Many trees not native to this area have been planted in Alum Rock Park. Continue 20 m more uphill from the Deodar cedar where you can see across Alum Rock Canyon.

1) *What large trees from Australia are planted on the opposite slope?* (eucalyptus)

2) *Looking to the left on the far slope, what other trees not native to, but often planted in San Jose do you see?* (palm trees)

d. There are a number of interesting native California plants to see on this hike.

1) 70 m from the view across the canyon is a *large Coast Live Oak (Quercus agrifolia) with roots greatly exposed. Are all the roots from the same tree?* (They appear to be.)

2) Walk 50 m more to the utility poles where there are several samples of one the most interesting native trees, the California Buckeye (*Aesculus californica)*. If your visit is in the spring, you will have the pleasure of seeing the spectacular pinkish white flower clusters that make the tree look as though it is covered with candles. The nectar and pollen from these flowers are poisonous to honeybees (Fuller and McClintock,1986). The five-part leaves are early **deciduous**, meaning they drop early in the dry season (in San Jose, usually in June) to prevent water loss to the tree (Fig. 2). The striking buckeyes (fruit) hang on the tree all summer and fall, looking much like ornaments. Native people put the poison-containing leaves, young shoots and crushed buckeyes into streams and ponds to stupefy fish, so that they floated to the surface for easy catching. When acorns were not plentiful, the native people **leached** the poisons from the buckeyes and ground them into meal (Balls, 1965). See how many buckeye trees you notice as your continue on your hike.

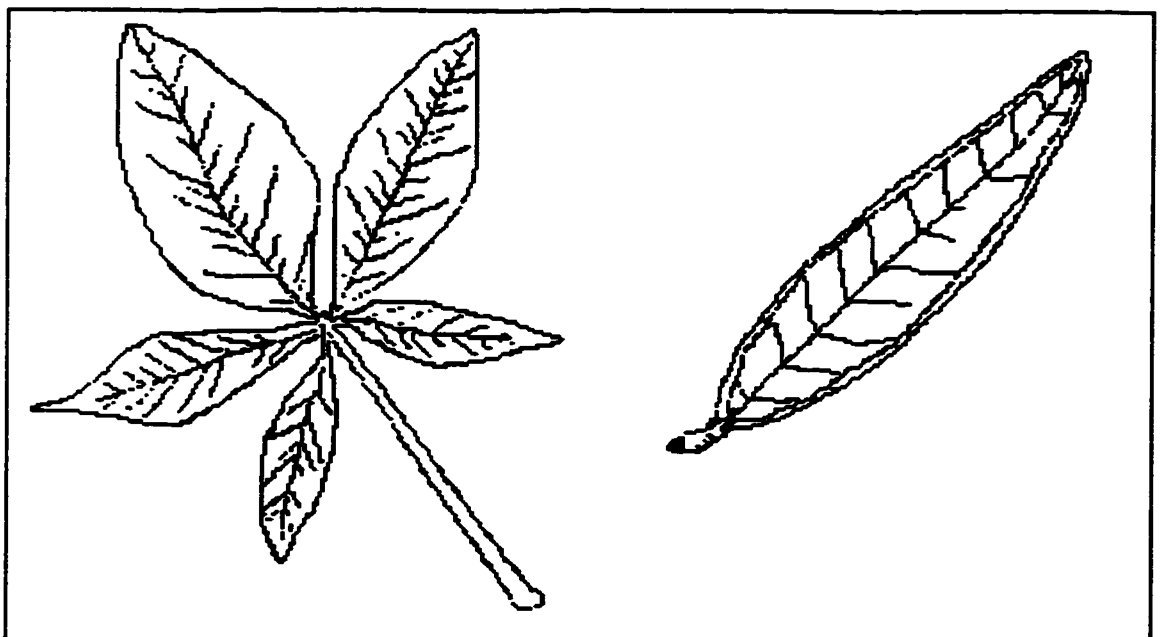

Figure 2: California Buckeye Leaf (l.); California Bay-Laurel (r.)

3) Walking just 20 m farther takes you to another interesting native tree, the California-Bay or Laurel tree (*Umbellularia californica*). Some children call this the "spaghetti tree" as bay leaves are used to flavor spaghetti sauce; native people roasted the nuts for food and used the leaves as a flea repellent and for many medicinal purposes (Balls, 1965). Break off a leaf and pass it around for the group to smell (Fig. 2).
4) *Can you find an intermittent stream that would probably contain water in wet weather? Where is it located?* (50 m uphill from the bay tree)
5) Continue up the hill 50 m more and look on the left bank to see California native bunch grasses. These grasses have mostly been displaced throughout California by annual Eurasian grasses.
6) *What native California plants were you able to identify?*

e. 110 m farther up the trail takes you to another viewpoint of the opposite canyon wall. *Can you see where the plants change suddenly? Why might this occur?* (grazing, different kind of soil, different slope)
   1) *Why does this side of the hill have more vegetation than the opposite slope?* (soil might be different, direction the slope faces is different) *Use the compass to determine which way the slope you are standing on faces.* (North) *Which way does the opposite slope face?* (South) *How does the direction a slope faces affect what plants can grow there?* (The south-facing slope receives more sunlight than the north-facing one, so more water is lost to evaporation; therefore, **chaparral** plants, oaks and grasses which are adapted to live in drier situations are able to survive there, while **riparian** plants with larger leaves do well on the cooler, more moist north-facing slopes.)
   2) *Where are most of the trees on the opposite slope? Why?* (They line the gullies because their larger size requires more water, and water flows down the gullies.)

f. It is 212 m farther to the trail leading to Inspiration Point. As you get close to the hilltop, try to find where the rock in the trail changes. (The whitish and rust colored rocks you see about 45 m beyond the paved road are the quartz keratophyre, so now you are walking directly on the volcanic rock.)

g. At Inspiration Point
   1) *How high above sea level is this volcanic feature?* (219 m or 730 ft.--see informational sign)

2) *How do you think Inspiration Point got its name?* (Before the trees grew so high, the view of the Santa Clara Valley was very inspiring.) Students could share recollections of other vistas that have inspired them.
3) *Using the Pacific Coast Tree Finder or the following clues, can you identify two kinds of oaks in the enclosed area here?* (Coast Live Oak with cupped leaves and toothed margins ; the Blue Oak with lighter bark and blue-green slightly lobed leaves.)
4) Move about 20 m down from Inspiration Point until you have a clear view of the Santa Clara Valley. Look across the valley to the base of the Santa Cruz Mountains; the San Andreas fault runs along the west side of the valley.
5) Observe Eagle Rock and Alum Rock, which line up with Inspiration Point and are also quartz keratophyres. *How tall are they?* (Eagle Rock is 239 m or 795 ft.high, and Alum Rock is 188 m or 623 ft. high) *Using the topographic map or Figure 3, can you locate Inspiration Point? How did you locate this peak? How high is it above the canyon floor?* (About 165 m and about 500 ft.)
6) From here you can also see both sides of Alum Rock Canyon.
7) You might have students draw or write about what they see from this vista. This is also a possible lunch stop.
8) *As you move down the hill to the road, can you spot two more different kinds of oaks?* (Interior Live Oak similar to the Coast Live Oak but with flat leaves, and the Valley Oak with lobed leaves and bark that breaks into plates.

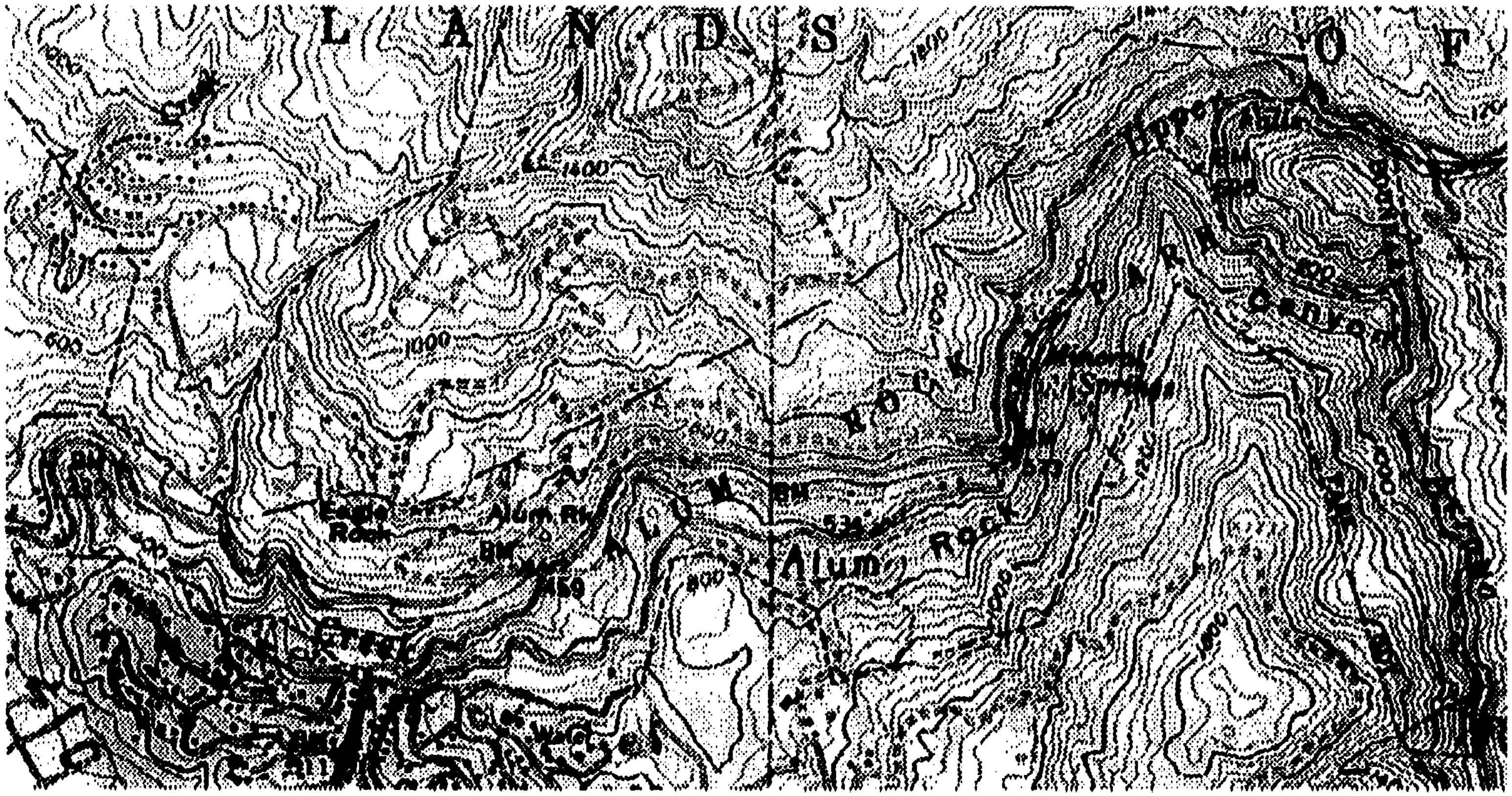

Figure 3: Togographic Map of the Alum Rock Park area. (Modified from Dibblee, U.S. Geological Survey 7.5, Calaveras Reservior Quandrangle, photorevised 1980.)

h. Continue west on the road 50 meters where an example of **sedimentary** rock, a large **conglomerate formation** is located on your left. Be aware that rattlesnakes (Fig. 4) could be sunning themselves here among the rocks, and that ticks (Fig. 5) are often in tall grass. Do not allow students to climb on the formation.

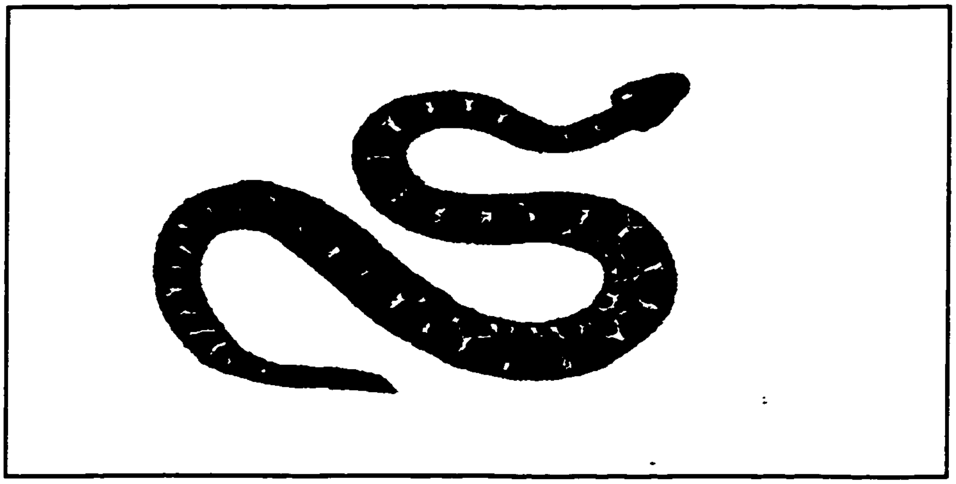

Figure 4. Rattlesnake. (Source: San Jose Regional Parks brochure, no date, Watch Your Step!)

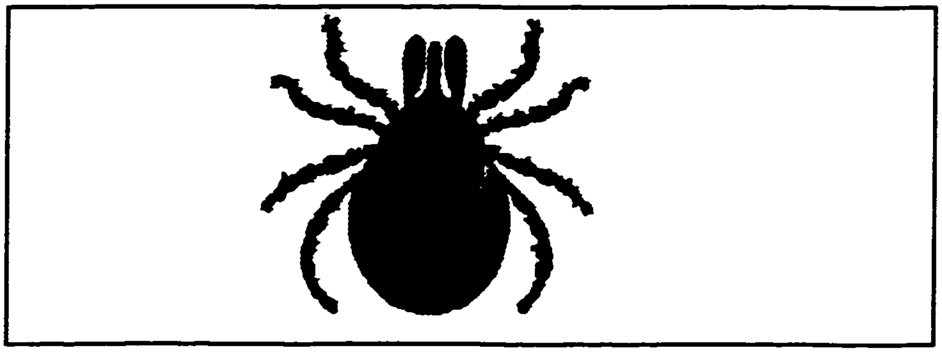

Figure 5. Tick. (Source: San Jose Regional Parks brochure, no date, Watch Your Step!)

1) *Why do you think that a nickname for this kind of rock is pudding stone?* (People used to eat puddings with lots of lumpy ingredients such as raisins.)
2) *How do you imagine this big formation of rocks got here? How can you tell that the rocks that make up the conglomerate have been moved by water?* (Some of the rounded pieces in these conglomerate boulders are formed by volcanoes, perhaps even from the ancestral Sierras. The pieces then washed down rivers

and were deposited under the ocean that was here before the Coast Ranges rose [Coyle,1984]. The rounded shape of the rocks shows that they were moved by water.)

3) *Which is older, the conglomerate or the rocks within it?* (the rocks within it)
4) *Are the rocks within the conglomerate well-sorted or poorly-sorted by size?* (They are poorly-sorted, meaning the conglomerate contains rocks of various sizes mixed together.)
6) Wet the rocks for better viewing. *Can everyone find the following rocks within the conglomerate?*
   a) *Quartz (grayish white with visible crystals)*
   b) *Different colors of chert (chemically the same as quartz, but the crystals are microscopic)*
   c) *Dark volcanic rocks (with large crystals in a* ***groundmass*** *of small crystals. A rock with two distinct grain sizes has a* ***porphyritic*** *texture.)*
   d) Granite-like rocks
7) *How many different kinds of loose rock from the ground can you match with a rock in the conglomerate formation?*
8) *What is the material surrounding the small rocks in the conglomerate? Use a magnifier and your fingers to find out.* (sandstone) *Look for places that show the surrounding material (the* ***matrix****) was stronger than the rocks within it (the* ***clasts****) and for places with evidence that the clasts were stronger than the matrix. Both are present. Describe the evidence for both.* Cracks through the conglomerate that break the clasts show that the matrix was stronger, while cracks in the matrix that bypass the clasts show that the clasts at that location were stronger.)
9) *Why do some of the rocks have a rust coloring?* (The iron in the rocks is reacting with the oxygen in the air to form iron oxide, i.e. rust.)
10) *Can you find moss, lichen. and grass growing out of the conglomerate? Each species of lichen is a different color. How many species can you find? How do you think the plants are affecting the rocks?* (Rocks are often broken down by plants.)
11) Look at the road surface; it is a people-made conglomerate. *How many different kinds of rocks does it contain?*

i. It is interesting to note that the conglomerate and the quartz keratophyre were both formed under the ocean, but under very different circumstances. Today we find them high in the Diablo Range.

j. Turn around now and go back down the hill to the Visitors' Center. You might take the steps down which are located less than 670 m (0.4 mi.)

from Inspiration Point, if you think they are not too steep to use. If you come to the trail post that says South Rim Trail 0.1 mi. and Inspiration Point 0.4 mi., you have gone past the steps.

VISITORS' CENTER (1/2 HR.)

a. See the displays of igneous rock (keratophyre but labeled rhyolite), sedimentary rock (conglomerate and sandstone) and metamorphic rock (serpentinite).

b. Look at the model of the Alum Rock Canyon and mentally trace the route of your trip.

NAME____________________
DATE__________PERIOD_____

STUDENT WORKSHEET FOR ROCKS OF ALUM ROCK PARK FIELD TRIP

STOP 1--ALUM ROCK

1. What caused this canyon to develop?

____

____

2. Why does the canyon narrow when it reaches the Alum Rock?

____

____

STOP 2--MINERAL SPRINGS AREA

3. What did these layers look like when they were laid down? How do you suppose they came to look like they do now? What pushed on these layers of rock?

____

____

____

4. In what kind of environment would shale and chert be deposited?

____

____

5. Which do you think would erode more easily, the shale or the chert? Why?

____

6. Do you think the boulders containing clam fossils came from this location or from upstream? Why?

____

7. Where were the rocks make of calcium carbonate used? On the sides of the bridge or on the top? Why?

____

INSPIRATION POINT HIKE

8. As you climb up the hill, what evidence do you see that the rocks and soil are moving down the slope?

____

9. Why do you think the concrete catch-basin was built here? (behind the Youth Science Institute) What problems might occur in this area if we get a lot of rain?

____

____

____

10. Can you find places where water has eroded the soil away from tree roots on the hill?

____

11. What large trees from Australia are planted on the opposite slope?

____

12. Looking to the left on the far slope, what other trees not native to, but often planted in San Jose do you see?

____

13. Look at the large Coast Live Oak with roots greatly exposed. Are all the roots from the same tree?

____

14. Can you find an intermittent stream that would probably contain water in wet weather? Where is it located?

____

15. What native California plants were you able to identify?

____

____

16. Look across at the opposite canyon wall. Can you see where the plants change suddenly? Why might this occur?

____

____

17. Why does this side of the canyon have more vegetation than the opposite slope? Use the compass to determine which direction the slope you are standing on faces. Which direction does the opposite slope face? How does the direction a slope faces affect what plants can grow there?

____

____

____

18. Where are most of the trees on the opposite slope? Why?

____

19. How high above sea level is this volcanic feature (Inspiration Point)?

____

20. How do you think Inspiration Point got its name? What other inspiring vistas have you seen?

____

____

21. Using the *Pacific Coast Tree Finder* or the following clues, can you identify two kinds of oaks in the enclosed area here? Cupped leaves and toothed margins: ______________________ Slightly lobed, blue-green leaves and lighter bark ____________________

22. How high above sea level are Eagle Rock and the Alum Rock?

____

23. Using the topographic map or Figure.3, can you locate Inspiration Point? How did you locate this peak? How high is it above the canyon floor?

____

____

24. As you move down the hill to the road, can you spot two more different kinds of oaks? How can you tell that they are different?

____

25. Why do you think that a nickname for conglomerate is pudding stone?

____

26. How do you imagine this big formation of rocks got here? How can you tell that the rocks making up the conglomerate have been moved by water?

____

____

27. Which is older, the conglomerate or the rocks within it?

____

28. Are the rocks within the conglomerate well or poorly-sorted by size?

____

29. Circle the rocks you were able to find within the conglomerate: quartz (grayish white with visible crystals), chert (chemically the same as quartz but with microscopic crystals), dark volcanic rocks (with large crystals in a groundmass of small crystals. A rock with two distinct grain sizes has a **porphyritic** texture), granite-like rocks.

30. How many different kinds of loose rock from the ground can you match with a rock in the conglomerate formation?

____

31. What is the material surrounding the small rocks in the conglomerate? Use a magnifier and your fingers to find out. Look for places that show the surrounding material (the matrix) was stronger than the rocks within it (the clasts) and for places with evidence that the clasts were stronger than the matrix. Both are present. Describe the evidence for both.

____

____

32. Why do some of the rocks have a rust coloring?

____

33. Can you find moss, lichen and grass growing out of the conglomerate? Each species of lichen is a different color, How many species can you find? How do you think the plants are affecting the rocks?.

____

34. Look at the road surface. It is a people-made conglomerate. How many different kinds of rocks does it contain?

____

APPENDIX A

CORRELATION OF RELEVANT STANDARDS WITH THE "TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK"

APPENDIX A:
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"National Science Education Standards" (National Research Council, 1996)	"Science Framework. for CA Public Schools" (Butts and Prescott, 1990)	"California Science Content Standards" (State of CA,1999)	"Teachers' Resource Guide to the Geology of Alum Rock Park"
1. UNIFYING CONCEPTS and PROCESSES STANDARD: As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes:	THEMES	1. INVESTIGATION and EXPERIMENTATION: Scientific progress is made by asking meaningful questions and conducting careful investigations. Students will:	(Sample entry--"Rocks" (Background Information, Act.3) This referrel is to the Guide Module called "Rocks of Alum Rock Park", the Background Information section and Classroom Activity 3)

APPENDIX A:
CORRELATION OF RELEVANT STANDARDS WITH THE "TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK"

a. Systems, Order, and Organization	Systems and Interactions	4th--6c (4th grade; Category 6; Subsection c). Formulate predictions and justify predictions based on cause and effect relationships.	"Mineral Springs of Alum Rock Park" (Field Trip Plan) "Water Quality of Penitencia Creek in Alum Rock Park" (Field Trip Plan) "Rocks of Alum Rock Park" (Background Information)
b. Evidence, Models, and Explanation	Scale and Structure	7th--7d. Construct scale models, maps, and appropriately labeled diagrams to communicate scientific knowledge	"Geologic Characteristics of Penitencia Creek in Alum Rock Park" (Activities 1,2) "Mineral Springs" (Act.1,2,3,4,5,6, Field Trip Plan) "Water Quality" (Act.1,2, Field Trip Plan) "Rocks" (Act.1,2,3,4,5,6)
c. Constancy, Change, and Measurement	Stability and Patterns of Change	3rd --5c. Use numerical data to describe and compare objects, events, and measurements. 5th--6f. Select appropriate tools and make quantitative observations. 8th--9d. Evaluate the accuracy and reproducibility of data.	"Geologic Characteristic" (Field Trip Plan) "Mineral Springs"(Act. 7, Field Trip Plan) "Water Quality" (Act.1,2, Field Trip Plan) "Rocks" (Field Trip Plan)

APPENDIX A:
CORRELATION OF RELEVANT STANDARDS WITH THE "TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK"

d. Evolution and Equilibrium	Evolution and Stability	6th--7g. Interpret events by sequence and time from natural phenomena. 6th--7h. Identify changes in natural phenomena over time without manipulating the phenomena.	"Geologic Characteristics" (Field Trip Plan) "Mineral Springs" (Field Trip Plan) "Rocks" (Field Trip Plan)
e. Form and Function	Scale and Structure		"Geologic Characteristics" (Field Trip Plan) "Mineral Springs" (Field Trip Plan), " Which rocks were used for which functions on the bridges?"

APPENDIX A:
CORRELATION OF RELEVANT STANDARDS WITH THE "TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK"

2. EARTH & SPACE SCIENCE: CONTENT STANDARD D: As a result of their activities in grades 5-8, all students should develop an understanding of:		2. EARTH SCIENCE	
a. Structure of Earth System			
The solid Earth is layered with a lithosphere, hot, convecting mantle, and dense, metallic core.	Scale and Structure		"Mineral Springs" (Activities 1,2)
Lithospheric plates on the scales of continents and oceans constantly move at rates of cm/yr. in response to movements in the mantle.	Energy, Systems and Interactions, Scale and Structure	Plate Tectonics: 6th--1a-g. Plate tectonics explains important features of the Earth's surface and major geologic events.	"Geologic Characteristics" (Field Trip Plan) "Mineral Springs" (Act. 1,2, 3,4, Field Trip Plan) "Rocks" (Act. 5,6, Field Trip Plan)

APPENDIX A:
CORRELATION OF RELEVANT STANDARDS WITH THE "TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK"

Land forms are the result of a combination of constructive and destructive forces.	Energy, Systems and Interactions, Patterns of Change, Evolution	Dynamic Earth Processes: 9th-12th--3a-d. ...operating over geologic time have changed patterns of land, sea, and mts. on the Earth's surface. Surface Processes: 4--5a-c.. Waves, wind, water, and ice shape and reshape the Earth's land surface.	"Geologic Characteristics"' (Act. 1,2, Field Trip Plan) "Mineral Springs" (Act.3,4,5,6, Field Trip Plan) "Rocks" (Act. 1,2,3,4, 5,6, Field Trip Plan)
Soils consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria.	Scale and Structure	Shaping the Earth's Surface: 6th--2a-d. Topography is reshaped by weathering of rock and soil and by the transportation and deposition of sediment.	"Geologic Characteristics" (Act.1,2, Field Trip Plan) "Rocks" (Act. 2)
Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle".	Systems and Interactions, Energy	Earth Sciences: 5th--3b-e. Water on Earth moves between the oceans and land through the processes of evaporation and condensation.	"Geologic Characteristics" (Act. 1,2, Field Trip Plan) "Mineral Springs" (Act. 5,6, Field Trip Plan)

APPENDIX A:
CORRELATION OF RELEVANT STANDARDS WITH THE "TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK"

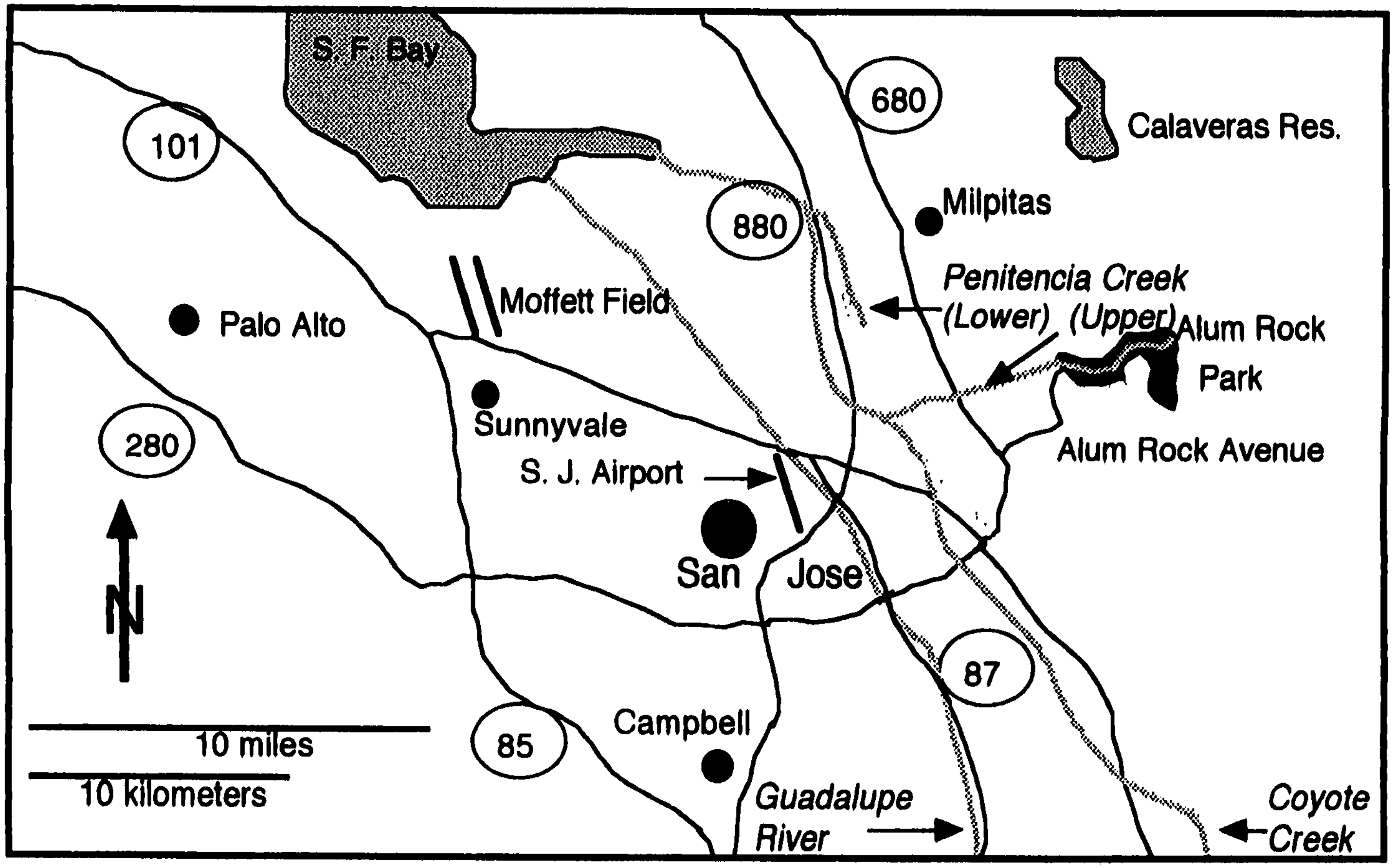
Water is a solvent.	Scale and Structure	Biogeochemical Cycles: 9th-12th--7a-d. Each element of Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of biogeochemical cycles.	"Mineral Springs" (Background Information, Act.5,6,7, Field Trip Plan) "Water Quality (Act. 1,2, Field Trip Plan)
The atmosphere is a mixture of nitrogen, oxygen, and trace gases that include water vapor.	Scale and Structure, Systems and Interactions, Energy	Biogeochemical Cycle: 9th-12th--7a-d. Each element of Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of biogeochemical cycles.	"Mineral Springs" (Background Information, Act. 5,6, Field Trip Plan)
Living organisms have played many roles in the earth system, including affecting the composition of the atmosphere, producing some types of rocks, and contributing to the weathering of rocks.	Systems and Interactions	Biogeolchemical Cycles: 9th-12th--7a-d. Each element of Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of biogeochemical cycles.	"Geological Characteristics." (Field Trip Plan) "Mineral Springs" (Background Information, Field Trip Plan) "Water Quality" (Act. 1, Field Trip Plan) "Rocks" (Field Trip Plan)

APPENDIX A:
CORRELATION OF RELEVANT STANDARDS WITH THE "TEACHERS' RESOURCE GUIDE TO THE GEOLOGY OF ALUM ROCK PARK"

b. Earth's History			
The earth processes we see today, including erosion, movement of lithospheric plates, and changes in atmospheric composition, are similar to those that occurred in the past.	Stability, Systems and Interactions		Act. 2, Field Trip Plan "Mineral Springs" (Act. 3, Field Trip Plan) "Rocks" (Background Information, Act. 2,5, Field Trip Plan)
Fossils provide important evidence of how life and environmental conditions have changed.	Evolution, Systems and Interactions	Earth and Life History: 7th--4a,c,e,f. Evidence from rocks allows us to understand the evolution of life on Earth.	"Geologic Characteristics" (Background, Act. 2, Field Trip Plan) "Mineral Springs" (Act. 3, Field Trip Plan) "Rocks' (Background Information, Act. 2,5, Field Trip Plan)

APPENDIX B

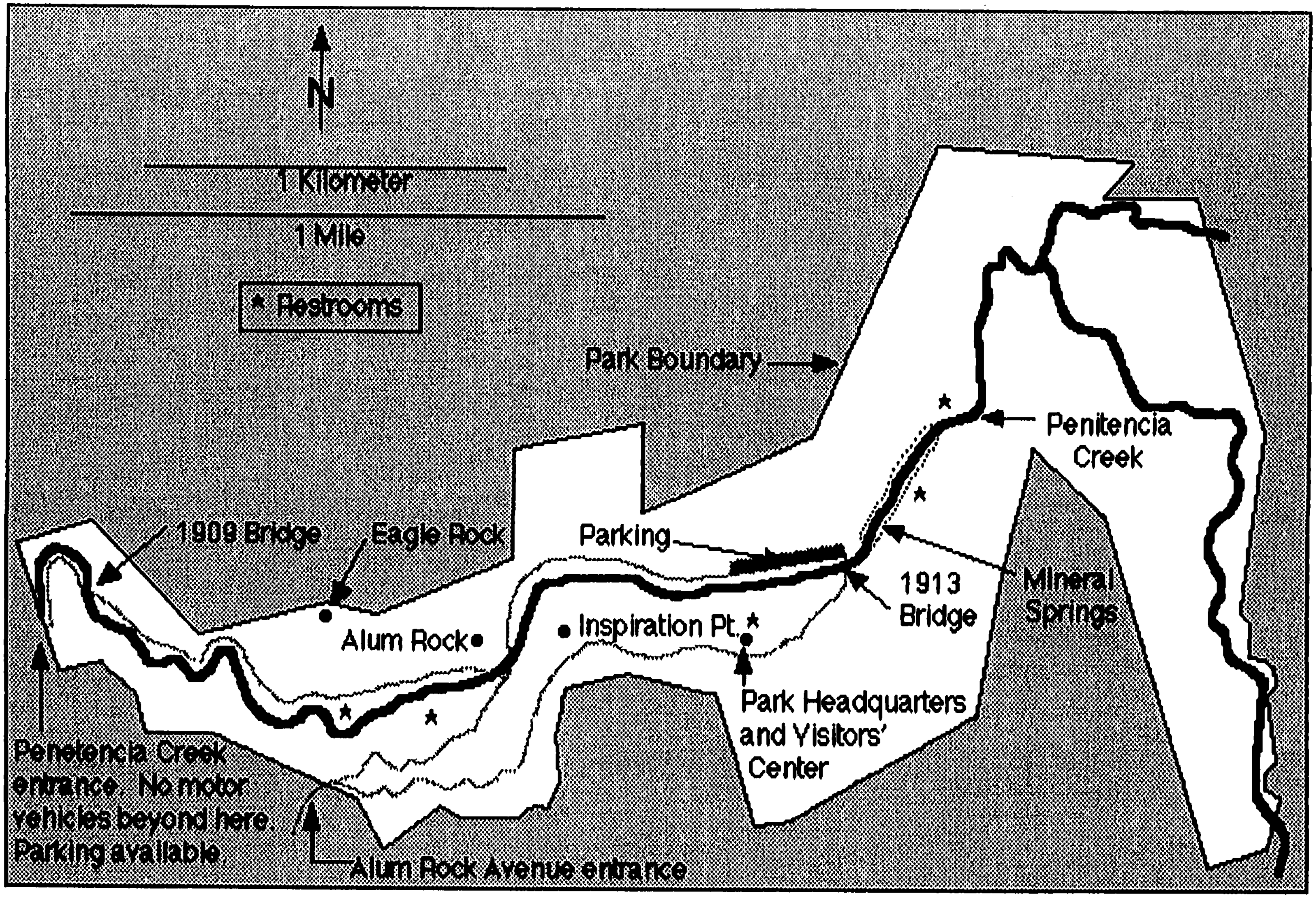
LOCATION MAP OF ALUM ROCK PARK



APPENDIX B: Location Map of Alum Rock Park. (Modified from Valley Transportation Authority, 1998; Dibblee, 1973.)

APPENDIX C

MAP OF ALUM ROCK PARK



APPENDIX C: Map of Alum Rock Park. (Modified from San Jose Regional Parks, no date. Alum Rock brochure.)

APPENDIX D

FREQUENTLY ASKED QUESTIONS ON THE GEOLOGY OF ALUM ROCK PARK

APPENDIX D: FREQUENTLY ASKED QUESTIONS ON THE GEOLOGY OF ALUM ROCK PARK

Is there any alum in Alum Rock Park?

No. The powdery white coating on the rocks at the mineral springs and on the igneous formation known as Alum Rock is not alum--potassium aluminum sulfate, $KAl(SO_4) \cdot 12H_2O$, but is **thenardite**--sodium sulfate, Na_2SO_4 (Hartesveldt and Harvey, 1972). Both alum and thenardite can be carried in solution and deposited when water evaporates. Both cause puckering of the mouth when sampled. Alum would have been more familiar to the early samplers because of its use as an astringent, and so the white powder was labeled as alum.

Are Eagle Rock and Alum Rock volcanoes?

No. They are extrusive igneous rocks, but never erupted from volcanoes. The quartz keratophyre (once called rhyolite) is believed to have formed on the sea floor and been placed in its present location by movement along faults.

How high are Eagle Rock, Alum Rock, and Inspiration Point?

The elevation of Eagle Rock, the highest of the three features, is 239 m (795 ft.) above sea level; it also rises the highest above the valley floor, about 130 m (400 ft.). Alum Rock, lowest of the three, is 188 m (625 ft.) above sea level and about 60 m (185 ft.) above the valley floor, while Inspiration Point is 219 m (730 ft.) above sea level and about 130 m (400 ft.) above the valley floor.

Why is Eagle Rock so named?

It was named for the eagles that formerly lived there. They have been gone since before World War I (Richards, 1922).

What are the fossils in the boulders in Penitencia Creek?

The fossils are clams, scallops and oysters (**pelecypods**) that were most likely formed when a shallow sea covered the area where the park is now (Coyle, 1984).

Is there a fault in Alum Rock Park?

There may be several faults in Alum Rock Park, but no fault called the "Alum Rock fault". At the present time (1999), geologists do not agree on where the faults go and which faults are which. Landslide movements have displaced old fault traces, as well as created landslide slip surfaces that are hard to distinguish from faults. Addtionally, erosional features such as gullies are often mistakenly called faults.

Was there once a meteorite in the park?

Undocumented reports from people living in the area in 1848 stated they saw a meteor fall (Richards, 1922). Dr. A.F. Rogers of Stanford University, analyzed it and stated that it contained several manganese minerals, including a new one named "kempite" (Crippen, 1951); the high percentage of manganese is not compatible with origin as a meteorite. Since manganese was a mineral needed during World War I, the City of San Jose sold it. The rock yielded 329 tons of ore, of which 52.6 percent was manganese (Crittenden, 1951). The boulder was not in place when found and is thought to have been part of a landslide. Its origin has not yet been determined.

Why are the mineral springs hot?

Hot springs are those with temperatures greater than that of the human body (37°C/98°F). These springs are actually not hot, but warm. The water is most likely heated when it travels deep in the earth through the greatly folded layers . Another possibility is the presence of magma at depth (Hartesveldt and Harvey, 1972).

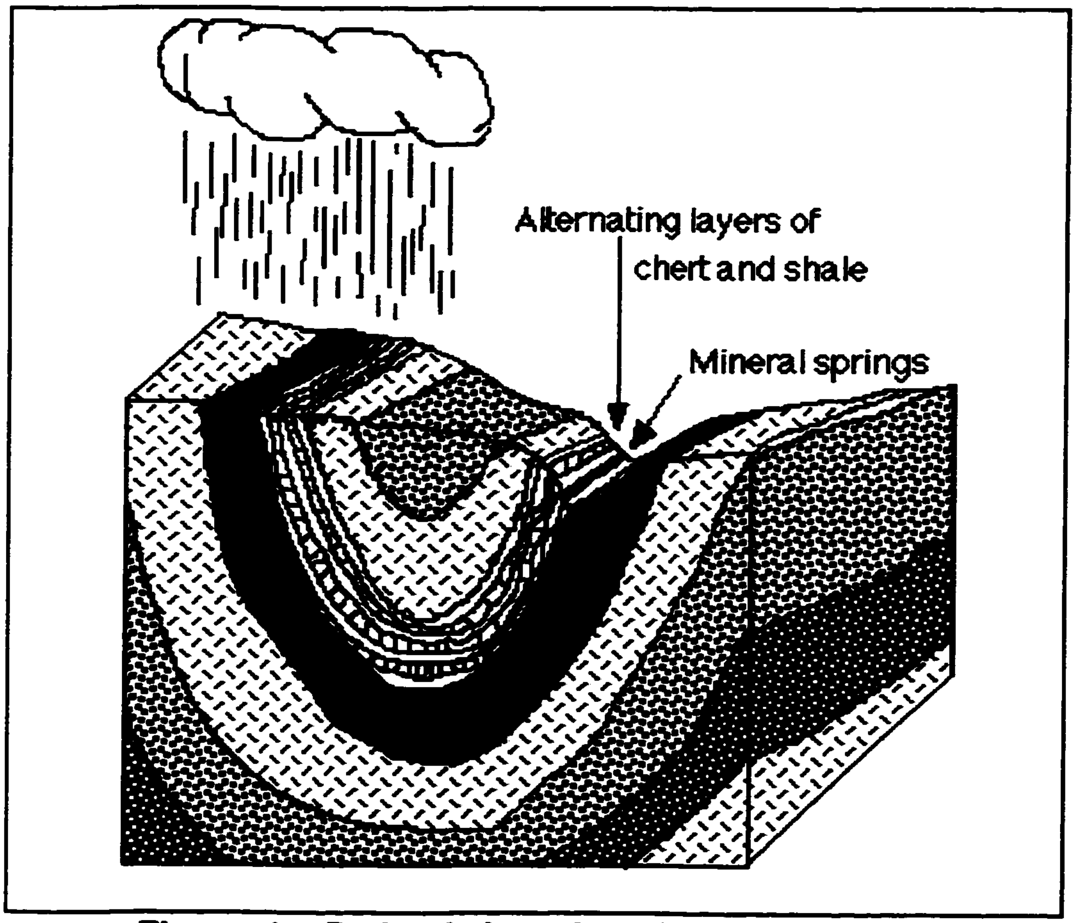


Figure 1. Path of the mineral springs water.

Did one of the mineral springs contain arsenic?

Spring #26 (see Mineral Springs Map in the Mineral Springs Module) has been walled up because personnel in the park noted dead birds around it and thought they might have been killed by arsenic in the water of this spring. Although the arsenic was not supposed to be at a level high enough to harm people, the spring was blocked off to insure safety (Hardesveldt and Harvey, 1972). C.F. Berkstresser (1968) listed 0.01 ppm of arsenic in one of the Alum Rock Park springs.

APPENDIX E

SOURCES OF MATERIALS

APPENDIX E: SOURCES OF MATERIALS

Acorn Naturalists	(800) 828-7777
Bay Earth Science Institute (BAESI) San Jose State University	(408) 924-5030 www.baesi.org
Forestry Suppliers, Inc.	(800) 647-5368
Hach Chemical Company	(800) 227-4224
LaMotte Company	(800) 344-3100
REI-Recreational Equipment, Inc. Saratoga, CA	(408) 871-8765
Science Kit & Boreal Laboratories	(800) 828-7777
United States Geological Survey Map Sales, Menlo Park, CA	(650) 329-4390
Ward's	(800) 926-2660

APPENDIX F

ADDITIONAL RESOURCES

APPENDIX F: ADDITIONAL RESOURCES

BOOKS AND ACTIVITY GUIDES

The Amazing Earth Model Book by Donald M. Silver and Patricia J. Wynn. This collection of paper models is suitable for the upper elementary grades and could be modified for middle school. Each model stands alone and can be used in any order. It is available from Scholastic Professional Books, P.O. Box 7502, Jefferson City, MO 65102 (1-800-325-6149) for $12.95.

Earth Science for Every Kid: 101 Easy Experiments that Really Work is one of a series by Janice VanCleave. These experiments for children 8-12 years old are simply written and use easily obtained materials. This book, published by John Wiley and Sons, is available from bookstores and may be ordered from the National Science Teachers' Association, Publication Sales, 1840 Wilson Blvd., Arlington, VA 22201-3000 for $10.95. (1-800-722-NSTA).

Earthquakes & Volcanoes by Ruth Deery for grades 4-8 contains brief selections emphasizing cause and effect, making predictions based on information, and drawing conclusions supported by evidence. It also includes illustrations to color and flip books to make. The lessons are sequential, but some can be omitted. It is available from Good Apple, Inc., Box 299, Carthage, IL 62321-0299 for $6.95.

Fossil (part of the Eyewitness series) written by Paul D.Taylor and illustrated with the photographs of Colin Keates is a photo essay for people of all ages. The information-filled captions and text make this sometimes difficult-to-understand-subject clear at an introductory level. The Eyewitness series is available at most bookstores for about $16.00 per title.

The Magic School Bus Inside the Earth by Joanna Cole is a delightful and informative book for elementary students. It is widely available at bookstores for $3.95.

Ranger Ricks's Naturescope--Geology: The Active Earth provides activities on plate tectonics, volcanoes, rocks and minerals, weather and erosion, fossils, and how geology affects people for students in grades K-8. It may be ordered for $7.95 from the National Wildlife Federation, 1400 Sixteenth Street, N.W., Washington, D.C. 20036-2266.

Rocks & Minerals, one of the Eyewittness Books, discusses the creation and decomposition of rocks and minerals, as well as how they are obtained and used by people. The text by R. F. Symes and photographs by Colin Keates open a fascinating field to readers of all ages. The Eyewitness Books are located in the children's section of most bookstores and sell for about $16.00.

Rocks and Minerals of California by Vinson Brown, David Allan, and James Stark contains keys to common California minerals and rocks, a brief history of their formation and location maps for interesting and extensive deposits. It is available from Naturegraph Publishers, Inc. 3543 Indian Creek Road, Happy Camp, CA 96039 or from many bookstores for $8.95.

Seismic Sleuths is a teaching unit published in 1995 by the American Geophysical Union (AGU) in conjunction with the Federal Emergency Management Agency (FEMA) for grades 7-12. The units include pre- and post-assessments of student knowledge of earthquakes and hazard preparedness, earthquake processes, causes and measurement, the science and history of seismology, effects on buildings and possible prevention of damage, and what people should do before, during and after an earthquake. Single copies may be obtained at no cost by contacting the FEMA. Warehouse at P.O. Box 2012, Jessup, MD 20794-2012 (1-800-480-2520).

Water, Stones, & Fossil Bones: Earth science activities for elementary and middle level grades is a collection of fifty-one earth science activities compiled by the Council for Elementary Science International and the National Science Teachers Association and edited by Karen K. Lind. Some background information, a description of the concepts or skills addressed, materials, procedures, and further challenges are included in each lesson. The paperback book may be orded from the NSTA Science Store, PO Box 90214, Washington, DC 20090-0214 (1- 800-399-722-NSTA) for the member price of $16.65 or $18.50 for nonmembers.

TEST KIT

The Pondwater Tour is a water quality test kit and curriculum for grades 4-8. The water quality parameters that are changed, tested for, and the significance analyzed are the following: dissolved oxygen, nitrate, pH , and ammonia. Data sheets and reagents for a class or 40 are included. The kit may be purchased from the LaMotte Company, PO Box 329, Chestertown, MD 21620 (1-800-344-3100) or from many other scientific supply companies for $49.95. Refill kits are available for $36.95.

VIDEOS

The Hayward Fault--We Can't Ignore It: Parts 1 and 2 prepared by Sue Hirschfield and Fred Klein is appropriate for middle school to college level students. Part 1 centers on observable landforms and an animated flyover of the Hayward fault. Part 2 contains additional information on earthquakes in the San Francisco Bay Area, fault creep, earthquake probability, and ideas for preparedness for high school and college students. Excerpts could be used with elementary students. The tape may be borrowed from the Library, Video Section, U.S. Geological Survey, 345 Middlefield Rd., Menlo Park CA 94025 (650-329-5009) or purchased with a 6-page report for $19.95, including tax, shipping and handling from the Instructional Media Center, Cal State University, Hayward, Hayward CA 94542, (510-885-3692).

When the Bay Area Quakes centers on the 1989 Loma Prieta earthquake. Written and produced by Doug Prose and narrated by Wendy Tokuda with live earthquake footage from local television stations, this twenty minute video was financed by the U.S. Geological Survey (U.S.G.S.). Explanations and illustrations clarify the four main earthquake effects (ground shaking, liquefaction, landslides, and ground ruptures) by employing examples from the Loma Prieta quake. U.S.G.S. scientists comment on earthquake prediction and monitoring. Suitable for upper elementary students and above, this video may be obtained from the U.S.G.S. Library in Menlo Park or by arranging an interlibrary loan through your local library. The call number is (200) W535 1990 Video.

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GLOSSARY

accreted--Stuck onto.

acidic--Pertaining to a substance that has more hydrogen (H^+) than hydroxyl (OH^-) ions; its pH is less than 7.

alluvial fan--A fan-shaped landform composed of sediments deposited by a stream when it comes from steep mountains and enters a plain or valley floor.

alluvium--Sediment deposited by flowing water.

anaerobic--Not needing oxygen for life processes

andesite--A medium colored, fine-grained, extrusive rock named for the Andes Mountains where it is commonly found.

anticline--Rock layers that are folded to form an upward-pointing arch.

asthenosphere--Part of the upper mantle, from about 100 to 250 km beneath the Earth's surface, where the rocks are plastic and mobile.

badlands topography--weakly cemented clay or silt slopes, with little or no plant cover, where erosion has formed many tiny and interweaving channels.

bar--A ridge-like accumulation of silt, sand, or gravel along the banks or at the mouth of a river.

basalt--An extrusive igneous rock containing many dark minerals.

basic--Pertaining to a substance that has more hydroxyl (OH^-) ions than hydrogen (H^+) ions; its pH is greater than 7.

Beggiatoa--A type of white, filamentous bacteria that obtains energy from sulfur.

Berryessa Formation--Part of the Upper Jurassic and Cretaceous Great Valley Group sedimentary rocks visible at the Penitencia entrance to Alum Rock Park

black fly larva--This larva occur in streams, where it attaches to rocks by means of suckers at the end of its club-shaped body; it moves around like a measuring worm. The small adult is often found near the streams where its larva is found.

blueschist--A metamorphic rock formed at high pressure and low temperature as occurs at a subduction zone; found in the Coast Ranges, blueschist is indicative of the Franciscan Assemblage.

boulder--A rock fragment larger than 256 mm in diameter.

Briones Formation--Cenozoic sedimentary rocks, some of which contain bivalve fossils, deposited in a shallow sea and later uplifted.

Calavaras fault zone--A zone that includes the right-lateral fault trending northwest from Hollister, where it appears to branch from the San Andreas fault, through the Diablo Range to near Danville.

cast--A replica of a fossil shell or skeleton made when minerals are deposited by water in a mold made by the fossil.

Celsius--Temperature scale on which water freezes at 0° and boils at 100°.

Cenozoic--The present geologic era beginning about 65 million years ago.

channel--The path that a stream follows.

chaparral--A community of shrubby aromatic plants adapted to very dry summers and mild rainy winters.

chemical/biogenic sedimentary rocks--Rocks made from minerals that precipitated from water; biogenic ones are made from skeletons of microscopic plants and animals.

chert--Dense, fine-grained sedimentary rock, made by the precipitation of silica from inorganic or animal sources such as radiolaria skeletons. It can be red, green, black, brown, gray, or white and breaks with a concoidal fracture.

Claremont Formation--Cenozoic layers of chert and shale originally deposited under the ocean and later uplifted from which the mineral springs in Alum Rock Park emanate.

clast--A fragment.

clastic sedimentary rocks--Rocks made up of fragments produced by the weathering of other rocks.

cobble--A rounded rock fragment with a diameter from 64 to 256 mm.

column--A stalactite joined with a stalagmite.

concoidal--curving.

conductivity--The ability of water or other substances to conduct electricity.

conglomerate--Sedimentary rock made from rounded gravel fragments.

convection current--The cyclical process that occurs in liquids and gases when they are heated and cooled; heating causes the fluid to be less dense, so it rises; cooling causes it to become more dense, so it sinks.

converging plate boundary--The zone along which two plates meet as they move toward each other.

core---The innermost layer of the Earth made up of an iron-nickel alloy. The outer core is probably liquid, while the inner core is most likely solid.

crust--The thin, outermost layer of the earth made up of thicker, less dense continental crust and thinner, more dense oceanic crust. It is made up of silicate minerals.

cyanobacteria--Also called blue-green algae or blue-green bacteria, these life forms, classified as monerans, do not have a nuclear membrane, so the nuclear material is spread throughout the cytoplasm. They are photosynthetic.

deciduous--Said of plants that shed all of their leaves at one time.

delta--A landform of sediment deposited by a stream when it flows into a standing body of water.

deposit--To lay down or let fall eroded Earth materials.

Diablo Range--One of the three major mountain blocks in the middle of the Coast Range belt, extending from the Contra Costa Hills in the North, along the east side of San Francisco Bay and the Santa Clara Valley, to the Gavilan Range in the South. It includes the tallest mountain in the San Francisco Bay Area, Mt. Hamilton (1,283 m/4,200 ft.), the site of the famous Lick Observatory.

diatom--Single-celled, microscopic, photosynthetic organism whose cell walls are composed of silica.

directional stress--Stress on a rock that is greater in one direction than in others.

divergent plate boundary--The zone along which two plates move away from each other and new lithosphere is created.

dripstone--Mineral deposits formed by precipitation from dripping water.

earthquake--The sudden rapid shaking of the Earth produced by the release of energy stored in rocks.

erode--To remove material by the action of water, wind or ice.

extrusive igneous rock--A rock that forms from the solidification of lava and from material exploded or ejected from a volcano.

Fahrenheit--Temperature scale on which water freezes at 32° and boils at 212°.

Farallon Plate--Oceanic plate that subducted under the North American Plate and partially melted to form the ancestral Sierra Nevada.

fault--A fracture in the Earth's crust along which movement has occurred.

flowstone--A deposit chemically precipitated from flowing water.

focus--The point within the Earth where an earthquake originates.

foliated--Layered as in a metamorphic rock when minerals are lined up because of directed stress.

formation--A mappable body of rock.

fossil--Any evidence of past life. May be direct evidence such as shells or bones or indirect evidence such as molds or footprints.

Franciscan Assemblage--A complex unit of Mesozoic rocks made up of fragments of ocean plates accreted to the North American continent by subduction and collision.

gabbro--a dark-colored, coarse-grained igneous rock.

gabion--A wire cage filled with rocks, used to prevent the erosion of a stream bank.

granite--A coarse-grained, intrusive igneous rock containing mostly light-colored minerals.

gravel--Sediment with a diameter from 2 to 4 mm.

Great Valley Group--Mesozoic sedimentary rocks that accumulated in a marine basin which formed next to the continent between the ancestral Sierras and the Mesozoic subduction zone.

greywacke (graywacke) sandstone--A "dirty" sandstone, containing dark fragments of shale, chert or other rocks that make it appear gray or greenish gray.

greenstone--A very fine-grained metamorphic rock made of green minerals, changed from the igneous rocks basalt or gabbro.

groundmass--The fine-grained material between the larger pieces in an igneous or sedimentary rock. *syn.* matrix.

Hayward fault zone--A zone that includes the right-lateral fault occurring along the westward base of the East Bay Hills and extending from at least Fremont in the southeast to San Pablo Bay in the Northwest.

hot spring--A flow of groundwater emerging naturally at the ground surface that is warmer than the human body temperature of 37°C (98.6° F).

igneous--A category of rocks formed when molten rock solidifies.

intrusive igneous rock--A rock that forms by the solidification of magma.

ion--A charged atom or group of charged atoms.

Jurassic--The second period of the Mesozoic Era, from about 135 to 190 million years ago; named for the Jura mountains between France and Switzerland.

L--The symbol for liter.

lateral fault--A fault along which the displacement is horizontal.

lava--Molten rock above Earth's surface.

law of superposition--In an undeformed sequence of sedimentary rocks, each layer is older than the one above it and younger than the one below it.

leach--Remove soluble components of a substance by letting a liquid percolate through it.

left lateral fault--Horizontal fault in which the side opposite the observer appears to have moved to the left.

lithosphere--The Earth's rigid outer 100 km made up of the crust and the part of the upper mantle above the asthenosphere.

magma--Molten rock underneath Earth's surface.

magnetometer--An instrument that measures the Earth's magnetic field and its changes.

mantle--The thickest of Earth's layers, lying between the crust and the core. It is made up of minerals rich in magnesium and iron.

matrix--The fine-grained material between the larger pieces in an igneous or sedimentary rock. *syn.* groundmass.

meander--One of a series of bends in a stream.

mélanges--Chaotic mixtures of variable types of rock containing fragments and blocks of all sizes set in a matrix of shale or serpentinite.

mesosphere--The area between the base of the asthenosphere and the core.

Mesozoic--Geologic era between the Paleozoic and Cenozoic eras, from about 225 to 65 million years ago.

metamorphic--A category of rocks formed from other rocks (igneous, sedimentary or other metamorphic rocks) by being subjected to heat, pressure, or the action of fluids. They are not heated enough to be melted.

meteorite--The stony or metallic material of a meteoroid that has fallen to Earth's surface from interplanetary space.

mold--An impression made into soil or sediment by a fossil shell or other organic structure.

Monterey Group--The Cenozoic sandstones, shales and cherts of which the Claremont Formation is one member.

mya--Abbreviation for millions of years ago.

neutral--A substance with an equal number of hydrogen(H^+) and hydroxyl (OH^-) ions; its pH is 7.

non-foliated--Metamorphic rocks that do not exhibit layering within the rock structure.

normal fault--A nearly vertical fault that occurs where rocks are being pulled apart. The block of rock on one side of the fault drops down in relation to the block on the opposite side of the fault.

normal polarity--A magnetic field that has the same direction as the Earth's present one.

Oakland Conglomerate--A conglomerate unit once thought to be younger than the Berryessa Formation (part of the Great Valley Group), but now considered to be a part of it; named orginally after the younger, already named Oakland Conglomerate, to which it was thought to be equivalent.

opalized quartz--Non-crystalline quartz containing water molecules.

ophiolite suite--Assemblage of rocks thought to represent ocean-floor sediment and the crust and upper mantle beneath them.

Orinda Formation--Gray, tan, green and purple clastic Cenozoic sedimentary rocks made from sediments deposited by fresh water.

Oscillatoria--A kind of green, filamentous, photosynthetic cyanobacteria that lives in the mineral spring waters.

ostracods--A group of unsegmented crustaceans that live in fresh water and in the ocean; also called seed shrimp, ostracods live in many of the mineral springs.

outcrop--A surface exposure of bare rock, not covered by soil or plants.

pebble--A rock fragment, usually rounded, with a diameter from 4 to 64 mm.

pelycepods--The bivalve group of mollusks (clams, oysters, mussels, and scallops).

peridotite--A coarse-grained igneous rock made of dark minerals and often altered to serpentinite.

pH--Measure of the concentration of the hydrogen (H^+) ion concentration of substances on a logarithmic scale that ranges from 0 to 14. A pH of 7 is neutral. Acids have a pH of less than 7 while bases have a pH of greater than 7.

pillow basalt--Pillow-shaped basalt that forms when lava solidifies under water.

pool--An area of relatively deep, slow-moving water within a stream, often on the outside of a bend.

poorly-sorted--Refers to sediments of different sizes being mixed together in a deposit.

porphyry--An igneous rock with two distinct grain sizes. adj. **porphyritic**

plunge pool--A depression in a stream bed formed by the force of falling water.

plutonic rock--Intrusive igneous rock.

quartz keratophyre--A rock that was originally igneous (rhyolite or andesite) that has been altered by contact with sea water into something different chemically.

radiolaria--Single-celled marine protozoa whose skeletons are made up of silica; *sing.* radiolarian.

rattailed maggot--This larva of one type of syrphid fly is able to live in highly polluted water because it has a long breathing tube; it lives where the creek water and mineral spring water mix.

reverse fault--A nearly vertical fault that occurs when rocks are being compressed. The block of rock on one side of the fault is pushed up relative to the block on the opposite side of the fault.

reverse polarity--A magnetic field that has the opposite direction as the Earth's present field.

rhyolite--A fine-grained extrusive igneous rock containing mostly light-colored minerals.

riffle--Shallow area of a stream where the water moves quickly over gravel and cobbles, causing ripples to be seen.

right lateral fault motion--Movement along a horizontal fault in which the side opposite the observer appears to have moved to the right.

riparian--Streamside.

run--Fast-flowing area of a stream where the water is too deep for ripples to be visible.

salol--An organic compound, phenyl salicylate ($C_6H_4OHCOOC_6H_5$) that has a crystalline structure.

sand--Rock fragments ranging from 0.062 to 2 mm in diameter.

sandstone--Sedimentary rock made from fragments of sand.

Santa Clara Formation--Late Cenozoic sediments of gravel, sand, silt and clay deposited by lakes and rivers and exposed around the edge of the Santa Clara Valley.

sediment--Fragments from rocks or skeletons of plants and animals.

sediment load--The material that a stream moves.

sedimentary--A category of rocks formed at the surface of the Earth from sediments, organic remains and/or minerals that precipitate from solution.

seismic--Pertaining to an earthquake.

serpentinite--Metamorphic rock made from serpentine minerals. This state rock of California is dark green, coarse- to medium-grained, and crisscrossed with fractures that are often filled with quartz or calcite.

shale--Sedimentary rock made from clay-sized particles which breaks into thin layers. It can be gray, tan, black, red, or green.

silt/clay--Sediment less than 0.062 mm in diameter.

spreading center--The new, growing edge of a plate; *syn.* divergent plate boundary.

stalactite--An icicle-like pendant of dripstone hanging from a cave ceiling.

stalagmite--A mound-like deposit of mineral material that is built upward from a cave floor by dripping water.

stratigraphic column--The arrangement of the sequence of rock strata of Earth's crust into units based on type of rock, fossil content, age, or other property.

strike-slip fault--A fault along which the displacement is horizontal.

subduction--The process by which an oceanic plate goes beneath another plate into the mantle along a converging plate boundary.

substrate--The material of a stream bottom.

syncline--Folded rock layers that form a downward-pointing trough.

syrphid fly--Also called a flower fly, the adult of this genus looks like a bee; the larva of the species found in the mineral spring water is called a rattail maggot.

terrane--A large piece of crust with a particular geologic character. A terrane differs from the rocks surrounding it and is typically emplaced by tectonic movements.

thenardite--Sodium sulfate, Na_2SO_4, the powdery white coating found on the rocks by the mineral springs and on Alum Rock; it was mistakenly thought to be alum.

thrust fault--A fault that occurs where horizontal compressional forces push one block over the opposing block.

transform plate boundary--The line along which two plates slide past one another.

travertine--Finely crystalline form of calcium carbonate deposited in bands or layers in mineral springs, especially hot springs, or in limestone caves as stalactites or stalagmites.

tufa--A light porous variety of calcium carbonate forming around springs.

turbidity--A measure of the relative clarity of water.

turbidity currents--Currents full of suspended sediment that move swiftly down under-water slopes and spread out on the floor of a body of water.

volcanic rock--Extrusive igneous rock.

well-sorted--Refers to sediments of the same size being deposited together.

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DIVISION OF MINES AND GEOLOGY
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