ALL THAT GLITTERS

THE SPLENDOR & SCIENCE *of* GEMS & MINERALS

Educator's Guide

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Dear Educator:

Welcome to *All That Glitters: The Splendor and Science of Gems and Minerals*. This guide includes an exhibition overview, links (in colored text), and curriculum to help make your Museum visit an engaging educational experience.

References to California Content Standards are included where appropriate. Full text of standards is available at http://www.cde.ca.gov/index.asp.

If you have questions related to this guide, please email the Museum Education Department at education@sdnhm.org.

To book a school group visit: http://www.sdnhm.org/education/teachers/register.html

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ABOUT: *All That Glitters*

All That Glitters: The Splendor and Science of Gems and Minerals explores the geological, historical, cultural, and economic aspects of minerals and gems.

Students will enjoy the sparkle and magnificence of jewelry from world-renowned museums and collections as well as the awesome beauty, wonder, and science of raw minerals.

All That Glitters also highlights the rich and surprising mineral history of California and San Diego County.

EARTH HAPPENS

Tourmaline, photo by Bill Larson

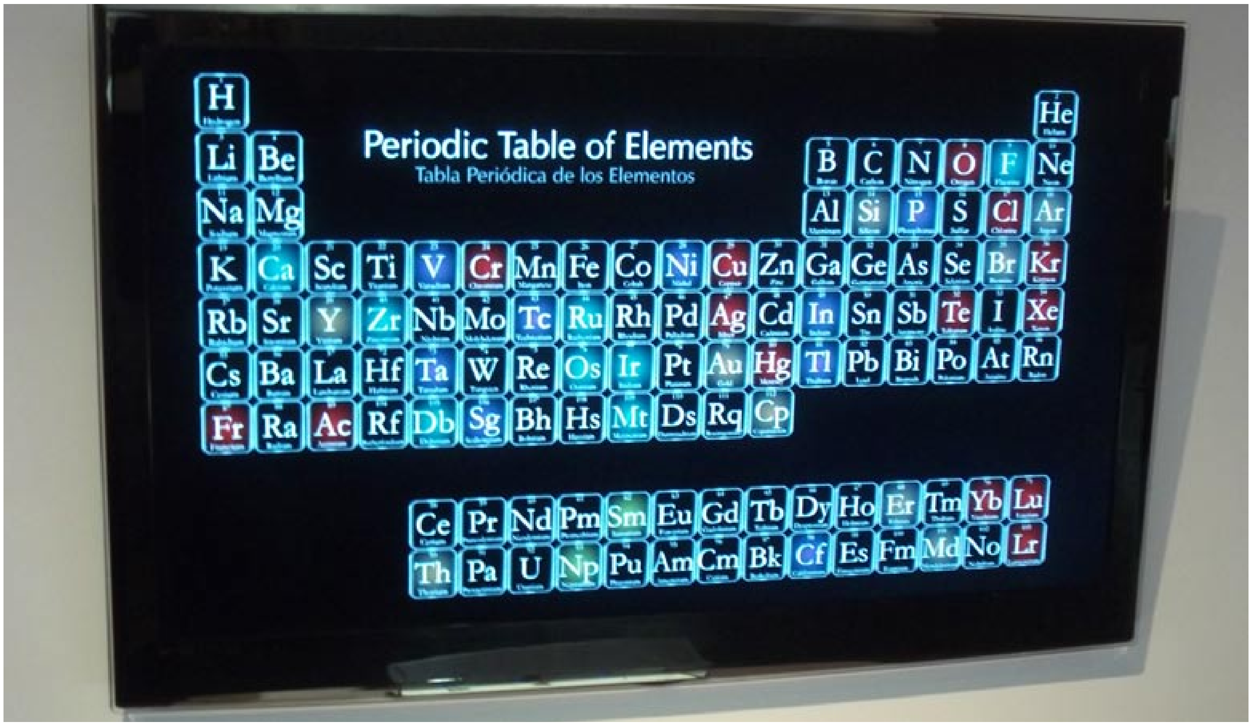
The Earth is a dynamic engine of recycling. Earth's basic ingredients, the elements, are continually in flux—ashes to ashes and dust to dust. Minerals are spectacular evidence of this elemental recycling. Minerals are precious because they are essential to life, and they are beautiful because they are tangible evidence of the enormous power and complexity of Earth processes. Minerals are touchable proof of Earth's magnificent systems. The results of growth, decomposition, plate tectonics, and atmospheric biological influences are all recorded in the Earth materials we call minerals.

Ask your students how fossils are a mineral record of both life and Earth processes. Students can explore a fossilization process in ***Who Moved the Body?*** on the Museum's website: http://www.sdnhm.org/exhibits/mystery/interactives.html. There are also fossil surprises throughout *All That Glitters*. Challenge your students to find them. They may be quick to find the amber cricket fossil, but there are also dinosaur bones inlaid in two of the Intarsia boxes, an iguana and a hummingbird carved of fossil tusk, a bowl crafted from petrified wood, and opalized sea shells. Visit http://nature.nps.gov/geology/nationalfossilday/ to learn more about National Fossil Day and Earth Science Week.

Minerals are inorganic solids (with the exception of mercury and opal) that have specific chemical compositions. Geologists classify minerals by identifying various properties that are characteristic to each. The outward shape of a mineral crystal is known as its "habit." Luster, hardness, color, streak, and cleavage are basic defining mineral properties, but sometimes further tests are required. Microscopes, acid, ultraviolet lamps, and a good nose are all part of the geologist's tool kit. Sometimes a quick lick may be necessary to distinguish salty halite ($NaCl$) from sylvite (KCl).

While most minerals are a combination of elements, there are some exceptions. These single ingredient minerals are called native elements. Metals like gold, silver, platinum and copper are native elements. A diamond, composed solely of carbon, is the only native element gem. In contrast, San Diego's mineral "star," tourmaline, is comprised of at least 11 different elements. Geologists have identified over 4,000 different minerals on Earth—each one a recipe, a chemical formula of our planet.

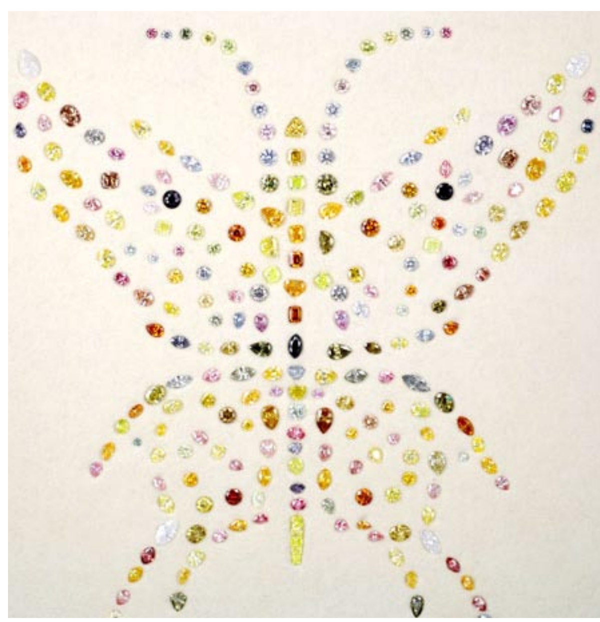
Opalized clam shells, photo by Tom Spann



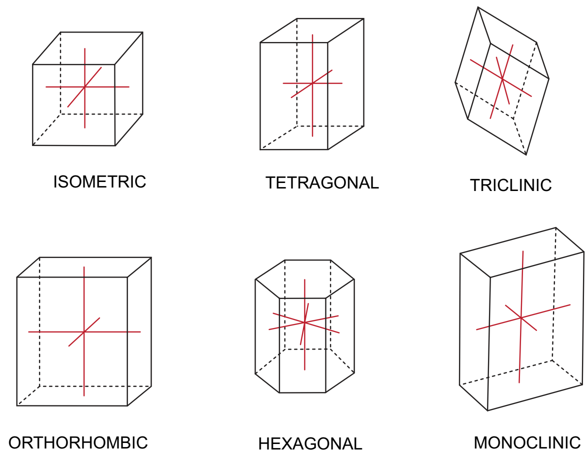
Ask your students to visit the interactive periodic table at the Mineral Informational Institute http://www.mii.org/periodic/MIIperiodicChart.html. Click on an element like Lithium, Calcium or Silica and find out more about the chemistry of individual minerals. Every year almost 50,000 pounds of minerals must be provided for each person living in the U.S. in order to maintain our standard of living. Use this online periodic table to learn more about the minerals involved in the production of everyday objects like pencils and computers. At the Museum, compare the chemical structure of a diamond to that of a tourmaline with the gallery's electronic Periodic Table.

Ingredients alone do not make a recipe. Minerals are cooked up from elements under a variety of chemical and physical conditions. Different formation conditions result in variances in the atomic structures and/or composition. Color is one such variance. Quartz, for example, ranges in color dependent upon the impurities or anomalies that have contributed to its formation. In the gallery you will see an eye-popping display of colored diamonds. With diamonds, most color differences are due to chemistry rather than physical conditions. Same pot, same stove, same basic ingredients—just a few differences in seasoning.

Color is commonly not a precise defining property of a mineral. Rubies and sapphires are varieties of the mineral corundum. One chief defining characteristic of a mineral is its structure, the internal arrangement of its atoms. Crystals form as the atoms join in a repeating pattern. There are six crystal systems, within which there are many classes.



Aurora butterfly made of different colors of diamonds



Selenite crystal

The Cave of Crystals located within the Naica Cave in Chihuahua, Mexico, holds some of the word's most amazing crystals, some of which are up to 36 feet (11 meters) in length. Extraordinary conditions led to the cave's crystal formations and to their discovery 300 meters underground. Mineral-rich water with temperatures as high as 136°F (58°C) enabled the mineral gypsum to form giant crystals, but the evacuation of this water for mining activity allowed these giants to be seen.

California State Content Standards
- Grade 4 Earth Sciences 4a, b
- Grade 5 Physical Sciences 1a–d
- Grade 8 Structure of Matter 3a–d, f
- Grade 8 Periodic Table 7a, b

Ask your students to learn about Naica Cave in Chihuahua, Mexico. Visit the official site: http://www.naica.com.mx/english/index.htm and National Geographic's article at http://news.nationalgeographic.com/news/2007/04/070406-giant-crystals.html. How did these crystals form? The Naica Mountains are rich in limestone and mineral deposits. Sulfur from the mineral deposits mixed with groundwater and dissolved the native limestone. Calcium from the dissolved limestone mixed with the sulfur and water to form the mineral gypsum (selenite.) Time, space and just the right solution yielded these crystal giants. Ask your students to explain how the Cave of Crystals is an example of a chemical reaction. What was needed in order for crystal formation to occur? Have your students identify the chemical formula for gypsum from the periodic table.

($CaSO4 \bullet 2H2O$)

California State Content Standards
- Grade 4 Earth Sciences 4a, b
- Grade 5 Physical Sciences 1a–d
- Grade 6 Resources 6a–c
- Grade 7 Earth and Life History 4a–d
- Grade 8 Structure of Matter 3a–d, f
- Grade 8 Periodic Table 7a, b

MINE OVER MATTER

San Diego is a gem of a county because it is a county rich in gems. Minerals such as tourmaline, garnet, quartz, beryl, topaz, and kunzite have been discovered and mined in this area. Pink tourmaline is the gem that made San Diego's mines famous. At the turn of the 20th century, the Empress Dowager of China started a tourmaline craze. As much as 120 tons of tourmaline were extracted from San Diego mines before 1911 when she died. Though the Chinese market collapsed, California gems are still valued and sought by many. Lepidolite, often associated with tourmaline, is another important San Diego mineral because it is a source of lithium. Today, lithium is used in batteries, but a hundred years ago it was used to grease the axles of locomotives. Mining depended on the railroad and the railroad depended upon mining axles.

How did San Diego become so rich in mineral resources? The mountains of this region were shaped by tectonic forces that created ideal conditions for many deposits to occur.

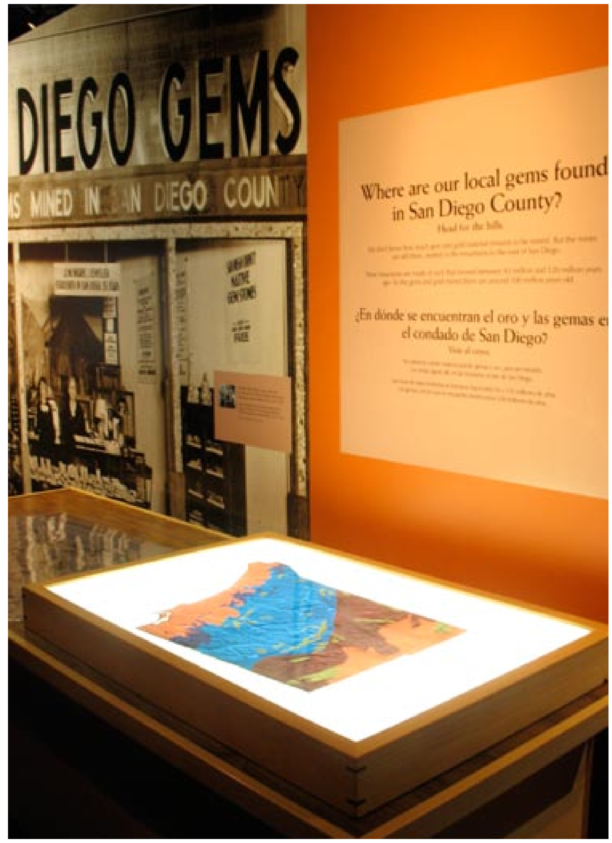
Time and space—the conditions and ingredients were perfect to cook up San Diego County's gem and mineral wealth. In fact, one native element made Julian famous in the 1870s—gold! The magma and water percolating millions of years ago was infused with gold, which crystallized into veins and pockets.

California State Content Standards
- Grade 4 Earth Sciences 4a, b
- Grade 4 Social Studies 4.4
- Grade 6 Plate Tectonics and Earth's Structure 1a, b, d–f
- Grade 7 Earth and Life History 4a–d
- Grade 9–12 Dynamic Earth Processes 3a–c
- Grade 9–12 California Geology 9a–c

Oil painting of the Chinese Empress Dowager Cixi (1835–1908) by Catherine Karl in late 1890s.


Gold crystal on quartz, photo by Tom Spann

Ask your students to visit the Museum's local geology research pages to investigate the formation of gem pockets: http://www.sdnhm.org/research/geology/geo_eastpluton.html. In the gallery you will see a large scale model of a fantasy gem pocket. At the Museum, study the block cross-section models diagramming how gold and gem deposits form. Ask your students to use the light-box map overlays to observe where gems and minerals have been found in relation to where our freeways and neighborhoods are now located, and in relation to the County's topographic features and the age of the rock deposits.



BLING!

Fabergé coral pigs

Beauty is in the eye of the beholder when it comes to answering the question, "What is a gem?" A gem may be an inorganic solid with a specific crystalline structure like tourmaline, or a mineraloid which does not have a specific crystal structure, like an opal. Some gems, such as pearls, jet and coral, have organic origins. How then do we define "gem"?

Jade Tiffany necklace, 1935

Beauty, durability, and stability are the defining qualities of gems. Rarity, demand, fad and fashion also contribute to a gem's value, but it is portability that makes them such a lasting commodity. Lots of wealth can be carted in a small package. This has made the difference for as long as people have been meeting and trading. The archeological record shows evidence of human bedazzling with pierced seashells reaching back 500,000 years.

Ask your students to navigate through the Metropolitan Museum of Art's Heilbrunn Timeline of Art. They can begin with the Egyptian amulets and follow a trail of gold and goodies to Louis Comfort Tiffany (http://www.metmuseum.org/toah/hd/egam/hd_egam.htm). While visiting the exhibition, your students will see examples of pre-Columbian gold circa 500 B.C.E. and a Tiffany necklace circa 1930.

Mother-of-pearl shell with pearls

The rarity of a gem is part of its allure, but the extreme durability of some gems creates a value beyond the aesthetic. Consider the sheen of nacre, mother-of-pearl; it is more than just a conceit of beauty for the invertebrate that once inhabited the shell. It is strong stuff. Scientists are working to reproduce a synthetic which will mimic the strength of nacre. This lustrous substance, which is essentially calcium carbonate, has amazing strength because of its nanostructure. Synthetic nacre could one day provide strong, light-weight panels for planes, cars and armor. How did the scientists get a good look at the molecular mystery of its strength? Using an atomic force microscope, they examined its polymer structure and probed the surface of the nacre with a minute diamond-tipped probe.

The diamond at the tip of that probe was synthetic. Laboratory-created gems are valued for their beauty but also have many industrial and scientific uses. A synthetic gem and its natural equivalent have identical chemical, physical and optical qualities. Synthetic gems should not be confused with imitation or simulant gems which may look like the real thing, but have different chemical and crystalline composition.

California State Content Standards
Grade 6 World History and Geography: Ancient Civilizations
Grade 7 World History and Geography: Medieval and Early Modern Times

Ask your students to discuss the idea of value. Is a diamond produced in a laboratory less or more valuable than one formed by geologic processes? Why? Ask them to consider the current and potential uses of manufactured diamonds in drills, probes, surgical tools, and high-tech optical and conductive devices. Do these applications change our response to a diamond's power as an object of beauty and rarity? Visit http://pubs.acs.org/cen/coverstory/8205/8205diamonds.html to find out more about the industrial uses of diamonds. There is a stunning display of laboratory gems in the gallery in addition to a set of Museum-grown crystals.

California State Content Standards
Grade 12 Principles of Economics
12.1.1, 12.2.2

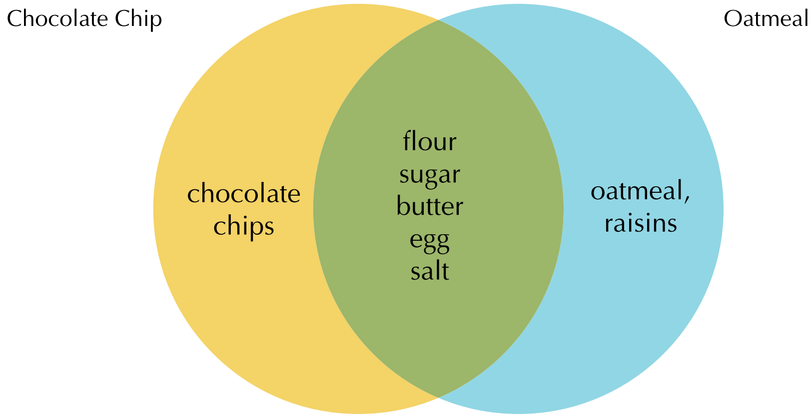
EARTH HAPPENS

The magnitude and mystery of Earth processes can be difficult to absorb. Rocks are the record of all this geophysical action and the properties of rocks reveal the processes that formed them. Rocks can be read like Earth stories and minerals are the alphabet in which these Earth stories are written. Help your students to understand the relationship between rocks and minerals with this Venn diagram activity.

GRANITE COOKIES

For each student you will need:

- Chocolate chip cookie
- Oatmeal cookie
- Pink granite
- Black and white granite
- Quartz
- Mica
- Pink feldspar
- White feldspar



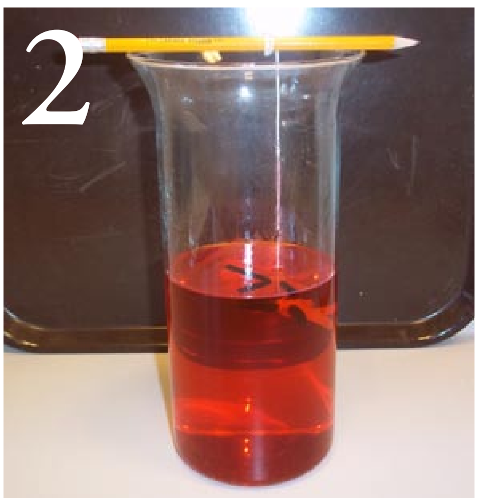
If you do not have access to granite and mineral specimens, images will suffice, but try to keep the cookies real. In this exercise cookies will be model rocks and their ingredients model minerals. Compare and contrast cookie ingredients using a Venn diagram. Now repeat the exercise with different colors of granite.

Find granite images at http://geology.about.com/od/more_igrocks/ig/granites/kingcitygranite.htm

Find mineral images at http://webmineral.com/specimens/index.php

Each piece of granite shows evidence of quartz and feldspar, but the difference in color may be due to distinct ingredients such as the cookies' chocolate chips and oatmeal. Minerals are the ingredients of rocks. The ingredients, such as the salt (NaCl) and the sugar ($C_{12}H_{22}O_{11}$) in the cookies, have different chemical compositions. Different Earth recipes result in different kinds of rocks, and different chemical formulas make up the more than 4,000 identified minerals.

EARTH HAPPENS



CAN'T WAIT FOR GEOLOGICAL TIME?
GROW CRYSTALS OVERNIGHT!

Here is an easy and fast way to grow mineral crystals overnight.

You will need:

- Pipe cleaners
- Scissors
- Heat-proof jar or measuring cup
- String
- Borax
- Boiling water

Create a snowflake shape by cutting a pipe cleaner in three sections and twisting them together at the center.

Suspend this snowflake with string from a pencil. The snowflake should fit inside your jar.

Pour the hot water into the jar, and then dissolve Borax in the water tablespoon by tablespoon. The ratio of Borax to water is three tablespoons per cup of water. You may tint the water or use different-colored pipe cleaners to vary your results.

Immerse your snowflake in the solution with the pencil resting across the jar mouth. Leave it overnight and BLING you have cooked up a mineral masterpiece.

Ask your students to use the periodic table to find out what elements make up Borax. (Na_2 B_4O_7) • 10 (H_2O) *There are just four: Sodium, Boron, Hydrogen, and Oxygen.*

Remind your students that crystals are the ***shapes*** minerals take when atoms join in a repeating pattern. Ask your students to identify the crystalline shape made from the Borax solution.

MINE OVER MATTER


Photo: SDNHM Research Library

California is the Golden State. Gold rushes have happened in other places, but California's gold rush was unique in scale. It was big! In the last half of the 19th century, California's population grew from about 100,000 to more than a million. Certainly, the eye-popping volume of gold being found was a motivation for many to head west. Between 1848 and 1859, miners recovered almost 88,340 kilograms (97 tons!) of gold in the state.

GOLDEN NUGGETS

Use a golden popcorn ratio to help your students visualize some gold rush statistics.

You will need:

- A bag of unpopped popcorn
- Dishes or cups to hold different amounts of kernels.

Let one kernel represent 1,000 people. The 1850 census showed that there were about 100,000 Californians. How many kernels do you need to represent California's population in 1850? How many more kernels would you need to represent a population of 1.2 million in 1900? (Hint: It is more than you have.)

The 88,340 kilograms of gold estimated to have been mined during the rush has a market value of more than $3 billion. Let each kernel represent $100 million. How many kernels more would you need to represent California's $32 billion agricultural product?

Now let each kernel represent 1/10 of an ounce of gold. In San Francisco during the rush the average value for gold was $20.67 an ounce. You need to buy a mule ($150), a pair of boots ($25), a mining cradle ($60), a blanket ($64), and pay your board for one week ($21). Remember each kernel is worth $1.60. How many kernels will pay your way? (Hint: This time you should have enough kernels!)

Sources for the data in the math problems:

http://www.learncalifornia.org/doc.asp?id=118

http://www.goldprice.org/

http://stuffaboutstates.com/agriculture/index.html

BLING

Eureka! I have found it! This sentiment has been on the California state seal since its creation in 1849 and was adopted as the official state motto in 1963. Legend goes that the Greek mathematician Archimedes exclaimed, "Eureka!" when he discovered a way to test the purity of a crown for King Hiero of Syracuse about 2,300 years ago. The king was troubled that the goldsmith had kept some of the gold provided for the crown's manufacture. Was the crown pure gold? Archimedes knew that when he lowered himself into the bath his body displaced some of the water. He decided to measure the displaced volume of water, and he discovered that the buoyant force acting on a submerged or floating object is equal to the weight of the displaced fluid. In other words, the weight of the water displaced by the amount of gold given to the goldsmith should be equal to weight of the water displaced by the crown. Too bad for that dishonest goldsmith!

ALL THAT GLITTERS IS NOT GOLD.

You can cook up some Eureka Candy and enjoy pretend gold during your study of California history.

You will need:

- 2 cups sugar
- 1 cup light corn syrup
- 1 cup water
- ½ teaspoon salt
- 1 tablespoon butter and a little more to grease the pans
- 1 teaspoon vanilla extract
- ½ teaspoon baking soda
- A candy thermometer

Pre-Columbian gold piece

DIRECTIONS:

1. Combine sugar, syrup, and water in a heavy light-colored skillet.
2. Cook, stirring constantly, until sugar is dissolved.
3. Add salt.
4. Cook, stirring occasionally to hard-crack stage (294º).
5. Add butter, vanilla extract, and baking soda. Stir to blend.
6. Pour onto two buttered cookie sheets.
7. While still warm, pull out to desired thickness.
8. When cold, crack and enjoy your Eureka Candy.

What object in the exhibition would you choose to give as a gift? Who would be the recipient of your gift and why?

Why do you think artists have chosen animals so many times to replicate in gems?

How does seeing these stunning results of Earth processes change your mind about geology?

RESOURCES:

Pellant, Chris. *Rocks and Minerals*. New York: Dorling Kindersley, 1992.

Pettit, Susan. “Cave of Crystal Giants.” www.nationalgeographic.com National Geographic. Web. August 2010.

“Minerals, Crystals, and Gems: Stepping Stones to Inquiry.” www.smithsonianeducation.org Smithsonian Center for Education and Museum Studies. Web. August 2010.

Pough, Frederick, H. *A Field Guide to Rocks and Minerals (Peterson Field Guides)*. Boston: Houghton Mifflin Company, 1988.