A Mine Is a Terrible Thing to Waste

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Overview

Topic: Geology, Minerals, Mineral Identification, Non-renewable resources, Mining, Environment, Scientific reasoning, Problem-based learning. This lesson uses video to focus student attention on the ways minerals are mined. Using mining as a starting point, the lesson uses problem-based learning to teach students mineral identification. Students explore issues related to mining including mineral value, operating cost and environmental concerns. In each activity, students explore, are engaged, and extend their knowledge (learning cycle). The teacher acts as a guide but may be called upon to be the expert in mineral identification or other aspects of the problem.

Time Allotment

Seven 45-minute periods

Media Components

Environmental Weekly #11, "Minerals"
TV/VCR
World Wide Web access/Computer lab
Websites as listed or as found using search criteria (see end of lesson for list)

Learning Objectives

The student will be able to:
- research information about mining using video and Web resources
- find the commodity value of minerals using the Web
- apply scientific knowledge to role play in making decisions relative to the lesson topic
- use physical properties to identify minerals, social trade-offs, and environmental costs

(This lesson addresses Va. SOL Science ES.1, ES.2, ES.3, ES.5, ES.7)

In addition, this lesson addresses the National Science Education Standards: Science in Personal and Social Perspectives: Content Standard F: Natural Resources; Science & Technology: Content Standard E: Understanding about science and technology; and the Benchmarks for Science Literacy: 3A The Nature of Technology: Technology and Science; 7E Human Society: Social Trade-offs; 8B The Designed World: Materials and Manufacturing.

Materials

- Chart paper and markers or chalk and chalk board
- A state road map (highlight the area where each mine is located as noted in part 6 below)

Per Group:
- Known Minerals Sets for practice: muscovite, biotite, fluorite, calcite, gypsum, quartz, hornblende, feldspar, pyrite, hematite, magnetite, and galena
- Mineral Assay Sets: Set One (Site 1): quartz, hornblende, muscovite, biotite and feldspar; Set Two (Site 2): calcite, halite, gypsum, fluorite and quartz; Set Three (Site 3): quartz, pyrite, hematite, galena, and muscovite.

Note: The sets were put together to provide students with an opportunity to learn to recognize important rock forming minerals. The minerals in each set may not overlap one another.

- Mineral Field Hardness Set: glass, iron nail, and penny
- Lab Set: streak plate, specific gravity scale or balance and graduated cylinder (density), 0.7 M Hydrochloric acid, mineral identification chart or mineral identification book.

Per Class: (optional equipment)

- Optional: Long wave UV light, Short wave UV light, 10x/30x stereomicroscope or 10x hand lenses

Per Student:

- Mineral Site Assay Sheet (attached)
- Mineral Properties Sheet (attached)
- Mineral Identification Chart (mineral ID charts are often included in earth science text books)
- (Optional) Scaffolding Chart (attached)

Teacher Preparations

- Reserve computer lab and/or media center to provide individual computer use.
- Review and verify sites. The teacher should become familiar with the information offered at each site and supplement as necessary.
- If possible prepare a file of useful web addresses and place the file on a central location or on each computer's desktop. Alternately, use www.porta-portal.com and establish a website for the class at that site. Use the "Preferences" to allow Guest Access Rights.
- Review search engines and searching techniques as necessary.
- Duplicate student handout materials.
- Have lab materials ready and minerals sorted as indicated in the materials list.
- Ready the VCR and TV. Cue the ***Environmental Weekly #11*** tape to 17:09 (visual cue: Modern Mining Open Pit Mine.)
- Science Lab Safety: Display MSDS for hydrochloric acid and remind students of safe lab practices including eye protection.

Key Terms List

- The students should be familiar with or be made familiar with: Mining, mineral, rock, natural resource, nonrenewable resource, renewable resource, open pit mine, strip mine, surface mine, deep-shaft mine, underground mine and wells for use in discussions.
- Other terms include: assay, shaft, adit, terrace, bench, commodity, waste rock, and tailings (tailing pond).
- Earth Science terms that will be introduced in the lesson are: luster, Mohs' hardness, streak, crystal system, fracture, cleavage, specific gravity, and color.

Time Cues

To synchronize your VCR with the time cues that are included with this lesson, zero/reset your time counter at the very beginning of the program, before the introduction and titles. Time cues are expressed as "minutes:seconds;" for example, 3:15 means three minutes and fifteen seconds.

Introductory Activity

(45 minutes)

1. Explore: Ask the students what a mine is? Record some of the responses on the board or chart paper. **FOCUS:** Watch the video and look for several ways in which minerals are mined. **PLAY** the video beginning at 17:09. **STOP** at 18:50. (Video cue: ***Modern Mining*** title). **FOLLOW-UP:** Name and describe several mining methods. **REWIND and REPLAY** as necessary. Compare their pre-viewing responses with the post-viewing list. Ask the students to think about (reflect on) what they know now compared to what they knew before viewing the video. Ask students what minerals are mined?

Note: Reflection can be done by giving the students a few moments to think or by writing in their journals. Discussion may also provide a good way to reflect.

2. Explore: Ask students what happens to a mine once the minerals have been removed? Record

responses on the board or chart paper. **FOCUS:** Look for ways in which a mine area is reclaimed. **PLAY** the video starting at 22:49 (Video cue: "Reclamation" title). **STOP** at 24:25 (Video cue: Deer leaping through field)**.** Ask, What do you think of mining reclamation? **FOLLOW-UP:** Ask, What concerns would you have if a mine was to be opened near you? Record responses on the board or chart paper. Have students reflect on their concerns.

Learning Activities

Note: There are three steps to focusing the students for their problem-solving activities.

1. FOCUS: Establishing the problem.

Say: You work for a mining company investigating three sites around the state. You have gone to the three sites and collected samples of the minerals present for assay in the lab. Site 1 is near major highways and railroad services. Site 2 is near major highways and a port, but has no rail service near. Site 3 is very remote with only secondary roads and no rail service near.

Problem: Each member of a group will assume the role of the Mining Geologist, the Mining Engineer, or a Mining Environmentalist. Groups with more than three students will have the extra student assigned to be the assistant to one of the others. What advice would you give the mining company about which mine to open based on profit (Geologist), on mining technique and transportation (Engineer) or on impact to the community and nature (Environmentalist)? Only one mine may be opened.

2. FOCUS: Determining what we know.

Have the students use the scaffolding chart (attached). Ask them to identify and list the facts and learning issues, and to write a preliminary action plan. Give samples to help them get started. These can be revisited throughout the exercise to make revisions.

3. FOCUS: Exploring.

Say: There are over 2000 known minerals. Of those only about 20 are common to most rocks and ores. In your [known] set of minerals, you have 12 common rock forming and ore minerals. Look at the minerals and try to group them by some property that you can observe. Allow about 10 minutes, then **Pause the Activity. FOLLOW-UP:** Say: Trade mineral sets with another group. Can you fit their minerals into your categories? Ask: What should we do to identify minerals?

The teacher may direct the students to books or sections of text books that teach mineral identification, web sites for mineral identification, or the teacher may offer to help the student learn to identify minerals (direct instruction).

4. FOLLOW-UP: Direct Instruction (Explanation)

At this point, students may see the need for expert advice on the identification of minerals. The teacher may use direct instruction and student practice to teach the students how to perform the physical and chemical properties tests used to identify minerals from a chart or book.

Sample: (Each part takes approx. 45 minutes)

A. Explain the property of luster and have the student sort the known minerals into groups using the property of luster. Check the results. Have the students trade mineral sets with other groups and sort by the type of luster again. Tell the students about streak and demonstrate the method. Have the students test the streak of the metallic minerals. Have the students test the streak of the nonmetallic minerals. Ask: How do they compare?

B. Have the student sort the known minerals by type of luster. Check the results. Teach the Mohs hardness scale and the use of the field test scale. Demonstrate the process. Have the students group the minerals by harder than glass (>5.5), harder than iron nail but less than glass (4.5-5.5), harder than penny but less than iron nail (3.5-4.5), harder than fingernail but softer than penny (2.5-3.5), and softer than fingernail (1-2).

C. Have the students sort the known mineral by the type of luster. Remind students of methods for finding density or teach how to measure specific gravity. Practice as needed. Have the students try to identify the metallic minerals. Check the results. Instruct the students about cleavage and fracture and demonstrate. Have the students try to identify the nonmetallic minerals. Check the results.

D. Use other physical and chemical properties tests including the acid test for carbonates. Demonstrate as needed.

5. Start the Activity: Mineral Assay. (Extend)

Say: You are going to use the physical and chemical properties of minerals to identify the mineral samples found at each site. Identify all the minerals for each of the three sites. (Allow 45 minutes for the groups to identify the minerals in each set.)

Stop. FOLLOW-UP: (Evaluation) Check for correctness of the identifications before proceeding.

6. Start the Activity: Internet Research.

Note: If the students are unable to find current commodity values for each mineral the students could look up the cost of the samples in a science supply catalog or use the Technology Failure Plan in this document. Assumptions needed to solve the problem: Each mine will produce 20,000 tons of each mineral. Metallic ores contain 25% usable metal.

The "mine geologist" should research the value of the minerals in each set from activity 5.

The "mine engineer" should research extraction methods for each mine as well as transportation costs. Assumptions: Transportation cost is $.05/ton/mile by truck or $.02/ton/mile by rail. Teachers in other states should choose locations within their state that are representative of the initial conditions. In Virginia, site 1 is located in Mineral County; site 2 is located near Saltville; and site 3 is in northern Rockingham County. For values see the Technology Failure Plan in this document. If the students are unable to find the mining cost, assume: $.0025/ton for open pit mines and $.003/ton for underground mines.

The "environmentalist" should research mine reclamation costs or other environmental issues such as water pollution by sedimentation, water pollution by acid drainage, water pollution by toxins or heavy metals, erosion, threat to endangered species and other wildlife through the destruction of habitats.

Stop the Activity.

Note: This may be a cross-curricular theme to be researched in conjunction with an ecology/environmental science class. Assumptions: The sets containing evaporates (halite) may be strip mined, with the metallic ore (galena) may be mined by open pit with the last set by underground mine.

Culminating Activities

1. FOLLOW-UP: Presentation of findings: Each group should present their findings to the class, representing the Mining Company Board of Directors, for approval.

2. Extension of the culminating activity: Hold a community forum with each group presenting their findings to the class which is split to represent the Mining Company Board who are for the mine and the Concerned Community Citizens Group against mining operations.

Assessment

Students' mineral assay sheets will be evaluated for correctness and completion as desired by the teacher. A panel discussion or a written report identifying the reasons to open one mine over another will be evaluated for correct use of facts, scientific inquiry, scientific communication and critical thinking.

Community Connections

1. Have the students visit a quarry.

2. Have the students visit a museum of natural history.

3. Have a water treatment plant supervisor as a guest speaker or visit a local water treatment plant and find out about minerals used in the purification process.

4. Have the students visit a manufacturing plant.

5. Have the students visit a recycling arena.

6. Have the students attend a public hearing where mining or pollution concerns are discussed.

Cross-Curricular Extensions

Ecology/Writing: Research and write about "Superfund Clean-up Sites."

Earth Science/Ecology: Report about reclamation efforts at a local quarry as a multimedia presentation or poster.

Career Search: Report about a career in mining, in quarrying, as a jeweler, as a manufacturer or other related topic. Include the dependence on earth science knowledge in securing a job, the amount and type of education required, starting salary, work conditions and availability of positions. Further extension could be to compare and contrast two careers in the earth science relating to the use of nonrenewable resources.

History/Social Studies:
- Students could extend their research and investigate how natural resources have influenced the establishment and spread of humans or human conflicts.
- Research and present the findings about mining historically carried on within 30 miles of the school.

Geography/Cartography/Geographic Information Systems: Students could create a resource map of the world/USA showing the location of the minerals identified. A legend and a title should be on the map.

Adaptations for students with special needs:
- Partner students with special needs with other students for the Internet research. Allow other students to read research findings to students with special needs.
- The teacher could make printouts of web pages containing the needed information and highlight the information for students with some special needs.
- The teacher may want to lead the class, a group, or an individual with needs in doing the assay, research, or help go through the problem steps.

References:

- National Research Council (NCR). 1996. National Science Education Standards. Washington, D.C.: National Academy Press.
- American Association for the Advancement of Science (AAAS). 1989. Science for All Americans: Project 2061. Washington, D.C.: AAAS. Benchmarks for Science Literacy. 8/23/2002 online www.project2061.org/tools/benchol/bolframe.htm
- Goodnough, K and Cashion, M. (2003, December). Fostering Inquiry through Problem-Based Learning. The Science Teacher. 70(9), 21-25

Optional Resources:

Caterpillar. Common Ground: Modern Mining and You, Teaching Aids. 1997 Caterpillar (Video). Printed materials available online at www.caterpillar.com/industry_solutions/mining/support_solutions/02_communications/communications.html

Websites:

Mineral Identification

http://rockhoundingar.com/pebblepups/basics.html
www.rockhounds.com/rockshop/mineral_id/
http://sciencespot.net/trimpe/MightyMinerals_IDGuide.pdf

Mine Geologist - Mineral Values

http://minerals.er.usgs.gov/minerals/pubs/of01-006/
http://minerals.usgs.gov/
http://minerals.usgs.gov/minerals/pubs/mcs/
www.mii.org/commonminerals.html
Search Criteria: minerals, mineral values, mineral commodities

Mine Engineer
www.mine-engineer.com/
www.miningwatch.org/emcbc/primer/
Search Criteria: mine engineering, mining costs, mine operation

Mine Environmentalist
www.osmre.gov/osm.htm
www.mii.org/recl.php
www.osmre.gov/acsihome.htm
www.epa.gov/epaoswer/other/mining.htm
www.miningwatch.org/emcbc/primer/
www.b-ville.net/nomine/
www.mininglife.com/environment/index.htm
www.consrv.ca.gov/OMR/

Endangered Species maps
www.nwi.org/Maps/ESAmap.html or
http://endangered.fws.gov/
Search Criteria: mine reclamation, mine dump, mining, mining pollution, mine waste, mining environment

Other Links
www.virginiarockhounder.com/earthscience.html
Learning cycle:
www.coe.ilstu.edu/scienceed/lorsbach/257lrcy.htm
5E leaning: http://education.gsfc.nasa.gov/edsummit/5e.html
National Science Teachers www.nsta.org

Environmental Concerns Regarding Mines
- Strip mines can produce erosion problems when large areas of soil become exposed
- Weathering of surface rock from open pit and strip mines can cause pollutants to run off into the water supply
- Depending on ore composition, mercury, arsenic, cadmium, or uranium from tailings may contaminate groundwater or the soil

- Abandoned underground mines sometimes collapse because of rotted support timbers or enlargement of the underground area by groundwater
- Open pit mines leave a large hole in the landscape, irreparably changing it
- Strip mines remove all vegetation, destroying existing habitat
- Destruction of habitat by mining can threaten endangered species
- Noise disrupts communities and may affect wild life
- Increased traffic by heavy vehicles causes pollution, dust, and vibration damage to roads, communities and may affect wild life
- Water quality may be affected by mining operations

Positive Aspects of Mines
- Provides minerals important for human use
- Source of employment/jobs
- Mines can work with agriculture (strip mine) to alternate sections of land to be mined in order to gain minerals while reducing erosion/runoff problems
- Mines can be reclaimed (strip mine) into a variety of agricultural uses such as fields for crops or grazing lands for livestock, sometimes aquatic habitats are possible as well
- Mines (open pit) can be reclaimed into recreational lakes for public use
- Mining operations can create ponds to contain and filter mine waste so that nearby waterways do not become contaminated
- Mining operations can use substances (such as powdered limestone) to neutralize
- Hazardous chemical from processing of ores
- Room and Post construction in some underground mines can be used in order to avoid collapse
- Mining sites can be chosen carefully in order to protect endangered species

About the Author

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B. H. Snellings has taught Earth Science at Page County High School in Shenandoah, Virginia since 1976. B.H. also taught information sciences/data processing as an adjunct instructor for Blue Ridge Community College and for the Page County Technical Center. He received his bachelors in education mathematics from Virginia Tech and is currently finishing his masters in education technology from JMU (‘04). B.H. is the Page County High School webmaster and was a member of the core development team for the “Exploring Earth Science in

Shenandoah National Park" integrated curriculum. B.H. has presented technology sessions for NTTI, VAST, NAGT and VSTE.

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Technology Failure Plan:

In the case of video failure the teacher should proceed with the exploration questions, but will have to provide direct instruction about mines, mining impact, and mine reclamation.

Single computer classroom (with internet): If the Internet is not accessible to all students equally, then the teacher may call all of the "geologists, the "engineers," and the "environmentalists" to rotate in groups on the single classroom computer or may display the information for the class to collect using any multimedia display that is available.

In the case of the Internet failure the teacher may want to provide the students with information from the following:

Sample Mineral Value Assay:

Mineral	Use	Process	Value/ton (2003)
Quartz	Glass, sand	Ground	$4.15
Hornblende	none	none	none
Muscovite	Electronics, sealant, lubricant	Ground	$120.00
Biotite	Electronics, vermiculite	Sheet, exfoliated	$30.00
Feldspar	Glass making, ceramics, abrasives	Ground	$55.00
Calcite	Cement	Ground	$70.00
Halite	Rock salt	Crushed	$20.00
Gypsum	Smelting, Glass making, Wallboard	Ground	$6.90
Fluorite (Fluorspar)	Glass, hydrofluoric Acid for etching	Fluoride removed	$20.00
Pyrite	Sulfuric acid	Sulfur removed	$25.00
Hematite	Iron ore	Crushed, smelted	$25.00
Galena	Lead ore	Crushed, smelted	$88.00

Transportation costs are calculated as follows:
Quartz – none, end user must transport at his expense
Hornblende – no value, must be disposed of at a cost of $10/ton
Biotite – none, end user must transport at his expense
Feldspar – none, end user must transport at his expense
Calcite – within 40 miles of the plant at a cost of $40.00/ton as cement
Halite – shipped to nearest port
Gypsum – shipped to Charlotte, NC
Fluorite – Shipped to Columbus, Ohio
Pyrite – none, end user must transport at his expense
Hematite and Galena – shipped to Birmingham, Alabama

MINERAL PROPERTIES

MINERAL PROPERTIES

Luster–The way the surface of a mineral reflects light.

- **Metallic**–reflects light like a metal
- **Nonmetallic**
  - dull or earthy
  - greasy or oily
  - pearly
  - silky
  - resinous
  - glassy or viterous
  - brilliant or adamantine

Breakage

Cleavage-split along smooth flat plains:

Perfect, Good, Fair in...

- 1 direction–basal
- 2 directions
- 3 directions

Fracture-breakage of a mineral

- **rough**-uneven or irregular
- **conchoidal**–shell-like
- **hackly**–jagged surfaces
- **earthy**–clay-like

Heft	SG	Sample
Light	2-3	quartz
Medium	3-5	barite
Heavy	5-10	galena

Hardness–resistance to being scratched

Mohs' #	Mohs' Mineral	Field Test
1	talc	soft, greasy, flakes on fingers
2	gypsum	scratched by fingernail
3	calcite	scratched by penny
4	fluorite	scratches penny, will not scratch iron nail
5	apatite	scratched by iron nail with difficulty
6	feldspar	scratches glass with difficulty
7	quartz	scratches glass easily
8	Topaz	Scratches quartz
9	Corundum	
10	Diamond	

Form–The general shape of the mineral

Crystal system

- **cubic**–blocky or ball-like
- **tetragonal**–needle-like or pyramids
- **hexagonal**–six sided prisms
- **orthorhombic**–diamond-shaped
- **monoclinic**–stubby tilted faces
- **triclinic**–flattened with sharp edges

Habitat

- **acicular**–needlelike
- **bladed**–knife blade-like
- **dendritic**–tree-like
- **equant**–block or cube
- **prismatic**–long in one direction
- **tabular**–flat plates

Aggregates of crystals

- **Massive**–lacking structure
- **Fibrous**–threadlike
- **Botryoidal**–globular
- **Druse**–projecting crystals
- **Micaceous**–thin flat sheets
- **Pisolitic**–small spheres

Mineral Assay Sheet

Name: _____

Class:

Site	Luster	Hardness	Streak	Color	Heft/SG	Form	Breakage	Other	Name	Value
1										
1										
1										
1										
1										
2										
2										
2										
2										
2										
3										
3										
3										
3										
3										

SCAFFOLDING CHART

Facts	Learning Issues	Action Plan
List the facts given in the problem	What do we need to know more about?	How will we learn what we need to know? How will we answer the question?