Sustainability – How Geosciences and Mining Contribute

This activity was prepared by Argenta M. Price, Jonathan G. Price, Elisabeth M. Price, Samantha Faga, and Matthew Miller, updated 3 November 2023 with applicable to Next Generation Science Standards, for use in the Teachers Workshops of the Nevada Mining Association's Education Committee. It is available online at https://www.nevadamining.org/education/classroom-activities/ .

BACKGROUND

Sustainable development, defined by the United Nations (UN) in 1987, is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The UN member nations adopted 17 sustainable development goals in 2015, with a target date for completion by 2030 (Table 1, Figure 1). This classroom activity highlights how the geosciences (geology, geophysics, geochemistry, geography, hydrology, etc.) and the mineral-resource industries contribute to these goals. With guidance from the teacher, students will represent one or more of the goals and enter into discussion about a hypothetical, proposed new mine. Students will inquire how the mining company will address the UN goals as it collaborates with stakeholders (anyone with concerns about the mine, including company employees, contractors, and shareholders; people in the local and regional communities; tribal governments; regulators from local, state, and federal agencies; non-governmental organizations that may oppose development of the mineral resource; and people who use the resources).

Throughout the world, the mining industry has been addressing environmental, social, and governance (ESG) issues that need to be addressed before a new mine can be developed. It commonly takes up to 20 years from the time of discovering a mineral deposit to obtaining all the environmental permits needed to develop it as a mine. Then, after mining has ended, the company must leave the property in a useful condition or restore it to pre-mining conditions. This involves engagement with stakeholders to not only secure the permits but also to obtain the "social license to operate." In this workshop, representatives from the mining industry will be available to discuss how their companies address ESG and sustainable development goals.

Many geoscience organizations and mining companies are addressing diversity, equity, inclusion, and justice (DEIJ) issues that have led to underrepresentation in the sciences, engineering, and industry. These issues are also linked to many of the sustainable develop goals.

The Earth Science Week packet with the theme of *Earth Science for a Sustainable World* (Figure 2) will be used in this activity. Teachers may find the listed references helpful in explaining how the geosciences contribute to sustainability.

SUGGESTED APPOACH FOR THE TEACHER

The following steps are meant to be completed in one classroom session (50 to 60 minutes).

Step 1 (7 minutes). Provide the students with some background about sustainability and its connections to geosciences and mining. Introduce the students to sustainability by giving them **Figure 1** and **Table 1** (concerning the UN sustainable development goals) and the **Worksheet** (**Pages 5 and 6**, with lists about the mining process and possible stakeholders). Use the **poster**

that is in the 2022 **Earth Science Week** toolkit produced by the American Geosciences Institute (also Figure 2). Another useful poster links projects that are part of the *Geoscientists without Borders* program with the UN sustainable development goals, available at https://www.earthsciweek.org/sites/default/files/webform/online-kit/GWB_poster_072821b.pdf . Ask the students: "What are some ways that geosciences and mining contribute to the sustainable development goals?"

Step 2 (3 minutes). Have the students work together in small groups (ideally groups of four). Ask each group to use the **Nevada highway map** and **Figure 3** to help select one of the following hypothetical, proposed mines and begin thinking about who may be concerned:

A. A new lithium mine near ranching land and traditional land of the Northern Paiute,
B. A new gold mine near the Humboldt River, or
C. A new crushed-rock quarry near an urban area.

Step 3 (7 minutes). Have the students in each group identify the stakeholders in the proposed mine (Who cares? Who is potentially impacted?). The Nevada highway map may help stimulate students to think about issues that require permits from the federal, state, and local governments and the overall social license to operate that would be granted by local and broader communities. Allow time for the students to identify all the stakeholders who may care about the mine.

Step 4 (18 minutes). Have the students in each group select two or more of the 17 sustainable development goals that they think may be important in making pro and con arguments about whether the mineral deposit should be mined. Then have a couple students focus on the pros (positive aspects of developing the mine in terms of the selected United Nations sustainable development goal) and a couple students focus on the cons (negative aspects, also in terms of the same sustainable development goal). At the end of the activity, students will be asked to summarize the main points that they discussed, with one student summarizing the pros and another student summarizing the cons. If time allows, have the students select another sustainable development goal for discussion of pros and cons.

The teacher circulates around the room, listening in on group discussions and providing guidance (to individual groups, or pausing the small-group discussion to provide guidance to the whole class as needed, if multiple groups are having the same issue). Use Table 2 as needed to help stimulate discussion. During the Teachers Workshop organized by the Nevada Mining Association, you have the advantage of asking industry representatives how their companies contribute to sustainable development goals. In your classroom, you can have students research the topics of mining and sustainability on the internet.

Step 5 (15 minutes). Have the two students from each group summarize their pro and con discussions with the entire class. [If time permits, this can be done by having students use post-it notes to write their pros (on one color) and cons (on another color) regarding their chosen sustainable development goals; post them on the walls of the classroom; then have the class examine all the notes.] Allow for additional discussion among the students. The teacher can raise additional points using Table 2 and can raise additional questions, such as

- What additional information would you need to form an opinion on whether the mine should be opened?
- Under what conditions should the mine not be allowed?
- Under what constraints should the mine be developed?

You can also ask the students to vote: Should the mine be permitted to open? If not, why? If not sure, what more information do you need?

IF MORE TIME IS AVAILABLE

The activity can be expanded by having students do homework to research issues that need to be addressed before a mine can go into production. Frame the task around making decisions about whether (or under what constraints) a proposed mine should be developed. Below are some ideas for items that the student groups can consider and products they can deliver to the full class.

Decide on goals for the problem and criteria the solution needs to fit. Describe what this mine might achieve if it is built. [What will it produce? How much? Why do we want that product? What will impacts be to the local people and environment? What are acceptable costs & acceptable negative impacts?]

Decide what factors are relevant. List stakeholders and create a brief summary of the impact the proposed mine would have on them.

Prioritize which factors and sub-problems to focus on for further investigation . Rank the UN sustainable development goals that are most likely to be impacted by this project (for purpose of choosing one or a few to investigate in more detail).

For example, the students may choose **clean water** as the top sustainable development goal. Research into the topic (next 2 decisions listed below) may reveal that the mining process may expose hazardous elements that can be dissolved in water (such as arsenic, which is commonly in rocks associated with gold and silver deposits), or that the mining process may use hazardous chemicals in ore processing (such as sodium cyanide, NaCN, used to extract gold and silver). Further research may show that permits from the State or Bureau of Land Management require that potentially hazardous chemicals (such as arsenic and cyanide) be removed or lowered to safe levels before waters from the mine site can be released into streams or groundwater. Arsenic can be removed through adsorption on iron-oxyhydroxide solids, and cyanide can be destroyed by oxidation.

Mines and their processing mills need water to operate, and this water commonly comes from groundwater. Groundwater also needs to be pumped out of the mine workings (whether it is an open pit or underground mine) while the mine is active. After mining ceases, groundwater at the mine site is gradually restored. If local water users are impacted by groundwater pumping (e.g., nearby springs used by wildlife or farmer's, domestic, or municipal wells), the mining company is obligated to mitigate the loss (e.g., by restoring riparian habitat in other areas or drilling new wells for nearby users). In some instances, the pumping at the mine or the post-mining plan provides water resources that were not previously available to local populations (Figure 4).

Decide what information is needed and how to obtain that information. Make a list of information about the stakeholders, mining company & practices, regulatory process, etc. that you would like to know in order to evaluate how the proposed mine would affect your selected UN goal. Research the needed information. Much of this information can be found on the internet.

Decide what are appropriate conclusions based on the information; maybe decide how reliable/believable the information is. Review new information and write down a list of what you learned from that information. Is any information conflicting? What sources of information or quality of data can be used to evaluate believability?

Decide what is best solution. What impact will this proposed mine have on the UN goal you chose? Based on what you've learned, do you think the mine should be developed (or under what circumstances or constraints should it be), or do you need more information? (About what factors would you want more information?)

Decide how to present findings, reflect/justify. Share with the class what your group learned/decided and your justification (including factors considered and information used) for that decision.

NOW FOR SOMETHING COMPLETELY DIFFERENT

Other activities that link mining to the sustainable development goals are offered in Figure 4, 5 and 6.

REFERENCES

American Geosciences Institute, 2022, Earth Science for a Sustainable World: Earth Science Activity Calendar, https://www.earthsciweek.org/sites/default/files/Calendar/ESWcalendar22-23_ADA_220919b.pdf .

American Geosciences Institute, 2021, Water Today and for the Future: Earth Science Activity Calendar, https://www.earthsciweek.org/sites/default/files/webform/online-kit/ESWcalendar21-22ADA_082421lock.pdf .

Capello, Maria A., Shaughnessy, Anna, and Caslin, Emer, 2021, The geophysical sustainability atlas: Mapping geophysics to the UN sustainable development goals: The Leading Edge (journal of the Society of Exploration Geophysicists), p. 10-24, https://doi.org/10.1190/tle40010010.1.

Gill, Joel C. 2017, Geology and the sustainable development goals: Episodes, v. 40, no. 1, p. 70-76, DOI: 10.18814/epiiugs/2017/v40i1/017010 .

United Nations World Commission on Environment and Development, 1987, Our Common Future (Brundtland Report), Oxford University Press, 383 p.

A poster about *Geoscientists without Borders*® projects that relate to different sustainable development goals:
https://www.earthsciweek.org/sites/default/files/webform/online-kit/GWB_poster_072821b.pdf

WORKSHEET for the SUSTAINABILITY ACTIVITY

Questions to answer within your group

A mine is proposed to open in a specific area of Nevada. (1) How might the mine (including the products that it produces) support the UN goals for sustainable development? (2) How might the mine hinder these goals?

Step 1. For background, please examine the 17 sustainable development goals (**Figure 1** & **Table 1**) and some ways geosciences and mining contribute to these goals (**Table 2**). Your teacher will summarize the general mining process:

- starting with exploration and initial community engagement
- collecting environmental baselines (water & air quality, plants, animals)
- assessing environmental, health, safety, economic, and social concerns through governmental permitting to be allowed to operate the mine
- extraction of ore and currently uneconomical rock that covers or is mixed with ore
- ore processing (such as milling to get the valuable element or mineral out of the rock)
- disposal of waste and stockpiling of rock that is subeconomic
- refining
- sales and additional manufacturing to create products
- ending with reclamation and long-term monitoring.

Step 2. Use the **Nevada highway map**, the map of active mines in Nevada, and the map of traditional lands of Indigenous people (**Figure 3**) to help you select one of the following hypothetical, proposed mines for further discussion about sustainability:

A. A new **lithium mine** near ranching land and traditional land of the Northern Paiute. [Lithium is used in light-weight batteries, particularly for electric vehicles and electronics.]
B. A new **gold mine** near the Humboldt River. [Nevada is the leading state for gold production. Gold is used primarily as money, but is also used in cell phones and energy-efficient windows.]
C. A new **crushed-rock quarry** near an urban area. [Crushed rock is used in construction of highways and buildings.]

Step 3. Think about the possible impacts of the mine on the economy (jobs at the mine & in the community; taxes for government & schools), people (health & safety), and environment (water, air, & ecosystems) that might be affected. Identify the stakeholders in the proposed mine (Who cares? Who is potentially impacted?). This might include:

- people in the local and regional communities
- tribal governments
- regulators from local, state, and federal agencies
- mining company employees, contractors, and shareholders
- non-governmental organizations that may oppose development of the mineral resource
- others (for example, people who use the resource)?

Make sure within your group that you identified all the stakeholders who care about the mine and its potential impacts and benefits.

Step 4. Select two or more of the 17 sustainable development goals that you think may be important in making pro (support) and con (hinder) arguments about the impact the mine may have on achieving these goals. Two students in your group focus on the pros (positive aspects of developing the mine in terms of the selected UN goal) and two students focus on the cons (negative aspects, also in terms of the same goal). Use Table 2 to help stimulate discussion. Discuss among your group what you will present to the rest of the class during Step 5 (at the end of the activity). One of you will summarize the pros; the other will summarize the cons. If time allows, select another sustainable development goal for discussion of pros and cons.

Step 5. Two students from each group summarize your discussions with the entire class. Explain how you answered the questions, for each of the sustainable development goals that you selected.

Sustainable development goal:

(1) How might the mine (including the products that it produces) support the UN goal for sustainable development?

(2) How might the mine hinder this goal?

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MODIFIED (for shorter time) WORKSHEET for the SUSTAINABILITY ACTIVITY

Questions to answer within your group

A mine is proposed to open in a specific area of Nevada. (1) How might the mine (including the products that it produces) support the UN goals for sustainable development? (2) How might the mine hinder these goals?

Step 1. For background, please examine the 17 sustainable development goals (**Figure 1** & **Table 1**) and some ways geosciences and mining contribute to these goals (**Table 2**). Your teacher will summarize the general mining process:

- starting with exploration and initial community engagement
- collecting environmental baselines (water & air quality, plants, animals)
- assessing environmental, health, safety, economic, and social concerns through governmental permitting to be allowed to operate the mine
- extraction of ore and currently uneconomical rock that covers or is mixed with ore
- ore processing (such as milling to get the valuable element or mineral out of the rock)
- disposal of waste and stockpiling of rock that is subeconomic
- refining
- sales and additional manufacturing to create products
- ending with reclamation and long-term monitoring.

Step 2. Use the **Nevada highway map**, the map of active mines in Nevada, and the map of traditional lands of Indigenous people (**Figure 3**) to help you select one of the following hypothetical, proposed mines for further discussion about sustainability:

A. A new **lithium mine** near ranching land and traditional land of the Northern Paiute. [Lithium is used in light-weight batteries, particularly for electric vehicles and electronics.]
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C. A new **crushed-rock quarry** near an urban area. [Crushed rock is used in construction of highways and buildings.]

Step 3. Think about the possible impacts of the mine on the economy (jobs at the mine & in the community; taxes for government & schools), people (health & safety), and environment (water, air, & ecosystems) that might be affected. Identify the stakeholders in the proposed mine (Who cares? Who is potentially impacted?). This might include:

- people in the local and regional communities
- tribal governments
- regulators from local, state, and federal agencies
- mining company employees, contractors, and shareholders
- non-governmental organizations that may oppose development of the mineral resource
- others (for example, people who use the resource)?

Make sure within your group that you identified all the stakeholders who care about the mine and its potential impacts and benefits.

Step 4. Select one of the 17 sustainable development goals that you think may be important in making pro (support) and con (hinder) arguments about the impact the mine may have on achieving these goals. Half of the students in your group focus on the pros (positive aspects of developing the mine in terms of the selected UN goal), and half of the students focus on the cons (negative aspects, also in terms of the same UN goal). Use Table 2 to help stimulate discussion. Discuss among your group what you will present to the rest of the class during Step 5 (at the end of the activity). One of you will summarize the pros; the other will summarize the cons.

Step 5. Two students from each group summarize your discussions with the entire class. Explain how you answered the questions, for each of the sustainable development goals that you selected.

Sustainable development goal:

(1) How might the mine (including the products that it produces) support the UN goal for sustainable development?

(2) How might the mine hinder this goal?

Sustainability - Next Generation Science Standards* – High School

Disciplinary Core Ideas

ESS3.C: Human Impacts on Earth Systems

- The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3)
- Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4)

Science and Engineering Principles

Engaging in Argument from Evidence

Engaging in argument from evidence in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Argument may also come from current scientific or historical episodes in science.

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations). (HS-ESS3-2)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student- generated sources of evidence consistent with scientific knowledge, principles, and theories.

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1)
- Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4)

Crosscutting Concepts

Cause and Effect

Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

- Modern civilization depends on major technological systems. (HS-ESS3-1),(HS- ESS3-3)
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-2), (HS-ESS3-4)

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*The Nevada Academic Content Standards for Science (NVACSS) are based on the Next Generation Science Standards and include ESS3.A – Natural Resources.

Sustainability - Next Generation Science Standards* – Middle School

Disciplinary Core Ideas

MS-ESS3 Earth and Human Activity - ESS3.A: Natural Resources

Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geological processes. (MS-ESS3-1)

Science and Engineering Principles

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6-8 builds on K-5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the student's own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (MS-ESS3-1)
- Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

Crosscutting Concepts

Cause and Effect

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)
- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1), (MS-ESS3-4)

Stability and Change

- Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ESS3-1), (MS-ESS3-4)

The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-ESS3-2), (MS-ESS3-3)

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*The Nevada Academic Content Standards for Science (NVACSS) are based on the Next Generation Science Standards and include ESS3.A – Natural Resources.

Table 1. The 17 UN sustainable development goals.

1. **No poverty**. End poverty in all its forms everywhere. To end poverty, everyone should have basic healthcare, security, and education.
2. **Zero hunger**. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
3. **Good health and well-being**. Ensure healthy lives and promote well-being for all at all ages.
4. **Quality education**. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5. **Gender equality**. Achieve gender equality and empower all women and girls. Gender equality is a human right and is vital for a peaceful, prosperous world.
6. **Clean water**. Ensure availability and sustainable management of water and sanitation for all.
7. **Clean energy**. Ensure access to affordable, reliable, sustainable, and modern energy for all.
8. **Decent work**. Aim for sustainable economic growth and decent employment for all.
9. **Industry and infrastructure**. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
10. **No inequalities**. Reduce inequality within and among countries.
11. **Sustainability**. Make cities and human settlements inclusive, safe, resilient, and sustainable.
12. **Responsible consumption**. Ensure sustainable consumption and production patterns.
13. **Climate action**. Take urgent action to combat climate change and its impacts.
14. **Life underwater**. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
15. **Life on land**. To stop degradation, we must preserve forest, desert, and mountain ecosystems.
16. **Peace and justice**. The aim is inclusive societies with strong institutions that provide justice for all.
17. **Partnership**. If all countries are to achieve the goals, international cooperation is vital.

Figure 1. The UN Sustainable Development Goals.

Figure 2. Earth Science Week poster, which is available from the American Geosciences Institute.

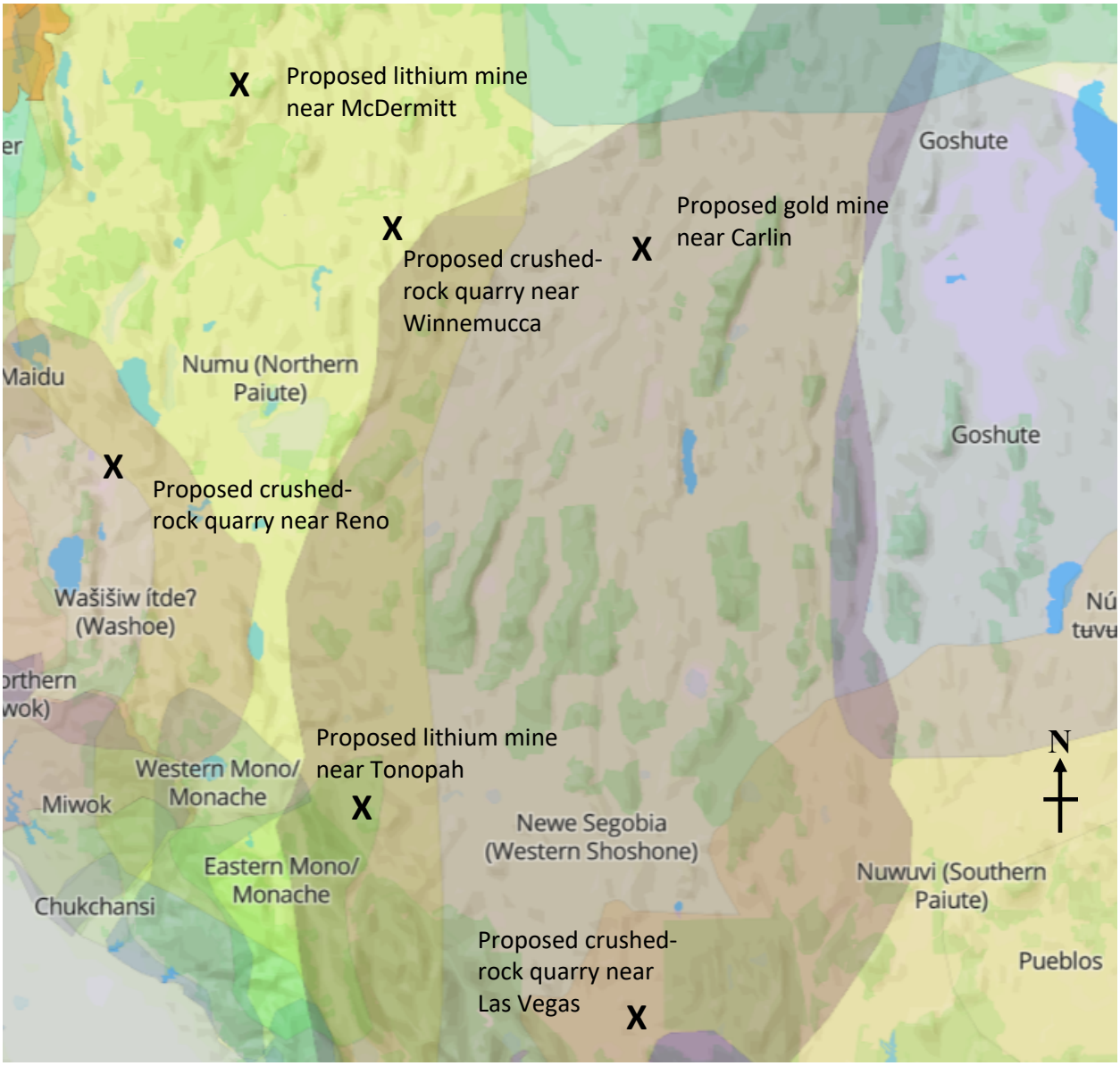


Figure 3. Screen clip from the Native Land Digital website, [Native-Land.ca | Our home on native land](), which illustrates overlapping traditional lands of Indigenous people. Note that Lake Tahoe, Pyramid Lake, Walker Lake, and Mono Lake are shown in blue on the western side of this map. Locations of hypothetical proposed mines are shown. How would you contact people who would have an interest in the development of a mine in this area?

Table 2. The 17 UN sustainable development goals and some ways that the geosciences and mining contribute. These points are to help the teacher stimulate discussion among the students.

	Goal	Geosciences	Mining
1.	**No poverty**.	Geoscientists have rewarding jobs.	Mining creates great jobs.
2.	**Zero hunger**.	Geoscientists work on soil integrity and find & protect water resources.	Companies protect water & soil resources and enhance of wildlife habitats. Mining provides resources for fertilizers.
3.	**Good health and well-being**.	Geoscientists develop clean water resources.	Companies stress job safety and provide insurance for employees and their families.
4.	**Quality education**.	Geoscientists learn environmental awareness & how nature works.	Companies support education in communities where they operate.
5.	**Gender equality**.	Equality exists in university education for geos.	Great jobs for women & men
6.	**Clean water**.	Geoscientists find clean groundwater.	Companies protect ground and surface waters.
7.	**Clean energy**.	Geoscientists are needed for all forms of energy, including finding resources.	Companies strive to minimize energy use. Mining provides the materials used in producing renewable energy.
8.	**Decent work**.	Geoscientists love their work.	Companies provide great jobs and help communities create jobs for when mining ends.
9.	**Industry and infrastructure**.	Geoscientists support engineering design of roads, bridges, dams, buildings, etc.	Mining provides the materials for all infrastructure.
10.	**No inequalities**.	Geoscientists help development throughout the world.	Mining provides jobs and support communities & countries in many ways.
11.	**Sustainability**.	Geoscientists assess natural hazards, including floods, earthquakes, landslides, and droughts.	Mining provides the materials needed to make cities and towns resilient.
12.	**Responsible consumption**.	Geoscientists study pollution and propose solutions for waste management.	Companies minimize consumption and optimize production.
13.	**Climate action**.	Geoscientists study climate change and its impacts.	Companies are moving toward zero net carbon dioxide production. Mining is needed for a low-carbon economy.
14.	**Life underwater**.	Geoscientists study ocean resources.	Mining of seafloor resources will be done responsibly.
15.	**Life on land**.	Geosciences are integral to the understanding of ecosystems.	Reclamation of mining sites preserves & enhances ecosystems.
16.	**Peace and justice**.	Geoscientists help governments realize their resource potentials.	Mining supports strong governance and local communities.
17.	**Partnership**.	Geoscientists collaborate with colleages throughout the world.	Mining is an international business that promotes global standards.

LEARNING ACTIVITY:

Mining Creates Reservoirs and Habitats

GRADES 6–9

MATERIALS

- Computer with internet access, library, local water supply utility, city utility company, or other source of research information

Stock piles of sand and gravel produced by mining a location like the reclaimed site in the second image.
Credit: Pixabay/Javier Alamo

Source: Minerals Education Coalition.
Adapted with permission.

There is an important interconnection between local mines and quarries that later become reservoirs and supply crucial water resources to local communities. The life cycle of a mine has different phases. Production supplies important resources such as construction materials and other important minerals. Then with the mine's closure and reclamation, it is sometimes used for freshwater storage and supply for the local community. Another part of a quarry's life cycle can be to offer new habitats and support biodiversity.

In this activity you will research information about community water sources and compare this to the amount a specific reclaimed quarry can contain.

PROCEDURE

1 Research information about your local community and learn the answers to these questions:
- What are the characteristics of potable water?
- What are the sources of potable water in your community?
- What is the average daily potable water use in your community?
- How is the potable water supply in your community kept safe to drink and use, as it is distributed to your homes, schools, businesses, and industries?

2 Look at the image of the geese swimming, which shows a reclaimed sand and gravel mine site where construction materials were mined to make concrete, asphalt, and other important things in a community. The reclaimed site is now a freshwater reservoir that contains 500,000,000 gallons (approx. 66,840,300 cubic feet) of water.
- How many days would this reservoir full of water supply your community's needs?
- If the reservoir were in your local ecosystem, what new habitats might be created? What kinds of animals, including fish species and vegetation, benefit from these new freshwater habitats?

A reclaimed sand and gravel mine site.
Courtesy of St. Louis East Lake Reclamation

EXTENSION

Find out where the nearest sand and gravel operation is. What products are mined or quarried there? Research how these products are used in constructing things like roads, buildings, and other important structures. Go to **MineralsEducationCoalition.org** to learn more about aggregates (stone, sand, and gravel) and try more activities about their important uses.

Go to **MineralsEducationCoalition.org/esw** for a new, accompanying lesson plan and more detailed standards correlations.

NGSS CONNECTIONS

- Science and Engineering Practices — Analyzing and Interpreting Data
- Disciplinary Core Ideas — Earth and Human Activity
- Crosscutting Concepts — Scale, Proportion and Quantity

Figure 4. Activity from the 2021 Earth Science Week toolkit, American Geosciences Institute.

SEPTEMBER 2022

LEARNING ACTIVITY:

Sources of Minerals

GRADES 6–12

MATERIALS
- Pen and paper
- Computer with internet access

Credit: ©Shutterstock/Tischenkolrina

Source: Mineralogical Society of America.
Adapted with permission.

We are surrounded by objects that we depend upon for our everyday lives. From our clothes to our phones, bikes, cars, showers, plates, chairs, televisions, computers, and nearly everything else, we rely on objects made of a variety of materials. But where do those materials come from in the first place, and what happens when we run out of them?

In this investigation, you will choose some everyday objects and trace their materials to their sources. Then you will think about the supply of these materials and what humans need to do to continue that supply while protecting the environment. You are thinking of how *sustainable* the supply is.

PROCEDURE

1 "Take a tour" around a room in your home or school. Make a list of as many different objects (products) in the room as you can.

2 Choose six different objects to research. On a clean sheet of paper, make a table for your objects with these columns: Name of Object; Object's Materials; Source of Materials; How Sustainable Is the Source of the Material.

3 Sort your six objects into groups based on their materials. For example, soft-cover books are made of paper, so "Paper" could be one of your groups. A soup pot can be made of copper metal, so "Metal" could be another group. Objects made of more than one material can be put into more than one group.

4 If you aren't sure what an object is made from, research it. Start at the Min4Kids website: **https://min4kids.org**

5 Your next task is to find out where your objects' materials come from. For example, what is the source of paper? Where do we get copper? How about plastic?

6 Next, you will be thinking about how *sustainable* the supply of materials is. For each material, find out: Is the material mined from Earth or is it grown? If it is mined, what parts of the world produce the material? What minerals make up the material? If it is grown, do the plants grow quickly, or do they take a long time?

7 Discuss: Which of your objects is made from easily found and replaceable materials? Which are made from materials that are harder to get or rarer? Based on this information, make a claim about which products are most sustainable. What ideas do you have about making the supply of materials more sustainable?

Credit: Wlodzimierz Dondzik / Alamy Stock Photo

Credit: R. Crosbie, CRH Americas

8 Other factors also need to be considered when determining if a product is sustainable, such as how much energy or water is used during its production. Conduct research to see which products require the most energy usage or water usage and add this to your claim about which products are most sustainable. Did your answers change? What other factors might you consider when determining sustainability?

NGSS CONNECTIONS

CCC: Cause and Effect; Energy and Matter; Stability and Change
SEP: Constructing Explanations and Designing Solutions
DCI: Earth's Materials and Systems; Natural Resources

SDG CONNECTIONS

11: Sustainable Cities & Communities
12: Responsible Consumption & Production

Figure 5. Activity from the 2022 Earth Science Week toolkit, American Geosciences Institute.

FEBRUARY 2023

LEARNING ACTIVITY:

Iron Minerals on the Moon

Credit: NASA

GRADES 6–8

MATERIALS

- Cup of iron-fortified breakfast cereal (Total® or Cornflakes® work well)*
- Strong magnet
- Water
- Clear plastic drinking cup or a resealable plastic bag
- Large spoon and bowl, or mortar and pestle (for crushing cereal)
- Spoon
- Scale (optional)

* Not an endorsement or recommendation.

SME FOUNDATION

MEC Minerals Education Coalition

Source: Minerals Education Coalition.
Adapted with permission.

This easy exercise models one of the processes currently being researched at four U.S. universities to enable recovery of iron and other materials found on the moon to construct an inhabited workstation. Research is being done to perfect magnetic separation techniques to recover iron-bearing minerals from the lunar soil.

Magnetic separation is used to separate iron from other materials in iron ore processing. Magnetic separation is also used when recycling Portland Cement Concrete Pavement to remove the reinforcing steel from the crushed materials. In this exercise, students will use magnetic techniques to separate the iron from iron-fortified breakfast cereal.

Credit: Joseph Bindner, Minerals Education Coalition

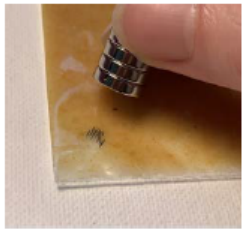
PROCEDURE

1 Put the cereal into a large bowl or mortar. Hold a magnet over the cereal to observe the attraction of the iron in or on the cereal flakes as they interact with the magnetic field created by the magnet.

2 Crush the cereal using a spoon or pestle until it is a fine powder. Don't use the bag to crush the cereal, as the bag will be punctured.

3 Place the crushed cereal in a clear plastic drinking cup or a zipper closure bag, then add enough water to make a suspension or slurry.

4 While swirling the slurry in the plastic drinking cup or closed bag, hold the magnet against the outside surface of the container. Notice the iron fragments (dark colored particles) that collect on the inside of the plastic container next to the magnet.



Credit: AGI/L. Mossa

5 Use the spoon to scrape the iron fragments from the inside surface of the container and reclaim them for further examination and analysis if desired.

6 If you have a scale, take the mass of the reclaimed iron.

7 Find the iron content of the cereal by looking at the nutrition label on the cereal box (often reported in milligrams, mg). If possible, conduct this test with other cereals and compare their iron content. Hypothesize whether you expect to reclaim more or less iron with the other cereals you test.

8 Discuss: Why are there particles of iron in the cereal? How was that iron originally obtained? Where is iron mined in the United States? What are some other uses for iron?

Go to **https://mineralseducationcoalition.org/esw** to learn more about iron, iron mining and the research into magnetic separation on the moon.

NGSS CONNECTIONS

SEP: Planning and Carrying Out Investigations
CCC: Energy and Matter
DCI: Earth's Materials and Systems; Natural Resources

SDG CONNECTIONS

9: Industry, Innovation, and Infrastructure
12: Responsible Consumption and Production

Figure 6. Another activity from the 2022 Earth Science Week toolkit, American Geosciences Institute.