Teaching Mineral Resources with an Emphasis on the NGSS Practices & Crosscutting Concepts

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InTeGrate
Interdisciplinary Teaching about Earth for a Sustainable Future

CIRES

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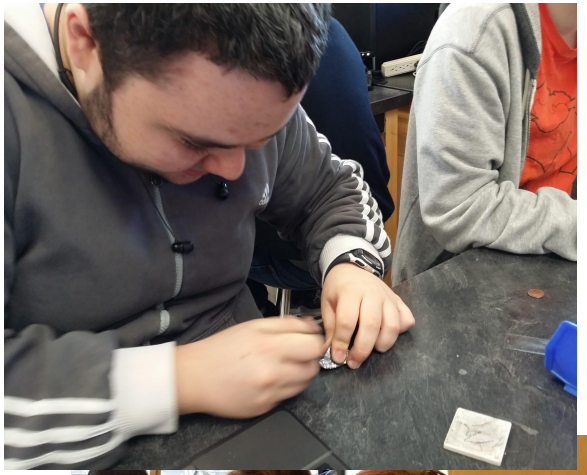
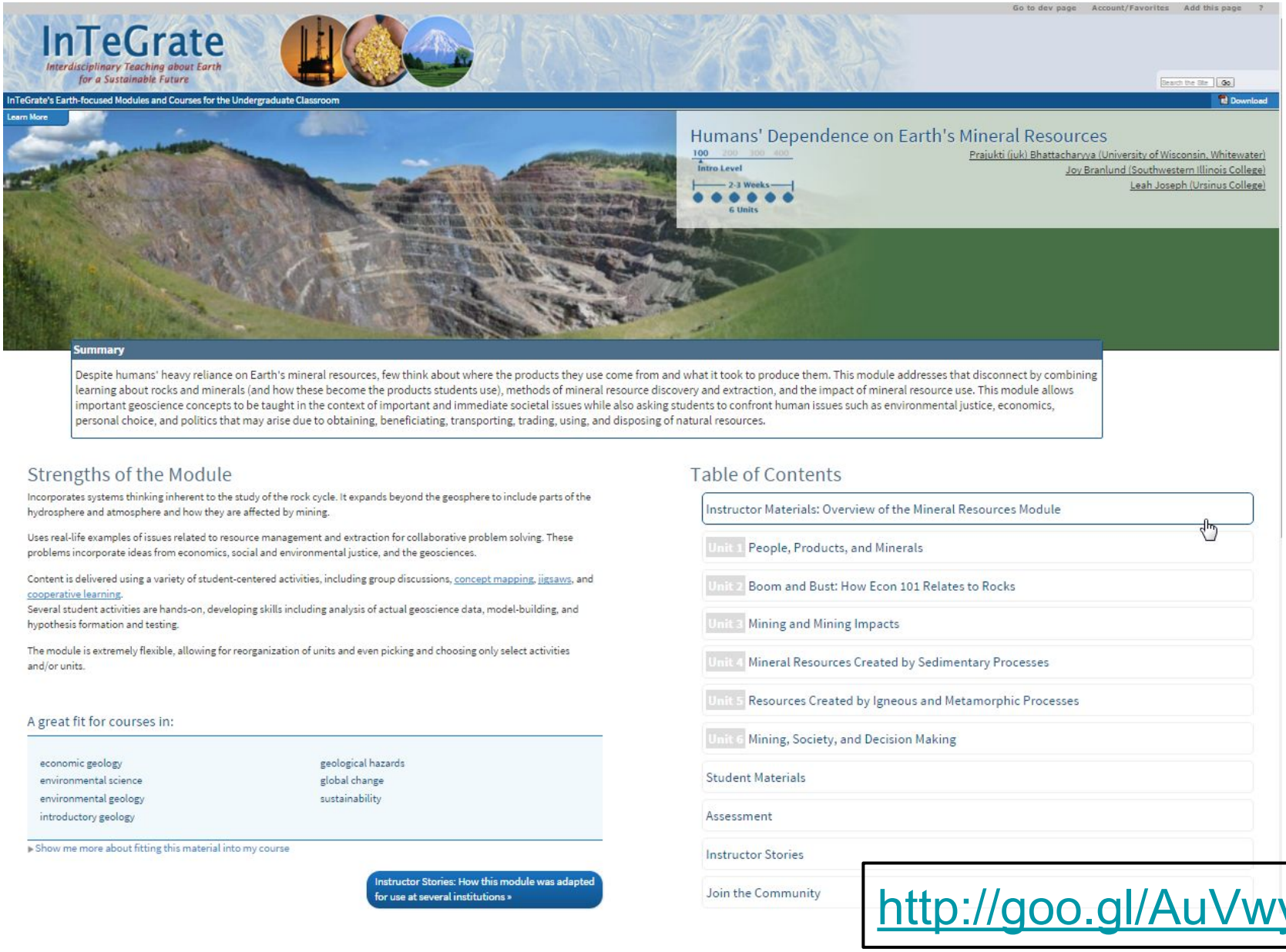
learning goals of this workshop:

- I can adapt InTeGrate module materials to align with NGSS crosscutting concepts, practices and DCIs.
- I can explain how and why managing mineral resources is a global challenge that depends both on geological (mineral forming) processes and non-geological factors with various impacts on the environment and communities.



InTeGrate website:



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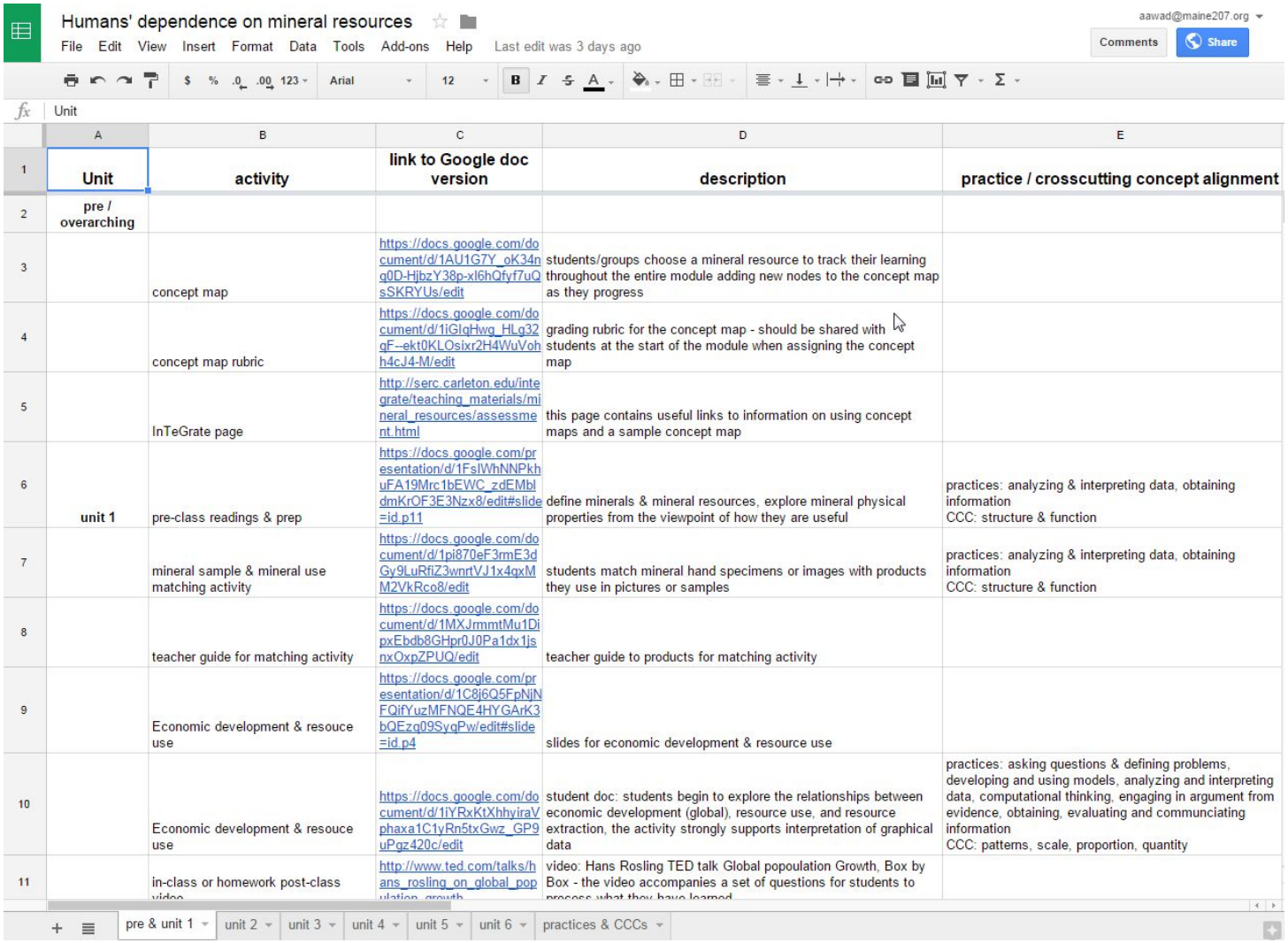
spreadsheet access to materials:



Humans' dependence on mineral resources

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fx Unit

	A	B	C	D	E
1	**Unit**	**activity**	**link to Google doc version**	**description**	**practice / crosscutting concept alignment**
2	**pre / overarching**				
3		concept map	https://docs.google.com/document/d/1AU1G7Y_oK34ng0D-HjbzY38p-xl6hQfyf7uQsSKRYUs/edit	students/groups choose a mineral resource to track their learning throughout the entire module adding new nodes to the concept map as they progress	
4		concept map rubric	https://docs.google.com/document/d/1iGIqHwg_HLg32qF--ekt0KLOsixr2H4WuVoh4cJ4-M/edit	grading rubric for the concept map - should be shared with students at the start of the module when assigning the concept map	
5		InTeGrate page	http://serc.carleton.edu/integrate/teaching_materials/mineral_resources/assessment.html	this page contains useful links to information on using concept maps and a sample concept map	
6	**unit 1**	pre-class readings & prep	https://docs.google.com/presentation/d/1FslWhNNPkhuFA19Mrc1bEWC_zdEMbldmKrOF3E3Nzx8/edit#slide=id.p11	define minerals & mineral resources, explore mineral physical properties from the viewpoint of how they are useful	practices: analyzing & interpreting data, obtaining information CCC: structure & function
7		mineral sample & mineral use matching activity	https://docs.google.com/document/d/1pi870eF3rmE3dGy9LuRfiZ3wnrtVJ1x4qxMM2VkRco8/edit	students match mineral hand specimens or images with products they use in pictures or samples	practices: analyzing & interpreting data, obtaining information CCC: structure & function
8		teacher guide for matching activity	https://docs.google.com/document/d/1MXJrmmtMu1DipxEbdb8GHpr0J0Pa1dx1jsnxOxpZPUQ/edit	teacher guide to products for matching activity	
9		Economic development & resouce use	https://docs.google.com/presentation/d/1C8j6Q5FpNjNFQifYuzMFNQE4HYGArK3bQEzq09SyqPw/edit#slide=id.p4	slides for economic development & resource use	
10		Economic development & resouce use	https://docs.google.com/document/d/1iYRxKtXhhyiraVphaxa1C1yRn5txGwz_GP9uPgz420c/edit	student doc: students begin to explore the relationships between economic development (global), resource use, and resource extraction, the activity strongly supports interpretation of graphical data	practices: asking questions & defining problems, developing and using models, analyzing and interpreting data, computational thinking, engaging in argument from evidence, obtaining, evaluating and communciating information CCC: patterns, scale, proportion, quantity
11		in-class or homework post-class	http://www.ted.com/talks/hans_rosling_on_global_population_growth	video: Hans Rosling TED talk Global popoulation Growth, Box by Box - the video accompanies a set of questions for students to process what they have learned	

pre & unit 1 | unit 2 | unit 3 | unit 4 | unit 5 | unit 6 | practices & CCCs

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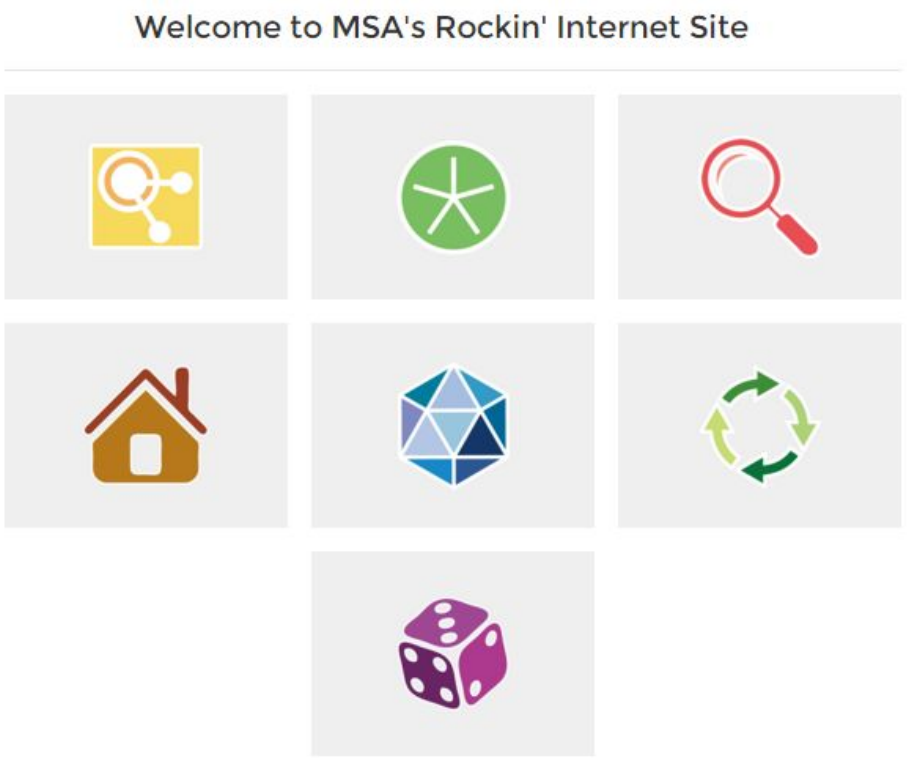
Related AGI Education Resources To Explore

	**Earth Science Week** Discover the resources offered through this international event, organized by AGI each October to promote better understanding and appreciation of Earth science and encourage stewardship of the planet. http://www.earthsciweek.org/classroom-activities
	**Big Ideas in Earth Science** Big Ideas videos bring to life the "big ideas" of Earth science—the nine core concepts that everyone should know. Teachers can use the videos in many ways. http://www.earthsciweek.org/big-ideas
	**Center for Geoscience and Society** Education Resource Network – The geoscience education resources on this site come from a variety of providers. The site provides visitors with the widest possible collection of curricula, classroom activities, teacher professional development opportunities, science education standards, virtual field trips, teaching ancillaries, and much more. http://geocntr.org/education-resources/ Critical Issues Program The Critical Issues Program provides a portal to decision-relevant, impartial, expert information from across the geosciences. http://www.americangeosciences.org/critical-issues
	**K-5 Geosource** If you are involved in elementary science education in any way, this Web site is for you. The site has a rich store of content, activities, services and links for you to explore, but this is only the beginning. http://www.k5geosource.org/index.html

Mineralogical Society of America resources:

[Mineralogy 4 Kids]
Mineralogy 4 Kids is the educational outreach website for the Mineralogical Socieety of America (MSA). This interactive website is designed to help children of all ages learn about mineral groups, properties, and identification. Visitors to the site can also learn about the rock cycle, crystals, and minerals used in homes. Additional resources are also listed.

[Mineral Identification: MSA Mineral Collector's Corner]
The Mineralogical Society of America provides an online Mineral Identification Key to help users recognize the attributes of many kinds of minerals. the site gives information about mineral properties, environments, and associations. The Mineral Identification Key website is primarily focused on the needs of collectors, including a description of how basic mineral identification kits can be assembled.



links to Google Docs versions of activities:

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Concept mapping a resource

Making learning visible: Concept mapping a resource

Sign up for one of the following commodities:

graphite	platinum-group metals	gypsum
tantalum	bauxite	manganese
tungsten	silica	lithium
gold	tin	REEs
chromite	iron	sulfur
copper	clays	phosphate
halite	cobalt	industrial diamonds
molybdenum	lead	zinc
nickel	cadmium	

Note: Some of the **commodities** in the list above are **mineral resources** (rocks and minerals), whereas others are elements extracted from mineral resources.

Use what you have learned about mineral resources as well as information about your specific commodity to draw a concept map showing:

- The geologic nature of the resource: for example, what is the mineral resource and the resultant commodity (mineral, rock, or element); what mineral and rock forming processes acted to create the commodity; in what geologic/geographic settings might these processes have occurred?
- Physical characteristics of the resource.
- The factors and people (people could be countries, companies, etc.) who determine the demand for the resource: for example, what is the commodity used for, who uses it, and what other things might influence the demand for this resource?
- The methods of mining and processing the commodity: for example, how and where does mining and processing occur; what environmental impacts occur; who is impacted by the overall mineral recovery process and in what ways?

Ideally, you should start this as soon as possible, filling in as much as you already know. Throughout this module, **add to your concept map** as you learn more about the commodity you choose and about mineral resources in general. You will use materials that you are learning in class, but you will also need to do *extra research and work outside of the class*.

Resources that may be helpful in addition to class may include your textbook, the USGS Minerals Yearbook website (http://minerals.usgs.gov/minerals/pubs/myb.html), the Mineral Information Institute website (http://www.mii.org/welcome), as well as other webpages. When you turn in the assignment, please include a list of the sources (with web addresses as appropriate) that you used to complete your concept map, although you do not have to denote which information you obtained from each source.

links to interesting videos:
tantalum - https://www.youtube.com/watch?v=eqiSyPsK0ag
tungsten - https://www.youtube.com/watch?v=EZhaKbrLbOQ
tin - https://www.youtube.com/watch?v=u6Kx2GMF4co
gold - https://www.youtube.com/watch?v=1RavnNmv5ns
gypsum
halite
copper

https://goo.gl/9JDDri
Concept map rubric

Rubric for Concept Map

	Exemplary 4	Exceeds standard 3	Meets standard 2	Below standard 1	Score
Organization	• Well organized • Logical format • Map is "freeflow" and not stringy • Follows standard map conventions	• Thoughtfully organized • Easy to follow most of the time • Follows the standard map conventions	• Somewhat organized • Somewhat incoherent	• Choppy and confusing	
Geologic nature of the resource					
Content	• All of the main concepts from the module are covered	• Almost all of the main concepts from the module are included	• The majority (>50%) of concepts from the module are included	• Many of the main concepts from the module are missing	
Connections	• The map answers the key questions asked in the instructions • Uses appropriate terminology (terms used in class) • All nodes (concepts) are accurately connected • Links are precisely labeled • Linking words demonstrate conceptual understanding • No misconceptions/errors evident	• The map answers most of the key questions asked in the instructions • Uses appropriate terminology (terms used in class) • All nodes (concepts) are accurately connected • Connections are clear and logical. They connect concepts to promote clarity and convey meaning. • Linking words are easy to follow but at times ideas unclear or connections incorrectly labeled • May contain some small errors	• The map answers some of the key questions asked • Most words are accurately connected • Connections are somewhat clear and convey some meaning • Makes some incorrect connections • Some links are not labeled • May contain errors	• The map answers some of the key questions asked • Only some concepts are accurately connected • Labels aren't clear, they convey little meaning and do not promote clarity • Many links are not labeled • May contain many errors, and/or concepts that don't belong	
Factors and people who determine resource demand					
Content	• All of the main concepts from the module are covered	• Almost all of the main concepts from the module are included	• The majority (>50%) of concepts from the module are included	• Many of the main concepts from the module are missing	
Content and connections	• The map answers the key questions asked in the instructions • Uses appropriate terminology (terms used in class) • All nodes (concepts) are accurately connected • Links are precisely labeled • Linking words demonstrate conceptual understanding • No misconceptions/errors evident	• The map answers most of the key questions asked in the instructions • Uses appropriate terminology (terms used in class) • All nodes (concepts) are accurately connected • Connections are clear and logical. They connect concepts to promote clarity and convey meaning. • Linking words are easy to follow but at times ideas unclear or connections incorrectly labeled • May contain some small errors	• The map answers some of the key questions asked • Most words are accurately connected • Connections are somewhat clear and convey some meaning • Makes some incorrect connections • Some links are not labeled • May contain errors	• The map answers some of the key questions asked • Only some concepts are accurately connected • Labels aren't clear, they convey little meaning and do not promote clarity • Many links are not labeled • May contain many errors, and/or concepts that don't belong	

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People, products & minerals

Human's Dependence on Earth's Mineral Resources
Unit I
People, Products, and Minerals
Post-class homework

Learning objectives
- Infer the relationships between sustainability, resource availability, population growth, and economic development.
- Extrapolate the impacts of growing populations and economic development on mineral resource extraction and use.

Population, economic development, and mineral resource use

In 1900, an estimated 1.65 billion people lived on Earth. Today, the population is more than 7 billion and still growing. By 2100, it is believed that an estimated 8–11 billion people will inhabit the Earth.

Every organism needs resources to provide food, water, shelter, and a location for waste disposal/processing. These resources are provided by the environment, which may include other organisms. Humans are unique in that we utilize so much of the planet for resource extraction and waste disposal to meet our needs and our desires. Our ability to innovate and act has enabled many of us in the developed world to enjoy a high standard of living, reshaping resources into "stuff" and consuming beyond our basic needs. For example, in 2005, the United States used 15% of extracted mineral resources but is only home to 5% of the world's population (Gerlinger and Krausmann, 2011).

→ Watch the TED talk "Global Population Growth, Box by Box" given by Hans Rosling (approximately 10 minutes) at:
http://www.ted.com/talks/hans_rosling_on_global_population_growth.html. There is an "Interactive Transcript" in the bottom right corner of the video if you want to read along. It might be helpful to read through the questions below before you watch the video.

1) Write down 10 items that you own that you feel you need in our modern U.S. society but that are in excess of truly basic survival needs (such as food, water, shelter, etc).

2) Circle any of the items on the list above (#1) that you think are likely to be owned by someone in an impoverished country.

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Minerals & Products

Humans' Dependence on Earth's Mineral Resources
People, Products, and Minerals
Part I: Minerals and Products

Here is a list of the minerals, and their chemical formulas, that we have in class today. Use this, and other properties of the minerals (such as hardness, color, etc.), to match them to the products listed on the back of this sheet (one mineral per product).

Mineral Name	Chemical Formula
Apatite	$Ca_5(PO_4)_3(F,Cl,OH)$
Bauxite	$Al(OH)_3$ - AlO · OH
Barite	$BaSO_4$
Calcite	$CaCO_3$
Chalcopyrite	$CuFeS_2$
Galena	PbS
Graphite	C
Gypsum	$CaSO_4 \cdot 2(H_2O)$
Halite	NaCl
Hematite (red)	Fe_2O_3
Hematite (specularite)	Fe_2O_3
Kaolinite	$Al_2Si_2O_5(OH)_4$
Muscovite	$KAl_2(AlSi_3)O_{10}(OH,F)_2$
Quartz	SiO_2
Talc	$Mg_3Si_4O_{10}(OH)_2$

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Economic development & resource use

People, Products, and Minerals
Unit 1/Activity 3

Economic Development and Resource Use

Learning Outcomes
- Infer the relationships among sustainability, resource availability, population growth, and economic development

Economic Development and Resource Use
The gross domestic product (GDP) of a country is frequently used as an indicator of a country's economic performance and its level of development. A per capita GDP is the overall GDP divided by the number of people in that country and can be used to more easily compare the economic performance of countries with different population sizes.

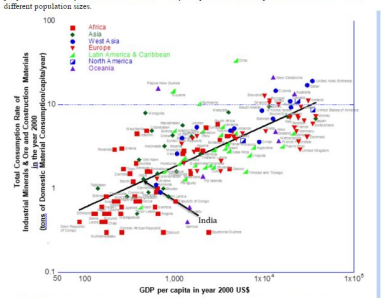

Figure 1. *The relationship between gross domestic product (GDP) per capita and the total domestic consumption rate of industrial minerals & ore and construction material in tons per capita for ~130 different countries in the year 2000* (Modified from UNEP Decoupling Report, 2011; Consumption (metabolic) rate data from Steinberger et al., 2010; GDP data from http://data.worldbank.org/indicator/NY.GDP.PCAP.KD). Country region from http://unstats.un.org/unsd/methods/m49/m49regin.htm with the exception of considering Mexico as part of North America). Not all the countries plotted are labeled above due to space restrictions.

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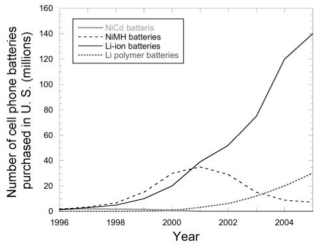
Rechargeable batteries & mineral resource use

Part 1A. Changing technology: cell phone batteries

In this part, we'll look specifically at batteries themselves. Use the graph below, which shows the number of cell phone batteries purchased annually in the United States, to answer questions 1–3.



1. Summarize in what ways the number of cell phone batteries has changed since 1996. You can write different answers for the different types of batteries.

2. Why do you think that the number of batteries used has changed?

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Rare earth elements

Rare Earth Elements: Supply, demand, consumption, price

Rare Earth Elements (REE) are extensively used every day in batteries, electronics, ceramics, and high-powered magnets, and they are vital for clean energy technologies as well. In this activity we will look at REE supply, and consumption and price data, and discuss possible future strategies for balancing REE supply and demand.

China supplies the majority of the world's REE. The Chinese government sets the maximum amount of REE that can be legally exported out of the country (i.e., **export quota**) each year. The following table shows the amount of the export quota each year for the years 2000–2010 (except for 2002, for which we have no data), and the price per ton of REE adjusted for inflation with respect to the value of U.S. dollars (USD) during 1998 (shown as 98$/t, which means 1998 dollars per ton).

Year	Total export quota (metric tons)*	REE price per ton** in USD during 1998, expressed as ($98/t)
2000	47,000	6,110
2001	45,000	5,330
2002	N/A	6,800
2003	40,000	5,450
2004	45,000	7,410
2005	65,580	5,500
2006	61,070	3,150
2007	59,643	4,160
2008	49,990	10,300
2009	48,155	7,100
2010	30,258	14,500

* Quota data from "China's Rare-Earth Production, Consumption, and Export Quotas for 2000 through 2011." (Tse Pui-Kwan, 2011, China's Rare-Earth Industry: U.S. Geological Survey Open-File Report 2011–1042, 11 p.) Data from 2005 onward show total export quota for domestic producers and traders, plus Sino–foreign joint ventures.

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Ore grades, waste, and remediation

Humans' Dependence on Earth's Mineral Resources
Unit 3
Mining and Mining Impacts

Part II: Ore Grades, Waste, and Remediation

Section I: Mining and Waste
Golden Sunlight Mine (GSM), near Whitehall, Montana, opened in 1983 and is still open today. It is one of the properties owned by the Canadian company Barrick Gold Corp. Take a look at the attached satellite image of Golden Sunlight Mine. Some remediation (slope stabilization) has been done by planting and growing vegetation on the west side of the West Waste Rock Dump Complex and on the northeast side of the East Waste Rock Dump Complex.

1) On the attached satellite image, use a marker to denote the boundaries of mining areas (e.g., draw a line around the Mineral Hill Open Pit Mine area, etc.) and a different color marker to denote the boundaries of waste areas (e.g., draw a line around the West Waste Rock Dump Complex, etc.).

2) Use the boundaries you created to estimate the approximate percentage of land surface area that is used for actual pit mining as opposed to the storage of mining waste products (including both waste rock and tailings). The approximate percentage of land surface used for pit mining as compared to that used in mine waste storage is:
   a. 90–100%
   b. 70–85%
   c. 45–55%
   d. 15–30%

3) For a sense of scale:
   a. Estimate the number of acres inside Tailings Impoundment #2 using the scale box (100 acres) on the map.

   b. If an American football field, including the end zones, is about 1.32 acres, approximately (mathematically) how many football fields would fit inside Tailing Impoundment #2? Show your calculations here.

4) Why might Tailings Impoundment #1 look different than Tailings Impoundment #2?