Economic Minerals Lab Part 2 - GLG110IN **Name** _____

Part A - How We Obtain Copper (Cu) from Ore *Note: Before starting this lab, watch the overview video.*

1. After watching Pyro and Hydrometallurgical Copper Processing (7:10), write two observations about how we get copper from ore.

A

B

Part B - Determining the % of Copper (Cu) in a Mineral

First, look at azurite, *chalcopyrite*, chalcocite, and malachite. Most people imagine that copper is mined as pure copper metal. That does happen, but that is rare. The copper in your phone, laptop, car and house probably was mined from an *ore body* that contained a copper-containing *mineral*. Using four copper-bearing minerals, some from Parts 1 of this lab, we will complete the data below for azurite. Then you will complete the data for chalcopyrite, malachite, and chalcocite on your own. Follow the steps below.

a. Write the symbol for each element that appears in the mineral's formula. In our example, below, azurite contains Cu, C, O and H. (Note: C is an element - carbon. O is an element - oxygen. Co is an element - cobalt. CO is not an element. CO is a *molecule* made of two elements - carbon and oxygen. OH is one molecule made of two elements - oxygen and hydrogen.) Use the periodic table.

b. As in the example below, record the number of atoms of that element in one molecule of the mineral.

c. Record the atomic weight (At. Wt) of each atom of the element. Round the atomic weight to the nearest integer. Boron, for example, at 10.81 will round to 11.

d. Multiply the # of atoms of the element times the atomic weight to get the total weight of that element in the mineral.

e. Add the weights of all the elements in col. 4 to get the total weight of *1 molecule* of the mineral, the molecular weight.

f. Divide the *total weight of the copper* by the *molecular weight* to get the % of copper in that mineral.

Example - Azurite - $Cu_3(CO_3)_2(OH)_2$ (Watch the video on how to do this.)

Element	# of Atoms	Atomic Weight (AMU)	Total Weight (AMU)
Cu	3	64	192
C	2	12	24
O	8	16	128
H	2	1	2
-	-	**Molecular Weight -> (Total the above.)**	346
-	-	**% Cu in Azurite (192/346) ->**	55

Chalcopyrite - $CuFeS_2$

Element	# of Atoms	Atomic Weight (AMU)	Total Weight (AMU)
Cu	1		
Fe	1		
S	2		
-	-	**Molecular Weight ->**	
-	-	**% Cu in Chalcopyrite (_____/_____) ->**	

Malachite - $Cu_2(CO_3)(OH)_2$

Element	# of Atoms	Atomic Weight (AMU)	Total Weight (AMU)
-	-	**Molecular Weight ->**	
-	-	**% Cu in Azurite (_____/_____) ->**	

Chalcocite - Cu_2S

Element	# of Atoms	Atomic Weight (AMU)	Total Weight (AMU)
-	-	**Molecular Weight ->**	
-	-	**% Cu in Chalcocite (_____/_____) ->**	

List the percentage of copper in each of the four minerals above.

2. azurite = __55____% Cu 3. chalcopyrite =_____% Cu 4. malachite =_____% Cu 5. chalcocite = _____% Cu

Part C - Determining the Cu in an Ore Body, a Car, a House & Cardinals Stadium

An "average" American car contains about 44 pounds of copper. A typical house contains 422 pounds of copper.

6. To get enough copper for a car would require (A)_____pounds of pure malachite. (Divide 44 pounds by your answer to #4 above. Example: If a mystery copper mineral, *not malachite*, is 25% copper, 44 pounds/.25 = 176 pounds.), a house would require (B) _____ pounds of pure malachite. (Divide 422 lbs by your answer to #4 above. Example? If a mystery mineral (*not malachite*) is 25% copper, 422 pounds/.25 = 1688 pounds.) Show work below.

7. A cubic foot of earth weighs ~187 lbs on average. To get 44 pounds copper for a car, we would dig up _____ cubic ft of malachite. (Divide 6A by 187.) For a house _____ ft^3. (Divide your answer from 6B by 187). Show any work below.

8. To get enough copper for a car would require (A) _____ lbs of pure chalcocite. (Divide 44 lbs by your answer to #5 above.) A house would require (B) _____ lbs of chalcocite. (Divide 422 lbs by your answer to #5 above.)

9. A cubic foot of earth weighs ~187 lbs on average. We would have to dig up about _____ ft^3 of chalcocite to get the copper for a car (Divide answer 8A by 187) or _____ ft^3 for a house. (Divide answer 8B by 187.)

Hey, your answers to the questions above are not so bad, but we don't mine just the mineral. We mine a deposit in which the mineral is hosted. The mineral is only PART of an ore body, in Arizona, often a porphyry copper deposit. (You'll read about this and watch a related video below.) That porphyry copper deposit contains not only the mineral that we want but also a lot of waste rock, usually silica material, called gangue. In this Morenci mine in 2016, 3.2 billion tonnes or 7,040,000,000,000 pounds of ore were mined. Only 0.16% of that ore is copper, less than one fifth of 1%! From each ton of rock mined, we get 3.2 pounds of copper. The rest, 98.84% or > 1,996 pounds was gangue, the waste product. The mine has to make a profit from this in order to stay open and provide us with Cu.

Examples

A rare copper mineral, chandlergilbertite, is 50% copper. A car requires 44 pounds of copper. To get that 44 pounds of copper from the chandlergilbertite in an ore body, we need 88 pounds of copper as 44 / .50 (X½) = 88 pounds. However, since the ore body is only .16% mineral, we now divide that 88 pounds by .0016. 88/.0016 = 55,000 pounds of ore for the 44 pounds of copper in one car.

An average house requires 422 pounds of Cu. To get that amount of Cu from chandlergilbertite in an ore body, we need 442 pounds of copper as 442 / .50 (X½) = 884 pounds. However, since the ore body is only .16% mineral, we now divide that 884 pounds by .0016. 884/.0016 = 552,500 pounds of ore for the 422 pounds of copper in one house.

10. As copper is 0.16% of an ore, how many pounds of earth need to be dug to get 44 lbs of Cu for your car? Asked another way, 44 pounds is .16% (not 16% but .16%) of what? (Example - If a car needs 100 lbs of copper, this would be our calculation -> 100lbs / .0016 = 62,500 lbs of earth. Show your work below.

11 Given that copper is 0.16% (.0016) of an ore, how many pounds of earth have to be dug up to get 422 pounds of copper for your house? Show your work below.

12. A cubic foot of earth weighs about 187 lbs. If 7,040,000,000,000 lbs of ore were mined in 2016 at Morenci, that means

_____ cubic feet of ore were dug up. Show your work. (Divide the big number by 187.)

13. The Cardinal's State Farm® stadium is ~104,000,000 cubic feet. How many stadiums (stadia, really) of ore did we mine? (Divide your answer to #12 by the volume of the stadium. Show your work.

14. The ore in the Miami mine is 0.16% copper. That means that mining 7,040,000,000,000 pounds of ore produced

_____ pounds of copper and _____ pounds of waste.

Part D - Arizona Copper Mines & Google Maps Geologic Maps & Ore Deposits & Google Maps

The meek shall inherit the Earth but not the mineral rights. - J. Paul Getty

Either *watch this short video by geologist Stephen Marshak* or read the following OR watch the video ***and*** read the passage below. In the video at 1:26. Note all the ***faults*** that occur around the magma intrusion. These faults will show up later in this assignment.

> *Typical Arizona copper deposits originate from the middle Mesozoic to early Cenozoic with igneous intrusions that are characterized as porphyry copper. Similar intrusions are found in New Mexico and Sonora, Mexico. The molten rock intruded into a variety of host country rock. When the pluton cooled and shrank, the country rock and the pluton fractured and brecciated. These fractures, pores and other openings left openings for hot hydrothermal fluids to move into what would become the primary ore body. These hot fluids corroded and altered the rocks. (Additionally, metamorphism created some skarn type deposits.) Later fluids brought mineralization of still more sulfide and oxide ores. Then the ore bodies were weathered at or near the surface of the Earth after eons of erosion removed overlying rocks. The weathering removed much of the ore from the near surface rocks and leached them down to the groundwater interface where they would recrystallize as new minerals in an area called a supergene enrichment zone. The variety of minerals that were produced through this sequence of events is mind-numbing as well as mine-enriching. The original intrusion brought an assortment of silicates as well as the copper containing sulfides chalcopyrite and bornite. Other sulfides and assorted minerals were also deposited with the original intrusions and later hydrothermal fluids. The metamorphism is responsible for much of the unique silicate assemblages where as the weathering and recrystallization produced most of the unique copper oxide, carbonate and sulfate mineralogy as well as some silicates, such as chrysocolla, and phosphates, such as turquoise. These weathered, colorful, near surface or surface deposits are called gangue deposits and although they are often not all that profitable themselves they do point prospectors to the potential riches below. The lower supergene enrichment zone produced economically valuable secondary sulfides such as chalcocite. Sulfides and sulfates make up the majority of the minerals in this area. (The Mines of Arizona)*

Use a computer (not a phone) to open the links below in 2-D satellite mode. Look around. Try 3-D. Measure.
Before starting, read about this area on Wikipedia *and about mine tailings.*
Most of the mines around Miami & Globe, Arizona are on U.S. Forest Service lands, lands that "belong to all of us".

15. A. Describe what appears to be happening at *Location 1*. *(GE)*



B) The total *area* of this feature is _____ sq miles. If you can't remember how to measure the area in Google maps, watch this video. The rough area of the mine is outlined in the image to the right.

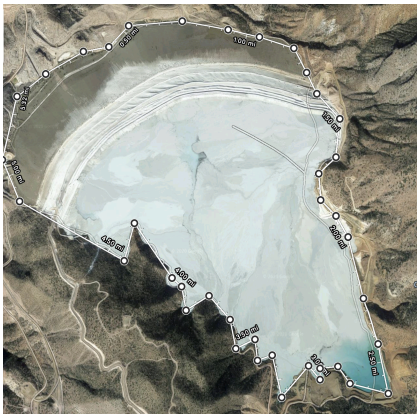
C) Where is this area in AZ?

16. The total area of this (top image to the right) is _____ square miles and the total area of this (bottom image to the right) is _____ square miles .

Describe what is going on here.



17. How have *you* benefited personally from what is happening in his area?



18. If you lived below these areas, might you have concerns about your drinking water? Explain.

19. On the northeast corner of the mine in location 1, Pinto Creek flows next to the mine going north. (This map opens in terrain view to make seeing Pinto Creek easier. For some reason, Google Maps colors the mine blue, the normal color for water. Ignore that.) Pinto Creek is an *ephemeral* stream, having water only during periods of precipitation. The first part of Pinto Creek's course is in the image to the right. Pinto Creek keeps going, but the rest of its course is not included in the image. You have to figure out where the water from Pinto Creek goes. Follow that water. Describe where those waters go over the 200 miles below the mine. Are large populations in Arizona affected by this mine? Explain your findings.

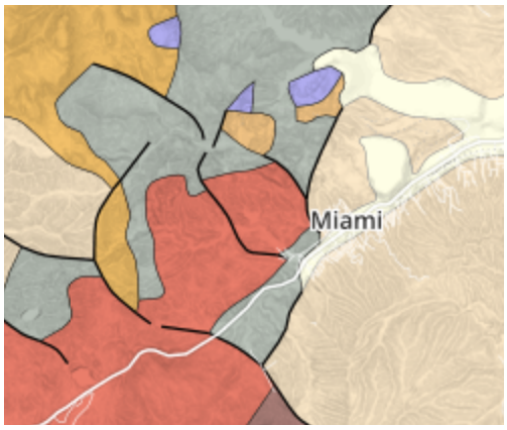


Part E - Geologic Maps & Copper Ore Deposits (If the map link below is broken, use this map.)

20. Find on the *Geologic Map of Arizona* the same area you just looked at in Google Maps. It will be a colored red and near Claypool, east of Chandler. Describe the rock formation in which the features above were found. Look for a legend description that mentions *copper*. Only one of the units includes the word "copper".

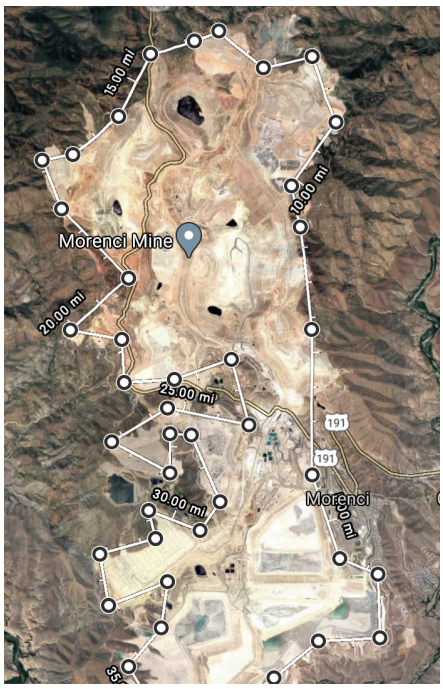
21. This formation's abbreviation is _____ & is_____ years old. (Ma = millions of years ago.)

22. The screenshot to the right shows examples of some thick black lines around Miami. (Do not look at the contacts, just the thick black lines. There are several different types of black lines.) What general event do all the black lines represent? _____



23. What might have caused the features indicated by the thick black lines to form? (See the introductory paragraphs in Part D above if you forgot already..)

24. Describe what is happening at *Location 2* (GE) as shown in the image to the right. Include the total area of this feature, including where this area is in Arizona.



25. On the *Geologic Map of AZ*, find Location 2. What do you notice about the type of rock at Location 2 compared with Location 1?

26. Follow the Gila River below Location 2 (GE) as shown in the image to the right. Only the first part of the river's course is shown. *Follow, follow, follow*. The river flows SW from the mine to Safford then NW to San Carlos Reservoir, then WSW Florence. Follow the Gila River WNW from Florence to ???. Or try a cool Google map tracing the path of the Gila River. Start at Morenci and follow the blue pins all the way.. Describe where the river goes over the 300 miles below the mine. Could large populations be affected by runoff from this mine? How is this different from the Pinto Creek drainage?



27. Look at Location 3 (GE). Before reading further, what do you think is happening here? Look carefully about 200' ESE of the mine.

28. Read *what has happened here*. What do you think?

29. Using Google maps, find one other Arizona (non-turquoise) mine , give the location and describe what is going on, what is being mined, how much has been mined. Use the web!

Summary Questions

30. Give 2 *specific* examples of how we *benefit* as a society from mining. Don't say, "*My life is gooder* cuz mining."

A B

31. List two detrimental consequences of mining.

A B

32. Hypothesize why we often do not consider the consequences of mining as much as the benefits.

33. A) Why should we never throw away metals that we have mined from ores? B) What should we do instead?

A B

34. Old mine sites or *brownfields* can be repurposed. *Read this* & comment. Good? Bad? Suggestions? Concerns?

35. Describe two specific things that you have learned from this lab (not what you learned *about*), a question you still have regarding this topic, a suggestion to improve this lab, or something you appreciate (3 points)

A

B

Historically, mining has been dangerous as you saw in the Navajo Coal / Black Lung Case History. The song, The Wreck of the Edmund Fitzgerald, is related to this as the ship was hauling iron ore to make the products we need.

---------- ***Stop printing. Don't read anything below here. Trespassers will be giggled at.*** ----------

https://www.geologyforinvestors.com/the-porphyry-copper-deposits-arizona/

Possible Future or Extra Credit Topics - Do not bother with anything below this line.

Mining Law of 1872

Virginia - Mountaintop Removal - Coal

Fort MacMurray

Fracking - Odessa, TX - Ft. Worth, TX, Erie Middle School, Erie, CO

Jerome

http://www-usr.rider.edu/~husch/env100mineralsnotes.htm

What are mineral resources? Why are they important?

Vocabulary

concentration factor	ore	resource	reserve
hydrothermal deposits	contact metamorphism	regional metamorphism	evaporite
placer deposit	metals	nonmetals	rock resources
open pit / quarry	strip mine	tailings	strategic minerals
native metal	smelting	slag	gangue
placer deposit	manganese nodule	economic mineral	

Which minerals/mineral resources do we mine most? Which minerals do we use most?

Metals Fe, Al, Sulfides - Cu, Pb, Zn, Au, Ag, Pt

Nonmetals S, Na + Cl, gypsum, phosphorous, potassium, cay

Sand & Gravel & Rock

Where do minerals concentrate? How do they concentrate?

Igneous - igneous processes, hydrothermal deposits,

Sedimentary - banded iron formation, evaporites, weathering, placer deposits

Mets - graphite, asbestos, garnet

Why do we have to mine in certain places?
What are the types of mines?
How do we locate minerals?
What minerals are in the USA? What are we lacking?
What minerals are in the USA? What are we lacking?
What are issues related to mining minerals?
How can we conserve minerals?

Bornite-Cu_5FeS_4 = ____% Cu Galena-PbS_____% Pb Magnetite-Fe_3O_4_____% Fe

After completing each part that includes a √, have your professor check your work before going on.
Part A - Identify the following as A - renewable or B - nonrenewable.
___1. sunlight ___2. O2 ___3. diamonds ___4. soil ___ 5. wind ___6. gold ___7. oil ___8. crops ___9. coal ___ 10. natural gas
Part B - Identify each ore as either A - metallic or B - nonmetallic. Not sure? See the mineral's formula on your lab or the web.
__1. sphalerite ___2. halite ___3. talc __4. galena __5. bauxite __6. gold __7. hematite __8. graphite __9. gypsum _ 10. azurite
Part C - Match the ore and write the symbol for the metal or metals derived (Some ores provide more than one metal.)
_____ 3. bornite _____ 6. galena _____ 9. pyrite
_____ 1. azurite _____ 4. chalcopyrite _____ 7. magnetite
_____ 2. bauxite _____ 5. copper _____ 8. malachite

Part D - Choose the one given word that completes the analogy. You may use the web.
Sponge Bob : Bikini Bottom Bart Simpson:__Springfield____ Riverdale, Springfield, Chandler, Winslow

1. reserves : known

2. profit : ore
3. halite : seasoning
4. sphalerite : zinc
5. soft : bituminous
6. quartz : glass
7. gypsum: wallboard
8. petroleum : animals
9. gasoline : petroleum
10. oil trap : shale

resources : _____ valuable, estimate, profitable, gangue discard : _____ reserve, mineral, gangue, survey feldspar : _____ steel, porcelain, plastic, glass magnetite : _____ Fe, Pb, Zn, Sp
hard : _____ lignite, peat, graphite, anthracite
hematite : _____ nails, makeup, Tums, porcelain
talc : _____ baby powder or makeup, acid, drills, oil and paraffin coal :_____ marine animals, plants, dinosaurs, graphite uranium : _____ sphalerite, chalcocite, galena, carnotite
oil reservoir : _____ sandstone, gneiss, quartzite, limestone

Part E - Give the name of each economically important mineral linked here.

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____ 8. _____

https://www.youtube.com/watch?v=QMIHEl08xok

In 2017, 737,000,000 pounds of copper was produced at Morenci. How much ore did this mean. 460,000,000,000,000 pounds or 230,000,000 tons. There are about 187 pounds of rock in a cubic foot. This means we mined 2,460,000,000,000 cubic feet