Minerals and Rocks to Mining and Construction

Natural Resources and Civilizations

If you cannot grow it, you must mine it.

Big Idea *Humans depend on Earth for resources*

EVERY YEAR: 38,016 pounds of new minerals must be provided for every person in the United States to make the things we use daily

9,737 lbs. **Stone** is used to make roads, buildings, bridges, landscaping and other construction uses, and for numerous chemical uses.

6,547 lbs. **Sand and Gravel** are used to make concrete, asphalt, roads, blocks and bricks.

713 lbs. **Cement** is used to make roads, sidewalks, bridges, buildings, schools and houses.

240 lbs. **Iron Ore** is used to make steel for buildings, cars, trucks, planes, trains, and for other construction and containers.

331 lbs. **Salt** is used in various chemicals, for highway deicing, and in food and agriculture.

149 lbs. **Phosphate Rock** is used to make fertilizers to grow food and in animal feed supplements.

149 lbs. **Clays** are used to make floor and wall tile, dinnerware, kitty litter, bricks, cement and paper.

12 lbs. **Aluminum (from bauxite)** is used to make buildings, beverage containers, autos and airplanes.

0.02* lb. **Lithium** – 87% of lithium mined globally is used to make batteries, increasingly important in many technological devices and electric vehicles. **Only partial use amount made public*

12 lbs. **Copper** is used in buildings, transportation, plumbing, electrical and electronic parts, and is integral in renewable energy production.

9 lbs. **Lead** is primarily used in lead-acid batteries in vehicles and other power systems, such as in communications.

5 lbs. **Zinc** is used to make metals rust-resistant, to make various metals and alloys, paints, rubber, and in skin creams, health care and nutritional supplements.

30 lbs. **Soda Ash** is used in all kinds of glass, powdered detergents, medicines, as a food additive, and for water treatment.

4 lbs. **Manganese** is used to make almost all steel for construction, and in machinery and transportation.

645 lbs. **Other Nonmetals** are used in glass, chemicals, soaps, paper, computers, cell phones, and more.

18 lbs. **Other Metals** are used in electronics, TV and video equipment, recreation equipment, and more.

0.04 lb. **Silver** is used in cars, solar technology, batteries and medical equipment.

Including These Energy Fuels

- 1,090 gallons of Petroleum
- 96,314 cu. ft. of Natural Gas
- 2,414 lbs. of Coal
- 0.15 lb. of Uranium

To generate the energy each person uses in one year.

SME Foundation
MEC
MINERALS EDUCATION COALITION

Construction

National Security

"RELIABLE ACCESS TO CRITICAL MINERALS IS A MATTER OF BOTH ECONOMIC AND GEOSTRATEGIC IMPORTANCE TO THE UNITED STATES. ALTHOUGH CONCERN ABOUT ACCESS TO MINERALS WAXES AND WANES, IT IS RISING NOW DUE TO INCREASING DEMAND, NEW COMPETITORS CAPTURING LARGE MARKET SHARES AND OTHER TRENDS THAT DEFY EASY PREDICTION. THESE SAME TRENDS CAN INTERFERE WITH FOREIGN AND DEFENSE POLICY GOALS AND GIVE MINERAL SUPPLIERS EASY LEVERAGE OVER THE UNITED STATES AND OTHER COUNTRIES RELIANT ON GLOBAL SUPPLY CHAINS."

CHRISTINE PARTHEMORE
FORMER FELLOW
CENTER FOR A NEW AMERICAN SECURITY

Top 10 Standard Materials

Used by Department of Defense

		Regular DoD Demand in STONS/YR
1	ALUMINUM METAL	275,219.8
2	COPPER	105,625.8
3	LEAD	88,464.8
4	FLUORSPAR ACID GRADE	56,544.5
5	ZINC	51,085.5
6	RUBBER (NATURAL)	29,490.3
7	MANGANESE ORE CHEM/METAL GRADE	25,041.8
8	NICKEL	17,311.8
9	CHROMIUM FERRO (FERROCHROMIUM)	9,667.8
10	CHROMITE ORE (ALL GRADES)	9,630.5

Source: "Reconfiguration of the National Defense Stockpile Report to Congress," U.S. Department of Defense, April 2009.

USGS
science for a changing world

A World of Minerals in Your Mobile Device

Mobile phones and other high-technology communications devices could not exist without min
of all components in a mobile device—including its electronics, display, battery, speakers, and
semi-processed materials (mineral commodities). Some mineral commodities can be recovered
and processing of other commodities. As an example, bauxite is mined for its aluminum conten
aluminum production process. The images below show the **ore minerals** (sources) of some mi
make components of a mobile device. On the reverse side, the map and table depict the major s
these mineral commodities along with how these commodities are used in mobile devices. For
http://minerals.usgs.gov.

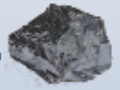
Display

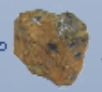
A mobile device's glass screen is very durable because glassmakers combine its main ingredient, **silica** (silicon dioxide or quartz) **sand**, with ceramic materials and then add potassium.

Layers of indium-tin-oxide are used to create transparent circuits in the display. Tin is also the ingredient in circuit board solder, and **cassiterite** is a primary source of tin.

Gallium provides light emitting diode (LED) backlighting. **Bauxite** is the primary source of this commodity.

Sphalerite is the source of indium (used in the screen's conductive coating) and germanium (used in displays and LEDs).





Banner image courtesy of freevector-archive.com

U.S. Department of the Interior
U.S. Geological Survey

Display

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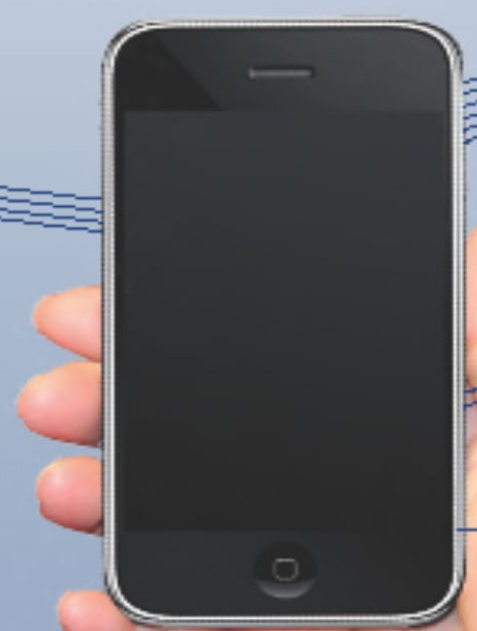
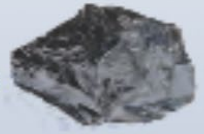


Banner image courtesy of freevector-archive.com

Electronics and Circuitry

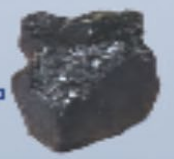
The content of copper in a mobile device far exceeds the amount of any other metal. Copper conducts electricity and heat and comes from the source mineral **chalcopyrite**.

Tetrahedrite is a primary source of silver. Silver-based inks on composite boards create electrical pathways through a device.



Silicon, very abundant in the Earth's crust, is produced from the source mineral quartz and is the basis of integrated circuits.

Arsenopyrite is a source of arsenic, which is used in radio frequency and power amplifiers.



Tantalum, from the source mineral **tantalite**, is added to capacitors to regulate voltage and improve the audio quality of a device.

Wolframite is a source of tungsten, which acts as a heat sink and provides the mass for mobile phone vibration.

Battery

Spodumene and subsurface brines are the sources of lithium used in cathodes of lithium-ion batteries.

Graphite is used for the anodes of lithium-ion batteries because of its electrical and thermal conductivity.

Speakers and Vibration

Bastnaesite is a source of rare-earth elements used to produce magnets in speakers, microphones, and vibration motors.

REE

Lutetium

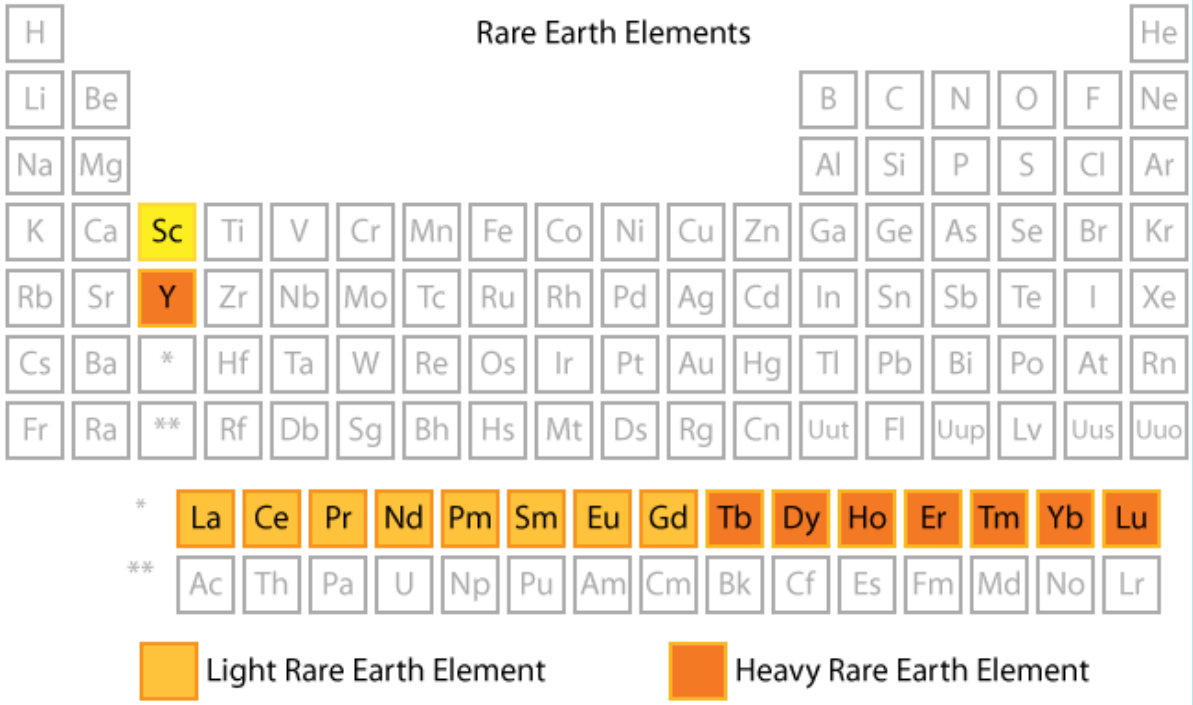
Neodymium

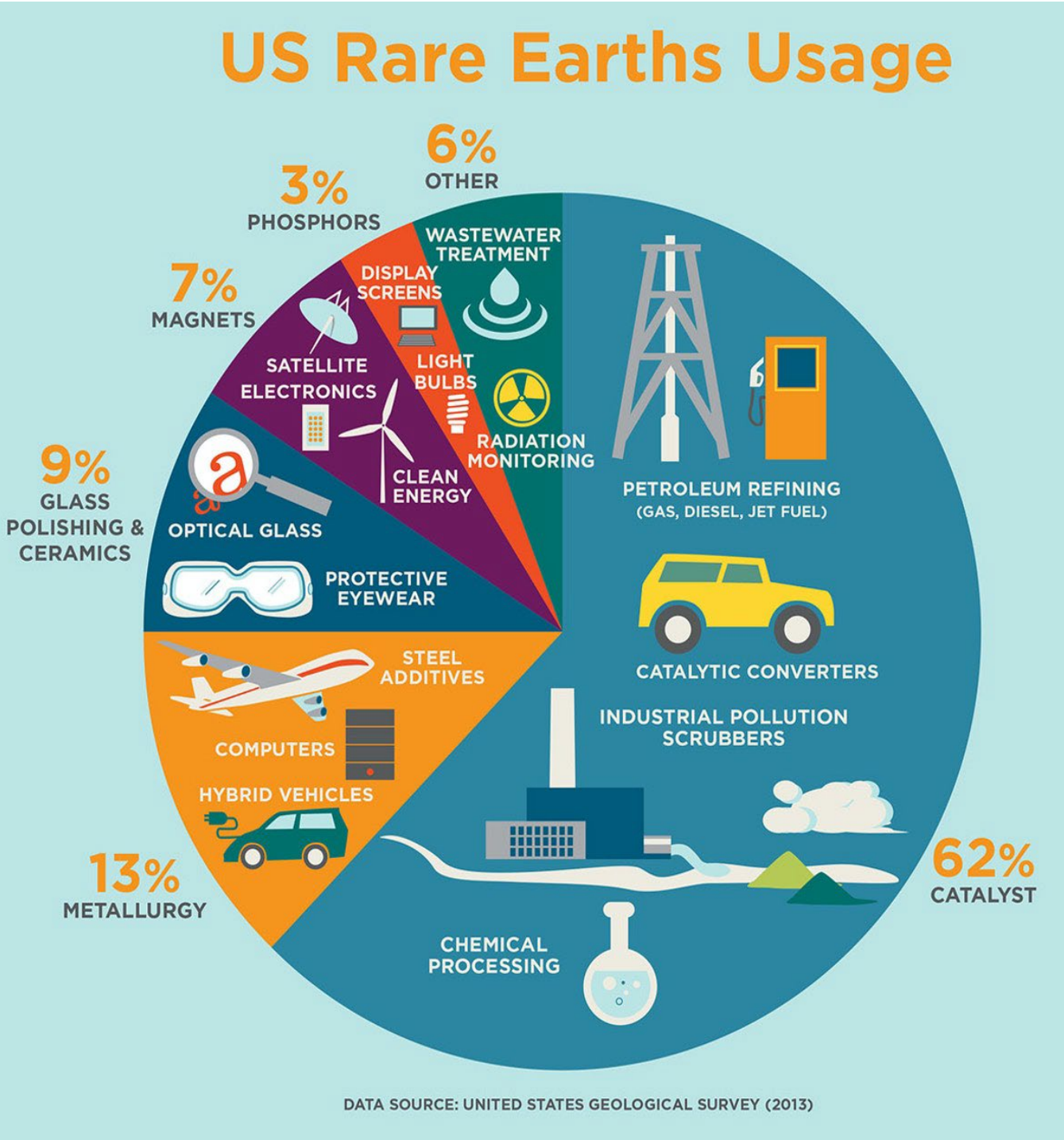
Yttrium

LED light bulbs

Electric Motors

Cancer treatments





REEs

TABLE 9.1 Rare Earth Elements and Their Applications

Element	Example Applications
Yttrium	Metal alloys, visual displays, lasers, lighting
Lanthanum	Optical glass, nickel-metal-hydride batteries
Cerium	Colored glass (flat-panel displays), automobile catalytic converters
Praseodymium	Super-strong magnets, metal alloys, specialty glass, lasers
Neodymium	Permanent magnets
Samarium	Permanent magnets, nuclear reactor control rods, lasers
Europium	Optical fibers, visual displays, lighting
Gadolinium	Shielding in nuclear reactors, X-ray and magnetic resonance imaging scanning systems
Terbium	Visual displays, fuel cells, lighting
Dysprosium	Permanent magnets, lighting
Holmium	Lasers, high-strength magnets, glass coloring
Erbium	Glass coloring, fiber-optic cables
Thulium	Lasers, portable X-ray machines
Ytterbium	Stainless steel, lasers
Lutetium	Petroleum refining

Adapted from Van Gosen et al. (2019).

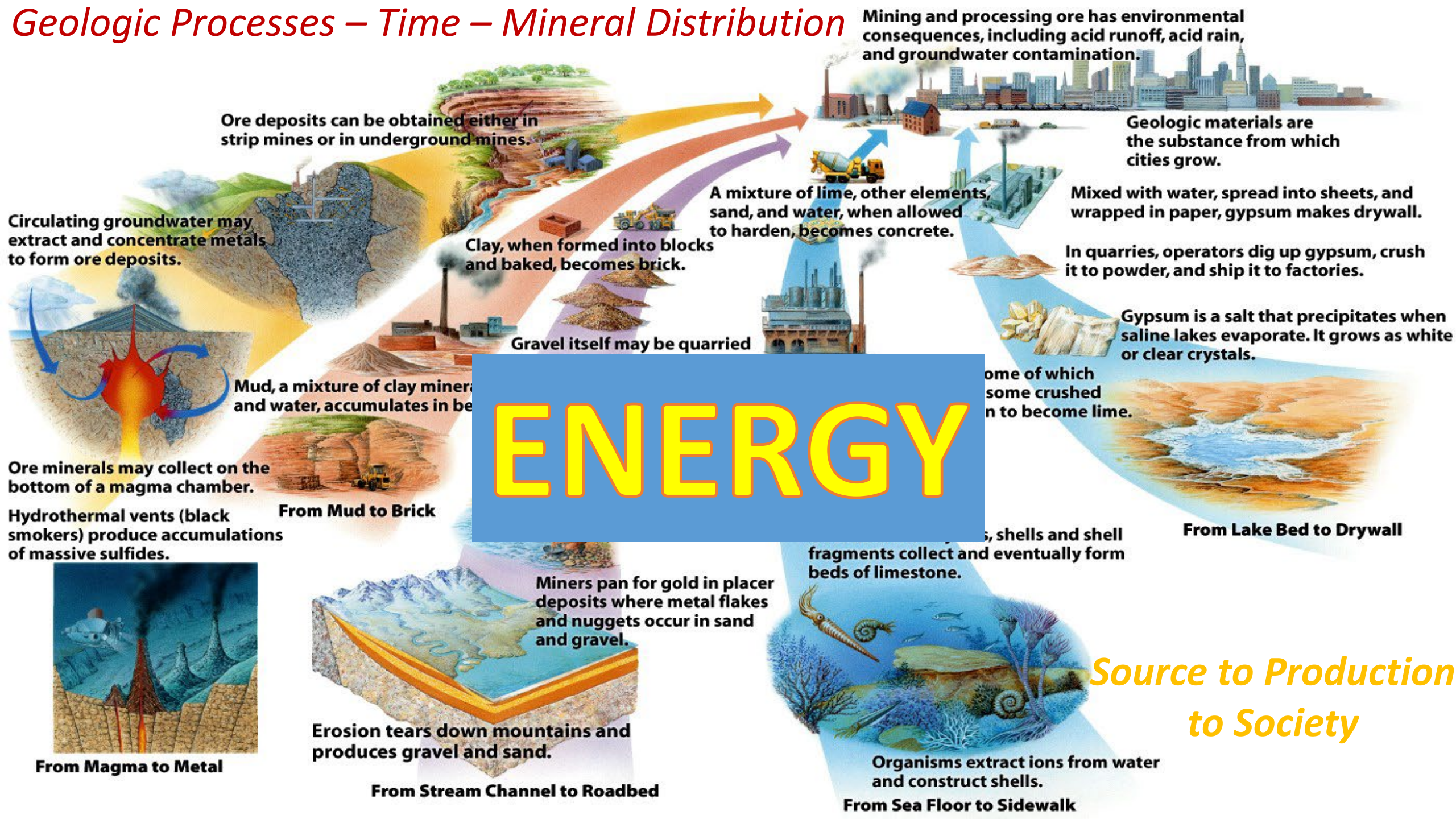
Metallic and Nonmetallic resources

- Mineral

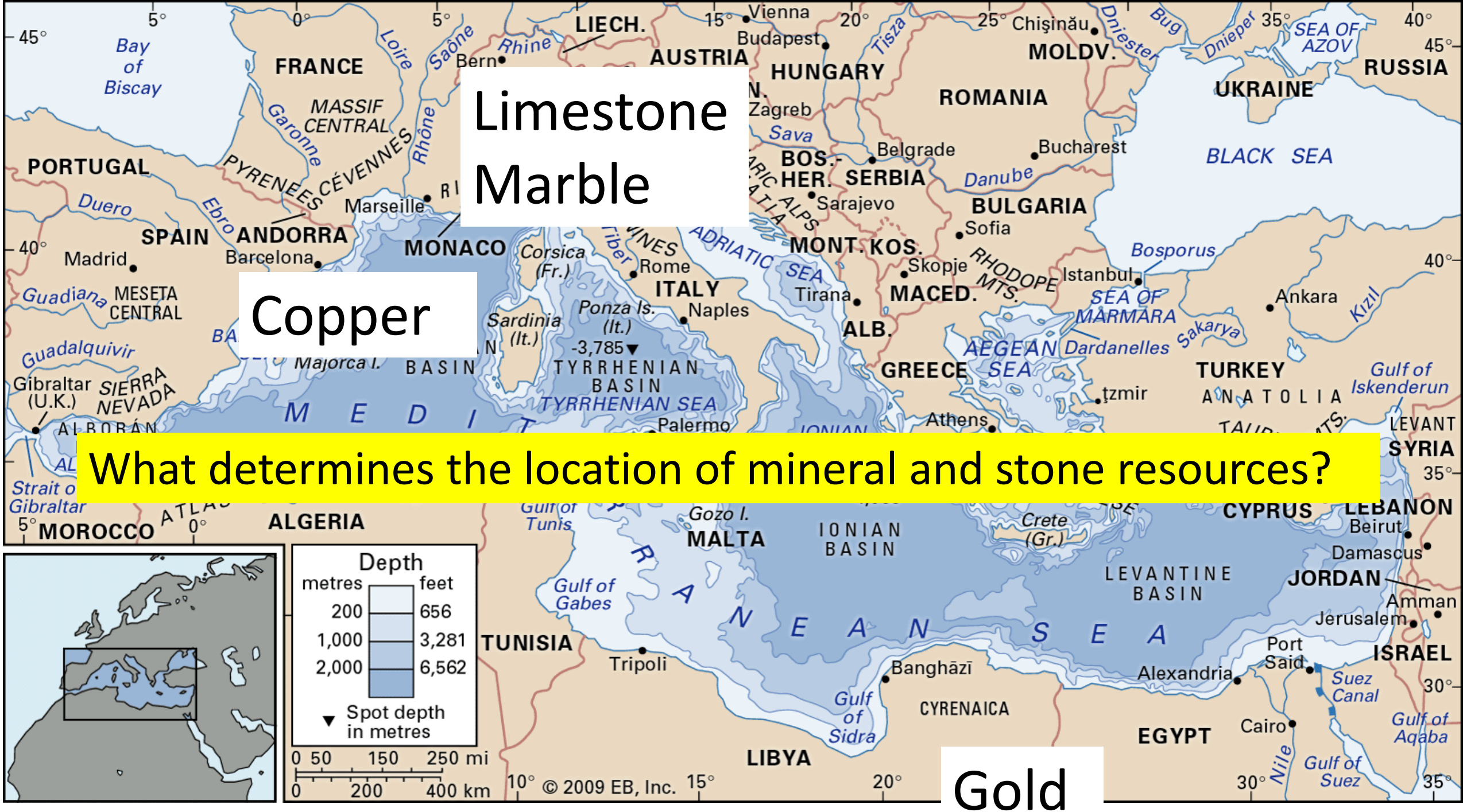
- Rock

- Ore

Geologic Processes – Time – Mineral Distribution



Source to Production to Society


Limestone
Marble
Copper
What determines the location of mineral and stone resources?
Gold
Depth
metres
feet
200
656
1,000
3,281
2,000
6,562
Spot depth in metres
0 50 150 250 mi
0 200 400 km
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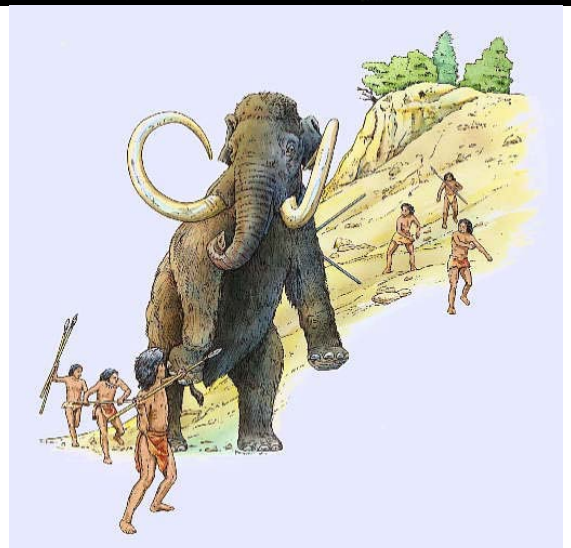
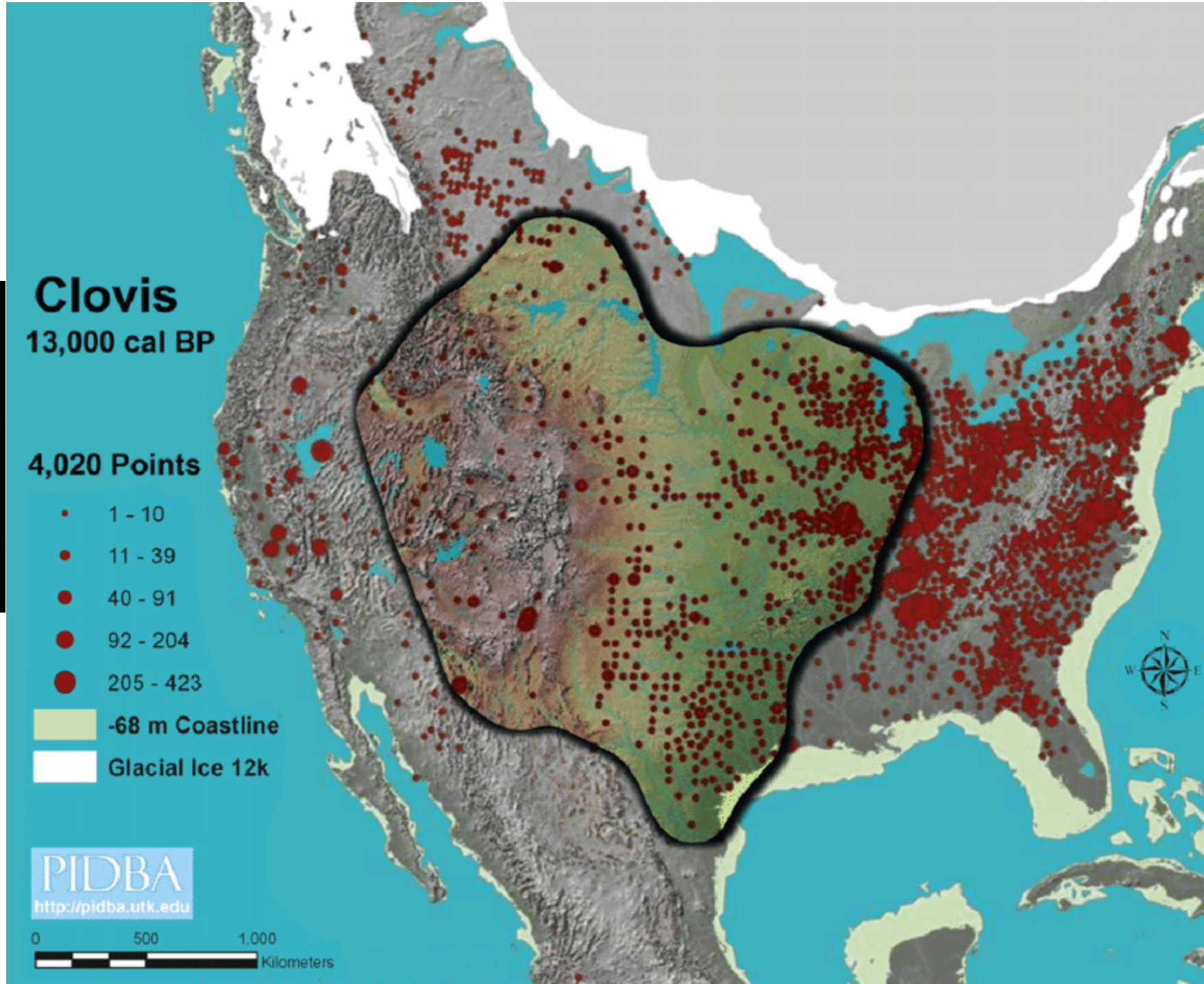
FRANCE
SPAIN
PORTUGAL
ANDORRA
MONACO
LIECH.
AUSTRIA
HUNGARY
ROMANIA
MOLDV.
UKRAINE
RUSSIA
BULGARIA
SERBIA
BOS.-HER.
MONT.
KOS.
MACED.
ALB.
GREECE
ITALY
TURKEY
SYRIA
LEBANON
CYPRUS
ISRAEL
JORDAN
EGYPT
LIBYA
TUNISIA
ALGERIA
MOROCCO
MALTA
Bay of Biscay
Loire
Saône
Rhine
Garonne
Rhône
Duero
Ebro
Guadiana
Guadalquivir
Sava
Danube
Dniester
Bug
Dnieper
Tisza
SEA OF AZOV
BLACK SEA
Bosporus
SEA OF MARMARA
Dardanelles
AEGEAN SEA
ADRIATIC SEA
TYRRHENIAN SEA
IONIAN BASIN
LEVANTINE BASIN
Gulf of Gabes
Gulf of Sidra
Gulf of Suez
Suez Canal
Gulf of Aqaba
Gulf of Iskenderun
Nile
Sakarya
Kizil
Strait of Gibraltar
Vienna
Budapest
Zagreb
Belgrade
Bucharest
Sarajevo
Sofia
Skopje
Tirana
Istanbul
Ankara
İzmir
Athens
Rome
Naples
Palermo
Marseille
Barcelona
Madrid
Bern
Chişinău
Tripoli
Banghāzī
Alexandria
Port Said
Cairo
Jerusalem
Amman
Damascus
Beirut
Corsica (Fr.)
Sardinia (It.)
Majorca I.
Ponza Is. (It.)
-3,785
Gozo I.
Crete (Gr.)
CYRENAICA
MESETA CENTRAL
SIERRA NEVADA
MASSIF CENTRAL
PYRENEES
CÉVENNES
ALPS
RHODOPE MTS.
ATLAS

Concepts

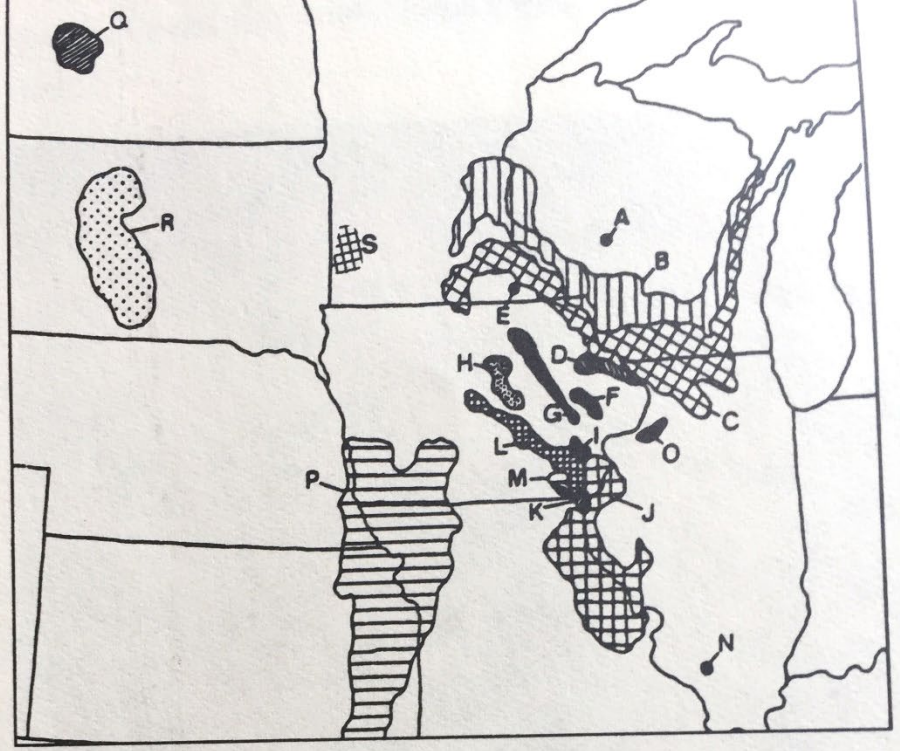
- Uneven distribution
- Quarries vs Pits
- Aggregate vs Sediment
- Cement vs Concrete

Technology




Clovis
13,000 cal BP
4,020 Points
1 - 10
11 - 39
40 - 91
92 - 204
205 - 423
-68 m Coastline
Glacial Ice 12k
PIDBA
http://pidba.utk.edu
0
500
1,000
Kilometers

Local stone – Knapping



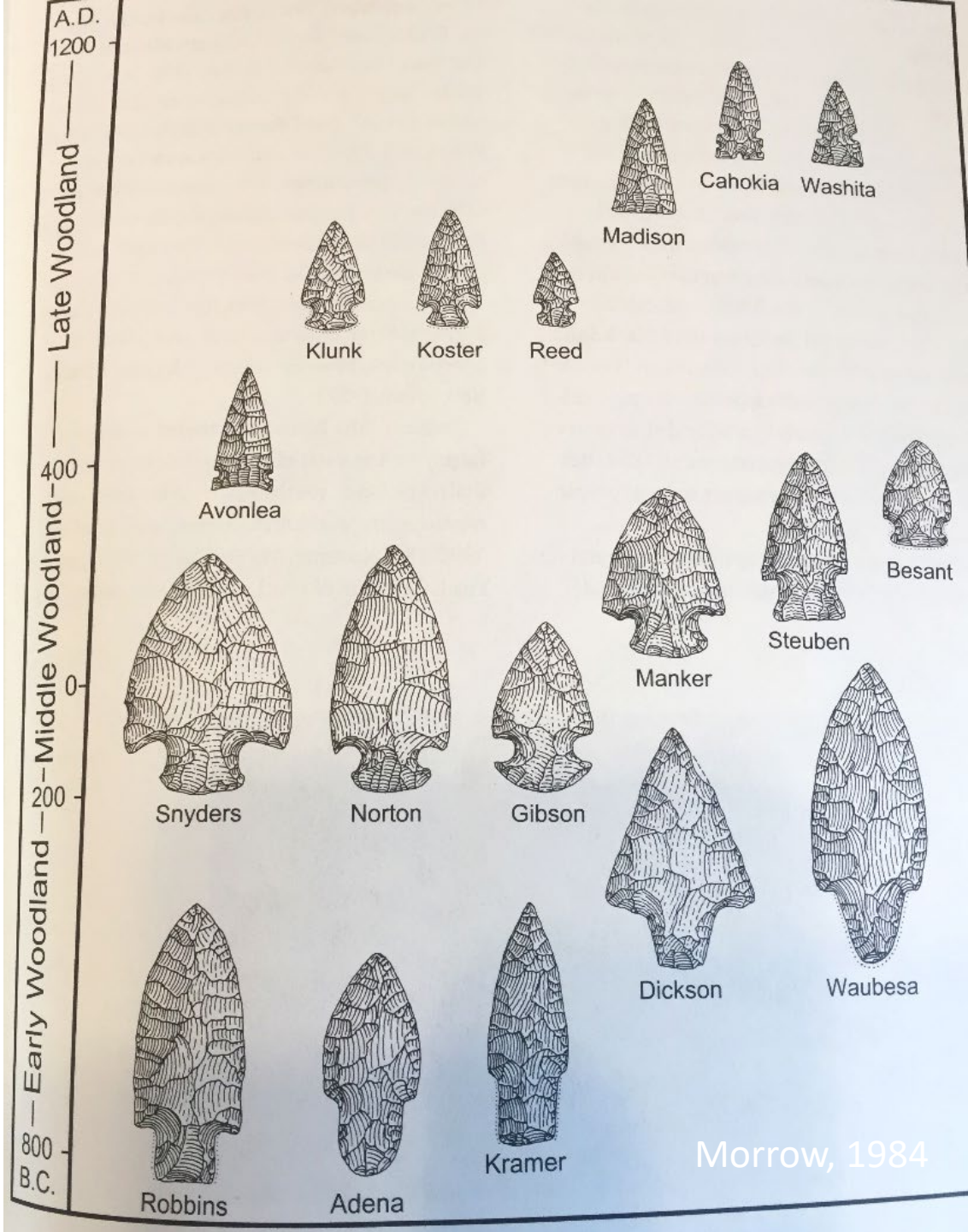
3.6. Outcrop locations of lithic materials commonly found in Iowa sites. (A) Hixton silicified sandstone; (B) Prairie du Chien cherts; (C) Galena/Platteville chert; (D) various Silurian cherts; (E) Grand Meadow chert; (F) Wapsipinicon chert; (G) Rapid chert; (H) Maynes Creek cherts; (I) Wassonville chert; (J) Burlington cherts; (K) Keokuk chert; (L) Croton cherts; (M) Spergen chert; (N) Cobden chert; (O) Moline chert; (P) Missourian and Virgilian series cherts; (Q) Knife River flint; (R) Bijou Hills silicified sediment; (S) Minnesota catlinite, or pipestone. After Morrow 1994.

Technology

Gazette, **January 27, 2017**

Woodland Innovation

Mound burials, Pottery, Plant cultivation



Morrow, 1984

Burials

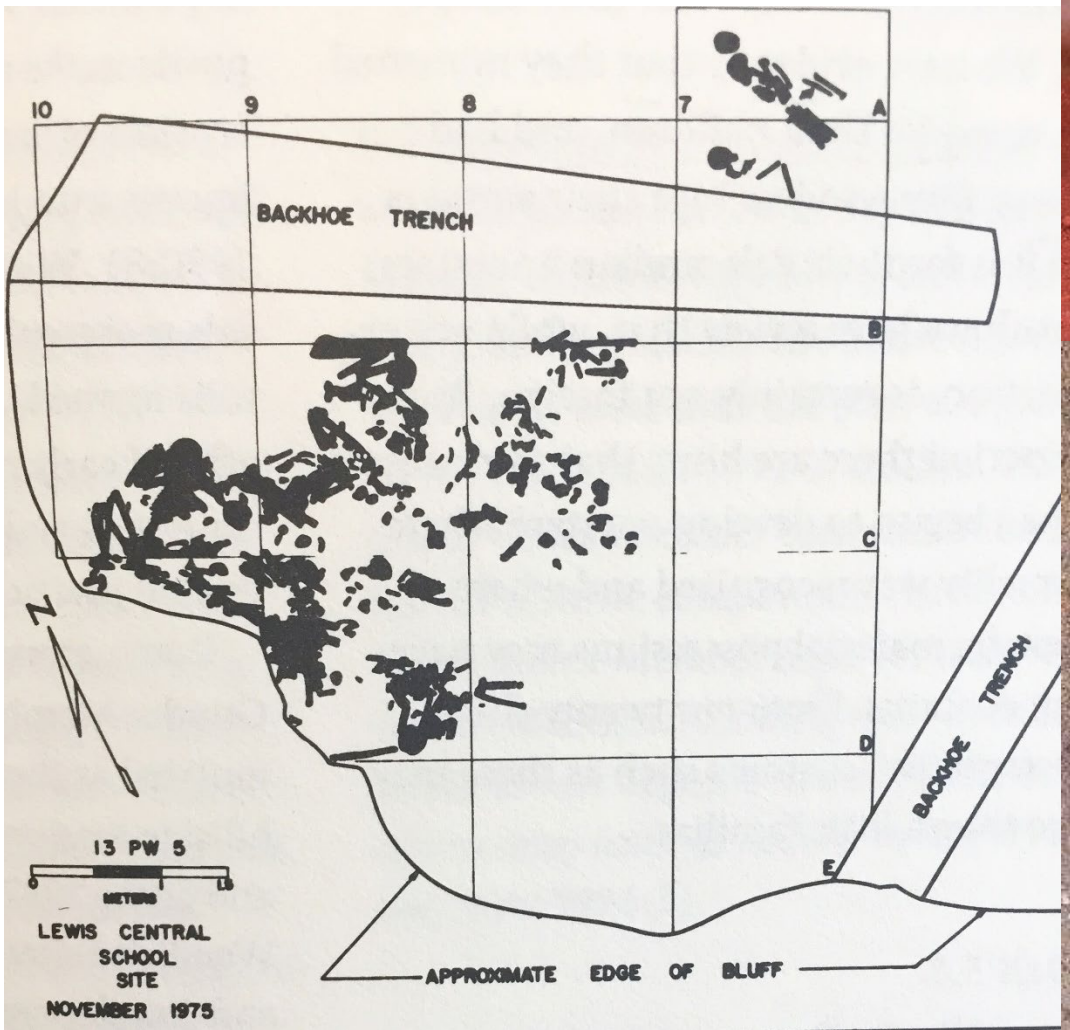
End of Archaic IA, Communal sites

Goods – Copper beads, Galena cubes, Exotic lithics, Red Ochre

Flexed vs. Mass

Status vs. Skill

Mourning & sense of place



Metallurgy

Begins archaic, Est. 3800 BCE

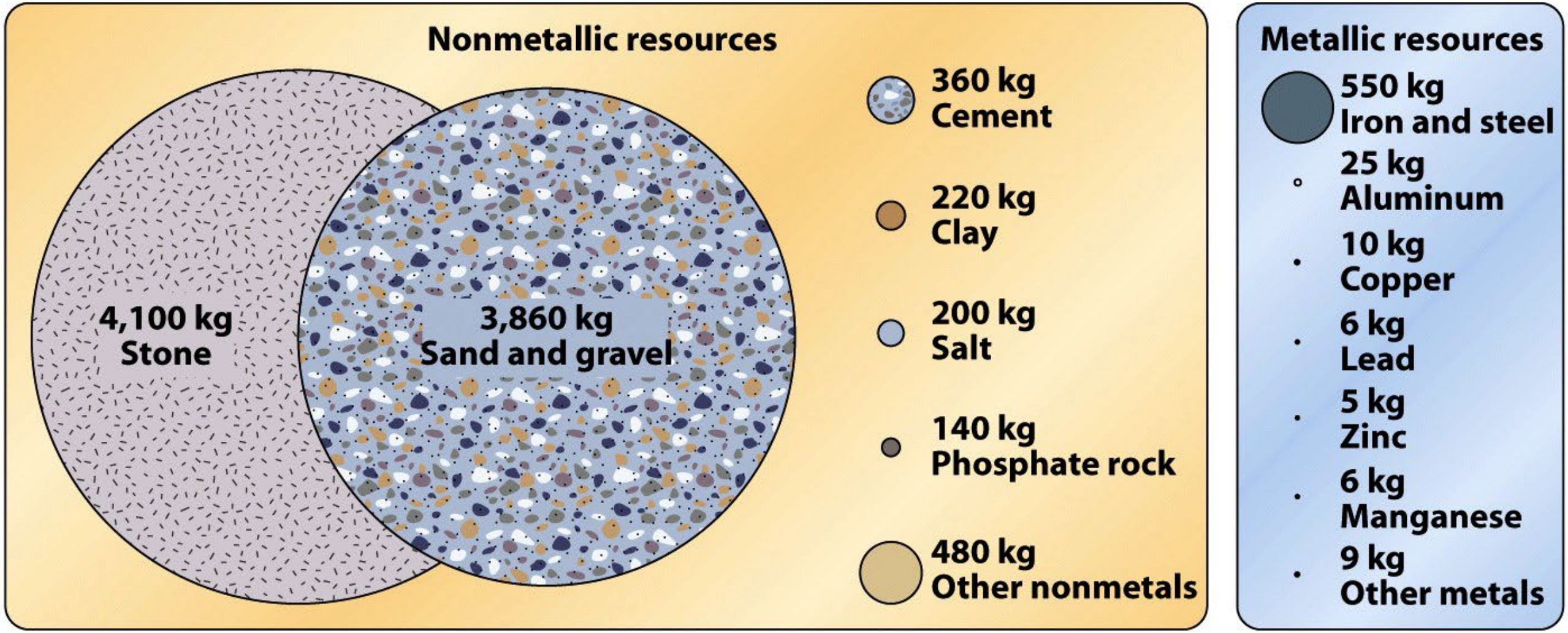
Source WI – MN

Trial and Error to annealing

Products – points, beads, hooks, awls, pendants

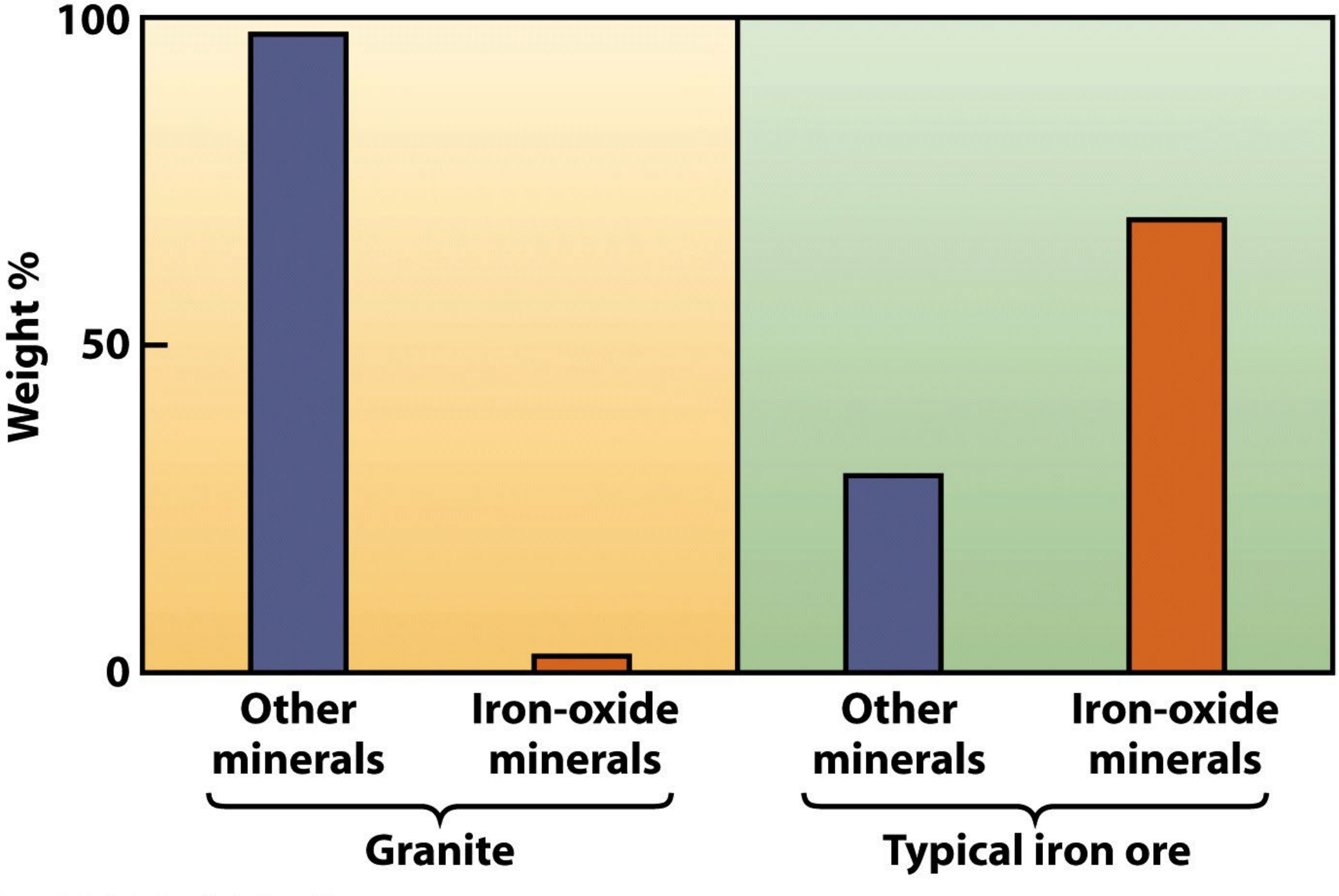
Eastern Iowa

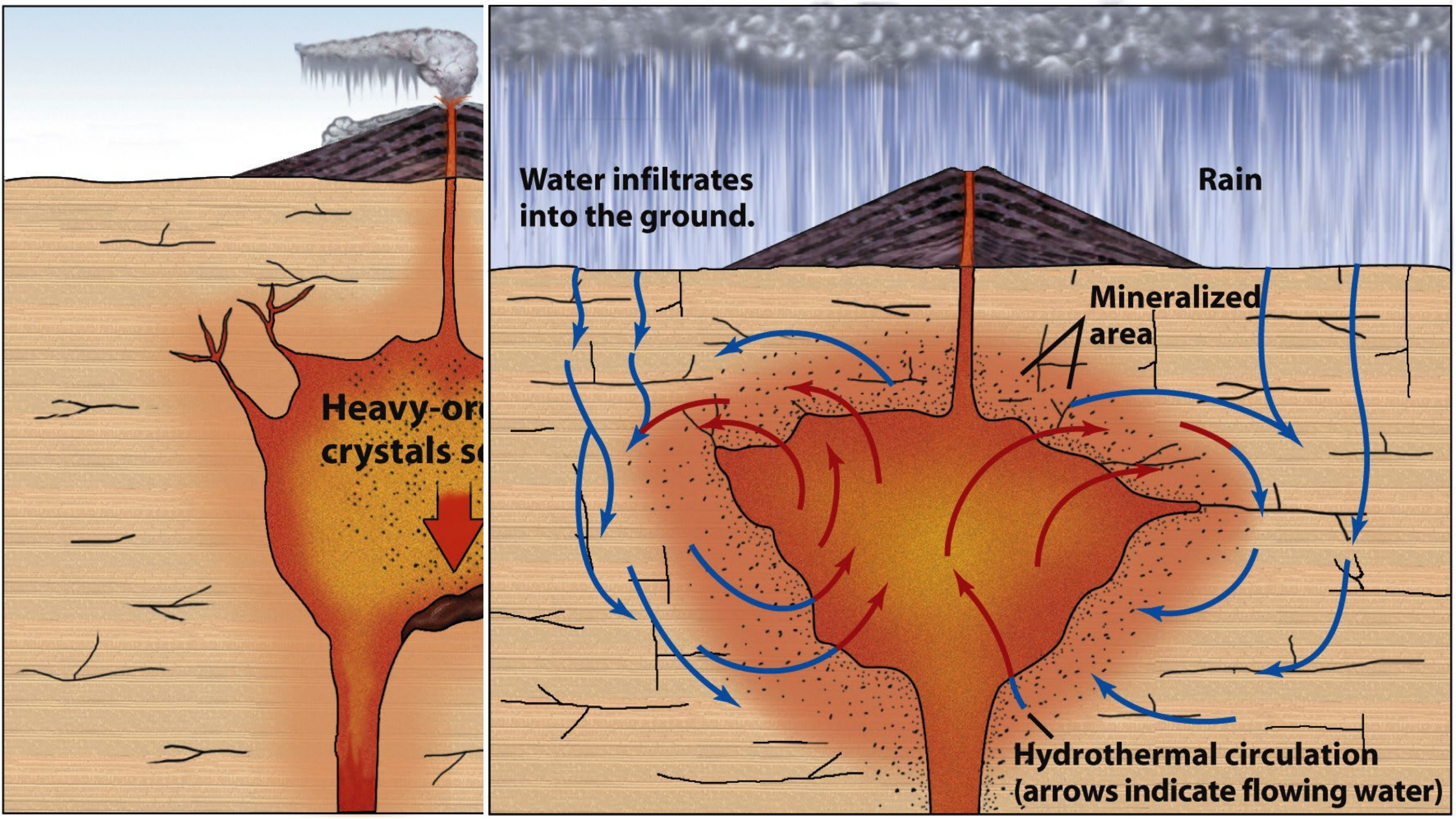

Varna Necropolis

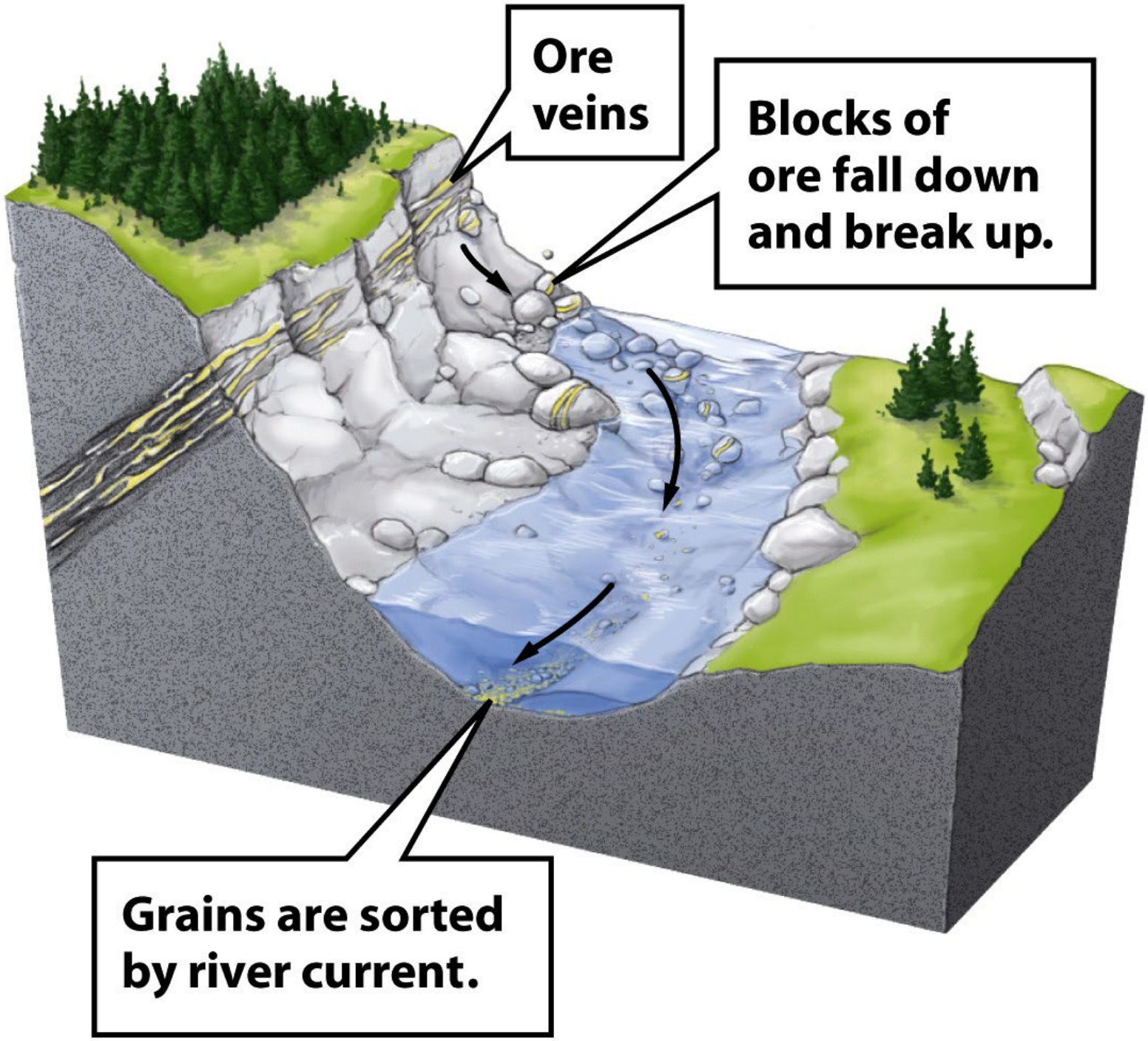

Nonmetallic resources
4,100 kg
Stone
3,860 kg
Sand and gravel
360 kg
Cement
220 kg
Clay
200 kg
Salt
140 kg
Phosphate rock
480 kg
Other nonmetals
Metallic resources
550 kg
Iron and steel
25 kg
Aluminum
10 kg
Copper
6 kg
Lead
5 kg
Zinc
6 kg
Manganese
9 kg
Other metals

Metal	Mineral Name	Chemical Formula
Copper	Chalcocite	Cu_2S
	Chalcopyrite	$CuFeS_2$
	Bornite	Cu_5FeS_4
	Azurite	$Cu_3(CO_3)_2(OH)_2$
	Malachite	$Cu_2(CO_3)(OH)_2$
Iron	Hematite	Fe_2O_3
	Magnetite	Fe_3O_4
Tin	Cassiterite	SnO_2
Lead	Galena	PbS
Mercury	Cinnabar	HgS
Zinc	Sphalerite	ZnS
Aluminum	Kaolinite	$Al_2Si_2O_5(OH)_4$
	Corundum	Al_2O_3
Chrome	Chromite	$(Fe,Mg)(Cr,Al,Fe)2O_4$
Nickel	Pentlandite	$(Ni,Fe)_9S_8$
Titanium	Rutile	TiO_2
	Ilmenite	$FeTiO_3$
Tungsten	Sheelite	$CaWO_4$
Molybdenum	Molybdenite	MoS_2
Magnesium	Magnesite	$MgCO_3$
	Dolomite	$CaMg(CO_3)_2$
Manganese	Pyrolusite	MnO_2
	Rhodochrosite	$MnCO_3$

Metal	World Resources	U.S. Resources
Iron	120	40
Aluminum	330	2
Copper	65	40
Lead	20	40
Zinc	30	25
Gold	30	20
Platinum	45	1
Nickel	75	less than 1
Cobalt	50	less than 1
Manganese	70	0
Chromium	75	0

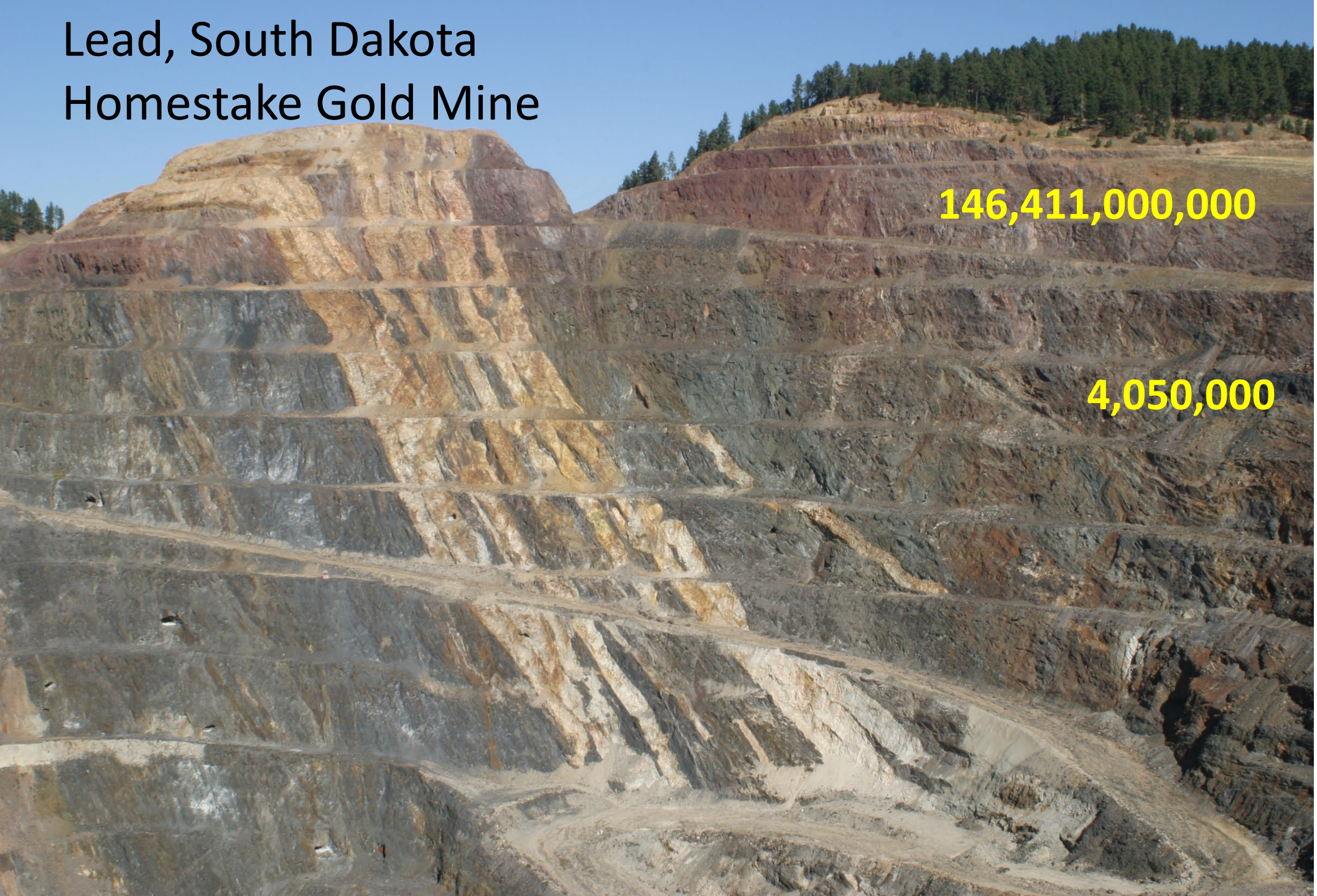

100
50
0
Weight %
Other minerals
Iron-oxide minerals
Other minerals
Iron-oxide minerals
Granite
Typical iron ore


Heavy-or
crystals s
Water infiltrates
into the ground.
Rain
Mineralized
area
Hydrothermal circulation
(arrows indicate flowing water)


Ore veins
Blocks of ore fall down and break up.
Grains are sorted by river current.

Open pit Mining

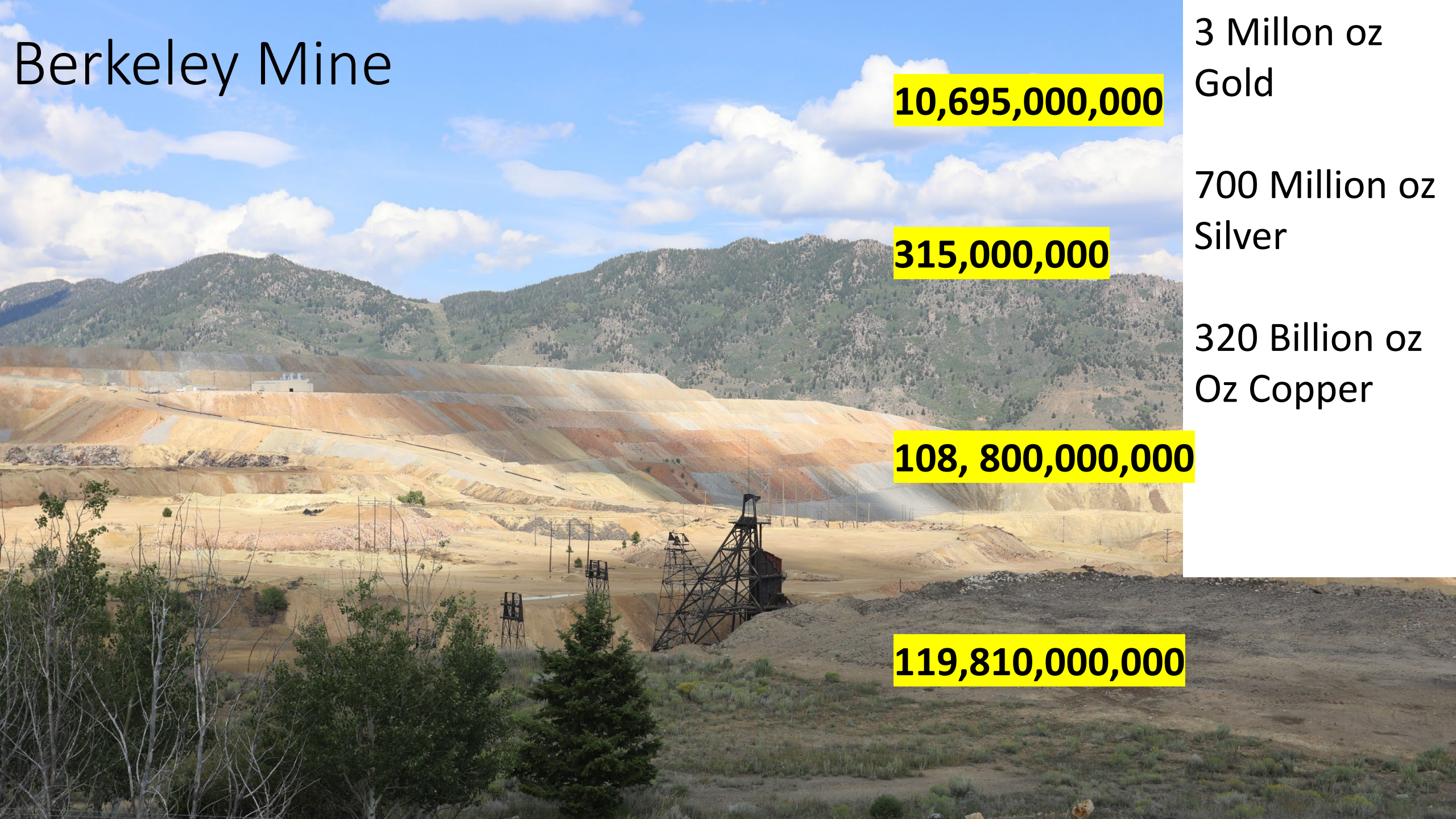

© K.C. Wald 2007



41 million oz, Gold

9 million oz Silver

Berkeley Mine



10,695,000,000

3 Millon oz Gold

315,000,000

700 Million oz Silver

108, 800,000,000

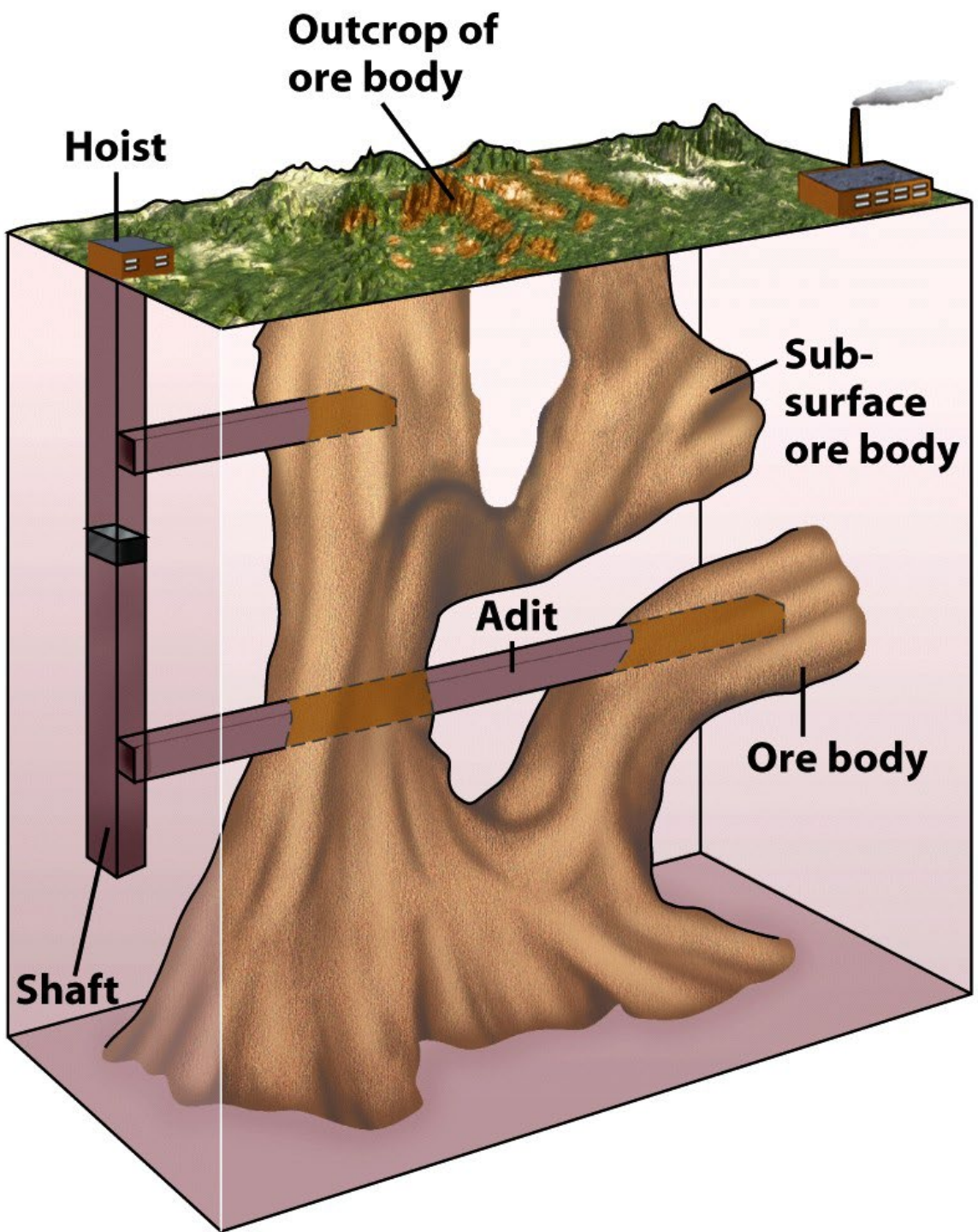
320 Billion oz Oz Copper

119,810,000,000

Banded Iron Formation (BIF)


MSA


PAUL R. TREGURTHA
THE
INTERLAKE
STEAMSHIP CO.



Underground mining

Minerals Create Economic Growth

Jobs and Wages

- A job in U.S. metals mining carries an average salary of approximately $85,500 a year—74 percent higher than the combined average of all private sector jobs.

- More than 1.3 million U.S. jobs are supported through minerals mining — 433,000 Americans are directly employed and more than 872,000 are indirectly employed.

- For every job in metals mining, an estimated 2.9 additional jobs are generated, and for every nonmetals mining job, an additional 1.8 jobs are created.

BMG

Martin Marietta Materials

IOWA LIMESTONE
PRODUCERS ASSOCIATION
Your limestone resource since 1945!

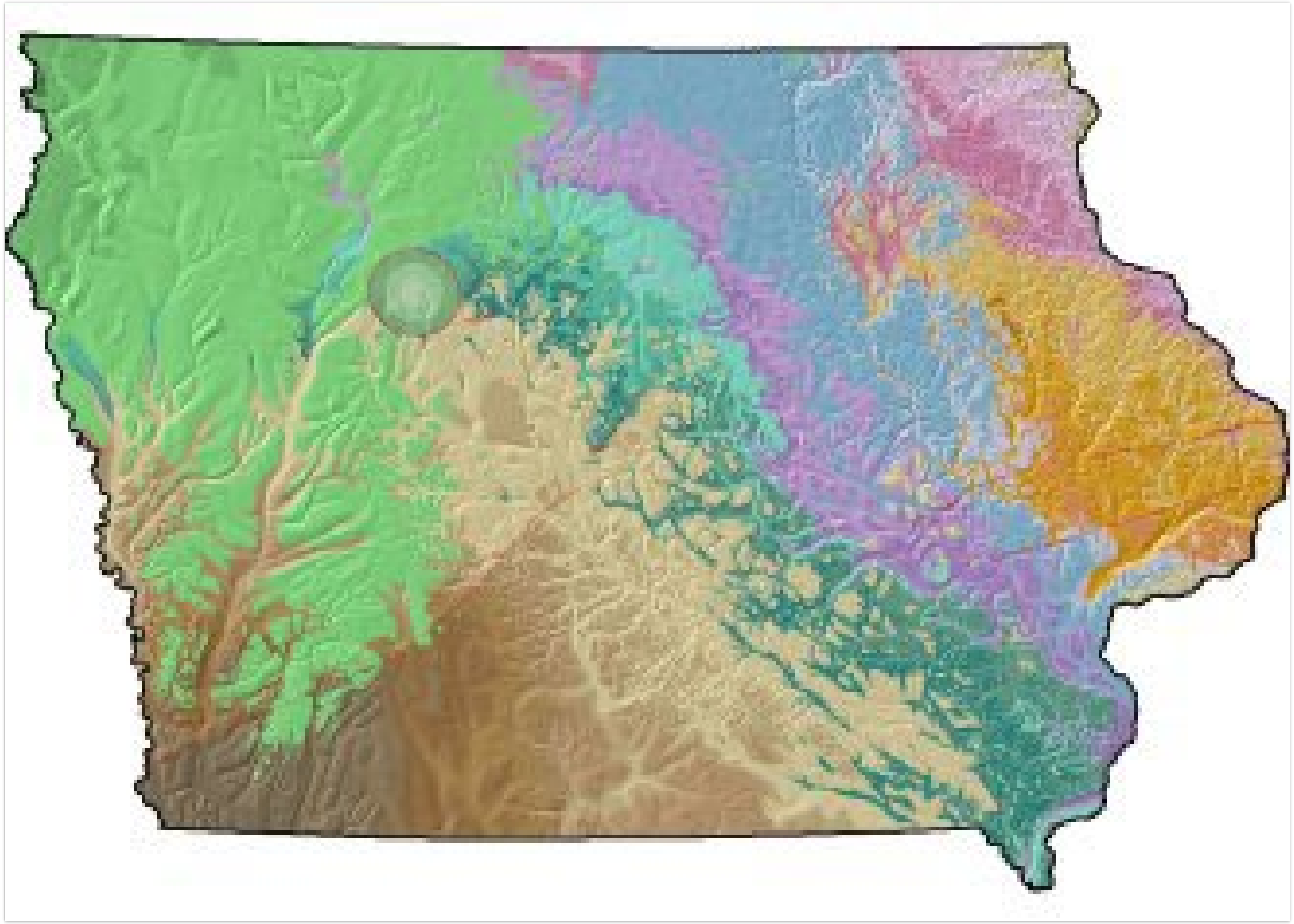
www.limestone.org

RIVER PRODUCTS COMPANY
IOWA CITY, IOWA

Wendling Quarries Inc.

Iowa's Minerals

- Galena
  - Lead
  - Zinc
- Gypsum
- Silica sand
- Iron



Metallic minerals

Iowa Lead & Zinc

- Near Dubuque, Iowa
- Start approx. 1650
- Peak 1830 to 1860
- End 1910

Dubuque, Iowa

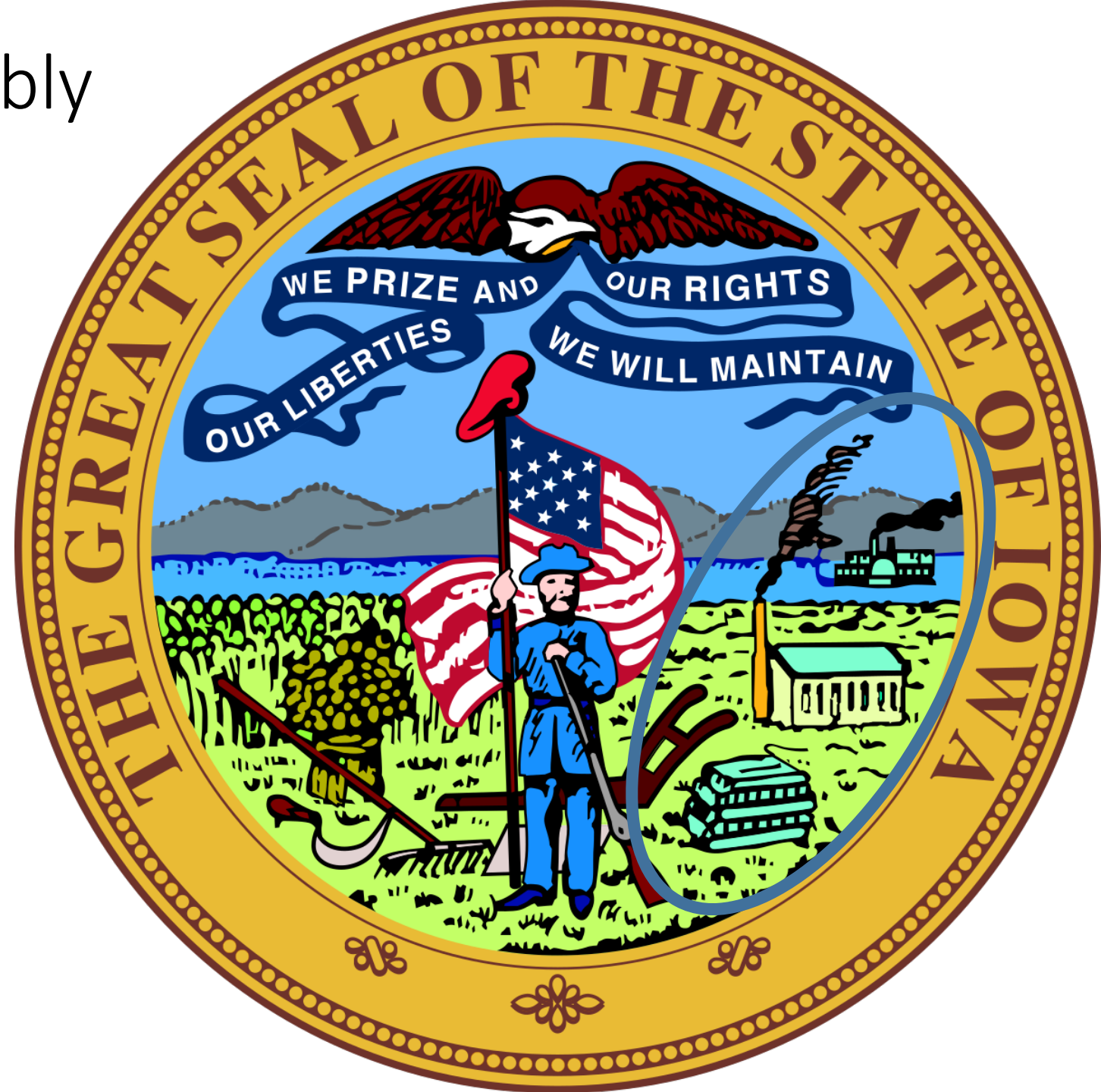
1847 First General Assembly

1852 Iowa Produced

87% of the U.S.A.'s Lead

and

10% of the global Lead.



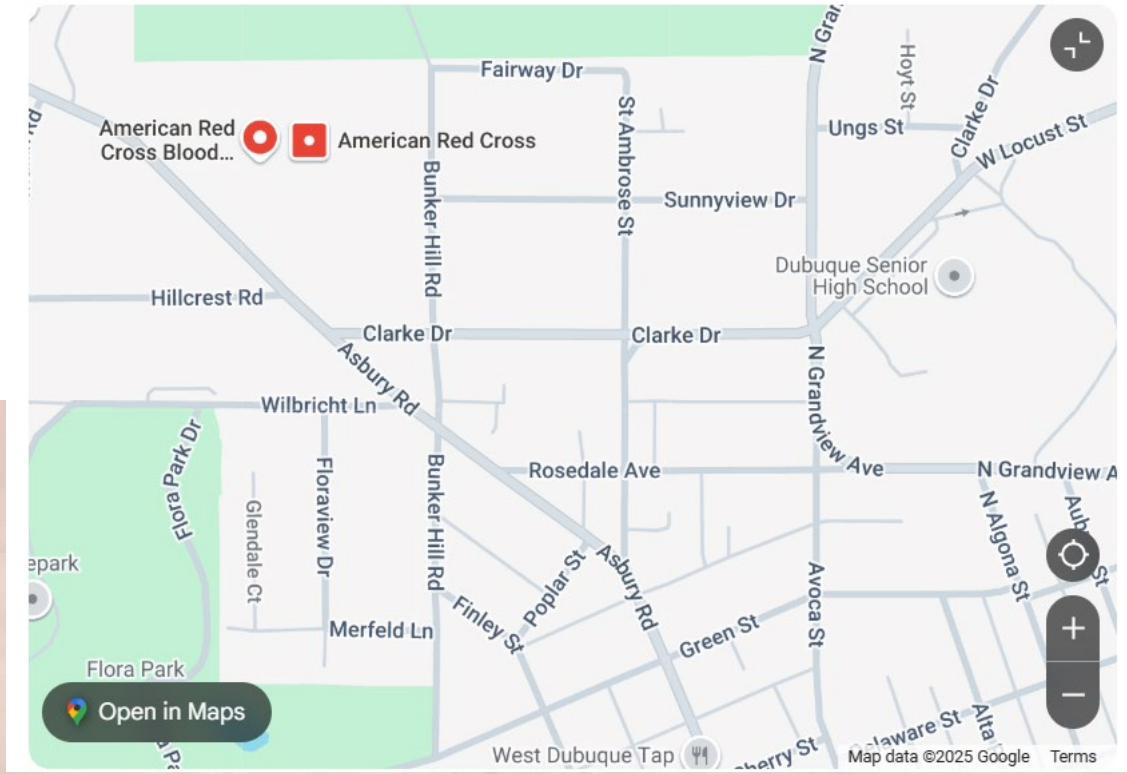
St. Joseph’s Asylum

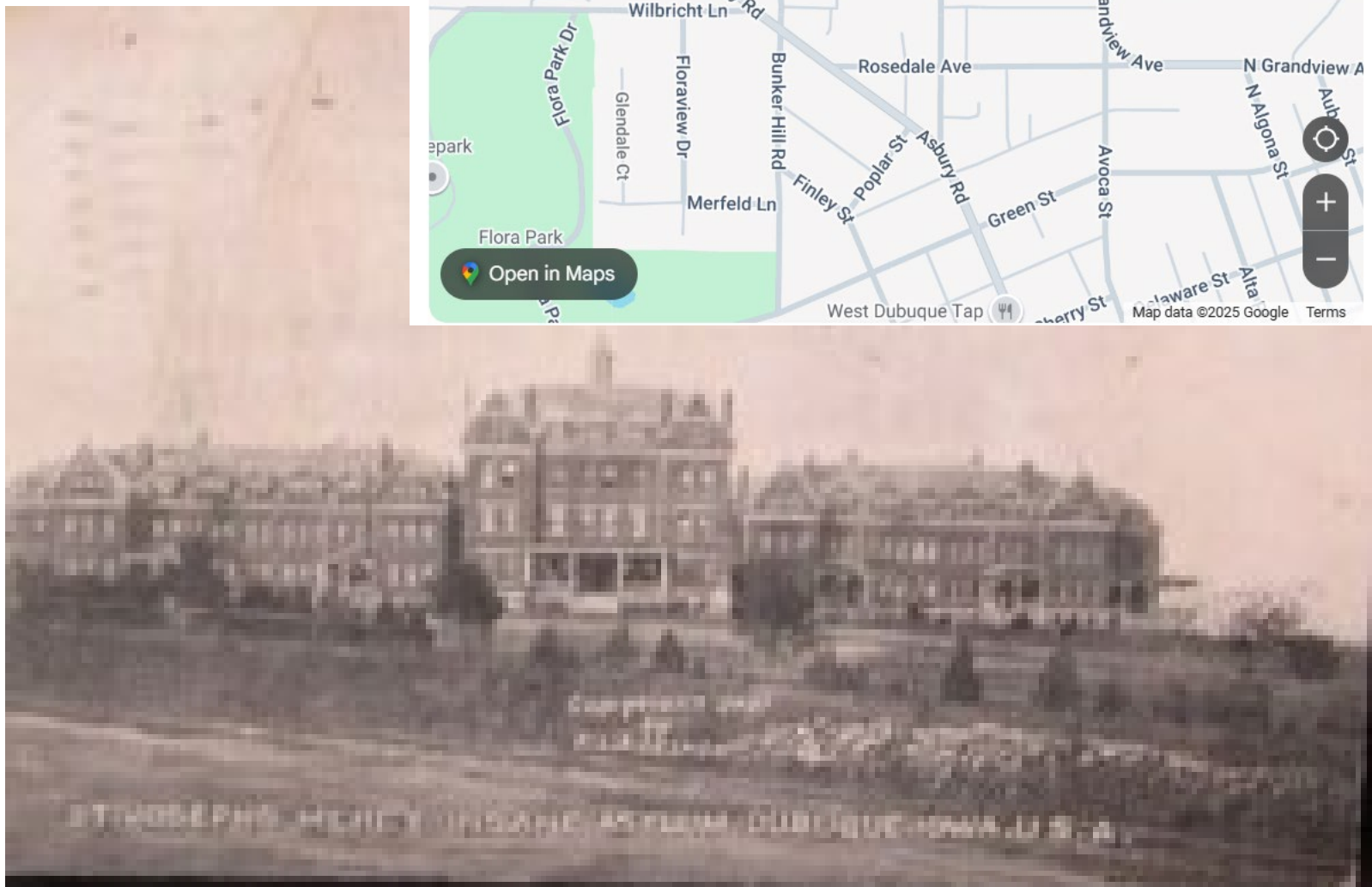
Construction began 1895

Could house 210 patients

Had 3 padded rooms

Could lead have been a contributing factor?





Iowa – Iron ore

- Waukon, Allamakee County
- Iron Hill deposit
- First mined in 1899
- Missouri Iron Company of St. Louis operated a plant in Iowa until 1918.

Non – Metallic

Iowa – Clay

- In 1900 there were 381 clay companies operating in 89 of Iowa's counties!
- Shale bedrock, river alluvium, glacial sediment
- Produced brick and tile
- Today only 3 companies mine clay for bricks in Dallas and Woodbury counties

Iowa – Cement

- Burnt lime via kiln fired limestone.
  - Calcining to produce quicklime or calcium oxide
  - $CaCO_3$ + Heat → CaO + CO_2(g)
- Silurian Age Dolostone
  - Hopkinton Formation
    - Farmers Creek Member
    - Marcus Member
- Jackson and Cedar Counties

Iowa - Portland Cement

- Hardens underwater
- Put Kiln burning out of business
- Four plants continue to operate in Cerro Grodo, Polk, and Scott counties.
- Accounts for approx. 40% of mineral production today in Iowa.

Iowa - Stone

- 19th century construction
- Primary production centers include Cedar, Jones, Des Moines, Marshall, Lee, Madison and Jackson counties
- In 1982, crushed stone surpassed Portland Cement as Iowa's leading mineral commodity
- There are nearly 500 registered quarries in Iowa today

Iowa – Gypsum

- Fort Dodge, Iowa 1850
- Two million tons per year at a value of $12 million
- Products
  - Wall board
  - Portland cement

Iowa – Sand and Gravel

- Important resource for Iowa's roads and construction.
- In Iowa's river valleys past and present…
- Approx. 16 million tons per year are mined per year at a value of approx. $60 million.

HUMANS DEPEND ON THE EARTH FOR RESOURCES

Earth is our home; its resources mold civilizations, drive human exploration, and inspire human endeavors that include art, literature, and science. We depend upon Earth for sustenance, comfort, places to live and play, and spiritual inspiration.

Geology affects the distribution and development of human populations. Human populations have historically concentrated at sites that are geologically advantageous to commerce, food production, and other aspects of civilization.

Natural resources are limited. Earth's natural resources provide the foundation for all of human society's physical needs. Most are nonrenewable on human time scales, and many will run critically low in the near future.

Resources are distributed unevenly around the planet. Resource distribution is a result of how and where geologic processes have occurred in the past, and has extremely important social, economic, and political implications.

Earth scientists help society move toward greater sustainability. Renewable energy sources, such as solar, wind, hydroelectric, and geothermal, are being developed. They will replace fossil fuels as those become scarcer, more expensive to retrieve from Earth, and undesirable due to environmental damage. Earth scientists foster global cooperation and science-informed stewardship that can help to ensure the availability of resources for future generations.