ME589/GEOC589 Advanced Topics

REE in Coal

Introduction

Virginia T. McLemore

Safety

- Start each class with a safety moment
  - Each student will be responsible for the day's safety moment
- Note where the restrooms are, emergency exits
- Call 911 in case of an emergency

Safety—cont

- **Always make sure that you have full instructions for the job to be done.**
  - Always know your objectives before starting your job.
  - Make sure you have read the SOPs relating to your job ahead of time.
    - **WHAT ARE SOPs?**
  - Make sure that you have copies of the SOPs with you.

Virginia T. McLemore

- Principal Senior Economic Geologist with the New Mexico Bureau of Mines and Mineral Resources (NMBGMR) since 1980
- Adjunct Professor with the Departments of Earth and Environmental Sciences, and Mineral Engineering at New Mexico Tech
- Worked on mineral-resource assessments and research projects on mineral resources in NM since 1980, including REE, uranium, and beryllium and other critical minerals deposits in NM
- Published more than 400 journal articles, books, and other reports
- New Mexico Tech, B.S. 1977, M.S. 1980; University of Texas at El Paso, Ph.D. 1993; Certified Professional Geologist CPG #7438

Class introductions

Name, where from, graduated, degree here

What do you expect to learn from this course?

CLASS REQUIREMENTS

Goals in this class

- How coal is formed
- Where coal is found in New Mexico
- Source of REE and critical minerals in coal
- Evaluate the potential of REE and other critical minerals in coal deposits in New Mexico, including in mine waste products
- Compare New Mexico coal deposits to other coal deposits in the world that contain REE and other critical minerals

Other

- Field trips will examine coal deposits in New Mexico
- Lab exercises will examine drill core and hand specimens
- Discuss how sampling plans are developed
- Petrographic and chemical analyses of coal
- SOPs and sampling plans
- Mine safety
- Other aspects of coal geology

Class

- The class will meet one day per week for 2-3 hrs—Tuesdays
- Remaining time spent on field trips or in occasional extra discussion sessions (other presentations, guest speakers)
  - Industrial Minerals Forum (Thursday) https://isgswikis.web.illinois.edu/FGIM/index.php/Main_Page
- May require extra time for the project presentations

Registration & Call for Abstracts 57th FGIM, 2021, Illinois

Abstracts

August 26th, 9:00 am - 4:00 pm

Time (CST)	Title	Author(s)
9:00 am	Well Looky Here! An Aggregate Project in Southwest Texas Gets an Unexpected Surprise – a Case Study in Deposit Optimization	Michelle M. Lee
9:30	"Slippery When Wet" – Road Surfacing Aggregate for a Wetter World	John Cowley
10:00	Sustainability in Midwestern Crushed Stone Aggregate Production	Donald G. Mikulic
10:30	Aggregate Evaluation Practices in the Laboratory, Have We Been Over Mitigating Our Concrete Aggregates?	Chris Braaten
11:00	Adapting Mineral Resource Estimates Across Software Packages	Gavin Clarkson
11:30	New Natural Pozzolan Ash Meadows California	Dan Eyde & Steve Wulfenstein
12:00	**Lunch Break**	
1:00 pm	Climate Change and Its Potential Effects on Potash Producers	Mark D. Cocker
1:30	Bauxite Red Mud Residue as a Mineral Resource	Mark D. Cocker, Floyd Gray, & Greta J. Orris
2:00	'Critical', 'Magnet', 'Battery', and Photovoltaic Materials – Market Facts and Hype: Implications for Responsible Exploration and Development Decision-making	Laura Simandl, George J. Simandl, & Suzanne Paradis
2:30	The Illinois Basin Carbon Ore, Rare Earth, and Critical Mineral Initiative (IB CORE-CM)	Jared T. Freiburg, Scott Elrick, & Franck Delpomdor
3:00	Rare Earth Extraction from Phosphorites as Byproducts of Fertilizer Mining	M. Humayun & T. A. Herbert
3:30	Mineralogical and Chemical Types of REE Mimeral Deposits in the Gallinas Mountains (Gallinas District), Lincoln County, New Mexico	V.T. McLemore, E. Owen, E. Haff, S.K. Kelley, M. Zimmerer, & A. Gysi

Lectures found on my web site

http://geoinfo.nmt.edu/staff/mclemore/home.html

or

https://geoinfo.nmt.edu/staff/mclemore/MineraldepositsofNewMexico.html

Textbooks

- Hoffman, G.K., 2016, Coal, *in* McLemore, V.T., Timmons, S., and Wilks, M., eds., Energy and mineral resources of New Mexico: New Mexico Bureau of Geology and Mineral Resources Memoir 50B, and New Mexico Geological Society Special Publication 13B, 80 p.

- Committee on Critical Mineral Impacts of the U.S. Economy, 2008, Minerals, Critical Minerals, and the U.S. Economy: Committee on Earth Resources, National Research Council, ISBN: 0-309-11283-4, 264 p., download from http://www.nap.edu/catalog.php?record_id=12034#toc

- Papers as assigned

Memoir 50—Energy and Mineral Resources of New Mexico

https://www.usgs.gov/centers/nmic/mineral-commodity-summaries

Class Details

- Exams: Midterm and Final—both are take home exams that will emphasize short answer and essay questions.
- Term project—you are required to do a term/research project that will involve some original work and meetings outside class.
- Field trips—there will be 2 or more field trips and a trip report on each trip will be required.
- Team work and group reports are encouraged, but midterm and final will be on your own.

Class Details

- Occasional lecture from me
- Each week, 3 of you will be assigned or will find an article on REE in coal and will summarize it (powerpoints)
  - Article is due by Sunday before class
- Everyone else will have read it
- We will discuss it in class
- 2 Volunteers to set up a class schedule for the papers and for safety presentations

Term projects

- Form a team of 2
  - Prefer one grad and one undergrad
- Research chemical data on REE and other elements in coal or associated deposits (humate, beach placer sandstones, coal wastes, shale, etc.)
  - New Mexico
  - Coal ash
  - Other coal basins
- Describe and interpret that data
  - Spreadsheets
  - Chemical plots
  - Basic statistics
  - Conclusions
- Will require team to meet at least once every 2 weeks

Term projects

- Products
  - Spreadsheet of chemical data
  - Powerpoint
  - Summary report (5-10 p.)
  - Periodic updates of progress during class

Grades

• Midterm	20%
• Final (comprehensive)	30%
• Lab exercises	10%
• Term project	15%
• Field trip reports	10%
• Class Participation	15%

Schedule

- Aug 24 Introduction
- Sept 14-18 NMGS field trip (I will be gone)
- Oct 13 Midterm due
- Nov 12 Optional field trip to Copper Flat mine, Hillsboro (copper mine)
- Nov 23, 30 Term project presentations
- Dec 3 Last day of classes
- Dec 6 Final due
- Dec 4-10 AEMA Reno (I will be gone)

Sources of data

- Internet
- http://minerals.usgs.gov/minerals/pubs/commodity/myb/
- http://www.minerals.com/
- USGS and DOE reports
- Societies (SME, others)
- My web site
- Library
- Bureau GIC records
- Other reports not in electronic form

Wikipedia

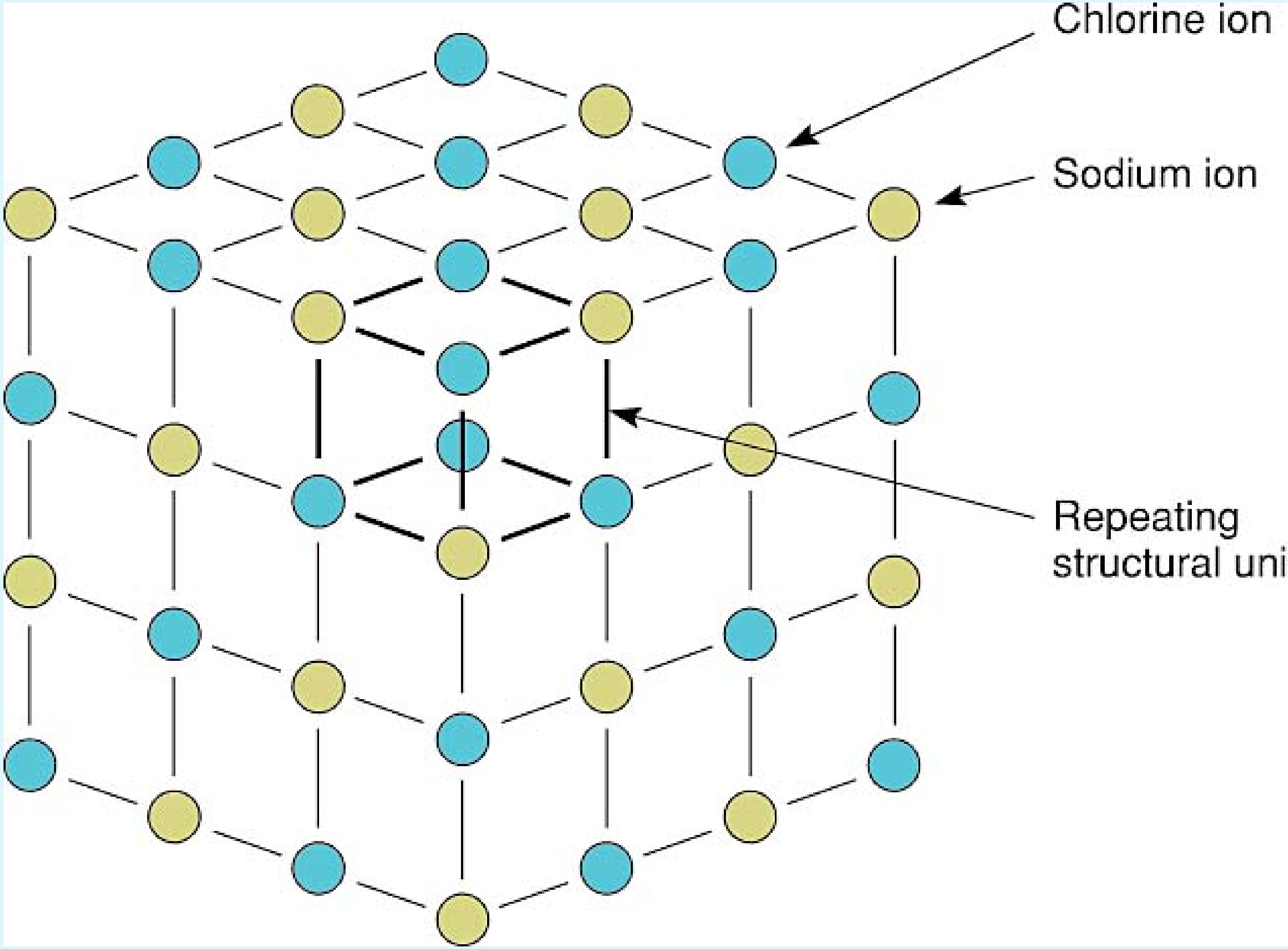
- Use sparingly
- Some of the information on Wikipedia is incorrect
- Some of your best data and sources of information are in the library and not in electronic form

- Be aware of using copyrighted material—get permission
- Cite references

What is a mineral?

What is a mineral?

- Naturally occurring
- Inorganic
- Solid
- Homogeneous
- Crystalline material
- With a unique chemical element or compound with a set chemical formula
- Usually obtained from the ground



A crystal is composed of a structural unit that is repeated in three dimensions. This is the basic structural unit of a crystal of sodium chloride, the mineral halite.

Another definition

Definition of Minerals

In industry, *minerals* refer to any rock, mineral, or other naturally occurring material of economic value, including metals, industrial minerals, energy minerals, gemstones, aggregates, and synthetic materials sold as commodities.

1. Metals - rare, difficult to find, expensive
2. Energy minerals – coal, oil and natural gas
3. Industrial minerals - non-metallic, such as salt, china clay, fluorspar
   - occur in large quantities in a few places
   - require specialised processing and are expensive
4. Construction minerals - sand and gravel, crushed rock, brick clay
   - deposits are extensive and common
   - transportation is economical over short distances only

A **mineral occurrence** is any locality where a useful mineral or material is found.

A **mineral prospect** is any occurrence that has been developed by underground or by above ground techniques, or by subsurface drilling to determine the extent of mineralization.

The terms **mineral occurrence** and **mineral prospect** do not have any resource or economic implications.

A **mineral deposit** is any occurrence of a valuable commodity or mineral that is of sufficient size and grade (concentration) that has potential for economic development under past, present, or future favorable conditions.

An **ore deposit** is a well-defined mineral deposit that has been tested and found to be of sufficient size, grade, and accessibility to be extracted (i.e. mined) and processed at a profit at a specific time. Thus, the size and grade of an ore deposit changes as the economic conditions change. **Ore refers to industrial minerals as well as metals.**

Mineral Deposits versus *Ore Bodies*

mineral deposit	≠	ore body
ore body	=	reserves
mineral deposit	=	± reserves + unmineable + uneconomic + mined

CLASSIFICATION OF MINERAL RESOURCES ON U.S. FEDERAL LAND

Locatable Minerals are whatever is recognized as a valuable mineral by standard authorities, whether metallic or other substance, when found on public land open to mineral entry in quality and quantity sufficient to render a claim valuable on account of the mineral content, under the United States Mining Law of 1872. Specifically excluded from location are the leasable minerals, common varieties, and salable minerals.

Leasable Minerals The passage of the Mineral Leasing Act of 1920, as amended from time to time, places the following minerals under the leasing law: oil, gas, **coal**, oil shale, sodium, potassium, phosphate, native asphalt, solid or semisolid bitumen, bituminous rock, oil-impregnated rock or sand, and sulfur in Louisiana and New Mexico.

Salable Minerals The Materials Act of 1947, as amended, removes petrified wood, common varieties of sand, stone, gravel, pumice, pumicite, cinders, and some clay from location and leasing. These materials may be acquired by purchase only.

It is important to recognize that mineral deposits are controlled by geological processes, not land ownership or classification, and that mineral resources are found in areas where the geology is favorable for the occurrence of mineral deposits, and not just anywhere on earth. Mineral deposits cannot be moved and can only be developed where they are discovered.

What are strategic and critical minerals?

Strategic and critical minerals

- Minerals needed for military, industrial or commercial purposes that are essential to renewable energy, national defense equipment, medical devices, electronics, agricultural production and common household items
- Minerals that are essential for use but subject to potential supply disruptions
- Minerals that perform an essential function for which few or no satisfactory substitutes exist
- The absence of which would cause economic or social consequences
- 33-50% minerals are classified as such

Presidential Executive Order No. 13817

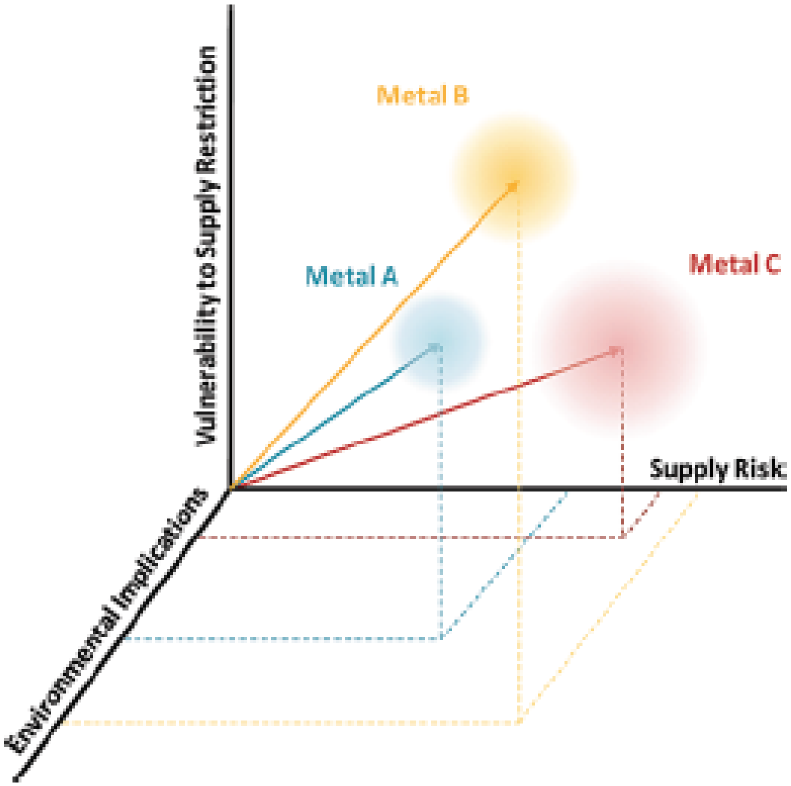
"*a mineral (1) identified to be a nonfuel mineral or mineral material essential to the economic and national security of the United States, (2) from a supply chain that is vulnerable to disruption, and (3) that serves an essential function in the manufacturing of a product, the absence of which would have substantial consequences for the U.S. economy or national security*"

- Demand
  - Material composition increasingly complex
  - Potential rapid growth in demand for some minerals
- Supply
  - Seemingly increasingly fragile
  - More fragmented supply chains, US import dependence, export restrictions on primary raw materials, resource nationalism, increased industry concentration

Criticality is context specific:

- What is critical for a given manufacturer or product may not be critical for another, what is critical for a state may not be critical for a country, and what is critical for national defense may be different than what is necessary to make a television brighter or less expensive.

- Recent studies have expanded the scope of criticality to include environmental and technological factors.



Graedel, T. E.; Barr, R.; Chandler, C.; Chase, T.; Choi, J.; Christoffersen, L.; Friedlander, E.; Henly, C.; Nassar, N. T.;Schechner, D.; Warren, S.; Yang, M.; Zhu, C., 2012, Methodology of metal criticality determination: Environ. Sci. Technol., 46, 1063• 1070.

USGS

2019 U.S. NET IMPORT RELIANCE[1]

Commodity	Percent	Major import sources (2015–18)[2]
ARSENIC (all forms)	100	China, Morocco, Belgium
ASBESTOS	100	Brazil, Russia
CESIUM	100	Canada
FLUORSPAR	100	Mexico, Vietnam, South Africa, China
GALLIUM	100	China, United Kingdom, Germany, Ukraine
GRAPHITE (natural)	100	China, Mexico, Canada, India
INDIUM	100	China, Canada, Republic of Korea, Taiwan
MANGANESE	100	South Africa, Gabon, Australia, Georgia
MICA, sheet (natural)	100	China, Brazil, Belgium, Austria
NEPHELINE SYENITE	100	Canada
NIOBIUM (columbium)	100	Brazil, Canada, Russia, Germany
RARE EARTHS[3] (compounds and metal)	100	China, Estonia, Japan, Malaysia
RUBIDIUM	100	Canada
SCANDIUM	100	Europe, China, Japan, Russia
STRONTIUM	100	Mexico, Germany, China
TANTALUM	100	Rwanda, Brazil, Australia, Congo (Kinshasa)
YTTRIUM	100	China, Estonia, Republic of Korea, Japan
GEMSTONES	99	India, Israel, Belgium, South Africa
BISMUTH	96	China, Belgium, Mexico, Republic of Korea
TELLURIUM	>95	Canada, China, Germany
VANADIUM	94	Austria, Canada, Russia, Republic of Korea
TITANIUM MINERAL CONCENTRATES	93	South Africa, Australia, Canada, Mozambique
POTASH	91	Canada, Russia, Belarus, Israel
DIAMOND (industrial stones)	88	India, South Africa, Botswana, Australia
BARITE	87	China, India, Morocco, Mexico
ZINC (refined)	87	Canada, Mexico, Australia, Peru
TITANIUM (sponge)	86	Japan, Kazakhstan, Ukraine, China, Russia
ANTIMONY (metal and oxide)	84	China, Thailand, Belgium, India
RHENIUM	82	Chile, Germany, Kazakhstan, Canada
STONE (dimension)	81	China, Brazil, Italy, Turkey
COBALT	78	Norway, Japan, China, Canada
TIN (refined)	77	Indonesia, Malaysia, Peru, Bolivia
ABRASIVES, fused Al oxide (crude)	>75	China, Hong Kong, France, Canada
BAUXITE	>75	Jamaica, Brazil, Guinea, Guyana
CHROMIUM	72	South Africa, Kazakhstan, Russia
PEAT	70	Canada
SILVER	68	Mexico, Canada, Peru, Poland

https://www.usgs.gov/centers/nmic/mineral-commodity-summaries

What are the differences between critical and strategic minerals?

Differences between critical and strategic minerals

- Minerals for military uses are strategic
- Minerals for which a threat to supply could involve harm to the economy are critical
- A critical mineral may or may not be strategic, while a strategic mineral will always be critical

History of strategic and critical minerals

- 1918: end of WW1 Harbord List developed
- 1938: Naval Appropriations Act
- 1939: Strategic Minerals Act
- 1940 Reconstruction Finance Corp formed to acquire and transport materials
- 1944: Surplus Property Act authorized strategic materials stockpile
- Became the Defense National Stockpile Center (DNSC)
- 1992: Congress ordered DNSC to sell the bulk of the stockpiles

What are green technologies?

What are green technologies?

- Environmental technologies or clean technologies
- Future and existing technologies that conserve energy and natural resources and curb the negative impacts of human involvement, i.e. environmental friendly (modified from Wikipedia)
  - Alternative power (wind turbines, solar energy)
  - Hybrid and electric cars
  - Batteries
  - Magnets
- Other technologies
  - Water purification
  - Desalination
  - Carbon capture and storage

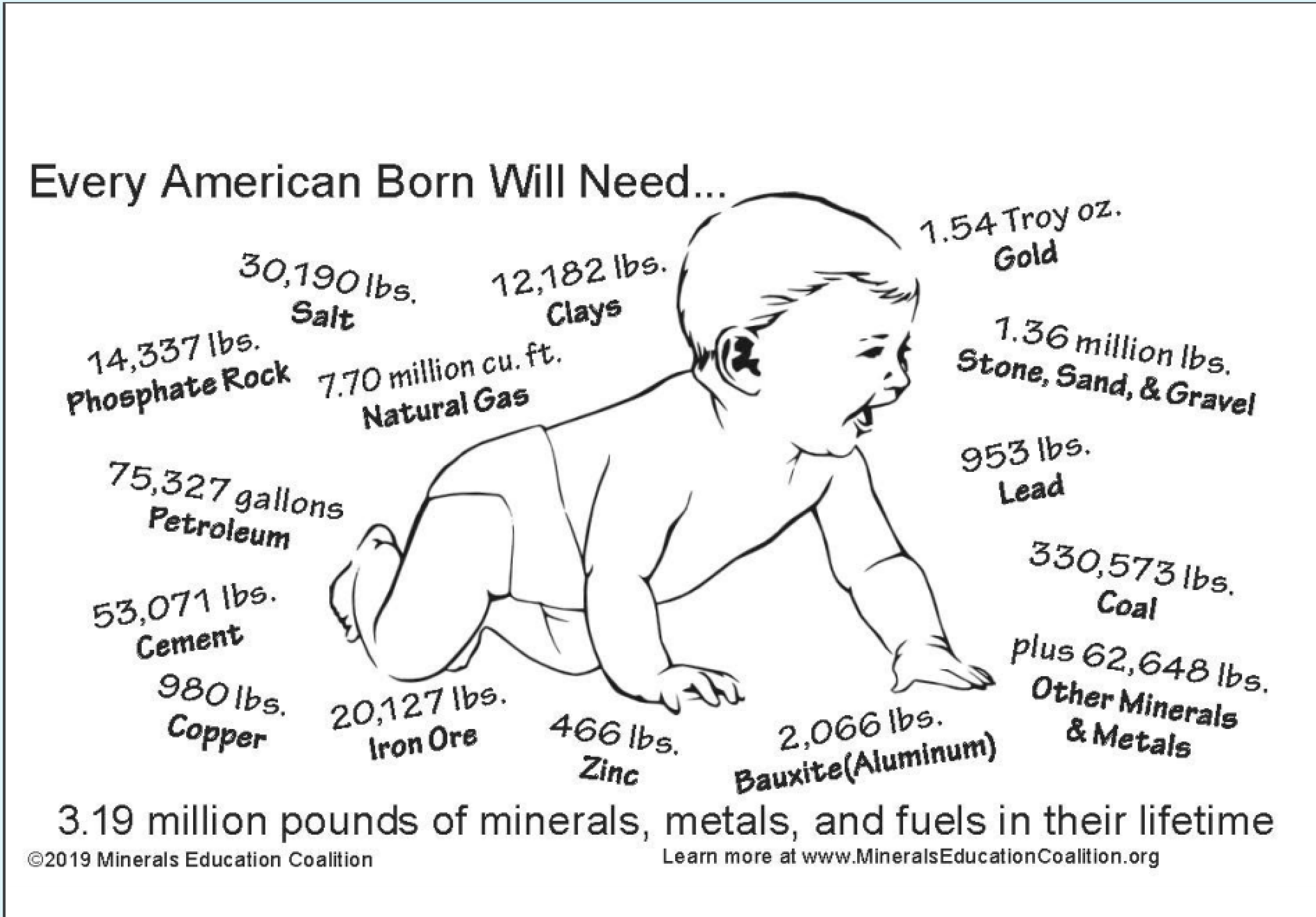
Why are minerals so important?

Why are minerals so important?

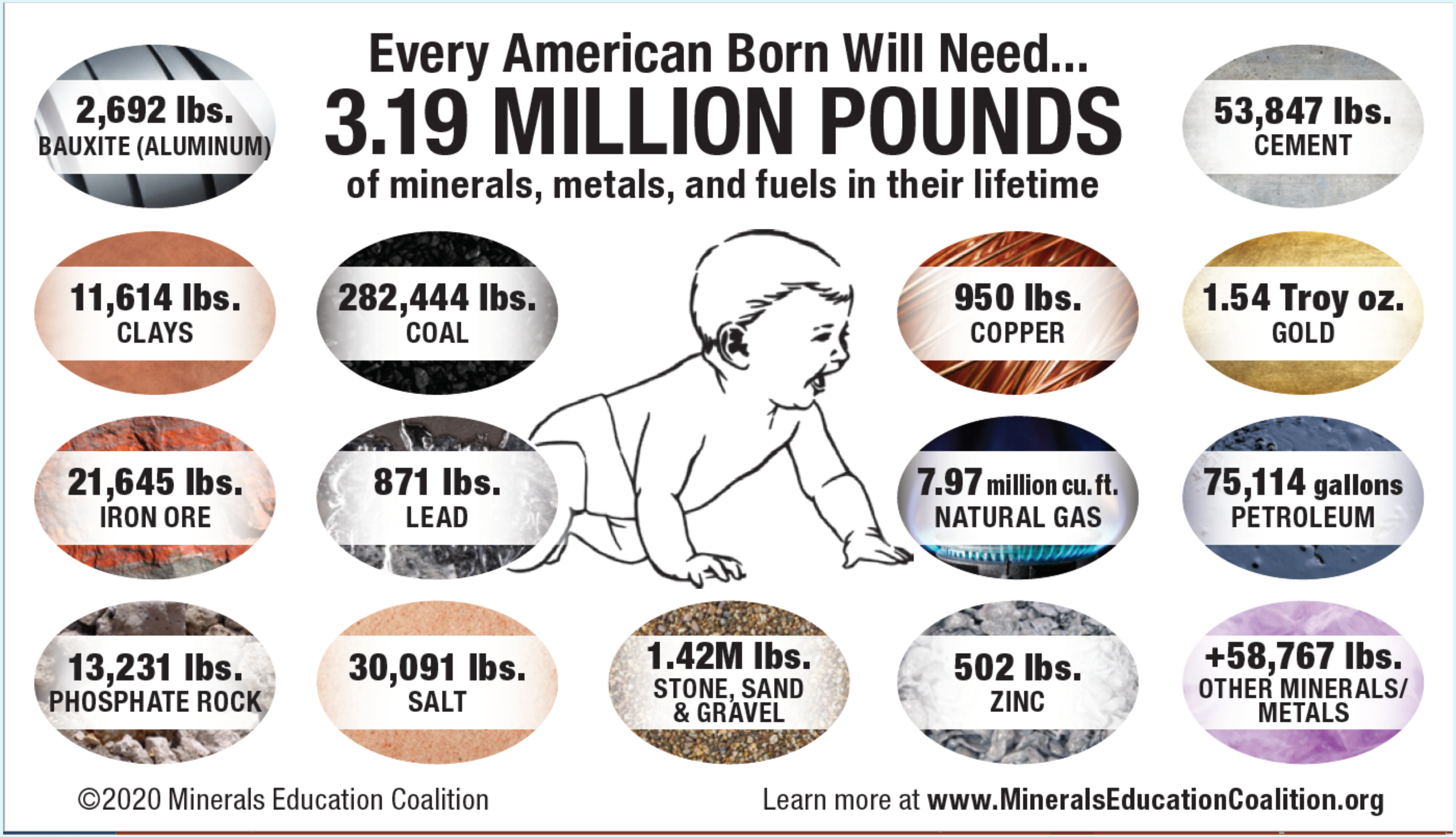
Your world is made of them!

The average American uses about two million pounds of industrial minerals, such as limestone, clay, and aggregate, over the period of a lifetime.

Building blocks of our way of life



https://mineralseducationcoalition.org/mining-mineral-statistics/



https://mineralseducationcoalition.org/mining-mineral-statistics/

Every Year— 38,052 pounds of new minerals must be provided for every person in the United States to make the things we use every day

8,509 lbs. **Stone** used to make roads, buildings, bridges, landscaping, and for numerous chemical and construction uses

5,599 lbs. **Sand & Gravel** used to make concrete, asphalt, roads, blocks and bricks

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

357 lbs. **Iron Ore** used to make steel— buildings; cars, trucks, planes, trains; other construction; containers

421 lbs. **Salt** used in various chemicals; highway deicing; food & agriculture

217 lbs. **Phosphate Rock** used to make fertilizers to grow food; and as animal feed supplements

164 lbs. **Clays** used to make floor & wall tile; dinnerware; kitty litter; bricks and cement; paper

65 lbs. **Aluminum (Bauxite)** used to make buildings, beverage containers, autos, and airplanes

12 lbs. **Copper** used in buildings; electrical and electronic parts; plumbing; transportation

11 lbs. **Lead** 87% used for batteries for transportation; also used in electrical, communications and TV screens

6 lbs. **Zinc** used to make metals rust resistant, various metals and alloys, paint, rubber, skin creams, health care and nutrition

36 lbs. **Soda Ash** used to make all kinds of glass; in powdered detergents; medicines; as a food additive; photography; water treatment

5 lbs. **Manganese** used to make almost all steels for construction, machinery and transportation

332 lbs. **Other Nonmetals** have numerous uses: glass, chemicals, soaps, paper, computers, cell phones

24 lbs. **Other Metals** have the same uses as nonmetals but also electronics, TV and video equipment, recreation equipment, and more

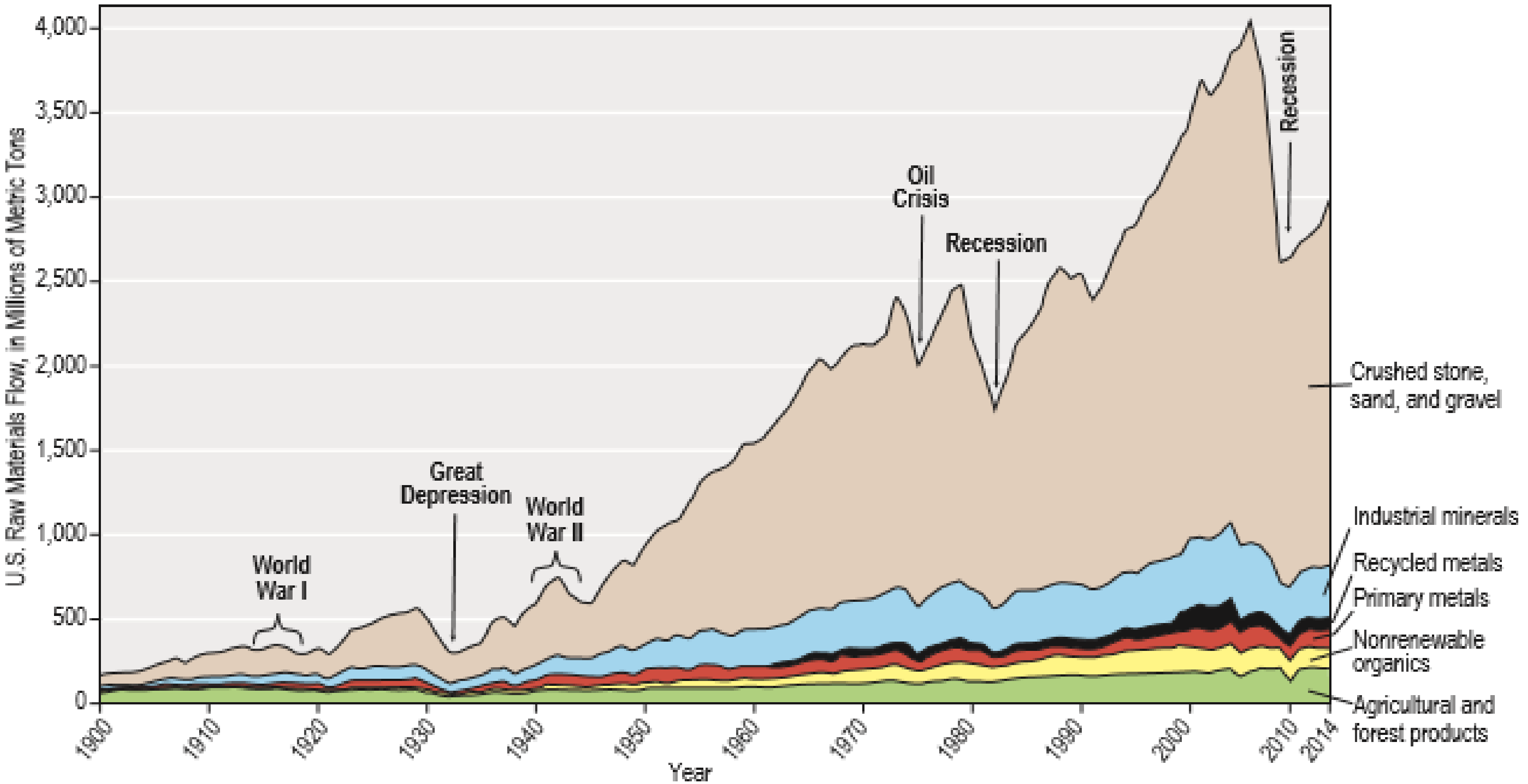
Including These Energy Fuels

- 951 gallons of **Petroleum**
- 6,792 lbs. of **Coal**
- 80,905 cu. ft. of **Natural Gas**
- 1/4 lb. of **Uranium**

To generate the energy each person uses in one year—

http://www.mii.org/pdfs/2011PerCapita.pdf

U.S. flow of raw materials by weight 1900-2014. The use of raw materials in the U.S. increased dramatically during the last 100 years (modified from Wagner, 2002).



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Assignment due next week

- Safety moment
- First 3 papers on coal
- Select teams of 2
  - **Title of project due Sept 7**

Assignment

- Mineral deposit models (Cox and Singer, 1986, http://pubs.usgs.gov/bul/b1693/Tlbc.pdf)
- Principles of a resource/reserve classification for minerals (http://pubs.usgs.gov/circ/1980/0831/report.pdf)
- NATIONAL INSTRUMENT 43-101, *STANDARDS OF DISCLOSURE FOR MINERAL PROJECTS (http://web.cim.org/standards/documents/Block484_Doc111.pdf)*
- Hoffman, G.K., 2016, Coal, *in* McLemore, V.T., Timmons, S., and Wilks, M., eds., Energy and mineral resources of New Mexico: New Mexico Bureau of Geology and Mineral Resources Memoir 50B, and New Mexico Geological Society Special Publication 13B, 80 p.