MINERAL RESOURCES OF TEXAS – HISTORICAL PERSPECTIVE, FUTURE POTENTIAL

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Think Day
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Historical Perspective

- University of Texas Mineral Survey 1901-1905

- Mineral Exploration and Mining originally an important component to BEG mission

- Program output reduced considerably when Jon Price and Chris Henry left TX for Nevada in early 1990's

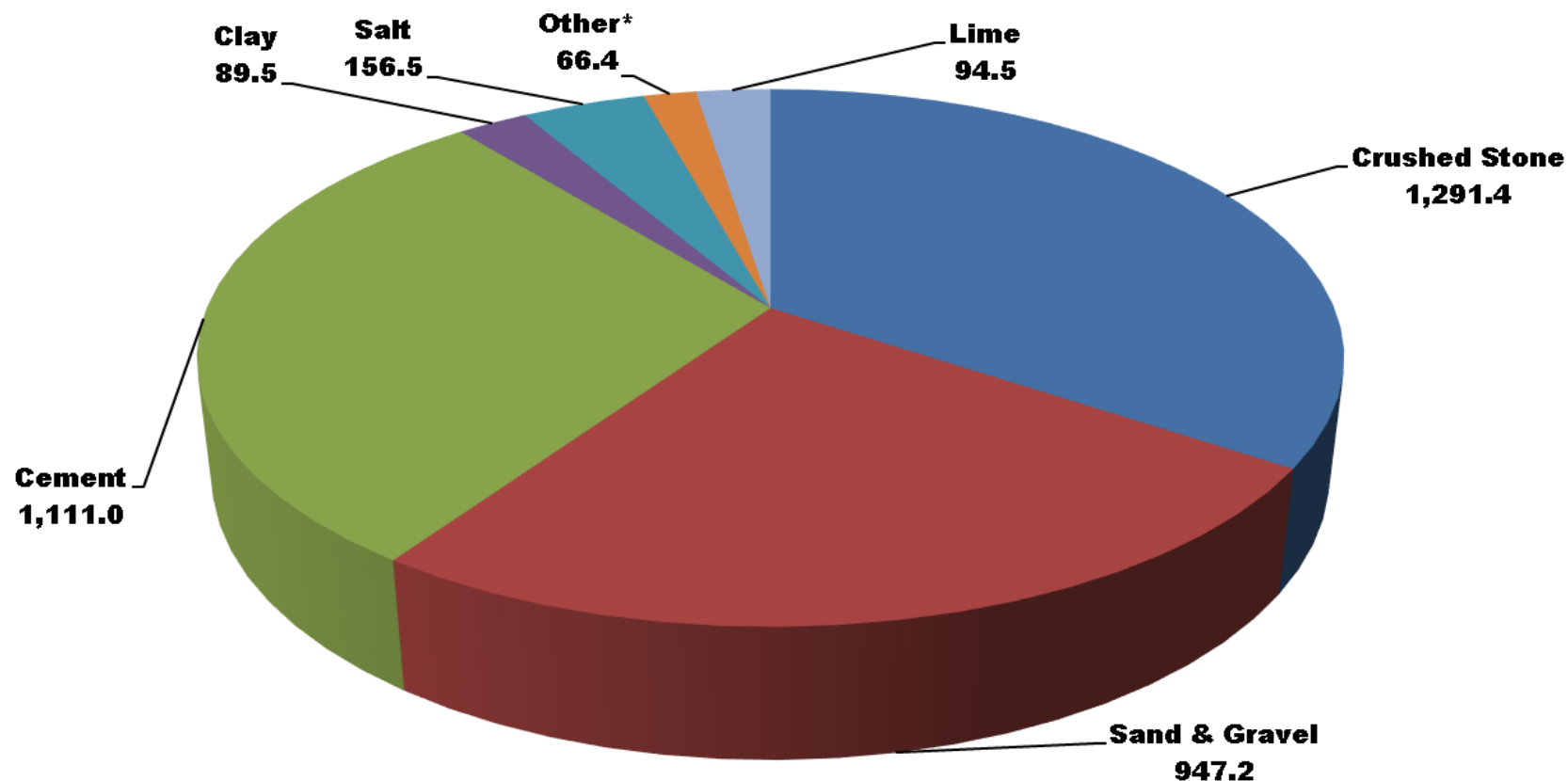- Hiring Brent Elliott in 2012 was a commitment to restart that program

Shafter mine, ca. 1890

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Resources (million tons)
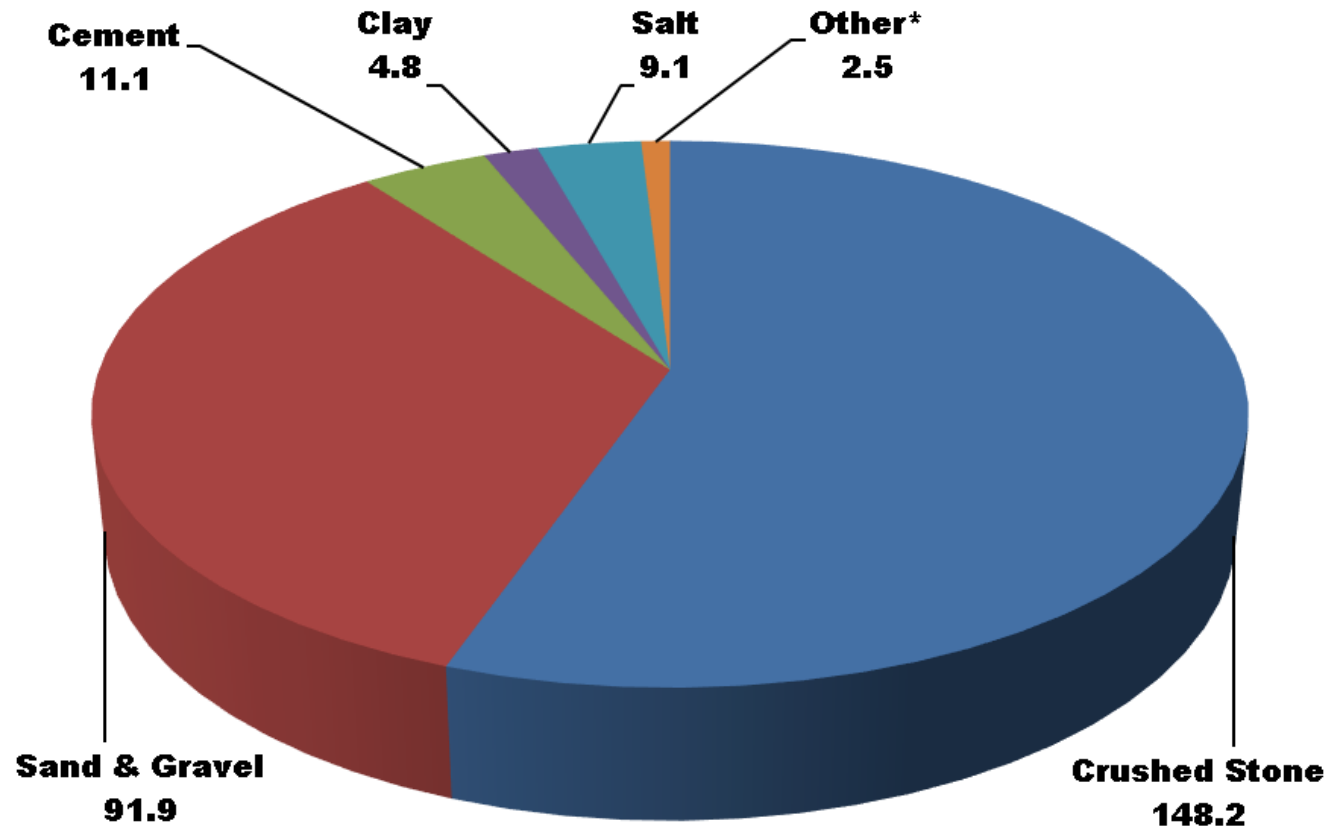
* Natural gemstones, crude gypsum, dimension stone, lime, crude helium, grade-A helium, crude talc, zeolites.

Resources (million $)

Clay 89.5 · Salt 156.5 · Other* 66.4 · Lime 94.5 · Crushed Stone 1,291.4 · Cement 1,111.0 · Sand & Gravel 947.2

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Texas Mineral Resources Today

Texas ranks #5-#8 in mineral resource production, providing the U.S. with more than 4% of total material annually

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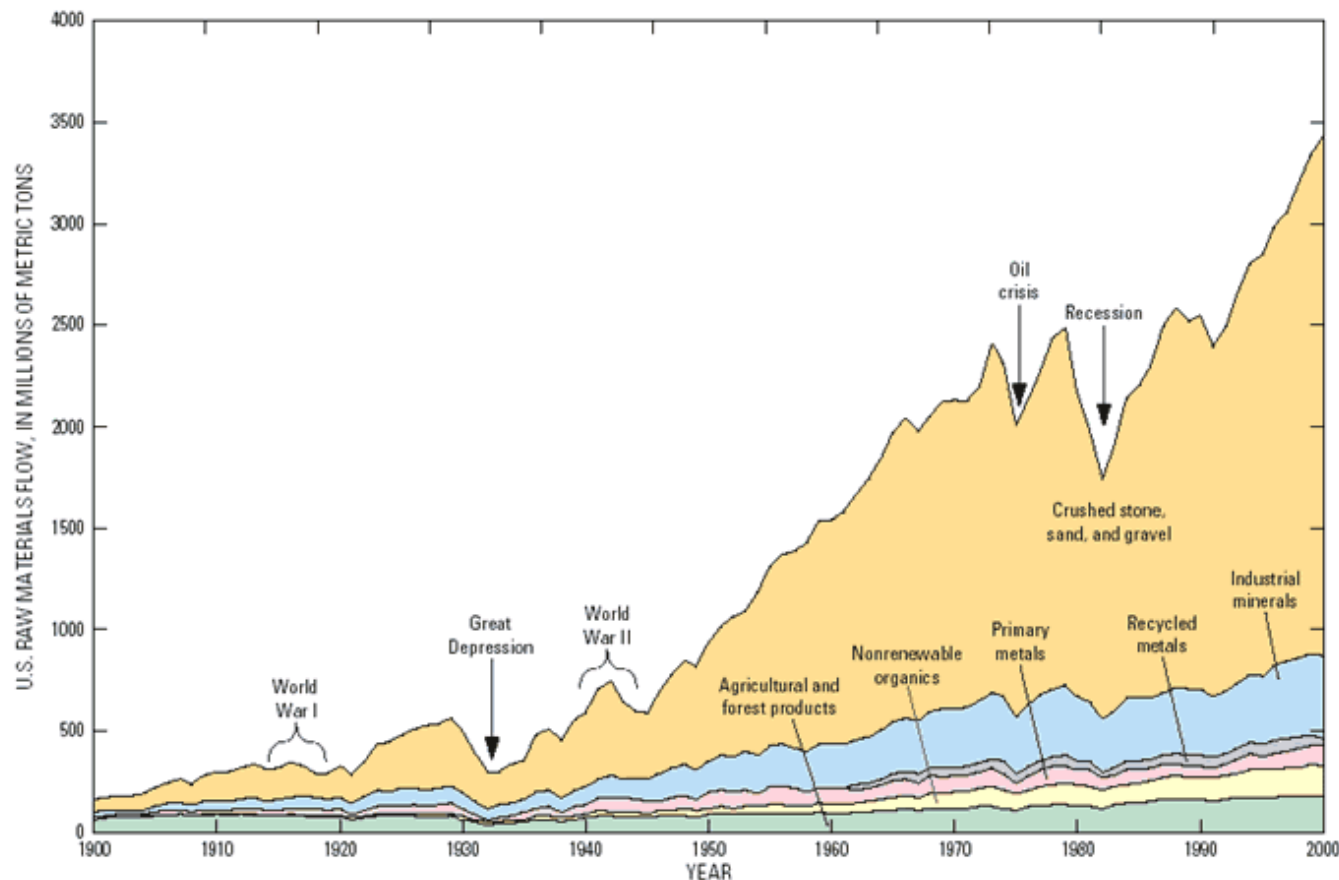
Texas Mineral Resources Today

Texas mineral resource value has doubled in the last 25 years to over $3 billion per year
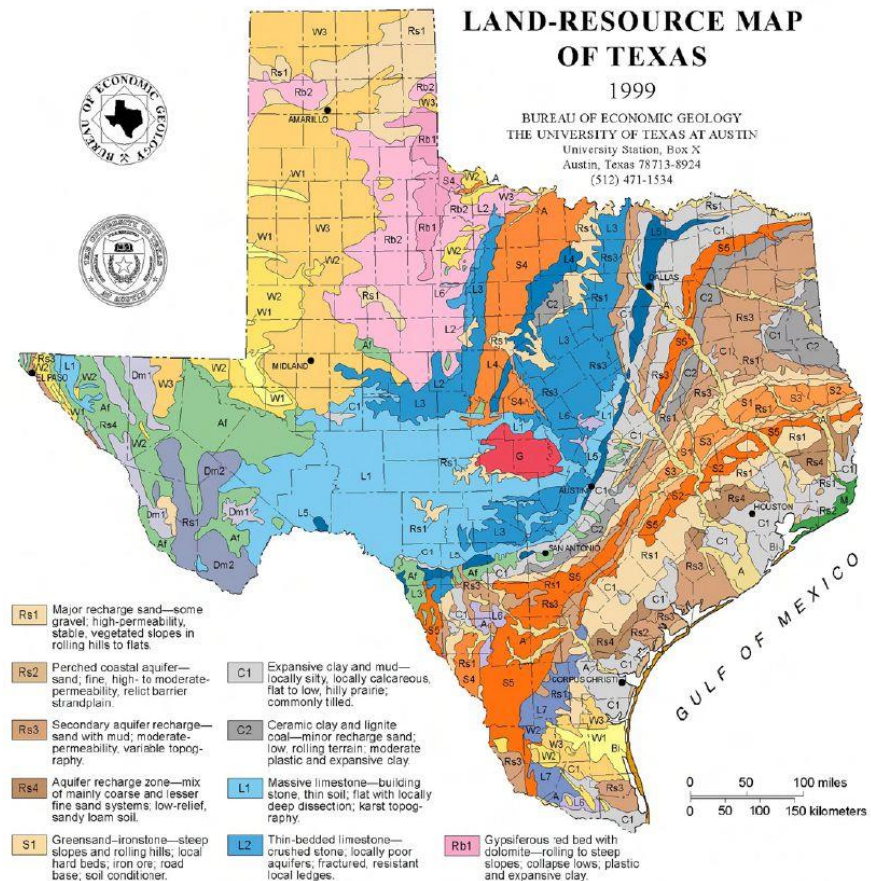

Annual Texas Mineral Resource Value
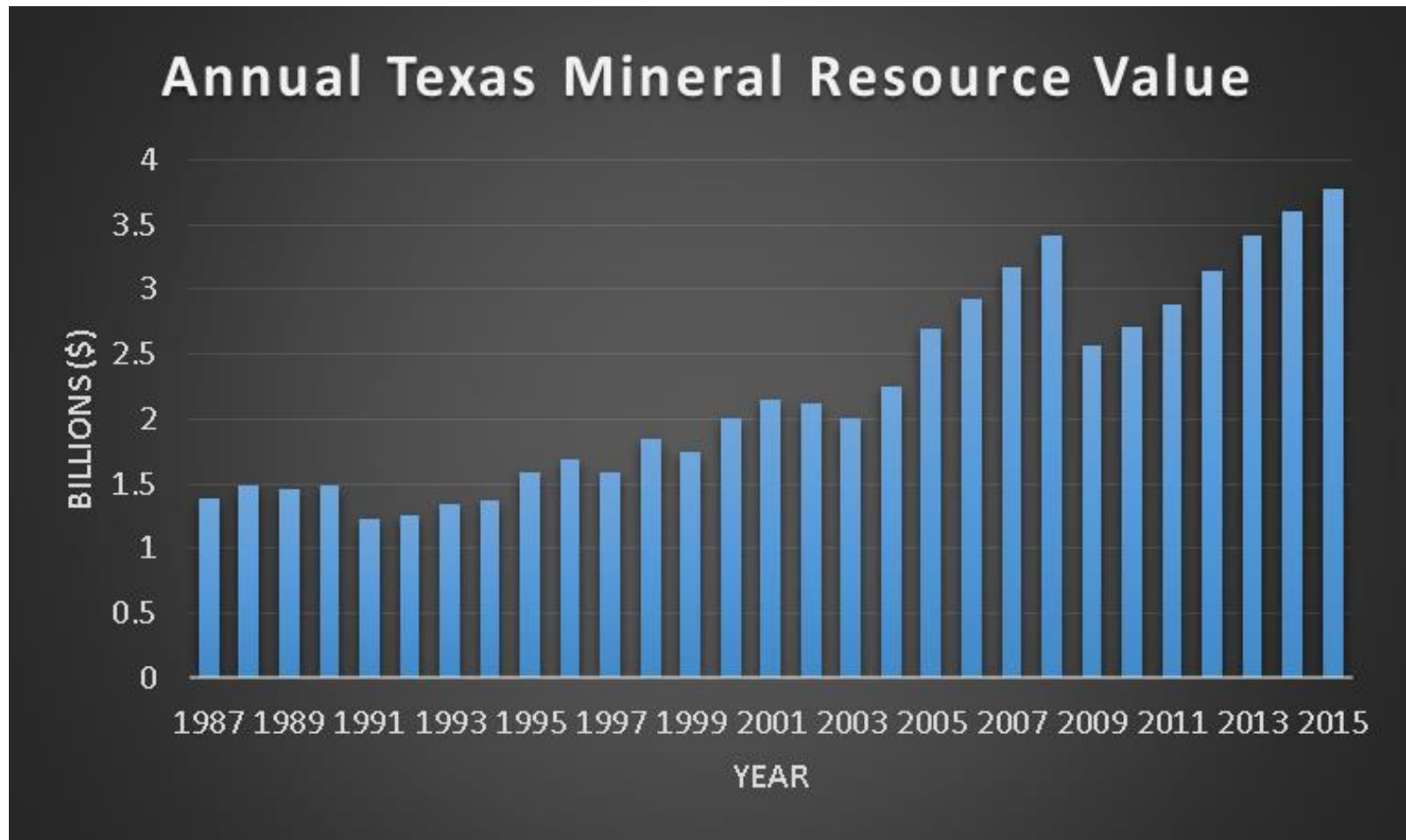
Texas Mineral Resources Today

- Texas population growth rate is 8.1%, 3rd in US since 2010

- Mineral resource revenue projected to double over the next 25 years

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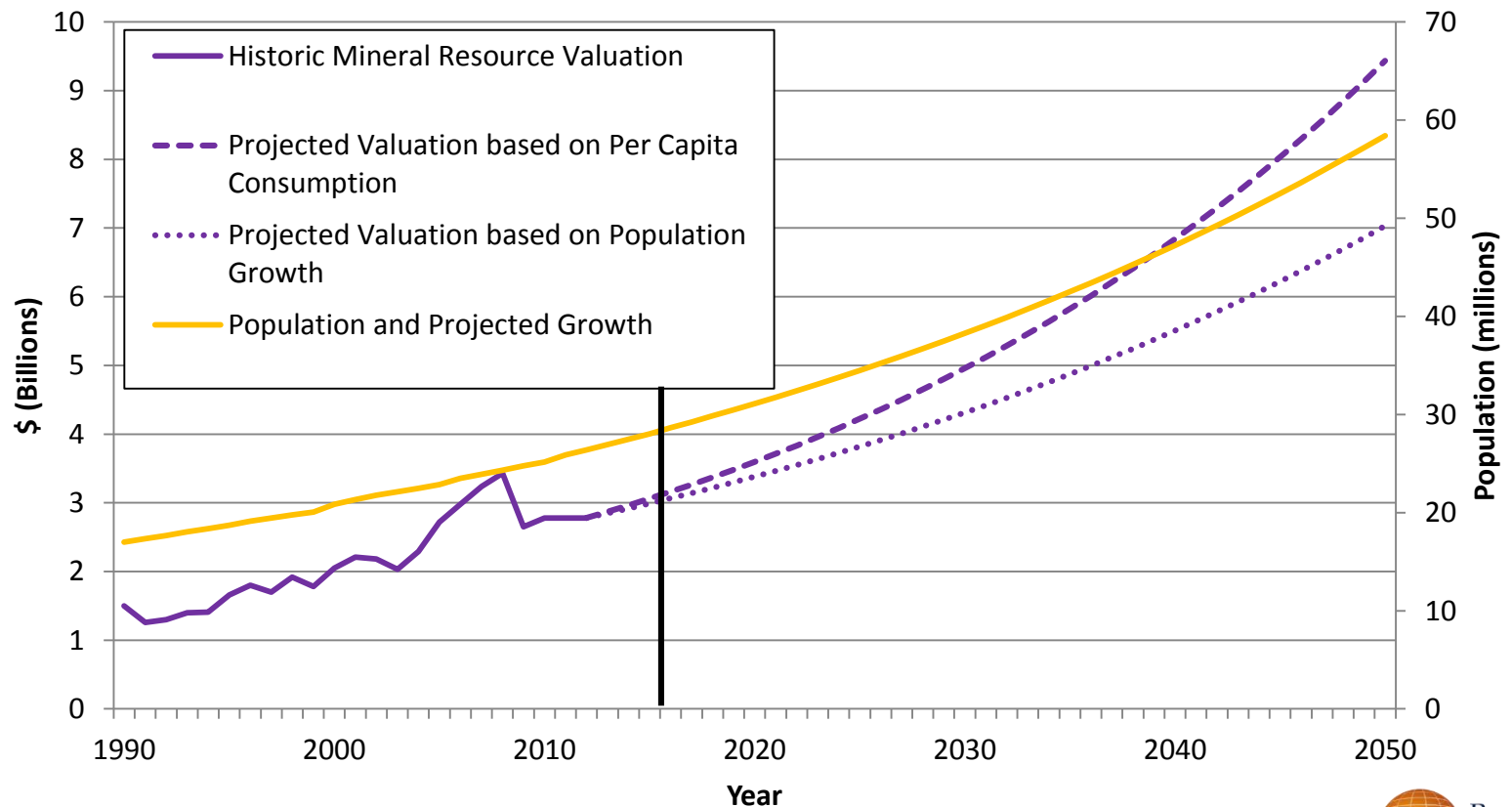
# Mapping Mineral Deposits – Leveraging Funds, Diversifying Outputs

- Existing funding sources

  - Federal STATEMAP Program – competitive grants program administered by USGS

    - Projects based on state requirements for geologic map information in areas of greatest need or where mapping is required to solve critical Earth science problems.

  - BEG STARR Program

    - Administered through Texas Comptroller's office, providing funds for BEG activities that directly contribute to tax base

LAND-RESOURCE MAP OF TEXAS
1999
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Rs1 — Major recharge sand—some gravel; high-permeability, stable, vegetated slopes in rolling hills to flats.

Rs2 — Perched coastal aquifer—sand; fine, high- to moderate-permeability, relict barrier strandplain.

Rs3 — Secondary aquifer recharge—sand with mud; moderate-permeability, variable topography.

Rs4 — Aquifer recharge zone—mix of mainly coarse and lesser fine sand systems; low-relief, sandy loam soil.

S1 — Greensand–ironstone—steep slopes and rolling hills; local hard beds; iron ore; road base; soil conditioner.

C1 — Expansive clay and mud—locally silty, locally calcareous, flat to low, hilly prairie; commonly tilled.

C2 — Ceramic clay and lignite coal—minor recharge sand; low, rolling terrain; moderate plastic and expansive clay.

L1 — Massive limestone—building stone, thin soil; flat with locally deep dissection; karst topography.

L2 — Thin-bedded limestone—crushed stone; locally poor aquifers; fractured, resistant local ledges.

Rb1 — Gypsiferous red bed with dolomite—rolling to steep slopes; collapse lows, plastic and expansive clay.

GULF OF MEXICO

0   50   100 miles
0 50 100 150 kilometers

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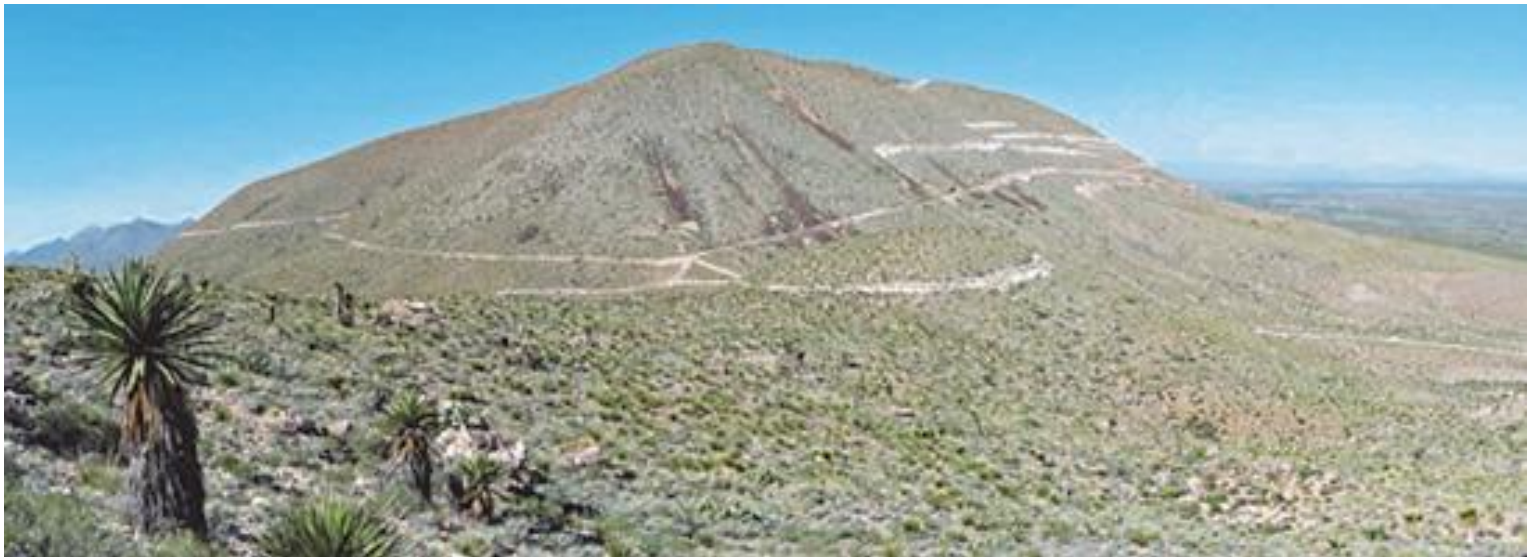
Mineral Resources Program – Uranium

Uranium resources research includes:

- Exploration techniques

- Estimation and reserve calculations

- Economic potential and supply chain mapping

- Supply and demand balances

- Application and integration with energy outlooks

- Country risk assessments and extractive issues

- Environmental risk and regulatory compliance issues (chemical mitigation, water issues, subsurface monitoring, etc.)
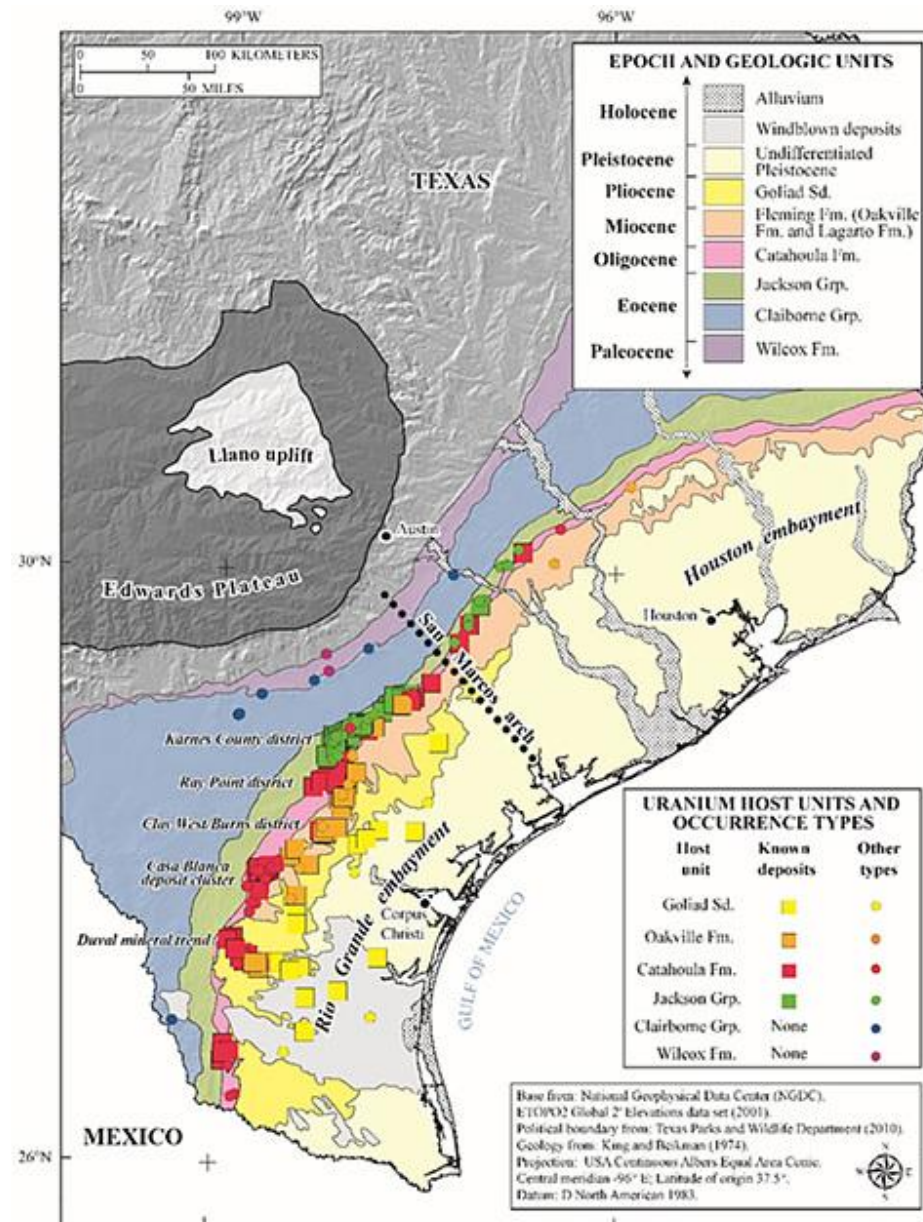
Mineral Resources Program – Rare Earth's

- Program addresses aspects from mineral genesis to exploration, extraction, processing, and economics

- Particularly relevant to governmental and industry partners who consider REE's as critical elements to energy and industrial activity
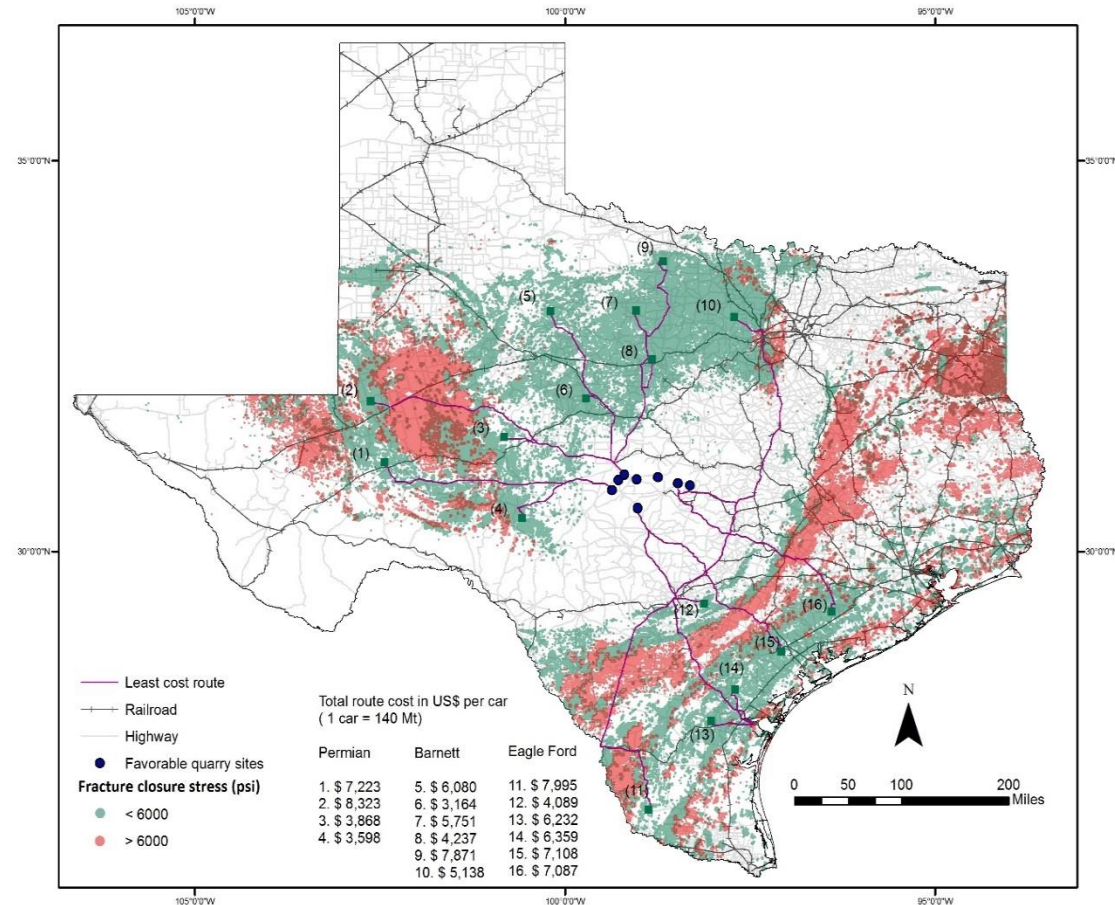
Mineral Resources Program – Industrial Minerals

- Market will continue to grow in Texas and in emerging markets

- One example: frac sands

  - We are developing exploration and logistics models and studying ways to make natural sands more efficient and cost effective in oil and gas production
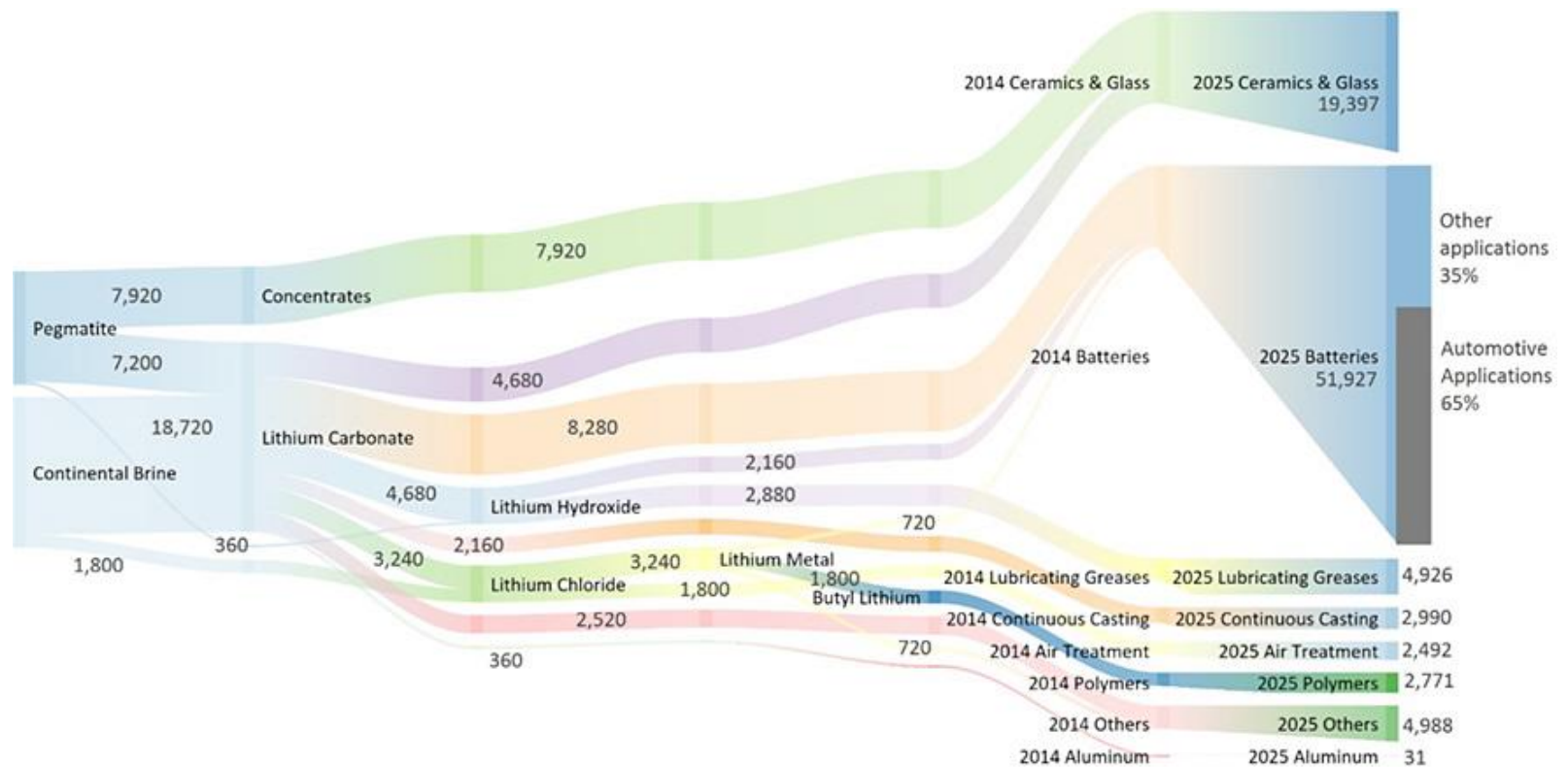
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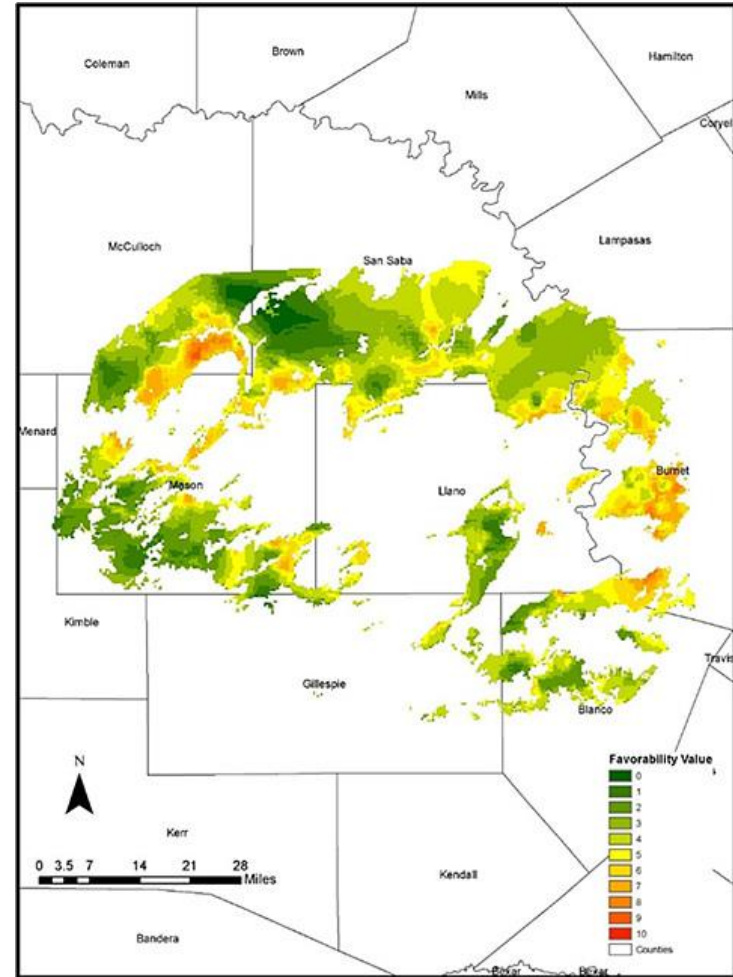
Optimizing Frac Sand Transportation

- Transportation logistics and optimization studies are significant to all commodities

- A study of basin closure stress and commercial frac sands, for example, help make the strongest argument for local frac sand resources

Least cost route
Railroad
Highway
Favorable quarry sites
Fracture closure stress (psi)
● < 6000
● > 6000

Total route cost in US$ per car
(1 car = 140 Mt)

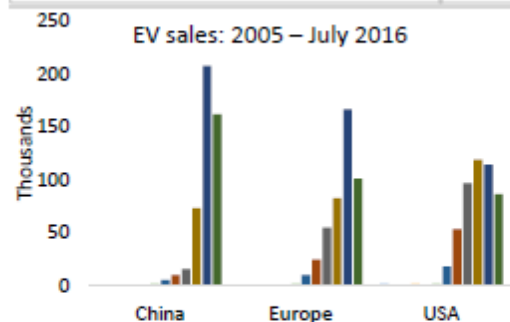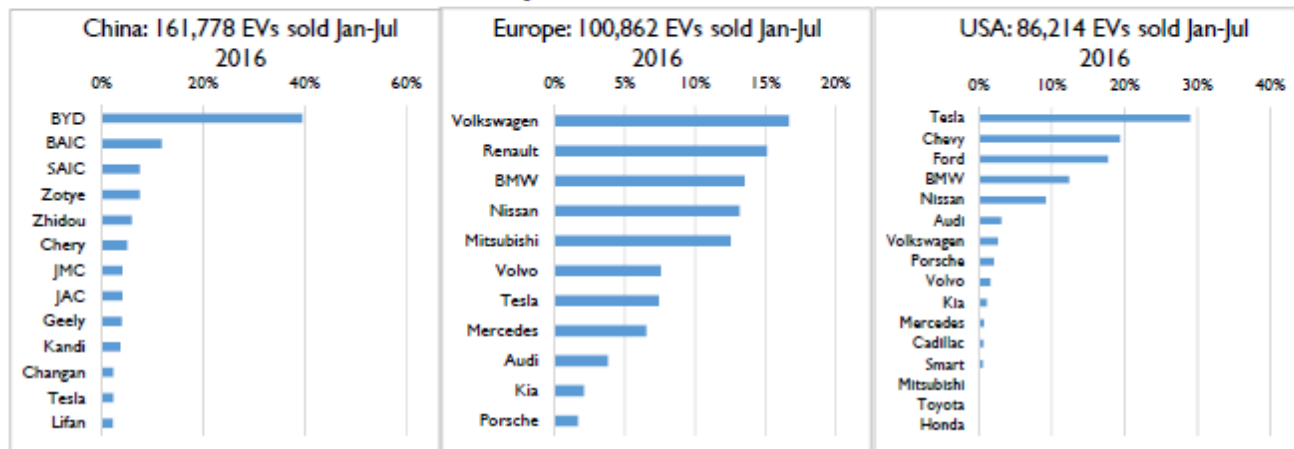|	Permian	Barnett	Eagle Ford
	1. $ 7,223	5. $ 6,080	11. $ 7,995
	2. $ 8,323	6. $ 3,164	12. $ 4,089
	3. $ 3,868	7. $ 5,751	13. $ 6,232
	4. $ 3,598	8. $ 4,237	14. $ 6,359
		9. $ 7,871	15. $ 7,108
		10. $ 5,138	16. $ 7,087

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Mineral Resources Program - Lithium

- Developing research on lithium and other critical minerals to battery storage technology and renewable energy technologies

A Market Driver for Lithium? Transport

EV Sales: China overtook Europe and USA; many companies in the sector, different companies dominate each market

China: 161,778 EVs sold Jan-Jul 2016
(companies: BYD, BAIC, SAIC, Zotye, Zhidou, Chery, JMC, JAC, Geely, Kandi, Changan, Tesla, Lifan)

Europe: 100,862 EVs sold Jan-Jul 2016
(companies: Volkswagen, Renault, BMW, Nissan, Mitsubishi, Volvo, Tesla, Mercedes, Audi, Kia, Porsche)

USA: 86,214 EVs sold Jan-Jul 2016
(companies: Tesla, Chevy, Ford, BMW, Nissan, Audi, Volkswagen, Porsche, Volvo, Kia, Mercedes, Cadillac, Smart, Mitsubishi, Toyota, Honda)

EV sales: 2005 – July 2016

2016 sales appear on track to surpass 2015 sales in all three markets. If sales continue at the same pace, 2016 EV sales can exceed 700,000.

- **Lithium carbonate content** requirement would be **12,000** metric tons (mt) LCE. 2015 **Global lithium production** was approximately **173,000** mt LCE.
- To reach BNEF's forecast of 41 million EV sales in 2040, the annual sales will need to grow at 18% annually, putting significant strain on the lithium supply chain.
- **Cobalt content** requirement would be **3,700** mt. 2015 **Global cobalt production** was **124,000** mt.
- Cobalt demand will grow more slowly than lithium demand as many battery manufacturers are moving to low-cobalt chemistries.

Data sources: EV Obsession, U.S. Bureau of Transportation Statistics, IEA, Argonne National Laboratory, company financial reports

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How Will the Lithium Supply Chain Evolve?

Total value of lithion carbonate trade in 2015 (USD)

Import
Export

250 million
150 million
50 million
10 million
5 million
1 million

Major Exporters
Chile: 245 million
Argentina: 63 million
Belgium: 36 million
Germany: 20 million
China: 13 million
USA: 10 million

Major Importers
South Korea: 82 million
Japan: 57 million
USA: 60 million
China: 55 million
Belgium: 38 million
Germany: 35 million

Value of total global exports: 400 million
Export value represented in graph: 365 million
Value of of export to other countries: 35 million

Developing research on:

- commodity markets

- upstream costs and benchmarking

- midstream logistics

- downstream end use

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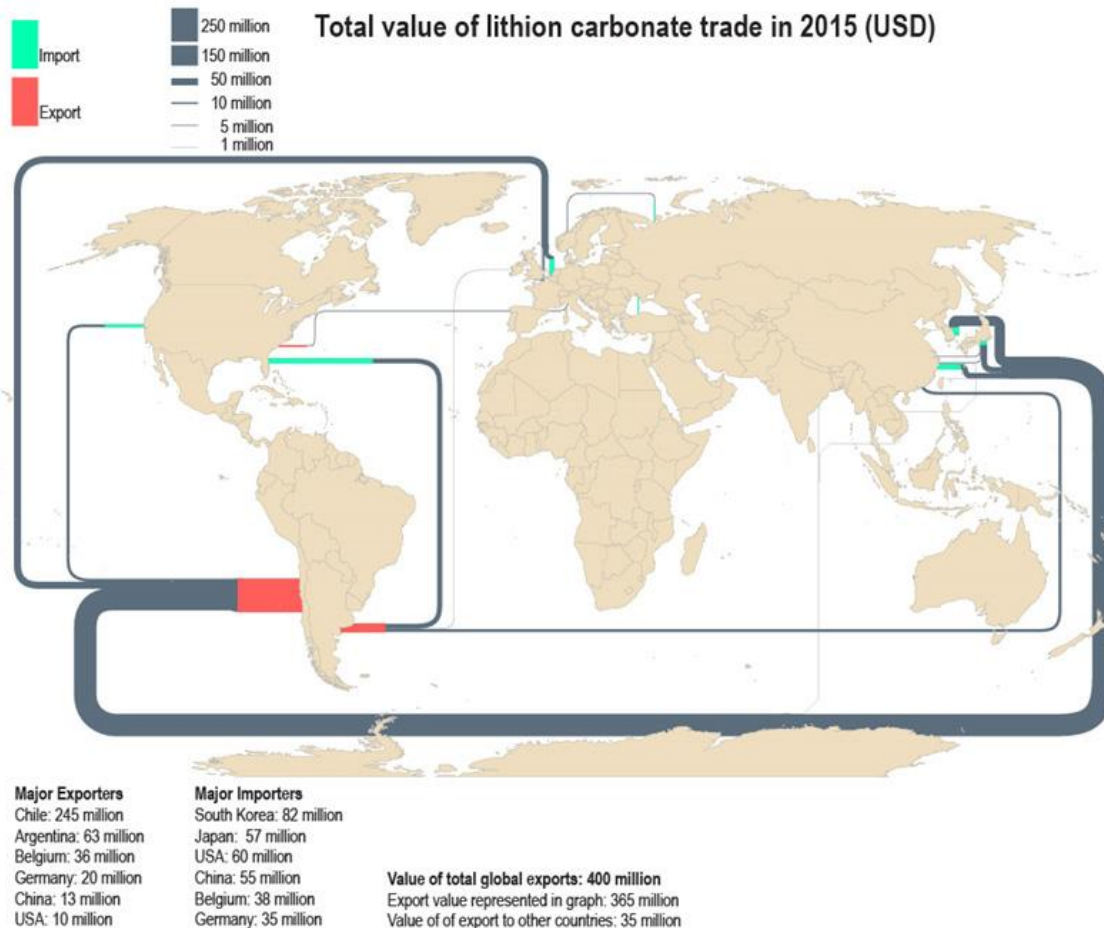
Texas Resources Map – New Outreach Tools

BEG is restarting the Minerals Circular series of publications, and we've also revamped a dynamic website:
http://igor.beg.utexas.edu/txmineralresources/
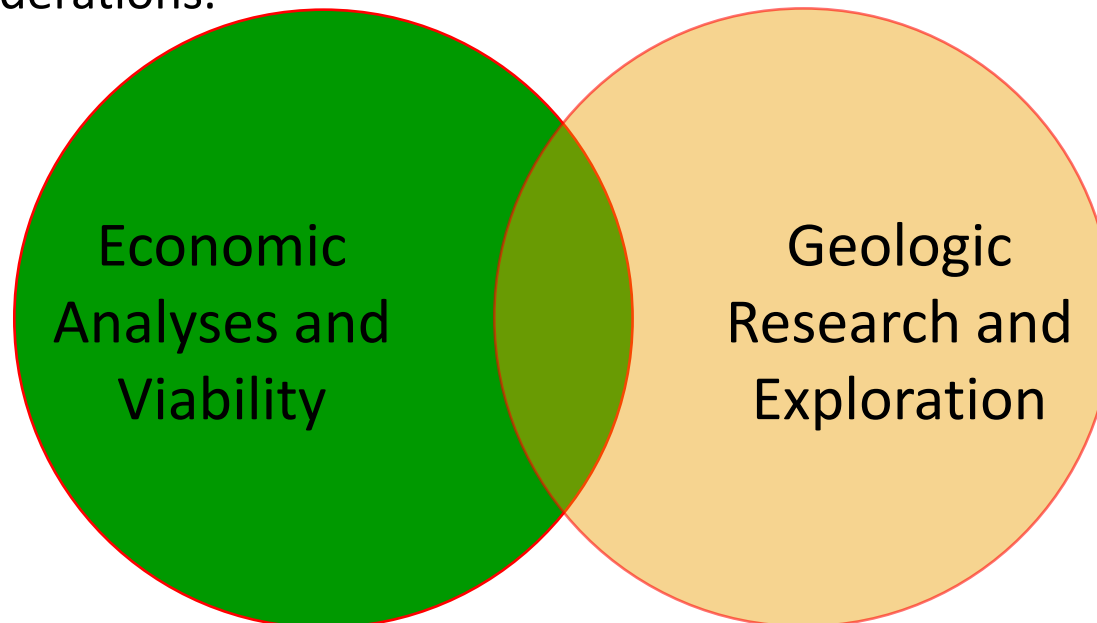

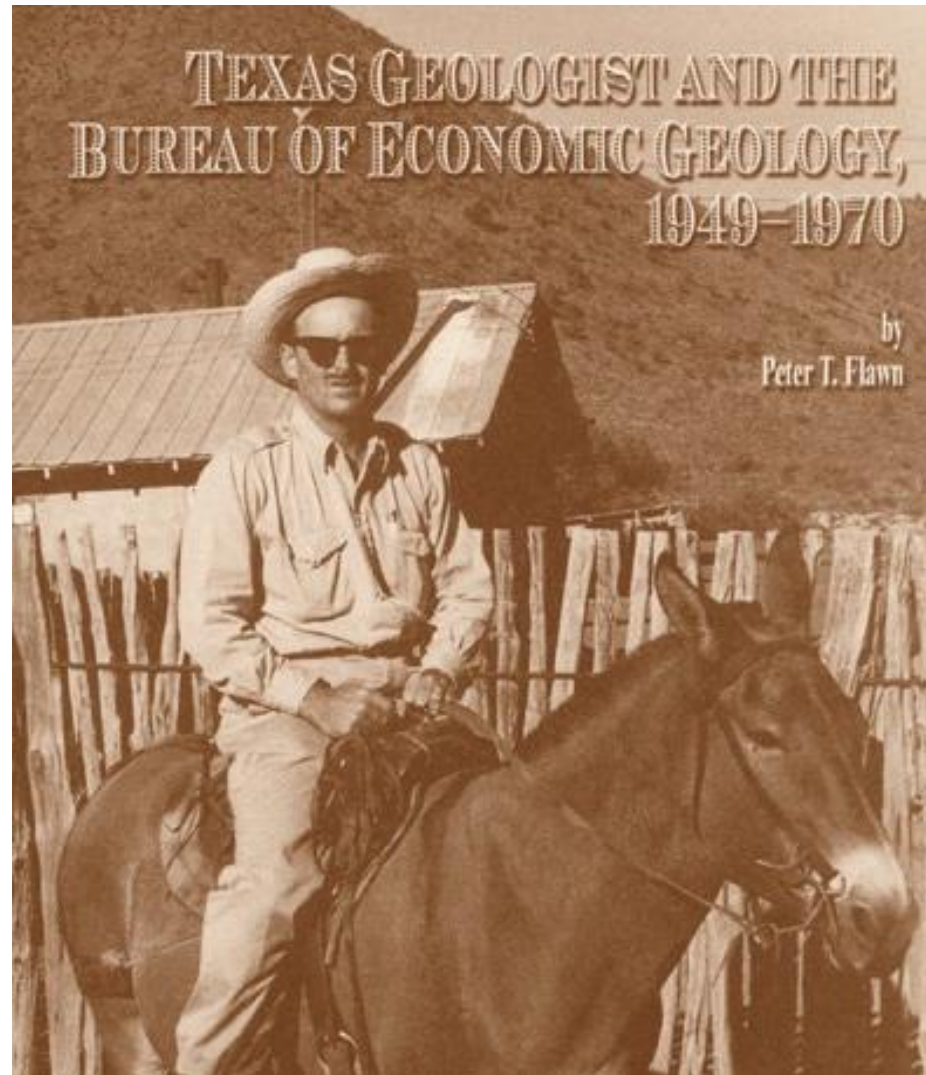Online Interactive Mineral Resource Map
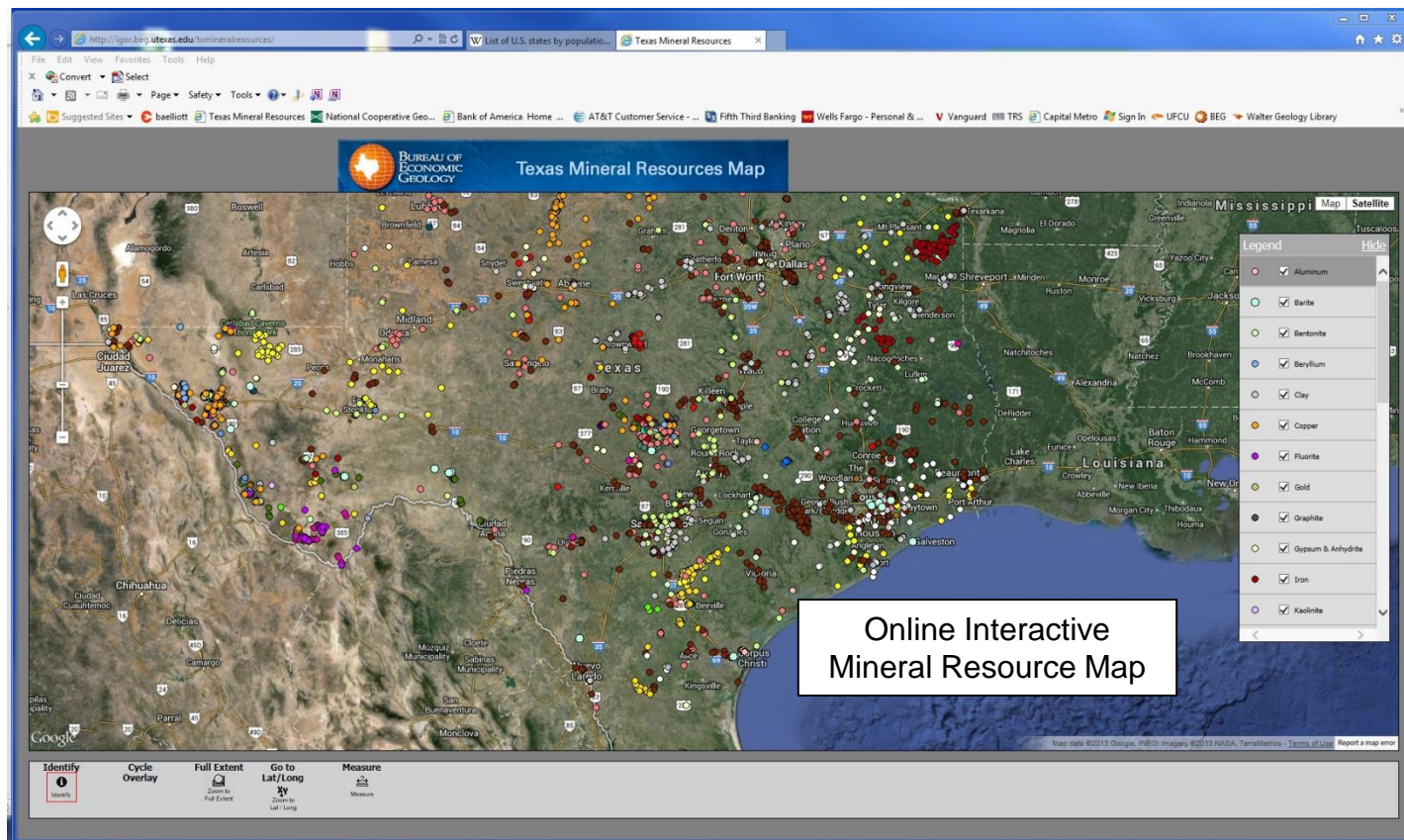
Economic Minerals Program – the Future

Developing stronger ties between Economic Minerals Program in Austin and CEE in Houston:

- Austin group conducts rigorous geologic analysis of resource potential, quality, recovery and operational issues like environmental compliance.
- CEE conducts rigorous economic and commercial frameworks analysis including value chains; market and outlooks; policy/regulatory considerations.

Economic Analyses and Viability

Geologic Research and Exploration

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Thank you!!

TEXAS GEOLOGIST AND THE BUREAU OF ECONOMIC GEOLOGY, 1949–1970

by Peter T. Flawn

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