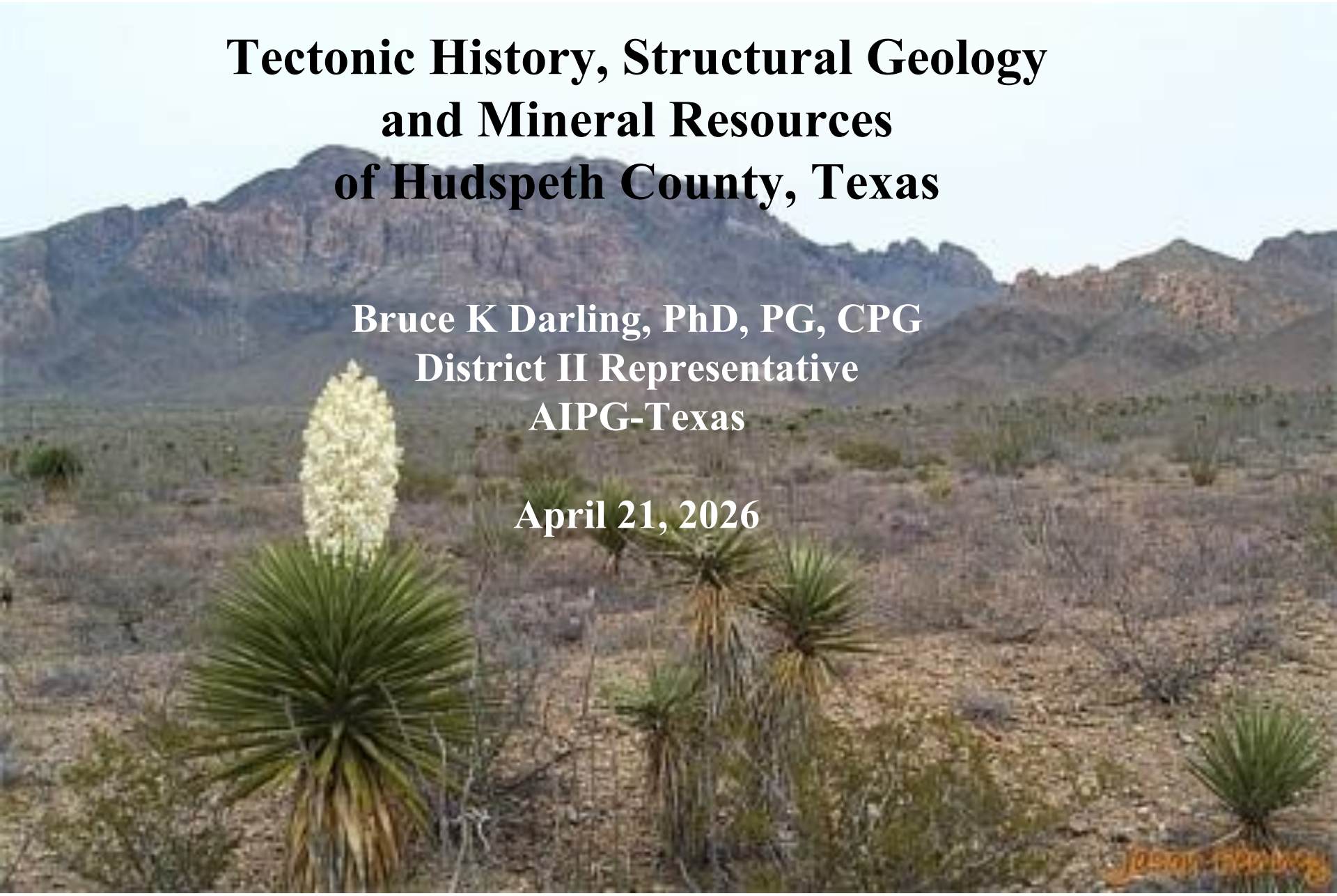


Tectonic History, Structural Geology and Mineral Resources of Hudspeth County, Texas

Bruce K Darling, PhD, PG, CPG
District II Representative
AIPG-Texas

April 21, 2026

Link to 2023 Guidebook: Geology of Hudspeth County

https://aipg-tx.org/the-aipg-tx-spring-2023-field-trip-guidebook-has-been-released-in-draft-version-geology-of-hudspeth-county-texas/

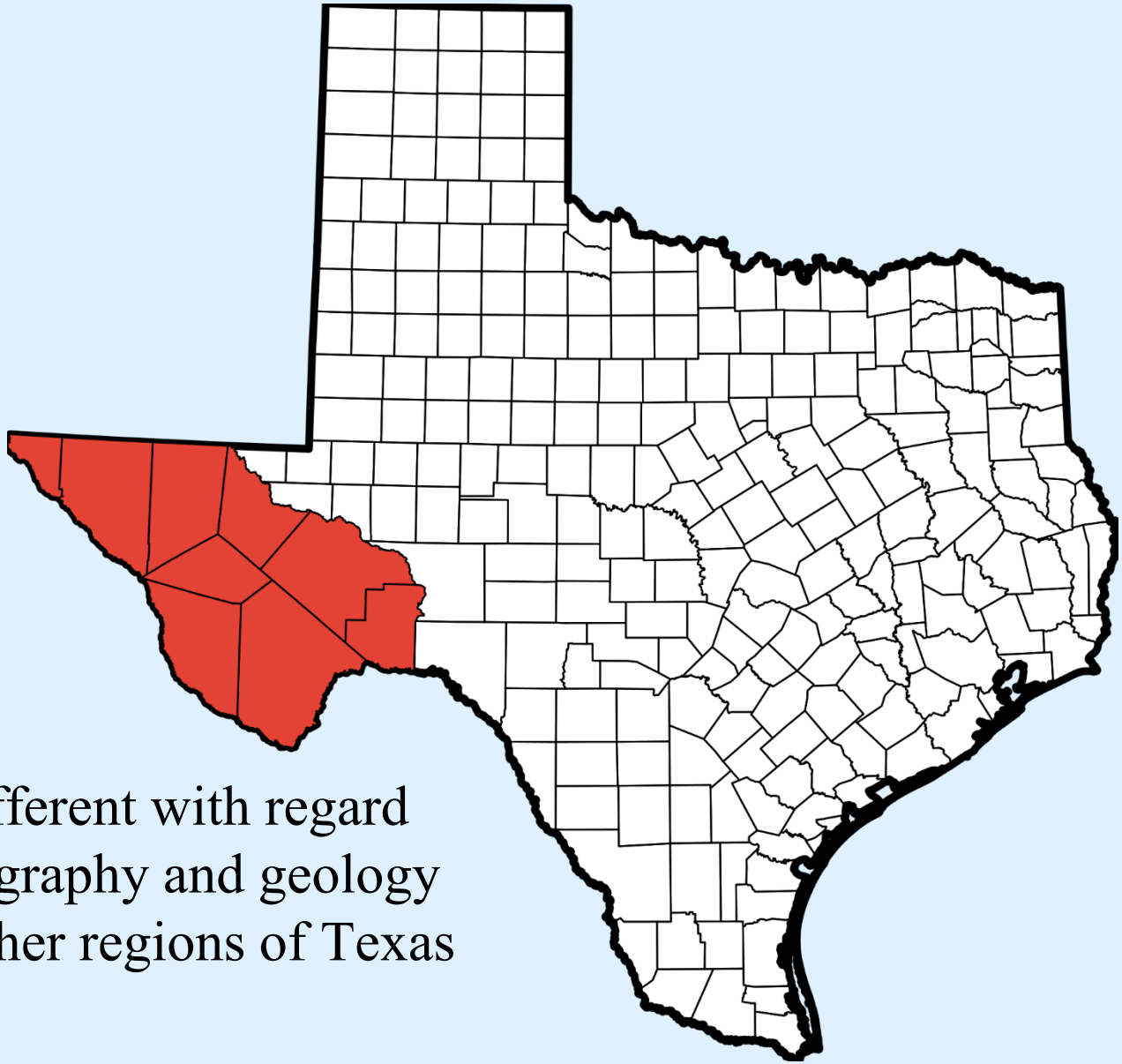
View toward the southwest from road to RAA radar station. Diabase dike intrudes Eagle Peak syenite.. Southern Eagle Mountains and Indio Mountains are south of the diabase dike. Photo by Paul Warren.

View toward the northeast from road to FAA radar station. Shown in the photo are Southeast Eagle Flat, Eagle Flat Draw, the Carrizo Mountains, Lobo Valley and Wild Horse Flat. The mountains in the upper right corer of the photo are the Wylie Mounta ins. Van Horn is in upper left quadrant of photo.

Sierra Blanca Mountain and Triple Hill as seen from FM 1111, near base of Diablo Plateau escarpment.

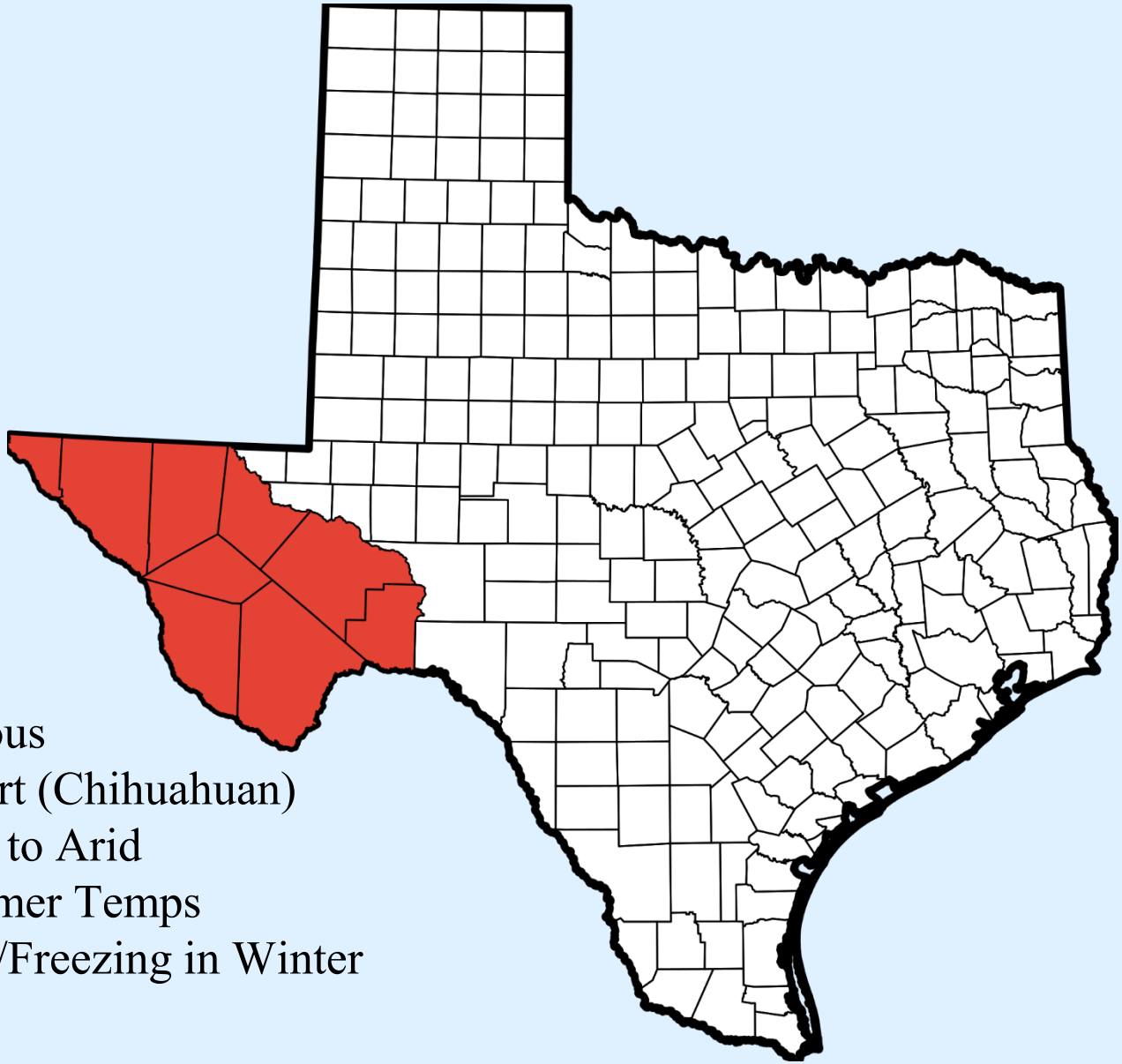
Basin and Range Physiographic Province

Basin and Range Physiographic Province of North America and location of Trans-Pecos Subprovince. Source: Bedient and others (1985).



Very different with regard
to physiography and geology
from all other regions of Texas

Trans-Pecos Texas



Mountainous
High Desert (Chihuahuan)
Semi-Arid to Arid
High Summer Temps
Very Cold/Freezing in Winter

Trans-Pecos Texas

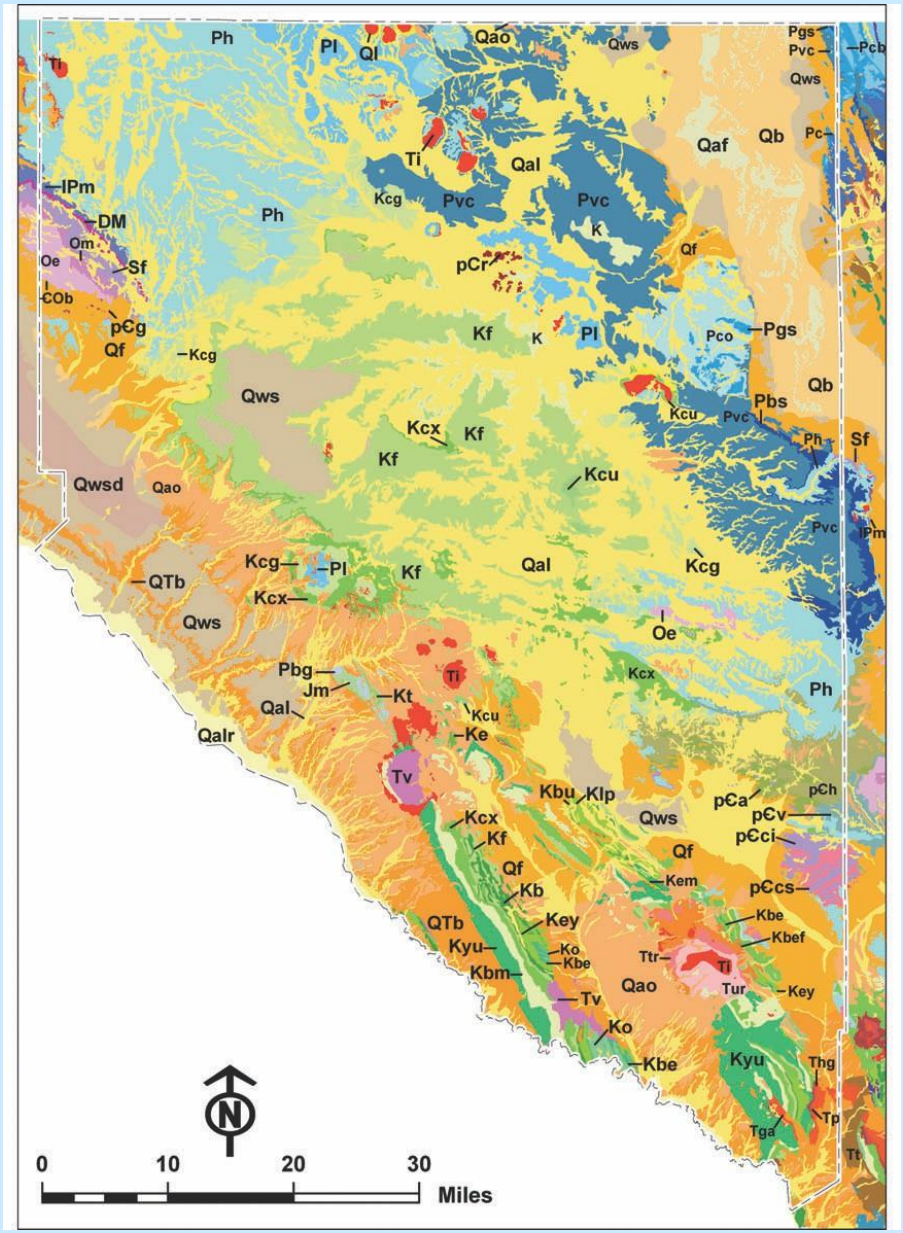
"Trans-Pecos is the 'solar plexus' of North America." William R. Muehlberger, comment to Bruce Darling while on a 3-day field trip to the Big Bend region, October 1985.

Tectonic Development and Structural Geology

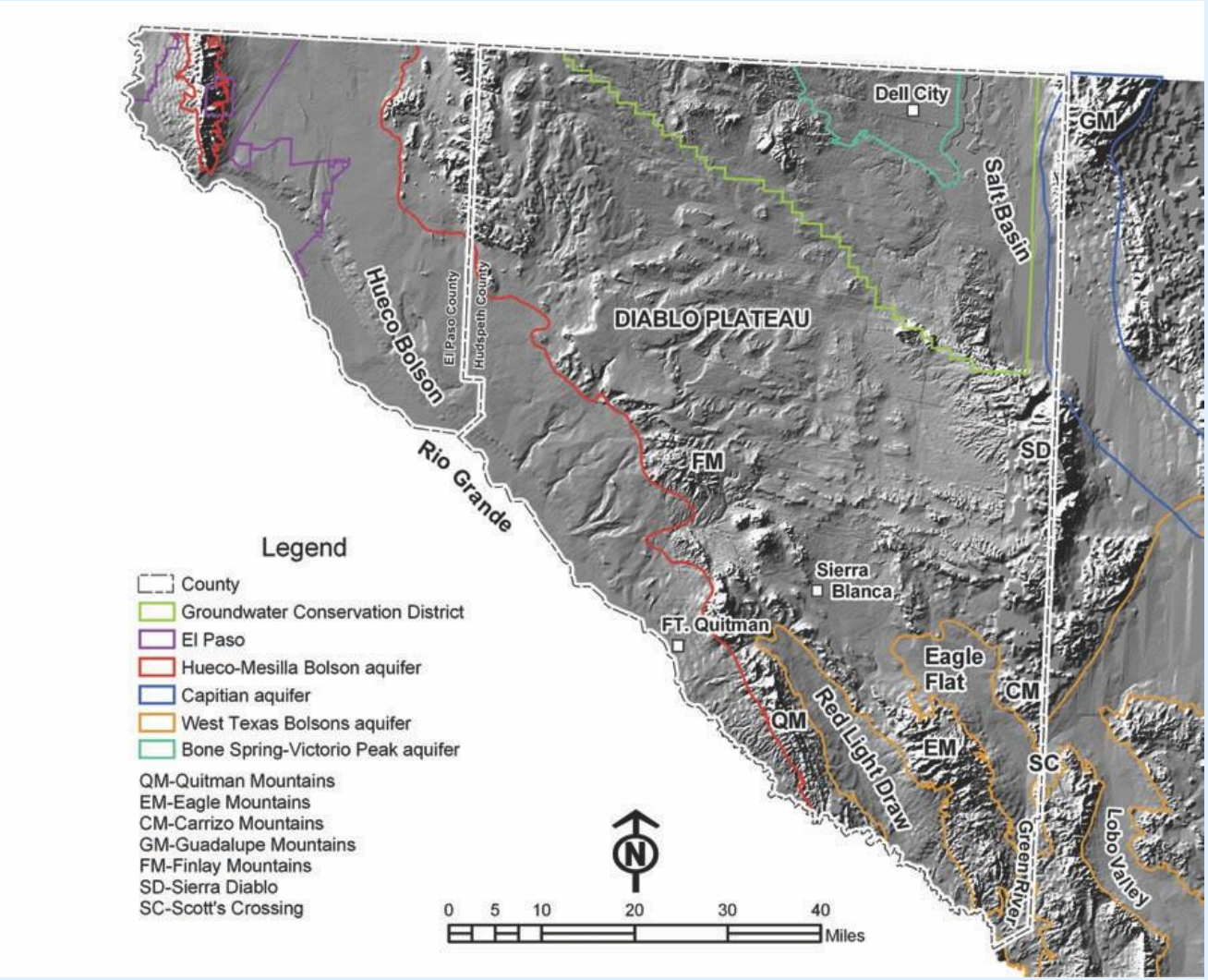
- 1.5 Ga (Proterozoic – Late Tertiary)
- Grenville Orogeny (1.3 – 1.0 Ga)
- Ouachita Orogeny (Late Pn – Early Pm)
- Laramide Orogeny (75 – 35 Ma)
- Tertiary Volcanism (48 – 17 Ma)
- Basin-and-Range Tectonism
  - 31 – 24 Ma (Beginning)
  - 23 Ma (Most Active Faulting)

Prof. William R. Muehlberger, right, examining Apollo 16 Lunar Sample 61016 inside the Lunar Receiving Laboratory at the Manned Spacecraft Center in Houston, circa 1972. Nicknamed, "Big Muley," after Muehlberger, the rock weighed 11.7 kilograms and was the largest collected during the six Apollo lunar landing missions.

Area: 4,572 mi^2
(11,851 km^2)

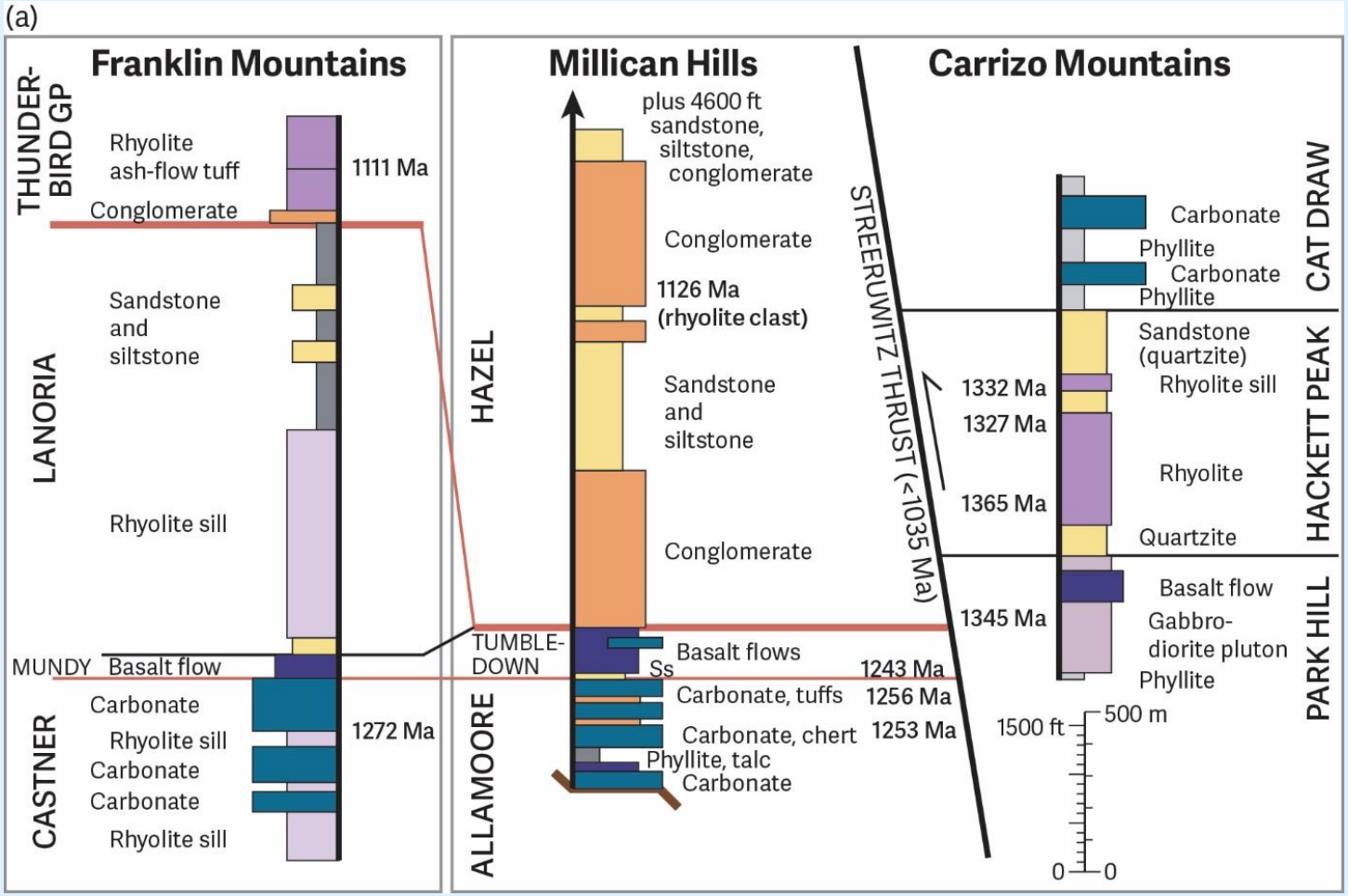


Hudspeth County – Geological Atlas of Texas
(Van Horn – El Paso Sheet)



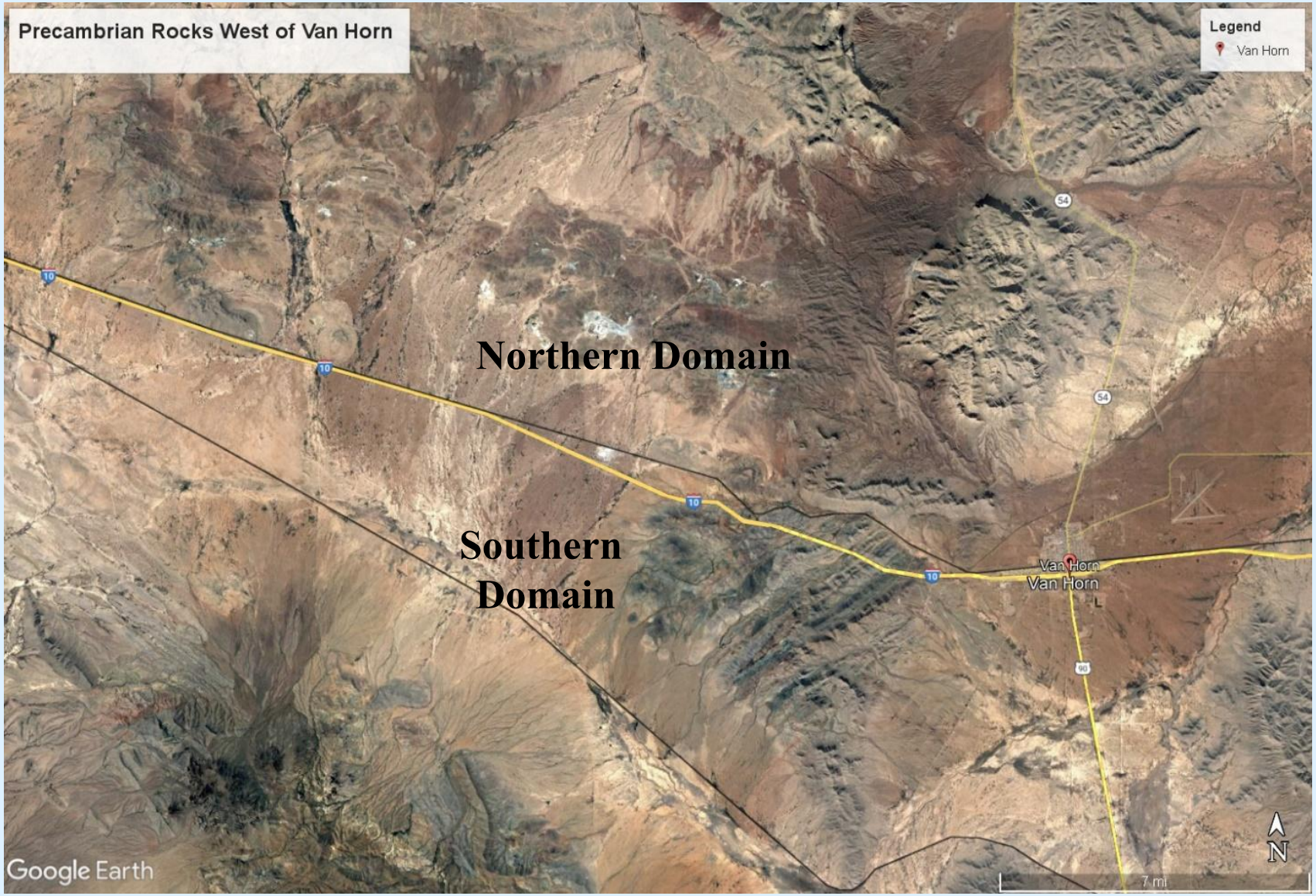
Physiographic features of El Paso, Hudspeth, and Westernmost Culberson counties

Northern Domain **Southern Domain**



Streeruwitz Thrust Fault and Division of Precambrian Rocks into Northern and Southern Domains. Source: Ewing (2016)

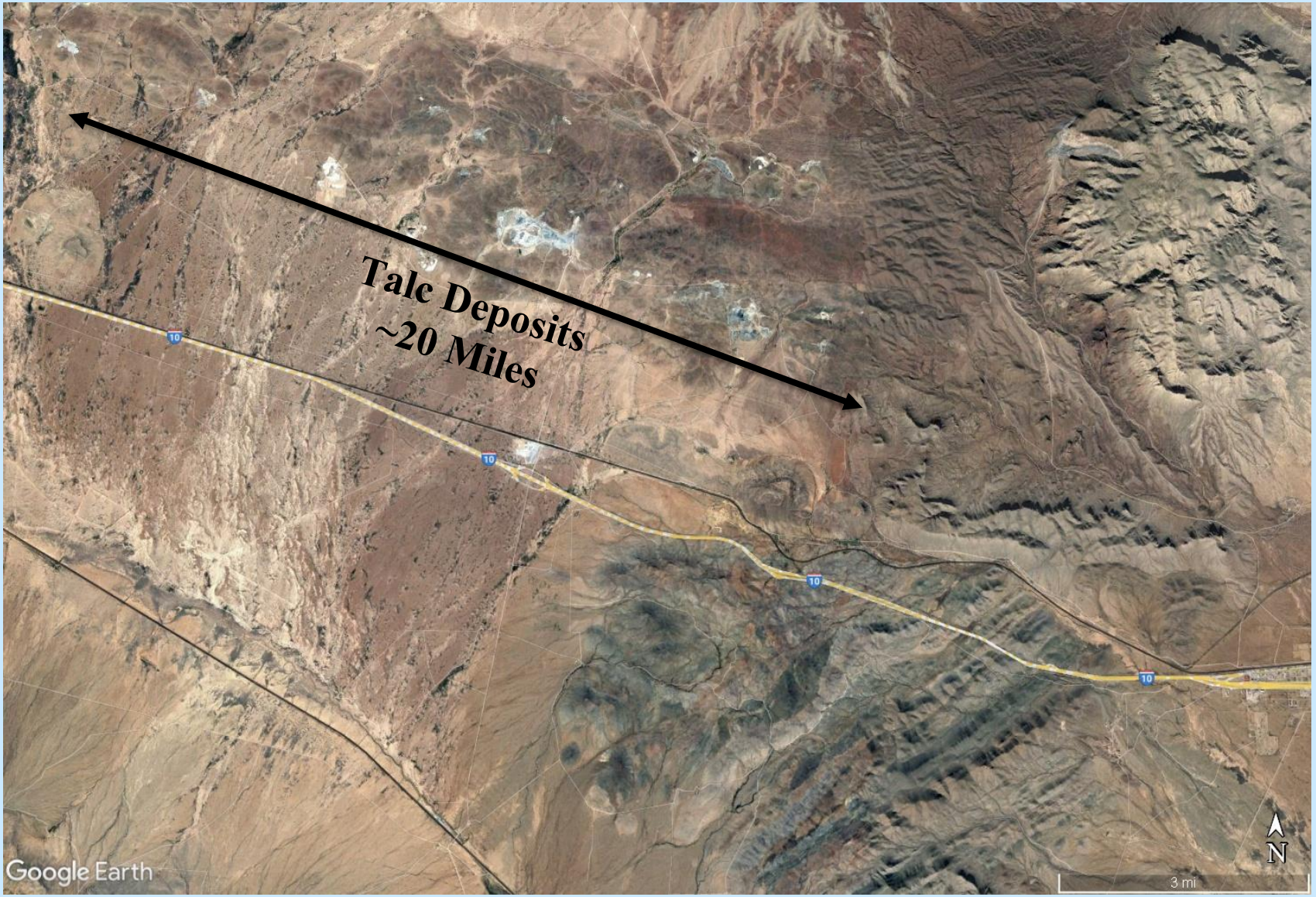
Note: Stromatolites in middle section of Allamoore Formation



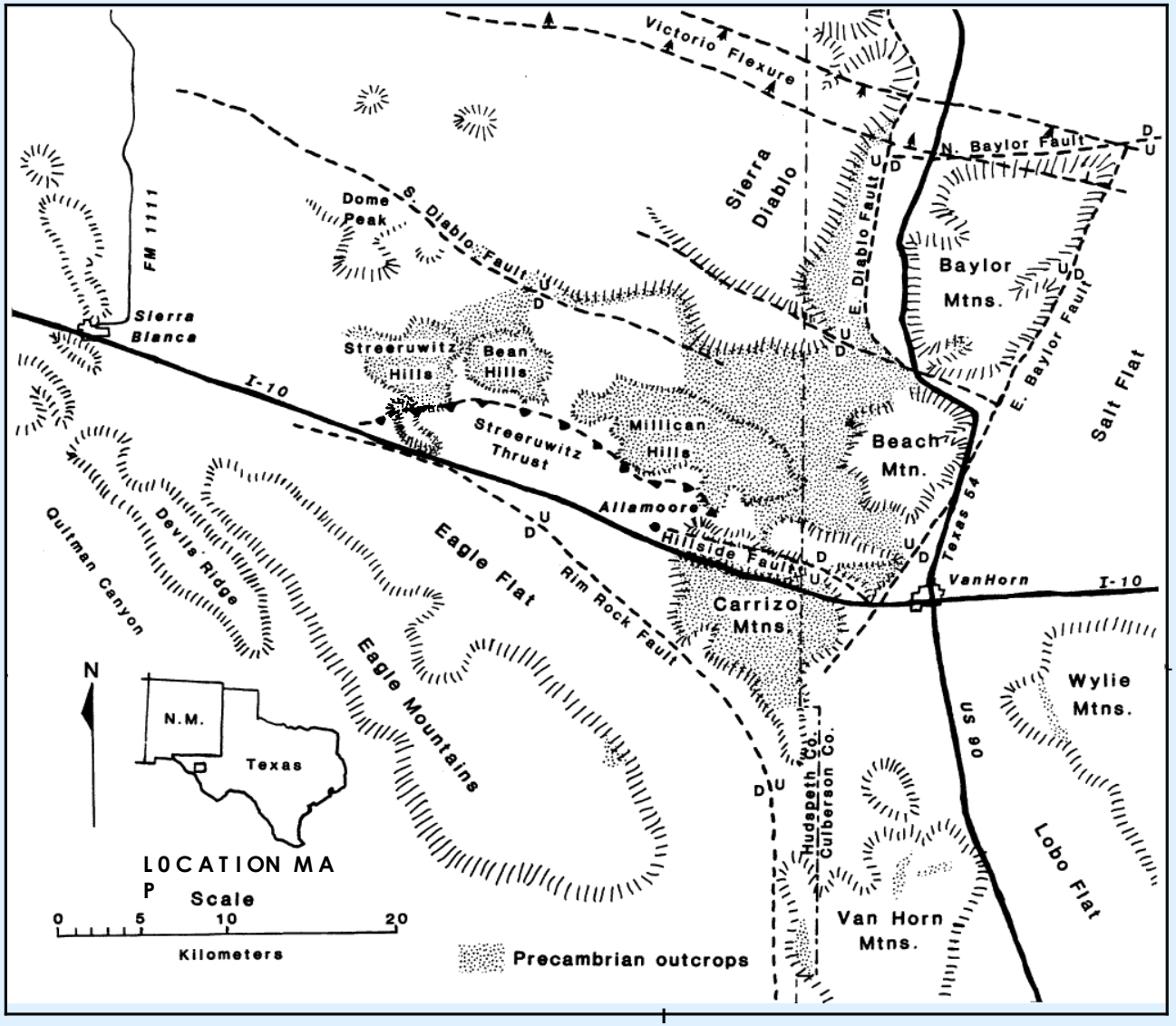
Northern and Southern domains of Precambrian separated by Streeruwitz thrust fault. Source (Google Earth)

Carrizo Mountains as seen from eastbound I-10 ramp at Allamoore.

Roadcut exposures of Southern Domain metamorphosed rocks (Cat Draw/Hackett Peak?) along westbound I-10 lanes between Van Horn and Allamoore.



Allamoore Talc District

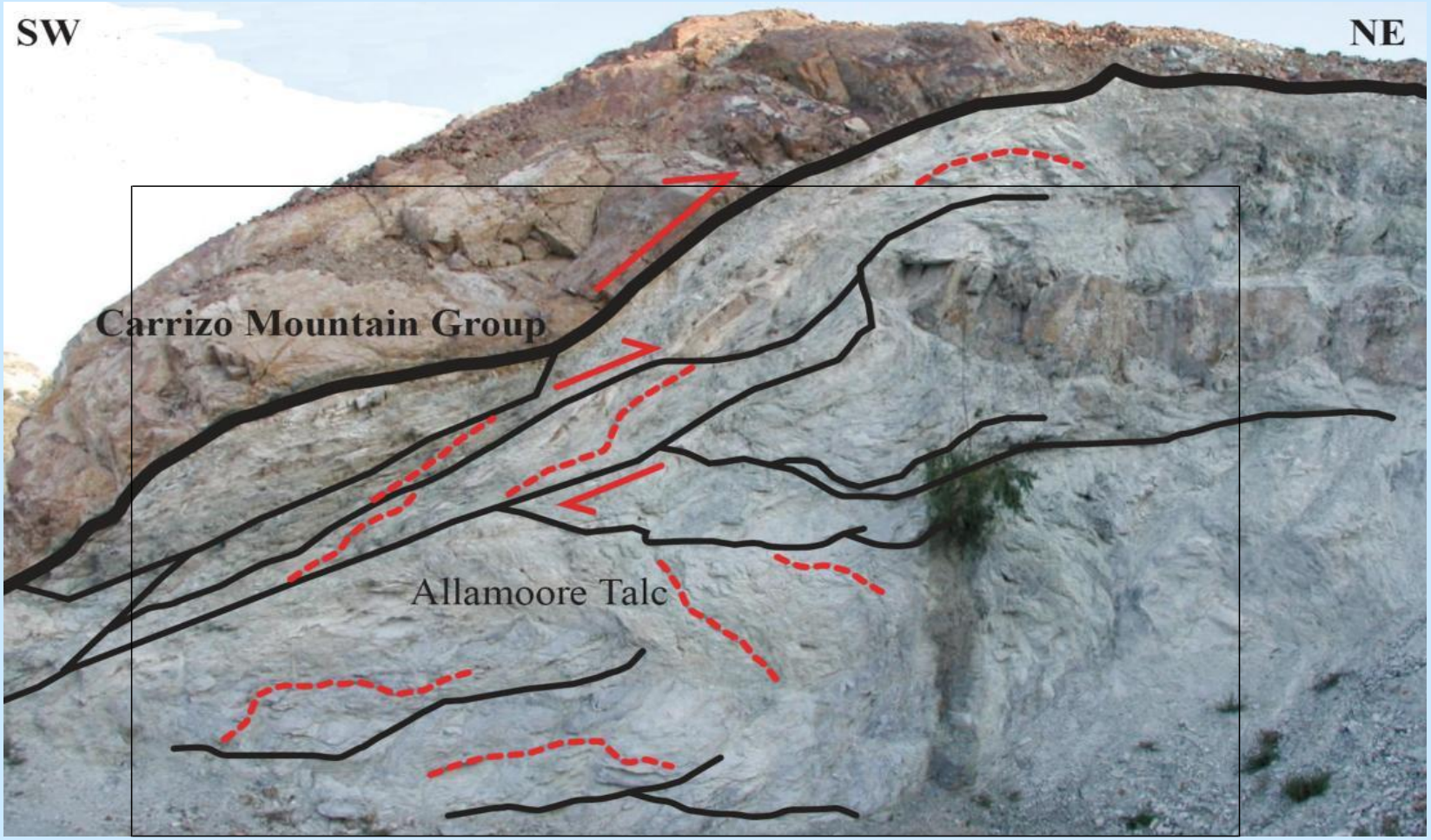

Victorio Flexure
N. Baylor Fault
Sierra Diablo
E. Diablo Fault
Dome Peak
S. Diablo Fault
FM 1111
Sierra Blanca
Baylor Mtns.
E. Baylor Fault
Salt Flat
Streeruwitz Hills
Bean Hills
I-10
Streeruwitz Thrust
Millican Hills
Beach Mtn.
Texas 54
Allamoore
Hillside Fault
VanHorn
I-10
Quitman Canyon
Devils Ridge
Eagle Flat
Rim Rock Fault
Carrizo Mtns.
Eagle Mountains
N
N.M.
Texas
LOCATION MAP
Scale
0 5 10 20
Kilometers
Hudspeth Co.
Culberson Co.
US 90
Wylie Mtns.
Lobo Flat
Van Horn Mtns.
Precambrian outcrops

Southern escarpment of Diablo Plateau
View toward the West as seen from HW 54

Diablo Plateau – E. Diablo Fault escarpment as seen from HW 54

Desert Rock Quarry

Desert Rock Quarry - Metarhyolite of Upper Carrizo Mtn Group



Exposure of talc and Carrizo Mountain Group along the Streeruwitz Thrust, Allamoore talc district. From Kyle (2011), after Davis (2007).

Allamoore Formation (Northern Domain), Natural Minerals talc mine, Allamoore, TX.

Folds in talc at main quarry, Allamoore.

Formation of Allamoore talc deposits

- Commercial deposits occurs in narrow fold-and-thrust belt that represents northernmost extent of Grenville front.
- Immediately below footwall of Streeruwitz Thrust.
- History of complex deformation and fluid flow that supplied silica to Allamoore dolostones.
- Dips ~70^{o} south; average thickness ~400 ft (122 m)
- Record of collision of north-verging continental mass with southern Laurentia, occurring in West Texas ~1.06 – 0.98 Ga.

Talc mining at Allamoore

- Initial production in 1952
- Several operators working 40 leases/pits
- High-grading was dominant mining method
  - Short-term profit but sacrifices long-term production capacity and minimizes life of project (ignores NPV and IRR)
- Annual production ~228,000 tons by 1982
- Most of the product used by ceramic industry
- Dal-Tile consolidated leases and brought in a bona-fide mining engineer (Ben File) to develop a comprehensive long-term mining plan.

Production

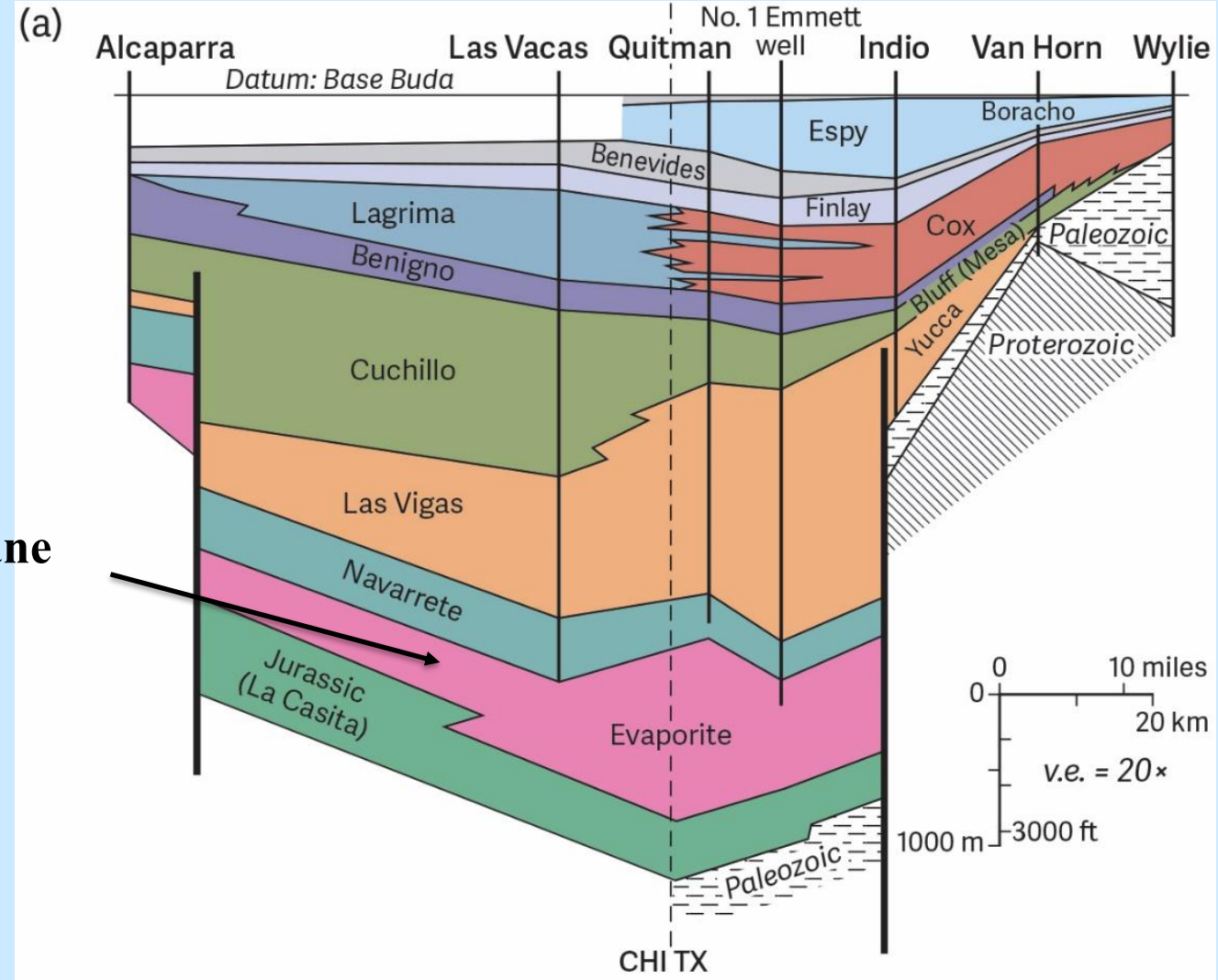
- ~96,000 tons/year
- 84,000 tons to El Paso plant
- 1,200 tons to Muskogee, OK plant
- 10,500 tons to Mexico
- Dal-Tile does not supply talc to competitors

Laramide Orogeny
(75 – 35 Ma)

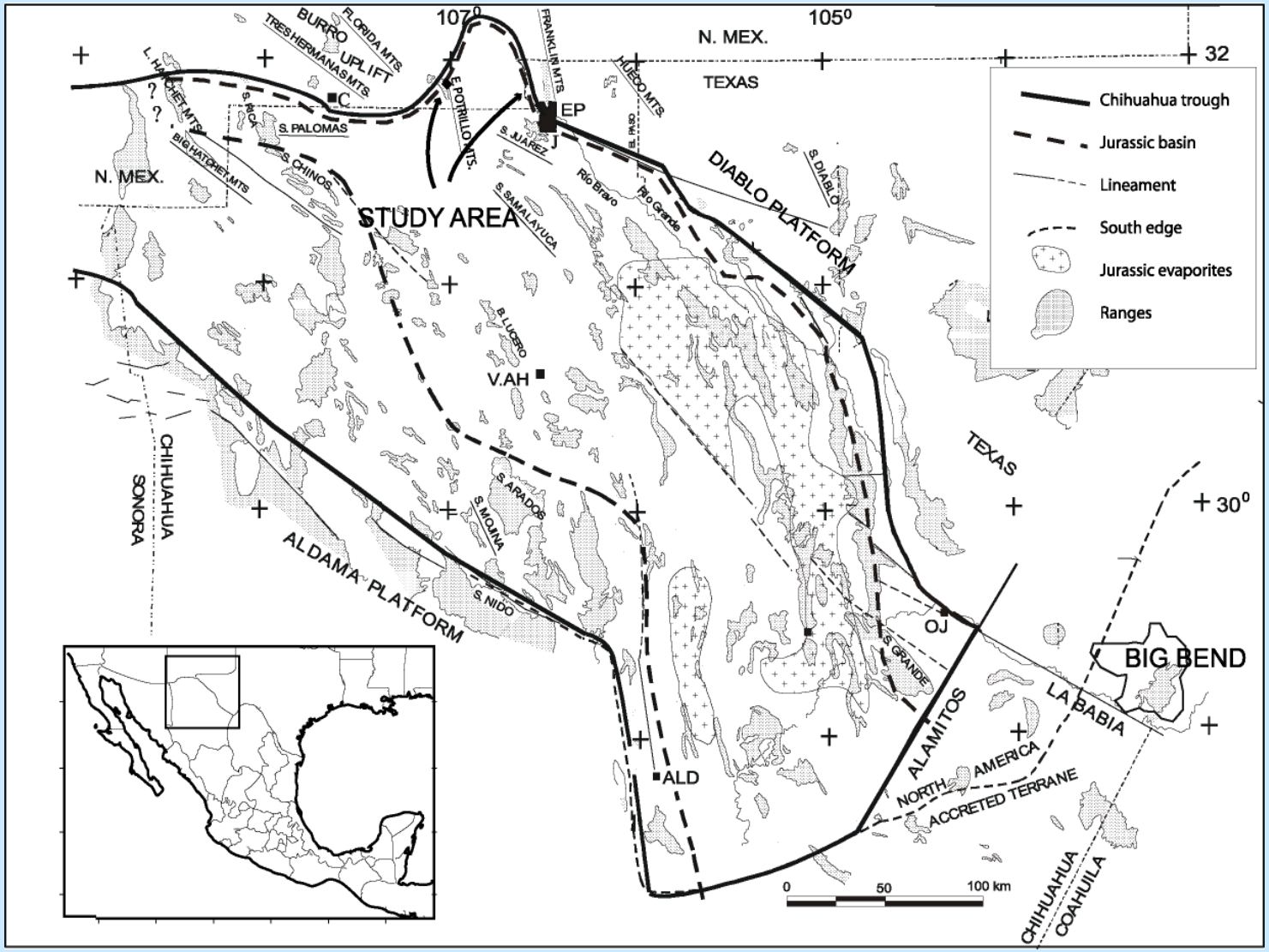
Chihuahua Trough

- Sedimentary (pull-apart) basin of Mesozoic (Jurassic/Cretaceous) age that lies along southwestern margin of North American craton.
- Northern boundary is Diablo Platform of Hudspeth County
- Southern boundary is Aldama Platform of the northern Mexican state of Chihuahua.
- Sediments were strongly deformed during Laramide Orogeny as Jurassic and Cretaceous formations were thrust toward the north-northeast, driven by flat-slab subduction of Farallon Plate.

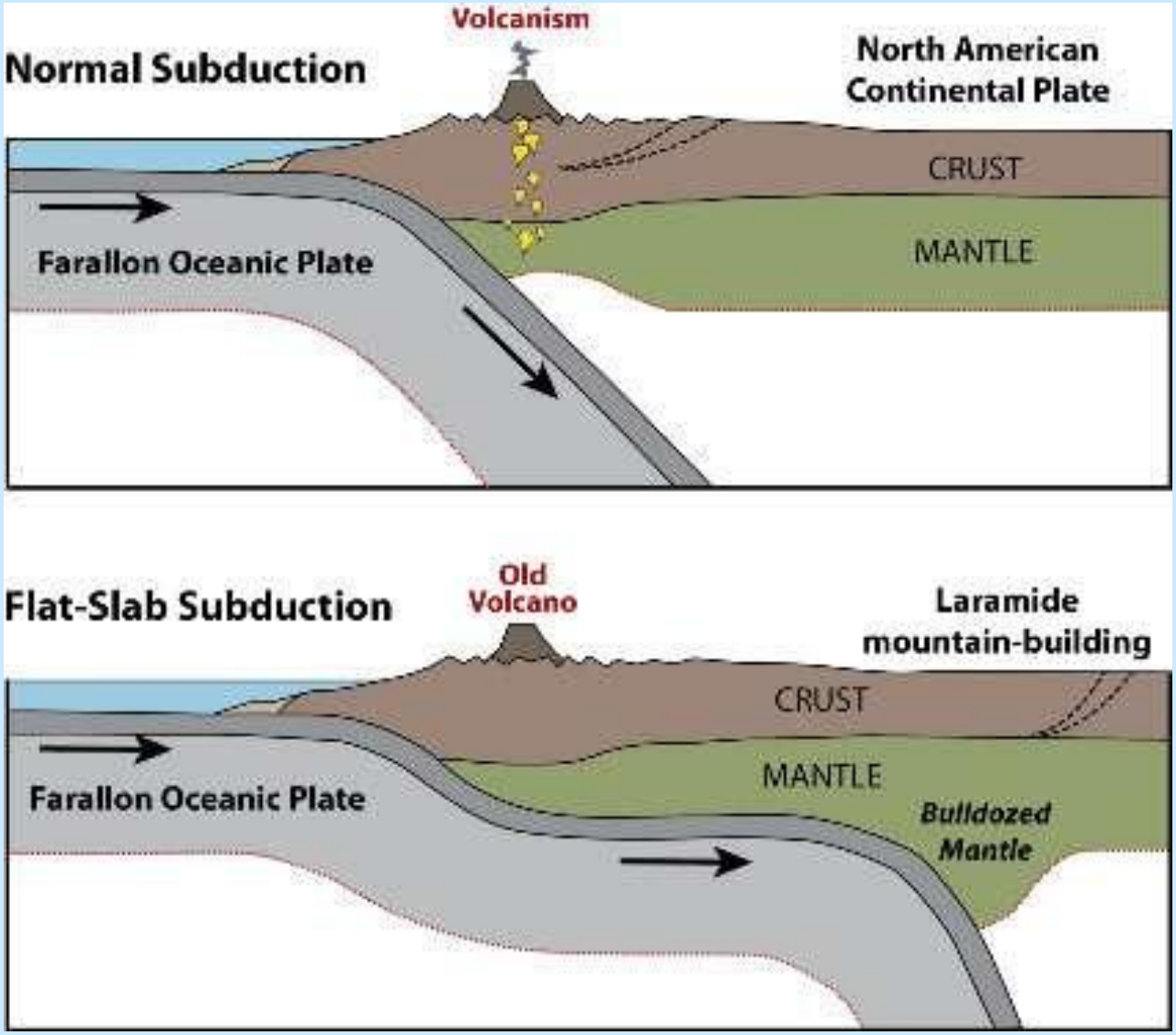
Glide plane



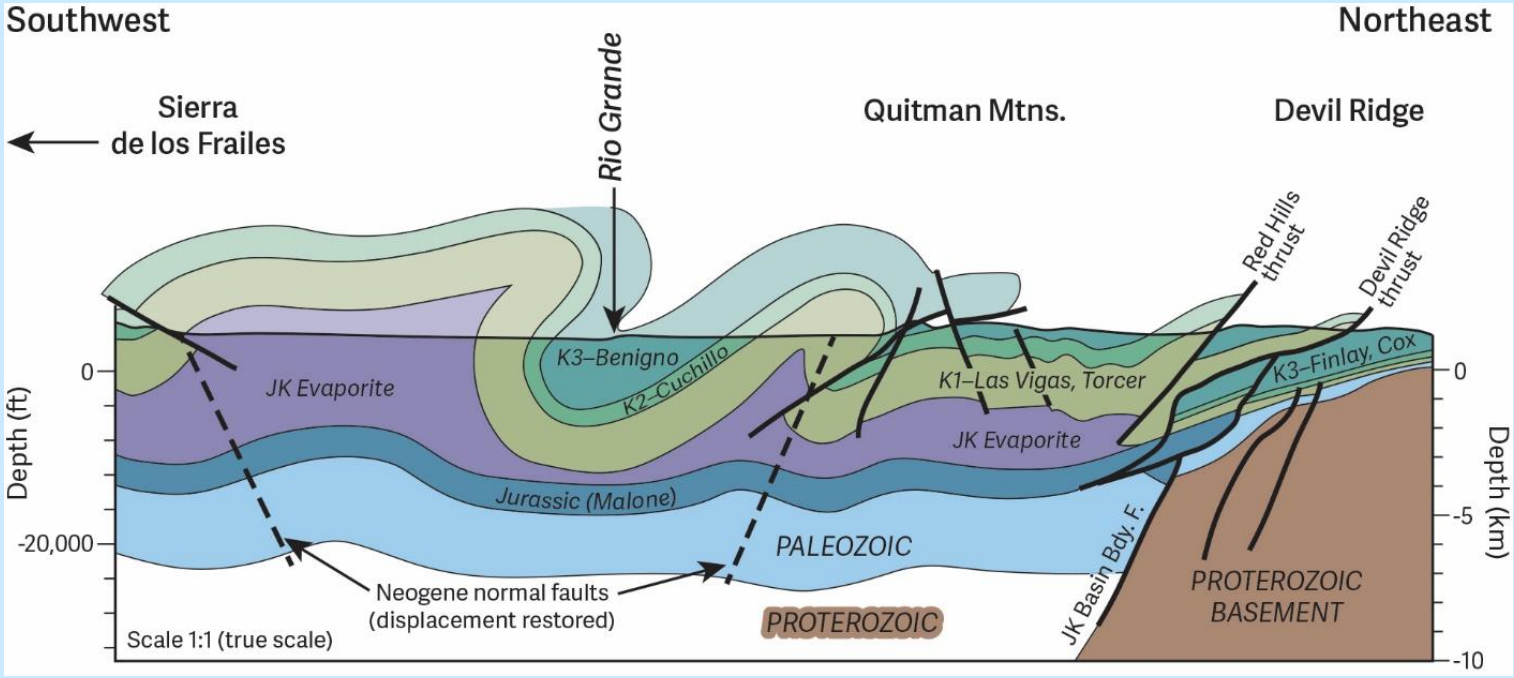
Jurassic and Cretaceous Formations of the Chihuahua Trough. Source: Ewing (2016), from Haenggi (2002)



Outline of Chihuahua Trough over map of northern Mexico, and southern areas of New Mexico and southwestern Texas. Source: Haenggi (2002)



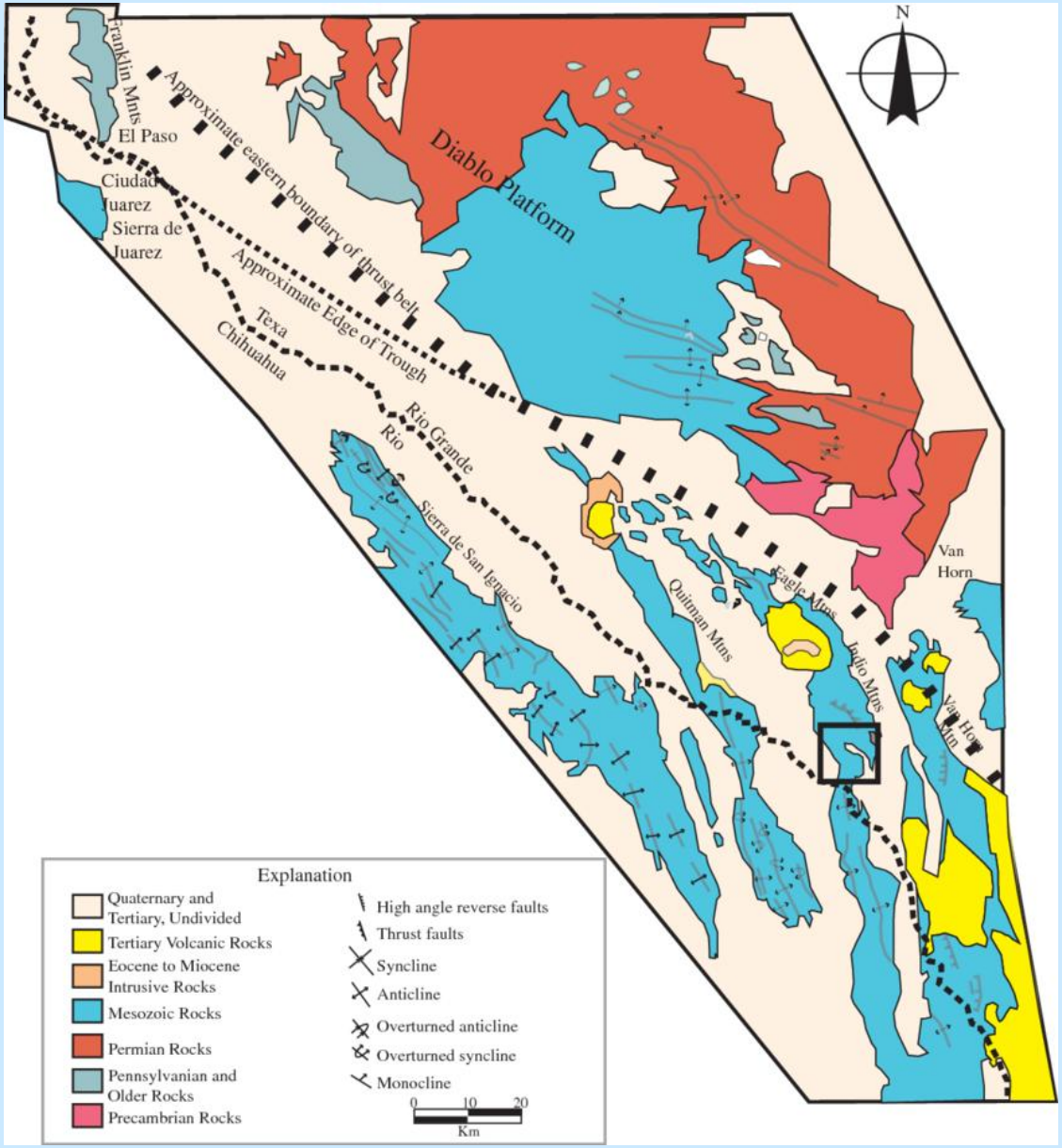
Subduction Models

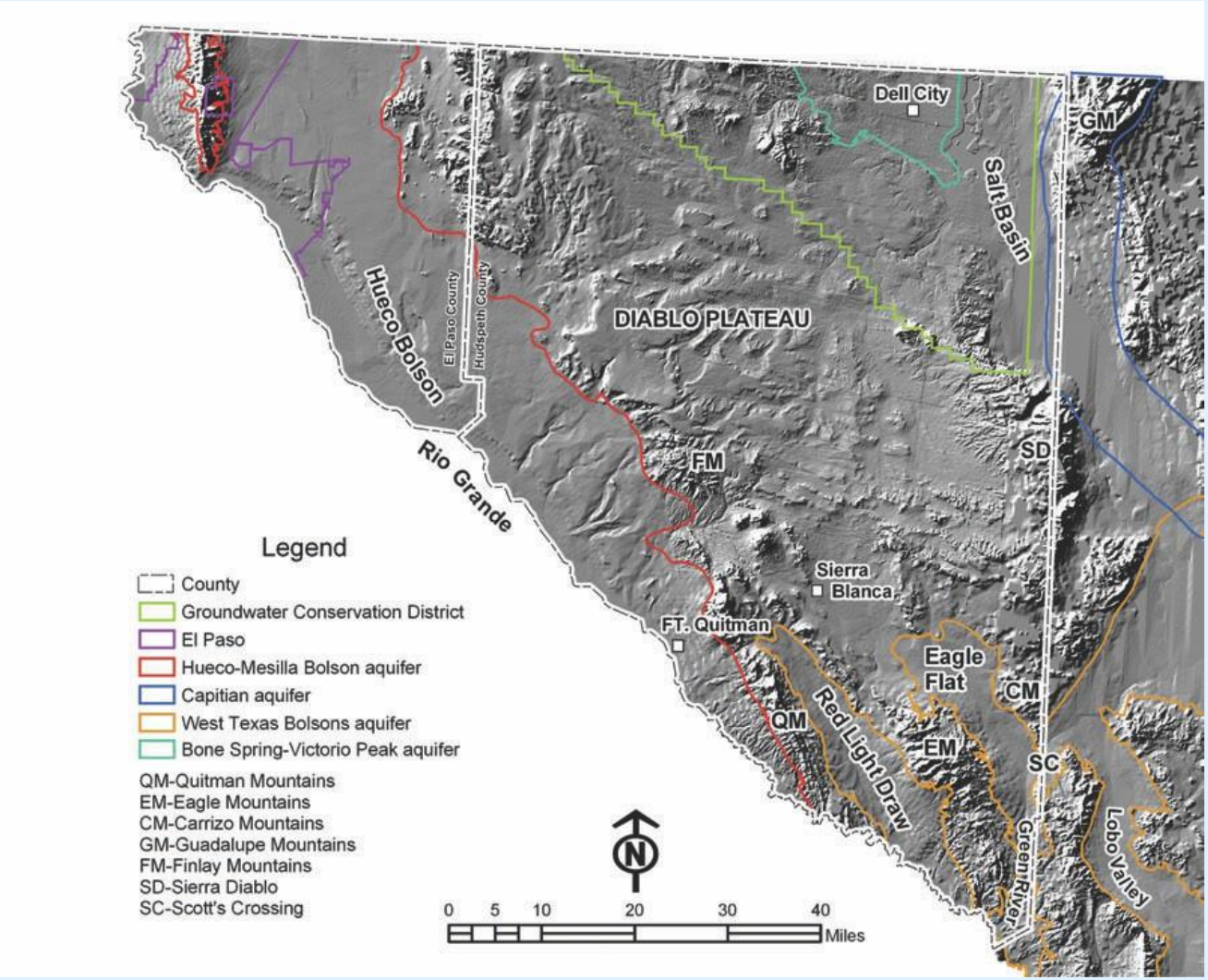


Structure cross section, Quitman Mountains area southwest of Sierra Blanca. Source: Ewing (2016), modified from Haenggi (2002)

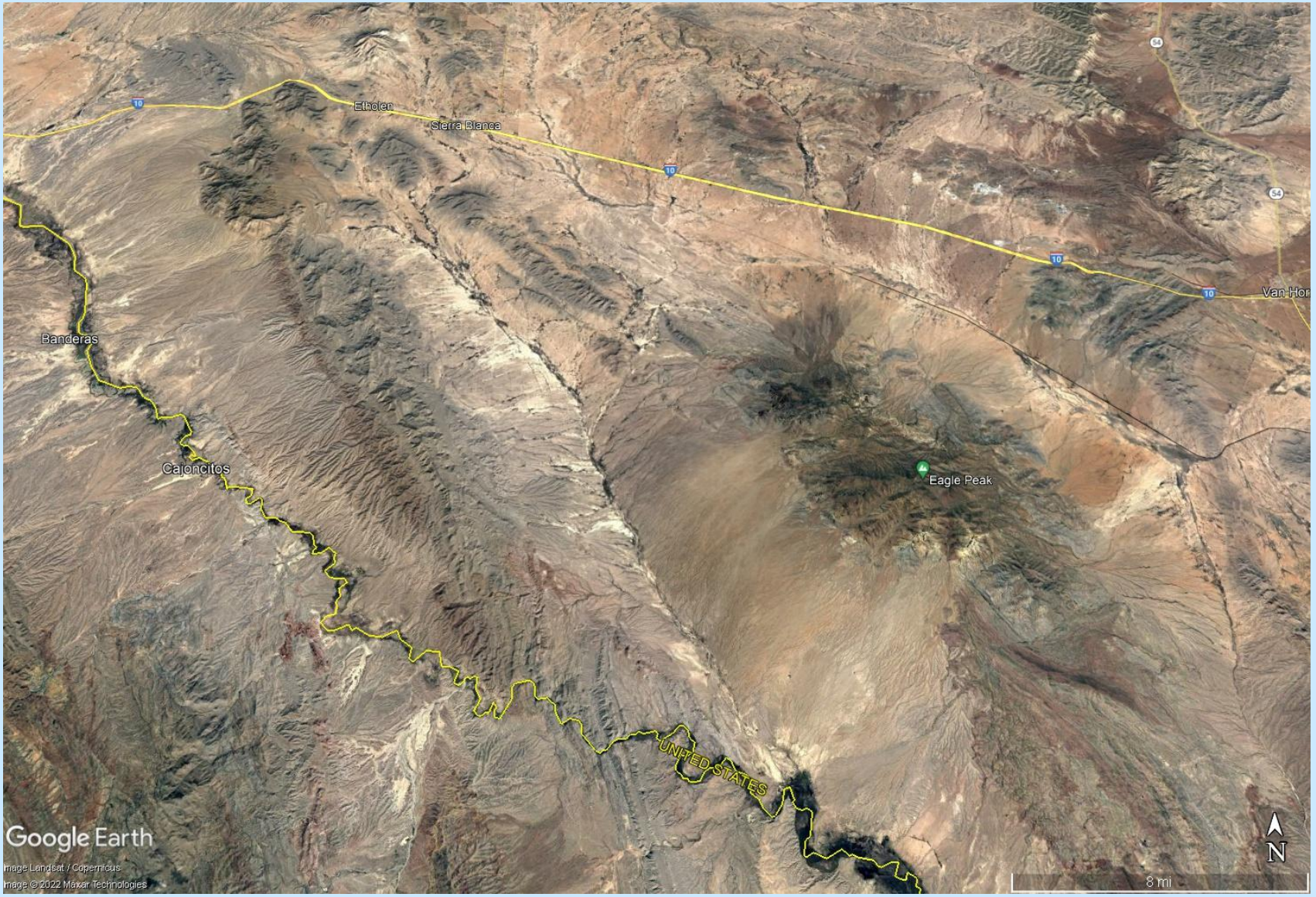
Tectonic map of northeastern margin of the Chihuahua trough southeast of El Paso. Note position of trough margin with respect to edge of fold and thrust belt (Ortega, 2007, after Rohrbaugh, 2001).

Figure does not show Sierra Blanca laccoliths!

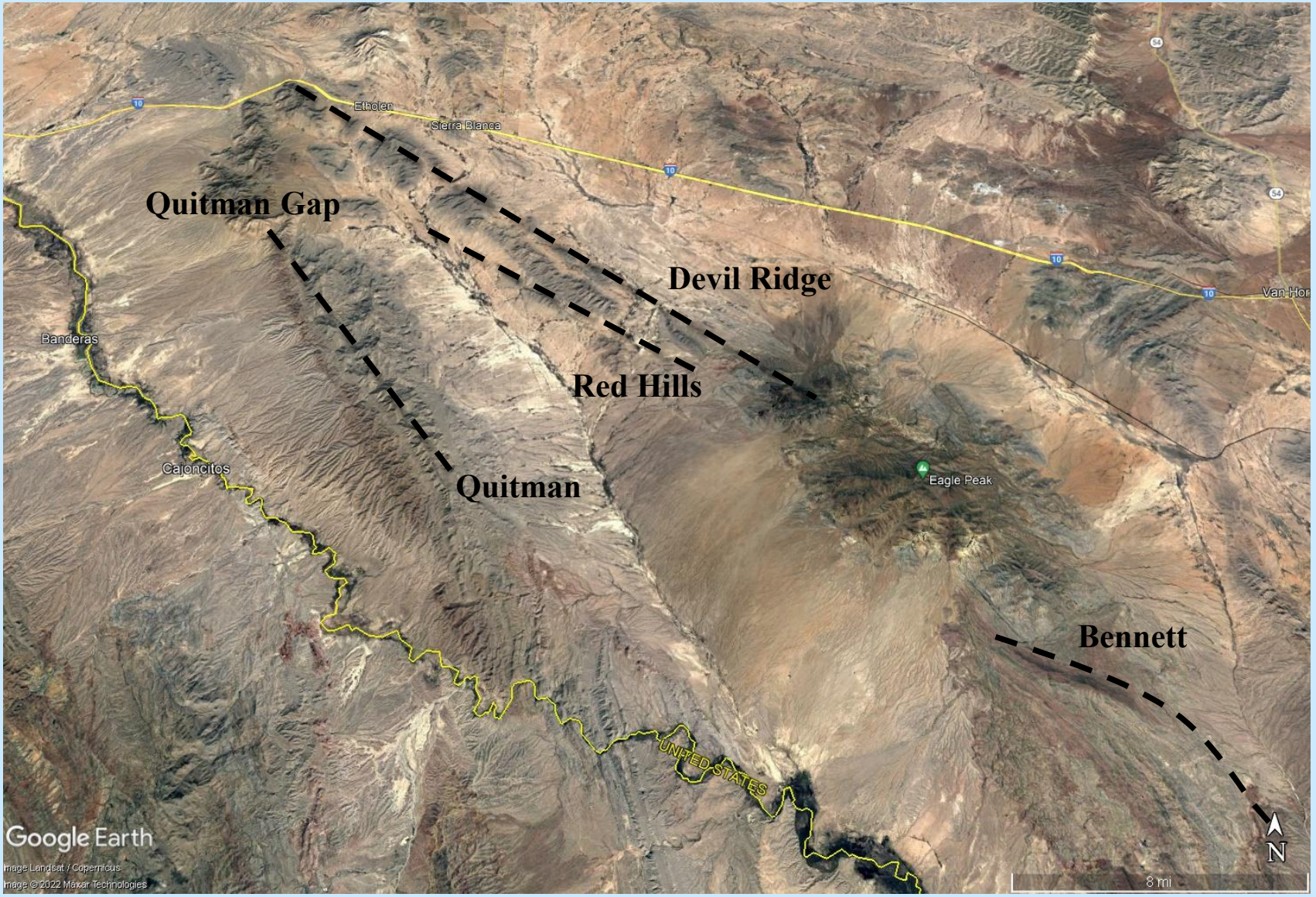




Physiographic features of El Paso, Hudspeth, and Westernmost Culberson counties



Laramide deformation



Laramide thrust faults

Structural differences between Devil Ridge, Red Hills, Indio Mtns, and So. Quitman Mtns

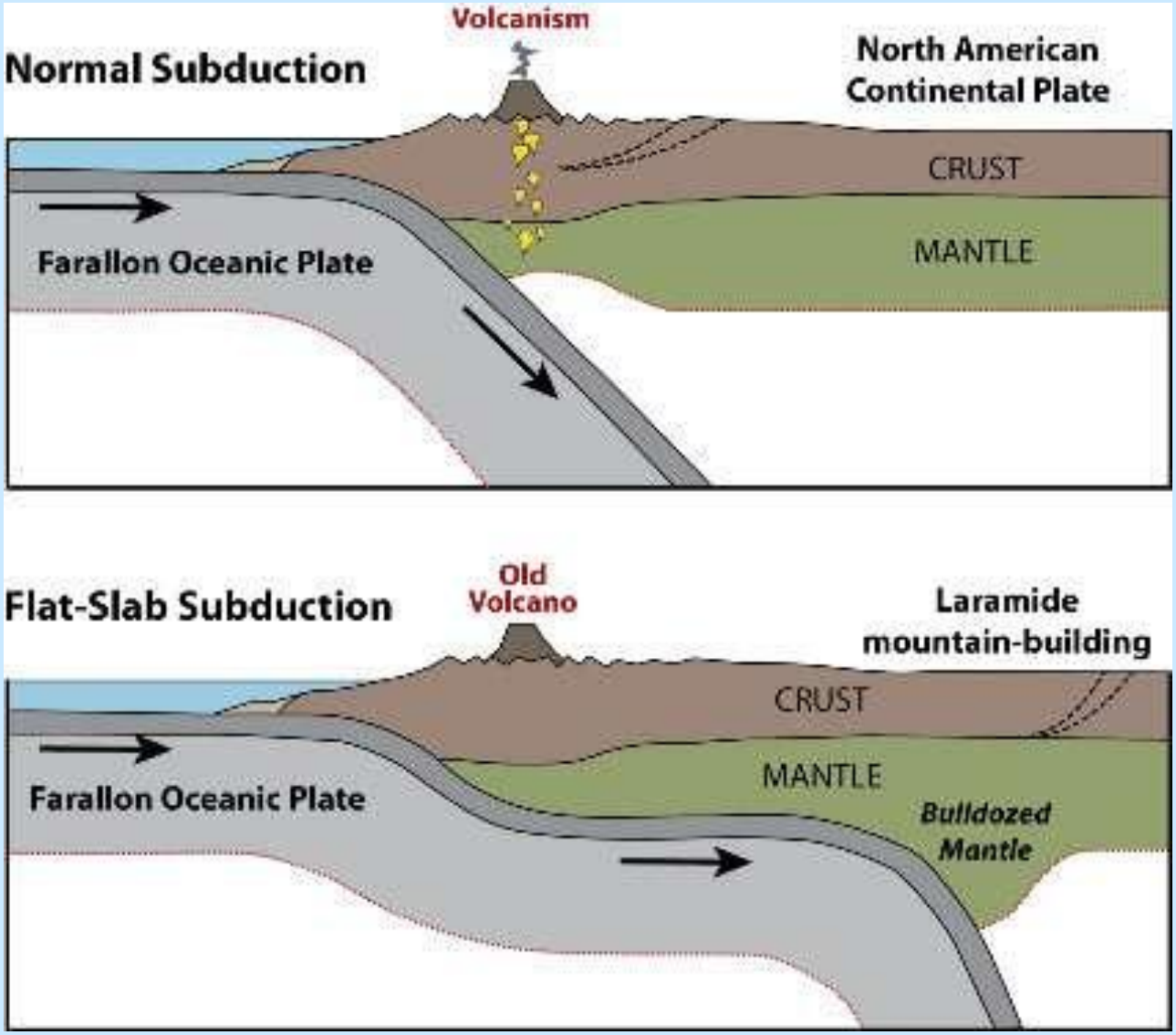
- Indio Mtns – complex system of thrust faults and minor folds
- Devil Ridge and Red Hills – less complex thrust faults and minor folds
- So. Quitman Mtns – NW-trending, nearly recumbent anticline
  - Overturning of beds increases toward the south
  - Movement along Quitman Thrust ~4,900 ft north-northeast
  - Thrust traced 8 mi south of Quitman Gap, and estimated to run 5 mi north

Quitman thrust fault as seen from Quitman Gap Road. Footwall beds are Cox sandstone, and thrust are hanging wall beds are Bluff Mesa limestone.

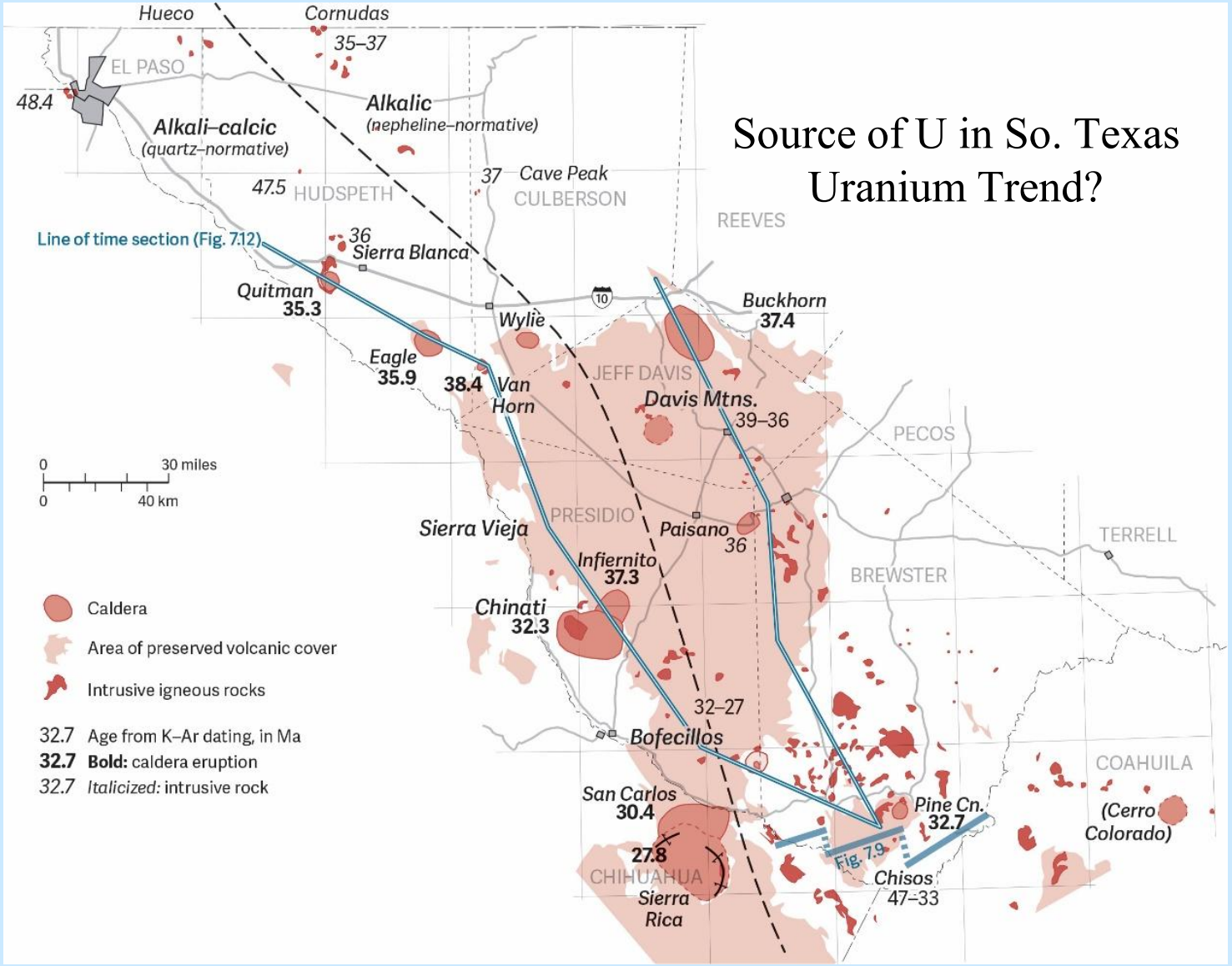
Aerial view (looking west) of Quitman Thrust Fault as viewed from Quitman Gap road.

West limb of Quitman Mtns

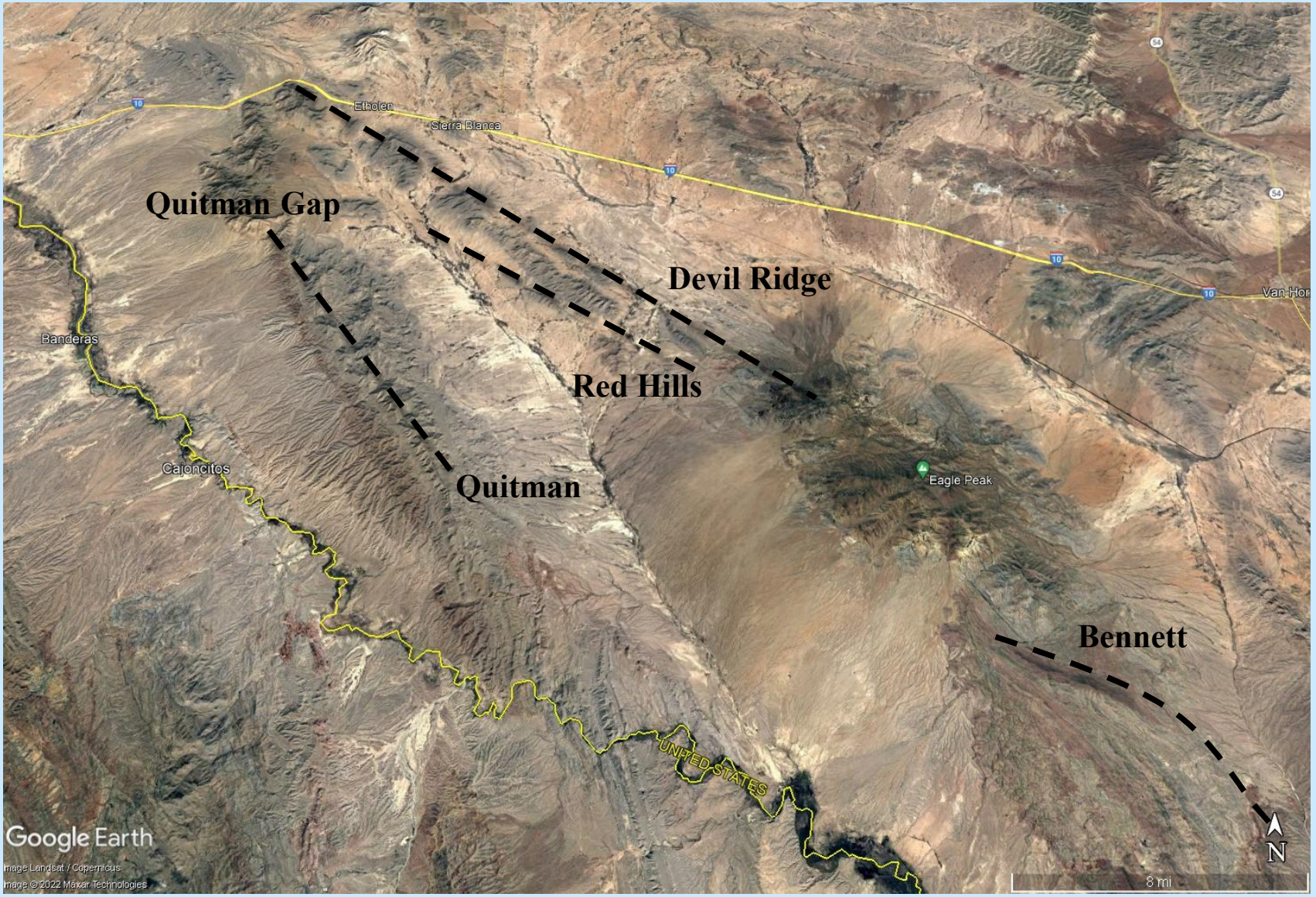
Tertiary Volcanism
(48 – 27 Ma)
Basin-and-Range Tectonism
(26 – 15 Ma)



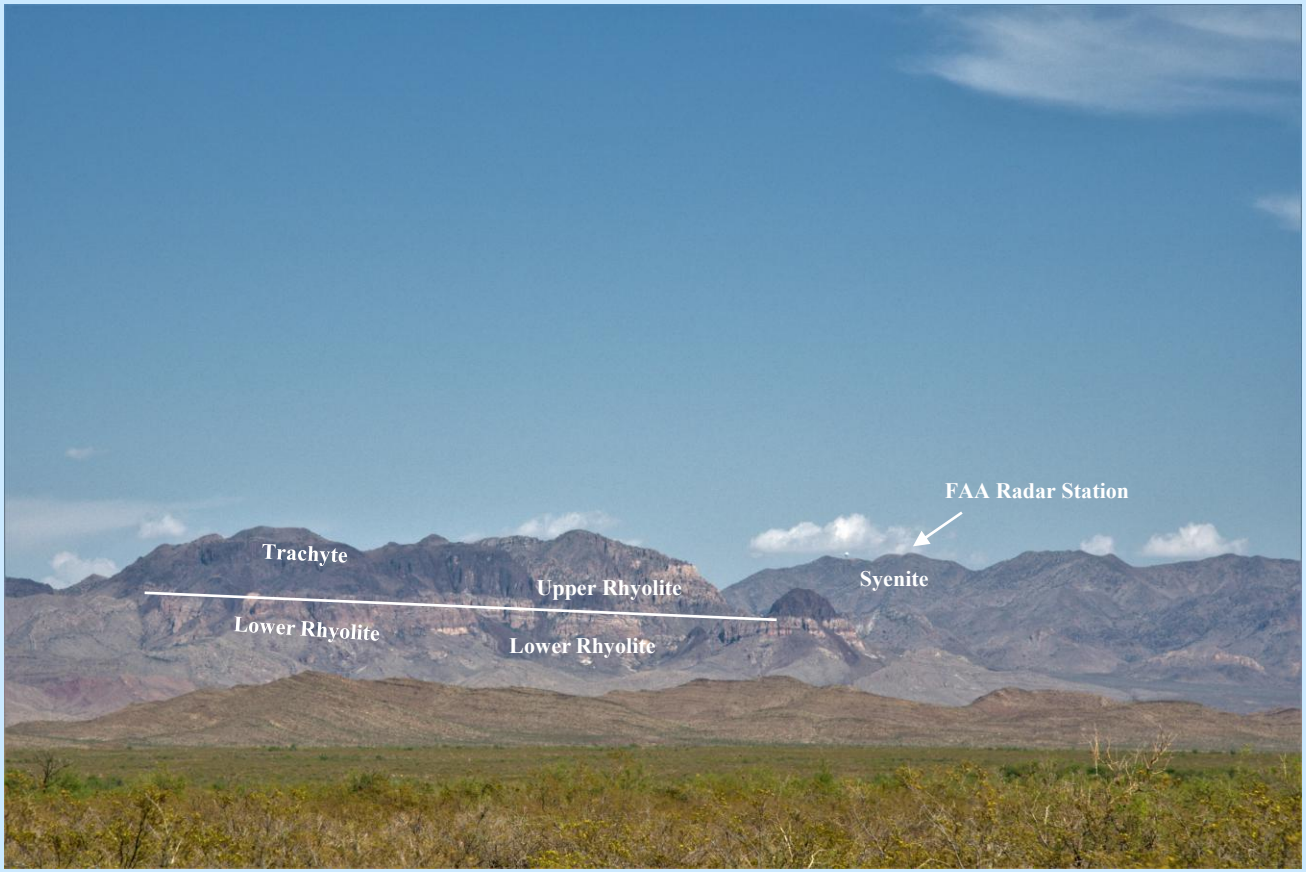
Subduction Models



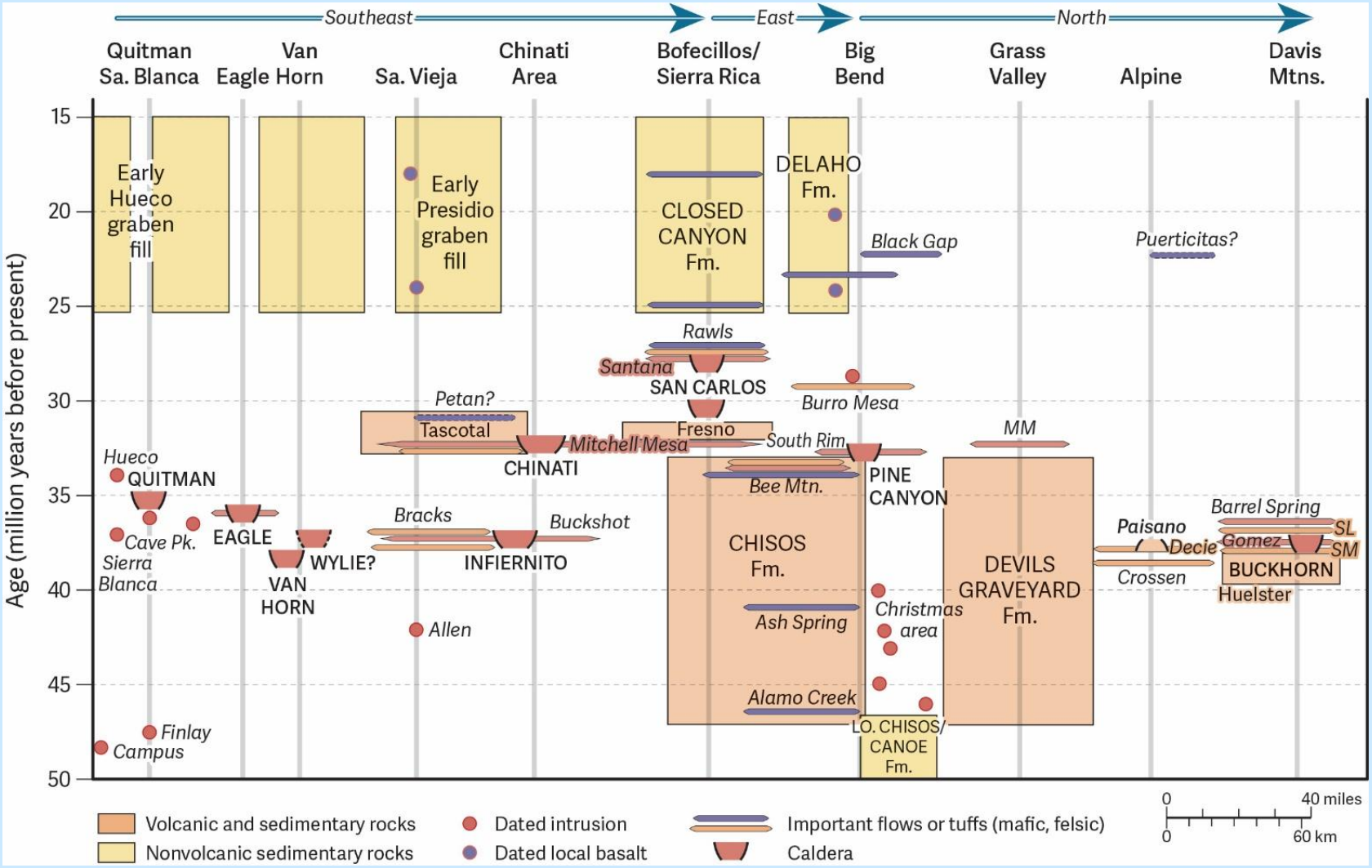
Eruptive centers, calderas, extent of volcanic deposits, and radiometric dates. Source: Ewing (2016), modified from Henry and Price (1985)



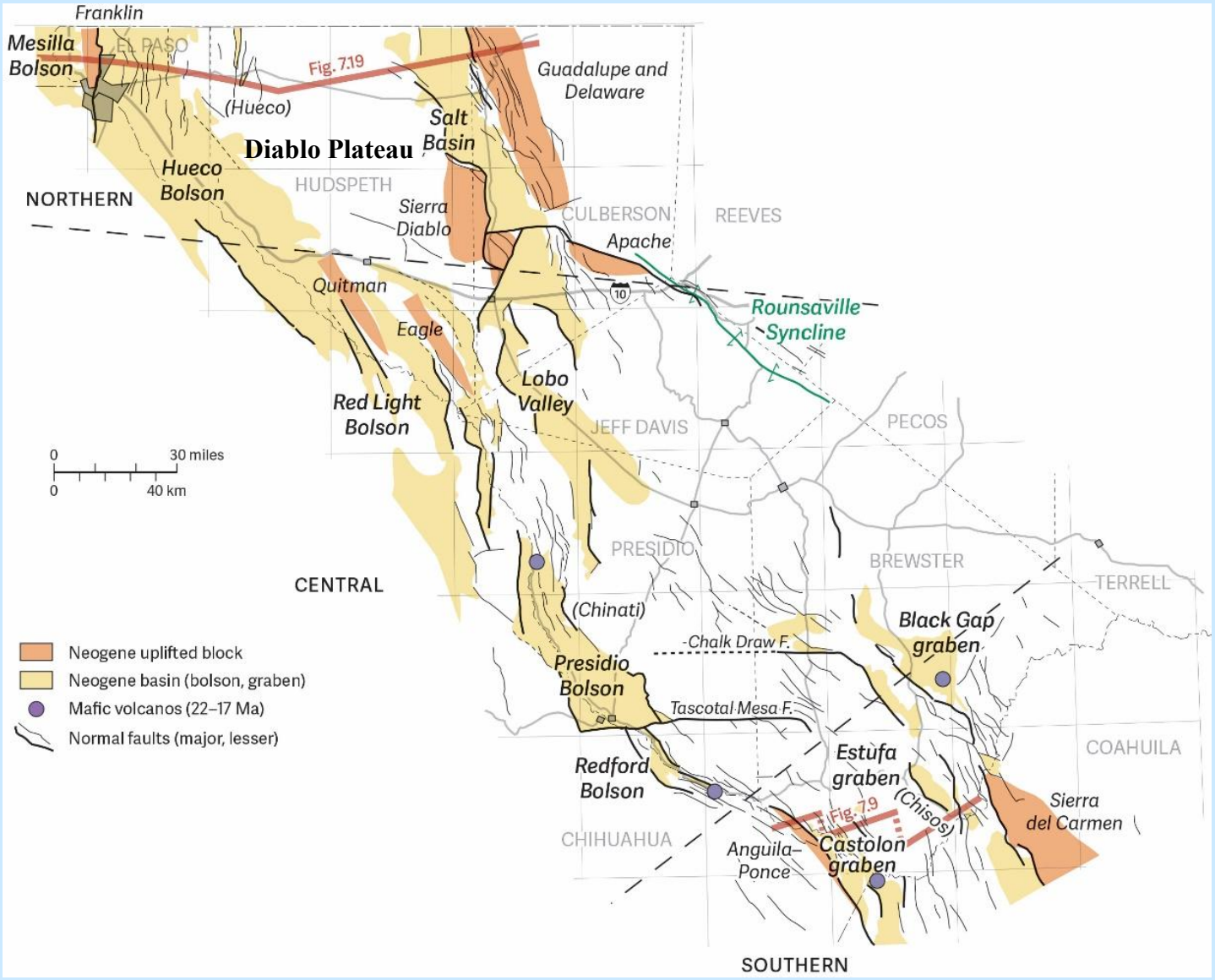
Laramide structures and Eagle Mtns



Western Eagle Mountains – volcanic rocks.



Time section of volcanic activity, formation of bolsons and calderas. Source: Ewing (2016)



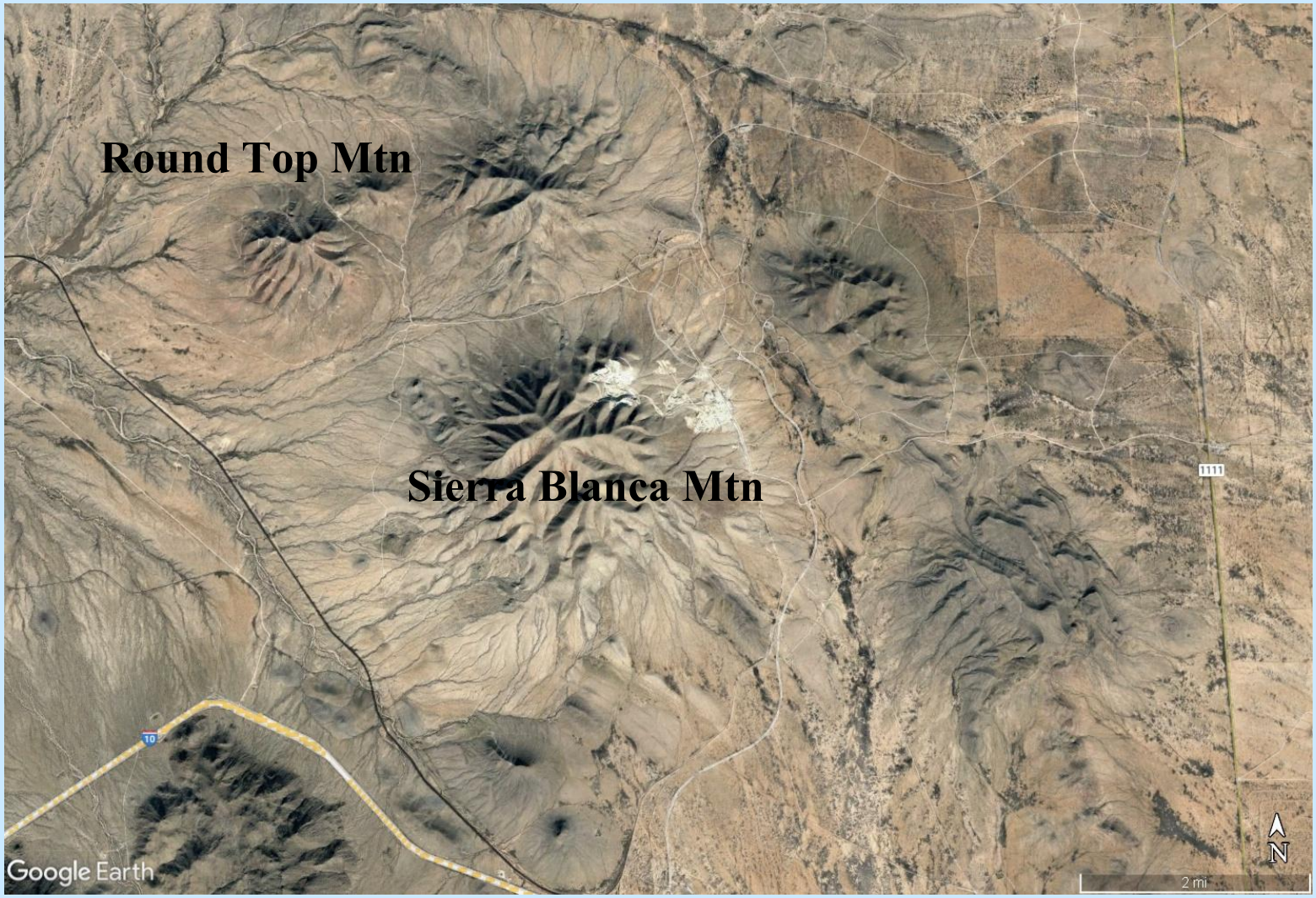
Tertiary Rift Basins of Trans-Pecos Texas. Source: Ewing (2016), modified from Henry and Price (1985)

Rare Earth Elements
Round Top Mountain

Sierra Blanca Mountain

Round Top Mountain

Sierra Blanca Laccoliths



Sierra Blanca Laccoliths

Sierra Blanca Laccolith Complex

- Five uncovered rhyolite laccoliths clustered in a structurally complex zone of the Trans-Pecos Magmatic Province.
- Located on the northern margin of the Chihuahua Tectonic Belt, at the southern boundary of the Diablo Platform.
- Sierra Blanca Mountain stands at an elevation of 6896 ft (2102 m) and about 1968 ft (600 m) above the surrounding flats.
- In order of decreasing size, the other peaks are Little Blanca Mountain, Round Top Triple Hill, and Little Round Top.
- Emplacement age of Sierra Blanca Mtn ~36.2 Ma (K/Ar).

Quartz rhyolite porphyry from Sierra Blanca quarry.

Debris at base of quarry wall.

(Left) Rock crusher at main quarry. (Right) Closeup view of rock crusher. Rock is run first through a jaw crusher and then through a cone crusher to reduce fragments to specified size range. Fragments that are larger than specified by Union Pacific are returned to the quarry by a conveyor system that empties the fragments into the jaw crusher for further processing.

Significant observations

- SBC represents unusual enrichment in HREE
- SBC is located in the stable block just beyond the mobile belt boundary, on the southwest margin of the stable block, south of the Diablo Platform.
- REE enrichment of the rhyolites is consistent throughout the laccoliths at levels well above crustal average.
- Enrichment in the HREE and incompatible trace elements Be, F, Rb, Y, Zr, Nb, Sn, and U, indicates economic potential beyond that of REE deposit alone.
- SBC shows zoning of REE, from enrichment of LREE on Little Blanca to HREE on Little Round Top and Round Top.

Significant observations

- Late- stage enrichment along fractured zones through the action of F-rich liquids is indicated by the higher concentration of F and associated REE.
- REEs are found in association with Y and F throughout the laccoliths. Yttrocerite and yttrofluorite are the main REE minerals.
- Round Top exhibits the least amount of geochemical differentiation in comparison to the other laccoliths.

Exploration history

- Exploration programs began in 1969 and continued through late 1970s.
- Initial target was fluorite, but attention later turned to beryllium after downturn of fluorite market. Cabot Corporation was primary operator.
- In 1987, Cabot and Cyprus Minerals formed joint venture, with emphasis on beryllium.
- In late 1990s, Cyprus left beryllium business to focus on copper with Phelps Dodge (later acquired by Freeport McMoran).
- Throughout most of 90s, there was no significant activity, and the properties fell back under control of the Texas General Land Office.
- Subsequently acquired by Standard Silver Corporation, which changed name to Texas Mineral Resources Corporation in 2010 to reflect focus on HREE.

Joint Venture with USA Rare Earths

- TMRC later entered into a joint venture with USA Rare Earths (USARE).
- In 2019, USARE acquired 80 percent stake in the Round Top Project.
- In 2026, USARE became sole operator of the Project by purchasing all of TMRC's outstanding shares for $73 million.
- USARE intends to extract ~40,000 metric tons/day of feedstock by 2030, targeting commercial production by 2028.
- USARE's strategy is to build a vertically integrated, U.S.-based, non-China REE supply chain, from mining at Round Top to manufacturing magnets at their facility.

Updated Preliminary Economic Assessment (PEA) August 2019 Highlights**

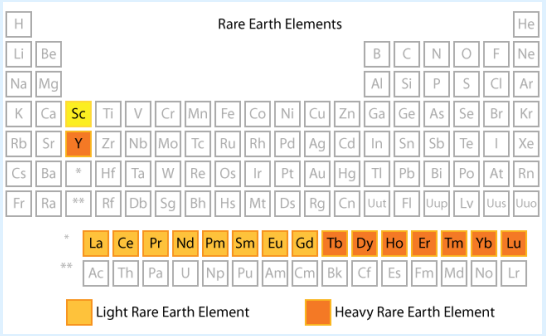
Initial CapEx	$350 million
NPV (10% Pre-Tax) (based upon current spot Mineral pricing)	$1.56 billion
IRR (Pre-Tax)	70%
Payback Period	1.4 years
Initial Life of Mine	20 years*
Average Annual Revenue	$396 million
Production Profile	Diversified mix of Rare Earths, Technology Metals and Industrial Minerals

*** Represents 14% of mining the measured, indicated and inferred resource **See Cautionary Notes to Investors**
including a complete on-site rare earth oxide (REO) and mineral separation plant, and a 25% contingency provision of $65.7 Million.

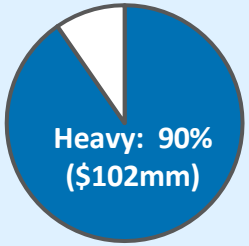
Round Top Contains a Favorable REE Composition

Symbol	Name	Heavy/ Light?	Selected Uses	Contained at Round Top?
Sc	**Scandium**	**H**	**Aerospace Components, Lighting**	✓
Y	**Yttrium**	**H**	**Computer Monitors, Phone Screens, Camera Lenses, Energy-Efficient Lighting, Lasers**	✓
La	Lanthanum	L		✓
Ce	Cerium	L		✓
Pr	**Praseodymium**	**L**	**Principal Magnet Metal used in Motors, Generators, Wind Turbines and Electric Vehicles**	✓
Nd	**Neodymium**	**L**	**Principal Magnet Metal – also Laser Range-Finders, Guidance Systems, Communications**	✓
Sm	**Samarium**	**L**	**Optical Lasers, Infrared-Absorbing Glass, Nuclear Reactors**	✓
Gd	Gadolinium	H		✓
Tb	**Terbium**	**H**	**High-Temperature Magnets, X-Rays, Lasers**	✓
Dy	**Dysprosium**	**H**	**High-Temperature Magnets**	✓
Ho	Holmium	H		✓
Er	Erbium	H		✓
Tm	Thulium	H		✓
Yb	Ytterbium	H		✓
Lu	**Lutetium**	**H**	**Petrochemical Industry, PET Scan Equipment, Cancer Treatment**	✓

Note: Elements ordered by Atomic #



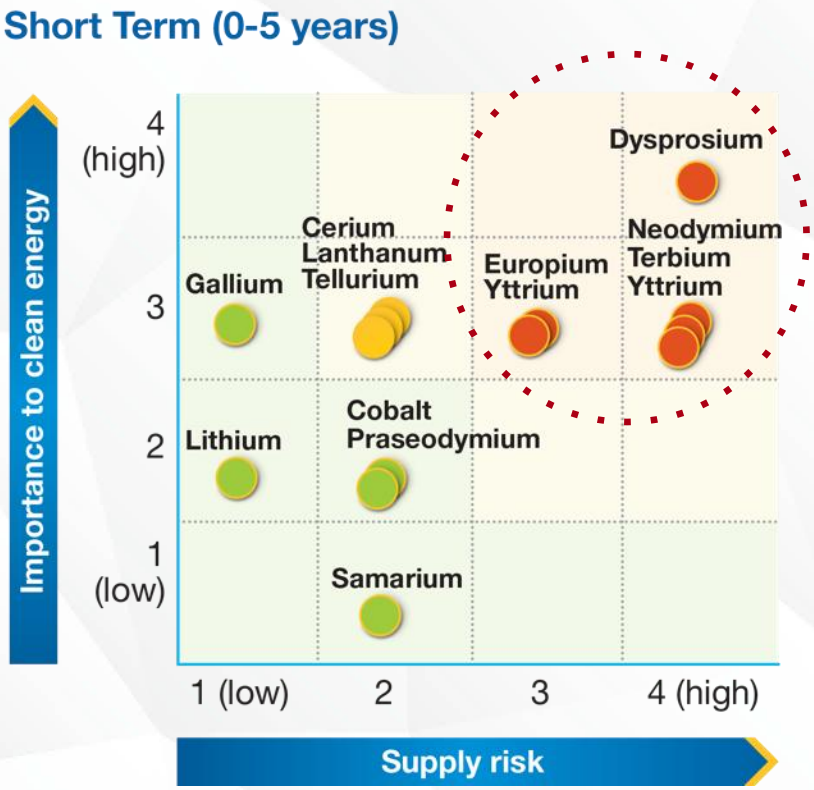
Annual Potential REE Revenue Composition

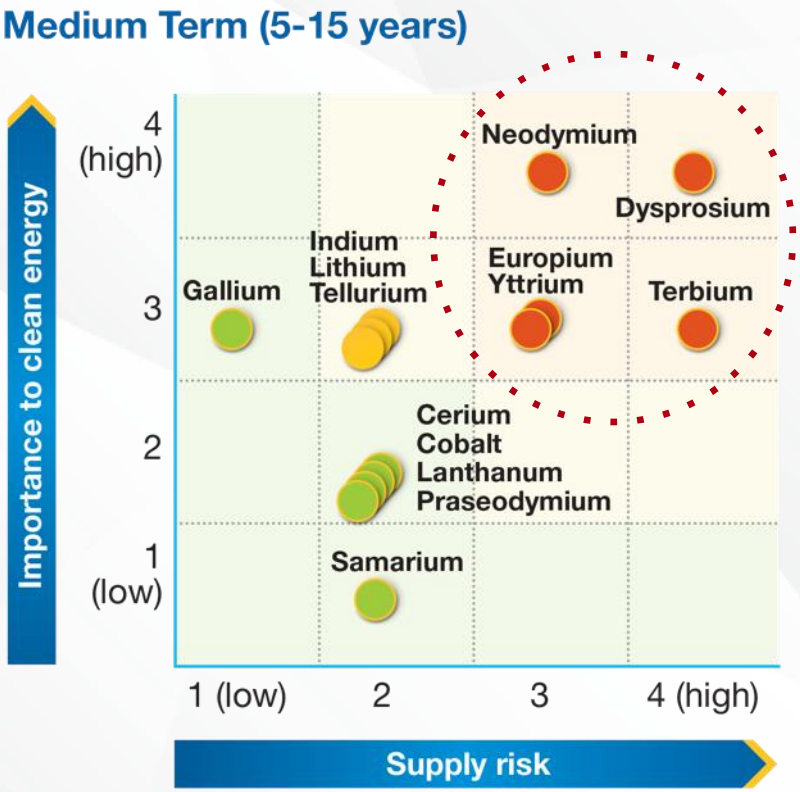


Bolded text describes ONLY prospective economically marketable rare earths based on current market conditions

Source: TMRC

TMRC's REEs Projected to Remain in Critical Demand and Short Supply

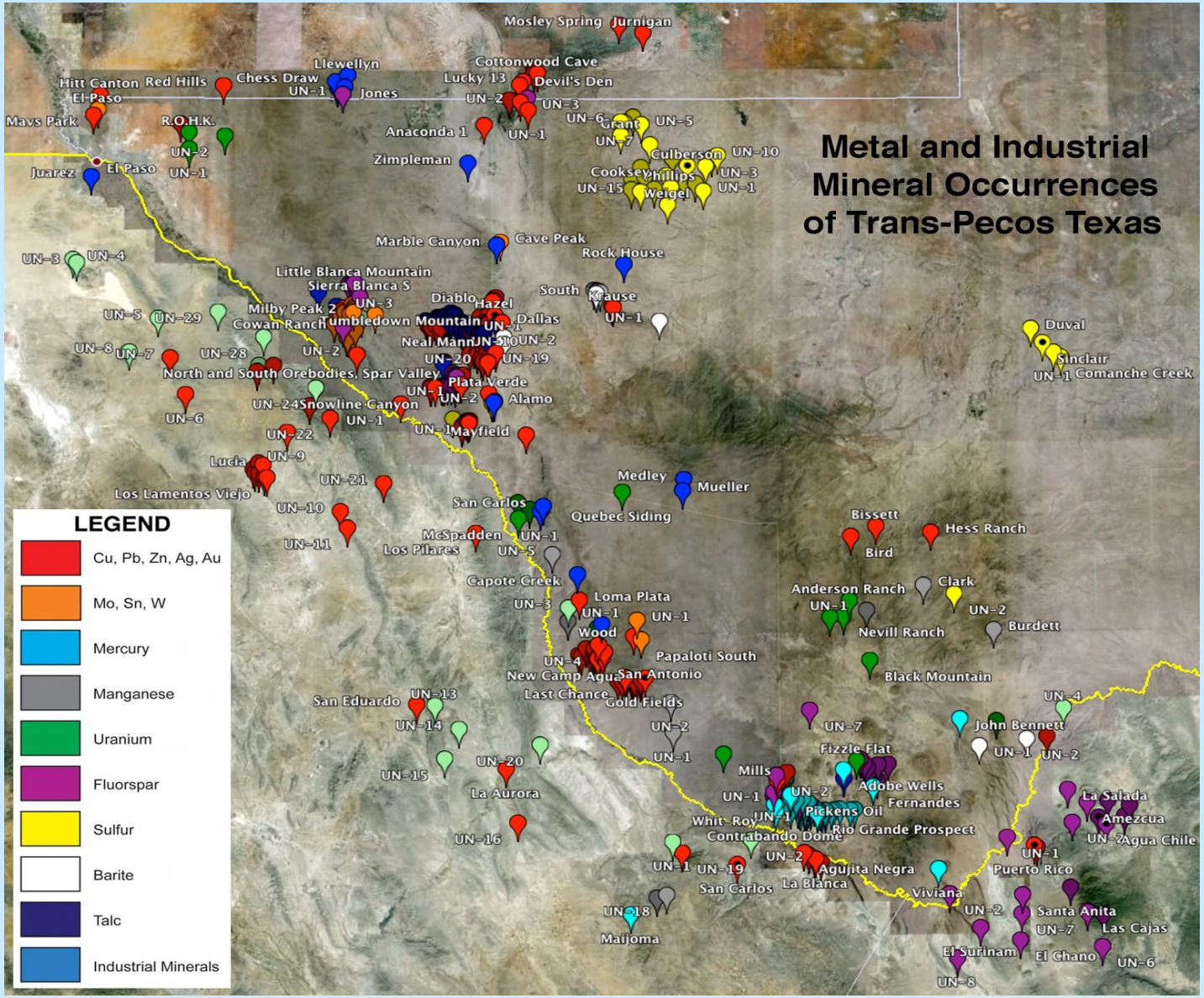




National Reserves vs Global Competitors

TEXAS MINERAL RESOURCES CORP.

Source: US Department of Energy ("DoE")



Metallic and Industrial Minerals of Trans-Pecos Texas.
Source: Becker and Kyle (2011)