Precambrian Basement Structure of the Diablo Platform and Its Influence throughout the Phanerozoic*

Steve Grimes[1]

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[1]Emperica, Houston, Texas (Stephen.Grimes@alsglobal.com)

Abstract

Strong evidence exists for deep Grenville (~1 Ga) oblique ramps within the Diablo Platform that have influenced structure throughout the Phanerozoic. The exposed Carrizo Mountain Group (CMG), the core of the Grenville orogen in Trans-Pecos Texas, comprises a long-lived structural high within the platform. During the 1060-980 Ma Grenville orogeny in the Trans-Pecos, the ~1.33 Ga volcano-sedimentary CMG was ductilely and brittlely deformed under NW-directed, predominantly dextral transpression, ultimately being thrust over carbonates of the 1250 Ma Allamoore Formation and depositing and folding alluvial fans comprising the Hazel Fm.

In NW exposures of the CMG, ~980 Ma structures swing from the NE strike that dominates to the SE, to the WNW trend dominating the foreland. Biotite-grade, oblique thrust-sense D1 mylonites show that this is not later open folding imposed upon D1 structure. Instead, the trend change is a part of the D1 deformation. The mylonitic foliation follows the same change in bedding, contacts, and S1 foliation, but mylonitic lineations all plunge moderately SE. In other words, transport direction is consistently to NW, but the foliation change marks a change in orientation of the flattening plane. This suggests flow over a NE-striking, SE-dipping, slightly oblique ramp, and a WNW-striking, SSW-dipping, oblique lateral ramp. These ramps may have been constructed entirely during the Grenville orogeny by ~980 Ma (i.e., as horses), or they may represent inversion of ~1.33 Ga faults within or bounding the CMG basin.

This change in trends occurs in regional structure from the Grenville to the Quaternary. Parallel, convergent, or tangential relations between structures show that the proposed ramps, and possible parallel ramps, exerted strong tectonic control. They explain the change from the dominant NE CMG structure to the WNW trend of the foreland fold belt, and the curve in the Grenville front. The NE CMG trend and the brittle, Grenville-aged Mineral Creek Fault Zone are also tangential to curved, post-Wolfcampian faults that parallel the Grenville front, or converge with those that do. (One of these faults connects with the post-Albian Victorio flexure, which parallels the fold belt.) These faults all converge upon a basin-bounding Cenozoic fault. Some of these faults may have provided the alternative inlets to the Delaware Basin that have been suggested by previous authors.

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Precambrian basement structure of the Diablo Platform and its influence throughout the Phanerozoic

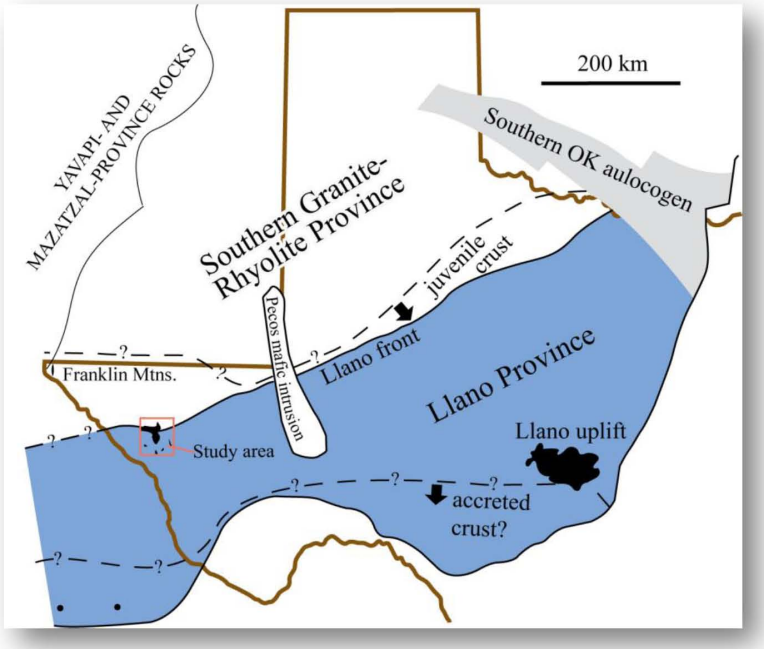
Steve Grimes, Ph.D., P.G., Empirica, 6360 W Sam Houston Parkway N, Suite 100, Houston, TX, 77041
stephen.grimes@alsglobal.com

ALS Empirica

RIGHT SOLUTIONS | RIGHT PARTNER

Presenter's notes: This presentation is about the Precambrian development of structural trends in Trans-Pecos Texas—showing evidence that they influenced structures throughout the Phanerozoic, possibly even those related to the development of the Permian Basin.

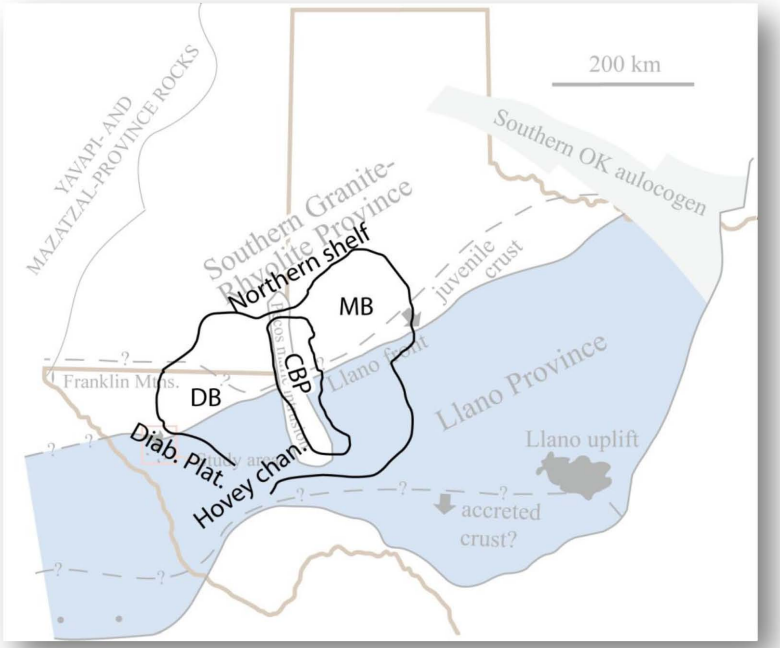
The Texas basement



- Mostly buried
- Grenville (~1 Ga) exposed in Llano, & near Van Horn
- VH exposures: basement high in Diablo Platform

Presenter's notes: Most of Texas basement inboard of the Ouachita front is either part of the Grenville orogen (the Llano Province, in blue) or the southern granite-rhyolite province. Exposures (in black); the Trans-Pecos TX Grenville is exposed near Van Horn.

The Texas basement



Leonardian paleogeog. / Ruppel & Ward 2013

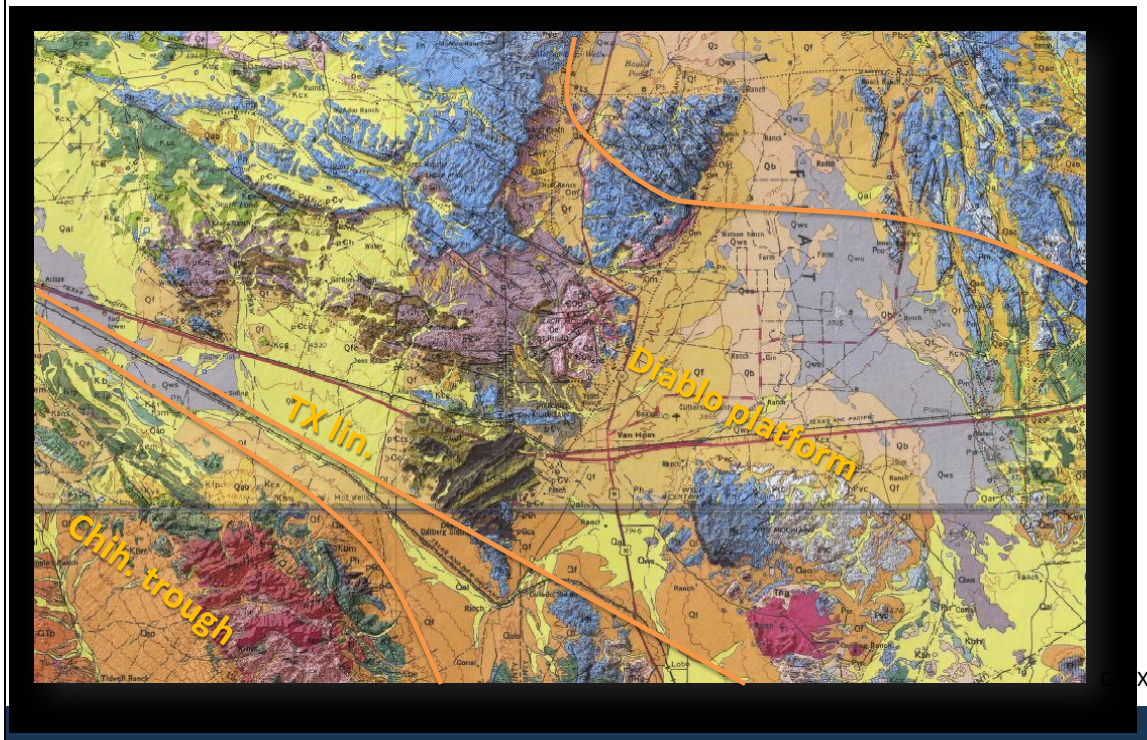
- Mostly buried
- Grenville (~1 Ga) exposed in Llano & near Van Horn
- VH exposures: basement high in Diablo Platform

Presenter's notes: The Permian Basin in relation to the basement. The Grenville and other Precambrian rocks form a long-time structural high in the Diablo Platform.

Carrizos & Streeruwitz thrust / fold-thrust belt

Presenter's notes: The Van Horn area, from the Geologic Atlas of Texas; Precambrian exposures shown in brown colors. Carrizo Mountains (lower right): type area of Carrizo Mountain Group (CMG), the metamorphic core of the Grenville in west Texas. CMG was thrust over foreland fold-thrust belt during Grenville along Streeruwitz thrust.
Focus here is on structural trends seen here: NE (in the Carrizo Mtns.), and WNW (the Streeruwitz & fold-thrust belt).

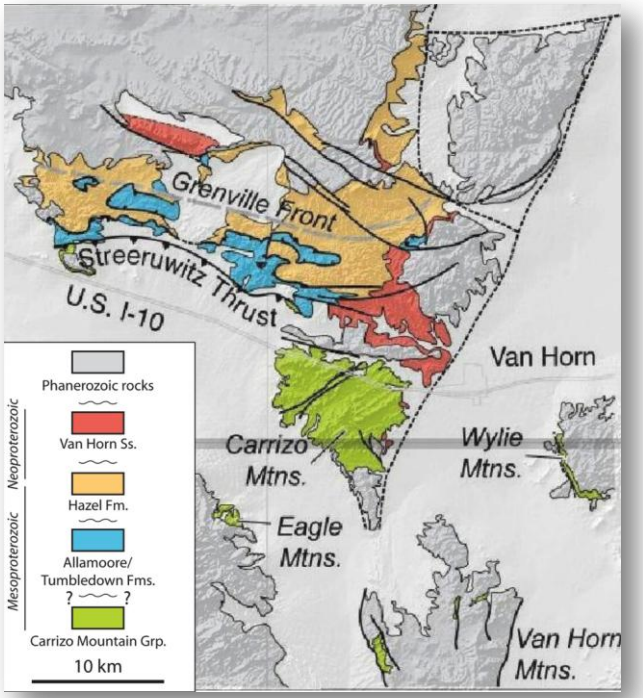
Van Horn area



Presenter's notes: Structural context for the region: Again, the Precambrian, in brown colors, within the Diablo platform; to the SW is the Chihuahua trough, and the parallel Laramide front; parallel to that, the Texas lineament. Note the influence of the WNW structural trend.

The ~1.33 Ga CMG and the foreland belt underlie several post-Grenville unconformities. So the presently-exposed Precambrian has comprised a long-lived structural high in the platform. The CMG has been exposed: *At the end of the Grenville (980 Ma).* In Late Proterozoic, during Van Horn Sandstone deposition. *During Cambrian-Ordovician, Bliss SS deposition?* In the Wolfcampian, during Hueco Fm deposition. *Today.*

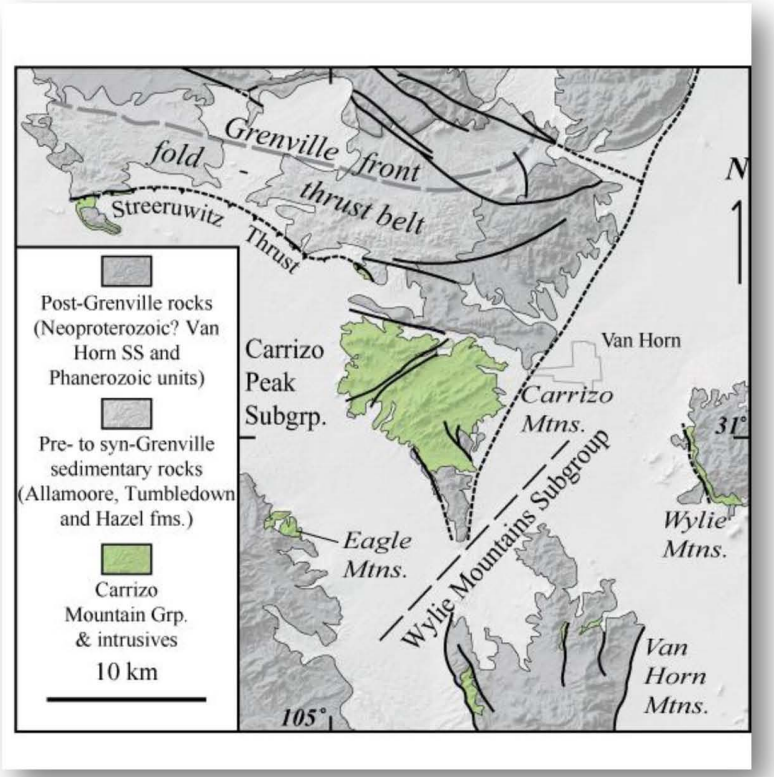
p€ in Van Horn area



- >1050 – 980 Ma: CMG ductilely deformed, metamorphosed
- ≤ 980 Ma: CMG thrust over Allamoore (deposited ~1250 Ma) and syn-tect. Hazel
- Later: VH SS deposited

Presenter's notes: Shown here are the main Precambrian units: the CMG in green; Allamoore and Tumbledown Fms. in blue; Hazel Sandstone in tan; and the Van Horn SS, unconformably overlying the other units, in red. The Trans-Pecos Grenville post-dates that in Llano (ending ~1100 Ma), but is coeval with the Grenville in Canada.

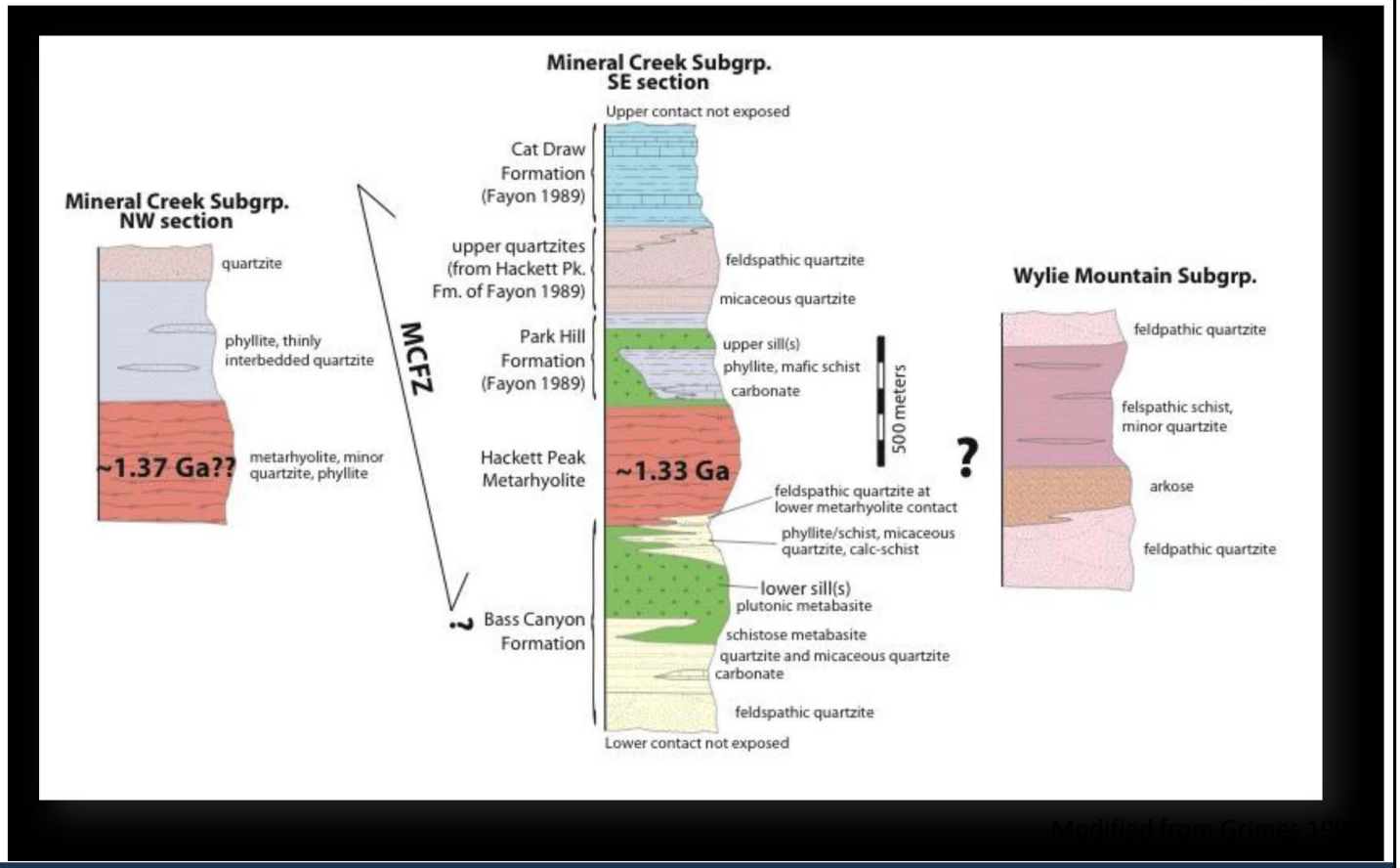
Carrizo Mountain Group (CMG)



- ~1.33 Ga
- Mostly clastic, volcanic, and volcano-sedimentary protoliths
- Extension, reworking of SGRP
- Primary structures more preserved in lower meta. grade structures to NW

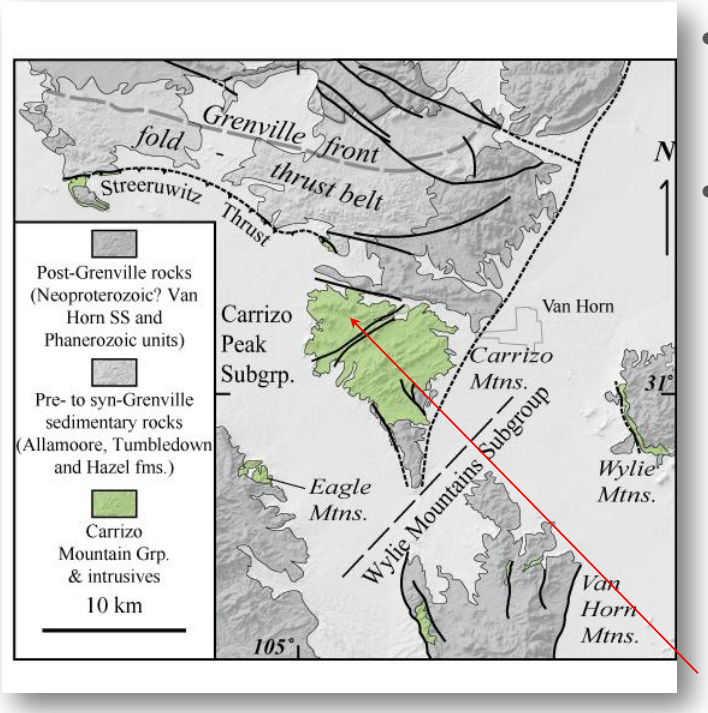
Presenter's notes: CMG volcano-sedimentary deposition represents late-stage extension and reworking of the southern granite-rhyolite province (SGRP) at ~1.33 Ga, possibly as early as 1.37 Ga. Slide 8

CMG Stratigraphy



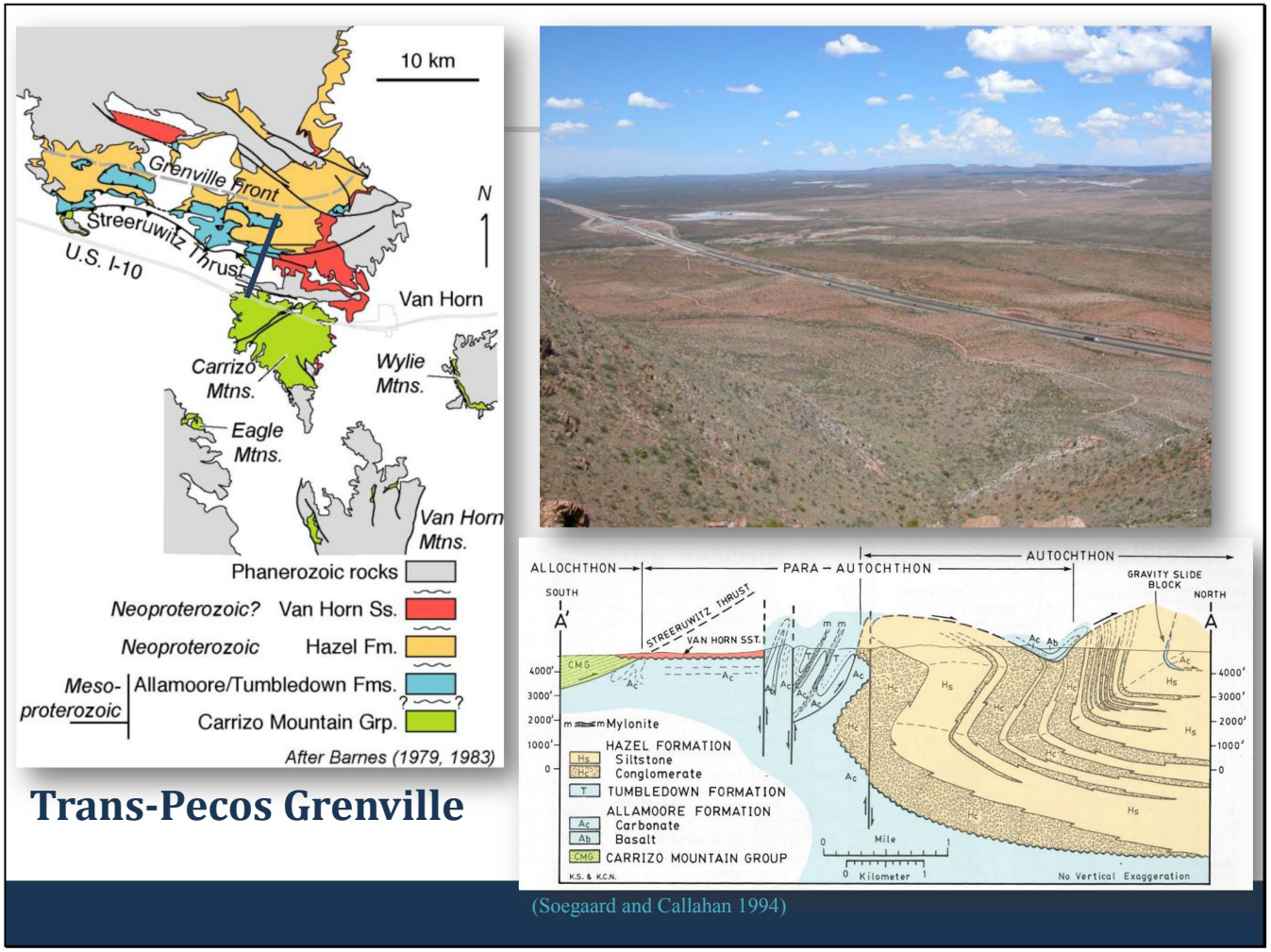
Presenter's notes: Stratigraphy is better defined farther NW, due to preservation of primary structure.

CMG deformation



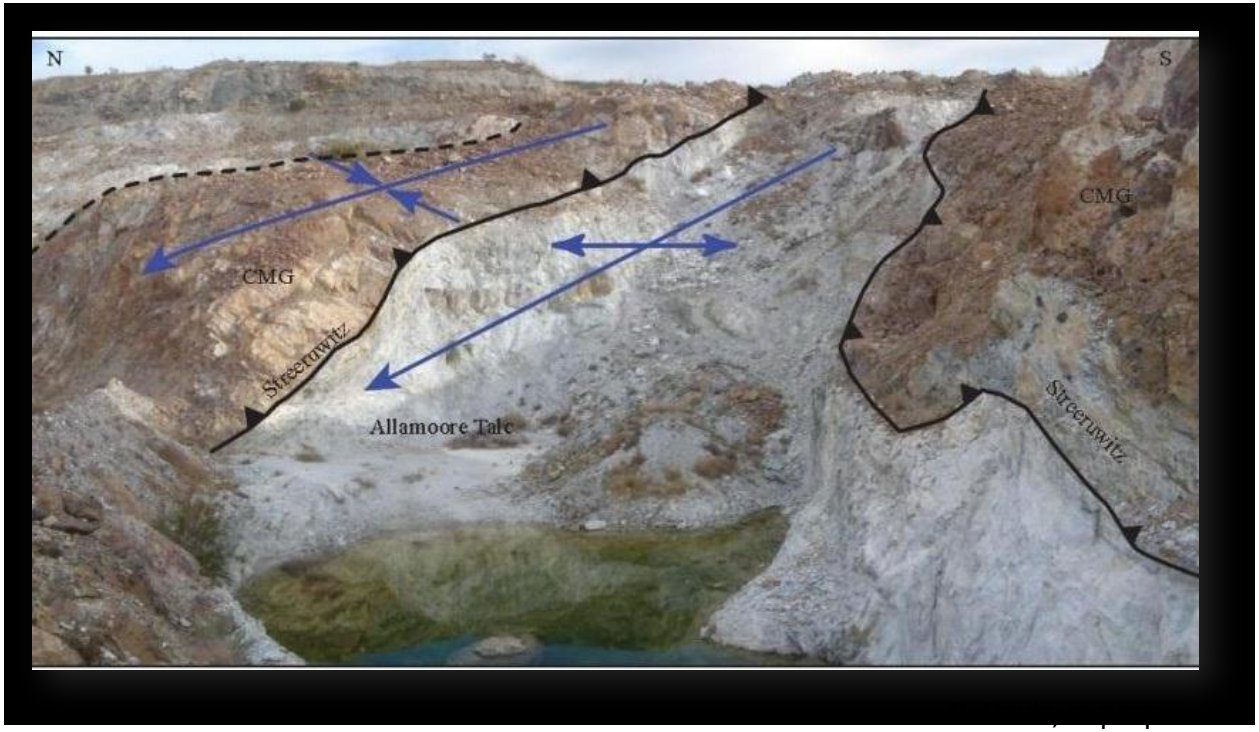
- Mostly dextral transpression (also in foreland)
- NW:
  - Overall transport
  - Deformation steps
  - Meta grade decreases
    - Sta grade
    - Bt grade
    - Syn-tectonic sedimentation in fold-thrust belt

Presenter's notes: Tectonics of the Trans-Pecos Grenville: mostly dextral transpressive deformation. In the CMG: *Tectonic transport was to NW.* Deformation stepped NW in time. *Metamorphic grade decreases NW, from staurolite down to biotite grade.*
Recent mapping in this area as indicated. Note that, to the SE, the NE trend dominates; in the study area, the WNW trend dominates.

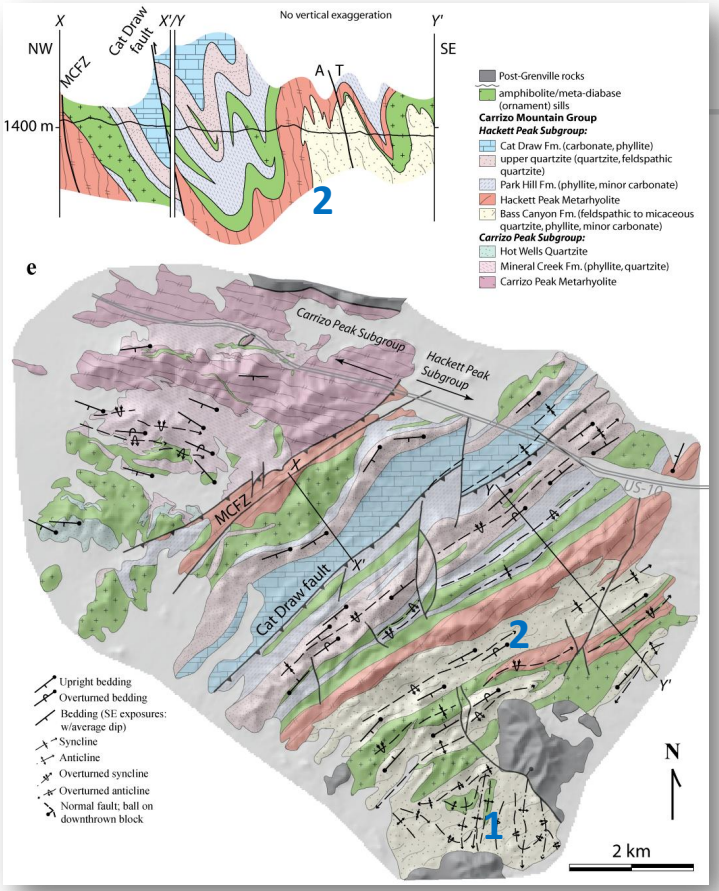


Presenter's notes: Dextral transpression dominated in the foreland as well. Note the section line through the foreland fold-thrust belt; section shown at right: *CMG was thrust over the Allamoore and Tumbledown Fms. The Hazel SS was deposited syntectonically.* Photo is a view from the CMG into the fold belt. Note blue pits in distance: talc mines in the Alllamoore, near the thrust front.

Folded Streeruwitz thrust in foreland:



Presenter's notes: Photograph, from Ben Davis, is one of those talc pits: the CMG (red) thrust along the Streeruwitz over the Allamoore (white); note deformation of the thrust. Where close to the thrust, the dolomitic Allamoore Fm. was metasomatized into economic talc deposits.



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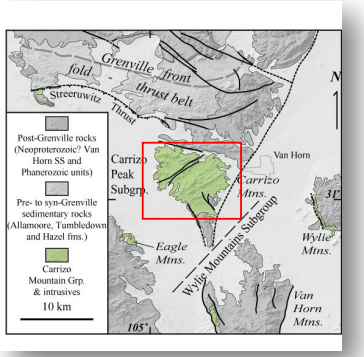
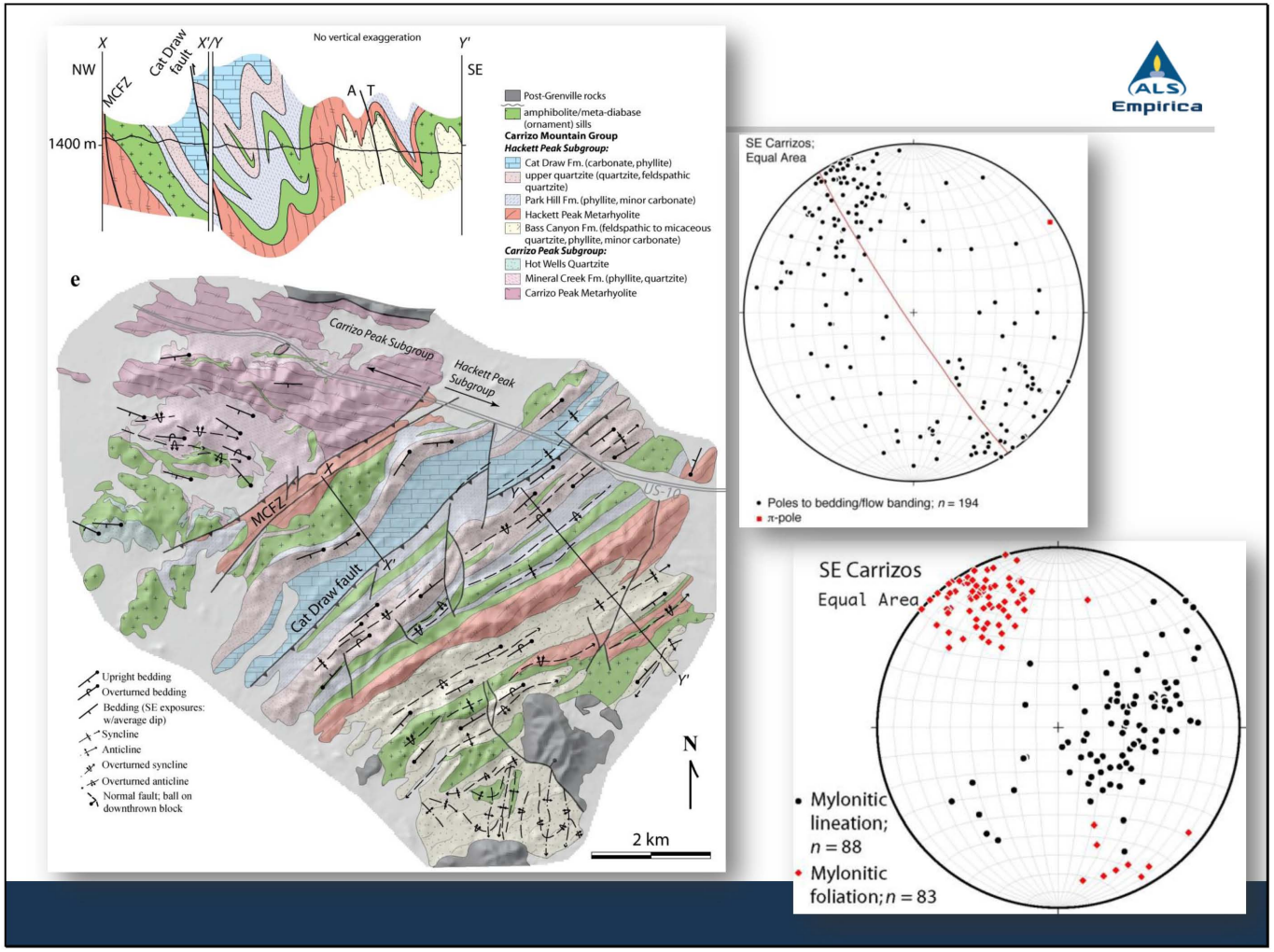
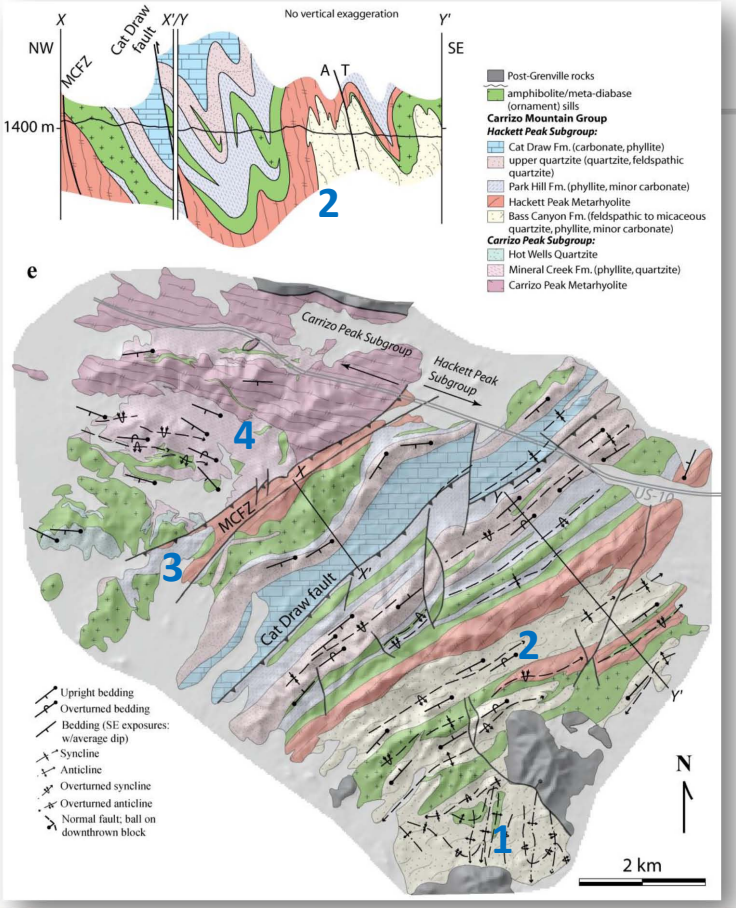
1. S Carrizos & to SE: polyphase deformation
2. Central Carrizos: NW-verging F_1 folds, oblique to reverse mylonites, penetrative deformation



Presenter's notes: The Carrizo Mtns is "keystone" exposure for the orogen, as it shows the kinematic linkages between hinterland and foreland. Three different structural domains occur: *At the S edge (1), and in exposures farther to the SE: complex polyphase deformation.* In the central Carrizos (2): the major deformation was D_1; later phases were relatively minor. *Deformation was penetrative in both structural domains.*



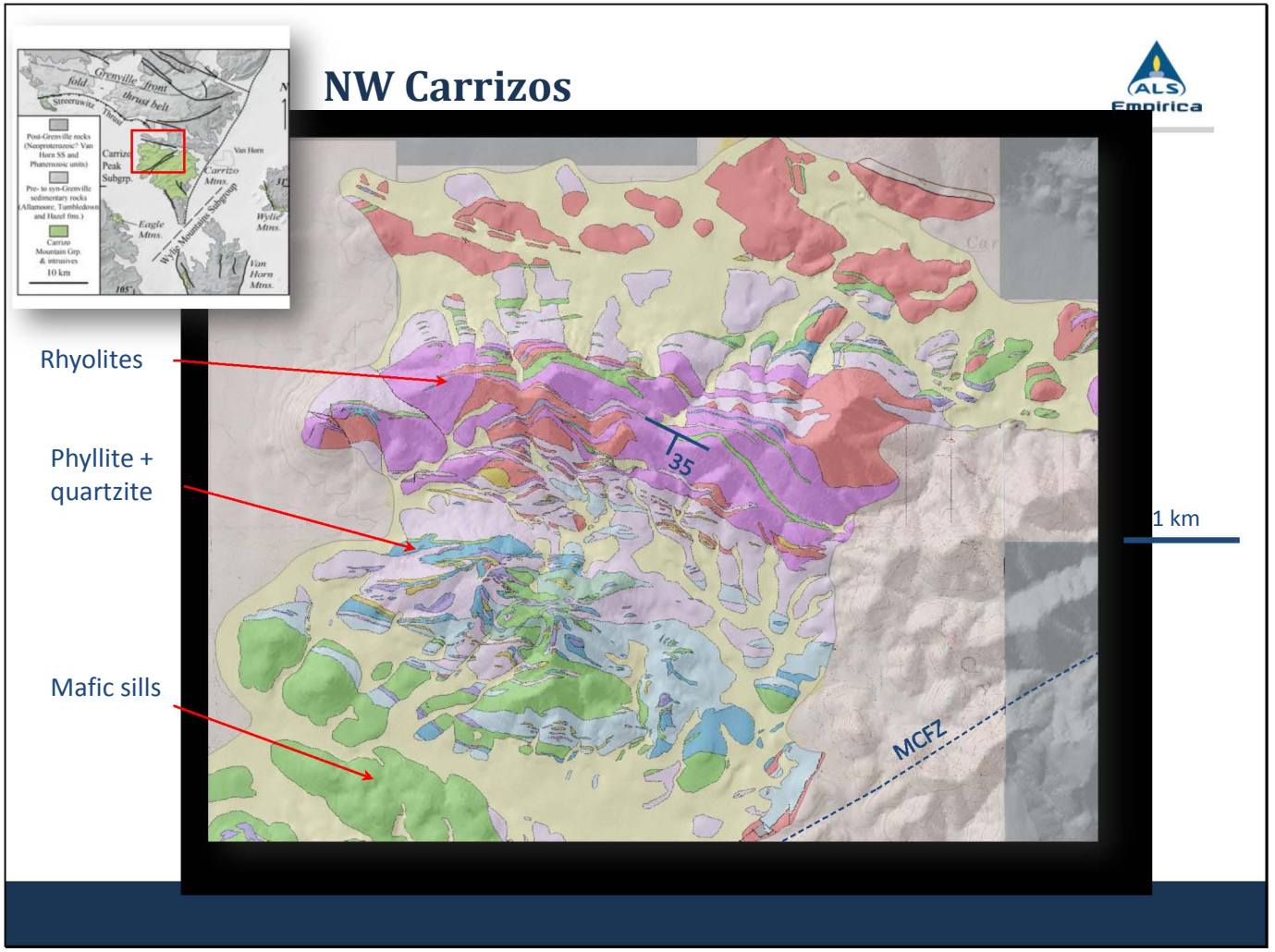
Presenter's notes: Central Carrizos D_1 deformation continued. Top stereoplot: Poles to bedding, shows sub-horizontal, NE-trending fold axis (in red). Bottom: Poles to mylonitic foliation in red, lineation in black. Note easterly plunge of lineation. Sense of shear was top-to-WNW, oblique to fold trend, indicating dextral transpression.



ALS Empirica

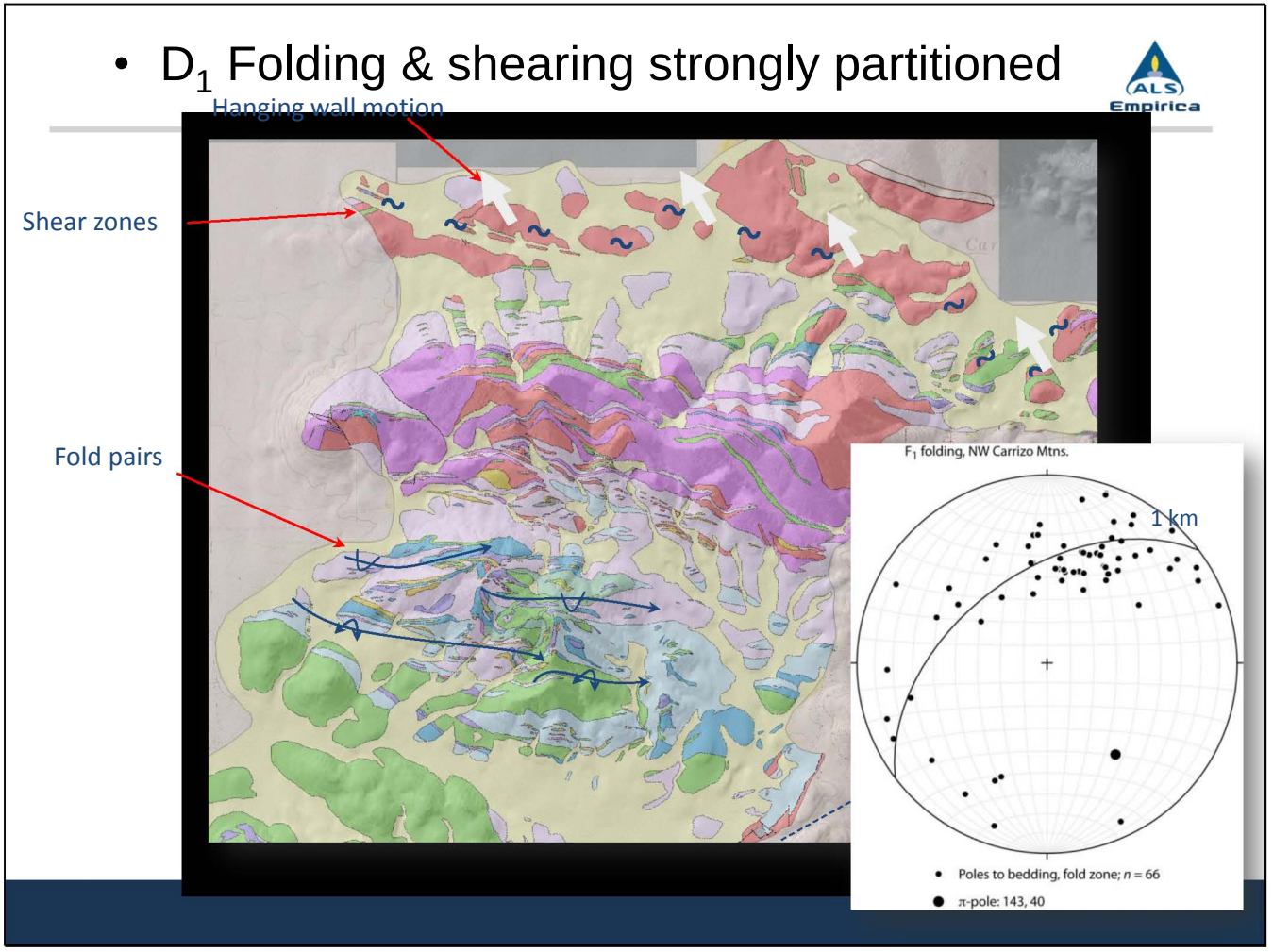
1. S Carrizos & to SE: polyphase deformation
2. Central Carrizos: NW-verging F_1 folds, oblique to reverse mylonites, penetrative deformation
3. Boundary: Mineral Creek fault zone (MCFZ)
4. NW Carrizos: partitioned; NNE-verging F_1 folds, oblique/thrust mylonites
5. Timing with respect to MCFZ?

Presenter's notes: The NW boundary of the Central Carrizos structural domain is the complex, brittle Mineral Creek fault zone (MCFZ) (3). In the NW (4), deformation was strongly partitioned, with NNE-verging F_1 folds and oblique thrust-sense mylonites. So a key question is: does the structural trend in the NW domain predate the MCFZ, or is it a product of MCFZ deformation? I show that it predates the MCFZ.

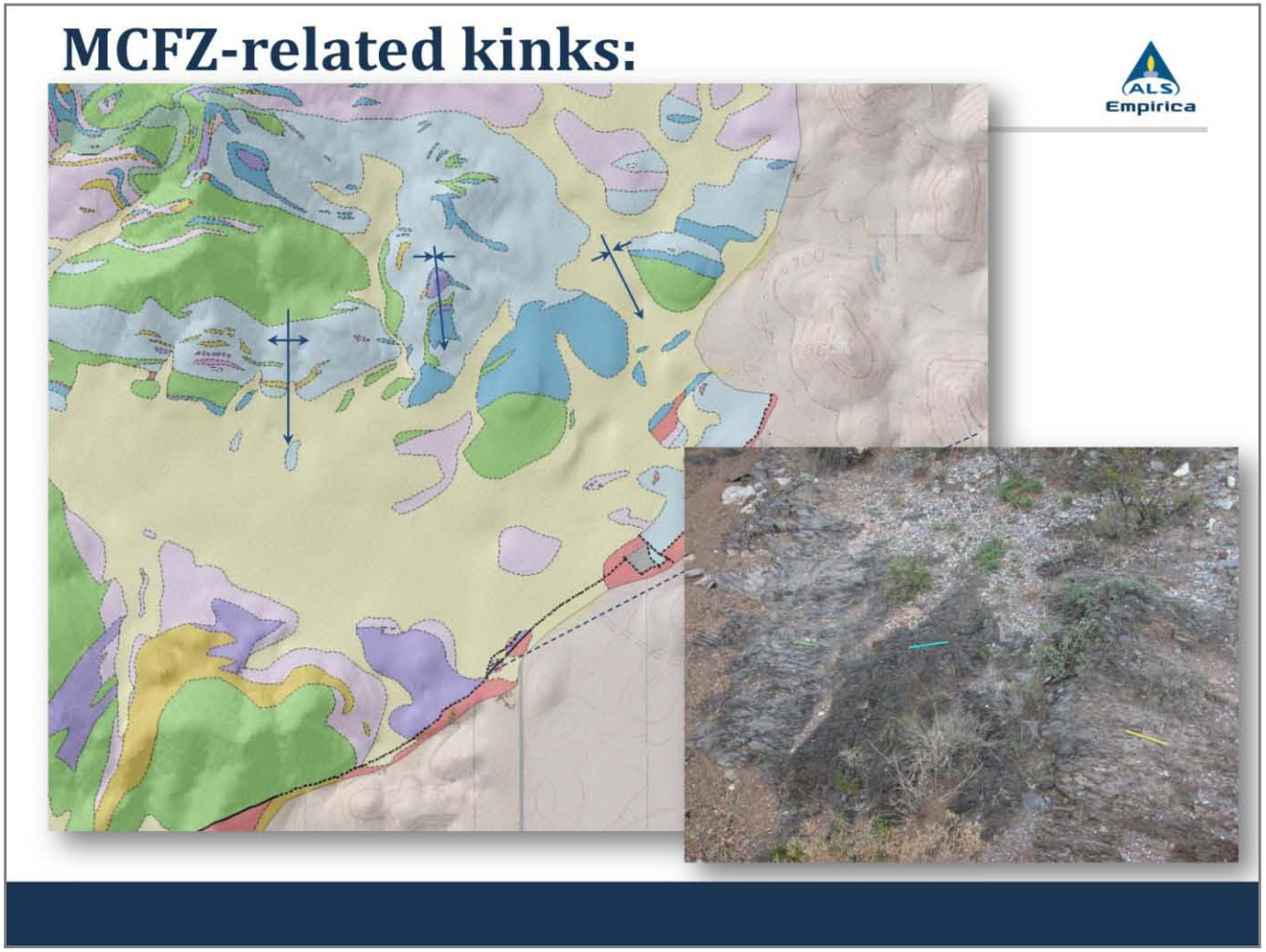


A more detailed map of the NW domain; note the MCFZ at lower right: *Mostly homoclinal exposure; moderately dipping to SSW, except for an overturned, map-scale fold limb, bed tops are to SSW*. Rhyolite units are shown in red and purple. *Phyllite units, with thin quartzite beds, in pastel colors*. Intruded by thick mafic sills, in green.

- D_1 Folding & shearing strongly partitioned

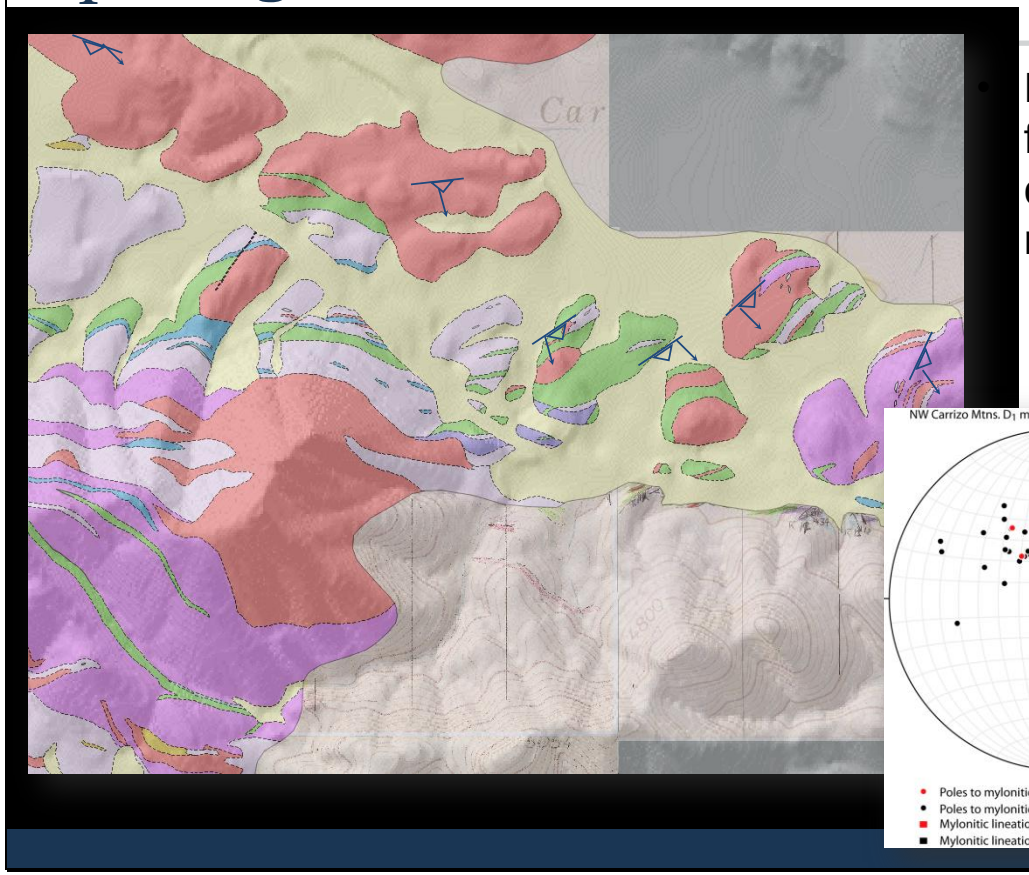


Presenter's notes: Unlike all CMG exposures SE of the MCFZ, deformation was strongly partitioned in the NW: *Major fold zone occurs only in the phyllites. Oblique thrust-sense mylonitic shear zones occur only in the lower rhyolites, and only in the upper 100 m of thick bodies.*
Stereoplot: Poles to bedding in the fold zone; note folds are reclined, SE-plunging, unlike folds to SE.

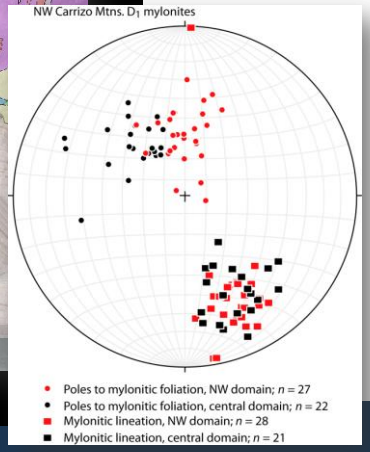


Presenter's notes: Folds occur, close to the MCFZ; they are clearly related to faulting. Note the axial planes indicated on the map. Photo: Smaller-scale examples in this area show the folds' brittle nature. Shown are three limbs of kinks; colored pencils are parallel to foliation. Folds affect (and postdate) all fabrics.

D_1 change in trends

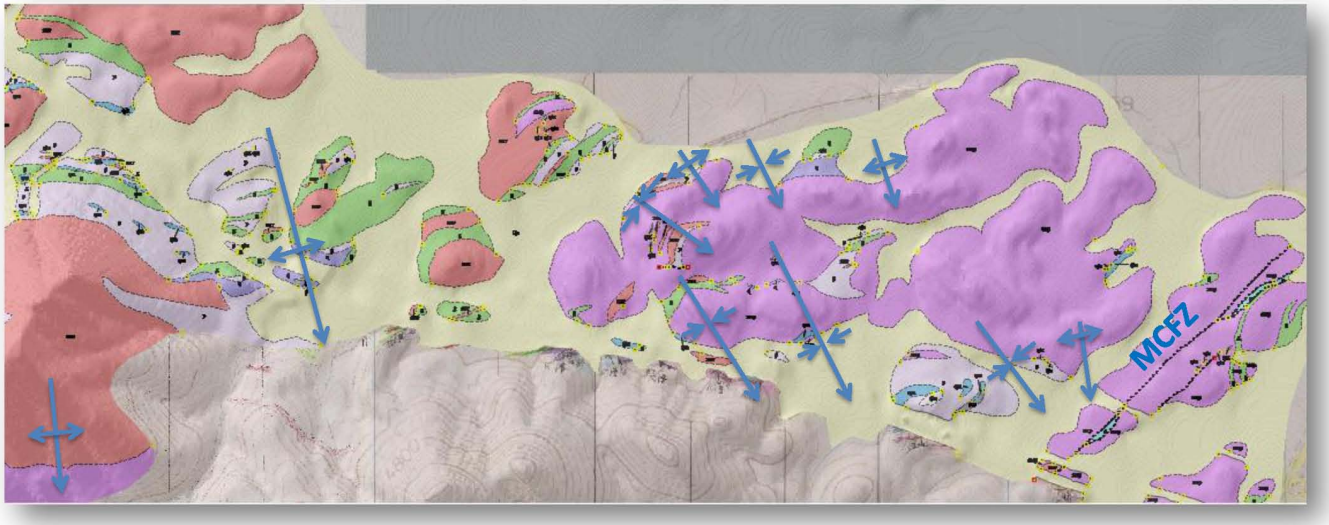


- Mylon. foliation changes, not lin.
  - Same shearing direction



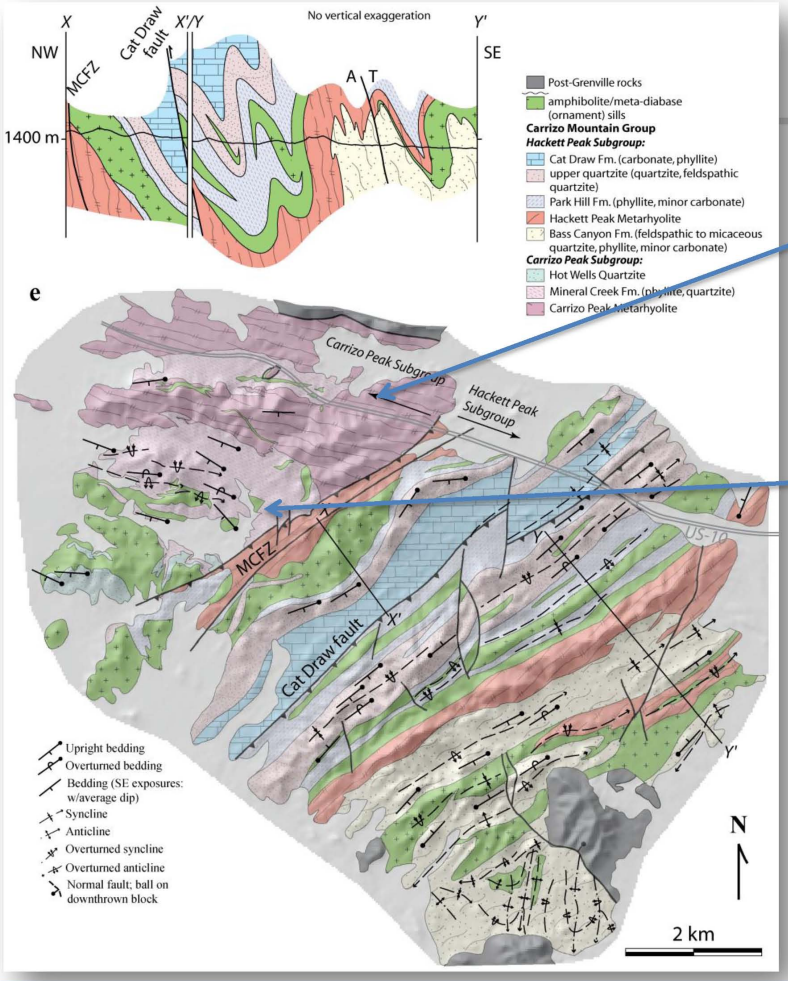
Presenter's notes: However, the mylonitic shear zones show an earlier change. Note the mylonitic foliation/lineation symbols on the map: *Foliation—marking the flattening plane of mylonitization—swings from NE to WNW strikes*. Lineation—marking the shearing direction—consistently plunges SSE. Stereoplot: Poles to WNW-trending foliation (red dots) show clear separation from those for NE-trending foliation (black dots).
Lineation trends measured from the same locations (red and black squares, respectively) are identical, though.

Folded zone near MCFZ

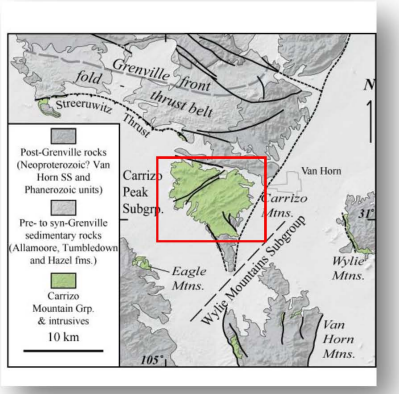


- "NW" vs "central" domains comprise fold limbs near MCFZ
- Mylonitic lineation unchanged
- →Original D_1 structure

Presenter's notes: Foliation and contact trends define broad folds near the MCFZ (at right). Because the folding does not affect the lineation, the mylonite cannot have been folded from a different orientation. The different trends are, therefore, a product of the D_1 deformation.

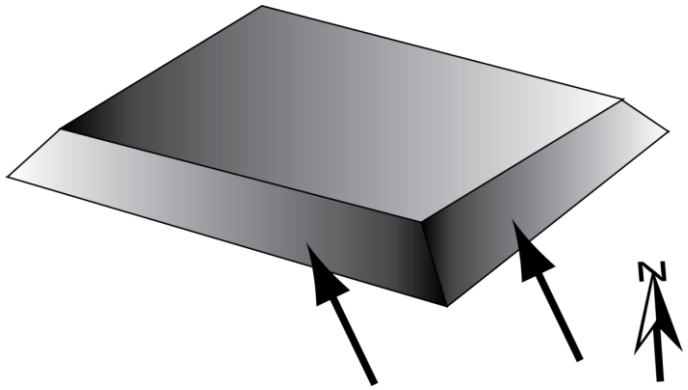


- D_1 NW vs. Central domain contrast preserved to NE
- Truncated by MCFZ to SW



Presenter's notes: So the NE and WNW trends are original elements of the early ductile deformation and were partially overridden by the MCFZ.

D_1 mylonitization: shear over oblique ramps

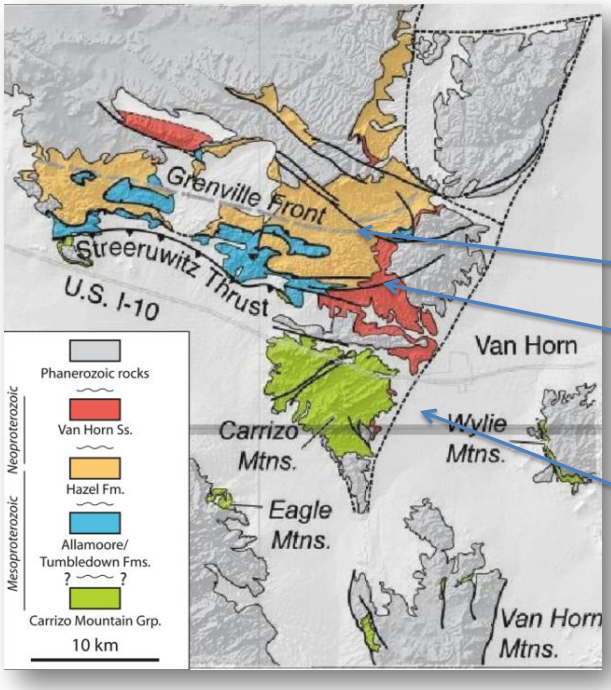


- Bt & Ms Ar-Ar ages: constructed by 980 Ma (Grimes & Copeland 2004)
- May be inverted CMG (~1.33 Ga) basin-bounding faults
- Probably duplex structure of several stacked ramps
- Evolved through orogeny

Presenter's notes: What could cause this divergence in the flattening plane? I interpret it as due to NNW transport over ramps oblique to the transport direction. Mica Ar-Ar ages indicate that D_1 in the NW Carrizos—the event shown here—took place at ~980 Ma.

What is the origin of the ramps? They could be ~1.33 Ga faults bounding the original CMG basin (i.e. basin inversion). The structure repeats regionally; thus there could have been stacking or translation of ramps. These structures almost certainly would have evolved through time.

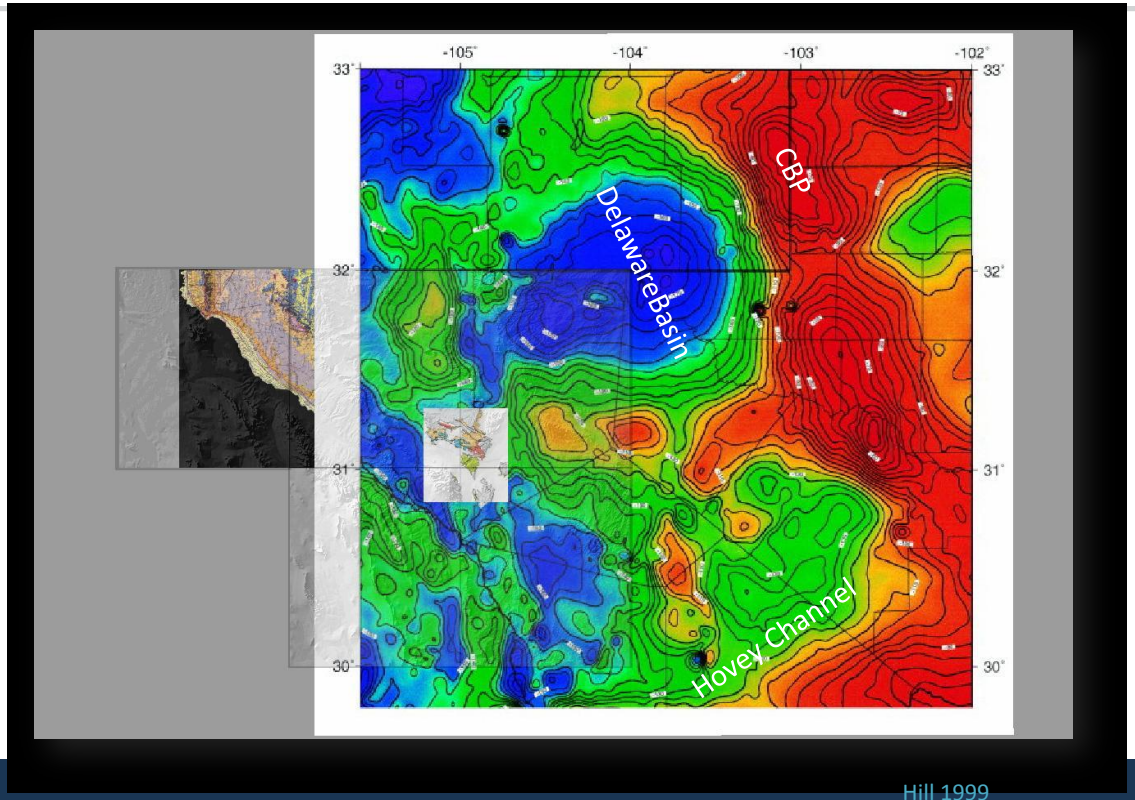
p€ structure, Phanerozoic structure



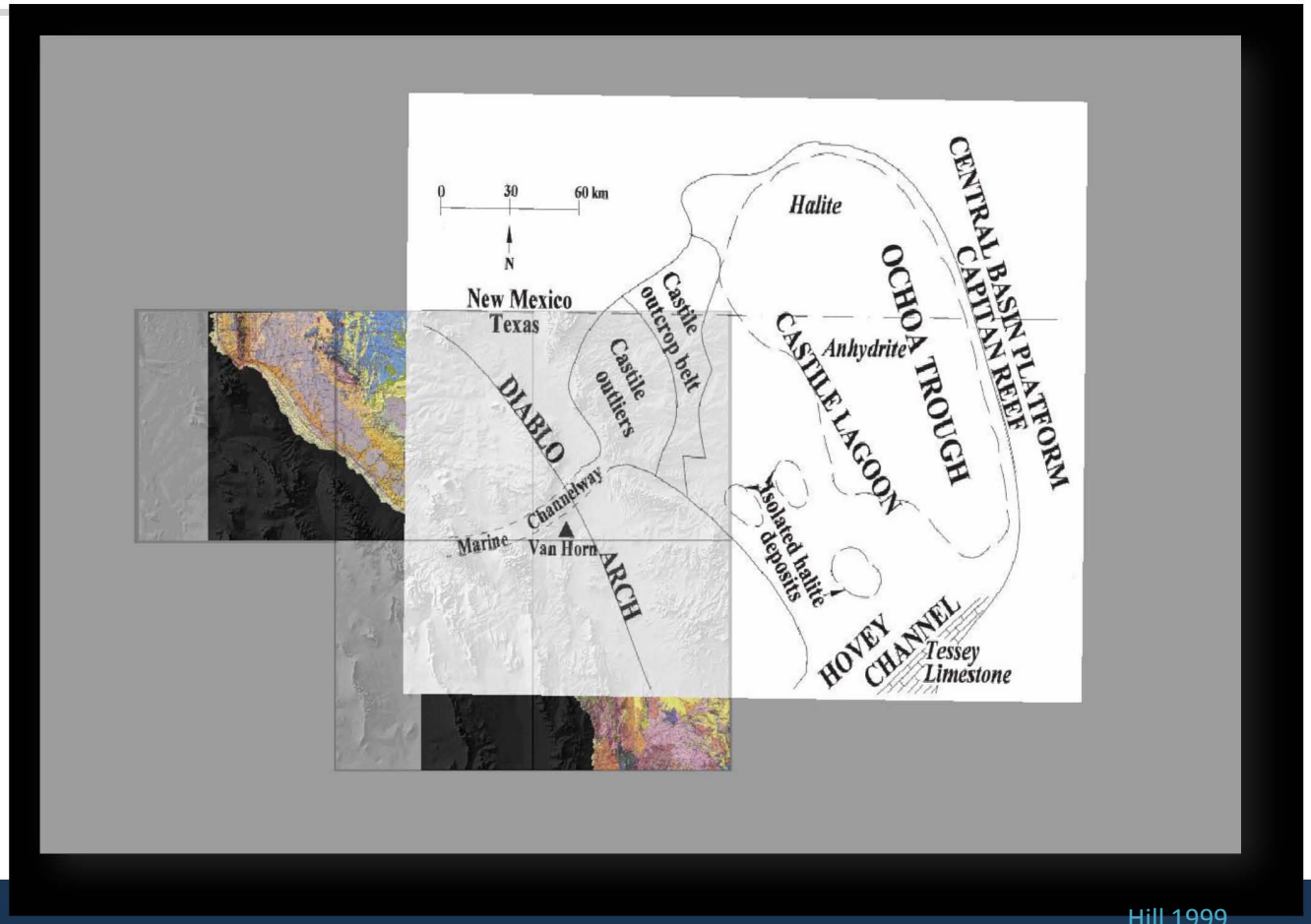
- CMG trends established ~980 Ma
- Parallel, converging or tangential structures:
  - Grenville front
  - Curved Pz-cutting faults (connect with post-Albian Victorio flexure?)
  - Quaternary basin-bounding fault (Collins & Raney 1997)

Presenter's notes: I noticed relationships between regional NE and NNW trends earlier; now I have evidence for their underlying nature and timing. Note the parallel, converging or tangential regional structures: *The curved Grenville front in the Hazel Fm.* Curved normal faults that cut the Pz section. One connects with the Victorio flexure—active post-Albian? *Faults converge with a basin-bounding Q fault. The NE trend in the CMG, and the MCFZ, is also convergent*. These structures suggest a salient in the Grenville front N of Van Horn, E of that, a reentrant.

NE trends in Delaware Basin?



Presenter's notes: Did these structures affect basin development in Permian? Possibly, these faults may have provided an alternative outlet to the Hovey channel.
Shown is a Bouguer gravity anomaly map of the region (from Randy Keller). Note location of the Texas Grenville map. Hill (1999) suggested an alternative outlet to the Hovey channel, in NNW-trending low-gravity regions (blue) to the NW, corresponding to the present-day Salt Basin.



Presenter's notes: Adams (1972) suggested a "Van Horn channel way;" this overlaps with the proposed Grenville reentrant.

Conclusions

- WNW / NE trend established during ~980 deformation in NW CMG
- Due to deep, ≥ 980 Ma oblique ramps
- Ramps affect structure through Phanerozoic
- Alt. to Hovey Channel?

Thank you