# *Second-day road log, Segment B, From Deep Well Ranch to the Fra Cristobal Range*

Eric P. Nelson, Mark A. Chapin, and James C. Hunter

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# SEGMENT B,
# FROM DEEP WELL RANCH TO THE FRA CRISTOBAL RANGE

E.P. NELSON[1], M.A. CHAPIN[1] and J.C. HUNTER[2]
[1]Geology Department, Colorado School of Mines, Golden, CO 80401; [2]Geoscience Consultants Ltd., 500 Copper NW, #325, Albuquerque, NM 82101

**Assembly point:** Deep Well Ranch
**Departure time:** 8:00 (from Deep Well)
**Distance:** ~26.6 mi to assembly from T or C
~80 mi round trip from T or C
**Stops:** 4

**Mileage**

0.0 **STOP 1.** View the eastern flank of the Fra Cristobal Range from the western slope of the Jornada del Muerto. An overview of the geology of the range is given by Nelson (1986). The range is a simple, normally faulted homocline on its eastern flank; some downfaulted and tilted blocks can be seen. The range is strongly deformed on its western flank (the attraction at stops 2, 3, and 4). Stratigraphically, the range consists of Precambrian granitic and metamorphic basement overlain by Paleozoic clastic, carbonate, and evaporite platform strata (Silurian, Devonian, and Mississippian missing), with a few bits of Mesozoic clastic strata preserved in normal-fault slices and outliers (Figs. 2B-0.0a, b). Some exploration roads (made by Tenneco Minerals between 1979 and 1982; Van Allen et al. 1983) can be seen climbing up to just below cliffs of San Andres Fm.; gypsum beds in the Yeso Fm. were the drilling target. A Quaternary basalt flow which contains ultramafic xenoliths can be

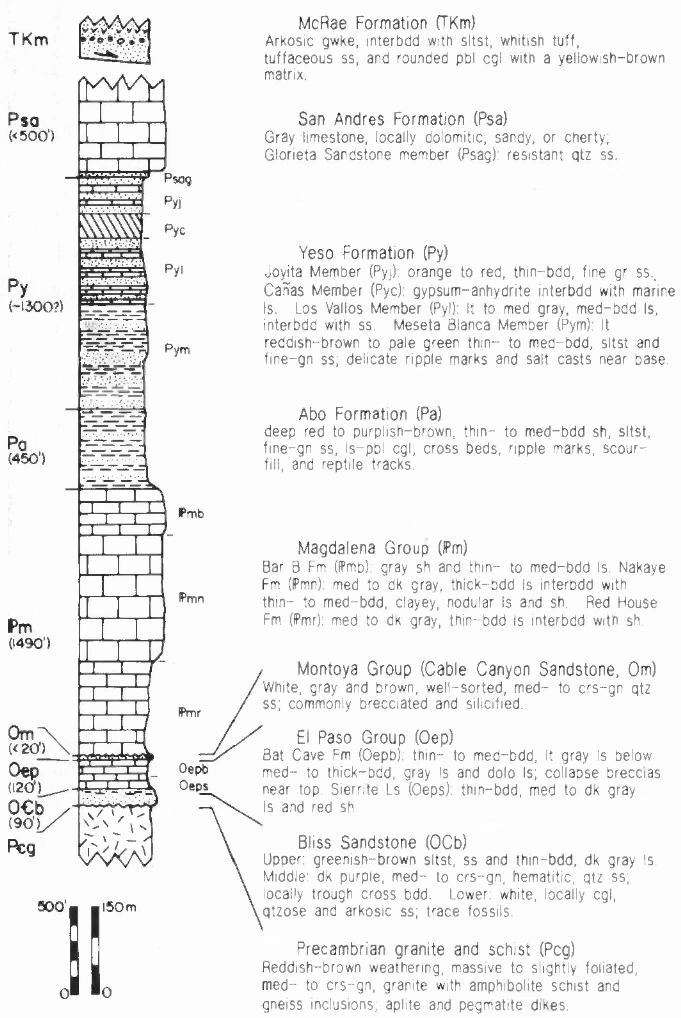


FIGURE 2B-0.0a—Stratigraphy of Fra Cristobal Range.

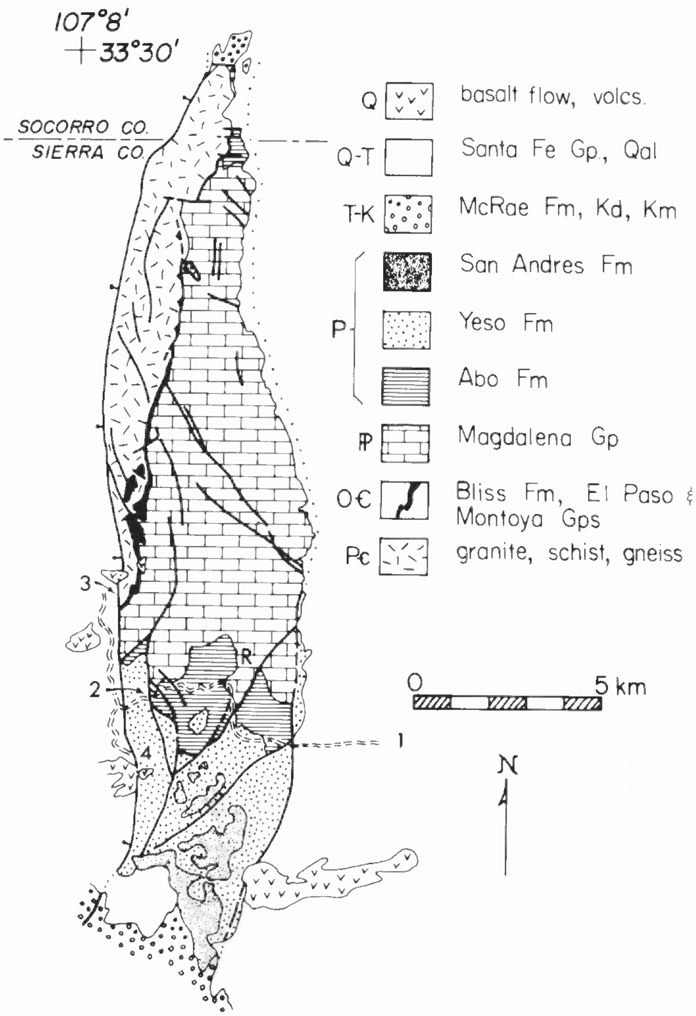


FIGURE 2B-0.0b—Generalized geologic map of Fra Cristobal Range. Sources cited in Nelson (this guidebook).

seen to the south on the pediment surface of the Jornada del Muerto. Remaining stops for the day require hikes of some difficulty; distance and elevation gain are listed for each stop. If you can only manage one hike, Stop 3 is a must, but also the hardest (500 ft elevation gain over 0.5 mi). Budget your energy carefully.

The entire Fra Cristobal Range, including the area covered by this road log, is within the privately owned Armendaris land grant. The landowners (Oppenheimer Industries Inc.) have agreed to allow one-time access for this field trip, but wish to note that publication of this field guide does not in any way imply that access is, or will be, available to the public. In addition, because the area visited in the Fra Cristobal Range is used for livestock, field-trip participants are asked to insure that land is subjected to minimum impact during the field trip. Please follow the directions of the field-trip leaders closely, particularly when in vehicles. Also, no litter please. **1.8**

1.8 Junction with Tenneco's gypsum exploration roads at the eastern, downfaulted edge of range. North and south of the road, blocks of San Andres Fm. downfaulted against Yeso Fm. **0.8**

2.6 Driving on a bench which follows subhorizontal Abo–Yeso contact; note that the Yeso Fm. is more reddish brown than the bright-red Abo Fm. The same contact can be seen at 12:00 in a hill just south of Red Gap; a northwest-trending fault (Gypsum Gap fault) runs between the hill at 12:00 and our location here. **0.4**

3.0 The road now makes a right-angle turn and trends north; the road to Gypsum Gap comes in from the left. Here the road follows subhorizontal Magdalena–Abo contact west of the Gypsum Gap fault. Downfaulted Abo Fm. can be seen to the northeast in hills on the east side of the fault. **1.0**

4.0 Red Gap exposes Abo Fm.; some surrounding hills are capped by Yeso Fm. View of Black Range to west. **0.3**

4.3 Road bends from west to roughly north through a small arroyo where the Magdalena–Abo contact can be seen. **0.3**

4.6 Small reservoir on left. Note green shales in Abo Fm. along road. **0.3**

4.9 Major pass leading to west flank of range. **Road down is steep and rugged; caution.** From 2:00 to 3:00 note upturned Magdalena Fm. on western flank of range. The road down follows Magdalena–Abo contact; gently dipping beds of Magdalena Fm. on right and Abo Fm. in hills on left. **0.7**

5.6 **STOP 2.** We will hike up to the saddle south of the road; beware of cactus and loose rocks (elevation gain = 200 ft, distance = 1,000 ft). Note lithologies in the Abo Fm. on the way up: mostly fine-grained, thinly bedded or laminated sandstones and some intraformational conglomerates with fine ripples and crossbeds; resistant 2–3 m thick sandy units are separated by finer-grained, less-resistant, bright-red shaly intervals; mud cracks and animal tracks have been found elsewhere in the area (Nelson 1986: fig. 9).

A major normal fault (Double Peak fault) comes through the saddle we are in and separates the western, deformed portion of the range from the eastern, homoclinal portion. Here the fault places Yeso Fm. against Abo Fm. on the east. To the north where it crosses the road, the fault places upper Abo Fm. against lower Abo Fm. on the east; it can be traced farther north to a saddle where Yeso Fm. is faulted against Magdalena Fm. on the east. Farther north, displacement on the fault dies out completely. Facing south, the fault passes through the next notch south where light-gray limestone beds in the Yeso Fm. (Los Vallos Mbr.) are faulted against Abo Fm. on the east. Fault drag is developed in Los Vallos beds adjacent to the fault in this notch.

A number of Laramide structures can be seen from here. Upturned Magdalena Fm. can be seen on the northern skyline; we will see the core of this major fold at Stop 3. A thrust fault (Hackberry thrust) and roll-over anticline in the Meseta Blanca Mbr. of the Yeso Fm. can be seen in the hill north of Hackberry Canyon (Nelson & Hunter 1986: fig. 8). Disharmonic box folds in the Meseta Blanca just to our left (best viewed from cars) are typical of intraplate deformation within the Yeso Fm. They suggest dual vergence, but a dominant westward vergence is indicated by statistical analysis of minor fold and thrust vergence (Nelson & Hunter 1986). Many low-lying hills to south and southwest expose strongly deformed Meseta Blanca Mbr. which we will see at Stop 4 (Hamburger Hill). The Double Peak fault may be a reactivated reverse fault that acted as a ramp or buttress during thin-skinned deformation.

South of Walnut Canyon two low-angle-normal-fault-bounded tectonic slices (one of San Andres Fm. and one of McRae Fm.) are placed on top of each other and on the Meseta Blanca–Los Vallos contact (Fig. 2B-5.6). Beds in the McRae slice are cut by the fault; those in the San Andres slice appear to parallel the fault (suggesting a ramp geometry similar to flat-ramp thrust geometries, Fig. 2B-5.6). Warren (1978) mapped these, along with a large area south of the Massacre Gap fault, as gravity-slide blocks.

To the west is the Elephant Butte Lake; west of the lake, from north to south, are the San Mateo Mtns., Sierra Cuchillo, and Black Range. The Caballo Mtns. are east of the Rio Grande, south of T or C. The Mud Springs Mtns. are in the rift near T or C. Cooke's Peak is the spire to far south straight past T or C. Note downcut alluvial deposits in the Rio Grande rift. **0.3**

5.9 Bright-red cliffs on left in bottom of canyon are Abo Fm. overlain by Yeso Fm.; Abo Fm. is faulted against Yeso Fm. to north (across canyon). **0.1**

6.0 Driving through small gorge near the mouth of Hackberry Canyon. Note intense fracturing and down-to-the-west, small-displacement normal faults within silicified, greenish sandstone beds of the lower Meseta Blanca Mbr. of the Yeso Fm. At the mouth of the canyon, limestone blocks on both sides of the road are blocks of San Andres Fm. caught in the range-boundary fault

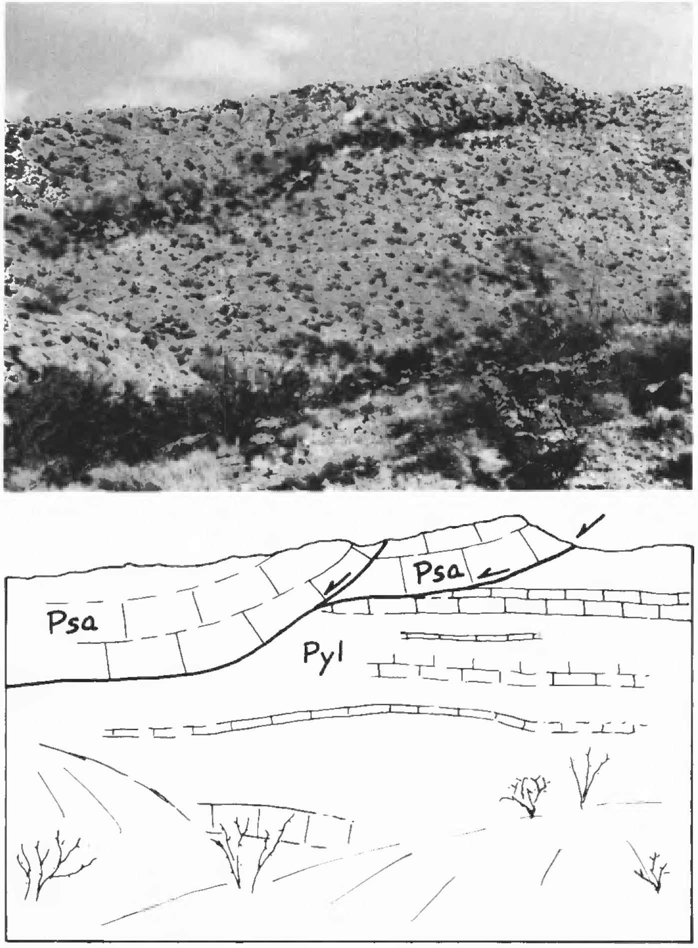


FIGURE 2B-5.6—Low-angle normal fault between detachment slice of San Andres Fm. (Psa) and Los Vallos Mbr. of Yeso Fm. (Pyl). Note that lower plate beds are truncated, but upper plate beds are parallel to fault.

zone (Walnut Canyon–West Vein fault) which is probably over 100 m wide in places and includes variably oriented blocks of different Paleozoic and Mesozoic units (Yeso, San Andres, Dakota, Mesa Verde, McRae, etc.). **0.2**

6.2 Road intersection; **turn north. 0.7**

6.9 The eastern, homoclinal section of Magdalena Gr. can be seen wrapping up steeply into the Hellion fold (Fig. 2B-6.9); the upturned Precambrian–Bliss Fm. contact can be seen in the background. At 10:00 is a low hill of Quaternary basalt. **0.2**

7.1 Crossing arroyo (mouth of Hellion Canyon). Outcrops of San Andres limestone on right just as you enter the canyon are blocks caught in the Walnut Canyon fault zone. This east-trending canyon exposes Magdalena Gr. and Abo Fm. on its north flank in the steeply plunging nose of the Hellion fold structure. The lower Yeso Fm. is exposed on the southern flank of the canyon. **0.3**

7.4 View to north along entire west flank of range from 11:00 to 12:00; note dark band of vertical Bliss Fm. on skyline, upturned Magdalena Gr. in cliff to northeast, and Magdalena Gr. in nose of Hellion anticline chopped off by Walnut Canyon fault. Basalt flow from 8:00 to 9:00. **0.8**

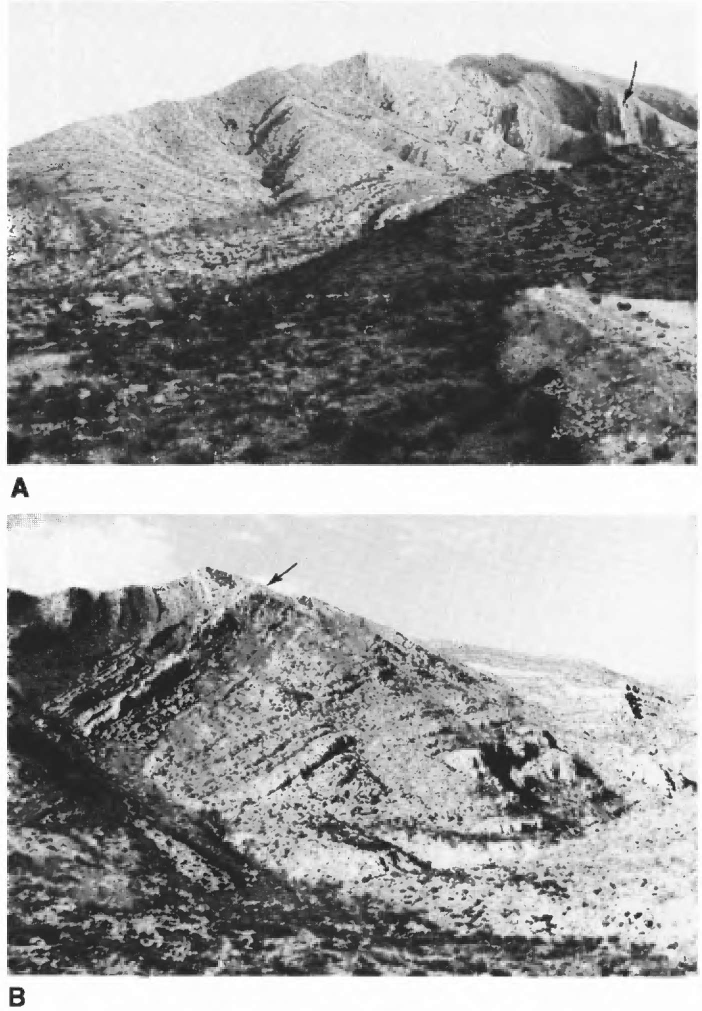


FIGURE 2B-6.9—Hellion fold structure exposed north of Hellion Canyon. **A,** Overturned Hellion anticline; **B,** overturned syncline to east. Arrow points to same limestone bed in Magdalena Gr.

8.2 To the east, white, silicified Cable Canyon Ss. can be seen wrapping around the south-plunging nose of the Hellion anticline. **0.3**

8.5 **STOP 3.** Hellion fold core. Lunch break will be at the top of hill after a short hike (elevation gain = 500 ft, distance = 0.5 mi); we will probably be gone for about two hours. If anyone has energy for only one hike during the day, this is probably the best choice. The plan here is to briefly discuss Stop 3 at the cars and point out features to be seen on the way up and at the top. Once on the ridge, the leaders will stop at the only good view of the Hellion fold core (Fig. 2B-8.5a) to point out various features. From there people can explore individually. We will be walking up the west flank of the overturned, basement-cored Hellion anticline; the fold has an odd map pattern mostly explained by structure–topography relationships (Fig. 2B-8.5b). The vertical to overturned eastern limb can be seen forming the upper slopes of Rainbow Ridge; note that the Precambrian–Cambrian unconformity is vertical to overturned here!

A number of features can be seen on the hike up. The silicified West Vein fault (= Walnut Canyon fault) cuts

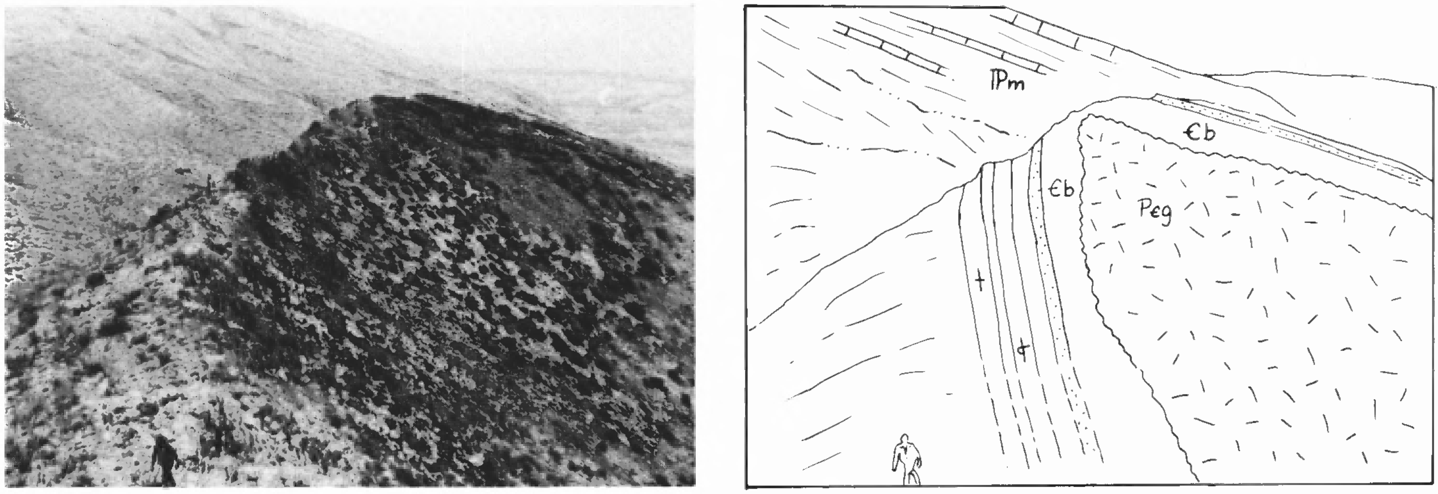


FIGURE 2B-8.5a—Core of Hellion anticline, looking south. Person at bottom is walking on vertical to overturned Bliss Fm. and western flank of hill in foreground is dip-slope of upright Bliss. Core of fold is Precambrian granite.

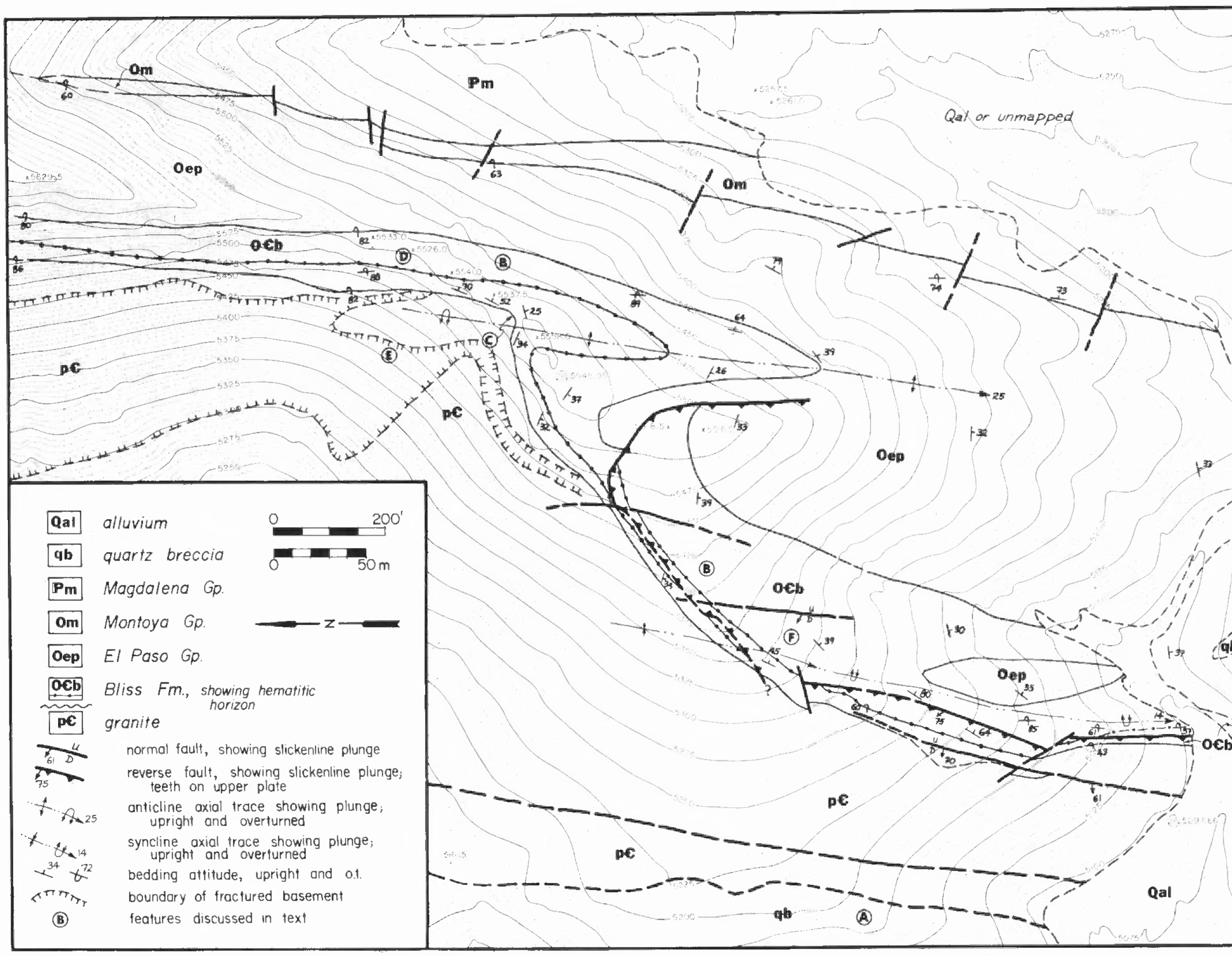


FIGURE 2B-8.5b—Geologic map of Hellion fold core. Circled letters refer to features mentioned in text: A = West Vein fault zone and prospect in Cu-mineralization; B = trace fossils, upper Bliss (two locations); C = basement-cover unconformity in core of fold and trace fossils in lower Bliss; D = mesoscopic kink folds in Bliss; E = closely spaced fractures in basement; F = slickensides in Bliss.

the Precambrian (Nelson 1986: fig. 4), and minor Cu-mineralization can be seen in a prospect near the fault zone. Note that fluorite–barite mineralization is most common along the West Vein fault (Van Allen et al. 1984). As we hike up the hill, note the stratigraphy in the Bliss Fm.; three distinct members can be recognized: (1) a basal, light-gray, quartzitic to arkosic, locally conglomeratic sandstone; (2) a middle, hematitic, cross-bedded sandstone; and (3) an upper, greenish-brown, trace-fossil-rich shale interbedded with, and transitional upward into, brownish carbonates. Farther north, channels are cut into the Precambrian and filled with a basal Bliss lag deposit containing boulders of the Precambrian (Nelson 1986: fig. 5). Horizontal and vertical trace fossils can be seen in the lower Bliss about 30 cm above the Precambrian (Nelson 1986: fig. 6).

On the ridge: The folded unconformity is exposed just below the notch on the north side of the hill (Fig. 2B-8.5a). Please use caution when scrambling on the north face of the hill (right in the Precambrian core of the fold), as it is both steep and covered with loose "ball-bearing" gruss. The contact can be followed back to the cars if desired. Other features on the ridge: Bedding-plane slickensides present in the Bliss Fm. were developed in response to some flexural slip folding. However, no shear can be seen along the unconformity. The fold core is very interesting in having a number of small offsets and some minor, small-displacement thrust and high-angle faults, most likely accommodating shortening during folding. Basement in the core of fold is structurally isotropic at a mesoscopic scale; no cleavage is developed, although microfaults are seen in thin section (Chapin 1986, Chapin & Nelson 1986). Open chevron folds are present in the upper Bliss on the steep limb of fold. These folds have the wrong asymmetry (S-folds, looking south) for development in response to flexural slip folding, and may have developed as basement-forced folding occurred.

To the south, note the near-recumbent, counterclockwise-asymmetry folds in the Magdalena Gr. in the south-plunging core of the Hellion anticline. In the cliffs to the east, Magdalena Gr. beds are complexly folded with fold axes subparallel to the trend of the hill and hinge planes only slightly less steep than the slope. The plunge of Hellion fold increases rapidly to the south, suggesting some basement-block control on the folding. To the north, along Rainbow Ridge, note Quaternary volcanic flows and agglomerates capping the ridge.

Retrace route to mile 6.2 on entry log. **2.3**

10.8 Turnoff to Walnut Canyon just west of the mouth of Hackberry Canyon. **Turn right.** Here we are driving along the Walnut Canyon fault zone where many lithologies of various formations are tectonically mixed. **0.3**

11.1 Turnoff to left goes to drilling pads along the mineralized fault zone. Note mottled colored shales of McRae Fm. exposed in the road. **0.5**

11.6 On top of pediment slope. Note Tenneco's drilling pads to east. The hills to east of the drilling pads are Meseta Blanca Mbr. of the Yeso Fm. **0.2**

11.8 Sharp turn west adjacent to major arroyo to south. Here we are driving on a basalt flow covering Santa Fe Gr. which erupted from vents near, but not directly on, the Walnut Canyon fault zone (Warren 1978). Skyline ridges in southern portion of range are San Andres Fm.; they show minor tilting and faulting (Fig. 2B-11.8). **0.2**

12.0 **Hairpin turn,** road descends steeply into arroyo. **Do not descend without 4-WD;** park at top and walk down. Before the turn, the Hellion anticline can be seen to the north. **0.4**

12.4 **STOP 4.** Walnut Spring, Hamburger Hill. Short, moderately steep hike up to view spectacular thin-skinned deformation in the Meseta Blanca Mbr. of the Yeso Fm. exposed in Hamburger Hill (elevation gain = 200 ft, distance = 1,800 ft). At the mouth of the canyon is Walnut Spring where the Walnut Canyon fault zone is exposed (Santa Fe Gr. is faulted against Meseta Blanca on the east; seen in gully north of Walnut Spring). Going up the canyon, note the closely spaced fractures related to the fault. Also note the lithologies in the lower Meseta Blanca Mbr.: reddish and greenish-gray, silicified sandstone with delicate ripple marks; these ripple marks are often associated with salt casts, some quite large (Nelson 1986: fig. 10). This level in the lower Meseta Blanca is where much of the thin-skinned deformation appears to root [no such deformation is seen in the Abo Fm. in the Fra Cristobal Range, although the Magdalena Gr. is thrust over Abo Fm. in the Caballo Mtns. (Kelley & Silver 1952)]. Note dip reversals and broad, open folds while walking up the canyon, some with disharmonic structure indicated by subhorizontal beds above them. Walking up narrow-sided gully, note small, asymmetric folds (both asymmetries are present) and mini-thrust faults in a 0.5 m thick, thinly laminated, silty or shaly layer in the Meseta Blanca Mbr. These features indicate bedding-plane slip and detachment which reflect the large-scale strain in the area.

Features in Hamburger Hill (north wall of Walnut

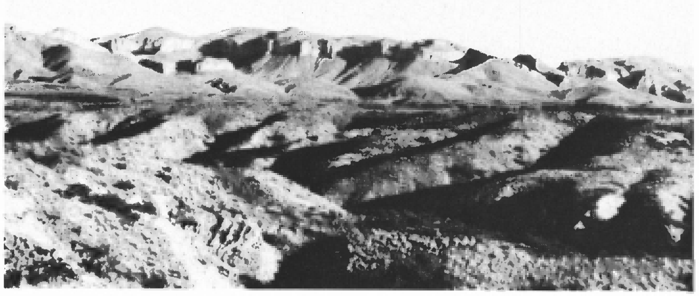

FIGURE 2B-11.8—Cliffs of San Andres Fm. variably tilted in southern Fra Cristobal Range.

Canyon; Nelson & Hunter 1986: fig. 12) are: (1) Apparent isoclinal folds on west side of hill; (2) large box folds on east side of hill; (3) thrust faults near the center of the hill, which may have been reactivated as normal faults during late Tertiary extension. Similar deformation can be seen in hills north of Walnut Canyon. Many silicified bands, which are related to rift faulting, can be seen in these hills; they cut across bedding and some have slip.

From Walnut Spring, we will retrace our route back to the mouth of Hackberry Canyon, through the canyon, and over the range at Red Gap. Total mileage back to Truth or Consequences is approximately 37 mi.

**End of trip.**