The Appleton oil field is located near the northern rim of the Gulf of Mexico basin. Use the data from well 4835-B in this field (Table 2.2) to solve the following problems. Find the subsea depths of the stratigraphic markers. Write a spreadsheet program using Eqs. 2.3 and 2.4 to find the coordinates of a point between two known points. Find the true vertical depths and the total rectangular coordinates of the formation contacts in the well. What is the orientation of the well where it penetrates the Smackover? Write a spreadsheet program to solve this problem based on Eq. 2.4. Find the true vertical depths and the total rectangular coordinates of the oil-water contact (OWC) and the base of the Smackover. Plot the locations of the stratigraphic tops relative to the surface location of the well on the map (Fig. 2.26). Connect the points to show the shape of the well in map view. How far from the well (horizontally and in which direction) would you expect to first find the intersection of the oil-water contact with the top of the Smackover Formation, assuming constant dip for the Smackover?

Table 2.2. Data from well 4835-B, Appleton field, Alabama. Kelly Bushing: 244 ft

Measured depth = log depth (ft)		True vertical depth (ft)	Depth subsea (ft)	Total rectangular coordinates (ft)	
0		0		0.00 N	0.00 E
928		928		1.72 N	1.93 E
2308		2308		4.53 N	9.51 W
3282		3282		6.37 N	6.29 W
4150	Eutaw				
4400	U. Tuscaloosa				
4811		4811		13.38 N	5.99 W
4890	M. Tuscaloosa				
5150	L. Tuscaloosa				
5525	L. Cretaceous				
6198		6198		30.82 N	17.30 W
7696		7695		61.48 N	7.50 W
8328		8327		74.90 N	1.25 E
8482		8480		74.59 N	18.82 E
8661		8655		71.22 N	53.19 E
8935		8922		66.16 N	117.74 E
9186		9161		62.25 N	194.12 E
9556		9512		54.50 N	310.78 E
10006		9940		34.61 N	447.09 E
10266	Cotton Valley				
10431		10346		7.63 N	568.29 E
11103		10982		55.68 S	777.65 E
11621		11470		116.46 S	938.37 E
11960		11791		142.28 S	1045.58 E
12370	Haynesville				
12450		12253		173.48 S	1206.13 E
12641		12432		185.03 S	1271.62 E
13020	Buckner				
13072	Smackover[a]				
13086		12851		210.98 S	1418.79 E
13190	OWC[b]				
13286	Base Smack				

[a] Attitude from dipmeter 12,056. [b] Oil-water contact.

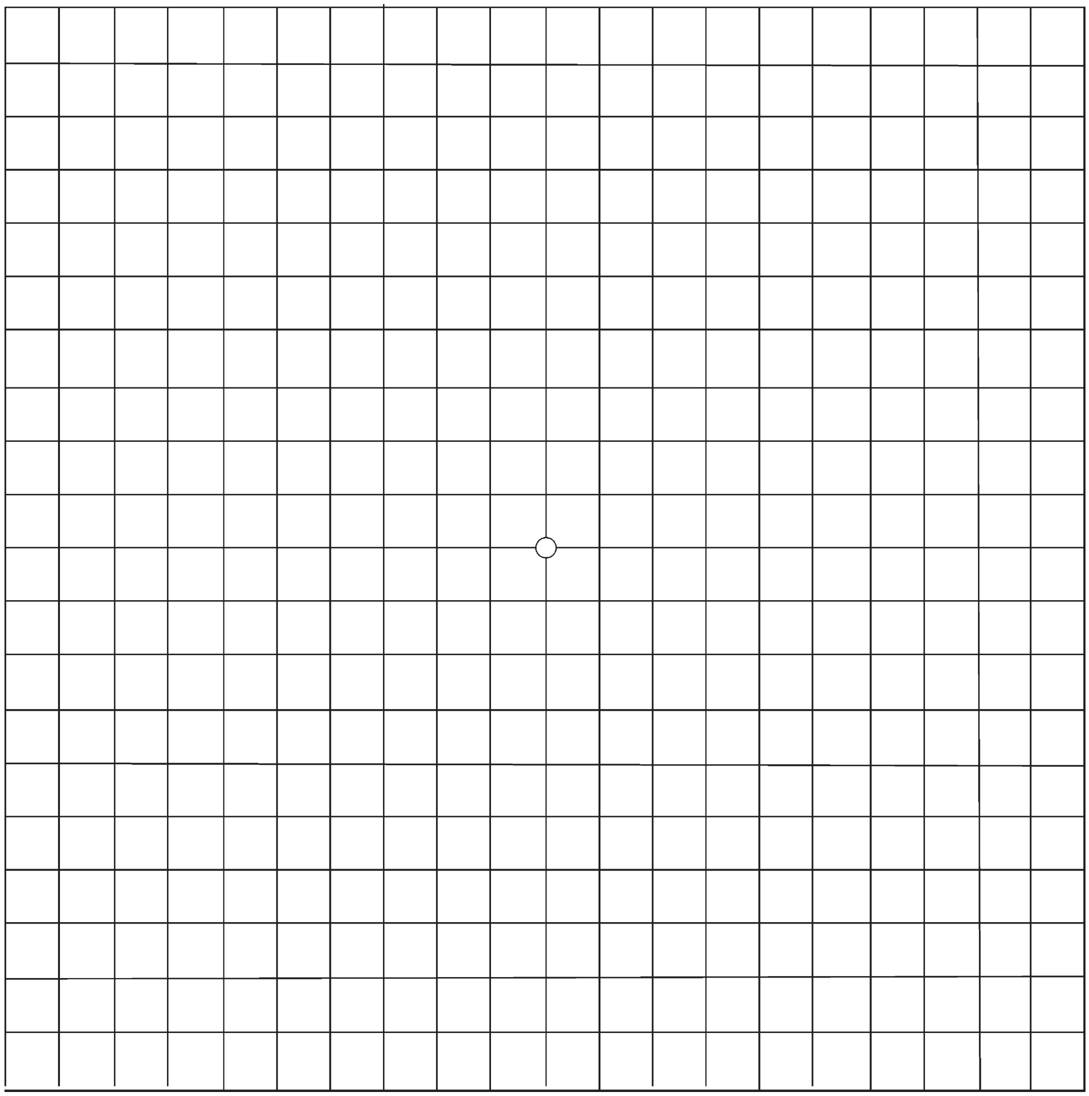


Fig. 2.26. Map grid for plotting points in a deviated well

Given the dip vector of the plane 35, 240, show on an overlay of a stereogram the trace of the plane, its dip vector, and its pole. Show the dip vector 25, 240 on a tangent diagram. What is the apparent dip along a line that trends 260?

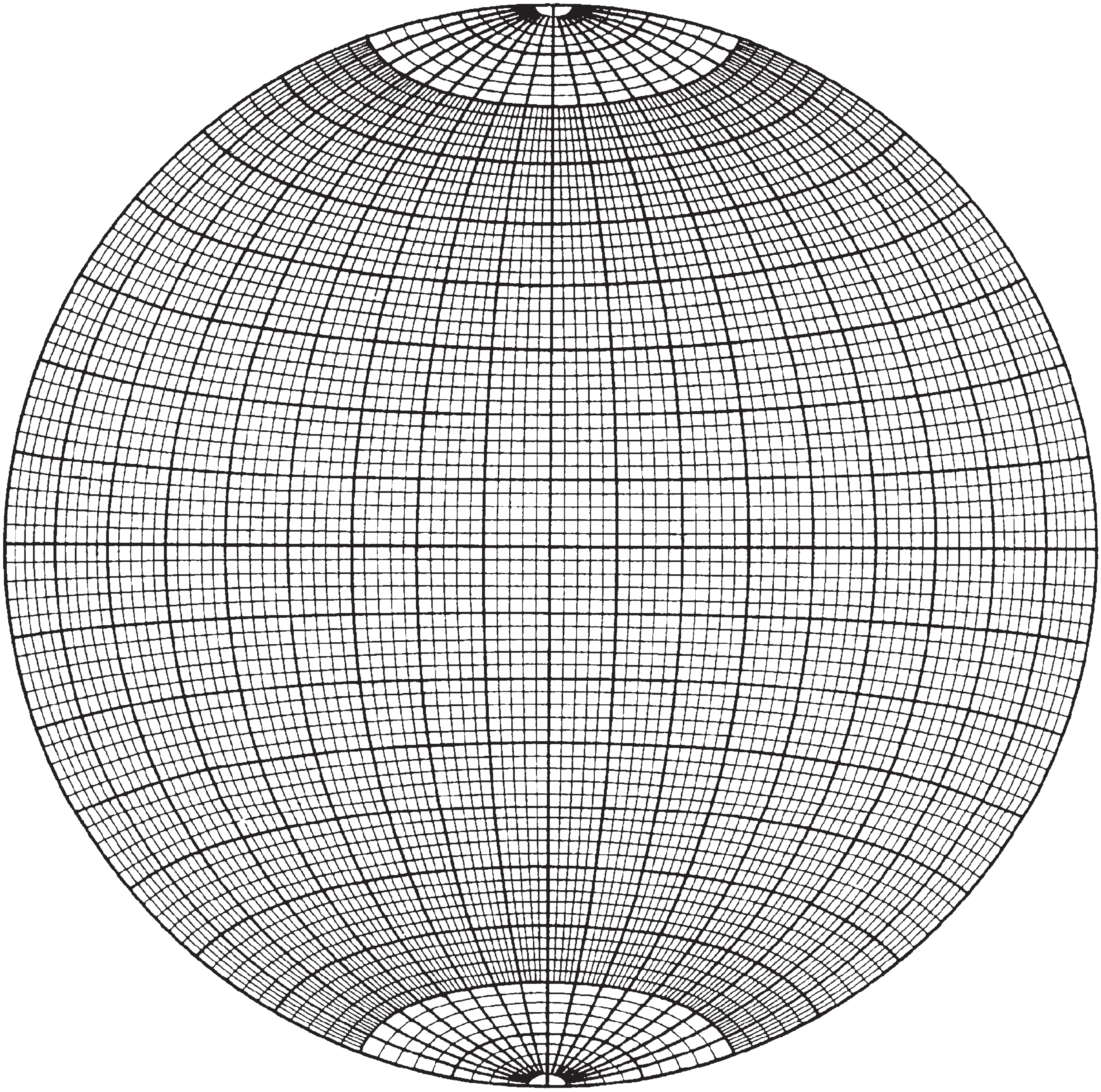


Fig. 2.28. Equal-area stereogram

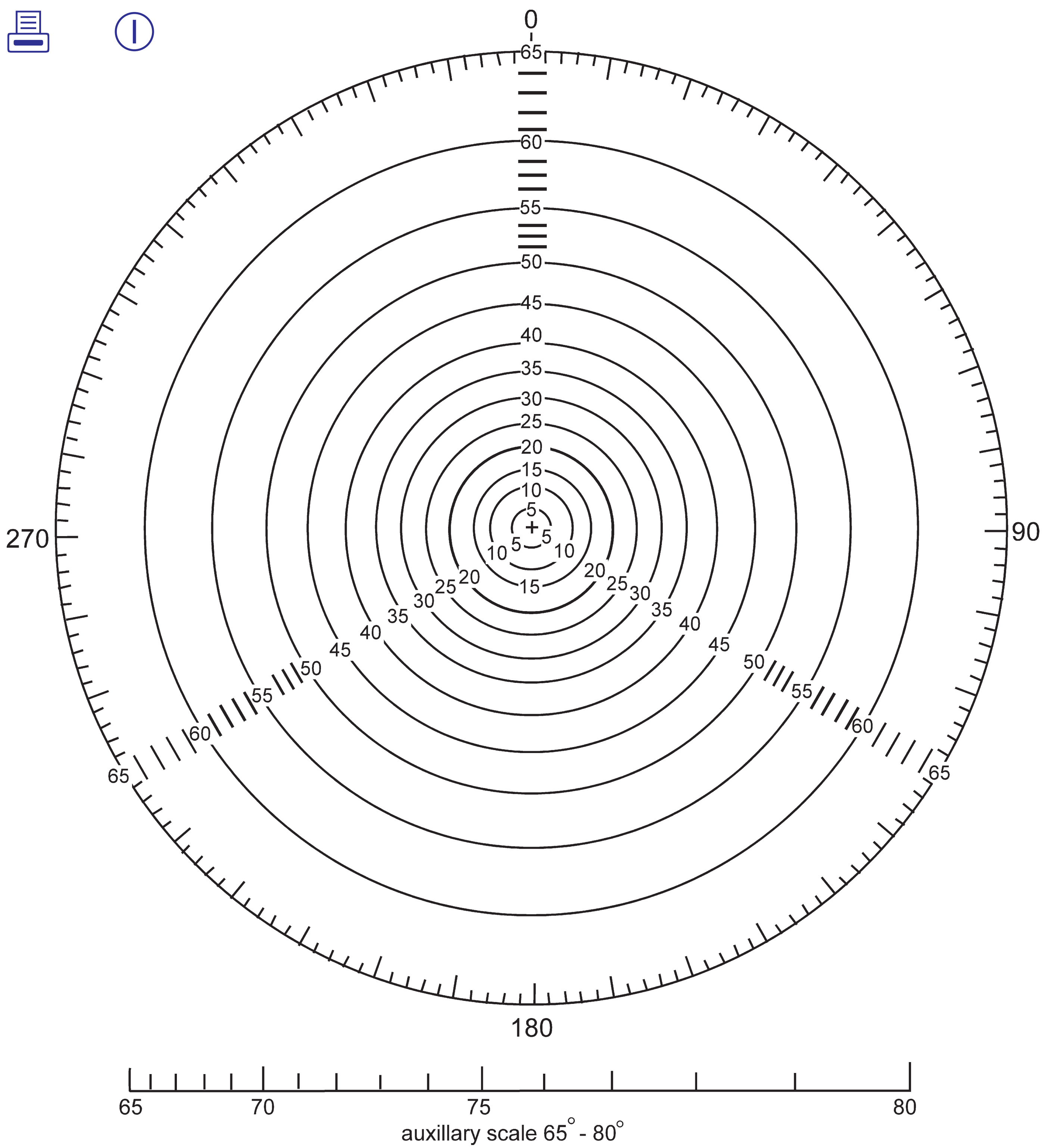


Fig. 2.29. Tangent diagram

Use the map of the Blount Springs area (Fig. 2.27) to answer the following questions. Find the attitude of the Mpm in its southeastern outcrop belt using the 3-point method. Draw structure contours for the Mtfp, Mpm, and Mh on the eastern side of the map. Are the upper and lower contacts of each unit parallel to each other? Do you think the contacts are mapped correctly? Determine the attitude of the eastern contact between the Mpm and the Mtfp by the 3-point method and from the structure contours. Are they the same? If they are different, discuss which answer is better. What would be the apparent dip of the Mpm in a north-south roadcut through the northwestern limb of the anticline?

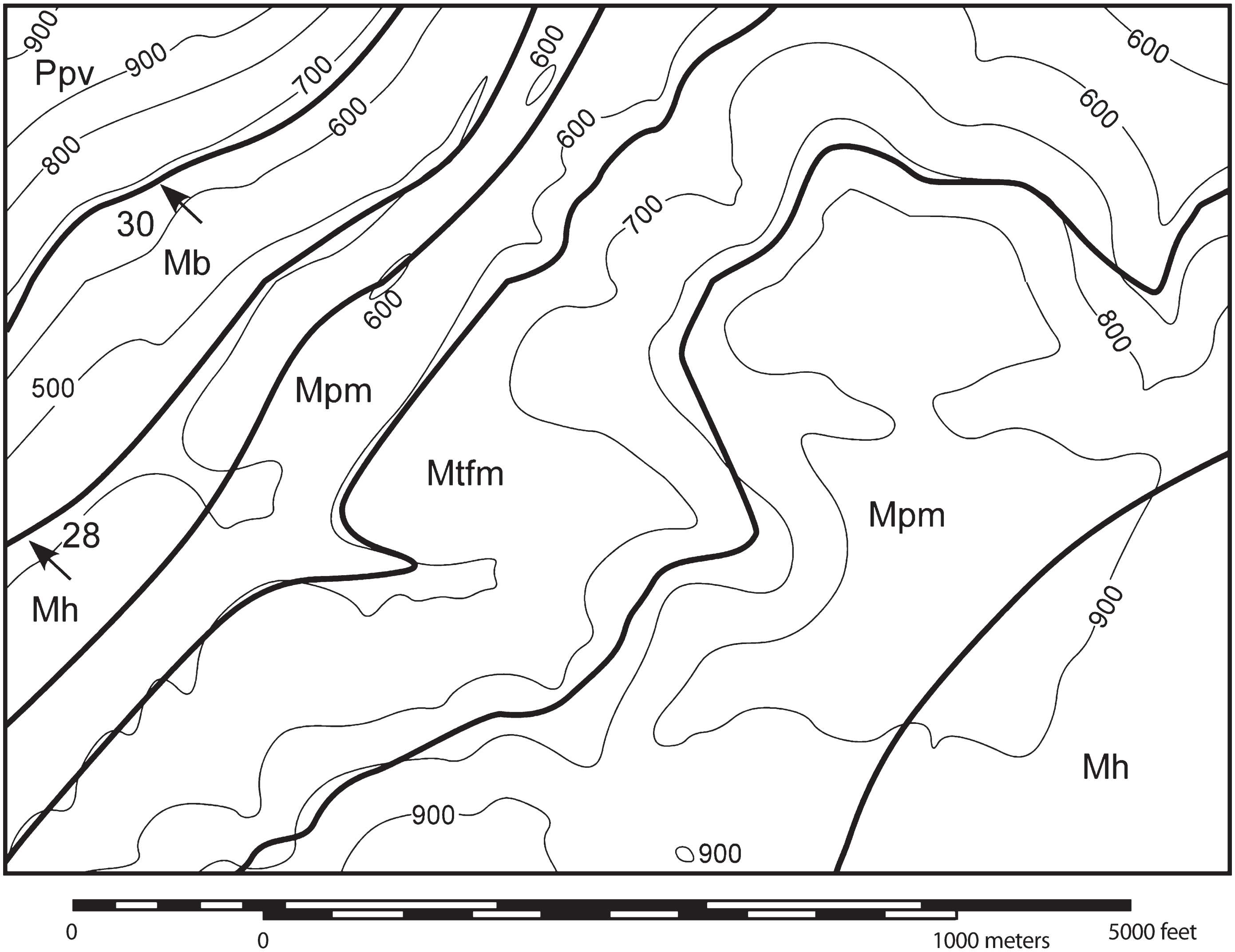


Fig. 2.27. Geological map of the northeast corner of the Blount Springs area, southern Appalachian fold-thrust belt. *Thin lines* are topographic contours (elevations in feet). *Thick lines* are geologic contacts. *Arrows* are dip directions. N*umbers* give the amount of dip

Use the data from the Weasel Roost Formation (Fig. 3.26) to try out different contouring techniques and to see the effect of trend biasing. Use interpretive contouring and assume a surface with no grain. Contour by parallel contouring: *(a)* assuming a northwest-southeast grain; *(b)* assuming a northeast-southwest grain. Draw crestal and trough traces on the structure contour maps just completed. Use interpretive contouring and assume a northeast-southwest grain. Define a TIN using greedy triangulation and contour by linear interpolation.

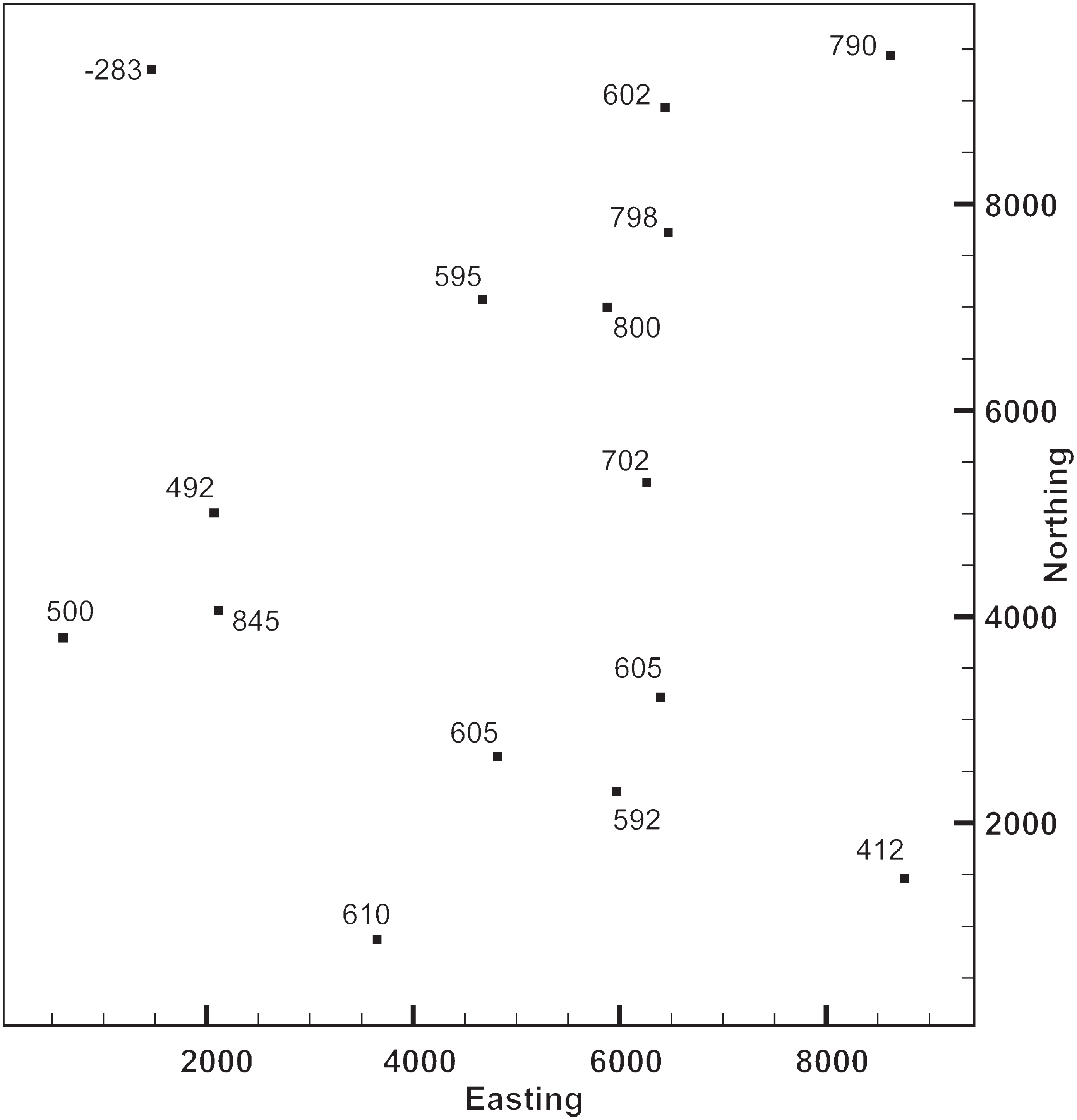


Fig. 3.26. Map of elevations (feet or meters) of the top of the Weasel Roost Formation

Contour the top of the Tuscaloosa sandstone in Fig. 3.27 using the bedding attitudes to help generate the contour orientations and spacings. The elevations are in meters.

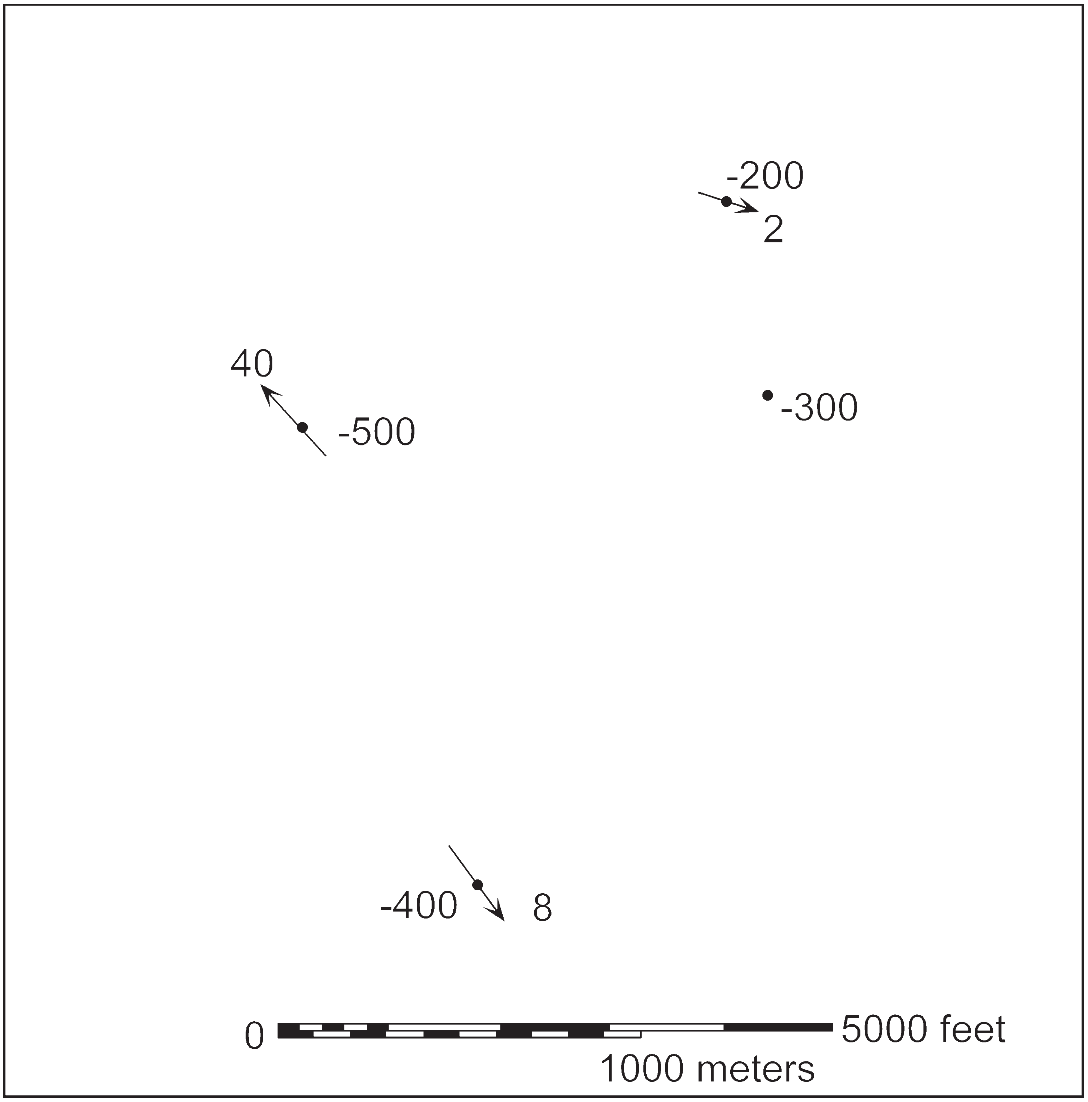


Fig. 3.27. Map of the top of the porous Tuscaloosa sandstone. Negative elevations are below sea level; azimuth of bedding dip is indicated by *arrows*

Find the elevation of the top of the Mtfp below the dot in Fig. 3.28. The thickness of the Mpm is 97 ft and the dip is 04°.

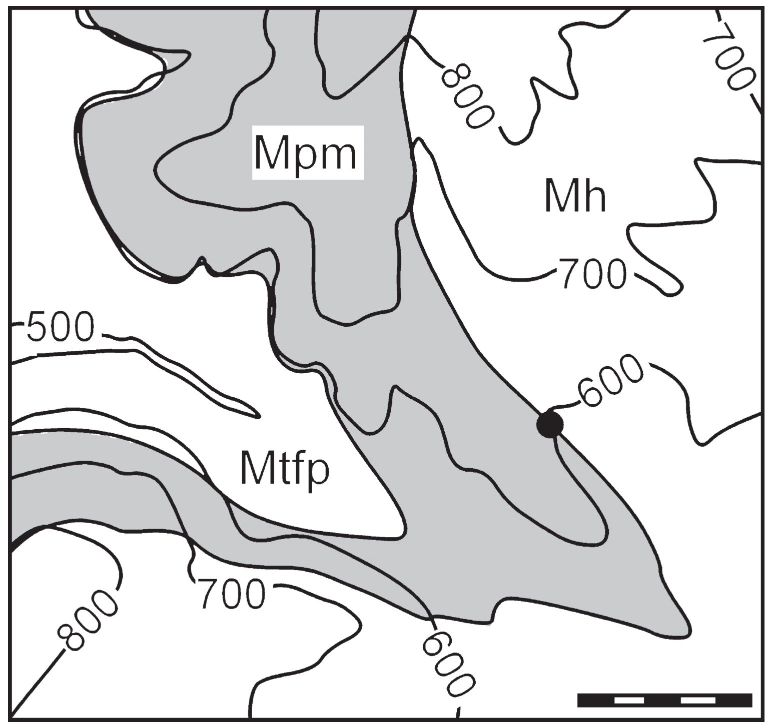


Fig. 3.28. Geologic map of the Mill Creek area. Topographic elevations are in feet and the scale bar is 1 000 ft

Use the geologic map of Fig. 3.29 to construct a projected structure contour map of the top of the Fairholme, a potential hydrocarbon reservoir. Use every point where a formation boundary crosses a topographic contour. Post all the elevations on your map before contouring. What is the best method for contouring this map? Explain your reasons. Is the geological map correct? Why or why not? Does the projected structure-contour map agree with the drilled depths to the top of the Fairholme? The wells to the Fairholme were drilled to find a hydrocarbon trap but were not successful. What is a structural reason for drilling the wells and what is a structural reason why they were unsuccessful?

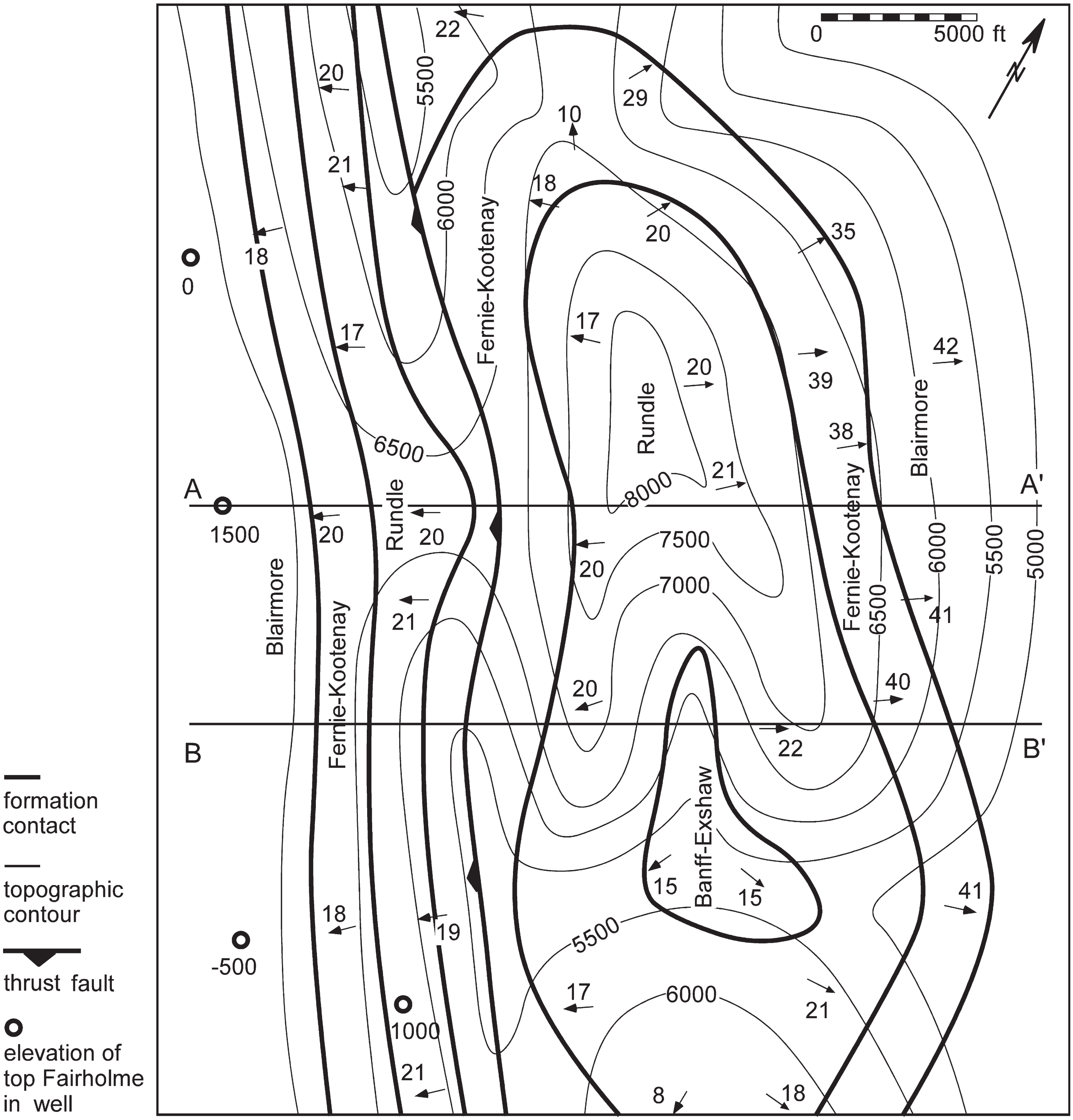


Fig. 3.29. Geologic map from the Canadian Rocky Mountains. All dimensions are in feet. The stratigraphic column (with thickness) from top to base is: Blairmore (2400), Fernie-Kootenay (700), Rundle (900), Banff-Exshaw (900), Palliser (800), Fairholme (1200). (After Badgley 1959)

Based on the data in Table 2.2, what is the isocore thickness of the Smackover? What is the true thickness of the Smackover given its attitude of 12, 056 from the dipmeter log and the orientation of the well from Exercise 2.9.1? Discuss the significance of the difference between the isopach and isocore thickness.

Table 2.2. Data from well 4835-B, Appleton field, Alabama. Kelly Bushing: 244 ft

Measured depth = log depth (ft)		True vertical depth (ft)	Depth subsea (ft)	Total rectangular coordinates (ft)	
0		0		0.00 N	0.00 E
928		928		1.72 N	1.93 E
2 308		2 308		4.53 N	9.51 W
3 282		3 282		6.37 N	6.29 W
4 150	Eutaw				
4 400	U. Tuscaloosa				
4 811		4 811		13.38 N	5.99 W
4 890	M. Tuscaloosa				
5 150	L. Tuscaloosa				
5 525	L. Cretaceous				
6 198		6 198		30.82 N	17.30 W
7 696		7 695		61.48 N	7.50 W
8 328		8 327		74.90 N	1.25 E
8 482		8 480		74.59 N	18.82 E
8 661		8 655		71.22 N	53.19 E
8 935		8 922		66.16 N	117.74 E
9 186		9 161		62.25 N	194.12 E
9 556		9 512		54.50 N	310.78 E
10 006		9 940		34.61 N	447.09 E
10 266	Cotton Valley				
10 431		10 346		7.63 N	568.29 E
11 103		10 982		55.68 S	777.65 E
11 621		11 470		116.46 S	938.37 E
11 960		11 791		142.28 S	1 045.58 E
12 370	Haynesville				
12 450		12 253		173.48 S	1 206.13 E
12 641		12 432		185.03 S	1 271.62 E
13 020	Buckner				
13 072	Smackover[a]				
13 086		12 851		210.98 S	1 418.79 E
13 190	OWC[b]				
13 286	Base Smack				

[a] Attitude from dipmeter 12, 056. [b] Oil-water contact.

Given a bed with dip vector 10, 290, and a measured thickness of 75 m in a vertical well, use the universal-thickness equation to determine its true thickness.

Use the map of the Blount Springs area (Fig. 2.27) to answer the following questions. What is the thickness of the Mpm between the structure contours using the map-angle equations and the pole-thickness equation? Are the results the same? If they are different, discuss which answer is better. What is the difference between the true thickness and the vertical thickness of the Mpm? What is the thickness of the Mpm in its northeastern outcrop belt, assuming that the dip is 28° at its northwestern contact and the value determined above occurs at its southeastern contact? Use the concentric fold model and the dip-domain model. Discuss the effect of changing the location of the axial surface on the thickness computed with the dip-domain model. Measure the thickness of the Mpm at 5–10 locations evenly distributed across the map. Measure thicknesses between structure contours where possible. Construct an isopach map from your thickness measurements. Is the unit constant in thickness? What would be the apparent thickness of the Mpm in a north-south, vertical-sided roadcut through the northwestern limb of the anticline?

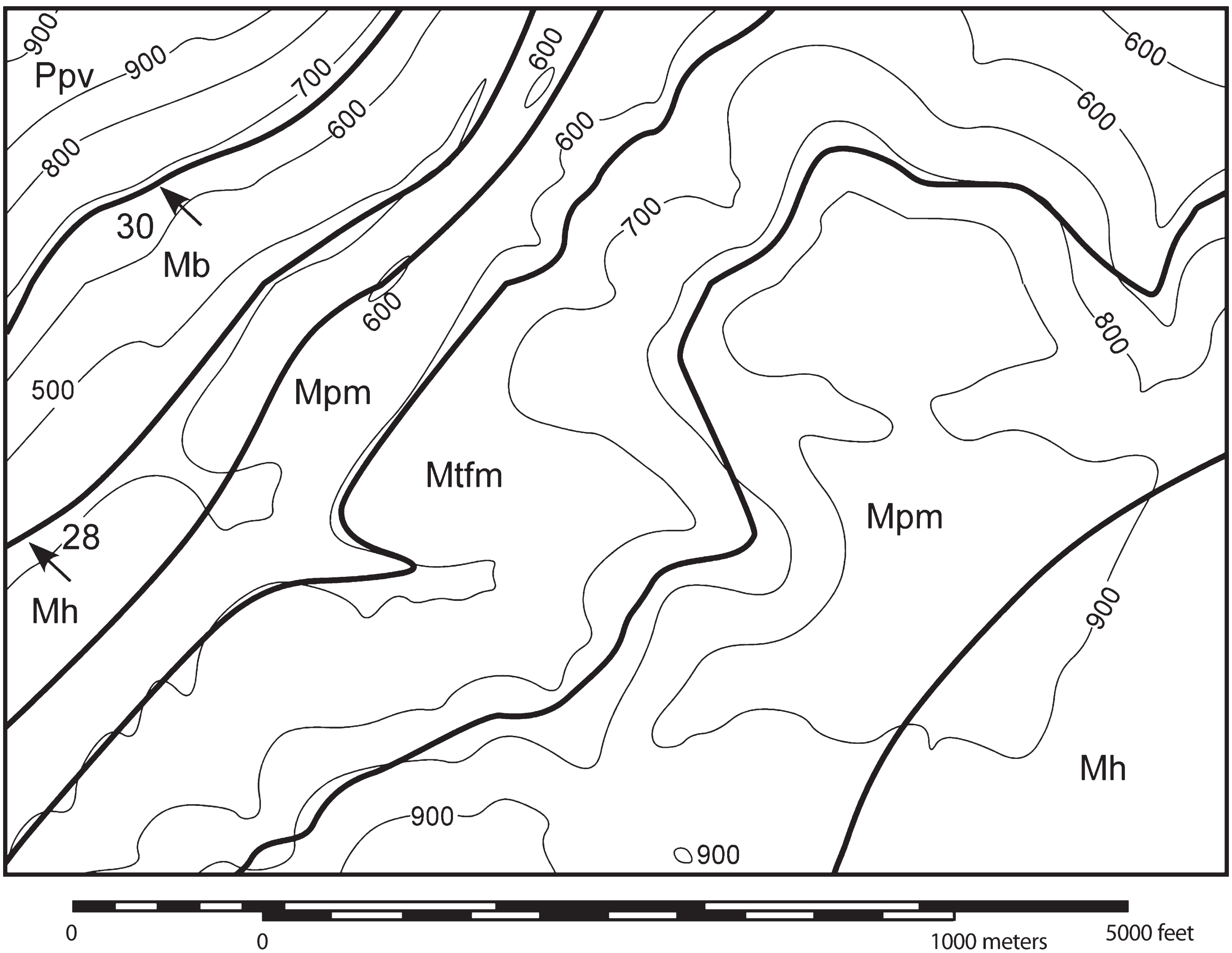


Fig. 2.27. Geological map of the northeast corner of the Blount Springs area, southern Appalachian fold-thrust belt. *Thin lines* are topographic contours (elevations in feet). *Thick lines* are geologic contacts. *Arrows* are dip directions. N*umbers* give the amount of dip

Make an isopach map of the sandstone thicknesses on the map of Fig. 4.19. The thickest measurements form a trend that could be a channel or the limb of a monocline. If the thickness anomaly is due to a dip change, what is the amount? If the thickness anomaly is due to paleotopography, what is the maximum topographic slope?

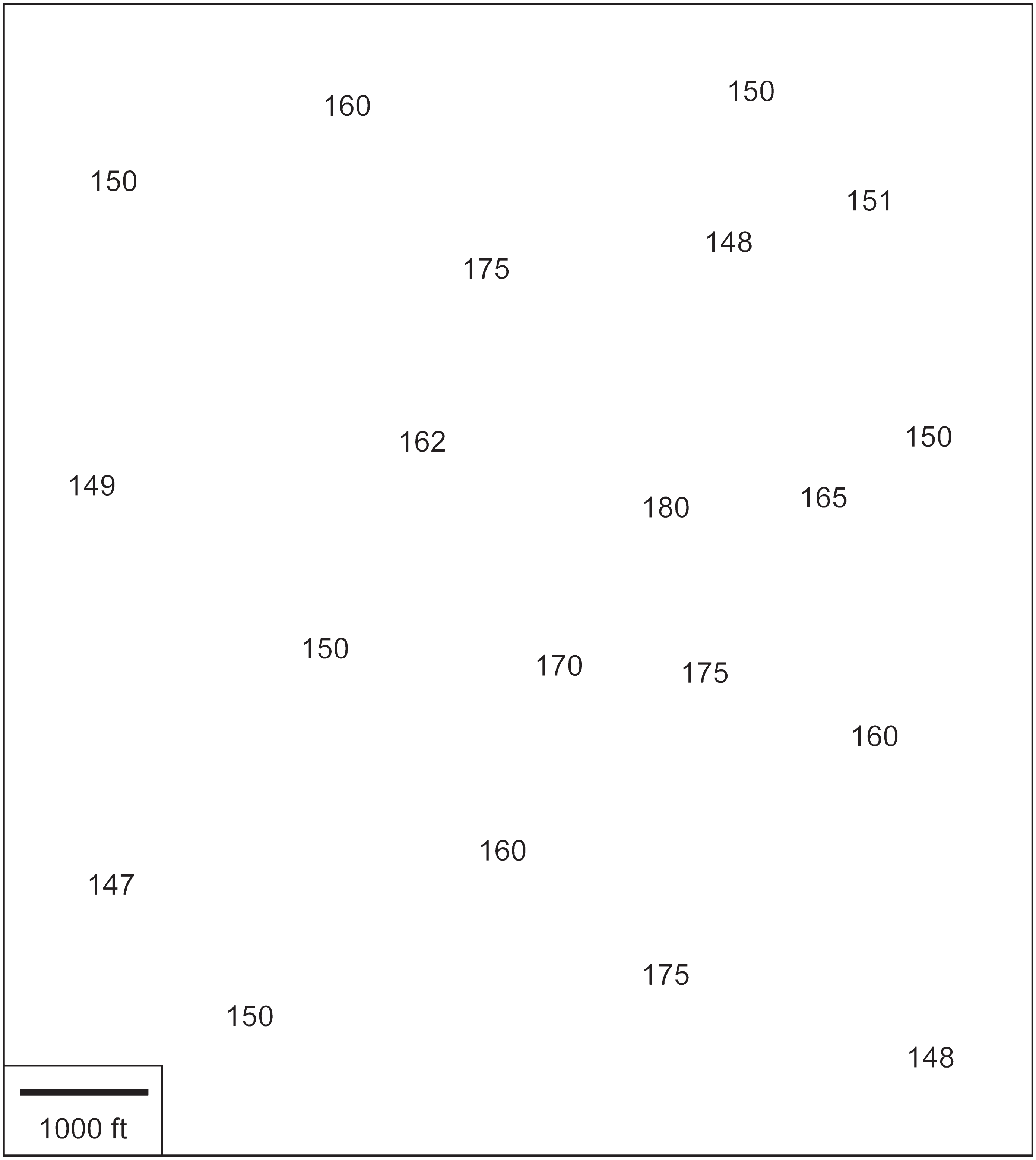


Fig. 4.19. Map of thicknesses (in feet) in the John S sandstone

Plot the attitude data from Table 5.1 on a stereogram and on a tangent diagram to find the fold style and plunge. How do the two methods compare?

Table 5.1.
Bedding attitudes across the central Sequatchie anticline from NW to SE

NW					SE
Dip	Azimuth	Dip	Azimuth	Dip	Azimuth
8	308	56	318	6	144
46	315	75	330	8	145
34	316	83	315	8	144
50	320	70	315	6	127
6	320	0	000	7	136
22	316	5	145	10	136
				9	136

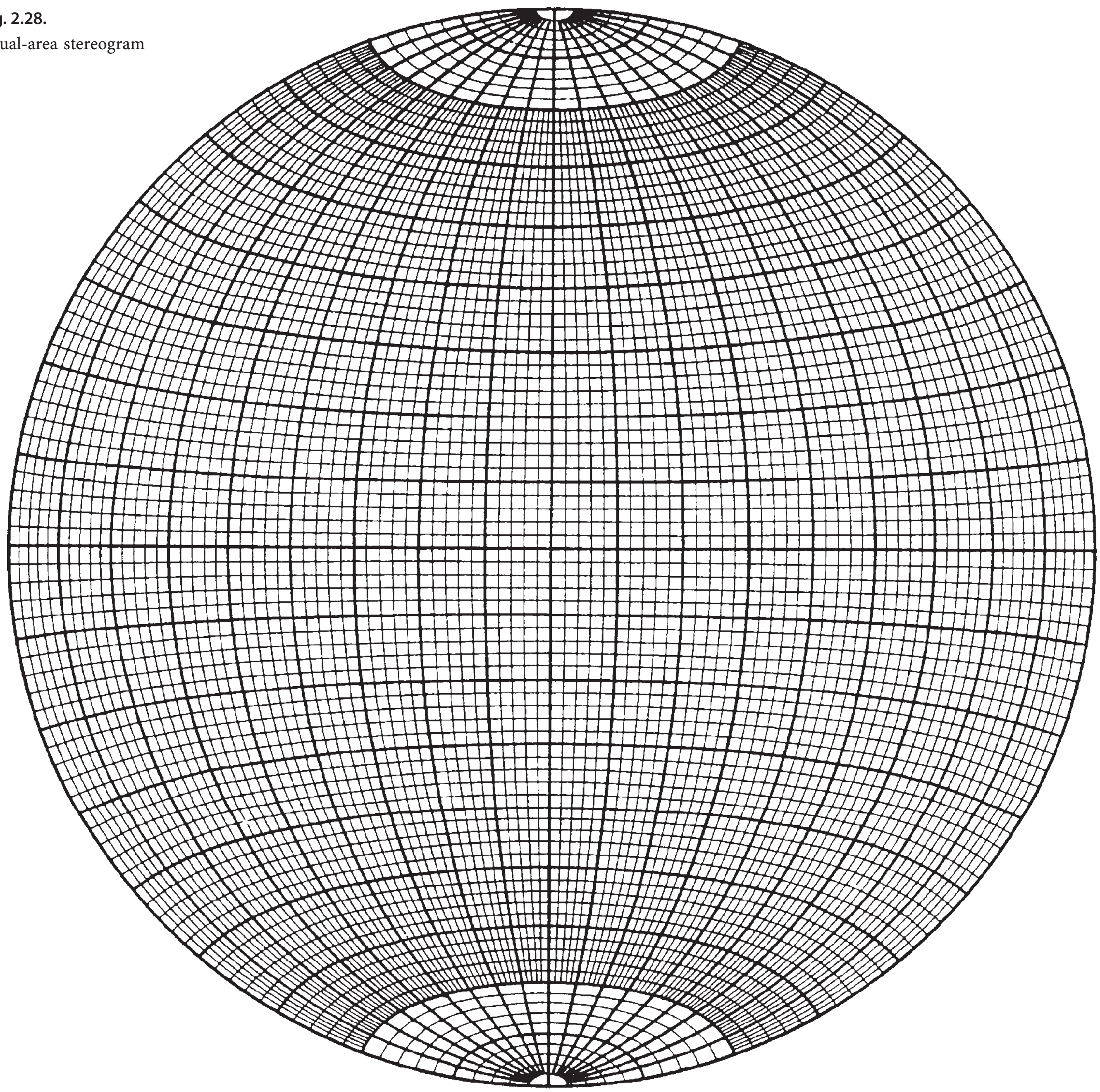


Fig. 2.28.
Equal-area stereogram

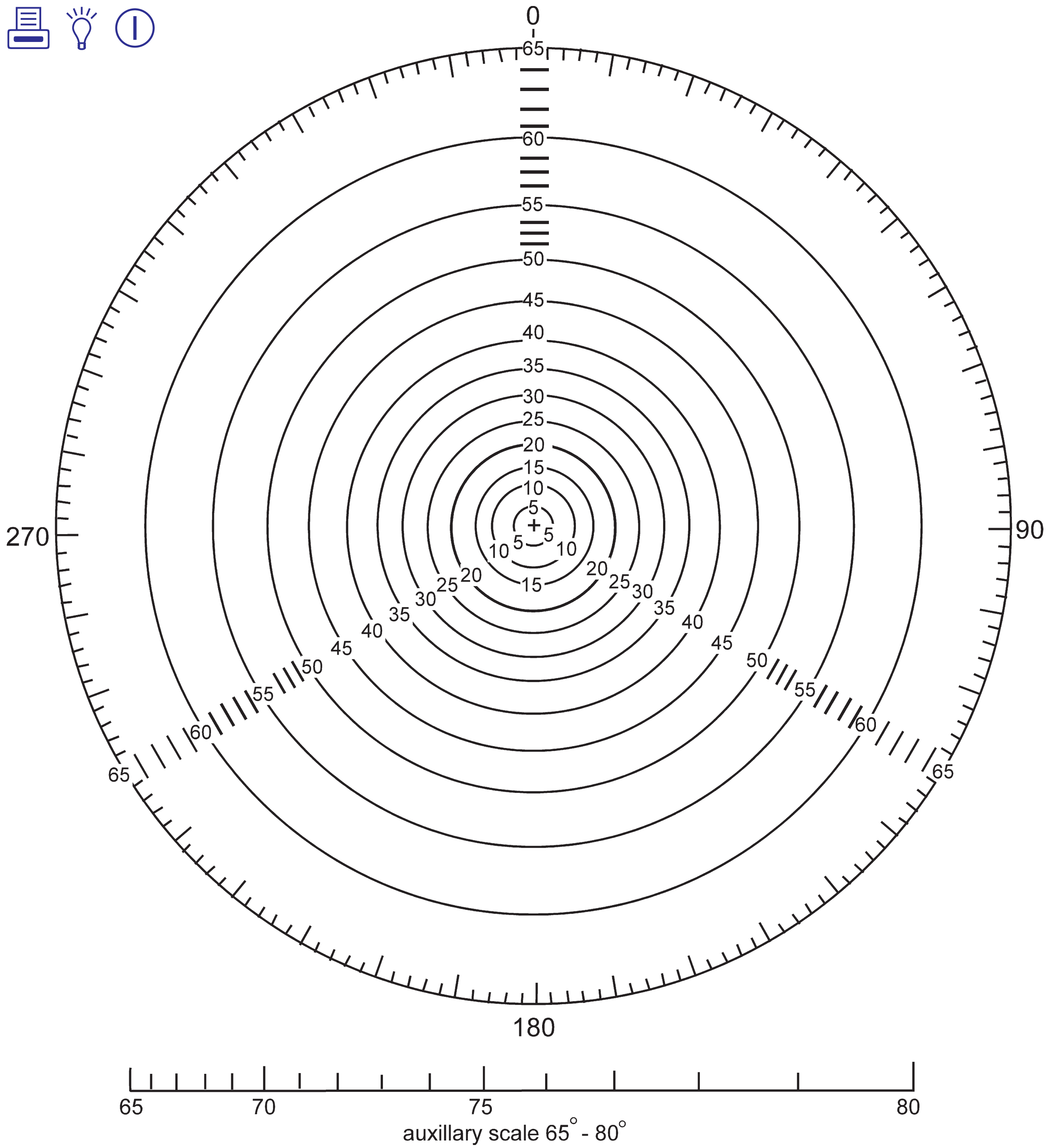


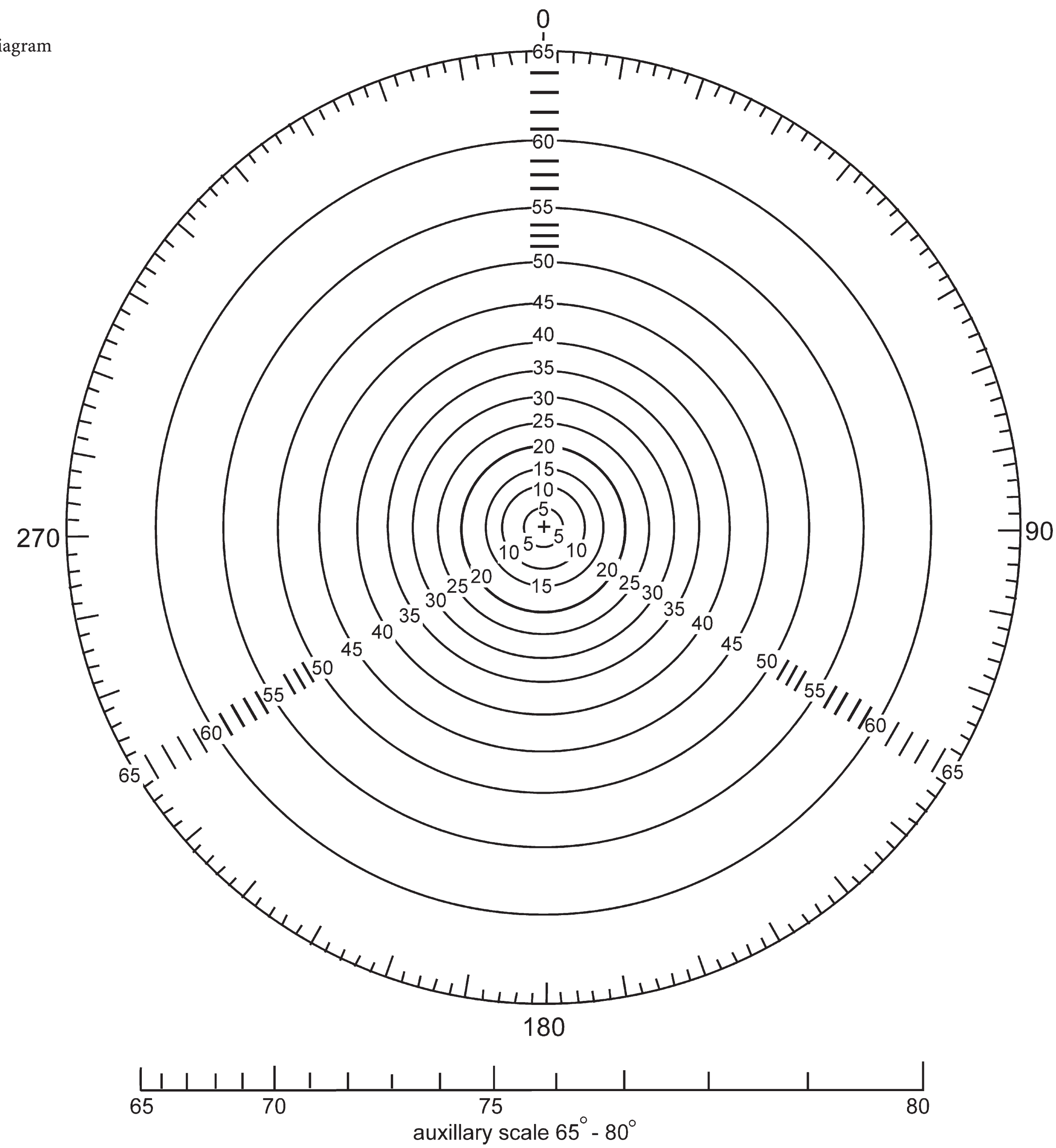
Fig. 2.29. Tangent diagram

The bedding attitudes below (Table 5.2) come from the Greasy Cove anticline, a compressional structure in the southern Appalachian fold-thrust belt. What is the π axis of the fold? Use a tangent diagram to find the axis and the style of the fold.

Table 5.2.
Bedding attitudes, Greasy Cove anticline, northeastern Alabama

Dip	Azimuth	Dip	Azimuth	Dip	Azimuth
46	316	55	316	60	310
55	311	40	295	14	124
12	319	26	281	60	304
20	248	25	275	10	270
10	266	14	294	16	307
12	243	15	173	12	150
24	154	22	154	28	231
20	129	30	128	30	119
35	143	25	114	32	131
25	120	70	151	26	165
20	345	12	255	11	258
15	160	12	190		

Fig. 2.29.
Tangent diagram



Use the map of a selected structure (for example, Fig. 3.3 or 3.29) to answer the following questions. Measure and list all the bedding attitudes on the map. Plot the attitudes on a stereogram and a tangent diagram. What fold geometry is present? Which diagram gives the clearest result? Explain. Define the locations of the crest and trough traces from the map. Are the directions the same as given by the attitude diagrams? Find the attitudes of the axial planes, and locate the axial-plane traces on the map. What method did you use and why? What are the problems, if any, with the interpretation? Do the axial-surface traces coincide with the crest and trough traces? What are the orientations of the axial-surface intersection lines? Show where these intersection lines pierce the outcrop.

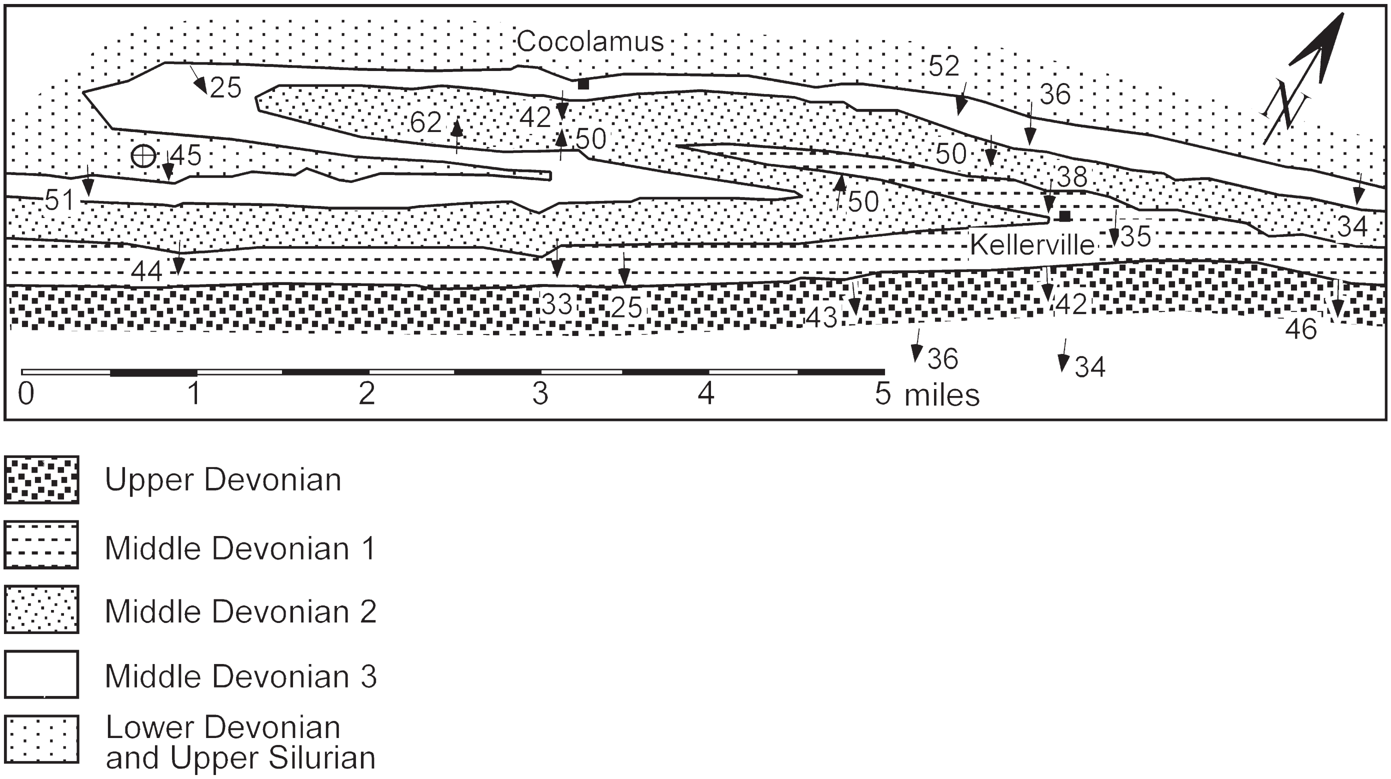


Fig. 3.3. Map of dip-domain style folds in the Appalachian fold-thrust belt in Pennsylvania. (After Faill 1969)

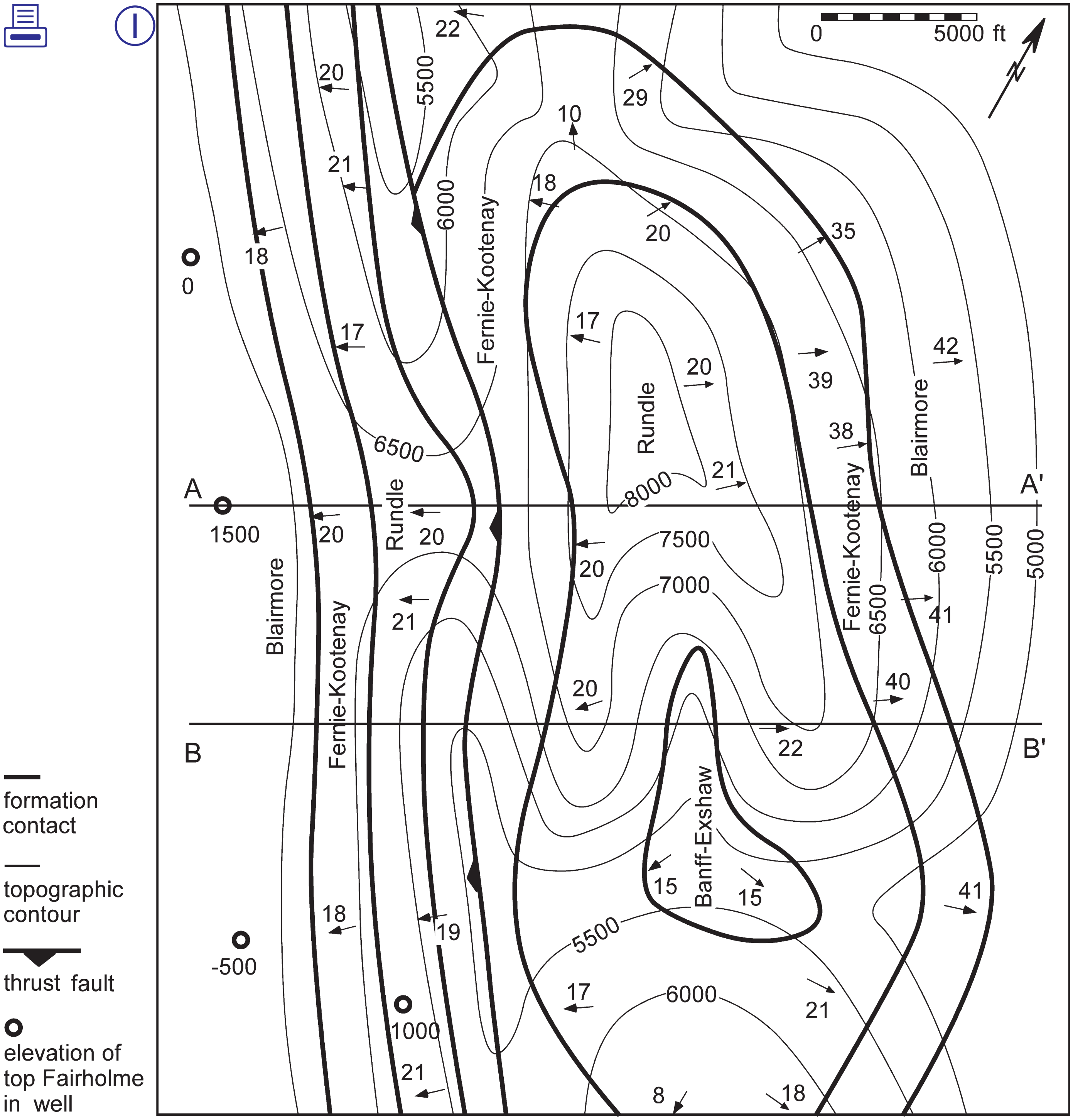


Fig. 3.29. Geologic map from the Canadian Rocky Mountains. All dimensions are in feet. The stratigraphic column (with thickness) from top to base is: Blairmore (2400), Fernie-Kootenay (700), Rundle (900), Banff-Exshaw (900), Palliser (800), Fairholme (1200). (After Badgley 1959)

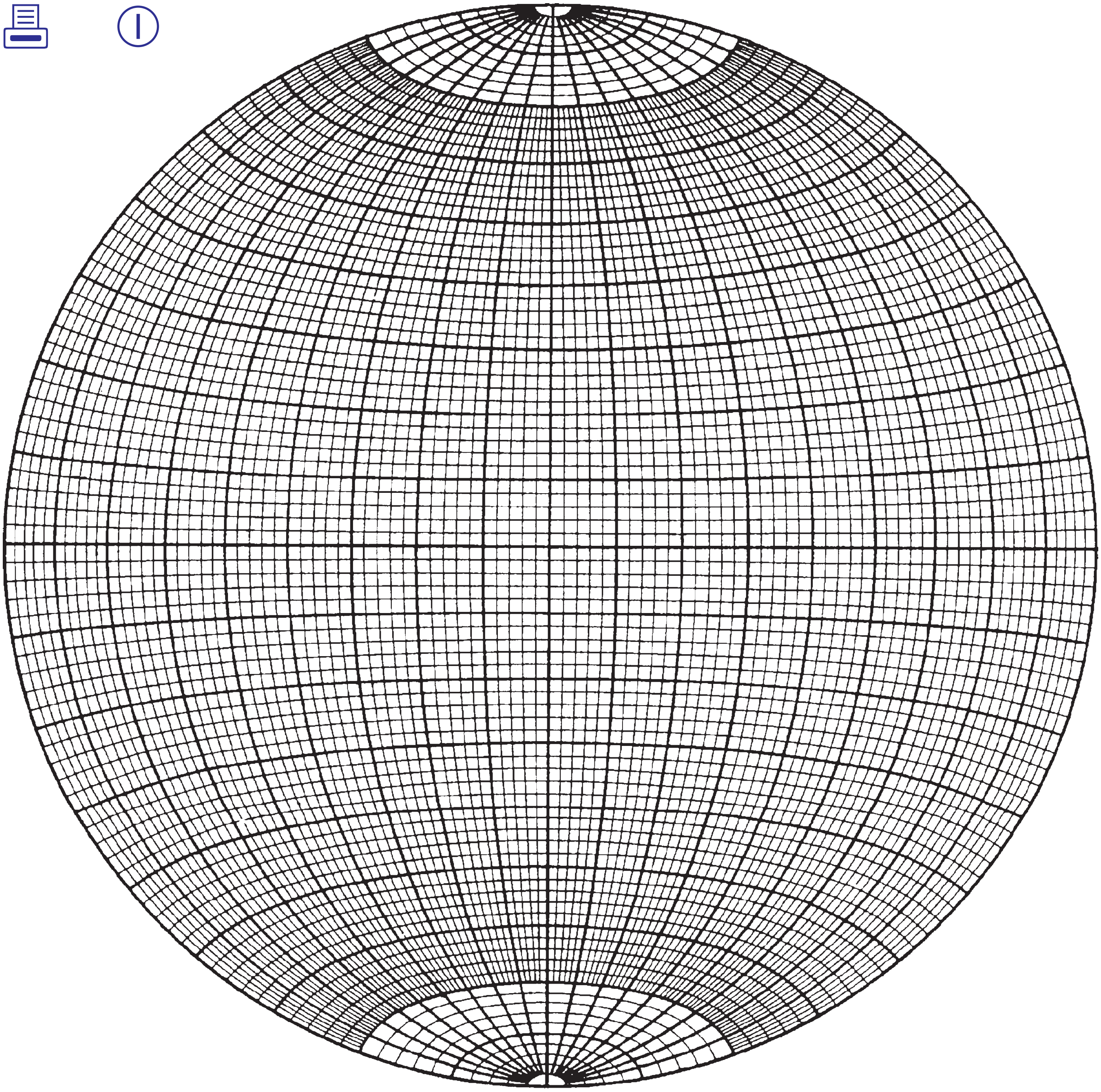


Fig. 2.28. Equal-area stereogram

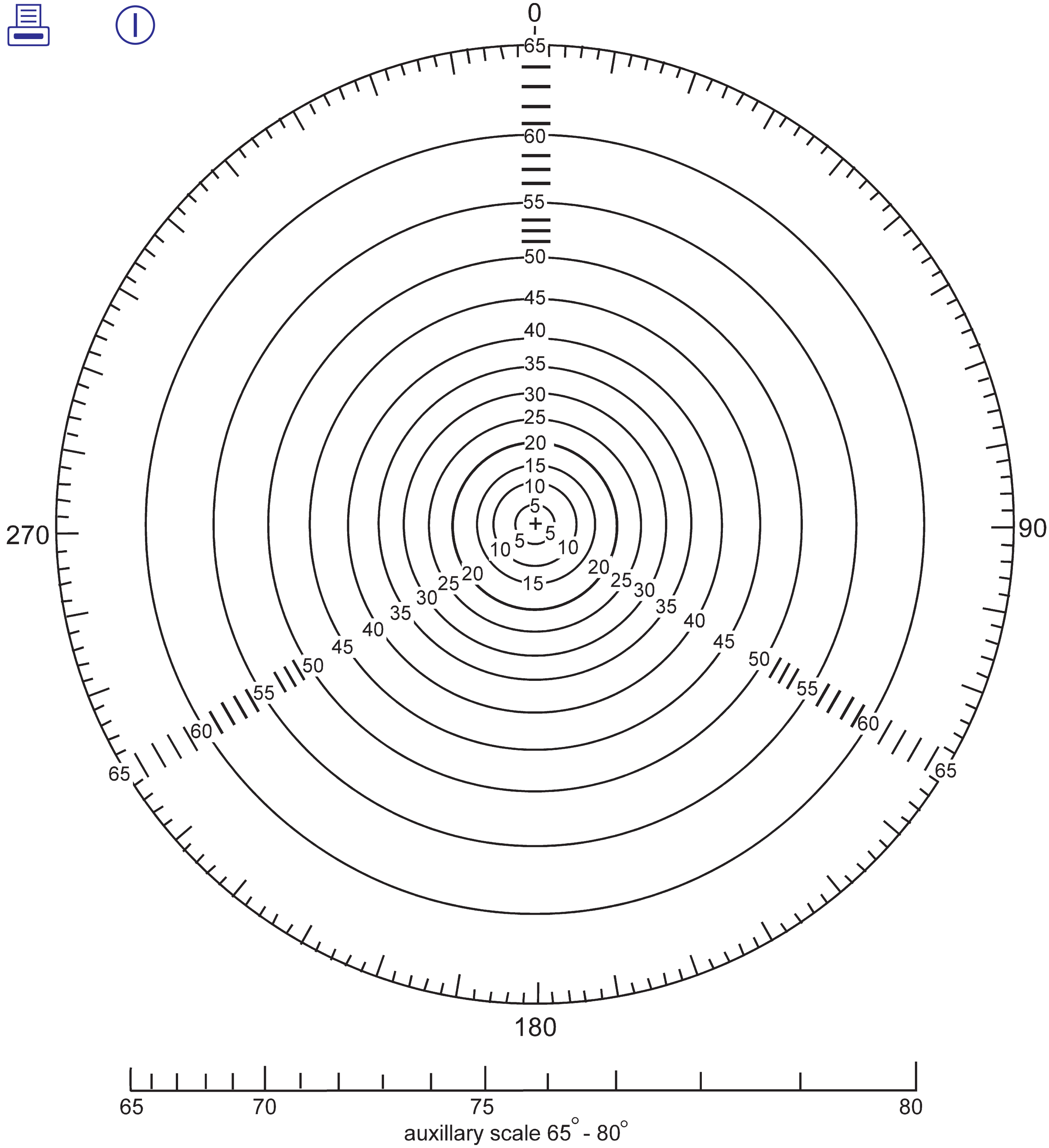


Fig. 2.29. Tangent diagram

Draw the cross section in Fig. 6.52 vertically exaggerated by a factor of 5 : 1. Draw the cross section in Fig. 6.52 horizontally squeezed by a factor of 1 : 2.

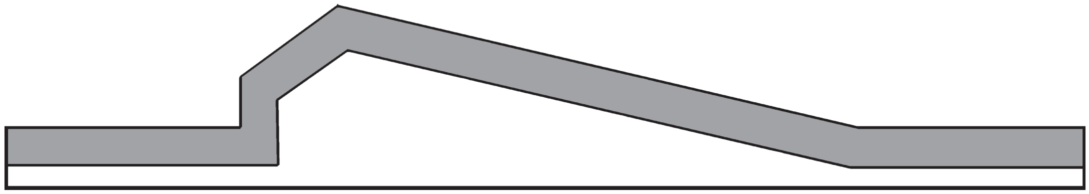


Fig. 6.52.
Cross section of a fold having constant bed thickness in shaded unit

Draw an east-west cross section across the northern part of the structure contour map in Fig. 6.53. Suppose a fault that dips 40° south cuts the structure in the blank area between the arrows. What would its trace be on the structure contour map? Is the fault normal or reverse? Draw a north-south cross section showing the fault.

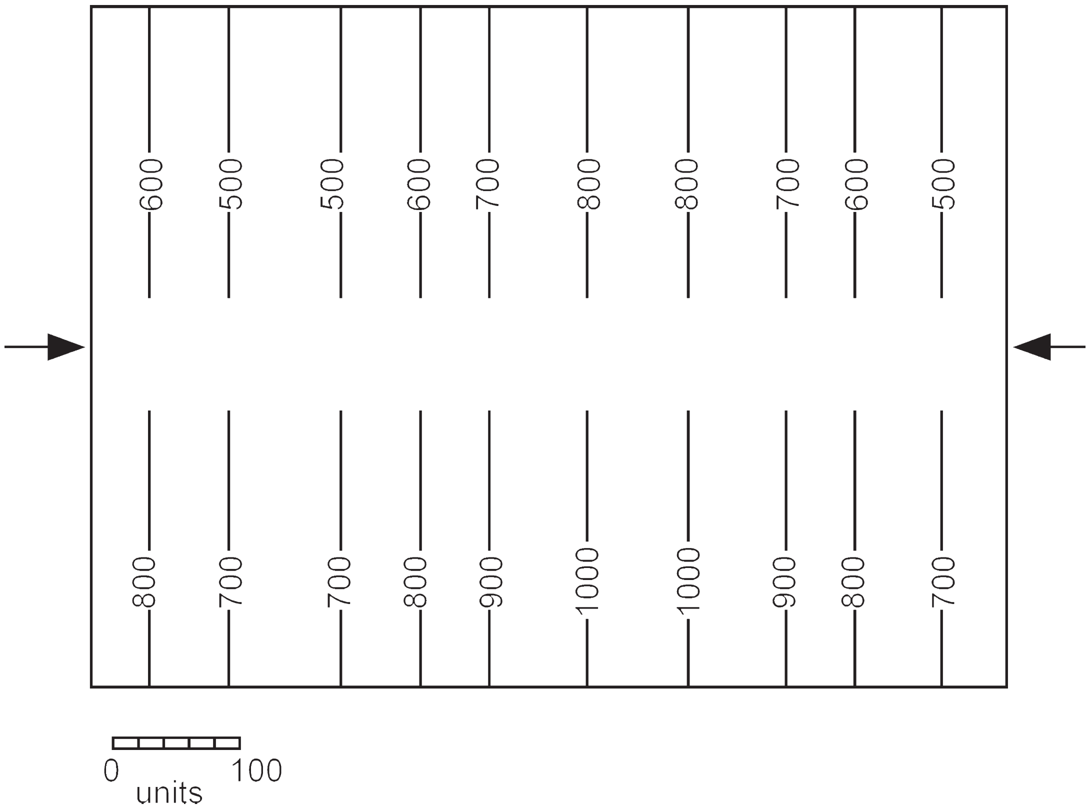


Fig. 6.53.
Unfinished structure contour map. *Arrows* indicate the general position of the fault trace

Draw a cross section perpendicular to the major structural trend in Fig. 6.54. Discuss any assumptions required. What are the dips of the faults? Are the faults normal or reverse?

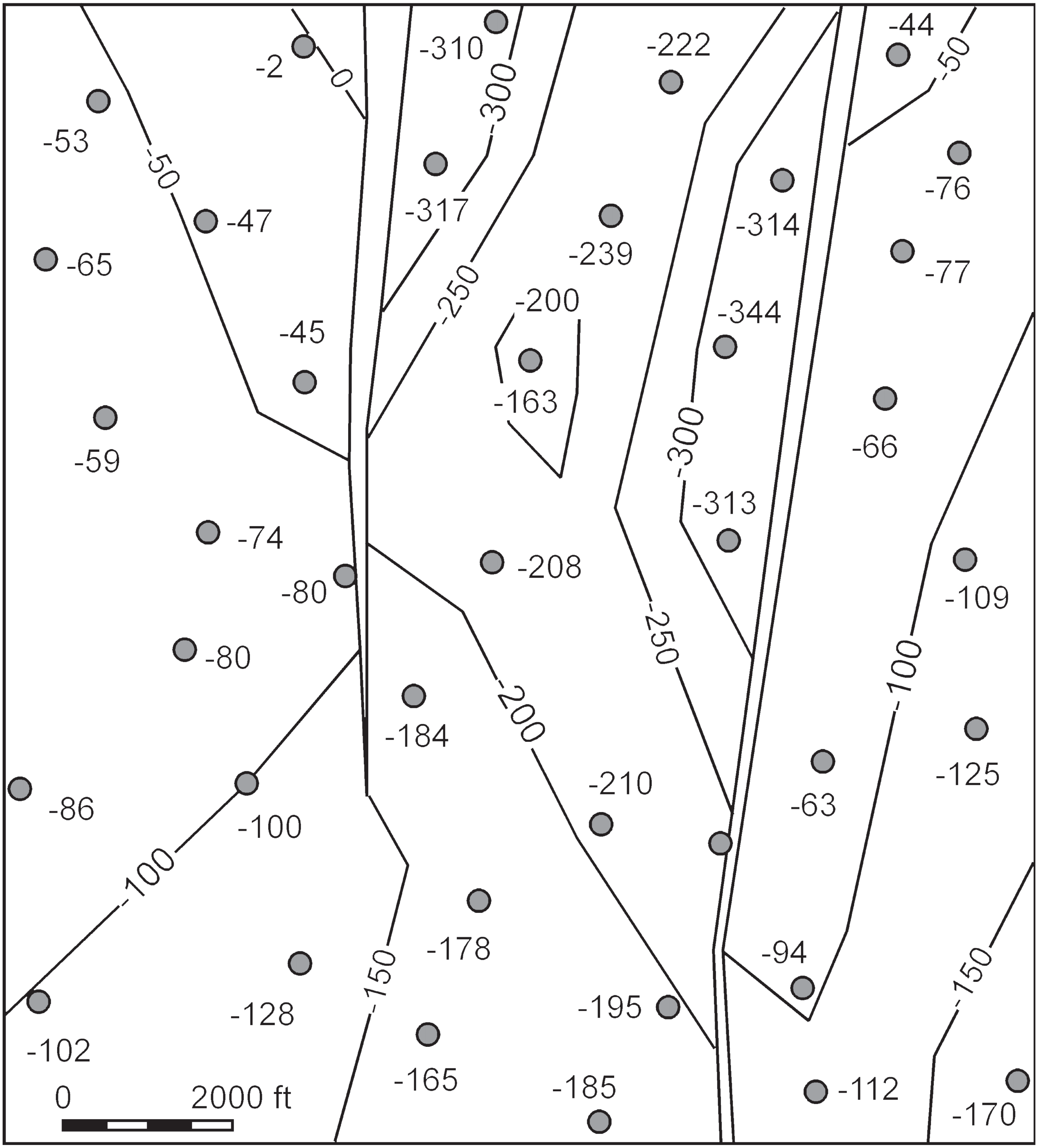


Fig. 6.54. Structure contour map of the top of the Gwin coal cycle. Elevations of the top Gwin are posted next to the wells. Units are in feet, negative below sea level

Draw cross sections along the three lines indicated on Fig. 6.55. Using the fault dip determined from the map, extend the faults above and below the marker horizon until they intersect. Which fault(s) formed last?

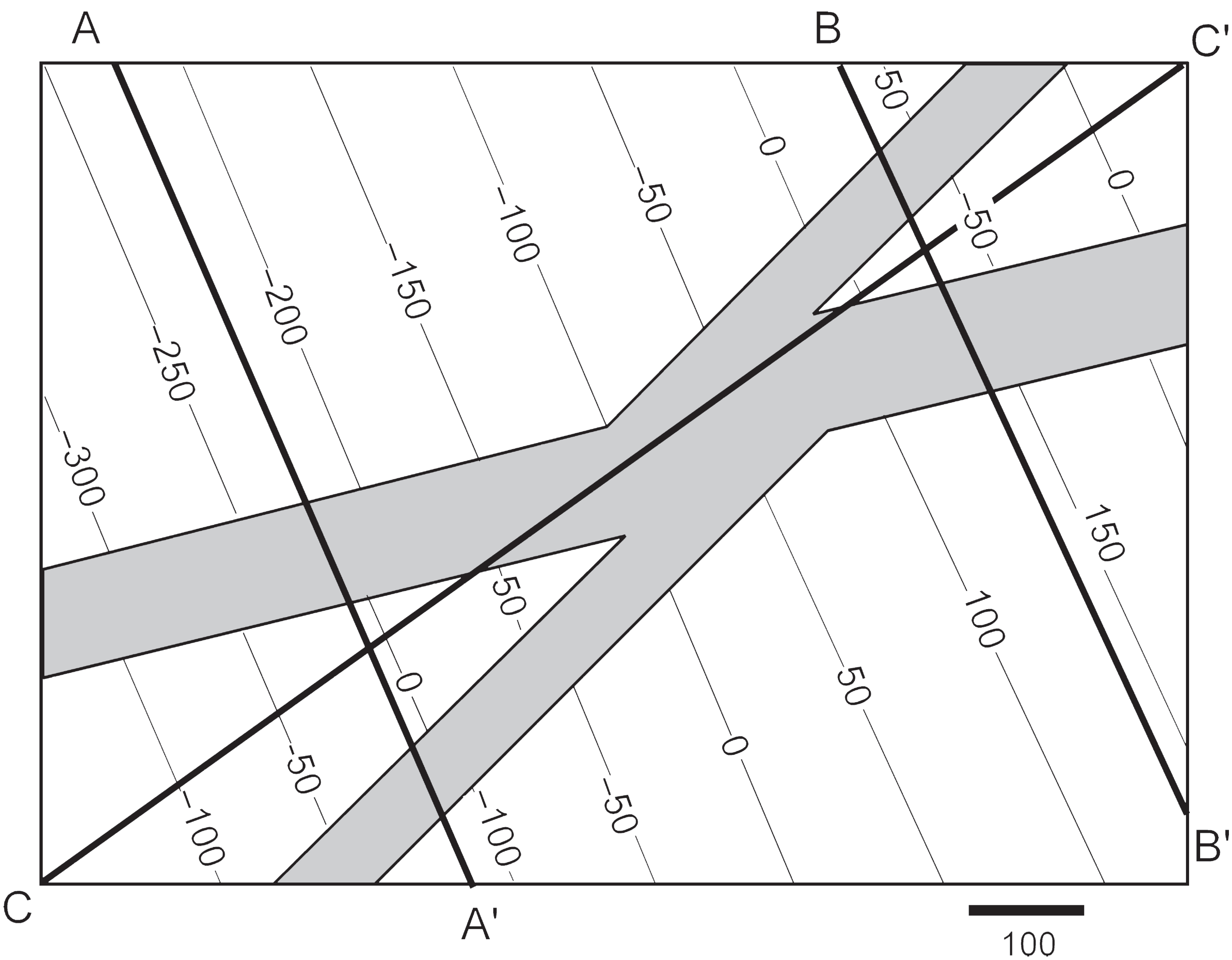


Fig. 6.55. Structure contour map of a normal-faulted surface. The horizon surface is missing in the *shaded* fault zones. Locations of lines of section *A–A'*, *B–B'*, and *C–C'* are shown

Draw cross sections along the three lines indicated in Fig. 6.56. Determine the dips of the faults from the map and then extend the faults above and below the marker horizon until they intersect. Which fault is youngest?

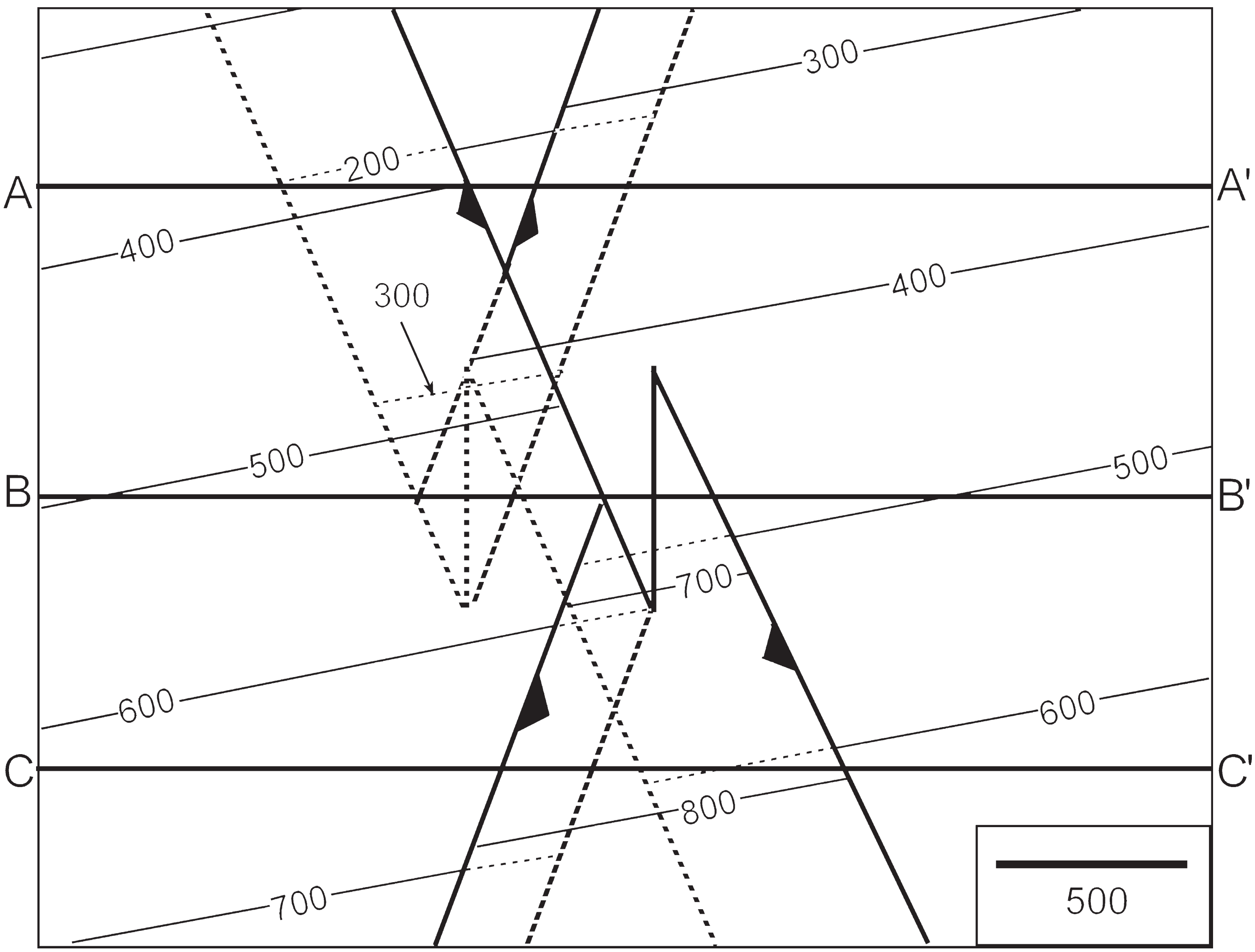


Fig. 6.56. Structure contour map of a reverse-faulted surface. The horizon surface is repeated by the fault zones. The fault cutoffs are *wider lines*. Hidden contours are *dashed*. The locations of lines of section *A–A'*, *B–B'*, and *C–C'* are shown

Complete the cross section in Fig. 6.57 by extending it into the air and deeper into the subsurface. How far can the section be realistically extended?

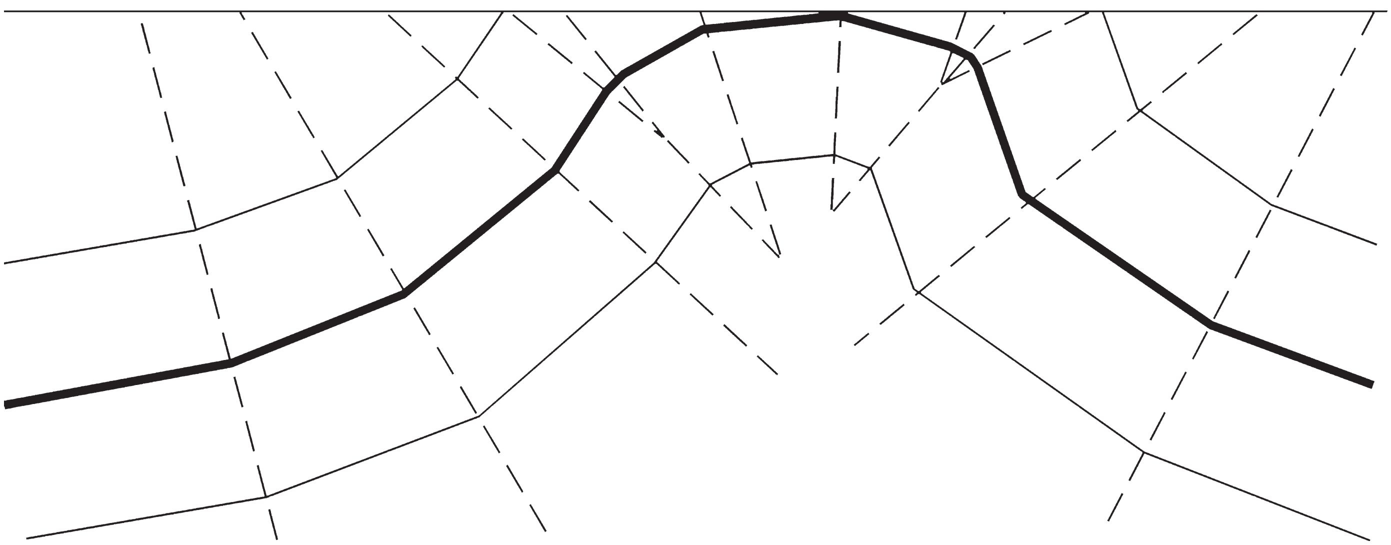


Fig. 6.57. Partially complete dip-domain cross section. *Dashed lines* are axial-surface traces

Complete the cross section in Fig. 6.58, keeping bed thicknesses constant. Use both the dip-domain technique and the method of circular arcs. Scan the section into a computer and complete using the smooth curves provided by a drafting program. Compare the results of the different techniques.

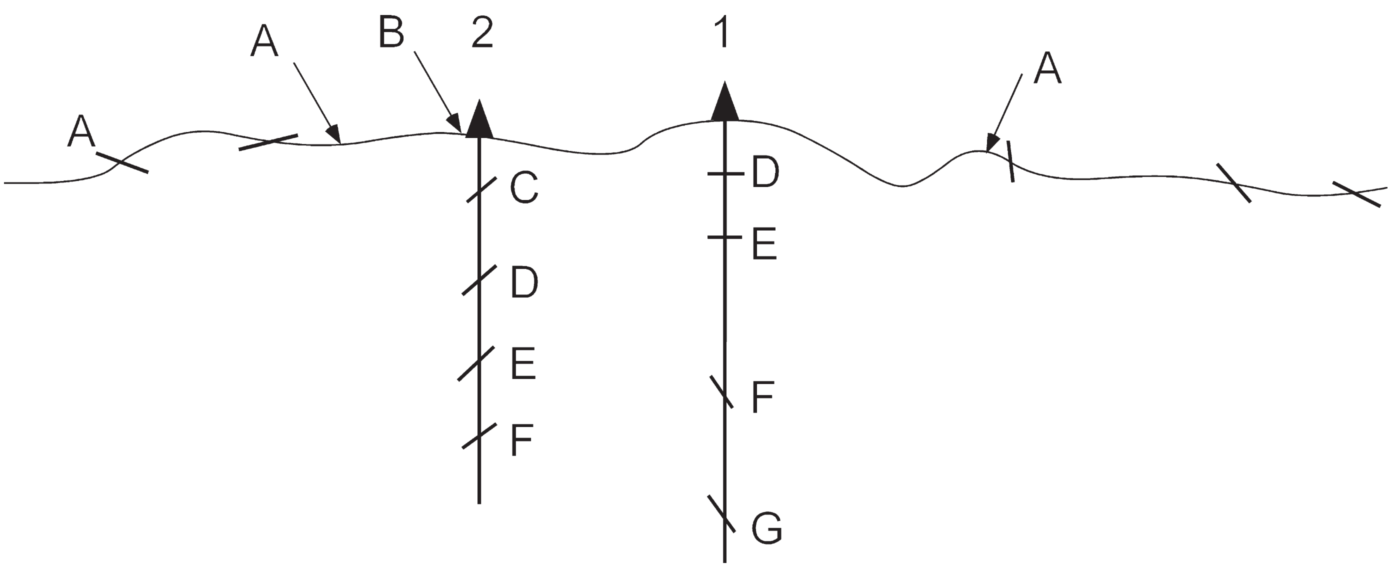


Fig. 6.58. Cross section through the Burma No. 1 and 2 wells. *Short lines* are surface dips. Letters *A–G* are marker horizons seen at the locations of dip measurements that can be correlated. *Arrows* point to locations where markers can be identified in outcrop but the dip cannot be measured. The dips in the wells are from oriented cores

Construct illustrative cross section A–A' from the map in Fig. 3.29 using the structure contour map constructed in Exercise 3.7.4. Use the dip-domain technique to construct the same cross section using only the surface geology along the profile. Use the circular arc technique to construct the same cross section using only the surface geology along the profile. What is the plunge of the central portion of the structure from a stereogram or tangent diagram? Project the northern part of the structure onto section B–B' using the method of along-plunge projection. Compare and contrast the cross sections. The wells to the Fairholme were drilled to find a hydrocarbon trap but were not successful. Use the map and cross sections to determine a structural reason for drilling the wells and a structural reason that they were unsuccessful.

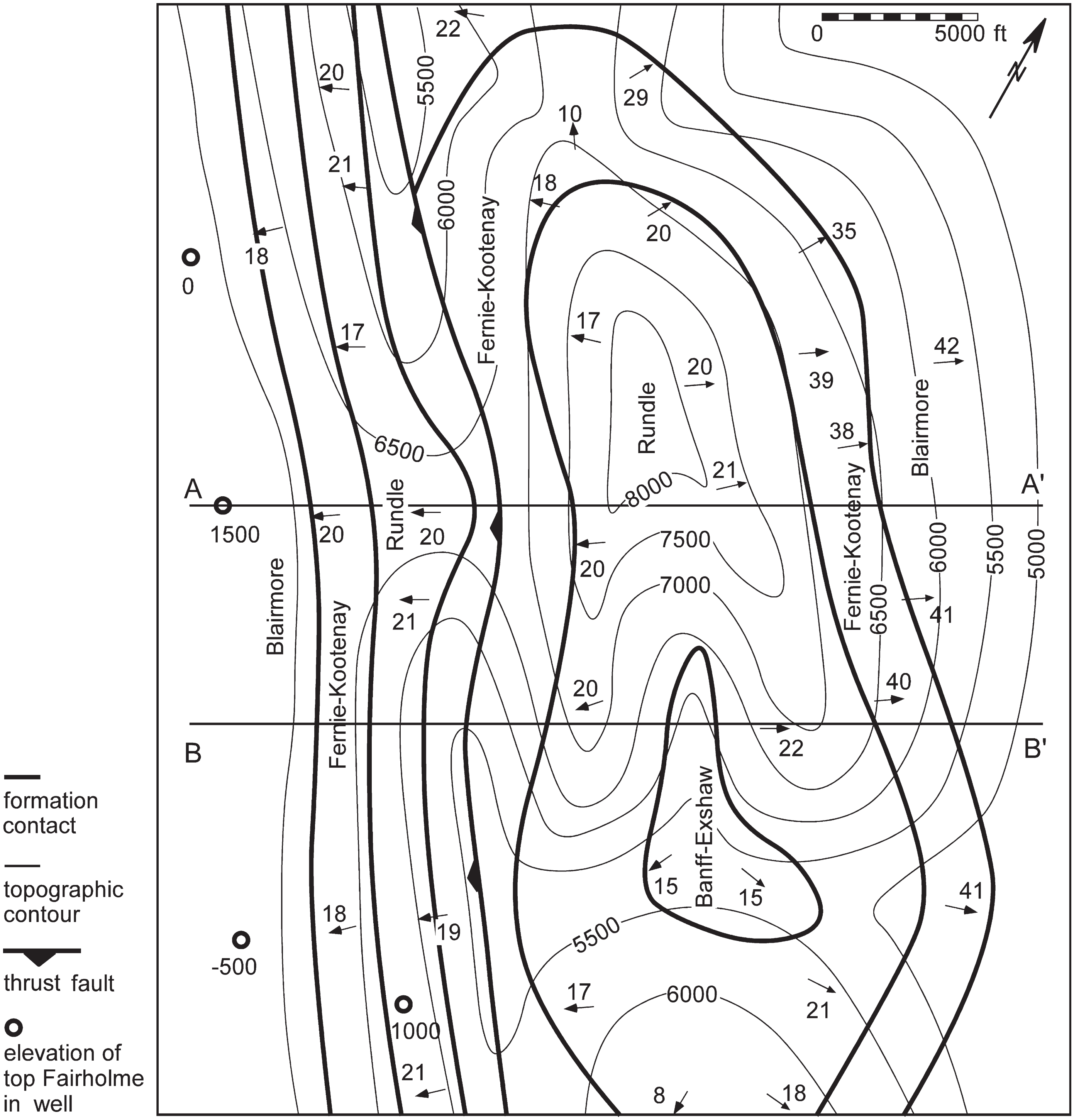


Fig. 3.29. Geologic map from the Canadian Rocky Mountains. All dimensions are in feet. The stratigraphic column (with thickness) from top to base is: Blairmore (2 400), Fernie-Kootenay (700), Rundle (900), Banff-Exshaw (900), Palliser (800), Fairholme (1 200). (After Badgley 1959)

Project the top reservoir onto the seismic line assuming the structure is normal to the seismic line (Fig. 6.59). Project the top reservoir onto the seismic line assuming the structure plunges 10° in the direction 225°.

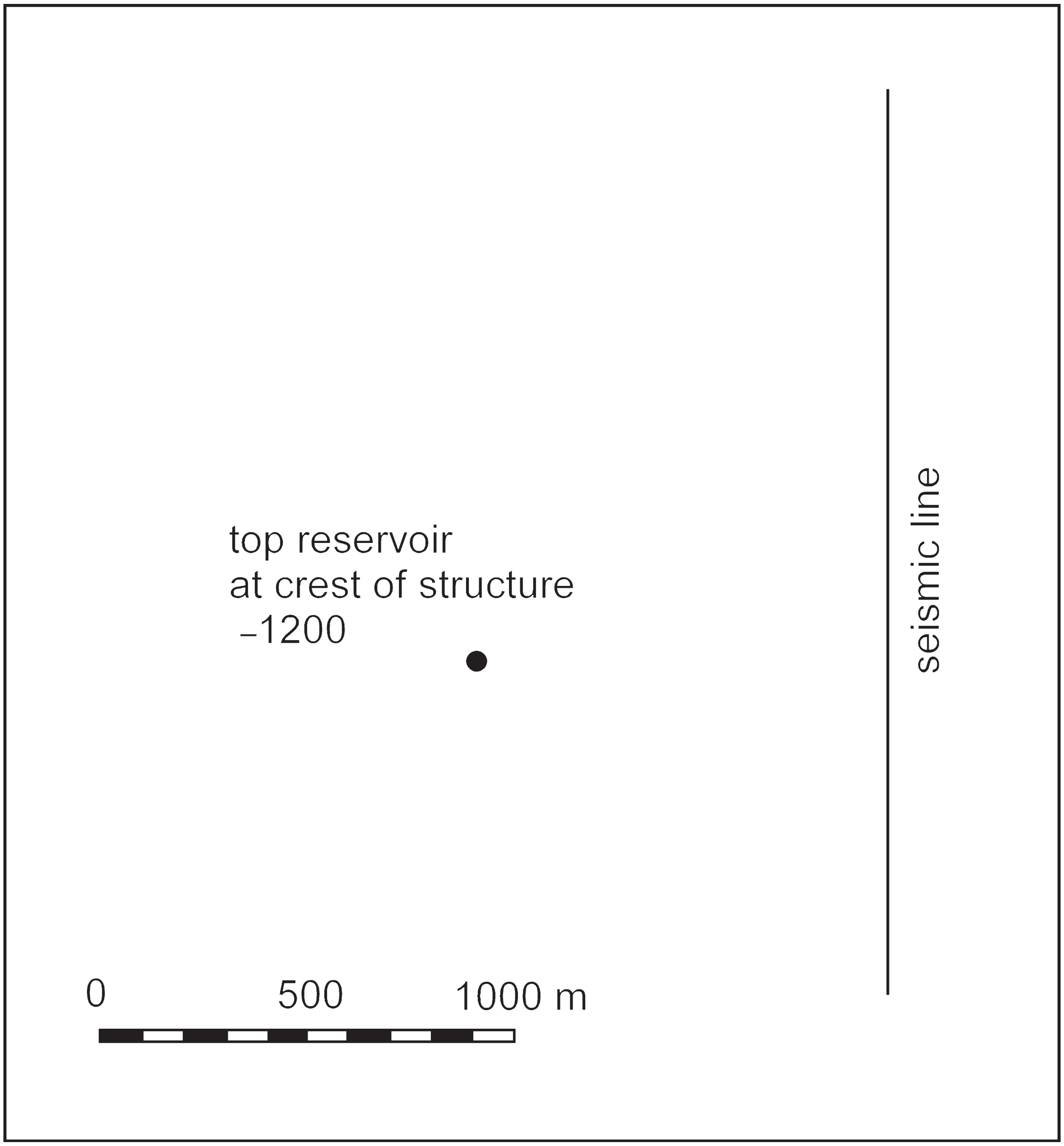


Fig. 6.59.
Map showing trace of a seismic line and the location of a well

Use the partially complete geologic map of Fig. 7.36, to do the following: Mark all the faults. Explain the reason for each fault. Indicate the sense of displacement on each fault.

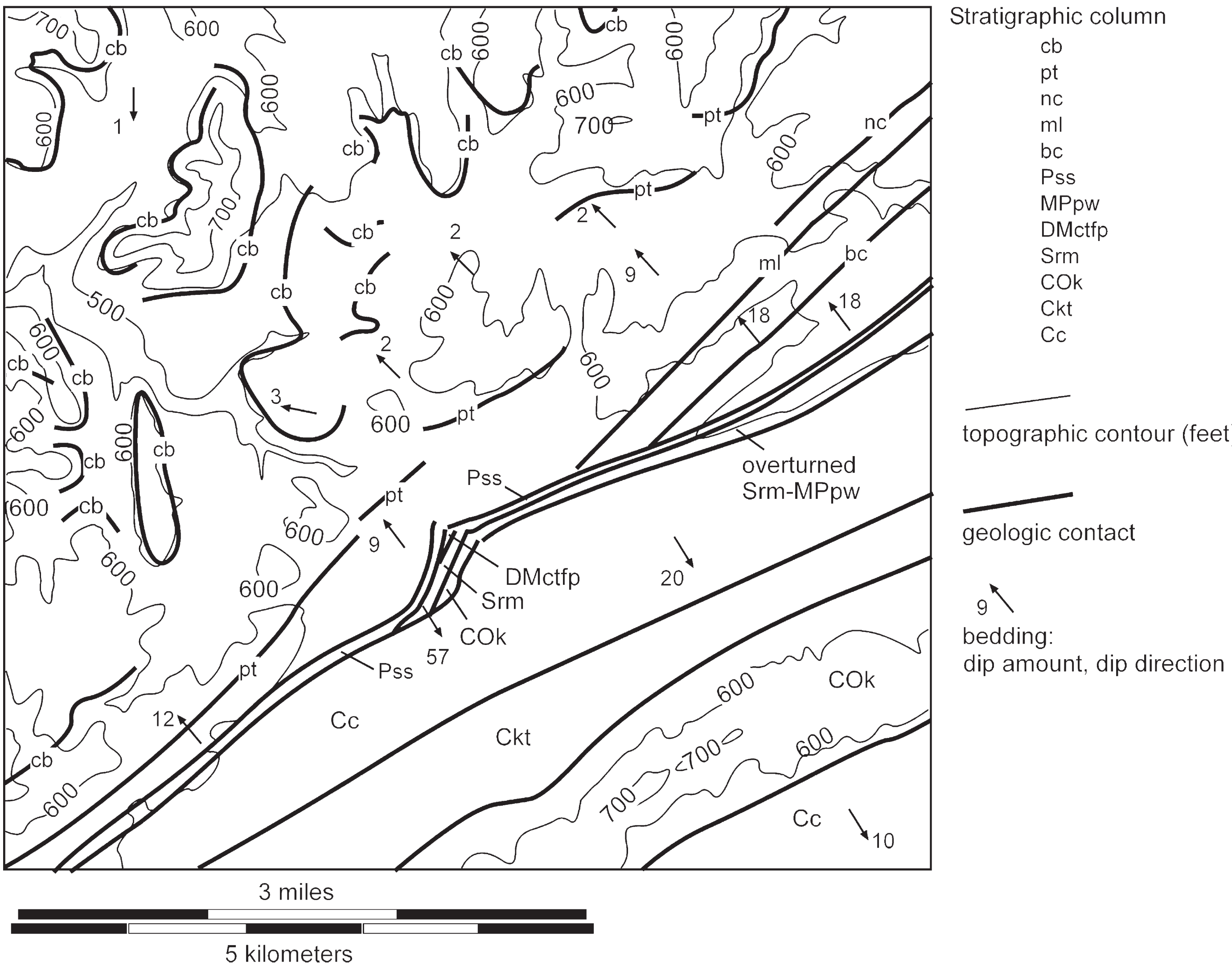


Fig. 7.36. Geologic map of the Ensley area, Alabama, with fault contacts not marked. (After Butts 1910; Kidd 1979)

Interpret the faults in Fig. 7.37.

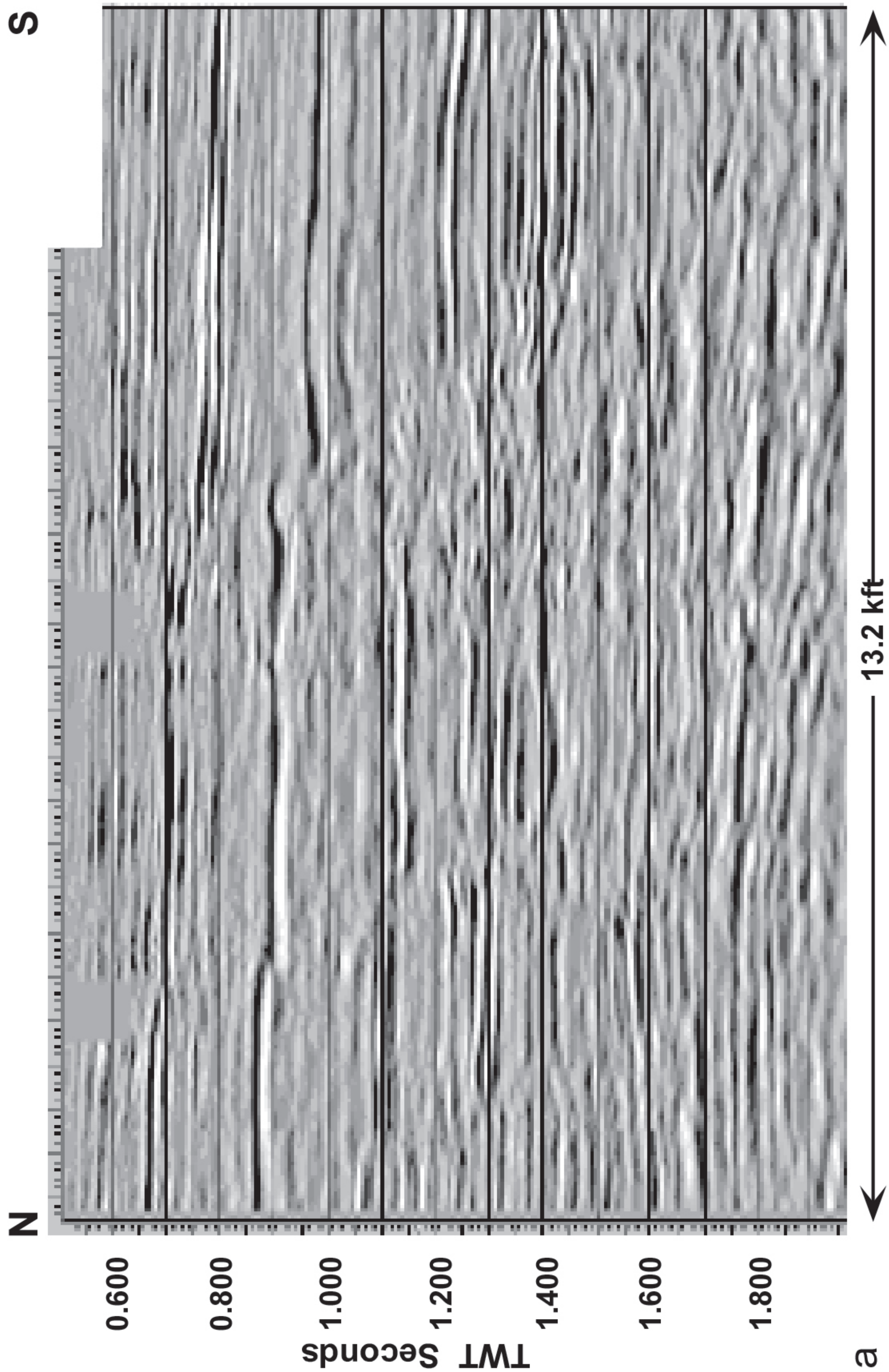
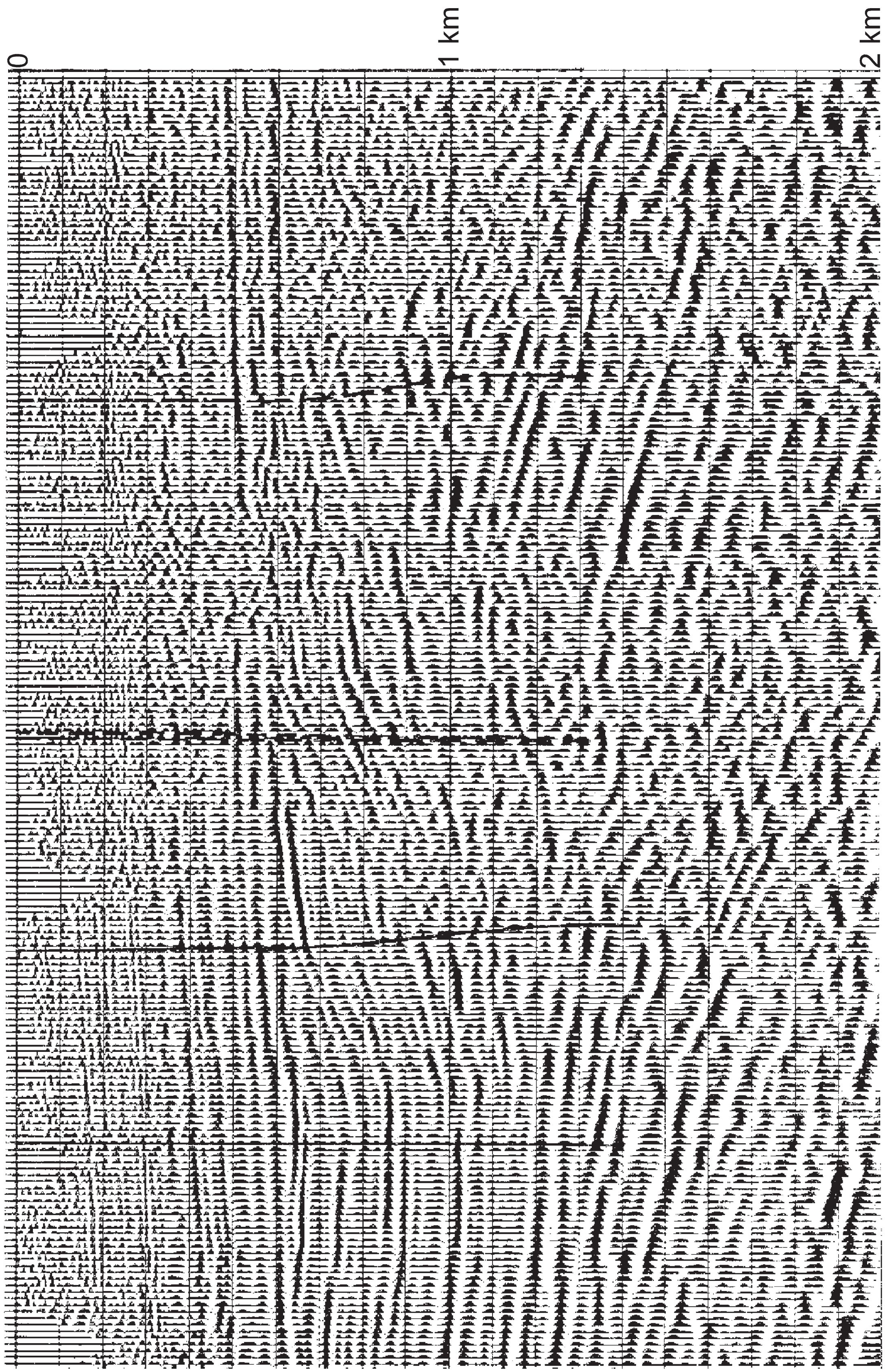


Fig. 7.37. Seismic line across part of Gilbertown graben system, Alabama (modified from Groshong et al. 2003a). V.E. approximately 1 : 1

Interpret the faults and unconformity in Fig. 7.38.

Fig. 7.38.
Seismic reflection profile from the Ruhr district, Germany. (Drozdzewski 1983)



Locate the position of the faults and the amounts of the fault cuts on the logs from the northern Gulf of Mexico (Fig. 7.40) based on the type log in Fig. 7.39. Example courtesy of Jack Pashin (Pashin et al. 2000).

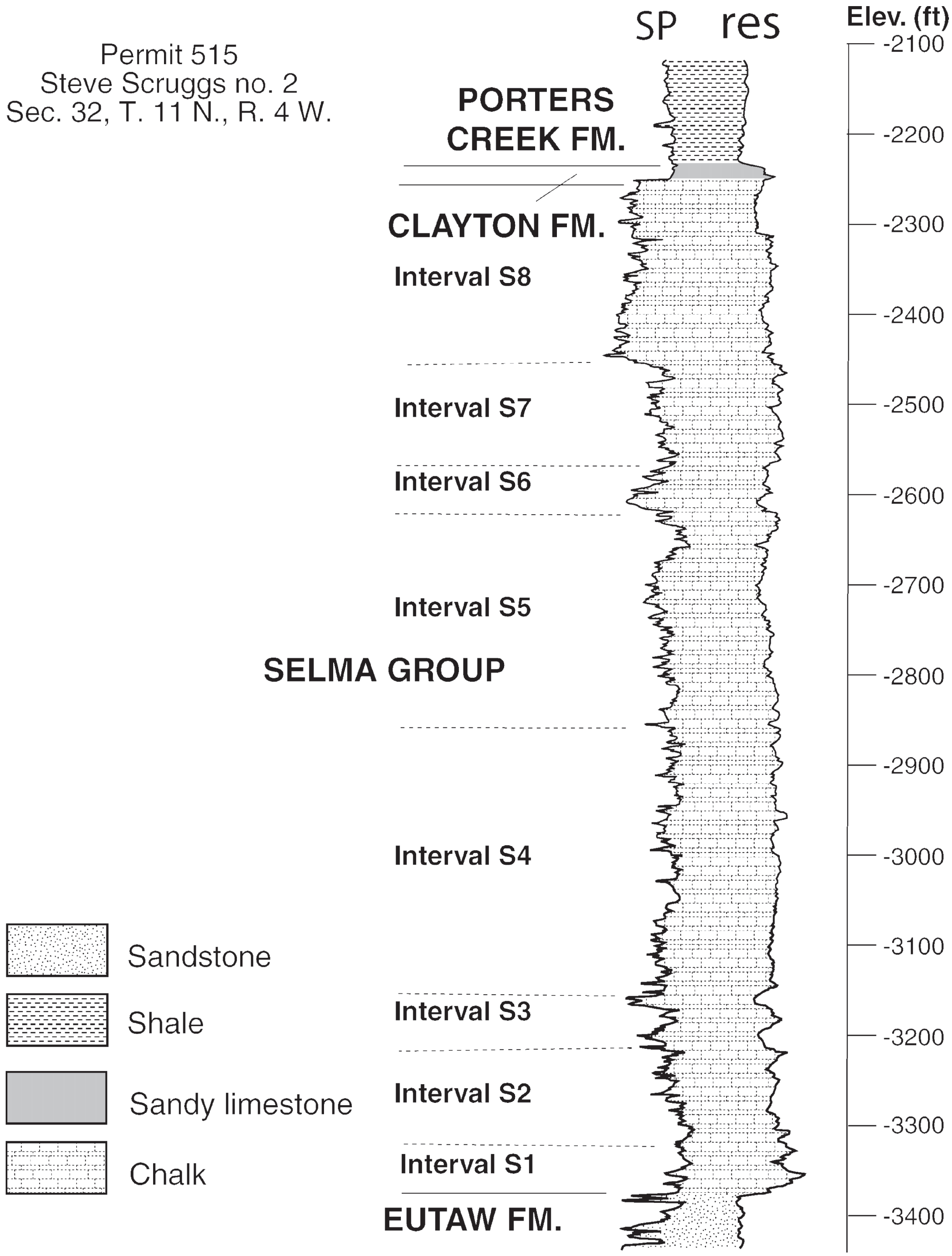


Fig. 7.39. Unfaulted type log of Selma Chalk, Gilbertown oil field

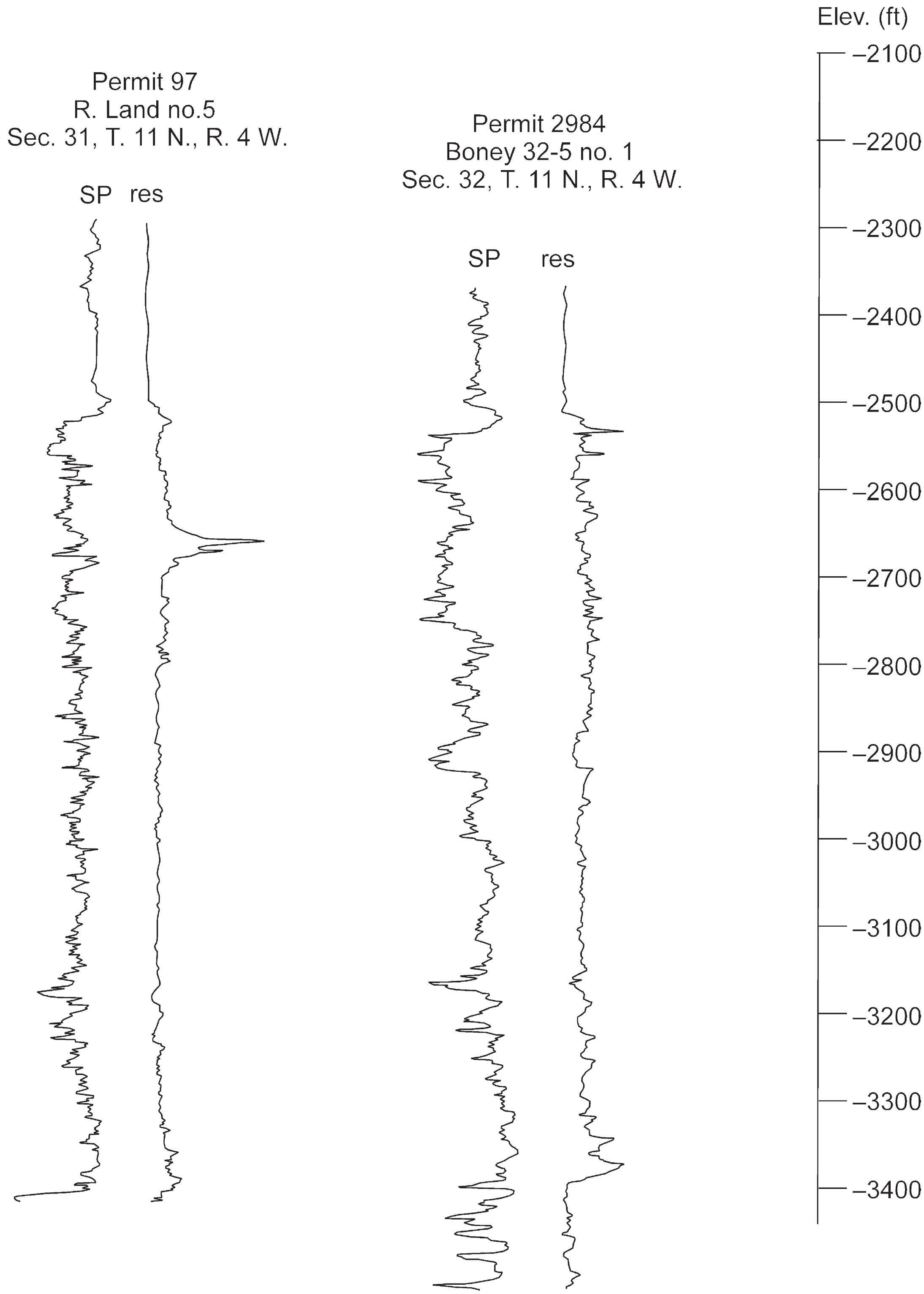


Fig. 7.40. Logs of two faulted wells in Selma Chalk, Gilbertown oil field

Contour a fault (Fig. 7.41) that includes all four wells that cut faults. Is the fault surface obtained reasonable? What is the attitude of the fault plane given by the three points 1, 4, 2? What is the attitude of the fault plane given by the three points 2, 3, 4? What is the attitude of a fault plane through wells 1, 2, and 3? Is this a possible fault plane? Why or why not?

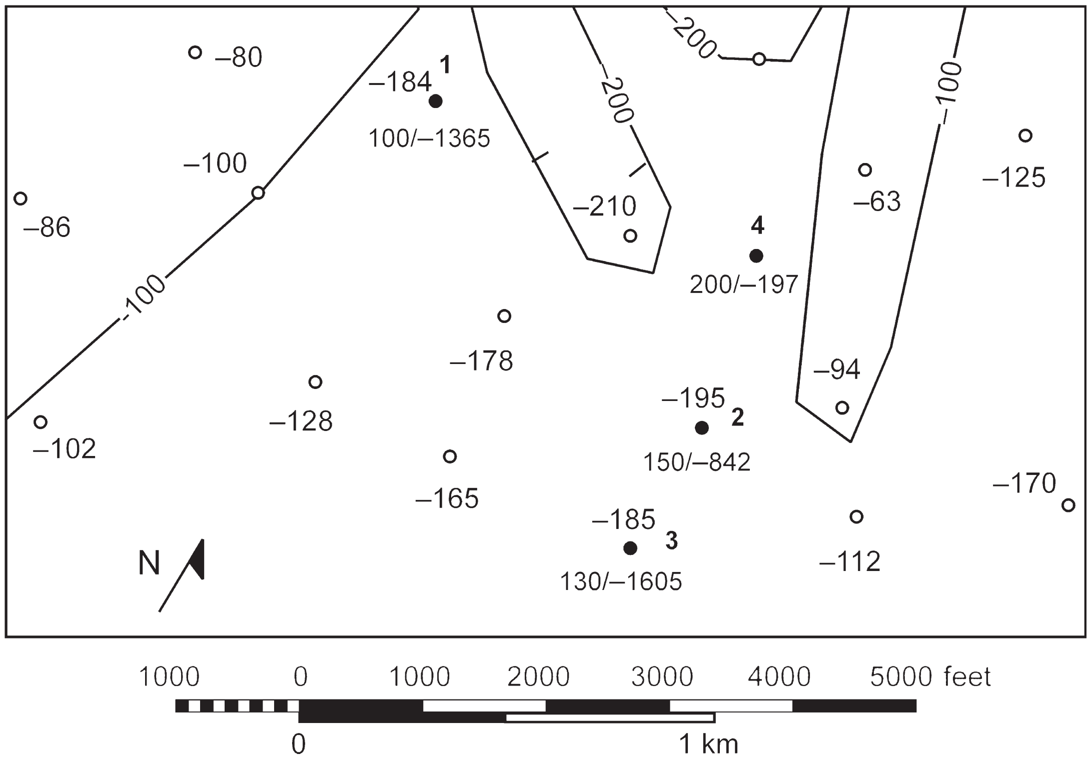


Fig. 7.41. Map of the southern portion of the Deerlick Creek coalbed methane field. *Open circles* are wells with the elevation of the top of the Gwin coal cycle (ft). *Solid circles* are wells with fault cuts; single number is top of Gwin if present, number pair is stratigraphic separation/elevation of fault cut. Structure contours shown on the top of the Gwin are tentative. Elevations below sea level are negative

Use Table 7.1 to answer the following questions. A fault in the Black Warrior basin of Alabama has a maximum displacement of 100 m. How long is it? What is the length range if the fault is a thrust in the Canadian Rocky Mountains? A fault in the Black Warrior basin is 5 kft long. What is its probable maximum displacement? What is the displacement range if the fault is a normal fault in the western United States?

Table 7.1. Ratio of maximum displacement to length for a variety of faults that die out in tip lines in the direction of the measurement. The first two measurements from Rippon (1985) are from Fig. 7.24a, the third is from Fig. 7.24b

Max. displ./ length	Direction measured	Size range	Fault type	Location	Reference
1/10 to 1/20	Dip	40 – 450 cm	Normal	Japan	Muraoka and Kamata (1983)
1/10 to 1/20	Strike	10 – 400 km	Thrust	Canadian Rocky Mts.	Elliott (1976)
1/8	Strike	1.5 – 21 km	Strike slip	Iran	Freund (1970)
1/82	Strike	2.5 km	Normal	Alabama	Chap. 7, Fig. 7.46
1/700	Strike	2 km	Normal	Derbyshire, UK	Rippon (1985)
1/450	Dip	1 km	Normal	Derbyshire, UK	Rippon (1985)
1/340	Strike	1.5 km	Normal	Derbyshire, UK	Rippon (1985)
1/90	Strike	10 – 200 m	Normal	Western USA	Dawers et al. (1993)
1/125	Strike	0.2 – 10 km	Normal	Western USA	Dawers et al. (1993)
1/30 to 1/50	Strike	0.2 – 10 km	Normal	Timor Sea	Nicol et al. (1996)
1/33	Strike	1 – 123 cm	Normal	Eastern USA	Schlische et al. (1996)

Find the heave, throw, and vertical separation for the faults listed in Table 7.2.

Table 7.2. Fault attitude and separation data

Fault attitude	Stratigraphic separation	HW attitude	FW attitude	Fault cut in	ρ	Heave	Throw	Vertical separation
60, 270	100	0	0					
60, 270	100	20, 070	30, 200	HW				
				FW				
30, 200	100	0	0					
30, 200	100	20, 070	30, 070	HW				
				FW				

Determine the expansion indices across both faults in Fig. 7.42. Discuss the growth of the faults and the relationship of growth to the hydrocarbon occurrence.

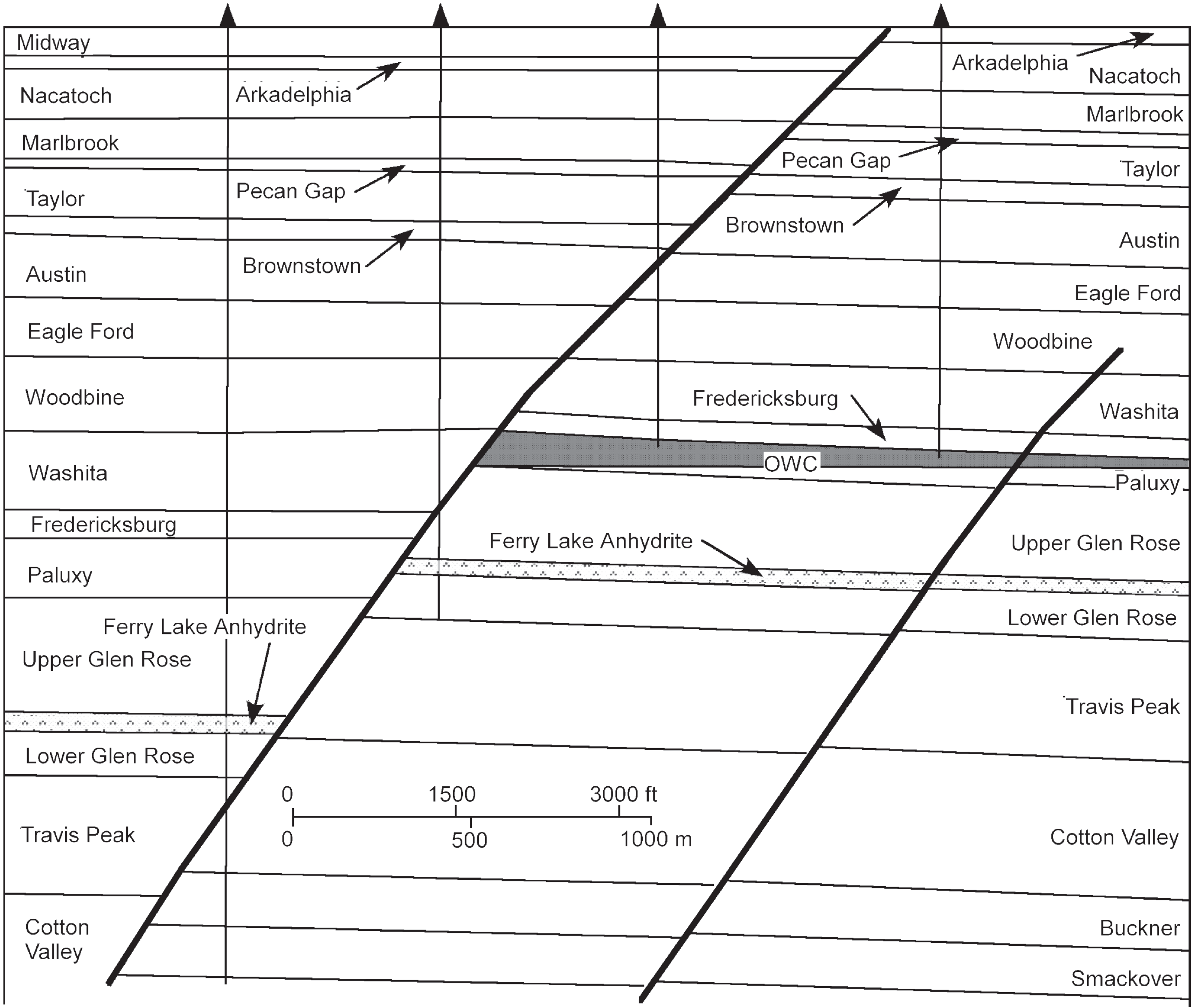


Fig. 7.42. Cross section of the Talco field, northern Gulf of Mexico, Texas. Oil field *shaded; OWC:* oil-water contact. (After Galloway et al. 1983)

Find the heave and throw on the fault at the point shown on the map in Fig. 8.49.

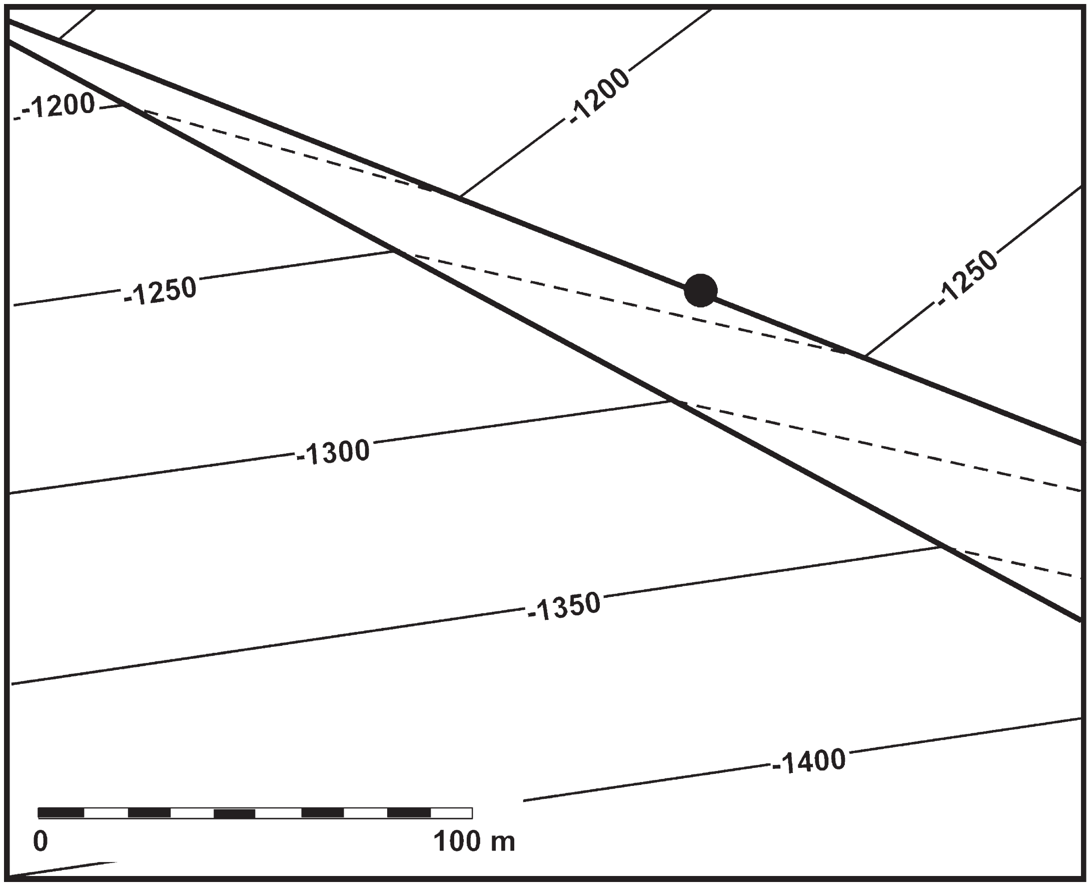


Fig. 8.49. Structure contour map of faulted surface

Construct the hangingwall and footwall cutoff lines on both maps in Fig. 8.50. What is the heave, throw, and gap for a point near the middle of each map?

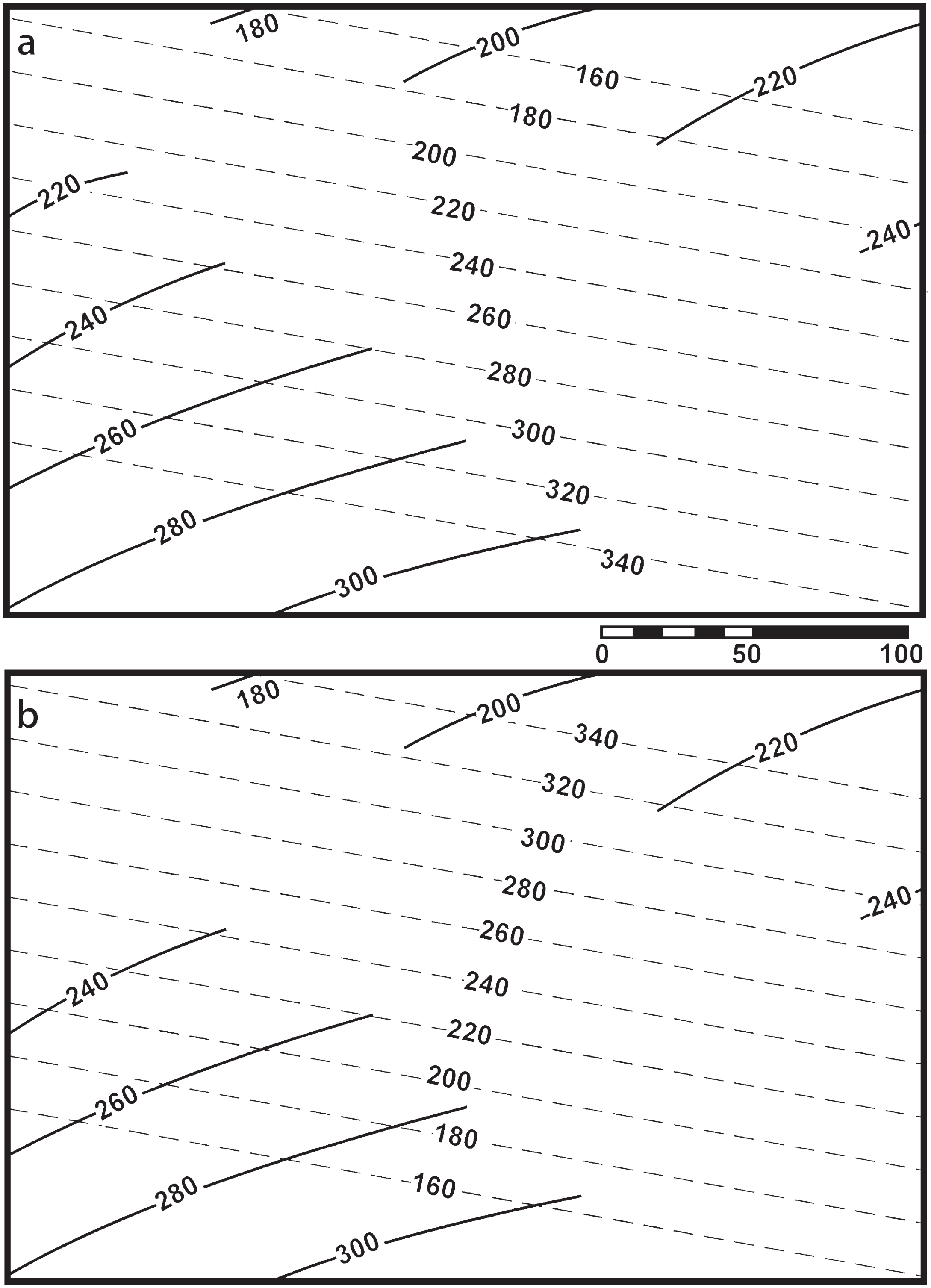


Fig. 8.50. Unfinished structure contour maps of a fault (*dashed lines*) and a marker surface on both sides (*solid lines*). **a** Fault dips north. **b** Fault dips south

Construct the missing fault trace and missing marker horizon on both maps in Fig. 8.51 for a fault throw of 40. Does the marker surface on the map belong to the hangingwall or footwall? Construct one map to show one to be a normal fault and the other to be reverse. What is the heave and gap for a point near the middle of each map?

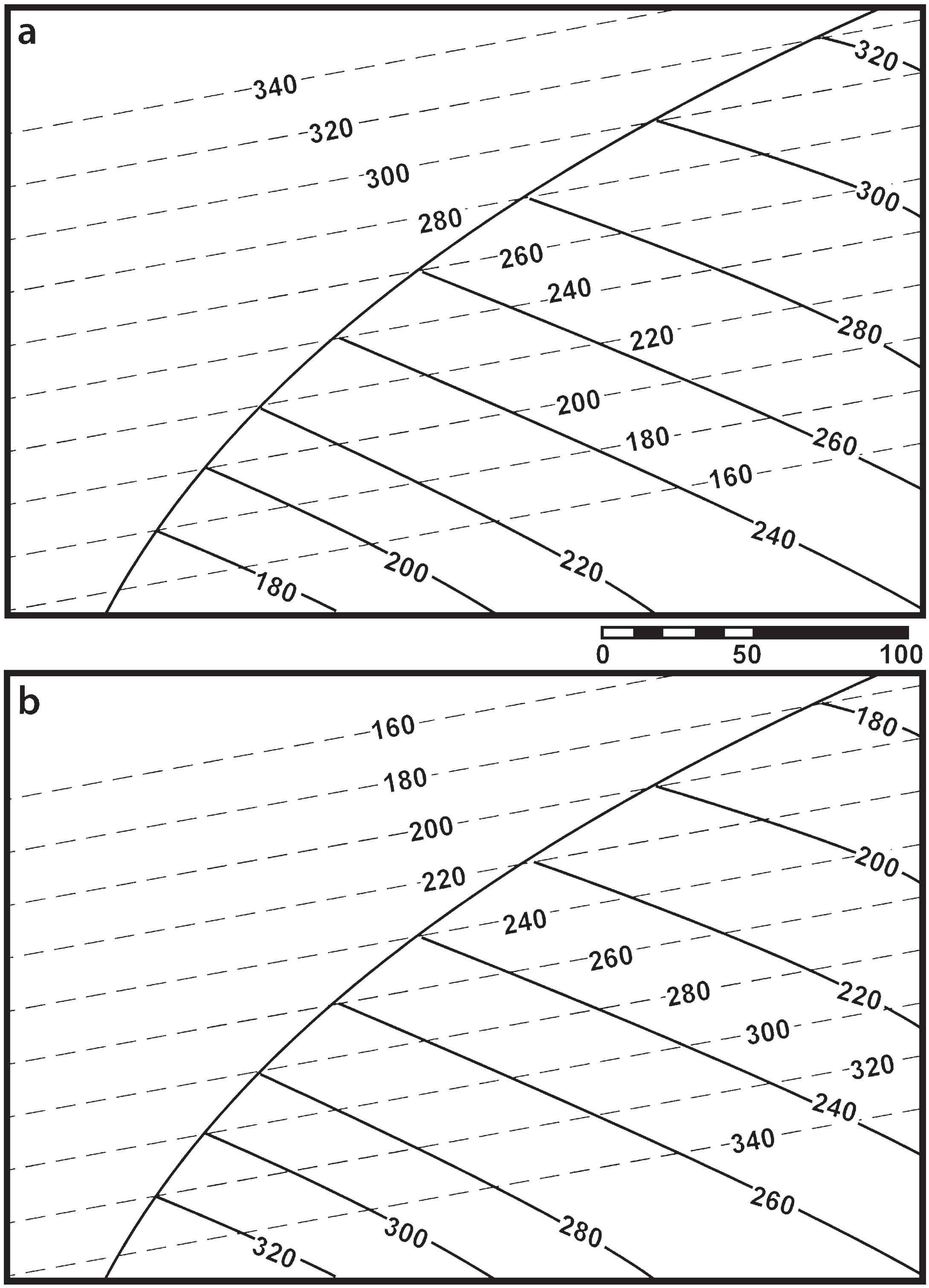


Fig. 8.51. Structure contour maps of a fault (*dashed lines*) and a marker surface on one side (*solid lines*). **a** Fault dips south. **b** Fault dips north

Use the subsurface information in Fig. 8.52 to make a structure contour map of the top of the Hamner Sandstone reservoir. What type of fault or faults are present? Are there any faults in the reservoir? What is the dip of the fault or faults? What is the calculated heave and throw at each fault cut? Do the fault map and fault separation data agree with the map?

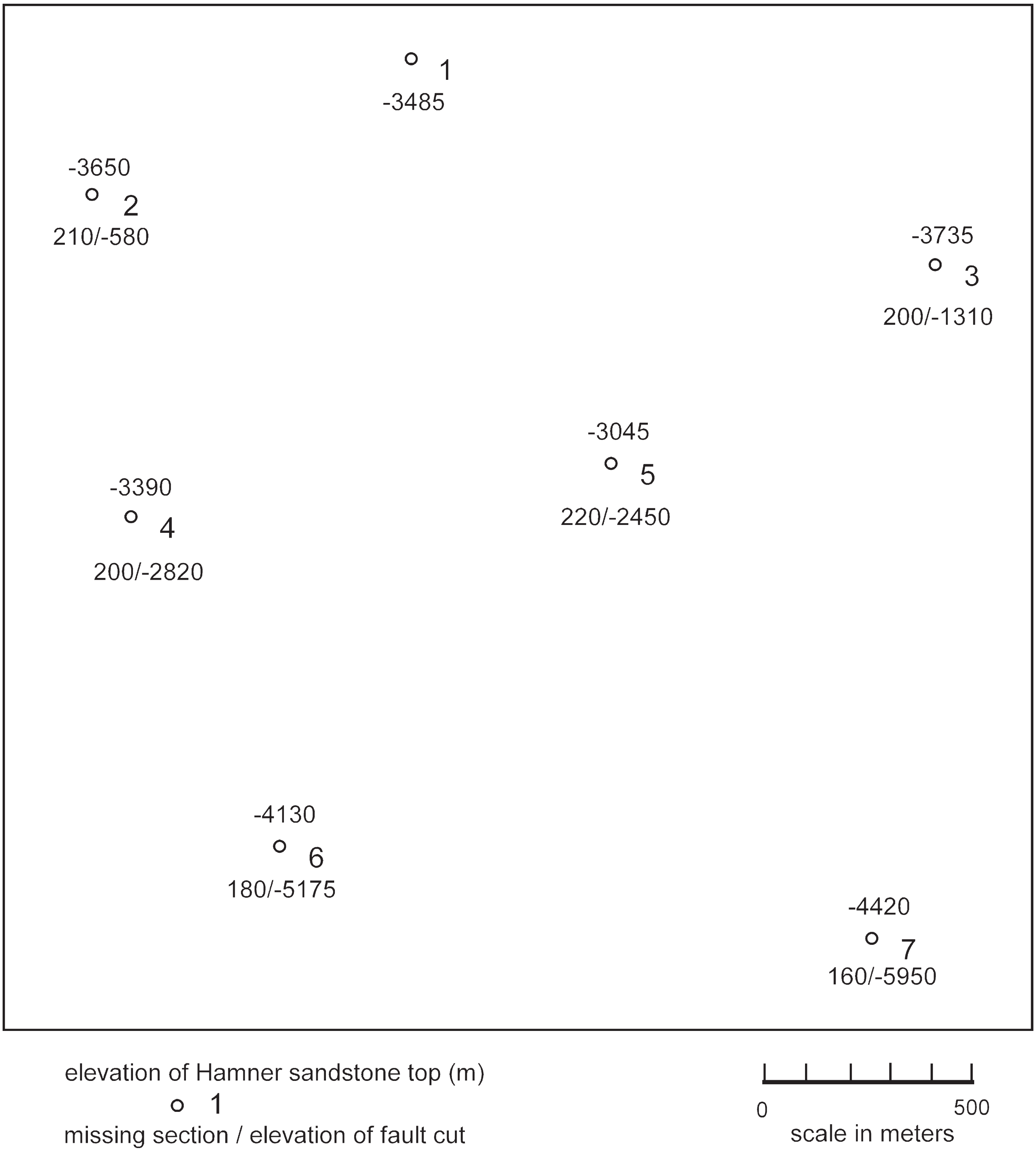


Fig. 8.52. Well data on the Hamner Sandstone reservoir. Wells (*numbered*) penetrate the Hamner Sandstone (*single number* is the elevation of the top contact). Fault cuts are indicated by a *pair of numbers* (amount/elevation). Elevations are in meters, negative below sea level

Determine the structure of the faulted Oil City Sandstone in Fig. 8.53. Is a single fault present? What kind? What is the evidence? What is the attitude of the fault? of bedding in the hangingwall? of bedding in the footwall? What is the heave and throw on the fault? Does the map agree with the attitude information? Explain the reason for the hydrocarbon trap.

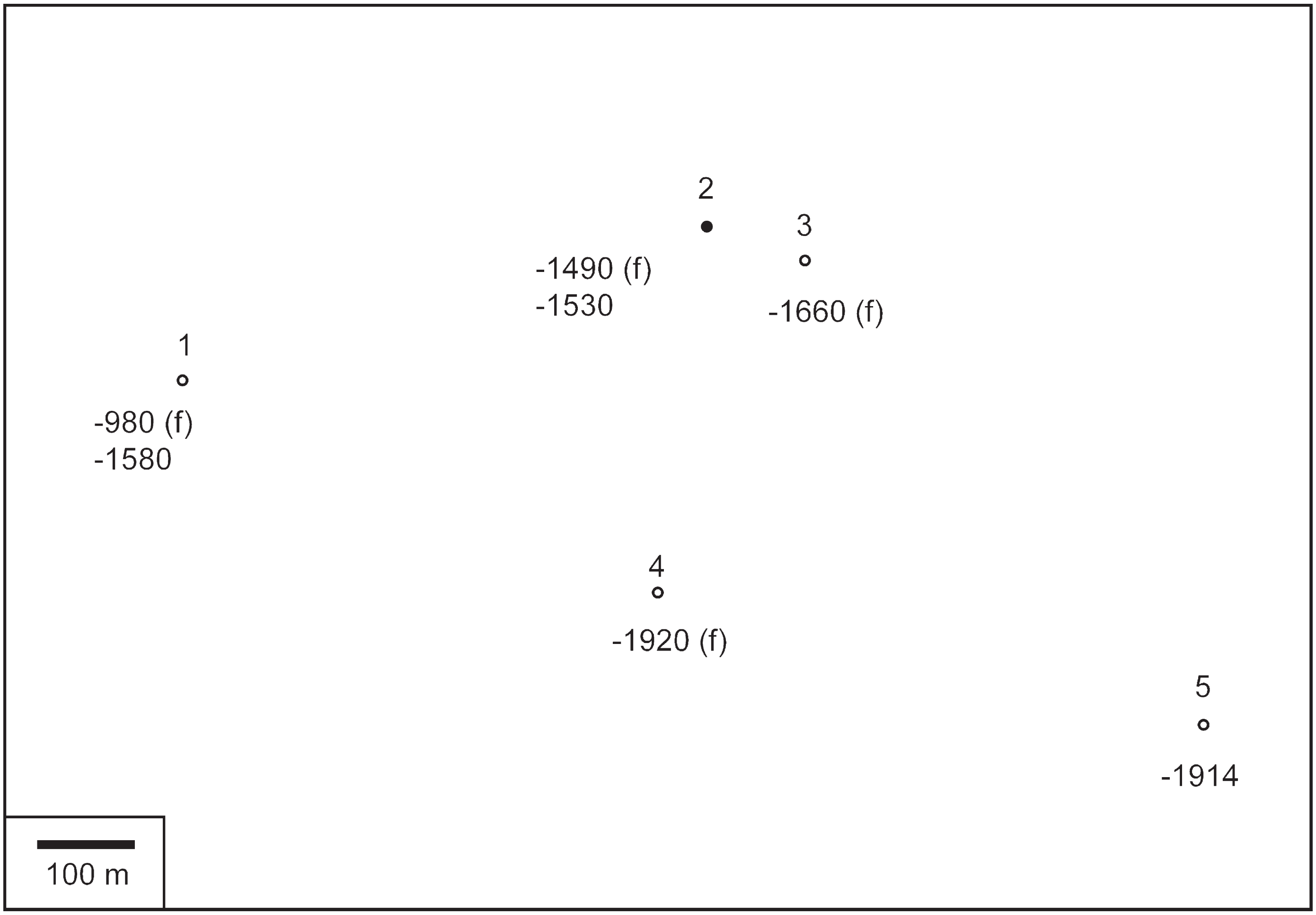


Fig. 8.53. Map of information for the Oil City Sandstone. Posted on the map are the elevations of fault cuts (*f*) and the top of the sandstone. Well *2* is an oil well. Dipmeters in well *1* indicate a bedding attitude of 10, 315 and a fault strike of 045; in well *5* the bedding attitude is 8, 315. Elevations are in meters

Map the fault (f) and the shale marker horizon (s) using the data in Fig. 8.54. Is a single fault present? What kind? What is the evidence? What is the attitude of the fault? of bedding in the hangingwall? of bedding in the footwall? What is the heave and throw on the fault? If a heavy liquid is spilled in the stream valley in the shaded area, could the fault provide a barrier to the fluid movement in porous units above the shale marker? Explain the reason behind your answer. Where would a fault trap for fluids lighter than water be located?

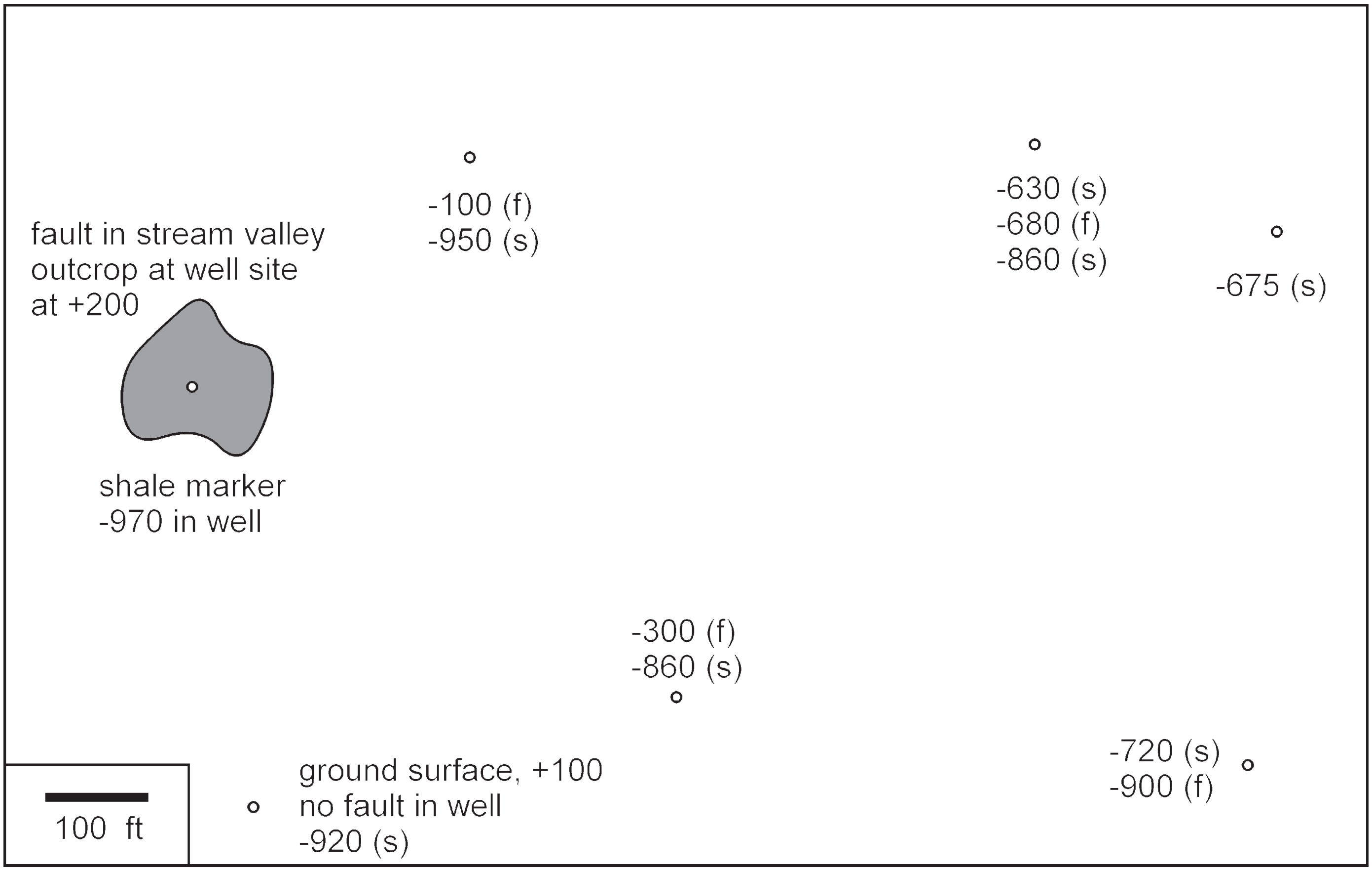


Fig. 8.54. A shale marker and fault cuts in a groundwater basin. Posted on the map are the elevations of fault cuts (*f*) and of the shale tops (*s*) in each well where present. Elevations are in feet, negative below sea level

Figure 8.55 is an isopach map. Locate the faults that explain the thickness changes. Indicate the upthrown and downthrown sides of each fault. Determine the throw on each fault. Make a structure contour map of the faults.

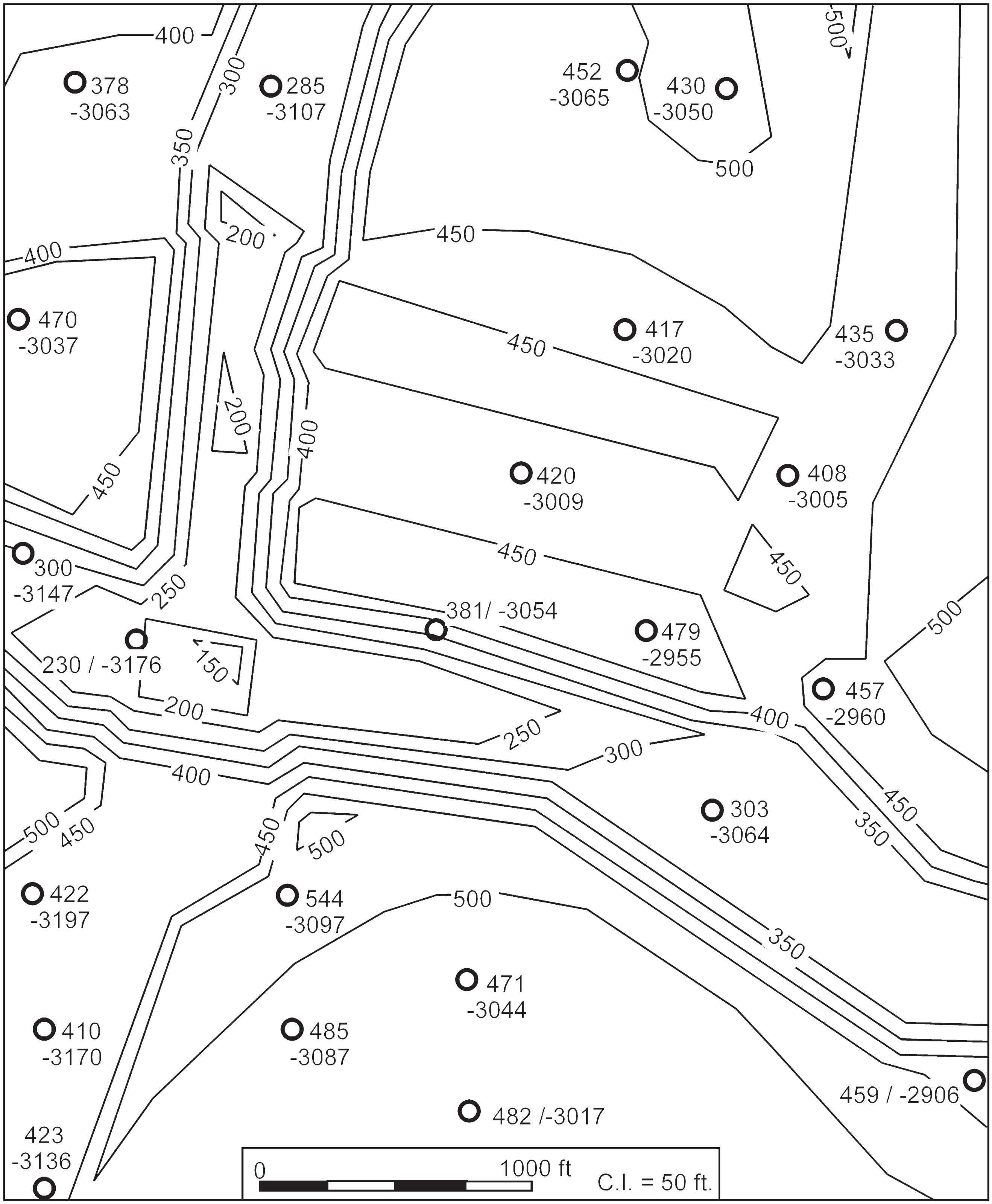


Fig. 8.55. Isopach map of the lower Taylor Formation above the Hawkins salt dome, Texas. Posted next to the wells (*circles*) are the thickness (upper or left-hand *number*) and the elevation of the formation top, in feet below sea level. (After Hintze 1971)

Construct a fault cutoff map for the northern fault on the structure contour map in Fig. 8.56. Project the cutoff lines to the blank profile below the map.

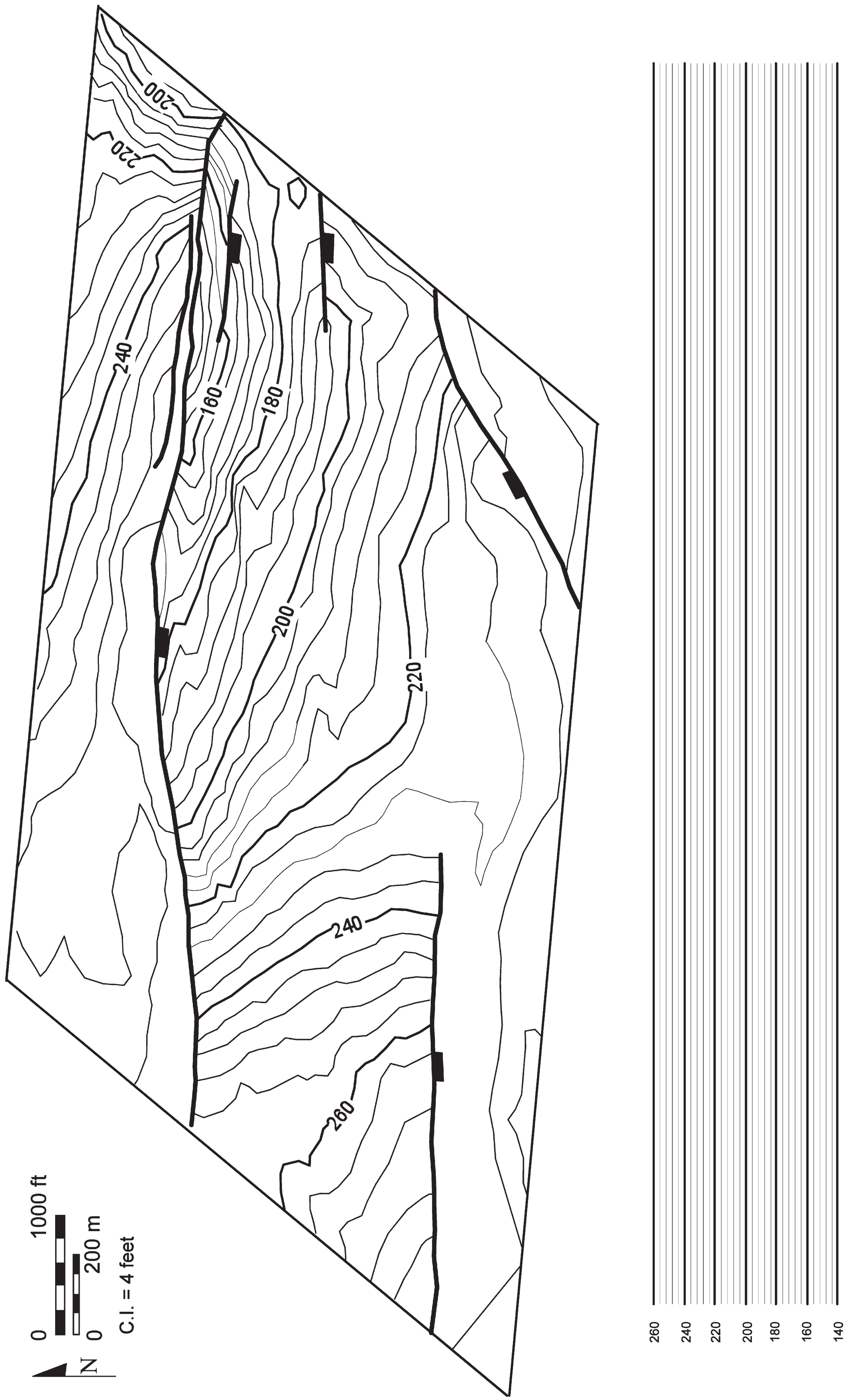


Fig. 8.56. Structure contour map with faults and blank cross-section template

Construct a fault cutoff map for fault A across the structure contour map in Fig. 8.57.

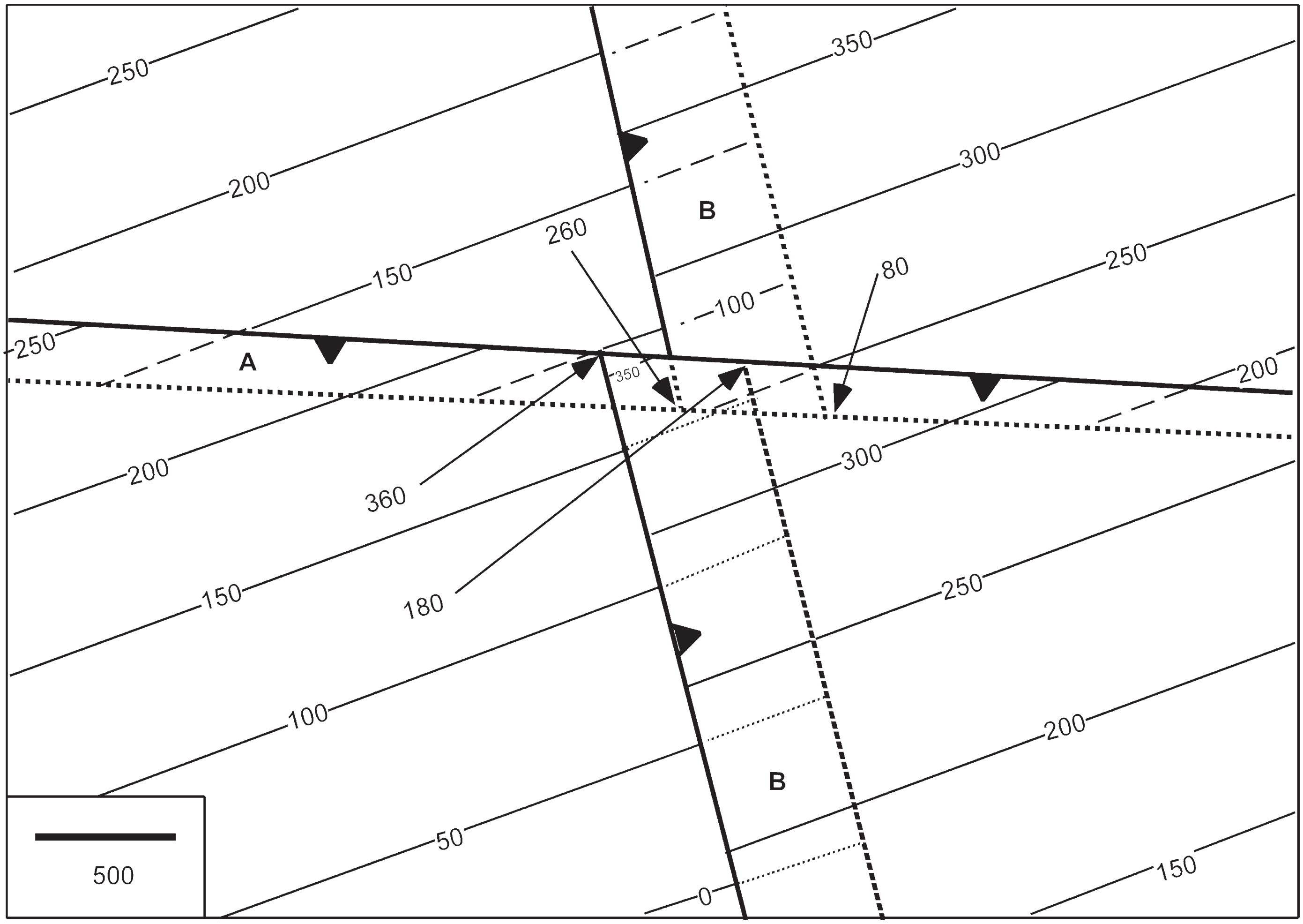


Fig. 8.57. Structure contour map of reverse-faulted marker horizon (*thin lines*). Faults are *thick lines*, hidden contours are *dashed*

Suppose a toxic liquid that is heavier than water is spilled onto the surface in the center of the structure illustrated by the Allan diagram in Fig. 8.58. Where will the liquid go? Will the liquid be trapped at a location on the cross section? If liquid is trapped, will it all be in the same location?

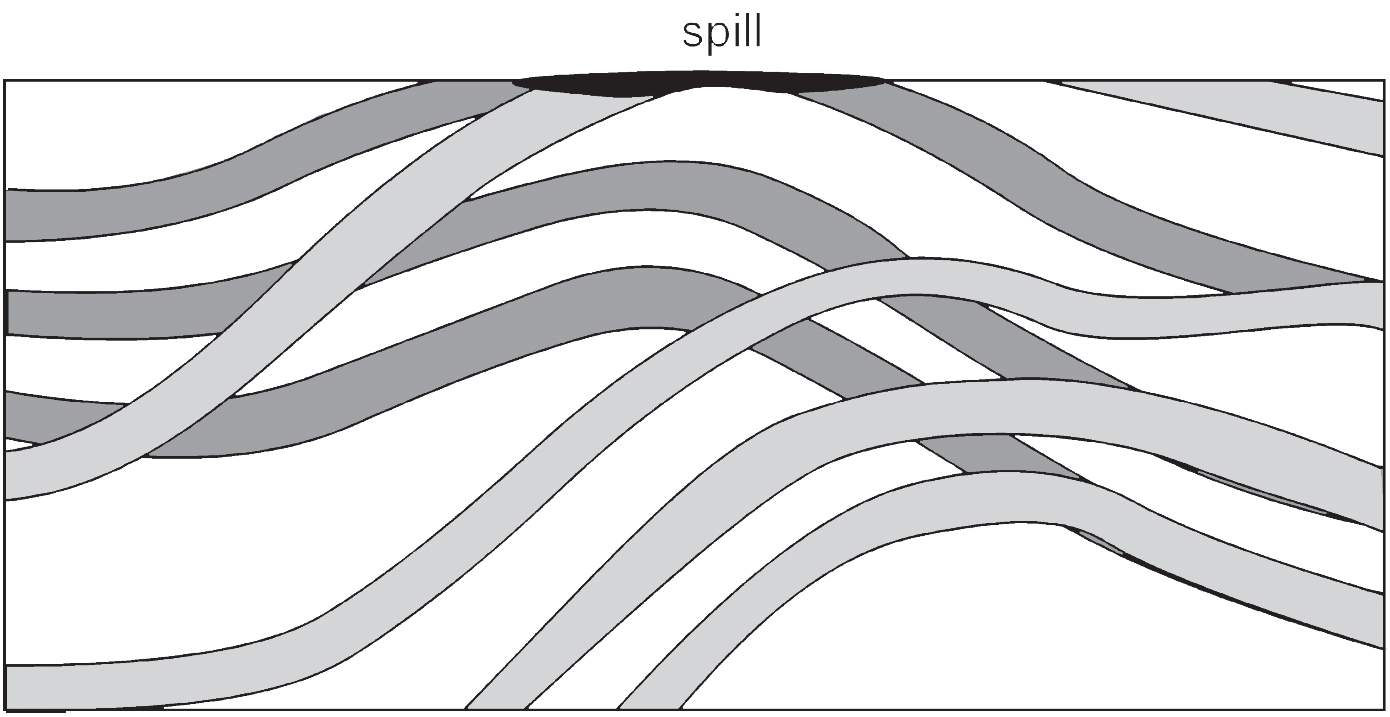


Fig. 8.58. Fault cutoff map, viewed from the hangingwall toward the footwall. The footwall beds have *darker shading* than the hangingwall beds. *Shaded* units are porous and permeable; *unshaded* units are impermeable

Based on the map in Fig. 3.29, answer the following questions. What is the 3-point dip of the fault at the surface? Construct a structure contour map of the fault from its surface dip. Intersect the previously-constructed structure contour map of the top Fairholme (Exercise 7.7.4) with the map of the fault. Does the projected structure contour map agree with the drilled depths to the top of the Fairholme?

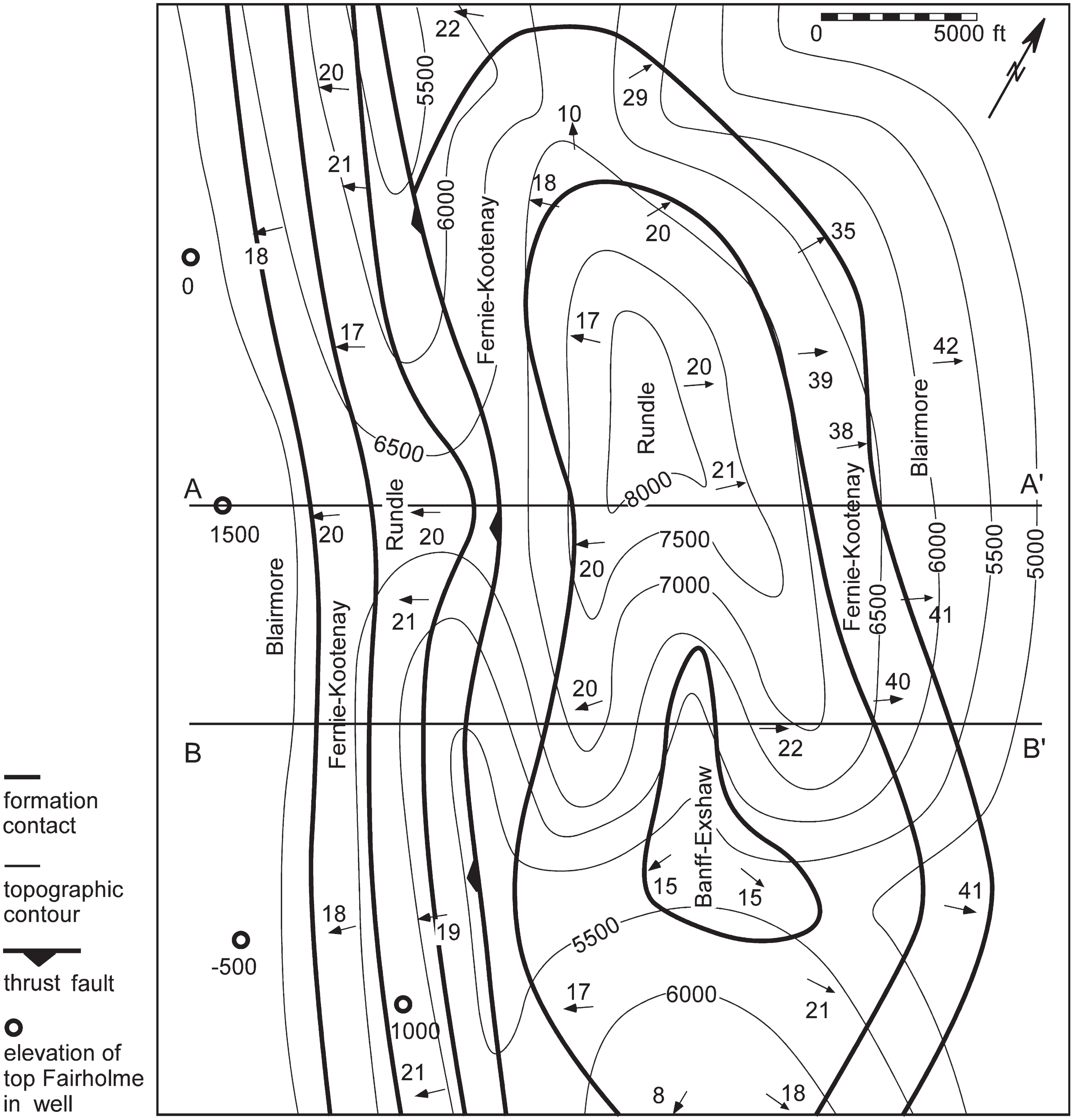


Fig. 3.29. Geologic map from the Canadian Rocky Mountains. All dimensions are in feet. The stratigraphic column (with thickness) from top to base is: Blairmore (2 400), Fernie-Kootenay (700), Rundle (900), Banff-Exshaw (900), Palliser (800), Fairholme (1 200). (After Badgley 1959)

Map the faults and the top of the Northriver Sandstone on the map of Fig. 8.59. Where is the relay zone? What is the attitude of the sandstone away from the faults? What is the attitude of the sandstone between the faults? What are the attitudes of the faults? What is the maximum throw and heave on the faults?

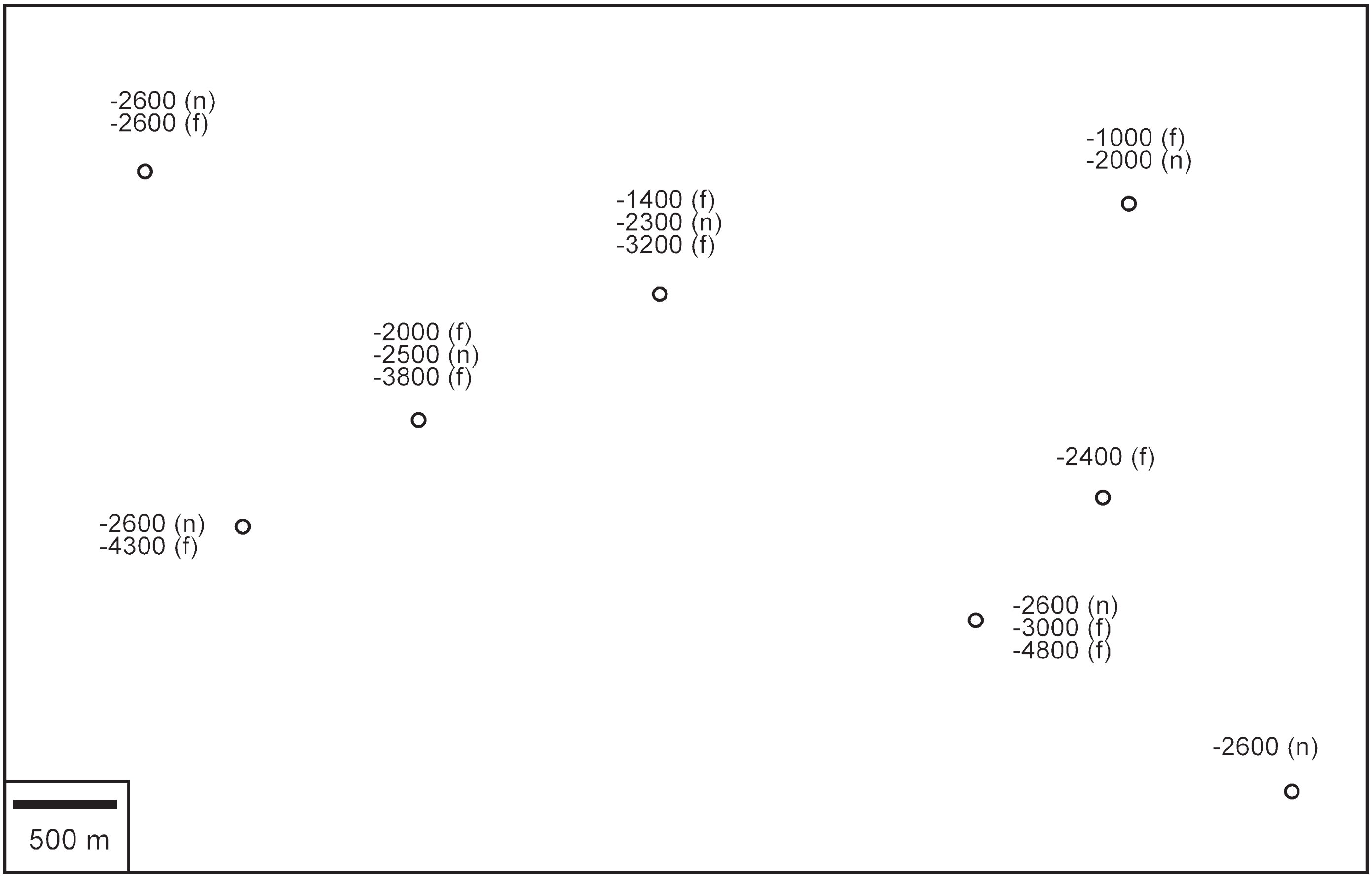


Fig. 8.59. Top of the Northriver Sandstone (*n*) and fault-cut elevations (*f*) in wells. Elevations are in meters, negative below sea level

Map the faults and the top of the Reef Limestone on the map of Fig. 8.60. Where is the branch line? What is the attitude of the limestone away from the faults? What is the attitude of the limestone between the faults? What are the attitudes of the faults?

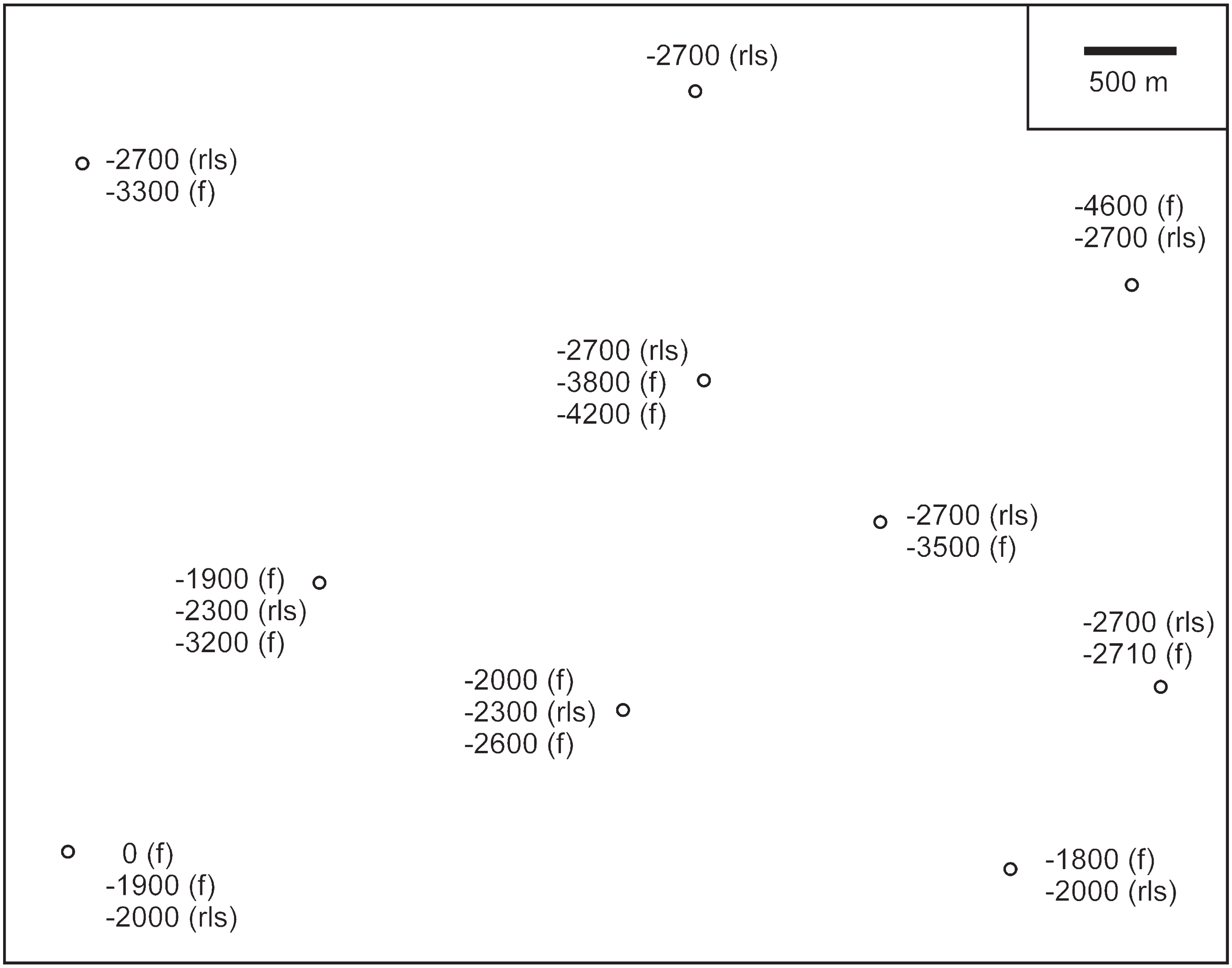


Fig. 8.60. Map giving the top of the Reef Limestone (*rls*) and faults (*f*) in wells. Elevations are in meters, negative below sea level

The water-well map of Fig. 8.61 shows a distinctive clay seam to be absent in some wells due to faulting. Map the faults and the top of the clay seam. Where is the branch line? What are the attitudes of the faults? What is the maximum throw and heave on the clay seam? If the clay seam is a barrier to ground water flow from the surface, where is this barrier absent? Is a spill of toxic heavy liquid in the southwest corner of the map area likely to sink below the clay seam? Why or why not? In which direction will a spill of heavy liquid in the southeast corner of the map migrate?

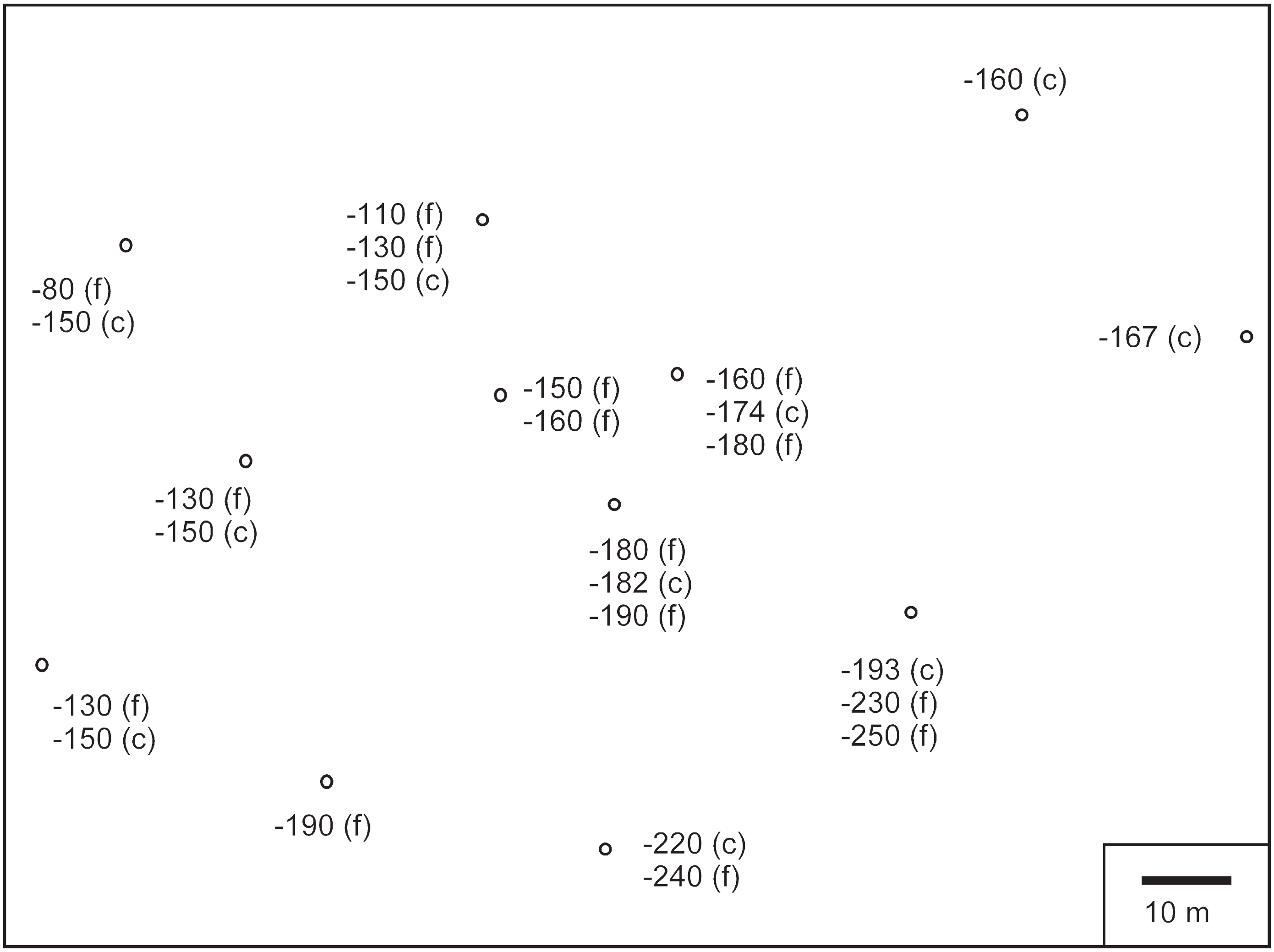


Fig. 8.61. Map of the top of a clay seam in water wells drilled into an alluvial aquifer. Elevations below sea level are negative

Two different fault trends occur in the area of Fig. 8.62. Map the faults and the A sand. What is the reason for the hydrocarbon trap in the A sand? What are the attitudes of the faults? What is the throw and heave on each fault? Which fault is older? If the hydrocarbons migrated before the formation of the younger fault, would the trapping potential of the structures be the same?

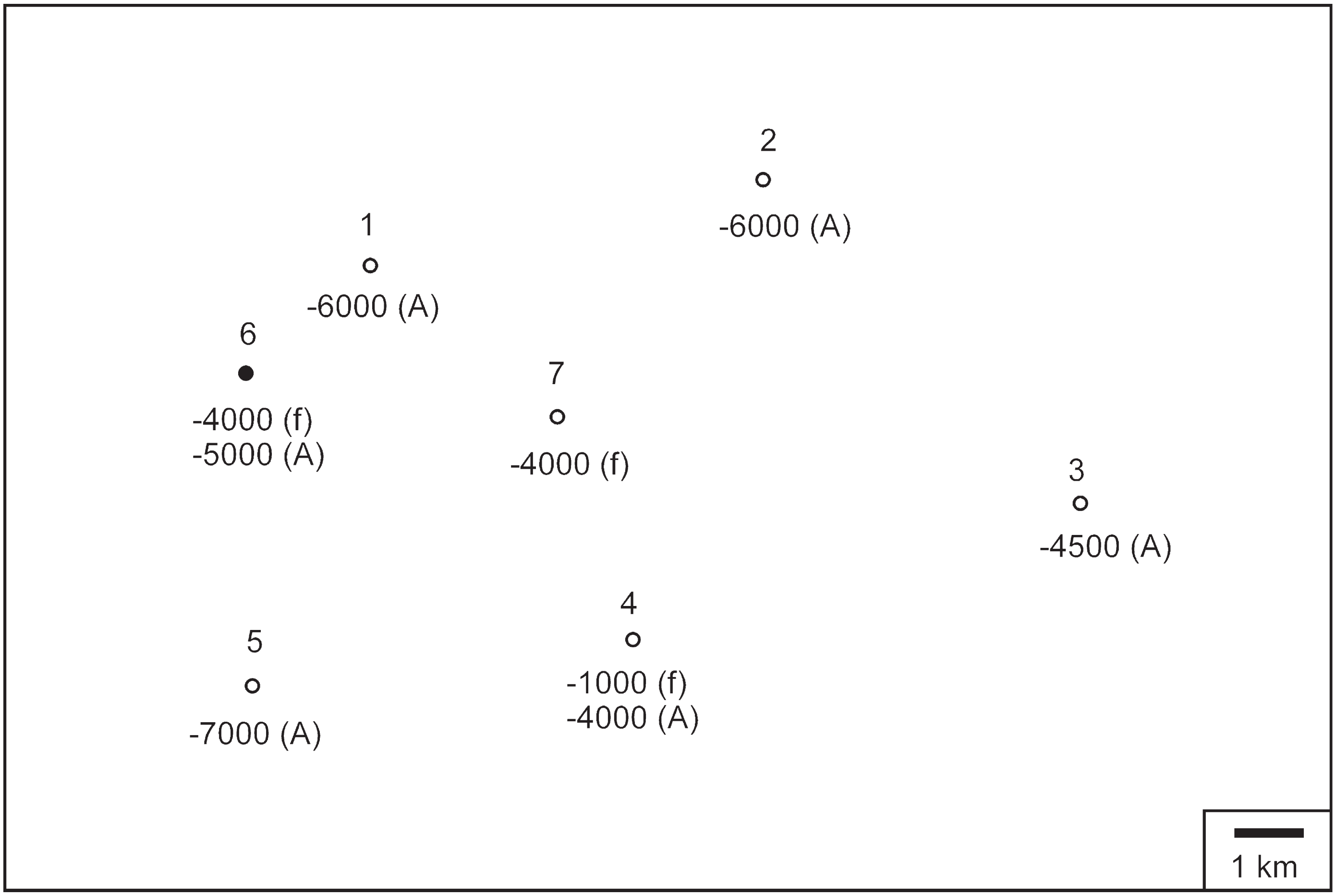


Fig. 8.62. Map of the top of the *A* sand (*A*) and faults (*f*) in wells drilled for oil. The *solid circle* is an oil well, *open circles* are dry holes. Everywhere away from the faults clear bedding dips are recorded on the dipmeter; they are about 27, 334. Close to the fault in well *4* the bedding dip is at azimuth 062. In well *6* the bedding dip close to the fault is at azimuth 189. In well *7* the dips of bedding are in all directions near the fault. Elevations are in meters, negative below sea level

Contour the Northport Dolomite in the map of Fig. 8.63, being careful to explain the fault cuts and the oil trap(s). Is there one oil field or two? What are the attitudes of the faults? What is the throw and heave on each fault? Which fault is older? If the hydrocarbons migrated before the formation of the younger fault, would the trapping potential of the structures be the same? Are there any additional hydrocarbon prospects?

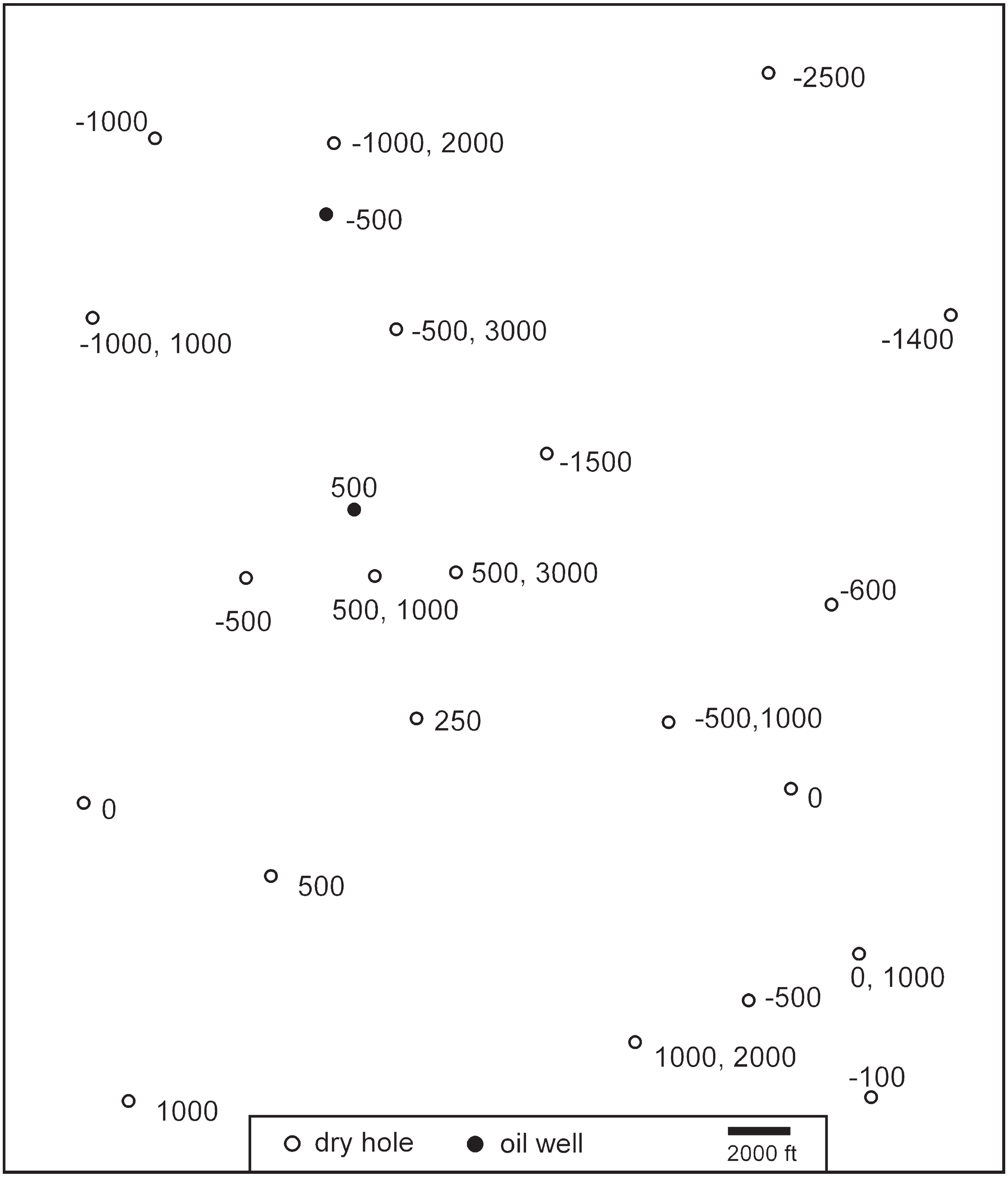


Fig. 8.63. Map of well information from the Northport Dolomite. *Two numbers* together next to a well give fault cut information: 500, 100: depth of fault cut, amount of fault cut. A *single number* by the well is the top of the dolomite. Where only fault-cut information is given, the dolomite is faulted out. The fault trends are generally northwest–southeast. Elevations are in feet, negative below sea level

Use the data in Table 9.1 to perform a complete SCAT analysis on the dip traverse across the Sequatchie anticline. Plot the azimuth-distance and the dip-distance diagrams. What are the *T* and *L* directions? What are the dip components in the *T* and *L* directions? Plot them on the dip-component diagrams.

Table 9.1.
Dip traverse across Sequatchie anticline

Distance from NW end of traverse (ft)	Dip, azimuth	T component (from 320/140)	L component (from 230/50)
256	8, 308	8 NW	1 SW
1 384	46, 315	45 NW	7 SW
1 640	34, 316	34 NW	2 SW
1 660	50, 320	50 NW	0
2 328	6, 320	6 NW	0
3 143	22, 316	22 NW	1 SW
3 261	56, 318	56 NW	1 SW
4 096	75, 330	75 NW	25 SW
4 253	Break		
4 253	83, 315	83 NW	~45 SW
4 528	70, 315	70 NW	13 SW
4 891	0, 000	0	0
5 147	Break		
5 323	5, 145	5 SE	1 SW
5 815	6, 144	6 SE	1 SW
6 404	8, 145	8 SE	1 SW
8 005	8, 144	8 SE	1 SW
10 942	6, 127	6 SE	1 NE
12 789	7, 136	7 SE	1 NE
13 466	10, 136	10 SE	1 NE
13 692	9, 136	9 SE	1 NE

Use the data in Table 9.3 to perform a complete SCAT analysis on the dip traverse across the Bald Hill structure to see if a fault is present and its location and orientation, given that the faults in the area are reverse.

Table 9.3.
Bald Hill bedding attitudes

Distance from the northwest (km)	Attitude Dip, azimuth	T component	L component
0.54	60, 310		
0.70	90, 289		
0.90	55, 311		
1.10	40, 295		
1.30	14, 124		
2.38	12, 319		
2.68	26, 281		

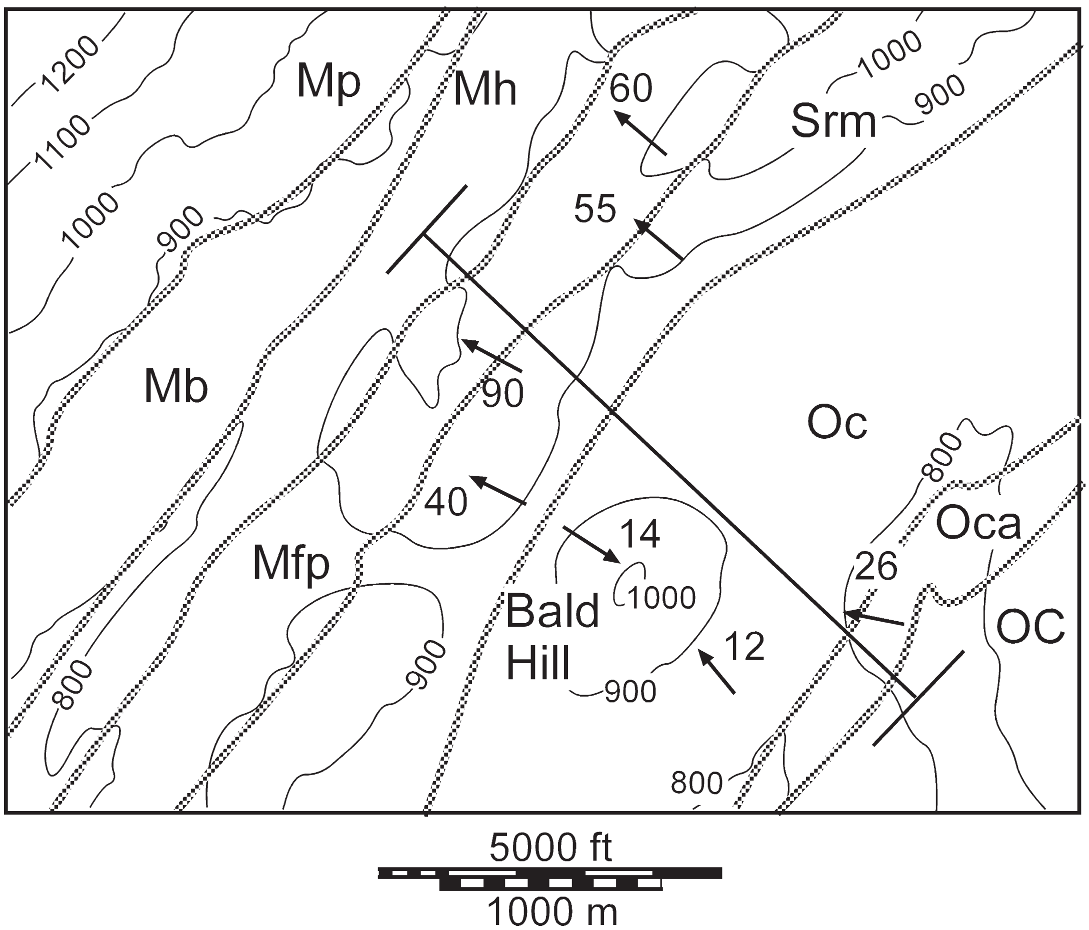


Fig. 9.26.
Geologic map of the Bald Hill area. Topographic contours (in feet) are *thin lines*; geologic contacts are *wide gray lines*. Data have been projected parallel to strike onto NW-SE traverse line. (Modified from Burchard and Andrews 1947)

Perform a complete SCAT analysis on the Greasy Cove anticline (Table 9.4). Consider both fold and fault geometry. The anticline is part of the southern Appalachian fold-thrust belt.

Table 9.4.
Southeastern Greasy Cove anticline bedding attitudes

Distance (ft)	Bedding attitude	T component	L component
0	10, 300		
200	35, 302		
500	43, 293		
600	85, 300		
1 200	90, 329		
1 500	70, 130		
1 600	45, 133		
2 000	70, 133		
2 100	30, 130		
2 200	50, 130		
3 500	60, 133		
4 000	40, 150		

Critique the cross section in Fig. 10.27. What might be the origin of any problems?

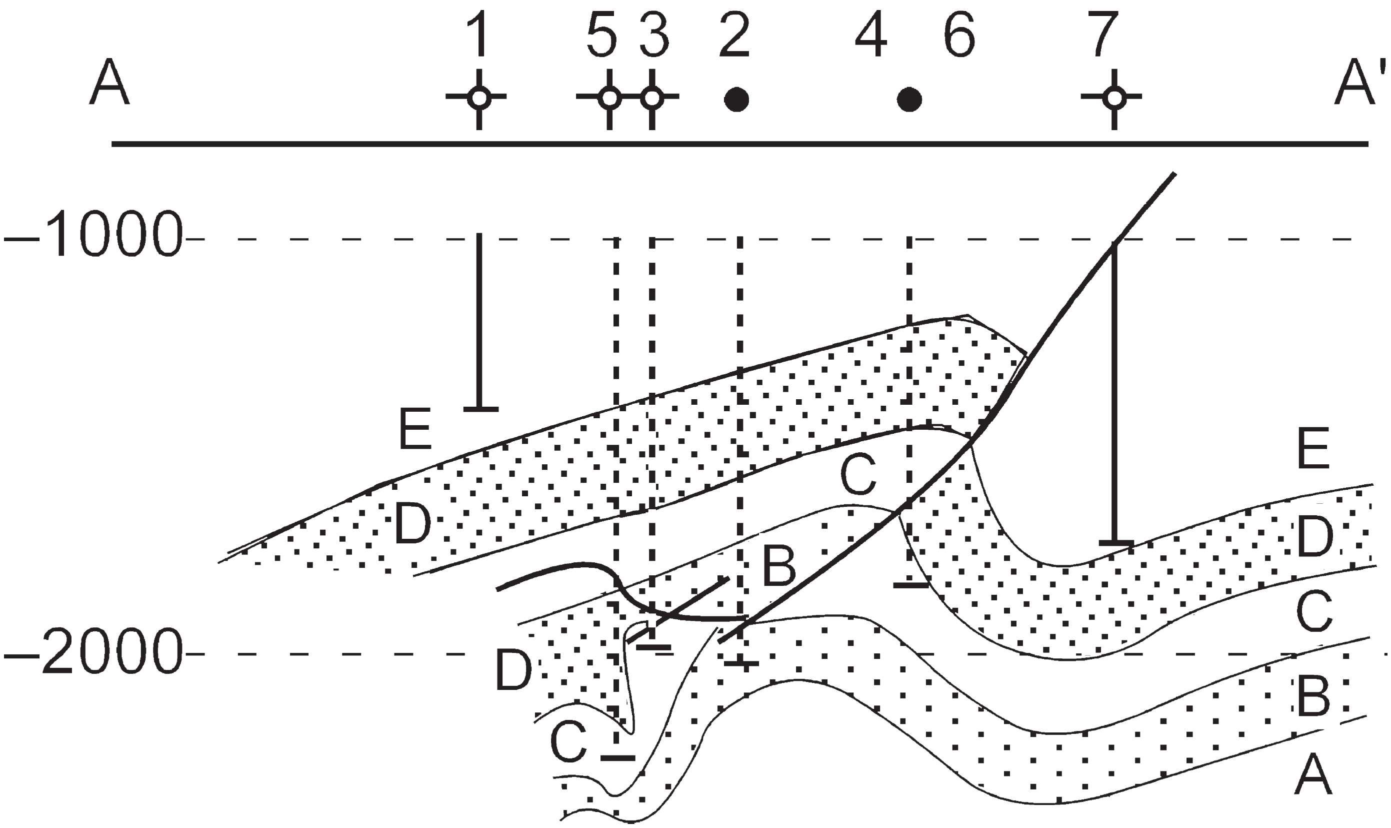


Fig. 10.27. Cross section of a compressional anticline (after Brown 1984). Elevations are in feet, *dashed wells* are projected to the line of section, *solid circles* represent oil producers, *open circles* are dry holes

The structure contour map of the top of a faulted limestone (Fig. 10.28) fits the well information and explains the hydrocarbon trap. Is the interpretation valid? Based on the map as presented, what kind of faults are present? In which direction do they dip? Where are the structural closures on the map? Could any of them be new hydrocarbon traps? Why or why not? Draw implied structure contour maps on the faults. Is the original map correct? Construct an improved map that honors all the well data.

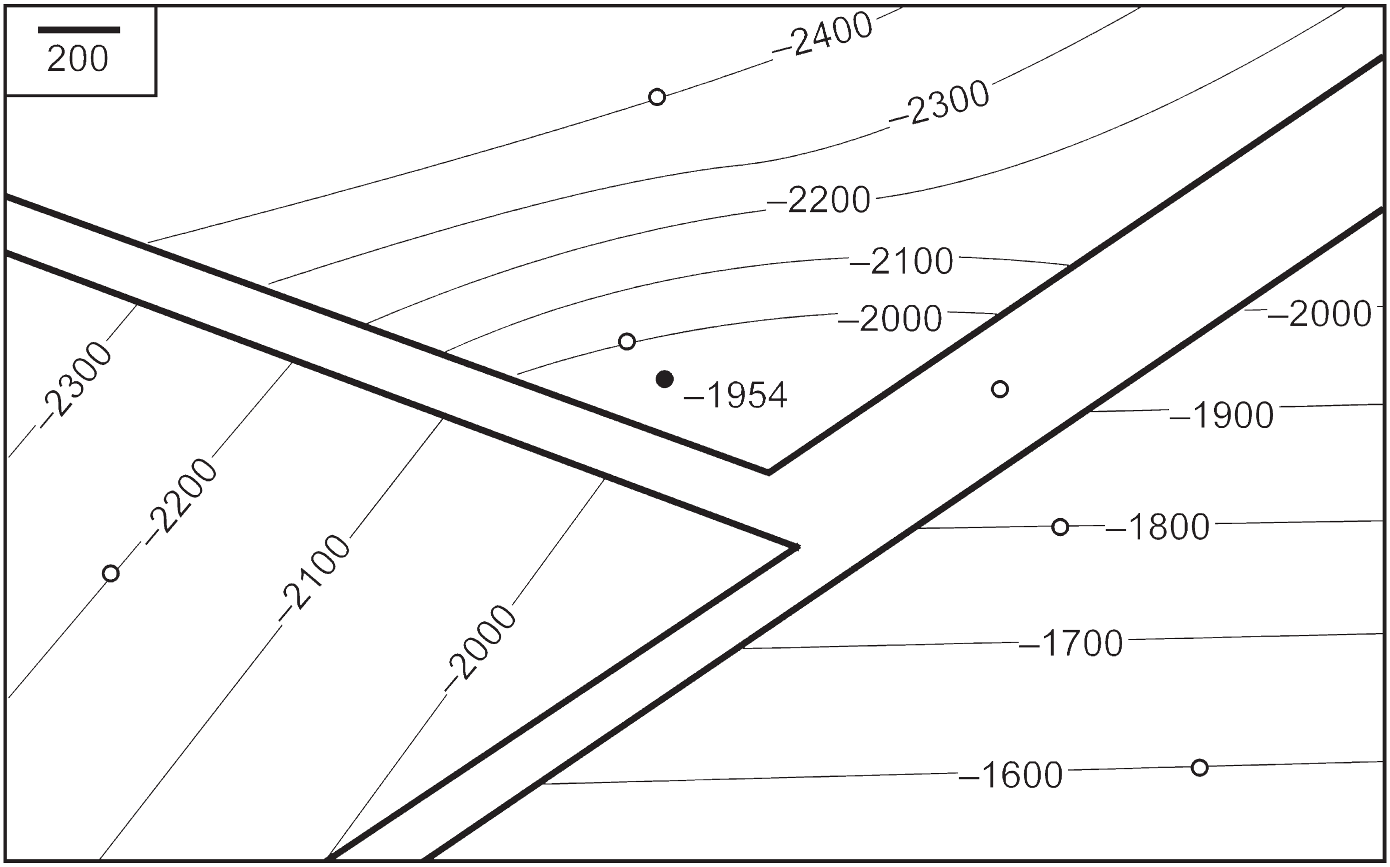


Fig. 10.28. Hypothetical structure contour map of the top of the Appling Bend Limestone gas reservoir. Contours are depths below sea level. The *solid circle* is a gas well, *open circles* are dry holes. The limestone is missing in the well in the fault gap. Choose the measurement units to be in either feet or meters. Elevations below sea level are negative

Is the fault in Fig. 10.29 valid? If not, can it be corrected? The well near the center of the map is thought to have a stratigraphic separation of 15.0 m. Is that correct? If not, what is stratigraphic separation is consistent with the map?

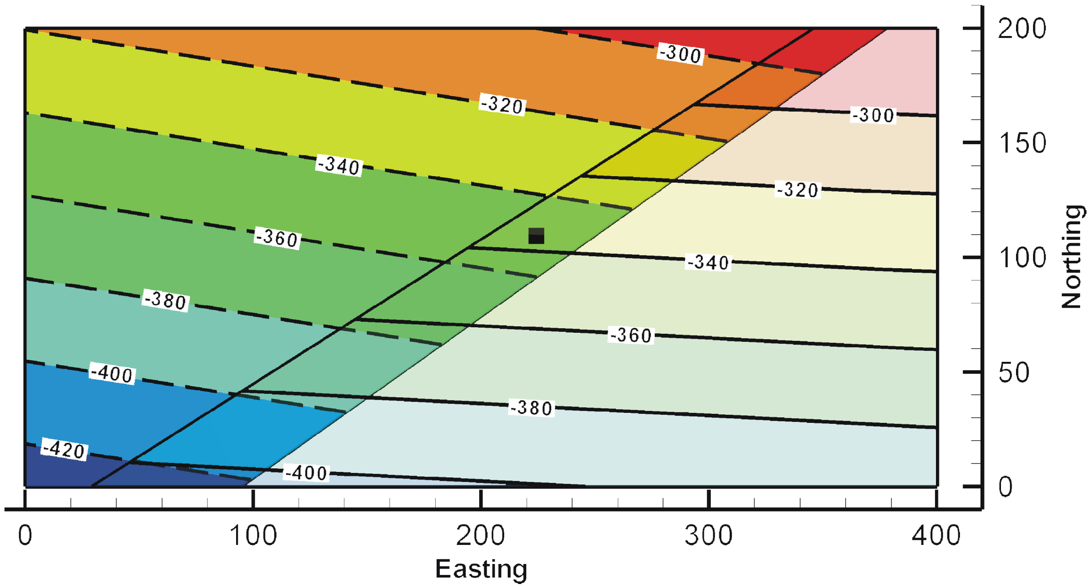


Fig. 10.29. Structure contour map of an offset horizon. Scale in m, *small square* is a well location

Validate (or invalidate) the cross section in Fig. 11.65. Is it length balanced? Is it area balanced? Apply the area-depth relationship to find the best-fitting lower detachment, displacement, and the strain in each layer.

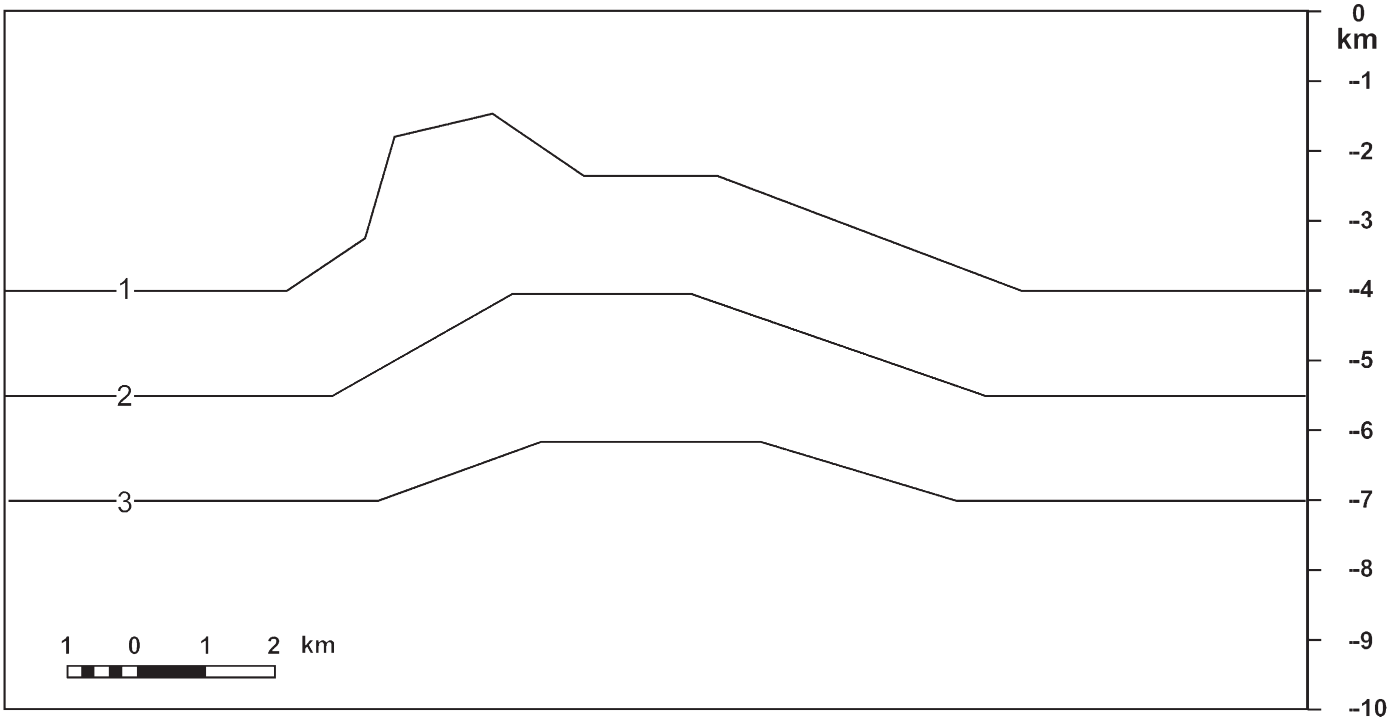


Fig. 11.65. Cross section of an anticline

Validate (or invalidate) the cross section in Fig. 11.66. Is it length balanced? Is it area balanced? Apply the area-depth relationship to find the best-fitting lower detachment, displacement, and the strain in each layer.

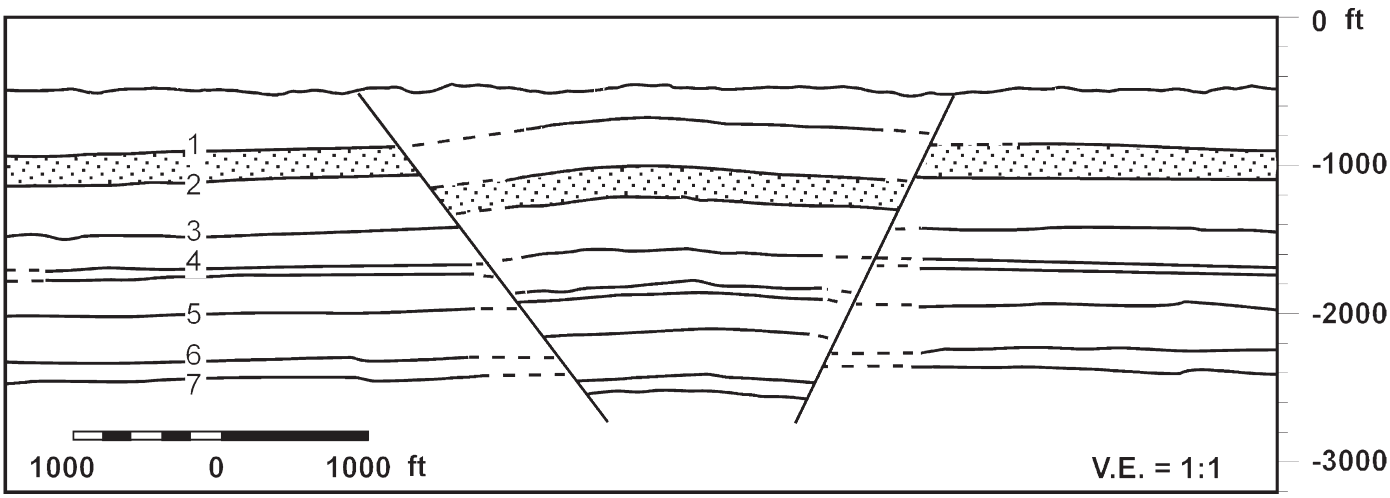
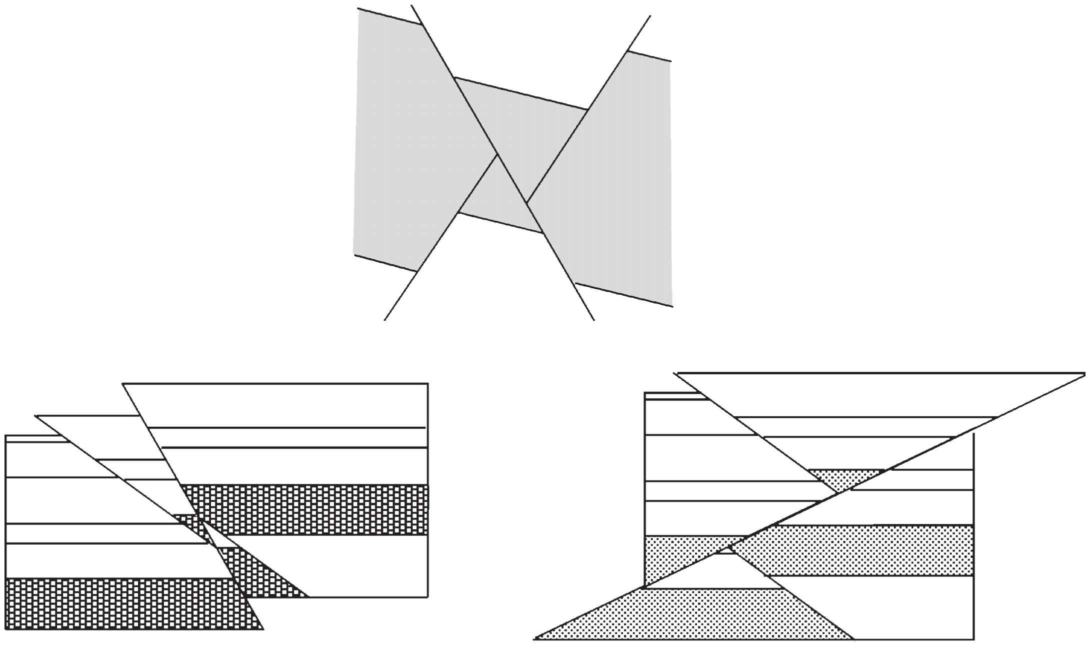


Fig. 11.66. Cross section of a full graben

Restore the cross sections in Fig. 11.67. Why is the rigid-body method appropriate? Are the cross sections valid? Show the structural evolution of each cross section.

Fig. 11.67.
Cross sections of structures formed by rigid-block displacement



Sequentially restore the cross section of the Rhine Graben in Fig. 11.68 to the top of the Bunte Niederroderner Schichten and the top of the Muschelkalk. What method is most appropriate? Is the cross section valid?

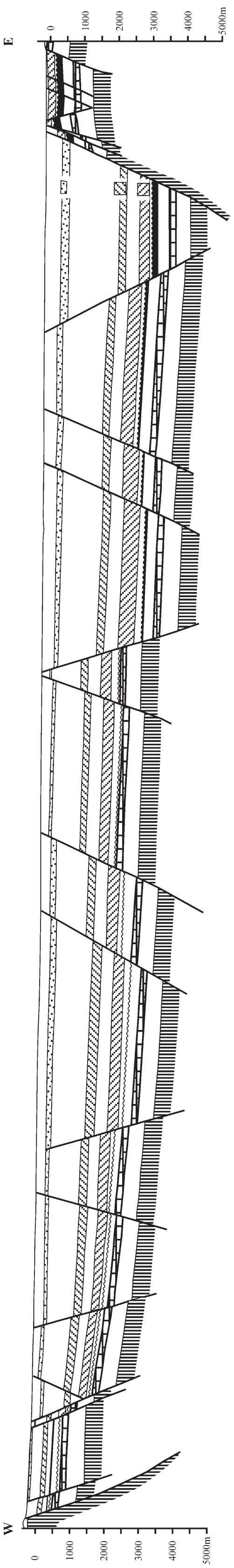


Fig. 11.68. Cross section of the Rhine Graben. (After Doebl and Teichmüller 1979)

Restore the cross section of the Sequatchie anticline in Fig. 11.69. Why is the flexural-slip method appropriate? Discuss the effect of the choice of pin line and loose line on the result. Is the cross section valid?

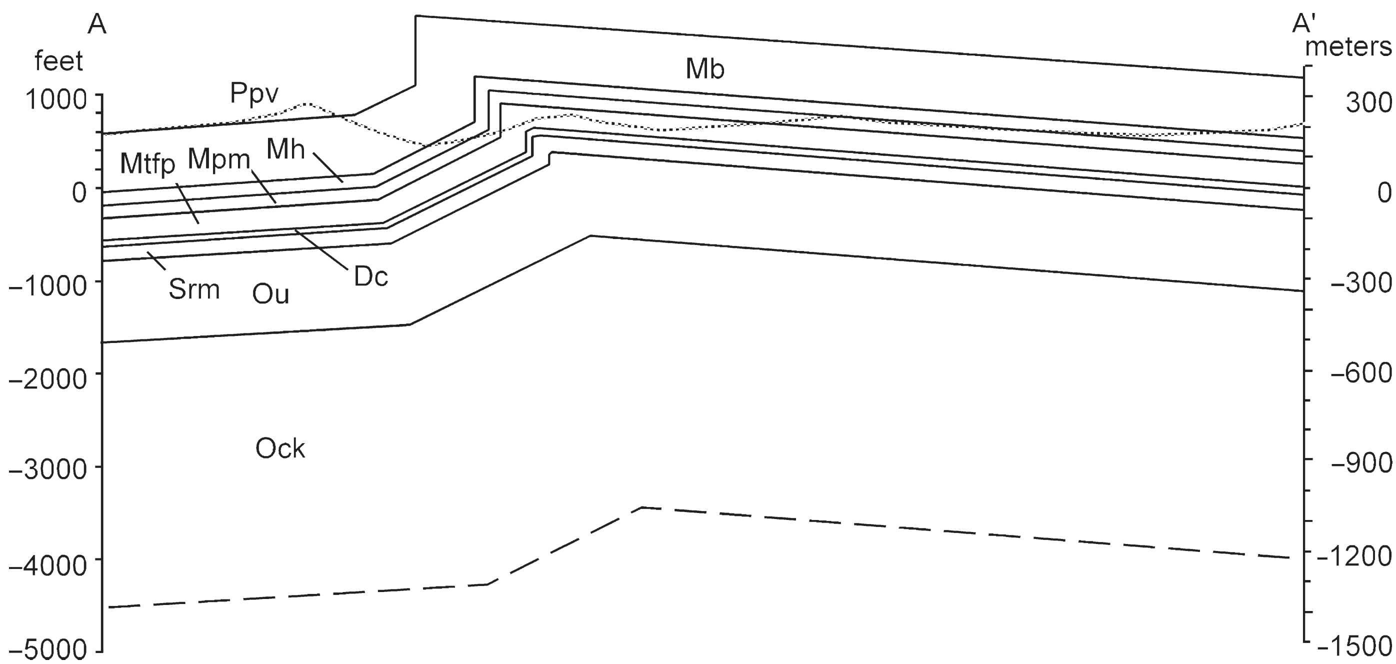


Fig. 11.69. Cross section of the Sequatchie anticline

Restore the cross section of the Velma area in Fig. 11.70. Use the flexural slip technique and preserve the original stratigraphic thickness changes. Is the cross section valid? Discuss the origin of the major faults and their sequence of formation.

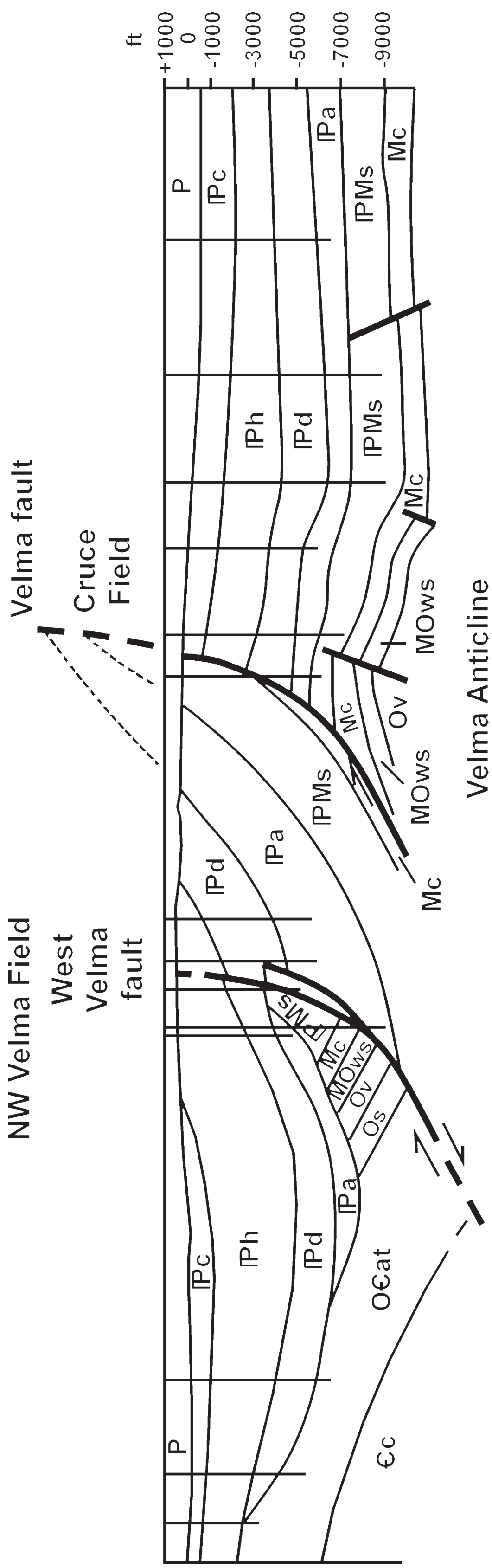


Fig. 11.70. Cross section through the Velma area, Oklahoma. (Redrawn from Perry 1989)

Restore the cross section in Fig. 11.71 by flexural slip. First it is necessary to correlate units across the faults. Discuss the effect of the choice of pin line and loose line on the result. Could the interpretation be questioned or improved? Is the cross section valid?

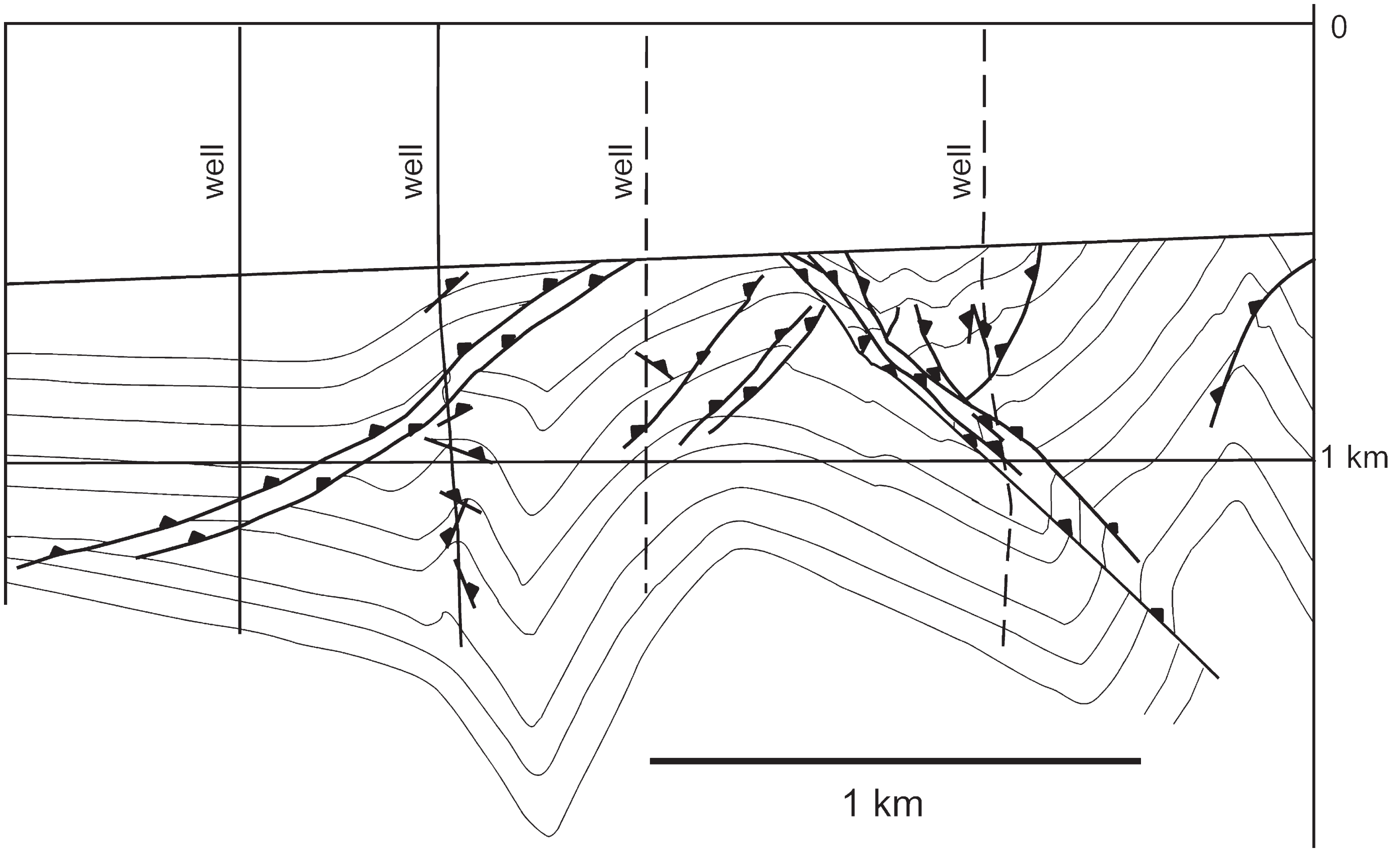


Fig. 11.71. Cross section of a portion of the Ruhr coal district, Germany. *Triangles* are located on the hangingwalls of the thrust faults. (After Drozdzewski 1983)

Restore the cross section of the Deer Park anticline (Fig. 11.72) by flexural slip or area balance, as appropriate. Construct an area-depth diagram for the entire anticline. What displacement caused the structure and what displacement is present on the upper detachment, if any? Based on the results, is the structure locally balanced or regionally balanced? Compute the layer parallel strains for each layer. Is the cross section valid?

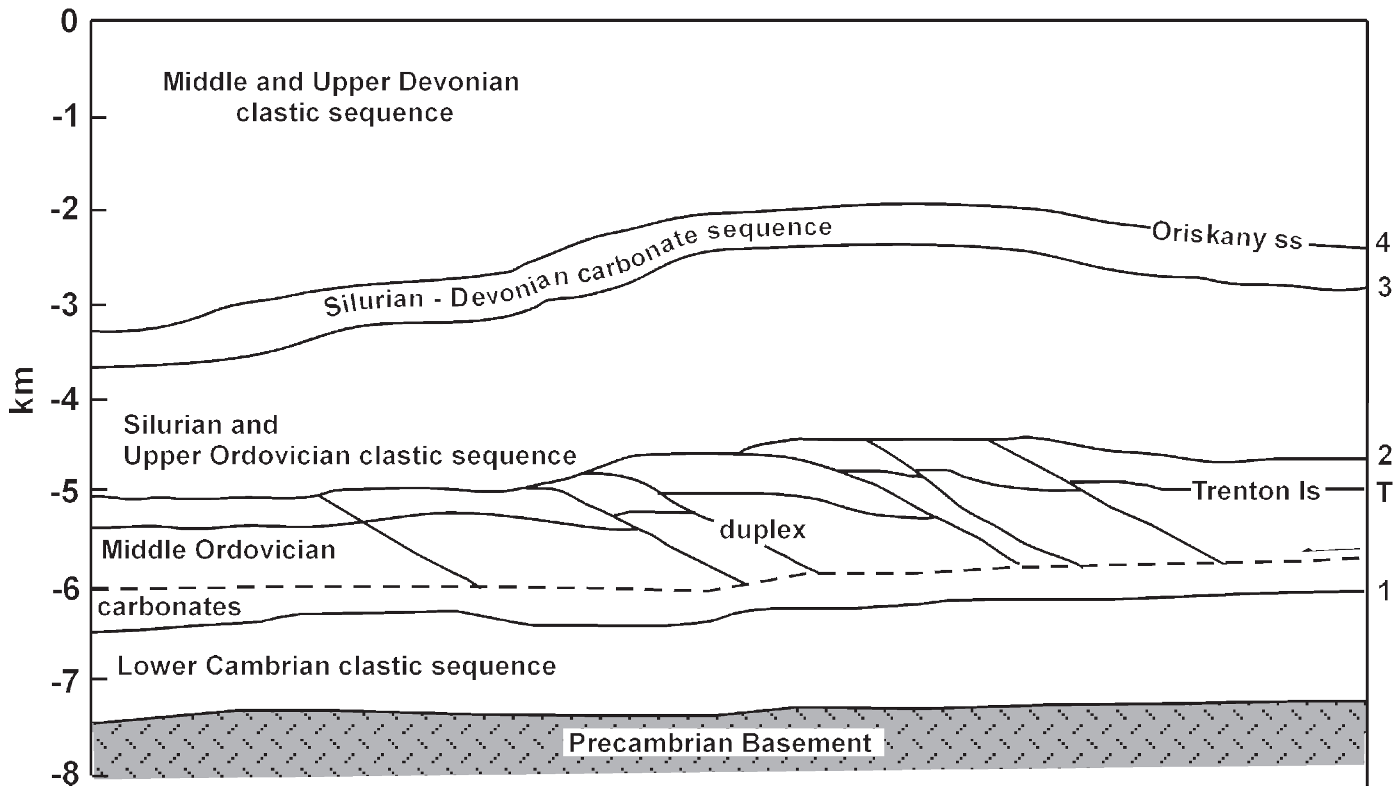


Fig. 11.72. Geological cross section across the Deer Park anticline, Appalachian Plateau fold-thrust belt, eastern U.S. The section is depth converted from Mitra (1986) using a velocity of 5 km s^{-1}. The inferred lower detachment is the *dotted line*. Epard and Groshong (1995) discuss the interpretation

The drape fold in horizons 1 and 2 in the South Hewett fault zone (Fig. 11.73) can be explained by an underlying rotated block. Apply the circular-arc fault model to predict the fault location and depth to detachment. The slip on some of the Zechstein normal faults has been reversed in the later deformation. Does the model explain which faults have reactivated?

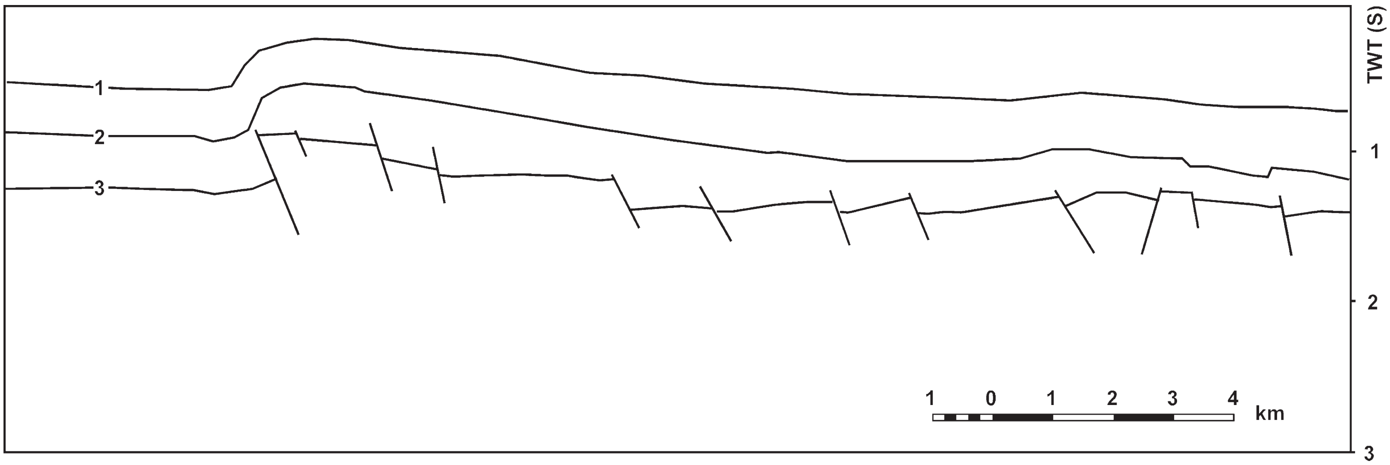


Fig. 11.73. The South Hewett fault zone in the North Sea. Interpreted and drawn from a seismic reflection profile in Badley et al. (1989). Assume the vertical exaggeration is approximately 1 : 1. Horizon *1:* top Creta-ceous Chalk; *2:* base-Cretaceous unconformity; *3:* top Zechstein; *TWT(S):* two-way travel time in seconds

Restore the growth normal fault in Fig. 11.74. This section contains growth stratigraphy and can be sequentially restored to the regional for horizons 2 and 3 to show the growth history. Why is the simple-shear method a reasonable choice? What is the appropriate choice of the regional? What is the most appropriate shear angle and how do you find it? Is the cross section valid?

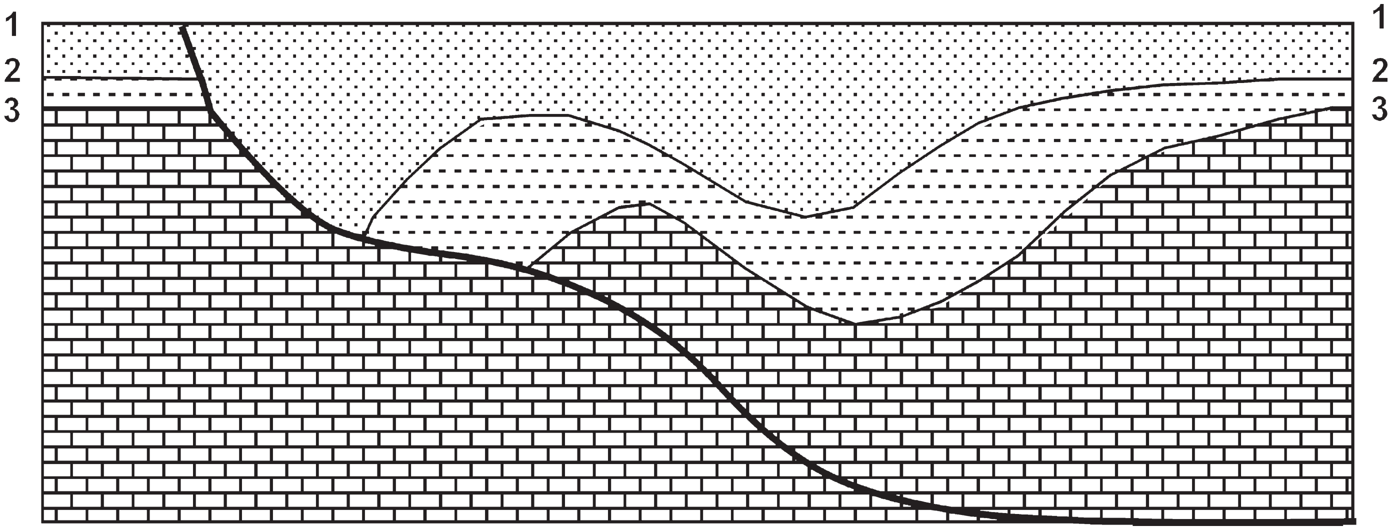


Fig. 11.74. Cross section of a ramp-flat normal fault

Restore the cross section in Fig. 11.75 by either rigid-block displacement or flexural slip. Discuss the reason for your choice of method. Predict the deep geometry of the Schell Creek master fault using oblique simple shear. Find the shear angle from the strain in the rollover.

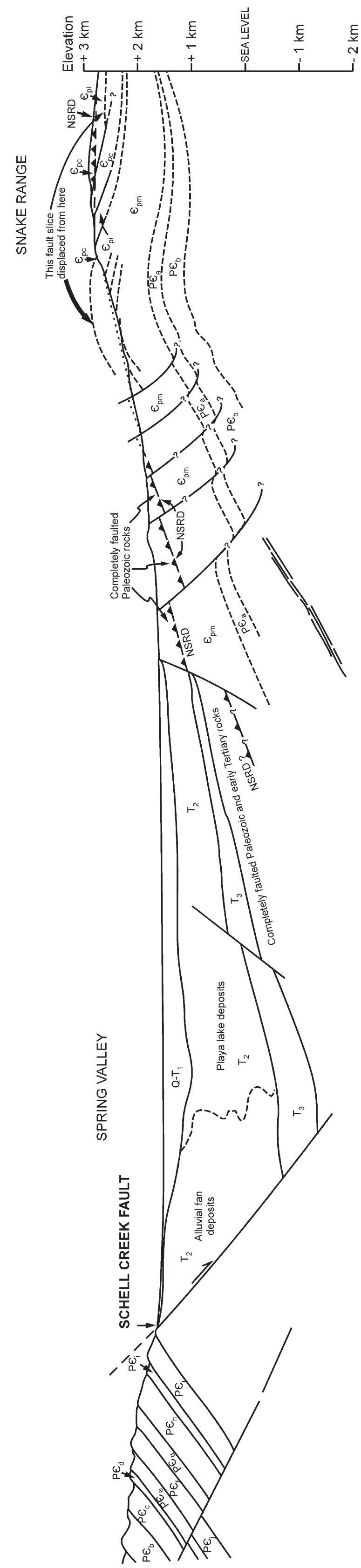


Fig. 11.75. Cross section of Schell Creek fault, U.S. Basin and Range province, Nevada from outcrop and seismic reflection profile. (After Gans et al. 1985). Groshong (1989) discusses the interpretation