Lab 10. Balanced Tectonic Cross Sections

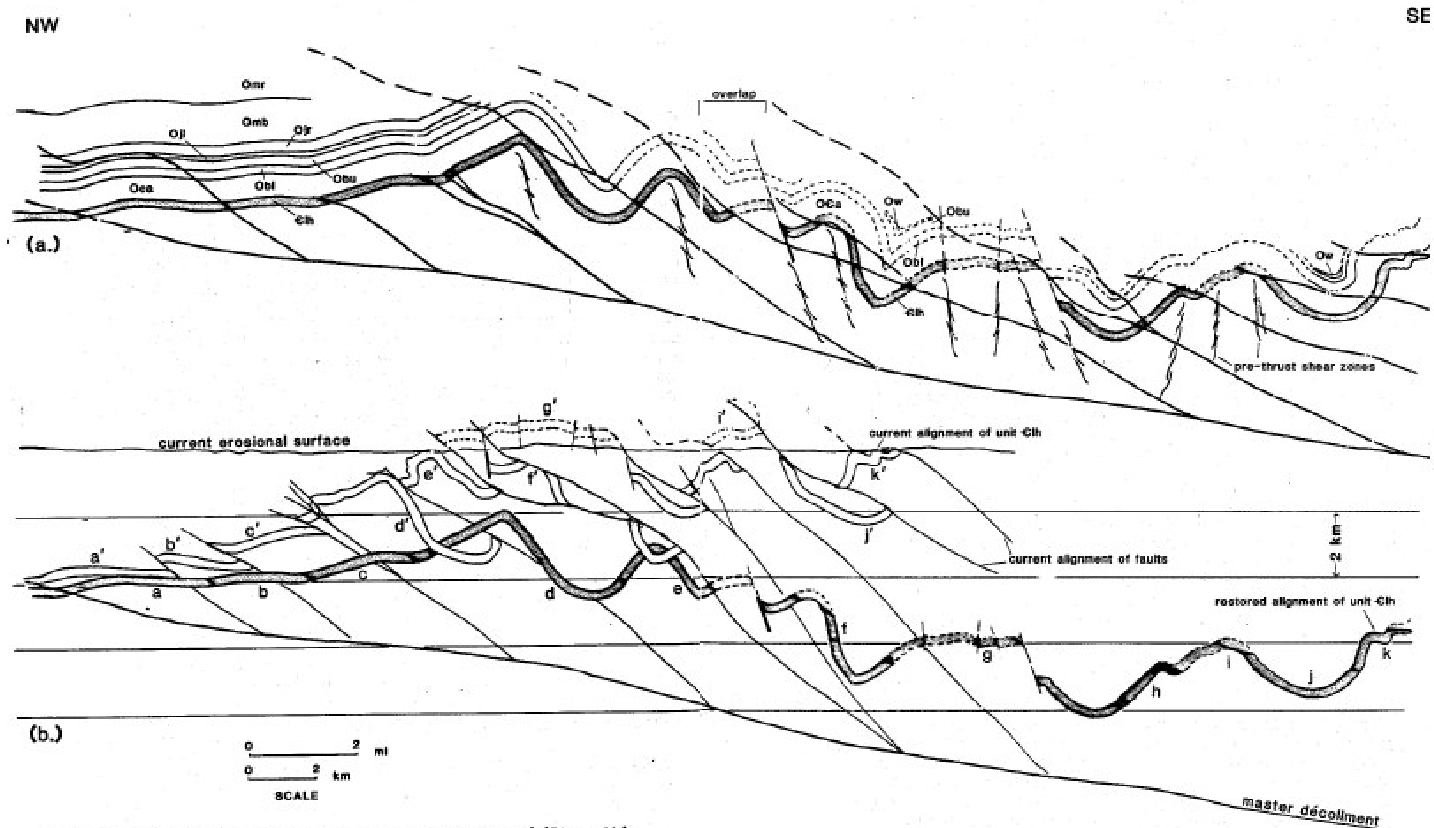
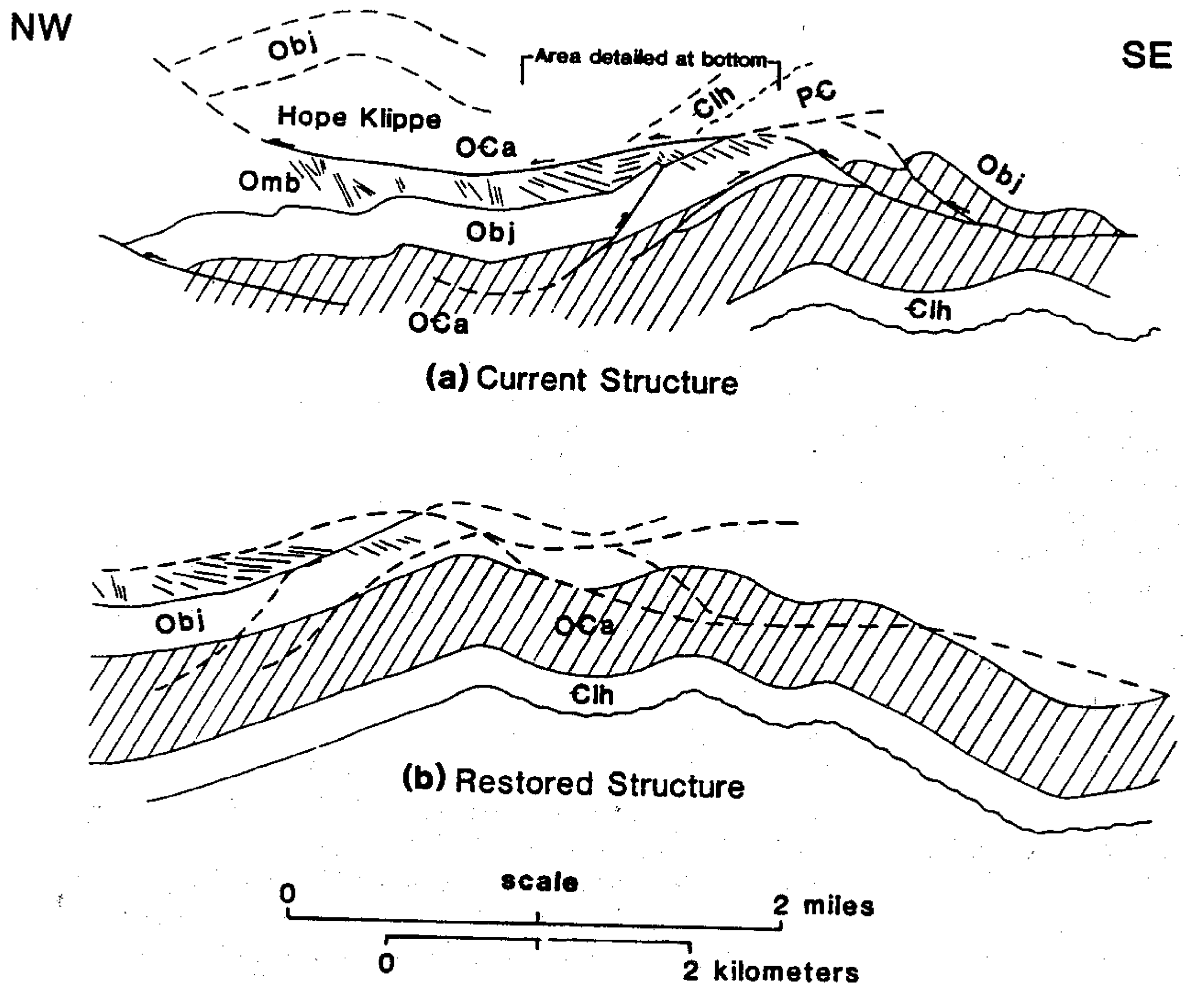


Figure 12 (a.) Restored structure of cross-section D-D′ (Plate 2b)
(b.) Structural relief diagram comparing Єlh unit for current and restored alignments



Adapted from

An Outline of Balanced Cross-Sections, 1985, Woodward, N.B., Boyer, S.E., and Suppe, John, University of Tennessee, Short Course on Balanced Cross Sections sponsored by the Structural Geology and Tectonics Division of the Geological Society of America Annual Meeting, Orlando, Florida, November.

Herman, G. C., and Monteverde, D. H., 1989, Tectonic framework of Paleozoic rocks of northwestern New Jersey; Bedrock structure and balanced cross sections of the Valley and Ridge province and southwest Highlands area: *in* Grossman, I. G., ed., Paleozoic Geology of the Kittatinny Valley and Southwest Highlands Area, N.J., Sixth Annual Meeting of the Geological Association of New Jersey, Trenton, N. J., p. 1-57.

Herman, G.C. 1984,

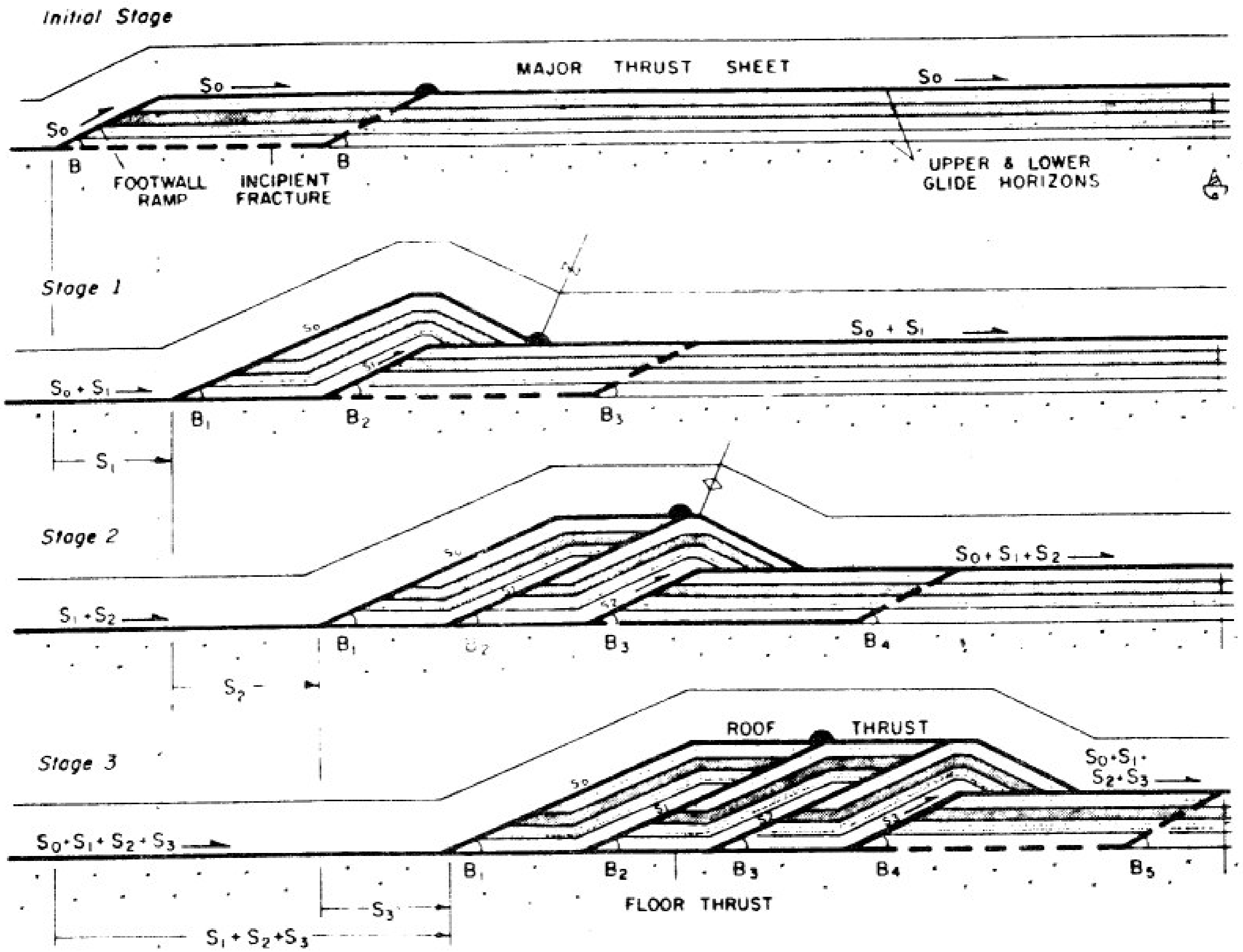


Figure 18 Progressive collapse of footwall ramp builds up the duplex. This is a measured graphical experiment, assuming plane strain and kink folding, with angles and ratios of dimensions typical of natural examples. Roof thrust sheet undergoes a complex sequence of folding and unfolding, seen by following black half dot (from Boyer and Elliott, 1982).

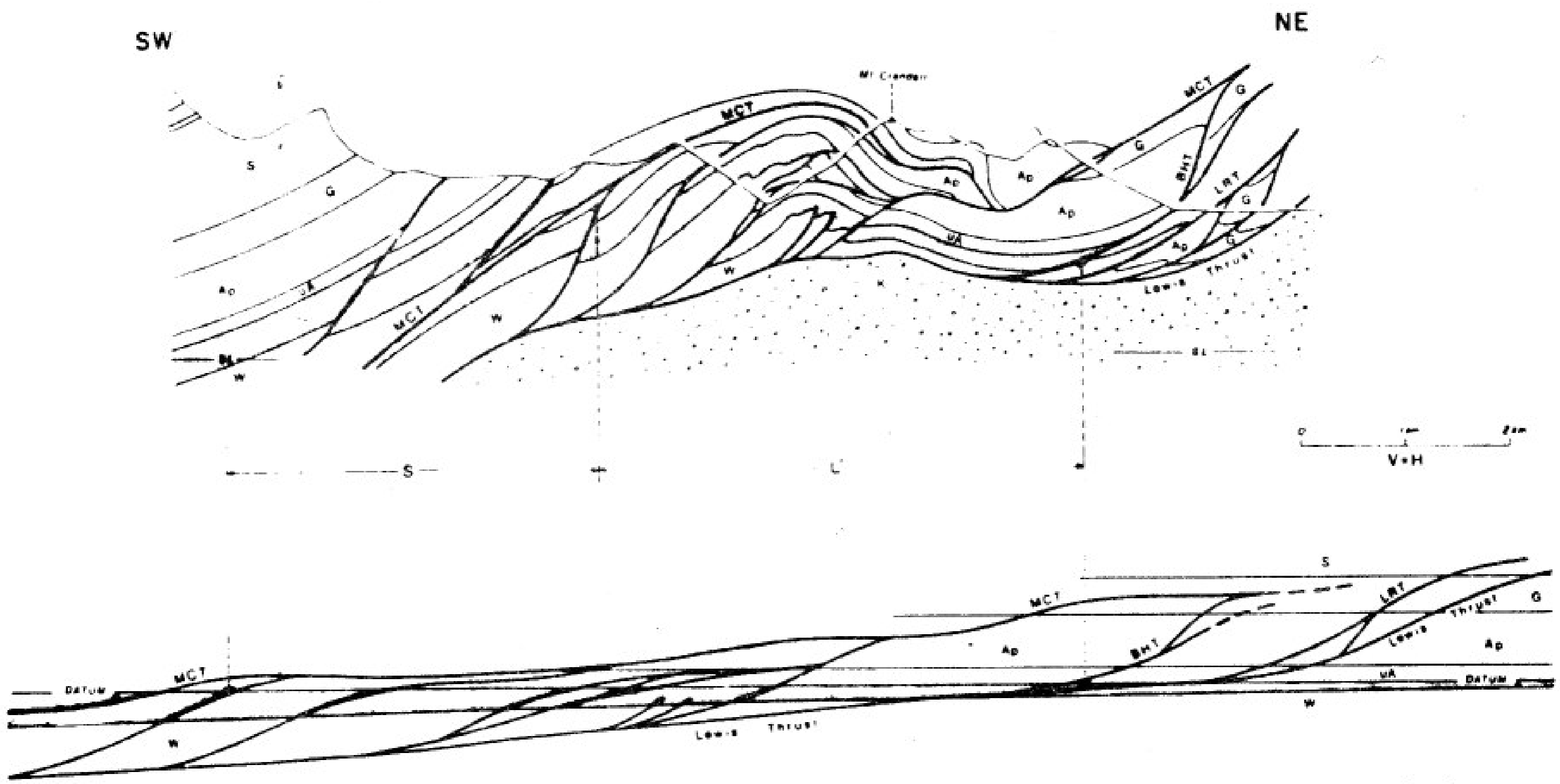
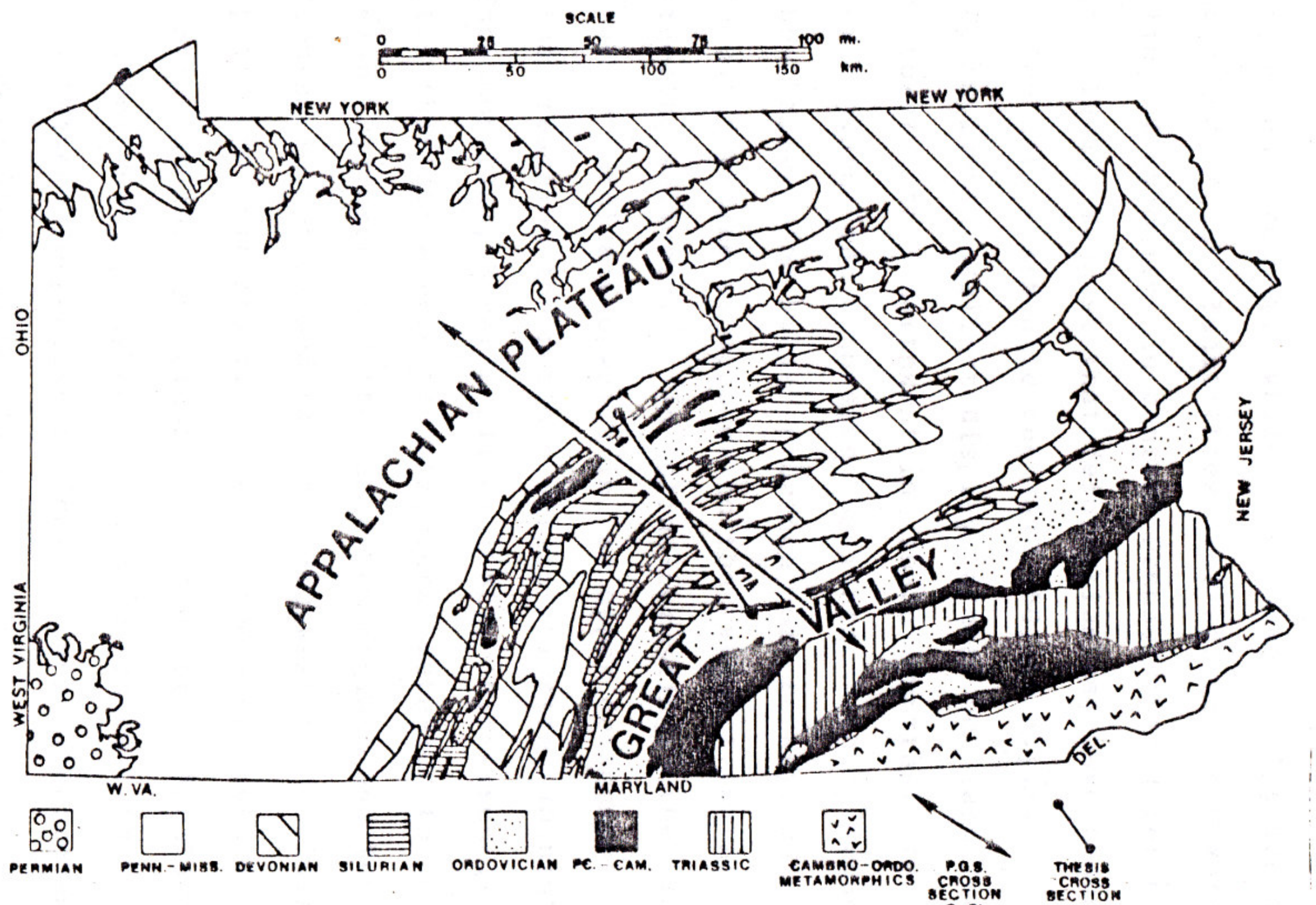


Figure 19 Precambrian Belt Supergroup, comprising Waterton (W), lower Altyn (fine stipple), mid and upper Altyn (uA), Appekunny (Ap), Grinnell (G), and Siyeh (S), is thrust over Cretaceous siliciclastics (K, with pebble pattern) by Lewis thrust. Mount Crandell thrust (MCT) is roof and Lewis thrust is floor to duplex, and folded horse just northwest of Mount Crandell suggests that duplex developed toward foreland. Cross section is balanced (with current distance L' between points recording a shortening of S), and is based on excellent control provided by over 2 km of local relief (Modified from Douglas 1952 from Boyer and Elliott, 1982).

FIGURE 1

GEOLOGIC MAP OF PENNSYLVANIA



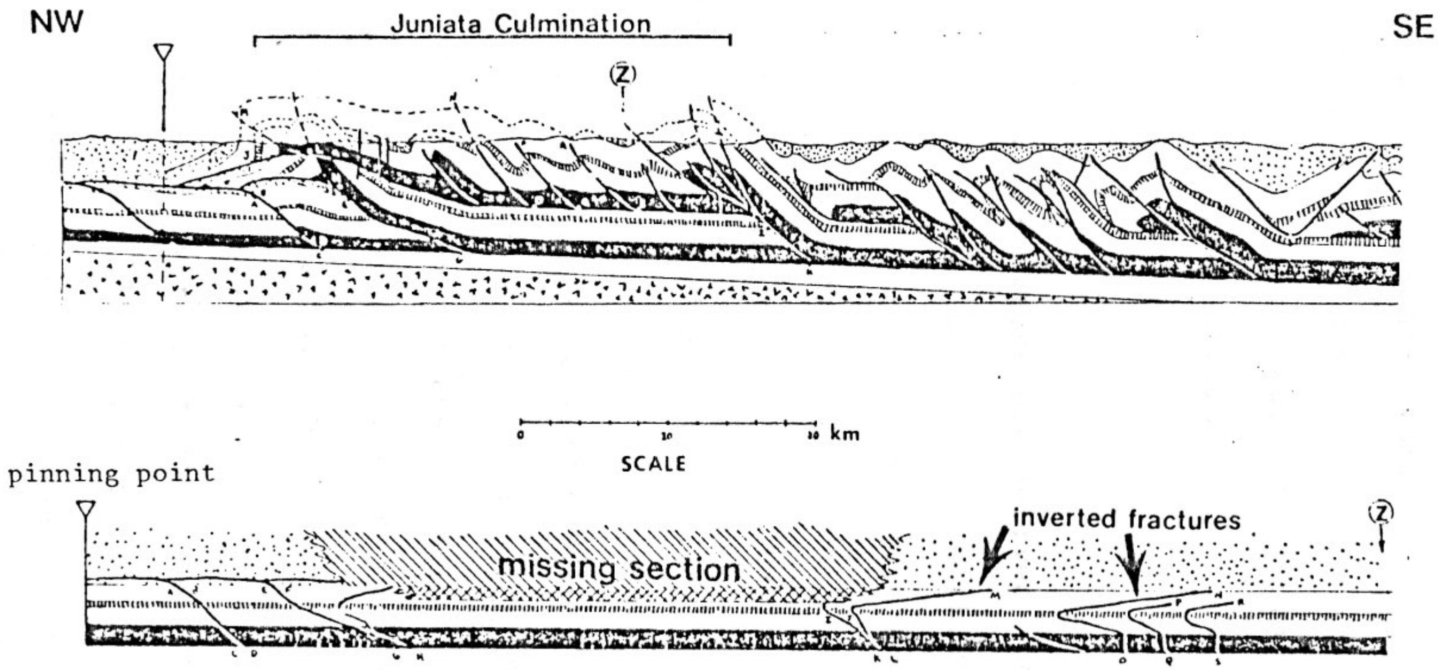
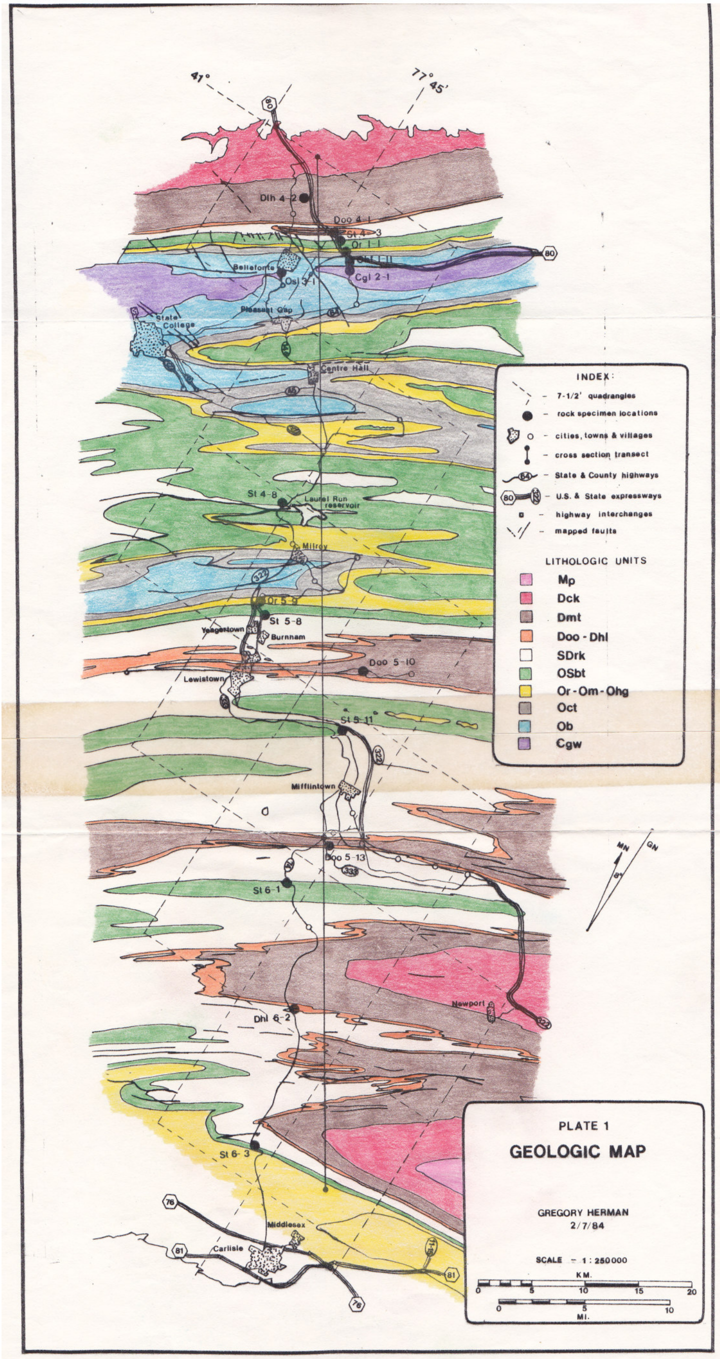
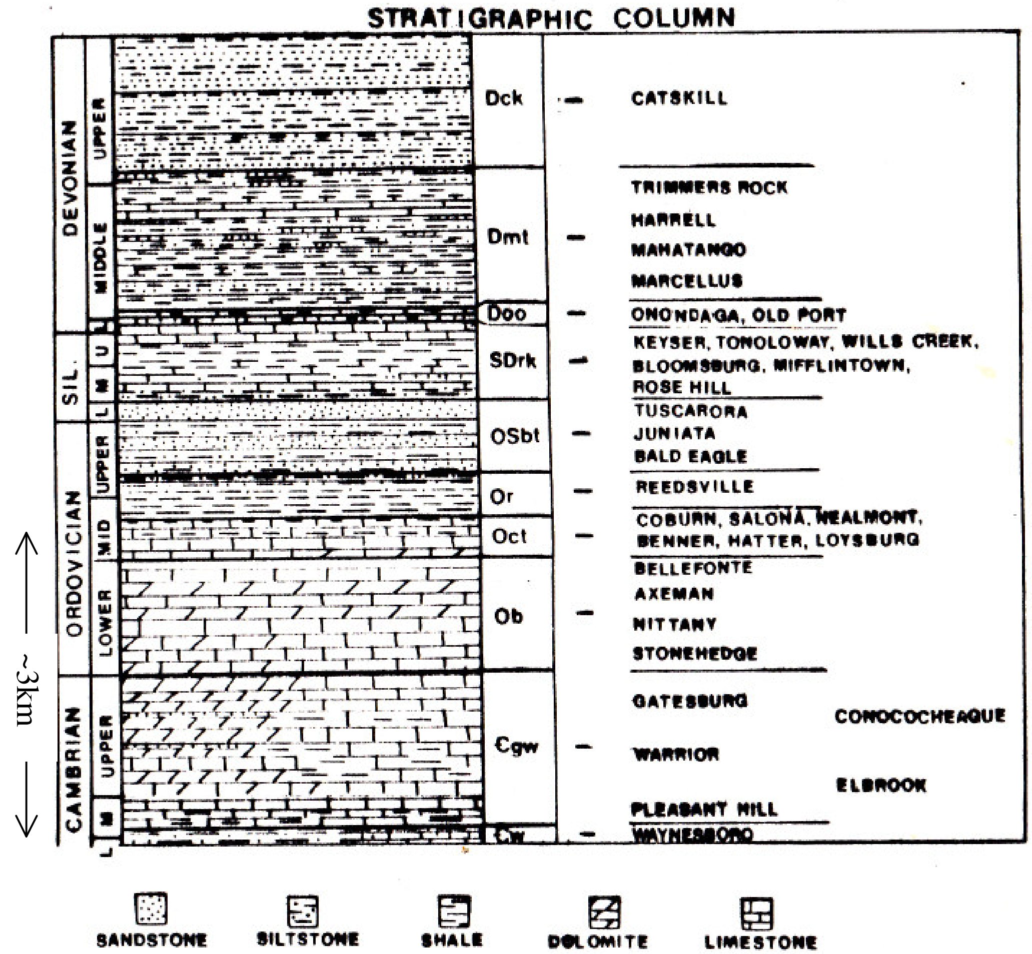
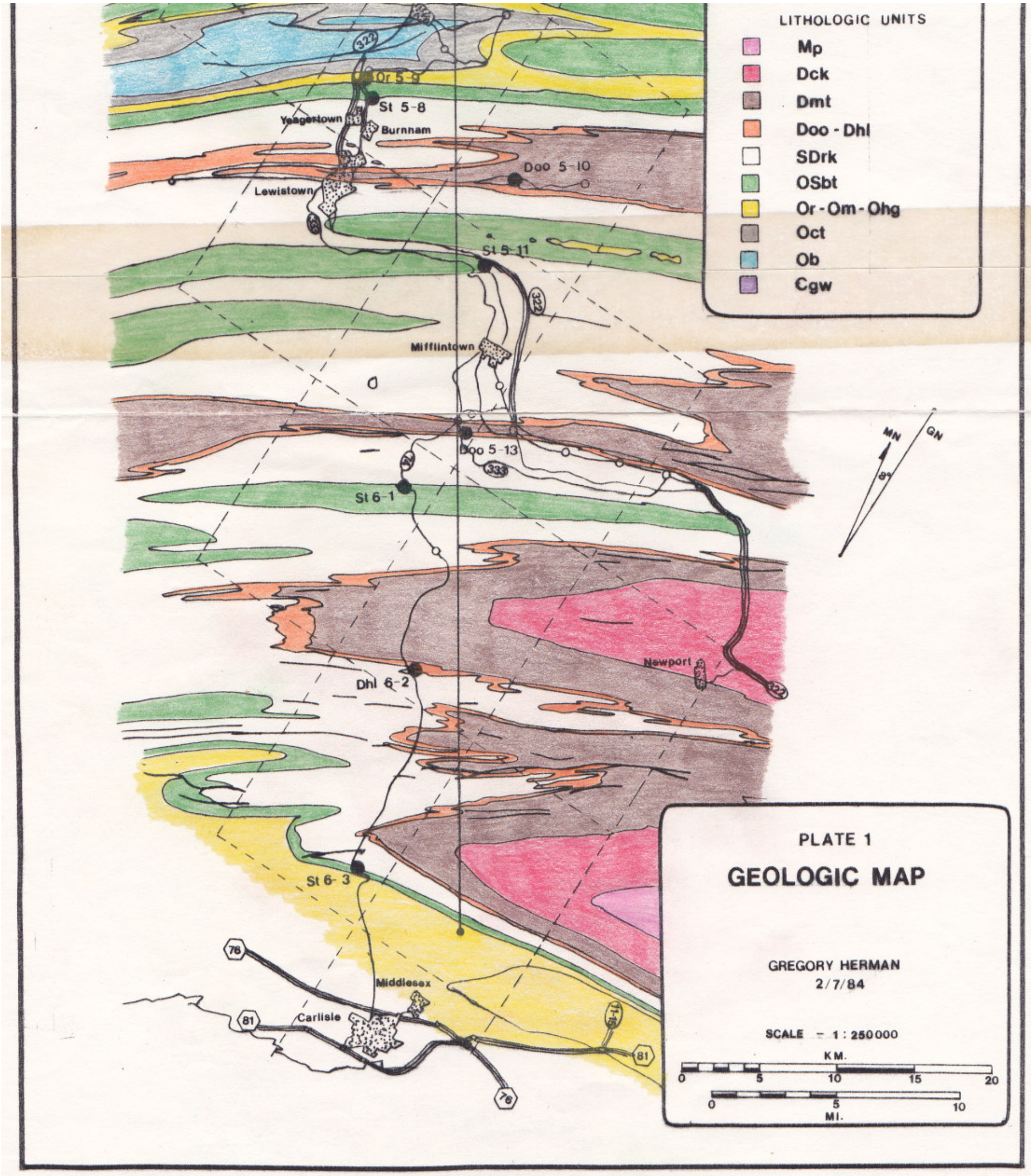


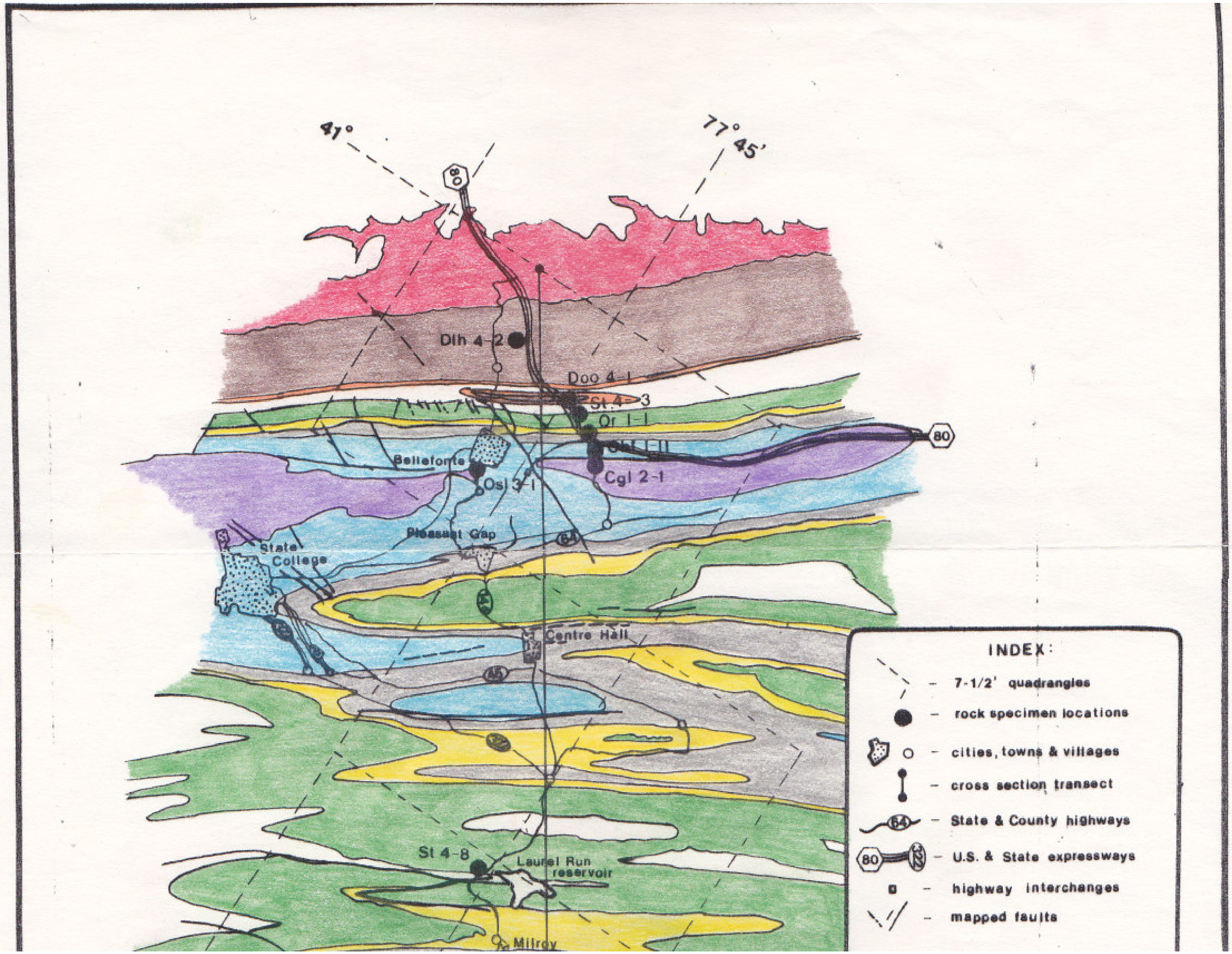
Figure 10. - Part of P.G.S. cross section c-c' - current and restored state

Note the 'flat-on-flat' solution for the Juniata Culmination in the current state and the inverted fracture array pattern and missing section in the restored diagram.

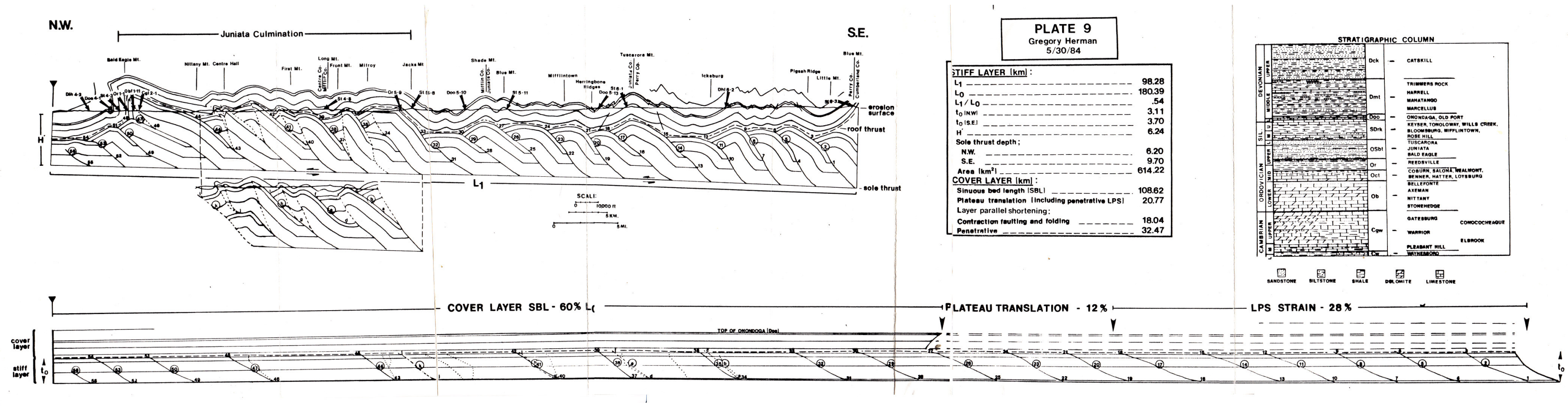

INDEX:
7-1/2' quadrangles
rock specimen locations
cities, towns & villages
cross section transect
State & County highways
U.S. & State expressways
highway interchanges
mapped faults
LITHOLOGIC UNITS
Mp
Dck
Dmt
Doo - Dhl
SDrk
OSbt
Or - Om - Ohg
Oct
Ob
Cgw
PLATE 1
GEOLOGIC MAP
GREGORY HERMAN
2/7/84
SCALE = 1 : 250000
KM.
MI.

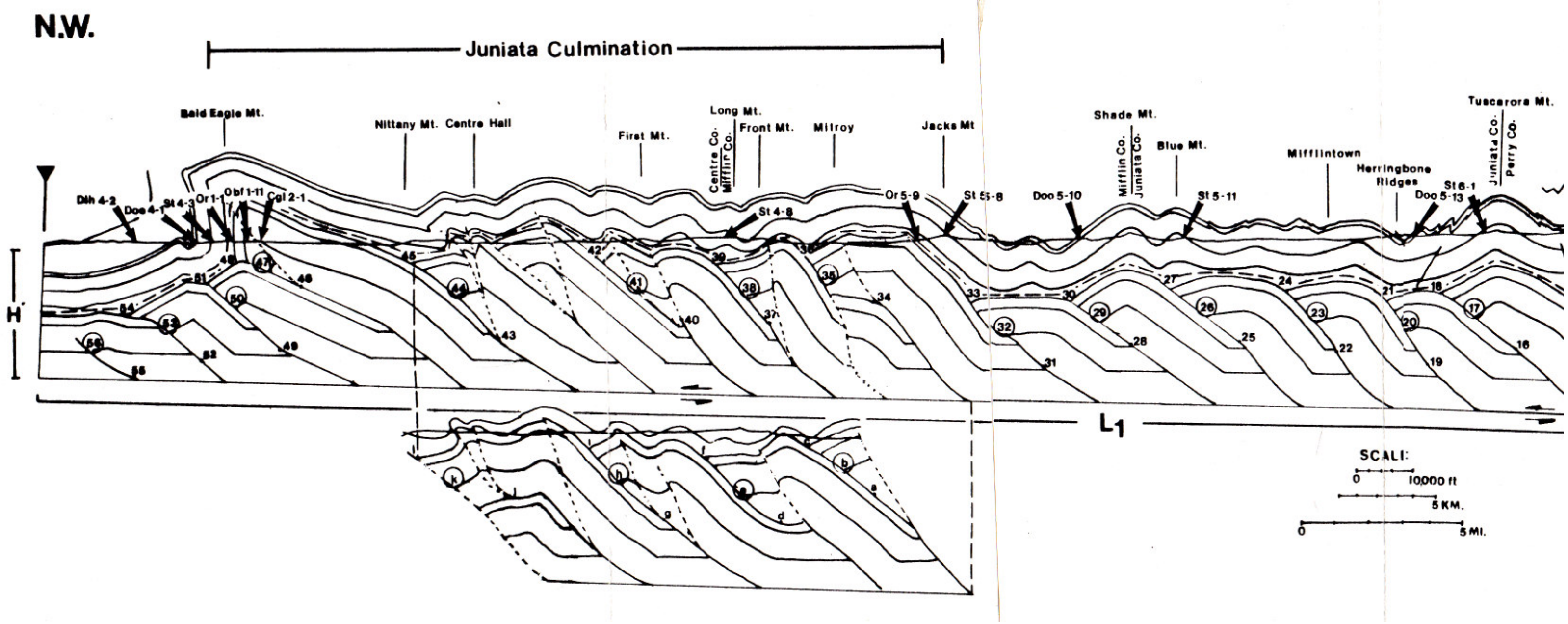

STRATIGRAPHIC COLUMN
~3km
DEVONIAN
UPPER
MIDDLE
SIL.
ORDOVICIAN
LOWER
CAMBRIAN
Dck
CATSKILL
TRIMMERS ROCK
HARRELL
Dmt
MAHATANGO
MARCELLUS
Doo
ONONDAGA, OLD PORT
KEYSER, TONOLOWAY, WILLS CREEK,
SDrk
BLOOMSBURG, MIFFLINTOWN,
ROSE HILL
TUSCARORA
OSbt
JUNIATA
BALD EAGLE
Or
REEDSVILLE
Oct
COBURN, SALONA, NEALMONT,
BENNER, HATTER, LOYSBURG
BELLEFONTE
AXEMAN
Ob
NITTANY
STONEHEDGE
GATESBURG
CONOCOCHEAQUE
Cgw
WARRIOR
ELBROOK
PLEASANT HILL
Cw
WAYNESBORO
SANDSTONE
SILTSTONE
SHALE
DOLOMITE
LIMESTONE

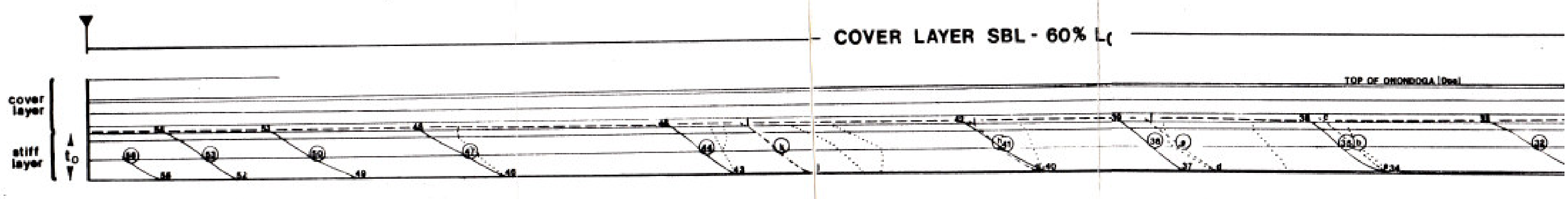

LITHOLOGIC UNITS
Mp
Dck
Dmt
Doo - Dhl
SDrk
OSbt
Or - Om - Ohg
Oct
Ob
Cgw
Or 5-9
St 5-8
Yeagertown
Burnnam
Doo 5-10
Lewistown
St 5-11
322
Mifflintown
Doo 5-13
333
St 6-1
MN
GN
Newport
Dhl 6-2
St 6-3
76
Middlesex
Carlisle
81
PLATE 1
GEOLOGIC MAP
GREGORY HERMAN
2/7/84
SCALE = 1 : 250000
KM.
0
5
10
15
20
0
5
10
MI.

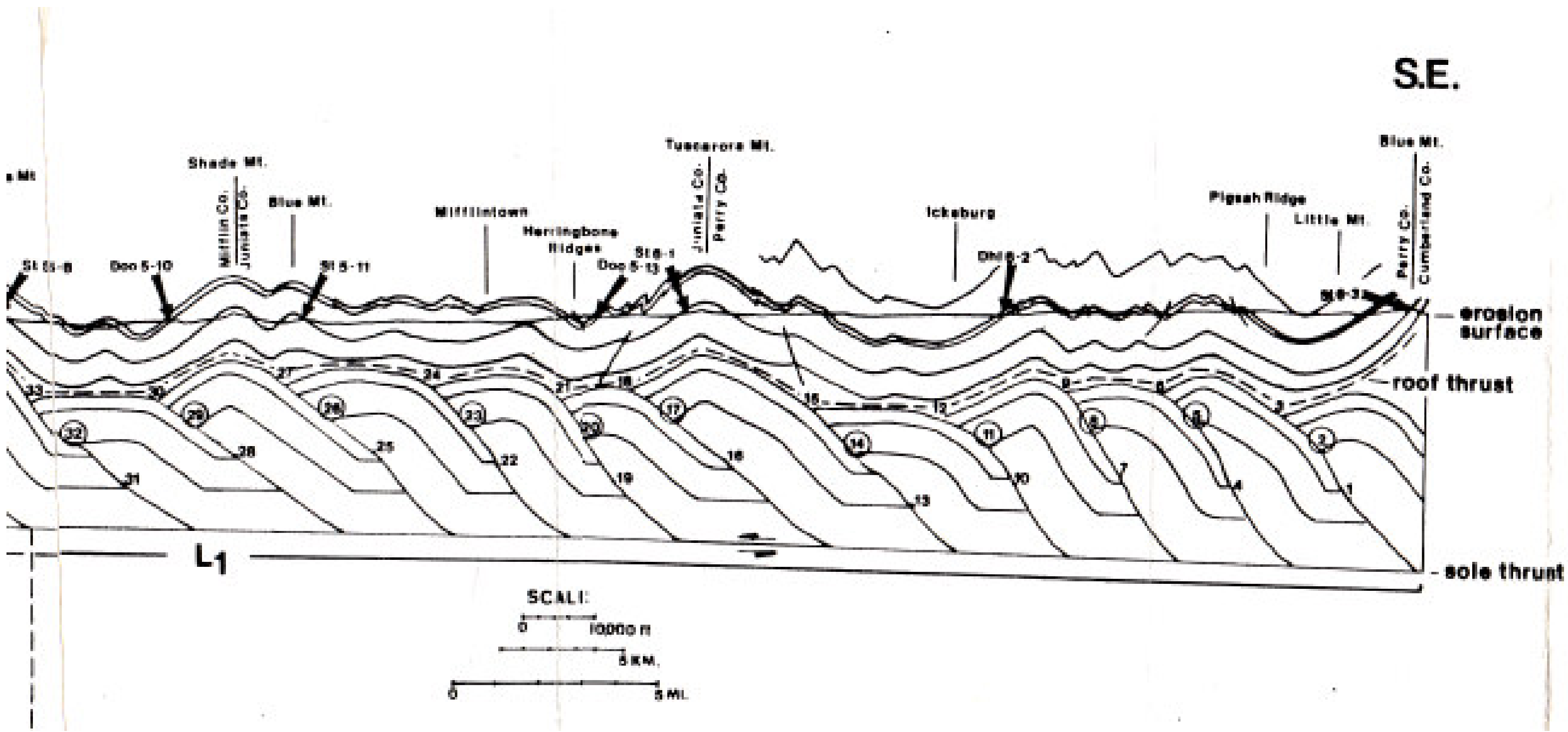

41°
77° 45'
80
Dlh 4-2
Doo 4-1
St 4-3
Or 1-1
Bellefonte
Osl 3-1
Cgl 2-1
80
Pleasant Gap
State College
64
Centre Hall
45
St 4-8
Laurel Run reservoir
Milroy
INDEX:
7-1/2' quadrangles
rock specimen locations
cities, towns & villages
cross section transect
State & County highways
U.S. & State expressways
highway interchanges
mapped faults

PASSIVE ROOF BLIND-THRUST DUPLEX




N.W.
Juniata Culmination
Bald Eagle Mt.
Nittany Mt.
Centre Hall
First Mt.
Long Mt.
Front Mt.
Milroy
Jacks Mt
Shade Mt.
Blue Mt.
Mifflintown
Herringbone Ridges
Tuscarora Mt.
Centre Co.
Mifflin Co.
Juniata Co.
Perry Co.
H
L1
SCALE:
10,000 ft
5 KM.
5 MI.


COVER LAYER SBL - 60% L
TOP OF ONONDOGA (Doo)
cover layer
stiff layer
t0


S.E.
Shade Mt.
Blue Mt.
Mifflintown
Herringbone Ridges
Tuscarora Mt.
Juniata Co.
Perry Co.
Mifflin Co.
Ickesburg
Pisgah Ridge
Little Mt.
Blue Mt.
Perry Co.
Cumberland Co.
Doe 5-10
erosion surface
roof thrust
sole thrust
L_1
SCALE
10000 ft
5 KM.
5 MI.

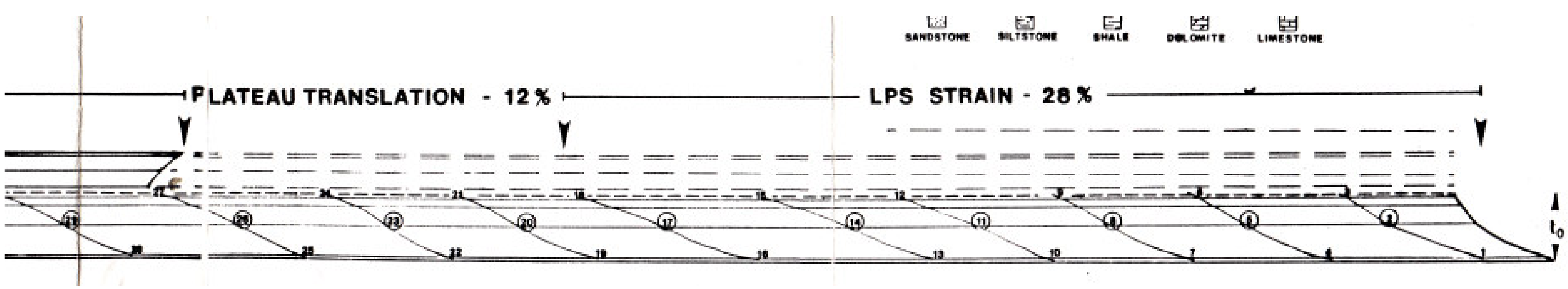
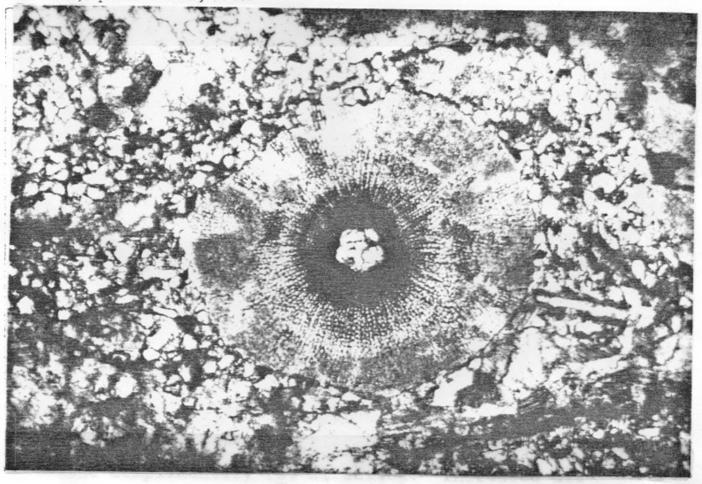

SANDSTONE
SILTSTONE
SHALE
DOLOMITE
LIMESTONE
PLATEAU TRANSLATION - 12 %
LPS STRAIN - 28 %
t_0

Plate 2
bedding plane

Or 1-1, plane lt., 10X



a

strike (b)

1 mm.

Or 5-9, plane lt., 10X

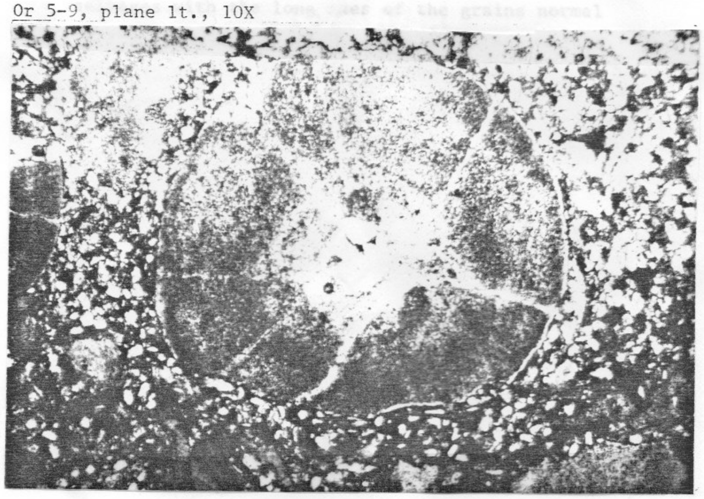


TABLE 3

Crinoid columnal measurements

Sample	Axial ratios (b:a)	Sample	Axial ratios (b:a)
Or 5-9	9.5:9.1 - 1.04	Or 1-1	9.0:8.6 - 1.05
"	8.7:8.0 - 1.09	"	8.2:7.7 - 1.06
"	9.6:9.1 - 1.05	"	7.3:7.0 - 1.04
"	9.8:9.3 - 1.05	"	7.3:6.1 - 1.20
Or 1-1a	9.5:9.1 - 1.04	"	8.8:8.5 - 1.04
"	10.0:9.5 - 1.05	"	9.0:8.8 - 1.02
"	9.0:8.5 - 1.06	"	10.1:9.5 - 1.06
"	11.8:9.8 - 1.20	"	6.5:5.9 - 1.10
"	10.2:9.7 - 1.05	"	6.8:6.6 - 1.03
"	9.0:7.7 - 1.17	"	7.5:6.4 - 1.17
"	7.6:7.3 - 1.04	"	6.0:5.5 - 1.09
"	16.0:13.0- 1.23	"	1.0:1.0 - 1.00
		"	8.7:8.3 - 1.05

range: 1.00 - 1.23
mean: 1.08
mode: 1.05

Note: the axial lengths are relative lengths from the graduated cross hairs of the occular lens.

Error in measurement resulting from columnal inclination to plane of measurement:

Average columnal width: 0.7 mm.
Average columnal diameter: 2.8 mm.

Maximum error results at maximum inclination ($\emptyset$ = Cot .7/2.8 = 14.04°).

At 14.04° inclination, the apparent diameter = 2.8/Cos $\emptyset$ = 2.89.

An apparent diameter of 2.89 equals an apparent columnal axial ratio of 1.03 (2.89:2.80). The maximum error resulting from measuring an inclined columnal is thus taken to be .03.

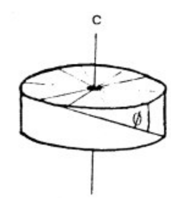


Plate 5
ac-plane

St 5-8, plane lt., 40X

c
a

0.1 mm

St 4-3, plane lt., 40X

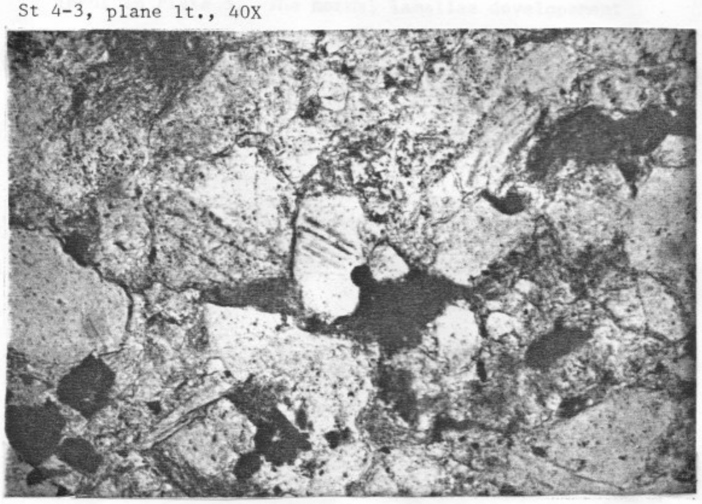
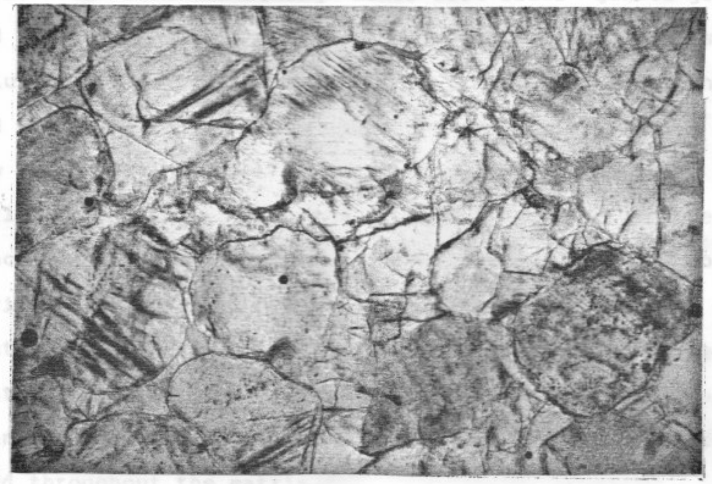


Plate 6
ac-plane

St 6-3, plane lt., 40X



c
a

0.1 mm

St 6-3, x-nicols, 40X

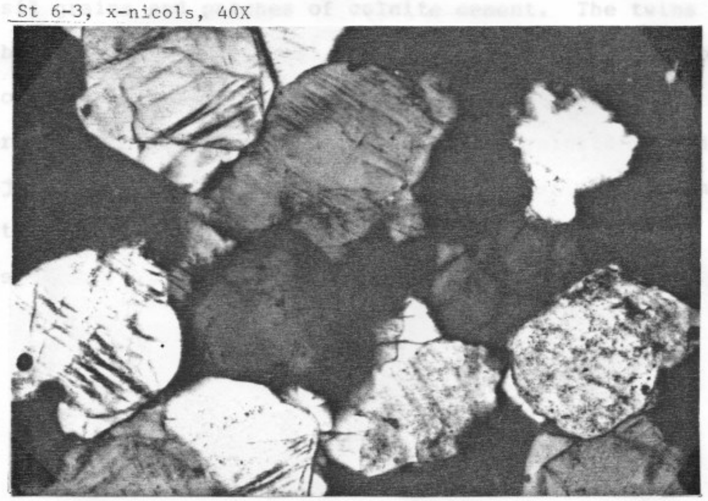
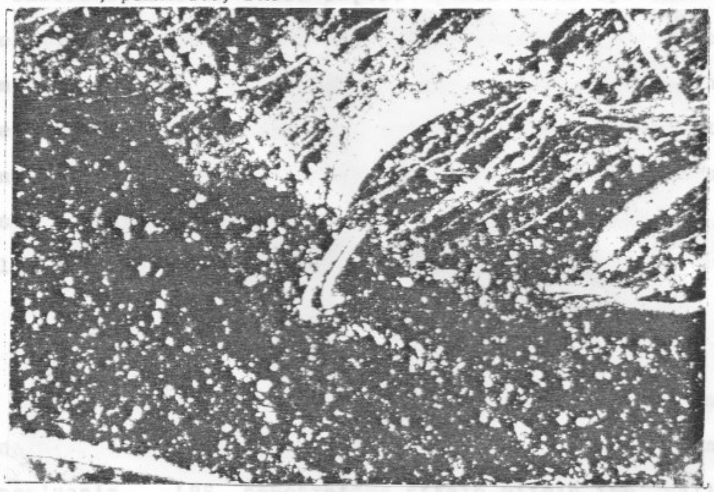


Plate 8
ac-plane

Doo 4-1, plane lt., 10X

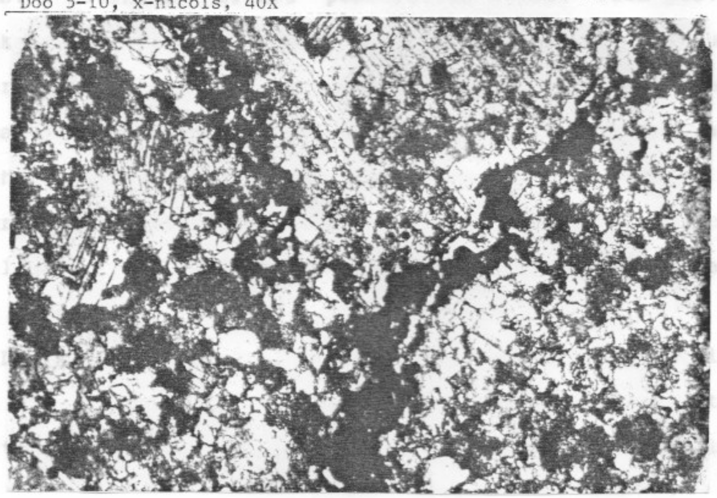


c
a

1 mm

0.1 mm

Doo 5-10, x-nicols, 40X



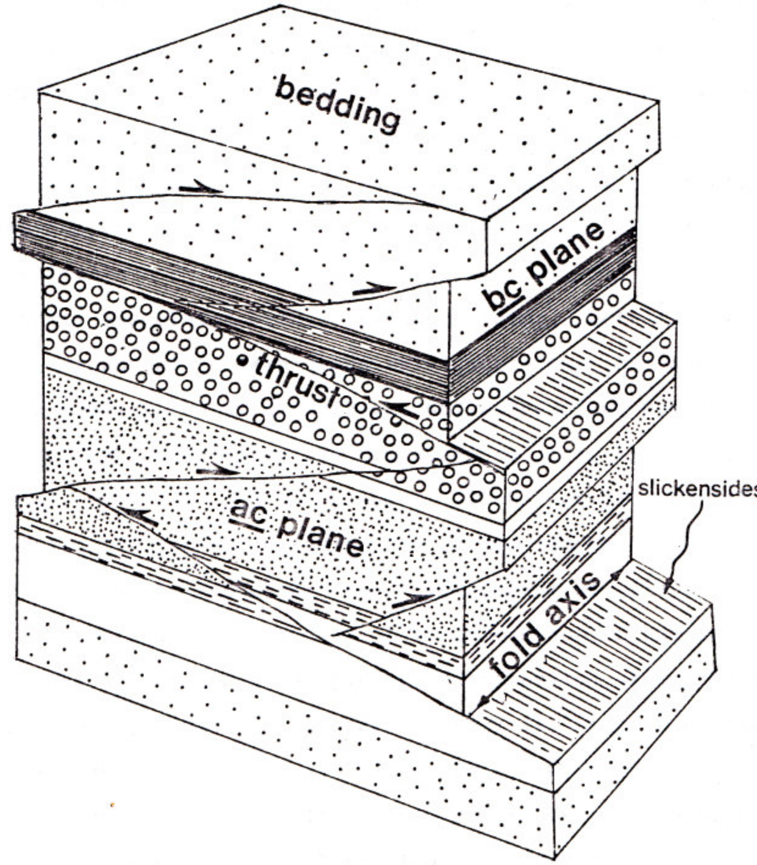


Figure 4. - Diagram showing wedge faulting and the structural coordinate system

Modified from Cloos and Broedel (1943, p. 1381). The inward movement of wedges has contracted and heightened the block.

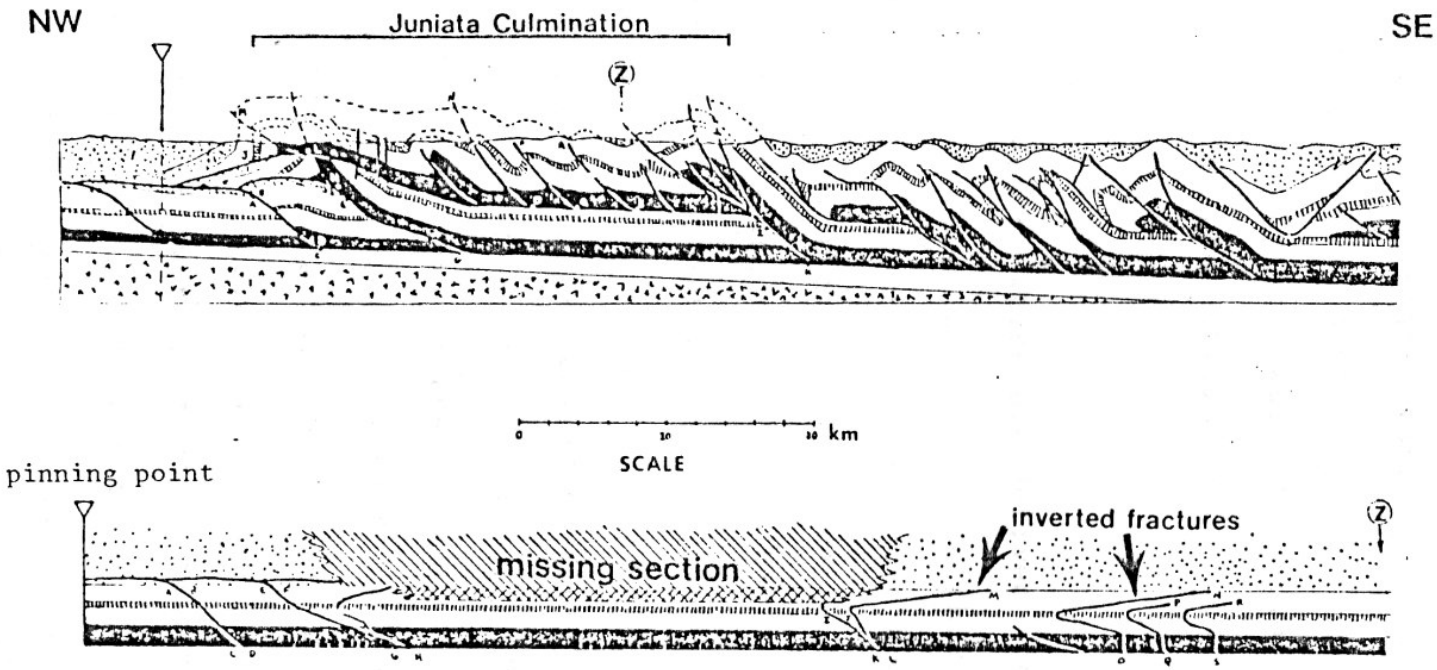
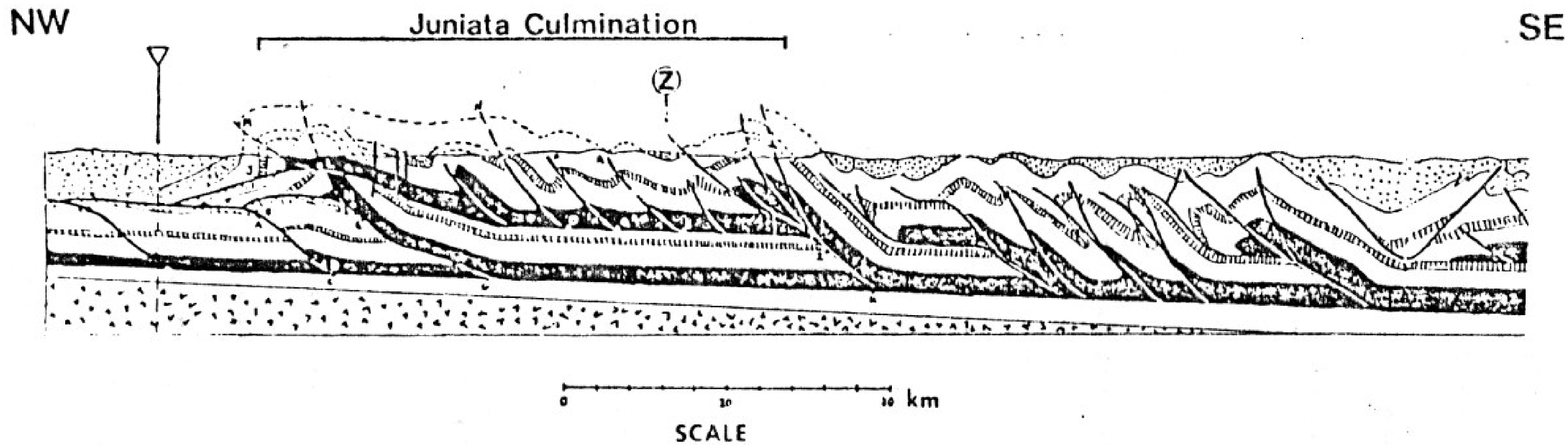


Figure 10. - Part of P.G.S. cross section c-c' - current and restored state

Note the 'flat-on-flat' solution for the Juniata Culmination in the current state and the inverted fracture array pattern and missing section in the restored diagram.


NW
Juniata Culmination
SE
Z
0
10
30 km
SCALE

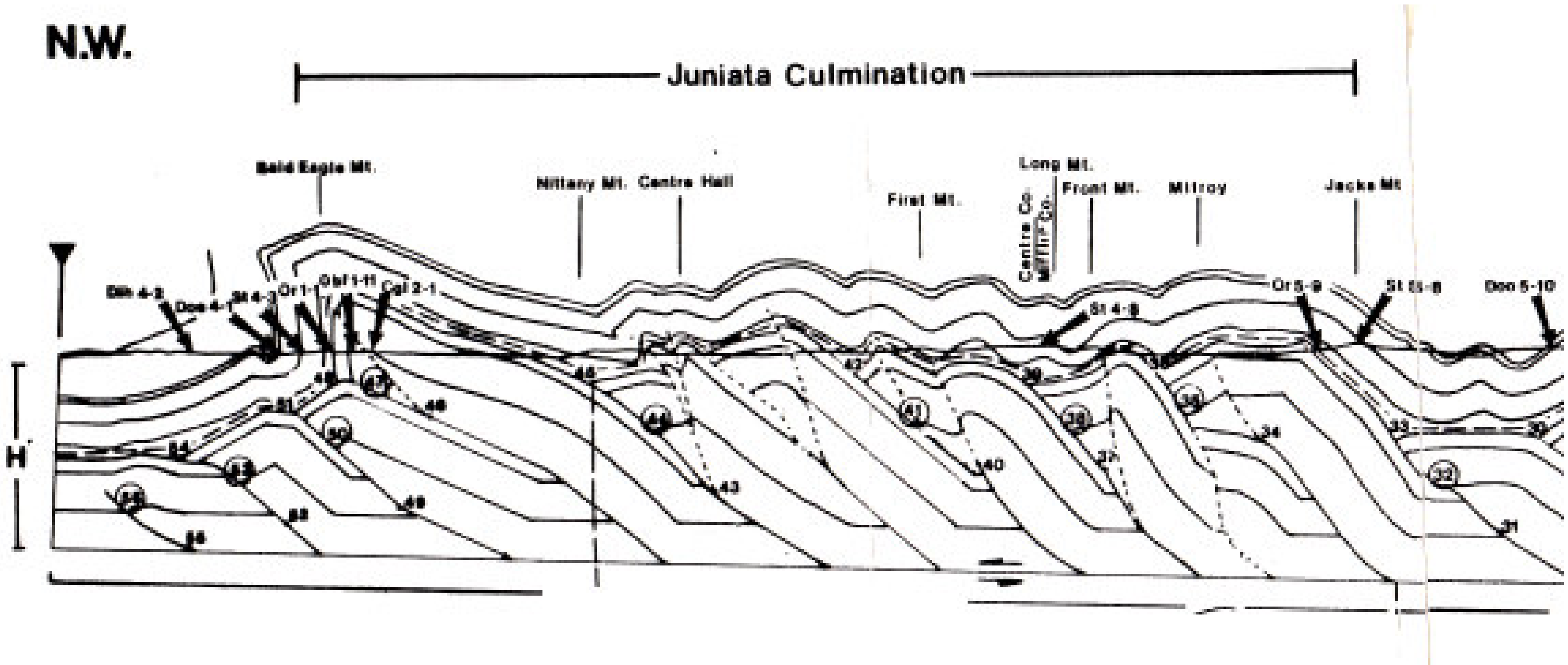
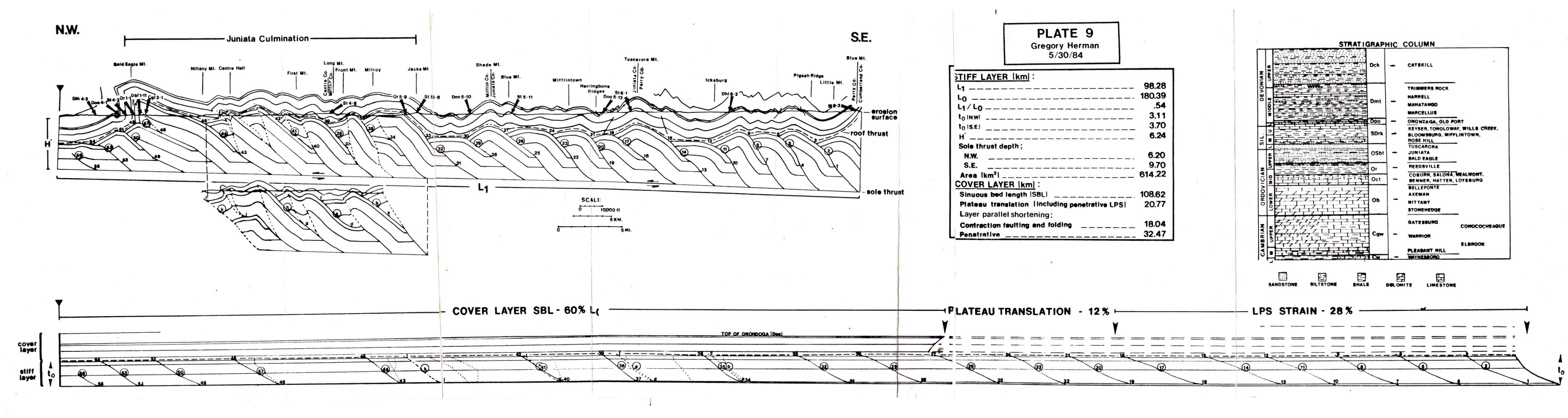

N.W.
Juniata Culmination
Bald Eagle Mt.
Nittany Mt.
Centre Hall
First Mt.
Long Mt.
Centre Co.
Mifflin Co.
Front Mt.
Milroy
Jacks Mt
H

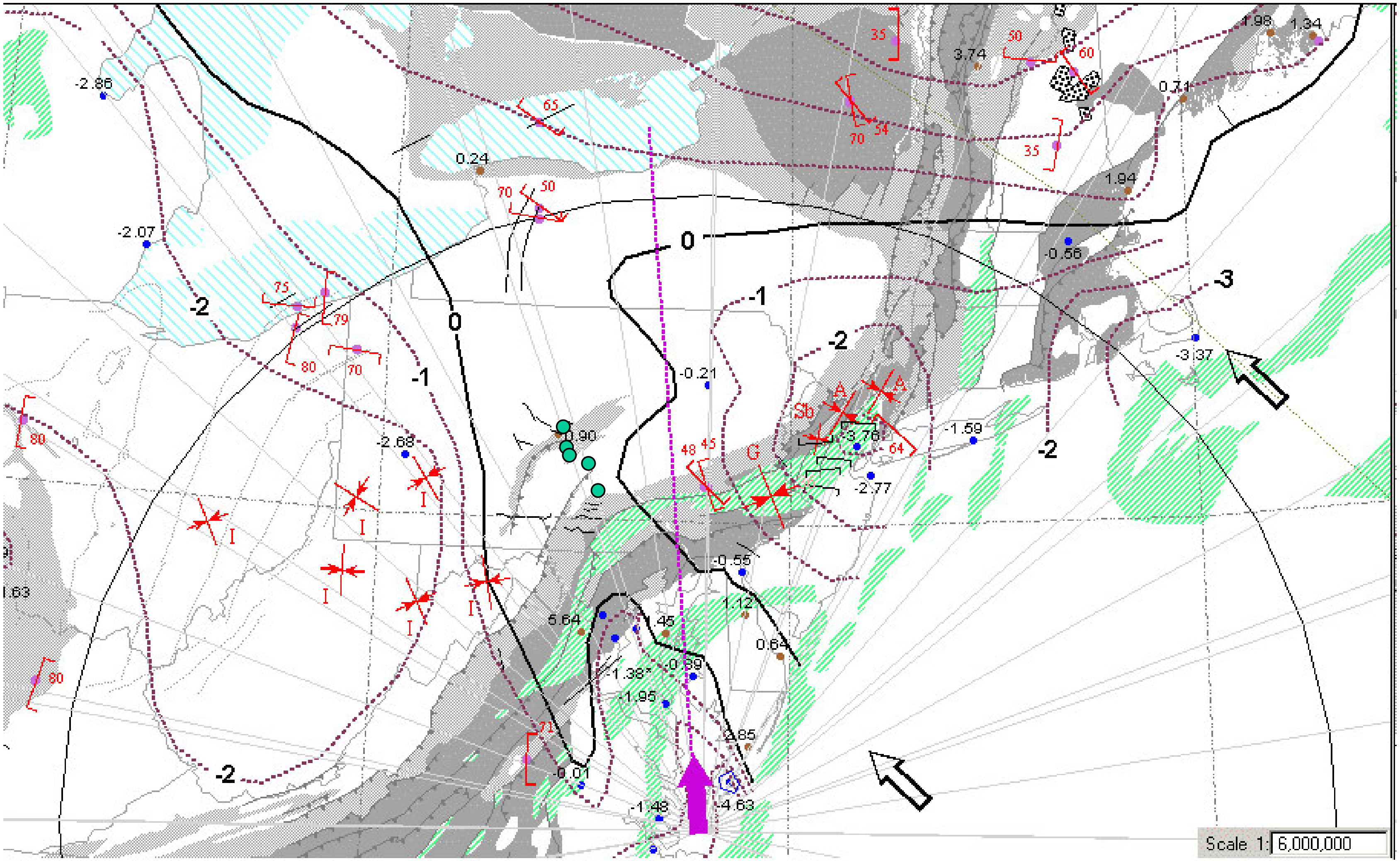
PLATE 9
Gregory Herman
5/30/84

STIFF LAYER (km):	
L_1	98.28
L_0	180.39
L_1 / L_0	.54
t_0 (N.W)	3.11
t_0 (S.E)	3.70
H′	6.24
Sole thrust depth;	
N.W.	6.20
S.E.	9.70
Area (km²)	614.22
COVER LAYER (km):	
Sinuous bed length (SBL)	108.62
Plateau translation (including penetrative LPS)	20.77
Layer parallel shortening:	
Contraction faulting and folding	18.04
Penetrative	32.47

Stiff layer:
180 km - 82 km
contraction & translaiton

Cover layer:
180 km = 108 sbl +20 pt
+18 cf +32 pLPS





Neotectonic map of the eastern USA, mid-Atlantic region showing generalized bedrock geology, isopleth contours of current, vertical crustal motions based on GPS data (NASA JPL), the direction of current, horizontal plate motions (black open arrows), the interpreted direction of impact for the Chesapeake Invader (purple arrow), structural contours for the top of preCambrian basement in Ohio (Ohio Geological Survey), the direction of the contemporary, horizontal component of crustal stress based on underground mine roof spalls (I), earthquake focal mechanism solutions (G, Sb, and A), shear planes based on seismic stress tensors (red structure symbols with dip values), and late-stage shear fractures in the Newark basin (black structure symbols from OPTV borehole analyses). Green hatchured polygons are Early Mesozoic extensional basins, dark-gray polygons are preCambrian rocks, and light gray polygons are Lower Paleozoic rocks. Some Great Lakes are shown with light-blue hatchures. GPS stations are color coded blue for negative vertical motions and brown for positive, respectively. Station numbers and motion isopleth values in mm/yr.

Unpublished map by G.C. Herman, NJ Geological Survey 3/13/2008