

## GEOLOGIC STRUCTURE OF THE KINGSTON ARC OF THE APPALACHIAN FOLD BELT

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The Appalachian orogen when observed in its areal extent from Alabama to Newfoundland shows in its pattern a series of arcs, some bowed northwestward toward the foreland, others bowed inward toward the eugeosynclinal belt. One of the more prominent of these arcs, bowed eastward and southeastward toward the crystalline core of New England, is located at Kingston, New York, its hing-zone being situated in the old Rondout and Wilbur districts of the City of Kingston. The western extremity of the arc lies in the vicinity of Rosendale, and in its northern extension continues to the environs of East Kingston and the Kingston-Rhinecliff Bridge on the Hudson River.

The type of deformation evident within the Kingston Arc may be of some interest to the structural geologist and the purpose of this field trip is to observe the geologic structure at several localities where exposures are favorable.

The scheduled stops are as follows:

- STOP I: The Nytralite Quarry, Route 32, Fly Mountain, about three quarters of a mile west of Kingston.
- STOP II: (a) Callanhan's Quarry, south of Rondout Creek, opposite Wilbur in Kingston, 5.2 miles from the Nytralite Quarry;  
(b) West Shore R.R. cut about one quarter mile east of Callanhan's Quarry.
- STOP III: The series of road cuts along Route 199 three miles north of Kingston.
- STOP IV: Outcrops at Glenerie Falls, Route 9W about 6.3 miles north of Kingston.

TABLE I.  
 AN ABBREVIATED AND SIMPLIFIED SEQUENCE OF THE ROCK  
 UNITS EXPOSED IN THE KINGSTON ARC SECTOR  
 (compiled from Chadwick (1933), Johnsen (1962), Oliver (1962),  
 Rickard (1962), Van Ingen (1903).

DEVONIAN

<u>Rock Unit</u>	<u>Thickness in Feet</u>
Onondaga Formation	
Five subunits of differing carbonate lithology .....	165+
Schoharie Formation	
Transition zone of clastic carbonate rock .....	220
Esopus Shale	
Massive silty shale, black to olive-brown .....	150
Glenerie Formation	
Siliceous limestones and/or sandstones .....	60
Port Ewen Limestone	
Dark gray siliceous and argillaceous limestone .....	140
Alsen Limestone	
Light gray limestone .....	20
Becraft Limestone	
Massive, semi-crystalline limestone .....	40
New Scotland Limestone	
Dark gray shaly limestone .....	100
Kalkberg Limestone	
Massive, dark gray argillaceous limestones and chert beds .....	38
Coeymans Limestone	
Dark gray massive limestone .....	13
Manlius Limestone	
Fine to medium-grained dark blue limestone .....	48

SILURIAN

Rondout Limestone	
Argillaceous dolomite to fine-grained limestone .....	39
Binnewater Sandstone	
Blue-gray quartz sandstone .....	0 to 13
	angular unconformity

ORDOVICIAN

"Hudson River Beds" (Normanskill and/or Martinsburg)	
Gray, gray-brown shales and sandstones .....	1000+

FIELD TRIP  
DESCRIPTION OF SCHEDULED STOPS  
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STOP I: The Nytralite Quarry on Route 32 is developed in the Esopus Shale. The operations of this company extend on both sides of the highway. Shale is trucked from the quarry floor to the crushers on the ridge of Fly Mountain, where the material is processed. It is then heated in the kiln, causing the shale to expand. A conveyor leads down the south side of Fly Mountain, where the expanded shale is loaded on barges in Rondout Creek to be carried down the Hudson River to markets in the New York City area. Trucks are used to carry the expanded shale to customers in the Mid-Hudson area.

Though the Esopus Shales are not highly resistant to erosion, in this area they commonly are minor ridge-makers. Where exposed, they show as massive blocks whose bedding is difficult to follow, but whose cleavage is readily apparent. The cleavage may therefore be easily mistaken for the bedding in an outcrop.

Both the cleavage and the extensive fracture pattern in the shales is reflected in details of the topography of the region. The strongly-cleaved shales are more easily eroded and the intersection of the cleavage with the accompanying joints results in the appearance of gently sloping planes dipping in various directions where the shales are exposed (Fig. 1 - The vertical lines indicate cleavage).

Where freshly exposed, the shales appear black, blue-black, or olive-brown. Often they show vertical white bands, a result of re-deposition on their cleavage surfaces of some of the minerals dissolved from the shale.

Weathering of the shales will often bring out color changes that emphasize the bedding planes. Occasional lenses or thin layers of other material, e.g., sand, help in the delineation of the bedding. Where the shales have been exposed to weathering, some of those having a greater lime content will show a grayer surface.

At this locality the beds are generally more gently dipping than the cleavage. The response of the shales to folding was not paramount; they show some flexures, but the continued impress of the deforming forces caused the shales to shear rather than to fold. Shear planes present in some cases cut across the cleavage. Where a conjugate set of shear fractures exist they are parallel to the cleavage (Fig. 3). The cleavage is generally parallel to the strike of the beds. However, it should be evident that strike joints will generally merge with the strong cleavage.

Occasional fossil shell fragments can be found in the shales. Nodules of pyrite are frequent.

STOP IIa: Callanhan's Quarry is in the village of Connelly south of Rondout Creek. From the quarry floor, facing northeast, approximately 170 feet of limestones have been exposed by the quarrying operation. There are three areas or "pits" where the quarrying operations take place all at varying distances from the northwest-southeast section line drawn across the quarry floor. In the accompanying section, the pits are labeled by number (Fig. 5).

The limestone, commercially known as "traprock", is crushed to different sizes after being blasted from the walls of the quarry. It is used primarily in various kinds of construction such as road metal for highways, and concrete aggregate for building construction. The Rondout Creek is used to transport bulk shipments of the material.

The limestones show three major high-angle reverse faults cutting through all

the beds exposed in the quarrying operation. There are numerous smaller faults. Looking to the southeast, one can see near-vertical faces of limestone. Bedding-surface slickensides are commonly seen in the quarry, for example, between the Alsen and Becraft units and within the New Scotland limestones.

The exposed southeast side of Pit 1 shows an extensive slickensided surface over much of its length. Also on this same surface and extending for many feet parallel to the slickensides are thick, rod-like mullion structures. The limestones in this pit are gently folded.

In Pit 2 there is an extensive fault zone which includes a major fault. Toward the southeast the quarry wall is near-vertical and shows extensive slickensides. There the beds are bent in a circular arc at the southeastern end of this section, and are folded synclinally.

The sharp folds are continued into Pit 3. Here the Becraft-New Scotland exposures are near vertical and show extensive slickensiding within the New Scotland beds.

STOP IIb: This stop is in the cut of the West Shore R.R. about one quarter mile east of Callanhan's Quarry. Near the road coming from the floor of the quarry to where it intercepts the railroad track there are exposures of the Hudson River sandstones. The contact of the Ordovician sandstones and the Silurian is not visible here. The Kalkberg and New Scotland beds can be seen just west of the railroad right-of-way. The Becraft limestone outcrop, to which an abandoned wagon trail leads, was mined in earlier years at this site. Many of the abandoned quarries in the Kingston area formerly exploited the Becraft or the Rondout limestones.

Of the quarrying operations the main evidence is a 100-foot shaft situated between the New Scotland and the Alsen through which the Becraft was removed. At the lowest part of the north wall in this shaft one can see part of the synclinal fold in the Becraft, which was also visible from the floor of Callanhan's Quarry. The railroad cut farther northward exposes the Port Ewen limestone (and its time-correlative deposits - the Connelly). The Port Ewen alternates with the Glenerie in exposures along the railroad tracks.

STOP III: This stop will be made along that section of Rt. 199 extending between Rt. 32 to Rt. 9W. (Approximately one quarter mile south of the entrance to Rt. 199 on Rt. 32 there is a good exposure of the angular unconformity between the Ordovician beds and overlying Silurian limestone). Along Rt. 199 the road cut exposes relatively gentle folding in the Devonian beds (Fig. 6). There are two low concealed areas in the section which are covered by swamp deposits and alluvium.

STOP IV: This stop is at Glenerie Falls and Rt. 9W approximately 6.3 miles north of Kingston. A plan view of the shear structures and the cleavage in the Glenerie Formation in this area is included (Fig. 4). The pattern which is shown in the plan view is seen as a side view where the Glenerie is visible along the highway. Some of the Glenerie exposures along the highway reflect the shear pattern so that the exposed blocks show as rectangles at times pointing toward the highway and at other times away.

The Esopus Creek which upstream meanders through its valley for several miles turns sharply to the east at Glenerie Falls and then flows north again at the foot of the Falls. Beyond, it continues between the confining Esopus Shales and the Glenerie, and has an approximately straight course almost to its mouth; it makes a bend at Saugerties and flows into the Hudson.

The rocks at the Falls clearly express the shear structure in the area. The weak, overlying Esopus Shales are being rapidly eroded. The presence of the Falls indicates a relatively youthful expression of the topography for the falls have not yet been planed down to grade.

## BIBLIOGRAPHY

1. Chadwick, George H. (1933) Geology of the Catskill and Kaaterskill Quadrangles, Part 2 Silurian and Devonian Geology. (NYS Mus. Bull. 336, Univ. State N.Y., Albany, N.Y.).
2. Dale, T.N. (1879) The Fault at Rondout, Amer. J. Sci., Vol. 18, 3rd Series, pp. 293-295.
3. Darton, N.H. (1894) Geology of Ulster County, Report of the State Geologist 1893 (NYS Mus. 13th Annual Report, Albany, N.Y.) pp. 2289 ff.
4. Davis, W.M. (1883) The Nonconformity at Rondout, Amer. J. Sci., Vol. 26, 3rd Series, pp. 389-395.
5. Field Guide Book (1962) (NYS Geo. Asso. 34th Annual Meeting).
6. Johnsen, John H. & Southard, John B. (1962) The Schoharie Formation in SE NY, (NYSGA Guide Bk., pp. A-7 to A-15).
7. King, Phillip B. (1959) The Evolution of North America, Princeton Univ. Press, Princeton, N.J.  
\_\_\_\_\_, (1950) The Tectonics of Middle North America, Princeton Univ. Press, Princeton, N.J.
8. Rickard, Lawrence V. (1962) Late Cayugan (Upper Silurian) and Heldebergian (Lower Devonian) Stratigraphy in N.Y., (NYS Mus. Bull. 386; Univ. State N.Y., Albany, N.Y.).
9. Van Ingen, Gilbert & Clark, P. Edwin (1903) Disturbed Fossiliferous Rocks in the Vicinity of Rondout, N.Y., Report of the State Paleontologist 1902 (NYS Mus. Rpt. 69) pp. 1176-1227.
10. Wanless, H.R. (1921) Geology of the Rosendale Quadrangle, Vol. 1 & 2. (MA Thesis Princeton University).
11. Willis, Bailey (1894) The Mechanics of Appalachian Structure, (13th Annual Rpt. U.S.G.S. 1893 Part 2) pp. 225 ff.
12. Woodward, Herbert P. (1957) Chronology of Appalachian Folding, (Bull. AAPG Vol. 41 # 10).

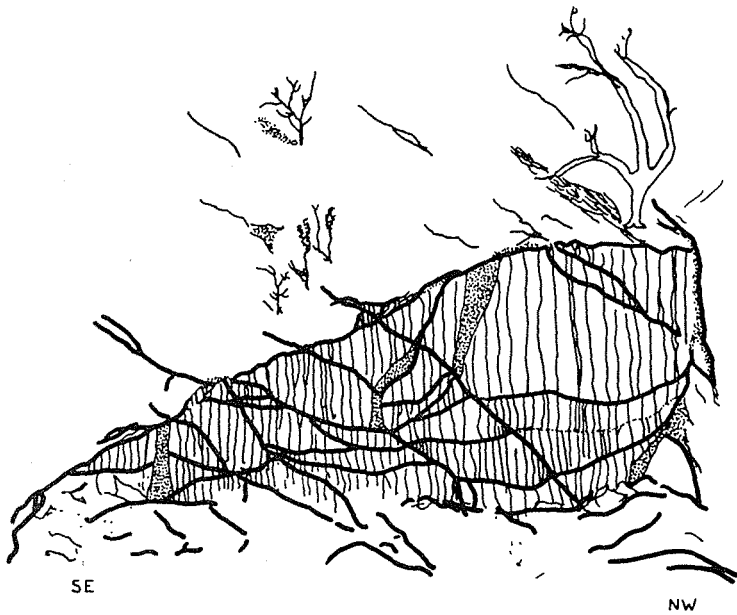


FIG. 1 ESOPUS SHALES EAST RT. 32 (STOP 1)  
FACING SOUTHWEST  
APPROXIMATELY 30FT X 70FT

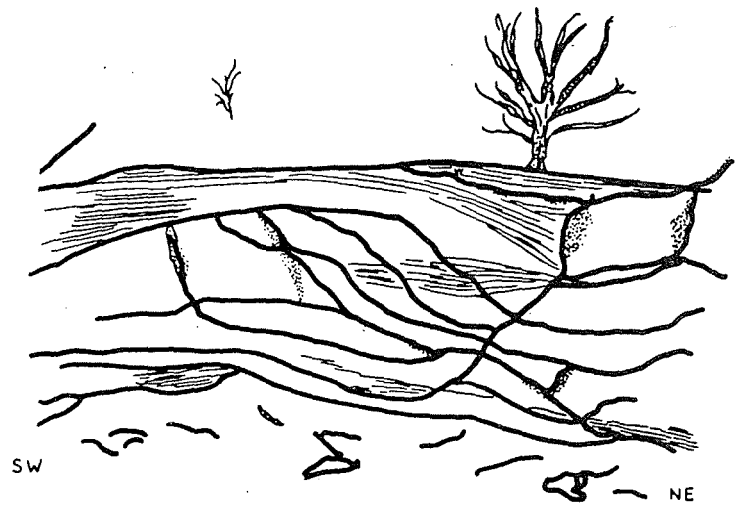


FIG. 3 ESOPUS SHALES WEST RT. 32 (STOP 1)  
FACING NORTHWEST  
AT RIGHT ANGLES TO CLEAVAGE  
APPROXIMATELY 60 FT X 180 FT

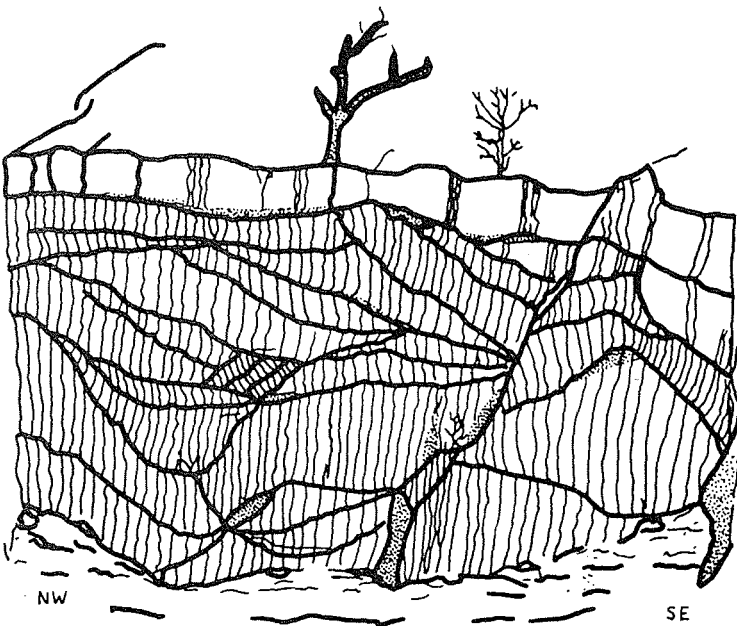


FIG. 2 ESOPUS SHALES WEST RT. 32 (STOP 1)  
FACING NORTHEAST  
APPROXIMATELY 35FT X 70FT

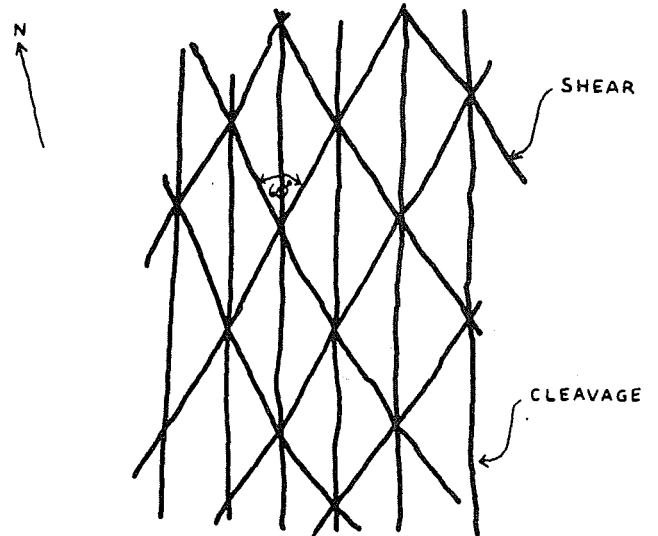
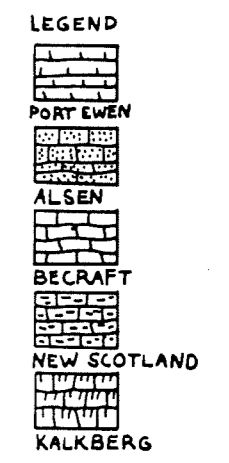
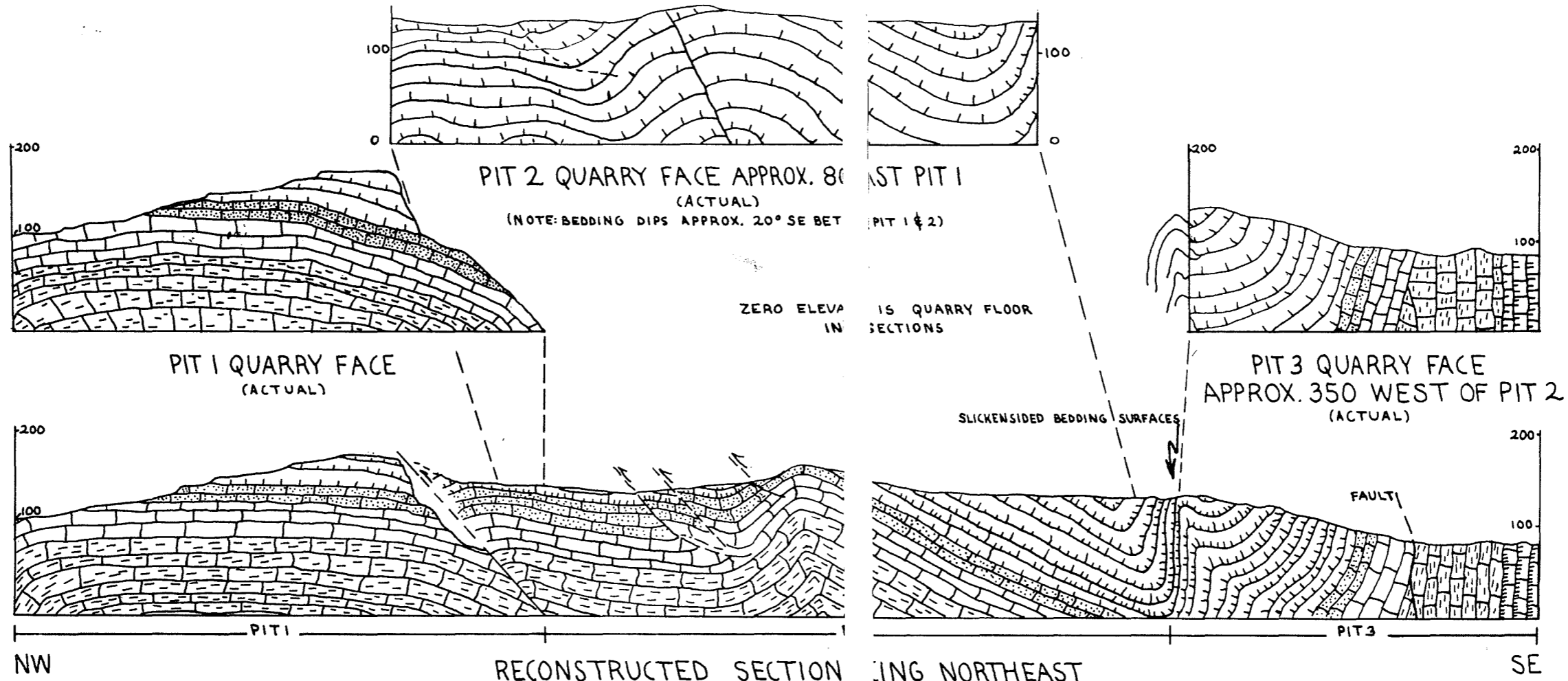


FIG. 4 GLENERIE ARENACEOUS LIMESTONE  
GLENERIE FALLS (STOP 4), PLAN VIEW OF  
SHEAR PATTERN PERPENDICULAR TO BEDDING  
APPROXIMATELY 3FT X 5FT



RECONSTRUCTED SECTION LOOKING NORTHEAST

NOTE: THESE FOLDS PLUNGE AWAY FROM THE VIEWER ABOUT 20° IN THE DIRECTION APPROXIMATELY 25°-30° NE

SCALE 1:1200 (HORIZONTAL EQUALS VERTICAL)

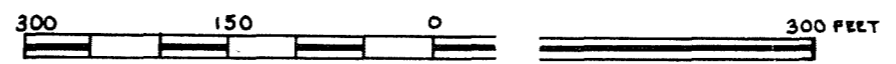


FIG. 5 CALLANHA QUARRY

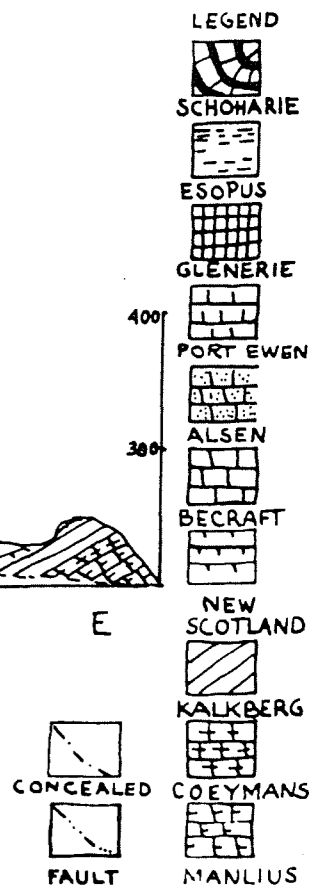
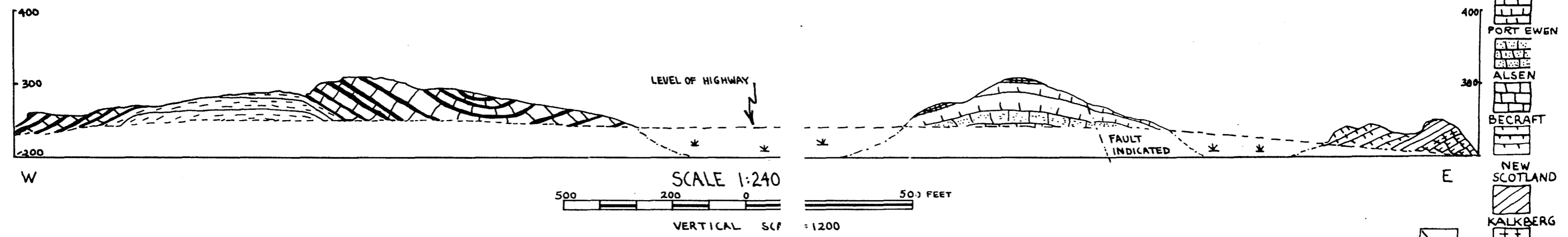


FIG. 6 RT 199 TO KINGSTON MINECLIFF BRIDGE

(FACING NORTH)

DASHED LINE IS ELEV. 199