STRUCTURAL GEOLOGY

Folds and Faults

The folds in the Cayuga Lake Basin are diminished Appalachian foreland folds. They have a more or less east-west trend and are superimposed on the regional dip (see structure map opposite). According to Bradley and Pepper (1938, p. 29) the arrangement of the folds "is characterized more by lack of system than by any clearly defined system. Folds that are plainly traceable across the area are exceptional; most of them are rather short and almost haphazard in their arrangement." In general, however, the axes trend northeastward to eastward and plunge gently southwestward to westward. The most northerly fold in the Cayuga Lake Basin is the Portland Point anticline. Another lies a few miles south of Ithaca, its axis running nearly through Danby. Ithaca lies above the deep syncline between the two.

The crest of the Portland Point anticline is marked by a low-angle thrust fault, visible in the competent Tully limestone in the southwest corner of the cement quarry. In the incompetent Windom shale (Moscow fm.) below it is scarcely traceable. On the opposite side of the lake, at the foot of Taughannock Falls, is another thrust fault, perhaps a continuation of the quarry fault. In both cases the thrust came from the south, with displacements of 30 to 100 feet.

Joints

This region is classic ground for the study of joint phenomena. First illustrated in 1843 by James Hall, the magnificently exposed joints in the Sherburne formation on the east shore of Cayuga Lake a few miles north of Ithaca are familiar features of many geology textbooks.

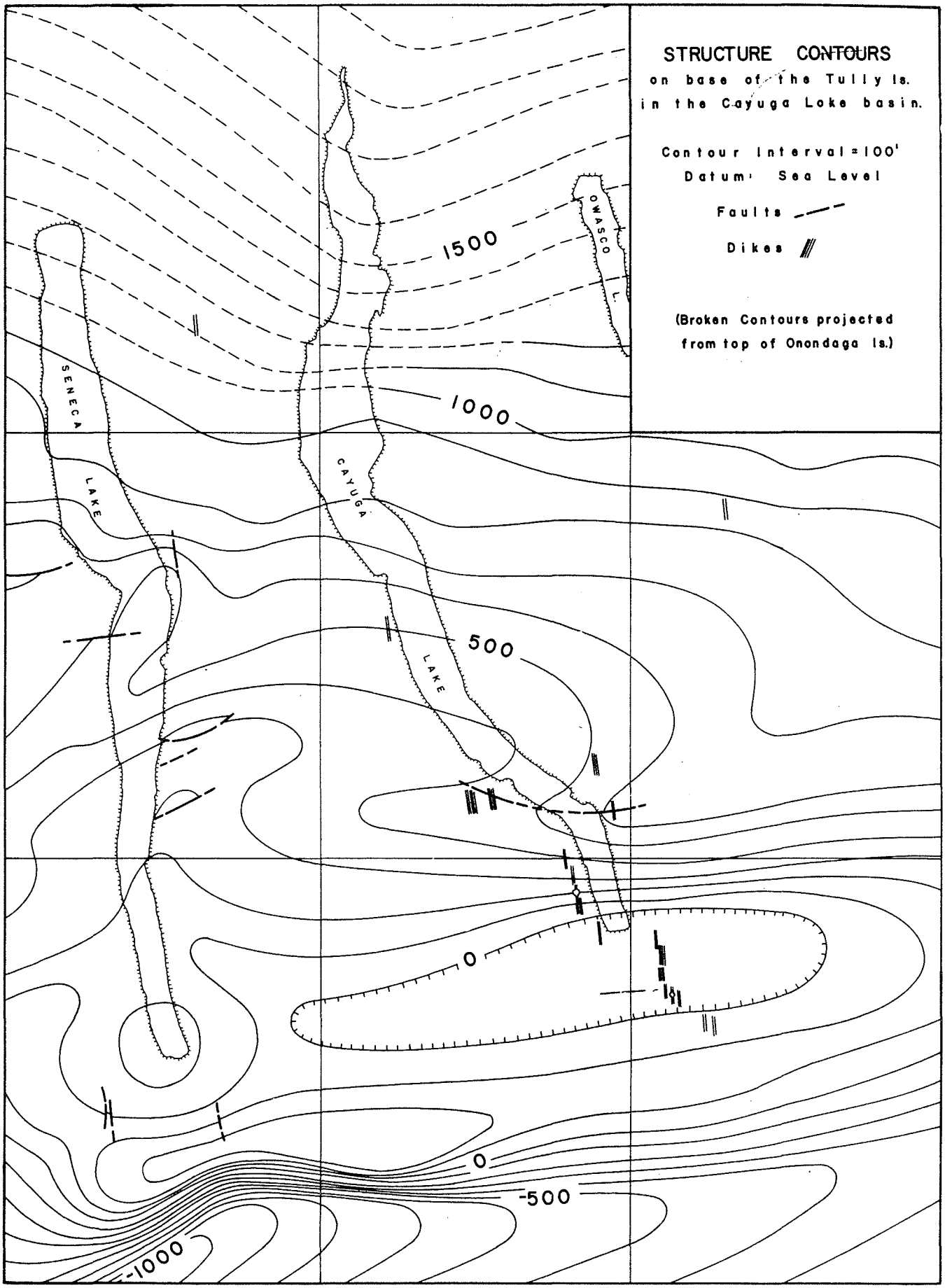
There are three joint sets in the region (see map of joint pattern, p. 13), and Sets I and II constitute a system:

Set I. The master or dip joints, composed of two conjugate shears intersecting at very acute angles (10°-30°) arranged with their mean direction swinging progressively from N 15-30 E eastward from Cayuga Lake to N 40-50 W to the west.

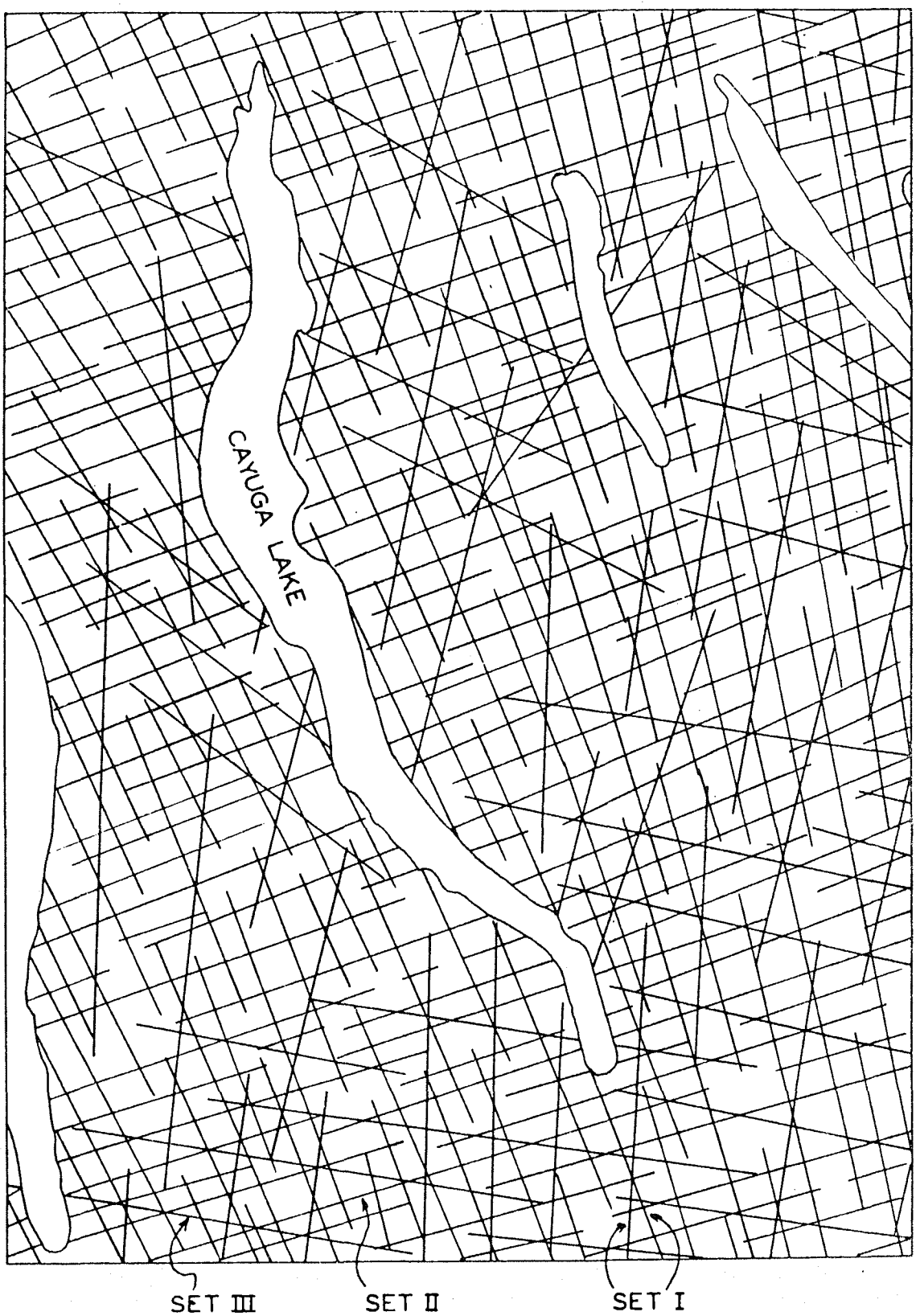
Set II. The strike joints, about perpendicular to the master joints of Set I. In plan, a series of slightly sinuate concentric arcs. To the westward the direction is about N 60 E, shifting centrally to N 70 E. They are better developed than Set III.

Set III. Tension joints arranged concentrically with a strike in the south of about N 84 W, and well-developed only in the southwestern part of the Cayuga Lake Basin. They are tentatively attributed to later tension effects than Set II.

The master or dip joints of Set I are believed to have resulted from simultaneous compression and tension (shearing), at right angles, and were the earliest formed. Those of Set II, the strike joints, developed


STRUCTURE CONTOURS
on base of the Tully ls.
in the Cayuga Lake basin.
Contour Interval = 100'
Datum: Sea Level
Faults
Dikes
(Broken Contours projected
from top of Onondaga ls.)
1500
1000
500
0
0
-500
-1000
SENECA
LAKE
CAYUGA
LAKE
OWASCO
L.

JOINT PATTERN IN CAYUGA LAKE REGION



progressively in areas of local weakness as a result of tension transmitted through the basement rocks. Their local departures from right angles to Set I show the influence of local plunging folds and variations from regional dip. These joints are not the result of Appalachian folding but may have resulted rather from the same stresses before folding began--the first effects of the stresses. Set III may be a later effect of the folding.

En Echelon Fractures

In the lower part of Taughannock Gorge, where the upper surface of the Tully limestone has been swept clear of the overlying Geneseo shale and debris, there is exposed a beautiful set of short, open, en echelon tension gashes and long shear planes, in a thick stratum of this competent formation. These suggest local rotational stress. The tension gashes trend N 60 W and the shears N 50 W. This occurrence is on the north flank of the Portland Point anticline just north of the axis which here is nearly east-west in trend. Torsional stresses, resulting from development of this fold may have been responsible for the gashes and shears, after the manner described by C. M. Nevin (1942, p. 114). The local operation of such stresses may have opened the first-formed dip joints (Set I) into which the dikes of the region were shot upwards from deep reservoirs, in places so abruptly as to be accompanied by explosive ascents (diatremes).

IGNEOUS ROCKS

The dikes referred to above are intrusions of alnoite ("peridotite", "kimberlite") (Martens, 1924). They occur in many places in the Cayuga Lake Basin (map, opposite p. 12) and are similar to those of Clintonville and Syracuse to the northeast. They are part of a system extending from the Monteregian hills near Quebec, across New York, western Pennsylvania, eastern Kentucky, western Kentucky, southern Illinois, and eastern Missouri to eastern Kansas, - a 1500 mile arc, referred to as the "Chestnut Ridge Disturbance." Washington (1922) remarked that these dikes appear to be surficial extensions of a general body of magma which underlies the greater part of this area."

At least 65 dikes are known to occur around the head of Cayuga Lake (Filmer, 1939-40), and those near Ludlowville were known in 1839 (Vanuxem, p. 260). All strike in the same direction, approximately north-south and follow either east or west components of the N-S conjugate shear joint set (Set I). None has a known linear extent of more than half a mile (Portland Point Quarry) and all soon pinch out in both directions. Their thickness ranges from literally paper-thin (especially at foot of Taughannock Falls) to about 12 feet (Williams Brook). Usually they are about 6 inches thick. At two sites they give way to modest-sized "pipes" or diatremes where the intrusive mass is a highly-altered, calcite-seamed mass with a roof of shattered country rock and containing xenoliths of underlying rocks, some of them derived from the deep-lying Pre-Cambrian basement 6000-8000 feet below.

The fresher dike rock is black to dark green and dense (Williams Brook, Cascadilla Creek) and shows brown mica prominently and fresh light green olivine, but the latter is usually serpentinized. With alteration the rock becomes lighter green (Portland Point Quarry) or greenish gray (Taughannock Falls), and weathers to an orange-brown soil (above Taughannock Falls). Originally the rock is presumed to have been composed of abundant phenocrysts of olivine and brown mica in a fine-grained groundmass of magnesia mica, melilite (only in freshest rock), perofskite, apatite, and magnetite. The principal secondary minerals are serpentine, chlorite, calcite, and pyrite. Minor minerals present in very small amount are: chromite, picotite, graphite, red garnet (pyrope), bright-green diopside, and enstatite. All of these minerals have been found in the diamond-bearing kimberlite of South Africa, but no diamonds have yet been found in the Cayuga Lake Basin dikes or in others of the same system.

The date of the intrusions is not definitely known. The youngest rocks intruded along the line of disturbance are Pennsylvanian, and there is no reason to suppose they are other than an effect of the Appalachian Revolution. Sheldon (1927, p. 366) summarized the data for the Cayuga Lake Basin:

"Fault stresses began early in the Appalachian Revolution and continued until after the joint planes and dikes were formed. The joint planes formed early in this time. The dikes were intruded later possibly at the climax of activity, but still before the end of fault movements."