THE HUDSON VALLEY BELT OF GRAPTOLITE SHALES AND NEGATIVE ANOMALIES OF GRAVITY.

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ABSTRACT. In reference to Longwell's paper on the Geologic Interpretation of Gravity Anomalies in the Southern New England-Hudson Valley region the writer points to the great thickness of the graptolite shales reached and the great depth of the geosyncline indicated by the radiolarian fauna and suggests that the Levis trough with the graptolite beds may have been the central portion of a mediterranean sea, the shallow littoral portion of which was formed by the adjoining so-called Chazy and eastern troughs. The great thicknesses of the westerly adjoining Schenectady and Canajoharie beds are considered as partly explained by the northwest swing of the negative isanomalies in the Mohawk valley and partly as a secondary effect of the strong sedimentation in the adjoining geosyncline.

PROFESSOR CHESTER R. LONGWELL published last year a paper on the Geologic Interpretation of Gravity Anomalies in the Southern New England-Hudson Valley region which proves of great interest to the students of graptolite shales by explaining the presence of these shales and their enormous thickness in the Hudson Valley region.

The presence and the great thickness of the graptolite shales of Ordovician age in the belt extending from the St. Lawrence River through the Lake Champlain basin and the Hudson Valley region has ever been a puzzle to the writer since he began the study of these shales and their graptolite biota.

It was obvious that there had existed throughout Ordovician time, beginning in late Cambrian time (if we include the Schaghticoke shale) and continuing to the end of Ordovician time, a great depression in this belt. The graptolites (see Ruedemann 1942) proved that the open ocean had access to this basin most of the time and that oceanic currents were able to sweep through it from the north bringing with them the graptolite faunas as free plankton and as epiplankton attached to seaweeds. It has even been claimed by the writer (1935, 1943) that the radiolarian fauna found in the chert associated with the graptolites indicated abyssal depths of over 12,000 feet attained at times by this intensely mobile belt, a portion of the St. Lawrence geosyncline.

It appears now from Longwell's excellent paper that a belt of strongly negative gravity anomalies discovered by pendulum observations of the United States Coast and Geodetic Survey extends through the Hudson River Valley from the north and is flanked on both sides, in Massachusetts and Connecticut on the east, and the Catskill Mountains in the west by strongly positive anomalies. In the deepest depression, east of Albany the anomaly amounts to −42 milligals and continues south, crossing the Hudson River north of the Highlands at −40 milligals, while in western Massachusetts and central Connecticut it rises to +40 milligals and on the other side under the eastern Catskills to +28 milligals.

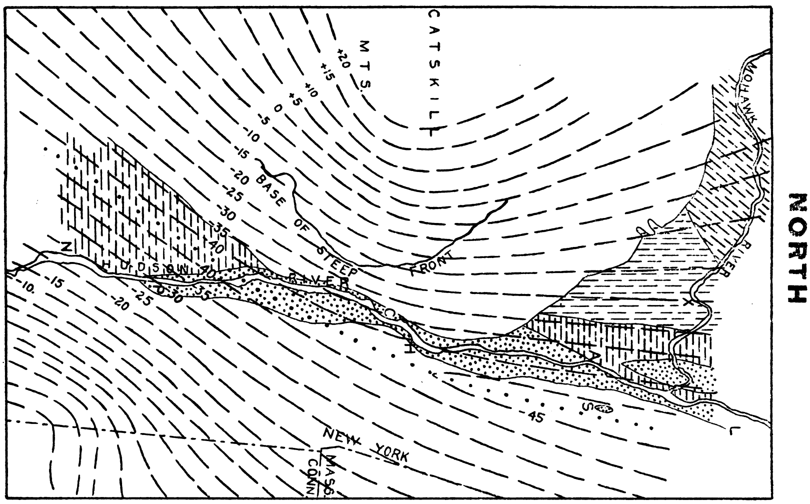

Fig. 1. Chart of the negative anomalies of the Hudson River Valley and the graptolitiferous formations connected with it.

Dotted = Normanskill beds: horizontal lines Snake Hill beds; vertical lines Schenectady beds; oblique lines Canajoharie shale. L = Logans Line separating the overthrust Lower Cambrian Nassau beds in the east from the graptolite beds. The latter are in the west covered by the Silurian and Devonian Helderberg formations. S = Snyders Lake inlier. A = Albany, H = Hudson, P = Poughkeepsie, N = Newburgh, X = Schenectady.

The anomalies are dependent according to Longwell's suggestion on the different distances of the base of the sial shell from the surface of the Earth, disregarding the influence of rock masses of abnormal densities at the surface, as such (volcanics) are not present in the region. Negative anomalies result from downward bulges of the sial shell.

To quote from Longwell (p. 589): "The two principal groups of negative anomalies are in the Hudson Valley belt and the Rhode Island basin, both of which were areas of subsidence, sedimentation and severe orogeny in the Paleozoic era."

We are here interested only in the Hudson Valley belt, the site of the graptolite shales, and wish to present some figures illustrating the amount of subsidence and sedimentation that took place there.

In the St. Lawrence geosyncline, where the graptolite beds were deposited, we obtain the following figures (Ruedemann, Bull. 285):

Name of formation	Minimum thickness	Maximum thickness in feet
Nassau beds	153	785
Troy beds	25	100
Schodack shales and limestone	20	200
Diamond quartzite	10	40
Bomoseen grit	18	50
Schaghticoke shale	30	30+
Deepkill shale	300	300+
Bald Mountain limestone	70	70+
Normanskill shale (Dale)	1200	2500
Rysedorph conglomerate	2.5	10
Tackawasick limestone	50	50+
Snake Hill shale	3000	3000+
	4885.5	7355+

The Lower Cambrian and Ordovician deposits of the geosyncline amount roughly to a minimum of 5000 ft. and a maximum of 7400 ft., or one mile and one and one-half miles respectively.

The pure graptolite shales are:

Schaghticoke shale	30 feet+
Deepkill shale	300 feet+
Normanskill shale	2500 feet+
	2830 feet or approximately one-half mile.

The impure graptolite shale (Snake Hill shale) amounts to 3000 ft. or another half mile.

The graptolite shales are black, very fine-grained sediments which were deposited at the lower slopes of continental shelves or at the bottom of the abysses, some at 12,000+ feet. They show by the rapidly changing graptolite faunas in often small thicknesses of beds, that they were very slowly deposited during long lapses of time. It is therefore certain that they represent a very great interval of time and a long continuation of the deep depression of the geosyncline, from late Cambrian time through the Ordovician era. This in itself is proof of a long existing fundamental condition such as the downward bulge of the sial foundation affords.

It may be added here that the discovery of radiolarian chert (Ruedemann & Wilson, 1935) in the graptolite shale has afforded another significant fact, namely that the bottom of the geosyncline may at times have dropped to depths of more than 12,000 feet, according to the evidence furnished by the radiolarian genera. This strange phenomenon can also be best explained by the influence of the great downward bulge of the sial fundament, as indicated by the strongly negative anomalies.

A peculiar problem is presented by the region to the west of the geosyncline, in which the great thicknesses of the Schenectady beds and of the Canajoharie shale, homotaxial to the Snake Hill shale, were deposited, in Trenton time. The Schenectady beds, reaching (Ruedemann, Bull. 285, p. 34) a thickness of 1000 feet and possibly 2880 feet consist of prevailing sandstone with interbedded shales. They contain a flora, consisting of a seaweed (*Sphenophycus latifolius* Hall), the index fossil, and a fauna of graptolites, brachiopods, gastropods, conularids, cephalopods, trilobites, ostracods and numerous forms of eurypterids, none of them in abundance.

The Canajoharie shale, which is partly contemporaneous with the Schenectady beds and contains an impure graptolite fauna of a few species mixed with other fossils extends westward from the Schenectady belt into the Mohawk valley, where it attains a thickness of over 1500 feet. Former investigations by the writer (Ruedemann, 1897), based on the parallel directions of the graptolites and cephalopods indicated a strong current sweeping from the northeast across the lower southern Adirondack massif and around it toward the west, where the shale is replaced by the Trenton limestone, deposited in purer water and of much less thickness.

The great thicknesses of the Schenectady and Canajoharie beds and the continued depression of the area of their deposition are, at least in part, explainable by the fact that the lines of negative anomalies swing sharply to the northwest under the eastern Catskills and in the lower Mohawk valley, indicating a widening of the downward bulge of the sial in that direction. It is further possible that the strong sedimentation in the geosyncline had a secondary effect on the beds of the neighboring region. The St. Lawrence geosyncline has been subdivided by Ulrich and Schuchert (1902) into several troughs, which were independent of each other at times. The central trough which contains the Lower Cambrian and the graptolite beds they term the Levis trough. This was flanked on the west by the Chazy trough which holds the Potsdam-Beekmantown-Chazy-Trenton series, and a third trough on the east. The writer has more recently (1942) held the view that the St. Lawrence geosyncline on account of the great depth it reached at times and the passage of the successive graptolite faunas through it may have reached the dimensions of a mediterranean sea. At that time the Levis trough would have formed the abyssal depths while the shallower portions on both sides—the Chazy and eastern troughs with the Chazy and eastern sequences—received the littoral deposits. However, that may be, it is obvious that only the Levis trough occupied the depression of the negative anomalies while the flanking troughs or the coastal regions of the mediterranean sea were in the areas of positive anomalies.

The great mass of Schenectady beds is capped in the Indian Ladder region near Albany by 410 feet of the Indian Ladder beds, consisting of black shales with interbedded calcareous sandstone layers. These beds are of younger age than the Utica and are homotaxial to the Frankfort shale of New York and the Southgate member of the Eden shale of Cincinnati. They occupy a narrow trough, only about five miles wide, extending from south to north. As indicated by the fauna the trough extended far into Pennsylvania where it connected with the west.

This strange formation marks a final narrowing of the downward depression in the area where the Schenectady beds were deposited.

A recent paper by F. J. Pettijohn (1943) deserves special notice in this place. The author points to the special type of sedimentation, which he calls the orogenic type, that has taken place in the Archean geosynclines of Canada. These were filled rapidly "with incompletely weathered and relatively unsorted material. The result was the production of conglomerates and graywackes."

It may be concluded that the Upper Normanskill beds, the Austin Glen member, consisting largely of grit and some conglomerate indicate such a condition of more rapid filling of the geosyncline than the lower black Normanskill shales do.

As is well known James Hall and Dana had recognized that the Appalachian geosyncline was the site of more rapid sedimentation of clastic material than the region to the west where the Trenton limestone was deposited. We know now that only a portion of the deposits in the geosyncline are of Trenton age and the others, especially the older ones, are not present west of the geosyncline.

From the deposition of the Normanskill grit it may be inferred that the geosyncline, which once reached abyssal depths was later being filled by the clastic materials, furnished by the beginning orogenic activity of the adjoining regions, notably the eastern.

No study has been made so far of the possible presence of megavarves, indicating cycles of seasonal changes.

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