DISCUSSION.

Cambrian and Ordovician Geology of the Catskill Quadrangle (N. Y.); by Dr. Rudolf Ruedemann. Bulletin 331, New York State Museum, Albany. "December 1942." (Actual publication in 1946.)—The Geology of the Catskill area, most concentrated and most visited of any in the East, has finally attained publication. New York State Museum bulletins 331 and 336 are off the press and with bulletin 307 give a fairly complete introduction to the whole Catskill region, whose bedrocks range from lowest Cambrian well into the upper Devonian in age. Part I, by Doctor Ruedemann, is here reviewed.

In this bulletin, the magic touch of a master hand has again resolved a wilderness of "Hudson River" beds into an orderly sequence of Cambrian, Canadian, and Ordovician formations and some new and startling conclusions are set forth. Here, as elsewhere north and south, the old Hudson River Group that was placed above the Utica turns out to be older even than the Trenton, in no way correlative with the Lorraine and "Frankfort" (a facies term) of farther west. Thus the situation in the Eopaleozoic of New York remains comparable to that in its higher Devonian strata. Facies correlations put together older beds at east with later ones at west. Only careful tracing and fossil collecting have been able to overturn these older views.

The study of this area (from Hudson to Annandale and Elizaville) has simplified the Cambrian succession as determined around Troy and amplified that of the Ordovician. The formations here recognized for mapping are (oldest at bottom):

Rysedorph polymict limestone conglomerate
Austin's Glen (upper Normanskill) shales and grits
Mount Merino (lower Normanskill) shales and cherts
Deepkill shales and cherts
(Break; middle and upper Cambrian missing)
Schodack shales and limestones
Burden iron ore (Bomoseen olive grit)
Nassau shales and quarzites.

The Bomoseen and assertedly equivalent Burden ore are mapped with the Schodack, which has been expanded to embrace also the Troy shales and limy quartzites as well as the (interbedded) Burden limestone conglomerate and Zion Hill ferruginous quartzite, formerly separately described in areas at north.

For the Nassau beds a possible late Precambrian age is mooted (pages 42, 61-62), partly through correlation with the Random terrane (page 60) of Newfoundland, and partly through the surmise that the Burden iron ore and other similarly situated ores over a wide area may be the erosional concentrates of the "Lipalian interval." But there is also (page 61) correlation of Nassau with the Hardyston quartzite of New Jersey which carries Olenellus; and there is, further (page 66), acknowledgment that the much higher Zion Hill iron-bearing bed marks "a reappearance" of the conditions that produced the Burden, both of these being included as lentils in the enlarged Schodack formation (compare figure 66). The reference to the Brayman (eastern Camillus) shale as a "regolith" (page 62) lacks support by other investigators. It is puzzling to read (page 38) that "most of" the five divisions of the Nassau are recognizable in the quadrangle, but (page 41) that "only a small portion," the "uppermost division E," is exposed.

In the Schodack formation are now recognized (pages 77, 67) at least two limestone conglomerates, the familiar Burden conglomerate of Grabau, low in the formation, another mistaken by Grabau for that but much higher in the Schodack, which may be called the *Claverack* conglomerate (type at Ham's Mills), possibly a third lying above the Zion Hill quartzite beyond the quadrangle limits. Doctor Ruedemann has not entertained the question as to whether the topmost beds here may be later than Schodack, possibly Upper Cambrian (compare pages 179-180).

The Ordovician beds are wholly clastics, representing (with the Cambrian) the complete section of the overthrust sequence except that the Schaghticoke shale has failed of recognition. A clean-cut separation has now been made between the lower and upper Normanskill, and the correct superposition of these beds has been determined—the part with interbedded grits (graywacke) being the upper and more western member. As to the boundary between the main outcrop belts of these two divisions of the Normanskill the engraved (colored) map differs greatly from the preliminary map (page 93) of 1936. Effort has been made to determine the thicknesses of these greatly mashed formations. At Austin's Glen on the Cats Kill (no resident knows this place by the map-maker's name "Austin Glen"), an outcrop of 355 feet across the strike (page 102) may much exceed the actual thickness here exposed, but the total thickness of this upper member is likely to be several times the estimate (page 107) of 500 feet (minimum), as the author himself suspects (page 88). The locality (pages 102, 104, 105) called "South Catskill" is West Catskill and the Post and Smith quarry is (pages 98, 102, 105, 115) at Broome Street (page 104) in a nose of what is locally called "Broomstick Hill."

The lower Normanskill, carrying interbedded radiolarian chert instead of grits, is referred to depths of over two miles for its place of deposition, the arguments for this being ably marshalled (pages 90, 101, 171, 174, 180; see also Ruedemann, 1942: bulletin 327—pp. 53-56) but so tied in with the "trough" theory (see beyond) as not to be wholly convincing. Similar cherts are reported (pages 84, 87, 94, 95) from the Deepkill shale associated (pages 80-83) with limestones and terrigenous quartzites of littoral type, hard to reconcile with "abyssal" conditions.

Two exposures of polymict limestone conglomerate are identified with the Rysedorph conglomerate of farther north (pages 87, 116-124, 180; pronunciation not indicated). The outcrop north of Elizaville (pages 123-125; see 120) carries pebbles with "Trenton" fossils, like type Rysedorph, but lies in contact with *Lower* Normanskill (Mount Merino) on both sides, only the west one of which is mapped as a faulted contact. It "covers an amazing area," with marginal dips of 45° and 60°, so that even if it is a "flat, overturned anticline" the thickness present must be very unusual. The other exposure, south of Mount Merino, without fossils but with pebbles of Lowville aspect and of chert, is veneered upon and involved in greenish shales necessarily either Deepkill or Mount Merino beds (the Austin's Glen has only gray to black shales), which two are the only formations mapped at this point, though "Normanskill grit" is said to occur "on both sides." These Trenton conglomerates, later in age than the shales and wholly exotic to them, furnish the most elusive problem (see beyond) in the entire Hudson River Ordovician belt. Certainly the evidence here is not that they lie in normal succession on the Normanskill (Austin's Glen member). Rather, they seem unconformable on various parts of the overthrust sequence.

The Becraft's Mountain outlier of Silurian and Devonian rocks was laid as a waif on Doctor Ruedemann's doorstep with suggestion that he could take over unrevised the published map and report by Doctor A. W. Grabau (1903). In so doing (pages 124-132), he has made two notable contributions, finding remnants (in occasional pre-Silurian depressions) of the iron-stained sandy Rondout beds (pages 10, 15, 126, 127, 181) like those at the nearest exposures west of the Hudson (see figure 11 of bulletin 336), and convincing proof of the great unconformity (pages 10, 15, 124, 127, 149, 168) at the level which he so aptly calls (page 10) a "fossil peneplain." Welcome also is the criticism of so many normal faults drawn on the Grabau map (page 132); although bringing this outlier struc-

turally into line with the western embed[1] may void the writer's hypothesis (bulletin 336—p. 230) of its ride upon the Taconic overthrust. Seemingly (see beyond), contrary to the remark on page 139, "Logan's" thrust passes directly under the mountain (figure 55) without visible effect upon it.

A slight error in names is noted. Although his map elements are the same as mine (bulletin 336), the combined Coeymans-Kalkberg is called simply "Coeymans" (pages 127-128) with the Kalkberg stated to be a member of that instead of part of the New Scotland (compare correct usage by Goldring in bulletin 332—p. 159; and by Ruedemann in bulletin 285—p.49). His "New Scotland" is only the Catskill shaly member of that formation. Thus the Coeymans-New Scotland boundary is made transitional (page 182), which is true of the Kalkberg-Catskill within the New Scotland, whereas the real division (Coeymans-Kalkberg) is the sharpest stratum-plane in the Helderbergian (see also beyond).

Since Alsen is basal Port Ewen as truly as Kalkberg is basal New Scotland, and is included in the 222 feet at Rondout, Grabau (page 129) was not mistaken. But absence of the shaly main Port Ewen here as on the west emphasizes the large sub-Oriskany break unmentioned in this report. The suggested break (page 181) between Rondout and Manlius must, however, have been very small.

Structural relations (pages 131-157), are most delightfully described, aided by picture and diagram. Especially novel is the matter on "boudinage" (pages 150-157) in the quartzite interlaminae of the Nassau slates, definitely proving "take-up" of compression by a general squeezing of the mass (compare bottom of page 145 and figure 51) rather than by plication as in the less metamorphic belt farther west (page 141; contrast figures 56-60 with 53, 54).

The "troughs" and "barriers" here interwoven (pages 37, 78, 135-137, 172-175, 176) will be considered beyond under history, but the evidence of overthrusting is convincing (pages 139-142) without recourse to these. The Coxsackie quadrangle map (bulletin 332) does not seem, however, to terminate "Logan's Line" (page 138) in the Hudson River (page 139) at Poolsburg opposite New Baltimore, but picks it up again for over two miles past Stuyvesant and resumes it (Nassau over Normanskill) at North Bay, Hudson, joining it to the fault on the Catskill sheet that passes under Becraft's Mountain (see pages 141-142) but which is inadvertently shown in diagram (page 149) as a low angle normal fault. The

[1] Note (by request). "Embed" (em'-bed), supposedly long current but not found in the dictionaries, is taken to mean the main mass (not simply the outcrop) of a given rock in situ as distinguished from transported blocks and perhaps from small outliers.

fault on east of Mt. Merino (same page) is also shown as normal, and is so described (page 142), but this likewise does not agree with the (colored) map.

The real Logan's Line is probably not this one at all but runs between the west edge of the Normanskill and the Snake Hill beds, and is here buried beneath the western embed of the Silurian and Devonian. That it is not between the Snake Hill and Canajoharie was already admitted (pages 137-138) in Ruedemann, 1930. These lesser thrusts separate the nappes (page 141) of the "shingle block" structure (page 138), do not bring distinct facies into juxtaposition, and probably lack such breadth of geographic translation (15 miles) as would be called for by the engaging theory (pages 50, 141) that the iron-ore belt has been torn out of the Harlem valley. The answer to the "moot question" (page 146) whether folding or thrusting accounts for the presence here of this iron-ore belt and of the "bird-shaper inlier" in Germantown is not in the asserted sundering of upper and lower Normanskill belts by these bodies, which is not sustained by either the older map (page 93) or the final map that as already noted differs so much from the older map, nevertheless both folds and faults are sufficiently evident in the maps (compare figures 21, 51, 55, 66). The final map does not agree with the text (page 145) as to the bounding faults of the Germantown inlier.

The historical interpretation (pages 171 to end), opening with a readable and enlightening discussion of geosynclines, proceeds to postulate subdivision of the St. Lawrence geosyncline into three "troughs" in which Eopaleozoic sedimentation went on independently and largely alternately (pages 136-138 quoted from 1930, and 172-176; see also 37, 78), a thesis long advanced in the bulletins on this general area for two such troughs. To these Doctor Ruedemann now adds a third for the eastern (or carbonate) sequence of Prindle and Knopf (1932), overlooking that this is the resident sequence (autochthone) and is overthrusted from the east by their Taconic sequence (his former eastern), a conclusion inevitable from the mapped field relations such as (their pages 293-294) fossiliferous Lower Cambrian overriding fossiliferous Lower Ordovician near Hoosick. Yet he is evidently (page 174 and diagram in Ruedemann, 1942: bulletin 327—p. 57) veering away from a theory that admittedly presents certain difficulties. One of these, not remarked by him (but by Kay, 1937—p. 272-273), is the source and route of the terrigenous sediments. Another is lack of any trace today in the overthrusted masses (pages 137, 173) of the hypothetical barriers (page 176; Precambrian rocks, in bulletin 285—figure 8). These have disappeared from the 1942 diagram, just mentioned, as has also the predicated alternation in the

separate troughs (compare figure 50, page 136, and "one general basin," page 180).

First to recognize facies changes (Dolgeville shale) in our Eopaleozoic rocks and extending such observations at length throughout the Mohawk valley, and also early to grasp the frequency and extent of overthrusting at the east, Doctor Ruedemann yet hesitates at the final step of original direct continuity of deposition across all the fault sequences, surely only because of having them in the wrong order, 1-3-2 as now instead of 1-2-3 as originally. An unpublished continuous section from Watertown via Utica to Albany drawn by me accurately to scale in 1935 shows the facial behavior of the Ordovician to follow closely the laws and pattern that govern in the upper Devonian (compare Holzwasser, 1926—p. 53), and as early as 1925 I pointed out to others (ibidem—p. 63; Kay, 1937—p. 272) the identity of the Snake Hill as a facies of the Canajoharie, thus not of a separate trough. Ruling out imagined abyssal depths for the cherts, one sees only normal coastal plain sedimentation from western Massachusetts to Lake Ontario, with the correlations shown in the accompanying table.

To locate a geosyncline in Massachusetts and shift it "after contraction" (page 172, compare 161-164) to eastern New York, albeit it looks that way on the Schuchert (1930) maps, as though the states remained stationary while the geosyncline slid over them, may be rather misleading but is the fault of using maps that are not palinspastic (Kay, 1935).

In the list of neighboring Precambrian outcrops (page 175), our nearest one, Stissing Mountain, has been left out.

What now becomes the really engaging problem is the unmentioned one of the Trenton limestone conglomerates, whose pebbles definitely derive from the resident sequence but whose present seat is on the overthrust slice, on rocks that in Trenton time lay presumably 100 miles farther east than now (Kay, 1937—pl. 5). Moreover it appears that these conglomerates rest not only upon the top of the Normanskill (Austin's Glen) as the last deposit in the area preceding the overthrust but also on the lower Normanskill (Mount Merino) and possibly even on the still lower Deepkill, as already mentioned. Since the matrix of the conglomerate itself is dated by early Trenton fossils, being clearly not a fault-breccia, can the translated block have suffered a large part of its present dislocation at the close of Normanskill (Black River) time coincident with the volcanic activity and marked break in sedimentation found by Kay (1937—pl. 2 and fig. 9) and been eroded down to the Deepkill on higher folds in Sherman Fall time? These are alarming suggestions, but not lightly to be disregarded in view of the similarly transgres-

Tentative Correlations
in Cambrian through Ordovician
of Eastern New York.

AGES	The Capital District Albany and Troy Quads.		Dutchess County	Taconic Quadrangle	Overthrust Blocks Logan's, Greylock
	Silurian capping		O	O	Silurian
UTICA	Indian Ladder	O	Overthrust by argillaceous rocks of the Taconic sequence including Nassau shale and probably younger beds.	Overthrust by argillaceous rocks of the Taconic sequence	(Lost by erosion)
TRENTON	Schenectady				
	Canajoharie	Snake Hill			
	Glens Falls	?Rysedorph			?Rysedorph
BLACK RIVER	*Amsterdam*			Walloomsac	Austin's Glen
CHAZY	*Chazy* (to north)			*Calcitic limestone and marble.*	Mount Merino
CANADIAN	*Beekmantown* (to north)		*Rochdale*		Deepkill
OZARKIAN	*Little Falls* *Theresa (Hoyt)*		*"Hoyt dolomite"*		Schaghticoke ?
UPPER CAMBRIAN	Potsdam (from north)		?	O	O
MIDDLE CAMBRIAN	o		o	o	o
LOWER CAMBRIAN	o		*Stissing*	*Rutland*	Eagle Bridge *Schodack* Mettawee Hoosac Bomoseen Rowe
	o		Poughquag	Cheshire	Nassau ?Rensselaer
	Precambrian		basement		? (Overthrust)

NOTES: O means re-eroded; o, not deposited. *Calcareous facies in italics.* Kay (1937—p. 272-273) refers Snake Hill to the western sequence. He likewise refers the Rysedorph polymict limestone conglomerate to the western sequence (page 277), stating that Ruedemann described it as interbedded in Snake Hill, which description I do not find. Its relations are always with the Normanskill, of the overthrust mass.

sive relations of the coeval Lacolle conglomerate (Kay 1937—p. 275-277) and the sudden westward shift of clastic sediments after Glens Falls limestone deposition.

The delayed decision to print the Catskill report as two bulletins obliged Doctor Ruedemann to include Silurian and Devonian history (note reference to "Part 2" in Contents, on front cover). Faced with this necessity he turned naturally to his Capital District bulletin (No. 285), with minor omissions lifting this bodily.

Unfortunately this fits not well in spots (Oriskany, and Schoharie), and in the fifteen years revolutionary changes have taken

place in Upper Devonian correlations, Silurian and Devonian paleogeography, and other details. No longer do the seaways of those times run as Doctor Schuchert pioneered them, the New Jersey gateway is delta-filled, the Albany bay proves a figment of Grabau's "Sherburne bar," true Portage rocks fail to kiss the Catskill summits in our map area. Clarke's theory of lower Marcellus becoming top Onondaga westward has misfired, but all of our "Marcellus" (Bakoven) seems only the partly calcareous basal part (Union Springs) of central New York while it is our "Hamilton" that is the bulk of the Marcellus, the true Hamilton being here the original. Catskill (Kiskatom) redbeds that Prosser mistook for "Oneonta." There are small slips—Salina following Rondout (page 181: compare bulletin 285—p. 172), an eastern source for the Manlius sea (page 182), "transition" beds from Manlius to Coeymans which are reworked Manlius marking an extensive erosional break (bulletin 336—p. 152; note qualifications in bulletin 285—p. 47, 173, here omitted), the Coeymans-New Scotland "transition" previously noted, the "well-set-off" Becraft (page 182) where there is indeed a troublesome gradation and interfingering (Grabau, 1903—p. 1062) here and all up and down the Appalachians (see Woodward's Devonian of West Virginia—p. 83, 95-97), inapplicability of the "turbulent sea" of the Oriskany sand (page 183) to our thin beds of (Glenerie) chert and silicious limestone with their frail fossils, and of the "sandy facies" of the "Schoharie" (Saugerties formation or "Leeds member") hereabouts (compare page 130). The discussion of the higher Devonian strata (pages 184-186) follows the wholly erroneous work of Prosser (see bulletin 336—p. 116, 125, 137). The "enormous amount of material" (page 186) that must have been removed above present exposures was the higher Upper Devonian (Catawissa, Montrose, Blossburg and other successively later redbeds), probably no Pennsylvanian and definitely no Mississippian strata.

Discussing the orogenic history (pages 160-170), Doctor Ruedemann analyzes (167-170) various age criteria worth careful attention, but (page 163) misinterprets Schuchert's maps (1930—figures 1 and 2, not "4" and "5") in saying that the second "clearly indicates the middle Hudson River region was only folded by the Taconian and Appalachian orogenies," whereas that figure (65 of the bulletin) shows only "present location of geosynclines" that (Schuchert, page 706) "in late Devonian time" were wholly "blotted out by the Acadian disturbance," and the map shows that this includes our area, while Schuchert's figure 4, that does map the orogenies, likewise carries the belt of Acadian folding south across our quadrangle with proper strike to "at least Newburgh" (his page 722), but gives an easterly direction to the Appalachian belt past

Kingston. Doctor Ruedemann recognizes (page 161), however, that the "Appalachian" or "Carboniferous" folds (pages 17, 139) may prove to be Acadian (compare bulletin 336—p. 227-230). But whether the eastwardly increasing metamorphism, with westward overthrusting of the less folded metamorphosed nappes (pages 141, 145), is Taconian, Acadian, or Appalachian, is another question not yet answered.

The subsequent history involves the controverted origin of the present drainage pattern (pages 22-26), presented with great fairness but without reference to important papers by Fairchild, Mackin and others. That the parallel west-southwest courses of the upper Susquehanna and the two Delawares (figure 7) were consequent on the dip slope does not agree with a known original (depositional) dip to west-*north*west, or with the oldest recognizable (mountain summit) peneplain (Guyot 1880) which slopes northwest; neither is it a case of structural control by anticlines (Hall, 1876; see bulletin 307—p. 35, 51, 68, 83) that have proved non-existent but still plague the literature on this subject (Strahler, 1945—p. 68). As the present regional dip here is east of south, these streams run nearly on the strike; and this regional dip into the geosyncline must date from Appalachian orogeny. It is more likely that the streams were controlled at first by parallel receding escarpments, and later rapidly intrenched. We must disagree also with carrying the Hudson River back to Cretaceous time (page 24), because the two branches of the "Cretaceous" Schoharie Kill plainly headed far east across the present Hudson Valley.

The physiography resultant from the long periods of erosion is treated with great clearness (pages 6-26) except for one matter—the Helderberg plateau which is a strata-controlled feature (figure 1, so retouched as to be worthless for evidence, and page 8) is confused with the Helderberg peneplain (figure 8 and pages 9-10) which is beveled across the strata and does not decline southward with them. The peneplain is continuous with the mature valleys extending from the north into the Catskill Mountains monadnock area and lacks representation under the east lea of the mountains. Its eastward counterpart would be in the Taconic Mountains, not in the much lower phyllite plateau whose existence seems to be purely a matter of differential hardnesses, not of erosional base-level. Throughout our quadrangles the Helderberg "plateau" has fallen to the level of the Hudson Valley (Albany) peneplain, which here reaches to the east foot of the Catskills.

The statement that the strike of the Eopaleozoic rocks (pages 13, 17) has a northeast skew, while true of the overlying Devonian ones, is not borne out by either the geologic or topographic map except for Mount Merino, nor is it true that the main glacial move-

ment was due south and responsible for the north strike of the ridges. The ice flow was definitely west of south, diagonal to these minor ridges but parallel to the great mural front of the Catskills, the edge of the phyllite plateau, and the course of the Taconic Mountains (western boundary of Massachusetts). In fact, this north strike of the Ordovician grits as they pass under the northeasterly striking scarp-front of the Silurian-Devonian limestones is one of the striking evidences of their unconformability, and distinguishes Taconian from Acadian folding.

The strange behavior of the Hudson tributaries on the east, which is duplicated on the west by that of the Kaaters Kill and Esopus (figure 8 and pages 24-26), is brought out but its explanation left to Professor Cook's glacial chapter, which is not here under review. See bulletin 336—p. 214-218.

Concerning the interesting suggestion that grade-plains are beaver work (pages 21, 26) one is inclined to ask which came first—the beavers, or the graded surface that enticed them by permitting broad shallow impoundment by dams. The conical hill east of Blue Stores (page 18; compare 199, bottom) called a drumlin has a gravel-pit (contoured) in the west base and was considered to be a kame by Doctor Fairchild, (see bulletin 336—p. 192).

The chapters on botany, zoology and economic geology (pages 26-30, 239-242) projected by me for the combined report have, to equalize space, been placed in Part I, that on minerals wholly omitted. In the list of trees, taken from Doctor Bray, one is astonished to find such southern species as the pawpaw, cucumber tree and coffee tree, none of which I have seen here, and also the redbud as native and the hackberry as abundant (page 28). The cactus colony at Saugerties (page 30) is due north instead of northwest of the railway station.

It is unfortunate that the intention to issue the combined maps with each part, as indicated by the caption on the map pocket, was abandoned, the maps printed separately. Still more regrettable from the standpoint of scientific accuracy and priority, is the dating as of December, 1942, a contribution to knowledge not off the press until February, 1943, and not yet distributed to the world in January of 1946. Every copy should be stamped with the date of actual release of this edition.

Besides evident misprints for Mastigograptus, Whitfieldella, Pterinea, Dodecatheon, occidentalis, Bell Pond, Plass Hill, Stafford, and more common words, there are Alexander for Alander, Greenfield for Greendale, gravity folds for gravity faults, and Malden (page 36) for Cementon: but more misleading is non-sense caused by editorial deletion of commas (note pages 9, 127, 145, 173, 176, 183) without regard to author's wishes. One misses a measure of

size in several figures and is left uncertain as to whether figure 30 shows Deepkill or (page 94) Mount Merino chert, whether figure 43 looks north when the river lies on that side of the track (see map) and whether this is not a syncline instead of an anticline; whether, on page 89, "homotaxial" (similar in order) or synchronous is intended; whether it is the Green Mountain range (page 175) or the Taconic that borders Massachusetts; and how a trough (page 180) can fill with thousands of feet of land-wash while its feeding slopes on both sides are lined unbrokenly with pure limestone accumulating. The limestone at Stissing Mountain (page 179) is now said to be Lower not Middle Cambrian. Since Coeymans is not a possessive but the family name of Barrent Pieterse Coeymans who owned the site of the present village, the right spelling of the Sieberella would seem to be coeymansensis, not "coeymanensis."

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