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STRATIGRAPHY AND STRUCTURE OF SOME KEWEENAWAN ROCKS, MICHIGAN

By

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STRATIGRAPHY AND STRUCTURE OF SOME KEWEENAWAN ROCKS, MICHIGAN

By

Harold A. Hubbard

The Ironwood area of western Michigan was mapped systematically and short reconnaissance trips were made to nearly all described localities that have features that bear on regional stratigraphic or structural problems in Michigan and Wisconsin. Several more places on Keweenaw Point should have been examined. The fieldwork on which the paper is based has been conducted by the U.S. Geological Survey in cooperation with the Geological Survey Division of the Michigan Department of Conservation.

Last year I described two sequences of volcanic rocks in the Ironwood area, the Traps of the South Range and the Portage Lake Lava Series.

This year I will suggest that four unconformable volcanic units are included in rocks previously considered part of the Portage Lake Lava Series. The South Range rocks seem to include two units, and some of Aldrich's North Flow Series may be younger than the Portage Lake Lava Series. As all geologists know, a change in stratigraphic interpretation casts doubt on earlier structural interpretations. The revision in earlier structural interpretations that I will suggest is that the Bad River thrust, the Lake Owen's thrust fault, the Keweenaw fault and the Douglas fault are really unconformities.

The contact between the rocks of the Traps of the South Range and the rocks of the overlying Portage Lake Lava Series and younger Keweenawan rocks has been considered to be a series of thrust faults in Wisconsin and an unconformity in Michigan. I think that the field relationships indicate that the contact is an unconformity in Wisconsin.

The Jacobsville sandstone covers the rocks between the Traps of the South Range and the Portage Lake Lava Series. The Jacobsville sandstone is much less deformed than the Portage Lake Lava Series and is probably unconformable on it.

The South Range rocks are unconformable on Animikie rocks which are about a billion years older. In the Ironwood area the pinkish lower Keweenawan quartz and sandstone is about 300 feet thick. It appears to be structurally concordant with gray but otherwise similar sandstones of the Tyler Slate which is traditionally assigned to the Animikie. The uppermost part of the lower Keweenawan sandstone was distorted by the lowermost flow and similar sandstones are interbedded with the lower flows. Because the Traps are conformable with lower Keweenawan rocks and are unconformable beneath the Middle Keweenawan rocks, I think the Traps of the South Range should be considered to be Lower Keweenawan in age.

The lower member is about 5000 feet thick in the Ironwood area and is composed of thin, fine-grained diabasic flows of dark-greenish andesitic basalt. The relationships of the lower member to the higher members

are obscure. In the Ironwood area, the middle member appears to be conformable on the lower member. West of the Ironwood area, Aldrich's mapping indicates that the lower member thins and wedges out near Mellen. West of Mellen the underlying Tyler Slate is also missing. The regional truncation suggests erosion and that the contact between the middle and lower members is an unconformity. The gabbro east of Mellen appears to be intrusive between the middle and lower members. The contact of the lower member with the middle and upper members is speculative because these members are not exposed east of the Ironwood area, except possibly near Mount Bohemia near the tip of Keweenaw Point. Near Lake Gogebic and in the Sturgeon River the Jacobsville sandstone is unconformable on rocks of the lower member.

The rocks of the middle member are quite distinctive. They are very fine grained to aphanitic basaltic andesites. About two-thirds of the rocks are flows, some of which are porphyritic with large white or pink feldspar phenocrysts.

Fragmental rocks that look very much like flows and that have been described as flows make up about a quarter of the Traps. The fragmental rocks are nondescript, generally monolithologic and very fine grained. The fragmental character is apparent generally only because of differences of texture within the rocks, and the pervasive lichen cover conceals most such features. The middle member also includes a few felsites and sandstones. It is about 5000 feet thick in the Ironwood area. The extrusive rocks of the middle member thin to the west, although the volcanic rocks plus intrusive gabbroic rocks have roughly the same stratigraphic thickness.

The upper member of the Traps of the South Range is composed of felsites and conglomerates. Exposures are rare and without magnetic data it would be difficult to show that the rocks of the upper member are part of the Traps. Ken Books of the U.S. Geological Survey has found that rocks of the middle and upper members have the same paleomagnetic remnant field direction, that remnant field direction is significantly different from the Portage Lake remnant field direction. Rocks of both members have distinctive aeromagnetic anomalies. The very low anomaly of the upper member is present only next to the high anomaly of the middle member. The rocks of the lower and middle members have higher anomalies than Portage Lake rocks of the Ironwood area, and westward, east of the Ironwood area, where the Traps of the South Range are buried, their anomalies are generally lower than the Portage Lake rocksanomalies. The broken pattern of anomalies southeast of the continuous band near Keweenaw point is associated with buried rocks that I suspect are rocks of the Traps of the South Range, although Bacon attributed these anomalies to rocks of a hypothetical Middle Range.

The felsites of the upper member of the Traps of the South Range in Wisconsin previously were correlated with the Chippewa felsite in Michigan. The low magnetic anomaly associated with the Wisconsin felsites passes about four miles south of Chippewa Hill in westermost Michigan.

The miscorrelation was made because the Portage Lake Lava Series thins greatly west of Lake Gogebic.

The conglomerates of the upper member at Davis Hill, Wisconsin, were formerly correlated with part of Copper Harbor Conglomerate on Keweenaw Point because both conglomerates contain felsite pebbles, but I think

that they are lithologically different. The Davis Hill conglomerate contains very little primary matrix material. Fragmental andesite and massive felsite are interbedded with it. The middle Keweenawan conglomerates contain felsite pebbles in an abundant matrix of finer volcanic particles. Interbedded fragmental andesite and massive felsite have not been described from the middle Keweenawan conglomerates, and I have not found any. Because several differences exist between the conglomerate at Davis Hill and the Copper Harbor Conglomerate, a correlation based solely on the presence of felsite pebbles seems unwarranted.

The upper member of the Traps of the South Range varies considerably in thickness. It is about 10,000 feet thick in the Ironwood area. It thins westward. At near Mellen it is only about 600 feet thick. The upper member thickens west of Mellen and it is about four thousand feet thick at Davis Hill, Wisconsin. The upper member is buried or absent east of the Ironwood area. The large variations in thickness suggest that it was eroded, and in fact, at Copper Falls State Park, north of Mellen, the Copper Harbor Conglomerate is disconformable on eroded upper member felsite. The contact was called the Bad River Thrust Fault by Aldrich to explain the absence of the Portage Lake Lava Series. The rocks of the Portage Lake Lava Series, the conformable Copper Harbor Conglomerate, and the overlying Nonesuch Shale all thin west from Lake Gogebic. The higher Portage Lake flows extend further west through the lower ones. Walter White attributed the thinning to progressive lapping against a topographic high centered near Mellen because magnetic and geophysical data suggest that the volcanic rocks are not repeated at depth.

At Copper Falls, steeply dipping but otherwise undistorted middle Keweenawan sand and shale are in contact with equally steeply dipping eroded lower Keweenawan felsite. The exposure is poor, but layers of coarser grained sediments can be traced. They are parallel with one another and with the higher sediments. There is no brecciation, no abnormal fracturing, and no local disturbance of the sediments. This is the only exposure of the Bad River thrust cited by Aldrich, and here the contact appears to be an ordinary unconformity, not a thrust fault.

The relationships at Davis Hill, Wisconsin, seem to provide additional evidence for an unconformity between the Traps of the South Range and the Portage Lake Lava Series. The Traps enclose gabbroic rocks that have Portage Lake paleomagnetic field direction, provided that the Traps dipped about 55° when the gabbros were intruded.

Aldrich recognized two unconformable lava sequences at Davis Hill. His South Flow Series is equivalent to part of the Traps of the South Range. His North Flow Series may be equivalent of the Portage Lake Series. But it appears to be unconformable over the gabbro with the Portage Lake paleomagnetite field direction. Aldrich recognized that the South and North Flow Series are unconformable. But he postulated that the unconformity is also a thrust fault, which he named the Lake Owen's thrust, because he erroneously correlated the conglomerate at Davis Hill with the Copper Harbor Conglomerate on Keweenaw Point, both contain felsite pebbles. Aldrich's ground magnetic data and recent aeromagnetic data suggest that the sequences really differ and offer no support for the repetition of strata. The data do not support the concept of the Lake Owens thrust fault.

Additional evidence for an unconformity between the Traps of the South Range and the middle Keweenawan rocks is provided by pebbles. Ophitic lavas are common in the Portage Lake Lava Series, but do not occur in the older traps. No pebbles of ophities rocks have been described from the middle Keweenawan rocks. I've probably looked at thousands of pebbles in the middle Keweenawan sediments. I have not found any pebbles of ophitic rocks except rare pebbles in Copper Falls Park. The virtually complete absence of ophitic pebbles shows that the Portage Lake Lava Series was not the source of the Middle Keweenawan sediments. (Some lower member-like ophitic rocks occur near St. Croix Falls and near Dairyland, Wisconsin). The presence of abundant pebbles of rocks typical of the Traps of the South Range suggests that it was the source of the middle Keweenawan sediments, and that the older volcanic sequence was being eroded during Portage Lake time.

Geophysical data indicate that rocks with different specific gravities and magnetic properties are present on opposite sides of the contacts previously shown as the Bad River thrust and the Lake Owen's thrust, but the geophysical data and geologic data are compatible with the contacts being unconformities only. Thrust faults seem to be unneeded complications.

East of the Ironwood area the relationships of the Traps of the South Range and the overlying rocks are less clear than to the west. Rocks of the middle and upper members may not crop out east of the Ironwood area. Lane correlated the volcanic rocks adjacent to Bete Grise Bay with rocks of the lower or middle member of the Traps of the

South Range even though the Bete Grise rocks are ophitic. No recent comparisons of the rocks of these areas have been published. The rocks at Bete Grise are discordant with the higher Portage Lake rocks. Cornwall interpreted them as being a fault-repeated part of the Portage Lake Lava Series, although they differ chemically; he also suggested the sequence might be unconformable. The Jacobsville Sandstone is unconformable on rocks of the lower member of the Traps of the South Range just east of Lake Gogebic and Sturgeon Falls.

The unconformity is of considerable interest because it has been used for more than eighty years to show that the Jacobsville sandstone is younger than the Portage Lake Lava Series. Although some previous workers have noted that the Traps differ in rock type from the Portage Lake Lava Series, all previous workers have considered the Traps of the South Range as part of the Portage Lake Lava Series. Because of this miscorrelation, the unconformity between the Traps of the South Range and the Jacobsville sandstone has been used to show that the Jacobsville sandstone is younger than both the Traps of the South Range and the Portage Lake Lava Series. That is, unconformity has been used as stratigraphic evidence of repetition of the Portage Lake Lava Series by the Keweenaw fault.

No evidence supporting the Keweenaw fault was discovered during the mapping of westernmost Michigan. In fact, the data are difficult to reconcile with a major thrust fault because there is no evidence of repetition of strata. The contact appears to be an unconformity. The Portage Lake Lava flows thin westward against a topographic high of eroded Traps of the South Range. If the Keweenaw fault exists, more

than eight miles of stratigraphic displacement occur along the unconformity where the unconformity joins the Jacobsville sandstone, about 20 miles east of the Ironwood area.

The published evidence for the Keweenaw fault is less conclusive than most geologists believe. I believe that two sequences of sediments may be present near the contact.

The Keweenaw fault was proposed by Irving and Chamberlin to explain the presence of supposedly Cambrian sandstones beneath the Precambrian Portage Lake rocks. The contact between the Portage Lake underlying sandstone was uncovered for Irving and Chamberlin by a force of miners in four ravines near Torch Lake.

The somewhat weakly indurated sediments dip steeply but are otherwise undeformed whereas the presumably much harder melaphyre was brecciated. It is now composed of fragments of volcanic rock in a clay matrix. If this is a fault contact, it is one along which only the harder rock was broken during deformation which dragged more than 300 feet of sedimentary rocks from a nearly horizontal attitude to their present steep dips without otherwise disturbing them. It seems more likely to me that this is an unconformity.

Irving and Chamberlin mention that the steeply dipping rocks contain more volcanic detritus than the gently dipping rocks. The steeply dipping beds are also more conglomeratic than the gently dipping beds. The difference in composition of the sediments, combined with the abrupt difference in dip, suggests that two sequences of sediments are present. The gently dipping sediments of the Jacobsville sandstone

appear to be unconformable on the steeply dipping sediments which can be called the sandstones of Torch Lake.

Although Irving and Chamberlin's Bulletin 23 provides the best description of the Keweenaw fault, their descriptions of the rocks are inadequate. I expect to spend more time studying these rocks because I am not now qualified to have an opinion on the reality of the Keweenaw fault. But the Keweenaw fault does not seem to be needed to explain the regional structural and stratigraphic relationships.

The Douglas fault is supposed to extend down the western side of the outcrop area. It was proposed to explain supposedly Cambrian sandstones beneath Precambrian volcanic rocks. Portage Lake-type rocks occur near the south end of the Douglas Range, north of Pine City. At one locality a sandstone in this sequence was described as having been jumbled by movement of a fault. The jumbled blocks are below the top of the steep bank of the Kettle River. They look like big talus blocks. The only rocks in place are almost horizontal. Volcanic rocks near Dairyland and the rocks at St. Croix Falls are ophitic but otherwise look like lower member South Range rocks, not Portage Lake rocks. An aeromagnetic map by Sims and Zietz suggests this too. South Range-type rocks near Duluth strike almost north south. The strike of rocks of the Douglas Range cut across the strike of these rocks, suggesting that the Douglas Range rocks are unconformable on them. These relationships suggest that younger volcanic rocks are

folded into syncline bordered by older rocks. A major thrust fault does not seem to be needed to explain the relationships.

At the classic locality of the Douglas fault on the Middle River volcanic rocks of unknown age can be inferred to overly steeply dipping Freda-type sedimentary rocks. The nearest outcrops are about forty miles apart. The volcanic rock nearest the contact is no more fractured than many other volcanic rocks in Michigan that are not related to faulting and in Michigan the Freda Formation is locally more distorted in places without the postulated thrust fault. The Douglas Thrust doesn't seem to be needed here. At American Falls three units are present, nearly flat-lying (Bayfield) sandstone, northward dipping conglomeratic sandstone (Oronto), and southward dipping volcanic rocks and detrital rocks. The horizontal sandstone is unconformable on the northward dipping conglomeratic sandstone. The horizontal sandstone is not in contact with the volcanic rocks and does not underly them. Some vertical faulting occurs too, but a major thrust fault does not seem to be needed to explain the relationship.

Sufficient data are available to suggest that the major discontinuities interpreted as thrust faults in the Lake Superior Region should be restudied to determine whether or not the field data actually support the concept of major thrust faulting in the Lake Superior Keweenawan rocks.