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# AROUND A GEOLOGIC CLOCK IN MINNESOTA[1]

Before anyone can understand the geological history of a region, two fundamental geological concepts must be thoroughly comprehended. These are the magnitude of geological time and the enormous gaps in the geological record of any one region.

To quickly gain an appreciation of the enormous number of years involved in reviewing the events of the past that have been recorded in the rocks of Minnesota, let us imagine that all the events in the geologic history of our state since the formation of the earliest known rocks are to be portrayed before our eyes on an enormous motion picture screen during one revolution of the hour hand on a clock. Twelve hours on our imaginary clock will then represent at least five hundred million years in the geologic history of our state. Each hour will represent over forty million years; each minute, seven hundred thousand years; each second, as it ticks by, will see eleven thousand, six hundred years in the geologic history of Minnesota move past us in review. On this clock of ours, the entire history of man on the earth will occupy less than a minute, and one-fifth of a second will serve for all the period recorded in the history of civilized man.

On our earth, mountains have been born where once the

[1]A radio talk presented over the University of Minnesota station WLB under the auspices of the Minnesota Historical Society on April 3. *Ed.*

seas were found. These mountains have grown old and have been worn away to level plains. Rocks that have slowly cooled from liquid masses deep in the earth have been exposed to view as the overlying rocks have been worn away by the elements. It should not surprise us, then, if great gaps in the geologic record of the past occur. Indeed, the surprising fact is that any consecutive account of the past events on the earth can be reconstructed.

Let us suppose that our twelve geologic hours in the past history of Minnesota are to begin at noon. By midnight all the events in the geologic history of the state will have passed in review. As our motion picture begins, we see Minnesota as the scene of enormous volcanic activity. Great flows of lava pour out of rents in the earth's crust and cover the land north and west of the present region of Lake Superior. Many of the lava flows are extruded from the interior of the earth beneath seas which cover parts of the surface of our state. In these seas are deposited sediments, some of which will later become the iron formation of the Vermilion Range.

As three hours on our geologic clock pass by — at least a hundred and twenty million years — we find the lava-covered land beginning to bulge and heave until the nose of a range of mountains appears. The range strikes east and somewhat north into Canada. These mountains extend in a general northeast, southwest direction across the area of Minnesota from the Canadian boundary line at Saganaga Lake to the southwestern corner of Minnesota. To the north they strike across Canada, following the general line of the St. Lawrence River into far-off Quebec.

From three o'clock till four o'clock, as our picture of Minnesota of the past moves on, the mountain range is slowly leveled away by the elements. At last we see that as our mountains were formed enormous quantities of liquid rock from the depths of the earth welled up beneath the folded surface rocks. This liquid rock had cooled and

formed great rounded knobs of granite and gneiss, which are gradually exposed as the mountains disappear. These are marked today by the many outcroppings of granite along the Minnesota River above Mankato and by granite around Saganaga Lake. The ancient lava flows were profoundly altered during the mountain-building movements, until they became the so-called green schists of St. Louis and Itasca counties. On our leveled mountain area, mud rocks and boulder rocks are deposited in another sea that has occupied the area. These are now preserved as the slates and conglomerates abundant in Koochiching and St. Louis counties.

From four to five o'clock we see mountains again raised and worn away, leaving other granite masses, similar to the older ones, outcropping in a broad belt north from the Mesabi Range to the Canadian border and beyond. These younger granites also outcrop south and west of Mille Lacs.

Geologists believe that on the ancient rocks which we have seen forming in the first five hours of our geological motion picture all the later rocks of our state were laid down. Thus, if we were to drill down through the younger rocks in any part of the state, we would, at some point, come to one of the ancient basement rocks — the granites, the altered sediments, and the ancient lavas.

During the hour from five to six o'clock we see a succession of events happening with comparative rapidity. Our ancient rocks are first covered by seas in which sediments, including the iron-bearing formations of the Mesabi Range, are deposited. They occupy most of north-central Minnesota. The quartzite with its interbedded pipestone layers, which is found in southwestern Minnesota, was probably deposited at this time. This quiet period of sedimentation ends with another extensive period of volcanic activity. Masses of molten rock are intruded from below and enormous sheets of lava flow from cracks in the earth's surface to cover the Lake Superior area and to spread west to the Mesabi Range and south to Taylor's Falls. These vol-

canic rocks are best studied along the north shore of Lake Superior.

At six-thirty on our geologic clock Minnesota again is affected by mountain-building movements, which center, however, in Ontario and Wisconsin. At this time, the great downward fold of rock which is later to be occupied by Lake Superior is partly formed. The lava flows of the North Shore today are seen to dip down underneath the lake.

For over half of our twelve hours of geologic time — at least two hundred and seventy-five million years — Minnesota has been close to the center of mountain-forming activity on the continent. The rocks at the surface, in consequence, are folded, crumpled, and altered; the relationships between the different masses of rock are obscure and difficult to determine. During the remaining five and a half hours on our geologic clock, Minnesota is far removed from the centers of mountain-forming activity, and the record which is preserved is to be found in the flat-lying mud rocks, lime rocks, and sand rocks deposited in the seas. Even this record is by no means complete, for Minnesota has been above the level of the ancient seas for longer periods of time than it has been submerged, and these long periods of erosion leave little evidence of past events for the geologist to study. It is the periods of rock formation, and not the periods of rock erosion, from which the geologist constructs his history of the past.

Another change takes place at this time in our geologic history of Minnesota. This is the appearance of abundant life in the seas. Heretofore the record has been meager indeed. Only the presence of a few dubious algæ-like forms in the rock has given any real clue to the life of our state. From this time forward the record of life is varied and interesting.

For the next half hour of our picture of Minnesota of the past — twenty million years or more — nothing appears

on the screen. We perhaps can guess at some of the events which transpired during this great lost interval of time. The mountains raised during the last recorded period probably were worn down and a thick bed of sandstone was deposited on the eastern flank of the ancient range. The area for hundreds of miles to the south and east of Minnesota was gradually warped down until a rock trough, communicating with the ocean through California, was formed. This rocky trough gradually deepened until the southeastern corner of Minnesota was submerged. The sea extended to the flank of the eroded remnant of the range of mountains which cut across Minnesota from the northeast to the southwest. This, then, is the condition which we see as the hour hand points to seven o'clock.

From seven o'clock to eight o'clock this arm of the sea, which has invaded our state from the southeast, occupies our interest. We see great rivers carrying sand down to the shore of this sea, where it is deposited in thick beds. As we watch the scene, we scarcely note the minor changes in conditions which cause beds of mud and limestone to be deposited at intervals between the beds of sand. Sometimes the boundary of the sea shifts slightly, bringing portions of the sea bottom above water, where the newly deposited sediments are rapidly eroded. Throughout this whole hour of geologic time, however, there is an almost continuous deposition of sediments in some parts of the southeastern corner of our state. These now appear as flat-lying beds of sandstone, shale, and limestone that outcrop along the river bluffs from Taylor's Falls south to the Iowa border and beyond, and along the tributaries of the Mississippi in southern Minnesota. These beds of rock are often pierced by the deep wells of the Twin Cities. Animals were abundant in this ancient sea and during this hour of geologic time we see many forms of lower invertebrates develop and pass out of existence. Trilobites — distant relatives of the crabs — are the highest form of life.

From eight o'clock until nine we again have a gap in the record of Minnesota of the past. Our ancient sea has retreated and the beds of rock that were deposited are everywhere being eroded. If we could glance at the continent as a whole, we would observe a sea occupying a trough where the Appalachian Mountains now lie and spreading as far west as Wisconsin, but never quite reaching Minnesota. For a brief period around nine o'clock we see a small portion of Minnesota again submerged by an arm of the sea which covers Iowa and extends far to the northwest. The intervening time has seen the rise of the fishes.

From nine o'clock until eleven-fifteen our screen is blank. During this great interval of time, Minnesota was everywhere above the sea and was being eroded. Important events were happening in many other parts of North America. The Appalachian Mountains had been formed. Life had made many advances. Land animals had appeared, and the age of enormous reptiles had almost run its course. Plant life had taken on an almost modern aspect. Suddenly, for a brief interval on our screen, we see the seas once more invading Minnesota — this time from the west. Our ancient Minnesota mountains have disappeared before the eroding elements, and the western sea deposits a thin layer of mud and sand over the eroded surfaces of mountains as well as ancient sea bottoms. The brief invasion of the sea is ended by its general withdrawal as the Rocky Mountains are formed. By eleven-thirty the last of Minnesota's seas has withdrawn.

It was a strange scene which we saw during the time of this last brief invasion of the sea, for some of the curious reptiles of the past — the dinosaurs — were to be found along the shore of the ancient sea in our own state.

Again our screen is blank as the end of our twelve geologic hours draws near. Only forty-three seconds — five hundred thousand years — are left. Suddenly a new scene flashes upon the screen. Again we see our state invaded.

This time the invader is not an advancing arm of the sea, but a sheet of ice. From the far north, ice rapidly spreads over the northern half of the continent and almost all of Minnesota is covered. The ice retreats and again advances. Four times the ice spreads south and retreats to the north, the last retreat taking place less than four seconds before our picture ends. As the ice retreats for the last time we see, almost in a flash, a large lake covering the northwestern corner of the state, where the water from the melting ice is dammed up between the retreating ice sheet at the north and the continental divide at the south. We see the water break through and drain off to the north as the ice finally withdraws past Hudson Bay.

Life again has changed. The age of reptiles has passed and the age of mammals is with us. We see shaggy elephants roaming Minnesota during the Ice Age. We even see early man.

Our last glimpse of Minnesota shows it much as it is today. Almost everywhere the rocks are covered by an uneven mantle of soil and boulders — the debris left by the melting ice. Thousands of tiny depressions in this mantle are filled with lakes. If we could see this last brief moment of the picture in slow motion we would see lakes being filled with peat, and river bottoms, no longer scoured by rushing torrents from the melting ice, filled with silt to a depth of hundreds of feet. We would see coniferous forests moving north, followed by deciduous forests. We would mark the cutting back of the Falls of St. Anthony from Fort Snelling to Minneapolis.

Now our twelve geologic hours of Minnesota's past are ended. We cannot help wondering what future geologic time holds in store for Minnesota.

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