SOME EVENTS IN THE GEOLOGICAL HISTORY OF SOUTHERN ILLINOIS

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From a geological point of view southern Illinois, along with southeastern Indiana, occupies a basin lying between the Ozark region of Missouri on the west, and the Cincinnati region on the east. Throughout geological time these two areas have been positive areas, that is regions which have had a tendency to be uplifted at intervals to a greater degree than their surroundings. At times they have been islands completely encircled by the waters of the ancient seas, at other times they have been covered by waters of much shallower depth than the adjacent areas.

In discussing the geological history of this area, as of any region, the geologist must draw his inferences concerning the succession of events from his field observations upon the rock strata of the earth's crust. Since geological time is inconceivably long, and since the complexity of geological history is exceedingly great, a consideration of the entire course of the geological history of southern Illinois would consume time far beyond that at my disposal this afternoon. I will, therefore, confine my remarks to a comparatively short time interval, namely that beginning with the Mississippian period and extending to the close of the Paleozoic era.

Rock strata of Mississippian age occupy a belt, including the Mississippi river bluffs and the adjacent region to the east for a distance of 15 miles or less, extending from a point in St. Clair County south of East St. Louis, to the valley of Big Muddy river. Strata of the same age occupy another belt extending eastwardly across Union, Johnson, Pope and Hardin Counties, from the Mississippi river to the Ohio, south of the Ozark upland which occupies the northern portion of the counties mentioned.

Throughout Mississippian time the southern Illinois basin was occupied by a great gulf-like embayment of the ocean which opened to the south; it was in a way an extension to the north of the ancient Gulf of Mexico. This embayment extended far beyond the limits of the present outcrops of

westward across Iowa and probably reached to the Rocky Mountain region. Cincinnatia was a low lying island or shoal water area. During this time, with no immediate source for terrestrial materials, the sediments accumulating over southern Illinois were largely calcium carbonate of organic origin, along with considerable quantities of colloidal silica which was precipitated from fresh waters entering the basin from rivers. Near the shore line clastic deposits must have been accumulating, but they did not reach to the area now occupied by southern Illinois.

After Burlington time the waters of the Illinois basin underwent a number of withdrawals and readvancements, but the waters of the basin probably had their greatest extension during the Burlington epoch. The Keokuk epoch was initiated by partial withdrawal of the waters of the basin, the northern shore line coming to occupy such a position that terrigenous material in the form of fine mud was somewhat extensively deposited as shale beds, as far south as southeastern Iowa and the adjacent parts of Missouri and Illinois, while in Burlington time the sedimentary accumulation in these same areas was wholly organic in origin. That part of the basin which is now southern Illinois, however, still remained at such a great distance from the shore lines that limestone accumulations continued uninterruptedly through the Burlington and Keokuk time, making it more difficult to separate the strata of these two epochs. In Warsaw time the shore line shifted still farther to the south, and by mid-Warsaw time it occupied a position somewhere between the southern border of Iowa and the city of St. Louis. At this time also, the ocean level was sufficiently lowered to permit the streams of Ozarkia to carry terrigenous material into the sea, so that the Warsaw formation of southern Illinois contains notable shale deposits, especially in the Mississippi river sections, although in southern Illinois, at a greater distance from the shore line, the sedimentation was continuously limestone.

Following Warsaw time there was a readvance of the northern shore line until the waters of the Illinois basin spread again into northern Illinois, and westward into Iowa for an unknown distance, and completely surrounded the

Ozark land which was sufficiently submerged to prevent any transportation of land detritus by the streams into the surrounding oceans. It was at this time that the Spergen limestone was being laid down, a formation which is a nearly pure limestone at most localities. In southeastern Iowa this formation lies unconformably upon the underlying beds, but in the southern portion of the basin there is no evidence of any interruption in sedimentation in passing from the Warsaw to the Spergen. If the exact southern limit of the condition of unconformity could be determined, the exact location of the southernmost position of the shore line in late Warsaw time could be established.

After Spergen time the waters of the Illinois basin again retreated southward to a position essentially the same as that of the pre-Spergen retreat. The evidence for this shifting of the shore line is exhibited in the uncomformable contact of the St. Louis limestone which lies next above the Spergen, or above whatever formation is subjacent. During the post-Spergen retreat the erosion of the surface of what is now southeastern Iowa was unequal, in places the whole of the Spergen was removed, while elsewhere a greater or less thickness of the formation remained. Where the Spergen was wholly removed the St. Louis limestone rests directly upon the Warsaw beds; elsewhere it rests uncomformably upon the Spergen. In southern Illinois the continuity of sedimentation from Spergen to St. Louis time was not interrupted, a condition indicating the continuous occupation of that portion of the Illinois basin by the ocean waters. The southern extent of the post-Spergen unconformity seems to be essentially the same as that of the post-Warsaw, and so far as can be determined from data now available, the shore lines of these times occupied about the same positions.

Again a fluctuation of the waters of the basin took place in the midst of the period of deposition of the St. Louis limestone, this withdrawal, followed by a readvance, being proven by a stratigraphic break in southeastern Iowa with the upper division of the St. Louis limestone resting uncomformably upon the lower portion of the same formation. This interruption is exhibited as far south as Alton, Illinois,

again initiate the distribution of sands over regions which had been limestone-shale depositing areas. These newer sand deposits, however, would soon become a part of the dry land surface where they would be subject to erosion, and a large portion of the material would be washed down again into the sea to be reworked by the waves, and eventually the final land surface would be constituted of the limestone strata which had been deposited at some distance off shore. With the next advance of the waters in the basin the calcareous land surface would become the floor upon which the next succeeding sandstone formation was deposited unconformably.

It is not clear that every one of the Chester sandstone formations which have been recognized in southern Illinois exhibits a condition of unconformity along its belt of outcrop with the underlying limestone, but the presence of unconformity or the lack of such a relation at these horizons is indicative of the position of the fluctuating Chester shore lines relative to the present outcropping belt of the formations. In the greater withdrawals of the waters of the basin the whole of southern Illinois doubtless became a part of the dry land surface, but in the lesser withdrawals the extreme southern position of the shore line was north of the present position of the Ohio river. During the entire succession of events of Chester time, the shifting shore lines must have repeatedly occupied every part of southern Illinois.

The original source of the sand which was finally consolidated in the sandstone formations of the Chester series may have been far away. Rivers draining the country far to the north must have emptied into the Illinois embayment during this time, and the sand and silt transported by them, perhaps from as far away as the Canadian highlands, may have been the original source of much of the material. The Ozark land to the west was probably a low lying region during much of the time, with sluggish streams which did not bring much land detritus into the basin, and there is no evidence that Cincinnatia was ever at any great elevation above the sea. The fact that several of the Chester sandstones become much reduced in thickness to the west is perhaps

evidence that the streams bringing the sand had their mouths toward the eastern side of the basin, the thicker portions of the formations being nearer the source of supply of the material. One of these formations, which has been named the Waltersburg sandstone, is conspicuously developed in proximity to the Johnson-Pope County line but thins to the east and the west, the lateral extent of the formation in an east west direction along the belt of outcrop, as a conspicuous member of the section, being not greater than forty miles. It is not improbable that this formation may have accumulated as a delta deposit opposite the mouth of a river entering the basin at this particular time in its history.

If the suggested interpretation of the succession of Chester sandstones and limestone-shale formations of southern Illinois is the correct one, then it would be expected that this same time interval would be represented by more continuous limestone strata at a distance from the shore line of the Illinois basin. The Chester Series is extensively represented in southeastern Tennessee and northeastern Alabama by a thick limestone formation which probably represents the whole succession of limestone-shale formations in southern Illinois. Only one thin sandstone member has been recognized in southeastern Tennessee which seems to occupy the position of the Hardinsburg sandstone of the Ohio valley. A similar sandstone which may be the same is present in the Alabama section.

With the final withdrawal of the waters of the Chester seas the Mississippian period came to an end and southern Illinois became a portion of a widely stretching dry land area, and remained in that condition for a long period of time. This land surface was sculptured by the action of streams which drained the area, and the whole surface doubtless was covered with a strange vegetation, very different from that of the present time. No record of this land life is preserved in our own state, but elsewhere sediments have been preserved, containing many fossil plants, which were deposited during this dry land period in Illinois. Finally a change in conditions was inaugurated, and

there began to accumulate a great series of sediments which were terrestrial in origin rather than marine. These sediments consist of extensive beds of cross-bedded sandstones which are commonly coarser in texture than the Chester sandstones, some beds of which include great numbers of smoothly rounded, white, quartz pebbles which vary in size from one-fourth of an inch to nearly an inch in diameter. These pebble beds or conglomerates are highly characteristic of the Pottsville formation, and are widely distributed in the hills of the elevated country crossing Illinois south of Carbondale. Associated with the Pottsville sandstones and conglomerates there are important beds of shale and more or less thinly bedded sandstones, and also locally some coal beds. The fossil remains which have been preserved in the Pottsville beds are land plants. More or less fragmentary trunks of the Carboniferous tree, *Lepidodendron*, are present in many places in the sandstones, and the shales in places contain abundant, well preserved plants, most of which are ferns or fern-like forms.

Pottsville formations quite similar to those in southern Illinois are widely distributed in North America. They are present in the sections as far away to the southeast as southeastern Tennessee, and northern Alabama, and to the southwest they extend into northern Arkansas. The exact conditions under which such formations could have accumulated are not easy to visualize. The source of the materials in these Pottsville beds, including the vast numbers of white quartz pebbles, is still a mystery to the geologist, and the manner in which they may have been spread so widely upon the land surface is not clear. Doubtless the land was low lying, and broadly meandering streams probably were an agent in spreading the materials. There must also have been estuaries, and broad, shallow basins occupied by waters in which quantities of mud accumulated, in which were buried in places the remains of some of the plants which lived near at hand.

There are a few records in southern Illinois of a thin limestone in this Pottsville series containing marine fossils, which bears evidence that once at least, marine conditions spread into southern Illinois in Pottsville time, remaining

for a short period only. After Pottsville time similar conditions persisted in southern Illinois through the period of deposition of the Carbondale and McLeansboro formations. The main coal beds which are so widely mined in southern Illinois are all included in the Carbondale formation. The McLeansboro also contains several thin coal seams, none of which, however, are workable. During all of this time the elevation of the whole of the Illinois basin must have been near sea level. During the intervals of coal formation great swamps covered the area, where the coal plants grew and where the beds of peat accumulated which later became changed to coal. At times these coal swamps were widely distributed and of long duration. At other times the coal swamps were local and of comparatively short duration. Between the periods of coal accumulation the basin was sometimes occupied by shallow, marine waters in which shale beds of impure limestones were formed, the marine origin of such beds being established by the presence of the marine fossils which are included in them. Other members of the Carbondale and McLeansboro formations doubtless were terrestrial in origin, similar to much of the sandstone and shale of the Pottsville formation.

After the close of Pennsylvanian time there was an exceedingly long period which has left no sedimentary record of the events which transpired, but during this time there was a period of notable deformation of the rocks of the earth's crust. This deformation resulted in uplift, and locally in the development of great fractures or faults through the rock strata, with differential movement of the blocks adjoining the fractures. The presence of the elevated belt of land across Illinois from the Mississippi to the Ohio river, south of Carbondale, is due to this deformation. The rocks constituting the summits of this range of hills are Pottsville in age, but at Carbondale and throughout the level country north of the hills the same Pottsville strata lie many feet beneath the surface. The amount of uplift along this belt must be equal to the difference between the elevation of the summits of the hills and the depth of the same Pottsville beds beneath the surface, to the north, and must amount to 1000 feet or more. The geology of the belt has

not been mapped in detail except for a short distance near Shawneetown on the Ohio river, where east-west faulting has been observed, but this faulting may not extend across the State. On the southern slope of the Ozark hills a remarkable series of faults has been mapped in Hardin, Pope and Johnson Counties.

The exact time when all of this faulting occurred cannot be determined with certainty. The deformation must have taken place after Pennsylvanian time for the strata of Pennsylvanian age are involved. The other limit which can be established is determined by the age of the gulf embayment deposits which stretch from the Gulf of Mexico coast line to southern Illinois. These deposits overlie the faulted rocks under consideration in an undisturbed condition. The age of the oldest of the embayment deposits is probably Cretaceous, so the age of the faulting would fall between the Pennsylvanian and the Cretaceous, a very long period of time, even to the Geologist. Within these time limits falls the close of the Paleozoic era, a time when much deformation was in progress in many parts of the world, and it is commonly assumed that the faulting in southern Illinois was accomplished, in the main, at that time.

In Hardin County it is significant that associated with the faults are found the remarkable deposits of fluorspar for which southern Illinois is famous, and also there are present in the same region numerous dikes of igneous rocks which penetrate the limestones and other formations of Mississippian and Pennsylvanian age. It is believed that there is some definite connection between the three phenomena, the faults, the mineral veins, and the igneous dikes. There is probably a considerable area of southeastern Illinois and the adjoining portion of Kentucky which is underlain by a great mass of igneous rock. This was in effect the site of a great volcano in the long distant past, most of whose lava was injected into and between the sedimentary rock strata. If any of the lava was ever extrusive on the surface, it has long since been removed by the processes of erosion. Numerous dikes, some of which may have extended to the surface when they were formed, are known to be present, and at least one mass in northern Hardin County,

near Sparks Hill, seems to be an ancient volcanic neck, or outlet. The most western of these dikes which has been observed is in Pope County about one mile west of Golconda. They have been observed at numerous localities in Hardin County, and are known to be present in some of the coal mines near Harrisburg. They have also been observed at many localities in Livingston and Crittenden Counties, Kentucky. Doubtless many other dikes are present within this region wholly covered by the surficial mantle rock, some of which may be discovered in the future. The depth beneath the present surface, of the great body of igneous rock with which these dikes must connect, is unknown, for it has never been pentrated either in mining operations or by deep drilling.

The presence of such an intrusion is believed to be responsible for at least some of the faulting of the region. When the mass was injected into the strata of the crust, the beds overlying it were necessarily bowed up, and in this process of bowing the beds were stretched and great fractures were formed. The amount of movement on opposite sides of these fractures was not the same so that faulting resulted. The faults which were formed during this upbowing process, however, probably were not the most complicated ones. While the deeply buried molten mass was still very hot and remained in a more or less plastic or viscous condition, the enormous weight of the overlying sediments resting upon it must have had a tendency to squeeze it out laterally so that the original dome would become lower and broader. With the readjustment of the crustal blocks in connection with this settling of certain arch-like segments of the dome, there was a virtual collapse of the strata in certain areas, occasioning extremely complicated faulting.

The fluorspar veins of southeastern Illinois are along certain of the faults in the more complexly faulted areas, or in rather close association with faults. The fluorine content of the mineral is a product of igneous rocks and doubtless was originally given off from the igneous rock which presumably underlies the entire fluorspar region. A determination of the actual genesis of the ores as they are found at the present time is complicated by many factors, but Mr. L.

W. Currier has made numerous observations which tend to prove that the present occurrence of the fluorspar is due to a replacement of crystalline calcite which first closed up the open spaces along fault planes.

Not all of the faults of southern Illinois were associated with the deep seated igneous intrusion, for certain of them are far from any known igneous dikes, and there must have been other stresses of the earth's crust at this time which were relieved by faulting. In general the more continuous faults in southeastern Illinois have a northeast-southwest direction. To the southwest they pass beneath the embayment deposits, as has been previously indicated, but it is perhaps significant that the projection of this belt of faulting in a southwesterly direction follows very closely the western border of the area occupied by the embayment deposits, and the suggestion may be offered that this whole embayment area may be the result of a downward dislocation of the crustal block lying southeast of the continuation of the faulting which is exposed across Pope and Hardin Counties, Illinois, but which is hidden to the southwest. Certain structural features as far southwest as northern Louisiana may possibly be associated with this same line of deformation.

Coming from the Ozark region west of the Mississippi river there is a belt of faulting which crosses the river in the vicinity of Grand Tower, Illinois. These faults have an east-west or northwest southeast direction, with the downthrow side on the north, and it is not unlikely that the eastward extension of some portion of this fault belt may be responsible for the uplifted Ozark ridge across southern Illinois.

The widespread distribution of the faults of southern Illinois establishes the fact that this area has been, in the geologic past, one of great crustal disturbance. Lines of weakness once established in the earth's crust repeatedly give way under the accumulating stresses, and it is not unlikely that movements of greater or less magnitude have taken place along certain of these fault lines at intervals since they were first established. It is quite possible that

the New Madrid earthquake of 1811 was the result of movement in some portion of this fault zone.

The events in the geological history of southern Illinois which have been mentioned and briefly discussed in this address constitute only a fragment of the complete history of the region. They are, however, the events which are recorded in the rock strata which are actually exposed in the region. Many hundreds of feet of strata underlie the whole of this portion of the state, beneath the formations which have been considered, but the history which they record is not so easily or so certainly determinable. There is also a long history since the close of Paleozoic time which is full of events of great interest, but neither this more ancient nor the more modern portion of the story can be considered at this time.