PRESENT STATE OF KNOWLEDGE REGARDING THE PRE-CAMBRIAN CRYSTALLINES OF ILLINOIS*

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The oldest sedimentary strata of Illinois rest on a foundation of igneous and metamorphic rocks which are commonly referred to as the pre-Cambrian crystallines or basement complex. Rocks of corresponding age crop out in the nearby states of Wisconsin, Minnesota, Iowa, and Missouri, but in Illinois they are buried under a variable thickness of later sediments and can be examined only in cuttings or cores from deep wells.

Six wells in Illinois penetrate these crystalline rocks, one each in Boone and DeKalb counties, two in Lee County, and two in Pike County, figure 1. The four wells in the northern counties encountered granite, but the two southern wells encountered rhyolite porphyry and granophyre. From 3 to 639 feet of these ancient igneous rocks were cut in the various wells. All were drilled as oil tests and all but one, the Herndon Drilling Co.—Campbell well in Pike County, were drilled with cable tools.

Data regarding the names of the wells and their locations, the depth and sea-level elevation of the tops of the crystalline rocks, and their thickness and character are given in table 1. The greatest and least depths are 3845 and 2221 feet respectively. In terms of elevation, the highest occurrence is 1401 feet below sea-level and the lowest is 3046 feet below sea-level, a range of 1645 feet. As a measure of the local relief involved, the difference in elevation of the crystalline surface is 356 feet in the two Lee County wells which are five miles apart, and 1088 feet in the two Pike County wells which are 8½ miles apart.

FIG. 1.—Location of wells that penetrate pre-Cambrian crystalline rocks.

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TABLE 1.—PRE-CAMBRIAN CRYSTALLINE ROCKS IN ILLINOIS WELLS

Name of well	Location	Top of crystalline rocks		Thickness penetrated, feet	Type of rock encountered
		Depth in feet	Sea-level elevation		
1. Northern Illinois Oil and Gas Co. Taylor No. 1	28-43N-3E Boone County	2925	–2105	73	Gray granite
2. Paul Schulte, Wyman No. 1	35-41N-5E DeKalb County	3845	–2935	639	Red granite
3. H. O. Carr, Vedovell No. 1	35-20N-10E Lee County	3465	–2690	187*	Red granite and felsite
4. Amboy Oil and Gas Co., McElroy No. 1	30-20N-10E Lee County	3760	–3046	12	Red granite
5. Herndon Drilling Co., Campbell No. 1	15-4S-5W Pike County	3204	–2488	3	Red–brown rhyolite porphyry
6. Panhandle-Eastern, Mumford No. 1	21-5S-4W Pike County	2221	–1401	5	Red granophyre

* As of April 26, 1949; well reported shut down.

From the limited information provided by the six wells and the character of the topography of exposed and buried pre-Cambrian surfaces in nearby areas,[1] it is inferred that the buried pre-Cambrian terrain in Illinois probably ranges from a broadly undulatory surface studded with scattered residual hills to one featured at least in part by close-spaced hills and valleys, and that a local relief of as much as 1000 feet may be a common situation. Regional warping and local faulting and folding in post-Cambrian time have doubtless modified the original attitude of this terrain. It has been suggested that the crystalline surface becomes generally lower eastward from the Ozark dome region of Missouri and southward from Wisconsin until it reaches depths greater than 11,000 feet below sea-level in southeast Illinois.[2]

Study of cuttings shows that with the exception of altered felsite encountered in the H. O. Carr—Vedovell No. 1 well in Lee County, the crystalline rocks found in the four wells in the northern part of the State all are red or gray granites of medium to coarse-grained texture. The common essential minerals in-

[1] Buckley, E. R., Geology of the disseminated lead deposits of St. Francois and Washington Counties; Missouri Bur. Geology and Mines, Vol. 9, Part 1., pp. 17-18, 1909.
Weidman, Samuel, The geology of north central Wisconsin; Wisconsin Geol. and Nat. His. Survey, Bull. No. 16, pp. 385-395, 1907.

[2] Workman, L. E., and A. H. Bell, Deep drilling and deeper oil possibilities in Illinois; Illinois Geol. Survey Rept. Inv. 139, p. 2060 and figure 14. Reprinted from Bull. Am. Assn. Petroleum Geologists, Vol. 32, No. 11, 1948.

FIG. 2.—Sketch of microporphyritic felsite from dike in granite from H. O. Carr-Vedovell well, Lee County. Rectangular crystals represent altered feldspar; bundles of curving lines represent crystallites arranged in flowage pattern; black represents opaque minerals; and the rest is cryptocrystalline material. Magnification 120X.

clude quartz, orthoclase and microcline feldspar, and biotite. The common accessory minerals are apatite, zircon, rutile, magnetite, and ilmenite. Chlorite and epidote also occur in small amounts. Plagioclase feldspar is present in such small amounts as to be practically an accessory mineral; oligoclase and andesine are the varieties found. Hornblende is rare or lacking in all except the Northern Illinois Oil and Gas Co.—Taylor well in Boone County, in which it is abundant. The granite in the Taylor well also differs from the other granites in that it is grayer, contains abundant titanite, much of which is in large grains, and has andesine rather than oligoclase as its plagioclase feldspar. This difference in mineralogical character might result either from compositional variations within a single granite mass or from the presence of a separate and different body of granite at the Taylor well locality.

From a petrographer's point of view, the most interesting feature of these northern wells is the altered felsite found in the granite in the H. O. Carr—Vedovell well, which because of its much different textural character is presumed to occur as dikes intrusive into the granite. The well penetrated successively 95 feet of granite, 35 feet of altered felsite, 52 feet of granite, 7 feet of altered felsite, and finally 3 feet of granite. The least-altered particles of felsite recovered in the cuttings are reddish and purplish brown in color, and as seen in thin section, figure 2, are composed of numerous tiny square to rectangular crystals of altered feldspar in a matrix consisting of numerous crystallites and of cryptocrystalline material of indeterminate composition which may have been glass originally. The crystallites around many of the tiny feldspar crystals are arranged in a pattern suggestive of flowage while the mass was still partly fluid.

The felsite has been altered to a light green waxy clay, whose X-ray diffraction pattern is that of a mica-montmorillonite mixed layer mineral in which the proportion of mica to montmorillonite is about 5 to 1.[3] The progressive nature of this alteration, presumably by chemically active hot water which traversed fractures alongside or within the dikes, may be observed in the appearance of various fragments in the samples. It is reflected first in a change in color

[3] X-ray analysis by W. F. Bradley, Chemist and Head, X-ray Division, Illinois Geological Survey.

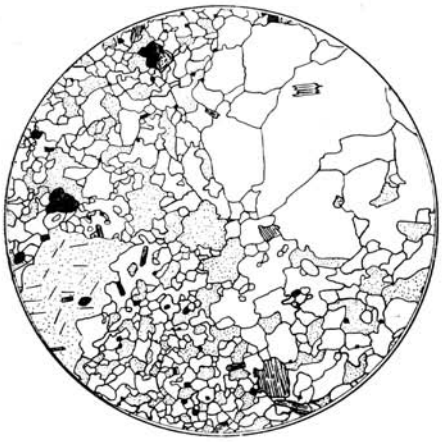

FIG. 3.—Sketch of rhyolite porphyry from Herndon Drilling Co.—Campbell well, Pike County. Clear grains are quartz, stippled are feldspar, black are mostly magnetite and pyrite, and grains with longitudinal lining are biotite and muscovite. Large areas of quartz appear as single grains in plain light. Magnification 48X.

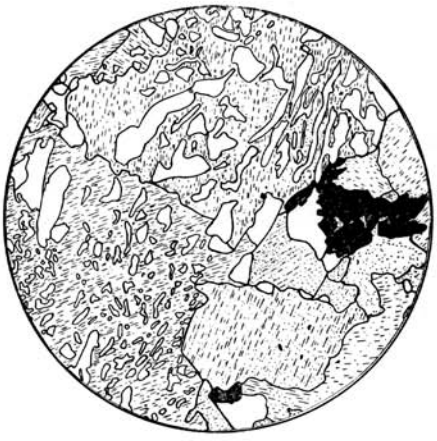

FIG. 4.—Sketch of micropegmatitic texture in granophyre from Panhandle-Eastern-Mumford well, Pike County. Quartz (clear) is intergrown with feldspar (dashed line pattern). Black grains are magnetite. Magnification 33X.

from brownish to mottled shades of tan and greenish gray and a slight decrease in hardness, then by increasing dominance of the green color and further decrease in hardness until in the final stage the entire mass is changed to soft green clay. In thin section the original microporphyritic texture of the felsite is clearly preserved in the green clay, a further proof that the latter is an alteration product of the felsite. Additional evidence that this alteration was caused by hydrothermal solutions is afforded by the presence of small fluorite crystals in the upper part of the uppermost dike and in the 45 to 50 feet of granite overlying the dike, the somewhat altered appearance of the granite immediately above the uppermost dike, and the presence of moderately abundant pyrite in the green clay.

The crystalline rocks in the Pike County wells are distinct petrographically from the granites found in the northern wells. The rock from the Herndon Drilling Co.—Campbell well is a purplish-brown rhyolite porphyry and that from the Mumford well a granophyre. Both of these rocks are fine-grained members of the granite clan and both are types common in the pre-Cambrian exposures approximately 125 miles south in the St. Francis Mountain area of southeastern Missouri.[4]

The rhyolite porphyry in the Campbell well consists of large crystals of feldspar and quartz up to 7 millimeters long, comprising together about 20 percent of the rock, in a

[4] Erasmus Haworth, Crystalline rocks of Missouri: Missouri Geol. Survey, Bulletin 8, pp. 81-222, 1895.
Tarr, W. A., Intrusive relationship of the granite to the rhyolite (porphyry) of southeastern Missouri: Geol. Soc. America, Bull. 43, pp. 965-992, 1932.

fine-grained, equigranular, fresh-looking groundmass consisting of 60 percent quartz and 40 percent orthoclase feldspar, figure 3. Other minerals present include minor amounts of muscovite and biotite mica, chlorite, pyrite, magnetite, hematite, zircon, and garnet. The large feldspar crystals include microcline, othoclase, and microperthite, and many of them have rectangular or partly rectangular outlines. The large quartz crystals are oval to lenticular in outline, and are made up of groups of interlocking smaller crystals. The edges of many of the large quartz grains are scalloped or embayed in the fashion commonly attributed to corrosion of early-formed crystals by the still-liquid portion of magma. Many of the large crystals have been fractured, either during flowage of the mass while partially liquid or as the result of later metamorphic shearing. The cracks in some of the crystals are filled with later quartz and in others by portions of the quartz-feldspar groundmass. Further evidence of flowage or shearing is faintly apparent in traces of banding caused by parallelism of the long axes of lenticular quartz grains and a slight color banding. In general, the equigranular mosaic texture of the groundmass and the completely random orientation of the micas suggest recrystallization as a result of metamorphism. The rock has been termed a recrystallized quartzite by some, but the large amount of feldspar in the groundmass and the general non-detrital appearance of both the individual crystals and the rock as a whole make this interpretation questionable.

The original character of the crystalline rock from the Panhandle-Eastern—Mumford well, the other Pike County occurrence, is more difficult to determine as the available samples consist entirely of fragments smaller than 1/8 inch. However, it is apparent that the rock is red in color and consists largely of quartz and the feldspars microcline and orthoclase. The very minor amount of accessory minerals includes magnetite, chlorite, zircon, fluorite, and pyrite. The overall texture is an uneven medium-grained mosaic of quartz and feldspar with a few larger rectangular microcline crystals which probably are phenocrysts. Thus the rock is probably a porphyry. The most conspicuous textural feature is the abundance of an intergrowth of quartz and feldspar in micropegmatitic fashion, figure 4. Porphyries of the type described are commonly termed granophyres and this name is therefore applied to the rock from the Mumford well.

In connection with the description of the crystalline rocks of Illinois, the Insane Asylum or City Sanitarium well in the city of St. Louis is of interest as it has been reported to have reached granite.[5] This well was drilled in 1869, at which time its depth of 3843½ feet, as originally reported, made it one of the deepest wells in the world. More recently the Missouri Geological Survey gives the total depth as 3883 feet[6] from which it is inferred that the well was deepened sometime in its history.

The original published log of the well reported that the last 40 feet

[5] Broadhead, G. C., On the well at the Insane Asylum, St. Louis County: Trans. Acad. of Sci. of St. Louis, Vol. 3, pp. 216-223, 1878. The occurrence of granite in this well is also mentioned in an anonymous note in American Jour. Sci. 3rd Series, Vol. 9, p. 61, 1875.

[6] Communication from Edward L. Clark, State Geologist, February 25, 1949.

drilled was hard red granite because cuttings contained grains of red quartz and feldspar[7] and this interpretation has been repeated in succeeding publications that made reference to the well. Lately the Missouri Geological Survey kindly supplied cuttings from the St. Louis well from depths of 3522 to 3848 to allow comparison of the reported granite with the granites in Illinois. Study of the samples indicates, however, that no granite or other crystalline rock was encountered, but that the material penetrated was entirely sandstone, in part feldspathic and shaly. Feldspar is present in the upper samples from 3522 to 3620, absent in the middle samples from 3620 to 3817, and increasingly abundant again in the lowermost samples. Mottled shale is present in various places. No mica was observed, nor any evidence that any of the quartz or feldspar grains came from the drilling of a quartzite or granitic rock. The most reasonable interpretation appears to be that the lower part of the St. Louis well to a depth of 3848 feet penetrated a thick sandstone section containing occasional feldspathic sandstone beds and beds of mottled shale.

[7] Broadhead, G. C., op. cit.