

THE AGE OF THE SPAVINAW GRANITE

H. A. IRELAND

Department of Geology, University of Oklahoma, Norman, Oklahoma.

There has always been considerable discussion as to the age of the Spavinaw granite and this paper is a history and resumé of the present ideas on the subject.

The granite outcrops about one-half mile west of the Tulsa water supply dam across Spavinaw creek in section 15, T. 22 N., R. 21 E., Mayes county in northeastern Oklahoma. The strike is N. 40 E. at the northern end and N. 30 E. at the southern end. The granite appears in five locations as follows:

1. The granite rises out of the stream bed and extends northward to the road for a short distance of about 300 feet and a width of 75 feet.

2. Another outcrop is 150 feet from the first, being 75 feet wide at the southern end and 50 wide at the northern end and about 125 feet long.

3. The third exposure about 450 feet from the second, is 200 feet long and 300 feet wide. At this location there is an old abandoned quarry, with many good blocks of granite still in place. Transportation costs have prohibited development and the quarry is abandoned.

4. An exposure occurs 200 feet north of number 3, and is about 175 feet long and 100 feet wide.

5. The last outcrop, about 5 by 10 feet, is due west from the outcrop number 3. Adjacent is a mineralized zone similar to the zone to the larger masses. This outcrop is probably a western knob of outcrop number 3.

The total distance of the outcrop is 1600 feet. Copper stains of varying amounts occur in several places. A zone of intense silicification extends on either side of the mass, decreasing away from the granite. A well drilled on the east flank near the south end struck the granite at a depth of 50 feet, 100 feet away from the outcrop. Near the north end on the same side, rotten granite was found at a depth of 74 feet, and 200 yards east the granite was not found at 95 feet. A well a few hundred feet west of the granite outcrop failed to reach it at 112 feet. These wells were drilled by W. E. Kay of Spavinaw, Okla. The wells tend to show that the granite is very narrow or ridge-like in its occurrence. Immediately west of exposure number 2, a shaft 87 feet deep was sunk by the government to mine pyrite to use in manufacturing sulphuric acid for use in war supplies. The shaft is now full of water and the only evidence of the shaft having encountered the granite is a few weathered fragments on the dump. There are numerous pits and prospect holes dug on all sides of the granite, all of which show no commercial ore. Pyrite, dolomite, and quartz crystals are common in cavities and veins adjacent to the igneous body.

Joints observed on outcrops number 1 and 2 show very interesting features. Viewed from the end the joints radiate fan-like. Viewed from

the side they are also fan-like and perpendicular to the surface of the rock mass. When observed from the top the joints are essentially parallel with the strike of the outcrop.

The rock itself is a coarse-grained granite. The feldspar grains are the chief color giving constituents and are chiefly orthoclase. The grains are up to ten centimeters in diameter. Black flakes of magnetite and hornblende are scattered throughout. The quartz is not apparent to the naked eye and a megascopic examination would cause one to call the rock a syenite. Examined under the microscope the rock is a distinct granite as will be described later. Some portions of the rock are green in character, especially around outcrop number 3.

The writer quotes verbatim the original microscopic description made by Dr. N. F. Drake. (Footnote no. 1).

CHEMICAL ANALYSIS OF SPAVINAW GRANITE

Silica (SiO ₂)	Per cent 71.10
Ferric oxide (Fe ₂ O ₃) and Alumina (Al ₂ O ₃)	20.60
Calcium oxide (CaO)	2.53
Magnesium oxide (MgO)	.99
Sodium oxide (Na ₂ O) and Potassium oxide (K ₂ O)	3.76
Loss on ignition	1.11
	100.09

The following is a petrographic analysis made by Mr. Robert Roth (2) of Indian Territory Illuminating Oil Company.

Drake, N. F., Proc. Amer. Phil. Soc., vol 36, no. 156, p. 338-342, 1898.

Feldspars, quartz, chlorite, and magnetite are principle minerals of the rock, while epidote and hornblende occur sparingly. A holocrystalline texture is shown throughout the rock. The most striking and the general microscopic feature is the granophyric and micropegmatitic structure. Through most of the feldspar crystals quartz is intergrown in a most intimate manner, so that each feldspar shows radiating and alternating quartz and feldspar in each crystal, the included quartz plates or prisms show the same orientation. Quartz occurs sparingly isolated in the larger crystals, but very rarely shows its outline. Feldspars are the predominating minerals. They are principally orthoclase but plagioclase crystals are rather common. The feldspars have a fine granular appearance and a reddish color. Phenocrysts of feldspar are quite common but they do not show crystal faces. Magnetite occurs in small opaque masses many of which show crystal outlines. They show a slight grouping through the rock and in places give a blended appearance to the crystals. The hornblende is the greenish variety and of a rather uncommon occurrence. The chlorite is common and occurs in greenish bands, spherular aggregates, and minute particles. Epidote is of rather common appearance. Personal communication.

The analysis of this rock shows it to be intermediate between an "alkali granite" and a syenite; it is in fact, much closer to a granite. The hand specimen shows no quartz, but a chemical analysis shows 71.10 per cent of silica. In a thin section it will be noticed that the quartz is present to a great extent and thus accounts for the large percentage of silica. The feldspars are largely of the soda type and are very well altered to a kaolinite-like material. The ferro-magnesian silicates are largely hornblende, probably of the arfvedsonite variety, giving blue and green tones, also augite. These feldspars are quite well altered. The texture of the rock is hypidiomorphic, which is very characteristic of the deep-seated consolidated rocks. These characters may be found throughout and show no change in any direction. The basic secretions separating out from this "acid syenite" are composed largely of hornblende and some augite. There is no muscovite or biotite in this rock. There is some sericite present along the twinning planes of the feldspar.

Conglomerate and breccia of quartzite and chert cemented by silica is found on a wooded knoll near a prospect hole 200 yards northeast of the last exposure of the granite. The knoll is undoubtedly a bulge with the granite close beneath. Sandstone of a quartzitic nature occurs in a gully on the south side of Spavinaw creek just east of the bridge and 200 yards west of the granite. The quartzite in the conglomerate is much more indurated than the above due probably to silicifying solutions. In many places cavities in the silicified zone show well developed quartz, dolomite and pyrite crystals as well as pseudomorphs after pyrite. Jasperoid is also quite common.

The layers overlying the granite are Ordovician dolomite and limestone somewhat sandy in places. These layers are highly silicified near the granite and less so at a distance. The formations over the granite are seen on the south side of the creek inclined away from the crest at five to ten degree angles, the dip being greater on the west side. At the crest of the granite there is a definite topographic bulge which is apparently associated with the structure of the granite. Other strata over the granite are the Chattanooga shale and the Boone chert.

There are two opinions as to the age of the granite. One is that the mass is a dike intruded in post-Ordovician time and the other that it is a Pre-Cambrian ridge.

D. D. Owens¹ first mentioned the outcrop in 1860 calling it a granitic axis, but he never visited the outcrop himself.

Dr. N. F. Drake² described it in detail in 1898, calling it a dike intruded into dolomite. This was the first article published by one who had studied the exposure and no one has written yet a better description. However, he now expresses himself as differing from his original opinion. He says:³

In 1901, G. I. Adams⁴ described the granite as a post-Carboniferous dike, dating the intrusion as contemporary with the folding and faulting of the Ozark uplift.

L. L. Hutchison and R. R. Severin⁵ studied the outcrop and called it a dike occurring after the Pennsylvanian. The inference was made from the fact that the Mississippian rocks overlying the granite were affected and that this region was in movement during the late Mississippian and early Pennsylvanian and the dike was contemporary.

In 1907, C. E. Siebenthal⁶ refers to the granite as a dike.

L. C. Snider⁷ in his report on northeastern Oklahoma in 1915 calls the rock a dike and gives verbatim Drake's description which he included since Drake's bulletin was not easily secured.

¹U. S. Geol. Survey Bull. 340, p. 189, 1907.

²Second Annual Report of Arkansas, p. 17, 1860.

³Op. cit.

⁴Personal communication.

Before I knew that there was any controversy as to whether this granite was a dike or a pre-Cambrian peak, I had suspected it to be the latter. I believe that the evidence is in favor of classing it as a pre-Cambrian peak.

⁵Adams, G. I., U. S. Geol. Survey, 22nd Ann. Rept., pt. 2, pp. 77-78, 1900-1901.

⁶Oklahoma Geol. Survey, Bull. 2, pp. 152-153, 1911.

⁷Okla. Geol. Survey Bull. 24, pt. 1, pp. 51-53, 1915.

F. L. Aurin, G. C. Clark, and E. A. Trager¹⁰ did not agree with the statements of earlier men and stated that the granite was pre-Cambrian peak or ridge, but they did not present in their paper any evidence for the statement.

Since 1921 many have visited the Spavinaw area and prominent geologists are on both sides of the controversy.

Mr. Fritz Aurin¹¹ says in regard to the trip of several years ago with Mr Trager:

Sidney Powers¹² believes the granite to be a buried hill with the anticline superposed on it, and compares it to a number of other anticlines of the oil fields underlain by similar hills many of which have been encountered by drilling wells.

Mr. Robert Roth¹³ as a result of his studies of the granite gives the following:

"It was our opinion that the granite was not an intrusion, but that of an old topographic high feature. There is no evidence of the ordinary features accompanying an intrusion such as contact metamorphism sills, and dikes. It was also our further opinion that the Ordovician dolomitic limestone had overlapped the granite. No sharp folding was observed either in the Ordovician or in the beds overlying the granite. There is considerable brecciation in the top of the Ordovician limestone at the contact of this formation and the overlying green shale as observed at a locality a short distance downstream from the granite outcrop. This breccia was made up almost entirely of chert and appeared to be mostly debris along the unconformable contact.

Dips of the surrounding sediments, that is in Ordovician or older are about the same as those described by Bridge and Dake in a reprint from the Missouri Bureau of Geology and Mines entitled "Initial Dips Peripheral to Resurrected Hills." These dips are not reflected in the overlying Mississippian and are soon dissipated in the older rocks, as those at Spavinaw dam are practically flat lying. Furthermore there are conglomerates and quartzites adjacent to this alkali syenite (granite) which are not metamorphosed. If the igneous rock were a dike or a pegmatite one must find some of the following conditions or else it cannot be classed as such: If it were a pegmatite the adjoining limestone, dolomite, and sandstone would be intensely altered, due to the pneumatolytic action of the hydrothermal gases emanating from this igneous mass. Nothing like this is found, but we do find a great amount of grahamite, marcasite, and pyrite adjacent to the mass which with the temperatures formed naturally by the dike would not exist in this proximity. The alkali syenite shows definitely no contact phases such as changes in texture from the central portion toward the contact which is always found adjacent to dikes and pegmatites. This point is probably the best evidence, proving that this mass is but an exposed remnant of a much larger mass. Furthermore the crystalline texture of that portion which is weathered is identical with any other portion of the ridge.

Mr. Luther White¹⁴ presents the following as evidence for the pre-Cambrian peak.

The granite at Spavinaw is not a dike. It is the granite core of an anticline. Exposure is due to uplift, overlapping, truncation, and erosion. Granite is encountered at remarkably shallow depths throughout northeastern Oklahoma, over the broad arch of the Ozark uplift. Granite is encountered on a dome at 480 feet at Inola, at Owasso at 1,365 feet. These wells show that the exposure of the granite at Spavinaw is not remarkable. The overlying rocks at Spavinaw dip away from the granite in all directions. I believe dips ranging from ten to twenty degrees may be measured around

¹⁰Bull. Amer. Ass. Pet. Geol. vol. 5, no. 2, p. 121 and p. 147, 1917.

¹¹Personal Communication.

¹²Personal communication.

¹³Personal communication.

¹⁴Personal communication.

the flanks of this structure. There is a notable lack of evidence of heat metamorphism. Fossils occur in the Ordovician dolomite in a splendid state of preservation within inches of the granite contact. Also they occur in greater abundance in the contact than they do at higher stratigraphic horizons. This indicates an abundance of life at the strand line, as would be expected. The absence of a basal conglomerate is striking. This is the case, however, at nearly all places in northeastern Oklahoma where the Arbuckle limestone-granite contact has been encountered in drilling wells, on the basis of sample observation.

Mr. C. W. Honess¹⁵ has visited the outcrop several times and studied thin sections from the area. He states:

To my mind after studying the outcrops, the granite must be a dike as originally interpreted by N. F. Drake, and I give the following reasons:

1. The granite is unusual. It is a pegmatite.
2. The chert at the contact is shattered vertically to bits as if by heat.
3. There is an absence of a basal conglomerate, and all other evidence of erosion at the top of the granite.
4. The cherty dolomites dip away from the granite at the rate of about five degrees, dipping southeast on the southeast side and northwest on the northwest side so that the granite is at the crest of an anticline.

Dr. S. Weidman of the University of Oklahoma believes the granite to be a dike. The evidence upon which he interprets the intrusive character of the Spavinaw granite is as follows:¹⁶
29, 1929.

1. The texture of the Spavinaw granite is not that of a normal granite but is distinctly pegmatitic, the granophytic and micropegmatitic character being the most striking feature of the rock. Pegmatites are characteristic dike rocks.

2. The extensive alteration of minerals within the granite such as the metasomatic replacement of the feldspar by epidote and sericite and the replacement of hornblende by chlorite are characteristic hydrothermal alterations and indicate a type of alteration commonly associated with contact metamorphism.

3. The Ordovician limestone along the contact with the granite is altered to chert or jasperoid, the limestone being completely silicified within a zone from 25 to 50 feet from the contact, beyond which to about a hundred feet or more silicification as well as dolomitization and the formation of pyrite has taken place. The chert along the contact is considered a metasomatic replacement of the limestone, and with the associated dolomitization and pyritization is interpreted as evidence of contact metamorphism developed at slight or moderate depths and under thermal conditions of moderate rather than high temperatures.

4. Parallel to and along the contact there is fissuring and brecciation of the jasperoid, and there is also a distinct arching of the overlying strata above the granite and these are common structural features associated with upthrusting by igneous intrusion.

There is no evidence of conglomerate or other distinctly clastic sediments derived from the granite along the contact and thus the character of the sedimentary rock at the contact supports the view that the granite is intrusive rather than basal to the surrounding rock.

6. The Spavinaw granite is similar in its pegmatitic texture to the intrusive pegmatite granite of Rose Dome,¹⁷ Woodson county, Kansas, and the development of chert and other phases of metamorphic rocks along the contact with the granite in both these localities is very much the same.

There is no doubt that the granite is intrusive, but the question is regarding the age of the intrusion, whether the vulcanism occurred in the pre-Cambrian or post Ordovician. The evidence of contact metamorphism is not sufficient to be conclusive that the granite was intruded post-Ordo-

¹⁵Personal communication.

¹⁶Weidman, S., Paper read before Okla. Academy of Science, Oklahoma City, November

¹⁷Twenhofel, W. H., and Bremes, B., Bull. A. A. P. G. vol 12, p. 757.

vician. There are no minerals such as wollastonite, vesuvianite, garnet, serpentine, or stauralite found in the contact zone. Alteration has taken place in the granite but such may have occurred previously. Quartz, pyrite, and dolomite crystals may be formed in a number of ways including that of contact metamorphism. There is no doubt that considerable mineralization has taken place adjacent to the granite but the mineralization has not exhibited the expected high temperature contact metamorphic minerals. In some way the presence of the granite has affected the zone and if intrusion has taken place it was different from the usual type. The granite as a solid may have been pushed up into the sediments by the vertical component stress resulting from lateral pressure. Such would give the folding and fracturing described, allowing the circulation of water which deposited minerals in the existing cavities and fissures.

The Spavinaw exposure is another of the many igneous outcrops occurring in the Mississippi valley. The Rose Dome intrusion in eastern Kansas, the peridotite at Manhattan, Kansas, the pegmatites and diorite sills of southeastern Oklahoma may be given to show that intrusions have occurred. In Camden county, in central Missouri, there is a pegmatite dike described by Winslow¹⁸ and by Adams¹⁹. The age is given as post-Ordovician and perhaps as post-Carboniferous.

¹⁸Winslow, Arthur, Missouri Geol. Survey., vol. 7, p. 432, 1894.

¹⁹Adams, G. I., U. S. Geol. Survey. Annual Report No. 22, pp. 77, 78, 1900-1901.