

Review of Precambrian Rift Stratigraphy

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Rice Formation

A thick sequence of feldspathic sandstone, arkose, and red and green, sandy, micaceous shale that underlies sedimentary rocks of Late Cambrian age in northern Kansas was named the Rice Formation by Scott (1966). The feldspathic sandstones are fine grained and predominantly grayish red to grayish orange-pink, or (in a very few samples) dark reddish brown in color. Some interbedded strata contain medium to coarse grains. The grains are generally rounded to subangular and frosted. The feldspathic sandstone generally is well-sorted and closely packed, but in some strata it is poorly

sorted; conglomeratic accessory constituents are dark-gray schist, quartzite, felsite, and granitic granules to pebbles, black ilmenite? grains, reddish-brown argillitic grains, and pyrite. Dolomite cement is common. Illitic clay matrix is 5-10% of the rock.

Interbedded with the feldspathic sandstone is gray and dark-reddish-brown shale. Red shale in core chips locally grades into green or mottled green shale that grades into siltstone. Observable accessory minerals are quartz, feldspar, and mica.

Distribution

The Rice Formation is recognized in two linear north-northeast-trending basins. From the basin west of the Sixth Principal Meridian, 36 wells, core chips from one well, plus thin sections from five holes have been studied. Twenty other drill holes reportedly penetrate pre-Reagan sedimentary rocks, but samples are not available. This western basin in which the Rice was deposited is called the Rice basin. It extends from Reno County north-northeast to Washington County. In the basin east of the Sixth Principal Meridian, 13 holes penetrate pre-Reagan sedimentary rocks that informally have been

called the Rice sedimentary group by Muehlberger et al. (1964), who correlate the thick sedimentary sequences in the eastern and western basins on the bases of lithology and stratigraphic position. No time relations are implied. Not a single well penetrates the entire formation. Therefore four typical drill holes, rather than a type well, are designated to represent the typical stratigraphic succession of rocks in the formation. In each of these holes, the Late Cambrian Reagan Sandstone overlies the Rice Formation and underlies the Arbuckle Group. The four wells are listed below:

Operator, Farm, Date Drilled	Location	Surface	Top of Elev.	T.D. Rice	Lithology
Continental No. 3 "A" HodgsonC SE 9-29-53	32-16S-8W Ellsworth Co.	1684	3873	3905	Feldspathic sandstone
Empire No. 13 Rolfs 9-25-35	14-17S-9W SE NW NE Ellsworth Co.	1795	3741	4050	Feldspathic sandstone, green and red shale
Continental No. 9 Ainsworth 7-23-51	24-18S-8W SE NE SE	1694	3658	3691	Feldspathic sandstone, green and red shale
Bishop No. 5 Reese 12-5-51	22-19S-9W NE NE NW Rice Co.	1694	3645	3820	Feldspathic sandstone, arkose, green and red shale, dolomite, and limestone

Age Relationships

Sedimentary rocks of pre-Upper Cambrian age that underlie the Paleozoic sedimentary rocks in the general area described above are collectively assigned to the Rice Formation; they range in age from as old as approximately 1,100 m.y. to about 525 m.y. The oldest Precambrian sedimentary rocks overlie the youngest volcanics associated with the main phase of rifting. It is thus tacitly assumed that the main phase of rifting in the southern portion of the rift is coeval with the rifting in the much better understood and dated northern part of the rift. The oldest Paleozoic sedimentary rocks overlying the Rice Formation are the sandstones of the Lamotte Sandstone or the equivalent Reagan Sandstone.

Another rock type that commonly is encountered in drill holes is arkosic detrital material generally called "granite wash," a term used to describe mostly arkosic detrital material resting on older Precambrian rocks (Goebel, 1968). It may range in age from Precambrian to Middle Pennsylvanian. These rocks are not restricted to the same area as those of the Rice Formation, but can occur anywhere in the state. It consists essentially of weathered and not necessarily transported material from the ubiquitous granite intrusives. Locally, the granite wash may reach thicknesses of up to 150 ft. This material may range in age from Precambrian to Middle Pennsylvanian.

Naming of the Rice Formation

The formal name, Rice Formation, was substituted for Rice sedimentary group by Scott (1966) and is applied to sub-Reagan rocks in both basins. A name is necessary because: 1) The Rice Formation is lithologically distinct from other material called "granite wash" and from overlying Reagan Sandstone; 2) many drill holes penetrate the Rice Formation in a 2,300 mi² area; and 3) the Rice Formation is evidence of important tectonic and sedimentary activity in pre-Late Cambrian time in Kansas that was previously unknown.

Discussion

Since the report of Scott (1966), a considerable amount of new information has become available, resulting in a better understanding of the nature of the sediments, their stratigraphic position, and the tectonic setting. The deepest penetration of the sediments in 1966 was 1,015 ft in the Wrightsman No. 1 Kunkle in Ellsworth County. Today, many more drill holes have penetrated Precambrian sedimentary rocks in excess of 1,000 ft, with the deepest penetration being 8,450 ft in the Poersch #1 drill hole completed by Texaco in 1985.

Based upon the new information it is necessary to reconsider the present usage of the term *Rice Formation* as defined originally and described above. The reasons for proposing to change the classification of the lithostratigraphic Rice Formation to the chronostratigraphic *Rice Series*, and a revised and updated definition of the rocks present within the "series" are discussed below.

Rice Series

Studies of the rocks in the better exposed northern portion of the rift in Minnesota, Michigan, and Wisconsin

show that a package of mostly sedimentary rocks were deposited in a rift-tectonic setting following the main phase of rifting characterized by the voluminous outpouring of basalts and related intrusive and extrusive rocks. These rocks are Precambrian in age and assigned to the Keweenawan Supergroup. Within the section, several formations are recognized and named in the three states; however, definite correlation between the variously named formations is in part controversial. The age of these sedimentary units is quite uncertain (Van Schmus and Hinze, 1985). Younger, mostly clastic sedimentary rocks of possible Precambrian and Cambrian age, such as the thick clastic sequence of the Mt. Simon Sandstone, occur widespread but are not necessarily related to rift tectonism.

In Kansas and adjoining portions of southern Nebraska, sediments deposited within the rift tectonic setting represent a unique and possibly economically significant package of rocks. The boundaries of the rift basin or basins into which these rocks were laid down are not well defined, especially along the western and southern margins of the rift trend. The area largely coincides with that proposed by Scott (1966) but may differ somewhat in the western part of the area where our knowledge of rift tectonism is poor.

Within the past few years, three drill holes have contributed greatly to our understanding of rift stratigraphy. Each of the holes penetrated several thousand feet of pre-Paleozoic rocks. Following is a list of the three holes:

Operator, Farm, Date Drilled	Location	Surface	Top of Elev.	T.D. Rice	Lithology
Texaco Inc. No. 1 Noel Poersch 3-6-85	31-5S-5E SW SW Washington Co.	1383	2846	11,300	Red arkose subarkose and siltstone. Basalt and gabbro.
Producers Eng. Co. No. 1-8 Friedrich 11-9-86	8-7S-5E NW NE NE Riley Co.	1317	2655	4439	Varicolored volcano- clastics and mafic
Producers Eng. Co. No. 1-4 Finn 10-26-86	4-4S-7E S S NE Marshall Co.	1348	2134	3972	Red arkose, gray shale and siltstone, minor volcanics

The Poersch #1 drill hole penetrated the thickest section of pre-Paleozoic rocks (Berendsen et al., 1988). A 300-ft-thick gabbro tops the sequence, followed by a thick unit dominated by basalt down to 7,429 ft. Minor pegmatites and red oxidized siltstone and arkose also occur in this interval. The lower part of the section consists mainly of red arkose and subarkose, together with minor amounts of red oxidized siltstone and shale. Some volcanic and other mafic units are interspersed. In the #1-8 Friedrich drill hole, the section consists of mafic intrusive and extrusive rocks that are partially oxidized, overlaying varicolored rocks that are predominantly volcanoclastics. In the Finn #1-4 drill hole, the top part of the section is marked by several hundred feet of medium- to dark-gray siltstone and shale, which is calcareous in part. Minor gray limestones are also part of the sequence. Downward, red oxidized arkoses and siltstones and minor mafic rocks characterize the section.

In addition to the three deep drill holes that provide excellent stratigraphic information, a significant number of basement drill holes have been completed since 1966 that give important structural information. This information suggests that along the trend of the rift, structurally separated basins occurred in which the stratigraphic succession may differ from neighboring basins.

The rocks that occur within the rift tectonic setting in Kansas and adjoining parts of southern Nebraska differ from the typical succession of rocks in the northern portion of the rift. To the north the extrusive activity seemed to have taken place in a well-defined relatively narrow time interval, followed by sedimentary rocks that filled the rift basin or basins. Thus the Keweenawan clastic rocks form a definite package of sedimentary rocks above the mafic extrusives that can be correlated over large distances.

In Kansas, on the other hand, it seems that mafic intrusive and extrusive rocks commonly overlie or are interbedded with sedimentary rocks. A large variety of sedimentary rocks have been encountered in the drill holes, making it impossible at this time to define the typical stratigraphy of sedimentary rocks within the rift. Because no thick section of exclusively mafic rocks not underlain by sedimentary rocks was encountered in any of the drill holes, and because no age dates are presently available for any of the mafic units, one can only speculate as to the relative age and stratigraphic position of the units in comparison with those found in the northern portion of the rift.

It is also impossible at this time to define meaningful stratigraphic units or to correlate rock units between the drill holes for which we have stratigraphic information. Neither are we able to compare relative ages of the rocks encountered in the drill holes. It is likely that significant thicknesses of rocks have been removed during erosional cycles prior to the deposition of the Upper Cambrian rocks or in certain places even at later times up to the Pennsylvanian.

Thus the typical rocks so far encountered within the rift basins of Kansas and parts of southern Nebraska are clastics, intrusive and extrusive mafic and minor acidic rocks, and some carbonate units. The clastics consist mostly of red, oxidized, fine- to coarse-grained arkoses, subarkoses, siltstones, and conglomerates. Medium- to dark-gray, partially calcareous siltstone and shale, interbedded with limestone, also occur in the sequence. The mafic rocks are gabbros and lavas. Some intermediate or acidic rocks including pegmatites occur. Flow tops are recognized in the lavas. The rocks are altered (albitized and epidotized) to varying degrees.

Recommendation

The term *Rice Series* is hereby proposed for the above-described sequence of rocks. The basis for reclassifying this package of rocks is that they cannot be correlated on lithostratigraphic criteria, but they occupy a clearly defined time-stratigraphic interval between the close of volcanism

associated with major rift activity and deposition of the pre-Upper Cambrian or younger sedimentary rocks. The series thus constitutes a major time-stratigraphic unit that can be correlated with other units deposited within the same time span in the rift tectonic setting.

References

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