Mineral Exploration History of North Dakota's Precambrian Basement

Timothy O. Nesheim

Introduction

Buried beneath hundreds to thousands of feet of rock and sediment, North Dakota is completely underlain, at variable depths, by igneous-metamorphic crystalline rock (e.g. granite, gneiss, and schist), which is collectively referred to as the Precambrian basement (figs. 1-3). The Precambrian basement beneath eastern North Dakota is part of the Superior Craton, a large portion of Earth's crust that has not experienced any significant volcanic and/or tectonic activity during the past 2.4 billion years (Nesheim, 2011).

Mineral resources such as nickel, iron, and gold are economically mined from similar crystalline basement rock of surrounding states and Canadian provinces. While such resources have yet to be mined from North Dakota's crystalline basement rocks, a

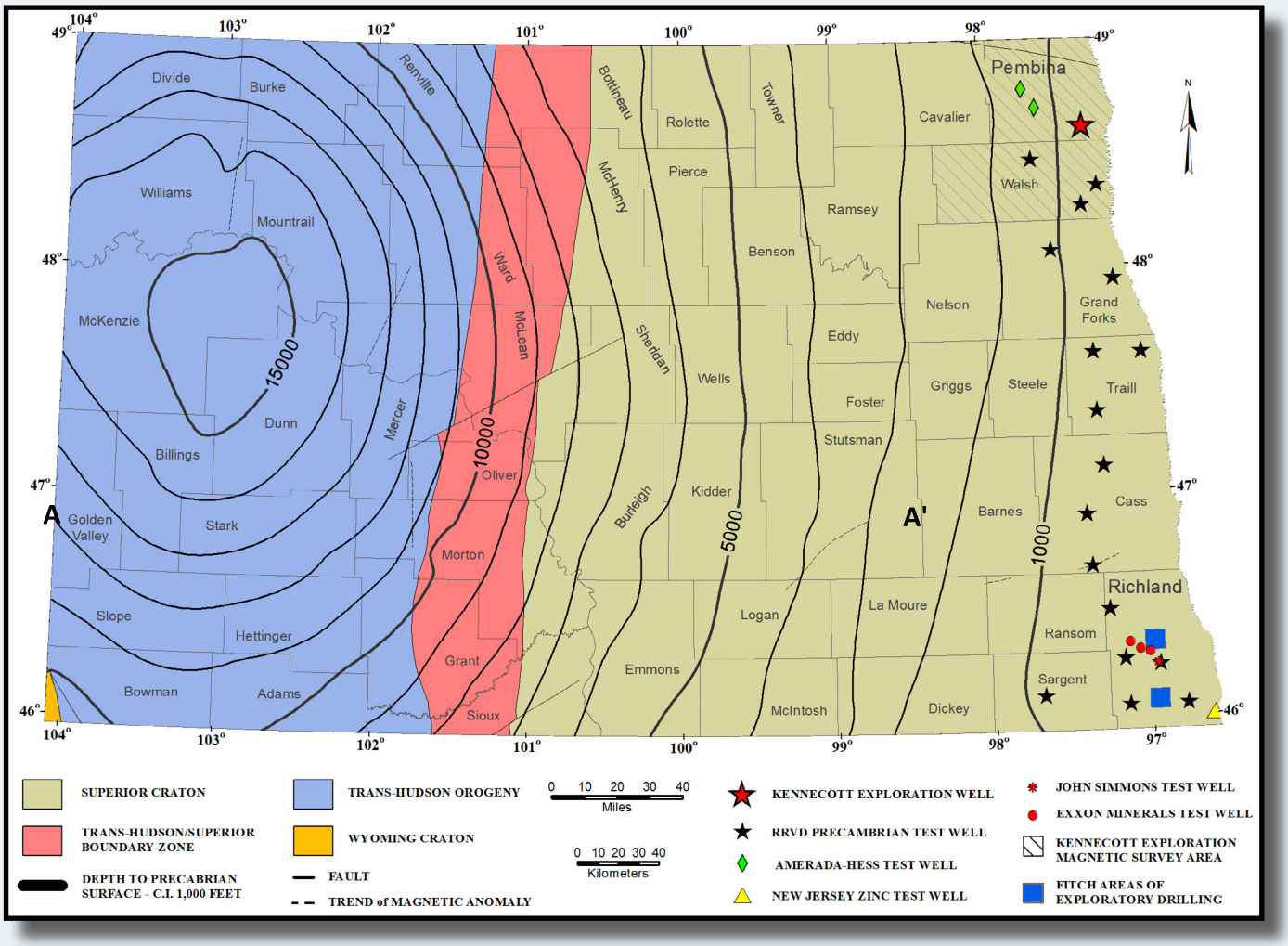

Figure 1. Geologic map of North Dakota's Precambrian basement with the locations of Precambrian mineral test wells. A & A' show the locations of the edges of the figure 2 cross section.

number of exploratory efforts have been attempted over the past several decades.

New Jersey Nickel Exploration Company

In September and October of 1964, The New Jersey Zinc Exploration Company drilled two exploratory wells in search of lead and zinc ore within the southeastern corner of Richland County (fig. 1, according to available well information). The two wells were drilled in close proximity to one another, the first well (D-2) was drilled vertically while the second well (D-3) was drilled directionally at a 45° angle. Each well initially encountered an approximately 120 foot vertical section of overburden/glacial drift before penetrating crystalline basement rock. While the reported analytical data collected from core samples did not indicate any substantial lead or zinc concentrations, both wells encountered over 90 feet of "regularly banded cherty taconite," which the company reported to average 36-38% total Fe (not specified if by weight or volume)! So while New Jersey Zinc Exploration did not appear to discover the lead and/or zinc ore they sought, they did encounter an iron-rich deposit.

Magnetic Anomalies in Pembina County

In October 1964, at about the same time the New Jersey Zinc wells were being drilled, the Topographic Branch of the United States Geological Survey reported difficulties with magnetic compasses while mapping in the Akra and Hensel areas of Pembina County in northeastern North Dakota (fig. 1, Moore and Karner, 1969). This observation was reported to the North Dakota Geological Survey, which prompted a University of North Dakota student, Tonis Tamms, to conduct a magnetic survey of the area during the summer of 1966 (Moore and Karner, 1969). Tamms's survey identified three areas with anomalously high magnetic signatures. During that same summer, Amerada-Hess Petroleum Corporation drilled two test wells, one into each of the two largest magnetic anomaly areas in search of economic ore deposits (Richardson, 1975). From the core samples that Amerada-Hess Corporation cut from their two wells, the magnetic anomalies appear to be the result of iron-rich meta-sedimentary rock bodies (fig. 3a) buried over 1,000 feet below the surface. Richardson (1975) commented that these iron-rich bodies may be of sufficient thickness and iron oxide content to justify further exploration, but the large reserves of near-surface iron ore within neighboring Minnesota precluded economic consideration.

Red River Valley Drilling Project

In 1977, Bendix Field Engineering initiated and completed the Red River Valley drilling program in an effort to evaluate the stratigraphy and uranium potential of the eastern margin of the Williston Basin (Moore, 1978). Thirty-two wells were drilled and logged along the North Dakota/Minnesota border, which cumulatively spanned approximately 18,000 feet of section (fig. 1). Drill cuttings and core samples were collected from various subsurface geologic units for analysis and evaluation. The program's objectives included evaluating both the sedimentary section and the underlying Precambrian. Twenty-six of the thirty-two wells penetrated and cored igneous/metamorphic rock from the Precambrian basement (fig. 3b). The findings of this project did not lead to a uranium ore discovery, but it did yield a substantial amount of information about North Dakota's subsurface geology -- information that may one day aid in finding and developing economic subsurface mineral deposits.

Uranium Exploration in Richland County

Also in 1977, two operators applied for permits to drill exploratory

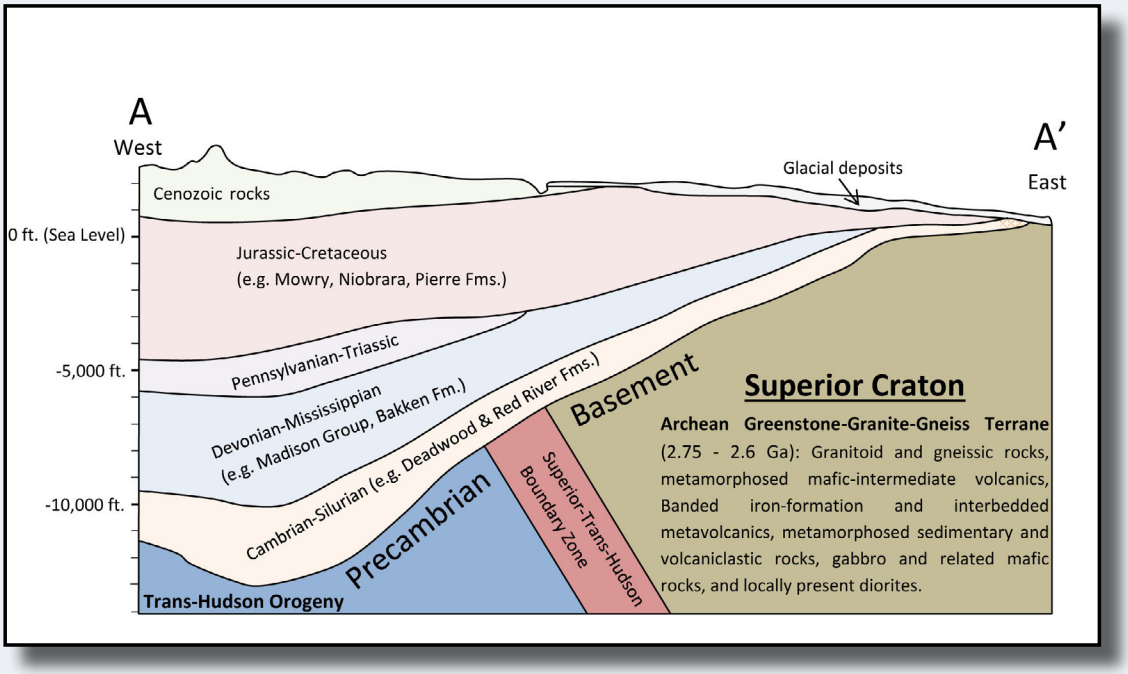

Figure 2. East-West cross section of North Dakota showing the approximate domains of the Precambrian basement units (darker colored domains) and the overlying sedimentary units (lighter colored layers). Note the decrease in sedimentary overburden on the Precambrian basement surface moving eastwards. The location of A-A' is shown in figure 1.

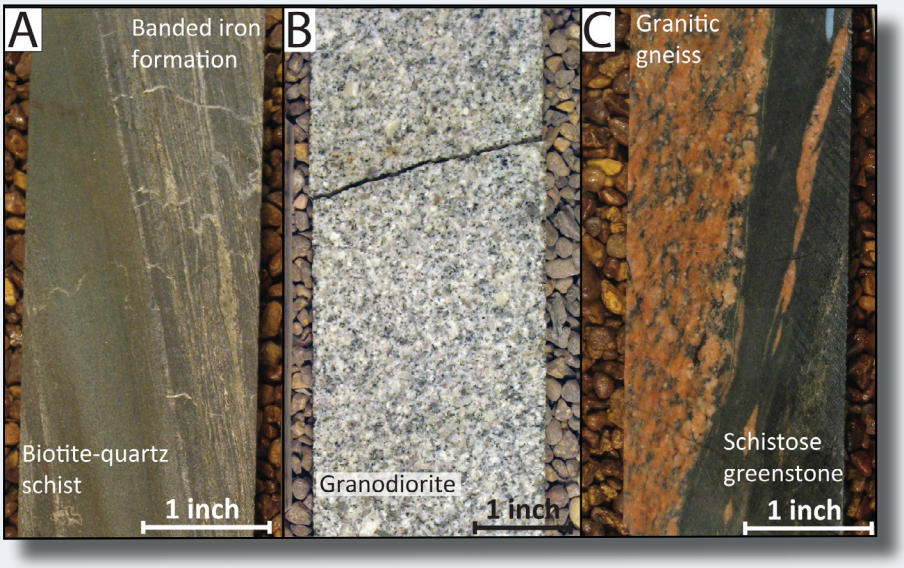

Figure 3. Examples of Precambrian basement core samples cut from various mineral test wells along eastern North Dakota, including: a) Amerada-Hess Corporation's Sig Sampson 1, b) Red River Valley Drilling Project test well #5, and c) Kennecott's 10NDV001.

wells in Richland County, the southeastern corner of North Dakota (fig. 1). John Simmons of Bismarck initially sought a permit to drill up to 20 exploratory wells spanning most of Richland County in search of uranium deposits. In the end, only two test wells were drilled, both within central Richland County during the month of July (fig. 1). Each well was drilled to an approximate depth of 430 feet, which likely penetrated the Precambrian basement surface, and were logged for gamma ray and resistivity. Uranium oxide (U_3O_8) concentrations were measured from drill cuttings collected in 5-foot increments with the highest reported concentration being 99 ppm (parts per million) U_3O_8. Based on letters in the well file, both wells were left unplugged for use by the landowner at the time. Later that same year, Rocky Mountain Energy Company of Denver, Colorado applied for a permit to drill approximately 30 exploratory test wells across Richland County. However, none were drilled.

Less than two years later, during the winter of 1978-79 David Fitch of Albuquerque, New Mexico drilled a series of 24 test wells in central to southern Richland County in search of uranium (fig. 1). Each well was logged, plugged, and abandoned in short order. The reported total depths for many of these test wells indicate they likely penetrated at least the upper, weathered portion of the Precambrian basement. Even though David Fitch's exploratory efforts never led to any resource development, the 24 test wells represent the most extensive exploratory drilling program completed in Richland County and the surrounding area to date.

The final round of uranium exploration in Richland County on record was conducted by Exxon Minerals Company. Exxon applied for drilling permits in the fall of 1980 and referred to their uranium exploration program as the Barney Project. The Barney Project initially involved plans to drill ten wells over a period of four years. Only three wells were drilled to total depths of 565 to 718 feet during January and February of 1981. Each well was logged using gamma ray, spontaneous potential (SP), and electrical resistance. Core samples were cut from the Precambrian basement section in two of the test wells (consisting of greenstone and granodiorite), indicating the Precambrian may have been their primary target interval of exploration. As with the previous exploratory drilling efforts in the area, the Barney Project did not lead to any uranium resource development but it did add valuable information on North Dakota's subsurface geology.

Kennecott Exploration's Kimberlite Test

The most recent mineral exploration test targeting North Dakota's Precambrian basement took place in August of 2010 by Kennecott Exploration, part of the global mining and metals company Rio Tinto. Conducting an airborne magnetic study of Pembina and Walsh counties in North Dakota, along with the adjacent counties in Minnesota, Kennecott identified several prospective locations to drill for mineral exploration (Nesheim, 2013). With diamonds as their primarily resource of interest, Kennecott drilled a single test well over the most prospective location based on their magnetic survey data. From core samples collected during the drilling of their test well, Kennecott encountered magnetically susceptible, magnetite-rich granitic gneiss (fig. 3c), which was interpreted to be the source of the magnetic anomaly they were targeting. Unfortunately, the encountered gneiss does not appear to be part of a mineable ore body.

Conclusions

To date, there have been only a handful of exploration efforts targeting North Dakota's hard rock, Precambrian basement. The lack of more extensive exploration, and development of possible iron ore deposits, is no doubt hindered by the lack of surface exposure and overall deep burial depths of our state's crystalline basement rocks. Even though past exploration efforts have not led to any mineral resource development, every well drilled and each bit of information collected will aid future exploratory efforts.

References

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