# GS-20 INVESTIGATION OF PRECAMBRIAN MONADNOCKS (NTS 62I/1 AND 62I/8)

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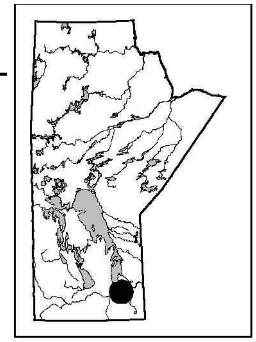

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## SUMMARY

A visit was made to view and sample Precambrian monadnocks northeast of Beausejour. All sites visited lie east of the Precambrian–Paleozoic boundary and consist of Precambrian granite of the Lac du Bonnet batholith. The rock outcrops rise 5 to 20 m above the surrounding prairie level and align in a linear fashion, trending approximately 020°. These sites have been known in the literature for many years and have been studied previously, but three-dimensional mapping in the Winnipeg region has confirmed that there are anomalous elevations. Since it appears that faulting may have occurred at Green Oak (north of Beausejour), these sites were visited for the sole purpose of collecting large samples for apatite fission track thermochronology, in the hope that the results would provide clues to the origin, tectonics and hydrocarbon–metallic-mineral generation of the Williston Basin.


## GENERAL GEOLOGY

The study area is underlain by Precambrian rocks, with the limit of Paleozoic sedimentary strata occurring at a north-trending boundary dissecting the area (Fig. GS-20-1). The Precambrian rocks consist of extensive bodies of granite and granite gneiss. The Precambrian monadnocks visited occur northeast of Beausejour (Fig. GS-20-1), on the Precambrian side of the eastern limit of Paleozoic strata, approximately 2 to 12 km east of the Precambrian–Paleozoic boundary. The monadnocks consist of Precambrian granite typical of the Lac du Bonnet batholith. Previous mapping of these outcrops was done by McRitchie (1969a, 1969b) and Schmidtke (1994). Regional stratigraphic dips are usually less than 3 m/km (McCabe, 1983).

### Local Bedrock Geology

Local bedrock geology consists of Precambrian and Ordovician rocks. The Precambrian rocks are mainly granite and granite gneiss of the Superior Province. The Ordovician rocks, which dip to the southwest, comprise two formations: the older Winnipeg Formation and the younger Red River Formation.

The Red River Formation strikes north to north-northwest and is exposed in outcrops and quarries near Garson (Fig. GS-20-1). It consists of mottled, dolomitic limestone containing abundant fossiliferous material, such as cephalopods, gastropods, corals and *Receptaculites*.

The Winnipeg Formation also strikes north to north-northwest across the study area and outcrops at Victoria Beach and along the west side of Lake Winnipeg (Hecla and Black islands). It consists of rounded, medium-grained, quartz-rich sandstone interbedded with olive-green shale.

The Lac du Bonnet batholith forms the dominant igneous rock body in the area. It is composed of a pink, finely to coarsely crystalline granite. Metavolcanic and metasedimentary rocks are also found in a number of narrow, east-trending belts.

## MONADNOCKS

Monadnocks are described as isolated hills or residual rocks rising conspicuously above the general level of a peneplain. They are erosional remnants of the original surface. The seven sites visited (Fig. GS-20-1) exhibit relief of 5 to 20 m (Fig. GS-20-2, GS-20-3), but adjacent coreholes indicate actual relief to be as much as 40 to 55 m above the regional unconformity surface. Site R8S may have near-surface bedrock, which would probably be Precambrian in age. Future drilling of site R8S would likely confirm the presence of near-surface bedrock. See Table GS-20-1 for more details on each site.

Unique, circular features were found at site R4S (Fig. GS-20-4). They range from 10 to 25 cm in diameter, are concave (3 to 5 cm deep) and some have 1 to 2 cm wide raised rims. Some occur in clusters of up three depressions. It was not determined whether they represent features inherent in the rock or are archeological features. The raised rims, though, may preclude them from being archeological features. They are probably not postglacial features because raised rims would likely have been eroded during glaciation. They may represent fallout from a meteor.

## BEDROCK TOPOGRAPHY

The Precambrian monadnocks outcrop in a linear pattern that trends north-northeast. They occur at elevations ranging from 230 to 238 m. The contact between the Winnipeg Formation and the Precambrian varies from 205 to 213 m in elevation. Individual outcrops of granite exhibit relief of 5 to 20 m above the neighbouring fields, but coreholes adjacent to these outcrops indicate additional relief of up to 35 m above the regional unconformity surface (McPherson, 1970; McCabe, 1983). These outcrops are approximately 20 km farther west than other Precambrian outcrops in the area. Regional structural data

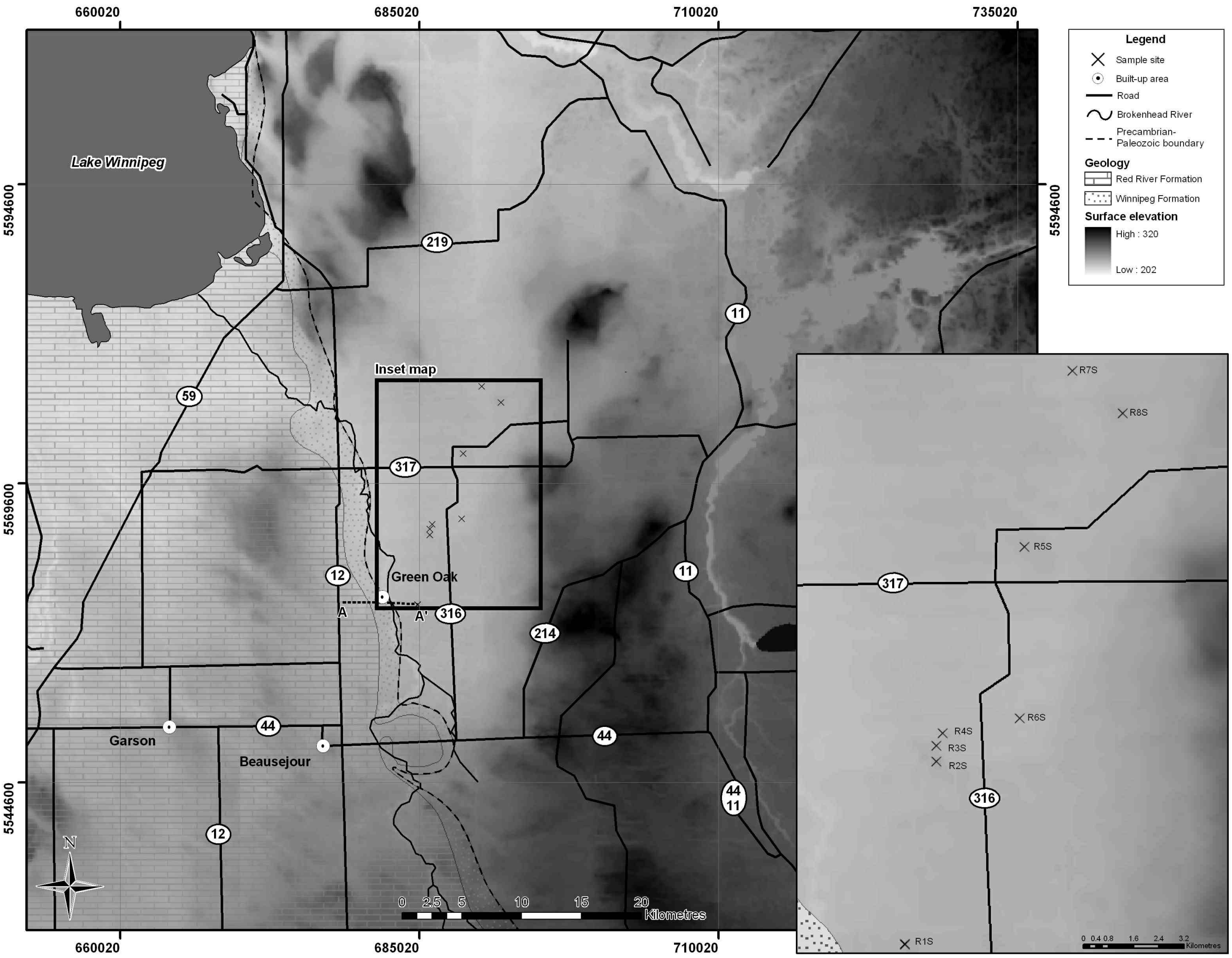


*Figure GS-20-1: Digital elevation model of the study area, showing monadnock sample sites and location of cross-section A-A' (see Fig. GS-20-5).*

*Figure GS-20-2: Sample site R6S, next to farmyard, looking northeast.*

*Figure GS-20-3: Sample site R7S, next to farm field, looking northeast.*

*Table GS-20-1: Details of monadnock sample sites.*

| Sample ID | Map ID #[1] | NTS | UTM | | Elevation (m) | Height (m) | Size | Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Northing | Easting | | | | |
| 88-01-02 | R1S | 62I/1 | 5559500N | 684900E | 234.9 | ~10 | Medium | |
| 88-01-03 | R2S | 62I/1 | 5565300N | 685900E | 238.4 | 15-20 | Very large | |
| 88-01-04 | R3S | 62I/1 | 5565800N | 685900E | 234.0 | 7-10 | Medium | |
| 88-01-05 | R4S | 62I/1 | 5566200N | 686100E | 233.6 | 10-15 | Medium | Circular features |
| 88-01-06 | R5S | 62I/8 | 5572154N | 688649E | 234.8 | 5-7 | Small | |
| 88-01-07 | R6S | 62I/8 | 5566664N | 688554E | 230.8 | ~5 | Small | |
| 88-01-08 | R7S | 62I/8 | 5577712N | 690234E | 232.6 | 5-10 | Medium | |
| 88-01-09 | R8S | 62I/8 | 5576357N | 691833E | 237.1 | ? | Small | No outcrop present |

[1]on Figure GS-20-1

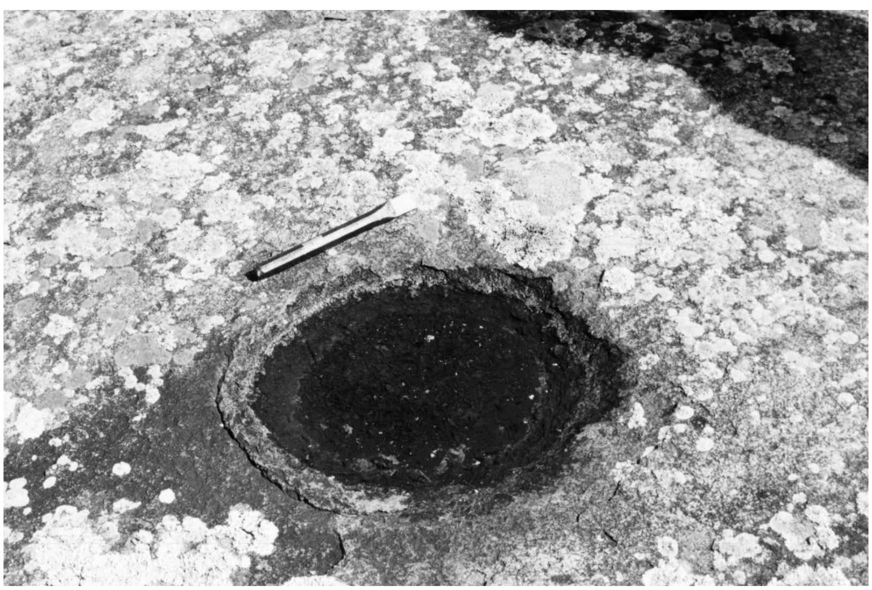

*Figure GS-20-4: Circular feature with raised rim at site R4S.*

suggest that these granite outcrops are at least 35 m higher than normal in the Green Oak area (McCabe, 1983).

Drilling was conducted by McCabe in 1983, 3 km due west of the Precambrian monadnock R1S (Fig. GS-20-5). The first corehole, M-2-83, intersected a thick sequence (29.7 m) of glacial sediments that rests directly on partially brecciated shale and sandstone of the Winnipeg Formation. The Winnipeg Formation was only 7 m thick in this corehole. The elevation of the Precambrian surface is close to that predicted by regional extrapolation. The second corehole, M-3-83, was located beyond the eastern limit of Paleozoic rocks in the area. After penetrating approximately 35.3 m of glacial sediments, it intersected Precambrian basement at an elevation approximately the same as in hole M-2-83. Lithology of the Precambrian in both holes is the same as in the granite outcrop to the east: massive pink granite typical of the Lac du Bonnet batholith. The third corehole, M-4-83, was to be drilled through the entire Paleozoic sequence into the Precambrian. Unfortunately, after penetrating the Red River Formation, drill rods jammed in a shale bed close to the top of the Winnipeg Formation and the hole could not be completed. In coreholes M-2-83 and M-3-83, the Precambrian surface appears to be at an elevation close to that expected for this area. East of this, an abrupt rise of at least 43 m occurs over a distance of 2.8 km, giving a gradient of 15 m/km. Regional gradients are usually less than 3 m/km (McCabe, 1983).

McCabe (1978) suggested that these Precambrian highs constituted structural-topographic islands during early Paleozoic (Winnipeg Formation) time, and drastically affected deposition of the Winnipeg strata. He also suggested that the abruptness of the features, and almost complete lack of other erosional relief on the Precambrian surface elsewhere in southern Manitoba, strongly suggest that the Green Oak paleotopographic high is structurally (?fault) controlled. The structure most likely developed during late Precambrian or even early Paleozoic time; otherwise, it would have been truncated by pre-Ordovician erosion.

Green Oak is not the only place along the present Paleozoic edge where anomalous relief is evident on the Precambrian surface. A similar feature is present near Beausejour, where drilling has indicated a bedrock low of approximately 35 to 40 m (Michalyna et al., 1975; Lebedin, 1978; Young, 1982). It is interesting to note that the Brokenhead River coincides with the Beausejour and Green Oak anomalous sites, and appears to follow what may be a zone of weakness (i.e., the Paleozoic–Precambrian boundary trough). Anomalous relief on top of the Precambrian is also present at The Narrows on Lake Winnipeg, where the Precambrian rises approximately 21 m over a distance of 2.2 km (McCabe, 1983).

## APATITE FISSION TRACK (AFT) THERMOCHRONOLOGY

A comprehensive apatite fission track (AFT) thermochronology study of the basement underlying the Williston Basin, its environs and the adjacent Precambrian Shield has been undertaken by a group of researchers, including the Geological Survey of Canada (Calgary) (Feinstein et al., 2000). Intracratonic basin tectonics remains a problem of economic significance. Thermal history variations, which can be measured by AFT thermochronology, control petroleum generation in the Williston Basin, and probably metallic-mineral generation in Phanerozoic sediments. Using AFT thermochronology, investigators have identified a thermal effect accompanying intracratonic basin subsidence. Clues to the origin, tectonics and hydrocarbon–metallic-mineral generation and emplacement history of the basin can be obtained using AFT thermochronology.

## ECONOMIC IMPLICATIONS

As previously mentioned, thermal-history variations control petroleum generation and metallic-mineral emplacement in the Williston Basin. An understanding of structural tectonics in the basin is crucial in solving these problems. Southard (1978) conducted early work in the area on the economic implications for uranium. An environment favourable for uranium concentration within the Winnipeg Formation, at or near its contact with Precambrian granite, includes a zone extending from

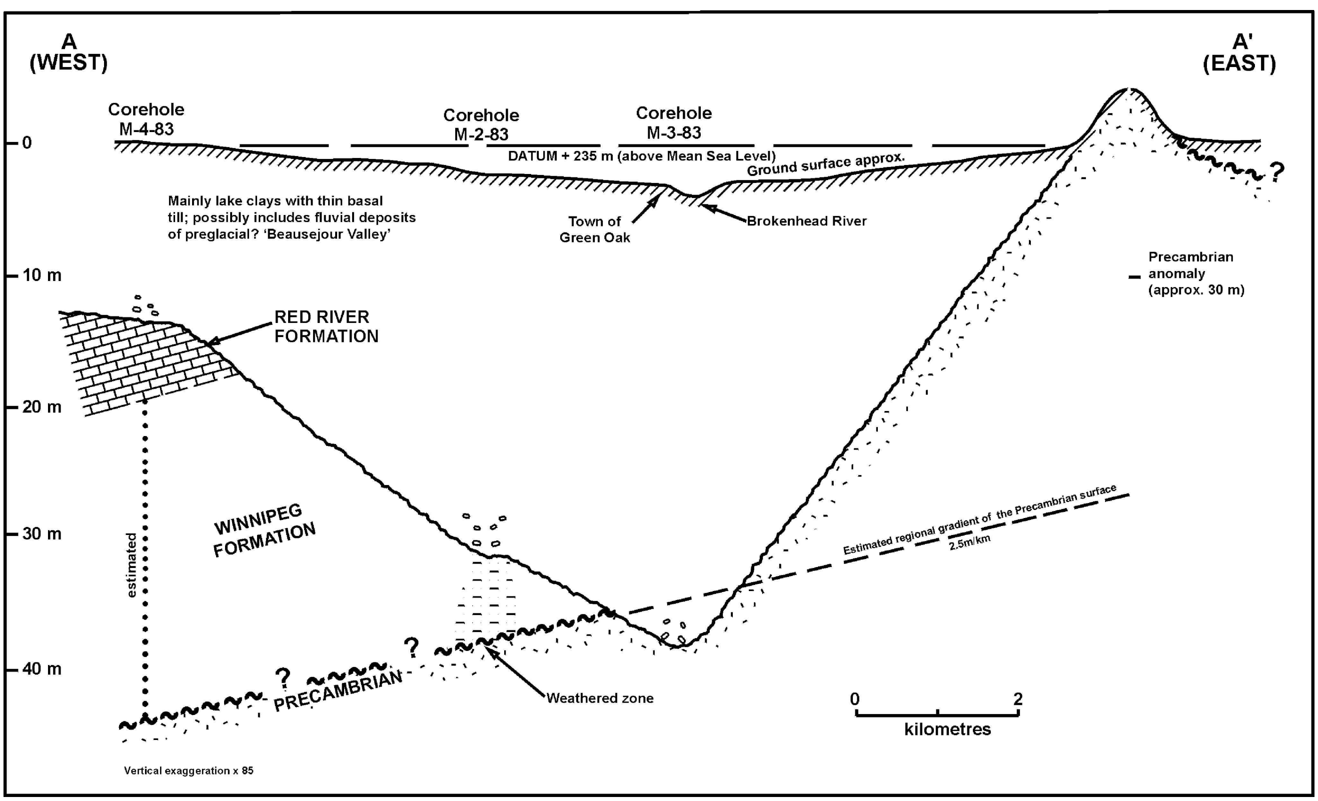


*Figure GS-20-5: Cross-section A-A', indicating a Precambrian high at sample site R1S. See Figure GS-20-1 for section location.*

the southern end of Lake Winnipeg into the United States (along the Precambrian–Paleozoic boundary). In this study, a total of 176 water wells were sampled and analyzed for Eh, pH, Pb, Cu, Zn, Fe and $^{222}Rn$. Southard's data indicate anomalous radon concentrations in a 7 $km^2$ area northeast of Beausejour. The high uranium values encountered could not be explained simply by uranium leached from the bordering granite terrain, suggesting that a source of concentrated uranium is probably present in the area.

Betcher et al. (1988) conducted a study of uranium in groundwater in southeastern Manitoba and reported high levels of the element in water wells sampled. Of the wells completed in the Precambrian bedrock, 61% had uranium concentrations above 20 µg/l (the recommended maximum concentration for Canadian drinking water). Maximum uranium concentrations (up to 2020 µg/l) are comparable to some of the highest levels measured worldwide. Groundwater in the overlying surficial Lake Agassiz clay also contained high concentrations of dissolved uranium. Uranium in groundwater associated with Lake Agassiz clay is thought to be brought into solution primarily by release from organic material during oxidation, followed by the formation of stable uranyl-carbonate (Betcher et al., 1988). Leakage of groundwater from Lake Agassiz clay into Precambrian rock aquifers was shown to provide a significant source of dissolved uranium to the groundwater in the Precambrian rocks, accounting for the coincidence of areas of high uranium concentration in both overburden and Precambrian rock aquifers. The Precambrian rocks also appear to serve as a significant source of dissolved uranium, probably by oxidation of reduced uranium (Betcher et al., 1988).

## CONCLUSIONS

Apatite fission track thermochronology will be carried out on rock samples from seven Precambrian monadnocks. The results will be useful in helping to determine the heating history of this part of the Williston Basin and establish evidence of tectonic disruptions along the Precambrian–Paleozoic boundary. The data will also help establish patterns of petroleum generation and metallic-mineral generation and emplacement in this portion of the Williston Basin.

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