Mineral composition and Fe oxidation study of crystalline basement of Northwest Territories for natural hydrogen potential

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Background

Natural hydrogen, generated through geological processed, is gaining attention as a carbon free energy source. Natural hydrogen generation is known to occur through processes such as serpentinization. In addition, it has been reported that hydrogen can be generated through the oxidation of transition metal bearing minerals when they react with H_2O. However, even if iron is present in the basement rock, no further hydrogen-generating reactions will occur if it has already been oxidized. Therefore, analyzing the oxidation state of Fe in the target rocks, which can participate in hydrogen-generating reactions, is considered essential for accurately evaluating hydrogen generation potential. In this study, we aim to assess the hydrogen generation potential by analyzing the oxidation state of Fe in basement rock samples that have high Fe content and are thus expected to have the potential to generate hydrogen.

Table 1 is the requested sample list. As noted in the previous approval, 10 g each of five samples were approved for XRD and Fe titration analyses; fragment samples will be requested later if needed. The remaining material will be returned as soon as it is received back from Actlab.

Table 1 – Requested core interval and proposed samples

Sample Name	Depth (m/ft)	Lithology Description	Well Name or Field station	UWI	proposed sample
Island River G50-8232F	8232.25	monzodiorite	Island River G-50	300G506010121000	5 g pulps
Laferte River A66-1869F	1869.75	igneous rock	Laferte River A-66	300A666150118300	5 g pulps
Rabbit Lake 2-2907F	2907.833	gabbro	Rabbit Lake no. 2 (0-25)	300O256100118450	10 g pulps ~1 cm peices of rock (10 g)
Davidson Creek P2-2722F	2722.75	monzogranite	Davidson Creek P-02	300P026220118150	5 g pulps
N Arrowhead River H31-6665F	6665.58	gabbro	N Arrowhead River H-31	300H316100122000	5 g pulps

Experimental Methods

Fe titration analysis

Fe titration analysis was conducted in Actlab (41 Bittern Street, Ancaster, ON, L9G 4V5). Fe titration analysis allows for the determination of the relative proportions of FeO and Fe_2O_3 in the sample, which can be used to assess the potential for hydrogen generation. Not all Fe_2O_3 contributes to hydrogen generation via oxidation; rather, hydrogen can only be produced when Fe remains in the reduced FeO state and subsequently undergoes oxidation. Therefore, quantifying the amount of FeO present in the sample is essential for accurately evaluating its hydrogen generation potential.

X-ray diffraction (XRD) analysis

The XRD analysis was also conducted in Actlab. Eight samples were submitted for semi-quantitative XRD analysis. Each pulverized sample was loaded into a standard holder. The XRD analysis was performed on a Bruker D8 Endeavour diffractometer equipped with Cu X-ray source and operating at the following conditions: 40 kV and 40 mA; range 4 - 70 deg 2θ; step size 0.02 deg 2θ; time per step 0.5 sec; fixed divergence slit, angle 0.30; sample rotation 15 rpm. The PDF4/Minerals ICDD database was used for mineral identification. The quantities of the crystalline mineral phases were determined using Rietveld method. The Rietveld method is based on the calculation of the full diffraction pattern from crystal structure data.

Results and discussion

Table 2 – FeO titration analysis results

Sample Name	C#	Depth (m/ft)	Lithology Description	Fe_2O_3(T)% XRF result	FeO % (titration)	calculated Fe_2O_3 %
Island River G50-8232F	C-711824	8232.25	monzodiorite	10.19	6.4	3.1
Laferte River A66-1869F	C-711827	1869.75	igneous rock	6.52	3.5	2.6
Rabbit Lake 2-2907F	C-711831	2907.83	gabbro	15.17	11.2	2.7
Davidson Creek P2-2722F	C-711832	2722.75	monzogranite	6.9	1.3	5.5
N Arrowhead River H31-6665F	C711836	6665.58	gabbro	14.89	9.7	4.1

Table 2 shows experimental results including FeO titration results. Fe_2O_3 (T) represents the total Fe amount determined by X-ray fluorescence (XRF) analysis (previously analyzed), and the FeO titration result is the wt% of FeO obtained by the titration method. The Fe_2O_3 (T) from XRF includes contributions from both Fe^{2+} and Fe^{3+}. Assuming the Fe^{2+} value from titration is correct, the actual Fe_2O_3 can be obtained by converting the FeO content into its Fe_2O_3 equivalent and subtracting that from Fe_2O_3 (T). Thus, the actual Fe_2O_3 is given as follows.

$$Fe_2O_3 = Fe_2O_3(T) - 1.1113 \times FeO$$

Among the five samples, C-711831 has the highest FeO wt%.

Table 3–XRD results for C-711831

Quartz	Plagioclase	Amphibole	Augite/Diopside	Biotite	Chlorite	Magnetite	Ilmenite	Sum (%)
11.4	42.7	1.0	32.5	1.2	9.0	1.8	0.4	100

Table 3 and figure 1 show XRD results for C-711831. The sample has highest value of Fe_2O_3 (T) and FeO among the five samples. The measured FeO and Fe_2O_3 values are thought to originate from multiple minerals. FeO is presumed to occur in augite, magnetite, and chlorite, and may also be present in small amounts in ilmenite and biotite. However, XRD and FeO titration results are insufficient to determine exactly how much FeO is hosted by each mineral. To more accurately estimate hydrogen generation, the FeO content of each individual mineral should be analyzed. Based on the FeO content, sample C-711831 may have a relatively high potential for hydrogen generation. However, a definitive evaluation would require further analyses, such as determining the Fe^{2+}/Fe^{3+} ratios in individual minerals and conducting reaction experiments to verify whether hydrogen is actually generated under relevant conditions.

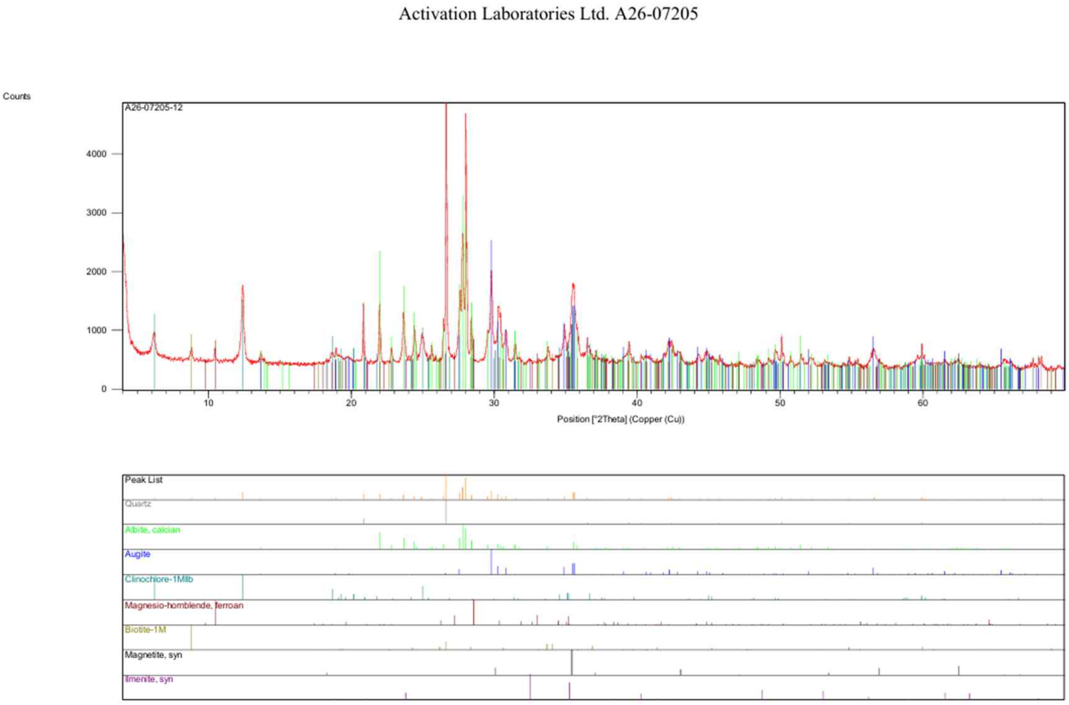

Figure 1. XRD results for C-711831.

Please note that this report presents only the analytical results of the samples and does not contain any commercial interpretation or assessment. As these data have not yet been published, they are not publicly available at this time.