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Work Requested By: Sonia Veltman

On Behalf Of: Veltwater Groundwater Specialists CC

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Mineralogical and Geochemical Analysis of One Waterberg Sandstone Sample

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1. INTRODUCTION

Ms Sonia Veltman, from Veltwater Groundwater Specialists CC, submitted one sandstone sample, labelled "Waterberg", for X-ray Diffraction (XRD), QEMSCAN and X-ray Fluorescence (XRF) Analyses in order to determine the mineralogical composition. This information will be used to predict the environmental consequences of the exposure of the rock to atmospheric (oxidizing) conditions.

2. METHODOLOGY

The sample was crushed to 100% -75 microns, and three representative aliquots were split off:

- Two aliquots were pulverised and one was submitted for X-ray Diffraction analysis and one for XRF (borate fusion) analysis. The XRD sample was subjected to X-ray diffraction analysis and the mineralogical composition was determined by selecting the best-fitting patterns from the ICDD database to the measured diffractogram, using Panalytical X'Pert Highscore analytical software.
- Two polished sections were prepared from the second aliquot for examination with the QEMSCAN. The raw data was processed using iExplorer software.

3. RESULTS

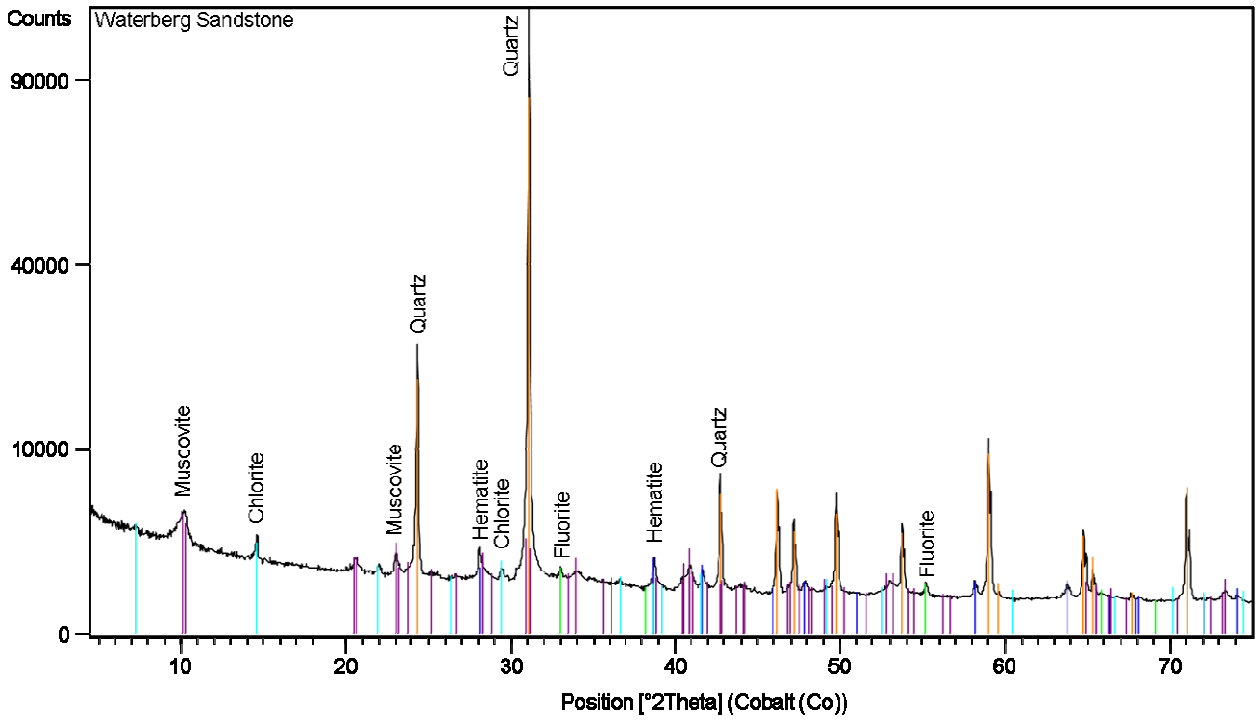
3.1. X-ray Diffraction Analysis

The results of the XRD analysis are presented in Table 1 and Figure 1. The results show that the sample comprises mainly quartz with a small amount of hematite and muscovite. The sample also contains minor amounts of chlorite and fluorite. The chlorite may be slightly overestimated due to preferred orientation of the mineral in the sample material. The double peak in the area of the first muscovite peak on the left hand side of the diffractogram (Figure 1) suggests that two types of mica and/or clay were detected in the sample, possibly muscovite and illite. Illite has a similar chemistry to muscovite but it usually has more silica and less potassium. It is finer grained than muscovite and is generally regarded as a clay mineral rather than a type of mica. No carbonate or sulphide minerals were detected by XRD.

Table 1: X-ray Diffraction Analyses

Mineral	Approx. Formula	Approx. Composition
Quartz	SiO_2	> 75 %
Hematite	Fe_2O_3	3-10 %
Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$	3-10 %
Illite	$(K,H_3O)(Al,Mg,Fe)_2(Si,Al)_4O_{10}[(OH)_2,(H_2O)]$	3-10 %
Chlorite	$(Mg,Fe)_5Al(Si_3Al)O_{10}(OH)_8$	< 3 %
Fluorite	CaF_2	< 3 %

Figure 1: X-ray Diffractogram



3.2. X-ray Fluorescence Analysis

The XRF data presented in Table 2 shows that the sample contains mostly SiO_2, with small amounts of Al_2O_3, Fe_2O_3 and K_2O. Other elements are present in trace amounts. There is only a small amount of Fe_2O_3 in the sample, which is present as hematite (with a small amount in chlorite and illite) and not as sulphide minerals. The loss on ignition (LOI) is indicative of the amount of hydrous minerals present in the sample. This agrees with the XRD results which show the sample contains mostly quartz with some Fe-oxide (hematite) and K-Al-hydrous-silicate minerals (muscovite, illite and chlorite) present, and no carbonate minerals. The low MgO content suggests the chlorite is Fe-rich (chamosite) and not Mg-rich.

Table 2: X-ray Fluorescence Analysis

XRF	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	K_2O	MnO
L DETECTION	*0.05*	*0.05*	*0.01*	*0.05*	*0.01*	*0.01*	*0.01*
U DETECTION	*100*	*100*	*100*	*100*	*100*	*100*	*100*
	%	%	%	%	%	%	%
Waterberg	86.20	5.57	0.44	0.12	3.75	1.54	0.02

XRF	Na_2O	P_2O_5	TiO_2	Cr_2O_3	V_2O_5	LOI	Total
L DETECTION	*0.05*	*0.01*	*0.01*	*0.01*	*0.01*	*-50*	*0.01*
U DETECTION	*100*	*100*	*100*	*50*	*100*	*100*	*120*
	%	%	%	%	%	%	%
Waterberg	<0.05	0.02	0.27	0.03	0.01	1.00	99.00

3.3. QEMSCAN Analysis

A bulk modal analysis (BMA) was carried out on the sample using QEMSCAN technology. The following minerals were detected in the sample during the BMA, in order of abundance: quartz, muscovite, Fe-oxide/hydroxide, fluorite and chlorite. Ilmenite, rutile and zircon were

also detected by QEMSCAN but not XRD, thus they are probably only present in very small amounts <3 mass%. A calculated chemical composition was determined from the BMA data for comparison with the XRF results (see Table 3). The XRF data in Table 2 has been converted from oxides to elements for comparison with the BMA data. The data in Table 3 shows the results of the BMA and the XRF analysis are very similar.

Table 3: Comparison of QEMSCAN BMA Calculated Chemistry and XRF Analysis

Waterberg	Si	Al	Ca	Mg	Fe	K	Mn
XRF Data	40.29	2.94	0.31	0.07	2.63	1.27	0.01
QEMSCAN Data	40.67	3.01	0.35	0.03	2.59	1.44	0.00

Waterberg	Na	P	Ti	Cr	V		
XRF Data	<0.05	0.00	0.16	0.02	0.00		
QEMSCAN Data	0.00	0.00	0.24	0.00	0.00		

4. DISCUSSION AND CONCLUSIONS

The XRD analysis shows that the sample contains mainly quartz with a small amount of hematite and mica/clay (muscovite/illite) and minor amounts of chlorite and fluorite. No carbonate or sulphide minerals were detected by XRD analysis. If any sulphide minerals are present, the amount will be negligible and any acid produced by their oxidation will be neutralized by the muscovite/clay and/or chlorite.

The XRF data confirms the interpretation of the XRD analysis as the sample contains mostly SiO_2 and small amounts of Al_2O_3, Fe_2O_3 and K_2O. There is only a small amount of Fe_2O_3 in the sample, which appears to be present as hematite and not as sulphide minerals. The amounts of CaO and MgO, which are the main components of calcite and dolomite, are very low and it can therefore be deduced that these (or other) carbonate minerals are not present in this sample. A low loss on ignition (LOI) value is also an indication of a low volatile content (i.e. carbonate/hydrous minerals).

The QEMSCAN calculated chemistry is very close to the XRF assayed chemistry giving a high degree of confidence in both sets of results and can thus be regarded as an accurate composition of the submitted sample.

Since no sulphides or other deleterious minerals were identified during the mineralogical and geochemical investigations, the material represented by this sample should not pose a threat to the environment when it is exposed to the oxidizing conditions of the atmosphere.