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Study of the scaling of water pipelines in the region of Tizni

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ABSTRACT

Scaling of drinking water pipelines has become one of the major problems encountered in the Tiznit region. The waters in this region have high hardness reaches 59 °F. We are interested in this work to the characterization of the Tartars collected in Talaint site, located 14 km from the city of Tiznit, using different analysis techniques: chemical analysis, differential thermal analysis (DTA), thermal gravimetric analysis (TGA), X-ray diffraction analysis (XRD), scanning electron microscopy analysis (SEM) and quantitative analysis by XRF. The analytical results obtained show that these tartars are formed mainly of two varieties of calcium carbonate calcite and aragonite.

1. Introduction

Drinking water supply to the Tiznit region is provided from Youssef Ben Tachfine dam on the Oued Massa and by Reggada and Talaint sources in Ouled Jerrar. Currently, the annual drinking water resources mobilized are of the order of $1.1.10^6$ m^3 including 3.10^5 m^3 of surface water transferred from the Youssef Ben Tachfine dam and $8.1.10^5$ m^3 from Talaint and Reggada underground water sources .

In our previous study, we showed that water of Tiznit region is very hard; its hardness reached 59 °F [1]. This hardness generated the formation of the hard and adherent deposits on the internal walls of the pipes and the structures that deliver drinking water. The technical consequences of this phenomenon are numerous: partial or complete clogging of pipelines, flow reduction, etc.

In the present work, we are interested in the characterization and identification of Tartars and scale deposits recovered in the water system and the Talaint reservoir using various analytical techniques. These techniques include chemical analysis (e.g. X-ray photoelectron spectrometry (XPS)), thermal gravimetric analysis (TGA), differential thermal analysis (DTA), X-ray diffraction (XRD), X-ray fluorescence (XRF) and scanning electron microscopic (SEM) analyses.

In this study, two water representative sites were selected: The Talaint reservoir and Talaint water system. Sampling was carried out according to the recommended standards [2].

The naturally formed deposits of tartar in water pipes were recovered from the following sites:

• Sample 1: collected from the reservoir of Talaint.
• Sample 2: collected from pipes of Talaint water system.

2. Analytical Techniques

The identification and characterization of the obtained tartars were performed through chemical Analysis using X-Ray photoelectron spectrometry XPS ESCALAB 250, examination by X-ray diffraction kind XPERT-PRO, thermal analysis DTA/TGA (simultaneous thermal analyzer) using equipment kind NetzschSTA409C, analysis by X-ray fluorescence using a spectrophotometer such AXIOS, and analysis by Scanning electron microscope analysis (SEM).

3. Results and discussion

3.1. *Chemical analysis of deposits*

The XPS spectra obtained for samples 1 and 2 are shown in Figures 1 and 2 respectively. They have been calibrated with respect to the main component C1 peak C-C /C-H set at 285 eV.

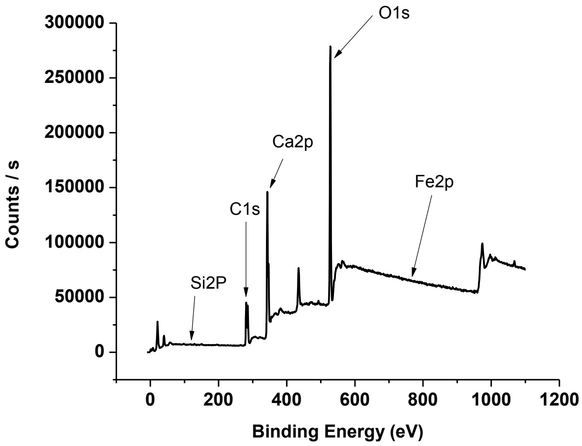


Figure 1: XPS spectra of the tartars collected from the Reservoir of Talaint

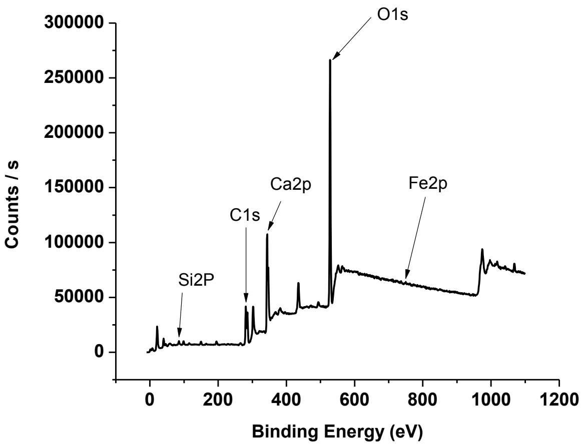


Figure 2: XPS spectra of the tartars collected from the Talaint water system

As clearly seen from XPS spectra (Figure 1 and 2), each energy peak corresponds to one type of atom only; the oxygen element (O1s) found at an energy of 532 eV, calcium at 346 eV, carbon at 285 eV, traces of silicon at 102 eV and iron at 710 eV.

The main peaks of oxygen, calcium and carbon indicate that the collected tartar deposits are mainly composed of calcium carbonate ($CaCO_3$).As a conclusion, XPS analysis shows that the two samples are formed mainly from three major elements; oxygen, carbon and calcium, which proves that these tartars are mainly made of calcium carbonate. To determine the exact chemical structure of each sample, X-ray diffraction (XRD) analysis was performed [3].

3.2 *Characterization of deposits by X-ray diffraction (XRD)*

XRD study was performed by means of a powder diffractometer type XPERT-PRO. The diffractograms obtained are shown in Figures 3 and 4.

Figure 3 shows that the tartar collected in Talaint reservoir is mainly composed of calcium carbonate with calcite structure, the thermodynamically more stable form of all varieties of calcium carbonate [4], and some traces of silica. Figure 4 shows that the tartar extracted from Talaint water system is 100 % calcium carbonate with aragonite structure, stable form of calcium carbonate at a temperature above 50 °C but also in the presence of certain ions such as magnesium [4].

3.3 *Thermal Analysis*

For the study of the thermal evolution of both tartars, we used the thermogravimetric analysis (TGA) and differential thermal analysis (DTA). This thermal behavior is studied for temperatures between 25 and 800 °C with a heating rate of 10 °C/min. All tests were performed in air. The TGA and DTA curves of the two tartars collected from the reservoir and the Talaint water system are shown successively in Figures 5 and 6.

The DTA curves (B and D) for both samples reveal two main endothermic peaks at temperature 748 °C, which corresponds to the decomposition of calcium carbonate, as shown in the TGA curves (A and C) of both samples, showing a mass loss at this temperature [5,6].

Chemical decomposition of calcium carbonate leads to the formation of calcium oxide and release of CO_2 gas, as illustrated in the following chemical reaction:

$$CaCO_3 \longrightarrow CaO + CO_2\uparrow$$

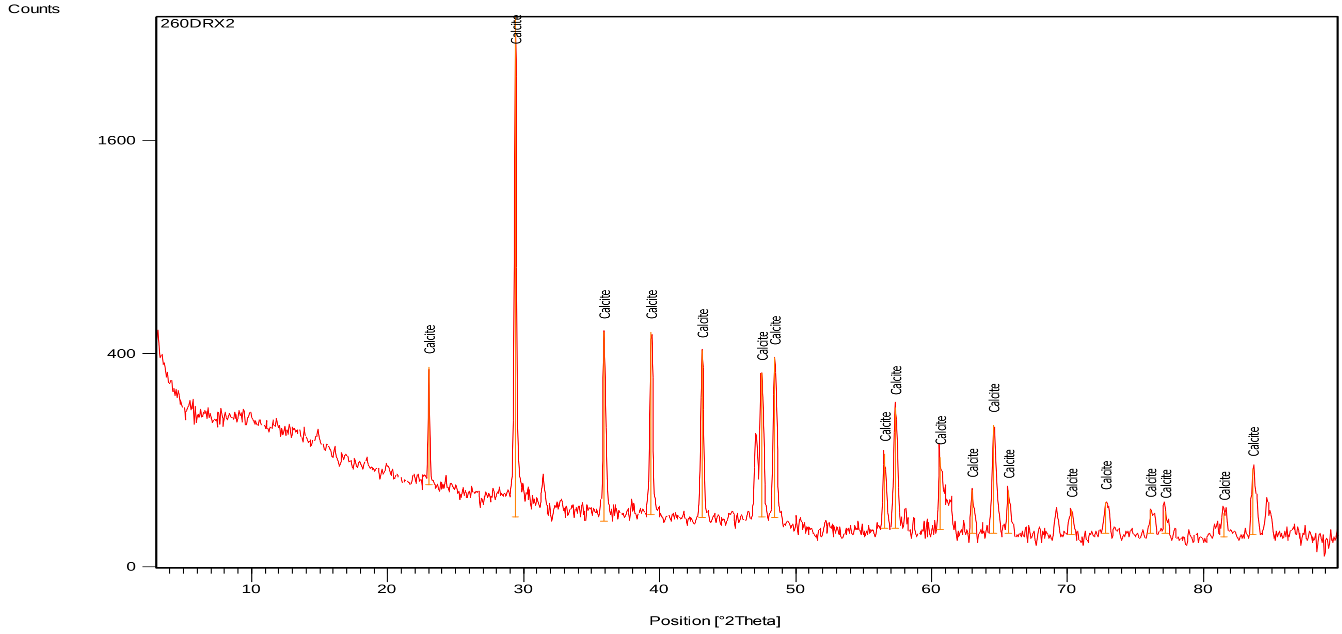


Figure 3: Diagram of tartars collected in the reservoir of Talaint

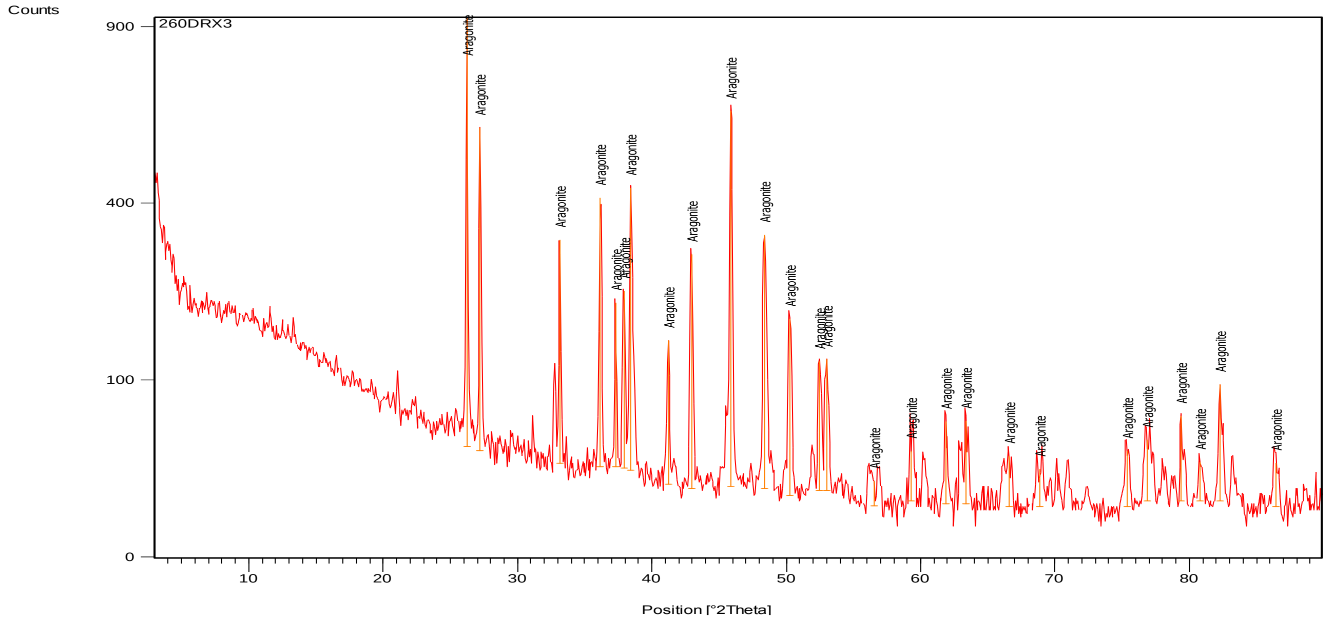


Figure 4: Diagram of tartars collected in Talaint water system

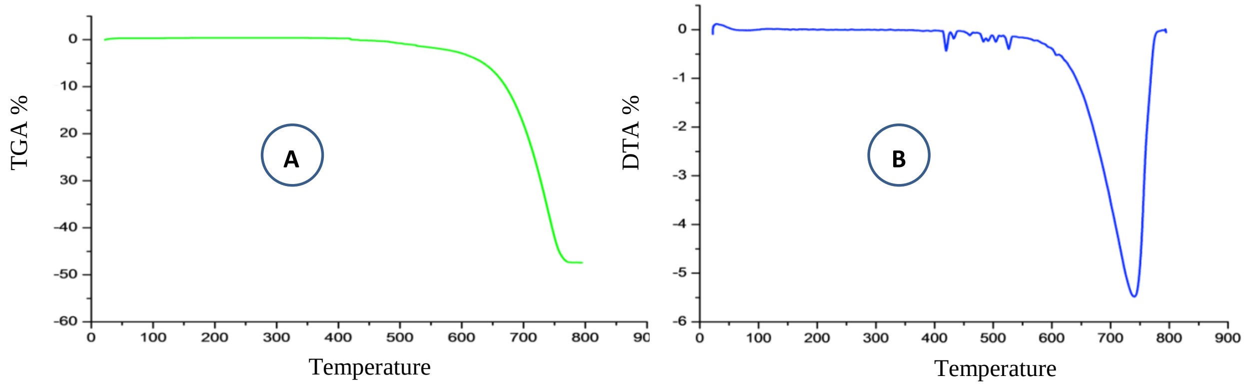


Figure 5: Thermal analysis TGA (A) and DTA (B) of collected tartar in the reservoir of Talaint

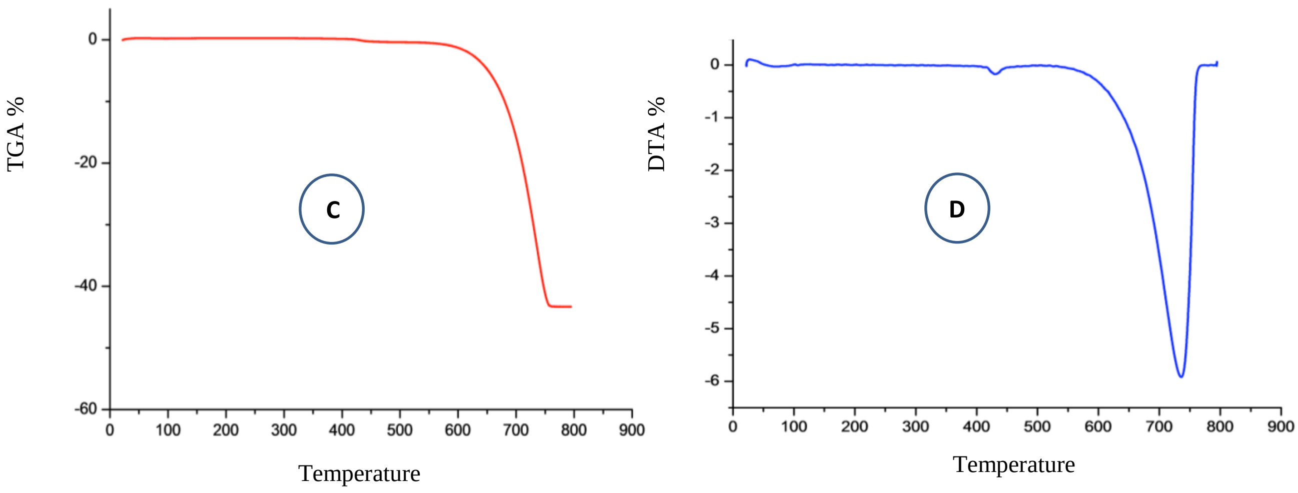


Figure 6: TGA Thermal analysis (C) and DTA (D) of tartar collected from the Talaint water system

The observed mass loss is 42.7 %, which is agreement with the calculated theoretical value 44 % for obtaining of CaO.

3.4 *X-ray Fluorescence analysis (XRF)*

For a more detailed characterization of these tartars and in order to highlight the elements present at trace, wended to use the X-ray fluorescence analysis which proves to be the method of choice to use as it is both sensitive and rapid and more or less non-destructive. Using this technique, we can identify the constituents of the two samples of tartar collected in the reservoir and from the Talaint water system (table 1) and determine the concentrations by means of the emission of characteristic X-rays [7].

Table 1: Chemical compositions of deposits collected within the reservoir (Tartar 1) and the Talaint water system (Tartar 2)

Composition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	P_2O_5	L.O.I*	$CaCO_3$
Tartar 1	0.45	0.12	0.03	54.22	0.37	0.00	0.18	0.03	0.05	43.69	96.82
Tartar 2	0.01	0.00	0.00	54.66	0.00	0.00	0.23	0.03	0.04	44.16	97.61

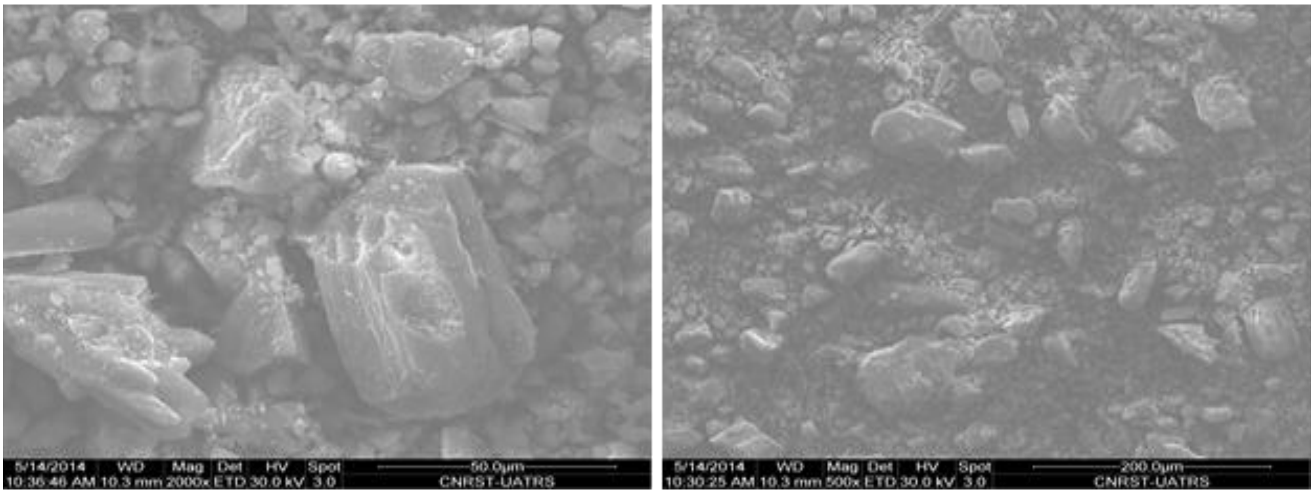
* LOSS ON IGNITION ANALYSIS

Quantitative analysis by XRF of two samples of tartar collected in the water system (Tartar 1) and in the Talaint reservoir (Tartar 2) coupled with Theo their previous experimental results have confirmed that the tartar 1 and 2 are mainly formed of calcium carbonate, 96.8 % and 97.6 % respectively. However, it is to note the presence of some traces of silica, magnesium oxide and potassium oxide in the case of tartar 1 while in the case of the tartar 2 only are found some traces of potassium oxide.

3.5 *Scanning electron microscopy (SEM) analysis*

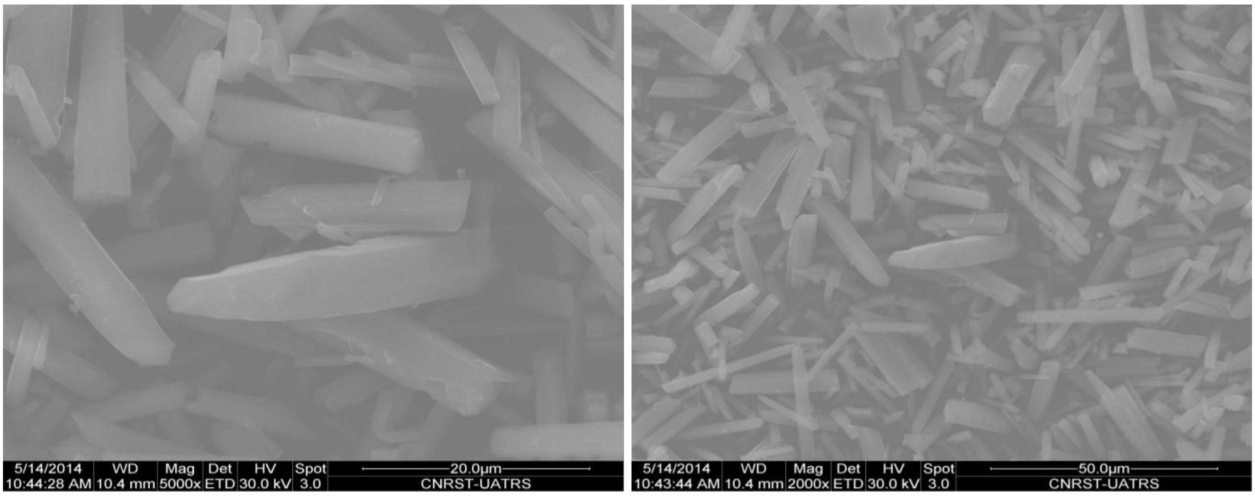
The pictures obtained by scanning electron microscopy for tartar recovered from the reservoir and the Talaint water systems are shown in Figures 7 and 8. Pictures of figure 7 show that these crystals of calcium carbonate are in the form of centered and compact facies, which characterizes the crystal morphology of the calcite variety of calcium carbonate [8, 9]. Calcite has a stair steps structure, due to the interpenetration of rhombohedra constituting the grains [10].

Pictures of figure 8 are in the form of long separate needles and correspond to the crystal morphology of calcium carbonate variety aragonite [10]. The aragonite takes the shape of a needle cut into small pieces of 4 μm long [8, 9].



micro-photo 1 micro-photo 2

Figure 7: Photographs of the recovered tartar in the Talaint reservoir



micro-photo 3 micro-photo 4

Figure 8: Photographs of the recovered tartar in the Talaint water system.

The results of the analysis of tartar from Talaint reservoir and water system using the scanning electron microscopy method have thus confirmed the previous results obtained by X-ray diffraction technique.

Conclusion

The analysis by XPS technique of tartar deposits recovered from the reservoir and the Talaint water system shows that the chemical composition of the surfaces of these samples are formed mainly of three major elements which are oxygen, carbon and calcium.

The analysis by X-ray diffraction allowed us to conclude that the reservoir and Talaint water system tartars are formed mainly of calcium carbonate variety calcite and aragonite respectively. The XRF has enabled us to confirm the chemical compositions of these Tartars and scanning electron microscopy also confirmed that these tartars are mainly formed of two varieties of calcium carbonate: calcite and aragonite. We could conclude that the calco-carbonic balance of water in this region is to be considered to explain the formation of scale in the pipes of drinking water.

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