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Contribution to the hydrochemical study of springs Jurassic of the Ziz high basin: Contribution of remote sensing

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Abstract

This work aims the evaluation of the physico-chemical quality of the Jurassic springs of the High Ziz basin and determination of the sources of pollution a view to map the quality of Jurassic layers. And determine their relationships with geolgic fractures. In this study, five springs were sampled during the month frome March to september 2014. September chemical elements were analyzed by ion chromatography: Chlorides, nitrates, sulfates, Sodium, Potassium, Calcium and Magnesium. To study and compare the spatial distribution of results, thematic maps were developed using a Geographic Information System (GIS). the use of remote sensing data together with image processing techniques and GIS aims to: 1) map fracturing Ziz high basin, 2) analyze their relationship with fracturing, 3) guiding the hydrogeological prospecting in the area. Analysis of the overall water quality revealed that the controlled items are average to very poor. These waters belong to three chemical facies:chlorinated- sulfated, calcic and magnesium facies, a calcium andmagnesium and bicarbonate facies and a chlorinated sodic and potassium facies. The degradation of water quality in the Jurassic aquifer of the high basin of Ziz could have geological and anthropogenic origins. The sources are related to the tectonic nodes at intersection of faultes.

1. Introduction

The availability of drinking water is one of the major objectives of development projects worldwide. This paper presents an application to the Ziz high basin characterized by a water shortage related to arid and dry climate with low rainfall and high temperatures accompanied by high evaporation [1-2]. Moreover, renewable water resources are often limited to a growing demand for this resource. View inadequate surface water and shallow groundwater, the search for new water resources is resolutely geared towards deep aquifers.

This study concerns the evaluation of the physico-chemical quality of the sources of the Ziz high basin. To do this, a sampling campaign was initiated in March 2014.

In this study, the use of remote sensing data and geographic information system (GIS) aims to: 1) mapping lineaments responsible for structuring Ziz high basin, 2) identify on the ground the main sources and analyze their relationship with sources, 3) direct the hydrogeological prospecting in the area.

2. Materials and methods

2.1. Study area

Ziz high basin (Figure 1) with an area of 4360 km², located in arid south-eastern Morocco (Central High Atlas) and belongs to the great basin Ziz-Rheris, surface water is scarce. limited to north by the Moulouya plain and South by the Anti Atlas mountain, the East by Eastern High Atlas.

2.2. Geological framework

The geology of the Ziz high basin (Figure 2) includes distinct structural domains that span from the Mesozoic until the Quaternary [3-4]. The Paleozoic comprises basal schists, quartzites and some intrusive rocks. It is reduced under large anticlines or some buttonholes [3]. The Mesozoic in the High Atlas, basalts, the Trias is constituted of detrital deposits, doleritic basalt with evaporite levels, in angular unconformity above the deformed Paleozoic basement and structured by several tectonic phases [5-6-7]. The Jurassic series rest conformably on the Triassic-Lias red formations. Their lithology consists essentially of dolomite, limestone, calcareous marl alternations, and silico-clastic detritus [7-8-9].

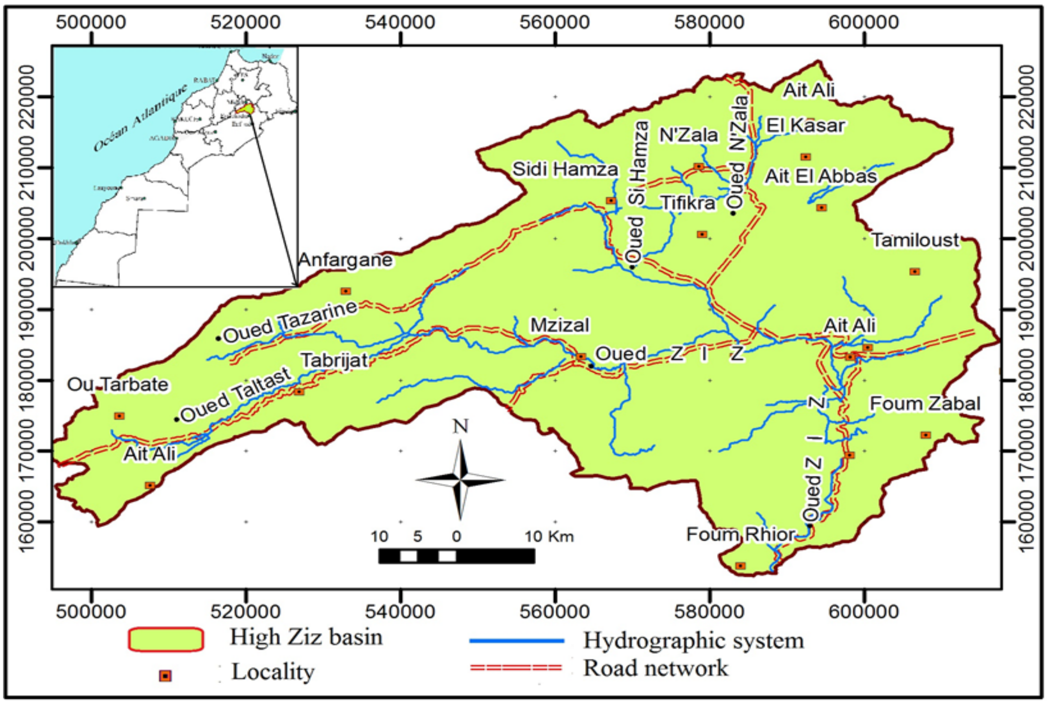

Figure 1: *Location Map of high Ziz basin and study area*

The Quaternary has a great lithological heterogeneity with deposits consisting mainly of conglomerates, gravels, pebbles, silts, of fluvio-lacustrine elements, sandstone, and marls sometimes.

Their thickness does not exceed 50 m.

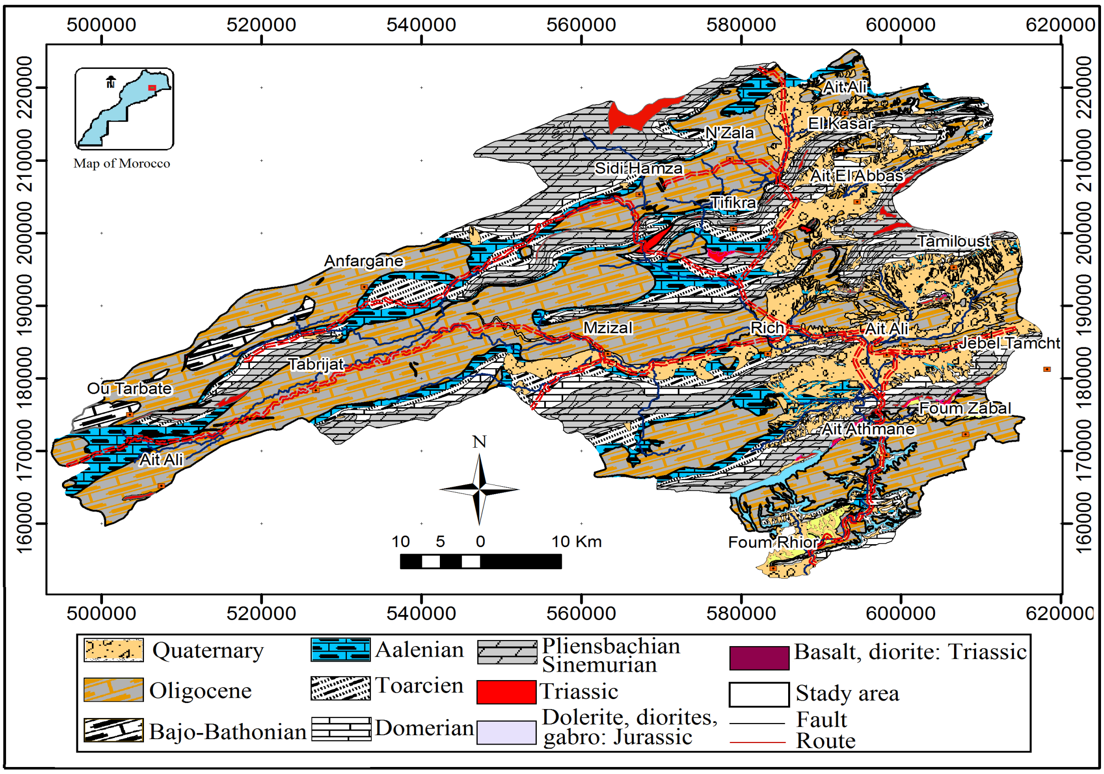

Figure 2: Simplified geological map at the Ziz high basin (Extracetd from geologicals maps of Midelt and of Rich-Boudnib [10-11].

2.3. Climate and Hydrogeological frame

Ziz high basin is located in a semi-desert bioclimatic stage. Temperatures have significant seasonal variations with a very hot summer and a very cold winter. The annual rainfall regime is characterized by the existence of two rainy seasons: autumn and spring [11-12].

The distribution of rainfall map in the Ziz high basin, obtained by isohyets method [1-13], based on the rainfall data of the hydrological basin agency Ziz-Rheris is presented in the figure 4.
The High Atlas contains a set of interconnected hydrogeological units Lias and Dogger (Figure 3), these aquifers give rise to several sources : The Lias is forming a relatively continuous system and Aalenien and Dogger aquifers form networks, fragmented into separate basins in each synclinal basin and usually without communication, sometimes with multiple aquifer levels. The waterproof series Toarcian-Aalenian separates between aquifers sets of lower Lias-Domerian and those of the Aalenien-Dogger. Communications between aquifers are only possible across the holes [13-14]. These waters belong to three chemical facies:chlorinated-sulfated, calcic and magnesium facies, a calcium and magnesium and bicarbonate facies and a chlorinated sodic and potassium facies [12]. The water depth, according to the survey conducted in February 2014 at twenty water points, varies from a few meters to more than sixty meters [12-14].
These aquifers give birth to several sources; the most important are those of Zaouia Sidi Hamza, Tahamdount, Aghbaloun'Kerdous and Toudgha, the average vulnerability is most dominant in the neighboring region [15-16].

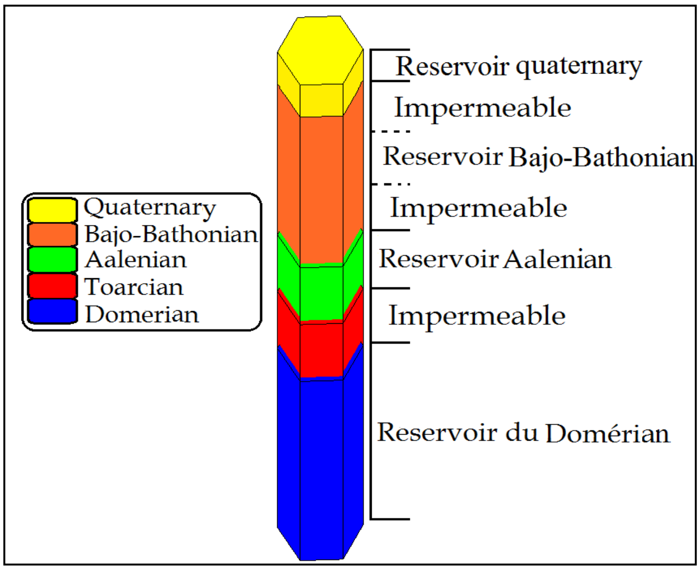

Figure 3: Principal reservoirs of the Ziz high basin [13].

2.4. Sampling and analysis

As part of this qualitative study of the Ziz high basin, A total of four samples for physico-chemical analyzes were performed in March 2014 (Figure 4).
The water analyses were performed at the UATRS platforms which are a set of technological unit that offers to the Moroccan universities and industry expertise, and different type of analysis.
The electrical conductivity, temperature, pH, and alkalinity, were measured at the sampling point. At the laboratory, the anions (chloride, sulfate, nitrate and bicarbonate) were measured by ionic chromatography and analysis of calcium, magnesium, potassium, sodium and Silicon were made by ion chromatography.

2.4. Lineaents extraction and analysis by remote sensing

The images used are satellite Landsat 7 ETM + (Enhanced Thematic Mapper) scenes p200r038 and p200r037, respectively acquired in April 12, 2001 and Mars 11, 2001 , the diversity of channels provides the interpreter a wealth of information to handle. This type of picture has the advantage of bring out the lineaments due to low sun angle, lack of spatial detail and regional coverage (185 km x 185 km). The approach to the extraction of useful geological information for this study can be divided into two levels: Pre-treatment and enhance the quality of images, filtering and mathematical morphology technique [17-18]. Analysis and processing of such data for the interpretation of lineaments were performed according to the following steps :

- Extraction of lineaments from ETM + image; The result of Principal Component Analysis (PCA) [18-19-20], allowed us to select the first components with a good compression of the spectral information. These images were used as entries for the application of more relevant techniques such as filtering [17-18-19], for the identification of lineaments (lithological or structural discontinuities). Filtering consist of applying in a neighborhood of the current pixel, a convolution of the image with a mask that represents the filter. This treatment allows us to detect discontinuity signals of the grayscale the current pixel relative to its neighbors within a particular direction [21-22-23]. We use in this case as a treatment, directional filters of Sobel, Prewitt and Yesou.

- Comparison of the results with the reality on the ground;
- Establishment of a structural map on which the sources will be postponed;
- Highlighting the relationship fracturing sources.

3. Results and discussion

3.1. Physical parameters (in situ analysis)

The analysis of this water revealed that the values of flow rates (Figure 4) oscillated between 8.1 L/s (Source Hamat Moulay Hachem) and 516.1 L/s (Source Zaouit Sidi Hamza).

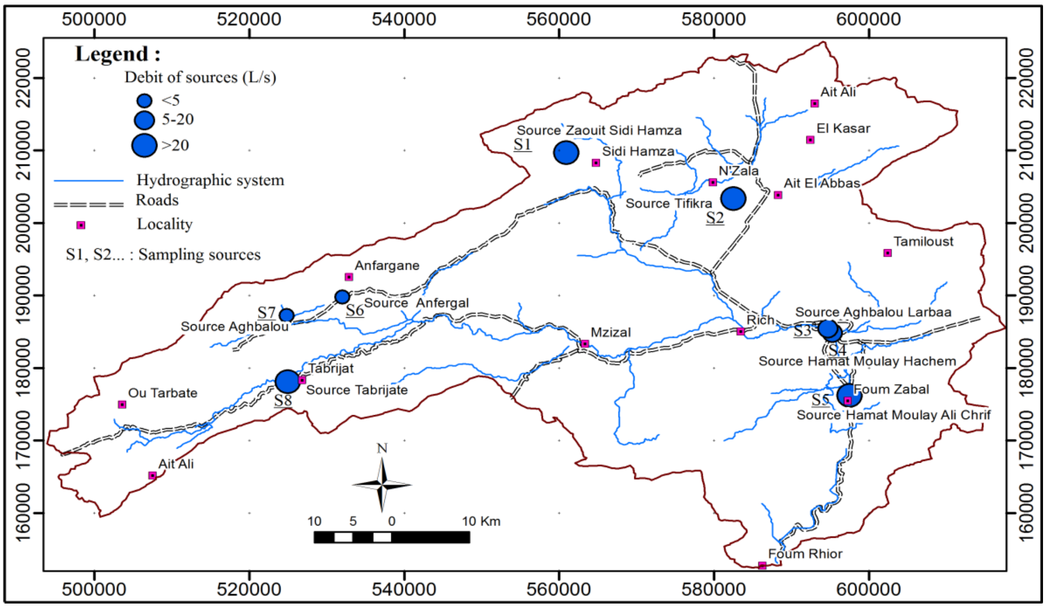

Figure 4: Spatial distribution of flow values of the sources of Ziz high basin (March 2014) and location Map of sampling points.

The temperatures recorded in this study vary between 10,1 °C and 50, 2 °C.

The data recorded in the the two upstream sources does not have large significant differences between souces, such as the thermal springs (Hamat), which belong to the large fault system Foum Zaabel, their temperature is between 50,2°C in the Hamat Moulay Ali Chrif (S5) and 30°C in the Aghbalou N'larbaa (S3) (Figure 5), the high temperature of the springs 3.4 and 5 could be a deep origin. Conductivity of sources water controlled (Figure 6), are mineralized with values that oscillated between 753 µS / cm and 12910 µS / cm.

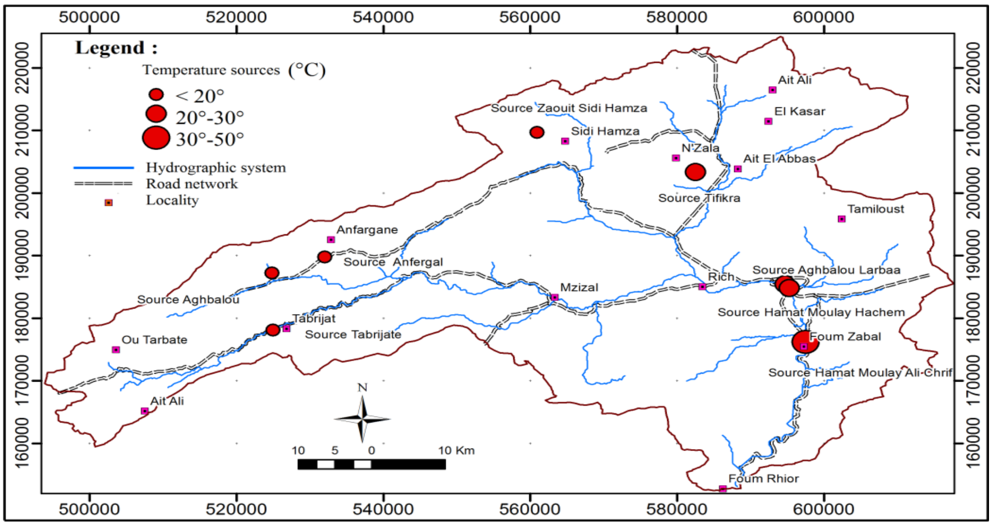

Figure 5: Spatial distribution of temperature values of the sources of Ziz high basin (March 2014)

These important values appear to result from leaching of the reservoir rock, such as for the thermal springs there was a fairly high conductivity. The analysis of pH of these sources has revealed that the pH (Figure 7), is close to neutral between 6.7 and 7.6, at all water points, the average values of the pH level of the study area were in the standards potability of groundwater.

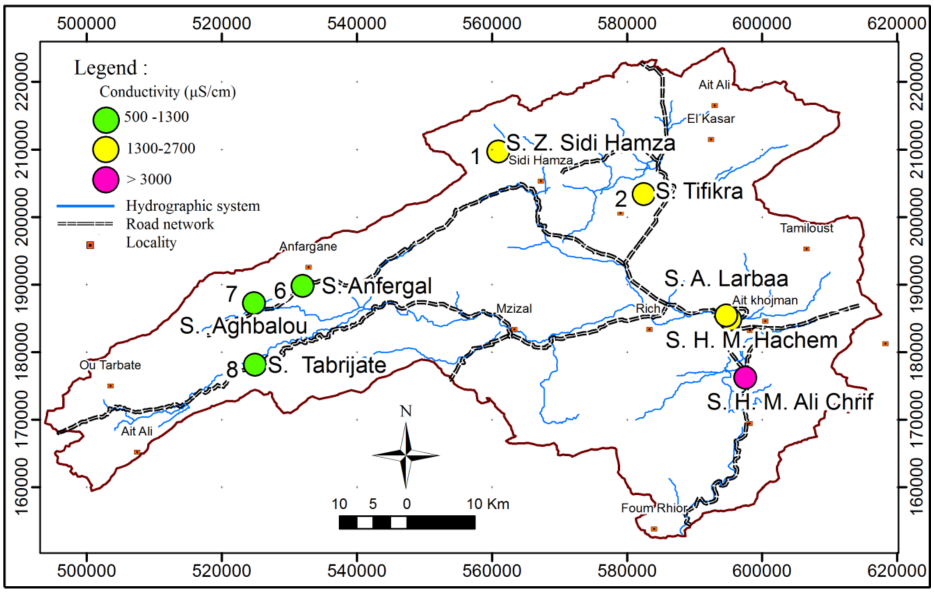

Figure 6: Spatial distribution of conductivity values of the sources of Ziz high basin (March 2014)

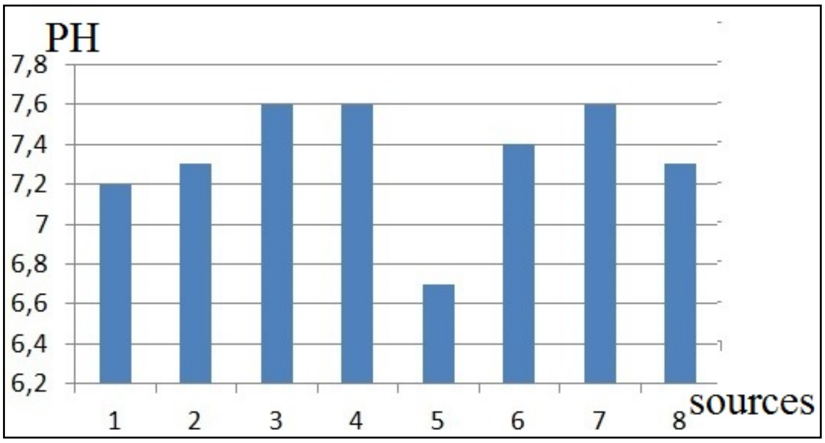

Figure 7: pH variation of the sources of Ziz high basin (March 2014)

3.2. Global mineralization

The concentrations of nitrates recorded during the study ranged from 0,6 mg/l and 31,3 mg/l, they have not exceeded Moroccan standards (Figure 11);

The concentrations of chlorides recorded during the study ranged from 20 mg/l and 4570 mg/l, the three sources downstream, they have very high values in particular the chloride with a concentration of 5470 mg/l at Moly Ali Cherif source (Figure 8), the source 5 showed a chloride content that exceeded the recommended standards.

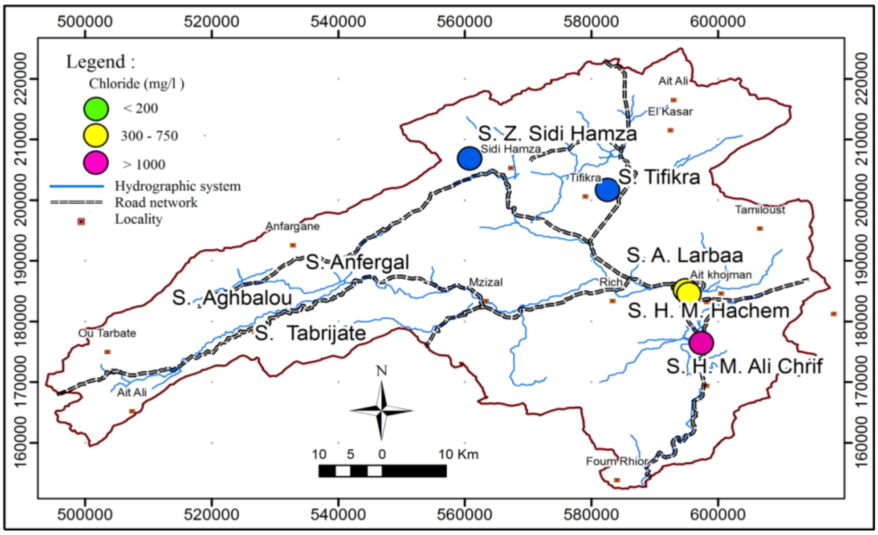

Figure 8: Spatial distribution of chloride values of the sources of Ziz high basin (March 2014)

The concentrations of sulfates recorded during the study (Figure 9) ranged from 76 mg/l and 1440 mg/l, to the source 5 except that exceeds standards, The levels high in the sources appear to be related to the Triassic salt formation in contact with the aquifer by faults that dominate the structure of the Ziz high basin. In contact with the gypsum, the water load in calcium sulphates. The concentrations of Manganese recorded ranged from 30 mg/l and 77 mg/l, the concentrations of bicarbonates recorded ranged from 155 mg/l and 214 mg/l, the concentrations of calcium recorded ranged from 78 mg/l and 458 mg/l (Figure 11). The presence of the ions is necessarily linked to the dissolution of minerals, the elements Ca^{2+}, Mg^{2+} and HCO_3^- are related to the dissolution of carbonate formations the rerservoirs (Figure 11). These waters have a sodium-potassium and chloride facies, and they are also in equilibrium with respect to calcite, dolomite and aragonite.

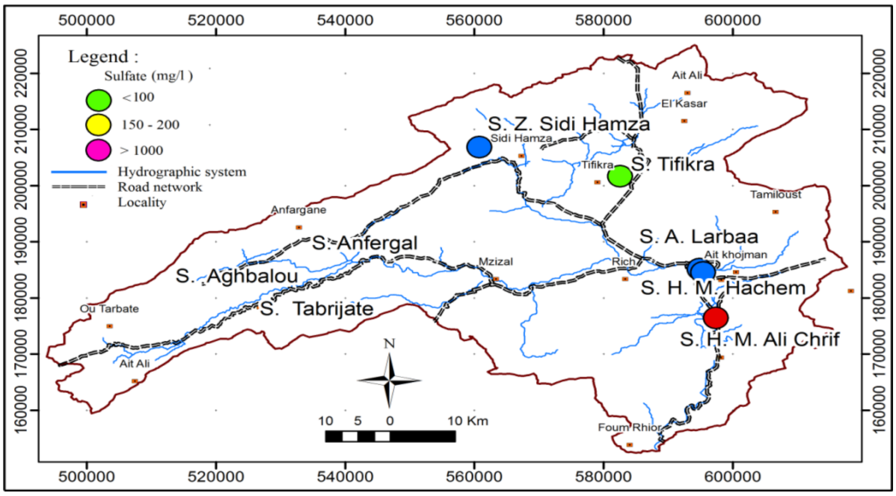

Figure 9: Spatial distribution of sulfate values of the sources of Ziz high basin (March 2014)

3.3. Piper diagram

The projection of water analysis on 2013 samples results on the Piper diagram reveals the following facies (Figure 10):

Chloride and calcium sulfated and magnesium : sources 1 and 2

Chloride Sodium and potassium or sodium sulfated : sources 3, 4 and 5, they are also in equilibrium with respect to the calcite, dolomite and aragonite. The spatial distribution of those facies chemical depends on the lithological nature.

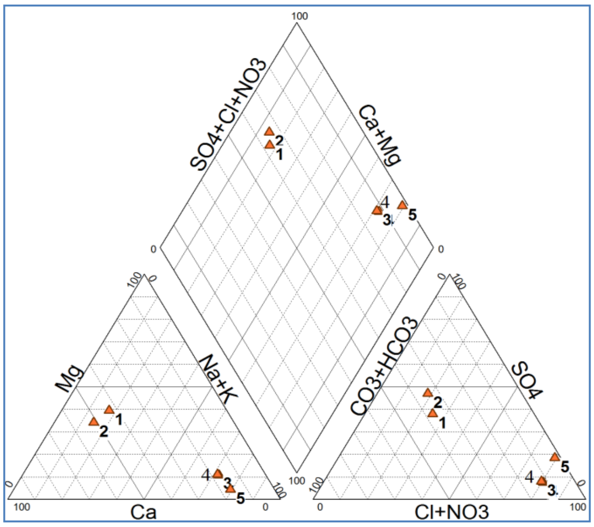

Figure 10: Chemical facies sources by Piper diagram (March 2014)

The results are similar with the results of 2013 with a little change in anions and cations values [16].

3.4.Schoeller-Berkaloff diagram

The graphical appearance obtained (Figure 11) to view the facies of the relevant mineral water.

Analysis of Schoeller-Berkaloff diagram allows us to conclude that the sources 3 and 4 had identical profiles with levees concentartion of sodium, potasium and chloride. The sources 1 and 2 had identical profiles with concentration the sodium, potasium and chloride less than the profiles 3 and 4. Except source 5, the chloride concentration, potassium, sodium and calcium is more remarkable contribution to other sources.

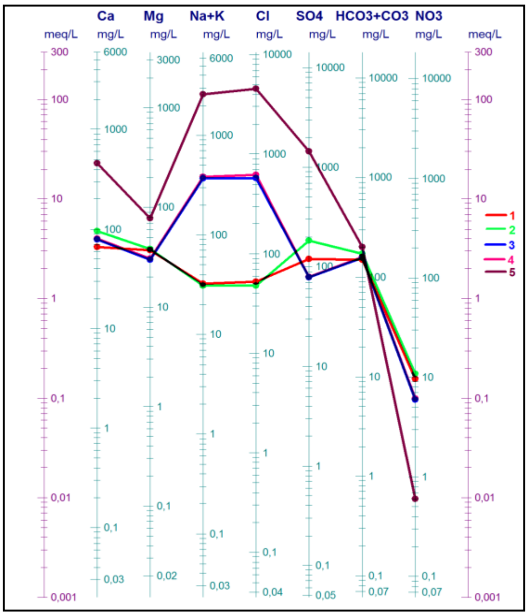

Figure 11: Schoeller-Berkaloff diagram

3.5.Classification Richards

The method of Richards is used to examine the use of water for irrigation in the study area. The choice of this method is closely related to the parameters that it uses (sodium, calcium, magnesium and electrical conductivity). Thus applying the classification Richards, the graphical representation of the samples suggests the following classes (Figure 12):

C2_S1 the field indicates that the risk is low alkalizing, thus usable for any type of soil while that salinization is average, it includes samples 1 and 2, so they are good for irrigation,

C3_S1 the field contain high values of conductivity that causes a high risk of soil salinization, it comprises respective samples 3 and 4.

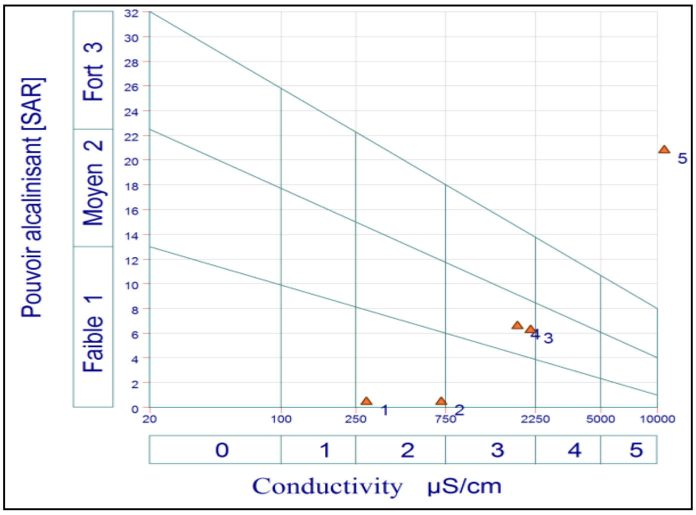

Figure 12: Irrigation water classification diagram of Ziz high basin (Mars2014)

These waters are bad for agriculture, there is a water suitable for irrigation of salt-tolerant crops on well-drained soils. However, changes in salinity should be monitored.

C5_S3 the field represent water with risk of abnormally high salinities and are, accordingly. Very bad for agriculture, it includes sample 5.

3.6.The global quality

The appreciation of the quality of source water is by the study of pollution parameters electrical conductivity, chlorides and nitrates, then by interpreting the overall quality (Figure 13).

Water samples 1 and 2 generally have good quality. This quality is due to nitrates state of a good quality.

The water samples 3 and 4 generally have an average quality. This quality is due to the state electrical conductivity and chlorides of average quality.

The water samples 5 generally have a very poor quality. This quality is due to the state electrical conductivity and chlorides of a very poor quality.

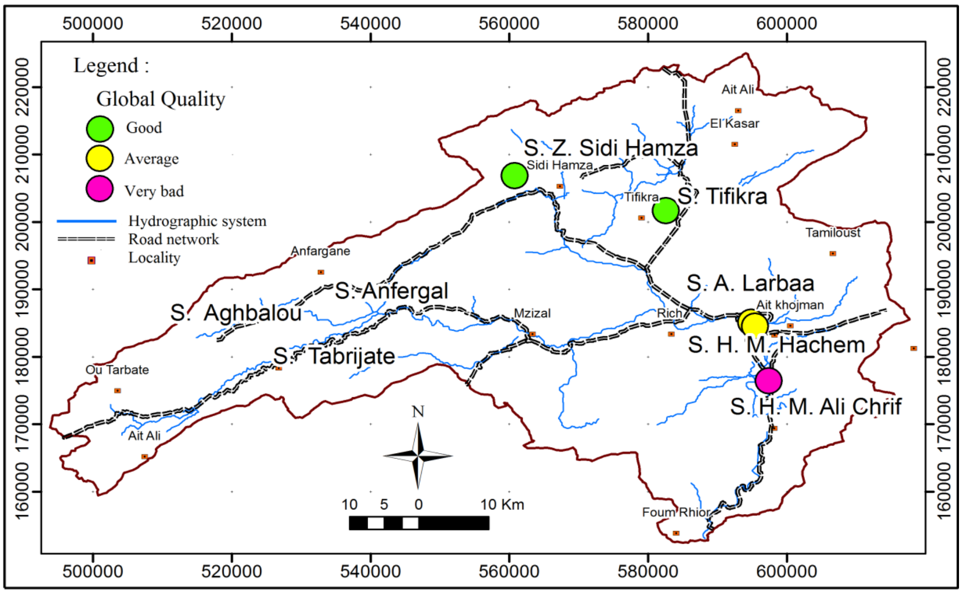

Figure 13: spatial variation of the overall quality of groundwater of Ziz high basin (March 2014)

3.7.Contribution of remote sensing

3.7.1.Lineament map

To avoid this confusion, all linear objects that are of geological origin (eg, roads, pipelines and terraces) appearing on digital topographic maps were superimposed on the map of lineaments. This allowed all non-linear elements plotted in geological map of lineaments to be eliminated and a map of lineaments, indicating geological lineaments, was realized. All obtained studies highlight that large existing lines on the satellite images are often attributed to fracture networks (Figure 15).

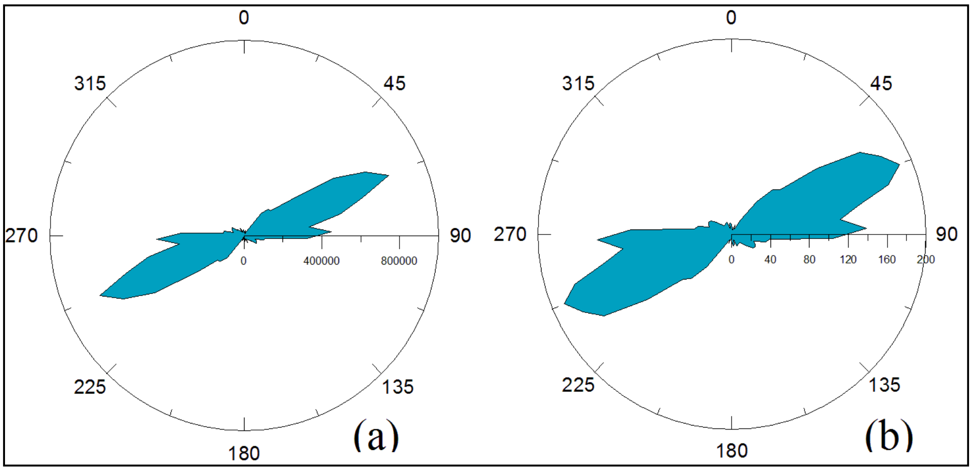

Figure 14: Directional rosettes lineaments of Ziz high basin (a) total lengths (b) frequencies.

The statistical analysis of lineaments to better understand the geometry of the lineaments system and identification of the main directions in the region, we used the method of directional rosettes (Figure 14) that are proportional to the total length of lineaments in classes of 10 degrees.

On the scale of the study area, the rosettes chart shows that dominant directions are NE-SW orientation to E-W complies with Atlases major directions of this part of the High Atlas the largest lineament are in agreement with previous results [24-25-26-27-28]. The rosettes show that the dominant flaws that are having a generally 70 direction (Atlas). It is important to note that the N-S directions are relatively less abundant.

3.7.2.Relationship between geologic fractures and distribution of water sources

We superimposed sources on maps of lineaments (Figure 15), The analysis of the map revealed that sources are related to the level of tectonic nodes that match the crossing accidents, the sources are located at least between two family break one E-W and the other NE-SW. Most sources listed on the map, ensure the drinking water supply of the neighboring population and irrigation. This explains the strong mineralization of sources at the faults leaching of salt-bearing rocks Triassic.

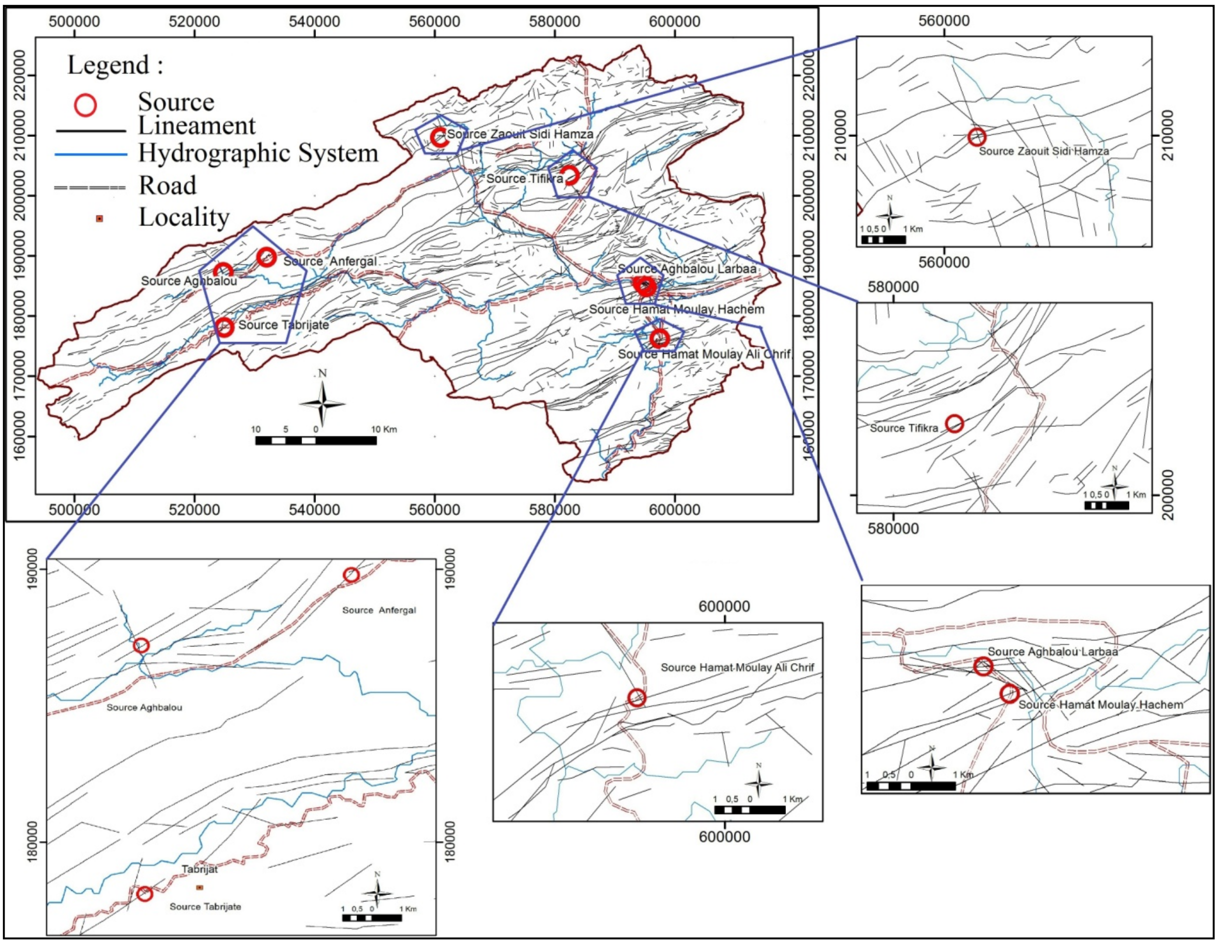

Figure 14: Distribution of sources related to the lineaments of Ziz high basin

Conclusions

The hydro-chemical study of sources waters of the Ziz high basin showed that the waters are moderately to highly mineralized.

Piper diagram highlights two types of chemical facie: 1) chloride and calcium sulfated and magnesium, and the other 2) chloride sodium and potassium or sodium sulfated. Spring water from the classification Richards are good to very bad for irrigation.

The overall quality of water from good to very poor, the degradation the quality of spring water in general by mineralization.

Analysis of satellite data show that the basin is mainly affected by a fault network NE-SW and E-W and the other direction are less abundant. Analyzing the map of lineament and sources shows that sources are related to the level of tectonic nodes that match the crossing accidents NE-SW and E-W.

The high temperature and high mineralization of sources could be a deep origin by Atlas faults.

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