GEOCHEMISTRY AND ORIGIN OF QUARTZ CRYSTALS FROM THE UPPER PART OF SARGELU FORMATION, RANIA AREA, SULAIMANIYAH, KURDISTAN, NE IRAQ

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ABSTRACT

Mineral characterization of samples collected from the upper part of Sargelu Formation at Rania area was carried out using the XRD and XRF techniques. The obtained results from this study show the presence of quartz, in well crystalline structure. The crystalline nature of quartz is studied by description and measurement of crystal axis and the forms of the quartz crystals. The results obtained show that these crystals are trigonal, type: α-quartz, with crystal forms of rhombohedron, trigonal dipyramid, and trigonal prism.

Geochemical analyses for both host rock and quartz crystals carried out using XRF instrument. The host rock is mainly composed of CaO and MgO, indicating dolomitic rocks, while the quartz crystals show the presence of traces of Al, Fe, Mg and Ca oxides accompanying the major component SiO_2.

The genesis of this well crystalline α-quartz was related to chemical precipitation from deeper groundwater supersaturated within silica, and the source of silica possibly from dissolution of radiolarians, either within chert layers or in adjacent limestone beds of Sargelu Formation.

جيوكيميائية وأصل بلورات الكوارتز فى الجزء العلوى من تكوين سرگلَو، منطقة رِانية، السليمانية، كوردستان، شمال شرق العراق

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المستخلص

تم دراسة الطبقات الرسوبية فى الجزء العلوي من تكوين سرگلَو وأظهرت وجود بلورات مختلفة الأحجام من الكوارتز. تبين من دراسة النماذج اليدوية بأن الكوارتز هو بشكل بلورات كاملة الأوجه في معظم الأحيان وهذه البلورات تابعة لنظام ثلاثي الأوجه ومن نوع ألفا (α) مع وجود أشكال معينيه وهرمية وهرمي ثلاثي الأوجه. أثبتت استخدام تقنية الأشعة السينية بأن بلورات الكوارتز هي من نوع ألفا.

التحليل الكيميائي للصخور المضيفة و بلورات الكوارتز باستخدام جهاز XRF أظهرت بأن الصخور المضيفة والتابعة لتكوين سرگلَو غنية بأكاسيد الكالسيوم والمغنيسيوم وهي صخور دولومايتية، أما بلورات الكوارتز فتحتوى على نسبة أثرية من أكاسيد الألومينا والحديد والمغنيسيوم والكالسيوم إضافة الى مكونه الرئيسي من أوكسيد السليكون.

يرجع أصل بلورات ألفا كوارتز الى الترسيب من المياه المشبعة بالسليكا ومصدر السليكا محتمل أن تكون من إذابة الراديولاريا سواء من طبقات الصوان أو من الطبقات الجيرية المجاورة في تكوين سرگلَو.

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INTRODUCTION

The farmers in the Spiaw village, near Rania town, are always collecting pure colorless crystals from the soil horizon. These crystals, also locally known as Denkolai sholen ice grains" are colorful, doubly terminated quartz crystals that occur in scattered soil horizon above carbonate beds of the upper part of Sargelu Formation (Middle Jurassic). Although authigenic euhedral quartz crystals are relatively common in evaporate sequences worldwide and throughout geologic history Spiaw Village megaquartz crystals are unique for their large size and crystal morphologies.

However, subsequent work has shown that doubly terminated euhedral quartz crystals are relatively common in ancient shallow marine carbonate and evaporate sequences (Wilson, 1966; Zenger, 1976 and Ulmer-Scholle *et al*., 1993). Other famous occurrences of authigenic quartz include Herkimer diamonds hosted by Cambrian dolomites in New York (Zenger, 1976). Large authigenic quartz crystals have been described in young Pleistocene carbonate-evaporite sediments in the Arabian Gulf (Chafetz and Zhang, 1998).

SAMPLES AND METHODS

The studied area is located in Spiaw village, Dolaraqa valley, 28.5 Km NW of Rania Town (Fig.1). Rania Town is about 145 Km NW of Sulaimaniyah City, Kurdistan, NE Iraq. Crystals of quartz were collected from the soils ranging in size from 2 mm to 5 cm (Fig.2). Samples from the host rocks were also collected in order to identify and study petrographically and geochemically. Petrographical study was carried out for the host rock in order to identify the components of the rock. The crystals were studied from the crystallographic point of view. The lower part of the Liassic carbonates either lack fossils or contains few fossils because of extensive dolomitization (as the case of Sargelu Formation), so that its age is uncertain and the nature of the lower boundary of the Liassic carbonates remains obscured.

Thin-sections were prepared from carbonate rock samples, and were stained with a mixture of alizarin red S and potassium ferricyanide to differentiate calcite from dolomite and their ferroan and non-ferroan phases (Dickson, 1966). All thin-sections were examined under an optical microscope. Representative carbonate samples and quartz crystal were analyzed for their mineralogical characteristics by X-ray powder diffractometry using Shimadzu XRD 7000 instrument and following the Iraqi Geological Survey standard work procedure. Semi-quantitative mineral abundances are obtained by comparing the intensity of peaks and the area under the peaks. Major elements of quartz crystals and host rocks analyzed by X-Ray fluorescence (XRF) in Bazian Cement Factory using press powdered pellet.

GEOLOGIC SETTING

The studied area is geologically located within the High Folded Zone (HFZ) of Iraq (Numan, 2000). The crystals distributed within the soil horizon, which were originated from the cavity filling with crystals after weathering and erosion (Fig.3). Geologically, the host rocks belong to the Sargelu Formation (Middle Jurassic), especially the upper part in which chert horizons are present (Fig.4). The rocks are hard and yellowish color forming ridges in the area. The formation is overlain by Naokelikan Formation with thin bituminous limestone beds. In this study only the host rock layers studied in detail in order to explain the geological conditions, which never been studied previously, for forming the large and clear quartz crystals in these cavities. The carbonate beds of the upper part of Sargelu Formation are rich in geodes filled with quartz crystals (Fig.3).

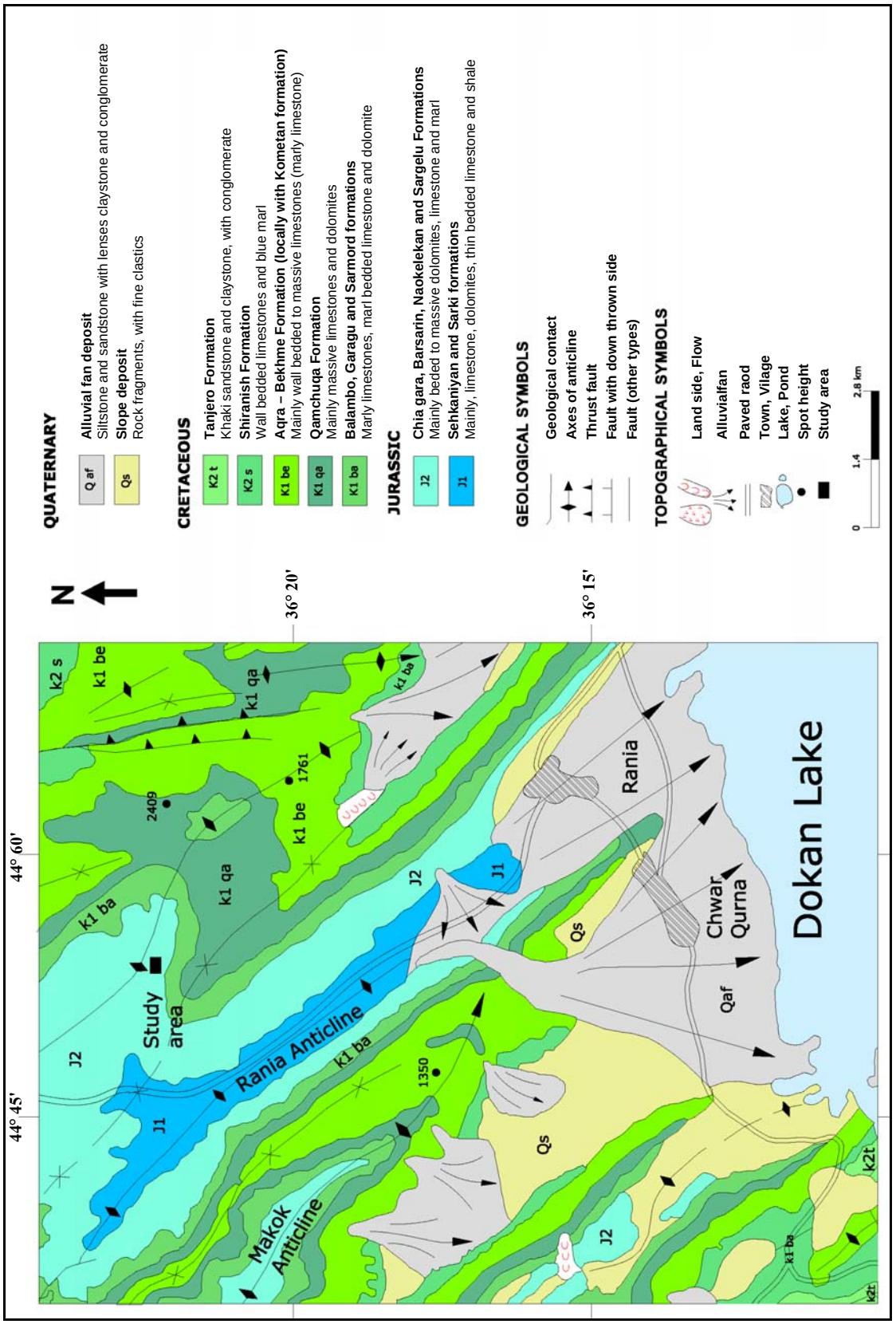

Fig.1: Geological map of Rania Region, Sulaimaniyah, NE Iraq (after Sissakian, 2000), and the location of study area

Fig.2: Clear megaquartz crystals as collected from the studied area

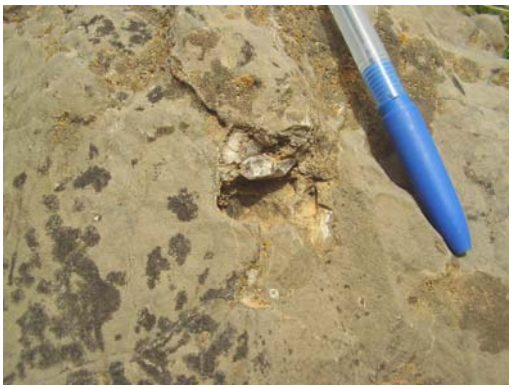

Fig.3: Quartz crystals filling the cavity in dolostone rocks

Fig.4: Upper part of Sargelu Formation and the chert beds are clearly recorded, Spiaw Village

CRYSTAL FORMS, SIZE AND COLOR

Quartz is found in a number of forms, most of which only differ by their varying colors or grain sizes, such as rock crystals, milky quartz, fine grained quartz, coarse grained quartz. Rock crystal is defined as colorless and transparent crystals of quartz (Nesse, 2000).

More than 50 crystals different in sizes and forms were collected from the cavities and soil horizons (Fig.2). The crystals are double terminated euhedral rock crystals, ranging in length from 2 mm up to 5 cm. Many of them have inclusions with dark colors, others are transparent without inclusions. Unfortunately, these inclusions not studied yet, the authors are planning to study them in detail in the future. Quartz crystals have the following general crystallographic properties:

Crystal system: Trigonal
Type: α-quartz
Class: 32 (Trigonal Trapezohedron)
Symmetry 1A3, 3A2, i
Form: Rhombohedron, trigonal dipyramid, trigonal prism

PETROGRAPHY AND MINERALOGY

The Sargelu Formation consists of thin-bedded, black, bituminous limestones, dolomitic limestones, and black papery shales with streaks of thin black chert in the upper parts (Bellen *et al*., 1959). The host rock of quartz crystals belong to the upper part of Sargelu Formation, and is composed of thin- to medium-bedded hard yellowish dolostones (Fig.4). Petrographic study indicates the presence of idiotopic dolomite grains as a major component (Fig.5), where limestone has been replaced by dolomite. X-ray diffractogram of the sample indicates the presence of dolomite as the major mineral with few percentages of calcite (not more than 5%), hence the rock is dolostone (Fig.6a). One of the quartz crystals studied by XRD in order to support crystallographic properties of crystals, the X-ray chart clearly indicates to quartz crystal (Fig.6b).

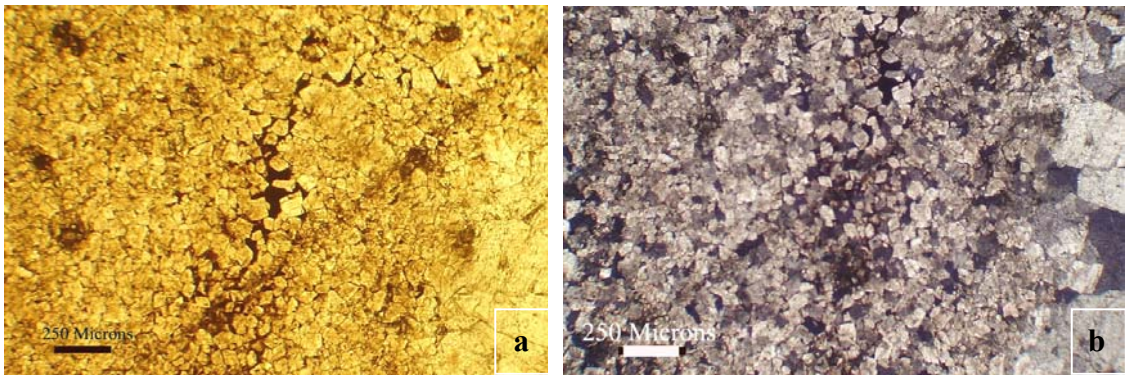

Fig.5: Photomicrographs of the host rocks, dolostone: **a)** under plane polarized light, **b)** under crossed – polars. Ideotopic crystals are clear and the intercrystalline porosity filled with organic matter

The crystals of dolomites ranged in size from 75 μm to 125 μm and the texture is mosaic euhedral forming sucrosic dolomite (Figs.6a and 6b). Many of the intercrystalline pores are filled with organic matter and bitumen. Intensive dolomitization destroyed all bioclasts in these beds, which the relics of original fabrics are absent or faint, except for some traces of unrecognized ghost fossils. Similar coarse dolomites with crystals ranged between 65 μm and 130 μm is described by Eren *et al*. (2007) were interpreted to be formed during late burial stage. In the late stage, the coarse crystalline dolomites formed as a result of the recrystallization of less size dolomites. Precipitation of the quartz crystals took place either concurrently with, or more likely, after dolomitization of the host carbonates.

The Sargelu Formation was deposited in basinal euxinic marine environment, with some inlayers showing either shallowing or better aerated conditions (Buday, 1980, and Jassim and Goff, 2006). The upper part of this formation, host rocks of the quartz crystals, shows the dominant of dolostone layers; indicate to the shallow environment. As there is no associated evaporites with this part, may be the model of meteoric-marine, mixing-zone is more suitable (Tucker, 1991) for deposition of these dolostone beds, which hosted the quartz crystals.

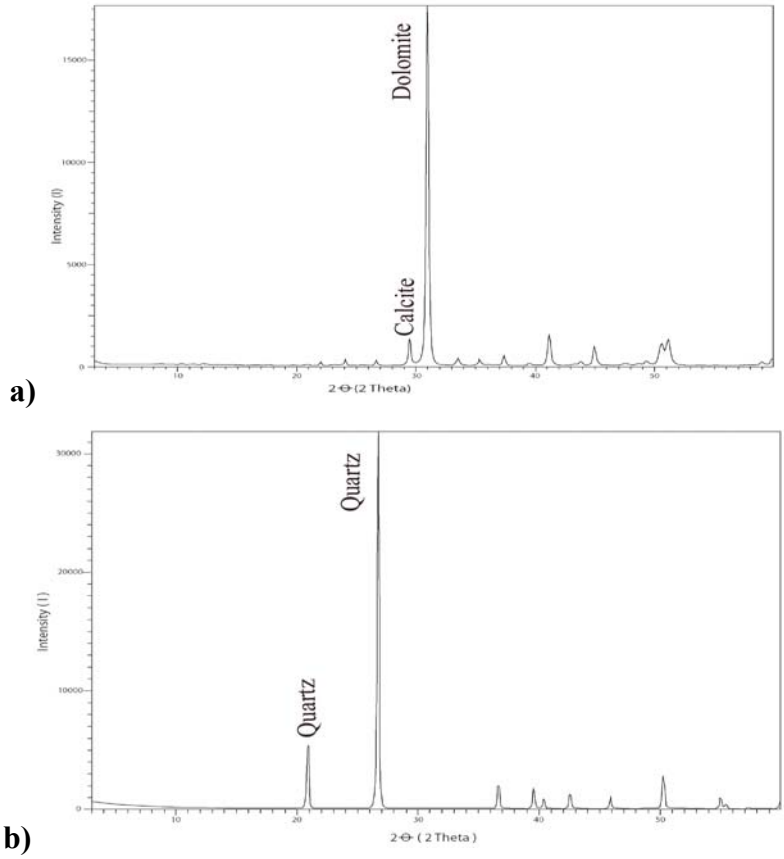

Fig.6: XRD charts: **a)** for the carbonate rocks (host rocks) indicating the dominant of dolomite and few percentage of calcite,
b) for the quartz crystal indicating the pure α-quartz

GEOCHEMISTRY

Geochemical information on the quartz crystals and host rocks is given in Table 1, which represent one sample from the host rocks and two from the quartz crystals analyzed by X-ray fluorescence (XRF) instrument in Bazian Cement Factory Sulaimaniyah city.

The results of the geochemical analyses of quartz crystal revealed the concentration of four major oxide groups, which are silica and alumina, iron, magnesia and calcium oxides. The enrichment of SiO_2 over other oxides by chemical process produces quartz. The source of silica is mainly radiolarian skeleton and chert, which are present in the upper part of Sargelu Formation and this opinion supported by Sherwani and Balaky (2006). MgO content is related mostly to the presence of dolomitic materials of the host rocks. Dolomite cement and rock fragments are the main source for CaO. Al_2O_3 and Fe_2O_3 content may relate to the presence of claystone of the Upper part of Sargelu Formation. Geochemical analysis of quartz crystal indicates clearly to the purity of quartz crystals.

The geochemical data of the host rock, which mainly dolostone, (Table 1), is clearly indicating to the presence of CaO and MgO as major components. SiO_2 and Al_2O_3 are around 1% and the other oxides are less than 1%. This composition is indicates to dolomitic rocks and coincides with the XRD results.

Table 1: The results of XRF study for the studied samples

Sample	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	L.O.I	Total
Host rock	1.10	1.03	0.51	34.69	21.48	0.13	0.33	0.12	39.3	98.69
Quartz crystal (1)	98.45	0.45	0.35	0.21	0.28	–	–	–	0.11	99.74
Quartz crystal (2)	99.24	0.16	0	0.17	0.24	–	–	–	0.08	99.81

GENESIS

Crystalline silica in the form of quartz is common component within the dolostones of the Sargelu Formation in the studied area. Crystalline silica is the scientific name for a group of minerals composed of silicon and oxygen. The term crystalline refers to the fact that the oxygen and silicon atoms are arranged in a three dimensional repeating pattern. This group of minerals has shaped human history since the beginning of civilization. Many hypotheses were forwarded by Ramasamy and Suresh (2009) for the genesis of well crystalline quartz and the source of silica in carbonate sediment such as weathering of silicate minerals, thermal springs, dissolution of amorphous silica, and dissolution of quartz. Quartz crystals within sedimentary rocks form when minerals released during weathering or by chemical precipitation accumulate in a basin and are consolidated (Ramasamy *et al*., 2004). The releasing during weathering was canceled because clear crystalline quartz can not be precipitated in the weathering environments. Hence the second hypotheses, i.e. chemical precipitations were concern. The well crystalline nature of the studied samples in Spiaw village needs high concentration of silica and low temperature and pressure. Such a condition can be achieved in the deeper groundwater because the concentrations of dissolved silica in rivers, streams, and lakes are a few tens of parts per million while the concentrations are also in this range in groundwater; the deeper the groundwater, the higher the silica concentration (Ampian, and Robert, 1992). The crystallographic study of the quartz crystals support this genesis which show all crystals of α-quartz type (Fig.2).

The source of this silica-rich solution possibly returned to the presence of radiolarian and chert as they are abundant in the host rocks (Sherwani and Balaky, 2006). Radiolaria skeletons are not stable in alkaline aqueous solutions, i.e. pH > 8 (Mohialdeen, 2008). The silica rich groundwater filled the cavities of the dolostone layers within the time became supersaturated and began to precipitate the quartz crystal of α-quartz type due to its stability form under ambient conditions low temperature and pressure.

CONCLUSIONS

The main points which can be concluded from this study are:

- Quartz crystals are of α-quartz type.
- The geochemical analyses for the both host rocks and quartz crystals coincide with the mineralogical composition.
- The origin of quartz crystals is from the groundwater supersaturated with silica. This solution in the cavities within the dolostone rocks precipitated crystal of quartz in the shape of geodes.

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