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Geology

Alpine Type Quartz Veins of the Fold System of the Greater Caucasus (within Georgia)

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ABSTRACT. The paper presents the characteristics of quartz of various generations contained in the Alpine-type quartz veins of the Lower-and Middle Jurassic schistose terrigenous formation of the fold system of the Greater Caucasus. Within the Alpine-type quartz veins there are three main generations of quartz: milky quartz belongs to the first generation; the second generation is represented by elongated, often parallel quartz crystalline aggregates and the third generation is the quartz druse. The Alpine-type quartz veins are commonly formed under the low temperature conditions and are genetically related with metagenesis of the rocks of terrigenous formation. Mostly, quartz veins are sterile from the useful components. Majority of the quartz aggregates contain gas-liquid inclusions of various forms and sizes that are the peculiarities of the quartz veins defining the conditions of metamorphism. *© 2017 Bull. Georg. Natl. Acad. Sci.*

Key words: quartz, alpine-type vein, generation, rock crystal

Quartz veins (Fig.1) of various thickness and length are widespread in layers of the schistose-terrigenous formations [1-3] of the Main Range, Kazbegi- Lagodekhi, Chkhalta- Laila and Gagra-Djava zones [4] of the fold system of the Greater Caucasus. They occur in layers characterized by unlike fissuring: shales of various thickness and granularity, slates, siltstones, plagioclase-quartz-bearing and arkosic sandstones and argillites.

In the generalized section of the schistose-terrigenous formation there predominate shales, siltstones and sandstones containing grains of the basic rock-forming minerals such as plagioclase (of albite-oligoclase series). Clay minerals and quartz are comparatively less; besides, it contains carbonate, mica (muscovite, rarely - biotite), potash feldspar fragments of the primary rock in small quantity. Terrigenous grains are cemented by the kaolin-hydromica-chlorite mass, sometimes with carbonate admixture.

Minerals composing hydrothermal quartz veins are mostly represented by turbid, dense, coarse-grained, milky quartz aggregates. Quartz almost always fills up the fissures in small pockets and voids. They are presented by well-developed rock crystal and rauchtopaz crystals and druses of various sizes.

Fig. 1. Transversal veins of hydrothermal quartz.

Fig. 2. Quartz homogeneous anchimonomineral vein.

Quartz network veins are often visually distinctly observed on natural exposures. Sometimes they are of several generations but homogeneous or anchimonomineral (Fig. 2).

The veins cross each other in various directions; rarely, they are spread in the direction of schistosity and lamination but generally they are represented by transversal bodies (veins) along the faults, fissures and cracks (Fig.3) of diverse and unequal forms and sizes.

Most of the quartz veins are genetically close to those of "Alpine type"; they are associated with schist-forming and fissuring processes caused by sandstone metamorphism and tectonic activity. The forms of their bodies are variegated depending on the basic rock fissuring, content and origin conditions. Most of the bodies are vein type, lenticular, elongated. The vein length varies from some centimeters to tens of meters. Natural cracks and fissures of various sizes, developed due to tectonic activities in sandstones and siltstones, represent favorable environment for formation of the Alpine type veins; at the same time they are effluent channels through which hydrotherms move. Sometimes in quartz veins there are observed enclosing strata relicts. Quartz of Alpine type vein is formed under certain conditions. They are generally associated with hydrothermal mineralization – the result of low temperature anchimetamorphism. Geological environment, together with pressure and temperature, is one of the most important factors in quartz Alpine type vein mineral-formation; here are meant mineral and chemical composition of quartz forming geological body, structural environment, temperature of percolated water, geochemical activity etc. Based on the data available in the literature and the results of our research the model of quartz veins origin and formation can be easily summarized as follows: in the Jurassic and Cretaceous system at the stage of submergence of terrigenous schistose layers accompanied by diagenesis and katagenesis processes the metamorphogene fluids were formed in parent rocks (at a depth of 7-12 km); the main sources of solution of the fluids were perclated waters and those [5] escaped at dehydration and disintegration of rock constituent water-containing minerals (clays, micas, oxides). As a result of chemical and ion-exchange reactions during the process of alteration in country rocks (argillites, shales, sandstones) there were formed metamorphogene fluids with the chemical composition depended upon the chemical and mineralogical composition of the enclosing rock. Hydrotherms, in their turn, affected the rocks of terrigenous formation though due to the low temperature of metamorphism, feeble permeability and geochemical activity the influence was not intense and the scale was small; therefore, Alpine type hydrothermal quartz veins formed in enclosing rocks are of comparatively small sizes.

Fig. 3. Quartz transversal bodies.

Alpine type veins represent a particular variety of hydrothermal veins. They include quartz segregations in lenticular and other fissure forms and cracks mostly perpendicularly oriented to spreading of enclosing rocks. Minerals, characteristic of Alpine veins are the following: quartz (often in the form of rock crystal in large voids), adularia (potash feldspar), albite, chlorite, epidote, rutile, titanite, anatase, brookite, hematite and, rarely, a zeolite group mineral. Alpine rocks, in one case, are not associated with eruptive rocks but in other case, sometimes magma pockets occur nearby, though there is no direct relation between them. Presumably, the formation of Alpine veins is related with the processes of leaching of rock constituent mineral components in enclosing rocks and of their crystallization in the existing fissure voids. The unity of these components is called lateral-secretion mineralization.

As is known, clay schists and argillites are generally distinguished by especially low permeability though tectonic stress causes formation of cracks and fractures in various directions whereas natural cracks and fractures in rock appear to be channels for filtration of fluids. Cracks and fractures can really increase the permeability of fluids being under high pressure that move in hypsometrically upper horizons; just in them Alpine veins are formed. The conversion is generally expressed by mineral and structural peculiarities that depend upon the degree of postdiagenetic conversion of the enclosed rocks, on the system of natural cracks, their orientation and frequency, fluids activity, the essence of fluid circulating channels and degree of their permeability. Informative value of Alpine veins determines the degree of post-genetic transformation of sedimentary rocks, establishment of mobilization and redistribution of components.

Alpine type veins are often associated with more or less large rock crystal-bearing voids the wall surfaces of which are covered with the druse of crystals. In Racha the rock crystal bearing quartz veins are associated with argillite and sandstone containing series. In Kazbegi the rock crystals are associated with Liassic shales, sandstones and argillites. In the river Arguni and Piriqita Alazani gorges the Alpine type quartz veins are mostly common in shales and argillaceous sandstones. Quartz veins are mostly filled by milky quartz aggregates. Rock crystal is comparatively rare and of comparatively small sizes. Applying polarizing microscope (Amscope PZ 600TC-8) there have been studied samples of quartz veins and enclosing rocks that are mostly represented by sandstones and metasandstones. Enclosing rocks and quartz veins practically do not react with hydrochloric acid except for certain cases. In thin sections there are often observed micro-cracks developed in various directions.

R. Akhvlediani [6] distinguished three main generations of quartz in Alpine type quartz veins from

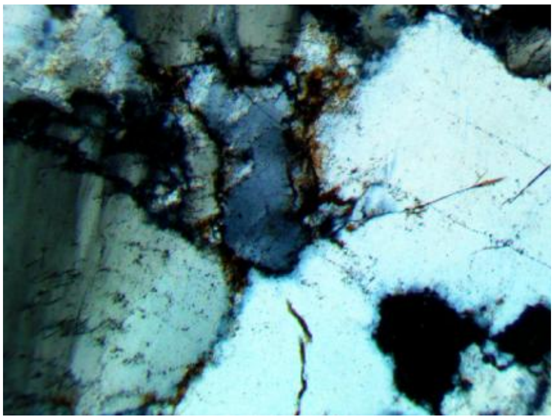

Fig. 4. Quartz aggregates under polarizing microscope.

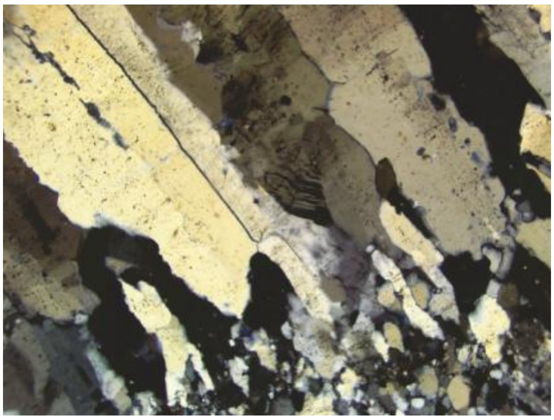

Fig. 5. Transition of quartz fine-grained, equigranular aggregates into elongated aggregates of the second generation.

the Khdestskali and Shoda districts. Quartz, milky-white aggregates (sometimes transparent) of which is represented by granular and massive texture, is attributed to the first generation. Most of the veins are filled by such type of quartz.

At low magnification under the microscope the quartz veins of the first generation are generally represented by monomineral quartz with spear-like, mosaic structure; it is characterized by striation. There scarcely occur quartz-feldspar and quartz-calcite containing veins. In thin section (#226/1), quarts is of block structure; the inner part of the vein is purer, cracked; in the cracks there is observed iron oxide; it is characterized by wavy extinction (Fig.4).

On the polished surface of quartz containing (# 227/1) sample there are distinctly observed quartz segregations of various thickness and length; some of them are wedge-shaped. In the thin sections there are fixed quartz aggregates of various generations. On comparatively large aggregates there are observed some defects, such as: cracks and pores that are often filled by relict material. Such quartzes are represented by relatively small size equigranular crystals and aggregates. In the matrix they create certain districts of accumulation and points to comparatively high speed of growth of quartz crystals at early stage. There occur comparatively less elongated quartz aggregates here; the direction of elongation coincides with that of the fluid flow. They partially or entirely fill voids of veinlets and veins and apparently it developed at the last stage of the first generation.

In thin section (227/1) – in the quartz veins formed in the sandstone also plagioclases of spear-shaped texture occur. Quartz is of several generations: fine-grained, of comparatively isometric form, equigranular of small sizes that create certain districts of accumulation in the matrix and indicates a high-speed growth of quartz crystals of early stage at the first generation. In salbandes of fine-grained quartz one can often observe comparatively elongated quartz crystals of the following generation (Fig.5) that sometimes take wedge-shape. The direction of the process of their origination determines striation and sometimes columnar and mosaic textures of quartz aggregates. Often in one and the same thin section there is observed quartz of the first and second generations and their transient phases; the transition is gradual.

In some parts of the thin section, between the granular quartz segregations of the first generation, there is distinctly observed the interlayer of quartz elongated aggregates belonging to the second generation (Fig.6). Sometimes quarts is characterized by greenish pleochroic coloring that can be caused by flaked or attached fine-dispersed mass of illite, chlorite or iron hydroxide on quartz crystal facets.

The second generation of quartz is represented by elongated, often parallel quartz crystalline aggregates; their length depends upon the intensity of the mineral-forming process simultaneously with which there crystallizes finest-grained chlorite; these embedded crystals give quartz greenish color. The third generation of quartz generates clear crystalline quartz druse of various kinds in Alpine type veins, the walls of which are covered by mountain crystals of various sizes developed on milky quartz surface or directly on the enclosing rock. Veins containing mountainous crystal are often of economic importance and represent the source of piezooptic quartz raw material. Most part of the Alpine vein quartz contain gas-liquid inclusions of various forms and sizes and, generally, of similar composition. The principal components are water and carbonic acid; hydrocarbons, metacolloids, carbonates occur in less quantity; they appear to be characteristic properties of quartz-vein formations and define the conditions of mineral formation. The typomorphic peculiarities of quartz in Alpine type veins differ by the following thermobaric-geochemical properties: form and size of gas-liquid inclusions, aggregate-phase composition, temperature of their homogenization, decryptogram configuration, volume of fluid saturation, ratio of gas-components of inclusions.

Milky quartz gas-liquid inclusions of Alpine veins of the Greater Caucasus Folded System are characterized by wide range interval of the homogenization temperature. The homogenization temperature of the gas-liquid inclusions of the most part of the aforementioned veins (40-60%) reaches 110-160°C; that of the other part (30-50%) is 160-260°C; comparatively smaller part (3-5%) undergoes a process of homogenization at 260-310°C and 330-350°C. As is known, the temperature increase in the Main Range zone of the Greater Caucasus Folded System equals to 25-30°C in the sediments of Lower- and Middle Jurassic schistose terrigene formations.

We consider that the temperature of quartz formation in the Alpine type veins from the schistose terrigenous formation of the Kazbegi-Lagodekhi, Chkhalta-Lailai and Gagra-Java zones of the Greater Caucasus Folded System corresponds to the temperature of metamorphism of the country rocks. This is confirmed by the fact that decryptometric characteristic properties of the Alpine vein and of newly formed quartz at the process of enclosed sandstones metamorphism are commonly identical [7]. Alpine vein quartz contains information on the system of transformation of country rocks. The similarity of the temperature parameters of gas-liquid inclusions discharge during decryption of fluidal inclusions [7] can be explained by the common nature of formation of quartz vein and regenerative quartz cementation during the deep catagenesis process at disclosing quartz grains. Applying X-ray fluorescent (EDX3600B) method there have been studied samples of quartz veins, country rocks and contact districts (about 150 analyses). The analyses were carried out in several points of grinned mass of the samples and on polished surfaces as well. At the given stage slightly increased content of nickel, zinc, zirconium, antimony and lead was observed; other elements were not practically fixed.

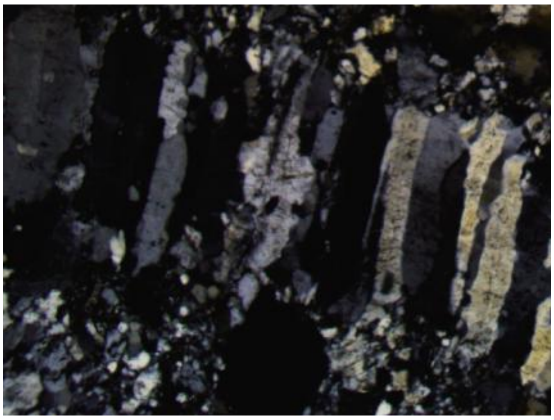

Fig. 6. Interlayer of quartz elongated aggregates of the second generation between the granular quartz segregations of the first generation.

In order to specify the essence and quantity of mineral phases, samples of the quartz vein and country rocks under study were analyzed by X-ray (DRON-3) method, in parallel to petrographic descriptions. In the quartz vein sample there are distinctly observed monomineralic quartz (95%) peaks; rarely Ca-Na feldspars whereas in country rocks – quartz, Ca-Na feldspars, Fe-Mg chlorites and traces of mica.

The Lower- and Middle Jurassic rocks of shistose terrigenous formation in the Fold system of the Greater Caucasus underwent the katagenesis process; their transformation intensity incresases together with the increase of depth and sometimes the katagenesis level ecquires elements of metagenesis [8, 9]; accordingly, as seen in the geological section of terrigenous rocks, the degree of recrystallization of the composing minerals increases upward from the bottom. At the initial stage of the katagenesis in the rocks of terrigenous formation there appear hydromica and chlorite; deeper katagenetic changes get evident by formation of fine-flaked sericite which transforms into muscovite; formation of light-color chlorite and segregation of quartz aggregate [8]. Alpine type quartz veins were formed at the expense of quartz-bearing sandstone, affected by waters leaked from the surface, and due to hydrothermal mineralization, caused by the temepature increase contemporaneous metamorphism; under the high hydrostatic pressue the aforemention veins travel along the natural cracks and fissures generally in the upward direction. Inspite the fact that cracks and fissures are mieralized, in most cases quartz veins are sterile from the useful component.

გეოლოგია

კავკასიონის ნაოჭა სისტემის ალპური ტიპის კვარცის ძარღვები (საქართველოს ფარგლებში)

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(წარმოდგენილია აკადემიის წევრის დ. შენგელიას მიერ)

სტატიაში წარმოდგენილია კავკასიონის ნაოჭა სისტემის ქვედა- და შუაიურული ფიქლებრივი ტერიგენული ფორმაციის ალპური ტიპის ძარღვების შემცველი სხვადასხვა გენერაციის კვარცის დახასიათება. ალპური ტიპის კვარცის ძარღვებში სამი მთავარი გენერაციის კვარცი გამოიყოფა. პირველი გენერაციისაა რძისებრ-თეთრი ფერის კვარცი, მეორე – წარმოდგენილია წაგრძელებული, ხშირად პარალელური კვარცის კრისტალური აგრეგატებით, ხოლო კვარცის მესამე გენერაცია სხვადასხვა სახის გამჭვირვალე კვარცის დრუზებითა და ჯაგრისებითაა წარმოდგენილი. ალპური ტიპის კვარცის ძარღვები, ძირითადად, დაბალტემპერატურულ პირობებში წარმოიქმნება და გენეტურად ფიქლებრივი ტერიგენული ფორმაციის ქანების მეტაგენეზისთანაა დაკავშირებული. კვარცის ძარღვები, უმეტეს შემთხვევაში, სასარგებლო კომპონენტებისგან სტერილურია. კვარცის აგრეგატების უმეტესობა სხვადასხვა ფორმისა და ზომის გაზურ-თხევად ჩანართებს შეიცავს, რომლებიც კვარცის ძარღვების მახასიათებლებია და განსაზღვრავს მეტამორფიზმის პირობებსაც.

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