Quartz “Pods” – An exploration guide to iron oxide-copper-gold mineralization?

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Quartz pods are a particular feature that has been identified in most of the Lufilian Arc study region of Zambia and Namibia, during an on-going Ph.D. research project on geochemistry, geochronology and metallogenic potential of granitoid rocks in that part of Africa. The term “quartz pod” is an informal name coined by the author for massive or sugary quartz bodies of varying dimensions. Features are very different from those of vein quartz and pegmatitic quartz bodies; what seems to differ most is their geometry. The shape of quartz pods appears to be roughly cylindrical, outcrops of undeformed bodies are round to elliptical, and their diameter varies from a few to several hundred meters. Some mapped bodies of quartz exceed four kilometers in diameter. There is geophysical evidence of even larger bodies. Quartz pods occur near intrusive bodies and around iron oxide-copper-gold mineralized systems. Most of the pods are made of white quartz, but color may vary greatly. Examples show change from milky white to dark gray smokey tones and to light pink or yellow tints. These colors are probably due to abundant gas, salt, iron oxide and sulfide micro-inclusions. Both translucent and milky varieties of quartz occur together. Different portions of a single body may be saccaroidal and/or massive. Quartz pods are seldom mapped in published geological maps of Zambia and Namibia. Identifying them in the field and studying their physico-chemical features may aid in the exploration of iron oxide-copper-gold mineralization.

Introduction

This note is written to call attention of researchers who might have come across similar quartz bodies in other parts of the world, and to share information about them with the international scientific community. If any of the readers can contribute to solve some of the questions stated here, the author would like to know about it. If any other researchers have carried out work on similar quartz bodies and/or on their association to iron oxide-copper-gold systems the author would appreciate contacting them.

Description of Quartz Bodies

Quartz bodies seem to be a particular characteristic of the Lufilian Arc, and may somehow be related to rift environments. They occur in many different types of rocks including limestones, dolostones, granitoids, various schists and gneisses. The author has seen them occur in an extense region, roughly 2000 km by 300 km; quartz pods are also expected to be found in SE Angola, the Katanga province of the Democratic Republic of Congo, and NW Botswana. The author tries to locate them wherever they are spotted, samples them for regional comparison, and whenever time allows, walks around them with a GPS to study their surface geometry. Several dozens of quartz bodies were intersected along the roads. Points of intersection were recorded, and constitute a simple measument of the size and abundance of quartz bodies in the Lufilian Arc. That chance sampling is not representative, but it is all available for the time being. A few of the quartz bodies were sampled with the hope to find particular chemical or physical features of use in exploration. Preliminary results described here are a by-product of field sampling for a regional project on granitoids in portions of the Lufilian Arc.

In many locations, quartz bodies have been found to host IOCG mineralization. At times the quartz bodies themselves acted as brittle rocks to hold massive magnetite and/or specular hematite mineralization with accompanying sulfides. This is shown on Figures 2D-2H.

The Egue farm, located NE of Otjiwarongo, Namibia and in the environs of the Otjikoto gold deposit has a massive quartz body, 500 meters in diameter. After carrying out airborne and field geophysics, the Namibian division of Anglo American drilled in the center of the body searching for metallic mineralization and could not find the bottom of the quartz body. A borehole 325 meters deep was collared in quartz and finished in quartz with minor disseminated pyrite. In this case, the quartz pod seems to be associated with the Otjiwarongo Batholith, a large granitoid entity that lies beneath Kalahari sand, Katangan carbonates and calcrete. The Otjikoto gold deposit, currently being developed by AngloVaal, is located a few kilometers away from the quartz pod; the Kombat copper mine also seems to be related to the Otjiwarongo Batholith. Both mineralizations have recently been classified by the author as iron oxide-copper-gold deposits. There might be more such deposits under cover.

Sometimes the country rock is deformed upward around quartz pods, as if they had somehow intruded themselves forcefully in a fashion similar to that of diapirs. This behaviour was observed in outcrops located to the west of the University of Namibia, Windhoek, as shown to the author by Dr. David Robertson from the University of Namibia.

Some published map sheets of Zambia have quartz pods on them. To the knowledge of the author, very few references specifically describe such bodies. Maybe they were considered to be just quartz veins of minor importance. There is very little mention of quartz bodies in Namibian geological literature.

Two Zambian locations display well-exposed quartz pods. One is located west of Kitwe along a road near the Congolese border. Another lies east of Solwesi and is shown on Figure 1. Both occur in clusters and have bodies that are more than 500 meters in diameter.

Four Rock Association

A four-fold rock association is observed in many parts of the Lufilian Arc. This is made up by small bodies of gabbro or diorite, small bodies of red-tinted felsic instrusive rocks, massive iron oxide bodies (magnetite and/or hematite) and quartz bodies. All of these seem to occur in rift environments, and their origin is not yet completely understood (See Fig. 1). Explaining the ubiquitous presence of these four rock types might provide ideas for the origin of iron oxide-copper-gold mineralization in the Lufilian Arc, and more importantly, may give clues for mineralization elsewhere.

Particles Enclosed in Quartz Pods

On some locations, the large quartz bodies contain isolated spherical iron oxide (hematite and/or magnetite) inclusions that vary in size from a 10 cm diameter to 1.5 cm diameter as shown on Figure 2D. It seems that the iron "bubbles" occur inside the quartz as if they were immiscible substances or xenocrysts. At times, hematite or magnetite cubes occur in quartz (See Figs. 2A, B and C). Sometimes xenoliths of any type of country rock are included within the quartz bodies. Shapes of these xenoliths vary widely. Can the FeOx spheres in quartz be a product of immiscible fluids, or incomplete assymilation of previous euhedral iron oxide minerals? What is the relationship with gabbroic bodies? With syenitic small bodies? With FeOx bodies?

At times the brittle character of quartz allows it to be host for braided or sub-parallel sheeted veinlet systems filled by hematite and sulfides (Figure 2H). Numerous field examples show braided veins, stockworks and various breccias where quartz is both the host rock and the single component of clasts. Figures 2D-2H illustrate that well at the scale of a handsample. This was observed on a sample from Tevrede, a rich copper and gold IOCG prospect in the northwest Kamanjab region, Namibia (www.bouldermining.com).

Studies that can be Done on the Quartz Pods

Investigations on the quartz pods might reveal interesting signatures that will probably contribute to the field exploration of IOCG deposits in southern Africa. On going research on quartz pods includes detailed macroscopic analysis of features, measurement of radioactivity and fluorescence under various wavelengths, cathodoluminiscence studies, detailed determination of specific gravity, chemical analysis, bibliographical review, studies of H and O isotopes, rare earth content, halogen content, fluid inclusion studies to detect salinity and temperature of emplacement, decrepitation studies to evaluate detailed chemical composition of the fluid inclusions, metallic content, study of the contacts with iron oxide inclusions, and study of the braided veins, their contacts with quartz and chemical characteristics.

The three-dimensional geometry of quartz bodies might be studied in a few well-known outcrops using seismic profiling, resistivity profiles, vertical electrical soundings and electrical tomography. Detailed IP profiles may also contribute significantly. Four sites for this have been identified in the Lufilian Arc. They are all easily accessible along main roads.

Practical Applications of the Quartz Pods

The fact that quartz pods are related with iron oxide-copper-gold mineralized systems is very significant. Their positive identification as part of IOCG systems might become a major breakthrough in mineral exploration. If as thought, the detailed chemical signature of quartz bodies from mineralized IOCG systems is found to be somewhat anomalous and characteristic, chemical analysis of outcropping quartz bodies and of large areas with quartz float may provide a new exploration tool. Positive field identification of IOCG-related quartz pods could help to select prospective areas for IOCG deposits.

Abundant float of white quartz in a circular area may be detected easily on arid regions. Outcrops of these quartz bodies offer a good color contrast with the country rock; thus black and white air photographs may be an aid to their location. The large outcrop area of some quartz pods can make them identifiable in ASTER images and on other remotely-sensed images. Large quartz pods in part of the Kamanjab Batholith in Namibia are evident on ASTER and hyperspectral airborne images.

Hypotheses About the Origin of Quartz Pods

The origin of the quartz pods is an unsolved mystery. Many hypothesis for their occurrence come to mind. 1) They may be a type of silicification alteration that is not yet well documented in the literature.

2) Maybe hyper-alkaline fluids could have dissolved silica and produced the quartz bodies. This idea was briefly proposed by Behr et al (1983). But how can the space for the pods come to be? How did silica get there? How did it get in place?

3) Maybe the quartz pods are produced by extremely alkaline fluids rich in HF that dissolve silica in rocks replacing it by iron sulfides. Silica migrates further out and precipitates quartz bodies. But again, the question is how can the space for quartz bodies be produced? How could one detect fluorine in fluid inclusions if the way to disolve silicates involves HF?

4) The evidence of “intrusive” quartz bodies is clear. Could the quartz pods be remnants of a quartz-only magma? Are these “quartzolites”? In some locations, country rocks have been seen to fold around the quartz bodies, and that may be an evidence of intrusion. Other hypothesis for the origin of folding might be differential compaction of the intruded rocks, or dissolution of water-soluble salts in the country rock.

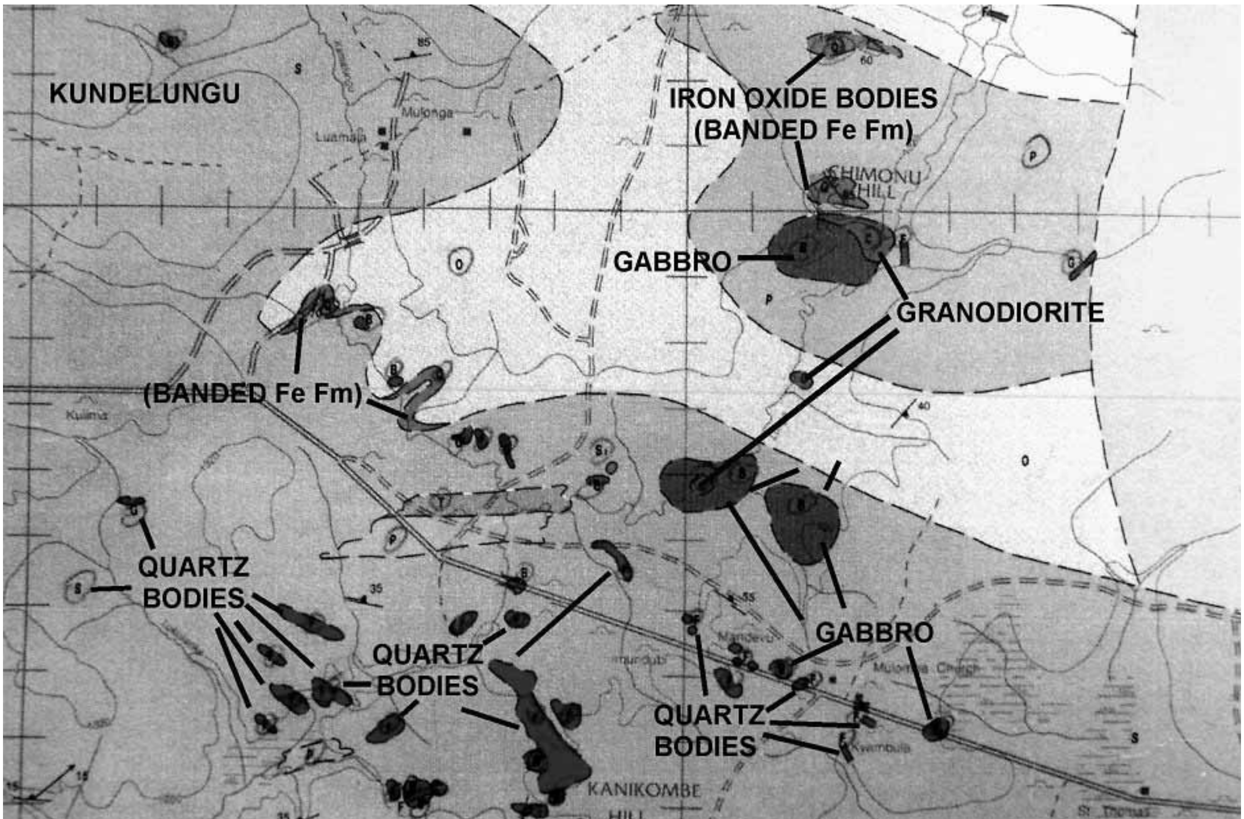

Figure 1.Quartz bodies, gabbros, felsic granitoids and iron oxide bodies that outcrop together east of Solwesi, Zambia. *These small bodies of rocks occur together in many locations of the Lufilian Arc. They seem to be a feature of rift environments. The double line that cuts across from left to right is the main road from Kitwe to Mwinilunga Kitwe to the east and Mwinilunga to the west. Host rocks in this case are Katangan carbonates and siliciclastic units. For scale, tick marks are separated 1 km. Interpreted from public 1:100,000 scale geological map sheet published by the Zambian Geological Survey Organization, Lusaka.*

References

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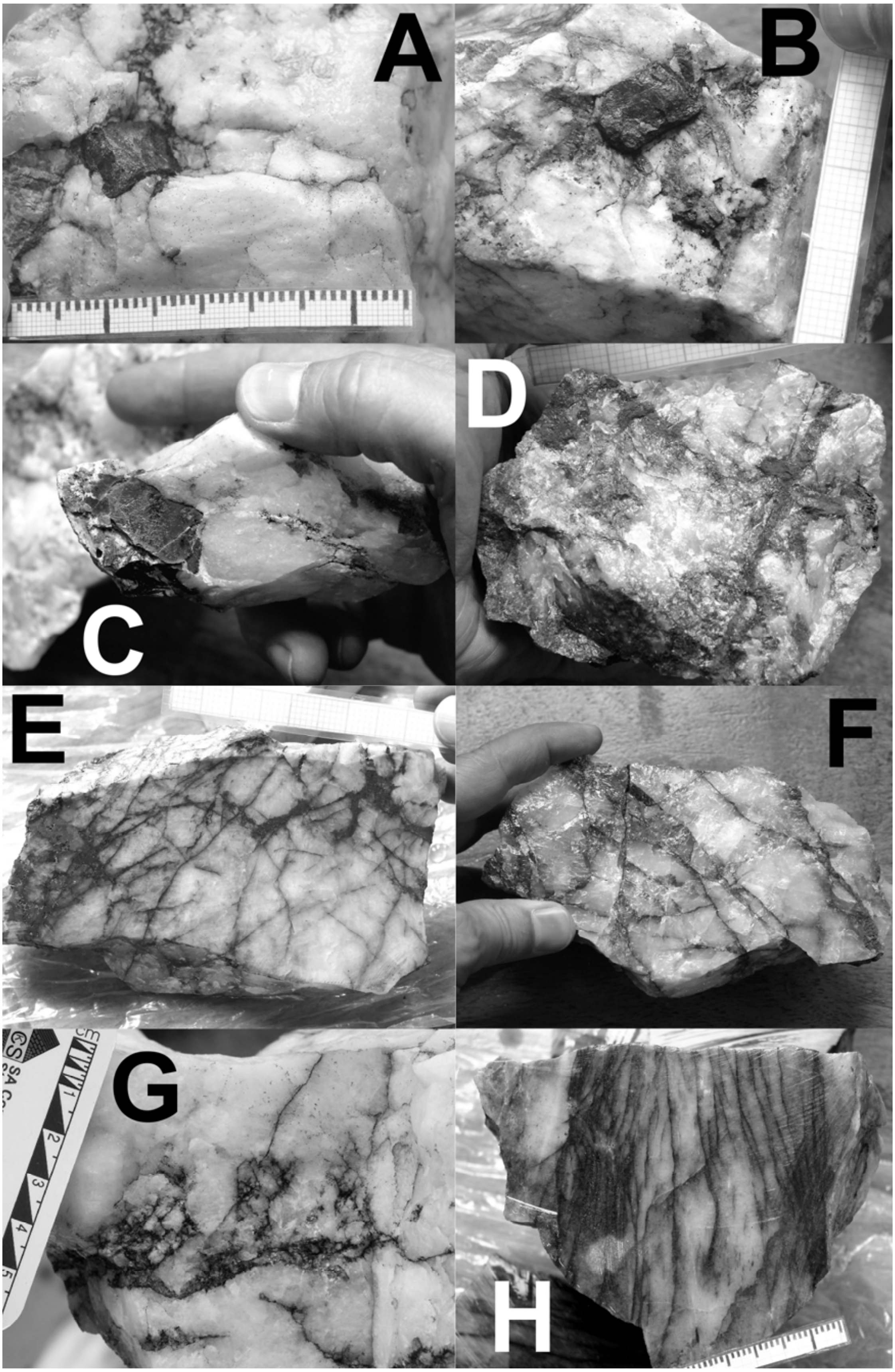

Figure 2. Various features of iron oxides in quartz pods of the Lufilian Arc. ***A*** *and* ***C*** *are cubic fragments of magnetite hosted by a quartz pod.* ***B*** *is a sub-rounded fragment of magnetite found inside a quartz pod.* ***D,*** *portion of a sulfide-rich, magnetite-filled stockwork hosted in a quartz pod.* ***E*** *and* ***F*** *are sulfide-rich, magnetite stockworks hosted in quartz pods. Field of view is 15cm.* ***G*** *is a hydrothermal angular clast breccia cemented by magnetite that is hosted in a quartz pod. Clasts are made of quartz fragments.* ***H*** *is a series of closely-packed, subparalled sheeted veinlets hosted in a quartz pod. A and E have scale marks every mm; B and D, every 2mm.*