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THE ASSOCIATION OF BARITE VEINS WITH ACID IGNEOUS AND METAMORPHIC ROCKS

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ABSTRACT

It was observed that barite veins are invariably associated with acid igneous rocks whether plutonic or volcanic and certain metamorphic rocks which tend to be acidic in composition. The present investigation tries to explain on chemical basis why does this association occur in nature.

The associated acid igneous and metamorphic rocks like granite, granodiorite, porphyrite and gneiss are all characterised by being rich in potash feldspar and biotite, in other words they are feldspar-mica rocks. These two minerals are known to be enriched in the element Ba. Weathering processes release Ba in solution. Once in solution, Ba migrates veinward to regions of sulfate in order to form the well known barite veins.

Another mechanism of forming barite veins depends on the fact that there is considerable Ba mobility and enrichment during metasomatism and granitization. This mobility with the presence of free SO_4^{2-}radical will help in formation of barite veins characteristic of granitized zones.

Magmatic hydrothermal fluids are shown here to be deprived from any significant amount of Ba. Thus hydrothermal origin usually attributed to many barite veins ought to be replaced by a mechanism based on either of the two mentioned models.

INTRODUCTION

Barite is widely distributed in different types of rocks in the world. The importance of studying the occurrence of this mineral is in connection with technological uses. Among these it is used as an absorptive material for radiation.

Barite goes in the construction industry in concrete aggregate to shield stationary nuclear reactors because it absorbs gamma radiation, its use reduces the amount of expensive shielding like for example lead shielding otherwise necessary needed. This makes barite a strategic mineral with expanding use in the field of protection and shielding from hazardous radiation.

It is observed that barite veins has certain affinity to be associated with acid igneous and metamorphic rocks. This association will be discussed here in some detail to find the rules, whether mineralogical or chemical, governing this association. As a matter of fact, the purpose of the present work is to find chemical explanation for the association of barite veins with the mentioned acid igneous and metamorphic rocks.

ASSOCIATION OF BARITE WITH ACID IGNEOUS AND METAMORPHIC ROCKS

As already mentioned, barite occurs in different countries associated with acid igneous and metamorphic rocks. In the following paragraphs the occurrences of the acid igneous and metamorphic rocks in different countries will be mentioned after Brobst [1970].

In South America and in Peru most of the barite has been mined from large hydrothermal deposits associated with andesitic volcanic rocks and diorite to granodiorite intrusive rocks of Tertiary age in the Rimae valley near Lima.

In the continent of Europe and in West Germany, barite veins in the Bad Lauterberg area, western Harz, had reserves of 1 million tons. These vein deposits are associated with granites of Variscan age, but not much is known about their geochemistry or genesis. In the Union of Soviet Socialist Republics, the veins of barite of hydrothermal origin were deposited in tectonic fractures in a tuff porphyry unit of Middle Jurassic age. These deposits are found in Transcaucasus region of Georgia, Armenia and Azerbaidzhan.

In France, barite occurs in hydrothermal veins in metamorphic rock and more rarely in basement granites. Typical vein deposits are in Central Massif and in southern France. Barite veins also occur in the contact aureole around the granite batholith of Mount Lozere in the Lozere and Gard departments. Among many barite veins in the Vosges Mountains of northeastern France, the large barite deposit at Val d'Ajol occurs in a mylonitized granite in the contact zone between the granite and Permian rocks. In Greece veins in granite are mined on Mykones.

The East German occurrences of barite are in metamorphic rocks in the outer contact zone of the Eibenstoker granite of Variscan age. At Huhn Trusetal, on the south western border of the Thuringer Wald, veins containing barite and fluorospar in the ratio of 3:1 occur in old Paleozoic mica schists and gneisses and associated Variscan granite. In Bulgaria barite is abundant in widely distributed deposits of lead and zinc associated with sedimentary and igneous rocks of Tertiary age in the Rhodope massif.

In Czechoslovakia deposits are reported to contain barite with fluorspar and quartz in the crystalline rocks of the Krusne and Smirciny Mountains in north western Bohemia. The deposits composed chiefly of siderite, barite and some sulfides are part of the Zips-Gomorer Erzgebirge in the old Alpine-West Carpathian ore province associated with intensive magmatic activity of the Gemeride granite of Middle Cretaceous age.

In the African continent, major barite resources are associated with the carbonatites of East Africa. In the Republic of South Africa the ore deposits are at or near the contact of recrystallized quartzite and biotite schist on the Gamsberg, a doubly plunging anticline. The origin of deposits is attributed to metasomatic replacement of the country rock from an igneous source. The Egyptian occurrences of barite are mainly in pink granite east of Aswan.

In Liberia six barite veins have recently been described in Precambrian granitic gneisses in an area of about 20 square miles in the Gibi area, eastern Montserrado county. Zambian deposits of barite occur near the contact of granite and schist south of Kafue river about 14 miles east of Kafue Township. Tanzanian barite is reported in carbonatites and occurs in concentrates from kimberlite pipes. In Uganda a considerable tonnage of barite possibly may be recovered from hematite lenses in granitoid gneiss at Muabuzi Hill north west Ankole. The deposit lies only miles from the Kampala-Kasese railway. Barite also occurs associated with the Sukulu carbonatite. Somalian deposits are in the area south of Berbera, in the Bihendula Range, barite fills fractures as much as 2 feet wide in gneiss.

Occurrences of the Near East countries are as follows. In India near Alangayam veins with quartz and 30 percent barite in porphyritic gneiss are several feet thick and have been traced for 7 miles. In the Tikamgarh district of Vindhya Pradesh, grey barite forms 30—45 percent of veins as much as 2.5 feet thick that cut the Bundelkhand gneiss. In Iran most of the barite is white, although some is red from iron stains, it commonly occurs in relatively thin, structurally controlled veins. The most common host rocks are the volcanic tuffs of the Oligocene and Miocene green beds.

Turkish barite occurrences are in the areas of Bilirkoy, Kizilkilise and Kasorkoy, Mur Province where barite veins as much as 40 m wide occur in schists of early Paleozoic age that generally strike west and dip north.

In the Far East countries like Japan, the Otaru Matsukuva mine in Hokkaido had yielded by the end of 1950, 80 percent of the nation's total production from high-grade ore replecements in volcanic rocks of Tertiary age. In North Korea in the Chaeryong-gang district many barite deposits are known in the limestone, shale, and clay-slate of the Masan-ni (Masanri) beds of the Middle Cambrian Choson system, and in the unconformably overlying succession of three units of porphyrite, breccia, conglomerate, sandstone, quartzite, tuffaceous shale, shale and limestone in the Upper Taedong (Daido) formation of Late Cretaceous age. The deposits in the Masanri beds are commonly lenticular or pocket-like, and those in porphyritic tuff beds are comparatively thick and have substantial reserves.

Finally in Australia barite deposits are known in the Northern Territory, Tasmania, Queensland, Victoria, and New South Wales. In New South Wales, the Kempfield area, about 30 miles south-south west of Bathurst, has yielded about 10 percent of Australia's total barite production from lenticular masses in schistose rocks about 1 mile from a granite mass.

THE MAIN BARITE OCCURRENCES

The foregoing occurrences of barite can be classified according to the type of the associated rock into three classes which are: barites associated with acid igneous rocks, those associated with metamorphic rocks and those associated with carbonatites. The more abundant occurrences are those associated with acid igneous rocks or at the contact of these rocks, these represent about 60%, of the studied occurrences. Then comes barites associated with metamorphic rocks and they represent about 30% of the studied occurrences. Finally barites occurring with carbonatites are about 10% of the studied cases.

THE GEOCHEMISTRY OF Ba IN RELATION TO BARITE VEIN FORMATION

Nockolds and Allen [1953] mentioned that Ba rises steadily in amount as the more acid rocks are approached. But in the E Central Sierra Nevada series, as in the Scottish Caledonian series, there is a sudden drop in the Ba content at the extreme acid end. Kolbe and Taylor [1966] on their study on the granites and granodiorites from Australia and South Africa observed as well a sharp decline of Ba in very acid rocks. El Sokkary [1970] during a study on some Egyptian granites and El Bouseily and El Sokkary [1975] showed that Ba has a mean value of 770 ppm in normal granites while in strongly differentiated rocks and pegmatites its concentration drops to about 100 ppm. The same authors added that Ba shows definite decrease with extreme fractionation.

In conclusion, it is possible to say that Ba reaches almost maximum concentration in igneous rocks approaching granitic composition (quartz diorite-granodiorite-granite) before it drops out in strongly differentiated rocks and pegmatites. Hydrothermal solutions remaining after the pegmatite stage would naturally be deficient in that element.

In any rock which is composed of feldspars, quartz and mica in different proportions, it is understood that the minerals carrying chiefly Ba are the potash feldspar and the mica specially biotite, plagioclase contributes Ba to a much lesser extent than potash feldspar [WEDEPOHL, 1974]. Therefore igneous or metamorphic rocks which carry an abundance of feldspar (particularly potash) and mica (particularly biotite) are liable to liberate much Ba in the weathering solutions.

ROSENQUIST [1939] leached a granite powder with distilled water and he found that BaO was enriched in the residue of the weathering solution to about nine times. Weathering of biotite was observed by BOETTCHER [1966] to lead to a decrease of the BaO content. SOLOMON [1966] reports Ba removal from granites by greisenization. Experimental weathering of K-feldspar in distilled water [PUCHELT, 1967] showed that Ba is preferentially released from this silicate structure into the solution.

Thus Ba tends to be released rather easily from feldspar-mica rocks subjected to weathering solutions. In other words, the weathering solutions from granites and similar rocks become enriched in Ba. LURYE [1963] concluded that all barite and its Sr content originates from the feldspar decomposition in the wall rocks. It seems that the weathering of granites can lead to solutions very rich in their Ba content.

Now if a granitic rock (or a rock rich in feldspars, particularly potash, and mica) contains an original hydrothermal vein which is composed dominantly of quartz plus sulphide minerals such as galena, pyrite or sphalerite. If these sulphides are subjected to weathering near the earth's surface where there is free access to atmospheric O_2 and where the oxidation potential is high, then SO_4^{2-} radical will be formed.

The Ba released from granitic and similar rocks can take the form of soluble $BaHCO_3$ which is an alkaline solution [CLARKE, 1939]. This alkaline solution on moving towards the original quartz-sulphide vein (now containing free SO_4^{2-} radical) can act in two ways: one active in dissolution of SiO_2 and removing it away and the other is the concomitant precipitation of $BaSO_4$. To this result, an evidence is given from the rock texture itself. Some barite specimens from Egypt [EL SOKKARY and ABDEL MONEM, 1977] are observed to contain quartzite remnants composed exclusively of quartz grains and in which barite flows as a plastic material filling cracks and small veinlets, sometimes the quartzite fragments are shattered and barite flows to fill the spaces between the shattered pieces indicating that it is later in its paragenetic sequence than quartz.

TOOKER [1963] was able to show that Ba, and other large ions, normally tends to be removed veinward from all Precambrian and Tertiary metamorphic and igneous rocks he investigated. In solution Ba migrates to the region of sulfate stability and thus is often bound to a narrow zone close to the earth's surface [WEDEPOHL, 1974].

The foregoing model proposed for the formation of certain barite veins associated with granitic and metamorphic rocks seems to be plausible, particularly if it is taken into consideration that magmatic hydrothermal fluids originally do not contain any significant amount of Ba, but obtain this element if possible by leaching suitable rocks.

Another way of formation of barite veins during metasomatism and granitization is as follows. ENGEL and ENGEL [1958] observed that granitized gneisses in the Adirondacks, New York generally showed much higher Ba values than normal gneisses. Thus there is considerable Ba mobility and enrichment during granitization and metasomatism. Any SO_4^{2-} radical present in a fissure or vein will attract the metasomatically mobilized Ba and form barite characteristic of granitized zones.

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