

Mineralogy and genesis of the Çanakçi (Ulukisla-Nigde) baryte vein deposits, Central Turkey

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The studied area is located around Çanakçi (Ulukisla) Village in the north of Bolcardag Unit, Central Turkey. The baryte mineralization occurs within Elmali vulcanite member belonging to Upper-Palaeocene aged Çiftehan complex which overlies unconformably the Alihoca ophiolites. The complex on the basis of lithological features can be divided into four members; Koçak shale-sandstone, Elmali volcanite, Aktastepe limestone and Üçtepe monzonite-diorite. The Elmali volcanites consists of basalt, andesite and trachyte lava flows, hypabyssal rocks, pillow lava and agglomerate. The lava flows have a E–W strike and are cut by hypabyssal rocks of different phases. The baryte mineralizations occur nearly 2km southeast-east and 3km southwest of Çanakçi village. The baryte mineralization in SW of Çanakçi village has nearly 1m thick and 33m length. Many small veins of baryte, nearly parallel to the main ore, are also present in the surrounding areas. Baryte veins contain mainly some galena.

Minerals were identified by ore microscopy, and major and trace element analyses were performed by the XRF method.

Mineralogy Megascopically, baryte ore is crystalline, white and pinkish white in colour. Microscopically, small amount of quartz is accompanied with baryte mineral. Baryte occurs mainly as euhedral but sometimes anhedral crystals. Baryte crystals are colourless, perpendicular sets of cleavage and greyish interference colours indicating small birefringence. Crystals are characterised by polysynthetic twinning, undulatory extinction due to mechanic twinning in common. Mechanic twinning and like mortar texture are also observed in minerals. Baryte is cut by very thin quartz, sphalerite and galena veins and some baryte inclusion formed in some quartz crystals, all of which indicates that baryte is formed early than quartz, sphalerite and galena. The baryte crystals may also show fibrous or

prismatic habit with patchy extinction reflecting the presence of considerable stresses during or after the deposition of baryte. The common opaque minerals are mainly galena, and rare sphalerite, chalcopyrite, pyrite, covellite, ilmenite and fahlore. Secondary minerals are anglesite, malachite, azurite, smitsonite, iron oxide and cerussite. The gangue minerals are represented by quartz, calcite chlorite and muscovite.

Chemistry Selected 4 samples from baryte occurrences were analysed for major and trace elements (Table 1).

As seen in Table 1, there is a negative correlation between the Ba and Al_2O_3 . Feldspar, muscovite and possibly some clay minerals are present in order to account for the Al_2O_3 content that ranges between 3.07–12.35%. FeO is very low (0.1–0.5%), suggesting that baryte mineralization occurred at very low temperatures. Extremely low Na_2O and CaO contents show clearly that calcium and sodium enriched fluids did not come to deposition environment during the baryte mineralization. Na_2O and K_2O occur principally as soluble salts mostly taking the form of chlorides, MgO does not behave as a soluble salt. The main impurity is SiO_2 (mainly in the form of quartz mineral) and ranges between 2.1–17.81 %. High ratio of Cu (109–161ppm) and TiO_2 (0.12–1.56 %) reveals that the mineralising fluids are of hydrothermal origin and mineralising fluids came up from through volcanics and intrusive rocks. S content of the baryte minerals are between 63984 and 74306 ppm suggesting that the baryte mineralization is epithermal in origin. In addition, the high Sr values (9605–13603ppm) reflect that the origin of Sr is related with volcanic activity. The very high Ba/Sr ratio implies that the origin of Ba is the hydrothermal (especially epithermal) origin (Werner, 1958; Starke, 1969). Zn content ranges from 2 to 793 ppm, suggesting that the baryte occurrence is related with volcanic activity (Marchig *et al.*, 1985). Pb

TABLE 1. Representative major (wt.%) and trace element (ppm) analyses of the baryte

Sample	HB-9	HH-18	HH-6	HH-8
SiO ₂	17.81	3.60	2.20	2.10
TiO ₂	1.56	0.14	0.12	0.12
Al ₂ O ₃	12.35	4.18	3.52	3.07
FeO	0.51	0.12	0.17	0.15
MnO	0.00	0.00	0.00	0.00
MgO	1.39	0.44	0.00	0.00
CaO	0.15	0.00	0.00	0.00
Na ₂ O	0.67	0.53	0.00	0.62
K ₂ O	1.11	0.12	0.70	0.04
P ₂ O ₅	0.06	0.00	0.06	0.00
Co	6	4	22	16
Cr	48	54	63	27
Ce	121	146	248	568
Ba	734750	959624	962635	788734
Sr	9730	9605	13603	12972
Rb	5	10	9	29
Pb	24	195	163	4728
Ga	11	12	10	6
Zn	183	793	5	2
Cu	109	129	161	137
Ni	19	9	bdl	13
S	73789	69145	74306	63984
Nb	10	7	8	7

value ranges from 24 to 163 ppm, except one sample (HH8) having very high Pb content (4728ppm), related mainly with galena. If volcanic activity is directly responsible for the mineralization, the mineral so formed should not show a negative Ce anomaly (Shimizu and Masuda, 1977). The high Ce contents in barytes studied (121–568 ppm) reflect the origin of Ce is related with volcanic activity.

Genesis It is well known that Ba usually does not form minerals of its own, thus it is distributed among a number of silicate minerals, mainly feldspars and micas, where it substitutes for potassium. During the first stages of magmatic differentiation, Ba is enriched in the liquid phase. With progressing crystallization, barium is incorporated essentially in K-feldspar and micas, residual melt then result in depletion generally contain less barium in compar-

ison with their embedding wall rocks of magmatic or metamorphic origin. This is most apparent in the main Ba-bearing minerals such as feldspars and micas (Heier and Taylor, 1959). It is likely that magmatic-hydrothermal fluids do not originally contain significant amounts of Ba; this element is probably derived by leaching suitable wall rocks (Engelhardt, 1936).

Generally gabbro, granodiorite and quartz-diorite, basalt, andesite and trachyte contain Ba average 246, 873, 303, 876 and 1177 ppm, respectively. In the study area, average Ba contents of the country rocks are; 2000 ppm for monzonite and diorite, 2056 and 2750 ppm for basalt and andesite, respectively (Bas and Temur, 1992). Therefore it can be deduced that there was very high Ba in the magmatic environment during the formation of monzonite and diorite. A part of the Ba throw towards the outside in liquid phase while some Ba formed in the rocks. Ba in the liquid phase participate in solution and then occurred the source of Ba deposit. The intrusive rocks produce the solution which get rich in Ba during the passing through the volcanic rocks. Seritization, epidotization and chloritization are widely observed in the volcanic rocks and it shows that the Ba-rich solution effected mutual by host-rocks.

Conclusions The alteration, mineral assemblages and chemical features indicate a hydrothermal origin for baryte vein deposits. Chemical data indicate that Ba was derived directly from a magmatic source. Ba-rich solutions originated from monzonite and diorite formed the baryte mineralization.

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