Gumbeites and associated ore mineralization of the Urals (Russia)

FULL TEXT

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Abstract

Five mineralogical facies of gumbeites at sheelite deposits of the Urals were distinguished and studied: calcite-biotite (450-390°C) and calcite-dolomite-biolite (400-360°C), early; biotite-dolomite (360-330°C) and dolomite (340-280°C), late; and phengite (305-250°C), the latest. Veins of K-feldspar + carbonate + quartz accompanying gumbeites and containing molibdosheelite, sheelite, tungstenrutile, apatite, Te-Bi-tetrahedrite, cupropavonite, benjaminite,...

Table 11. Oxygen isotope composition in coexisting quartz and sheelite

nos.	Quartz			Sheelite				$\Delta^{18}O$, ‰	T_{calc}, °C
	$\delta^{18}O$, ‰ (SMOW)	T_{hom}, °C	$\delta^{18}O_{H_2O}$, ‰*	$CaMoO_4$, mol %	$\delta^{18}O$, ‰ (SMOW)	T_{hom}, °C	$\delta^{18}O_{H_2O}$, ‰**		
Veins with Mo-sheelite I									
1	9.4			17.8	5.9	450–390	9.1		
2	10.9			15.0	6.5	(420)	9.6		
3	11.2			7.5	5.0		8.0	6.2	468
Veins with Mo-sheelite II									
4	12.6	340–310	6.4	4.4	5.5	400–360	8.2	7.6	387
5	10.8	(325)	4.6	1.8	4.2	(380)	6.8	6.6	424
Veins with sheelite III									
6	12.8	335–280	6.3	0.5	3.4	360–330	5.6	9.4	261
7	11.9	(310)	5.4	0.2	3.1	(345)	5.3	8.8	286
8	12.9		6.4	0.2	3.0		5.2	9.9	243
Veins with sheelite IV									
9	9.0	340–280 (310)	2.5	0.1	1.3	335–285 (310)	3.1	7.6	343
10	10.5	335–295 (315)	4.1	0.1	2.2	335–285 (310)	3.9	8.3	310
Veins with sheelite V									
11	11.7	330–260 (295)	4.6	<0.1	2.5	330–280 (300)	4.1	9.2	269
Veins with sheelite I									
12	12.5	360–295 (330)	6.6	0.1	5.8	360–330 (345)	8.0	6.7	413
Veins with sheelite II									
13	11.0	335–295 (315)	4.6	0.1	2.7	335–285 (310)	4.1	8.3	310
14	12.6	330–260 (295)	5.6	<0.1	2.1	330–280 (300)	3.7	10.5	223

Note: Analyst V.I. Ustinov (Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences). 1–11—samples from the Gumbeika deposit; 12–14—samples from the Shartash occurrence. In brackets are mean *T* values.
* Calculated with the model of Matsuhisa *et al.* (1979).
** Calculated with the model of Weselowski, Ohmoto (1986).

to –9.1‰ (Fig. 9). In accord with the C isotope composition in carbonates, the ore deposition in gumbeites occured due to interaction between deeply generated fluids with carbonates of host rocks. This is especially clear for the Balkan deposit.

Calculated values of $\delta^{18}O_{H_2O}$ in quartz, sheelite (Table 11 and Fig. 9), and muscovite ($\delta^{18}O$ = 7.2‰, $\delta^{18}O_{H_2O}$ = 3.2‰) prove the deep source of gumbeite-forming fluids in the Urals, either metamorphogenic, or magmatogenic.

GENERAL FEATURES OF GUMBEITES

Gumbeites and accompanying K-feldspar–carbonate–quartz sheelite bearing veins and metasomatic rocks are localized inside the intrusive bodies, and outside, near their contacts. These rocks and veins are the result of carbon dioxide metasomatism of moderate temperature (450–260°C, commonly 390–330°C). The geological age of gumbeites is similar to the age of some dikes of the Shartash granodiorite complex and the Gumbeika monzonite complex. The depth of gumbeite formation corresponds to mesoabyssal levels. The hydrothermal fluids were essentially carbon dioxide–aqueous (P_{fl} = 3.4–2.6 kb), with moderate salinity (9–16% NaCl eq.) with KCl–NaCl–$MgCl_2$ ($CaCl_2$ less abundant), metamorphogenic state, produced by a deep seated source. Hot fluids invaded cold rocks, therefore the inner zones of metasomatic zonation contain relatively high-temperature mineral assemblages (biotite with high Ti content), and the outer zones contain mineral assemblages of lower temperature (biotite and phlogopite with lower Ti content). CO_2, S, and K_2O were added, and SiO_2 and Na were lost during the

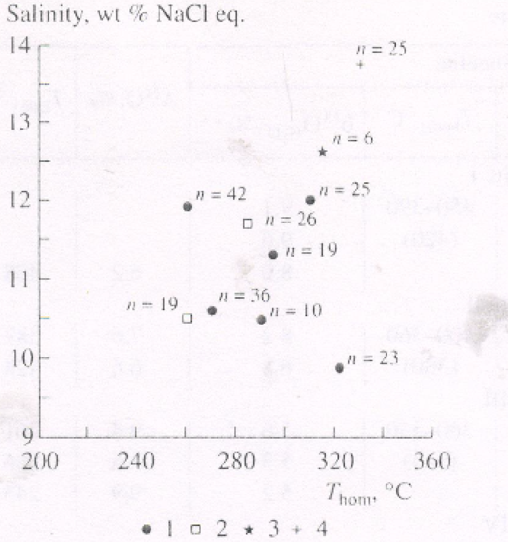

Fig. 6. Formation parameters of ore veins in gumbeites. (1, 2) Quartz from veins of the Gumbeika deposit; (1) veins with sheelite IV; (2) veins with sheelite V; (3, 4) quartz from veins of the Shartash occurrence; (3) with sheelite I; (4) with sheelite II; (*n*) number of determinations.

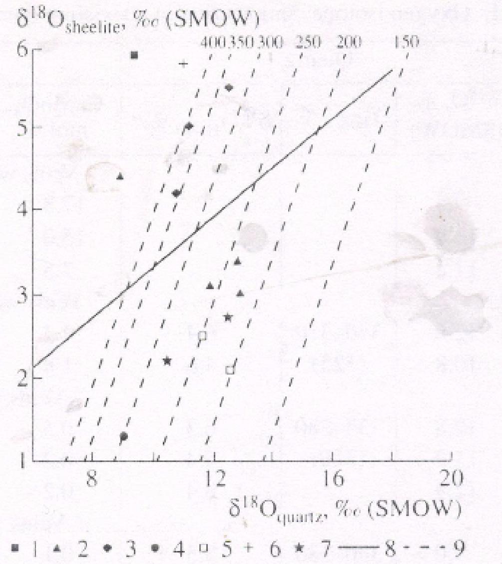

Fig. 7. Oxygen isotope composition in coexisting quartz and sheelite from ore veins in gumbeites. (1–5) Quartz veins of the Gumbeika deposit: (1) with Mo-sheelite I; (2) with Mo-sheelite II; (3) with sheelite III; (4) with sheelite IV; (5) with sheelite V; (6, 7) quartz veins of the Shartash occurrence; (6) with sheelite I; (7) with sheelite II; (8) regression line for deposits in berezites; (9) isotherms, °C.

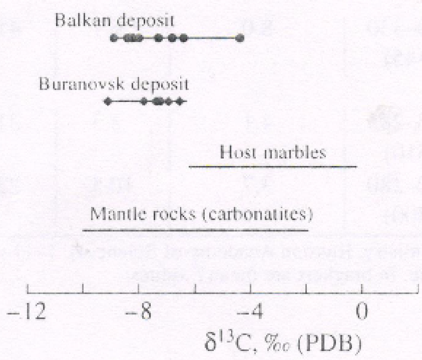

Fig. 8. Isotope composition of C in carbonates from veins in gumbeites of the Urals after our data and that of A.F. Korzhinskii (1959). Isotope composition of the mantle rocks (carbonatites) is plotted after data of Wilson (1989).

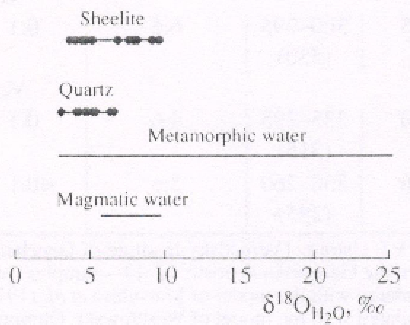

Fig. 9. Oxygen isotope composition of fluids which deposited sheelite and quartz in gumbeites of the Urals. Isotope composition of oxygen from magmatic and metamorphic waters after (For, 1989).

metasomatic process of gumbeization. Phosphorus was mobile: it was removed from inner zones and added into others. Apatite occurs practically in every vein in gumbeite assemblage. The mobility of the phosphorus was probably one of the reasons of the sheelite formation, because it contributed to the stability of polytungsten complexes in solution, which are regarded as the probable form of tungsten transport (Detusheva *et al.*, 1990).

Gumbeite mineral types changed with decreasing temperature from 450 to 305°C: calcite–biotite ⟶ calcite–dolomite–biotite ⟶ dolomite–biotite ⟶ dolomite ⟶ phengite. High-temperature veins contain molibdosheelite, tungsten-rutile, monazite; middle-temperature veins contain sheelite, rutile, molibdenite, Ag–Bi–galena, cupropavonite, benjaminite, and some others; veins formed at the lowest temperature contain Cu–Pb–Sb-sulfosalts, and poor Au–Te mineralization with aikinite. The sheelite deposition was a multistage process, and the content of Mo, Ce, La, and Nd in sheelite decreased from the early to the late stages. Most of Fe is in pyrite, hematite, and carbonates, and this is probably the reason for the high relative content of Zn in fahlore in gumbeites.

The higher content of Mo in sheelite, the occurrence of hematite, and fahlore rich with Cu^{2+} reveal the rather high redox potential in solutions which formed gumbeites. The redox potential decreased from the early to the late ore stages, and the ratio CH_4/CO_2 in the fluid increased in the same direction.

COMPARISON OF GUMBEITES AND OTHER SHEELITE—BEARING PLUTONOGENIC HYDROTHERMAL METASOMATITES

Gumbeite and skarns. Sheelite and molibdosheelite in skarns commonly associate with pyroxenes, amphyboles, plagioclase, and garnets. In gumbeites, the only silicates associating with sheelite and molibdosheelite are K-feldspar and micas. Sheelite in skarns shows low total REE, and particular low Eu content (mean values are 260 and 1 ppm, respectively), and high LREE/HREE ratio value (more than 30) (Getmanskaya *et al.*, 1984). Sheelite from the Urals gumbeites contains 830–2190 ppm REE, 11–32 ppm Eu, LREE/HREE = 5–20. Fahlores in skarns contain up to 20–50% Ag (Chvileva *et al.*, 1988), but in gumbeites—less than 4% Ag.

Gumbeites and greisens. Sheelite in greisens associates commonly with fluorite, is poor in Mo (because it is deposited by very acid fluids), contains little Eu (no more than 2 ppm), and its mean ratio value LREE/HREE = 26 (Getmanskaya *et al.*, 1984). Typical minerals of Bi in greisens are bismutite, bismuth, kosalite, galenabismutite, joseite, ingodite, and hedliite (Chvileva *et al.*, 1988).

Gumbeites and berezites. Sheelite in berezites associates with quartz, carbonates, and sericite, but not with K-feldspar and biotite. Sheelite from some gold deposits is enriched with Eu, Sm, and Tb, poor in Mo, and shows the low ratio value LREE/HREE = 1 (Table 2). Berezites have no hematite, apatite, complex Bi–Pb–Cu–Ag sulfides, meneghinite, bournonite (enriched with As and Bi), and fahlores with Bi, Te, and Se (the fahlores there are commonly enriched with Ag), i.e., all minerals typical for gumbeites are missing in berezites.

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