

## A COMPARISON OF GALKHAITE FROM NEVADA AND FROM THE TYPE LOCALITY, KHAYDARKAN, KIRGIZIA, U.S.S.R.

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### ABSTRACT

Galkhaite from one of the type localities, Khaydarkan, Kirgizia, U.S.S.R., has been compared with galkhaite from the Getchell mine, Humboldt County, Nevada, U.S.A. The average composition of the Khaydarkan material is  $(\text{Hg}_{4.46}\text{Cu}_{0.90}\text{Zn}_{0.42})_{25.78}\text{Ti}_{0.07}\text{Cs}_{0.43}(\text{As}_{3.32}\text{Sb}_{0.44})_{23.76}\text{S}_{12}$ . There are minor compositional differences from the Getchell mine material, and these account for an increase in the unit-cell parameter from 10.365(3) [Getchell] to 10.393(2) Å [Khaydarkan]. Essentially, there is no significant difference between the minerals, apart from a lower (Cs + Ti) content in the Khaydarkan material. Their powder-line intensities are indistinguishable.

**Keywords:** galkhaite, type locality, Khaydarkan, Getchell mine (Nevada), microprobe analyses.

### SOMMAIRE

La galkhaïte de la localit  type de Khaydarkan (Kirgizie, U.R.S.S.), a  t  compar e   celle de la mine Getchell, dans le comt  de Humboldt (Nevada, E.U.A.). La composition moyenne du mat riau de Khaydarkan est  $(\text{Hg}_{4.46}\text{Cu}_{0.90}\text{Zn}_{0.42})_{25.78}\text{Ti}_{0.07}\text{Cs}_{0.43}(\text{As}_{3.32}\text{Sb}_{0.44})_{23.76}\text{S}_{12}$ . Il y a des diff rences mineures de composition avec le mat riau de la mine Getchell, qui expliquent l'accroissement de la maille, de  $a$  10.365(3) [Getchell]    $a$  10.392(2)   [Khaydarkan]. Il n'y a pas de diff rence essentielle entre les deux mat riaux, sinon la teneur en (Cs + Ti), qui est plus faible   Khaydarkan. Leurs clich s de poudre sont identiques au point de vue de l'intensit  des raies.

**Mots-cl s:** galkhaïte, localit  type, Khaydarkan, mine Getchell (Nevada), analyses par microsonde.

### INTRODUCTION

In a previous paper, the authors reported that galkhaite from the Getchell mine, Humboldt County, Nevada, contains more Cs than Ti, and has a composition equivalent to  $(\text{Hg,Cu,Zn,Ti}, \square)_6(\text{Cs,Ti}, \square)(\text{As,Sb})_4\text{S}_{12}$ . It was shown that Ti is distributed between the 12*d* sites (with Hg, etc.) and the 2*a* sites (with Cs), and that neither

site was fully occupied. The cell edge *a* of the mineral is 10.365(3)   and the space group is  $I43m$  (Chen & Szymański 1981). No material from either of the type localities (Gal Khaya in Yakutia or Khaydarkan in Kirgizia, U.S.S.R.) was available at the time for a comparative analysis. The type material was reported to have a composition  $(\text{Hg,Cu,Zn,Ti})(\text{As,Sb})_2\text{S}_2$  and a cell edge 10.41(1)   (Gruzdev *et al.* 1972). Cs was not reported in the type material from either locality, and this leads to the question of whether the minerals from the Getchell mine and the two type-localities are actually the same. As the X-ray powder patterns of the type materials and the Nevada material are very similar, it is also possible that the Nevada material is a cesium analogue of galkhaite.

Recently, Roy Kristiansen of Torp, Norway, kindly provided us with a specimen of galkhaite from Khaydarkan, Kirgizia, U.S.S.R. This type-locality material was compared with the Getchell mine material; the results are presented in this paper.

### CHEMICAL COMPOSITION

Galkhaite from Khaydarkan was first examined using an SEM equipped with an energy-dispersion analyzer, and subsequently analyzed using an electron microprobe. The analytical conditions of the microprobe analyses were: accelerating voltage 20 kV, and the following emission lines and standards:  $\text{SK}\alpha$  and  $\text{CuK}\alpha$  enargite,  $\text{HgM}\alpha$  cinnabar,  $\text{FeK}\alpha$  argentopyrite,  $\text{CsL}\alpha$  CsCl,  $\text{TiL}\alpha$  and  $\text{AsL}\alpha$  lorandite,  $\text{ZnK}\alpha$  ZnS, and  $\text{SbL}\alpha$  chalcostibite. The data were processed using a modified EMPADR VII computer program of Rucklidge & Gasparri (1969). The reasons for choosing these emission lines and standards have been explained in Chen & Szymański (1981). A crystal from the Getchell mine was analyzed at the same time for direct comparison (No. 4, Table 1). Table 1 shows that the compositions of galkhaite from Khaydarkan are fairly consistent, the average

TABLE 1. ELECTRON MICROPROBE ANALYSES OF GALKHAITE

	Khaydarkan, Kirgizia U.S.S.R.			Getchell Mine, Nevada U.S.A.		
	1	2	3	4**	Av.*	Range*
S	22.1	22.3	22.4	22.1	22.0	20.9-22.7
Hg	52.2	51.7	51.9	50.0	50.7	48.3-53.0
Zn	1.6	1.6	1.7	1.5	1.8	0.3- 2.5
Cu	3.3	3.4	3.3	3.3	3.2	1.6- 3.6
Sb	3.3	3.0	3.1	nd	0.3	nd - 3.1
As	14.0	14.5	14.6	15.8	15.2	14.5-15.9
Cs	3.4	3.3	3.2	5.6	5.1	3.7- 7.1
Tl	0.8	0.8	0.9	3.0	2.4	nd - 4.2
Total	100.7	100.6	101.1	101.3	100.7	99.9-101.8

\* Average and range of 47 crystals (Chen & Szymański 1981).

\*\*Crystal No. 2, Table 1 of Chen & Szymański (1981) re-analyzed.  
nd - not detectable.

corresponding to  $(\text{Hg}_{4.46}\text{Cu}_{0.90}\text{Zn}_{0.42})_{25.78}\text{Tl}_{0.07}\text{Cs}_{0.43}(\text{As}_{3.32}\text{Sb}_{0.44})_{23.76}\text{S}_{12}$ . In general, the composition is within the range of the compositions of galkhaite from the Getchell mine. Hg and Sb appear to be somewhat higher than the average Getchell composition, whereas As, Cs and Tl appear to be low. The most significant difference appears to be in the proportion of (Cs+Tl). For the Getchell material, a linear antipathetic compositional relationship between Cs and Tl was found, with the slope of the relative proportions being about 3Cs:2Tl (Chen & Szymański 1981). The Khaydarkan material has (Cs+Tl) = 0.5 atoms; this is much lower than any Getchell mine material analyzed, for which the average (Cs+Tl) is 0.88 atoms. Fortuitously, perhaps, the value of 0.5 atoms is close to the least-squares refined population parameter (0.48) found by Divjaković & Nowacki (1975) in their structure analysis of Getchell mine galkhaite, when the atom in the 2a sites was considered to be exclusively Tl. Because of this unusually low value (0.5) for the Khaydarkan material, the mineral was reanalyzed for rubidium. Although first indications appeared to show the presence of Rb, it was found that, after background correction, the intensity initially attributed to Rb ( $\text{RbL}\alpha$ , 1.693 keV) was in fact due to the  $\text{HgM}\zeta_1$ ,  $\zeta_2$  lines (1.714, 1.710 keV). No Rb peaks were found.

#### X-RAY DATA

X-ray powder-diffraction patterns were obtained using  $\text{CoK}\alpha$  radiation and a 114.6 mm Debye-Scherrer camera for the Getchell mine and Khaydarkan samples of galkhaite. They are indistinguishable, except for a slight difference in cell edge: 10.365(3) Å for the Getchell mine, 10.392(2) Å for Khaydarkan. The latter is very close to the value of 10.41(1) Å reported by Gruzdev *et al.* (1972) for material from the

same source. The values of 10.365(3) Å (Chen & Szymański 1981) was found for material of composition  $(\text{Hg}_{4.22}\text{Cu}_{0.87}\text{Zn}_{0.53}\text{Fe}_{0.03})_{25.85}\text{Tl}_{0.30}\text{Cs}_{0.59}(\text{As}_{3.42}\text{Sb}_{0.06})_{23.48}\text{S}_{12}$ . The powder pattern of galkhaite from the Getchell mine reported by Botinelly *et al.* (1973) is in excellent agreement with the one obtained here, even to the value given for the cell edge (10.36 Å).

It appears that there is a small but consistent difference between the cell edge of galkhaite from the two localities, and this appears to be related to the minor compositional differences. The cell-edge difference can be explained by two factors. Firstly, owing to the differences in the covalent radii of the atoms in the 12d position [ $^{199}\text{Hg}^{2+}$ ,  $^{63}\text{Cu}^{2+}$  and  $^{112}\text{Zn}^{2+}$ , 1.10, 0.71 and 0.74 Å, respectively; Shannon (1976)], an increase in the proportion of Hg relative to Cu+Zn will result in an increased cell-edge. Secondly, a less-occupied atomic position gives rise to increased interatomic distances (Shannon 1976). In the present case, the Khaydarkan material has both a higher mercury content (first point) and a lower (Cs+Tl) content, which results in a lower occupancy of the 2a sites (second point) the result is a longer cell edge. The same explanation can be advanced to account for the difference between our value [10.365(3) Å] and that found by Divjaković & Nowacki (1975), 10.379 (4) Å, for their Getchell mine galkhaite of composition  $\text{Hg}_{4.56}[\text{Cu},\text{Zn}]_{1.44}\text{Tl}_{0.48}\text{As}_3\text{S}_{12}$ . It should be noted that the galkhaite from the Getchell mine does show large compositional variations.

#### CONCLUSIONS

1. Galkhaite from the Getchell mine, Nevada, is essentially identical to the galkhaite from the type locality, Khaydarkan, Kirgizia, U.S.S.R.
2. The compositions of Khaydarkan galkhaite,  $(\text{Hg}_{4.46}\text{Cu}_{0.90}\text{Zn}_{0.42})_{25.78}\text{Tl}_{0.07}\text{Cs}_{0.43}(\text{As}_{3.32}\text{Sb}_{0.44})_{23.76}\text{S}_{12}$  and that of the Getchell mine galkhaite,  $(\text{Hg}_{4.42}\text{Cu}_{0.88}\text{Zn}_{0.48})_{25.78}\text{Tl}_{0.21}\text{Cs}_{0.87}(\text{As}_{3.55}\text{Sb}_{0.04})_{23.59}\text{S}_{12}$ , are similar, although minor variations occur in Hg, As, Sb, Cs and Tl. The (Cs+Tl) content in the Khaydarkan galkhaite is very low, approximately 0.5 atom per formula unit; however, with always more Cs than Tl, the majority in the 2a sites is filled with Cs.
3. The cell edge of the Khaydarkan galkhaite is 10.393(2) Å, and that of the analyzed specimen from the Getchell mine is 10.365(3) Å. The larger cell of the Khaydarkan material can be explained by a greater proportion of Hg in the 12d sites and of vacancies in the 2a (Cs, Tl) sites in the structure.

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