



THE CHEMICAL COMPOSITION OF ALLANITE OF THE UKRAINIAN SHIELD, AS TECTONIC CONDITIONS INDICATOR

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Allanite (orthite), an epidote group mineral, general formula $A_2M_3[SiO_4][Si_2O_7]O(OH):A=Ca,Ce;M=Al,Fe$

It occurs as a characteristic accessory mineral in granite, granodiorite, syenite, monzonite, granite pegmatites skarns [Lyakhovich et al., 1968] and is found in glaucophane schist, and garnet lherzolite as well. There are also allanite phenocrysts in acid volcanic rocks [Hoshino et al., 2005].

Our attention was attracted to the work of Japanese scientists (Hoshino et al., 2005), they studied the chemical composition of allanite of granitic rocks of Japanese island arc by EMPA. They placing a data on the diagram of Al_2O_3 - Fe_2O_3 - ΣREE_2O_3 and comparing them with literature data for allanite from Proterozoic anorogenic granitoids of different tectonic zones of the Earth crust and concluded reducing of oxygen fugacity (f_{O_2}) during crystallization of minerals in the series: intracontinental zone - island arcs - continental margin. When reducing of f_{O_2} , the quota of Fe³⁺ in the allanite begins decrease, which in turn gives an indication of the tectonic conditions of allanite formation.

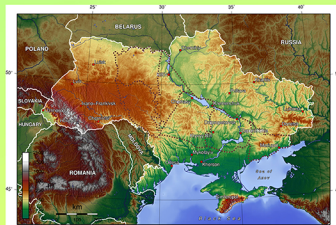


Fig.1 The borders of the Ukrainian Shield and its blocks (dotted line)

Table 1. Chemical composition of allanite of Ukrainian Shield ore

	1*	2*	3	4	5	6	7	8	9*	10	11	12	13	14	15*	16*	17
SiO ₂	28.9	29.7	30.54	30.4	29.3	31.82	30.3	27.5	29.16	33.91	32.36	35.4	31.62	31.48	35.16	30.03	30.74
TiO ₂	0.59	0.21	1.47	1.3	1.62	0.96	1.56	1.14	0.82	1.39	0.44	—	0.55	0.77	2.12	1.02	0.38
Al ₂ O ₃	16.13	12.5	15.8	15.6	15.8	10.36	15.55	14.7	9.29	15.07	14.5	19.78	17	14.6	14.05	18.16	15.21
FeO	4.18	11	6.56	3.3	2.63	25.76	4.94	9.93	16.97	3.88	11.96	0.97	3.72	4.72	5.98	13.12	1.62
Fe ₂ O ₃	9.83	6.55	12.1	14.94	16.37	—	14.65	12.07	18.04	12.31	1.9	12.95	10.41	12.35	7.9	—	13.6
CaO	13.39	14.47	7.28	7	7.7	5.73	7.7	8	4.4	11.03	10.92	12.55	12.6	9.72	9.57	8.52	8.92
MgO	1.22	0.55	1.53	0.86	0.94	0.69	0.75	1.44	1.86	1.19	1.75	0.06	2.05	0.43	2.81	0.36	0.16
MnO	1.41	1.97	—	—	—	0.27	—	—	0.32	0.2	—	0.16	—	0.55	0.39	0.1	0.26
K ₂ O	0.05	0.017	0.04	0.04	0.06	—	0.22	0.05	0.09	0.36	—	—	—	—	0.59	—	0.22
Na ₂ O	0.1	0.027	0.04	0.04	0.04	—	0.03	0.11	0.13	0.14	—	—	—	0.13	0.73	—	0.17
TR ₂ O ₃	18.82	19.09	22.8	23.6	22.9	19.58	21.9	21.84	17.1	15.89	18.7	15.52	18.08	22.61	14.97	24.97	25.07
TiO ₂	—	0.4	0.4	0.4	0.4	2.08	0.4	0.56	—	0.89	—	0.78	—	0.78	1.71	1.8	1.13
H ₂ O*	—	1.04	1.56	2.49	2.5	1.82	2.42	2.7	1.16	3.23	8.1	1.9	3.54	2.21	4.08	0.3	2.79
H ₂ O*	—	0.17	0.06	0.11	0.2	0.5	0.09	0.39	0.8	0.26	0.5	—	—	0.05	—	0.1	—
Σ	99.58	99.6	100.14	99.88	100.46	99.57	100.51	100.43	100.15	99.75	100.63	100.07	99.57	100.48	100.2	100.49	100.27

Remarks. The places of allanite finding: 1,2 - Anadol ore occurrence; 3-8 - the granites and pegmatites of Eastern Azov region; 9-12 - Saltychansk granites and pegmatites, 13 - the epidote metasomatism of West Azov region, 14-15 - Tokiv granite, 16 - Zhytomyr granite, 17 - the pegmatites of Korsun-Novomyrovgrad pluton.

1 - The chemical laboratory of IGMOF NAS of Ukraine, analyst O. Krasnyuk; 2 - 17 [Lyakhovich et al., 1968; Lazarenko et al., 1981]

Allanite-(Ce) from Anadol'sk ore mineralization (point 2), as it follows from the diagram (Fig. 2), indicates the formation of it in terms of the active continental margin with low oxygen potential. The most allanite samples of granites and pegmatites of the Eastern Azov region (chemical analyses are collected in Table 1) resides in the same field on the diagram. Figurative point of allanite from granites and pegmatites of Saltychansk ore occurrence (West part of Azov megablock), Zhytomyr and Tokiv granites located in the field of intracontinental tectonic zone. Obviously, the scattering of points, are caused by uneven content of elements in the various allanite generations which arose due to metamorphic process. That clearly demonstrates two similar analyses from some ore mineralization (points 6 and 7 on the diagram). So Hoshino's diagram cannot be used to separate of the Ukrainian shield allanite because it has the instability composition. However, even taking into account of the discrepancies in the results caused by different methods and techniques of analysis and samples preparation methods clearly recorded a large quota of Fe³⁺ in the allanite of the Eastern Azov ore occurrences. Apparently, this is a result of the special status of the Azov megablock of Earth crust in the Precambrian.

We decided to use this diagram to check the possibility of its application to allanite of the Ukrainian Shield (Fig. 1). Allanite in the Ukrainian Shield is common accessory mineral in diorite, tonalite, granite pegmatites and granites; moreover, in some granite of Saltychansk complex it is a rock-forming mineral [Tab. 1][Lazarenko et al., 1981]. In recent years, in the Azov megablock was strike unique ore occurrences of vein-type also known as Anadol allanite "dyke" where allanite content are ranges from 10-80%.

In discriminatory diagram Al_2O_3 - Fe_2O_3 - ΣREE_2O_3 (Fig. 2), figurative points 1 and 2 (Anadol ore occurrences, Azov megablock) fall into the opposite fields. We assume the scattering of points are due to different methods of analysis of the samples. However, in this case, the point would be swapped of places, as convincingly shown for beryl family minerals [Platonov et al., 2012], where the excessive of Fe³⁺ content is due to the "wet" analysis. Consequently, I conclude that the points scattering are caused by heterogeneous composition of allanite that, in fact, confirmed by electron microscopic analysis [Melnikov et al., 2012] and optically-microscopic observations.

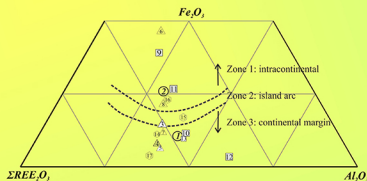


Fig.2 Hoshino's discriminatory diagram and figurative points of allanites composition of geological complexes of the Ukrainian shield. The point's numbers are corresponding to the numbers of analysis in Table 1.

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