

LITHOCHEMICAL AND GEOCHEMICAL FEATURES OF THE ROCKS OF THE CHADAK ORE FIELD (CHATKAL–KURAMA REGION, UZBEKISTAN)

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ABSTRACT

The Chadak ore field, one of the key gold-bearing areas of the Chatkal–Kurama region (Uzbekistan), is characterized by complex volcanic–plutonic structures and intensive hydrothermal alteration. This study presents the lithochemical and geochemical characteristics of volcanic, subvolcanic, and intrusive rocks within the Chadak ore field, aiming to identify geochemical features associated with gold mineralization. The ore field comprises three structural tiers formed by Carboniferous–Permian volcanic–sedimentary sequences intruded by granitoid complexes. Lithochemical and geochemical investigations were conducted on quartz porphyries, granodiorite porphyries, and metasomatized rocks using multi-element analytical methods. Ore-related elements (Au, Ag, Cu, Pb, Zn, As, Sb, W) distribution patterns were analyzed, and correlations were evaluated.

Results reveal heterogeneous ore element distribution and distinct geochemical halos associated with fault-controlled mineralized zones. Quartz porphyries and granodiorite porphyries show elevated Cu, Pb, Zn, As, Sb, and W, while metasomatized rocks are enriched in As, Cu, and Sb–W associations. Correlation analysis indicates copper–polymetallic and arsenic–antimony–tungsten elemental associations, reflecting multistage hydrothermal processes.

Identified lithochemical and geochemical features confirm the key role of structural control and hydrothermal alteration in gold localization. The results can be effectively used for local forecasting and exploration of concealed gold-bearing zones in similar volcanic–plutonic environments.

Key words; Chadak ore field; lithochemistry; geochemistry; metasomatism; structural control; gold mineralization.

INTRODUCTION

Gold mineralization in the Chatkal–Kurama region is closely linked to Carboniferous–Permian volcanic–plutonic complexes and multistage hydrothermal processes. Expanding gold resources in this region requires identification of concealed and deep-seated ore bodies, which in turn depends on understanding geological structure, magmatic evolution, and geochemical characteristics of ore-controlling systems.

The Chadak ore field is one of the most significant gold-bearing areas in the eastern Kurama Mountains. Previous studies addressed magmatism, structural controls, ore mineralogy, metasomatic alteration, and metallogenic evolution. Genetic models emphasize volcanic–plutonic interaction and fault-controlled hydrothermal activity.

Despite extensive exploration, the lithochemical and geochemical characteristics of host rocks and metasomatites remain insufficiently systematized, particularly regarding primary geochemical halos and element associations related to gold. Identifying typomorphic geochemical features of volcanic, subvolcanic, and intrusive rocks is essential for local-scale forecasting and exploration efficiency.

This study aims to characterize the lithochemical and geochemical features of rocks from the Chadak ore field, determine distribution patterns and associations of ore-related elements, and evaluate relationships between geochemical halos, structural zones, and hydrothermal alteration for refining criteria for predicting concealed gold mineralization.

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MATERIALS AND METHODS

The Chadak ore field is located within the Beltov-Kurama volcano-plutonic belt, on the southern slope of the Kurama-megaanticline, in the junction zone of the Ugam-Kumbel and North Fergana deep faults (Zonenshayn L.P., et al. 1976). According to various authors, the ore field is confined to a system of submeridional and northwestern faults controlling the placement of volcanic and intrusive formations and ore mineralization (Kanash O.A., Tangelson M.A. et al. 1976).

In the structure of the Chadak ore field, three structural tiers are distinguished: the lower (D3-C2), represented by limestones, volcanogenic-sedimentary layers, and granodiorites of the Karamazar complex; the middle (C2-P1), composed mainly of volcanics of the Bulgalin and Nadak complexes; and the upper (P1), including formations of the Oyasay, Shurabsay, and Kyzylnurina complexes (Golovanov I.M. 2001). Volcanogenic rocks are represented by andesites, trachyandesites, dacites, and rhyolites, and subvolcanic bodies and dikes are widespread. Intrusive formations formed in the late Paleozoic within the Hersin tectonomagmatic cycle and include the Karamazar, Kuyundin, Chulaksai, and Kanimansur complexes.

The gold-silver mineralization of the Chadak ore field is primarily associated with hydrothermal processes and formed in several stages: early hydrothermal (upper Carboniferous), skarn-hydrothermal, and late hydrothermal (Permian) (Tsoy V.D., et al. 2015). The main mass of gold and silver is associated with quartz-adulyar-calcite and chlorite-carbonate-quartz mineral associations.

Ore bodies are confined to zones of intensive tectonic disturbance, primarily to submeridional and northwestern faults, where metasomatic changes of rocks - quartzification, sericitization, chloritization, and pyritization - are widely developed. Geochemical studies have shown the uneven distribution of Pb, Zn, Cu, As, Sb, and W in volcanics, in intrusions, and metasomatites, reflecting the multi-stage nature of ore formation (Sadykova L.R. 2022).

Within the ore field, the Pirmirob and Guzaksay gold-silver deposits are distinguished, belonging to the number of reference objects of the Chatkal-Kurama region. The modern geological and genetic model of the Chadak ore field was developed by R.Kh. Mirkamalov and co-authors from the perspective of geodynamics and magmatism evolution (Mirkamalov R.Kh. 2010).

RESULTS

1. **Lithochemistry:** Quartz porphyries and granodiorite porphyries show elevated Cu, Pb, Zn, As, Sb, and W; metasomatized rocks enriched in As, Cu, Sb-W.
2. **Geochemical Halos:** Fault-controlled zones display distinct elemental halos, useful for exploration targeting.
3. **Elemental Associations:** Two main associations:
 - Copper-polymetallic: Cu-Pb-Zn-Ag-Au
 - Arsenic-antimony-tungsten: As-Sb-W-Au
4. **Hydrothermal Alteration:** Multistage processes indicated by overlapping metasomatic and mineralized zones.

DISCUSSION

- Fault systems acted as conduits for mineralizing fluids, concentrating gold and associated elements.
- Distinct geochemical halos around porphyries and metasomatized rocks indicate primary control on mineralization localization.
- Identified elemental associations reflect sequential hydrothermal events, consistent with multistage magmatic-hydrothermal evolution.
- Lithochemical and geochemical criteria improve prediction of concealed gold zones, especially where surface expression is weak.

Content of ore elements, in g/t in the rocks of well 1027

Table №. 1:

№ skv	№ samples	Rock name	Ag	Cu	Pb	Zn	As	Bi	Sb	Mo	W
Skv №-1027	30001	granodiorite-porphyrines	0.1	40	30	20	30	0.5	7	0.6	20
	30002	granodiorite-porphyrines	0.2	20	6	10	30			3	20
	30003	granodiorite-porphyrines	0.4	100	20	20	30		7	10	5
	30004	granodiorite-porphyrines	0.1	40	4	20	0	0.5		1	3
	30005	granodiorite-porphyrines	0.4	60	20	20	0	0.6		0.5	8
	30006	granodiorite-porphyrines	0.6	100	40	30	0	0.5	8	1	5
	30007	granodiorite-porphyrines	0.3	30	15	30	0	0.5	7	0.8	5
	30008	granodiorite-porphyrines	0.2	10	20	30	0		7	0.6	5
	30009	granodiorite-porphyrines	0.2	20	15	20	0		7	0.6	8
	30019	granodiorite-porphyrines	0.1	100	10	10	0	0.5		0.8	3
	30020	granodiorite-porphyrines	0.5	100	20	20	0	0.5	7	0.6	3
	30022	granodiorite-porphyrines	0.2	80	15	20	0	0.5	7	0.8	
	30023	granodiorite-porphyrines	0.5	50	60	20	0	0.6	10	0.6	3
	30024	granodiorite-porphyrines	0.3	100	10	30	80	0.5	7	2	5
	30025	granodiorite-porphyrines	0.6	150	200	100	80	0.6	7	20	10
	30026	granodiorite-porphyrines	0.3	150	10	10	0	0.5	7	1	5
	30027	granodiorite-porphyrines	0.2	20	8	20	0	0.5	7	0.5	5
	30028	granodiorite-porphyrines	0.3	80	30	30	0	0.5	7	0.8	3
	30029	granodiorite-porphyrines	0.4	60	15	50	0	0.6	7	1	5
	30030	granodiorite-porphyrines	0.3	20	15	30	0	0.5		0.4	5
30031	granodiorite-porphyrines	0.5	30	150	60	0	0.6	10	0.6	8	
30032	granodiorite-porphyrines	0.2	6	10	20	0	0.5		0.3	5	
30033	granodiorite-porphyrines	0.2	8	6	30	0	0.5	7	0.4	10	

Correlation of the content of chemical elements in the primary geochemical halos of the southern end of the Chelpeksai, Chulakterek, and Far zones of the Chadak ore field

	Ag	Cu	Pb	Zn	As	Bi	Sb	Mo	W
Ag	1								
Cu	0.603	1							
Pb	0.547	0.451	1						
Zn	0.557	0.084	0.446	1					
As	-0.007	-0.109	-0.127	-0.003	1				
Bi	0.527	0.900	0.437	0.070	-0.103	1			
Sb	0.237	0.001	-0.012	0.074	0.439	-0.038	1		
Mo	0.267	0.162	0.406	0.422	0.089	0.088	0.110	1	
W	0.201	0.048	0.118	0.097	0.127	0.058	0.051	0.101	1

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	Ag	Cu	Pb	Zn	As	Bi	Sb	Mo	W
Ag	1								
Cu	0.464	1							
Pb	0.625	0.308	1						
Zn	0.568	0.236	0.861	1					
As	0.252	0.508	0.460	0.512	1				
Bi	0.602	0.078	0.638	0.589	0.186	1			
Sb	0.488	-0.169	0.460	0.139	-0.254	0.601	1		
Mo	0.425	0.516	0.664	0.676	0.682	0.383	-0.155	1	
W	-0.220	-0.226	0.125	0.041	0.291	0.098	-0.121	0.156	1

Correlation of the content of chemical elements in the primary geochemical halos of the southern end of the Chelpeksai, Chulakterek, and Far zones of the Chadak ore field

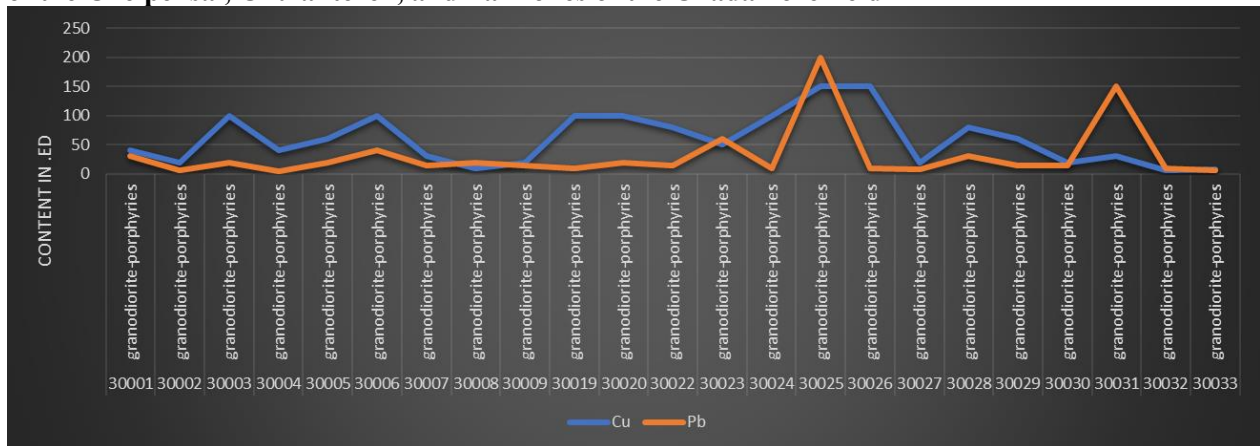


Fig. 1. The content of copper and lead in samples

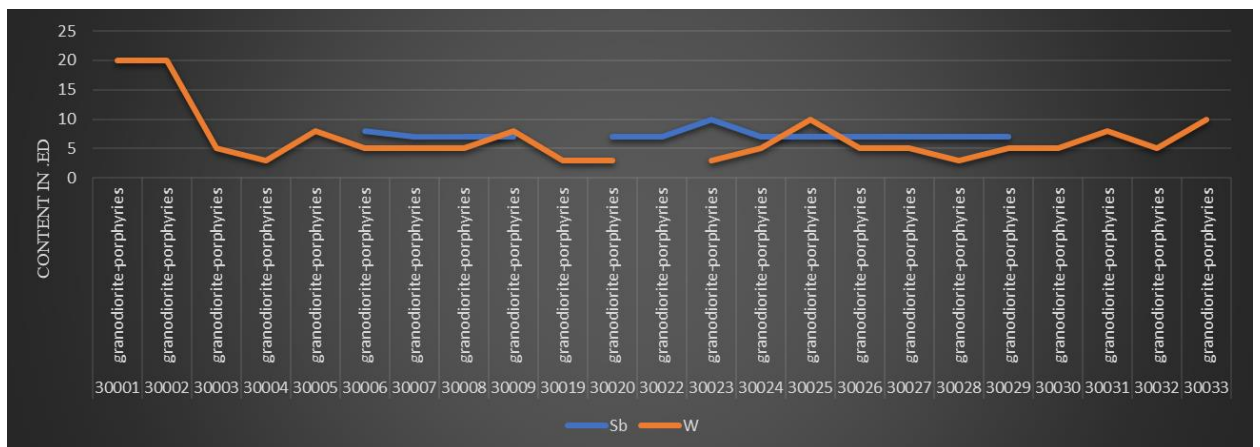


Fig.2. The Content of antimony and tungsten in samples

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Correlation of the content of chemical elements in the primary geochemical halos of the southern end of the Chelpeksai, Chulakterek, and Far zones of the Chadak ore field

	Ag	Cu	Pb	Zn	As	Bi	Sb	Mo	W
Ag	1								
Cu	0.512	1							
Pb	0.930	0.454	1						
Zn	0.491	0.523	0.360	1					
As	0.998	0.691	0.930	0.327	1				
Bi	0.148	0.105	-0.029	0.444	-0.225	1			
Sb	0.965	0.575	0.969	0.217	0.974	-0.120	1		
Mo	0.715	0.352	0.571	0.360	0.873	0.600	0.578	1	
W	0.452	0.255	0.492	0.612	0.099	0.548	0.222	0.332	1

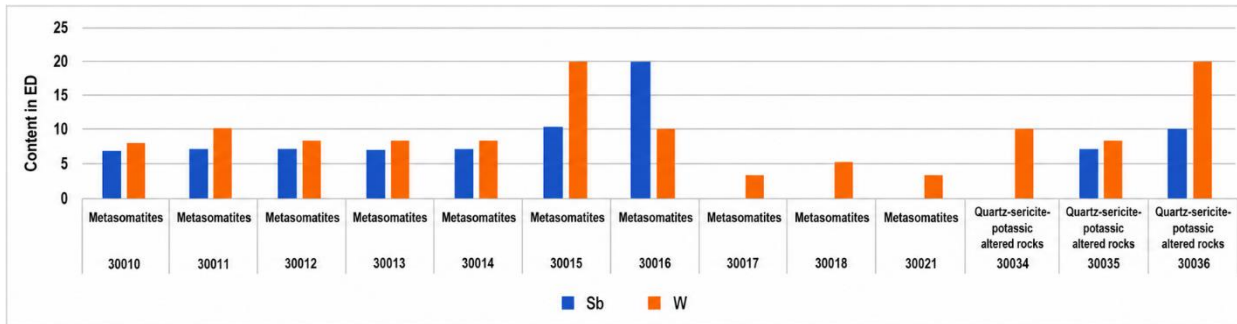


Fig. 3. The content of antimony and tungsten in samples

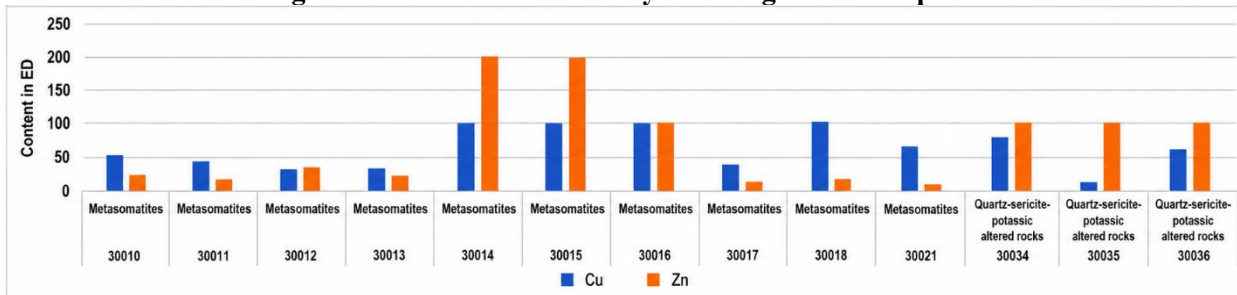


Fig. 4. The content of copper and zinc in samples

CONCLUSIONS

Gold mineralization is structurally controlled, primarily by submeridional faults. Quartz porphyries, granodiorite porphyries, and metasomatized rocks show distinct geochemical features forming exploration-targeted halos. Copper-polymetallic and arsenic-antimony-tungsten associations reflect multistage hydrothermal processes. Integration of structural, lithochemical, and geochemical data provides practical criteria for predicting concealed gold mineralization. Findings enhance understanding of volcanic-plutonic gold-bearing systems in the Chatkal-Kurama region, aiding local forecasting and regional metallogenic modeling.

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