ANAS Transactions **Earth Sciences** **1 / 2026**

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MAGMATIC-HYDROTHERMAL EVOLUTION AND ORE POTENTIAL OF THE BEKTAKARI-BNELIKHEVI KNOT, BOLNISI ORE DISTRICT, LESSER CAUCASUS

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Keywords: *hydrothermal alteration, geochemistry, mineralisation, magmatism*

Summary. This study investigates the petrological, geochemical, and geodynamic characteristics of intrusive and sub volcanic rocks within the Bektakari–Bnelikhevi ore knot, situated in the southern segment of the Lesser Caucasus. The research integrates detailed mineragraphic observations with whole-rock geochemical data obtained from 17 samples collected from eight drill cores. Major and trace element compositions were determined using X-ray fluorescence (XRF) spectrometry, providing a robust dataset for evaluating magma evolution and hydrothermal alteration processes. Petrographic examination reveals significant variability in mineral assemblages, textures, and alteration patterns, reflecting complex magmatic differentiation and subsequent hydrothermal overprinting. The intrusive rocks display systematic compositional trends consistent with a calc-alkaline magmatic series generated in a subduction-related tectonic environment and influenced by mantle-derived melts interacting with crustal components. Geochemical discrimination diagrams show pronounced enrichment in large-ion lithophile elements (LILE) together with depletion in high-field-strength elements (HFSE), supporting formation in a convergent margin setting associated with arc magmatism. Mineragraphic observations of sulfide assemblages, including pyrite, chalcopyrite, sphalerite, and galena, indicate multiple stages of hydrothermal mineralisation linked to evolving magmatic fluids and structural pathways for fluid migration. These features collectively suggest the presence of a long-lived magmatic–hydrothermal system capable of generating metal-enriched fluids and favourable conditions for ore deposition. The results highlight the metallogenic significance of the Bektakari–Bnelikhevi ore knot and contribute to a broader understanding of arc-related mineralisation processes within the Lesser Caucasus sector of the Tethyan metallogenic belt.

Introduction

The Bektakari-Bnelikhevi region, located in the Lesser Caucasus of southern Georgia, occupies a structurally complex segment of the Arabia-Eurasia convergence zone, shaped by long-lived subduction, back-arc extension, and subsequent collisional events (Adamia et al., 2010). This tectonic setting has played a critical role in magma generation, emplacement, and associated hydrothermal activity, thereby creating favorable conditions for ore-forming systems in arc-related plutonic complexes.

The regional geology is defined by a thick Upper Cretaceous volcano-sedimentary sequence, comprising Campanian and Senonian carbonate–terrigenous units (Gasandami and Mashavera suites), which are intruded by Cenomanian–Turonian dioritic and quartz dioritic plutonic bodies (k1, k2 units). These plutons are spatially and genetically associated with rhyodacitic and basaltic subvolcanic rocks (K2 units), emplaced along major fault systems and structurally prepared conduits. The intrusive and subvolcanic rocks are characterised by widespread hydrothermal alteration zones, often accompanied by disseminated and vein-hosted sulfide mineralisation. These features suggest prolonged magmatic-hydrothermal evolution in a tectonically permeable upper crust.

The geological map of the Bektakari-Bnelikhevi region (Fig.1) highlights the spatial association between dioritic intrusions, subvolcanic rocks, and mapped mineralised zones. Notably, alteration halos and drillholes concentrate near intrusive contacts and along fault-controlled zones, indicating the influence of syn- and post-magmatic structural controls on fluid migration and metal deposition. Recent remote sensing-based studies further emphasise the role of structural lineaments and alteration patterns in delineating prospective zones within the Bektakari–Bnelikhevi ore knot (Mindiashvili et al., 2024a). This structural magmatic interplay is typical of subduction-related metallogenic belts worldwide (Richards, 2003; Sillitoe, 2010), where magmatic arcs interact with deep-seated trans-crustal faults to localise ore systems.

Despite clear mineral potential of the region, recent studies have demonstrated the value of integrating geochemical datasets with advanced analytical approaches, including machine learning, to better constrain hydrothermal system architecture and ore-forming processes within the Bektakari–Bnelikhevi ore knot and the Bolnisi ore district (Mindiashvili et al., 2024b). Nevertheless, the petrological and metallogenic framework of the Bektakari-Bnelikhevi intrusive system remains undercharacterised. Accordingly, the objective of this study is to investigate the petrogenesis of the intrusive and subvolcanic rocks using mineragraphic and geochemical data, to reconstruct their formation conditions, and to assess the geodynamic and metallogenic processes that influenced ore localisation. By linking the mineralogical and geochemical features to the regional tectonic context, this research contributes to a broader understanding of arc-related ore-forming systems in the Lesser Caucasus and adjacent segments of the Tethyan metallogenic belt.

Method of study

This study integrates mineralographic and geochemical analyses to investigate the petrogenesis and metallogenic potential of intrusive and subvolcanic rocks in the Bektakari–Bnelikhevi ore knot. 17 representative rock samples were collected from 8 drill cores targeting geologically distinct intrusive bodies and hydrothermally altered zones. Sampling was based on lithological variation, visible mineralisation, and stratigraphic position.

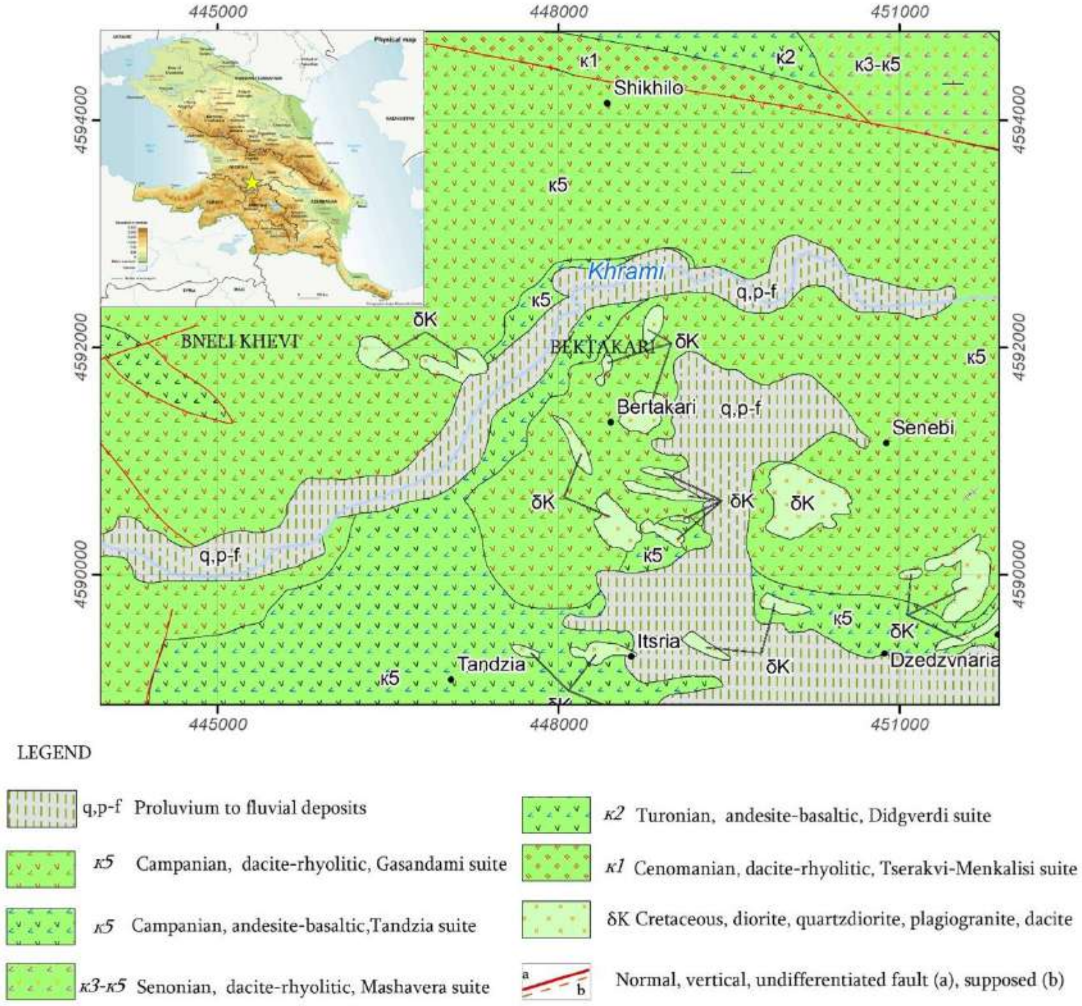

Fig. 1. Geological map of the Bektakari–Bnelikhevi region (modified after Adamia et al., 2020), showing Upper Cretaceous volcano-sedimentary units, intrusive complexes, and mapped fault systems. The spatial distribution of units highlights tectonomagmatic controls on ore-forming processes

Mineralographic investigations were conducted on polished thin sections using reflected light microscopy. The objective was to identify ore minerals, describe their textural associations, and interpret the paragenesis of the mineralising system. Particular focus was placed on the morphology, mutual relationships, and replacement textures of pyrite, chalcopyrite, sphalerite, galena, and associated quartz minerals. These observations followed standard practices outlined by Craig and Vaughan (1994) and were supplemented with high-resolution photomicrography.

Geochemical analyses were carried out using X-ray fluorescence (XRF) spectrometry to determine the concentrations of major and trace elements. Sample preparation followed conventional protocols, including crushing, pulverizing, and pelletizing. The obtained elemental data were used for petrological classification, magmatic trend analysis, and tectonomagmatic interpretation.

Interpretation of the geochemical data employed a range of classification and discrimination diagrams. The Total Alkali–Silica (TAS) diagrams proposed by Cox et al. (1979) and refined by Middlemost (1994) were applied for basic rock classification. Additional classification followed the Enrique and Esteve (2019) scheme on plutonic rocks, which integrates alkali-lime index, silica saturation, and aluminium saturation indicators. Chemical variation was further explored using the R1–R2 diagram of De la Roche et al. (1980), and magmatic affinity was assessed with the AFM ternary plot after Irvine and Baragar (1971).

To evaluate the alumina saturation state, the Alumina Saturation Index (ASI) was calculated following the method outlined by Maniar and Piccoli (1989). Tectonic setting discrimination was based on the Ti–V (Shervais, 1982), Ti–Zr (Pearce and Cann, 1973), and Ti–Zr–Sr diagrams. Trace element behavior and geochemical signatures were visualised using multi-element spider diagrams normalised to primitive mantle values (Sun and McDonough, 1989; Taylor and McLennan, 1985).

Data visualisation and statistical processing were performed using GCDkit (Janoušek et al., 2006) and IgPet software. All geochemical interpretations were conducted by established international standards for igneous petrology and ore geology.

Results

The petrochemical and mineragraphical composition of the intrusive rocks from the Bektakari–Bnelikhevi ore knot reflects a coherent magmatic and hydrothermal evolution shaped by a convergent tectonic regime. The data reveal compositional convergence around intermediate to post-mafic magmas, evolving through subduction-modified petrogenetic processes and culminating in structurally controlled ore formation.

The polished section observations demonstrate diverse sulfide assemblages reflecting successive mineralisation pulses (Fig. 2).

Pyrite is ubiquitously present as both early and late-stage phases, forming euhedral crystals as well as anhedral overgrowths and fine-grained dissemination. Its associations with chalcopyrite, sphalerite, galena, and quartz vary in space and texture across sampled intervals. In several specimens, sphalerite appears to be partially replaced by chalcopyrite, implying an evolving sulfur and metal activity within the ore fluids. Intergrowth textures between chalcopyrite and galena, and their inclusion in quartz vein fragments, suggest cyclic fluid influxes and overprinting episodes, commonly seen in arc-related polymetallic systems (Hedenquist and Lowenstern, 1994; Sillitoe, 2010).

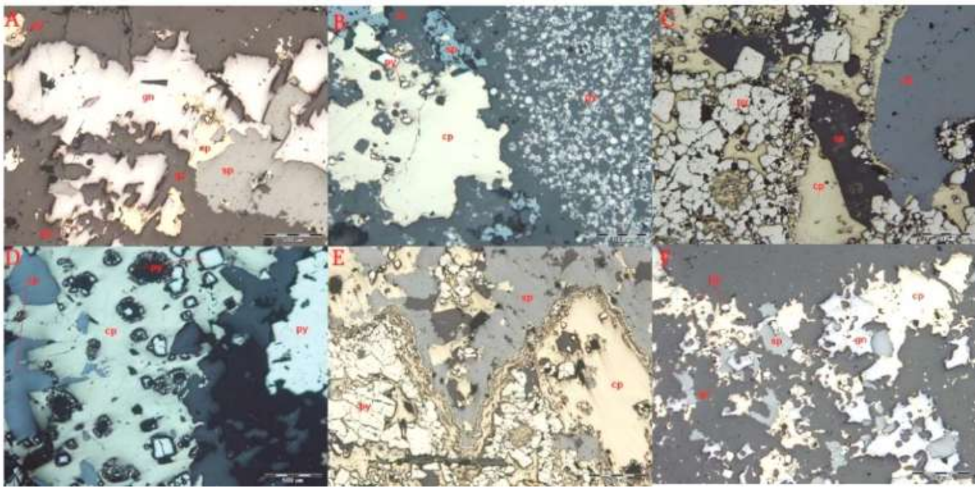

Fig. 2. Reflected light photomicrographs of representative ore textures. (A) Intergrowth of sphalerite (sp), galena (gn), and pyrite (py) with minor quartz (qz) and epidote (ep) in a sulfide-rich veinlet. (B) Chalcopyrite (cp) surrounded by fine-grained disseminated pyrite and sphalerite; quartz is present along vein boundaries. (C) Zoned sulfide texture with chalcopyrite (cp) and pyrite (py) embedded in sphalerite (sp) matrix; quartz vein (qz) crosscutting sulfides. (D) Large chalcopyrite grains with disseminated pyrite and sphalerite in a vein-parallel setting. (E) Pyrite overgrowth on earlier chalcopyrite cores, forming reaction rims within a sphalerite-rich matrix. (F) Disseminated pyrite within a sphalerite-galena-chalcopyrite assemblage, associated with quartz veins (qv); evidence of replacement and co-precipitation

Geochemical classification reveals a compositional spread dominantly within syenodioritic to quartz-dioritic fields, with additional representation of gabbroic varieties. This is evident in the TAS and R1–R2 classification schemes, which underscore a calc-alkaline lineage (Fig. 3).

The AFM ternary diagram (Fig. 4) further delineates a dual trend toward both tholeiitic and calc-alkaline magmatism, implying the influence of varying degrees of mantle melting and potential crustal assimilation during magmatic ascent. The consistency of metaluminous to weakly peraluminous signatures across the studied samples observed through alumina saturation indices corresponds with typical subduction-related intrusives. Such values point to source magmas derived from an enriched lithosphe-ric mantle wedge, occasionally modified by recycled crustal inputs (Maniar and Piccoli, 1989; Barbarin, 1999).

The trace element distribution patterns show significant deviation from mid-ocean ridge or within-plate settings (Fig. 5). HFSE depletions (notably Nb, Ta, Ti) coupled with LILE enrichments (Cs, Rb, Ba) form a geochemical fingerprint characteristic of arc magmas, where slab-derived fluids contribute incompatible elements to the mantle source (Sun, McDonough, 1989).

The clear negative Nb–Ta anomalies support the hypothesis of a subducting slab's involvement, consistent with models of fluid-mobile element transport during subduction metasomatism (Pearce and Peate, 1995). This interpretation is reinforced by tectonomagmatic discrimination diagrams (Fig. 6) Ti–V, Ti–Zr, and Ti–Zr–Sr plots consistently position the samples within fields associated with island arc tholeiites and calc-alkaline basalts. The concentration of data in these fields underscores a magmatic origin rooted in arc-related tectonics, consistent with the geodynamic evolution of the Lesser Caucasus region during the Late Cretaceous (Adamia et al., 2010).

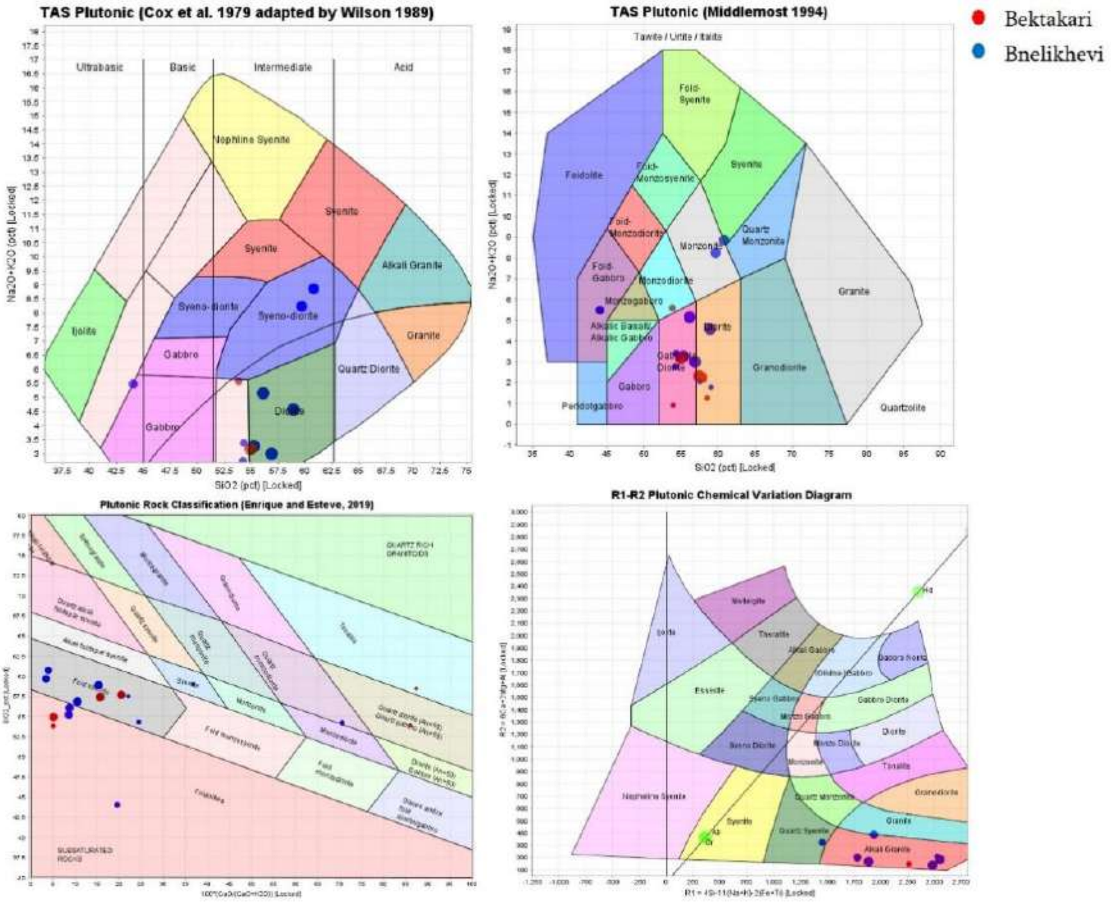

Fig. 3. Geochemical classification diagrams of intrusive rocks from the Bektakari–Bnelikhevi region. (Top left) Total Alkali–Silica (TAS) diagram after Cox et al. (1979) as modified by Wilson (1989), showing that most samples plot in the syeno-diorite to quartz diorite fields, consistent with intermediate plutonic compositions. (Top right) TAS classification scheme from Middlemost (1994), confirming the calc-alkaline nature of the samples and their distribution across quartz diorite, monzodiorite, and gabbro fields. (Bottom left) multi-parameter plutonic rock classification diagram integrating CaO–Na$_2$O–K$_2$O ratios and silica content, indicating a dominant cluster in the metaluminous, arc-related field. (Bottom right) R1–R2 classification diagram after De la Roche et al. (1980), further constraining the samples within the monzonitic to dioritic compositional range

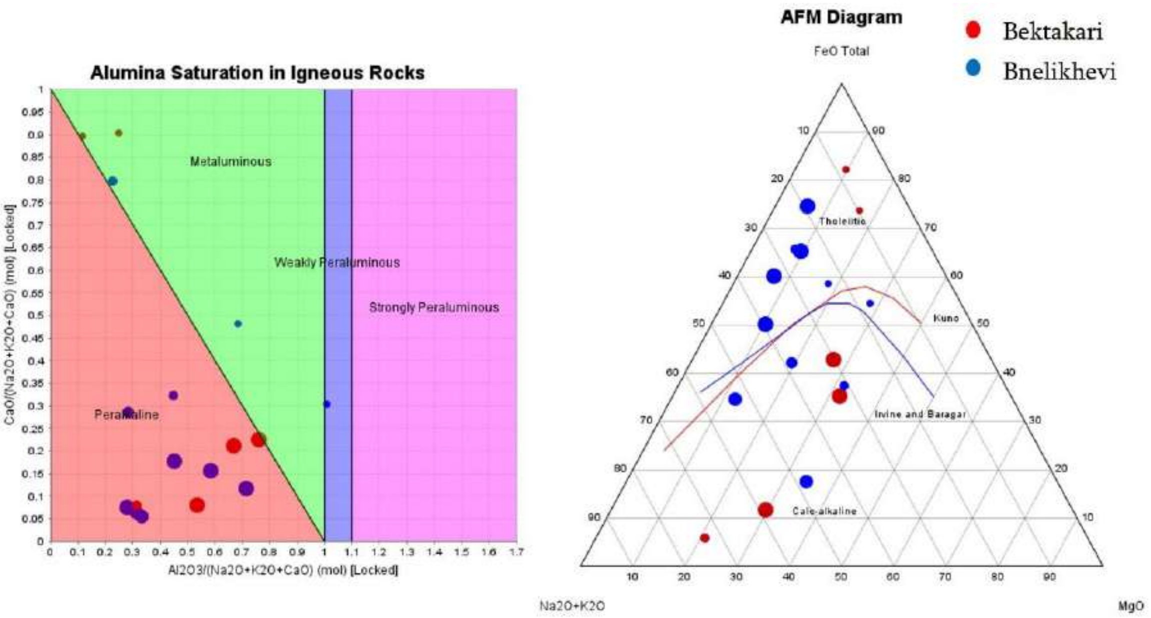

Fig. 4. Geochemical indicators of magmatic affinity and alumina saturation in intrusive rocks from the Bektakari–Bnelikhevi region. (Left) Alumina Saturation Index (ASI) diagram after Maniar and Piccoli (1989), plotting molar $Al_2O_3/(Na_2O + K_2O + CaO)$ versus $CaO/(Na_2O + K_2O + CaO)$, shows that the samples are predominantly metaluminous to weakly peraluminous, with minor peralkaline signatures. These characteristics are typical of arc-related calc-alkaline intrusions and suggest magma generation from a hydrated mantle wedge, variably influenced by crustal assimilation. (Right) AFM (FeO^*–MgO–($Na_2O + K_2O$)) ternary diagram modified after Irvine and Baragar (1971), indicating dual magmatic trends spanning both tholeiitic and calc-alkaline fields. This suggests varying degrees of partial melting and magmatic differentiation, consistent with subduction-modified arc environments.

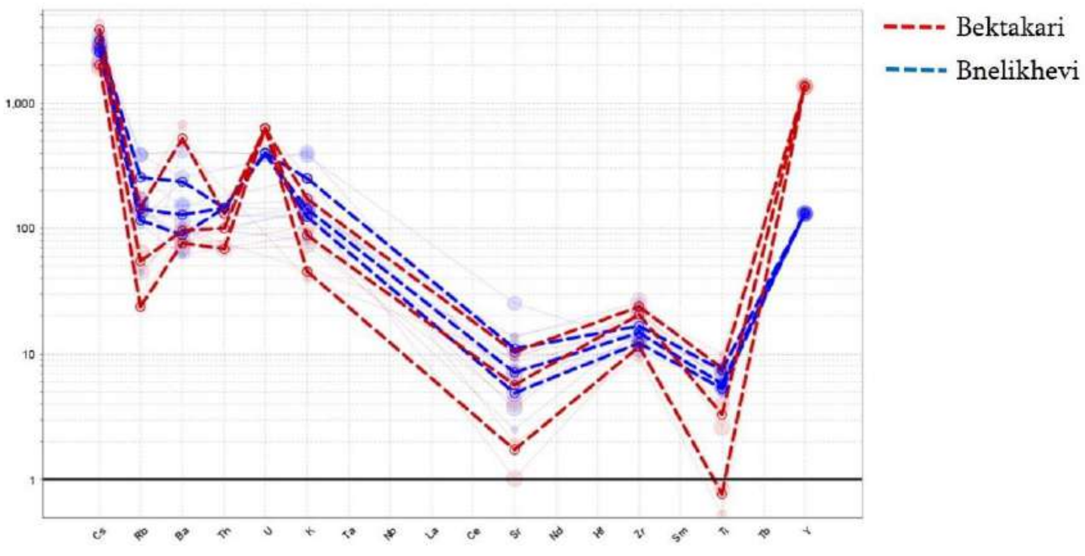

Fig. 5. Primitive mantle-normalised multi-element spider diagram of representative intrusive samples from the Bektakari–Bnelikhevi ore knot**,** showing trace element patterns for Bektakari (red dashed lines) and Bnelikhevi (blue dashed lines). Normalisation values are after Taylor and McLennan (1985)

The integration of mineralogical textural relationships and geochemical data suggests that mineralisation was genetically linked to the magmatic evolution of the host intrusions. The observed replacement textures and sulfide zoning are indicative of dynamic ore-forming processes driven by volatile exsolution and fluid phase separation from crystallising melts. These processes are typical of porphyry-style systems where magmatic fluids ascend and precipitate metals in structurally favorable zones (Richards, 2003). Notably, the temporal overlap between intrusive emplacement and ore mineral precipitation supports a synchronous magmatic-hydrothermal system. The presence of high-temperature minerals (pyrite, chalcopyrite) alongside secondary alteration products implies a downward temperature gradient, compatible with late-stage fluid evolution in an open hydrothermal system.

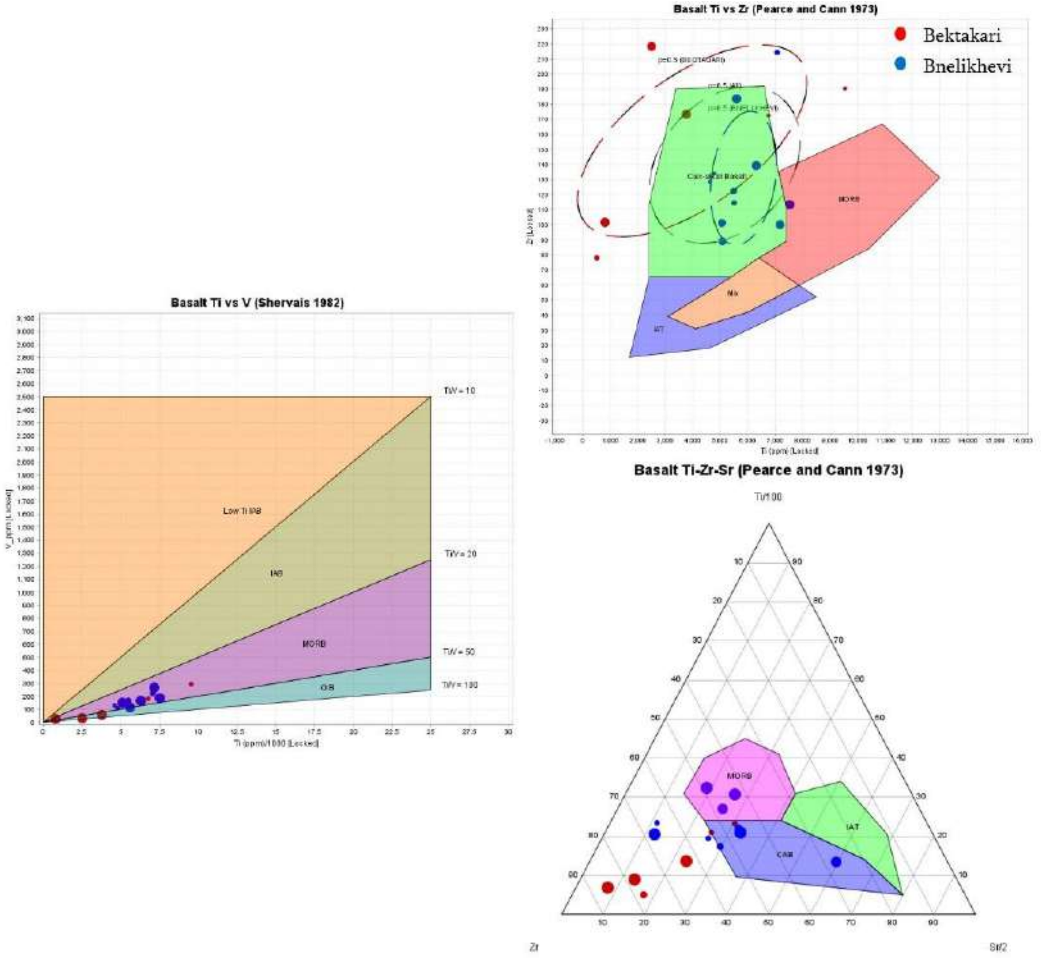

Fig. 6. Tectonic discrimination diagrams on intrusive and subvolcanic rocks from the Bektakari–Bnelikhevi region. (Top right) Ti vs Zr plot (Pearce and Cann, 1973) shows that most samples plot within the calc-alkaline basalt (CAB) and island arc tholeiite (IAT) fields, suggesting derivation from a subduction-modified mantle source typical of volcanic arc settings. (Top left) Ti vs V diagram (Shervais, 1982) further supports an island arc basalt affinity with most samples falling within the IAB field and exhibiting low Ti/V ratios, characteristic of fluid-fluxed mantle wedge magmatism. (Bottom right) Ti-Zr-Sr ternary plot (Pearce and Cann, 1973) demonstrates compositional clustering within the arc-related fields (CAB, IAT), reinforcing a tectonomagmatic environment influenced by subduction zone dynamics. These results collectively indicate that the Bektakari and Bnelikhevi magmatic systems are products of arc-related geodynamic processes

Discussion

The integrated mineralographic and geochemical data from the Bektakari–Bnelikhevi intrusive complex provide a coherent framework to understand the magmatic evolution, tectonic setting, and metallogenic significance of this ore-bearing system. The magmatism of the region reflects hallmark characteristics of subduction-related processes with implications for the broader metallogenic architecture of the Lesser Caucasus, a segment of the Tethyan Metallogenic Belt.

The compositional and tectonomagmatic characteristics of the studied rocks point toward a calc-alkaline suite formed in a convergent margin setting. This is evidenced by systematic enrichment in large ion lithophile elements (LILE: Rb, Ba, K, Th) and depletion in high field-strength elements (HFSE: Nb, Ta, Ti), which are geochemical hallmarks of arc magmatism (Sun and McDonough, 1989). The negative anomalies in Nb–Ta and Ti, paired with high Th/U ratios, are indicative of slab-derived fluids influencing the mantle wedge, resulting in the generation of hydrous, oxidised, and metal-fertile melts (Macpherson et al., 2006).

The AFM and R1-R2 trends, showing coexistence of tholeiitic and calc-alkaline characteristics, reflect a magmatic evolution pathway driven by varying degrees of partial melting, fractional crystallisation, and possible magma mixing. Such duality is typical in arc-front to back-arc transitions, where both fertile mantle sources and crustal assimilation exert control on magma chemistry (Dilek and Altunkaynak, 2009). The metaluminous to weakly peraluminous nature of the intrusive bodies, as suggested by the ASI plot, also aligns with arc-type granitoid series (Barbarin, 1999).

The mineral associations observed, primarily pyrite, chalcopyrite, sphalerite, and galena, display clear evidence of multiple hydrothermal pulses. Textural features such as replacement rims, intergrowths, and fine-grained dissemination indicate dynamic redox conditions during mineral deposition. These textures are consistent with ore-forming systems where metal precipitation occurs via sulfidation, boiling, and fluid mixing (Hedenquist and Lowenstern, 1994; Sillitoe, 2010).

Moreover, the close spatial and temporal relationship between the intrusive host rocks and mineralisation, as evidenced by replacement textures and ore distribution, suggests a genetic link to synmagmatic fluid release. This model aligns with globally recognised porphyry and epithermal systems, where metal transport and deposition are primarily driven by magmatic-hydrothermal fluids exsolved during magma crystallisation (Richards, 2003). The observed mineralogical zoning, from chalcopyrite-rich to sphalerite- and galena-dominated zones, likely reflects cooling gradients and progressive fluid-rock interaction.

The geochemical and mineralogical characteristics of the Bektakari–Bnelikhevi system are in strong agreement with other ore-bearing magmatic complexes within the Lesser Caucasus and East Anatolian Accretionary Complex. This region has been shaped by the long-lived subduction of the Neotethyan oceanic lithosphere and subsequent collisional events during the Late Cretaceous to Cenozoic (Adamia et al., 2010). Similar geodynamic processes are known to control porphyry and epithermal Cu-Au-Mo mineralisation throughout the Tethyan Belt, including in the Zangezur (Armenia), Çöpler (Turkey), and Bor-Madjanpek (Serbia) districts (Janković, 1997).

The tectonic discrimination diagrams (Ti–V, Ti–Zr–Sr) firmly place the Bektakari–Bnelikhevi rocks within the arc-related field, further supporting the regional-scale subduction imprint. The metallogenic evolution of this region thus reflects a classic model of arc magmatism, fluid-melt separation, and ore formation in an active continental margin, with Bektakari–Bnelikhevi representing a prospective segment within this system.

The identified mineral assemblages, fluid evolution textures, and magmatic geochemistry point to a metallogenically fertile magmatic system capable of concentrating Cu–Pb–Zn–Au metals. Given the compositional similarity to arc-related porphyry systems and the presence of ore-controlling structures, the Bektakari–Bnelikhevi zone holds significant potential for porphyry and epithermal-style mineralisation.

The identification of calc-alkaline, hydrous, and oxidised intrusions favorable for metal transport and precipitation supports exploration models that prioritise intrusive centers associated with LILE-enriched, HFSE-depleted geochemical signatures. Furthermore, the vertical mineralogical zoning observed suggests differences in mineralisation processes, where early magmatic-hydrothermal mineralisation is overprinted by lower-temperature, fluid-dominated alteration phases.

Conclusion

The Bektakari–Bnelikhevi intrusive system emerges from this study not simply as a site of mineral accumulation but as a complex and evolving geochemical environment, where magmatic and hydrothermal processes are intricately interwoven with the structural architecture of the upper crust. The system reveals internal coherence in its magmatic chemistry and external variability in its ore mineralogy, suggesting that metal deposition was governed less by single-event fluid pulses and more by protracted geodynamic conditions that preserved thermal and compositional gradients over time. This complexity does not imply chaos, but rather a subtle equilibrium between melt evolution, volatile segregation, and permeability structure, each contributing to metallogenic expression of the system.

While the available data shed light on the spatial and compositional patterns of the intrusive bodies and their associated mineralisation, they also underscore the limitations of a solely petrochemical and mineralographic perspective. The absence of temporal constraints inhibits a precise reconstruction of the mineralisation chronology. Moreover, the lack of direct fluid composition data leaves opens the question of the origin, temperature, and redox state of the hydrothermal solutions responsible for metal transport and deposition. These unresolved dimensions prevent full integration of the Bektakari–Bnelikhevi system into regional metallogenic models, particularly those concerning the diachronic evolution of arc-related porphyry systems in the Lesser Caucasus. To address these gaps, future investigations should move beyond static observations and embrace temporally and chemically resolved methods. Isotopic analyses of rocks and minerals would clarify the sources of magmas and fluids, while micro thermometric and stable isotope techniques could refine the conditions of ore precipitation. Establishing the timing of intrusive phases and mineralisation events would critically strengthen genetic interpretations and may even reveal episodic metal enrichment related to tectonic pulses. Additionally, integrating geophysical models with structural mapping and drill core analysis could illuminate the deeper architecture of the magmatic plumbing system, enhancing our understanding of how fluids migrated, pooled, and mineralised.

Acknowledgment

The authors express their sincere gratitude to Rich Metals Group (RMG) for providing access to geological and geochemical data, which served as a foundational resource for the completion of this research. The authors also acknowledge Caucasian Mining Group (CMG) for geological mapping materials and the geological map of the Bolnisi ore district used in this study.

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МАГМАТОГЕННО-ГИДРОТЕРМАЛЬНАЯ ЭВОЛЮЦИЯ И РУДНЫЙ ПОТЕНЦИАЛ КОМПЛЕКСА БЕКТАКАРИ-БНЕЛИХЕВИ, БОЛНИССКИЙ РУДНЫЙ РАЙОН, МАЛЫЙ КАВКАЗ

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Резюме. В данной работе рассматриваются петрологические, геохимические и геодинамические особенности интрузивных и субвулканических пород рудного узла Бектакари–Бнелихеви, расположенного в южной части Малого Кавказа. Исследование основано на детальном минераграфическом анализе 17 образцов горных пород, отобранных из 8 буровых скважин, а также на данных валового химического состава, полученных методом рентгенофлуоресцентной спектрометрии (XRF). Комплексное использование минераграфических наблюдений и геохимических данных позволило выявить особенности магматической эволюции интрузивных тел и связанных с ними процессов гидротермальной минерализации. Интрузивные породы характеризуются значительным текстурно-композиционным разнообразием и формируют кальциево-щелочную магматическую серию, связанную с субдукционно-модифицированным мантийным источником и взаимодействием мантийных расплавов с континентальной корой. Геохимические дискриминационные диаграммы демонстрируют обогащение крупноионными литофильными элементами (LILE) и обеднение высокозарядными элементами (HFSE), что характерно для магматических систем, формирующихся в условиях конвергентных окраин и островных дуг. Минералогические и текстурные особенности сульфидной минерализации, представленной пиритом, халькопиритом, сфалеритом и галенитом, свидетельствуют о многостадийной гидротермальной активности, тесно связанной с процессами кристаллизации магмы и последующей циркуляцией рудоносных флюидов. Установленные текстуры замещения и зональности минералов отражают динамические изменения физико-химических параметров рудоотложения. Полученные результаты подтверждают существование длительно функционировавшей магмато-гидротермальной системы, контролируемой структурными и термическими факторами. Рудный узел Бектакари–Бнелихеви рассматривается как перспективный участок в пределах тетисского металлогенического пояса и в контексте дуговых рудообразующих систем Малого Кавказа, что подчеркивает его металлогенический потенциал и значение для дальнейших геологоразведочных исследований.

Ключевые слова: *гидротермальное изменение, геохимия, минерализация, магматизм*

BEKTAKARİ-BNELIHEVİ KOMPLEKSİNİN MAQMATOGEN-HİDROTERMAL TƏKAMÜLÜ VƏ FİLİZ POTENSİALI, BOLNİSİ FİLİZ RAYONU, KİÇİK QAFQAZ

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Xülasə. Təqdim olunan məqalədə Kiçik Qafqazın cənub hissəsində yerləşən Bektakari–Bnelihevi filiz düyününün intruziv və subvulkanik süxurlarının petroloji, geokimyəvi və geodinamik xüsusiyyətləri araşdırılmışdır. Tədqiqat 8 qazma quyusundan götürülmüş 17 süxur nümunəsinin mineraloqrafik təhlili və rentgen-flüoresans spektrometriyası (XRF) vasitəsilə əldə edilmiş ümumi kimyəvi məlumatlarına əsaslanır. Mineraloqrafik müşahidələr və geokimyəvi analizlərin birgə tətbiqi intruziv süxurların maqmatik təkamül xüsusiyyətlərini və onlarla əlaqəli hidrotermal minerallaşma proseslərini daha dəqiq müəyyən etməyə imkan vermişdir. İntruziv süxurlar tekstur və tərkib baxımından müxtəlifliyi etdirir və subduksiya ilə modifikasiya olunmuş mantiya mənbəyi ilə əlaqəli kalsium-qələvi maqmatik sıra əmələ gətirir. Geokimyəvi diskriminasiya diaqramları iri ionlu litofil elementlərin (LILE) zənginləşməsini və yüksək yüklü sahə güclü elementlərin (HFSE) azalmasını nümayiş etdirir ki, bu da konvergent kənar və qövs tipli maqmatik mühit üçün səciyyəvidir. Pirit, xalkopirit, sfalerit və qalenitdən ibarət sulfid minerallaşmasının tekstur və paragenetik xüsusiyyətləri çoxmərhələli hidrotermal fəaliyyətin mövcudluğunu göstərir və maqmatik təkamüllə sıx bağlıdır. Əvəzlənmə teksturaları və mineral zonallığı filizəmələgəlmə proseslərinin fiziki-kimyəvi şəraitinin zamanla dəyişdiyini göstərir. Alınmış nəticələr uzunmüddətli fəaliyyət göstərmiş maqmatik-hidrotermal sistemin mövcudluğunu və onun struktur, tektonik və istilik amilləri ilə idarə olunduğunu təsdiqləyir. Bektakari–Bnelihevi filiz düyünü Tethys metallogenik qurşağı və Kiçik Qafqazın qövs tipli filiz sistemləri çərçivəsində perspektivli sahə kimi qiymətləndirilir və regionun metallogenik potensialının öyrənilməsi baxımından mühüm əhəmiyyət kəsb edir.

Açar sözlər: *hidrotermal dəyişiklik, geokimya, minerallaşma, maqmatizm*