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Mineralogical and geochemical characteristics of the Siahrudbar bauxite deposit, Golestan Province, north of Iran

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Abstract: The Siahrudbar deposit is located about 25 km southwest of Aliabad-Katool city in the Golestan Province, north of Iran. This deposit lies between the Triassic limestone (Elika Formation) and Jurassic sandstone (Shemshak Formation). Mineralogical studies indicate the presence of major minerals such as diaspore, hematite, anatase, kaolinite, and chamosite accompanied by minor minerals such as boehmite, goethite, rutile, calcite, moscovite, clinoclar, quartz, and tridymite. Calculation of enrichment factor showed that the bauxitization processes at Siahrudbar were accompanied by enrichment of elements such as Al, Fe, Ti, V, Cr, Co, Ni, Ga, Th, U, Y, Zr, Ta, Nb, Hf, and REEs. While elements such as Si, Mg, Na, K, P, Ba and Rb were leached out of the profile and suffered depletion. Futhermore, elements like Ca, Mn, Sr and Cs experienced both partial leaching and fixation. Based on the results of geochemical studies, changes in pH and Eh of the weathering solutions, adsorption, presence of organic matter, function of carbonate bed rock as a geochemical barrier, existence in resistant minerals, and fixation in neomorph mineral phases played crucial role in distribution of the trace and rare earth elements in the studied ores. Consideration of the correlation coefficients among elements demonstrated that the neomorph phosphate minerals can be conceived as the potential host of rare earth elements.

Keywords: *Bauxite; Siahrudbar; Golestan province, trace and rare earth elements; Ce and Eu anomalies; Enrichment factor.*

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Mineralogy, geochemistry and conditions of formation of The Band -e-GhichyCopper-Celestite deposit Torud area, South of Shahrood

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Abstract: Band-e-Ghichy copper deposit is located in the northern margin of the Central Iran structural zone, about 120 km south of Shahrood and 70 km south east of Torud. Copper mineralization occurred in the rock units including sandstone, conglomerate and siltstone with the Oligocene age. Mineralization has occurred in the form of stratiform (syngenetic), stratabound (epigenetic) and supergen (the surface processes). The minerals forming the deposit include sulfide (chalcocite, covellite, bornite, chalcopyrite and pyrite) and carbonate (malachite and azurite) minerals. The main mineralization forms in the reduction zone as well as in the red formations and is controlled by permeability, the content of organic materials and sulfides in the host rock. Due to the expansion of Eocene andesitic lavas in the adjacent area of the deposit and the presence of volcanic fragments containing copper-bearing minerals in host conglomerate units, it can be concluded that the source of copper in the region is attributed to volcanic units. Based on geochemical studies, sandstone of the region have a felsic to intermediate source rocks and the copper element in the base metals has the highest production coefficient (4 to 8 weight percent) and shows the highest correlation with silver. According to the basic characteristics of Band-e-Ghichy copper deposit such as host rock, mineralogy, structure and texture, companion elements, depositional environment and important mineralization factors, this deposit can be considered as a copper deposit with a sedimentary host and red bed type.

Keywords: *Copper; Sandstone; Oligocene; Red bed; Band-e-Ghichy; Torud.*

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Mineralogy and fluid inclusion investigations in the Zarshuran gold deposit, north of Takab, NW Iran

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Abstract: The Zarshuran Carlin-type gold deposit is located about 30 km north of Takab, West-Azarbaidjan Province, NW Iran. Interaction between the ore-forming fluids and the host carbonates and shales resulted in development of the decarbonatization, argillic, alunite, silicic, and sulfide alteration zones in the study area. Based on mesoscopic and microscopic studies on drill core samples, gold mineralization is mainly associated with Au-bearing pyrite and arsenic-containing pyrite generated during two stages. The mineral assemblages associated with these stages are As-bearing pyrite, realgar, orpiment, cinnabar, stibnite, and colloform sphalerite together with lesser amounts of sulfosalts (tetrahedrite and getchellite) intergrown with jasperoid and quartz. The microthermometric studies on liquid-rich 2-phase fluid inclusions in euhedral quartz crystals intergrown with the Au-bearing sulfides showed that the ore-forming fluids had an average homogenization temperature (T_h) and salinity of about 260°C and 9.2 wt% NaCl equivalent, respectively. The variation trends in salinity and T_h of fluid inclusions could be explained by a combination of mixing and dilution of ore-bearing fluids with subsurface waters of meteoric origin. These processes were likely the principal cause for instability of Au-bearing complexes and hence gold deposition in the veins/veinlets. In addition, on the basis of the obtained pressures from microthermometric data the estimated depths for ore formation were within the range of 160 to 300 meters correlated with 40 to 75 bars, which is in agreement with some known Carlin-type gold deposits. In general, the geological, mineralogical, textural, and microthermometric data provided sufficient evidence to categorize the gold mineralization at Zarshuran as Carlin-type.

Keywords: *Carlin; gold mineralization; fluid inclusions; Carlin-type; sulfosalts; Zarshuran*.

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Investigation of genesis and fluid origin in Noghduz gold bearing quartz veins, East Azarbaijan Province, northwest of Iran

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Abstract: The Noghduz prospecting area, as a part of the Arasbaran metallogenic zone is located about 20 km east of Ahar, East-Azarbaijan Province. The mineralization host rocks are andesite-trachy andesite with the age of Late Eocene. The hydrothermal alterations exposed in this area are silicic, argillic, and propylitic. Pyrite is the main hypogene sulfide mineral which is accompanied by lesser amounts of chalcopyrite and bornite. The most important supergene minerals in this area are iron oxyhydroxides (hematite, limonite and goethite) and malachite that accompany the hypogene mineral assemblage. Gold mineralization occurred within quartz-sulfide veins/veinlets in this area. The microthermometric measurements in the primary 2-phase (L+V) fluid inclusions in quartz crystals associated with mineralization indicate that the mineralizing fluids had temperatures and salinities within the range of 160-334°C and 0.53-3.39 wt% NaCl equivalent. respectively. The presence of hydrothermal breccias, pseudomorph of quartz after bladed calcite, and mono-phase gas inclusions are indicative of boiling of the hydrothermal fluids responsible for mineralization. The sulfur isotopic analysis of pyrite shows that the values of isotopic composition of this element is close to the range of magmatic source. Also, the oxygen and hydrogen isotopic data demonstrated that the meteoric waters constituted a great portion of the ore-bearing fluids at Noghduz area. The presence of structural and textural evidence along with fluid inclusion studies (salinity and homogenization temperature) indicate that the gold mineralization at Noghduz area is of epithermal type.

Keywords: *Fluid inclusions; stable isotopes; epithermal gold; Noghduz; Ahar; East-Azarbaijan.*

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Mineral chemistry and thermobarometry of amphibolites from the Qotur metamorphic complex (West Azerbaijan Providence, NW Iran)

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Abstract: The Qotur metamorphic complex consists of metabasites, gneisses, marbles and calc-silicates as well as serpentinites which is cropped out at the west border of West Azerbaijan and Turkey. The amphibolites from the Qotur metamorphic complex can be classified as two types of ortho- and para-amphibolites. Minerals in this ortho-amphibolite are hornblende, plagioclase, zircon, titanite, and opaque minerals. The para-amphibolites are characterized by presence of calcite and quartz in addition to amphibole and plagioclase in their mineral assemblages. Tremolite/actinolite, chlorite and sericite are the retrograde phases of the green schist facies. Granoblastic and nematoblastic textures are the common textures of these rocks. Investigation of mineral chemistry and P-T estimations of amphibolites are the aim of this project. Based on electron microprobe analyzes on amphibolites, the amphibole and plagioclase compositions are determined as magnesio-hastengsite and oligoclase, respectively. Plotting of amphibole and titanite compositions on Ti vs. Si and Fe vs. Al diagrams respectively, shows their metamorphic genesis. The thermobarometry results of amphibolites have been obtained on the basis of amphibole and plagioclase compositions as well as utilizing of petrogenetic grids and experimentally determined phase diagrams. The peak metamorphic temperatures and pressures are estimated about 550-650°C and 6-8 Kb .The geothermal gradient is calculated about 25 °C/Km for the obtained temperatures and pressures which corresponds with continental collision conditions. It seems that Cretaceous closure of the Neotethys and its subsequent continental collision during Late Oligocene- Miocene formed the studied amphibolites at the continental crust of the Qotur area.

Keywords: *Amphibolite; mineral chemistry; thermo-barometry; Qotur; NW- Iran.*

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The Malayer plutonic complex: field geology, petrography and geochemical interpretation

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Abstract: The geochemical signatures like discordant variation of major and trace elements among felsic-intermediate and basic rocks and mafic enclaves of Malayer region on binary variation plots, decreasing values of FeO_t, TiO_2, MgO, MnO and CaO accompanied with increasing of SiO_2 content from basic to felsic rocks, and decreasing Ni, Cr and Co with increasing SiO_2 are considered as indications of magma mixing/mingling event in the petrogenesis of high potassium calk-alkaline granitic rocks of the Malayer region. Felsic and basic rocks of Malayer pluton show different REE pattern (LREEs/HREEs), where Eu-anomalies values such as La_N/Sm_N content as an index for concentration of LREEs and Gd_N/Yb_N content as an index for the concentration of HREEs are different. The relative enrichment in LILEs (e.g. U, Th, Ba, Rb, Cs, K) than HFSEs (Y, Yb, Zr, Ti, Tb, etc), constant variation of compatible elements (such as V, Ni, and Cr) in the differentiated phases, and negative anomaly of Nb and Ta can be attributed to the role of the components from the subducted oceanic plate as long as crustal components in the formation of granitic magma. The results show that magmatic differentiation associated with crustal contamination and partial mixing (or mingling) is responsible for the formation of granitic and dioritic intrusions, while magmatic enclaves are generated by magma mixing process. Negative Eu-anomaly in the felsic-intermediate rocks with respect to their concordant REEs variations suggests plagioclase fractionation plays role in their petrogenesis. The non-concordant REEs variations and less enriched LREEs in basic rocks are consistent with partial melting process of an ultrabasic source. The heat transfer and further crustal anatexis may lead to extensive granitization. The mixing of basic magma and anatectic melts is suggested as being responsible for the generation of microgranular mafic enclaves and basic dykes.

Keywords: *Malayer plutonic rocks; magma mixing; magmatic fractionation; partial meltig.*

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Microstructure and chemical changes of sepiolite and vermiculite clays on the effect of elements adsorption

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Abstract: One of the applicable methods to control the pollution of heavy metals is the use of an adsorbent mineral. The aim of this research is to investigate the effect of Nickel and Zinc elements on microstructure properties of sepiolite and vermiculite clay minerals. To address the absorption experiment studies, four treatments (vermiculite, vermiculite + sand soil, sepiolite and sepiolite + sand soil) with six concentrations (0, 0.0001, 0.0005, 0.005, 0.01, 0.05 M) of Zn and Ni solutions were used. Based on the results, the adsorption process of Zinc was found to follow the Freundlich isotherm model, while the Langmuir equilibrium isotherm fit the experimental data of Nickel reasonably well. In addition, sepiolite and vermiculite soils revealed better adsorption capacities for Nikel and Zinc element, respectively. The X-ray micrographs showed that with increasing Nickel and Zinc pollutants concentration, mineral plates expanded and consequently the structures changed. Generally, it could be concluded that both clay soils had substantial adsorption power of pollutants and their microstructure was the main factor for this mechanism.

Keywords: *Adsorption; d-spacing; pollutant; clay minerals.*

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Petrogenesis of pillow lavas based on mineralogical and geochemical data in the eastern part of Sabzevar ophiolite

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Abstract: Sabzevar ophiolitic pillow lavas contain variolitic, porphyritic with microlitic matrix, intersertal and amygdaloidal textures and include plagioclase, clinopyroxene (augite-diopside), olivine, amphibole (magnesiohastingsite) and opaque minerals. The chemical composition of clinopyroxenes show a calc-alkaline magmatic series and a tectonic environment within plate alkaline basalts. Geochemically, these rocks are divided into two groups. Group 1 is basically calc-alkaline andesite with low TiO_2 and group 2 is alkali basalt with high TiO_2. N-MORB normalized trace elements diagram shows that group 1 is enriched in Th, U, La and depletion in Ta, Nb, Ti and group 2 is enriched in Th, Ta and Nb. Calc-alkaline rocks have produced in a subducted tectonic environment by a continental crust and erupted southwards on the Turan plate. In contrast, alkaline rocks formed within plate oceanic and then tectonically accreted in the forearc setting.

Keywords: *Sabzevar ophiolite; pillow lava; mineral chemistry; Mesozoic; northeast Iran.*

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Damanghor intermediate sulfidation epithermal Au mineralization, Northern Bardaskan: geology, alteration, mineralization, and geochemistry

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Abstract: The Damanghor gold mineralization occurrence is located in north of Bardaskan, Khorasan Razavi Province, and Taknar zone.The geology of the area consists of Precambrian green sericite schist and metarhyolite, intruded by diabase. Mineralization in this area is in vein form with N50E stribe and 70NW dip and hosted by schist and metarhyolite with 300 meters length and 2 to 35 meters width. Disseminated and veinlet mineralization includes primary minerals of pyrite and chalcopyrite and secondary minerals such as covelit, malachite, azureite, hematite, goethite and limonite with quartz, sericite, and lesser clay minerals. Silicic-sericitic alteration is the most important alteration zone associated with mineralization. Based on rock samples taken from explorative trenches, gold anomalies range from 0.3 to 12.5 ppm, silver up to 30 ppm, copper up to 860 ppm, and zinc about 9252 ppm.Based on the evidence of host rock, the type and extent of alteration, structural control, shape and type of mineralization and primary minerals and geochemical anomalies, the occurrence of Damanghor gold mineralization is epithermal with intermediate sulfidation state that is related to hydrothremal derived from Cenozoic magmatic activities.

Keywords: *Mineralization; alteration; geochemistry; intermediate-sulfidation state; epithermal gold; Damanghor; Taknar Structural zone.*

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Biotite and feldspar chemistry: An approach to the petrogenesis of the Gapdan pluton (NW of Zahedan)

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Abstract: The 43Ma Gapdan granitoid pluton is a part of Zahedan-Saravan granitoid belt and is located about 50 km NW of Zahedan. The pluton is mainly composed of biotite granite and granodiorite in composition and consists of quartz, plagioclase, K-feldspar, biotite, Fe-Ti oxides, zircon, apatite, and allanite. The granitoid rocks are mainly granular in texture, although they display poikilitic, perthite and myrmekite textures. The present paper aims to determine nature, the physico-chemical of crystallization and tectonic setting of the pluton based on mineral chemistries of biotite and feldspar. The biotite chemistry represents that the pluton is I-type and calc-alkaline which formed in an active continental margin. Biotite thermo-barometry presents that the mineral has been crystalized at 850 ^{o}C and 2-5 kbar, while two-feldspar thermometry shows temperatures of 555-734 ^{o}C which is a subsolidus re-equilibrium temperature of elements for Gapdan granitoid rocks. The pluton hosted lots of sedimentary and igneous enclaves, suggesting the parent magma was contaminated with country rocks during ascending and emplacement.

Keywords: *Mineral chemistry; biotite granite; granodiorite; Gapdan; Zahedan.*

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Mineral chemistry, thermobarometry, petrogenesis and tectonic setting of the Nokeh intrusion in the northern Semnan (Central Iran)

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Abstract: The Nokeh intrusion exposed in the northern Semnan area. The intrusion is composed of monzonite-quartz monzonite and granite-granodiorite and was intruded in the Eocene carbonaceous tuffs, where the country rocks converted to magnetite-skarn. Plagioclase, orthoclase, quartz, biotite, amphibole and clinopyroxene are the constituent minerals of Nokeh intrusion. The study rocks represent granular, granophiric and mirmekitic textures. The Nokeh intrusion is metaluminous to peraluminous, calc-alkaline, I-type and belongs to subalkaline magmatic series. Based on EMPA data, clinopyroxenes, amphiboles, biotites and plagioclases are diopside, edenite, Mg-biotite and oligoclase to labradorite in compositions and formed in temperatures ranged from 1110 to 1160, 700, more than 800 and less than 700 °C respectively. Clinopyroxene, amphibole and biotite calc-alkaline affinity, low Ti and Ca-Si enrichment in the clinopyroxene composition and amphibole formation in a high-fugacity environment, confirm that Nokeh intrusion formed in a magmatic arc of active continental margin. On the basis of tectonic discrimination diagrams, the investigated samples fall into volcanic arc domain resulted in subduction of Neothetian oceanic lithosphere beneath Central Iran block.

Keywords: *Granitoid; mineral chemistry; thermobarometry; metaluminous; I-type; volcanic arc; Nokeh; Semnan.*

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Mineral chemistry and physical conditions of crystallization in Filshour and Goft dioritic intrusions, Southwest of Sabzevar

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Abstract: The Late cretaceous dioritic intrusions of Filshour and Goft in southwest of Sabzevar are situated in the northern edge of central Iran zone. The rocks of these plutons show porphyry, granular, ophitic and subophitic textures and are composed of amphibole, plagioclase and clinopyroxene (in diorites), along with quartz (in quartz diorites). The amphiboles of these rocks are in the group of calcic amphiboles and Mg-hornblende type. Plagioclase composition ranges from anorthite to labradorite. The obtained equilibrium and closing temperatures and pressures in amphiboles and plagioclases based on different thermo-barometery methods are in the range of 763-918 Cº and 3-5.5 Kb (10-18 Km depths). The Pyroxenes are in the range of Ca-Mg-Fe pyroxenes with augitic composition and crystallized from a magma under the high oxygen fugacity in 2-5 Kb pressures and 1000-1100 ºC temperatures. The amphibole and pyroxene chemistries indicate the subalkaline nature of the magma and a subduction related magmatic arc setting for these intrusions that is compatible with the intra-oceanic island arc environment of the Upper Cretaceous magmatic rocks of the supra-subduction oceanic basin of Sabzevar.

Keywords*: Mineral chemistry; thermobarometery; dioritic intrusions; Sabzevar; Iran.*

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Crystal size and shape distribution of plagioclase in the basaltic andesites, North of Gavkhouni

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Abstract: Plagioclase is the most abundant mineral in basaltic andesites in the north Gavkhouni. Olivine and pyroxene are the other rock forming mineral there. In their 3-dimensional shapes, they are unequal and varies between bladed to prolate. Plagioclase sometimes exhibit dusty texture, oscillatory zoning and sinusoid growth. Based on crystal size distribution data, the rate of crystal nucleation of plagioclase varies between $2.77*10^{-8}$-$3.07*10^{-8}$ $mm^{-3}s^{-1}$ in 71.78 - 17.77 years. The results indicate the higher nucleation rate, rapid cooling and a short crystal residence time in the magma chamber. The crystal size distribution diagrams show the high frequency of smaller crystals and the coarsening of the average crystals. However, the presence of two populations of plagioclase indicates the interfering of new magma with the same chemical composition and new crystal population into the magma chamber. This event can increase the volume of the magma chamber pressure and eruption of the magma.

Keywords: *Basaltic andesite; crystal size distribution; crystal residence time; plagioclase.*

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Apatite as a main source of REE during crystallization of monazite mineral in Esfordi Fe-Apatite deposit, northeast of Bafq

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Abstract: The Esfordi deposit is located at northeastern Bafq and is one of the well-known magnetite-apatite deposits in the area which consists of ore minerals hosted REE. Among the various ore minerals, apatite is one of the unique minerals because of its significant properties such as providing a budget of elements (especially in the case of REE), stability over widespread temperature and pressure domains and exclusively ionic interchanges as a respond to re-equilibrium with new environment. All of which can fit the apatite as a main source feeding the new mineral nucleation like monazite during a hydrothermal alteration. Based on petrography and geochemistry studies, mineralization of four generation apatite accompanied with dropping of REE amount in each stages and increasing of residual Ca and P in the next generations. In contrast, culminating amount of REE beside Na, F and limited Cl reached in nucleolus monazite and led to the formation of two generation of monazites. On the BSE images of apatite, the depleted areas are associated with micro-channels and micro-pores containing monazite. Consequently dissolution of nucleolus monazites provides a well chance to form the second generation of monazite as bigger grain than the first ones.

Keywords: *Apatite; monazite; rare earth elements; Esfordi Fe-Apatite deposit; hydrothermal alteration.*

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Petrography, geochemistry and determination of temperature and pressure of crystallization of pyroxene and plagioclase minerals in diabasic and lamprophyre dykes of Jupar block (south of Kerman)

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Abstract: A set of diabasic and lamprophyre dykes, trending NW-SE, cut the Neogene volcanic rocks that exposed in the south of Kerman city and west of Glomac village. They are characterized by porphyritic and glomeroporphyry textures. Lamprophyres contain course-grained phenocryst of olivine- pyroxene- amphibole in a matrix containing feldspars. diabasic rocks are dominated by main minerals including diopside and feldspar. Thermo-barometric studies of pyroxenes show that the rocks under discussion have formed under pressure of 6 Kb and temperature of 1200°C. Thermometry of the feldspar in dykes show 500- 650 °C. This low temperature caused changes in the freezing point of the feldspar composition during crystallization. Based on the pyroxene chemistry and tectonomagmatic environment diagrams, all of studied samples plot in the island arc setting of a subduction zone and show active continental setting characteristics. The primary magma of the studied rocks is the melting of a lherzolite garnet mantle source.

Keywords: *Diabae; lamprophyre; alkaline; garnet mantle; Central Iran; Jupar.*

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Characteristics of the ore- bearing quartz veins using fluid inclusions, Andarian, NW Iran

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Abstract: Andarian area is located north of Tabriz city, north west Iran, and tectonically is a part of Ahar-Arasbaran magmatic belt. Geology of the area includes Miocene shallow pluton, Cretaceous flysch-type sediments, metamorphic rocks (hornfels and skarn) and volcanic rocks. Mineralization occurred in two stages: primary and secondary. The primary ore minerals include Au, pyrite and stibnite. Malachite, azurite and iron-hydroxides are the main minerals of the secondary phase. Two phases of liquid-rich and gas-rich inclusions are the most common type of inclusions. The average formation temperature of quartz-gold vein deposit is 237°C with low salinity (with an average of 8.7 wt% NaCl equivalent). The pressure of entrapment for fluid inclusions is between 26 to 51 bars, which is equal to the depth of 270-550 m. Based on fluid inclusions studies, the gold bearing quartz veins formed in epithermal condition.

Keywords: *Quartz; fluid inclusion; gold mineralization; Andarian*.

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Deposition and characterization of SnO_2:Sb thin films fabricated by the spray pyrolysis method

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Abstract: In this study, thin films of transparent semiconductor tin oxide doped with antimony impurities on the glass substrates with different concentrations of antimony that have been prepared using spray pyrolysis method. The effects of different concentration of antimony on the structural, optical, and electrical properties of the thin films were investigated. Prepared layers were characterized by X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM) and optical absorption (UV-vis). XRD analysis showed that samples have polycrystalline with orientations (110), (101), (200), (211) and (301) that was related to tin oxide phase. With increasing concentrations of antimony overall average size of nano-crystalline grains increased and the average grain size increased-decreased. Optical studies of samples showed that, increasing of antimony concentration caused reduction of transmission in the range of visible light from 72% to 15% and the optical band gap from 3.72 to 2.98 eV. Increasing of antimony concentration led to increasing-decreasing behavior of electrical resistance. Thermoelectric studies of samples revealed n-type conductivity in them.

Keywords: *thin film; tin oxide; antimony impurity.*

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The effect of Ga-doping on the structural and optical properties of ZnO thin films prepared by spray pyrolysis

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Abstract: In this research, zinc oxide thin films with gallium impurity have been deposited using the spray pyrolysis technique. The structural and optical properties of these films are investigated as a function of gallium doping concentrations. The ZnO and ZnO:Ga films grown at a substrate temperature of 350 ºC with gallium doping concentrations from 1.0 to 5.0.%. The XRD analysis indicated that ZnO films have nanocrystalline wurzite structure with (002) preferential orientation and grain size varied from 39.1 to 16.1 nm. The optical properties of the thin films have been performed using UV-Vis spectrophotometer and band gap energy values are determined. The results show that the transmittance of these films was higher than 90% in the visible region and by adding Ga up to 5.0%, band gap films have been increased.

Keywords: *Zinc Oxide; spray pyrolysis; Gallium doping; thin films; band gap energy.*

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