地球史における花崗岩系列と関連する鉱化作用
The Granitoid Series and Related Mineralization in the Earth History

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Granitoids distributed in the Inner Zone of SW Japan were identified to have the accessory components of magnetite and ilmenite to the north, but only small amounts of ilmenite toward the south in 1971, then named later as “magnetite-series and ilmenite-series” granitoids. Associated ore deposits also show characteristic minerals. Native sulfur was mined nearly all from the Quaternary magnetite-series volcanic belts. Native Au-Ag (typically argentite AgS) deposits occur in Neogene to Quaternary magnetite-series terranes. Cu (typically chalcopyrite $CuFeS_2$) -Pb (galena PbS) -Zn (sphalerite, ZnS) and Mo (molybdenite, MoS_2), occur also as sulfides in vein and skarn types of the late Cretaceous to Neogene magnetite-series igneous terranes. On the other hand, the ilmenite-series ores are characterized by none sulfide mineral commodities, such as cassiterite (SnO_2) and wolframite ($(Fe,Mn)WO_4$) and scheelite ($CaWO_4$). Therefore, distribution of sulfur in the magmatic stage is the key to the metallogeny of the two series.

Oxidation status of the earth surface has been changed in the earth history. The oldest foliated granitoids in the Greenland showed low Fe_2O_3/FeO ratios equivalent to the ilmenite series. In the Berberton region of South Africa, the Archean TTG suites appear to belong also to the ilmenite series, but pink granites younger than 3.0 Ga were found to be the first magnetite series.

In the western Australia, aeromagnetic map shows the Archean Pilbara craton of the ilmenite-series granitoids, but Proterozoic Yilgarn craton is composed dominantly of the magnetite-series.

Au-mineralized sheared zones are hosted in the green stones, with the Au-mineralizing systems: a broadly uniform, low to moderate salinity, mixed aqueous-carbonic fluid capable of carrying Au, but limited capacity to transport base metals. The oldest Sn deposits are known to occur together with biotite and aplitic granites of 1.8 - 1.6 Ga (Rb-Sr), within the Bushvelt ultramafic to mafic body. These granitic magmas were found partial melting products of the middle crust by heat brought-up by the Bushvelt ultramafic magmas. The oldest Li-mica pegmatite-bearing dikes (age: 2.5 Ga) have been mined in the western Australia.

キーワード：花崗岩系列、硫化物鉱化作用、酸化物鉱化作用
Keywords: Granitoid series, Sulfide mineralization, Oxide mineralization

花崗岩系列と花崗岩成因論

Granite-series and the origin of granitic magma

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磁鉄鉱系列・イルメナイト系列花崗岩類（花崗岩系列）は地域スケールで帯状配列し、活動年代によっても系統的に変化する。したがって、両系列の成因は上部地殻での局所的な現象ではなく、花崗岩質マグマの起源に密接に関連している。日本列島の花崗岩類の各種データをコンパイルすると、花崗岩類の活動度と沈み込み速度に正の相関があり、95-85Maに主にイルメナイト系列花崗岩からなる活動の極大期が認められる。イルメナイト系列の割合は110Ma頃に急上昇し、70Ma頃に急減する。イルメナイト系列のSr同位体初生値は、白亜紀に規則的に上昇するが、磁鉄鉱系列は時代にかかわらずほぼ安定している。Nd同位体初生値もほぼ同様な傾向を示す。このことは、花崗岩質マグマへの堆積岩類の同化率が白亜紀に規則的に上昇し、70Ma付近で下降することを意味する。このような現象は、海嶺の沈み込みによる下部地殻の部分溶融やマグマ溜まりと壁岩との反応では説明が困難である。
Sr-O同位体ダイヤグラムにおいて、一部の高Sr岩体を除く大部分の花崗岩類はsource contaminationを示す曲線（下に凸）に調和的である。また、Sr-Nd同位体初生値ダイヤグラムにおいても、大部分の花崗岩類は極めて枯渇した物質と堆積岩類との同化分別作用によって形成されたことを示唆する。これらのデータを整合的に説明するには、堆積岩類とマントル物質が反応しつつマグマが形成されるセッティングが必要である。この堆積岩類は、比較的均質で普遍的に存在し、マグマ形成場にまでもたらされる必要があることから、沈み込み堆積岩類と判断される。したがって、日本列島における花崗岩系列は、主としてマグマ形成場における初源マグマと沈み込み堆積岩類の反応率に依存すると推察される。また、花崗岩質マグマの原物質は、下部地殻ではなくマントル物質と反応した沈み込み堆積岩類が主体である可能性が高い。

キーワード：花崗岩、日本列島、沈み込み帯
Keywords: granite, Japan Arc, subduction zone

北海道北部・歌登金鉱床の熱水変質作用・鉱物記載と鉱床形成条件
Hydrothermal alteration, mineralogical description and ore-forming conditions of the Utanobori gold deposit in northern Hokkaido, Japan

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The Utanobori gold deposit is a low-sulfidation type epithermal gold deposit located in northern Hokkaido, Japan. In this study, we investigated geological features of gold-mineralized quartz-adularia veins and hydrothermally altered host rocks from viewpoints of mineral association and paragenetic sequences, bulk chemical compositions, mineral chemical compositions and physicochemical conditions in order to reveal characteristics of gold mineralization and ore-forming environment.

The study area and its surroundings are composed of slate of the Cretaceous to Paleogene Hidaka Supergroup, the Miocene Esashi Formation, the Kemomanai Lava, the Kinkomanai Lava, the Pliocene Penke Formation and the Quaternary terrace and alluvial deposits (Osanai et al., 1963). The gold-mineralized quartz veins are hosted in silicified conglomerate, sandstone, mudstone and tuff of the Esashi Formation. Previous studies based on K-Ar dating reported an ore-forming age of 12.1±0.6 Ma on adularia from the Utanobori deposits, and a same formation-age of 12.1±0.6 Ma on a bulk dacite from the Kinkomanai Lava (Ministry of International Trade and Industry (MITI), 1997).

The Esashi Formation, host rocks of mineralization in the Utanobori deposit, shows hydrothermal alteration with zoning distribution such as 1) quartz + K-feldspar ±chlorite-smectite mixed layer, 2) quartz + K-feldspar + illite ±smectite, 3) quartz + kaolinite ±illite ±smectite, and 4) quartz + plagioclase + chlorite-smectite mixed layer ±calcite, in order from the silicified zone to the periphery zone.

A representative high Au-Ag grades quartz-adularia vein shows three mineralization stages of Stages I, II and III with subdivided twelve sub-stages. Among them, the Stages I and II are the main gold mineralization stages. The veins are composed of gangue minerals of quartz and adularia and ore-minerals of electrum, naumannite, chlorargyrite and Fe-Sb-oxide or hydroxide. Quartz shows fine-grained equigranular, mosaic, microcrystalline, colloform and comb textures. Electrum shows average Au/(Au+Ag) compositions of 52.5, 65.7 and 55.5 atomic % in the Stage I-b, Stage I-d and Stage II-a, respectively. XRF spot analysis along the mineralization sequences revealed that 1) the amount of adularia gradually decreases from the Stages I to III, 2) the gold deposition is not directly associated with adularia, and 3) the highest concentrations of Au, Ag, Se and Sb were observed in a sulfide band of the Stage I-d. On the basis of the fluid inclusions microthermometry data by MITI (1997), frequent ranges of homogenization temperatures are 260-270℃ and 220-230℃ in the Stages I and III, respectively. Fugacity of selenium based on the electrum tarnish method was estimated to be $\log f\mathrm{Se}_2$ = -14.2 to -12.8 and -13.1 to -11.6 atom for the Stages I-b and I-d, respectively.

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キーワード：歌登鉱床、浅熱水金鉱化作用、熱水変質作用
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Geochemical mapping using surface water and stream sediments of the mineralized Lom Basin, East Cameroon.

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The Lom Basin is heavily mineralized especially in gold owing to its regional geological setting. Consequently, most research in this region have reported either the rock type, age, and the formation history or the reconnaissance gold investigations. However, the geochemical database of the area is scanty and no regional geochemical mapping has been performed. Although this area has a long artisanal mining history and is a major target for industrialized mining, pollution studies have received limited attention. The present study seeks to i) conduct a systematic stream water and bottom sediment sampling in the area based on the International Geological Correlation Programme (IGCP, 1995) recommendations; ii) determine trace element levels in the sediments and natural water systems and iii) develop geochemical/risk maps of the study area. We target to sample 50 surface water and sediments of streams and major rivers draining the catchment. The geochemical background shall be determined by analysing surface water samples for cations by AAS and anions by Ion Chromatography (IC); and sediments for trace metals using ICP-MS. It is expected that the geochemical baselines and toxic levels of both sampling media shall be established for the construction of a geochemical/risk map of the area. This is important in environmental monitoring. Preliminary results shall be presented in this talk.

Keywords: Geochemical mapping, Surface water, Stream sediments, Lom Basin, East Cameroon

フィリピン・ディナガット南部地域のニッケルラテライト鉱床におけるレアアース濃集帯の酸化還元状態に関する地化学的な研究

Geochemical Study on Redox Conditions of REE Zone in Nickel Laterie Deposit, South Dinagat Island, Philippines

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Recently, the demand of REE is increasing but its production of REE is limited to a few countries. Therefore it is important to look for alternative sources of REE production. It is economically effective to produce REE as by-product of other resource deposits. Nickel laterite deposits, which account for over 60% of global nickel supply, are being investigated as a possible REE resource because weathering of nickel laterite produces significant concentration of REE, especially Sc. One of the factors that control the geochemical behavior of REE during weathering process is soil pH and redox condition. The objectives of this study are to describe the geochemical characteristics of REE during the formation of nickel laterite in South Dinagat Island and to propose a practical and convenient on-site geochemical tool for REE exploration in nickel laterite deposits.

The harzburgite is considered to be the bedrock in this area, and thin section observation revealed that it mainly consists of olivine, orthopyroxene, lizardite, saponite and garnierite. In this study, laterite samples are classified as limonite (FeO>60%), earthy saprolite (30%<FeO<60%) and rocky saprolite (FeO<30%).

The XRF and ICP-MS analysis revealed that there is no apparent correlation between nickel, which is main product of nickel laterite deposits, and scandium, which is investigated as by-product. Nickel is concentrated in the fractures of lower limonite and saprolite as secondary formed hydrous Mg silicate. On the other hand, Sc exhibits correlation with immobile elements such as Fe and Al resulting in Sc concentration in the shallower zone. Weathering caused the Sc concentration to increase about 5.6 times, up to 75ppm, in the shallower zone compared with Sc content in bedrock because mobile elements percolate downward during weathering. Y and the lanthanides, except for Ce, showed different behavior from Sc. Y and Ln are concentrated in the negative Ce anomaly zone in the chondrite-normalized REE pattern. In oxidizing conditions, soluble Ce^{3+} is oxidized to Ce^{4+}, which easily precipitates as very insoluble CeO_2. However, the other REE is drained from the shallower zone and percolates downward. Consequently, positive Ce anomaly is observed in the shallower zone and negative Ce anomaly is observed in the deeper zone. Y and Ln are concentrated to increase up to 57ppm in negative Ce anomaly zone. Combined above geochemical data with on-site soil pH and Eh analyses, there is possibility to practically extract REE concentration zone. ΣREE (Sc, Y and Ln) is concentrated to increase about 3.2 times up to 126ppm in the horizon where pH values shows less than 7.0 compared with compared with ΣREE content in the horizon where pH values shows more than 7.0. Furthermore limonite and earthy saprolite, where Sc is concentrated, show pH values less than 6.5 and reveal Eh values more than 550mV.