

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 Ag₂S) deposits occur in Neogene to Quaternary magnetite-series terranes. Cu (typically chalcopyrite CuFeS₂) -Pb (galena PbS) -Zn (sphalerite, ZnS) and Mo (molybdenite, MoS₂), 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 (SnO₂) and wolframite ((Fe,Mn)WO₄) and scheelite (CaWO₄). 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 Fe₂O₃/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 Bushveld ultramafic to mafic body. These granitic magmas were found partial melting products of the middle crust by heat brought-up by the Bushveld ultramafic magmas. The oldest Li-mica pegmatite-bearing dikes (age: 2.5 Ga) have been mined in the western Australia.

Keywords: Granitoid series, Sulfide mineralization, Oxide mineralization

Granite-series and the origin of granitic magma

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The distribution of magnetite- and ilmenite-series granites (granite-series) shows zonal arrangement in a regional scale, and the ratios of two series granites systematically varied by their age. The facts indicate that the genesis of granite-series is not attributed to local phenomena but is closely related to the origin of granitic magma. The compilation of previous studies on granites in Japan Arc shows that granite activities are positively correlated with the convergence-rate of oceanic plates at the time, and the maximum activity occurred during 95-85 Ma, which comprises mostly ilmenite-series granites. The ratios of ilmenite- and magnetite-series rapidly rose at ca. 110 Ma, and dropped at ca. 70 Ma. The initial Sr isotope ratios (SrI) of ilmenite-series granites systematically rose in Cretaceous, whereas those of magnetite-series were fairly stable regardless of their ages. The similar variations can be found in the initial Nd isotope ratios (NdI). The facts above suggest that the assimilation-rate of sedimentary rocks into granitic magma systematically rose in Cretaceous, and dropped at 70 Ma. The phenomena are hardly explained by lower crustal melting by the ridge-subduction or the assimilation of wall rocks during emplacement of granitic magma.

In the Sr-O isotope diagram, the plots of most granites except for part of high-Sr granites are consistent with the curves of source contamination (convex downward). The SrI-NdI diagram also indicates that most granites were formed by the assimilation-fractional crystallization processes between strongly depleted materials (= mantle materials) and sedimentary rocks. To explain the data consistently, the geological setting of which mantle materials react with sedimentary rocks during magma generation is necessary. The sedimentary rocks should be common and homogeneous materials, and should be drawn into magma source regions. The materials met the above conditions are subducted sediments. Therefore, it can be deduced that the granite-series in Japan Arc depends mainly upon the reaction-rate between primitive magma and subducted sediments. Furthermore, it is also inferable that the main source materials of granitic magma in Japan Arc are not lower crustal materials but subducted sediments reacted with mantle materials.

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Keywords: granite, Japan Arc, subduction zone

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 \pm chlorite-smectite mixed layer, 2) quartz + K-feldspar + illite \pm smectite, 3) quartz + kaolinite \pm illite \pm smectite, and 4) quartz + plagioclase + chlorite-smectite mixed layer \pm 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°C and 220-230°C in the Stages I and III, respectively. Fugacity of selenium based on the electrum tarnish method was estimated to be $\log f_{\text{Se}_2} = -14.2$ to -12.8 and -13.1 to -11.6 atom for the Stages I-b and I-d, respectively.

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Ministry of International Trade and Industry (1997) Rare Metal Potential Investigation Report in 1996 Fiscal Year: Northern Hidaka Region. 75P.

Osanai, H., Mitani, K., Ishiyama, S. and Matsushita, K. (1963) 1:50,000 Geological Map of Japan, Nakatonbetsu with Explanatory Text. 58P.

Keywords: The Utanobori deposit, Epithermal gold mineralization, Hydrothermal alteration

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

Geochemical Study on Redox Conditions of REE Zone in Nickel Laterite 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 ($\text{FeO} > 60\%$), earthy saprolite ($30\% < \text{FeO} < 60\%$) and rocky saprolite ($\text{FeO} < 30\%$).

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.