Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

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Epithermal mineralization at Takarajima of the Tokara Islands

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[Introduction] The Ryukyu volcanic arc is located southwest of Kyushu across 1200 km length. Volcanic isldans of the Tokara Islands are known to belong to the Ryukyu arc, whereas several submarine volcanoes in the west part have not been well investigated. Yokose et al. (2007, 2010) proposed existence of some large submarine calderas at intervals of about 100 km in this region. Takara Shima island and Ko-Takara Shima Island located about 80 km north of Amami-Oshima, are considered as to constitute a part of somma of the Takara Shima Caldera. In Takara Shima Island, occurrence of altered tuff breccias associated with obvious quartz veins including sulfide minerals had been reported (Osako, 1976; Nakano et al., 2008). A few trials of mining operation had been attempted in the island, such as at the Takara Shima gold mine and Sagigazaki copper mine, until 1960's. In May 2013, we found large boulder rocks of a few meters diameter associated with numerous quartz veins, at the Tsumiishi coast located at the east part of the island. We report mineralogy of the quartz veins and sulfide minerals within them, and discuss pressure and temperature conditions of the mineralization.

[methods] We collected about 10 samples from the Tsumiishi coast and the ruin of the Takara Shima gold mine. The former samples were split off with a hammer from the boulder. The later samples were collected from the ground where used to be a spoil bank of the gold mine. Rock forming minerals and sulfide minerals were investigated by microscopic observation, and analysis using an electron probe micro analyzer (EPMA) and x-ray diffract meter (XRD). Chemical composition of the sulfide minerals was determined by EPMA analysis. Abundance of trace elements in the quartz veins was examined by instrumental neutron activation analysis (INAA). Homogenization temperature of fluid inclusions in the quartz veins was detemined using a heating stage.

[results] Variety of quartz veins were observed from vein of dozens cm width to stockwork texture with a few μm width. We identified chlorite, pyroxene and plagioclase as rock forming minerals, among which some of pyroxene was altered to chlorite. As ore sulfide minerals, chalcopyrite, galena, sphalerite and pyrite were identified in most of the samples. As minor sulfide/sulfate minerals, covelline, tetrahedrite, chalcocite, greenockite and barite were identified. Electrum was found in only one sample collected from the gold mine ruin, whereas trace amount of Au was determined by INAA in the quartz veins of the samples collected both from the gold mine ruin and Tsumiishi coast. Pseud-acicular and mosaic (jigsaw) textures were observed in the quartz veins in some samples from the Tsumiishi coast. Homogenization temperature of fluid inclusions containing two phases in the quartz vein was determined as above 210 ℃ for only one sample from the Tsumiishi coast.

[discussion] The characteristic textures of the quartz vein suggest boiling of hydrothermal fluid (e.g., Henley, 1985) which may accompany precipitation of metal sulfide minerals . Existence of liquid-vapor two-phase fluid inclusions in the quartz vein supports this idea, and enables.us to estimate mineralization depth around 200-300 m based on the homogenization temperature. Together with this range of mineralization depth, the observed assemblage of sulfide minerals suggests intermediate sulfidation type epithermal mineralization, which is usually observed at about a few km away from the heat source magma (e.g., Sillitoe, 2010). Therefore, the epithermal mineralization at Takara Shima island could be attributed to hydrothermal activity which is driven by a heat source magma beneath the submarine caldera (sea)floor. Present activity of high temperature (nearly 100 ℃) hot spring at the Ko-Takarashima may suggest continuity of the hydrothermal system.

Keywords: Hydrothermal mineralization, Submarine volcanic caldera, sulfide mineralization

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Mineralogical and Geochemical Study of Hydrothermal Ores from the Hatoma Knoll Hydrothermal Field in the Okinawa Trough

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Hydrothermal activity at the Hatoma Knoll in the ca. 1500 m water depth of southern Okinawa Trough is characterized by abundant sulfate (anhydrite and barite) mineralization associated with active venting of significantly Cl^-depleted hydrothermal fluid up to 300 oC. Since exclusive sulfate mineralization would be explained by less participation of metal species into the vapor phase during the phase separation of hydrothermal fluid, sulfide mineralization below or just above the seafloor could be expected. In order to investigate potential for sulfide mineralization at the Hatoma Knoll, we intensively collected hydrothermal sulfide/sulfate ores which were half buried within a sediment-covered seafloor. We report mineralogical and geochemical features of these brecciated mound ores and collapsed chimneys.

Our samples were collected during dive expeditions of YK07-04, NT08-13, NT11-20 and KY14-02, employing the manned submersible SHINKAI 6500 or ROV (remotely operated vehicle) Hyper-Dolphin 3000 of JAMSTEC. Constituent mineral of the collected samples was identified by microscopic observation and X-ray diffractometery (XRD), and chemical composition of specific sulfide minerals was determined by an Electron Probe Micro Analyzer (EPMA).

Based on the mineral assemblage and its texture, the hydrothermal ores can be classified into five types. Type I (fine-grained sulfide ore) is characterized by dendritic texture which suggests precipitation under the quenching condition. Type II (sulfide dominant ore) is dominated by abundant sulfide minerals of sphalerite, galena and tetrahedrite. Among this type of ores, some specific ores were recognized and identified as following two sub-types; (1) Type II' (Sb-rich chimney) is characterized by abundant occurrence of Sb-contained sulfide minerals such as tetrahedrite, and (2) Type II" (coarse-grained sulfide ore) is distinctive from other samples by substantially larger grain size of sphalerite up to 1 cm. Type III (barite dominant As-rich chimney) is characterized by abundant occurrence of barite with arsenic sulfide minerals (orpiment and realger).

Two interesting features were recognized with respect to the chemical composition of sulfide minerals. Sphalerite crystal in the Type I chimneys often exhibits an anomalously high Mn content up to 11.4%. Moreover, tetrahedrite in the Type II' sample contains high Ag content ranging from 8.27 to 18.90 %. Ag content and Sb/(Sb+As) ratio in the tetrahedrite crystal shows a positive correlation, although some ore samples showed an unusually high Ag content. Some Ag-Sb bearing sulfide minerals other than tetrahedrite were also identified, which supports strong correlation between Ag and Sb.

Keywords: Okinawa Trough, Hatoma Knoll, Seafloor massive sulfide ore deposit, Ag-rich tetrahedrite

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Sulfur isotopic compositions of stibnite in antimony deposits, southern Myanmar

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Antimony (Sb) deposits are generally formed by precipitation from metamorphic (diagenetic) or hydrothermal fluids and can be accompanied by Au or W in some deposits. In southern Myanmar, many Sb deposits are distributed north and south although the ore genesis is not studied well. In this study, we discuss sulfur isotopic compositions of stibnite (Sb_2S_3) and Sb(-Au) mineralization of some Sb deposits.

The Sb deposits are hosted by the Carboniferous to Early Permian Mergui and Lebyin Groups consisting mainly of mudstone, sandstone and limestone, consisting of stibnite-quartz vein-type and disseminated ore bodies. It is not well understood whether the ore bodies were formed from metamorphic fluids or fluids which are contributed from magmatic hydrothermal components. Granitic rocks (both magnetite-series and ilmenite-series), which could be the heat source of the hydrothermal fluids, are regionally distributed in the Sb metallogenic province although volcanic rocks are rarely found. The Sb ores consist mainly of stibnite and quartz, and occurrences of other minerals are uncommon. Stibnite occurs as euhedral elongated crystals and coexists with massive milky quartz. Fine-grained pyrite crystals are found in stibnite and quartz under a microscope. In one of the samples, stibnite is rimed by an alteration mineral, cervantite (Sb_2O_4).

Sulfur isotope ratios (δ^{34}S) of stibnite range widely from -9.4 to +8.2 ‰. The light isotope ratios ($\delta^{34}S < 0$ ‰) are interpreted probably from sulfur of sedimentary host rocks, whereas the heavy isotope ratios ($\delta^{34}S > 0$ ‰) are attributed to result from contributions from high-temperature or oxidized hydrothermal fluids. Magnetite-series granitoids generally show heavier sulfur isotope ratios than ilmenite-series, however no significant relationship was found between the isotope ratios and distribution of granitoids.

Stibnite is accompanied by Au mineralization and Au is recovered in some of the Sb deposits. Results of fire assay show that these Sb ores contain 0.1 to 3 ppm Au, approximately. The Au-bearing stibnite samples show positive sulfur isotope ratios.

Keywords: antimony, stibnite, sulfur isotope, deposits, gold, Myanmar

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REE-bearing Minerals in Granitoids at Sibolga and Panyabungan, North Sumatra, Indonesia

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Granitoids in the western part of North Sumatra are being studied to elucidate the genesis of REE mineralization on the basis of mineralogical and geochemical methods. Eleven samples were analyzed by petrography, XRF, SEM and ICP-MS to identify REE-bearing minerals and determine REE concentration.

The granitoids at Sibolga and Panyabungan are separated by 166 km distance, which formed in different settings, but both of the two magmas share ilmenite-series and metaluminous affinity. Petrographic study revealed that granitoids in Sibolga are A-type and ilmenite-series alkali feldspar granite and quartz syenite, formed within plate setting, and that I-type and ilmenite-series quartz syenite in Panyabungan was formed in volcanic arc setting. Allanite, apatite and titanite in the granitic rocks at Sibolga and Panyabungan contain Y, Ce, La, Pr, Nd, and Yb.

The setting changed due to change in tectonics during Late Permian to Cretaceous, from continental rift to magmatic arc setting. The enrichment of REE in the Sibolga and Panyabungan granitoids was caused by crystallization of allanite, apatite, and titanite.

Keywords: Sibolga, Panyabungan, Granitoids, A-type, I-type, ilmenite-series

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Metallic mineralization and petrography of granitoids at the Phon Tiou - Boneng tin mining area, central Laos

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Recently demand and price of tin have been increasing because of development of lead-free solder alloy as a global industry standard. Indium tin oxide (ITO) is also known as a high technology material used for liquid crystal display and so on.

The Phon Tiou and Boneng deposits located in central Laos are medium-scale (>10,000 t Sn) residual and placer tin deposits with total reserves of 10,100 t and 11,600t Sn, respectively. The mining target is cassiterite (SnO_2). Besides, there are several base metal and precious metal deposits and prospects in this area. Recently, Laotian, Thai, Chinese, Russian and North Korean companies are mining mainly tin and processing using shaking table method, in addition to small-scale miners. There are few studies that described metallic mineralization in this area. Objectives of this study are to elucidate petrographic and chemical characteristics of granitoids and metallic mineralization in the Phon Tiou - Boneng tin mining area, specially revealing a source rock of cassiterite, based on magnetic susceptibility, radioactivity, microscopic and EDS-SEM observation, bulk chemical compositions and sulfur isotopic compositions.

The Phon Tiou - Boneng tin mining area is located in Truong Son fold belt formed by Indosinian orogeny during Permian-Triassic period. Basement rock of the study area is Silurian-Devonian sandstone, mica schist and limestone. It is covered by Carboniferous and Jurassic sedimentary rocks, and Quaternary alluvial deposits. There are Triassic granitoids of the Say Phou Ngou and Phon Tiou complexess.

Magnetic susceptibility of the Say Phou Ngou and Phon Tiou granitoids complexes ranges from 0.02×10^{-3} to 1.5×10^{-3} SI and from 0.02×10^{-3} to 0.15×10^{-3} SI, respectively, indicating characteristics of almost ilmenite-series. The radio activity of granitoids ranges from 0.19 to 0.34μS and there is no distinct difference between the two complexes. Both the granitoids are composed mainly of quartz, K-feldspar, plagioclase, biotite of 300-700μm across and +/- zircon as primary minerals, showing equigranular texture. On the basis of the modal compositions, the Say Phou Ngou and Phon Tiou granitoid complexes are classified petrographically as syenogranite-monzogranite, and syenogranite, respectively. The granitoids of Say Phou Ngou complex (162-242 ppm Zr) contain relatively large amount of zircon included in biotite compared to those of the Phon Tiou complex (64-74 ppm Zr). The Phon Tiou complex (6-9 ppm Sn) is slightly enriched in tin compared to the Say Phou Ngou complex (2-3 ppm Sn).

Grain size of cassiterite contained in alluvial deposits and the concentrate after the table shaking separation ranges from 50 to 200μm. The SnO_2 concentrate is ca. 60 wt% and the concentrate contains magnetite, goethite, zircon (ca. 1,500 ppm Zr) and wolframite (ca. 450 ppm W). A sample of cassiterite-bearing alluvial deposits collected from a mining site contains ca. 1,000 ppm Sn and ca. 500 ppm Zr. The Sn content of a hard rock collected from the outcrop beside the mine is up to ca. 1,500 ppm, and we concluded that it is the source rock of cassiterite. The rock is composed mainly of equigranular quartz of 150-200μm across and their interstice is filled by goethite and cassiterite, implying that it is a hydrothermally altered and/or leached granitoid.

$\delta^{34}S_{CDT}$ of sulfides from sulfide veins in an outcrop and ores in a stockpile are negative suggesting that the sulfur was derived from biogenic sulfide of sedimentary rocks and/or from ilmenite-series granitoid magma into which biogenic sulfide of sedimentary rocks was incorporated.

Keywords: Laos, Phon Tiou - Boneng, residual and placer tin deposits, cassiterite, granitoids