JAHN Bor-ming, USUKI Masako, ISHIHARA Shunso, OKAMOTO Kazuaki and USUKI Tadashi, 2013. Accretionary Orogens of the Japanese Islands and Their Comparison with the Central Asian Orogenic Belt: Sr-Nd-Hf Isotopic Evidence. *Acta Geologica Sinica* (English Edition), 87(supp.): 302-304.

Accretionary Orogens of the Japanese Islands and Their Comparison with the Central Asian Orogenic Belt: Sr-Nd-Hf Isotopic Evidence

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The formation style of the Japanese Islands has been taken as a classic model for the accretionary orogeny and often serves as an example for understanding the crustal evolution of other accretionary orogens. Recent geochemical and isotopic studies on granitic rocks indicate that the crustal development in SW Japan is significantly different from that in NE Japan (Hokkaido included). Granitoids are the major component of the continental crust, and the mode of their generation can shed light to the problem of crustal growth. A large proportion of Mesozoic and Cenozoic granitoids from SW Japan have imprinted geochemical and isotopic signatures of old continental crust (Jahn, 2010). Consequently, the subduction-accretion complexes in SW Japan are probably composed much of "recycled" continental crust of Proterozoic ages. The Pre-Tertiary basement rocks beneath NE Japan (north of the Tanakura Tectonic Line) consist of Cretaceous sedimentary rocks and granitoids of the Abukuma Terrane, and an Ordovician to Cretaceous complex known as the Kitakami Terrane. The northern Kitakami consists mainly of a Jurassic accretionary complex and intrusive Early Cretaceous granitoids; whereas the southern Kitakami comprises Paleozoic high-P metamorphic rocks, shallow-marine sediments of Silurian to Cretaceous ages and intrusive Cretaceous granitoids. The island of Hokkaido is built with a Jurassic accretionary terrane in the west, a Cretaceous-Paleogene forearc basin and accretionary complex with the Hidaka collision belt in the center and a Cenozoic island arc in the east (= Chishima or Kuril arc terrane). In contrast to SW Japan, the available geochemical and Sr-Nd isotopic data suggest that the granitoids from NE Japan are quite "juvenile", derived by partial melting of sources with dominant mantle component. NE Japan and Hokkaido have taken a crustal development path sufficiently different from SW Japan.

In the island of Hokkaido, Paleogene and Neogene granitoids are volumetrically small but widespread in central Hokkaido (Hidaka Belt). New zircon geochronology on nine granitic and one gabbroic rocks from the Hidaka Belt reveals three distinct magmatic episodes at (1) 45-46 Ma (3 granites), (2) 37.0 ± 0.5 Ma (1 granite), and (3) 18-19 Ma (5 granites and 1 gabbro). The early Eocene granites (45-46 Ma) occur in the northern part of the Hidaka Belt. The zircon age of 37 Ma for a granite from Shirataki is similar to that of a tonalite and a granite from the Hidaka metamorphic belt (37.4 ± 0.3 Ma; Kemp et al., 2007). So, this late Eocene episode of granitoid emplacement is well established. All granites possess volcanic arc chemical characteristics. Their REE patterns are fractionated, with distinct negative Eu anomalies. The isotopic signatures (I_{Sr} = 0.7044 to 0.7061; $\varepsilon_{Nd}(T)$ = +1.0 to +4.7; T_{DM-1} = 400-1000 Ma; zircon $\varepsilon_{Hf}(T)$ = +8 to +19) demonstrate their juvenile characteristics. The granites do not show any significant change in chemical and isotopic compositions with the emplacement time. The Eocene granites were most probably generated by melting of subducted accretionary complex in a prolonged period from 46 to 37 Ma in supra-subduction zone; whereas the Miocene granites were formed by melting of accretionary complex in a back-arc rifting setting. In both cases, the accretionary complex was dominated by the subducted mafic crust and "ocean plate stratigraphy" with little Paleozoic or older crustal component. So, Hokkaido provides an excellent example of juvenile crust addition to the continental crust.

A comparison with the Central Asian Orogenic Belt (CAOB) reveals a close similarity between NE Japan (+ Hokkaido) and the Junggar Terrane, whereas the crustal evolution of SW Japan may be more comparable with the composite Tianshan orogen. In conclusion, (1) the crustal development of NE Japan (juvenile) is distinguished from

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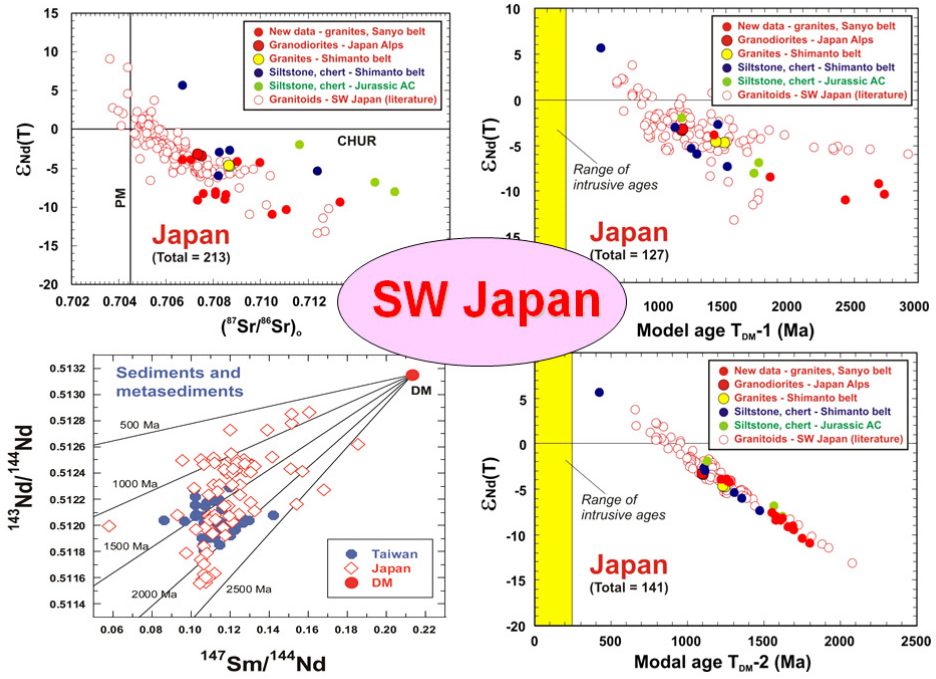

Fig. 1. Sr-Nd isotopic compositions and Sm-Nd model ages of granitoids from SW Japan.

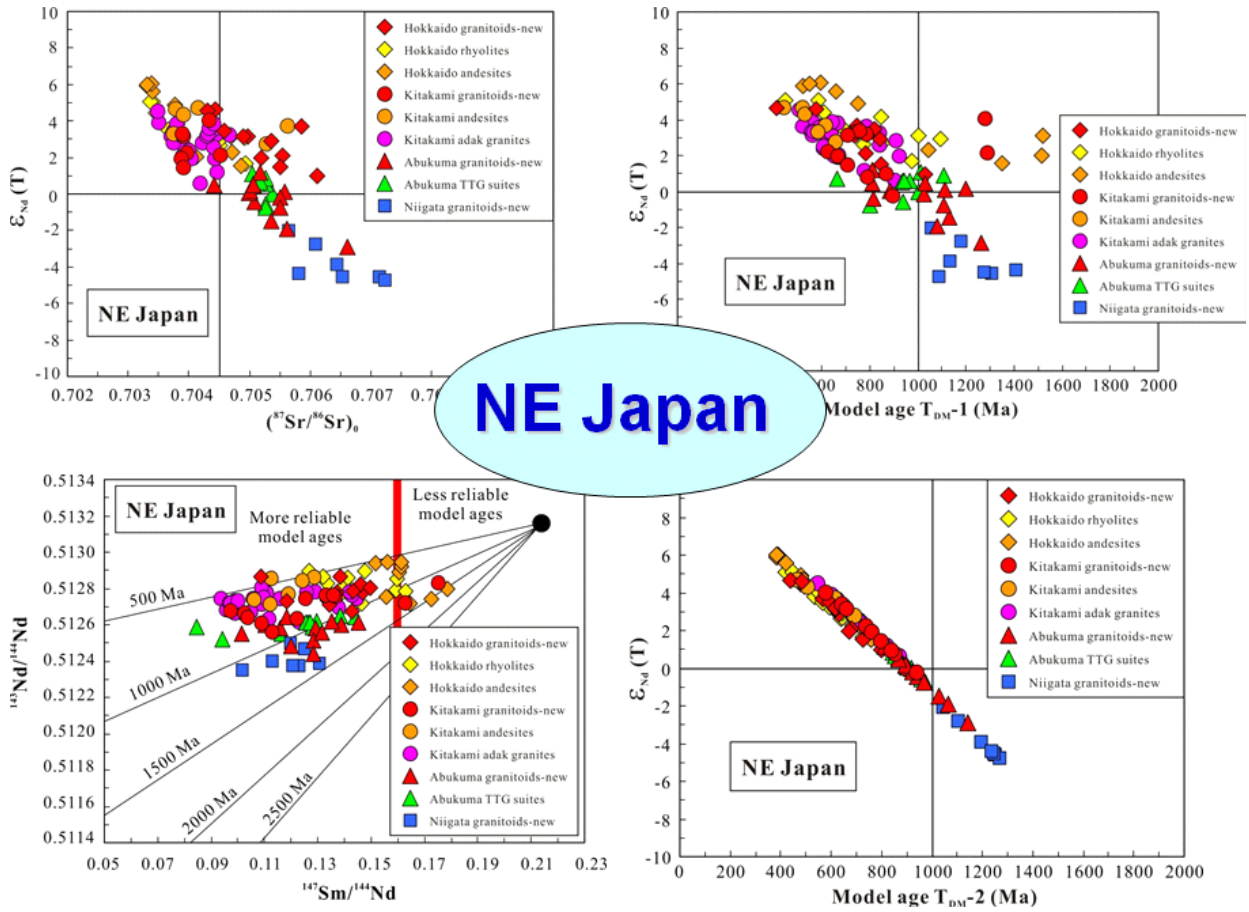

Fig. 2. Sr-Nd isotopic compositions and Sm-Nd model ages of granitoids from NE Japan (Hokkaido included).

that of SW Japan (juvenile + recycled); (2) accretionary orogens could be distinguished by the nature of the accreted lithological assemblages. Orogens with dominantly island arc assemblage would witness generation of granitoids with juvenile characters. This is best exemplified by the granitoids of NE Japan (Hokkaido included) and many terranes of CAOB, such as the Junggar Terrane of China (e.g., Chen and Jahn, 2004; Tang et al., 2012) and the Lake Zone of Mongolia (Kovach et al., 2011); (3) by contrast, orogens with accretionary complexes accreted to a continental margin with Precambrian basement would see generation of granitic rocks with more crustal signature. This is represented by SW Japan, in which the component of "recycled Precambrian crust" is significant in the granitoid magma generation; (4) the isotopic signature of SW Japan may support the tectonic model of Maruyama et al. (1997) and Isozaki et al. (2010) in which Proto-Japan was initially developed along the coast of SE China, and shared a similar source region (the Cathaysia) with Taiwan during the late Paleozoic to late Mesozoic. The shared source of SW Japan-Taiwan-SE China is evidenced by the Nd isotopic signatures and inherited zircon age patterns.

Key words: accretionary orogeny, Japan, Central Asian Orogenic Belt, Nd isotopes, granitoids, Sr-Nd-Hf isotopes, juvenile crust

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