Allanite as an indicator of origin and tectonic setting for granitic rocks, Japan: implications for fractionation in manganese and rare earth elements, and for difference in Sr-Nd isotope compositions.

M. Hoshino1,*, M. Kimata1, Y. Arakawa1, N. Nishida2, and M. Shimizu1

1 Earth Evolution Sciences, Graduate School of Life and Environmental Sciences, University of Tsukuba, Tennoudai 1-1-1, Tsukuba, Ibaraki, 305-8572, Japan

hossy716@arsia.geo.tsukuba.ac.jp

2 Chemical Analysis Division, Research Facility Centre for Science and Technology, University of Tsukuba, Tennoudai 1-1-1, Tsukuba, Ibaraki, 305-8577, Japan

Twenty-six samples of allanites originating from granitic rocks, Japan, were examined by EPMA. Fourteen analyzed allanites contain appreciable amounts of MnO (0.14-0.59 a.p.f.u.). Therefore, the present allanites are significantly divided into Mn-rich (more than 0.14 a.p.f.u.) and Mn-poor (less than 0.14 a.p.f.u.) types. The relationship between Mn-rich and Mn-poor allanites is established by the coupled substitution: Mn$^{2+}$ + (MREE, HREE)$^{3+}$ \[\text{[Mn-rich types]} \leftrightarrow \text{Ca}^{2+} + \text{LREE}^{3+} \text{[Mn-poor types]}\]. Moreover Mn-rich and Mn-poor allanites differ considerably from each other in chondrite-normalized REE concentration: Mn-poor allanites have some chondrite-normalized patterns indicative of the LREE enrichment, while such patterns in Mn-rich ones show the MREE enrichment. Mn-rich allanites are characteristic of the allanites from granitic rocks in Japan (Hoshino et al. 2006). Primary magmatic allanites (e.g., Chesner & Ettlinger 1989) have the same patterns, reflecting LREE-enrichment, as observed in the studied Mn-poor ones. On the other hand, secondary allanites (e.g., Exley 1980), influenced by hydrothermal fluid, have the REE patterns similar to those of the Mn-rich allanites. These geochemical characters may represent that Mn-rich and Mn-poor allanites derive their origins from hydrothermal fluid and magmatic melt, respectively.

Complication of the chemical compositions of the present allanites which reveals Th-incorporation as the coupled substitution of 3Th$^{4+} + \Box \leftrightarrow 4\text{REE}^{3+}$, provides an explanation for the observation that higher Th concentrations characterize allanites from the island arcs. Moreover, from the global viewpoint of allanite mineralogy, the ternary Al$_2$O$_3$-Fe$_2$O$_3$-$\Sigma$REE$^{3+}$ diagram illustrates that allanites are grouped, according to their origins, into three classes suggestive of tectonic backgrounds for the crystallization localities; (1) intracontinental, (2) island arc and (3) continental margin. Therefore Mn, REE and major element contents in allanites become an indicator for both the origins of the host rocks and the crystallization localities of allanites from granitic rocks.

The isotopic compositions of Sr and Nd were analyzed for seventeen allanites (11 samples of an Mn-rich type, and 6 samples of an Mn-poor type) of the present samples by mass spectrometer. The analyzed Mn-rich samples have $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.70812-0.71379 and $^{143}\text{Nd}/^{144}\text{Nd}$ ratio of 0.512454-0.512067, while Mn-poor samples have $^{87}\text{Sr}/^{86}\text{Sr}$ ratio of 0.70637-0.70711 and $^{143}\text{Nd}/^{144}\text{Nd}$ ratio of 0.512583-0.512529. In other words, there is a negative correlation between $^{87}\text{Sr}/^{86}\text{Sr}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ ratios for the analyzed Mn-rich and Mn-poor allanites. The above identifying characteristics suggest that the geneses of Mn-rich and Mn-poor allanites are consistent with the origins of ilmenite-series and magnetite-series granitoid, respectively.