論文内容の要旨

論文題目：Water content of the upper mantle beneath island arcs and its tectonic implications: Petrologic study of Aogashima Volcano, Izu Arc, Japan

（島弧下上部マントルの含水量と沈み込み帯テクトニクスとの関係：伊豆弧青ヶ島火山の岩石学的研究）

氏名　荻津　達

Subduction zone is believed to be an important tectonic environment where surface materials return to the mantle, and plays an important role in martial recycling in the earth. Subduction zone magmatism is more complicated and diverse as compared to those of mid-ocean ridges and hot spots mostly because of the contribution of H_2O-rich fluid which is thought to be expelled from the subducting, and the complexity of thermal and flow structures of the wedge mantle. In order to understand such complex subduction zone magmatism, quantitative estimation of melting conditions and clarification of its tectonic controls must be done. In this thesis, melting conditions including, degree of melting, melting temperature, melting pressure, and H_2O content in mantle were determined by more rigorous approach. This thesis is motivated from petrologic study of Aogashima Volcano, which is a extremity of tholeiite magmatisms, providing a key data set to enhance systematics observed among world arcs.

Basalt and basaltic andesite from Aogashima Volcano in the Izu arc are characterized by extreme FeO-enrichment, which is less extreme but the common feature of frontal volcanoes in the Izu arc. By looking at aphyric basalts and groundmass of plagioclase phyric basalts, which clearly represent melt, the series of the composition is identified as the differentiation trend for Aogashima Volcano. The fractionation trend and composition of plagioclase in the marginal part constrain the crystallization conditions of plagioclase: pressure of ~0.1GPa and water content of ~1wt%. Saturation water content at 0.1GPa is much higher than ~1wt%, indicating that degassing cannot explain the low water content. The MgO content in plagioclase for a given An content shows a negative correlation with the FeO^t/MgO of its groundmass, which shows a genetic relationship between plagioclase and the host groundmass. It is concluded that the primary magma of Aogashima Volcano is low in H_2O when it formed in the mantle, and fractionated significant amount of plagioclase, giving rise to the extreme Fe-enrichment.

A rigorous least-squares approach to estimate melting conditions in the upper mantle from major element composition of a single volcanic rocks, in which crystallization and melting parameters are simultaneously and consistently optimized, is developed in this thesis. The optimized parameters are (1) degree of partial melting, (2) melting pressures, and (3) H_2O content in primary melt as melting parameters, and (4) pressure of fractional crystallization and (5) temperature of erupted magma as crystallization parameters. Melting temperature is also estimated from the relationship among melting degree, melting pressure, and H_2O content in the mantle.

Melting conditions were estimated for frontal volcanoes of world arcs. The estimated degree of partial melting ranges from 0.04 to 0.28. Volcanoes from the same arc show consistent degree of melting except for those from Central American arc. The melting pressure ranges from 1.2 to 2.3 GPa. The range of pressure in each arc is up to 1.0 GPa, but is mostly less than 0.5 GPa. There is a positive correlations between degree of melting and melting pressure, which can be regarded as the global trend. The H_2O contents in the mantle show a weak positive correlation with degree of partial melting for the lower range of degree of partial melting (<0.18). At higher degree of partial melting, the H_2O contents in source mantle vary widely. These estimations are roughly consistent with other studies, such as Plank and Langmuir (1988) or Sakuyama (1983). There is a good overall linear positive correlation between degree of melting and melting temperature as well as melting pressure and melting temperature. The abundance of high field strength elements (HFSEs) in the source mantle are also determined from the concentration in volcanic. The HFSE abundance in source mantle for world arcs is roughly overlapping with the depleted MORB source mantle and mostly less than the primitive mantle.

From a clear positive correlation between melting pressure and temperature, melting is inferred to be primary controlled by the decompressional melting of mantle with various potential temperatures as in the case of global correlation for MORB, and the most critical factor that controls arc magmatism is thought to be temperature of the wedge mantle, which is strongly controlled by the return flow induced by slab subduction. From the comparison with the estimated melting conditions and tectonic parameters, a controlling tectonic parameter is specified, which is the difference between absolute velocity of subducting slab and convergence velocity ($V_{abs} - V_c$). The $V_{abs} - V_c$ show a positive correlation with melting temperature with a few exceptions. At the same time, the existence of back arc volcanism and extensional tectonics are associated with arcs with high $V_{abs} - V_c$. The across arc variation of melting conditions are estimated in the Izu arc, which shows two-dimensional distribution of melting temperature and H_2O content in the mantle. The source mantle of frontal volcano is estimated to be depleted than that of backarc volcanoes, by extraction of a few % of batch melt. The two-dimensional structure of melting conditions provide robust constraint on melting mechanisms, thermal structure, and material transportation in the arc mantle wedge above the subducting slab.