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Development of isotope analysis of fluid inclusions by secondary ion mass spectrometry I

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Fluids play important role for element migration and circulation on the surface and interior of planets, and often control geological phenomena. The fluid caused geological phenomenon was indirectly assumed from the record of rock formed at the time. On the other hand, fluid inclusions trapped in minerals give the direct information of the fluid. Moreover, individual analysis for each fluid inclusion can reveal fluid evolution during a series of geological action because spatial position of fluid inclusions in the mineral corresponds to course of geological time. Especially, isotope analysis provides useful information for the origin of fluid.

In traditional mass spectrometry, analysis of fluid inclusions was conducted by extraction procedure method. The candidate for application of this method was limited because this method can measure fluid inclusions with a size of 1mm or larger. The fluid inclusions in rock have often several micrometers to several dozen micrometers in size. Therefore, development of mass spectrometry applicable to such minute fluid inclusions is important. In-situ analysis of fluid inclusions is expected to make significant progress for the study of evolution of fluid. Secondary ion mass spectrometry (SIMS) is an analysis method having such spatial resolution. However, SIMS can not analyze fluid because the sample should be exposed in high vacuum. In this study, we developed a sample preparation method in order to analyze fluid inclusions by SIMS.

The requirements for stable analysis of SIMS are (1) flat and smooth mirror surface, (2) fluid inclusions are exposed to polished surface, (3) conductive sample surface.

In order to satisfy (1) and (2), we developed freezing polishing instrument to polish the sample keeping fluid inclusions in a frozen state. The instrument has a lapping table including liquid nitrogen bath. The temperature of the table during polishing is controlled at -100 degree by automatic temperature controller. It takes approximately 14 minutes to cool the lapping table from room temperature to -100 degree. Freeze and dry polish of fluid inclusions is realized with alumina polish sheet on the lapping table.

In order to prevent condensation of water vapor in the atmosphere on the polished surface and make conductive surface (condition (3)), the polishing instrument and an ion coater (SANYU SC-701AT) are put in a glove box with nitrogen atmosphere. The sample stage of ion coater usable in cooling state satisfy condition (3) by making gold thin film on the polished surface keeping the temperature of sample below -100 degree during gold coating. A reflection microscope having a cold stage to observe surface condition is also put in the glove box. We are currently developing a simple observation method to check the exposed surface of frozen fluid inclusions.

Keywords: fluid inclusions, secondary ion mass spectrometry, freezing polish, isotope