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High sensitive noble gas mass spectrometer equipped with a Giese-type ion source

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Although noble gas isotopes are powerful tracers in geosciences, their extremely low abundances in mineral and rock samples make their analysis quite difficult. For example, concentration of ^{3}He, which is a good indicator of mantle-derived component because of its primordial origin, is as high as 0.01 parts-per-trillion in volcanic rocks and mantle-derived materials. Such scarce noble gas isotopes are detected with a special mass spectrometer operated in static mode. We have made it possible to detect 10^{3} to 10^{4} atoms of noble gas isotopes by modifying a commercial sector-type single focusing noble gas mass spectrometer (VG5400), which is equipped with a double collector system to detect ^{3}He and ^{4}He simultaneously with a secondary electron multiplier and Faraday cup, respectively [1]. Here we report an attempt of further improvement of sensitivity of the mass spectrometer by installation of a new ion source (Giese-type source).

The Giese-type electron ionization (EI) ion source is equipped with two electrostatic quadrupole lenses [2]. This source has been reported to have up to two orders of magnitude higher sensitivity than conventional Nier-type EI source because of the absence of a beam defining slit to collimate the ion beam and thus high transmission [3]. We designed a Giese-type source to have an adequate resolution to separate $^{3}He^{+}$ from HD^{+} and $H_{3}{}^{+}$, to have the source housing volume as small as possible, and to be bankable at up to 300 ℃ to reduce outgas from the source materials. The ion and electron optics were based on a calculation by Lu and Carr [4] and refined using SIMION-3D software [5]. Prior to the installation on the mass spectrometer, the ion beam profile emitted from the source was monitored by a microchannel plate and phosphor screen to optimize the configuration of the quadrupole lens.

A sufficient mass resolution over 500 essential for ^{3}He/^{4}He analysis has been achieved with an improved sensitivity approximately three times higher than the previous condition. The amount of helium required to obtain a precision with ^{3}He/^{4}He ratio is two orders of magnitude smaller than that with the condition installed by the manufacture. However, total ion transmission is estimated to be about 30%, suggesting further refinement of the source condition is required to obtain the maximum sensitivity.

References: [1] H. Sumino et al., J. Mass Spectrom. Soc. Jpn., 49, 61-68 (2001). [2] C.F. Giese, Rev. Sci. Instrum., 30, 260-261 (1959). [3] E.T. Kinzer and H. Carr, Rev. Sci. Instrum., 30, 1132 (1959). [4] C.-S. Lu and H.E Carr, Rev. Sci. Instrum., 33, 823-824 (1962). [5] D.A. Dahl, Int. J. Mass Spectrom., 200, 3-25 (2000).

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