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Provenance study of Asian dust based on cathodoluminescence analysis of single quartz grain

Kana Nagashima[1*], Hirotsugu Nishido[2], Masahiro Kayama[2], Shin Toyoda[2], Yasuhito Igarashi[3], Ryuji Tada[4]

[1]JAMSTEC, [2]Okayama University of Science, [3]Meteorological Research Institute, [4]The Univeristy of Tokyo

Numerous tracers, such as mineralogical component, strontium (87Sr/86Sr) and neodymium isotopes (Liu et al., 1994; Biscaye et al.,1997; Bory et al., 2002, 2003; Kanayama et al., 2002, 200 5), rare earth element composition (e.g., Svensson et al., 2000), oxygen isotope (Mizota et al., 199 2; Hou et al., 2003) and ESR intensity of quartz (Ono et al., 1998; Sun et al., 2007), have been investigated to discriminate source areas of Asian dust. However, these analyses need large volume of samples (mostly more than 10 mg) and the applications to the dust samples are limited. Then, here we developed a provenance-tracing method by using a cathodoluminescence (CL) spectral of "single" quartz grain for applying it to small volume of aeolian dust samples, such as aeolian dust caught by dust-sampler and dust in the ice cores.

CL is the emission from a solid which is excited by electron beam. Since CL spectroscopy and microscopy provide information on the existence and distribution of defects and trace elements in minerals, CL analyses have potential to characterize dust-source areas. CL spectra of quartz have been demonstrated to show different patterns between the quartz from hydrothermal, plutonic, volcanic and metamorphic origins (e.g., Zinkernagel, 1978; Gotze et al., 2001), suggesting the spectra reflect the condition of the quartz formation and the local environment. Then, here we conducted CL spectral analysis of quartz in the surface samples from two major deserts in Asia, the Taklimakan Desert and Gobi Desert in southern Mongolia (hereafter Mongolian Gobi). CL spectra were measured in the areas of approximately 4 micron square for each quartz grain by a Scanning Electron Microscope-Cathodoluminescence (SEM-CL) at the Okayama University of Science, a SEM (Jeol: JSM-5410) attached with a grating monochromator (Oxford Instruments: Mono CL2), where EDS system can be used in combination with SEM-CL. The CL signals were collected by photon counting method using a PMT (Hamamatsu R2228) in the range from 300 to 800 nm.

Most of the silt size quartz in the samples from the Taklimakan Desert and the Mongolian Gobi exhibit double peaks in blue region at around 450 nm (2.75 eV) and red region at around 620 nm (2.00 eV). The CL intensities of red peak from the Mongolian Gobi are mostly larger compared to that from the Taklimakan Desert. In addition, the wavelengths (energy) of the red peak show slight but significant differences between the samples from the two deserts. This result implies that the red peaks of CL spectra of the quartz samples from the two deserts originate from different defects of quartz, and the characteristics of the red peaks have potential to distinguish the source areas of Asian dust. The major source of the quartz in the Taklimakan Desert is considered to be around Pamir-Kunlun Mts. (Isozaki, 2009), and the quartz is expected to have suffered high-grade metamorphism due to the India-Asian collision. If true, it is possible to consider that the different CL spectra between the quartz from the Taklimakan Desert and the Mongolian Gobi represent different degree of metamorphism for mother rocks of the quartz. We will further apply this method to dust fall samples from Fukuoka and Akita since 1963, and

examine the decadal-scale provenance changes of aeolian dust transported to Japan.

Keywords: dust, cathodoluminescence, quartz