Development of provenance study using quartz shapes and surface microtextures

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[Introduction]
Quartz is highly resistant to weathering and various surface microtextures are formed and preserved on grains. The microtexture of a quartz surface (MQS) reflects the sedimentary history of the grain, including its parent rock, transportation process, and depositional environment. The relationship between MQS and sedimentary history has been investigated by using scanning electron microscopy (SEM) (Krinsley et al. 1973; Mahaney, 2002). The types and frequency of microtexture may be different from previous studies in foreign countries because MQS relates to the geological and geomorphological settings at sampling sites. However, surface textural analysis has primarily been used to estimate fault activity, and the variation in MQS have not been studied aiming to the provenance study in Japan. In this study, we observed the quartz grains of Japan to reveal the relationship between quartz morphological features and sedimentary history. In addition to the SEM observation, the image analysis and statistics analysis were applied.

[Sampling and methods]
Nineteen fluvial sediments and nineteen coastal sands were collected in Japan. Carbonates, iron oxides and organic matters were removed from samples by chemicals and quartz grains (0.1 to 1 mm) were randomly handpicked under a stereomicroscope. After coating with a layer of platinum, twenty quartz grains for each sample were observed by SEM. Quartz shape was estimated by roundness (Takashimizu et al. 2016) and fractal dimension (Suzuki et al. 2013) using SEM images and ImageJ. A total of fifteen MQS was observed with reference to the previous study (Vos et al. 2014). The number of grains possessing each microstructure was counted in every sample. Their frequency distributions were applied to the principal component analysis (PCA) using statistical software.

[Result and Discussion]
Fluvial grains showed angular outline, high relief and large number of conchoidal fractures, which were probably produced by a powerful impact or pressure on the grain surface (Vos et al. 2014). Small hole of less than 10 μm can be observed on some samples. It derived from small inclusions, and its frequency may show the differences of parent rocks of samples.
Most of the quartz in seacoast are characterized by rounded outline and medium to low relief. On the surface, there are many v-shaped percussion cracks, which are produced by grain-to-grain collision in subaqueous environment (Krinsley et al. 1973). Some coastal samples had angular outline and many conchoidal fractures like fluvial sediments, but v-shaped percussion cracks are scarcely observed. It may be because grains of these coastal areas were supplied by steep rivers near sampling site. It means quartz shapes and surface microtextures of beach sands relate to the sediment supply.
Frequency distribution of MQS was applied to the PCA, and samples collected from the same area could be grouped in PCA scores plot. The first principal component (PC1) was explained by chemically formed microtextures and the second principal component (PC2) was explained by mechanically ones. PCA is effective method to grouping the samples under similar sedimentary history.
It is revealed that the morphological diversity of quartz grains can be observed, even in areas with complex geological and geomorphological settings such as Japan. The types of MQS were similar to the

previous studies in foreign lands, but some types were sparsely observed compared to the previous report. MQS reflect parent rock, transportation systems and depositional environment, so it is important to comprehensively discuss the result of quartz analysis referring to the natural environment of sampling area.

(Krinsley et al, Cambridge University Press, 1973: Mahaney, Oxford University Press, 2002: Takashimizu et al. Prog. Earth Planet Sci., 2016, 3:2: Suzuki et al, J. Geol. Soc. Japan, 2013, 119(3), 205-216: Vos et al. Earth-Science Reviews, 128(0), 93-104)

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