THERMAL HISTORY OF SOME BASALTS AND VOLCANIC LAVAS

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In most geological samples, signals of iron ions (Fe^{3+}) are found in the measurements by Electron Spin Resonance (ESR). The signals tells us not only the existence of Fe^{3+} ions in the sample, but also the information on the sites occupied by Fe^{3+} ions. In this work, we have a preliminary result that the cooling rates of volcanic materials (basalts, lavas, etc.) can be estimated by signals of Fe^{3+} ions in those samples.

We have measured a scoria (SC) and two volcanic lavas (LV1,LV2), got at Mt. Mihara in Izuoshima Is., and a pillow basalt (PB). The former three samples were offered by Hot Springs Research Institute of Kanagawaken Prefecture and the latter one is by Geophysics Institute of Tokyo University. We crushed these samples of 200-300 mg and got signals at room temperature by an ESR spectrometer (JEOL, RE1X). We also investigated the changes of signals from the samples heated in air at 300-900C.

Fig.1 (a),(b), and (c) show the signals by Fe^{3+} ions in basalts and lavas. The upper ones are signals before heating and the lower after heating. The numbers indicates the gains of ESR spectrometer and the number just after the sample name of lower figures are the temperatures of heating in centigrade degree.

The scoria shows one large peak at g=2 (about 335 mT). This signal is by free Fe^{3+} ions in amorphous glass formed at the time of rapid quenching. The lavas and the basalt show not only an peak at g=2 but also other peaks at g=4 (150 mT) and at g=9 (70 mT). These signals are due to a fine structure of Fe^{3+} at high spin state in some crystalline field. The cooling rate of lavas are more moderate than that of scoria, the some crystals including Fe^{3+} are formed in lavas and a basalt.

Fig.1(a), (b), and (c) also show that the signals at g=2 increase after heating, but the increasing rates are different from each other. Fig.2 shows the change of intensity of a signal at g=2. The intensity is normalized to the one before heating. It is shown in Fig.2 that the temperatures at which the signals at g=2 start changing are different from each other.

In the cooling process of volcanic materials, the Fe^{3+} ions move to the equilibrated disposition at each temperature. But in the case that the duration period needed to be equilibrated is longer than the period during which the temperature is maintained, the dispositions of Fe^{3+} are frozen, remaining not to be equilibrated. Inversely, in a stepwise heating experiment the temperature at which Fe^{3+} ions start to move indicates the temperature at which disposition of Fe^{3+} were frozen in the past cooling process. We can observe that Fe^{3+} ions start to move by change of ESR signals. The duration period required for equilibration of Fe^{3+} disposition is a function of temperature, then, the sample which has a higher "frozen" temperature is supposed experience higher cooling rate and the sample which has a lower "frozen" temperature is supposed to experience lower cooling rate. Indeed the signal from a scoria, which is rapidly cooled in air start changing at higher higher temperature than the ones of lavas. The cooling rate of a pillow basalt is estimated to be lower because the signal is estimated to start increasing before 400C (Fig.2), and it is probable because heat would have been supplied from the internal regions to the region where we took samples, it is at 5 cm from the surface.

We had a preliminary result that cooling rates of volcanic materials can be estimated by ESR signals. However, further investigations are needed to estimate cooling rates quantitatively, for example, to get activation energy of signal changing, etc. We will have useful information of cooling rates of volcanic materials, for example, estimations of the size of rocks at the time of formation and the heat flow supplied the rock in the past.

Fig.1(a) Fig.1(b) Fig.1(c)

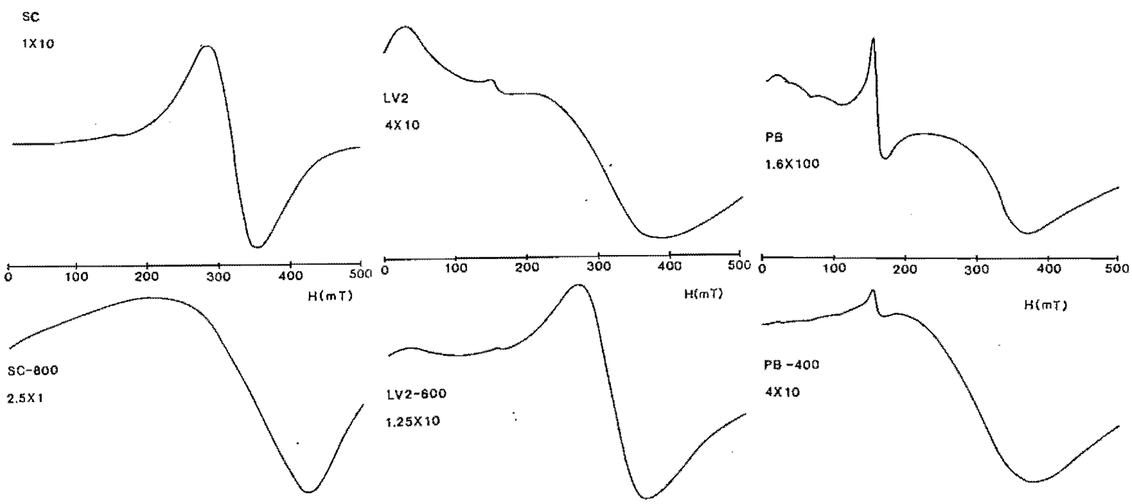

Fig.2