# Determination of pressure effect on the thermocouple electromotive force using multi-anvil apparatus

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Our understanding of Earth's interior highly depends on physical and chemical properties of Earth materials which were determined based on high-pressure and high-temperature experiments. Temperature in high-pressure and high-temperature experiments is mostly determined using a thermocouple without any pressure correction. This may lead to erroneous results in estimated temperature and thus physical and chemical properties of Earth materials due to significant pressure effects of the thermocouple electromotive force (EMF). Getting and Kennedy (1970) determined the pressure effect on the EMF of two types of thermocouples up to 3.5 GPa and 1000°C. However, no new knowledge has been obtained on the absolute pressure effect on thermocouple EMF for more than 40 years.
In this study, we developed a method to determine the absolute pressure effect on thermocouple electromotive force, based on a single wire method using Kawai-type multi-anvil apparatus. By applying this method, single wire EMFs were measured up to a pressure of 7 GPa and temperature of 600°C for chromel and alumel, which passes through the entire length of the pressure medium. The chromel and alumel wires were contained in semi-sintered MgO and dense $Al_2O_3$ insulating tubes, and the portions of the wires in MgO and $Al_2O_3$ were subjected to higher and lower pressures, respectively. The temperature along the single wires was calibrated by separate experiments employing multiple thermocouples. Pressure conditions along the wires were evaluated based on in situ X-ray diffraction using synchrotron X-ray radiation and a thermal equation of state of Ni. The pressure effect of the Seebeck coefficients of chromel and alumel, determined by the analyses of single wire EMFs and pressure-temperature profiles along the wires, was virtually consistent with that of previous lower-pressure or lower-temperature studies. The difference between the nominal temperature by chromel-alumel thermocouple (type K) and the real temperature was calculated to be from 0 to −3°C in conditions up to 7 GPa and 600°C. Since the multi-anvil apparatus is capable of achieving much higher pressure and temperature, the method presented in this study promises to reveal absolute temperature correction for thermocouples over a wide range of pressure and temperature conditions.

Keywords: thermocouple, high-pressure and high-temperature experiments

 