High Pressure Mineral Physics

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1. Introduction

The objective of High Pressure Mineral Physics is to investigate the planetary interior and to innovate new materials on the basis of the physical properties data of constituent materials benefited from highly brilliant X-ray from the Spring-8.

Recent progress of multi-anvil apparatus with the sintered diamond anvil enable us to reach the pressure and temperature conditions of the deep planetary interior. It covers pressure regions to those found in the Earth's lower mantle and the center of Mars. Its large volume cavity makes it possible to control the pressure environment (hydrostatic or differential stress conditions) and to realize uniform temperatures in the sample space. Thus the multi-anvil press is a suitable facility for the study of the planetary interior and the material innovation. In this beamline (BL04B) we primary conduct in-situ observation of the constituent materials of planet under high-pressure and high-temperature.

2. Research Subject

Various kinds of high pressure minerals constitute the planetary mantle. Metallic iron with substantial amounts of the lightening elements (e.g., H, O, S, Si etc.) constitutes the planetary core both in liquid and solid states. In order to clarify chemical composition, mineralogical constitution, and thermal state of the planetary interior, we need quality data on the physical properties of these materials.

Different kinds of experiments on the candidate silicate minerals and the iron alloy will be carried out using X-ray diffraction and radiography techniques. These include: 1) structure of high pressure phases, 2) phase diagrams, 3) equations of state, 4) kinetic properties of the phase transitions, and 5) rheological properties .

The large volume multi anvil apparatus also enables us to investigate the physical properties of the melt under pressure. The following experiments will be conducted using the multi-anvil press .

1) Study of structures and phase transition in liquid states of silicates and iron alloys.

2) Density and viscosity measurements of melt. The falling sphere method combined with radiography will be used to measure these physical properties of melts.

3) Kinetics of solid-liquid reactions. Experimental study of the chemical reactions at high pressures between solid and liquid will give us many important informations for the understanding of magmatic processes in the Earth and synthetic processes of industrial materials such as diamond.

3. Experimental Facilities

Our experimental station is located at up-stream of the High Temperature station in BL04B.

A large volume multi-anvil type high pressure apparatus is installed in this experimental

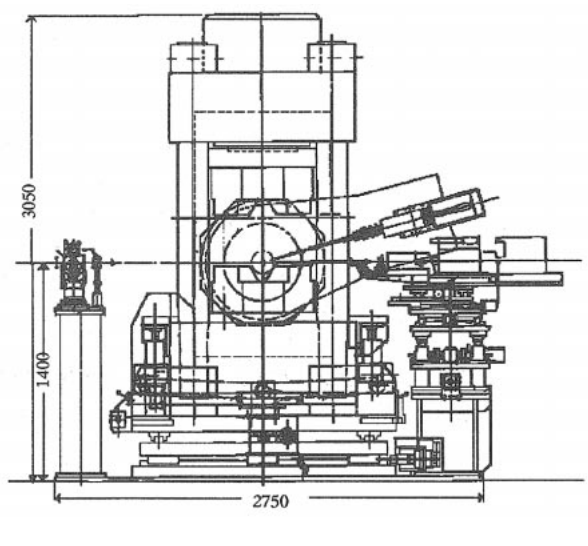

Fig.1. Design of 1500 ton press.

station. The high pressure apparatus is a 1500 ton ram-force uniaxial press (see Figure 1).This apparatus is operated in the two-stage compression mode, in which the first stage is the DIA-type apparatus with six anvils and the second stage consists of eight anvils of the MA8-type apparatus. The octahedral sample space is compressed by the truncated comer of 8 inner cubic anvils which, in turn, compressed by the outer first stage 6 anvils. Ei-ther the tungsten carbide or the polycrystal-line sintered diamond is used for the second stage anvil. This system has a capability of generating pressures up to 40 GPa and a temperature of 3000 K in a large sample volume ($1mm^3$) by using the sintered diamond anvils.

Two single-axis goniometers are equipped for this apparatus . One is the goniometer with the diffraction angle of ± 15° in the vertical plane, which can be operated by using one sintered diamond anvil as a window transparent to X-rays (Figure 2). The other is the horizontal goniometer with diffraction angle of ±10°, which is available to the use of both the sintered diamond and the tungsten carbide as the second stage anvils (Figure 2). In order to extend the diffraction angle to 10 degree, the silt is cut on the one side of first stage anvil.

This press is mounted on an X-Y-Z* translation stage with a rotation axis (±10°)

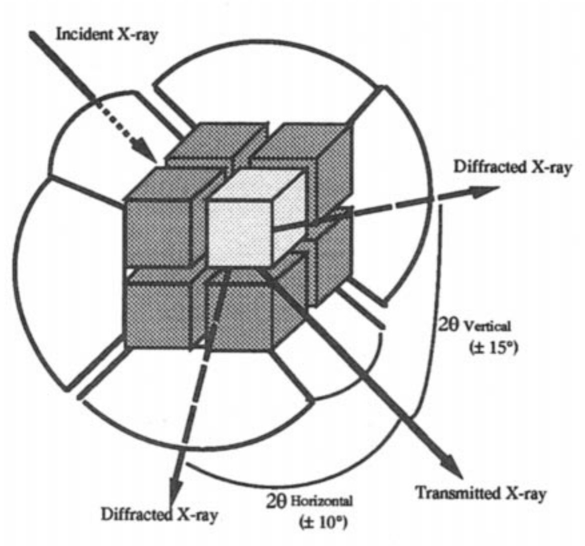

Fig. 2. Schematic drawing of the two-stage high pressure apparatus.

and controlled to align the beam with the sample. The divergence slit is mounted separately on a Y-Z positioning stage in front of the press. The vertical goniometer is mounted on a Y-Z positioning stage, and the horizontal one is mounted on an X-Y-Z stage.

The Ge-SSD is used for the detector system in the energy dispersive diffraction exp eriment.

*X axis is parallel to the beam, Y axis is normal to the beam, and Z is a height.

Table 1 . Specifications for the proposed high pressure apparatus.

Ram force	1500 ton
Guide block	DIA type
1st stage anvil	WC with 19 mm truncation for sintered diamond anvil
	Maraging steel with 50 mm truncation for tungsten carbide anvil
Goniometer	Vertical (±15°)
	Horizontal (±10°)