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SHOCK WAVE APPARATUS FOR STUDYING MINERALS AT HIGH PRESSURE AND IMPACT PHENOMENA ON PLANETARY SURFACES

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ABSTRACT

Shock wave and experimental impact phenomena research on geological and planetary materials is being carried out using two propellant (18 and 40 mm) guns (up to 2.5 km/sec) and a two-stage light gas gun (up to 7 km/sec). Equation of state measurements on samples initially at room temperature and at low and high temperatures are being conducted using the 40 mm propellant apparatus in conjunction with Helmholtz coils, and radiative detectors and, in the case of the light gas gun, with streak cameras. The 18 mm propellant gun is used for recovery experiments on minerals, impact on cryogenic targets, and radiative post-shock temperature measurements.

FACILITIES

Two propellant (18 and 40 mm) diameter and one two stage light gas (160 mm 1st stage; 25mm, 2nd stage) guns are being operated to obtain equation of state, impact and shock recovery data of geophysical and planetary science interest.

(a) Propellant gun (18 mm)

This apparatus employs up to 20 g of propellant and accelerates $\sim$ 20 g projectiles to speeds of $\sim$ 2.5 km/sec in approximately 2 m. The barrel and a portion of the impact assembly is evacuated. Impact velocity is determined to a precision of $\sim$ 1% by means of the projectile obscuring two laser beams which are detected with photodiodes. Although some photographic recording has been carried out, this apparatus has been principally used for shock recovery experiments[1-8], impact experiments at low temperatures[9] post-shock radiative temperature measurements[10,11], and gas recovery experiments from volatile-bearing minerals[12].

(b) Propellant gun (40 mm)

This 6m long apparatus employs up to 0.5 kg propellant to launch 100g projectiles to 2.5 km/sec. Three laser beam observations, over 1.5 m baseline, determine projectile velocity to better than ± 0.3%. Double flash x-ray radiography using two 150 KV Field

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Emission, 30 nsec duration sources are used to carry out impact studies or provide additional impactor speed data. Recovery experiments on larger samples[13] and spall studies at low speeds[14], have been carried out with this apparatus. The latter employ a compressed gas breech which permits operating apparatus at speeds of as low as ∿100 m/sec. For optical recording the apparatus utilizes a Beckman and Whitley 339 continuous writing streak camera which permits in conjunction with a 75 μF 5KV xenon light source, shock velocities and free surface velocities to be determined using optical recording methods[15-18]. Measurements on low temperature materials have been undertaken[19,20] and preheated molten oxide measurements are in preparation[21]. Absorption and thermal emission spectroscopy is carried out with a 0.5 m Ebert, Jarrell-Ash Monochrometer apparatus[22-24].

(c) Light Gas Gun Apparatus

This apparatus utilizes a continuous x-ray source and photomultiplier to detect[25] the emergence of the ∿ 20 gram projectile from the muzzle of the 6m long, H_2 driven, 25 mm diameter second stage of this gun and provide a light source and x-ray trigger. Two Field Emission 15 nsec 150 KV flash x-ray generators provide images of the projectile in flight and yield projectile velocities to an accuracy of better than ± 0.2%. Upon impact with a mineral target, shock and free surface velocity are recorded with a Model ID TRW Image Converter Streak Camera writing at 35 mm/μsec. A 30 MHZ oscillator driving a Pockel's cell provide time marks on the streak record at 16.67 nsec intervals. Hugoniot and release adiabat data for a series of oxides, silicates and sulfides have been obtained to pressures of ∿ 200 GPa[26-32].

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