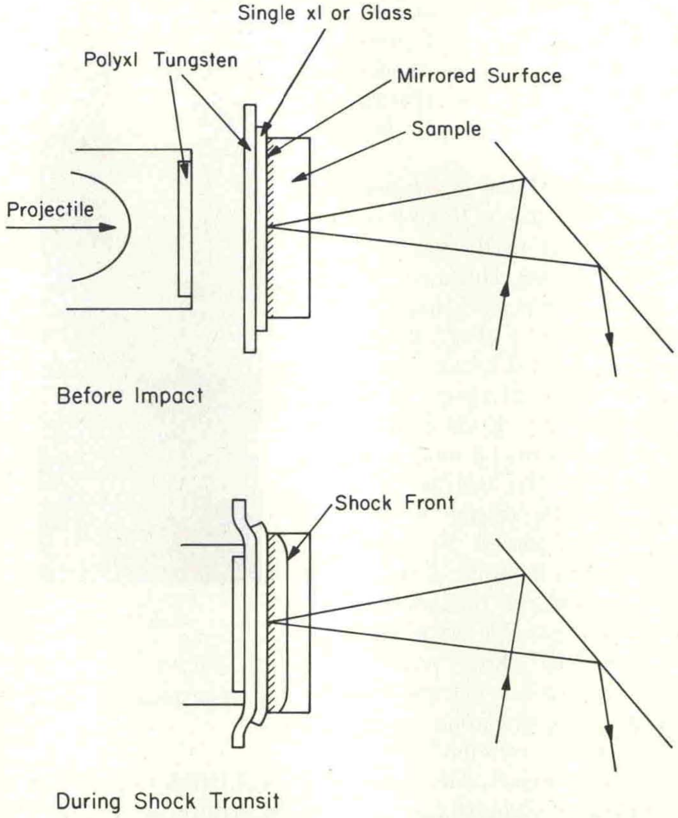

Fig. 7. Detail of the sample arrangement before impact (above) and during shock transit (below) showing light path and regions of the sample studied.

mounted on a thin slab of single-crystal material or glass with the side toward the sample polished. This extra layer smooths the shock front, which is optically rough when it leaves the polycrystalline material of the projectile and driver plate. Without this layer, the mirrored surface of the sample ceases to be a good specular reflector when the shock passes it. To date, samples as thin as 3 mm and as small as 12 mm in diameter have been successfully used. Thinner samples could be used by sandwiching them between glass, sapphire, periclase, or the like.

The light path within the target is also indicated in Figure 7. The near normal (6½°) incidence reduces reflection losses at the free surface, and the double path length allows greater total absorption than a single transit. The light path after impact is also indicated. In this case the path samples both high- and low-pressure regions. As the shock progresses through the sample, the low-pressure spectrum fades out and is gradually replaced by the high-pressure spectrum.

This system has been used successfully to obtain spectra of periclase (MgO), soda lime glass, and ruby. Data for periclase and ruby are discussed below.

HIGH-PRESSURE ABSORPTION SPECTRUM OF MgO

The spectrum of periclase at zero pressure is completely featureless in the visible region. A study of the spectrum of shock-compressed MgO was undertaken to determine the feasibility of using the material as a 'window' to permit the measurement of spectra in thinner samples and at higher pressures (by using a reflected shock technique). To be useful for this application, the material must retain its transparency during shock compression. In addition, such a study is of interest in order to better interpret spectra of MgO shocked to high pressures and recovered. *Gager et al.* [1964] have observed F centers in MgO recovered from a shock pressure in excess of 500 kb. Such features should be observable in these absorption spectra whether they are produced on loading or unloading.

Figure 8 shows a record of the absorption spectrum of MgO shocked to 465 ± 10 kb final pressure. The pressure is inferred from the impact velocity and the known Hugoniots of the tungsten flyer and driver plate [*McQueen et al.*, 1970] and sample [*Carter et al.*; 1971]. Such a shock should be preceded by an elastic precursor with a normal stress of about 90 kb [*Ahrens*, 1966]. The difference in velocity of the two shocks should be about 1.5 mm/μsec, the elastic shock traveling at 10.1 mm/μsec. In the upper part of the picture (region A) we see the spectrum of the unshocked MgO followed by a sharp decrease in intensity, indicating the arrival of the shock at the internal mirror surface. It is not possible with this experiment to separate the three possible causes of this decrease, which are (1) absorption in the shock front, (2) degradation of the mirror by the shock, or (3) rotation of the mirror by an oblique shock impact. Any or all of these features could lead to observed featureless decrease in light intensity. Below this discontinuity (region B) the spectrum is progressively changing from that of unshocked MgO to that of shocked MgO. The opacity of the shocked material is greater than that of the unshocked material, but no spectral features are apparent. This may be an intrinsic effect due to compression of MgO to 465 kb, or it may be due to scattering off of numerous shock-induced imperfections in the crystal. In the absence of any other data, we favor the latter cause.

There are two discontinuities in rapid succession at the end of region B. These are attributed to arrivals of the elastic and plastic shocks at the free surface of the sample, which can be expected to degrade the surface sufficiently to yield a substantial (featureless) decrease in light transmission. From the time separation between mirror encounter and free surface emergence we can calculate the shock velocities to be 8.0 ± 0.5 and 9.9 ± 0.1 mm/μsec for the plastic and elastic waves, respectively. These values are in very good agreement with those of *Ahrens* [1966], especially in view of the rather diffuse nature of the second arrival in Figure 8.

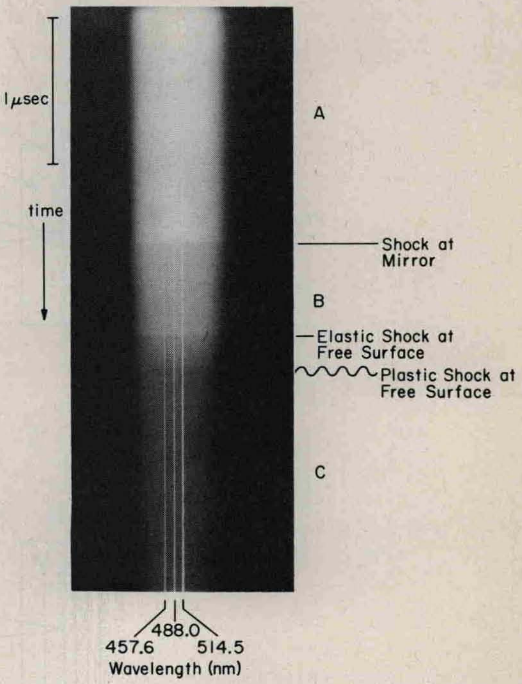

Fig. 8. Absorption spectrum of periclase (MgO) shocked to 465 kb.

In region C of the record we have the spectrum of MgO while it unloads from 465 kb. There is no change apparent across this region, indicating that no changes in the opacity of periclase occur during the first 1½ μsec of unloading. This is sufficient time to permit complete unloading of the MgO back to the mirror (unless the low-pressure shock wave reflected from the rear surface of the flyer plate interferes). If color centers have been produced in this event, they must be few in number, in some other spectral region, or not yet in their ground state. It is concluded that shock pressures greater than 465 kb are required to produce substantial populations of color centers in periclase. Because of the qualitative nature of intensity measurements with the present system, the term substantial cannot be more qualitatively defined.

RUBY SPECTRA

Although Fe^{2+} is by far the most abundant of the transition metal ions in the mantle, its