Report on experiments under proposal HS2438

The purpose of this beamtime was to determine the elastic properties of iron-bearing magnesium silicate perovskite, $(Mg,Fe)(Si,Al,Fe)O_3$, which is presumably the most abundant phase of the lower mantle. During our initial beamtime at ID-28 in 2004, we examined a number of single crystal and some polycrystalline samples. The primary target in these experiments were the single-crystal samples since they yield the single crystal elastic constants, as well as the aggregate elastic properties (e.g., bulk and shear moduli) by Voigt-Reuss-Hill or Hashin-Shtrikman averaging.

A few single-crystal samples were examined and it was determined that a sample with about 9% Fe was must suitable for single-crystal data collection. This particular sample has a composition that would be expected for a "pyrolite" bulk composition for the lower mantle. We then spent most of the beam time collecting inelastic xray scattering spectra of energy versus Q for scattering from longitudinal and transverse acoustic phonons in the a-c plane of the crystal. From these the acoustic velocities were determined. As examples, figures 1-3 below show the dispersion curves for two longitudinal modes and one transverse mode. Note that all of the data seem to fall within the linear portion of the dispersion curves. The velocities obtained from the data in Fig. 1-3 in several directions allowd us to determine the following single-crystal constants:

C11 = 392 GPa (V_L = 9480 m/s) C55 ~ 146
C33 = 420 GPa, (V_L = 9995 m/s) C13 ~ 103
C44 = 171 GPa, (V_T = 6380 m/s)

The results for C55 and C13 are less certain and additional data should be collected for these constants. This would be done with the additional beam time we are requesting.

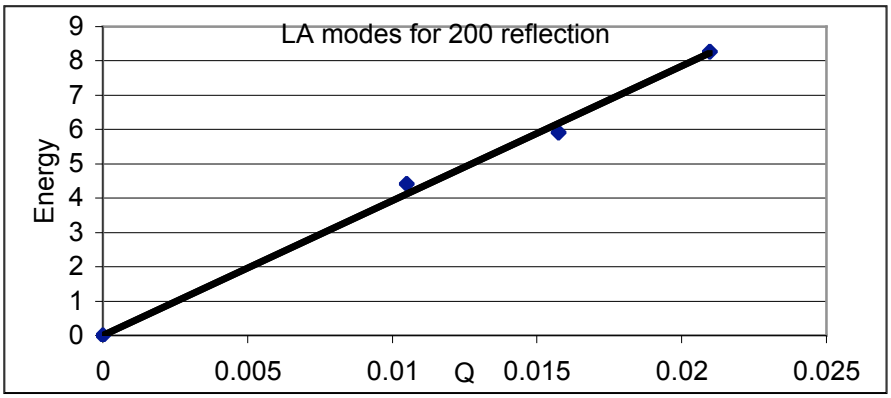

Fig. 1: IXS dispersion curve for a longitudinal acoustic (LA) mode with propagation direction parallel to **a** (200).

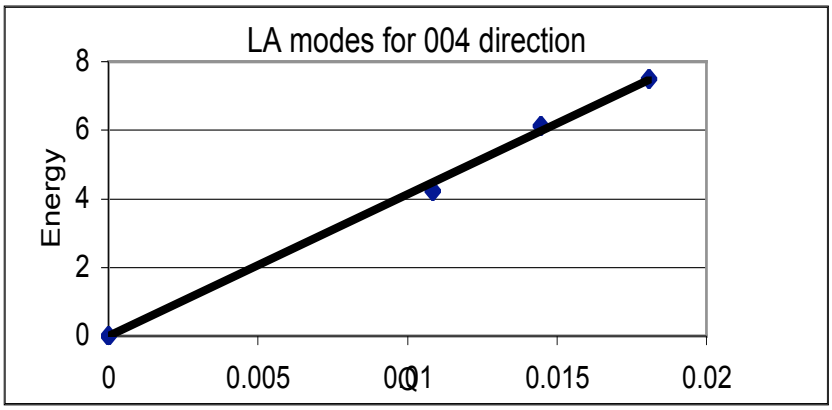

Fig. 2: IXS dispersion curve for a longitudinal acoustic mode with propagation direction parallel to c (004).

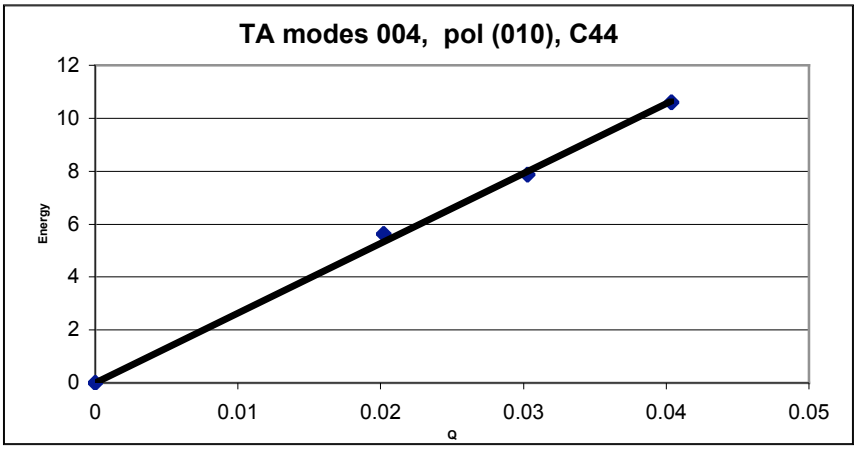

Fig. 3: IXS dispersion curve for a transverse mode with propagation direction parallel to c (004) polarized parallel to (010).

We are requesting additional beam time to finish the work we've started on this perovskite sample. This work is a first step toward our ultimate goal of being able to use inelastic x-ray scattering to determine the single crystal elastic properties of deep earth oxide materials at high pressures characteristic of the deep mantle, using the diamond anvil cell. We have already made a highly significant finding, in that Fe lower the elastic moduli of magnesian perovskite significantly. If this result holds up on the collection of additional data, it will resolve a long standing controversy in mineral physics and will have an impact on our understanding of lower mantle composition.