Elastic Shear Anisotropy of Ferropericlase in Earth's Lower Mantle

Hauke Marquardt,1* Sergio Speziale,1 Hans J. Reichmann,1 Daniel J. Frost,2 Frank R. Schilling,1† Edward J. Garnero3

1.GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany. 2Bayerisches Geoinstitut, Universität Bayreuth, 95440 Bayreuth, Germany. 3School of Earth and Space Exploration, Arizona State University, Box 871404, Tempe, AZ 85287, USA.

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WANG Riping
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Introduction

1. Seismic anisotropy in Earth's D'' layer have been definitely detected in recent decades. Seismic anisotropy is an essential indication for the mantle convectio model.
2. The most possible candidate mechanism of seismic anisotropy is lattice preferred orientation of constituent minerals which have elastic shear anisotropy.
3. Ferropericlase possibly has significant effect on seismic anisotropy through lattice preferred orientation, as it accommodate much more strain than hard perovskite.
4. Pressure dependence elastic shear anisotropy of ferropericlase, which is unclear before, is required to understand lowermost mantle seismic anistotropy
5. This paper experimentally (Brillouin spectroscopy method) shows a much large pressure dependence of elastic shear anisotropy of ferropericlase than previous prediction. Related geology understanding is discussed.

Previous Study

1. Elastic anisotropy of ferropericlase and pure MgO have been detected at low pressure.

2. Iron effect of Elasticity of (Mg0.94,Fe0.06)O has been detected at spin transition pressure, such as Crowhurst et, al, 2008, but there is not sufficient constrain on *C12* and*C44,* which is necessary to evaluate its anisotropy properties.

Experimental Method

1. Single crystals of $(Mg_{0.9},Fe_{0.1})O$ with size 0.1mm was synthesis at high PT condition.

2. Brillouin spectroscopy was performed up to 69GPa in DAC with pressure-transmitting media.

3. Density of sample, which is necessary to invert the Brillouin data to elasticity, is obtained at high pressure on beamline.

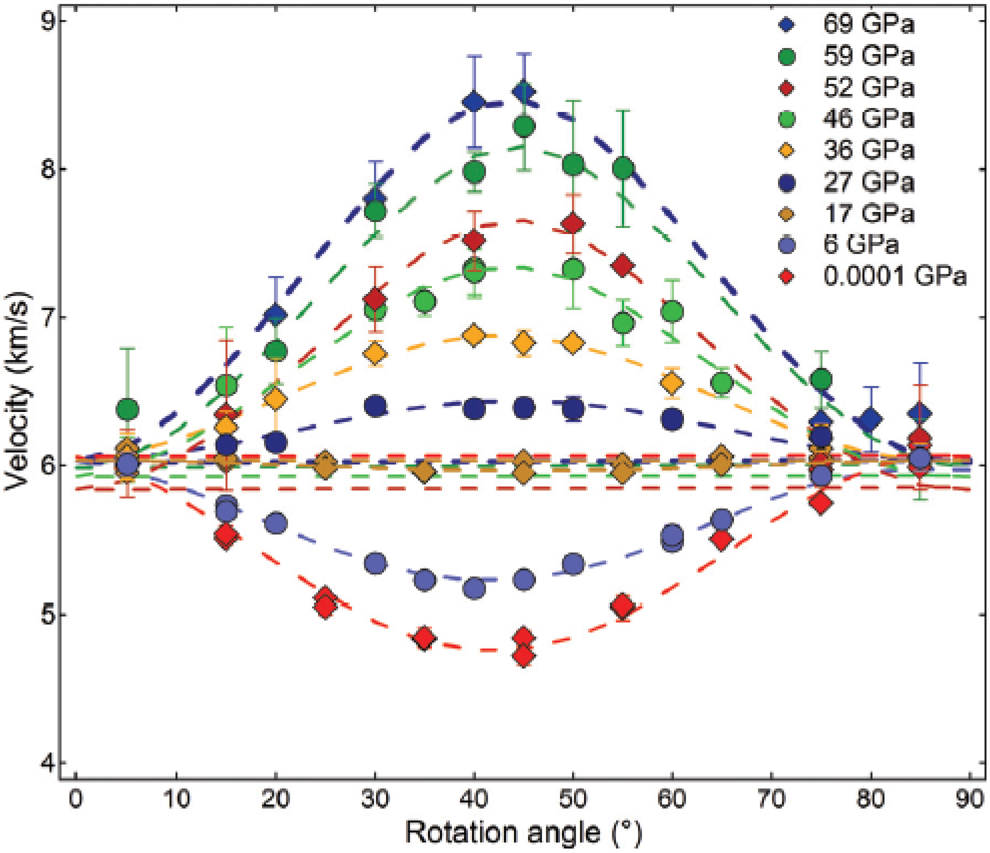
Characterizing Anisotropy

1. Definition of shear wave anisotropy(%):

   $(vs[001]-vs[011])/((vs[001]+vs[011])/2)$

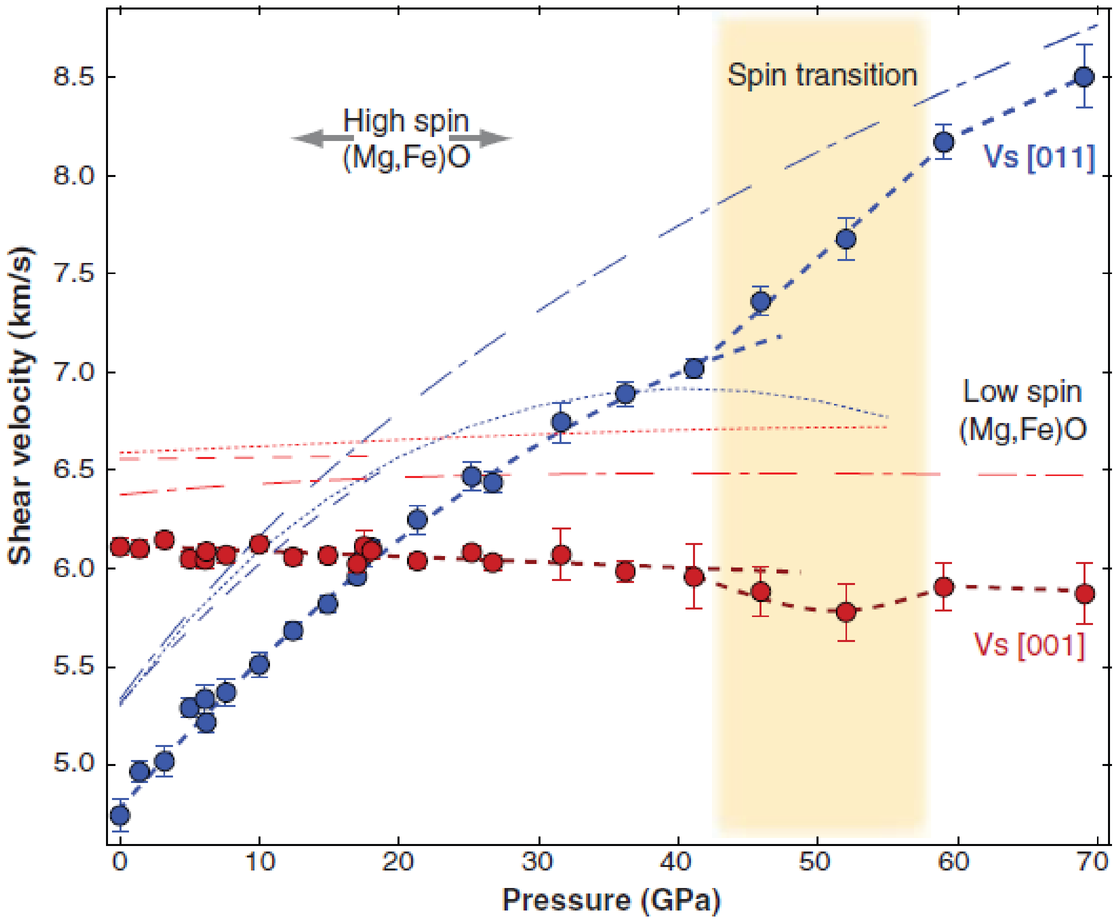
2. In Brillouin scattering method, shear wave is obtained by detecting frequency shift Δf through equation $V = d\Delta f = \lambda\ \Delta f\ /(2\ n\ \sin\ \phi/2)$.

Raw Data of Brillouin spectroscopy



Experimental results

1. Propagation alone [001] is almost pressure independent.
2. Propagation alone [011] is highly pressure dependent.
3. Fastest propagation direction is inversed at 18GPa.
4. At 45GPa, corresponding to spin transition of iron, shear wave velocity alone [011] clearly increased.

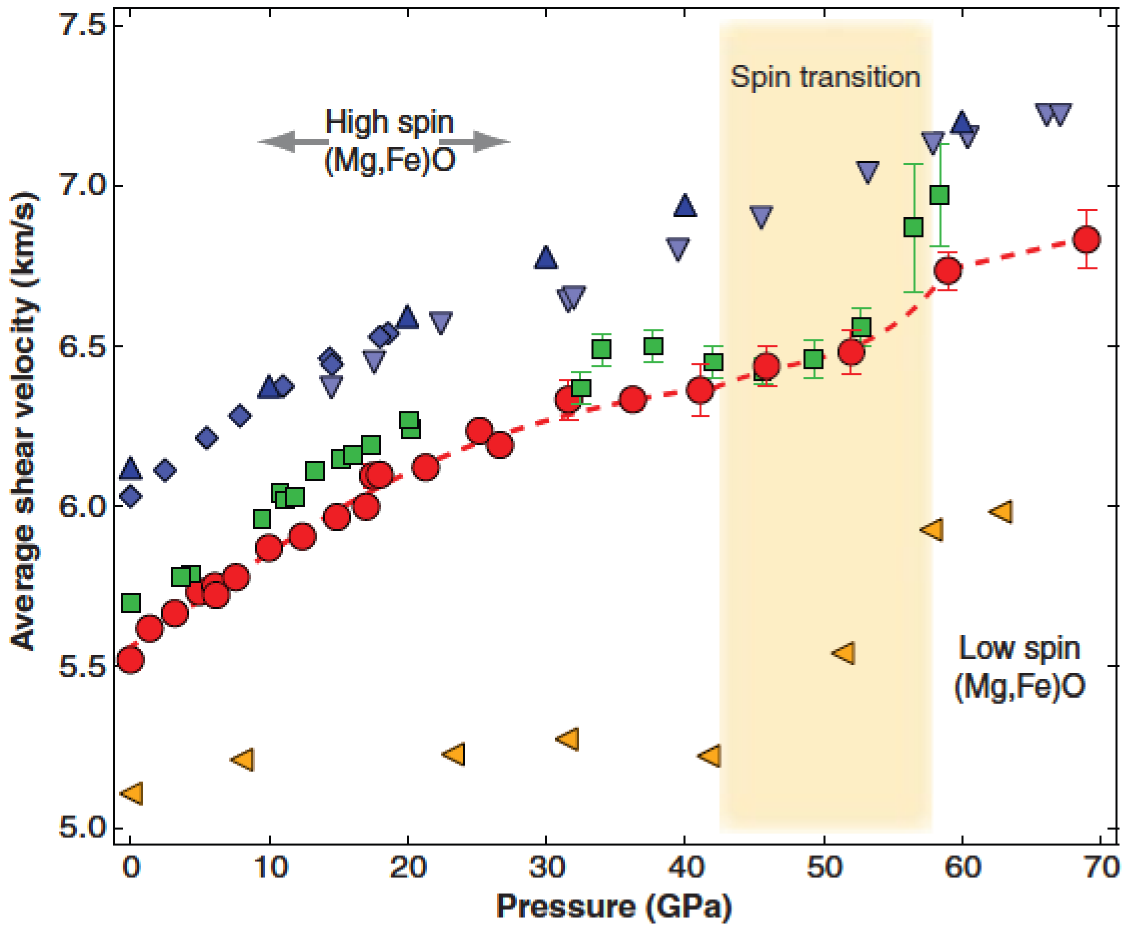


Structural understanding of spin transition effect

1. $(c_{11}-c_{12})/2$ and c_{44} are use to calculate the maximum and minimum shear velocity.

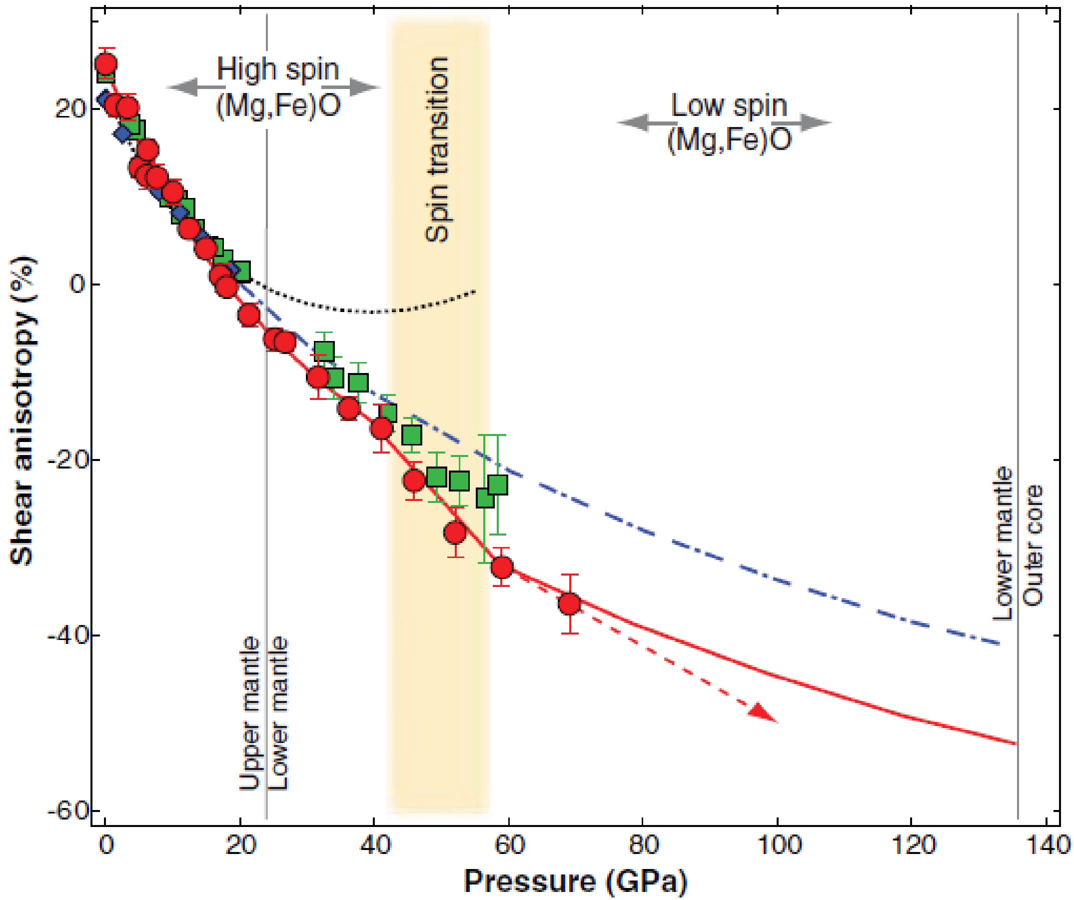
2. Asymmetrical electron distribution high spin iron results in high value of c_{12}, while symmetry electron distribution of low spin results in low value of c_{12} and high value of c_{11}. High pressure prefer low spin state and high $(c_{11}-c_{12})/2$, resulting a high anisotropy.

Increasing iron fraction in ferropericlase causes marked difference in average shear velocities.



.Increasing iron fraction in erropericlase causes marked ncrease in shear anisotropy.

2. The difference between the elastic anisotropy of MgO and .S (Mg0.9,Fe0.1)O is distinct.



Elastic anisotropy of the lower mantle

1. 20% (Mg0.8,Fe0.2)O contribute about equally to overall possible seismic shear anisotropy as 80% perovskite.

2. It shows strong iron content dependence of estimation of elastic anisotropy of lower mantle assembly. But consensus on iron partition behavior has not been reached

3. large anisotropy of ferrropericlase reaches the requirement of lattice preferred orientation mechanism in understanding seismic anisotropy of D" layer.