Seismological evidence for heterogeneous lowermost outer core (F-layer) of the Earth

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We present seismic evidence for heterogeneous structure in the layer directly above the inner core (F-layer), which suggests a localized concentration of light elements.

In this study, we examined the F-layer structure beneath Australia using core phases on vertical-component seismograms of Hi-net in Japan for earthquakes near the South Sandwich Islands. We analyzed the waveforms using the method developed by Ohtaki and Kaneshima (2015). The method uses two observations that are particularly sensitive to the layer structure and are relatively insensitive to the structure of the other parts of the Earth. The first observation is the frequency dispersion in P-waves that graze or are diffracted at the inner core boundary (PKPbc); the second observation is differential travel times between the P-waves reflected from the inner core boundary (PKiKP) and those that turn above the boundary (PKPbc). The dispersion is sensitive to the velocity gradient just above the inner core boundary, but insensitive to the velocity values in the F-layer. The differential travel time is sensitive to the velocity values between the PKPbc turning depth and the inner core boundary, but insensitive to the velocity gradient in the F-layer. The observed PKPbc dispersion requires nearly constant velocity on the inner core boundary in this region. The observed CD-BC necessitates that cumulative velocity in the F-layer is close to that of PREM. The velocity model which satisfies both the observations has nearly constant and smaller velocities than PREM on the boundary and faster ones above.

This feature is in contrast to the F-layer velocity model for the region beneath the northeast Pacific (FVW) (Ohtaki and Kaneshima, 2015), which has a somewhat gentler velocity gradient and smaller velocities than PREM in the whole F-layer. Velocity in the liquid core has a little dependence on temperature (Ichikawa et al., 2014). Thus the difference in velocities between the two regions is ascribed to the relative abundance of light elements. The reduced velocity gradient on the inner core boundary beneath Australia signifies chemically unmixed materials there. The higher velocities than FVW and also PREM indicate a localized higher concentration of light elements in the F-layer.

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