Intrinsic attenuation factor Q of partially molten Fe–S–O system

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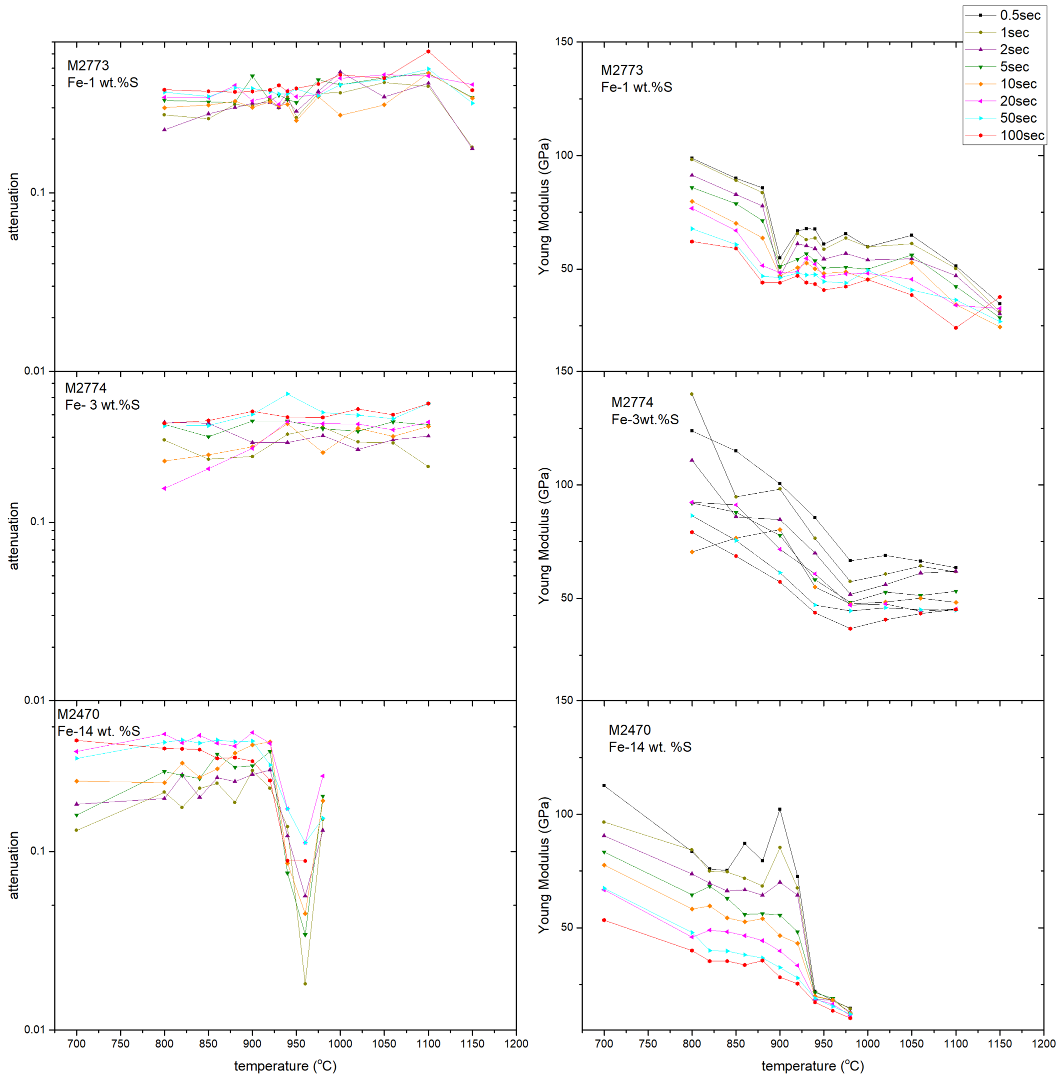
Heterogeneous seismic structures have been found at the top of the Earth’ s inner core in terms of attenuation and velocity (Iritani et al., 2014; Souriau and Romanowicz, 1997; Tanaka, 2012). The outermost part of the inner core with approximately 30 km thickness shows low attenuation, then attenuation increases beneath this layer (Cao and Romanowicz, 2004; Ibourichene and Romanowicz, 2018; Waszek and Deuss, 2013). The positive and negative correlations between velocity and attenuation were observed from the uppermost inner core in different areas: Pacific center in the inner core has negative correlation and the rest area has positive correlation (Attanayake et al., 2014; Godwin et al., 2018). In this study, experiments on attenuation of partially molten Fe–S–O system were performed to explain the possibility that could cause seismic anomalies.

We investigated Fe-S-O system. Sulfur and oxygen are regarded as the representative light element in the Earth’ s core. Fe samples with 1, 3 and 14 wt. % S were synthesized in piston cylinder apparatus at 900°C and 1 GPa. a small amount of oxygen was included accidentally. In-situ X-ray radiographic observations were performed at the bending magnet beam line BL04B1 at SPring-8. Deformation-DIA press with a facility of cyclic loading was used. This system could produce sinusoidal displacement in a wide range of oscillation periods from 0.2 to 100 s and generating variable amplitudes (Yoshino et al., 2016). Q value characterizing intrinsic attenuation was determined by phase lag of sample strain against the reference material at 1 GPa and up to 1200°C.

The experimental results show that frequency dependence of attenuation is not remarkable except for a fine grained-sample, whereas decrease of attenuation was found at 1100 and 920°C for Fe- 1 wt. %S and Fe- 14 wt. %S samples, respectively. The attenuation drop would occur with increasing melt fraction. Experiments of Fe-14 wt. %S sample along heating and cooling paths were done to check the influence of grain growth during experiments. Data obtained from both heating and cooling paths show that abrupt change of the attenuation occurred at around 925°C. The Young’ s modulus calculated from the strain ratio of sample and reference shows strong temperature dependence. An obvious drop occurred between 900 and 980°C in association with the occurrence of partial melting. Relationship between velocity and attenuation anomalies of the Fe–S–O system shows a positive correlation when melt fraction reaches a certain value.

Partial melting could decrease Q^{-1}, which could explain the relative low attenuation on uppermost 30 km layer throughout the top of the inner core. Combing with the positive correlation between attenuation and velocity, a large amount of partial melting could occur on the uppermost 30 km layer of the rest area except the Pacific hemisphere in the inner core.

Keywords: attenuation, partially melting, Young Modulus, inner core


M2773
Fe-1 wt.%S
M2774
Fe- 3 wt.%S
M2470
Fe-14 wt. %S
attenuation
0.01
0.1
Young Modulus (GPa)
150
100
50
M2773
Fe-1 wt.%S
M2774
Fe-3wt.%S
M2470
Fe-14 wt. %S
0.5sec
1sec
2sec
5sec
10sec
20sec
50sec
100sec
700
750
800
850
900
950
1000
1050
1100
1150
1200
temperature (°C)