The regulation mechanism of the redox state of the Earth's magma ocean inferred from high-pressure experiments on redox disproportionation of Fe^{2+} in silicate melt

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Venue: Zoom

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The redox state of planetary mantles controls the chemical composition of volcanic gases and thus planetary atmospheres. Based on geological constraints on zircon, the Earth's upper mantle may have been oxidized as today around 4.4 billion years ago [Trail et al., 2011]. This indicates that great mantle oxidation event occurred after the core formation within 0.2 billion years. Redox disproportionation of Fe^{2+} in a magma ocean followed by the precipitation of metallic Fe into the core has been proposed as an oxidation mechanism of the Earth's mantle [e.g., Hirschmann, 2012; Armstrong et al., 2019; Deng et al., 2020]. Such a disproportionation reaction could have increased the redox state of the surface of the magma ocean close to the present Earth's upper mantle. However, the Fe^{3+} content produced by the redox disproportionation of Fe^{2+} in a magma ocean is largely different between two previous studies [Armstrong et al., 2019; Deng et al., 2020]. Here we conducted new high-pressure experiments on the redox disproportionation of Fe^{2+} in silicate melts at pressures from 8 GPa to 27 GPa and temperatures above the liquidus. Our results are partially consistent with the previous experimental study [Armsrong et al., 2019], but we found that $Fe^{3+}/\Sigma FeTotal$ in silicate melts equilibrating metallic Fe at pressures above 20 GPa becomes higher than the present Earth's upper mantle. If this is the case, oxygen sink is required to reduce the redox state of the magma ocean for explaining the redox condition of the Earth's upper mantle around 4.4 billion years ago. In the seminar, I will present our experimental results and discuss the possible regulation mechanism of the redox state of the Earth's magma ocean.