Thermal maturation of carbonaceous material as a proxy for earthquake slip: Evaluation of effects by initial maturity, heating rate, and mechanochemical activation

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Thermal maturation of carbonaceous material (CM) has been used as a proxy for frictional heating in a fault zone during an earthquake. CMs have complicated molecular structures and are classified into lignite, bituminous coal, and anthracite depending their initial maturities. During an earthquake, not only temperature in a fault zone rises rapidly but also mineral particles and CMs suffer by shear deformation. However, these factors have not been comprehensively investigated. In this study, we investigated changes in maturity of three types of CMs (lignite, bituminous coal, and anthracite) and graphite. Samples were forced by shear deformation by using a rotary shear apparatus, and then were heated in a tubular electric furnace. The conditions of the friction experiments were as follows: slip rate, 1 mm/s; axial load, 1 and 3 MPa. The target temperatures of the heating experiment were from 300 to 1300 ℃ at 100 ℃ interval and the heating increments were several tens and 0.1 ℃/s. The heated CMs and graphite were analyzed by using infrared (IR) and Raman spectroscopies. The spectrum of heated lignite showed ,a disappearance of C-H chain at ≧ 490 ℃ under slow heating, and at ≧ 890 ℃ under rapid heating. The difference in temperature where the peak was disappeared was 80 ℃ between damaged and undamaged lignite samples. In bituminous coal, disappearances of C-H chain at ≧ 490 ℃ and ≧ 970 ℃ were observed under slow and rapid heatings, respectively. No difference in temperature where the peak was disappeared was observed between damaged and undamaged bituminous samples. In the cases of anthracite and graphite, there was no peak of C-H chain. Raman spectra of lignite sample that unheated and heated showed a difference in the intensity ratio of G and D bands, but no differences were observed in bituminous coal, anthracite, and graphite even though that suffered shear damage. Therefore, thermal maturation of CMs has complicated effects causing from initial maturation, heat rate, and mechanochemical damage and their consideration is needed when the maturation is used as a proxy of frictional heat recorded in faults.

