Visualization of the rapid crack propagation driven by a pressurized air in viscoelastic gels

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Sudden expansion of the external water heated by a magma source sometimes fractures the country rocks so that causes explosive eruption, known as a phreatic eruption. If the steam expansion fractures the juvenile magma and erupts it out, the eruption is called as a phreatomagmatic eruption. Fine ash generated by phreatic/phreatomagmatic eruptions has smaller grain size than those generated by dry (without external water) eruptions.
Experiments of buoyancy-driven fluid-filled cracks as a model of a dike propagation by a magma ascent have revealed that the importance of the pressure inside the cracks. In contrast, the stress perturbation propagates at the shear wave velocity, which may become an upper limit of a fracture propagation. A sudden expansion of a steam from a point source may cause phreatic/preatomagmatic explosive eruptions, but the fracture mechanism has not yet understood well.
In this study, we visually observe a rapid crack propagation using the expansion of a pressurized air from a point source in transparent gels. We use three types of gels: (gel1) a hard quasi-Maxwell fluid with a shear modulus of 10^4-10^5 Pa, (gel2) a soft quasi-Maxwell fluid with a shear modulus of 10^3 Pa, and (gel3) a quasi-Voigt solid with a shear modulus of 10^2 Pa. We introduce a pressurized air from the bottom of the gel, visually observed the pressure perturbation and the crack propagation by using polarized sheets, and record it by a high-speed video camera.
In gel1 and gel3, a thin air sheet with a sharp tip, usually recognized as a crack, propagates into the gel. On the other hand, in gel2, the air becomes a thick sheet with a round tip, which is more like a slug rather than a crack. In all experiments, the pressurized air erupts out the ash-like small particles generated by the friction between the pressurized air and the clack walls. The propagation velocity of the crack does not exceed the calculated shear wave velocity in gel1, but does in gel3. These results suggest that the combinations of the rheology and the gas pressure inside the cracks generate a variety in the shape of crack/slug and the fracture mechanism. The various shapes of the crack/slug may be observed as the difference of the resonance frequency by seismic signals.

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