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Coupling extrusion, drumbeat seismicity and magmatic outgassing at Mount St. Helens using effective stress concepts

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We present a model to explain shallow "drumbeat" seismicity associated with volcanic extrusion of a solidified plug at Mount St. Helens using Coulomb-type friction and concepts of effective stress. This contrasts with a previous model, that relied on a highly non-linear description of the frictional force to simulate the observed behavior [*Iverson et al.*, 2006]. Although the approximation for friction in that study is consistent with laboratory observations of the gouge material, we show that it is not a necessary condition for explaining drumbeat seismicity. We show that simple, rate-independent Coulomb-type friction at the interface wall between the plug and the conduit also produces a drumbeat response, with the periodicity strongly controlled by the effective contact area between the plug and conduit walls. The advantage of this formulation is that concepts of effective stress can be used, and leads to an alternative mechanistic explanation for the observations. Namely, variations in fluid pressure between the ascending plug and the conduit affect the effective area in frictional contact and thus control the drumbeat periodicity. This result allows the effects of trapped fluid overpressure generated by degassing magmas into the problem, and therefore the potential to additionally relate to observed CO_2 and SO_2 degassing events.