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Effects of elastic, density and strength discontinuities on dike propagation path.

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We present a 2D numerical model describing dike propagation in proximity of a discontinuity in elastic parameters, density and fracture toughness of the embedding medium. Dikes are modeled, employing the boundary element technique, as fluid filled cracks in plane strain configuration. Dikes open and propagate in an infinite elastic medium, made up of 2 welded half-spaces with different rigidities, densities and fracture toughness. The pressure gradient along the crack is assumed proportional to the difference between the densities of host rock and fluid. We take into account the compressibility of the fluid and a variable density in order to conserve the mass of the intrusion during its motion. Our model allows to set a tectonic stress field and an arbitrarily tilted boundary separating different media. The path followed by the crack is found by maximizing the total energy release, given by the sum of the elastic and gravitational contributions. Propagation is allowed when the energy release during the motion exceeds a fracture threshold. The output of this code gives the path followed by the crack during the motion, the trend of the energy release per unit of propagation length, the dike shape, the stress and displacement fields induced in the surrounding medium. The mathematical simulations provide a sort of "refraction" phenomenon, that is a sudden change in the direction of propagation when the crack crosses the boundary separating different rigidities: if the dike enters a softer medium, its path deviates toward the vertical, if the dike enters a harder medium its path deviates away from the vertical. Even if the magma density is low enough to provide positive buoyancy, dike may become arrested as a horizontal sill along the interface, if the rigidity contrast is large or if the fracture toughness is lower along the interface (e.g., layers are weakly welded). Density discontinuities by themselves do not provide the same effect: dikes arrest near the neutral buoyancy level without deviating from the initial direction of propagation. A density discontinuity in presence of an elastic discontinuity, changes the "refraction" angle and the depth of dike arrest. Gravitational energy plays a major role during propagation; in particular, in proximity of a rigidity discontinuity, this role is enhanced by the shift of the center of mass due to changes of dike shape. Mathematical results were validated by laboratory experiments performed injecting tilted air-filled cracks through gelatin layers with different rigidities.