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Segmented lateral dyke growth in a rifting event at Bárðarbunga volcanic system, Iceland

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Crust at many divergent plate boundaries forms primarily by the injection of vertical sheet-like dykes, some tens of km long. Previous models of rifting events indicate either a lateral dyke growth away from a feeding source, with propagation rates decreasing as the dyke lengthens, or magma flowing vertically into dykes from an underlying source, with the role of topography on the evolution of lateral dykes not clear. We show how a recent segmented dyke intrusion in the Bárðarbunga volcanic system, grew laterally for over 45 km at a variable rate, with an influence of topography on the direction of propagation. Barriers at the ends of each segment were overcome by the build-up of pressure in the dyke end; then a new segment formed and dyke lengthening temporarily peaked. The dyke evolution, which occurred over 14 days, was revealed by propagating seismicity, ground deformation mapped by Global Positioning System (GPS), interferometric analysis of satellite radar images (InSAR), and graben formation. The strike of the dyke segments varies from an initially radial direction away from the Bárðarbunga caldera, towards alignment with that expected from regional stress at the distal end. A model minimizing the combined strain and gravitational potential energy explains the propagation path. Dyke opening and seismicity focused at the most distal segment at any given time, and were simultaneous with a magma source deflation and slow collapse at the Bárðarbunga caldera, accompanied by a series of M>5 earthquakes. The dyke growth was slowed down by an effusive fissure eruption near the end of the dyke. Lateral dyke growth with segment barrier breaking by pressure build-up in the dyke distal end explains how focused upwelling of magma under central volcanoes is effectively redistributed over long distances to create new upper crust at divergent plate boundaries.