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Mechanical interaction between central volcanoes in Iceland

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For many years there have been discussions as to the possible interaction between active central volcanoes in Iceland. The ideas derive partly from the fact that some central volcanoes are quite close to each other, and most belong to volcanic systems many of which are also very closely spaced. To test the possibility of a mechanical interaction between central volcanoes, we have run many numerical models using the finite-element program Ansys. We selected 8 central volcanoes from the central part of Iceland, namely where the North Volcanic Zone meets the East Volcanic Zone. Some of these central volcanoes are located beneath the ice sheet Vatnajokull, but most are known or inferred to have calderas and shallow, crustal magma chambers. Two of the central volcanoes have double calderas. The average distance between the nearby volcanoes (excluding the double calderas) is about 30 km. These volcanoes include Grimsvotn, which erupts on average once every decade and is the most active central volcano in Iceland.

In all the models we used a homogeneous, isotropic crust with a Young's modulus of 20 GPa and a Poisson's ratio of 0.25, both values being typical for the uppermost part of the crust in Iceland. In all the models we applied a tensile stress of 5 MPa (equal to the maximum in situ tensile strength of typical solid rocks) in a direction parallel with the spreading vector in this part of Iceland, that is, N105˚E. In most models, each of the single calderas was modeled as 8 km in diameter, and its location taken from a general geological map of the area. Using these boundary conditions as a basis, as well as the geometries of the calderas (and inferred shallow magma chambers), we made models that belong to 4 main classes. In the first class, all the calderas have the same size, but where double calderas exist they are modelled as such. In the second class, double calderas are modelled as single and all the calderas have the same size.

In the third class, the double calderas are shown as single but with a diameter of 12 km (instead of the standard 8 km diameter). And in the fourth class, the geometries of the calderas are not idealised, but rather modelled as presented on the map.

The basic results are as follows. There is a strong mechanical interaction between all the nearby central volcanoes in all the model classes. That is, between all the nearby central volcanoes there are zones of high tensile stress. In particular, in the fourth class of models, where the geometry is most similar to the actual geometry of the calderas, there are tensile stresses close to, or slightly greater than, the in situ tensile strength of the crust. The present preliminary results thus indicate that mechanical interaction, including dyke propagation from one volcano to another as well as seismic and strain events, may be common in this part of the volcanic zones of Iceland.