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The problem of caldera ellipticity

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Collapse calderas are structurally delimited by reverse ring faults and are surrounded by peripheral concentric normal faults. In the simplest scenario, circular magma chambers produce circular calderas. Many natural calderas, however, are elliptical in shape. Previous studies have mainly focused on localised stress regimes related to magma chamber inflation and deflation only. Evidence is mounting up, however, that the structural development of calderas and especially the degree of their ellipticity depends on various pre-existing conditions. A number of possible mechanisms may explain elliptical calderas: 1) The initial geometry of the underlying magma chamber(s) 2) The distribution and orientation of pre-existing regional faults, 3) The influence of pre-existing topography, 4) The influence of the regional stress field on fault geometries related to caldera subsidence and 5) progressive post-caldera distortion. To better understand the relationship between caldera morphology, reservoir size, reservoir depth and regional tectonic influence, we designed three experimental series. One series investigated intrusion of silicon gel into tectonically active sand piles to shed light on initial chamber geometries. Silicon gel chambers respond systematically to applied tectonic stress and associated calderas would be clearly elliptical in shape. Additionally, exploitation of pre-existing faults by the injected gel occured in some cases. Another series of experiments looked at the effect of pre-existing topography (e.g. pre-caldera cones). Topography was found to have a substantial influence on the near surface geometry of the ring fault, but does not affect the deep structure of a ring fault system. A third experimental series was designed to evaluate the influence of orthogonal tectonic stresses on caldera shapes. Elliptical calderas were produced in all cases where a tectonic stress was applied. Frequently, pre-existing basement structures influenced the shape of calderas also. It is proposed that all of the above mentioned processes variably affect caldera formation. Despite the ability to distinguish between

these different processes on theoretical grounds and on the basis of experimental and numerical studies, distinction between e.g. caldera fault distortion, pre-existing weaknesses and elliptical chamber growth, will prove extremely difficult in nature. This is in part due to incomplete exposure of an entire caldera - magma chamber system, but also due to the often complementary effects of the mechanisms outlined above. Only very detailed analysis of further field, experimental and numerical data will resolve the relative importance of either mechanism and will probably have to be done for each caldera individually.