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TITLE: Continuous subsidence in the Thingvellir rift graben, Iceland: Geodetic observations since 1966 compared to rheological models of plate spreading

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ABSTRACT BODY: Plate spreading across the Mid-Atlantic Ridge in south Iceland is partitioned between overlapping rift segments – the Western Volcanic Zone (WVZ) and the Eastern Volcanic Zone. The Thingvellir graben lies along the central axis of the WVZ. A central piece of the graben, between main boundary faults spaced 4.7 km apart, has subsided over 30 m since the postglacial lava last covered it about 9000 years ago. A rifting episode without eruptions occurred in 1789. An ~7 km long leveling profile crosses the graben was initially measured in 1966. It has been remeasured five times, most recently in 1990 and 2007. A subsidence of about 1.5 mm/year is observed along the central part of the profile, compared to its end. GPS measurements since 1994 document a spreading rate of 3.5 mm/yr or less, distributed over the ~50 km width of the WVZ. This is only a fraction of full spreading between the North American and Eurasian plates in South Iceland, which is 18.7 mm/yr in direction N103°E according to the MORVEL plate motion model and mostly accommodated by the EVZ. The GPS vertical velocities, corrected for post-glacial rebound, suggest maximum subsidence of ~4.00 mm/yr in the center of the rift, and a broad (>50 km) zone of subsidence across the WVZ. The length of the leveling profile is short compared to the width of the zone of subsidence, so it only captures a fraction of the overall subsidence. A two-dimensional (length and depth) finite element model (FEM), considering a temperature-dependent non-linear rheology is used to fit the observed surface deformation. The model is stretched to reproduce the observed deformation, with varying rheological parameters and thermal boundary conditions. The model considers, in particular, different depth to 700°C isotherm at the rift axis. The best-fit model, solved by minimizing the residual between the observed and modeled surface displacements, is found for a 700°C isotherm at 5 km depth at the rift axis, with a thermal gradient of 140°C/km above. This depth is consistent with a locking depth inferred from previous elastic dislocation models. The magma inflow in the system is not sufficient to keep up with the subsidence caused by the stretching, causing subsidence. The combined observations and model show that the deformation zone of the WVZ is almost ten times larger than the width of the central segment of the Thingvellir graben.

KEYWORDS: 1209 GEODESY AND GRAVITY Tectonic deformation, 3040 MARINE GEOLOGY AND GEOPHYSICS Plate tectonics, 7220 SEISMOLOGY Oceanic crust, 9335 GEOGRAPHIC LOCATION Europe.

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