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Constraints from broadband magnetotellurics and mantle xenolith geochemistry on lithospheric thickness and stabilisation age of the Rehoboth Terrane, southern Africa

M.R. Muller (1), A.G. Jones (1), R.L. Evans (2), C. Hatton (3), M.P. Hamilton (1), M. Miensopust (1), A. Mountford (4), C.J.S. Fourie (5), D. Hutchins (6), T. Ngwisanyi (7) and the SAMTEX team.

(1) Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin 2, IRL. (2) Woods Hole Oceanographic Institution, Clark South 172, Woods Hole, 02543 MA, USA. (3) DeBeers Group Exploration, Private Bag X01, Southdale, Johannesburg, 2135, ZAF. (4) Rio Tinto Exploration, 6 St James's Square, London, SW1Y 4LD, GBR. (5) Council for Geosciences, 280 Pretoria Street, Silverton, Pretoria, 0001, ZAF. (6) Geological Survey of Namibia, 1 Aviation Road, Windhoek, NAM. (7) Geological Survey of Botswana, Private Bag 14, Lobatse, BWA. (mark.muller@dias.ie)

The Rehoboth Terrane (also known as the Nama Terrane) of Southern Africa, located beneath thick Kalahari sand cover, has to date been interpreted primarily on the basis of potential field data patterns. The thickness and stabilisation age (Archaean or Proterozoic) of the Rehoboth lithosphere, and its tectonic relationship with the adjacent Kaapvaal Craton, are poorly constrained by available information. The Rehoboth Terrane is flanked to the east by the Kalahari Lineament, regarded as the western margin of the Archaean Kaapvaal Craton, to the southwest by the ˜1.1 Ga Namaqua-Natal Belt, and to the northwest by the late Proterozoic Ghanzi-Chobe Belt. A 1400 km long magnetotelluric (MT) traverse, recently acquired across the Rehoboth Terrane and its margins, has provided a deep electrical resistivity image of the lithosphere. Together with independent constraints provided by peridotite mantle xenoliths from the Gibeon kimberlite field, located towards the margins of the Rehoboth Terrane, the deep electrical image has allowed an estimate to be made of the lithosphere thickness, and its stabilisation age. This work forms part of the wider Southern African MT Experiment (SAMTEX) which has acquired over 550 MT stations across the sub-continent since

mid-2003.

MT data were recorded at 68 broadband stations, deployed at roughly 20 km intervals and recording data for two or three night periods, as well as at 7 coincident long-period stations deployed at roughly 60 km intervals along the southern portion of the profile, recording data for a 1 month period each. Three different robust processing codes of Jones, Egbert and Chave (see e.g., Jones, 1989) were used variously at stations along the profile in an effort to derive the best possible MT responses, particularly in the presence of severe noise encountered along the southern portion of the profile. MT data at each site were decomposed using the method of Groom and Bailey (1989), as implemented in the program “STRIKE” by McNeice and Jones (2001), to remove local galvanic distortion and isolate the assumed 2-D (or 1-D) response of the regional geology. A 2-D electrical resistivity model along the profile was derived from the decomposed station responses using the inversion method of Rodi and Mackie (2001), as implemented in WinGLinkő software. Given temperature as the primary control on dry mantle electrical resistivity (e.g., Xu et al., 2004), the observed resistivity structure beneath the Rehoboth Terrane is consistent with a significantly thinner lithopshere (estimated to be about 140-150 km thick) and an elevated geothermal gradient with respect to the adjacent Kaapvaal Craton.

Our MT electrical image, and predicted lithospheric thickness of about 140-150 km, is consistent with the xenolith geochemistry from the Gibeon field that points to a Proterozoic affinity and age of stabilization for the Rehoboth Terrane: (i) the Rehoboth lithosphere is less depleted reflecting lower degrees of partial melting: Mg# = 91.8 (vs 92.6 for the Kaapvaal) (Hoal et al., 1995); (ii) the maximum depth of equilibration observed to date for all xenoliths is 150 km (see e.g., Hoal et al., 1995; Boyd et al., 2004) suggesting thin lithosphere; and (iii) the maximum Re depletion ages observed are between 2.0 and 2.2 ś 0.2 Ga (Hoal et al., 1995), indicating the time of the earliest lithosphere forming event. The Re depletion ages are about 1 Ga younger than those observed on the Kaapvaal Craton (Boyd et al., 2004).