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Cyclic frictional-viscous slip oscillations along the base of an advancing nappe complex, Naukluft Nappe Complex, Central Namibia

G. Viola (1), **N. S. Mancktelow** (2) and J. A. Miller (3)

(1) NGU, Geological Survey of Norway, N 7491, Trondheim, Norway, (2) Geologisches Institut, ETH-Zentrum, CH-8092, Zurich, Switzerland, (3) Geology Department, University of Stellenbosch, Private Bag X1 Matieland 7602, South Africa

The Naukluft Nappe Complex (NNC) is a spectacular, far-travelled, fold and thrust belt klippe of the Panafrican Damara Belt in Central Namibia. Estimates of the SE-directed displacement range between 50 and 80 km. The NNC (70 km x 30 km), which is dominated by carbonates with lesser shales and quartzites, consists of a stack of several separate nappes now resting on the Nama foreland basin. The entire nappe stack was thrust along an out-of-sequence, nearly planar, horizontal structure, the "Naukluft Thrust", which is very well exposed over a map area of ca. 2000 km^2. The footwall sedimentary units of the Nama Group record a two-fold deformation history that also affected the crystalline basement in a thick-skinned fashion. Regionally consistent fold asymmetry and bedding-cleavage relationships confirm top-to-SE shearing.

The Naukluft Thrust plane is usually, but not ubiquitously, marked by a thin dolomitic band called the Sole Dolomite (SD), containing characteristic rock units not found in either the footwall or hanging wall and clearly discordant to structures both above and below. The SD has been considered to play a crucial role in the development of the basal thrust that brought the complex to its current tectonic position. In detail, this thrust zone consists of several distinct lithological components whose typical distribution (when all present) from bottom to top is: (1) a massive, ochre-yellow weathering dolomite; (2) a polymict “gritty dolomite” (called in the past the “Sole Dolomite”), (3) strongly foliated and isoclinally folded calcmylonites, and (4) an upper massive dolomite. A very discrete ($<$ 50 mm thick, often $<$ 10mm thick) planar brittle fault (5) can occur at any level within this sequence. Our investigations show that the gritty

dolomite forms by progressive cataclasis of the massive dolomite (1). Moreover, clasts of gritty dolomite are observed randomly oriented within a similar gritty dolomite matrix, suggesting multiple pulses of brecciation and self-brecciation. The gritty dolomite locally forms injection veins into the calcmylonites, and these veins are themselves boudinaged, indicating broadly coeval cataclastic and ductile deformation. We suggest that the SD was a pre-existing sedimentary horizon that was exploited by the nappe pile and whose character evolved during nappe transport through both ductile and brittle reworking. Structural relationships with the under- and overlying units suggest that this sedimentary horizon may have been deposited unconformably in a small "foreland basin" at the toe of the advancing thrust sheet.

The evolution of structures within the thrust zone is linked to the presence and flow of (over-pressured) pore-fluids. Field observations suggest that several pulses of fluid-induced brittle deformation overprinted, in a cyclic fashion, ductile structures formed during emplacement of the nappe pile. A "fault-valve" behaviour is suggested for the basal detachment of the Naukluft Nappe Complex, with bulk shortening being accommodated by incremental slip during a (possibly intermittently seismic) history of combined viscous and frictional flow.