Structural control of fluid flow on a carbonate platform margin: an example from the Otavi Mountainland, Namibia *Vortrag*

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Fault inversion and alteration influence fluid pathways over the period of deformation and thereafter. Relationships between the formation and site of ore deposits can be established if the stages of deformation can be linked to specific hydrothermal events. In order to find new indications on the genesis and distribution of known and eventual further base metal mineralisation in the Otavi Mountainland (OML) in northern Namibia, we started a cement-stratigraphic and detailed structural investigation.

The OML is positioned in the north-eastern part of the Damara belt, on the northern tip of a foreland fold and thrust belt. The ENE-trending belt in northern central Namibia results from the pan-African collision of the Congo with the Kalahari Craton. The pan-African tectonic evolution of the OML is summarised in Fig. 1. Sedimentary lithologies in the OML consist of the Neoproterozoic Damara sequence with the siliciclastic and volcanoclastic Nosib Group at the bottom, overlain by the Otavi Group carbonates and the molasse-like Mulden Group. Deposition proceeded from Cryogenian to late Ediacaran or early Cambrian (Frimmel et al. 2004, amongst others).

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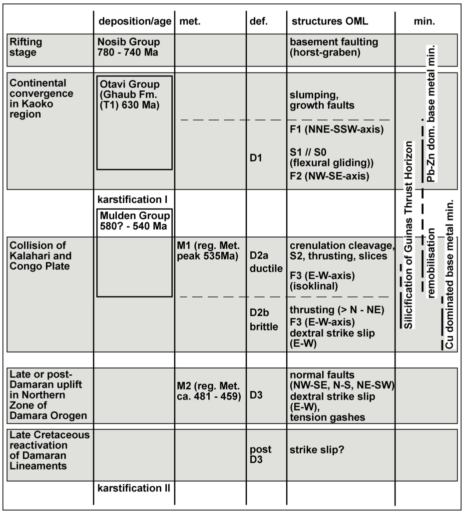

Figure 1: Tectonic evolution of the OML (ages after Frimmel et al. (1996), Frimmel (2004), Goscombe et al. (2004), Haack and Martin (1983), Haack et al. (1980), Hoffmann et al. (2004))

The present study focuses on the north-western OML, southwest of the mining town of Tsumeb. The dominating structure in this area is the NW-SE striking Guinas Fault. The Guinas Fault is a shear zone that divides an area, which is different in sense of stratigraphic features, the grade of pre-, syn- and post-Damaran deformation and the type and grade of mineralisation. The northern area is enriched by Cu-rich base metal sulphides, whereas the southern area is almost barren.

The carbonate successions in the Guinas Fault area are part of the Tsumeb Subgroup (upper Otavi Group, lithozones T4–T8). North of the Guinas Fault the massive dolomites of the Hüttenberg Formation (T6–T8) are unconformably overlain by conglomerates and sandstones of the lower Mulden Group. South of the Guinas Fault T6 and lower

T7 show almost the same stratigraphy, but instead of the laminated dolomites, there are thin laminated and thick bedded limestones with intercalated mass flow breccias. Total thickness of the T7 in the south is about 600 m, but in the north only about 35 m (Petzel, 1993). This huge difference in thickness could either be caused by (1) tectonic nappe stacking in the south, (2) lateral facies change obliterated by the thrusting or (3) due to growth faulting during the deposition of the Hüttenberg Formation. Mass flow breccia lenses embedded in the laminated limestones of the T7 lithozone exist only southwest of the Guinas Fault. Clasts of carbonate sediments from the northeastern area are enclosed in the mass flows. Restricted to the northeast there are algal reefs pointing to shallow marine conditions, whereas the mass flows and the dark limestones and shales might have been deposited at a slope just south of the Guinas Fault. Therefore the origin of the Guinas Fault as a growth fault along an unstable slope at the southwestern margin of a carbonate platform is possible. Similar growth faults have been reported from the central OML.

Differences in the deformation south and north of the Guinas Fault are even bigger. South of the Guinas Fault our study examined a wide range of Damaran deformations. Bedding parallel first cleavage S_1 is marked by thin chert layers, which are isoclinal folded around an NW–SE axis. The second cleavage cuts S_1 and small scale thrusts and nappe stacking evolve. Therefore nappe stacking is evident south of the Guinas Fault, but only on a minor scale and tectonic thinning of the limestone units might have partly neutralized the greater thickness of the stacked

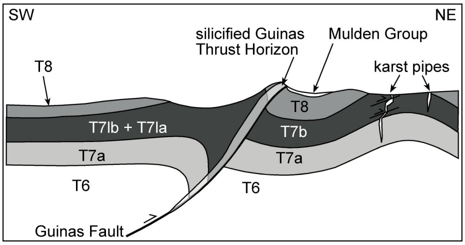

Figure 2: transect of the Guinas Fault and the upper Tsumeb Subgroup (Hüttenberg Fm., T6–T8); not to scale

T7-litho-units. A major lateral facies change is not likely, because the small dimension of thrusting is not sufficient to obliterate the major facies change. The hanging wall of the Guinas Fault itself is a thrust horizon, which is made up of a highly silicified oolitic dolomite. Silification happened in a late stage or even after the main phase of the northeastward thrusting (D_2) along this horizon.

A transect through the Guinas Fault (Fig. 2) shows a displacement of the carbonates of the upper Tsumeb Subgroup (T6–T8, Hüttenberg Formation) along the Guinas Thrust. The carbonates are thrusted over the Mulden siliciclastics, indicating that the thrusting is of an Early Cambrian age developed during D_2. Karst pipe structures, filled by Mulden siliciclastics, are common hosts for mineralisation in the northern OML, like the Tsumeb Pipe, which is deformed by Damaran tectonics. Karstification down to the middle Tsumeb Subgroup occurs preferred at fractures, which are related to the syn-D_2 folding event. The Guinas Fault has been involved again during the late Damaran uplift (D_3), as minor normal faulting along the floor thrust of the silicified thrust horizon can be referred to D_3.

Applying our data to the base metal mineralisation in the northwestern OML, we find implications for the formation and alteration of ore bodies. Deposition of primary base metal mineralisation has started at the latest during the deposition of the lower Mulden siliciclastics (ca. 580-540 Ma) and before the peak metamorphism of the Damaran orogenesis in the OML (ca. 535 Ma). Ages of around 530 Ma (Kamona et al. 1999) may indicate an upper age of the primary mineralisation or its syn-Damaran remobilisation (Fig. 1). Adequate conduits for mineralising fluids could have been the Guinas Fault/Thrust itself, stratigraphic horizons of higher porosity in the Tsumeb Subgroup and karst structures in the upper levels (Fig. 2). In a later stage of the Damaran orogenesis (Fig. 1) hydrothermal fluids could have moved along these pathways to the area north of the Guinas Fault, whereas the distribution to the south was prevented by the syn-D_{2b} silicified Guinas Thrust horizon that acted down to the lower Tsumeb Subgroup as a dam for the ascending fluids (Fig. 2). The result is a highly-deformed, almost barren area in the south, the inverted Guinas Growth Fault and the silicified Guinas Thrust Horizon in the center and the less deformed Uris-Tsumeb-mining area with all the base metal sulphide deposits, as a precursor for further supergene Cu- and V-enrichments in the north.

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