Contrasting fluid regimes in an advancing nappe complex, Namibia

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The Naukluft Nappe Complex (NNC) is a spectacularly preserved example of a structural klippe in the foreland of the Pan-African Damara Belt in central Namibia. Exposed over an area of ca. 2000 km^2, the NNC is underlain by the Naukluft Thrust, an out-of-sequence, nearly planar, horizontal structure usually marked by a thin-dolomitic horizon referred to as the Sole Dolomite (SD). The SD played a crucial role in the development of the Naukluft Thrust that brought the complex to its current tectonic position, and probably represents a pre-existing sedimentary horizon, exploited by the nappe pile, whose character evolved during nappe transport through both ductile and brittle reworking.

Detailed stable isotope profiling across the SD at seven locations has been undertaken to investigate the relationship between fluid flow and thrust propagation in more detail. Along the leading edge of the thrust, the SD has relatively homogeneous positive $\delta^{13}C$ values ~ +3.0 ‰ and variable $\delta^{18}O$ values (14 - 23 ‰), giving a marked horizontal trend in $\delta^{13}C$ vs $\delta^{18}O$ space. In contrast, the SD along the trailing edge of the thrust has variable but negative $\delta^{13}C$ values, around (-0.5 to -6 ‰), with still variable $\delta^{18}O$ values, defining a positive trend in $\delta^{13}C$ vs $\delta^{18}O$ space, although each traverse tends to plot in a distinct field. Sr-isotopes have a broadly negative correlation with dolomite $\delta^{18}O$, with the highest Sr-isotope values recorded in the SD and little difference between the leading edge and trailing edge. However, Sr-isotopes of the SD are significantly higher than surrounding Upper Proterozoic carbonate successions in central Namibia.

The trailing edge and leading edge clearly illustrate the operation of two different fluid flow regimes. $\delta^{13}C$ values of the leading edge are interpreted as original values and the spread in $\delta^{18}O$ but not $\delta^{13}C$ is interpreted to reflect the influence of low-T exchange with an H_2O-rich fluid possibly derived from foreland basement rocks. The trailing edge is interpreted as a result of higher-T fluid-rock interaction in response to compaction and dewatering of the underlying carbonaceous sediments during thrusting. The composition of the fluid is dependent on the lithologies being overridden at any given point in time. The stable isotope character of the SD therefore reflects the complex interplay between compositionally heterogeneous fluids derived from variable footwall rocks and the cyclic nature of fluid generation in response to thrusting being accommodated by incremental slip during a history of combined viscous and frictional flow.