Paper Number: 3704

Paleomagnetic Data Bearing on the Thermal History of Upper Permian to Lower Triassic (?) Beaufort Group Strata, Karoo Basin, South Africa

Geissman, J.W.[1], Gastaldo, R.A.[2], Neveling, J.[3]

[1] Dept. of Geosciences, University of Texas at Dallas, Richardson, TX 75080, USA, geissman@utdallas.edu.
[2] Dept. of Geology, Colby College, Waterville, ME 04901, USA
[3] Council for Geoscience, 280 Pretoria Street, Silverton, Pretoria, 0001

The thermal history of Karoo Supergroup strata, deposited in the Karoo Basin from the Late Carboniferous to Early Jurassic, has long been of interest, with recent attention devoted to possible unconventional hydrocarbon resources in parts of the succession. The early thermal history of the basin is variable, as studies have demonstrated a general north to south/southwest increase in burial diagenesis during early stages of metamorphism attending Cape Fold Belt tectonism. This pattern is complicated by both regional and local effects of widespread mafic magmatism associated with emplacement of the ca. 183 Ma Karoo Large Igneous Province (LIP). The response of Karoo Supergroup strata to such thermal effects bears on extracting meaningful magnetic polarity stratigraphic records from these rocks. A multifaceted effort is underway to better understand the timing of inferred environmental changes in the Karoo Basin, from Late Permian to possibly Early Triassic (?) time, as recorded in Beaufort Group strata. We have obtained a robust paleomagnetic data set from selected localities in an attempt to construct a polarity record for sections that previously have been interpreted to encompass events associated with the end-Permian extinction.

Magnetic polarity records inherently require the preservation of early-acquired (primary) remanence (RM); demonstrating such preservation in Karoo strata is challenging. This is due, in part, to the fact that paleomagnetic field directions for the Early Jurassic (Karoo LIP) are similar to directions of Late Permian age. In our work, we obtain multiple independent samples (i.e., 7 to 10+) per individual horizon (bed) to assess the uniformity of the RM. Strata at the Old Lootsberg Pass (OLP) and Tweefontein localities, Eastern Cape Province, are characterized by a north-northwest seeking, moderate to steep negative inclination RM, interpreted to be of normal polarity; typical initial RM intensities range from ~1 to 5 mA/m. In most cases, this RM persists in progressive thermal demagnetization to about 580° C, the maximum laboratory unblocking temperature (T_{lub}) for pure magnetite. However, some beds uniformly show dual component behaviour, with unblocking of a normal polarity RM to 425-450° C and, thereupon, the isolation of a south-southeast, moderate to steep positive inclination (reverse polarity) RM. We interpret this fact to indicate that, for the OLP section, any RM persisting above T_{lub} of about 425°C is pre-Karoo LIP in origin, and likely primary. If the RM unblocked below about 425°C is a thermoviscous RM then, based on theoretical relaxation time/magnetization blocking relations for pure magnetite, these rocks were heated to ~150-300° C for ca. 1 Ma (+/-) (temperature estimates vary according to relaxation time/RM blocking relations).

The Beaufort Group section at the Bethulie (BT) locality, Free State Province, is cut by several thin (less than 2 m wide) Karoo LIP dikes, and permits several detailed contact tests. Strata well-removed from obvious dikes show by both normal and reverse polarity characteristic RM. For example, site BT15 is dominated by a well-defined reverse polarity RM; a relatively weak, superimposed normal polarity RM is fully unblocked below 400°C. If this overprint RM is of thermoviscous origin, our observation also implies that Bethulie strata experienced elevated temperatures (i.e., ~100 to 250°C+) for ca. 1 Ma (+/-). Contact tests are positive, in that host strata adjacent (within less than 1-2 dike widths) to dikes have been thermally remagnetized and have enhanced initial RM intensities (>50 mA/m). Hence, documentation of a primary RM in Beaufort Group strata, which appears in some areas to be preserved, requires careful laboratory- and field-based assessment.