The 2,7 Ga Pilbara Drilling Project, Western Autralia: Paleomagnetic Results

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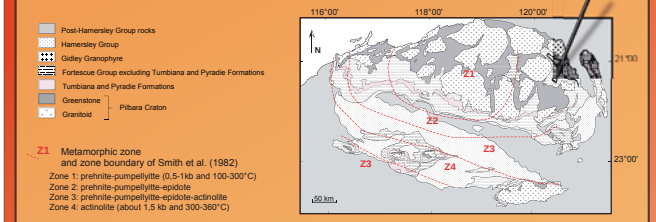
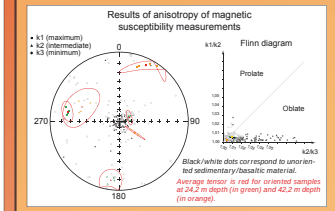
Paleomagnetic studies of Precambrian rocks provide important informations on early Earth geomagnetic field and tectonic regime. However Precambrian rocks sequences can be affected by weathering, alteration and/or metamorphism, which may considerably hamper the determination of the paleomagnetic field. The one hundred metre core drilled in the Tumbiana Formation (Fortescue Group) in northwestern Australia provides an exceptionnal opportunity to study unaltered and relatively undeformed Late Archean material (2,7 Ga).

Geologic map of the Northern Pilbara Craton

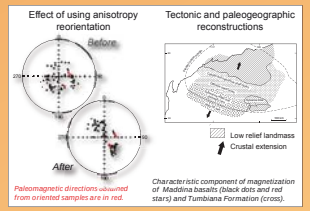
Modified from Thorne and Trendall (2001)



The drill hole has a plunge angle of 75° toward 323°N, perpendicularly to the strike and dip of the strata. At least, three small cylindrical specimens (15 mm diameter, 13 mm long) have been sampled every meter downcore, perpendicularly to the axis of the core (ie parallel to the stratigraphy). Measurements of anisotropy of magnetic susceptibility were used to re-orient samples from unoriented segments of the core with respect to the oriented parts (only ~0,6 metre in the upper basaltic part). Both thermal and alternating field demagnetization have been conducted in order to check for the consistency of the paleodirections.

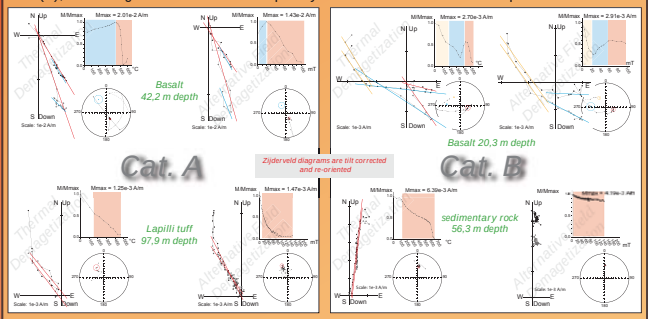


Directions of principal axes of susceptibility ellispoids are plotted on stereographic projections. Flinn diagramm indicate the shape of the ellipsoids. Percentage of anisotropy lies between 0,15% and 2,98% for the Maddina basaltic flows. Note that K1 and K2 axes are interverted between oriented samples. Percentage of anisotropy lies between 0,56% and 8,55% for the samples of the Tumbiana Formation.

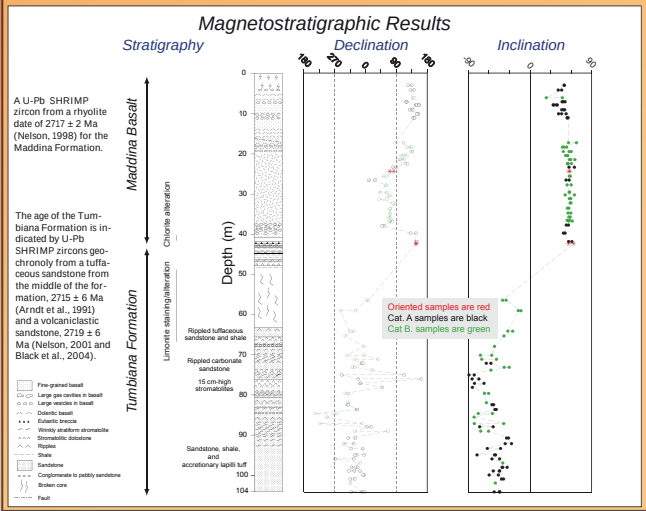


Because re-orientation using magnetic susceptibility anisotropy is successful, it suggest that it would be the expression of a major geological event. It coincide with the axes of crustal extension seen on tectonic and paleogeographic reconstructions during deposition of Kylena, Boongal, Tumbiana, Pyradie, Maddina and Bunjinah formations (after Thorne and Trendall, 2001)

Two distinct behaviour of the samples upon demagnetization: in the first case (A), the same components are isolated by thermal and alternative field demagnetization. In the second case (B), AF demagnetization fails to completely isolate the characteristic component.

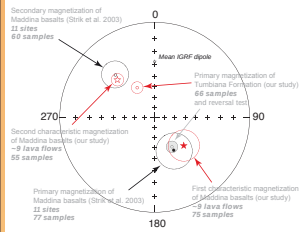


Magnetostratigraphic Results



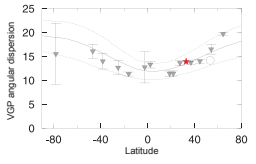
Given our poor knowledge of the Archean geomagnetic field, the interpretation of the paleomagnetic directions relies on a few assumptions. In particular, we have to assume that the Earth's magnetic field behaved as a geocentric axial dipole (GAD), even though it is still a topic of debate.

Comparison with "previous results" from surface oriented cores *(Strik et al. 2003)*



Paleosecular variation

Latitudinal dependency of the virtual geomagnetic poles



Triangle are data from 0-5 Ma lavas, circle shows results based on paleomagnetic data from and Pilbara Craton (Strik et al., 2003), red star is based on our results. A model modified from Constable and Parker (1988) is shown (solid line) with its 95% confidence limits (dashed lines) from Jonhson and Constable 1996. Figure after Smirnov and Tarduno (2004).

Plate motion rate

Mean age : 2721,0 ± 5,4 Ma
-Upper limit= 2715 ± 2 Ma U-Pb on zircon (Blake et al. 2004, Maddina formation)
-Lower limit= 2727 ± 5 Ma U-Pb on zircon (Blake et al. 2004, Tumbiana formation)
Mean paleolatitude : 34,2° ± 9,3° Strik et al., 2003 + our study

Mean age : 2756,5 ± 3,6 Ma
-Upper limit= 2741±3 Ma U-Pb on zircon (Blake et al. 2004, Kylena formation)
-Lower limit= 2772±2 Ma U-Pb on zircon (Wingate 1999, Black Range Dolerite Suite)
Mean paleolatitude : 56,1° ± 8,9° Strik et al., 2003

Δage = 35,5 ± 6,5 Ma Δlatitude= 21,9° ± 12,9°

Finally, we are able to evaluate the speed of the tectonic plate at 2,7 Ga between two extreme cases:
- 2,4 cm.yr^{-1} is obtained with the longer time and shorter displacement.
- 13,3 cm.yr^{-1} is obtained with the shorter time and the longer displacement.

Conclusion

I - The reversal of the Earth's magnetic field probably occured 2,7 Ga ago.

II - VGP scatter seems to be similar to recent times.

III - Our mean plate velocity of 7,9 ± 5,5 cm.yr^{-1} at 2,7 Ga is much lower than previously proposed (100 cm.yr^{-1}) and comparable to today's highest plate velocity.

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