Short-term fluctuations of the geomagnetic field deduced from sea-surface magnetic profiles during chrons 33R to 19R.

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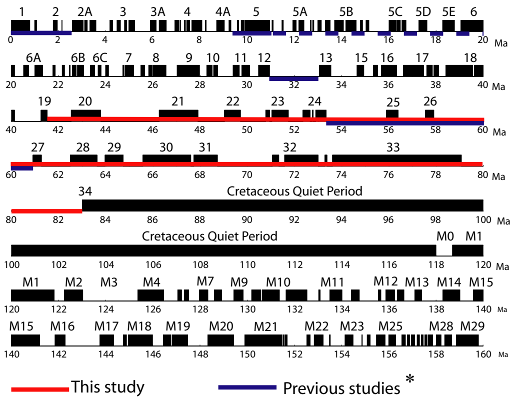
1. Introduction

Study of marine magnetic measurements may complement measurements of the remanent magnetisation acquired on volcanic rocks or sediments in order to recover the long term evolution of the magnetic field intensity. Indeed, the magmatic oceanic crust is a good recorder of the magnetic reversals but also of the variations of the magnetic field intensity. The goal of this study is to use marine magnetic anomaly profiles to estimate fluctuations of the magnetic field for a period when the reversal rate was low (40-83 Ma) compared to the last million years. For this purpose, we compute stacks of profiles in different areas. The comparison of these stacks reveals many micro-anomalies that are coherent worldwide and thus due to fluctuations of the magnetic field.

Geomagnetic polarity timescale

(Cande and Kent, 1995)

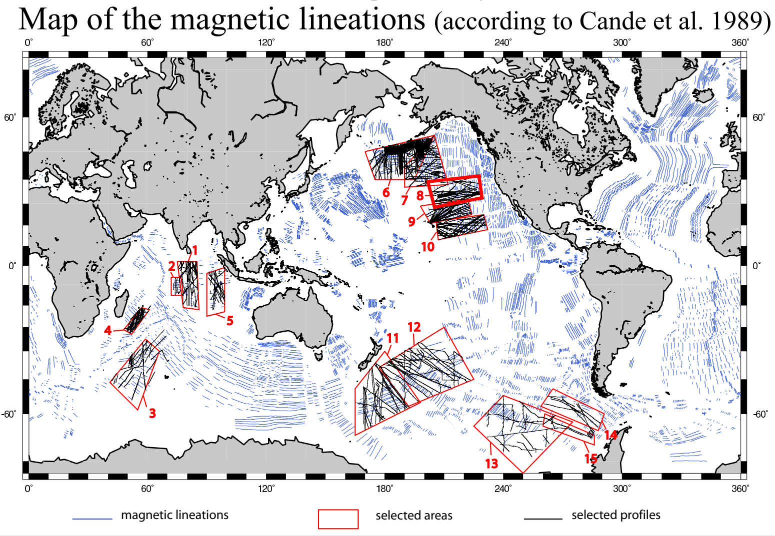


* including Blakely (1974), Cande and Labrecque (1974), Cande and Kent (1992b), Bowers et al. (2001), Gee et al. (2000), Pouliquen et al. (2001a,b).

2. Data selection

Sea surface magnetic profiles are extracted from a global database (NGDC) complemented by french data from the Indian Ocean.

Map of the magnetic lineations (according to Cande et al. 1989)



3. Data Analysis

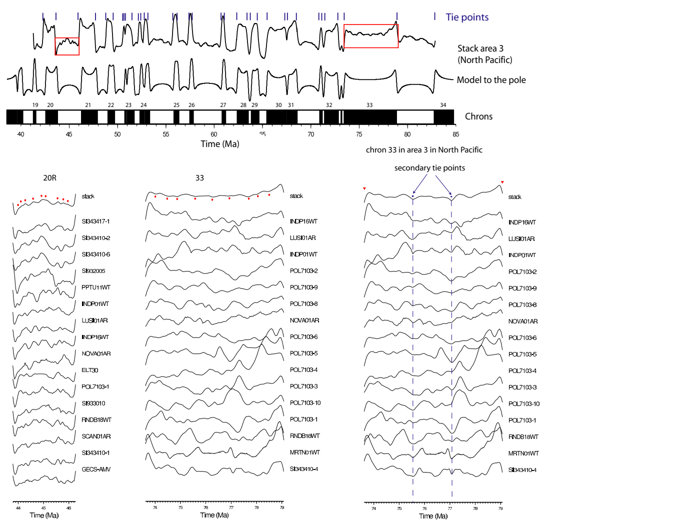
1. Reduction to the pole

Reduction to the pole is obtained by applying the inverse phase filter $e^{i\theta}$ (Schouten and McCamy, 1972). Skewness of the magnetic anomaly profile is determined visually by searching for the best angle θ so that the profile resemble an anomaly model computed to the pole. All profiles of a given area are reduced to the pole with a same average angle, assuming the variation of the skewness angle remain small enougth

2. Stretching and stacking the profiles

Reversals are used as tie-points in order to convert distances into times, assuming a constant spreading rate between tie-points.

Example of stack in area 8 (North Pacific):



3. Toward the highest resolution stack

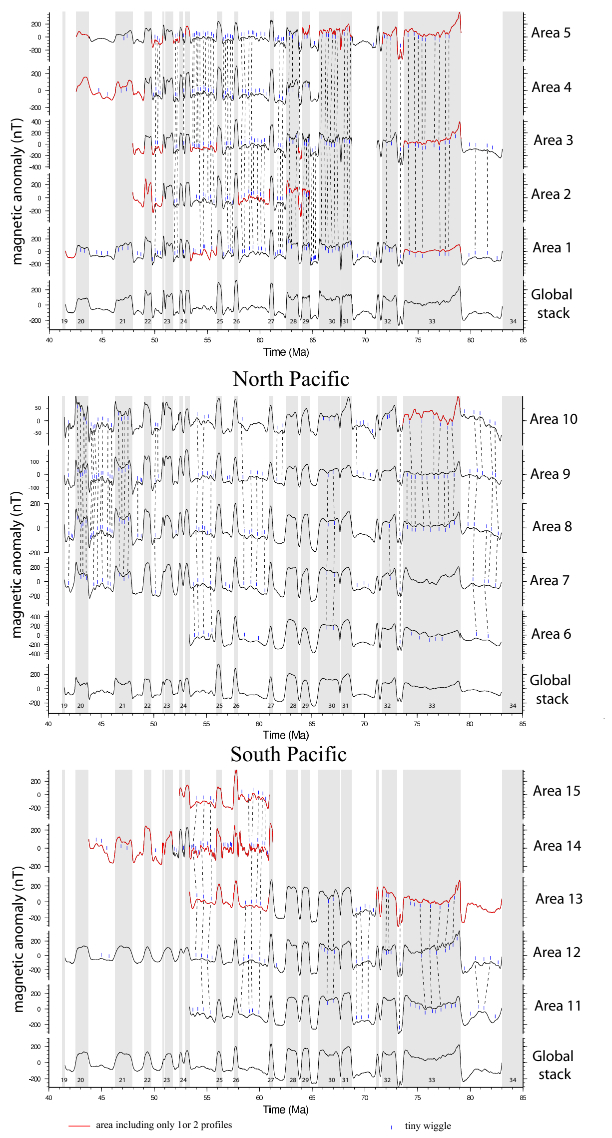
The density of tiny-wiggles strongly depending on the spreading rate, we selected profiles with the highest spreading rates :

- for chrons 19R to 21R : areas 3,4,5 from North Pacific
- for chrons 22 to 29R : Indian Ocean
- for chrons 30 to 33R : profiles selected in South and North Pacific and Indian Ocean

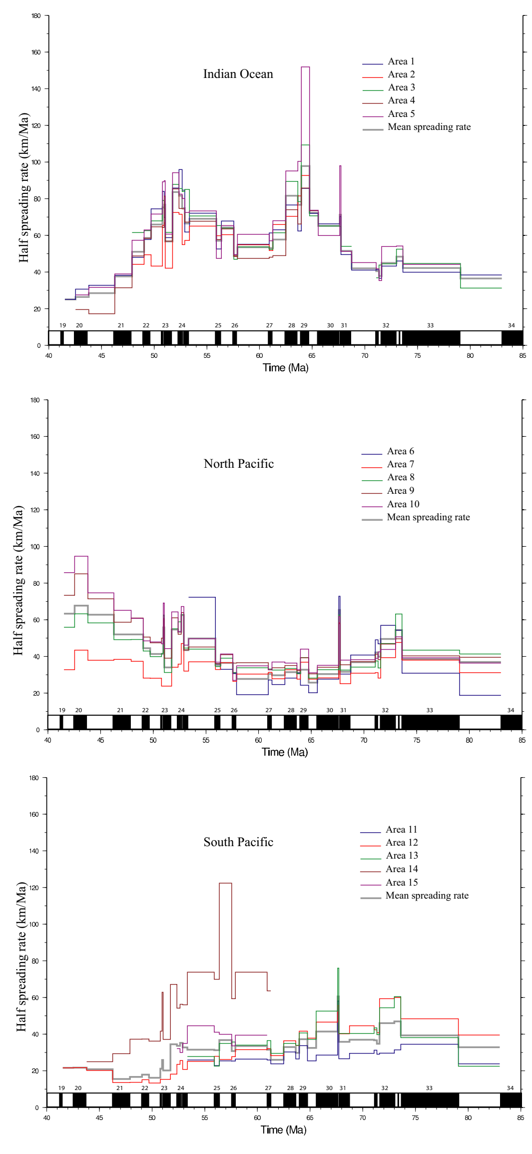
A few anomalies being very long, we added secondary tie-points in order to improve the stack.

4. Results in the different areas

Regional stacks

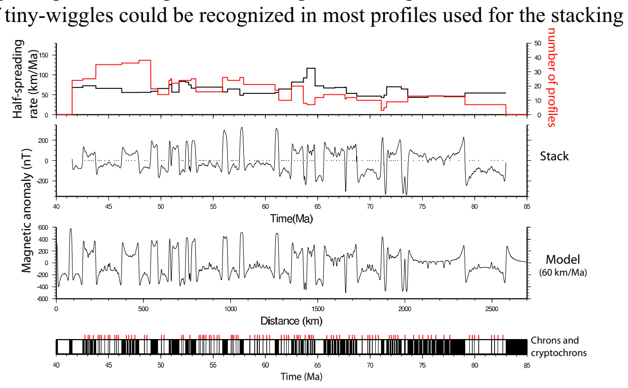


Spreading rates



5. The highest resolution stack

We modelled the highest resolution stack in terms of cryptochrons (i.e. short intervals of opposite polarity). Before picking the tiny-wiggles, we tested the stability of the stacks by repeating the stacking after removing one of the profiles. We also checked that the pattern of tiny-wiggles could be recognized in most profiles used for the stacking

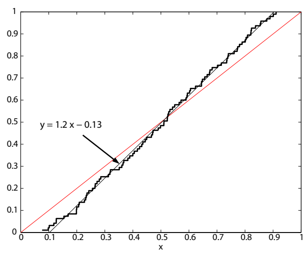


The mean half-spreading rate of the profiles used for the stacking is about 60 km/Ma and always higher than 40 km/Ma.

6. Temporal distribution of tiny-wiggles

a. Inside chrons

Cumulative distribution function of x



For each tiny-wiggle, we estimated x, the time elapsed since the beginning of the chron, normalised to the duration of the chron.

x=0 beginning of the chron

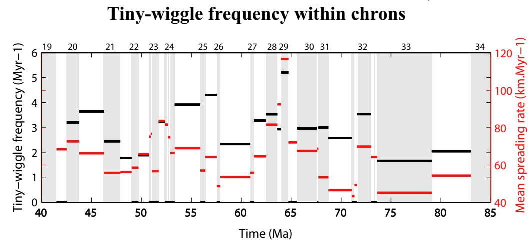
x=1 end of chron

There are no tiny-wiggle with x less than 0.1 or larger than 0.9, i.e. close to the reversals. We interpret this as the result of the width of the anomalies produced by reversals "hiding" any possible nearby tiny-wiggle.

The cumulative distribution function being a straight line for 0.1< x < 0.9, the distribution of tiny-wiggles inside chrons otherwise appears to be homogenous.

b. Within the investigated period

Tiny-wiggle frequency within chrons



For short chrons, because of the width of reversal anomalies, no tiny-wiggle can be detected.

The correlation between tiny-wiggle frequency and mean spreading rate otherwise suggests that spreading rates have some influence on the number of tiny-wiggles.

No long term trend in the tiny-wiggle frequency is seen.

7. Conclusion

Tiny-wiggles are ubiquitous during the period 40-83 Ma and their distribution seems to be rather homogeneous.

Tiny-wiggles can be correlated between different basins and different oceans and can thus be confidently ascribed to past variations of the magnetic field. Although, for convenience, we used cryptochrons to model the tiny-wiggles, most of them are more likely due to variations in intensity of the geomagnetic field such as excursions.

Beyond their interest for geomagnetic studies, it should be added that the tiny-wiggles may be used as fine scale markers in order to unambigously recognize major anomalies and reconstruct the tectonic history of oceanic basins.

References

Blakely, *J. Geophys. Res.*, Vol. 79, No 20, 2979-2985, 1974.
Bowers et al., *J. Geophys. Res.*, Vol. 106, No B11, 26379-26396, 2001.
Cande and Kent, *J. Geophys. Res.*, Vol. 100, No B4, 6093-6095, 1995.
Cande and Kent, *J. Geophys. Res.*, Vol. 97, No B10, 13917-13951, 1992a.
Cande and Kent, *J. Geophys. Res.*, Vol. 97, No B11, 15075-15083, 1992b.
Cande and Labrecque, *Nature*, Vol. 247, 26-28, 1974.
Cande et al., Magnetic Lineations of the World's ocean basins (map), AAPG, 1989.
Gee et al., *Nature*, Vol. 408, 827-832, 2000.
Sandwell and Smith, *J. Geophys. Res.*, Vol. 1021, No B5, 10039-10054, 1997.
Schouten and McCamy, *J. Geophys. Res.*, Vol. 77, No 35, 1972.
Pouliquen et al., *J. Geophys. Res.*, Vol. 106, No B6, 10941-10960, 2001a.
Pouliquen et al., *J. Geophys. Res.*, Vol. 106, No B12, 30549, 2001b.