THE ENHANCED ANALYTIC SIGNAL OF THE REDUCTION TO THE MAGNETIC POLE DATA IN THE SOUTH OF VIETNAM

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ABSTRACT: *The technique of the analytic signal (or the enhanced analytic signal) of potential field data to determine the locations of geologic boundaries has developed in recent decades. In theory, the application to magnetic data was independent to the direction of magnetization of the sources. However, in practice the amplitudes of the analytic signal depend on ambient parameters. Some authors have shown that the analytic signal applied to the reduction to the magnetic pole gave better results. In this paper the enhanced analytic signal of reduction to the magnetic pole of the south of Vietnam – at the low latitudes - is calculated and the results are compared to the ones that are obtained by the the direct application of the enhanced analytic signal of magnetic anomalies.*

1- INTRODUCTION

The analytic signal based on the horizontal and vertical gradients of potential- field anomalies has been developed to the determination of locations of boundaries and depths of the causative sources. The application of analytic signal was carried out by many authors (Nabighian, 1972, 1984; Roest et al., 1992). In Viet Nam, the enhanced analytic signal (Hsu et al., 1996) was applied to interpreting geologic boundaries and the depths to their sources in the south of Vietnam with pretty good results (Dang Van Liet, 2004) [2]. An important characteristic of the analytic signal of the magnetic anomalies is that it is independent to the direction of magnetization of the sources. However in practice, the amplitudes of the analytic signal depend on ambient parameters such as the intensity of magnetization, the inclination of the Earth's field and the strike of the geologic boundary. By contrast, the amplitudes of the analytic signal of gravity anomalies are only related to density contrasts and depths of boundaries. So the application of the analytic signal to magnetic data is more complex than gravity data. However, in the magnetic's interpretation there is a method called the reduction to the magnetic pole (Baranov, 1959; Silva, 1986, Hansen and Pawlowski, 1989; Blakely, 1995). This method transformed the measured total-magnetic field anomaly into the vertical component of the field caused by the same source of distribution magnetized in the vertical direction. So the reduction to the magnetic pole data behave as the gravity data. In dealing with the difficulties of the analytic signal for magnetic data, geophysicists used the reduction to the magnetic pole instead of using the magnetic data and they obtained better results (Bilim and Ates, 2003).

In this paper, we calculated the enhanced analytic signal of the reduction to the magnetic pole to detect the locations of geologic boundaries in the south of Vietnam – the region at the low latitudes.

2- PRESENTATION OF THE RESEARCH METHOD

2.1- Enhanced analytic signal

According to Nabighian (1984) the amplitude of the analytic signal in the 3- D was:

$$|A_0(x,y)| = \sqrt{(T_x)^2 + (T_y)^2 + (T_z)^2} \qquad (1)$$

where, T is the potential-fiel anomaly, and:

$$T_x = \frac{\delta T}{\delta x}; \quad T_y = \frac{\delta T}{\delta y}; \quad T_z = \frac{\delta T}{\delta z} \qquad (2)$$

To avoid the interferential effects of the adjacent anomalies, Hsu et al. (1996) proposed the n^{th} order enhanced analytic signal:

$$|A_n(x,y)| = \sqrt{(\Delta^n T_x)^2 + (\Delta^n T_y)^2 + (\Delta^n T_z)^2} \qquad (3)$$

and they discussed that in practice the method needed the amplitude of the second-order enhanced analytic signal to detect geologic boundaries. The amplitude of the second-order

$$|A_2(x,y)| = \sqrt{(\Delta^2 T_x)^2 + (\Delta^2 T_y)^2 + (\Delta^2 T_z)^2} \qquad (4)$$

enhanced analytic signal was:

where $\Delta^2 = \delta^2 / \delta z^2$. In theory the straight lines connecting the maximum amplitudes of the second-order of enhanced analytic signal were the locations of geologic boundaries. However, in practice the magnetic data are affected by the magnetization of the sources so they are usually asymmetric. In consequence the maximum amplitudes of the second-order of enhanced analytic signal aren't clearly distinguished so it is difficult to determine the locations of geologic boundaries. The results should be improved by using the symmetrical data that were the reduction to the magnetic pole data.

2.2- Reduction to the magnetic pole

The aim of the reduction to the magnetic pole is to transform the observed total magnetic data to magnetic data (of a surveyed area) at the magnetic pole, so the new data are symmetrical and they are easy to interpret. Baranov (1957) firstly proposed this method and since then many authors have developed this method in either the space domain or the wavenumber (frequency) domain – especially at low magnetic latitudes – (Silva, 1986, Hansen and Pawlowski, 1989, Blakely, 1995).

The reduction to the magnetic pole in the wavenumber domain was given:

$$F(\Delta T_t) = F(\psi_t).F(\Delta T) \qquad (5)$$

where $F(\Delta T_t)$ was the Fourier transform of the reduction to the magnetic pole data, $F(\Delta T)$ was the Fourier transform of the observed data and $F(\psi_t)$ was the reduction to the magnetic pole filters.

In the case the field was affected by induced magnetization of magnetic sources and the observed area was near the equator, the $F(\psi_t)$ was given (Grant and Dodds, 1972) :

$$F(\psi_t) = \frac{1}{[\sin(I) + i\cos(I)\cos(D-\theta)]^2} \qquad (6)$$

where (I) and (D) were the magnetic inclination and declination respectively and (θ) was the wavenumber direction, $\theta = \tan^{-1}(v/u)$ with v and u were the wavenumbers in NS and EW directions respectively. In (6), the filter approaches infinity when (I) approaches to 0 and (D - θ) approaches to $\pi/2$. This effect, the amplitude of $F(\psi_t)$ attains large values within narrow pie-shaped segments. Moreover these high-amplitude segments extend to the longest wavenumbers of the spectrum and this is a characteristic of the filter in low-latitude (Blakely, 1995).

Grant and Dodds (1972) solved this problem by introducing a second inclination (I') that is used to control the amplitude of the filter near the equator (Mac Leod et al. 1993):

$$F(\Psi_t) = \frac{[\sin(I) - i.\cos(I).\cos(D-\theta)]^2}{[\sin^2(I') + \cos^2(I').\cos^2(D-\theta)][\sin^2(I) + \cos^2(I).\cos^2(D-\theta)]} \qquad (7)$$

(| I'|) was chosen greater than (| I |) so the unreasonably large amplitudes were avoid. This is the simplest method to reduce the magnetic data to the pole and its imperfection was that the remanent magnetization was neglected.

3- APPLICATION TO THE SOUTH OF VIETNAM

3.1 Region and data

In this paper, the south of Vietnam is a region from Camau (8°30'N latitude) to Binhlong (11°40'N latitude) and Hatien (104°30'E longitude) to Xuyenmoc (107°30'E longitude) (Figure 1). It comprised the west area (Mekong delta) and the east area of the interior of the south of Vietnam. The region was divided into many zones: they were Bien-hoa swell, Can-tho basin, Soc-trang swell and Ha-tien swell. In this region there were many

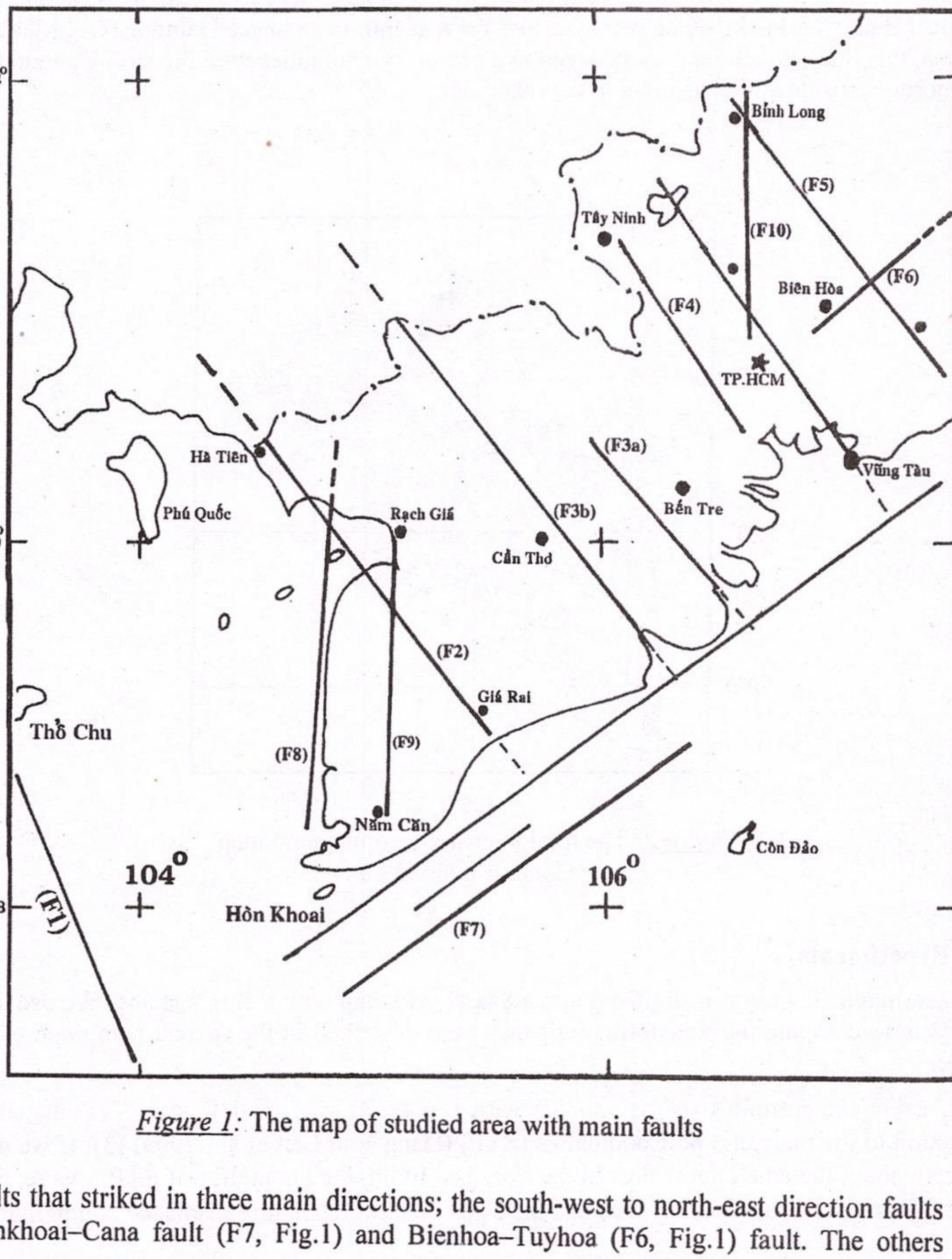


Figure 1: The map of studied area with main faults

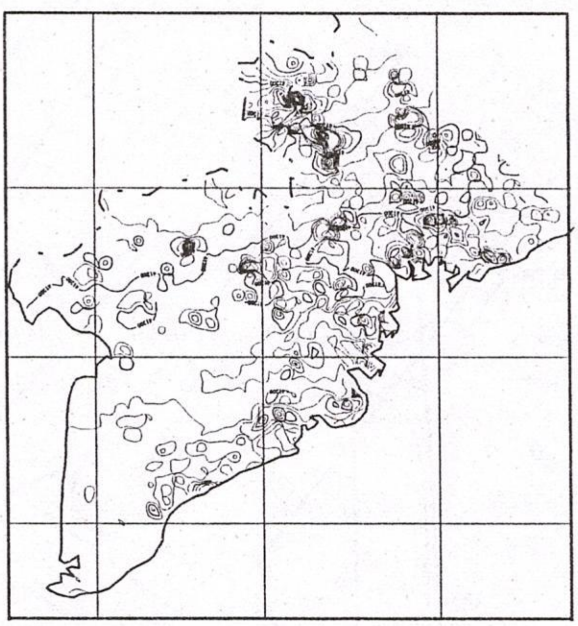
faults that striked in three main directions; the south-west to north-east direction faults were Honkhoai–Cana fault (F7, Fig.1) and Bienhoa–Tuyhoa (F6, Fig.1) fault. The others with south-east to north-west direction were Giarai–Hatien fault (F2, Fig.1), Tien river fault (F3a, Fig.1), Hau river fault (the main fault) (F3b, Fig.1), Vamcodong-Saigon rive fault (F4, Fig.1), Dautieng–Vungtau fault (intersection with F10, Fig.1) and Binh Long–Chua chan fault (F5, Fig.1). The Rachgia-Namcan (F9, Fig.1) and Locninh–Thudaumot faults (F10, Fig.1) had direction from south to north (Cao Dinh Trieu and Pham Huy Long, 2002).

With the magnetic data of this region, we used a total aeromagnetic intensity map 1985,0 of Department of Geology and Minerals of Vietnam. The map of the south of Vietnam had scale of 1/5000.000 with 25 nT contour interval. The survey was flown with north-south traverse lines at 2000m spacing and about 300m altitude. The aeromagnetic map of the south of Vietnam (Fig. 2) showed that all the strong and complex anomalies concentrated in Bienhoa swell, Soctrang swell and the east coastalside. The structural magnetic elements in Bienhoa swell struck in south-east to north-west direction; on the contrary the magnetic elements in Soctrang swell struck south-west to north-east direction. The weak anomalies were in Cantho basin. In other words, if we drew a line to connect Damdoi (Ca- Mau) to Mochoa, this line was a boundary between two groups of anomalies with the strong anomalies in its north-east side and vice-versa in the other side

11^{0}B

10^{0}B

9^{0}B



105^{0}Đ 106^{0}Đ 107^{0}Đ

Figure 2: The total intensity aeromagnetic map
Contour interval 50nT

3.2- Experiments

The aeromagnetic map was digitized into a 84x52 grid map with a 5km spacing. We use these grid data to compute the transformations that were described in the second paragraph of this paper.

First, using the formulas of (5) and (7) with $I = 8^o$, $D = 2^0$ and $I' = 45^0$ calculated the reduction to the magnetic pole anomalies (RTP) (Dang Van Liet et al., 2005) [3]. If we don't concern about the small anomalies in the Can-Tho basin, the anomalies of RTP were more clearly than the magnetic anomalies and their positions were slightly displaced comparing to

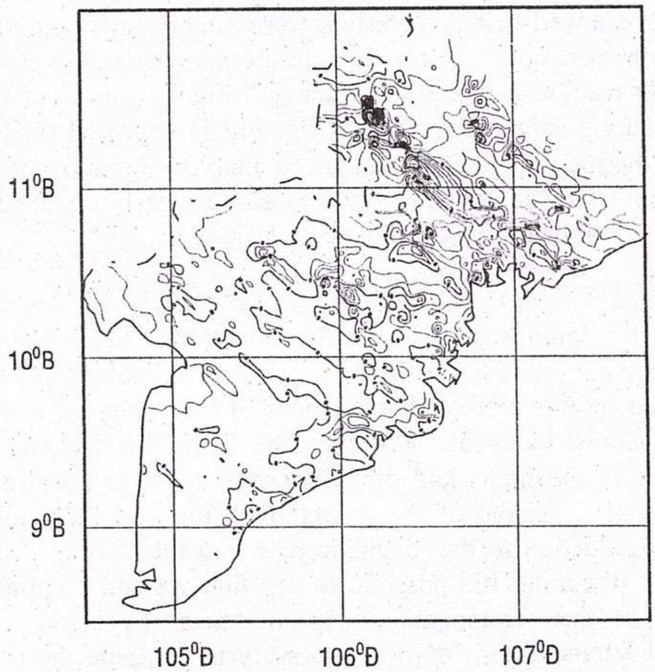


Figure 3: Reduction to the pole transformation of the aeromagnetic data. Contour interval 100 units

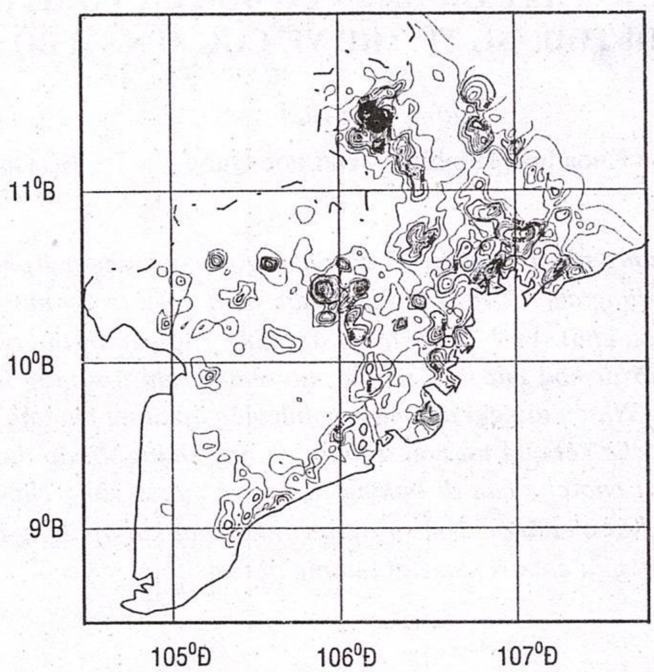


Figure 4: The enhanced analytic signal of reduction to the pole Contour interval 500 units

the original anomalies (Figure 3). In Bien-Hoa swell, the anomalies stretched in south-east to north-west direction.

Second, the enhanced analytic signal of reduction to the magnetic pole anomaly was calculated (Dang Van Liet, 2004) [1], and results were shown in Figure 4. The comparison of these results with the ones that were directly performed on the total intensity magnetic field (Dang Van Liet, 2004) [2] showed that both results were slightly different. The following faults such as Baria-Locninh, Soctrang-Travinh, Rachgia-Longxuyen and Dongthap-Hieuliem faults appeared on the both results. The Giarai-Hatien (F2, Fig.1), Hau river and Tien river (F3b, F3a, Fig. 1), Vamcodong-Saigon river faults (F4, Fig.1) appeared on Figure 4 more clearly than the results of the map obtained by enhanced analytic signal of the aeromagnetic field. Especially the Locninh-Thudaumot fault only appeared clearly on the Figure 4. The discussions about the results will be reprented in the conclusions.

4- CONCLUSIONS

The enhanced analytic signal was applied to the reduction to the magnetic pole of the south of Vietnam - the area was in the low latitudes - and the declination had the very small values. The results obtained by this method and the ones of the enhanced analytic signal of magnetic anomalies were almost identical. However, the faults that had the south-west to north-east direction especially the faults had direction from south to north appeared more clearly on the enhanced analytic signal of the reduction to the magnetic pole. This event explained that the map of reduction to the magnetic pole had the dominant anomalies that struck on the declination's direction. It's possible to say that we can compute directly the enhanced analytic signal of the aeromagnetic map to detect the locations of geologic boundaries in the south of Vietnam and it's not necessary to compute the reduction to the magnetic pole.

ÁP DỤNG PHƯƠNG PHÁP GRADIEN CÓ ĐỘ PHÂN GIẢI CAO TÍNH CÁC DỊ THƯỜNG TỪ THU VỀ CỰC Ở NAM BỘ

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TÓM TẮT: *Phương pháp gradien có độ phân giải cao (phương pháp tín hiệu giải tích được nâng lên) áp dụng cho từ và trọng lực được phát triển trong những năm gần đây để xác định ranh giới địa chất. Về lý thuyết, khi áp dụng cho các dị thường từ, kết quả sẽ không phụ thuộc vào độ từ hoá của các nguồn; tuy nhiên, khi áp dụng kết quả vẫn phụ thuộc vào sự từ hoá này. Nhiều tác giả đã chứng minh việc áp dụng phương pháp cho các dị thường từ thu về cực sẽ cho kết quả tốt hơn. Trong bài nầy chúng tôi áp dụng phương pháp gradien có độ phân giải cao cho các dị thường từ thu về cực ở vùng Nam bộ - một vùng thuộc vĩ độ thấp (nhỏ). Kết quả được đem so sánh với kết quả khi áp dụng trực tiếp phương pháp gradien có độ phân giải cao trên các dị thường từ của vùng.*

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