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The characteristics of the magnetic anomaly and magnetosphere structure in the Nansha islands and surrounding areas

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Abstract: From 1987–1994, the South China Sea Institute of Oceanology, Academia Sinica of China, made two comprehensive geophysical surveys in the Nansha islands and surrounding areas with the research vessel "Shi Yan 2" where 14,000 km magnetic measurements were made. Based on the data collected from 1987–1992, together with the data obtained recently, characteristics of the magnetic anomaly in the Nansha islands and surrounding areas were studied and analysed. The magnetic anomaly data was also processed. Based on the upper and lower surface of the magnetic basement, the relationships between the magnetic anomaly, magnetosphere structure and oil and gas basins of this region were analysed.

DATA PROCESSING

In order to comprehensively understand the characteristics of the magnetic anomaly in this region, especially all kinds of anomalous integration and distribution, as well as the magnetic anomaly of the deep layer, a magnetic anomaly planimetric map of this region was drawn based on the grid of 2' x 2' (about 20 km x 20 km) under the conditions of sparse lines. Based on this grid value, two dimension fields transform programme in frequency space was used for data processing. According to the linear gradient of high frequency part of the power spectrum, the magnetic body's bottom surface (or called curieisotherm) in this region was calculated.

THE CHARACTERISTICS OF MAGNETIC ANOMALY

Magnetic type

Because the surveyed area is located in low latitude zone, its magnetic anomaly is normal negative. On the background of negative anomaly, there are four kinds of distribution (Fig. 1). These kinds of anomalies show different magnetic substances or different depths of magnetic basement.

Magnetic anomaly A (Fig. 1a)

This kind of anomaly is a peaklike one. Its wavelength is short and vary tremendously. In its northern wing, the anomaly is comparatively high and comparatively low in its southern wing. There is secondary interference on the lower part of its southern wing. This kind of anomaly is low and only appears on L1 and L2 lines or the southern part of Liletan. It exists around sea mountains, which may be related to the mountain's composition. It can be seen as a kind of shallow strong magnetic anomaly.

Magnetic anomaly B (Fig. 1b)

It is a kind of low, broad and gentle magnetic anomaly. It has a broad wavelength, sometimes up to tens of kilometers. It two wings are symmetrical. Secondary interference is insignificant and seldom varies. This kind of anomaly is found mainly in the southern part of the surveyed area. It may be related to the deep layer's magnetic basement.

Magnetic anomaly C (Fig. 1c)

It is a kind of anomaly with high negative and strong variation of background. There appears to be obvious secondary interference under the condition of strong negative anomaly (about 300nT). This kind of anomaly mainly concentrates in the middle and western parts of the surveyed area. It is deduced that this kind of anomaly may be made of highly negative and considerably deep magnetic bodies.

Magnetic anomaly D (Fig. 1c)

It is a variable negative anomaly. It mainly appears under the condition of low background anomaly, which is close to the zero line (under –100nT). It vibrates as waves, with wavelength about 10 km and amplitude about 50nT. It often consists of a few waves, and is mainly distributed

in the middle-southern part of the surveyed area. We can calculate its value with three columnar upright models. It is composed of some low magnetic bodies (J = 400 x 10s A/m) with certain depth (about 4 km). It is most likely a kind of granite with middle-low magnetic.

The distribution characteristics of magnetic anomaly

A. Depth of the magnetic basement

From the depth map of the magnetic basement (Fig. 2), the depth of the magnetic basement and the depth of nonmagnetosphere can be located. From the depth of the magnetic basement, especially from the nonmagnetic layer isopach map obtained by the depth of magnetic basement minus the depth of water (Fig. 3), it can be seen that the variation of the magnetic bodies' depth or the nonmagnetic bodies' thickness appears as a zone-like structure in the northeast and a block-like one in the northwest. In the surveyed areas, it appears low in the southwest, south, southeast and northeast. Nonmagnetosphere is thick. All of these almost correspond one to one with the several larger sedimentary basins (Wananxi, Zenmo, to the south of the South China Sea trough and surrounding areas). But in the middle and northern part of the surveyed area, the magnetic basement is high and nonmagnetosphere is thin. It shows that the Nansha island reef is a upwelling area as a whole, but inside it there are some little sags, which are small in depth and area. The thickest part of nonmagnetosphere is located in the southern part of or inside the Zenmo basin. The depth of magnetic basement is between 8 and 13 km, and that of the nonmagnetosphere is 8 and 12 km. The thickest part (12 km) is located at the boundary of the southern continental slope and shelf of South China Sea. But near the south 200 m isobath and along it, there is a low raising, which has a 1,000 km depth difference from the neighbouring sag.

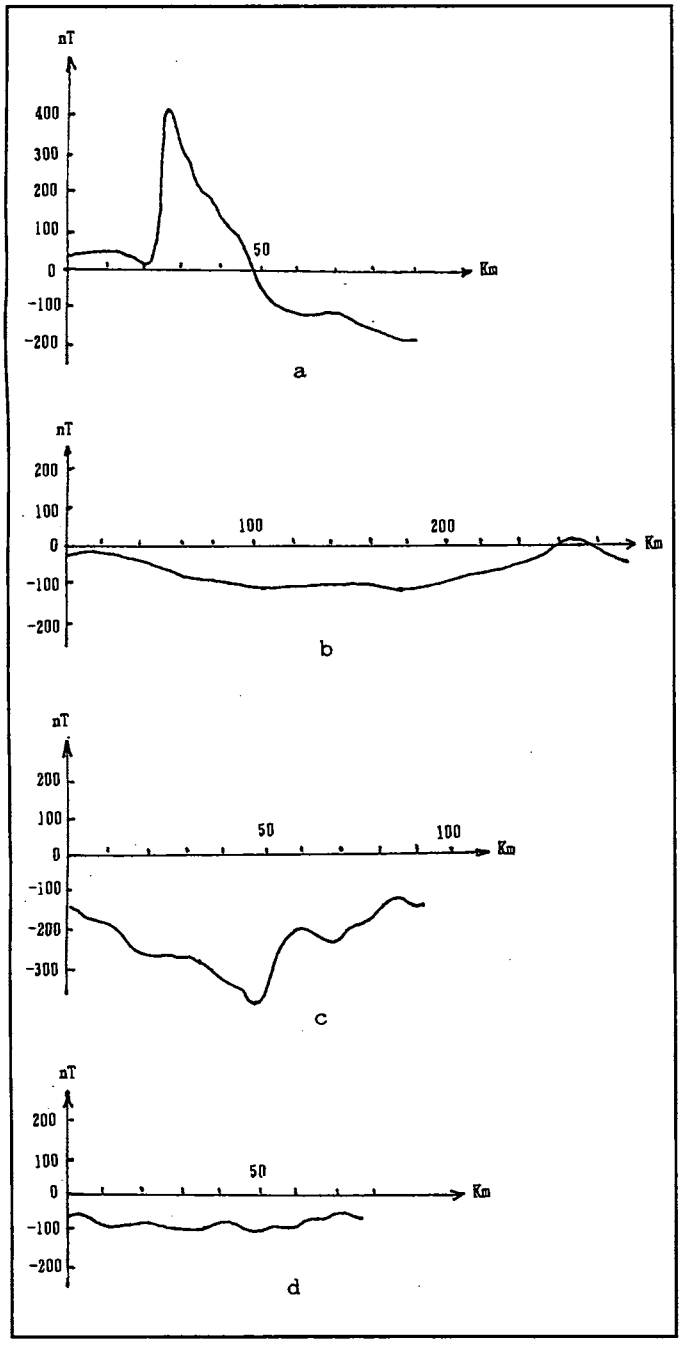

Figure 1. Magnetic type a, b, c and d.

B. The depth of the lower surface of the magnetic body and the magnetosphere's thickness.

In all of the area surveyed, the lower surface depth of the magnetic body (Fig. 3) is between 26 and 17 km, and shows the characteristics of shallow in the south and north, and deep in the east and west. From north to south, the lower surface depth deepens from –17 to 23 km and raises from –23 to –17 km. And from west to east, it shallows from –23 to –21 km, to middle the depth shallows to 23 km and to east to –26 km. From the isopach map of magnetosphere (Fig. 4), it appears thick in the northeast and shallow in the southeast. Magnetic layer depth is more than 17 km in the northeastern part and less than 16 km in the southeastern part, the shallowest part is located in the southern continental slope, only 11 km. The interesting thing is that the distribution of the lower surface depth is similar to that of the MOHO as a whole, and the two kinds of depths are the same as a whole too. This coincidence undoubtedly bring some inspiration to the study of the structure of the uppercrust of Nansha islands and surrounding areas, which will be studied later.

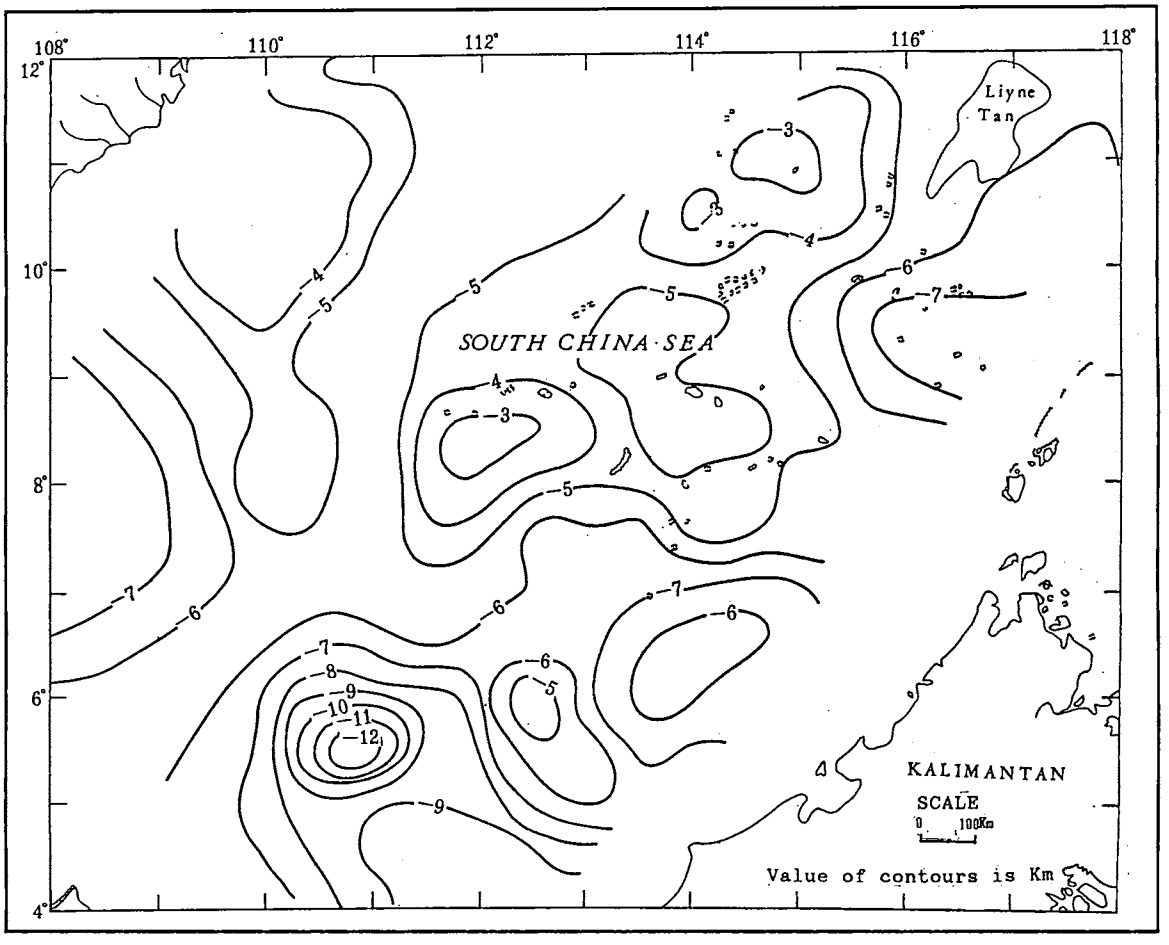

Figure 2. Depth map of the magnetic basement.

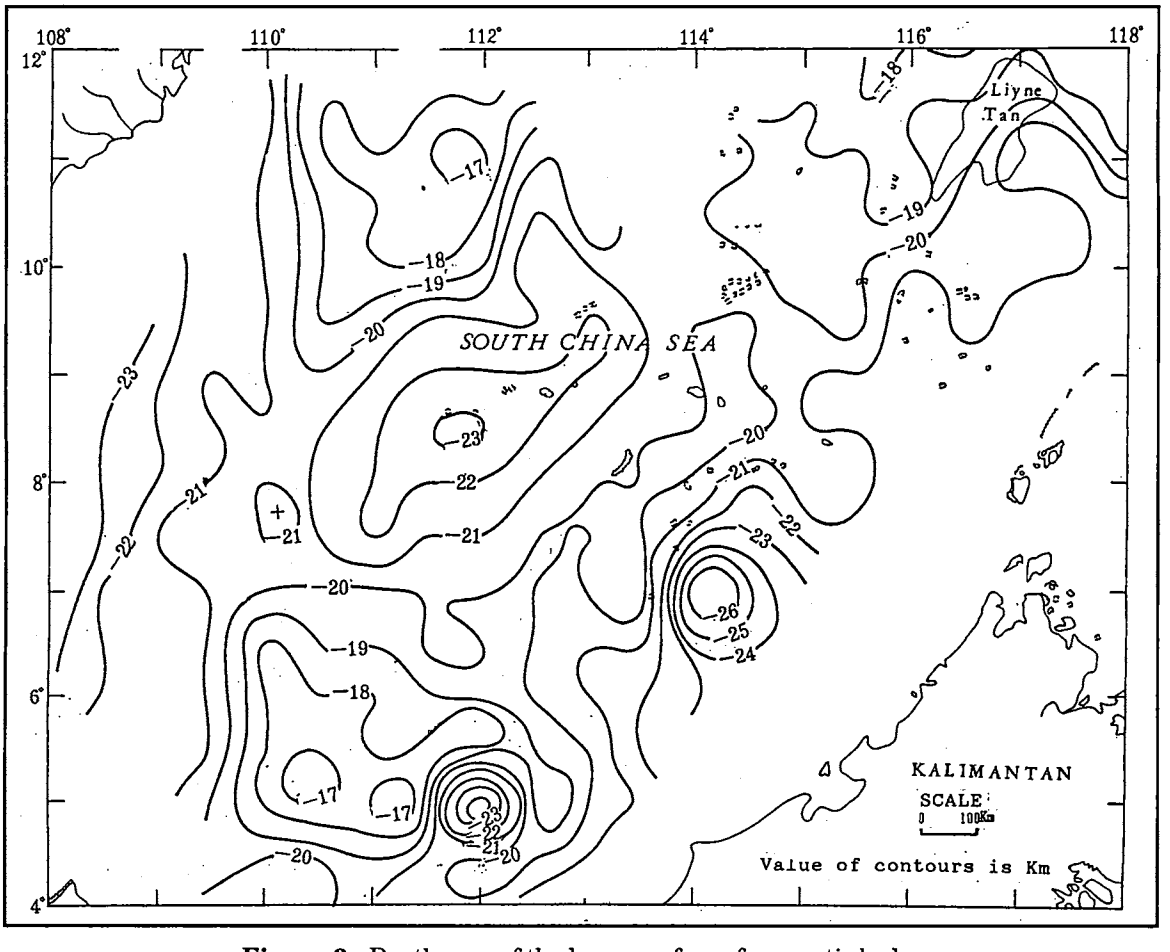

Figure 3. Depth map of the lower surface of magnetic body.

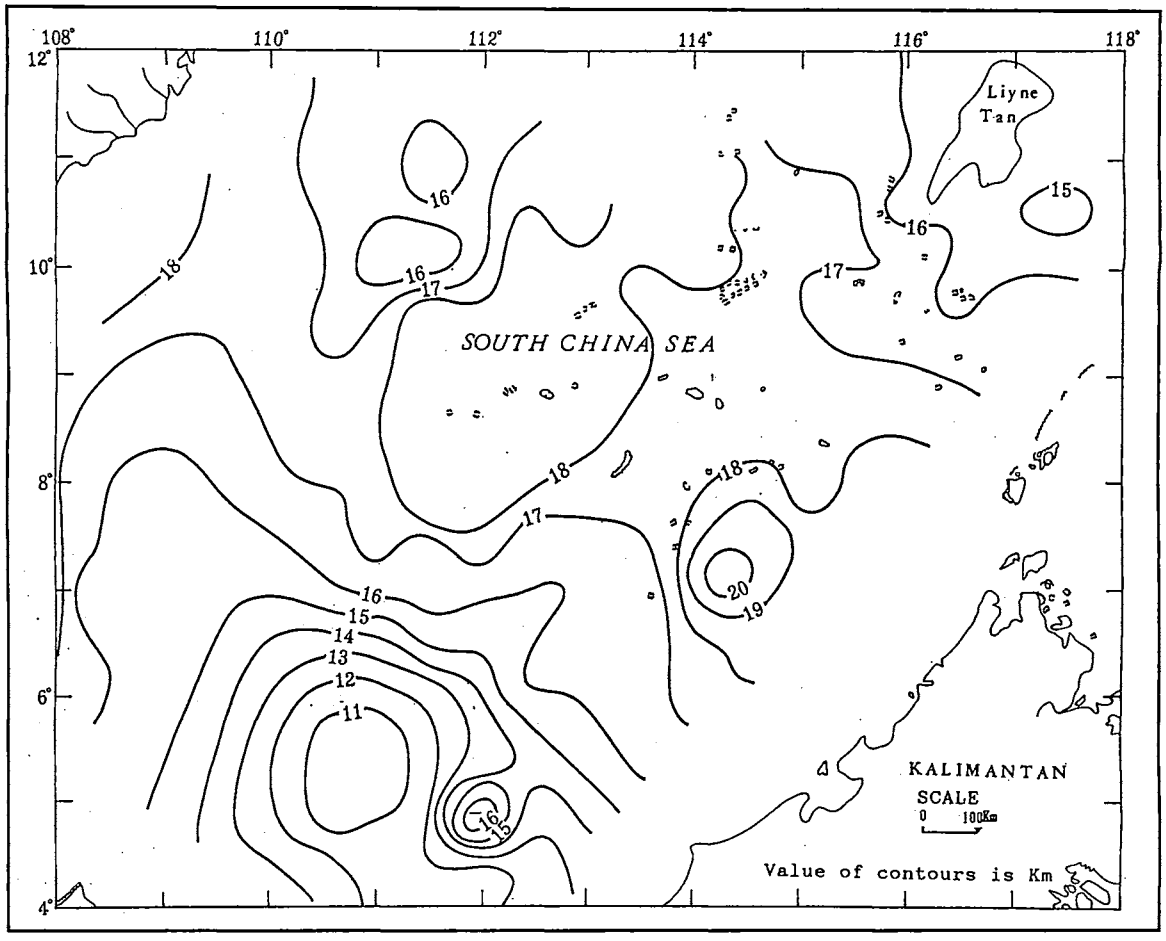

Figure 4. Isopach map of magnetosphere.

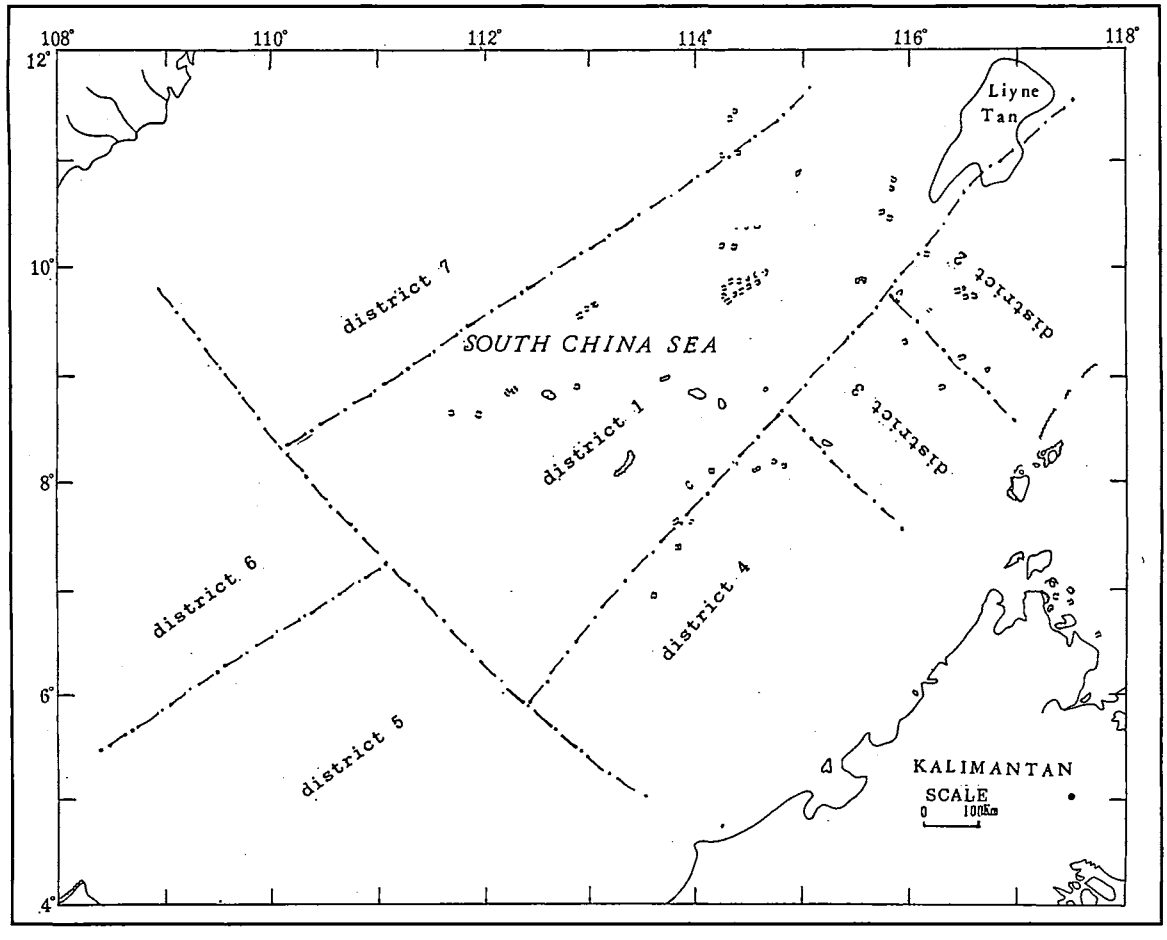

Figure 5. Magnetic districts.

MAGNETIC DISTRICTS

According to the characteristics of all kinds of space constitution and distribution of magnetic anomaly as well as maps of data processing and map analysis of the magnetic basement, the whole surveyed area can be divided into seven magnetic districts (Fig. 5). The distribution of magnetic anomaly and the magnetic basement are interpreted as follows.

District 1: Magnetic basement upwelling areas from Zenhe shallows to Nansha shallows

This district is located in the middle part of the surveyed area and slightly towards the west. The northern part is bounded in the south by the central sea basin of the South China Sea. Its southern part is to the north of Nanweitan, with a bar-block shape and a northwest trend. Whether shallow or deep, the magnetic anomaly appears at a whole to trend northeast. The magnetic basement is high in those parts with strong anomaly variation in the whole area surveyed, while the depth is mostly less than 3 km. Inside it, there is a small depression, about 5 km deep, where the magnetosphere thickness is about 20 km with little variation, but variation around it is strong.

District 2: Magnetic basement depression area in the southern part of Liletan

This district is located in the northeastern part of the area surveyed to the south of Liletan, to the east of District 1, and to the north of Xingyi reef. It has a slightly northwest trend. The anomaly is mainly formed by a single, block-shaped magnetic anomaly body. The amplitude value of the anomaly vary slightly, under 150nT. The depth of the magnetic basement is deeper (about 5 km), and the nonmagnetic basement is from 4 to 5 km thick. The thickness of the magnetosphere is between 22 to 24 km. It is a magnetic basement depression area. The upper crust structure may not be the same as that of District 1.

District 3: The magnetic basement upwelling area in Xingyi reef

This district is located to the south of District 2, to the east of District 1, and on the south towards the middle Nansha trough. It is slightly block-like in shape with a northwest trend. The amplitude value of the anomaly varies strongly. The depth of the magnetic basement is less than 4 km, and the thickness of the nonmagnetosphere is 22 km. It is also a magnetic basement depression area. Its upper crust structure may be the same as that of District 2.

District 4: The magnetic basement depression area in Nansha trough

This district is located to the south of District 3, to the east of District 1, and on the south to the border of south Nansha trough. It has a block-like shape with a northwest trend. The amplitude value of the anomaly varies slightly, basically the same as that of District 2. The depth of the magnetic basement is about 6 km, and the thickness of the nonmagnetosphere is 4 km. Here, the magnetosphere is the deepest of the whole survey area, and its thickness gets up to 24 km. It is also a magnetic basement depression area. Its structure is different from that of the other districts. Its upper crust structure is unique too.

District 5: Zenmo magnetic basement depression area

To the north of this district is District 1, and to its northwest is District 6. The southern part of the district is out of the area surveyed. On the east it is in the line of Natuna island and Wananxi shallows. All of the area is mainly a low and gentle magnetic anomaly. Its magnetic basement is the deepest of the whole survey area, but the magnetosphere is the thinnest. It can be roughly divided into two parts. Approximately bounded by the isopach 200 m, the northern depression and the southern deep depression are separated. This low convex appears to have a slight northwest trend. Compared with the neighbouring depression, its height difference is about 1,000 to 2,000 m.

District 6: The magnetic basement depression area in western part of Wanantan

This district is located in the southwestern part of the area surveyed. It is bounded on the east by District 1, and on the south by District 5. The magnetic anomaly in this district is block-like in shape with a northwest trend.

The amplitude value of the anomaly varies strongly. But it is mainly the anomaly with secondary interference whose amplitude varies strongly. It may have relationship with large intrusive bodies in this district. But these bodies may not be highly magnetic. The magnetic basement also has much variation in this district, between 4 and 6 km. The nonmagnetosphere is thin, generally less than 3 km, and in its northern part less than 2 km. The lower surface of the magnetic is shallow, generally less than 20 km from south to north while the magnetosphere's thickness decreases from 22 to 16 km. Hence this crust structure in the south may not be the same as that of the north.

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