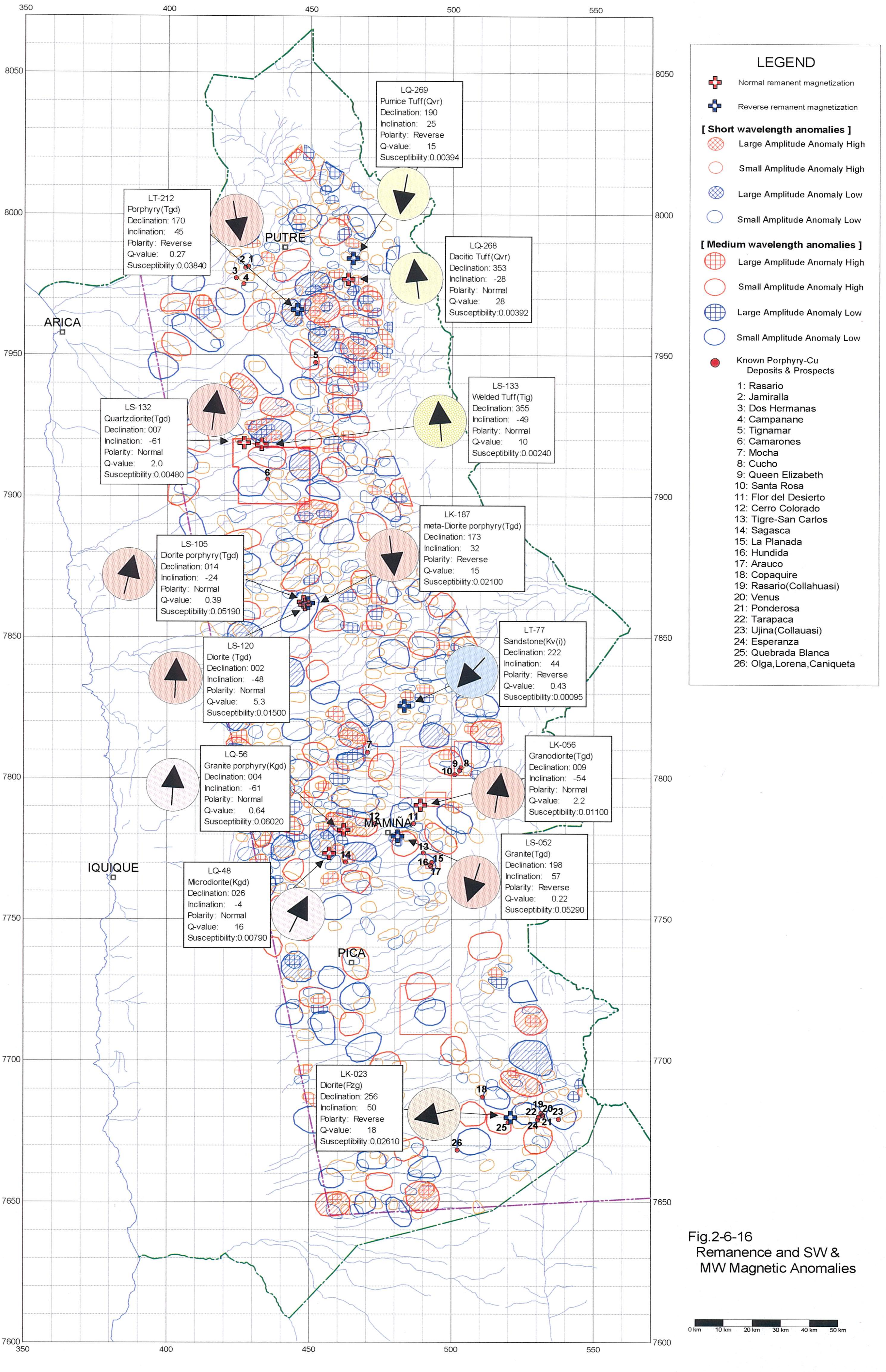

Fig.2-6-16
Remanence and SW & MW Magnetic Anomalies

6-2-3 Magnetic anomalies and geology

(1) Magnetic anomalies and Quaternary volcanic rocks

Map of short and medium wavelength magnetic anomalies and Quaternary volcanic rocks (Qv) distribution is shown in Figure 2-6-17. Many short wavelength magnetic anomalies occur in the Quaternary volcanic rock area to the north of 7800km, and strong correlation between them is clearly observed. Of these short wavelength magnetic anomalies, those at topographic protrusion such as mountain summits and clear ridges are indicated by red marks. These were also observed in areas other than north of 7800km such as at the southeastern edge of the area where 3 were extracted and the total of the whole survey area became 63. About 70% of the extracted anomalies were high anomalies.

The short wavelength magnetic anomalies coinciding with topographic protrusion and not in Quaternary volcanics were also extracted and marked by a triangle. Of these, the anomalies south of 7800km are all located in the basement rocks with the exception of the 4 at 15km northeast and 30km north of Pica. The 4 anomalies near Pica and north of 7800km, many of them are in Tertiary ignimbrite area, and these are considered to be the cases where ignimbrites with generally magnetic susceptibility are showing magnetic anomaly by strong remanent magnetization.

(2) Magnetic anomalies and Tertiary-Quaternary ignimbrites

Map of short and medium wavelength magnetic anomalies and Tertiary and Quaternary ignimbrite distribution are shown in Figure 2-6-18. Since Tertiary ignimbrite possibly occur under Quaternary sediments, the extraction included Quaternary sediment areas.

The area of Tertiary ignimbrite has low topographic relief, and the correlation of magnetic anomalies and topography is not clear. But deep valleys are often dissected in these rocks and magnetic anomalies on the plateaus between two valleys are not uncommon. These anomalies are believed to have been caused by ignimbrite and they are marked by red circles in Figure 2-6-18. The red circles are all short wavelength anomalies and 11 of them are high and 4 are low anomalies.

Medium wavelength magnetic anomalies are not easy to extract, but those with some correlation to topography amounted to 5 high and 8 low anomalies and they are marked by red triangles.

In Quaternary ignimbrite areas, magnetic anomalies correlated to topography could not be extracted.

(3) Magnetic anomalies and intrusive rocks

Map of medium and long wavelength magnetic anomalies and pre-Tertiary and Tertiary intrusive rock distribution are shown in Figure 2-6-19. Intrusive rocks occur collectively near Putre in the north, Mamiña in the central part, and near Collahuasi in the south.

About 60 to 70 percent of the intrusive rocks are correlated to medium or long wavelength magnetic anomalies, but some are not associated with magnetic anomalies, and these have been marked with triangles.

Many intrusive rocks generally show strong magnetism, but some show weak magnetism (Tgd, Kgd) as seen in Figure 2-6-11, and magnetism weakens with phyllic and acidic alteration. Thus there are cases where intrusive bodies do not show magnetic anomaly.

The Tertiary intrusive body southwest of Putre does not show magnetic anomaly. Theoretically, it is very possible that if the polarity of remanent magnetization is reverse and its Q value is close to 1.0, then the induced and remanent magnetization eliminate each other resulting in no anomaly. This intrusive body may well be such a case. Also reverse magnetic polarity and remanent magnetic measurement with Q value of 0.27 are obtained from a same Tertiary intrusive body to the south of Putre (Table 2-6-4).

(4) Magnetic anomalies and basement rocks

Map of medium and long wavelength magnetic anomalies and pre-Tertiary basement rock distribution are shown in Figure 2-6-20. Basement rocks, like intrusive rocks, occur collectively near Putre in the north, near Mamiña in the south, and near Collahuasi in the south, but many small outcrops are confirmed in other areas.

Around 60 to 70% of the basement rocks are correlated to medium and long wavelength magnetic anomalies. The areas of basement rocks without magnetic anomalies are marked with triangles, and most of them are sedimentary rocks.

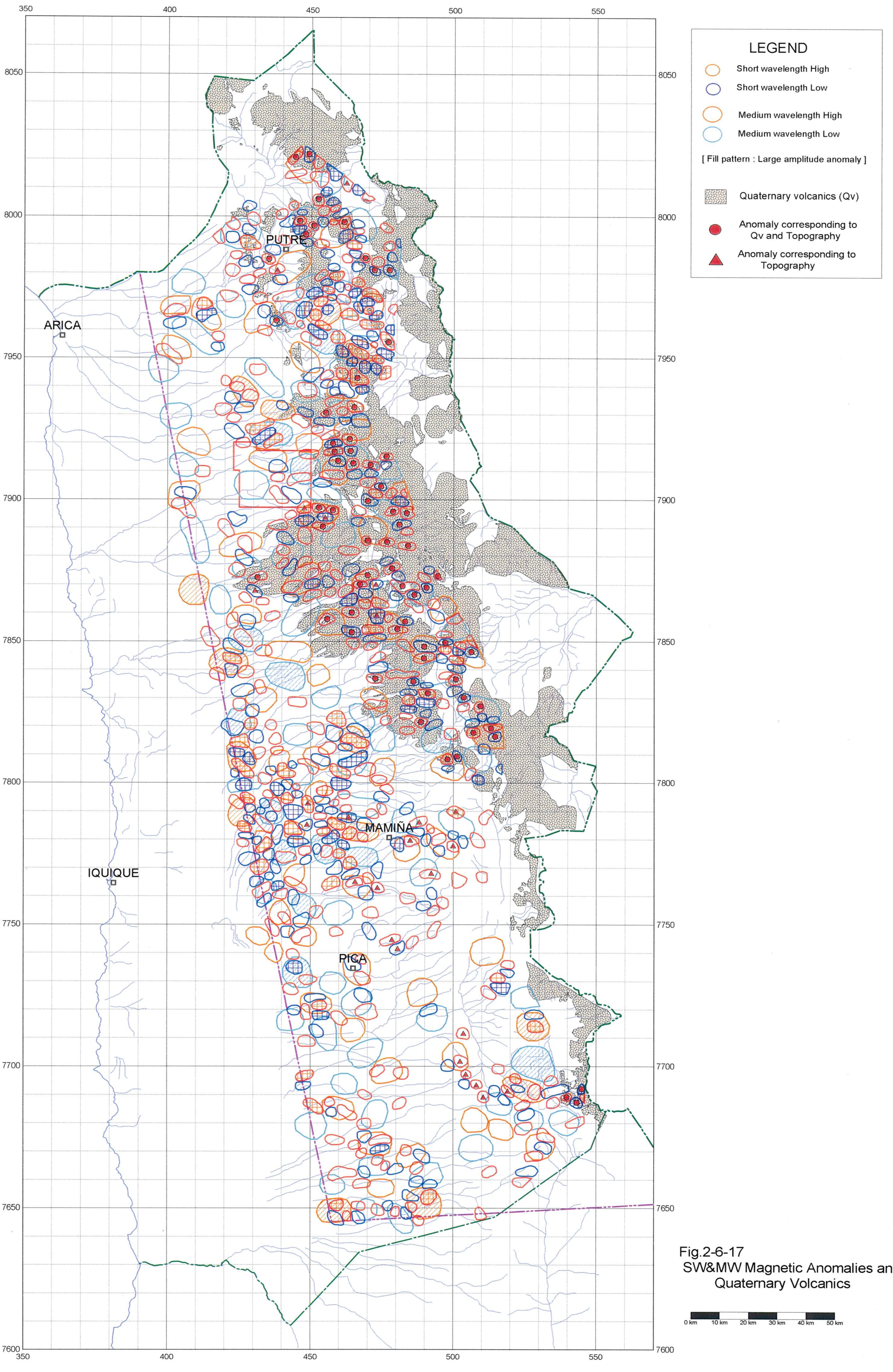

Fig.2-6-17
SW&MW Magnetic Anomalies and Quaternary Volcanics

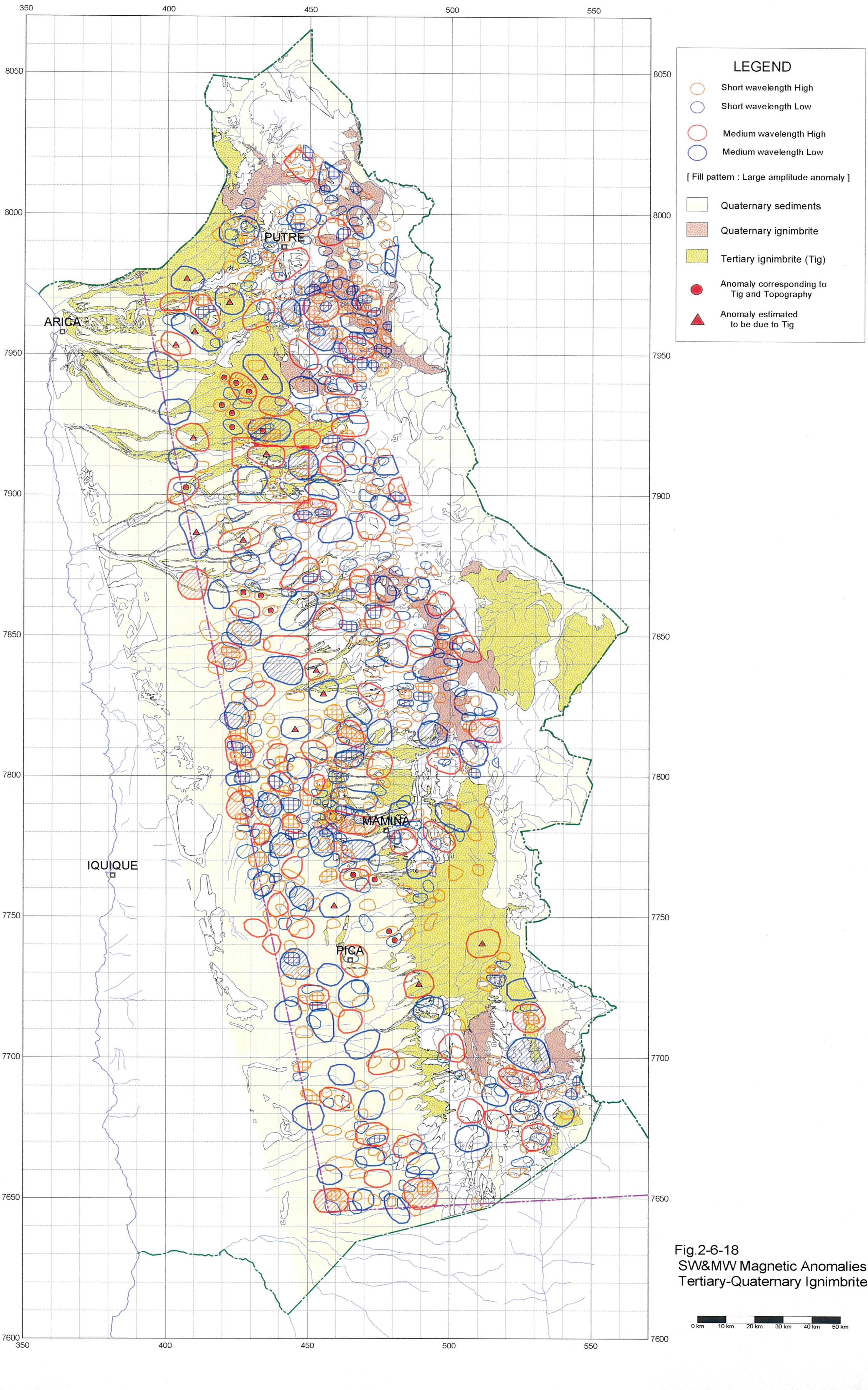

Fig.2-6-18
SW&MW Magnetic Anomalies and Tertiary-Quaternary Ignimbrites

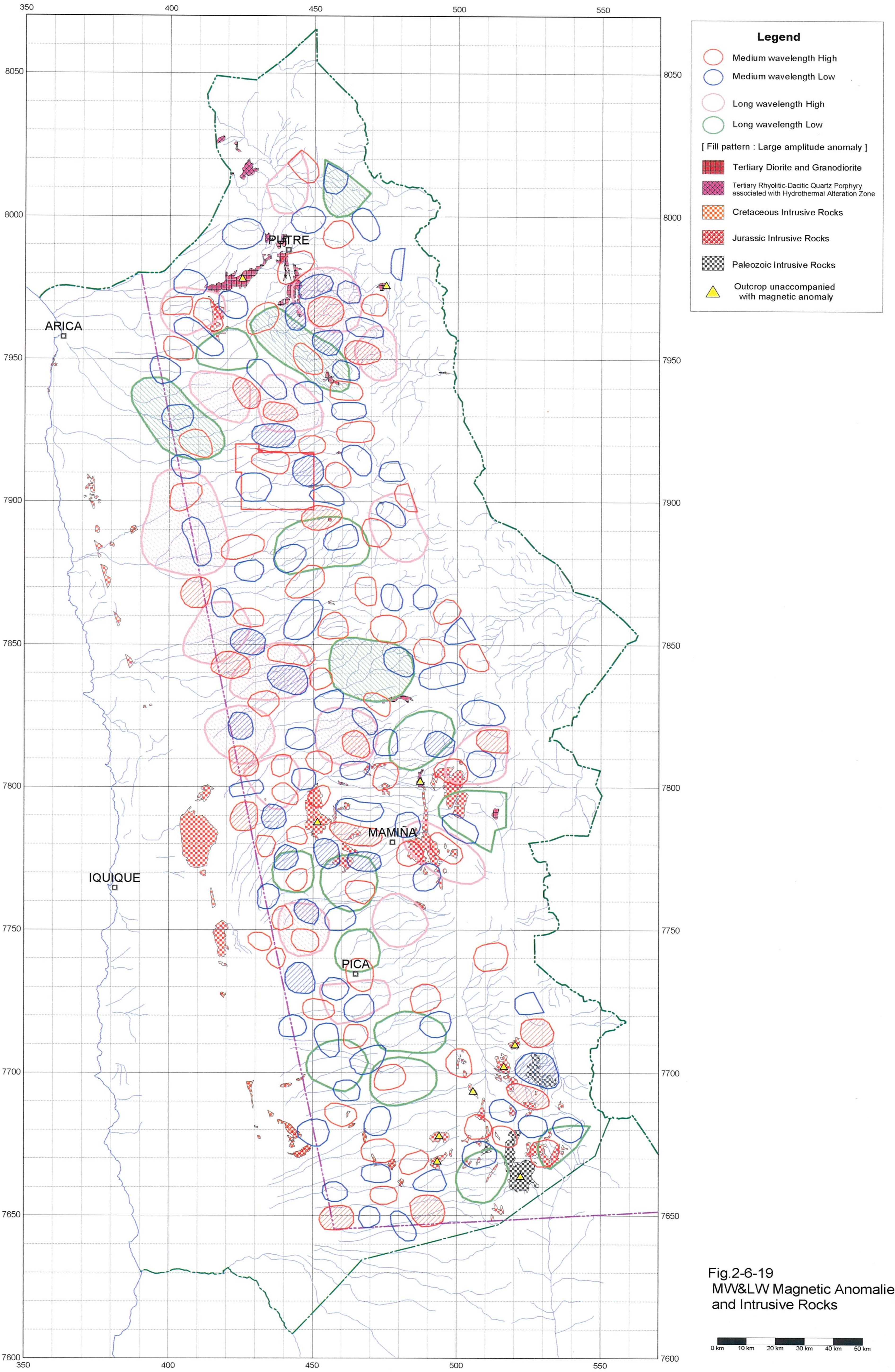

Fig.2-6-19
MW&LW Magnetic Anomalies
and Intrusive Rocks

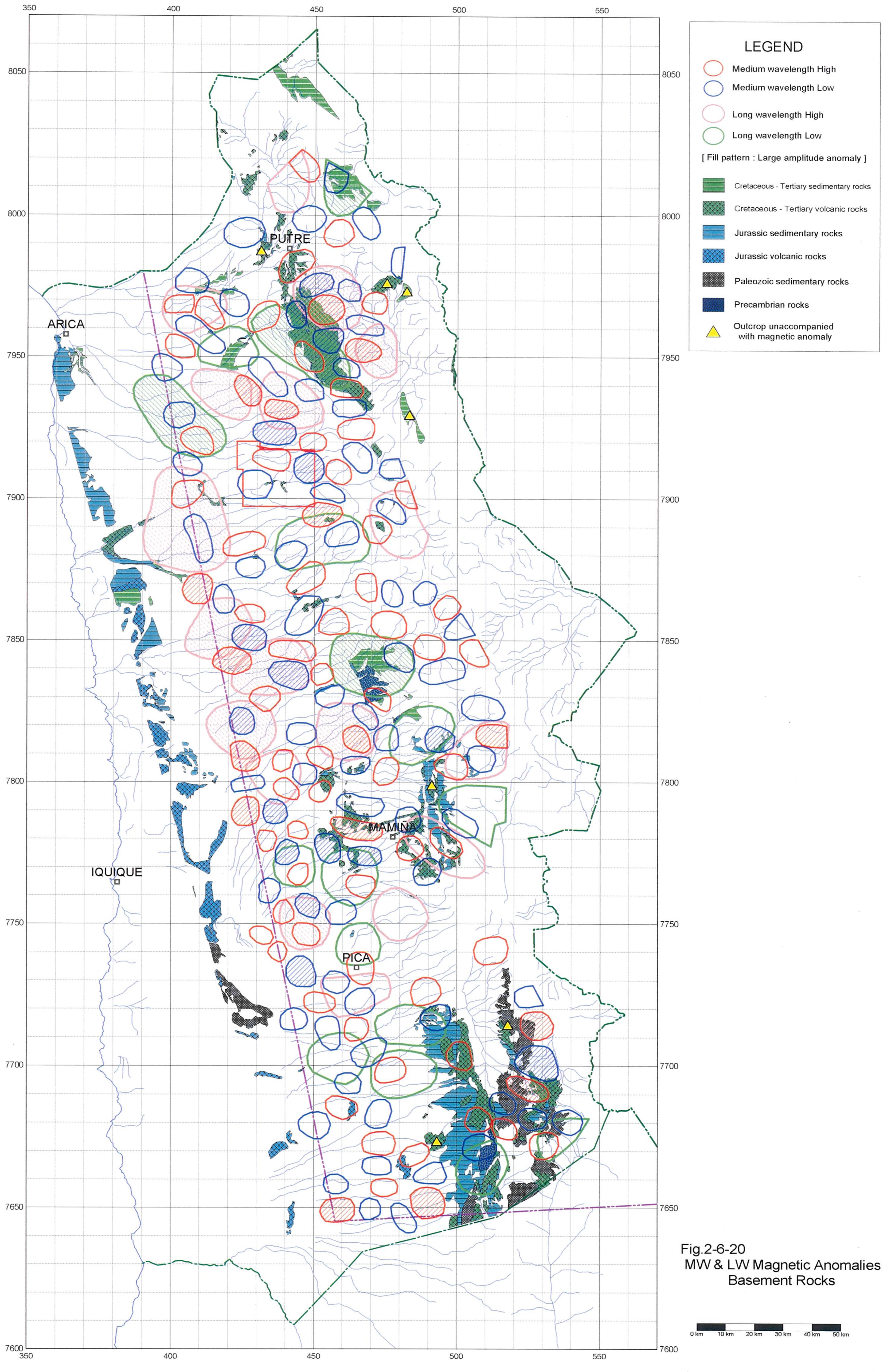

Fig.2-6-20
MW & LW Magnetic Anomalies and Basement Rocks

6-2-4 Two-dimensional modeling

Two dimensional modeling regarding magnetic susceptibility distribution was carried out along 30km long lines extending through 12 drilling sites. The drilling was done in the northern half of the survey area. The drilling sites and lines for modeling were plotted on the total magnetic intensity map, and it is shown in Figure 2-6-21. Also drilling sites and modeling lines were plotted on a geologic map and on a reduced to the pole magnetic map, and they are shown in Figures 2-6-22 and 2-6-23. The modeling lines were set in the N-S direction in line with the direction of the magnetic field.

Modeling was carried out by dividing the subsurface area into three layers. Short wavelength total magnetic intensity was used to be fitted for the first layer, medium wavelength total magnetic intensity for the second layer, and long wavelength total magnetic intensity for the third layer. The upper surface of the first layer was placed 300m below the earth's surface, while the lower surface was placed 1,800m below the assumed flight height (= calculation point). The upper surface of the second layer was set to coincide with the lower surface of the first layer and the lower surface was placed at a constant depth so that the average thickness of this layer would be about 2,500m.). The upper surface of the third layer was set to coincide with the lower surface of the second layer and the lower surface was placed at 30km below sea level. The thickness of the above layers were determined, after some trials and errors, to satisfy conditions such as; to be within harmonious range of the magnetic susceptibility values obtained by modeling and those actually measured, and extreme gap of magnetic susceptibility does not exist between adjacent layers.

Each layer was divided into blocks of; 1km width for the first layer, 2km width for the second, and 3km for the third. The magnetic susceptibility of each block was assumed to be homogeneous. For the second and third layers, calculated and measured magnetic anomaly values were fit by changing the magnetic susceptibility but without changing the shape of the blocks. But for the first layer, improvement of fitting was attempted by changing the shape of the upper and side surfaces as well as the magnetic susceptibility. For the zone between the earth's surface and the first layer, magnetic susceptibility value of $1.0 \sim 5.0 \times 10^{-3}$ was assumed from the drilling data.

The results of the 2-dimensional modeling is shown in Figures 2-6-24 to 2-6-35. The calculated magnetic susceptibility values are shown in these figures and these values are grouped into 8 ranks which are shown in different colors. Also assumed structural lines are drawn for zones with remarkable horizontal gap of magnetic susceptibility, and boundary lines are drawn for parts where layered or massive structure can be distinguished in susceptibility distribution to clarify their existence.

Regarding Lines 3, 4, 5, and 6, a confluence of blocks with high susceptibility is largely raised from the third to the second layer, and the shape of the rise indicates the possibility of the high magnetic body being an intrusive rock body.

Regarding Lines 7, 8, and 10; these lines contain strong magnetic blocks in some parts. But on the whole, a confluence of not very strong ($7.5\sim10\times10^{-3}$) magnetic blocks is raised from the third to the second layer. Magnetism of this confluence is not strong, but the shape indicates the possibility of an intrusive body.

Lines 1, 11, 12 are lines where basement rocks have been confirmed by drilling. The following common structure occurs along these lines. A confluence of blocks with weak negative susceptibility(reverse remanent magnetism) occurs in the third or third to second layer, and this is surrounded by not very strong positive blocks. The meaning of such magnetic susceptibility distribution is not clear at this point, but the shape indicates the possibility of an intrusive body.

The confluences of blocks with laterally continuous magnetic susceptibility along the first layer or from the first to the second layer were obtained in many modeling lines. Such confluences are considered to be, from the form of distribution, very possibly expressions of ignimbrite occurring on the surface. Some confluences inferred to be ignimbrite show high magnetic susceptibility. This generally appear to be incompatible to the magnetism of ignimbrites. But results of remanent magnetism measurements show that they can cause the strong magnetic anomalies similar to those by intrusive rocks. Thus the above is not necessarily contradictory.

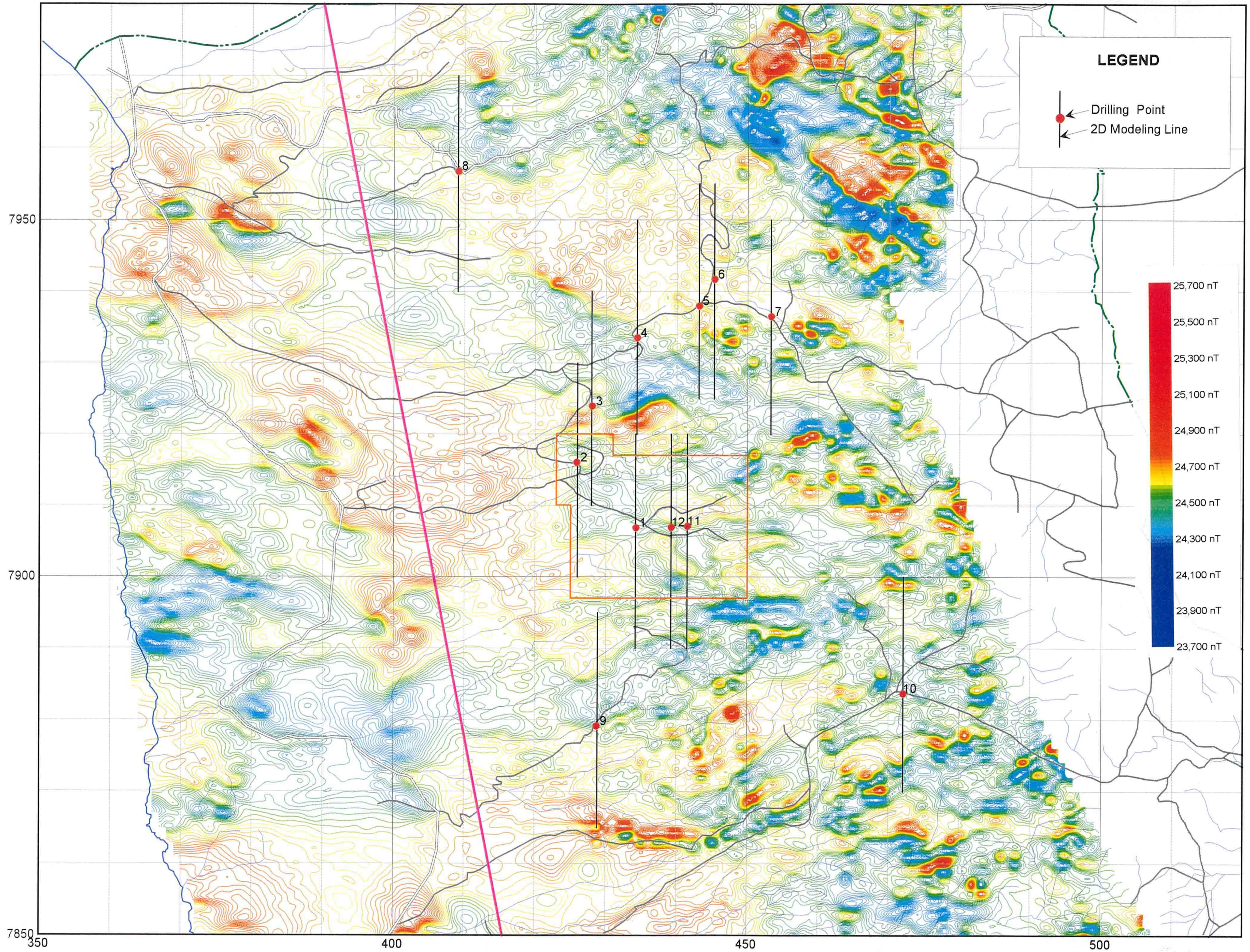

Fig.2-6-21 Location of 2D Modelling Lines and Total Magnetic Intensity

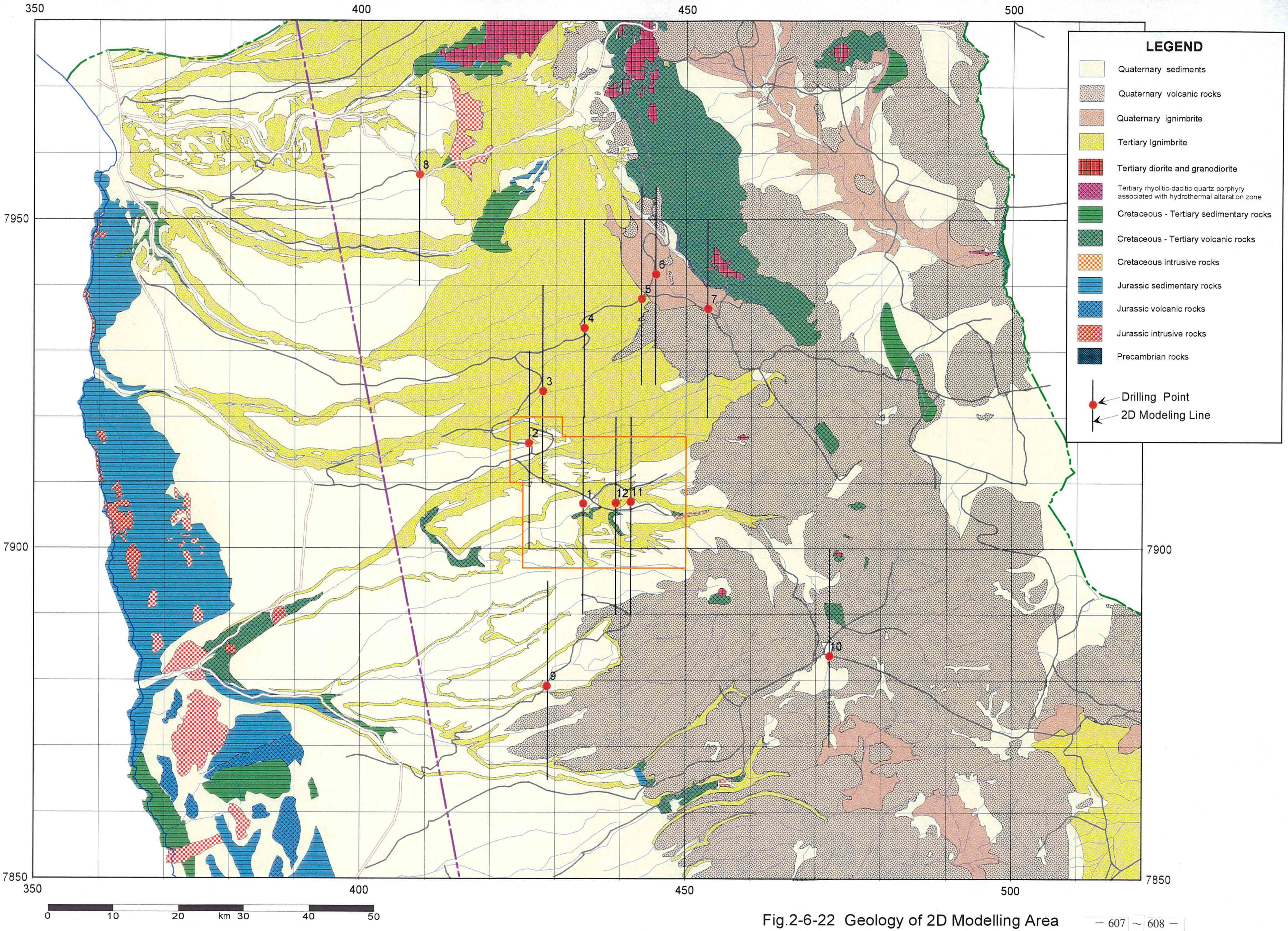

Fig.2-6-22 Geology of 2D Modelling Area

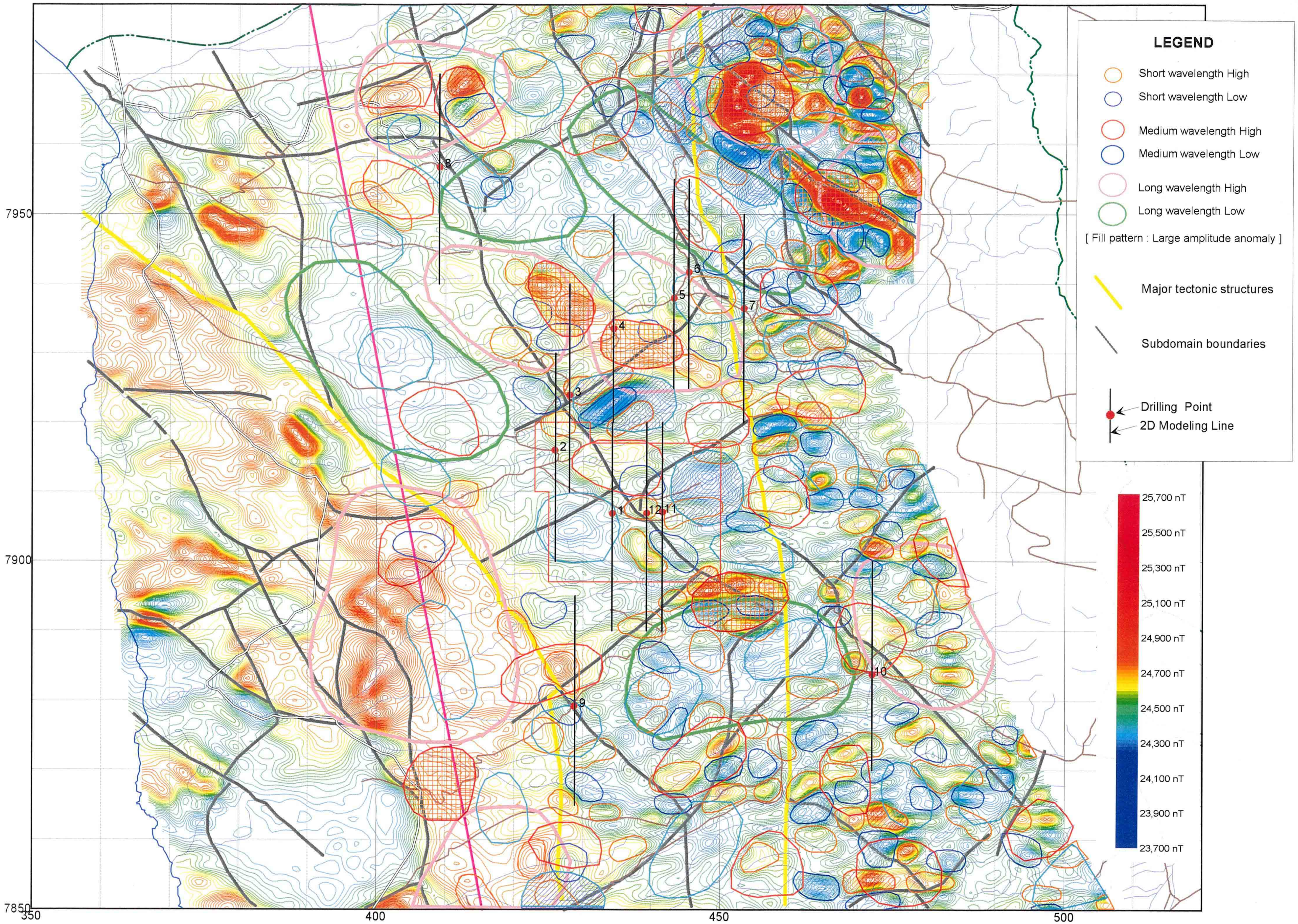

Fig.2-6-23 Reduced to the Pole and Magnetic Structures of 2D Modelling Area