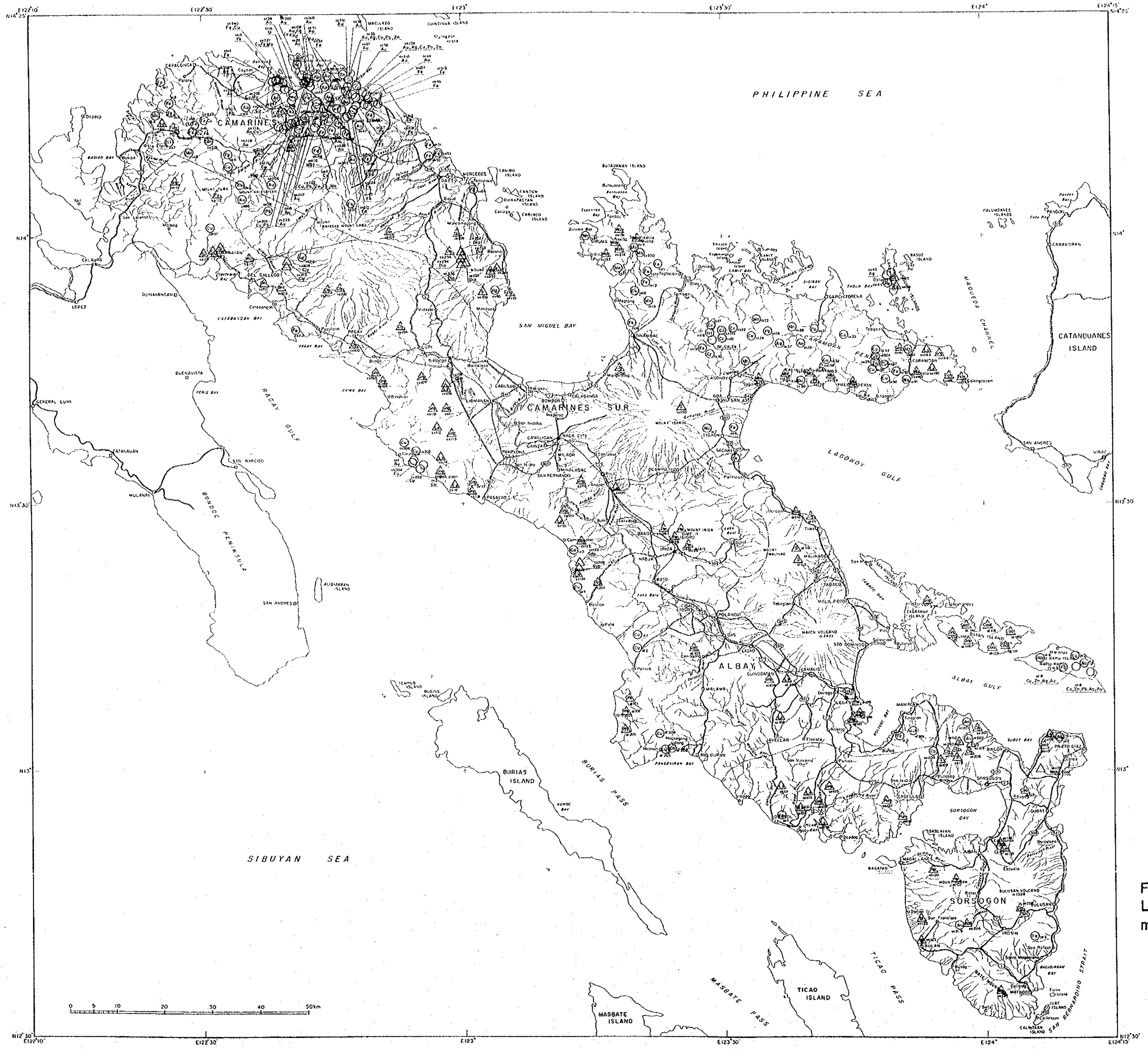


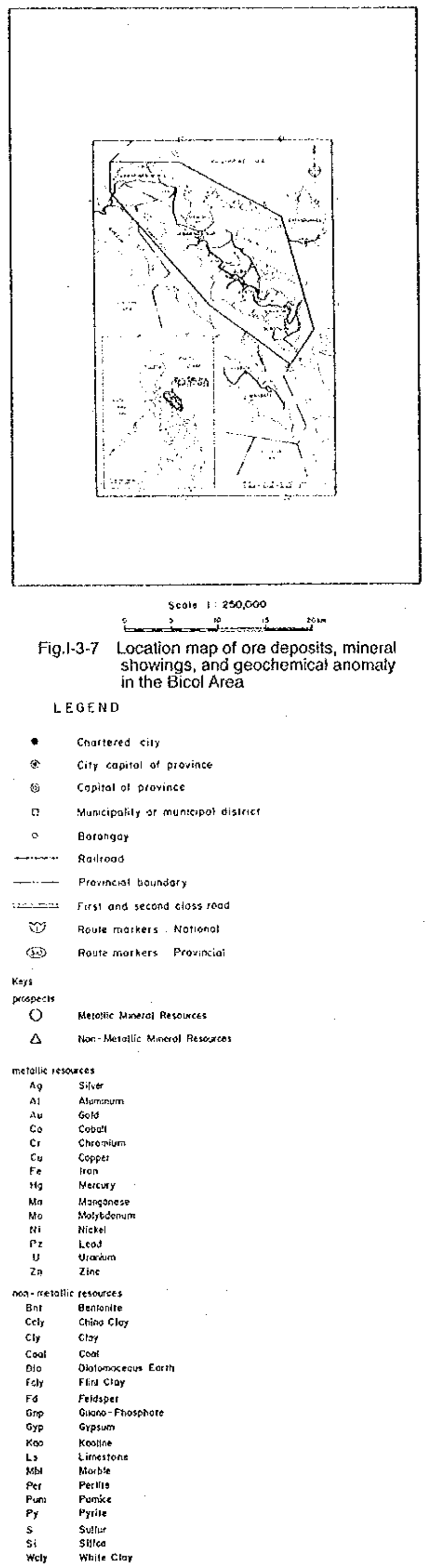


Fig. I-3-7*
Location map of ore deposits, mineral showings, and geochemical

3-2-1 Gold

The Bicol region has the Paracale gold deposit zone, known as one of the most important such zones in the Philippines.

The gold deposits and mineral showings of Camarines Norte can be classified into the following three areas in terms of distribution:

1. The Jose Panganiban-Paracale area
2. The Sta. Elena-Tabas area
3. The Nalesbitan-Tuba area

Of those areas, 1. and 2. represent the second most important gold production area in the history of the Philippines, having produced more than 160 t of gold in the past (Mitchell and Leach, 1991).

The Jose Panganiban-Paracale Area

That area is located approximately on the north side of the east-west line connecting Paracale and Jose Panganiban. It is an area with distribution of the ultrabasic rock considered to be the Cretaceous period ophiolite sequence and the Paracale granodiorite distributed through it (Fig. I-3-1).

Most of the gold deposits distributed in the area were developed before World War II, and many of the mines were closed by the end of the fifties. Many of them underwent further prospecting in the eighties in a redevelopment effort, but only one of the mines is still operational: the Longos Mine of the company United Paragon (actual production figure for 1994: 2.37 t of gold; MMAJ Resource Information Center, 1977).

Among the main mines located in this area are the Longos Mine (cn37), the La Suerte Mine (cn225), the San Mauricio (Olecram) Mine (cn230), the Magna Mine and the Paracale Gumaos Mine (cn30). All of them are of the metalliferous vein type, with the characteristics indicated below. Mitchell and Leach (1991) consider all of them to be epithermal gold mines, whereas Sillitoe et al.(1990) consider them to be the metalliferous vein type of gold base metal mineralization often observed in the vicinity of porphyry type copper and gold systems.

- Wall rock: Paracale granodiorite (Mitchell and Leach (1991) call it the Paracale trondjhemite)

- Direction: N 10° E strike, with steep slope
- Distribution: Most of it is distributed at the north side contact (with the ultrabasic rock) of the Paracale granodiorite body. There is hardly any distribution of it at the south side contact.
- Morphological characteristics: The veins are thicker at the fringe of the granodiorite bodies, and the mineralization there is also more pronounced. It disappears within several meters to several tens of meters after entering the ultrabasic rock. The vein width gets narrower going toward the inside of the granodiorite rock body, and the grade also declines until a "barren core" is reached.
- High grade part: At intersections of veins and where branch veins leave main veins.
- Characteristics of the veins: There are two kinds of veins:
    1. Green quartz veins: Distributed near contact with the ultrabasic rock.
    2. White quartz veins: This kind is more frequent. Quartz and quartz-calcite veins. fine-grained quartz stringers, vugs, coarse sphalerite and galena bands, etc. are observed. Also characterized by high base metal content.
- Ore minerals: pyrite, pyrrhotite, arsenopyrite, chalcopyrite, bornite, covelline, sphalerite, galena, and tetrahedrite. Characterized by many base metal sulfide minerals, Pb, Ag, Zn and Cu having been recovered at many mines. Mo and W also present in traces. The combined Pb and Zn content is 0.5-1.0%.
- Fluid inclusion homogenization temperature: According to the data available on the veins of the San Mauricio (Olecram) Mine (cn230) for the most part it lies within the range 220-300° C.
- Other characteristics: The veins undergo the following change from the deep part to the shallow part: Deep part: Quartz vein with clear profile and without development of alteration zone of the wall rock. Shallow part: Change to stringers, with silicification and developed sericite alteration of the wall rock and with decline in gold content.

Extraction took place at a depth of approximately 300 m (because there is inflow of water at the deep part).

Sta. Elena-Tabas Area

This area extending from the Larap Peninsula through the vicinity of Batobalani and to the north of Mt. Bagacay, is situated south of the above-mentioned Paracale area. It roughly coincides with the "base metal belt" and "iron belt" defined by Frost (1959). It is an area of distribution of the Universal formation, considered to date back to the late Paleocene epoch to the Eocene epoch, which is intruded by many stocks of what is called the Tamisan diorite (middle Miocene epoch). That Universal formation is also intruded by about twenty small rock bodies of dacitic porphyry assigned to the Pliocene epoch (United Nations, 1987).

The gold deposits and mineral showings of this area are divided by Mitchell and Leach (1991) into the following two types:

1) Base metal and gold showings accompanying iron deposits

2) Epithermal vein type deposits

The following deposits and mineral showings are cited by that source as belonging to type 1):

- Matanlang porphyry copper and molybdenum deposit

  According to Sillitoe and Gappe (1984), this deposit has a gold grade of 0.4 g/t Au. This will be discussed further in a later section (concerning copper).

- Submakin base metal mineral prospect (cn222)

  The sulfide ore has a gold grade of 0.26 g/t Au.

- Penarco magnetite and base metal deposit

  Gold anomalies are noted in soil thought to originate in calcite veins cutting the skarn.

- Pinagbirayan Munti magnetite deposit (cn239)

  In geochemical exploration of the soil the abnormal values of 3.9 ppm Au and 3 ppm Ag were obtained. In rock samples the values were 0.3 ppm Au and 0.2 ppm Ag. The value for copper was 350 ppm.

- Tabas mineral showing (cn219)

  Gold particles have been detected in the soil and in heavy minerals. The soils originate in the hornfelsized mudstone and andesite-diorite breccia that is the wall rock of the magnetite deposits.

The gold accompanying such porphyry copper and base metal-iron skarn deposits occurs widely in this area, but its economic value is considered to be low.

The following deposits and mineral showings are cited by that source as belonging to type 2): Paracale National, Paracale d'Oro Mine, Nico Mine, Exiban Mine (cn203, cn228) and Santa Rosa Sur (Tidi) (cn207), etc.

The common characteristics are the fact that they are all the metalliferous vein type of deposit and the fact that they are all amply accompanied by not only pyrite but also chalcopyrite, sphalerite, bornite, covelline and other base metal sulfide minerals. Furthermore, in many cases the fluid inclusion homogenization temperature has the comparatively high value of 250-270° C. Geologically they are distributed in the Universal formation of the Eocene epoch, and around them there is distribution of small rock bodies of diorite from the middle Miocene or dacite porphyry from the Pliocene. The main deposits are briefly discussed in the following.

The Paracale National deposit has two veins with a north-northeast strike as its main ore bodies, and its gold grade is 6-9 g/t Au. Its ore minerals are pyrite, chalcopyrite and sphalerite >>(?) bornite, chalcocite and covelline. The fluid inclusion homogenization temperature of the quartz vein is 255-270° C. Between the two veins there is a developed zone of illite-quartz-pyrite alteration which going eastward becomes a zone of epidote-chlorite alteration. There is accompaniment by skarn mineralization.

The Exiban deposit (cn203, cn228) is situated at the southwest end of the Sta. Elena-Tabas area. The wall rock is andesite, siltstone and tuff of the Bosigon formation dating back to the early Miocene which are intruded by diorite and dacite dikes. Recently boring data, too, as been given by James and Fuchs (1990). Mineralization is to be noted in veins with a north-northeast direction and in shear zones. The veins are massive to cockscomb quartz veins accompanied by calcite and dolomite. The gold is accompanied by pyrite. There is also up to 3% accompaniment by chalcopyrite and bismuth tellurides. In the deep part molybdenite is also to be observed. The cobalt content of the sulfides is 1000 ppm. James and Fuchs (1990) are of the opinion that the magmatic constituent contributed the most to such mineralization considering the combination of minerals and the fluid inclusion homogenization temperature, and they surmise that there is basic rock in the deep part from the fact that cobalt is included.

The Santa Rosa Sur (Tidi) deposit (cn207) is located 1 km east of the Paracale National Mine. In the eighties it was exploited by small operators. After a high-grade part was discovered, the company Benget started strip mining in 1988. Mineralization is to be seen in shear zones and at quartz stringers. From the direction of the old pit it can be seen that the vein direction has a strike in the direction of the east. There is a zone of developed silicification with a width of 2 m in the quartz-illite-pyrite alteration zone with a width of approximately 7 m. Pyrite veins are also to be observed. The fluid inclusion homogenization temperature of the pyrite has values of 210-260 ℃.

The Nalesbitan-Tuba Area

This area is situated near the provincial border between Camarines Norte and Quezon. In it are distributed the Macogon formation dating back to the Pliocene and, to the southwest of it, the Tigbinan formation, which is assigned to the late Cretaceous period. The United Nations (1987) says that before World War II there was extraction of gold and silver at the Tuba Mine located near Mt. Tuba in the Tigbinan formation, but there are no details concerning that in view of the fact that the existing literature does not mention it.

The Nalesbitan Mine (cn204) is discussed in detail by Sillitoe et al. (1990). Furthermore, a summary description of recently implemented exploration is given in "Mining Philippines '97" . The following is an outline description of the characteristics of the mine.

- Location: The mine is located on a ridge with an elevation of 100-300 m and running in the northwest direction at the upper reaches of the Palali, a tributary of the Bosigon River.
- Wall rock: The deposit lies in hornblende andesite and homogeneous lapilli tuff considered to belong to the Macogon formation dating back to the Pliocene epoch.
- Mineralization: The mineralization is restricted by a fault in the northwest direction (a left lateral fault). It is distributed over an elevation interval of approximately 150 m from 300 m to 150 m on a ridge top outcropping to the surface. The mineralization zone continues for 1.3 km in the direction of the strike, the width varying between 145 m and 12 m. Mineralization exists in two en echelon strips of hydrothermal rubble running in the northwest-southeast direction that are subject to chalcedonic silicification. Those silicified rubble strips broaden as the depth gets shallower, and it appears that they each converge arterically going down to deeper depths. Furthermore, a large number of chalcedonic quartz stringers are to be observed in the silicificated rubble strips as well as evidence of repeated occurrence of brecciation and vein activity. The mineralization strips have been subjected to oxidation by supergene to a depth of 130 m. At places where sulfide minerals remain gold occurs accompanied by sulfides that include copper of the rubble strip matrix and veins. However, it appears that there has been no copper or gold mineralization in the initial-stage chalcedonic quartz-pyrite strips. The most frequent combination of sulfide minerals is pyrite-chalcocite, and next come the combinations pyrite-bornite and pyrite-covelline. At some places there is occurrence of enargite with accompaniment of chalcocite and bornite. Gold and silver tellurides are to be observed as exsolution lamella of enargite. No galena or sphalerite are to be found.
- Homogenization temperature: According to the United Nations (1987), the homogenization temperature of the quartz is 210-240° C. Sillitoe et al. (1990) reported 223-225° C and estimated the depth of trapping of the fluid at 300-500 m

below the old groundwater level.

- Alteration: Silicification strips occur lenticularly with a northwest trend. That is roughly in the middle of the hydrothermal brecciation zone. They consist of chalcedonic silica and contain considerable quantities of pyrite dissemination. The silicification strips are surrounded by an advanced argillic zone. The combination quartz-kaolinite-alunite is predominant, with accompaniment of trace quantities of sericite and diaspore. An illite zone is distributed around the silicification zone and advanced argillic alteration zone. There are illite and smectite mixed-layer clays, further outward becoming the combination chlorite-calcite.

Sillitoe et al. (1990) asserted that this mineralization was formed in a "dilational jog" that occurred in the lateral fault system and surmised that the mechanism for precipitation of the gold was boiling. Furthermore, they suggested the possibility of existence of a porphyry type copper and gold deposit deep down in this area in view of the fact that there are more copper sulfides and a higher Mo content than in the case of other gold deposits of the acid-sulfate type.

The findings of the prospecting program recently implemented by El Dore Mining Corporation can be summarized as follows:

- A deposit with the high grade of 81 g/t Au was found at a point 300 m northeast of the strip mining (Mill site/Singko Zone). That mineralization strip can be pursued 250 m in the strike direction and has a maximum width of 25 m. It has roughly the same direction as the first open-pit deposit.
- High-grade ore was also found at Bagong Trese, Tres and Bagong Dose.
- An IP anomaly (700 m x 400 m) was found deep at Bagong Dose (about 800 m south of the open pit). Dissemination-type sulfide ore is surmised, and there are hopes regarding the possibility of a porphyry type deposit. The small quartz vein at the surface of Bagong Dose has a grade of 30 g/t Au.

3-2-2 Copper

Many copper deposits and mineral showings are distributed in Frost's (1959) above-mentioned "base metal belt" and the Paracale area in Camarines Norte. Furthermore, several copper mineral showings are to be found bunched together in eastern Sta. Elena in the west part of that province.

A famous copper deposit is the Larap deposit (cn14) in Camarines Norte. That deposit is one that used to be worked as the Larap iron mine, as will be discussed later in the section on iron. It occurs in the skarn formed by substitution of limestone in the Universal formation of the Paleocene epoch to Eocene epoch along with intrusion of the diorite to syenite porphyric porphyry of the middle Miocene epoch. In the deposit there are magnetite-pyrite strips, chalcopyrite-molybdenite strips and gold-quartz-calcite veins overlapping those strips. The ore reserves are reported (BMG, 1986) to consist of about 17 million t (Cu: 0.42%, Mo: 0.09%, Au: 3 g/t, Fe: 22%).

In addition, in the way of copper and molybdenum mineral showings considered to be porphyry type mineralization there are the Matanlang, Meycauayan and Igang mineral showings. The Matanlang mineral showing is situated about 1.5 km southeast of the Larap deposit. Middle Miocene quartz diorite has intruded into the Larap volcanic rock. There is also intrusion by dacitic porphyry dikes. Sillitoe and Gappe (1984) consider that there is porphyry type copper and molybdenum mineralization rich in gold. 65 million tons of ore reserves with a grade of 0.35% Cu, 0.05% Mo and 0.4 g/t Au are reported. The white quartz veins are accompanied by molybdenum, and the homogenization temperature is 300-360℃ (United Nations, 1987). The Meycauayan mineral showing is located about 4.5 km west-southwest of Batobalani. According to the United Nations (1987) surface survey, mineralized diorite intrudes into the andesite, and soil geochemical anomalies showed the following values: Cu 250 ppm, As 28 ppm, Te 0.5 ppm, Mo 63-208 ppm. Quartz stringer stockwork is developed in the quartz-sericite alteration zone. The mineralization is considered to be a porphyry type copper and molybdenum system with low gold grade. There is also distribution of acid alteration zones consisting of pyrophyllite, diaspore, quartz and alunite. The Igang mineral showing is situated about 7.5 km west of Batobalani. The Philippine Iron Mine carried out boring in 1974, confirming the following mineralization in the marbleized limestone and skarn zones: Cu 1.2% and Mo 0.05% (United Nations, 1987).

As mentioned above, on the south side of the Paracale area in Camarines Norte are to be found a large number of iron deposits and mineral showings, and in the case of many of them copper occurs in accompaniment with such iron mineralization. Those iron deposits are thought to be skarn type deposits, and therefore they are expected to be accompanied by copper. Of those, the main one is the Larap deposit, as mentioned above. Others include the Dawahan-Penarco mineral showing (cn237), the Capacuan deposit (cn17, cn238), the Batobalani mineral showing, the Submakin mineral showing (cn222), the Dagang mineral showing, the Agusan deposit (cn42), the Pinagbirayan deposit (cn220) and the Tagas mineral showing (cn45, cn219).

Chapter 4 Summary of Discussion

4-1 Airborne Geophysical Survey

The summary of the re-examination of the magnetic and radiometric data in comparison with the results of the field survey as follows.

Airborne Magnetics

Airborne magnetic anomalies within the study areas may have been caused by:

- Anomalously low or high original content of magnetite in the rocks,
- A secondary destruction of magnetite, and
- A Reversed Remanent Magnetization

The airborne data identified several "magnetic flat regions". A magnetic "flat region" is shown by a gentle gradient of the magnetic field. This "flat" magnetic signature can apply to both high and low magnetic anomalies. Topographic flat and destruction of magnetite cause reduction of the gradient of the magnetic field. The destruction of magnetite is primarily due to hydrothermal alteration within an epithermal system, although other processes such as weathering can play a part.

Based on field observations from the three project areas, most of the magnetic lows and magnetic flat regions are characterized by zones of hydrothermal alteration and/or landslide areas that expose some clay minerals.

Airborne Radiometrics

If hydrothermal alteration occurs at the surface, a high radiometric Potassium anomaly is likely to be developed. However, in the project areas, the radiometric Potassium anomalies are observed concentrated in areas with exposed rocks and /or float conglomeration, but not necessarily altered zones. The high potassium anomalies do not extend across ridges or flat topographic areas that have a thick soil or vegetation cover. We can therefore conclude that potassic alteration has either not occurred, or is masked by recent alluvial or colluvial deposits.

Based on field observations, the variation in the distribution of Thorium approximates to the distribution of different lithological units within the project areas. This could be due to the little difference of Thorium content between soil and rocks.

We can conclude that areas with low magnetic signature have a high potential to be the pathways for fluids. The low magnetic signature appears to develop due to demagnetization by hydrothermal fluids. We can also conclude that the interpretation of geology and hydrothermal alteration from magnetic and radiometric signatures is particularly useful where there is difficult access and poor exposure due to rugged topography and thick vegetation like the Bicol area.

4-2 Characteristics of geology and mineralization of the Bicol Area

Bicol area can be divided in three Belts, namely, the northeastern Belt, central Belt and southwestern Belt on the basis of the distribution of the geological formation. These three Belts can also be recognized in terms of the ore deposit formation Belt (Fig. II-3-5).

The Central Belt is defined as a zone in which Pliocene to recent volcanic rocks distributed in the central part of the Bicol Peninsula. Northeastern Belt and Southwestern Belts are the zones, not including the Central Belt, where Cretaceous basements including the ophiolite sequence is distributed with the intrusion of the Tertiary intrusives. In these Belts, the northeast part of the Bicol area is called the Northeastern Belt, and the area lying along southwest coast is called the Southwestern Belt. Of these Belts, the Southwestern Belt is covered with the Tertiary sedimentary rocks, so that its distribution area is intermittent and narrow.

In the Northeastern Belt, there are many ore deposits and mineral showings. The mineralization is mainly divided into three types as follows reflecting the geology. One is the mineralization related to ultramafic rocks. The second is the mineralization related to green schists and mica schists. And third is that related to Miocene intrusives. Of these, an important one is the hydrothermal deposit deriving from the activity of the magma during the Miocene in the Belt. The hydrothermal deposits consist of the porphyry copper type deposit, skarn type deposit and vein type deposit.

The vein type deposits have been considered as epithermal deposit (Mitchell and Leach, 1991). However the occurrences of the vein and alteration, the mineral assemblages, and the thermometric study of fluids inclusions indicate that the temperature and depth of the formation are higher and deeper than the typical epithermal deposits. Moreover the vein system occur within or close to the Miocene intrusives. Those data may show the most of the vein type deposits are "mesothermal" or sub-epithermal low sulfidation type deposits.

There are several known copper mineral showings in the Southwestern Belt. Gold is also accompanying the copper.

As far as these ore showings are concerned, however, it is difficult to identify the nature of the mineralization, since the scale is small, and the data based on sufficient survey are not available. Nevertheless, judging from that there is a distribution of diorite near the copper and gold prospects, there is the possibility that they can be so-called mesothermal vein type ore deposits associated with the intrusion.

The northwest end of the Central Belt has a distribution of Nalesbitan ore deposit, which is a epithermal high sulfidation type deposit. Further, the phase II survey has clarified that there is a distribution of the epithermal low sulfidation type mineralization in Kilbay area lying along the northwest end of the Central Belt. In western part of Bacon-Manito, Gate Mountains and northwestern part of Tiwi-Mt. Malinao area of the Central Belt, the feature of alteration suggest the existence of epithermal system. But geochemical analyses of the altered rock suggest no more than the potential presence of the gold and copper in terms of geochemical anomaly level.

Considering the relationship between the mineralization and geological structure, many of the mineral vein type ore deposits in the Northeastern Belt are controlled by NNE to NE-trending fracture system. Especially, in Paracale, Larap-Exiban and Bagacay areas, the mineral veins of the NNE-trending are predominant. Since these deposits are considered to have been formed in Miocene. The fracture system may be built in response to the tectonic events occurred during the Miocene. However, the nature of the fracture system could not be clarified through this survey.

On the other hand, in the Central Belt, more particularly, in the areas of Legazpi, Irosin and Tiwi, which have been covered by airborne geophysical survey, WNW-trending left-lateral fault and ENE-trending fault are predominant, though relatively small faults of NS system exist. The hydrothermal alteration zones distribute along these faults. In these three areas, the left-lateral WNW-trending faults are the oldest faults, and these faults suggest to have been the passages of the hydrothermal solution. The same result has been obtained through the lineament analysis by using the satellite image. Further, in the Nalesbitan deposit lying in the northwest end of the Central Belt, the dilational jog lying along the left-lateral WNW-trending fault is considered controlling the mineralization (Sillitoe, et al., 1990). Similarly, in the Kilbay area situated in the northwest end of the Central Belt, the faults and quartz veins of WNW to NW-trending and a number of quartz veins of NE to ENE-trending were observed. A WNW-trending topographical feature lying along the south side of Susungdalaga Mountains suggest the existence of faults, and these faults seem to control a distribution of hydrothermal alteration zone. A dilational zone is considered to develop along these left-lateral WNW-trending faults, and such geological structure is considered to be a promising area for the formation of ore deposit.

4-3 Geochemical features of the three belts and each of the areas

In order to delineate the geochemical characteristics of the three belts and each area in which field survey was conducted, the features of the distribution of chemical analyses values were examinted.

The Northeastern Belt has provided the samples showing highest contents of those elements discussed above, namely, Au, Ag, Bi, Cu, Co, Cr, Ni, Pb and Zn. In various areas of the Central Belt, samples, almost equal in number, were collected and so it is possible to compare the areas where the samples were collected. Kilbay area of the Central Belt has provided the samples having the highest concentrations of Au, Ag, As, Cu, Ni, Pb and Sb. The Southwestern Belt have provided the samples showing relatively high contents of As, Bi, Cr, Cu and Ni, this tendency is rather similar to that of the Northeastern Belt. The above geochemical features of the three belts may reflect the style of mineralization and geology distributed in the belts. In other words, it may reflect the erosion level of the belts. The geochemical feature of each area is summarized up in Table II-3-1.

4-4 Selection of Promising areas

The summarized process of selecting promising areas based on the result of the 2-year survey is shown in the flowchart given in the front page of this report.

In selecting promising areas, the importance is attached to the two factors, namely, the mineralization potential and the condition of existing mine claim.

The mineralization potential was evaluated in consideration of the geological features, occurrence of mineralization and alteration, and the analytic data. In actual evaluation, high marks are given when the presence of ore deposit can be expected with reference to the magma-hydrothermal conception model (Fig. II-2-18 and Fig. II-2-19) even in the cases where the deposit itself had not been detected, or where the ore deposit was not exposed on the ground surface.

Concerning the condition of the existing mine claims, the areas where no mine claim was established are put higher priority. If the mining claim are already applied for the areas, MPSA application area got higher priority than FTAA. In the cases of the FTAA, relatively low priorities were given even when the deposit potentiality is high.

As the result, three areas, namely, Kilbay area, Mt. Bagacay area and Larap-Exiban area, have been chosen as the areas with high potential for mineralization. Of these areas, Kilbay area and its vicinity are not only found to have the highest potential for the epithermal gold deposit but also have least mine claims and exploration projects under way, and so this area is concluded to be the most promising area for starting new exploration project.
The latter two areas are given lower priority due to the reasons that many mine claims have already been established, and that many exploration activities have been carried out in these areas.

Chapter 5 Conclusion and Proposals

5-1 Conclusion

The Bicol area can be divided into the following three zones by its geology, the age, distribution, and occurrence of mineralization and alteration. These zones can be recognized as metallogenic belt.

Northeastern Belt
Central Belt
Southwestern Belt

As a result of this survey in the Bicol area, the following three areas were selected as high potential area for mineralization.

Kilbay area
Mt. Bagacay area
Larap-Exiban area

If the Bicol area is divided into three metallogenic provinces, the Kilbay area is situated in the Central Belt and has a high potential for the existence of an epithermal gold deposit. In addition, mine claims are seldom established and exploration activities are rarely performed in these areas. Therefore, the Kilbay area and its surroundings are considered to be the most promising as a new exploration project area.

Among the metallogenic provinces, the Mt. Bagacay area and Larap-Exiban area are situated in the Northeastern Belt, and are selected as a high potential area for the existence of a porphyry-type gold and copper deposit, skarn-type ore deposit, and sub-epithermal vein-type ore deposit. Considering many applications for a mine claim (MPSA) are made in the Mt. Bagacay area and Larap-Exiban area and these areas have been explored for a long time, priority is given to the Kilbay area.

However, because the surface of the earth is covered with vegetation, little rock is exposed. The depths have not been surveyed much for a porphyry-type ore deposit. Therefore, it is conceivable that there is still room for exploration.

5-2 Proposals for future exploration project

As mentioned in the section "Selection of promising area" in Part II Chapter 3, the Kilbay area was selected as a promising area. When considering a new exploration project, it is advisable to explore not only the range of survey in Phase II but an area expanded to the northwest shown in Fig. III-2-1 (we call it "Kilbay – Nalesbitan – Tuba area" in this Chapter). The reasons are given below.

Firstly, the central position of the hydrothermal system in the Kilbay area surveyed in Phase II area has not been located yet. It was made clear that a hydrothermal alteration zone accompanied by gold mineralization is also distributed on the north of the Susungdalaga Mountain. It will be possible to clarify the center of the hydrothermal activity by discovering the extension.

Secondly, the Nalesbitan ore deposit is distributed approximately 10 km north of the Kilbay area. This is the only gold deposit discovered so far in the Central Belt. This gold deposit is an epithermal deposit of the high-sulfidation system. A mineralization occurs in the "dilational jog" in the WNW-ESE direction (Sillitoe et al., 1990). Therefore, a hydrothermal ore deposit may exist along a fault in this NW-SE direction. The SE extension of this Nalesbitan trend may extend to the north of the Susungdalaga Mountain or the vicinity of the catchment basin of the Labo River.

Recently it has been made clear that the Lepanto gold deposit and the Far South East (FSE) porphyry-type gold and copper deposit are formed simultaneously in the same magma-hydrothermal system (Arribas et al, 1995; Hedenquist et al., 1998). They are controlled by the Lepanto fault of the NE-SW system. As Sillitoe et al. (1990) pointed out, a porphyry-type ore deposit may exist in the depths on the extension of the Nalesbitan trend on the analogy of the Lepanto-FSE ore deposit. In addition, the Victoria ore deposit, an epithermal low sulfidation gold deposit, has been recently discovered near the Lepanto-FSE ore deposit. A gold deposit of the low sulfidation system similar to the Victoria ore deposit might exist in the Kilbay area.

Thirdly, hot springs as high as 80℃ rise even now in the Kilbay-Alawihaw creek, among the Kilbay area surveyed in Phase II. These hot springs have relatively high silica and salt concentrations. This fact suggests that deep hydrothermal solution may rise and hydrothermal solution as high as approximately 150℃ may exist in the depths. Consequently, it is not convenient to explore a gold deposit near the Kilbay-Alawihaw creek because of high temperatures. It is advisable to explore other places, where the area expanded to northwest, with lower underground temperatures.

Fourthly, a gold deposit of a vein-type is distributed in the Tuba area. From its geological setting, it is estimated that this gold deposit has an origin and a formation age similar to those of vein type gold deposits distributed in the Paracale area.

It is advisable to cover this area first by the airborne geophysical survey. As described in Part II Chapter 3, it is because the detailed analysis of magnetic and radiometric responses is very effective to know the lithological distribution, geological structure, and distribution of alteration zones. In particular, in a place such as the Bicol area that is covered with thick vegetation and cannot be surveyed satisfactorily due to its hard accessibility and security problem, the airborne geophysical survey is a very effective method. Then a detailed field survey is required.

The present survey made it clear that a "dilational zone" caused by a left lateral WNW-trending fault system and a ENE-NE-trending fault system intersecting diagonally with that is promising as a passage of hydrothermal solution. Therefore, it is necessary to discover a possible area where such a "dilational zone" develops by the airborne geophysical survey and to make field survey around this zone. From their K-Ar age, since it is judged that Susungdalaga volcanic rocks were formed in the Gilbert chron, volcanic rock corresponding to the reverse geomagnetic polarity epoch of this period may exist. The magnetic data needs to be carefully analyzed.

The following areas could be the candidate areas for a further exploration project in the Bicol Region, although the priorities are lower than the above-mentioned area. Those areas are also shown in Fig. III-2-1.

Larap – Mt. Bagacay
Gate Mountains
Northwestern part of Tiwi – Mt. Malinao
Caramoan Peninsula

The Larap – Mt. Bagacay area includes the Larap – Exiban area and the Mt. Bagacay area, which are surveyed in Phase II. Though many MPSA covered this area and the area has been explored for long time. However, This area may still have high potential for porphyry type Cu – Au deposits, vein type gold – base metal deposits, and placer gold deposits which may be secondary deposits of the former two deposits.

This Survey shows the extension distribution of hydrothermal alteration zone in the Gate Mountains and the Northwestern part of Tiwi – Mt. Malinao area for the first time. The Survey does not show high potential for the gold mineralization in the both areas. However, we can expect more extension of the hydrothermal alteration zone in the both areas. In that sense, there may be room for further exploration in the both areas.

In Gate Mountains area, there is no drilling data near the area. That is one of the reasons why we could not evaluate the potential of the deeper part of the hydrothermal alteration zone convincingly. We can expect much more extension of hydrothermal alteration zone along the WNW-trending fracture. In order to check the potential of the deeper part of the hydrothermal alteration zone, we recommend a drilling survey at a deeper part of the WNW-trending fractures.

We found the quartz vein within sericite/smectite mixed clay zone in the Northwestern part of Tiwi – Mt. Malinao area. We evaluate the potential for the gold mineralization in the deeper part of the alteration zone, because those quartz veins do not have any gold mineralization. However, we also found out the extensive steam-heated acid alteration zone in the northeastern part of the area. Underneath of the acid alteration area may have room for further exploration.

In Caramoan Peninsula, the field survey of Phase I was conducted in the Siruma Peninsula and Tamban – Olas area in the western part of the Caramoan Peninsula. Phase II field survey was conducted in eastern part of the Caramoan Peninsula. Though we do not have enough data to evaluate the potential of the Caramoan Peninsula, this area may have higher potential from the following point of view.

The Tertiary intrusives are distributed in the ophiolite sequence in western part of the Caramoan Peninsula. In this geological setting, there is a possibility that volcanogenic massive sulfides related to the ophiolite sequence exist and the Tertiary intrusives could re-distribute and re-concentrate the mineralization. In particular, the geological settings of Tamban – Olas area is similar that of the Paracale district. Tamban – Olas area may have potential for the same type of gold deposit in the Paracale district. As a whole, gold and copper showings accompanied with green schist and mica schist are distributed in the Caramoan Peninsula. In part, gold and copper mineralization occurred in the shear zone of the schists. We might expect the shear zone hosted mesothermal lode type deposit in the area. However, the area is covered by the application of FTAA as a whole.

PART II

Chapter 1 Airborne Geophysical Survey

1-1 Objectives

The prime objective of this study has been to produce a detailed geological map from a combination of airborne magnetic and radiometric data, Panchromatic SPOT imagery and geological data provided by JMEC (JMEC report, 1998). A solid geological interpretation map that shows the structure and possible zones of alteration has been produced, at the scale of 1:50,000.

1-2 Survey Area

The following areas were selected on the basis of the results of analysis of existing data, analysis of satellite images and the ground truth survey for airborne geophysical (magnetic and radiometric measurement) survey (Fig. I-1-2).

1) Legazpi Area (Western part of Bacon－Manito area)*
2) Irosin Area (Gate Mountains area)
3) Tiwi Area (Northwestern part of Tiwi-Mt. Malinao area)
* ( ) the name of the field survey area

The latitudes and longitudes of four corners of each rectangular areas are shown as follows;

1) N13° 33':E123° 40'-N13° 26':E123° 40'-N13° 26':E123° 30'-N13° 33':E123° 30'
2) N13° 10':E123° 56'-N13° 00':E123° 56'-N13° 00':E123° 49'-N13° 10':E123° 49'
3) N12° 45':E124° 10'-N12° 30':E124° 10'-N12° 30':E123° 56'-N12° 45':E123° 56'

The sea area is excluded from those areas.

[Reasons for Selection]

Three areas were selected on the basis of the following selection criteria from among the areas extracted as promising areas in the Phase I field survey:

a. Priority to areas with possibility of existence of epithermal gold ore deposits.
b. Priority to areas for which FTAA has not been set up as mining rights.

From the viewpoint of potential regarding ore deposit endowment, the areas around the existing ore deposits in the Camarines Norte is also promising, but those areas were not selected as not meeting the above selection criteria.

Each areas were decided on the basis of the following view points:

(1) Legazpi Area

- The ground truth survey showed wide distribution of the alteration zone, which indicates the shallow parts of the epithermal system, and it is possible that epithermal gold ore deposits exist in deeper parts.
- At the east part of this area, there is an active geothermal system. The alteration zone is distributed in the somewhat old volcanic rock zone to the west part of this area. It is possible that the hydrothermal fluid in the western side of this area used the same trending fractures as the present reservoir. It will be possible to narrow down the promising area if it is possible to analyze those fractures in airborne magnetic survey.
- The east side of the Bacon-Manito area was excluded from the airborne magnetic survey area. That is because the volcanic rock distributed in this area is too young to form hydrothermal ore deposits. They are very deep even if they have been formed.
- In the satellite image analysis there is dense concentration of crossing of NS trending and EW trending lineaments.

(2) Irosin Area

- In this area Pliocene to Pleistocene volcanic rock is distributed. The ground truth survey made it clear that the alteration zone of the shallow parts of the epithermal system is distributed in it.
- Satellite image analysis shows dense concentration of crossing of NE trending and NW trending lineaments as well as NS trending lineaments. The ground truth survey have also made it clear that there is distribution of a comparatively wide alteration zone along the NW trending lineaments, and it is considered that airborne magnetic survey will make it possible to further clarify the relationship between the fracture system and the alteration zone.
- This areas is larger than the others, but access is poor, and there is little existing data on it. It is therefore considered that a more efficient survey will be possible starting next year thanks to increase of the quantity of data by means of airborne magnetic survey.

(3) Tiwi Area

- The northwest side of Mt. Malinao has undergone considerable topographical dissection and is older than Mt. Malino. Assuming that hydrothermal ore deposits exist, it is possible that they will be found at more shallow places than Mt. Malinao area.

- In the ground truth survey, a lot of silicified rock and quartz vein floats were noted on the east shore of Lake Buhi, which suggests wide distribution of a epithermal alteration zone in this area and points to the possibility of the existence of epithermal ore deposits.
- In satellite image analysis, the density of lineaments is high and NE trending and NW trending lineaments are crossed in this area.
- From the fact that low-sulfidation style mineralization has been confirmed in geothermal drilling in the Tiwi active geothermal system, there is a possibility of existence of ore deposits of the same kind in this area.
- Because of poor access in the ground truth survey and the lack of existing data, it was not possible to adequately determine the distribution of the alteration zone. We expect that the airborne magnetic survey could give us more information for further exploration.
- The anomaly map of the regional airborne magnetic survey carried out by the World Bank (flight line intervals of about 2 km; data that has not undergone polar magnetic conversion), shows some small magnetic anomalies in this area. And the detailed airborne magnetic survey could elucidate the extent of the alteration zone or geothermal system.

1-3 Survey Specifications

Flight line spacing : 200m
Flight line direction : North-South
Tie line spacing : 1,000m
Tie line direction : East-West
Sensor height : 80m
Magnetometer sample interval : ～5m
Magnetometer cycle rate : 0.1 seconds
Magnetometer resolution : 0.001 nT
Radiometric sample interval : ～50m
Radiometric cycle rate : 1 second
GPS cycle rate : 1 second

Data Acquisition Company

World Geoscience Co. Ltd.(WGC) was chosen to acquire airborne geophysical data. Airspan company was also chosen to fly a helicopter for this.

1-4 Data set for interpretation

Hard copy contour maps prepared from the processed data sets are displayed with UTM grids, using the WGS 84 spheroid in Zone 51, with additional longitude/latitude graticules projected into the Clarke 1866 spheroid, Zone 51, central meridian 123°. The images used in this airborne geophysical study have been interpreted primarily at the scale of 1:50,000, although use of WGC's computer digitising system has allowed for more detailed interpretation and data capture. A typical range of images that have been used in this study include:

1) *Colour and Grey-scale Total Magnetic Intensity (TMI), Reduced to Pole (RTP) images* (Appendix 1). This imagery shows a direct measurement of the earth's magnetic field and is used mainly for identifying high amplitude magnetic features, from near surface to depths of several hundred meters. A transformation by "reduction to pole" has been applied in order to center magnetic features over the true ground position of their source.
2) *Colour and Grey-scale First Vertical Derivative (1VD) of TMI, RTP images* (Appendix 2). This type of imagery displays the highest frequency anomalies and is useful in structural mapping, with particular reference to defining faults and lineaments in conjunction with near surface litho-magnetic boundaries.
3) *Pseudo Depth Slicing Image (PDS)* (Appendix 3). This is a frequency-domain filtering technique, that is applied to total magnetic intensity or reduced-to-the pole magnetic grids to produce a series of grids highlighting different frequency ranges in the data. Problem arise with the pseudo depth slicing method when the materials at shallow depths have a high magnetic susceptibility. This can effectively hide or overpower the low amplitude magnetic fields of deeper bodies. Often, interpretation of the bulk structure of an area can be assisted by using the second and third pseudo depth slices to generalize the magnetic texture.
4) *Colour Digital Terrain Model (DTM)* (Appendix 4). The image is produced from calculating the difference between the GPS height information and the radar altimeter data recorded by the helicopter. The topographic image is spatially accurate as it is geo-rectified using the aircraft positioning system. Resolution of imagery is approximately 25m. The image provides high resolution topographic information and is effective in showing subtle highs and lows in the landscape, as well as positions of faults.
5) *Ternary Radiometric Images (potassium - red; thorium - green; uranium - blue)*

(Appendix 5). High values of individual channels show as that colour (eg. green for thorium). Co-incident values in more than one channel combine to show as, thorium/potassium - yellow, thorium/uranium - cyan, potassium/uranium – magenta, all three - white. This imagery provides information on the characteristics and composition of surface deposits. It may distinguish areas of alteration and define lithological boundaries. However, it is subject to subtle changes due to regolith cover and weathering profiles.

6) *Clipped Potassium radiometric images* (Appendix 5) *and Radiometric Potassium, Thorium, and Uranium Counts* (Appendix 6). Clipped potassium radiometric image displaying the uppermost 5%, 10%, 15%, 20%, 30% and 45% of the radiometric count, therefore enhancing the most intense anomalies and deleting much of the background noise.

7) *Spot images* (Appendix 7)

Panchromatic SPOT data was purchased by WGC over the Irosin Project area. The Panchromatic SPOT scene was rectified using Philippine topographic sheets at the scale of 1:50,000. The image was produced as a photographic hardcopy print at the scale of 1:50,000 and as part of a mosaic at the scale of 1:250,000. The imagery was also provided in a digital format. The UTM grids on the images were generated by using a UTM projection WGS 84, Zone 51 and the Longitude/ Latitude grid used the Clarke 1866 spheroid.

The Panchromatic SPOT image used in this study are shown in Appendix 7. The imagery has a standard pixel size that enables a resolution of approximately 10m. These grey-scale Panchromatic images highlight significant tonal and textural changes that indicate variations in lithology and structure of outcropping or sub-cropping rocks (see Appendix 7).

1-5 Methodology

Method of interpretation is the same for the three areas.

The interpretation technique is aimed at visualisation of structures and identification of anomalous features in the data that may be mineralised. The following components are identified from the airborne geophysical data to develop a litho-structural framework.

- Structural information such as the identification of magnetic linear trends, eg bedding/ volcanic layering and the subsequent truncations and offsets of these trends which may indicate, faults and fractures. This trend data permits structural visualisation by the interpreter, whereby macroscopic structures such as folds may be identified. Recognition of normal, strike-slip or thrust faults in airborne geophysical data is often possible through recognition of associated structures and analysis of overall geometry of a survey area.

- Magnetic and radiometric units which comprise geological bodies with uniform or characteristic magnetisation or radiometric signature. These units may or may not coincide precisely with rock units that outcrop, as magnetic volcanic flows may be overlapped by successive non-magnetic volcanic flows.
- Discrete sub-circular magnetic highs believed to reflect intrusive plugs.
- Broad areas of increased magnetic response, especially if supported by pseudo-depth slice data and Euler depth solutions, which may be caused by an intrusive body at depth (possibly indicating a volcanic centre).
- Sub-circular features, often having subdued magnetic response that may correlate to volcanic centres.
- Broad areas of demagnetisation which may represent extensive areas of magnetite destructive alteration.
- Intense sub-circular magnetic lows which may be intrusive bodies.

The next stage of interpretation involves identifying areas with anomalously high radiometric Potassium values as these areas may represent zones of possible alteration. Outcrop data from published geological and/or field maps are compared to the airborne geophysical interpretation and lithological rock units assigned to areas of different magnetic response. Although in some areas the magnetic data correlate well with the published mapping at 1:50,000 scale, it was difficult to get an overall consistency. In many areas the information obtained from the airborne magnetic data differs considerably from the radiometric and Panchromatic SPOT data and the mapped geology, as these data sets depict the surface geology while the airborne magnetic data is mapping any magnetic body below the helicopter. This data was then combined with the Panchromatic SPOT imagery to refine these features. For example, faults and fractures can be positioned with more accuracy on the Panchromatic SPOT imagery.

The procedure followed for the effective interpretation of the litho-structure from the Panchromatic SPOT imagery involves building the map from successive layers of data. The following procedure was adopted to obtain maximum information from the image:

- ❖ Adequate drainage was marked to allow geographical correlation with published 1:50,000 scale geological maps.
- ❖ Annotation of bedding and/ or foliation traces of marker horizons and major bedding

surfaces (primary surfaces) and their dip and strike, taking care to accurately follow curvatures and dislocations in the trends. This allows lithological subdivisions and boundaries to be determined and emphasise the regional structure.

- As the primary units are identified, fault and/or fracture trends that truncate or displace these units, or abrupt changes in the attitude of bedding or foliation traces or prominent changes in topography are annotated. Lithological boundaries are interpreted on the basis of colour, vegetation, texture and geomorphology characteristics. Secondary bedding/ foliation surfaces are also annotated in sufficient quantity to emphasise the regional structure and provide representative impression of the level of stratigraphic layering.
- Fold axial traces were interpreted from bedding and foliation trends and attitudes.
- Fault/ fracture/ lineament trends are added to produce a representative impression of structural complexity and show characteristic differences between units.
- After producing the factual interpretation map the data is combined with the factual airborne geophysical interpretation. Lithological boundaries and structures that may have been obscured on the original Panchromatic SPOT data can now be extrapolated using the airborne geophysical data. Due to the structural and lithological picture now available, it is possible to produce a more informed interpretation of the tectonics active in the area. It is usually at this stage that the movement direction of a "factual" major tectonic lineament can be resolved, eg thrust, normal fault etc.

Initial interpretation maps were checked against the available published geological maps and field data provided by the JMEC, prior to compiling a preliminary legend. Corrections to the maps can be made to the digital data sets. Final interpretation maps are produced as hard copy colour paper prints of all digital data and then finally laminated. Final edition maps have now been produced.

1-6 Results of Interpretation : Legazpi area

The interpretation maps produced during this study show the subdivision of the magnetic responses into various magnetic packages. These packages were then classified into probable lithology types based on the mapped geology and/or interpretation of the Panchromatic SPOT imagery and radiometric data (Fig. II-1-1).

Note that the naming of these units is based largely on a PNOC map and report (PNOC pers comm). There has been no field reconnaisance to verify the interpretation by World Geoscience Corporation during this study.

1) Increased Potassium Response

In order to identify areas of increased potassium response it is generally best to look initially at the Total Count Potassium image or contour map (Appendix 6). It can also be interpreted on the Ternary Radiometric images and contours as areas of enriched Potassium appears as either a strong red colouration or white (see Appendix 5). However, although a white colouration is usually perceived as a high concentration of all three (Potassium: Thorium: Uranium) radiometric elements it can also simply represent equal proportions of these elements.

Mapping of hydrothermal alteration is considered an important component of the airborne geophysical survey. Mineralised areas in the Legaspi Project area are often associated with argillic (alunite-kaolinite-adularia) alteration. Alunite is a hydrothermal alteration product that contains potassium. It may therefore be that potassium data appears to map this alteration and is probably mapping hydrothermal fluid activity elsewhere in the area. Areas of high or increased Potassium response were therefore outlined from the contoured data and are shown on the interpretation maps (Fig. II-1-2).

Areas of particular interest are generally those that are associated with faults and fractures (Fig. II-1-2). The distribution of increased Potassium response is primarily scattered and discontinuous. However, there is a broad WNW-ESE trend through the centre of the area, probably following the major strike-slip structure. A lesser distribution of Potassium anomalies is also observed through the southern part of the area, in this region the anomalies appear to follow the secondary structural NE-SW trend (Fig. II-1-2).

However, the more scattered, mottled, broad distribution of apparently equal high values of Potassium: Thorium: Uranium may suggest that the anomalies are related to a distribution of a distinct lithology rather that structurally controlled alteration (see Appendix 5: Radiometric Ternary, Legazpi area). Combining the radiometric Potassium count with the 1st Vertical Derivative image (Appendix 2) shows that the Potassium high zones correspond with the regional structures but do not match consistently with a single magnetic signature (Fig. II-1-2). This supports the assumption that the high signature is related to alteration and not simply representative of a high radiometric signature from a non-magnetic lithology.

2) Zones of Demagnetisation

Extensive areas of reduced magnetic response are evident from the airborne geophysical data (Fig. II-1-2). Several causes are proposed:

- Narrow linear zones are evident in a number of locations across the study area coincident with interpreted faults. The major anomalous zone trends WNW-ESE across the centre of the project area (eg. 1444000mN, 595000mE). It is possible that movement of hydrothermal fluids along the structures have caused demagnetisation of the surrounding volcanic rocks.

- The generally narrow but continuous zones with low magnetic signature across the centre of the project area, become much broader where the WNW-ESE trending faults are intersected by faults trending approximately NE-SW (e.g. 144400mN, 594800mE; 1444500mN, 600000mE).

These areas have the potential to have been pathways for fluid movement and appear to have been subject to demagnetisation by hydrothermal fluids. In order to resolve some of the ambiguity and categorise the different areas with low magnetic signatures, field-checks are required. It may be possible to determine several different causes for a similar magnetic response. If this proves to be the case then a review of the interpretation may have to be made using the new field criteria as a guide. However, overall the potential for mineralised zones within the study area is evident. Field checks should initially be restricted to areas where areas of magnetic low and faults are in close proximity.

3) Structures and Intrusive Bodies

Probably the two main results of this study are the recognition of a coherent structural data set and the identification of a number of possible intrusive bodies (Fig. II-1-3). From the Panchromatic SPOT image and airborne geophysical data, it can be seen that the study area is extensively faulted and fractured. By reviewing the available data it has been possible to determine a series of major regional and more localised left-lateral strike-slip related structures.

From the Panchromatic SPOT image (Appendix 7) and Digital Terrain Model (DTM)(Appendix 4), numerous linear features can be seen. These linear structures usually follow unusually straight segments of drainage. Comparison with published maps (see JMEC report 1998) show that some of these drainage courses are faulted and brecciated. Many of these Panchromatic SPOT /DTM linear trends also coincide with displacement or truncations of magnetic horizons.

The differentiation of structures into categories of major or minor is loosely based on the affect the structures have on the data sets. If they affect features on all the data sets they are usually regarded as major, if they only effect one of the data sets they are usually regarded as minor.

Geophysical images such as the 1st Vertical Derivative (Appendix 2) contain an abundant amount of structural data. However, to develop an initial simple structural framework an interpretation of pseudo-depth slices was made (Appendix 3).

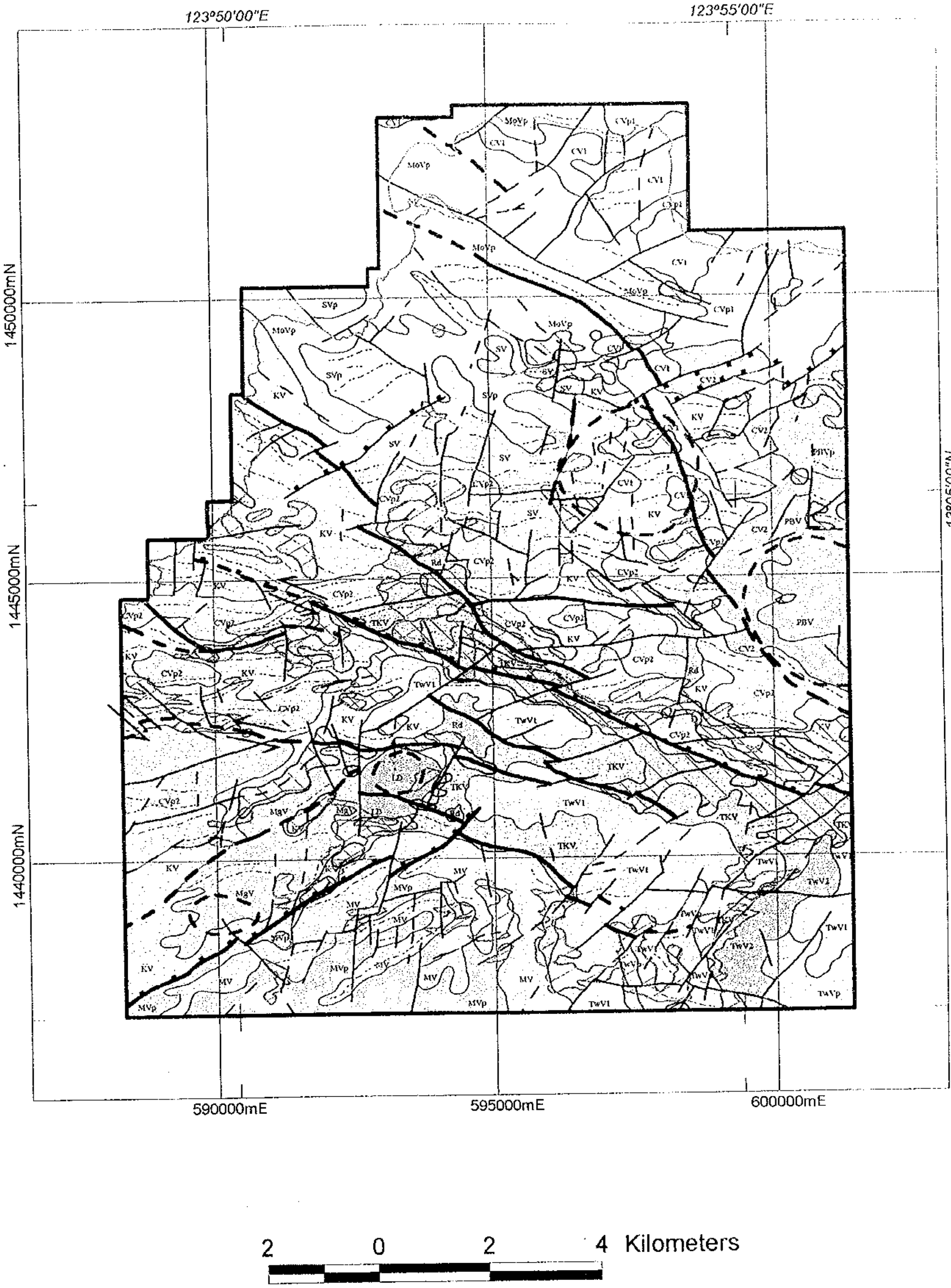


Fig. II-1-1 : Legaspi Project Area - Philippines. Geological Interpretation of Airborne Magnetic and Radiometric data, and Panchromatic SPOT Imagery. Legends on following pages.

Legend

Coastline

Project Boundary

STRUCTURAL SYMBOLS

Lithological boundary

Linear magnetic trends

Major Fault - Confident, Inferred

Minor Fault - Confident, Inferred

Sense of lateral movement along fault

Sense of normal displacement on fault

Circular Structure, possible volcanic vent or intrusion

MAGNETIC SYMBOLS

Zone of reduced magnetic signature, may correspond to areas of demagnetisation of volcanic rocks due to hydrothermal alteration.

RADIOMETRIC SYMBOLS

Areas of increased potassium signature, may correspond to areas of alunite - kaolin alteration

Rd	Low magnetic signature and flat texture. Possibly coincident with accumulations of Recent alluvium.
PBVp	Low magnetic signature with weak, semi-continuous linear texture. Possibly coincident with Palayan-Bayan volcanics (pyroclastics).
PBV	Moderate to high magnetic signature with broad-wavelength, linear texture. Possibly coincident with Palayan-Bayan volcanics (lavas).
CVp2	Moderate to high magnetic signature with a broad-wavelength, apparently flat-lying texture. High total radiometric count. Possibly coincident with Young Cawayan volcanics (pyroclastics).
CV2	Low to moderate magnetic signature and broad wavelength, possible flat-lying texture. Low total radiometric count. Possibly coincident with Young Cawayan volcanics (lavas).
CVp1	Low magnetic signature and weak, chaotic, undulating, rounded texture. Possibly coincident with Old Cawayan volcanics (pyroclastics).
CV1	Moderate magnetic signature and broad-wavelength, apparently flat-lying texture. Low to moderate total radiometric count. Possibly coincident with Old Cawayan volcanics (lavas).
TwV2	High magnetic signature with broad wavelength, flat-lying texture. May simply represent thick accumulations of TwV1 or may be a distinct volcanic Unit. Possibly coincides with the Tanawon volcanics (young lavas).
TwVp	Low to moderate magnetic signature with an undulating, rounded texture. Possibly coincides with Tanawon volcanics (pyroclastics).
TwV1	Moderate to high magnetic signature with chaotic, undulating, broad-wavelength, possibly flat-lying texture. May coincide with the Tanawon volcanics (old lavas).

KV	Very low to moderate magnetic signature and flat texture. possibly coincides with Kayabon volcanics (lavas and pyroclastics).
TKV	Very low to moderate magnetic signature and undulating rounded texture. Possible zone of demagnetisatio caused by hydrothermal alteration. Possibly coincides with the Tikolob volcanics.
SVp	Low to moderate magnetic signature and strong linear fabric. Possibly coincides with Sagpon volcanics (tuff breccias).
SV	Moderate to high magnetic signature and strong linear fabric. Possibly just thick accumulations of SVp. May coincide with Sagpon volcanics (lavas).
MgV	High magnetic signature and broad-wavelength, sub-linear fabric. Possible coherent lava flow. Very high total radiometric count. May coincide with Magaho volcanics (lavas and pyroclastics)..
LD	High magnetic signature and broad-wavelength, flat-lying, possibly sub-circular texture. May be coincider with the Lison Dome.
MVp	Low to moderate magnetic signature and weak linear texture. May coincide with the Malobago volcanics (pyroclastics).
MV	High magnetic signature and strong, broad-wavelength, sub-linear fabric. May coincide with the Malobag volcanics (lavas).
MoVp	Low to moderate magnetic signature and flat-lying, very broad-wavelength texture. possibly coincides with Manitohan Volcanics.

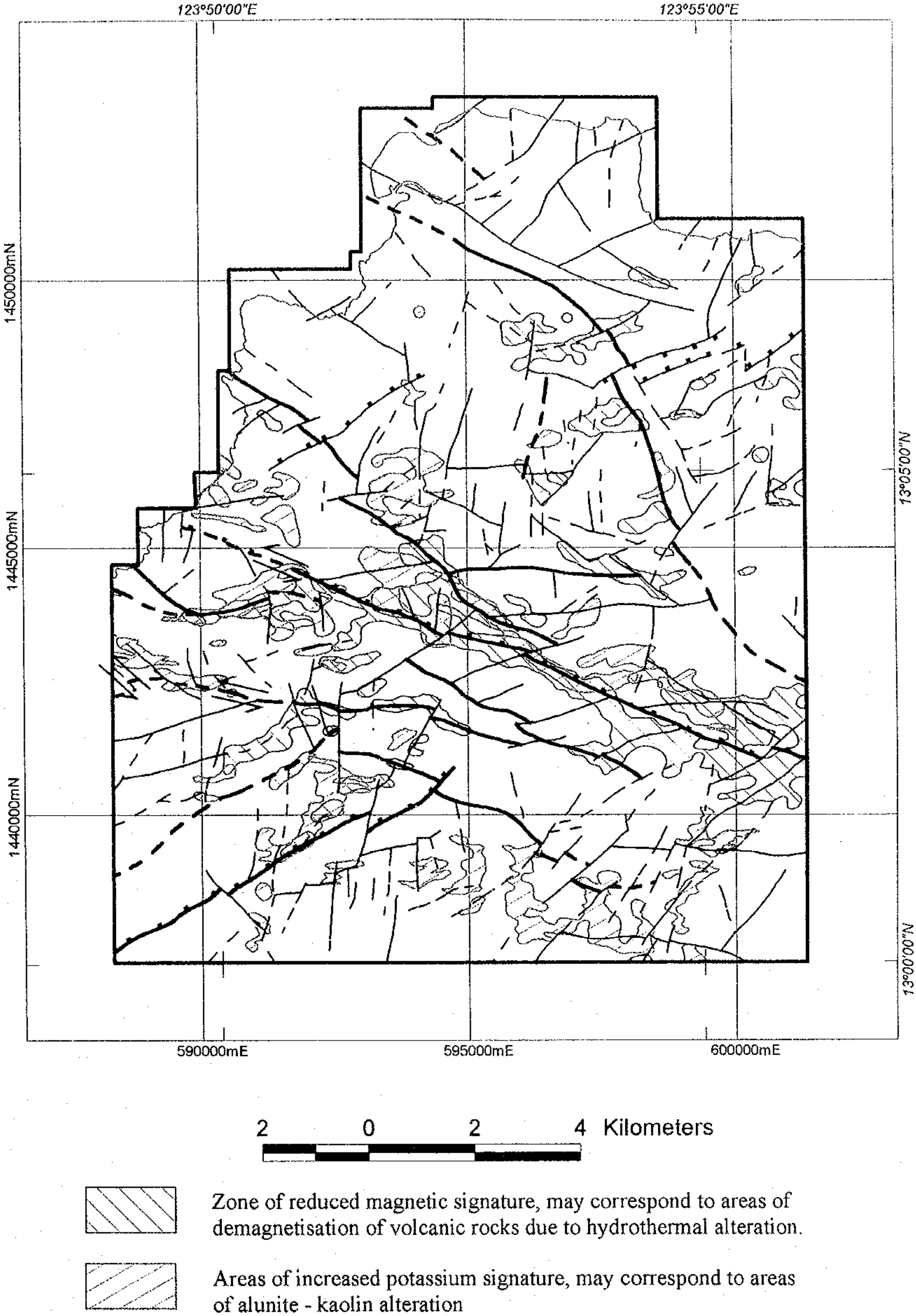
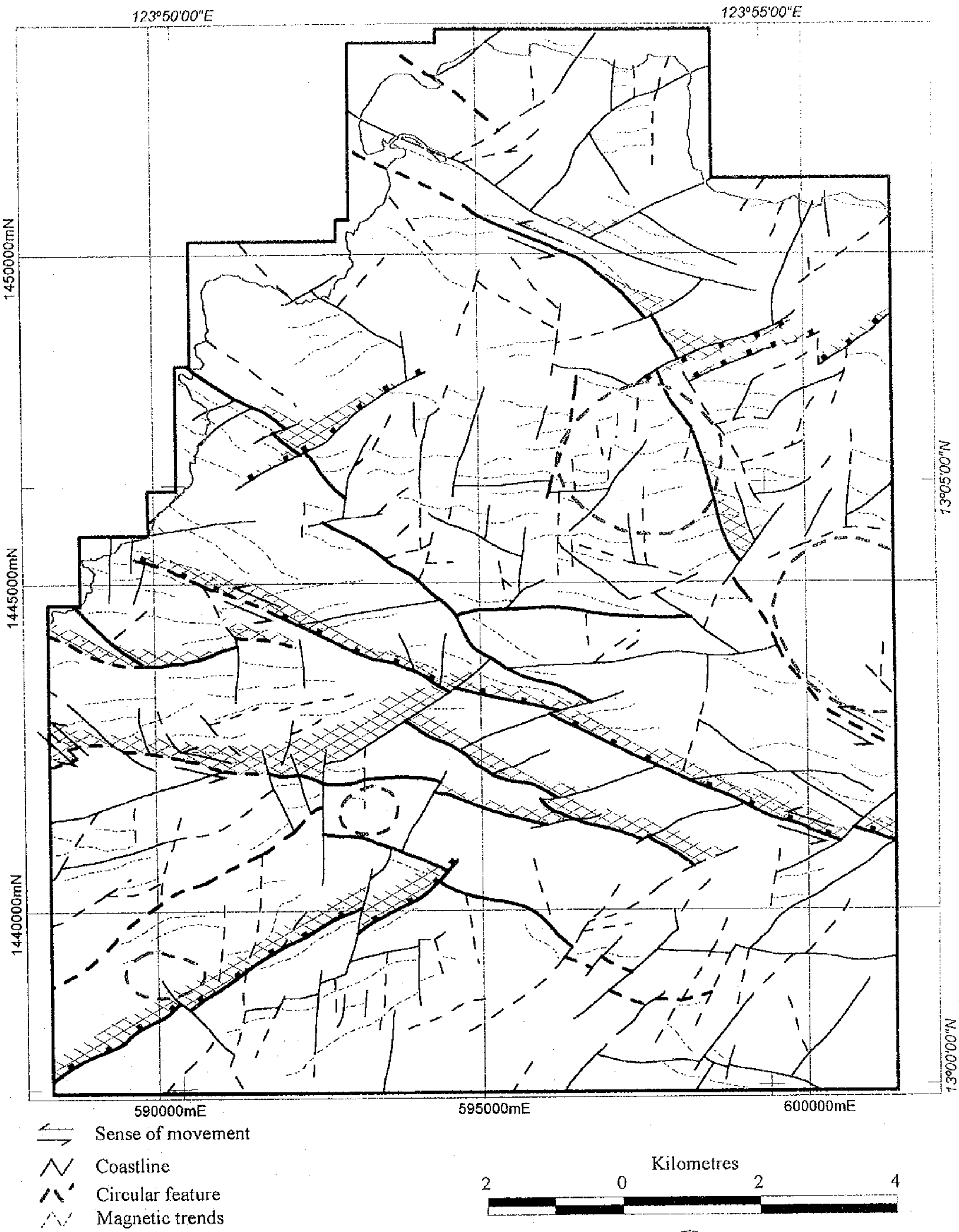


Fig. II-1-2 : Legaspi Project Area - Philippines. Magnetic lows and Potassium highs combined with faults from aeromagnetic interpretation.



Sense of movement
Coastline
Circular feature
Magnetic trends
Major Fault - Confident
Major Fault - Inferred
Minor Fault - Confident
Minor Fault - Inferred
Project Boundary
Possible dilation zone

Fig. II-1-3: Structural Interpretation with possible zones of dilation

Due to the high magnetic character of some of the near surface volcanic rocks the pseudo-depth slices have not been able to effectively filter the data and produce a "true" basement image. Nevertheless, the distribution of magnetic units on the basement slice clearly delimits a series of structurally bounded blocks (Appendix 3).

Two major fault directions are evident striking WNW-ESE and NE-SW. From the apparent relative movement directions along these faults and the distribution of magnetic indicator units, the WNW-ESE faults are regarded as the oldest, offset by younger NE-SW faults. The "major" WNW-ESE trending faults appear to offset magnetic horizons on the 1VD magnetic imagery at 1444500mN, 5920000mE, with a left-lateral displacement. From the apparent "relative" age of the magnetic units it may also be suggested that this fault has a normal displacement with downthrow to the NE. Two major splays appear to branch off the major left-lateral structure at 1444000mN, 595000mE and 1443500mN, 600000mE. The sharp truncation of the near surface volcanic rocks (Fig. II-1-1) by the NE-SW trending structures probably indicate normal faulting, downthrow to the NW. At least two possible interpretations can be proposed, (a) normal faults occurred prior to volcanism with high magnetic signature, resulting in accumulation of the volcanic material against the fault, or (b) normal faulting post deposition of the volcanic unit with high magnetic and subsequent preferential erosion of the uplifted block. Interpretation "a" is preferred.

To develop the basic framework for the fault geometry a series of images were used, these include Total Magnetic Intensity - Reduced to the Pole (Appendix 1) with different sun illuminations and Total Magnetic Intensity - Reduced to the Pole 1st Vertical Derivative (Appendix 2), using both colour and grey-scale enhancements. In an attempt to provide a "clear" interpretation correlation with the Panchromatic SPOT image (Appendix 7) and DTM was ensured prior to excessive capture of faults and fractures. The initial detailed structural interpretation clearly shows a complex arrangement of structures, while maintaining the overall simple fault geometry. Instead of single major faults, it is clear that broad fault zones are developed. This is expected, as fault geometries are known to splay with a decrease in depth due to a reduction in confining pressure.

With increase in the detail of interpretation a series of minor structures are developed. Faults appear to be arranged in a fairly chaotic pattern. However, by assessing the styles of the major faults, e.g. strike-slip, it is possible to group minor faults with particular strike, and develop a possible explanation for their development in terms of a strain model. There are three distinct locations that have a radial character that may indicate the presence of an intrusive body.

❖ Lismore Dome (1441000mN, 593000mE); radial, high magnetic signature, although pseudo-depth slicing does not provide supporting evidence. This possible intrusion does coincide with resistivity data supplied by the PNOC. However, this possible intrusive anomaly is bounded by a series of faults. It is therefore a possibility that this apparent anomaly is simply the result of preferential weathering along faults.

- Eastern boundary (1444000mN, 601000mE); a subtle moderate to high magnetic signature with a vague circular character is noted. However, pseudo-depth slicing appears to indicate a more coherent circular body at depth (see Appendix 3). This signature from depth may however, simply be a buried magnetic lava flow rather than an intrusion. From the structural information, it is possible that the major fault trending the NW is actually displaced around this body.
- Central area (1447000mN, 597500mE); characterised by a sub-circular, subdued magnetic response, topographic circular feature and a radiometric Ternary high. The local structures also appear to bend around this anomaly, possibly indicating a substantial competent body at depth.

Faults appear to control both the location and extent of the volcanic rocks. It is expected that volcanic centers are at least partially fault controlled. From the analysis of fault displacement it is possible to determine zones of dilation.

There are sharp boundaries to the zones of demagnetization, which possibly reflect faults that are acting as the regional pathways for the fluids.

Several sub-circular structural features can be delineated from the offset and distribution of linear magnetic horizons. These structures may be caused by emplacement of intrusive bodies. However, due to the extensive sets of faults throughout the area it is possible that weathering along faults at right angles may have caused these apparent circular structures.

The main fault structures within the study area show a coherent pattern (Fig. II-1-3). What is possibly more significant is that these structures can also be explained in the context of a broader regional setting. The location of possible intrusive bodies within the area can also be explained in terms of the local tectonic regime.

The WNW-ESE trending structure in the airborne geophysical data can be linked to a far more laterally extensive structure evident on the Panchromatic SPOT imagery. This structure has been termed the Legazpi Lineament by a number of previous authors. From an analysis of the available fault geometries this structure can be determined as a left-lateral structure with splays diverging with a NW to NNW strike direction.

The most northerly major splay in this area, can be traced on the Panchromatic SPOT imagery to the north, passing along a major line of Volcanic centres and through the centre of the Tiwi project.

On a more local scale N-S trending faults within the area could easily be related to extension fractures developed at 45° off the major left-lateral faults. The area is also cross-cut by major NE-SW faults with an apparent normal displacement with downthrow to the NW. These faults are also laterally extensive when identified on the Panchromatic SPOT imagery. These structures are possibly related to the Philippine Fault and hence are of a young age. They certainly have a relative younger age than the major left-lateral faults in the area. As the Philippine Fault in this area is convex to the NE and the regional movement direction is to the NW, an extensional environment is likely to develop. It is proposed that this NE-SW structure is related to this young, currently active extensional structural regime.

As mineralisation is considered to be related with pre-Philippine Fault development, the main structures to focus attention should be dilation zones related to the WNW-ESE left-lateral faults.

From this study it can be propose that the structural regime for the Legazpi area is conducive for providing structural traps/ dilation zones that have the potential to be mineralised. During the interpretation various features have been recognised that can be interpreted as possible intrusive bodies, see Fig. II-1-3. The approximate distribution of these intrusive bodies relative to the major structures again supports the proposal of a dilational regime active across the prospect area. These possible intrusive bodies provide potential sources for the production of mineralised fluids.

4) Areas for Further Exploration

The presence of "older" intrusive bodies is potentially an important factor for gold mineralisation in this area. Although the role of intrusive bodies in the mineralising event is not well understood, they may be important either directly as a fluid or heat source, or indirectly by creating fractures during their emplacement. The present volcanic centre to the east of the project area may be indirectly affecting the mineral prospectivity of the area.

It is difficult to directly target areas of potential gold mineralisation in the survey area, as the regional controls on gold mineralisation are not well understood. However, possible styles of gold mineralisation may be related to one or more of the following.

- Rims of Calderas/ volcanic centres/ sub-circular features

Sub-circular features have been included on the interpretation map. These anomalous areas are considered as potential centres of "old" volcanic activity. With the formation of a volcanic centre and extrusion of volcanic material accompanied by fracturing. Both major and minor structures are formed. The structures directly associated with the volcanic activity may provide pathways for syn-tectonic fluids. Such structures are also potential sites for reactivation by successive volcanic activity or movement of fluids.

❖ Areas of Reduced Magnetic Response

Areas of demagnetisation are evident from the airborne geophysical data and are included on the final interpretation maps. It is proposed that these may reflect large-scale alteration of the volcanic rocks associated with an extensive episode of hydrothermal fluid movement. Potentially these fluids may have been mineralised. Further work is required in order to understand the relationship between the areas of demagnetisation and the alteration associated with the mineralisation. Proximity to WNW or N trending structures is considered important, as these appear to act as conduits for the regional movement of the fluids.

❖ Specific areas of interest include:

- The zone of demagnetisation along the major WNW-ESE trend, but particularly where they coincide with Potassium high zones (1444500mN, 591500mE; 1444500mN, 594000mE and 1443000mN, 599500mE). Alteration has been identified in some of these areas by the field survey.
- Similar characteristics occur at 1440000mN, 592500mE, with the exception these anomalies fall along a NE trending fault. However, this locality has the advantage of being in close proximity to a possible "old" intrusive body.

1-7 Results of Interpretation : Irosin area

The interpretation maps produced during this study show the subdivision of the magnetic responses into various magnetic packages. These packages were then classified into probable lithology types based on the mapped geology and/or interpretation of the Panchromatic SPOT imagery and radiometric data (Fig. II-1-4).
Note that the naming of these units is based largely on a PNOC map and report (Delfin et al., 1993, PNOC pers comm). There has been no field reconnaisance to verify the interpretation by World Geoscience Corporation during this study.

1) Increased Potassium Response

In order to identify areas of increased potassium response it is generally best to look initially at the Total Count Potassium image or contour map (Appendix 6). It can also be interpreted on the Ternary Radiometric images and contours (Appendix 5), as areas of enriched Potassium appear as either a strong red colouration or white (see Appendix 5). However, although a white colouration is usually perceived as a high concentration of all three (Potassium: Thorium: Uranium) radiometric elements it can also simply represent equal proportions of these elements.

Mapping of hydrothermal alteration is considered an important component of the airborne geophysical survey. Mineralised areas in the Irosin Project area are often associated with argillic (alunite-kaolinite-adularia) alteration. Alunite is a hydrothermal alteration product that contains potassium. It may therefore be that potassium data appears to map this alteration and is probably mapping hydrothermal fluid activity elsewhere in the area. Areas of high or increased Potassium response were therefore outlined from the contoured data and are shown on the interpretation maps (Fig. II-1-4).

Areas of particular interest are generally those that are associated with faults and fractures (Fig. II-1-5). The distribution of increased Potassium response evident on the clipped Potassium images (Appendix 5) is primarily concentrated into the NW quadrant of the project area as discontinuous anomalies. However, there is a broad NW-SE trend with a slight elongation to the SE through the centre of the area, possibly following the major strike-slip structure. This area lies to the west of the Irosin Caldera in a locality where a number of faults appear to cross-cut the Caldera boundary. It is therefore possible that fluids from the present volcanic activity are affecting this area in preference to the remainder of the project area. This would result in the apparent irregular distribution of anomalies, which should be considered when looking for "older" alteration systems. The remainder of the project area is relatively barren of major Potassium anomalies with one exception at 140000mN, 618000mE. At this locality a large, very high anomaly with a NW trend is clearly defined, however, no obvious explanation can be proposed and it requires field-checking.

A review of the Total Count radiometric data shows a broad distribution of apparently equal high values of Potassium: Thorium: Uranium. This high radiometric signature is distributed across the SW half of the project area, coincident with the mapped extent of the Gate Volcanic rocks. This broad radiometric response is interpreted to be the result of the distribution of a distinct lithology or suite of lithologies, rather than structurally controlled alteration. However, variations in the radiometric signature are evident, possibly indicating differences in the volcanic rock type. Therefore, the radiometric signature has been used significantly to redefine the distribution of the Gate volcanic rocks previously constrained by by

Delfin et al., (1993) and the PNOC (pers. Comm.).

2) Zones of Demagnetization

Extensive areas of reduced magnetic response are evident from the airborne geophysical data (Fig. II-1-5). Several causes are proposed:

- Narrow linear zones are evident in a number of locations across the study area coincident with interpreted faults. The anomalies are apparently randomly orientated with no preferred trends. However, to the SW of the area around locality 1390000mN, 610000mE a series of apparently radial trends are developed. These trends may signify the presence of an intrusive body and the area warrants field-checking. Several similar areas are also evident within the Gate volcanics. It is possible that movement of hydrothermal fluids along the structures have caused demagnetisation of the surrounding volcanic rocks.
- Around locality 1403000mN, 617000mE a large magnetic low anomaly is evident. This area is close to the present Irosin Caldera and may reflect current hydrothermal alteration. However, a possibly circular magnetic anomaly is also present, which may indicate the presence of an intrusive body.

These areas with a magnetic low signature have the potential to have been pathways for fluid movement and appear to have been subject to demagnetisation by hydrothermal fluids. In order to resolve some of the ambiguity and categorise the different areas with low magnetic signatures, field-checks are required. It may be possible to determine several different causes for a similar magnetic response. If this proves to be the case then a review of the interpretation may have to be made using the new field criteria as a guide. However, overall the potential for mineralised zones within the study area is evident. Field checks should initially be restricted to areas where areas of magnetic low and faults are in close proximity.

3) Structures and Intrusive Bodies

Probably the two main results of this study are the recognition of a coherent structural data set and the identification of a number of possible intrusive bodies (Fig. II-1-5). From the Panchromatic SPOT image (Appendix 7) and airborne geophysical data, it can be seen that the study area is extensively faulted and fractured. By reviewing the available data it has been possible to determine a series of major regional and more localised left-lateral strike-slip related structures.

From the Panchromatic SPOT image and Digital Terrain Model (DTM), numerous linear features can be seen. These linear structures usually follow unusually straight segments of drainage. Comparison with published maps (see JMEC report 1998) show that some of these drainage courses are faulted and brecciated. Many of these Panchromatic SPOT /DTM linear trends also coincide with displacement or truncations of magnetic horizons.

The differentiation of structures into categories of major or minor is loosely based on the affect the structures have on the data sets. If they affect features on all the data sets they are usually regarded as major, if they only effect one of the data sets they are usually regarded as minor.

Geophysical images such as the 1st Vertical Derivative (Appendix 2)contain an abundant amount of structural data. However, to develop an initial simple structural framework an interpretation of pseudo-depth slices was made (Appendix 3).

Due to the high magnetic character of some of the near surface volcanic rocks the pseudo-depth slices have not been able to effectively filter the data and produce a "true" basement image. Nevertheless, the distribution of magnetic units on the basement slice clearly delimits a series of structurally bounded blocks (Appendix 3).

Two major fault directions are evident striking WNW-ESE to NW-SE and NE-SW. From the apparent relative movement directions along these faults and the distribution of magnetic indicator units, the WNW-ESE faults are regarded as the oldest, offset by younger NE-SW faults. The "major" WNW-ESE trending faults appear to offset horizons on the Panchromatic SPOT imagery, with a left-lateral displacement. From the apparent "relative" age of the magnetic units it may also be suggested that this "major" fault has a normal displacement with downthrow to the NE. A major splay appears to branch off the major left-lateral structure at 1399500mN, 608500mE. This structure then follows a more NW trend. These magnetic discontinuities are also clearly observed on the Panchromatic SPOT imagery and can be traced for considerable distances. The sharp truncation of the near surface volcanic rocks (Fig. II-1-4) by the "minor" WNW-ESE trending structures (1393000mN, 610000mE) possibly indicate normal faulting, downthrow to the NE. At least two possible interpretations can be proposed, (a) normal faults occurred prior to volcanism with high magnetic signature, resulting in accumulation of the volcanic material against the fault, or (b) normal faulting post deposition of the volcanic unit with high magnetic and subsequent preferential erosion of the uplifted block. Interpretation "b" is preferred.

The other major structure that is clearly defined on the magnetic data is the Irosin Caldera. This sub-circular structure occurs to the central north of the project area. The downthrow is clearly to the N of the fault defined by thick accumulations of recent sediments. Local alluvial fan deposits are also apparent, eg. 1405000mN, 609000mE.

To develop the basic framework for the fault geometry a series of images were used, these include Total Magnetic Intensity - Reduced to the Pole with different sun illuminations (Appendix 1)and Total Magnetic Intensity - Reduced to the Pole 1st Vertical Derivative (Appendix 2), using both colour and grey-scale enhancements. In an attempt to provide a "clear" interpretation, correlation with the Panchromatic SPOT image (Appendix 7) and DTM was undertaken prior to excessive capture of faults and fractures. The initial detailed structural interpretation clearly shows a complex arrangement of structures, while maintaining the overall simple fault geometry. Instead of single major faults, it is clear that broad fault zones are developed. This is expected, as fault geometries are known to splay with a decrease in depth due to a reduction in confining pressure.

With increase in the detail of interpretation a series of minor structures are developed. Faults appear to be arranged in a relatively chaotic pattern. However, by assessing the styles of the major faults, e.g. strike-slip, it is possible to group minor faults with particular strike, and develop a possible explanation for their development in terms of a strain model. Several anomalous areas are evident on the interpretation that may indicate the presence of intrusive bodies.

- Malobago Dome (1405000mN, 621000mE); radial, moderate to high magnetic signature, and a distinct radiometric halo that clearly identifies two closely related circular bodies. These actually coincide with mapped rhyolitic intrusive bodies.
- Northern boundary (1409000mN, 615000mE); a broad, moderate to high magnetic signature with a variable magnetic low anomaly form a sub-circular character. This area coincides with the southern extremity of the Bulusan Volcanic suite. To the south is a well-defined structural feature in the Irosin Caldera.
- Southwest area (1390000mN, 610000mE); characterised by a sub-circular, subdued magnetic response, topographic circular feature and a radiometric Ternary low. Magnetic low signature anomalies appear to radiate from this feature, possibly indicating the presence of an intrusive body or "old" volcanic vent.
- Central area (1402500mN, 609500mE), small sub-circular magnetic anomaly, surrounded by areas of magnetic low. Possibly indicative of an intrusive body or volcanic vent.

Faults appear to control both the location and extent of the volcanic rocks. It is expected that volcanic centres are at least partially fault controlled. From the analysis of fault displacement it is possible to determine zones of dilation.

There are sharp boundaries to the zones of demagnetisation, which possibly reflect faults that are acting as the regional pathways for the fluids.

Several sub-circular structural features can be delineated from the offset and distribution of linear magnetic horizons. These structures may be caused by emplacement of intrusive bodies. However, due to the extensive sets of faults throughout the area it is possible that weathering along faults at right angles may have caused these apparent circular structures.

The main fault structures within the study area show a coherent pattern (Fig. II-1-6). What is possibly more significant is that these structures can also be explained in the context of a broader regional setting.

The WNW-ESE trending structure in the airborne geophysical data can be linked to a far more laterally extensive structure evident on the Panchromatic SPOT imagery. This structure is sub-parallel with the Legaspi Lineament to the North, and oblique to the Philippine Fault. From an analysis of the available fault geometries this structure can be determined as a left-lateral structure with splays diverging with a NW to NNW strike direction. This structure is considered to have a left-lateral strike-slip displacement. It is also considered to be a relatively "old "structure.

On a more local scale N-S trending faults within the area could easily be related to extension fractures developed at 45° off the major left-lateral faults. The area is also cross-cut by major NE-SW faults with an apparent normal displacement with downthrow to the NW and SE. These faults are also laterally extensive when identified on the Panchromatic SPOT imagery. These structures are possibly related to the Philippine Fault and hence are of a young age. They certainly have a relative younger age than the major left-lateral faults in the area. As the Philippine Fault in this area is convex to the NE and the regional movement direction is to the NW, an extensional environment is likely to develop. It is proposed that the NE-SW structures are related to this young, currently active extensional structural regime.

As mineralisation is considered to be related with pre-Philippine Fault development, the main structures on which to focus attention should be dilation zones related to the WNW-ESE left-lateral faults.

From this study it can be proposed that the structural regime for the Irosin area is conducive for providing structural traps/ dilation zones that have the potential to be mineralised. During the interpretation various features have been recognised that can be interpreted as possible intrusive bodies, see Figure 9. The approximate distribution of these intrusive bodies relative to the major structures again supports the proposal of a dilational regime active across the prospect area. These possible intrusive bodies provide potential sources for the production of mineralised fluids.

4) Areas for Further Exploration

The presence of "older" intrusive bodies is potentially an important factor for gold mineralisation in this area. Although the role of intrusive bodies in the mineralising event is not well understood, they may be important either directly as a fluid or heat source, or indirectly by creating fractures during their emplacement. The present volcanic centre to the east of the project area may be indirectly affecting the mineral prospectivity of the area.

It is difficult to directly target areas of potential gold mineralisation in the survey area, as the regional controls on gold mineralisation are not well understood. However, possible styles of gold mineralisation may be related to one or more of the following.

❖ Rims of Calderas/ volcanic centres/ sub-circular features

Sub-circular features have been included on the interpretation map. These anomalous areas are considered as potential centres of "old" volcanic activity. With the formation of a volcanic centre and extrusion of volcanic material accompanied by fracturing. Both major and minor structures are formed. The structures directly associated with the volcanic activity may provide pathways for syn-tectonic fluids. Such structures are also potential sites for reactivation by successive volcanic activity or movement of fluids.

❖ Areas of Reduced Magnetic Response

Areas of demagnetisation are evident from the airborne geophysical data and are included on the final interpretation maps. It is proposed that these may reflect large-scale alteration of the volcanic rocks associated with an extensive episode of hydrothermal fluid movement. Potentially these fluids may have been mineralised. Further work is required in order to understand the relationship between the areas of demagnetisation and the alteration associated with the mineralisation. Proximity to WNW or N trending structures is considered important, as these appear to act as conduits for the regional movement of the fluids.

❖ Specific areas of interest include:

- The zones of demagnetisation around the sub-circular anomaly at 139000mN, 610000mE which also coincide with a Ternary radiometric low. This area could represent an old

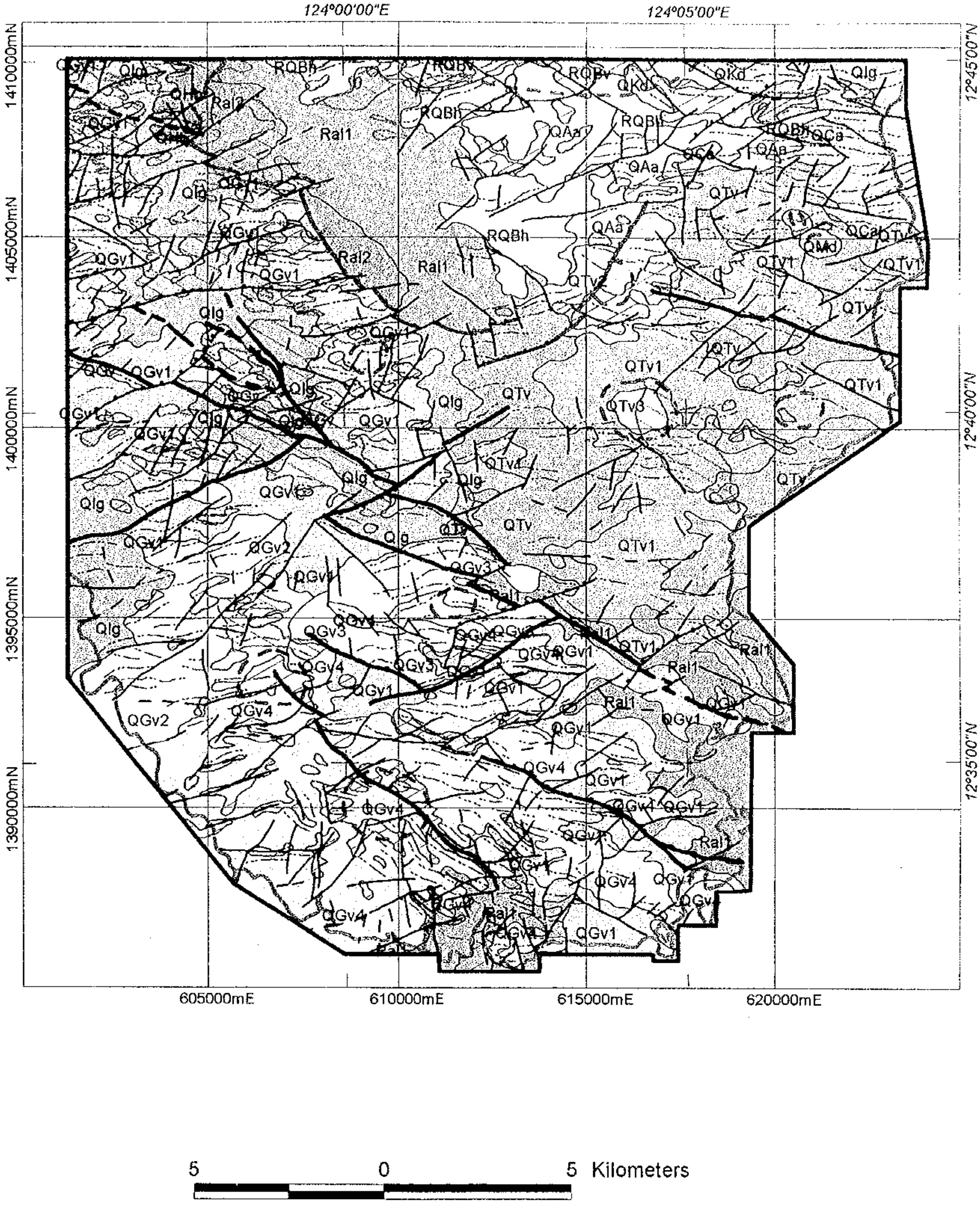


Fig. II-1-4 : Irosin Project Area - Philippines. Geological interpretation of Airborne Magnetic and Radiometric Data, and Panchromatic SPOT Imagery. Legends on following pages.

Legend

Coastline

Project Boundary

STRUCTURAL SYMBOLS

Lithological boundary

Magnetic linear trends

Major Fault - Confident, Inferred

Minor Fault - Confident, Inferred

Sense of normal displacement on fault

Caldera rim, with sense of displacement

Circular anomalies, possible volcanic vents or intrusive bodies

MAGNETIC UNIT

Zones of reduced magnetic signature relative to adjacent units. May correspond to areas of demagnetisation of volcanic rocks due to hydrothermal alteration.

RADIOMETRIC UNIT

Areas of increased potassium signature, may correspond to areas of argillic alteration.

AIRBORNE-MAGNETIC UNITS

RECENT

Ral2	Low magnetic signature and flat magnetic texture. Apparent radial distribution from a magnetic source with a moderate signature. Distribution possibly coincident with locally developed alluvial fan deposits.
Ral1	Low magnetic signature and flat magnetic texture. Topographic low. Distribution partially coincident with accumulations of recent slope wash and alluvial deposits.

LATE PLEISTOCENE

Post-Caldera Group

RQBh	Moderate magnetic signature and subdued short-wavelength linear magnetic texture. Possibly coincident with flank lahars and pyroclastics of the Bulusan Volcanic sequence.
RQBv	Very low to moderate magnetic signature and chaotic sub-linear magnetic texture. Possibly coincident with strato-cone lavas and breccias of the Bulusan Volcanic sequence.
QKd	High magnetic signature and weak, linear, broad-wavelength magnetic texture. Possibly coincident with the Talatak Dome.
QAa	High magnetic signature and weak to chaotic, linear, broad-wavelength magnetic texture. Low total radiometric signature. Possibly coincident with the Agoho Andesite.

Caldera Group

QIg	Low magnetic signature and weak, linear, short-wavelength magnetic texture. Moderate to high radiometric potassium signature. Possibly coincident with the Irosin Ignimbrite.
QMd	Discrete sub-circular anomalies with a moderate magnetic signature and flat magnetic texture. Distinctive radiometric halo. Slight topographic high. Coincident with the Malobago Dome.

EARLY PLEISTOCENE ?

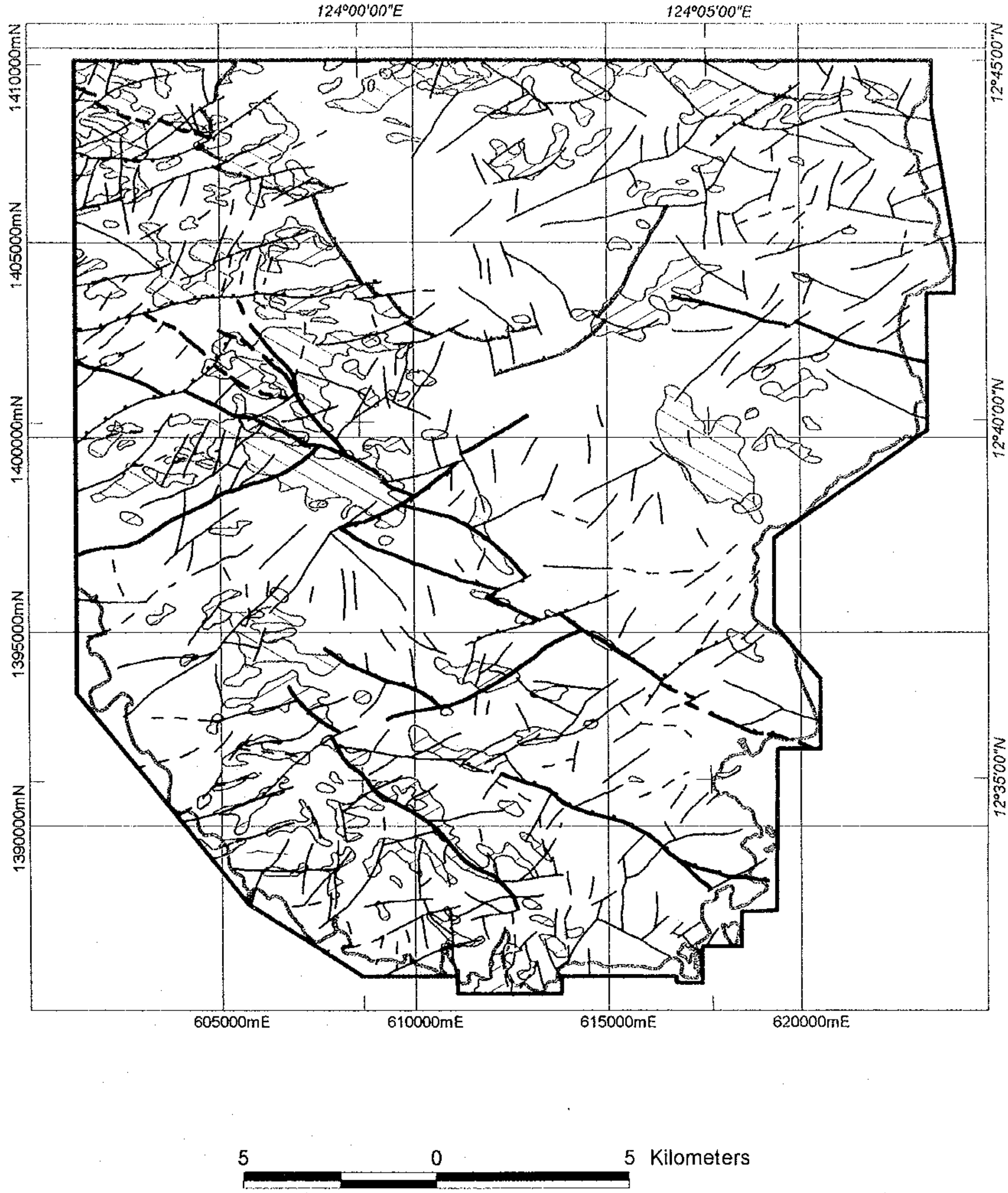
Pre-caldera Group

QHb	Low to moderate magnetic signature and weak, linear magnetic texture. Moderate to high radiometric signature. Possibly coincident with the Homahan basalt.	
QCa	Low to moderate magnetic signature and strong, short-wavelength linear magnetic texture. Low total radiometric signature. Possibly coincident with the Calunan Andesite.	
QTv3	Moderate to high magnetic signature and moderate sub-circular magnetic texture. Partially coincident with a very high total radiometric signature. Possible intrusive centre.	Units coincident with the Tabon-Tabon Volcanics
QTv2	Very low to very high magnetic signature possibly due to hydrothermal alteration along major faults or remanent magnetism.	Units coincident with the Tabon-Tabon Volcanics
QTv1	Moderate to high magnetic signature and chaotic, short-wavelength, sub-linear texture. Possibly represents a thicker volcanic sequence of unit QTv.	Units coincident with the Tabon-Tabon Volcanics
QTv	Low to moderate magnetic signature and chaotic, short-wavelength sub-linear texture. Possibly represents a thin magnetic volcanic sequence over basement with low magnetic intensity.	Units coincident with the Tabon-Tabon Volcanics

PLIOCENE

Pre-Bulusan

QGv4	High magnetic signature and broad-wavelength sub-linear texture.	Units coincident with the Gate Volcanics.
QGv3	High magnetic signature and broad-wavelength linear textures. Possibly a distinctive volcanic lava flow.	Units coincident with the Gate Volcanics.
QGv2	Moderate magnetic signature and weak short-wavelength linear texture.	Units coincident with the Gate Volcanics.
QGv1	Moderate magnetic signature and flat magnetic texture.	Units coincident with the Gate Volcanics.
QGv	Moderate to high magnetic signature and stong linear fabric. Possible dyke or build-up of volcanic material along major faults.	Units coincident with the Gate Volcanics.



Zones of reduced magnetic signature relative to adjacent units. May correspond to areas of demagnetisation of volcanic rocks due to hydrothermal alteration.

Areas of increased potassium signature, may correspond to areas of argillic alteration.

Fig. II-1-5 : Irosin Project Area - Philippines. Magnetic lows and Potassium highs combined with faults from aeromagnetic interpretation.

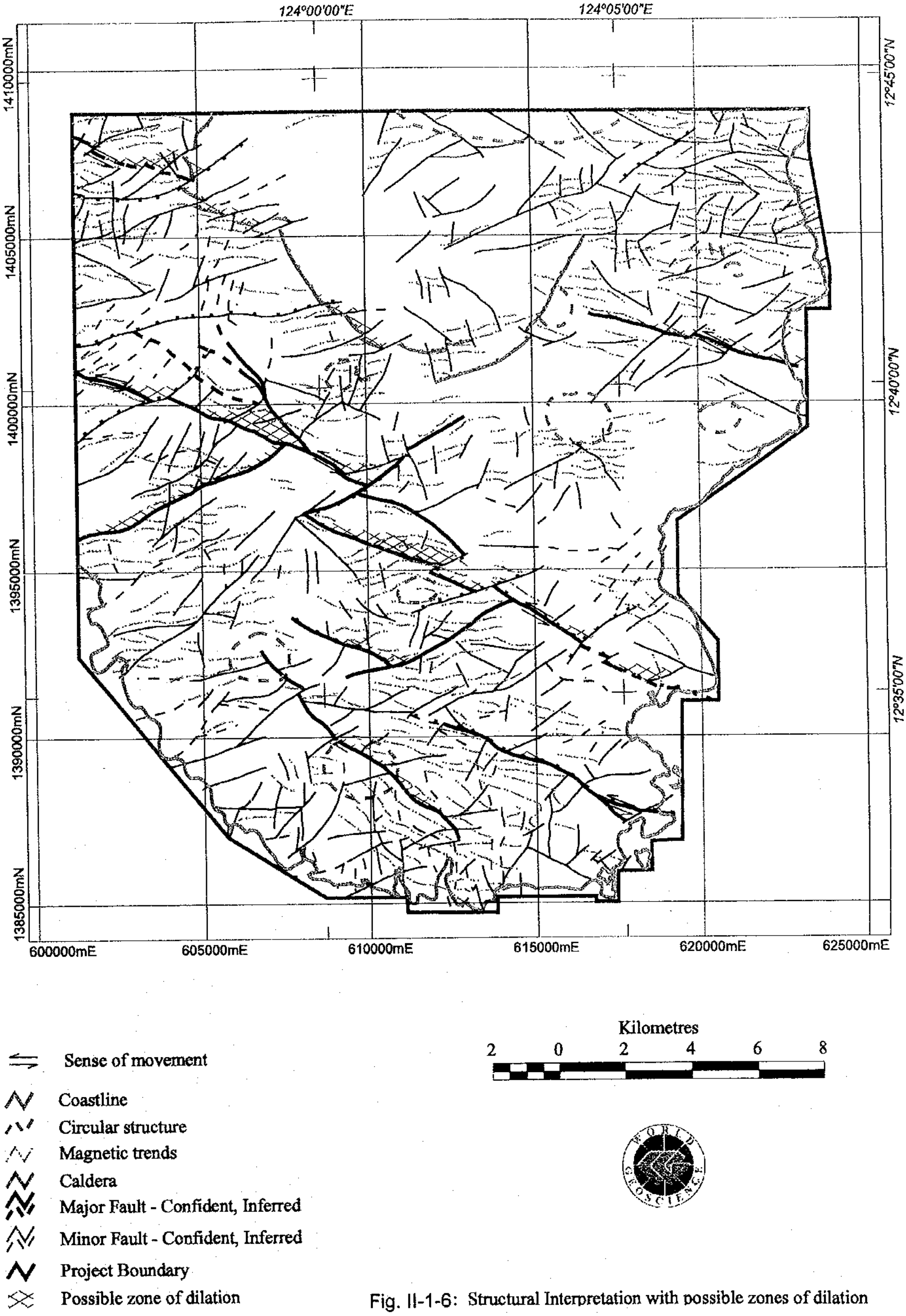


Fig. II-1-6: Structural Interpretation with possible zones of dilation

volcanic vent.

- The major Potassium anomaly at 1400000mN, 618000mE, the origin of which is not understood.

The area in general within the NW quadrant of the project area, as this region has a number of Potassium high and magnetic low anomalies and is extensively dissected by major and minor faults

1-8 Results of Interpretation : Tiwi area

The interpretation maps produced during this study show the subdivision of the magnetic responses into various magnetic packages. These packages were then classified into probable lithology types based on the mapped geology and/or interpretation of the Panchromatic SPOT imagery and radiometric data (Fig. II-1-7).

Note that the naming of these units is based largely on a PNOC map at the scale 1:250,000 by the BMR regional Office V. There has been no field reconnaisance to verify the interpretation by World Geoscience Corporation during this study.

1) Increased Potassium Response

In order to identify areas of increased potassium response it is generally best to look initially at the Total Count Potassium image or contour map (Appendix 5). It can also be interpreted on the Ternary Radiometric images, as areas of enriched Potassium appear as either a strong red colouration or white (see Appendix 5). However, although a white colouration is usually perceived as a high concentration of all three (Potassium: Thorium: Uranium) radiometric elements it can also simply represent equal proportions of these elements.

Mapping of hydrothermal alteration is considered an important component of the airborne geophysical survey. Mineralised areas in the Tiwi Project area are often associated with argillic (alunite-kaolinite-adularia) alteration. Alunite is a hydrothermal alteration product that contains potassium. It may therefore be that potassium data appears to map this alteration and is probably mapping hydrothermal fluid activity elsewhere in the area. Areas of high or increased Potassium response were therefore outlined from the contoured data and are shown on the interpretation maps (Fig. II-1-8).

Areas of particular interest are generally those that are associated with faults and fractures (Fig. II-1-8). The distribution of increased Potassium response evident on the clipped Potassium images (Appendix 5) is primarily concentrated as discontinuous anomalies along faults with a NE trend. However, there is a minor anomaly to the southwest of the project area (1489000mN, 559000mE) that may prove to be significant due to its apparent structural position.

A review of the Total Count radiometric data shows a broad distribution of apparently equal high values of Potassium: Thorium: Uranium. This high radiometric signature is distributed across much of the project area, and as significantly as high anomalies, areas which have a low total radiometric signature are clearly defined (1487500mN, 565000mE). This low radiometric signature coincides well with a Quaternary pyroclastic deposit mapped by the BMG Regional Office V. The broad radiometric response is interpreted to be the result of the distribution of a distinct lithology or suite of lithologies, rather than structurally controlled alteration. However, variations in the radiometric signature are evident, possibly indicating differences in the volcanic rock type. Therefore, the radiometric signature has been used significantly to redefine the distribution of the volcanic rocks previously constrained by the BMG Regional Office V.

The effects of thick cover (sediment/ water) are clearly seen with the very low radiometric signature. This provides some indication as to the penetration effects of this particular technique.

2) Zones of Demagnetisation

Extensive areas of reduced magnetic response are evident from the airborne geophysical data (Fig. II-1-8). Several causes are proposed:

- Narrow linear zones are evident in a number of locations across the study area coincident with interpreted faults. The anomalies are generally orientated with a NE-SW trend. However, local broadening of the anomalies tends to develop where NE faults cross-cut NW trending faults (e.g. 1494000mN, 562000mE).
- To the SW of the area around locality 1488000mN, 560000mE, an anomaly that follows an approximate NW trend is developed. This anomaly may signify the presence of a structurally controlled alteration zone and warrants field-checking. It is possible that movement of hydrothermal fluids along the structures have caused demagnetisation of the surrounding volcanic rocks.
- Along the southern boundary of the project area another broad area with magnetic low signature is evident (1485000mN, 559000mE). It is difficult to say with any confidence whether this area follows more of a NW or NE fault trend. It is however, significant and should be checked in the field.

These areas with a magnetic low signature have the potential to have been pathways for fluid movement and appear to have been subject to demagnetisation by hydrothermal fluids. In order to resolve some of the ambiguity and categorise the different areas with low magnetic signatures, field-checks are required. It may be possible to determine several different causes for a similar magnetic response. If this proves to be the case then a review of the interpretation may have to be made using the new field criteria as a guide. However, overall the potential for mineralised zones within the study area is evident. Field checks should initially be restricted to areas where areas of magnetic low and faults are in close proximity.

3) Structures and Intrusive Bodies

Probably the two main results of this study are the recognition of a coherent structural data set and the identification of a number of possible intrusive bodies (Fig. II-1-9). From the Panchromatic SPOT image and airborne geophysical data, it can be seen that the study area is extensively faulted and fractured. By reviewing the available data it has been possible to determine a series of major regional and more localised left-lateral strike-slip related structures.

From the Panchromatic SPOT image and Digital Terrain Model (DTM), numerous linear features can be seen. These linear structures usually follow unusually straight segments of drainage. Comparison with published maps (see JMEC report 1998) show that some of these drainage courses are faulted and brecciated. Many of these Panchromatic SPOT /DTM linear trends also coincide with displacement or truncations of magnetic horizons.

The differentiation of structures into categories of major or minor is loosely based on the affect the structures have on the data sets. If they affect features on all the data sets they are usually regarded as major, if they only effect one of the data sets they are usually regarded as minor.

Geophysical images such as the 1st Vertical Derivative contain an abundant amount of structural data. However, to develop an initial simple structural framework an interpretation of pseudo-depth slices was made (Appendix 3).

Due to the high magnetic character of some of the near surface volcanic rocks the pseudo-depth slices have not been able to effectively filter the data and produce a "true" basement image. Nevertheless, the distribution of magnetic units on the basement slice clearly delimits a series of structurally bounded blocks (Appendix 3).

Two major fault directions are evident striking NNW-SSE to NW-SE and NE-SW. From the apparent relative movement directions along these faults and the distribution of magnetic indicator units, the NNW-SSE and NW-SE trending faults are regarded as the oldest, offset by younger NE-SW faults. The "major" NNW-SSE trending faults appear to offset horizons on the Panchromatic SPOT imagery, with a left-lateral displacement. A series of major splays appear to branch off the major left-lateral structure at 1492000mN, 562500mE. This structure then follows a more NW trend. These distinct lineaments that disrupt the magnetic trends can be correlated with features on the Panchromatic SPOT imagery and traced for considerable distances. The sharp truncation of the near surface volcanic rocks (Fig. II-1-7) by the "late" NE-SW trending structures (148500mN, 565000mE) possibly indicate normal faulting, downthrow to the SE. At least two possible interpretations can be proposed, (a) normal faults occurred prior to volcanism with high magnetic signature, resulting in accumulation of the volcanic material against the fault, or (b) normal faulting post deposition of the volcanic unit with high magnetic and subsequent preferential erosion of the uplifted block. Interpretation "a" is preferred.

One significant feature in this project area is defined by the curvature of a distinctive marker horizon in the vicinity of 1488000mN, 560000mE. The structure in question appears to be constrained to the NE and SW by NW trending, left-lateral structures. The area between these two major structures has been subject to transpression and transtension, expressed by buckling and fracturing of the magnetic marker horizon. The resulting fold contains fractures around the hinge zone and has a high Potassium overprint. The area also has a low magnetic signature. This area would be a prime target for a detailed field-check.

To develop the basic framework for the fault geometry a series of images were used, these include Total Magnetic Intensity - Reduced to the Pole with different sun illuminations (Appendix 1) and Total Magnetic Intensity - Reduced to the Pole 1st Vertical Derivative (Appendix 2), using both colour and grey-scale enhancements. In an attempt to provide a "clear" interpretation, correlation with the Panchromatic SPOT image (Appendix 7) and DTM (Appendix 4) was undertaken prior to excessive capture of faults and fractures. The initial detailed structural interpretation clearly shows a complex arrangement of structures, while maintaining the overall simple fault geometry. Instead of single major faults, it is clear that broad fault zones are developed. This is expected, as fault geometries are known to splay with a decrease in depth due to a reduction in confining pressure.

With increase in the detail of interpretation a series of minor structures are developed. Faults appear to be arranged in a relatively chaotic pattern. However, by assessing the styles of the major faults, e.g. strike-slip, it is possible to group minor faults with particular strike, and develop a possible explanation for their development in terms of a strain model. Several anomalous areas are evident on the interpretation that may indicate the presence of intrusive bodies.

- ❖ Northeast boundary (1496000mN, 564000mE); a broad, moderate to high magnetic signature with a variable magnetic low anomaly form a sub-circular character. The area also has a circular radiometric appearance a Ternary radiometric enriched signature.
- ❖ Southern boundary (1485000mN, 562500mE); from the Panchromatic SPOT image this area is clearly the margin of a volcanic centre situated further to the south. The area is characterised by units that appear to radiate from a source just to the south of the study area, which would coincide with the volcanic centre. The area also has a topographic circular feature and a radiometric Ternary low.
- ❖ Central area (1492500mN, 558000mE), small sub-circular magnetic anomaly, surrounded by areas of magnetic low. Distinctive radiometric low, and apparent topographic low and magnetic dome. Possibly indicative of an intrusive body or volcanic vent.

Faults appear to control both the location and extent of the volcanic rocks. It is expected that volcanic centres are at least partially fault controlled. From the analysis of fault displacement it is possible to determine zones of dilation.

There are sharp boundaries to the zones of demagnetisation, which possibly reflect faults that are acting as the regional pathways for the fluids.

Several sub-circular structural features can be delineated from the offset and distribution of linear magnetic horizons. These structures may be caused by emplacement of intrusive bodies. However, due to the extensive sets of faults throughout the area it is possible that weathering along faults at right angles may have caused these apparent circular structures.

The main fault structures within the study area show a coherent pattern (Fig. II-1-9). What is possibly more significant is that these structures can also be explained in the context of a broader regional setting.

The NNW-SSE to NW-SE trending structures in the airborne geophysical data can be linked to a far more laterally extensive structure evident on the Panchromatic SPOT imagery. This structure appears to be a splay off the Legaspi Lineament to the south, and presently sub-parallel to the Philippine Fault. From an analysis of the available fault geometries this structure can be determined as a left-lateral structure with splays diverging with a NW to NNW strike direction. This structure is considered to have a left-lateral strike-slip displacement and is considered to be a relatively "old "structure.

On a more local scale, N-S trending faults within the area could easily be related to extension fractures developed at 45° off the major left-lateral faults. The area is also cross-cut by major NE-SW faults with an apparent normal displacement with downthrow to the NW and

SE. These faults are also laterally extensive when identified on the Panchromatic SPOT imagery. These structures are possibly related to the Philippine Fault and hence are of a young age. They certainly have a relative younger age than the major left-lateral faults in the area. As the Philippine Fault in this area is convex to the NE and the regional movement direction is to the NW, an extensional environment is likely to develop. It is proposed that the NE-SW structures are related to this young, currently active extensional structural regime.

As mineralisation is considered to be related with pre-Philippine Fault development, the main structures on which to focus attention should be dilation zones related to the approximately NW-SE left-lateral faults.

From this study it can be proposed that the structural regime for the Tiwi area is conducive for providing structural traps/ dilation zones that have the potential to be mineralised. During the interpretation various features have been recognised that can be interpreted as possible intrusive bodies, see Fig. II-1-9. The approximate distribution of these intrusive bodies relative to the major structures again supports the proposal of a dilational regime active across the prospect area. These possible intrusive bodies provide potential sources for the production of mineralised fluids.

4) Areas for Further Exploration

The presence of "older" intrusive bodies is potentially an important factor for gold mineralisation in this area. Although the role of intrusive bodies in the mineralising event is not well understood, they may be important either directly as a fluid or heat source, or indirectly by creating fractures during their emplacement. The present volcanic centre to the east of the project area may be indirectly affecting the mineral prospectivity of the area.

It is difficult to directly target areas of potential gold mineralisation in the survey area, as the regional controls on gold mineralisation are not well understood. However, possible styles of gold mineralisation may be related to one or more of the following.

❖ Rims of Calderas/ volcanic centres/ sub-circular features

Sub-circular features have been included on the interpretation map. These anomalous areas are considered as potential centres of "old" volcanic activity. With the formation of a volcanic centre and extrusion of volcanic material accompanied by fracturing. Both major and minor structures are formed. The structures directly associated with the volcanic activity may provide pathways for syn-tectonic fluids. Such structures are also potential sites for

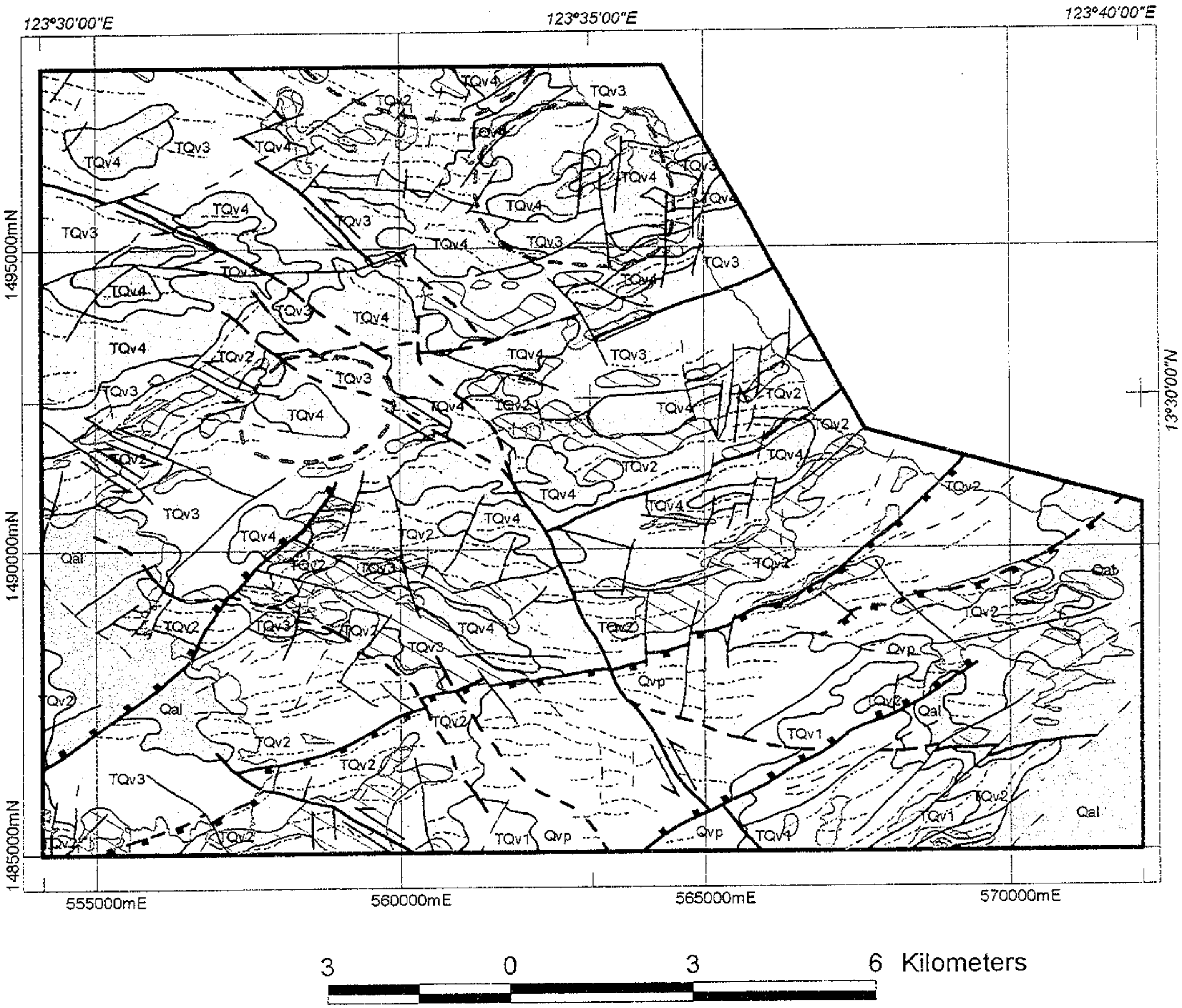


Fig. II-1-7 : Tiwi project area - Philippines. Geological interpretation of Airborne Magnetic and Radiometric Data, and Panchromatic SPOT Imagery. Legends on following pages.