# CHAPTER VIII

## INVESTIGATION SCOPE AND APPLIED TECHNICAL METHODS

Given the document analysis and summarization of the prospecting at 1:25,000 scale, 15 potential areas were selected. However, in order to ensure the effective and detailed prospecting for each area and to obtain the defined objectives and tasks, it would be essential to select specific areas to be further prospected. Therefore, the selection and technical methods are of importance as they are decisive to the effectiveness of the prospecting work and associated costs.

Followings are the specific criteria for the selection:

- Having clear mineral occurrence and pre-existed control works.

- Having analytical data which define ore presence or indications related to the existence and development of mineralization at various levels.

- Having geological structure favorable for mineralization existence and development.

Given these principals, the potential areas or ore prospects will be subjected to three prospecting and investigation levels as follows:

- Mineralization area or zone subjected to preliminary prospecting at 1/10,000 - 1/5,000 scale.

- Mineralization area or zone subjected to detailed prospecting at 1/10,000 scale.

- Mineralization area or zone subjected to "preliminary prospecting-investigation" at 1/10,000 scale.

Follow is the selected prospecting and investigation levels applied to each specific area:

**II – 1 – AREAS AND INVESTIGATION LEVELS:**

As described above, there are 15 mineralization-potential areas occurred within 8 submeridian-trending ore zones and ranges. Given the mineralization levels, these areas will be prospected and investigated as follows:

**II – 1 – 1 –Mineralization zones to be preliminarily explored at 1/10,000 – 1/5,000 scale**

*A – Mineralization zone No. II:*

It was formed by two Au mineralization occurrences extending to one wing of a fault located between two intrusions with difference in composition: a batolite acid intrusion occurred to the west and mafic-ultramafic intrusion occurred to the east.

Besides these gold mineralization occurrences, there are also alluvial gold haloes and geochemical haloes of indicative elements for the gold mineralization. Given these characteristics, the preliminary exploration at 1/10.000 – 1/5.000 scale is selected for two areas of Au – II – 1 and Au – II – 2.

Apart from Au mineralization objects in hydrothermal formations, the gossan occurrences are also the subjects with further investigation warranted for assessment of the gold grades.

### B – Mineralization zone No. III:

It is the longest mineralization zone extending from the north to the south within the licensed area of the Viet Lao Joint-stock Company and a mining division – Ministry of National Defence.

It is symmetric to the ore zone No. II through mafic and ultramafic intrusion band. The entire zone consists of quartz-sericite schist, intercalated with lenses of limestone and layers of quartzite. There have been ore prospects found in this zone and 3 km$^3$ was explored.

The preliminary exploration at scale of 1:10,000 to 1:5,000 will be applied to the three areas of Au – III – 1, Au – III – 2 and Au – III – 3 within this zone.

Like the mineralization zone No. II, the entire zone is commonly controlled by the sub-meridian fault system going through. It is primarily controlled to the eastern mafic and ultramafic intrusion.

Fe and Au mineralization occurrences are found in three areas mentioned above, of which there are some Au-bearing gossans and presence of geological contours indicative of Au mineralization.

### C – Mineralization zone No. IV:

It is characterized by iron mineralization extending along the sub-meridian strike. It contains many magnetite iron prospects conformable with the country rocks like quartz-sericite schist.

This ore zone was preliminarily explored at 1:10,000 scale, according to the available geogical documents; for example ore outcrops controlled the development strike and the length of the mineralization body was defined in the plan.

### D – Mineralization zone No. V:

It extends from the northern boundary to the centre of the Noong Key Uc area along the sub-meridian strike. It is located in the Noong Key Uc area marked as Au – V – 1.

Many gold prospects found within Noong Key Uc were freely exploited for the past years. Ore occurs in type of sulphide-poor quartz veinlets intersecting or conformable with the quartz-sericite schist or forming strocvert in overlying quartzite formations. In addition, relatively thick elluvial-delluvial placer bodies have existed within Noong Key Uc, according to the prospecting data. To the north of this Au-bearing area are one limonite-containing weathered iron prospect and one overlying high-grade Sn geochemical halo. These are indicative of a fairly large mineralization

area. This area will be subjected to preliminary exploration at scale of 1:10,000 to 1:5,000.

### E – Mineralization zone No. VI :

It is located in the east of the licensed area and within Ban Choung. The only one Au-bearing area in this zone is Au-VI-1.

It extends to the south in an arc-shape and then to the W-N-W, encompassing the Cenozoic basalt extrusive formations. This change in development direction may be due to the development of basalt extrusion. However, the gold-bearing area trends to develop along the sub-meridian strike formed by the fault system in the same strike.

This zone will be prelimarily explored at 1/10,000 to 1/5,000 scale.

### F – Mineralization zone No. VII:

It is located in the northeastern boundary of the 250 km$^2$ area. Its southern part trends to extend to Mineralization zone No. V in the south. It is clearly represented by gold-bearing area No. Au – VII – 1 (regarded as the clearest indication).

Given the description mentioned above and the remote sensing documents, this area will be preliminarily explored at scale of 1/10,000 to 1/5,000.

### G – Mineralization zone VIII:

It is located in the S-SE of the investigated area, comprising intrusive rocks with different age and composition. It covers the Au-IX-1 area subjected to preliminary prospecting.

In this zone, there are gold prospects occurred in the limonite formation with Au grades ranging from 0.5 to 3.4 g/T and occurrence of geochemcial haloes (Sb, Ce, As, Sb, Zn) indicative of mineralization.

The entire mineralization development area is sheared and controlled by the NE-SW fault. In addition, there are limonite formations associated with the gold mineralization result, possibly formed by surface weathering.

**II – 1 – 2 -  Mineralization zones subjected to detailed prospecting at 1:10,000 scale:**

The areas subjected to detailed prospecting at 1:10,000 scale are the ones with specific mineralization occurrences, for example direct indications including dispersion haloes of heavy minerals defining the presence of minerals or indirect indiations including geochemical haloes defining the mineralization development. As no specific ore outcrops are defined, it is necesary to apply the detailed prospecting at 1:10,000 scale. This method will help outline the areas in more detailed level. Given the available documents, following is the areas to be under the detailed prospecting:

### A – Mineralization zone I:

It is located in the northwest of the 250 km$^2$ project area prospected at 1:25,000 scale. It is distributed in the Devonian acid intrusions marked as No. Au – I – 1.

In this area, there are dispersion haloes of Au graded I and II, and an existence of geochemical haloes (Cu-I, Sb-II and III, As-I, Zn-I, Pb-I) indicative of the gold presence. These haloes are controlled by the N-NW fault system.

### B – Mineralization zone No. V:

This zone subjected to detailed prospecting is within Area No. Au – V – 2.

This area acts as an intersection of two ore zones and its mineralization occurrences are fairly clear, comprising dispersion haloes of Au graded I and II, weathered iron occurrences outside the area and indicative geochemical haloes of Sb – II, III, Pb – I, II, III, Cu – I, Bi – II.

### C – Mineralization zone No. VII

It is located in Area No. Au – VII – 2, distributed to the south of the ore zone VII and contains subtle ore occurrences. Therefore, the further investigation over this area is warranted.

### D – Other relevant areas:

They are an SE-trending expension of mineralization zone. Within this scope, there are two areas No. Au – VIII – 1 and Au – VIII – 2 to be subjected to detailed prospecting at 1:10,000 scale. In case of positive results, these areas will be subjected to detailed prospecting at 1:5,000 scale.

**II – 1 – 3 - Mineralization zones subjected to preliminary prospecting – investigation at 1:10,000 scale:**

These areas are the ones with unclear ore occurrences and the extension of the mineralization zones. They are characterized by presence of dispersion haloes of heavy minerals and sediment geochemical haloes. The limited prospecting at 1:25,000 scale may result in the indefinite determination of mineralization. Therefore, in order to avoid the resource loss and define other potential areas for the next investigation, these areas will be subjected to preliminary prospecting-investigation at the scale of 1:10,000.

The following table indicated the areas subjected to preliminary prospecting at 1/10,000 to 1/5,000; detailed prospecting at 1:10,000 scale and preliminary prospecting - investigation at 1:10,000 scale:

| No. | Ore zone-range | Investigation area | Area km$^2$ | Investigation object | Investigation level |
|---|---|---|---|---|---|
| 1 | Mineralization zone II | Au – II - 1 | 10.20 | Au mineralization | Premilinary prospecting at 1:10,000 to 1:5,000 scale |
| 2 | | Au – II - 2 | 4.86 | | |
| 3 | Mineralization zone III | Au – III - 1 | 4.80 | | |
| 4 | | Au – III - 2 | 3.42 | | |
| 5 | | Au – III - 3 | 7.92 | | |
| 6 | Mineralization zone IV | Fe – IV - 1 | 4.75 | Fe mineralization | |
| 7 | Mineralization zone V | Au – V - 1 | 5.00 | Au mineralization | |
| 8 | Mineralization zone VI | Au – VI - 1 | 5.43 | | |
| 9 | Mineralization zone VII | Au – VII - 1 | 9.00 | | |
| 10 | Mineralization zone VIII | Au – IX - 1 | 7.72 | | |
| | *Total* | | **63.10** | | |
| 11 | Mineralization zone I | Au – I - 1 | 10.20 | Au mineralization | Detailed prospecting at 1:10,000 scale |
| 12 | Mineralization zone V | Au – V - 2 | 3.03 | | |
| 13 | Mineralization zone VII | Au – VII - 1 | 2.13 | | |
| 14 | Related area | Au – VIII - 1 | 6.20 | | |
| 15 | | Au – VIII - 2 | 3.85 | | |
| | *Total* | | **25.41** | | |
| 16 | Remaining area | | **86.49** | Au, Sn, Ni, W, Fe Mineralization | ….. – investigation at 1 :10,000 scale |

## II – 2 – TECHNICAL METHODS APPLIED:

The proper application of technical methods over the delineated areas is essential for the effective investigation. The selection of technical methods will be based on the investigation objects and levels and it will be conducted as follows:

### II – 2 – 1 GEOLOGICAL WORK:

### II – 2 – 1 – 1: Technical methods applied to the preliminarily prospected areas

As for areas needed to be prospected and assessed, the investment in technique is of the highest level so as to be able to define potential areas towards the assessement of reserve categorized 122 and the following mining design. There will be different technical methods applied to accurately define mineralization areas.

### *A) As for magnetite and hematite iron ore:*

Given the ore outcrops found in the first phase, iron orebodies were defined. These bodies are composed of magnetite which is martitized to be hematite. In the event of magnetic ore, the ground magnetic survey, in addition to the geological methods, will be applied to define anomalies as a foundation for the implementation of next phases. As for the iron mineralization areas, the following technical methods will be applied:

*+ Geological work:*

- Geological route is applied to establish maps of petrographic structure and minerals in accordance with the norms of mineral prospecting and investigation at scales.

*+ Geophysical work:*

- Conducting ground magnetic surveys in accordance with geological routs to outline mineralization-related anomalies.

- Given the ground magnetic survey results and geological documents, conducting IP profile surveying and IP sounding in order to detect covered orebodies and define the mineralization depth.

*B) As for Au mineralization:*

It is a complicated and diversified geological object.

In order to accurately outline mineralization areas, the investment in geological techniques is of the most importance. Following is the major technical methods to be applied:

*+ Geological investigation:*

- Using geological routes to detect ore outcrops and establish maps of petrographic structure and ore development.

- BLEG (*Bottle line elemente grade*) sampling over the hydrographic network at denser spacing to support the determination of potential areas. The following table shows the work volume and BLEG sampling locations (table -1).

Table 1 : BLEG samples for investigation area 1/10,000 to 1/5,000 scale

| No. | Investigation area | Quantity of samples | Drawing No. | Note |
|---|---|---|---|---|
| 1 | Au – II – 1 | 49 | II – 1 – 2 | |
| 2 | Au – II - 2 | 17 | II – 2 – 2 | |
| 3 | Au – III - 1 | 25 | III – 1 – 2 | |
| 4 | Au – III - 2 | 10 | III – 2 – 2 | |
| 5 | Au – III - 3 | 34 | III – 3 – 2 | |
| 6 | Au – V - 1 | 17 | V – 1 – 2 | |
| 7 | Au – VI - 1 | 21 | VI – 1 – 2 | |
| 8 | Au – VII - 1 | 53 | VII – 1 – 2 | |
| 9 | Au – IX - 1 | 44 | IX – 1 – 2 | |
| | *Total* | *270* | | |

- Pan concentrate sampling in hydrographic network at denser spacing (like BLEG sampling), sampling volume of $30dm^3$ in minimum per each sample for easy founding of gold because the targeted areas are characterized by concentration of abundant fine-grained gold and minor coarse gold. The number of samples collected in areas is shown in the following table (table – 2).

Table 2 : Concentrate sampling for investigation area 1/10,000 to 1/5,000 scale

| No. | Investigation area | Quantity of samples | Drawing No. | Note |
|---|---|---|---|---|
| 1 | Au – II – 1 | 75 | II – 1 – 2 | |
| 2 | Au – II - 2 | 26 | II – 2 – 2 | |
| 3 | Au – III - 1 | 28 | III – 1 – 2 | |
| 4 | Au – III - 2 | 13 | III – 2 – 2 | |
| 5 | Au – III - 3 | 50 | III – 3 – 2 | |
| 6 | Au – V - 1 | 44 | V – 1 – 2 | |
| 7 | Au – VI - 1 | 23 | VI – 1 – 2 | |
| 8 | Au – VII - 1 | 62 | VII – 1 – 2 | |
| 9 | Au – IX - 1 | 53 | IX – 1 – 2 | |
| | **Total** | **374** | | |

- Given the geological investigation results and assay results of BLEG samples and alluvial-proluvium samples, it is possible to outline potential areas and dig swallow pits for slope pan concentrate coupled with geochemical sampling in the 100 x 100 grid (lines at 100m interval, hole spacing on line of 100m). The elluvial-deluvial pan concentrate coupled with geochemical sampling is conducted with 0.20m$^3$ volume and these samples will be comprehensively panned to assess the elluvial-deluvial placer bodies and supplement the forecasted resource and reserve. The preliminary prospecting results of slope placer bodies will be in detail in follow-up steps. Total number of samples for areas is shown in the following table (table – 3):

Table 3 : BLEG samples and alluvial-proluvium samples for investigation area
1/10,000 to 1/5,000 scale

| No. | Investigation area | Quantity of samples | Drawing No. | Note |
|---|---|---|---|---|
| 1 | Au – II – 1 | 292 | II – 1 – 3 | |
| 2 | Au – II - 2 | 137 | II – 2 – 3 | |
| 3 | Au – III - 1 | 293 | III – 1 – 3 | |
| 4 | Au – III - 2 | 135 | III – 2 – 3 | |
| 5 | Au – III - 3 | 271 | III – 3 – 3 | |
| 6 | Au – V - 1 | 208 | V – 1 – 3 | |
| 7 | Au – VI - 1 | 235 | VI – 1 – 3 | |
| 8 | Au – VII - 1 | 240 | VII – 1 – 3 | |
| 9 | Au – IX - 1 | 227 | IX – 1 – 3 | |
| | **Total** | **2038** | | |

Along with slope pan concentrate sampling, geochemical samples will be collected in the above areas so as to define detailed geochemical haloes as a basis for the implementation of the next trenching work.

*Pan concentrate and geochemical samples will be collected in lines. Sample numbering will indicate the followings:*

+ Investigation area.

+ Axial line number is shown in Roman numeral.

+ Horizontal line number is numbered in the sequence of from north to south and in Roman numeral.

+ Hole number is placed in the sequence of from west to east and ascending Roman numeral. In the event of two or more samples collected from one hole, the numerator is hole number and the denominator is order of a sample collected in that hole.

For example, the Au – II – 1 area will be shown as follows:

**(Au – II – 1) I – L1 – H1/2**

- The sampling is conducted in ore outcrops and excavation works. Each sample is 1m long, 0.20m wide and 0.05m deep (1x0.2x0.05) m.

**II – 2 – 2 - Technical methods applied to the detailed prospecting areas:**

Due to limitation of the initial documents, to avoid waste in the investigation over these areas, it is necessary to understand that selection of proper technical methods is essential for accurate determination of areas needed to be further invested and major investigation target is gold mineralization. Therefore, the technical methods designed for the areas subjected to detailed prospecting are: digging trenches to control mineralization width at sparser network and no geophysical surveying conducted.

The following tables shows the methods applied to the detailed prospecting at 1:10,000 scale:

- BLEG sampling for the specific areas (table – 4):

Table 4 : BLEG samples for investigation area 1/10,000 scale

| No. | Investigation area | Quantity of number | Drawing No. | Note |
|---|---|---|---|---|
| 1 | Au – I – 1 | 40 | I – 1 – 2 | |
| 2 | Au – V – 2 | 17 | V – 2 – 2 | |
| 3 | Au – VII - 2 | 14 | Vii – 2 – 2 | |
| 4 | Au – VIII – 1 | 39 | VIII – 1 – 2 | |
| 5 | Au – VIII – 2 | 29 | VIII – 2 – 2 | |
| | *Total* | *139* | | |

- Pan concentrate sampling (table 5):

Table 5 : Concentrate sampling for investigation area 1/10,000 scale

| No. | Investigation area | Quantity of number | Drawing No. | Note |
|---|---|---|---|---|
| 1 | Au – I – 1 | 46 | I – 1 – 2 | |
| 2 | Au – V – 2 | 22 | V – 2 – 2 | |
| 3 | Au – VII - 2 | 16 | Vii – 2 – 2 | |
| 4 | Au – VIII – 1 | 41 | VIII – 1 – 2 | |
| 5 | Au – VIII – 2 | 37 | VIII – 2 – 2 | |
| | *Total* | *162* | | |

- Digging swallow pits for slope pan concentrate and geochemical sampling (table – 6)

Table 6 : Concentrate and geochemical sampling for investigation area
1/10,000 scale

| No. | Investigation area | Quantity of number | Drawing No. | Note |
|---|---|---|---|---|
| 1 | Au – I – 1 | 150 | I – 1 – 3 | |
| 2 | Au – V – 2 | 102 | V – 2 – 3 | |
| 3 | Au – VII - 2 | 255 | Vii – 2 – 3 | |
| 4 | Au – VIII – 1 | 222 | VIII – 1 – 3 | |
| 5 | Au – VIII – 2 | 127 | VIII – 2 – 3 | |
| | *Total* | *856* | | |

- Digging interception and discovery trenches (table – 7) :

Table 7 : Quantily of number trenches for investigation area 1/10,000 scale

| No. | Investigation area | Quantity of number | Drawing No. | Note |
|---|---|---|---|---|
| 1 | Au – V – 2 | 525 | V – 2 – 4 | |
| 2 | Au – VIII – 1 | 650 | VIII – 1 – 4 | |
| | *Total* | *1175* | | |

*Regulations on sample number applied to these areas shall be similar to the ones applied to the preliminary prospecting areas and shall be strictly executed.*

**II – 2 – 3 - Technical methods applied to areas to be preliminarily prospected and investigated:**

The prospecting at scale of 1:25,000 over these areas was limited due to their geomorphologic characteristics. Therefore, given the analysis of their geomorphology and geological structure and some documents, the main technical methods applied to these areas include:

- Geological routes to detect outcrops with mineralization occurrences.

- Collecting alluvial-proluvium pan concentrate samples with large volume (30 dm$^3$) over the denser hydrographic network.

- BLEG sub-sampling over the denser hydrographic network of the working step at 1:25,000 scale.

- Assaying samples in accordance with the common requirements.

Given the outcomes obtained, it is possible to find more areas with direct indication of mineralization towards the detailed prospecting at 1:10,000 scale.

**II – 2 – 2 - TOPOGRAPHIC SURVEY:**

In order to meet requirements in respect of topographic documentation for the prospecting of Vang Tat-San Xay-Attapu gold deposit located in the People's Democratic Republic of Lao, the Geophysical Devision established the proposal for topographic survey (Drawing N$^o$ X).

**Objectives and Tasks**

Establish plane and elevation-controlling grids.

Edit and digitize topographic maps at 1: 10,000 scale.

Output data from designs to the field, in respect of locations of exploration and geophysical lines and geological works.

Define coordinates, elevations of geological works, beginning and ending points of axial and horizontal lines and intersections of axial and horizontal lines.

**II – 2 – 2 – 1: TECHNICAL DESIGN FOR SURVEY**

**1. Governing norms and procedures**

- Standard TCXDVN 364 : 2006 – Measuring and processing GPS data.

- Standard TCN 43 – 90 – Topographic mapping at scales of 1/500, 1/1000, 1/2000, 1/5000 issued in 1996 by the General Department of Cadastry (for outdoor work).

- Standard TCN 42 – 90 - Topographic mapping at scales of 1:500, 1:1000, 1:2000, 1:5000 issused in 1996 by the General Department of Cadastry (for indoor work).

- Signals for topographic maps at scales of 1:500, 1:1000, 1:2000, 1:5000 issued in 1995 by the General Department of Cadastry.

- Normative regulations on surveying in geological investigation and exploration issued in 1990.

- Regulations on managing quality of geological mapping products and works issued in 1997 by the General Department of Cadastry.

**2. Topographic characteristics and available documents**

*a) Topographic characteristics*

The area to be surveyed is located in an extremely difficult region in Vang Tat commune, San Xay district, Attapu province, Lao People's Democratic Republic. This area is characterized by dense, primeval forests with high and big trees, and strongly sheared topography. With these topographic characteristics, the local travel is extremely difficult, and therefore this area is categorized V in respect of the difficulty in traveling.

*b) Available documents and usage scope*

While studying and collecting the relevant geodesic survey documents, we have collected some documents as follows:

*+ In respect of plane and elevation control*

The central region has triangular points H IV defined by the Viet Lao Company in 2008 using GPS technology. The triangulation points were linked by leveling technique.

*+ In respect of topographic maps.*

There has been a topographic map scaled 1:50,000 issued in 2002 by the General Department of Cadastry, which was established by recompiling the map scaled 1:50,000 UTM issued in 1968 by the National Geographic Home of Da Lat.

The topographic map at 1:5,000 scale was established in 2009 based on the airborne photos.

+ *Usage scope.*

Triangulation points H IV will be used as a basis for establishment of polygon 1 and for elevations of polygon networks 1 and 2.

Topographic map scaled 1: 50 000 will be used as reference documents

Topographic map at 1:5000 scale established from airborne photos will be used for compilation of topographic map scaled 1:10,000

**3 – Plane control**

*a) Polygon 1, polygon 2*

*@ Technical requirements.*

– Polygonal network 1 will be established in accordance with the technical specifications in respect of the accuracy:

+ Relative error of the traverse: 1:10,000

+ Variance mean error : $\pm$ 5"

+ Closing error: 10"$\sqrt{n}$

n means angles in a traverse

– Polygonal network 2 will be established in accordance with the technical specifications in respect of the accuracy:

+ Relative error of traverse: 1:5 000

+ Variance mean error: $\pm$10""

+ Closing error: 20"$\sqrt{n}$

n means angles in a traverse

*@ Selecting bench mark locations.*

Bench marks will be established in fixed locations with open visibility.

While establishing a control grid by using GPS technology, all benchmarks will be placed in open and clear locations and transmitting station spacing is at least 500m. The visibility will be within the scope with angle of 75$^o$ and over. The angle in all cases will not be less than 55$^o$ and will be hidden in one side. The above parameteres will be clear for proper selection of time domain.

Polygonal benchmarks 1 and 2 will be concreted, the benchmark centre will be made of porcelain button and the surface will be carved with benchmark number and working organization name..

*@  Surveying methods and machine.*

*+ Polygonal network 1:*

The base points for establishment of polygonal network 1 are 2 triangular points graded IV.

The network comprises 11 points numbered from C I-1 to C I-11. It is designed to be 3 closing circle and surveyed by GPS-using Trimble device 4600ls-1 ton produced by an American firm. Total length is 73.1 km.

+ *Polygonal network 2:*

The base points for establishment of polygonal network 2 are triangular points graded IV and polygonal point 1.

The network comprises 12 points numbered from C II-1 to C II-12. It is surveyed by GPS-using Trimble device 4600ls-1 ton produced by an American firm. Total length is 46 km.

Accuracy of GPS 4600ls device

Length:

$$\sigma = ea2 + ( b.10^{-6} D)^2$$

Azimuth:

$$m\alpha = e\ p^{"2} + q^{"2} / D^{"2}$$

of which:

a    fixed error (mm)

 b    Fixed error factor

D   length of surveying side (km)

As for receiver 4600ls

a = 5mm , b = 1, p" = 1, q" = 5

Ms = ± 5mm ±5mmxD(D : surveying side in km)

Before surveying, PLAN software will be used to establish daily surveying schedule and forecast table of observable satellites.

Coordinates used to establish the forecast tables are mean longititudes and latitudes of the surveying area. Time for schedule establishment while observing: 60'.

- Minimum observing time:          60minutes

- Number of consecutive satellites in minimum: 4

- PDOP selected while surveying is not more than: 4,0

- Satellite anglar threshold is more than $15^0$

- Surveying height of antenna in 2 times (starting and ending time with accuracy of 1 mm)

- Using softwares allowed by the Ministry of Natural Resources and Environment to solve the network and side errors. The calculation will ensure to meet the following criteria:

1. Allowable explanation:          Fixed

2. Ratio:          > 1.5

3. Rms:          < 0.02+0.004*S km

4. Reference Variance:          < 30.0

5. RDOP:          < 0.5

Upon surveying, the equipment will be checked in accordance with the requirements:

a) Check operation of functional keys including soft and hard keys. All keys will be at good conditions.

b) Check the stability in signal receiving through pilot surveying testing (no less than 60 minutes).

c) Check the data transmission from receiver to computer.

d) Device placement locatins: clear and open. Surveying should be conducted in fine weather conditions in order to ensure the good quality of signal receiving.

**4 – Elevation control**

The elevation control network comprises 23 points: 11 points of polygonal network 1 and 12 points of polygonal network 2. Surveying is conducted by GPS technology, Trimble device – 1 ton, coupled with polygonal networks 1 and 2. The minimum surveying time is 60' in a surveying course. Accuracy in leveling, closing error (fh = ±50 $\sqrt{L}$)mm.

**5 -  Outputting data from designs to the field**

Geological works comprise portal, drill hole locations, axial line system will be converted and located in the field. Depending on the locations of designed works, technical methods will be applied in accordance with GPS technology and comprise one of the followings:

Geodesic polar coordinates

Intersection method

Straight-line method.

While outputting dat from design to the field, technical specifications will be executed, particularly Articles 8-11,8-25 of 1990 Normative Regulation on Geological surveying.

**6 – Geological mapping (inputting data from field to map)**

Data collected from geological and geophysical works by using surveying device will be plotted. Following are surveying methods which can be selected and applied:

Geodesic polar coordinates

Intersection method

Vision distance traverse method

Using total-station or GPS device

**7 – Establishing exploration lines.**

Arrangement of exploration lines shall be in accordance with the geological and geophysical designs.

Intervals on axial lines will be surveyed by Total station Leica TC407 and Leica TS02 or other devices with the same accuracy. Intersection of axial and horizontal lines will be marked by fixed benchmark and surveyed as major works.

Intervals on horizontal lines will be surveyed in vision distance with accuracy 1/300 with theodelite device DT 02, alluminium mia 3m, or other devices with equivalent accuracy.

Starting and ending points of the horizontal lines will be marked with fixed benchmark and surveyed as a minor works.

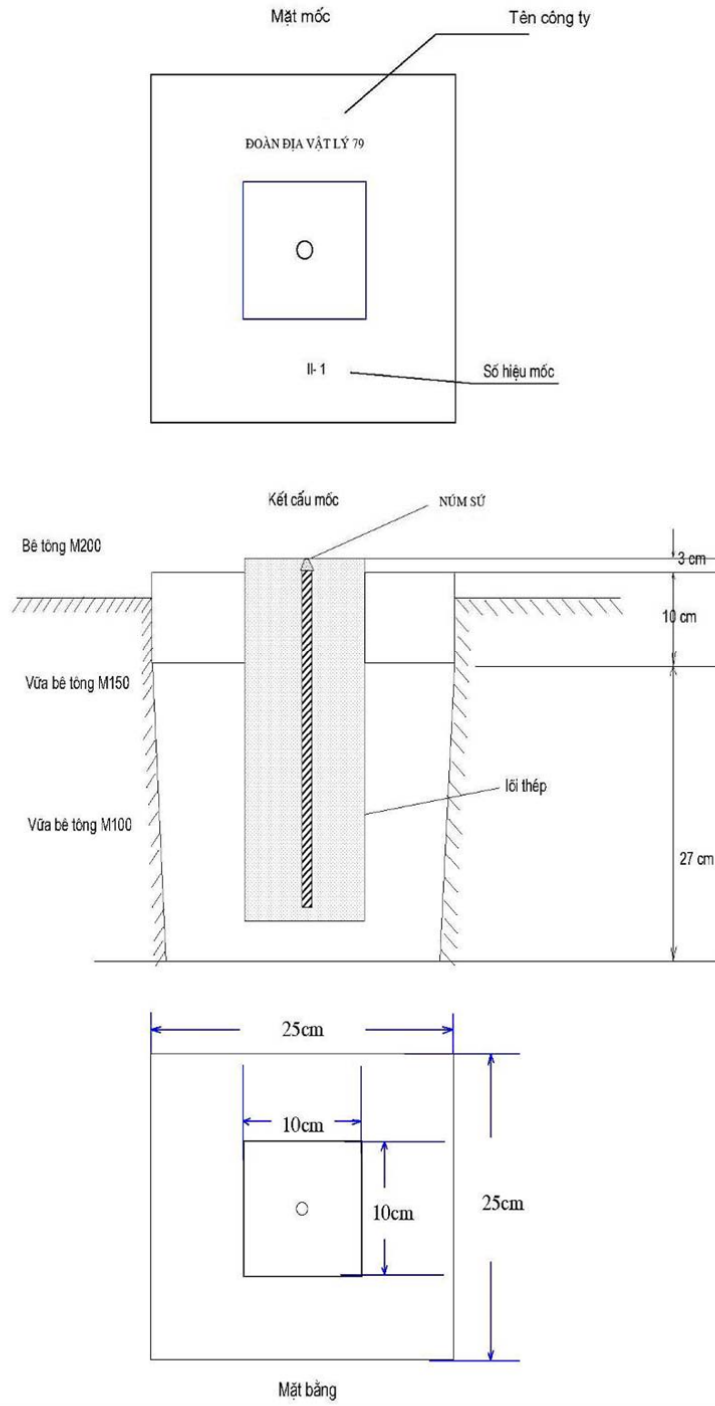**8 – Compile and digitize topographical maps scaled 1:10 000.**

- Toporgraphical maps scaled 1:10 000 will be compiled and digitized from ones scaled 1: 5000 by graphical softwares like Mapinfo, Cad…

All contents shown in maps, map frames and legends will be displayed by symbols and signals shown in Book "Signals of topographical maps 1:200, 1:500, 1:1000, 1:2000, 1:5000 and 1:10000" issued by the Ministry of Natural Resources and Environment of Vietnam.

All maps shall comprise plane and elevation controlling points, topographic and geological features as well as geological work and geophysical line locations

The Vang Tat - San Xay – Attapu Gold Mine area is divided into 10 sheets based on the area subjected to mineral prospecting and investigation scaled 1:10 000 to 1:5,000.

# MỐC ĐƯỜNG CHUYỀN CẤP 2

Mặt mốc                                Tên công ty

ĐOÀN ĐỊA VẬT LÝ 79

II- 1            Số hiệu mốc

Kết cấu mốc        NÚM SỨ

Bê tông M200                                3 cm

10 cm

Vữa bê tông M150

Vữa bê tông M100                     lõi thép

27 cm

25cm

10cm

10cm        25cm

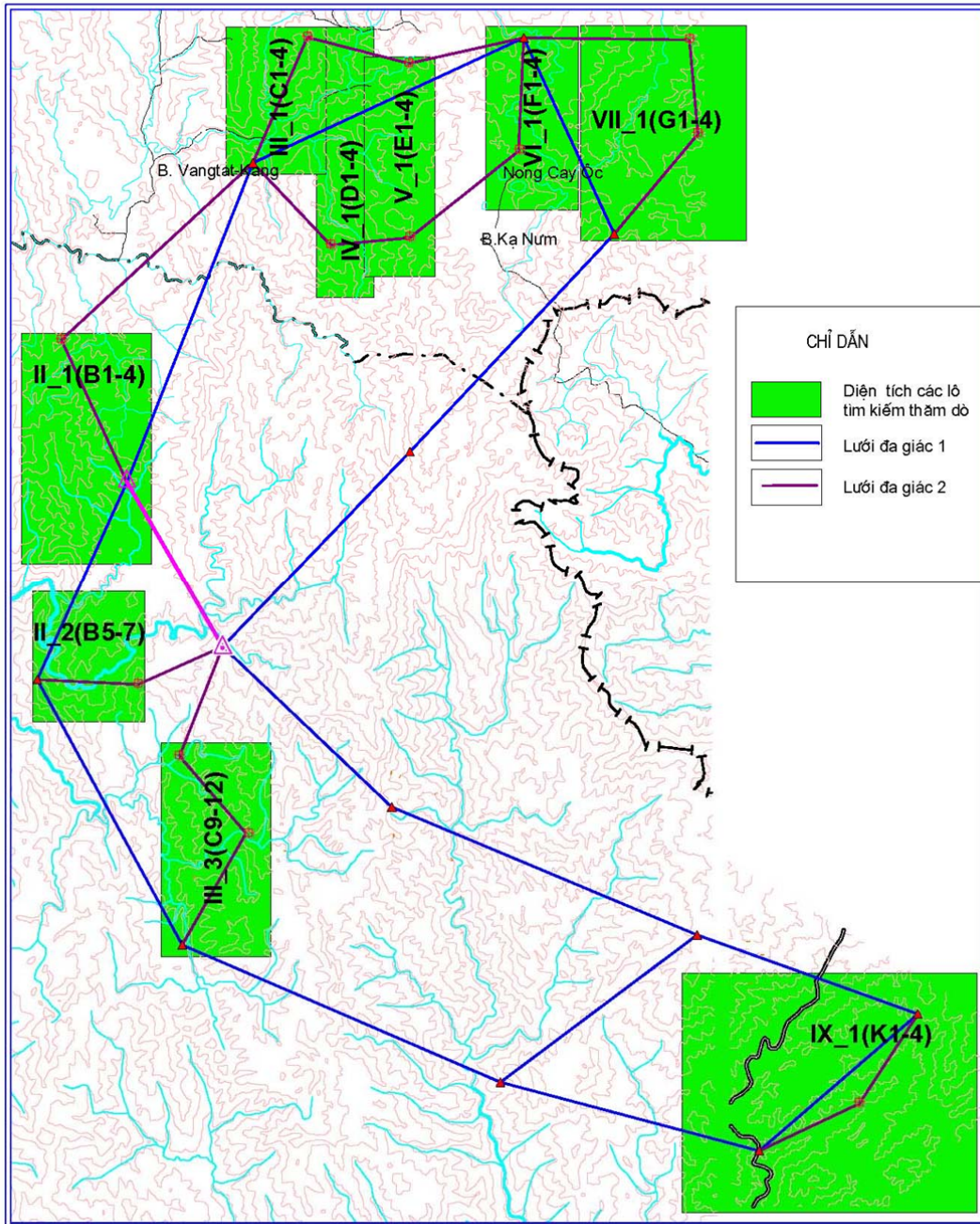Mặt bằng

Mốc đường chuyền cấp 2: Secondary traverse

mặt mốc: benchmark surface

- Company name
- Geophysical party No. 79
- Benchmark No.
- Kết cấu mốc: Benchmark structure
- Concrete M200
- Concrete grout M150
- Concrete grout M100
- Núm sứ: porcelain button

Lõi thép: reinforcement

Scheme of sheet combination

# SƠ ĐỒ GHÉP MẢNH



Legend:
- Area of exploration plots
- Polygonal network 1
- Polygonal network 2

**II – 2 – 3 : GEOPHYSICAL WORK:**

*Objectives and Tasks:*

**-** Define locations, scope, distribution area, depth of altered zones, Au, Fe-bearing mineralization zones, and especially unknown orebodies.

- Define geological factors: boundaries of rock members, magmatic blocks, geological faults… in connection with Au, Fe-bearing mineralization zones

- Select potential locations for design of drilling and excavation programs.

**A) TECHNICAL METHODS AND VOLUME**

*a) Rationale for method selection:*

- Geological-geophysical prospecting results in 2008 and geological prospecting results at 1:25,000 scale in 2009.

- Proposal's objectives: define scope and reserve of Au, Fe-bearing mineralization zones.

Given the above rationale, we propose the following methods:

- Induced polarization survey

- Magnetic survey

*b) Methods applied and work volume.*

*@ Induced polarization surveys*

*Objectives*: Define locations, scopes and development depth of altered zones and Au, Fe-bearing mineralization zones; Define boundaries of geological objects, structural factors of the prospecting areas; and Select locations for design of excavation programs.

*Surveying machine*: Equipment used for IP method is either multipolar receiver Elrecpro and transmitter VIP 3000 manufactured by the Republic of France, or other IP equivalents. Conductors connecting electrode with surveying device are the ones JCP-5 produced by Russia. Equipment and devices will be carefully checked before surveying in order to ensure the compliance with technical specifications.

*Grid of measurement points*: IP surveys will be arranged in line pattern with the line interval of 100m and the point spacing of 20m on lines. The grid of measurement points are 100x20m.

*Surveying technique*: The IP surveying method will be conducted with equipment system of either Dipol-Dipol or Pol-Dipol with dimensions d = a = 20 m; n = 6, d = a = 40m; n = 3 (dimension (n = 7 - 9). This will ensure the economic efficiency and meeting requirements of studying swallow to deep objects.

Following is the IP surveying layout plot with two equipment system of either Dipol-Dipol or Pol-dipol:

A    B         M1        N1

$\leftarrow - - d - - \rightarrow$         $\leftarrow - - d - - \rightarrow$    M2         N2
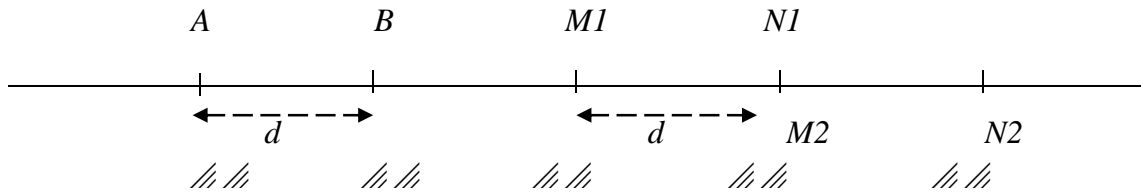
- Layout plot for Pol-Dipol with pole B at infinity

A              M1              N1

$\leftarrow - d - \rightarrow$

$\leftarrow - - d - - \rightarrow$              M2              N2
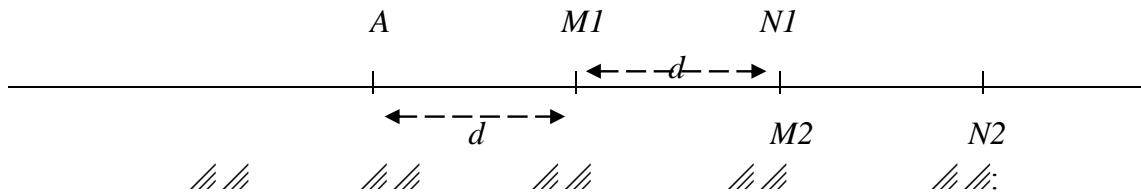
Of which: n: multiple of distance of two dipole centres against the dipole dimension $r_i = nd$; $n = J + 1$.

n = 1,2,3,4,5,6,7,8, 9 as j = 0,1,2,3,4,5,6,7,8 meaning the order of dimension displacement of surveying devise.

The depth depends on the distance r and is defined by the following formula:

$$Z_i = n \ \dfrac{r_i}{2} \ ; \ j=1,2,3,4...7,8 \text{ means the prospecting depth order}$$

The dimension of the surveying device is as follows:

- Equipment system Dipol-Dipol

| n | A(m) | B(m) | M(m) | N(m) |
|---|------|------|------|------|
| 1 | 0 | 20 | 40 | 60 |
| 2 | 0 | 20 | 60 | 80 |
| 3 | 0 | 20 | 80 | 100 |
| 4 | 0 | 20 | 100 | 120 |
| 5 | 0 | 20 | 120 | 140 |
| 6 | 0 | 20 | 140 | 180 |
| 7 | 0 | 40 | 180 | 220 |
| 8 | 0 | 40 | 220 | 260 |
| 9 | 0 | 40 | 260 | 300 |

- Equipment system Pol-dipol

| n | A(m) | M(m) | N(m) |
|---|------|------|------|
| 1 | 0 | 20 | 40 |
| 2 | 0 | 40 | 60 |
| 3 | 0 | 60 | 80 |
| 4 | 0 | 80 | 100 |
| 5 | 0 | 100 | 120 |

| 6 | 0 | 120 | 160 |
|---|---|---|---|
| 7 | 0 | 160 | 200 |
| 8 | 0 | 200 | 240 |
| 9 | 0 | 240 | 280 |

**With the above equipment system, theoretically we are able to study geological objects with depth ranging between 15m and 130m.**

**The surveying methods are automatically conducted via the software of Electre II. The surveying software will start only when the technical specifications of surveying devices are met.**

*e. Proposed volume of IP surveying.*

Given the geological-geophysical prospecting results, we have outlined 10 mineral prospects, of which there are nine Au prospects and one Fe prospects. Grids of IP lines are proposed to be established for 9 areas with 328 lines and 7730 points in total (7029 measurement points and 701 testing points).

Work volume for each area is shown as follows

| Work Area | Quantity of measurement lines | Line length (m) | Quantity of points | |
|---|---|---|---|---|
| | | | Measurement points | Testing points |
| Area II_1(B1-4) | 9 | 500 | 180 | 126 |
| | 3 | 500 | 60 | |
| | 5 | 800 | 140 | |
| | 13 | 400 | 182 | |
| | 11 | 500 | 220 | |
| | 15 | 610 | 330 | |
| | 6 | 700 | 144 | |
| *Total* | *62* | *4,010* | *1256* | *126* |
| Area III_3(C9-12) | 36 | 620 | 720 | 90 |
| | 9 | 500 | 180 | |
| *Total III_3(C9-12)* | *45* | *1,120* | *900* | *90* |
| Area V_1(E1-4) | 8 | 500 | 160 | 64 |
| | 20 | 700 | 480 | |
| *Total V_1(E1-4)* | *28* | *1,200* | *640* | *64* |
| Area VI_1(F1-4) | 11 | 510 | 220 | 78 |
| | 5 | 620 | 100 | |
| | 7 | 940 | 238 | |
| | 11 | 550 | 220 | |
| *Total VI_1(F1-4)* | *34* | *2,620* | *778* | *78* |
| Area VII_1(G1-4) | 7 | 700 | 168 | 80 |
| | 4 | 500 | 80 | |
| | 2 | 700 | 48 | |
| | 3 | 1000 | 114 | |

| | | | | |
|---|---|---|---|---|
| | 2 | 800 | 56 | |
| | 1 | 400 | 12 | |
| | 8 | 500 | 160 | |
| | 8 | 600 | 160 | |
| *Total VII_1(G1-4)* | *35* | *5,200* | *798* | *80* |
| Area IX_1(K1-4) | 10 | 500 | 200 | 80 |
| | 9 | 530 | 180 | |
| | 12 | 390 | 168 | |
| | 13 | 500 | 260 | |
| *Total IX_1(K1-4)* | *44* | *1,920* | *808* | *80* |
| Area VII_2(B5-7) | 6 | 600 | 120 | 41 |
| | 7 | 800 | 196 | |
| | 4 | 700 | 96 | |
| *Total VII_2(B5-7)* | *17* | *2,100* | *412* | *41* |
| Area III_1(C1-4) | 23 | 600 | 460 | 92 |
| | 8 | 380 | 112 | |
| | 7 | 570 | 140 | |
| | 1 | 770 | 27 | |
| | 6 | 860 | 186 | |
| *Total III_1(C1-4)* | *45* | *3,180* | *925* | *92* |
| Area III_2(C5-8) | 2 | 600 | 40 | 50 |
| | 4 | 800 | 112 | |
| | 3 | 1100 | 126 | |
| | 3 | 1000 | 114 | |
| | 6 | 500 | 120 | |
| *Total III_2(C5-8)* | *18* | *4,000* | *512* | *50* |
| Total | *328* | *25,350* | *7029* | *701* |

*- Allowable errors:* $\delta\eta_k \leq \pm 10\%; \delta\rho_k \leq \pm 7\%.$

*f. Surveying results***:**

**- Polarization profile on each surveying line.**

**- Resistance profile on each surveying line.**

**- Geological-geophysical profile on each surveying line.**

**The above results will enable us to outline boundaries and ore-bearing altered zones.**

@ *Magnetic survey:*

*Objectives*: Define scope of ground anomalies to assess the geological characteristics and relationships with iron ore and other types of ore; define development direction of orebodies, ore-bearing mineralization zones; and assess their potential depth.

*Surveying device*: Use proton magnetometer typed MMΠ - 203 và MINIMAG produced by Russia. Prior to field seasons, all devices will be checked in the Unit of Geophysical Machines Verification (VILAS - 009). In every survey, magnetometers used will operate at the same time.

*Surveying grid*: Grids will be arranged in geological lines with line interval of 250m and point spacing of 5m on lines.

+ *Grid of testing points*: used to test surveying devices before and after a surveying campaign. These grids will be numbered from KT1, KT2…KT15, fairly evenly established within prospecting areas and connected to one common point (Article 48, Normative Regulation on Ground-based magnetic exploration). Locations of testing points on the design plot may be changed to facilitate the grid establishment.

Testing points will be in accordance with the following requirements:

- Near camp, easy in traveling, flat terrain, no strong wind and sufficient light.

- Away from industrial works, traffic roads, transformers, electric lines and other items which can vary magnetic field at testing point location in any time or generate unconformable magnetic field at surveying device placement locations…etc.

Mean square error of each testing side is defined by:

$$\sigma_m = \pm\sqrt{\frac{\Sigma\delta_i^2}{N-1}}$$

Of which: $\delta_i$ means difference between surveying No. i at the testing point and mean value of surveying times N at that point. The specified error is $\sigma_m \leq 7$ nT.

Mean square error of the testing point grid will be defined by:

$$\sigma_c = \sqrt{\frac{\sum_{i=1}^{n}\sigma_i^2 P_i}{r}}$$

$\sigma_c \leq \pm 10$ nT

Of which: $\sigma_i$: difference between two values of magnetic field of polygonal side no. i before and after balancing

P$_i$: weight of polygonal side no. i, n: number of sides of a standard grid, r: number of polygons. The specified error is $\sigma_{KT} \leq 10$ nT.

+ *Grid of measurement points*: Measurement points are at 10-meter intervals. In case of detecting anomalies, the measurement points are at five-meter intervals. Measurement point spacing on each geophysical surveying line is 5m in average. Each surveying time will start and end at a testing point. In case of detecting ground magnetic anomalies, magnetic surveying routes are

still underway until reaching a stable condition without anomalies (possibly beyond the studying area)

While recording, it is essential to specify ending and starting points of a surveying range of 5m, 10m or denser.

In order to assess the surveying accuracy, independence surveys will be conducted evenly over the prospecting area.

$$\sigma_{th} = \sqrt{\frac{\Sigma \sigma_i^2}{2n}}$$

Of which: $\sigma_i$ means the difference between two surveying times.

n means number of testing points.

The specified error is $\sigma_{th} \leq \pm 15$ nT.

Mean square error of surveying data will be defined by:

$$\sigma = \sqrt{\sigma_c^2 + \sigma_{th}^2}$$

The specified error is $\sigma \leq \pm 20$ nT.

*d. Surveying magnetic variation*: The magnetic variation and magnetic surveyings are conducted at the same time. The commencement time for this work is 1-2h earlier than the daily magnetic surveying courses at a testing point at camp. While surveying, the magnetometer will be worked every 5 minutes. The proposed work volume :  2 months/machine.

*e. Volume* :

- Testing point: 5 ones.

- Measurement points: Total square No. IV-1: 2,336km$^2$, measurement point spacing on a geological line: 10m, measurement point density: 100m$^2$/point, number of measurement points as proposed: 23,360, testing points (10% of measurement points): 2,336. Magnetic survey based on proposed line: 1780 measurement points and 180 testing points.

Total magnetic surveying points: 23,360 + 2,336 +1,780+180 = 27,927 points

*f. Outcomes*:

- Magnetic anomaly plots ΔTa

- Magnetic anomaly maps ΔTa

**B) METHODS OF ANALYZING AND PROCESSING GEOPHYSICAL DOCUMENTS**

*a) Resistivity surveying.*

*+ Quantitative processing:*

The IP sounding materials will be processed by software RES2DINV produced by Geomoto Software (Malaisia). The material processing will be conducted by the smoothness-constrained least-squares method. This software facilitates the automatic processing for establishment of 2D resistivity profiles for two parameters of IP and Resistivity. Of IP/Resistivity method, processed rock physical parameters (resistivity

and polarization) are main information for determination of Au-bearing sulphide mineralization zones.

The processing of Resistivity/IP sounding materials will produce two files: profile of apparent resistivity ($\rho_k$) and polarization value ($\eta_k$). These files are in image type and can be converted by other softwares like surfer, mapinfor and Autocad.

The processed IP sounding materials will be interepreted based on the characteristics of ore-bearing mineralization zones and accompanied elements, characteristics of country rocks, distribution locations, forms and ore depth. The interpretation will be conducted in combination with observation of exposed orebodies and processing of documents in respect of several deposits with the same origine and geological characteristics.

The outcomes of processing IP sounding materials are to establish a geological-geophysical profile comprising ore-bearing mineralization units, boundaries between rock members and geological faults.

### b) Magnetic surveying.

### + Including the following steps:

- Adjust magnetic variation.
- Balance grids of testing points.
- Convert surveying data to one base testing point.
- Defining magnetic anomaly $\Delta T_a$.

The magnetic anomaly $\Delta T$ will be defined by:

$$\Delta T_a = T_{qs} - (T_{kt} + \Delta T_0) - \delta T - \Delta T_g$$

Of which

$T_{qs}$ : Figure read from the device at a measurement point.

$T_{kt}$ : Figure read from the device at a testing point.

$\delta T$ : Adjust the magnetic variation at the surveying time against the magnetic field value defined in morning.

$\Delta T_0$: Magnetic field incremental of a testing point over a base testing point.

$\Delta T_g$ : Adjust gradien of a normal magnetic field

### II – 2 – 4: ESTABLISHMENT OF GEOLOGICAL WORKS

The primary geological works are swallow holes for pan concentrate and geochemical sampling, sill-intercepting trenches and drilling.

The above works will be conducted as soon as there are results of detailed investigation.

### a) Pitting for pan concentrate and geochemcial sampling:

These pits will be places in lines with line spacing of 100m and hole spacing on a line of 100m. One pit is 1x1x1 m in dimension (wide x long x deep).

The pit numbering will comprise the followings:

+ Prospecting area.

+ Axial line

+ Horizontal line

+ Pit number

Total work volume for this item is shown in the sampling section.

*b) Trenching*

There are two types of trenches

- *Discovery trench:* is dug over the entire development area of high-grade heavy minerals dispersion haloes and geochemical contours, perpendicular to the proposed mineralization development direction and geological structure. The trenches will be placed in lines at 100-metre intervals.

- *Interception trench:* in case of discovery trenches dug, their control grid will be established with line intervals of 100m and therefore, trenches will control the entire mineralization body or zone.

The trenching volume for the area to be preliminarily explore dis shown in the following table.

| No. | Investigation area | Volume (m$^3$) | Drawing No. | Note |
|-----|--------------------|-----------------|-------------|------|
| 1 | Au – II – 1 | 2650 | II – 1 – 4 | |
| 2 | Au – III - 1 | 1675 | III – 1 – 4 | |
| 3 | Au – III - 2 | 1350 | III – 2 – 4 | |
| 4 | Au – III - 3 | 1375 | III – 3 – 4 | |
| 5 | Fe – IV - 1 | 250 | IV – 1 - 4 | |
| 6 | Au – V - 1 | 750 | V – 1 – 4 | |
| 7 | Au – VI - 1 | 1075 | VI – 1 – 4 | |
| 8 | Au – VII - 1 | 525 | VII – 1 – 4 | |
| 9 | Au – IX - 1 | 1275 | IX – 1 – 4 | |
| | *Total* | *10,925* | | |

The trench numbering will comprise the followings:

+ Investigation area

+ Main axial line shown in the Roman numeral.

+ Horizontal line shown in the Latin numeral and in ascending order (from north to south and from west to east).

+ Trenches on a line is shown in the same order as horizontal line.

For example :

**(Fe – IV – 1) I – L2 – T4.**

Channel samples from trenches will be collected in the ascending order and from left to right. Numerator means the sample number and denominator means channel samples collected from one trench.

- Drilling will be conducted given the trenching results and geophysical materials obtained. Drilling will be conducted in grids so as to evaluate the forecasted reserve resource 333.

### c) Exploration drilling:

This work controls initially the exposed orebodies through interception trenches.

The exploration drilling network in the preliminary exploration has not been in compliance with the control depth of 100m in terrain plane.

Drilling numbering will indicate the followings:

+ Preliminary exploration area.

+ Axial line + horizontal line.

+ Drill hole number on a line.

Along with the above symbols, core samples collected from the ore-bearing depth will facilitate the material reading.

### II – 2 – 5: SAMPLING, SAMPLE PREPARATION AND ANALYSIS:

- The sample preparation will be conducted in accordance with the general technical norms. As for BLEG samples alone, they will be stored at temperature of < $60^{o}C$ in order to ensure that Hg is not evaporated before analysis.

- As for BLEG samples, it is necessary to focus on finding of elements indicative of geochemistry associated with Au mineralization, like As, Ce, Pb, Zn, Cu, Sb, Bi, Hg.

- Samples will be analyzed for determination of grades of Au and Ag through fire assay; of which 10% will be analyzed in AAS method to define other elements like *As, Sb, Cu, Pb, Zn, Ba, Hg* associated with Au which acts as an element to compare with BLEG samples of geochemical contours.

The results of prospecting and evaluating forecasted resource reserve categorized 333 will be a basis to outline areas subjected to follow-up exploration so as to upgrade the resource reserve to category 122 favorable for mining design.

### + Sampling, sample preparation and analysis:

As for iron ore, the sample preparation will be conducted with specialized equipment.

- Samples collected in type of observation ones will be used for studies of mineral composition and of mineral origin for following-up assessement of mineralization scope.

- Channel and core samples will be collected in accordance with the technical specifications.

- The sample analysis is prepared based on criteria of assessing the ore quality and defining useful elements like TFe, Mn and unuseful elements S, P, Pb, Zn, As…