CHAPTER III
GEOLOGICAL EXPLORATION AND ENVIRONMENTAL PROTECTION PROBLEMS

In order to serve for prospecting and evaluation of mineral resources of categories 122; 333; and 334A, together with geological and hydrogeological-geoengineering surveys, there are other indispensable related works such as geodesic, geophysic, drilling and engineering works, samples' processing and analyzing, which all were implemented in combination in the exploration work at the Vang Tat Gold Mine.

To guarantee information for report on exploration, such work as geodesic, geophysic works are presented in separation in the form of appendix enclosed with the report. Thus, appendix 01: Report on the results of geodesic work; appendix 02: Report on the results of geophysic work. These works are briefly mentioned in this report.

III.1 – GEODESIC WORK

III.1 -1 - The aim and task:

+ Mapping network control plane, altitude of exploration areas serving for lineation and reserves calculation of gold ore in the Vang Tat Gold Mine and taking as basis for determination geological engineering and relief mapping.

+ Determining coordinates, altitude and plotting geological engineering on the map.

+ Determining system of survey lines: axis lines and transversal lines.

+ Compilation of topographic map at the scale of 1/2.000 (h = 2 m) for an area of 3 km^2.

III.1 – 2 – Relief characteristics and related materials and data:

+ The surveying area belongs to high mountainous region with altitude of > 1000m. Dense vegetation, mostly primeval forest, that effect to the opening direction for arrangement of control grid and compilation of topographic map. According to the classification of difficulties, the surveying area belongs to difficulty level 5.

+ Available data on the area are only topographic map on the scale of 1/100.000 supplied by Geological mapping Survey of Lao P.D.R. The mark of coordinates, altitude of State ĐCCS III on the Vietnam-Laos border are using as basis for establishment of network controlling plane, altitude serving for topographic mapping and measurement of geological engineering.

III.1 – 3 - Content, results and implemented work volume:

***1*. Establishment of triangulation grid H IV**

- *Measurement equipments:*

The triangulation grid of IV class has been measured by GPS technology using equipment for setallete locator model 4600LS produced by US Trimble Firm. The accuracy of equipment is:

- Ms = ±5 mm + 1 x 106 x D (D – length of measurement edge in km)

- *Implementation results*

The state triangulation grid of IV class includes 7 points designated from GPS.1 to GPS.6, starting from the state coordinates mark at the Vietnam-Laos border. The relative error of edge measurement is < 1/ 80.000, azimuth biquadratic error of edge 1". Technical norms are satisfied regulations of geodetic procedures in force.

2. Establishment of analytic grid I

The basis of the analytic grid I is transmitting points class IV. The analytic grid I includes 4 points designated from CI.1 to CI.4 which are measured by locator GPS model 4600ls produced by US Trimble Firm. The technical norms of the analytic grid I are satisfied regulations of geodetic procedures in force. The transmission grid class IV and the analytic grid I are adjusted by specialized software of Trimble Firm.

3. Establishment of polygonal grid II

The basis for arrangement of polygonal grid II are transmitting points class IV, analytic points I. The polygonal grid II is arranged by 2 corresponding polygons. The line 1 is symbolized from CII.1 to CII.5 with 5 points. The line 2 is symbolized from CII.6 to CII.13 with 7 points (enclosed herewith drawing showing arrangement of control grid). The polygonal grid II is measured by electronic multi-meter TCR.407 produced by Switzerland in 2006 with accuracy of angular measurement $m\beta = \pm 5$" and that of linear measurement $m_s = 3$ mm ± 3ppm. The horizontal angle is measured by 3 reversible circles (ring?). The length and height difference are measured double time towards and return. The result is taken as average of measurement times. The polygonal grid II is put in adjustment software of Hanoi University of Mining and Geology.

4. Establishment of altitude control grid:

The altitude control grid includes 24 points which is implemented at the same time with plane control, the accuracy is corresponding to technical quadrant, discrepancy ($fh = \pm 50 \sqrt{L}$)mm.

5. Establishment of mapping control grid:

The mapping grid includes transmitting longitude-latitude paths and transmitting distance of vision paths. Totally, there are 6 transmitting longitude-latitude paths including 26 points and 7 transmitting distance of vision paths including 68 points.

6. Compilation of topographic map:

- Ex-professional mapping :

The topographic map at the scale of 1:2000 with 2m regular height space was compiled by comprehensive measurement on the points of transmitting path h IV, analytic I, polygon II, points of latitude-longitude transmitting path, etc of an area of $3km^2$.

In order to increase survey control points, additionally develop machine stations by polar coordinate method from the basic plane control points.

To carry out center plumb, machine balance, orientation and measurement of detailed points. Detailed measurement points were measured by a method of data storing in meter, transmitting data from meter into computer by data storing software already planted in the computer.

The detailed points were measured according to coordinate program of the machine station, coordinates of altitude were directly determined, all points of typical relief such as mountain saddle tops, rivers, streams, gorges, vertical walls, etc have been presented. Geographical object points such as roads, houses, storages were also plotted on the map. Due to complicated relief, the profile measurement method was used for adding more detailed points, so that to ensure a density of 65 points/dm^2 on the drawing and average space between points is 20m.

- Editorial work of topographic map:

All of control points, geographical locations and ground objects, geological and geophysical engineering were expressed on the drawings. The ground objects were mapped and delineated due to scheme and noted on measurement number. All typical ground objects in the mine were expressed. After mapped, drawings were compared and controlled in the field and then were digitalized, edited in accordance with regulations and responding with right number and stored in USR and in CD.

Contour lines were drawn according to interpolation method, equal height place is 2m. The topographic map was compiled at the scale of 1/2.000 including two sheets: 1 and 2.

7. Relief profile survey, leading geological and geophysical engineering out to the field:

- The systems of axis lines serving for geophysical survey and field trip are lead out to the field from designs including 3 axis lines, 47 points of exploration lines from line 2 to line 30A with the spaces between lines being 100m and 50m.

- Relief profile survey at the scale of 1/2.000 with total length of 32.46 km.

- To lead engineering out to the field 33 exploration drill holes by polar coordinate method (azimuth and length).

- To measure and to plot all geological engineering onto map by electronic multi-meter TCR 407 based on points of measurement stations from latitude-longitude slop lines up according to method of direct measurement of coordinate of point altitude. Measured geological engineering include:

- 33 drill holes.

- 21 exploration and exploitation drifts.

- 32 points of axis lines and 94 starting and ending points of horizontal lines, engineering were plotted onto the topographic map for correlation, comparison and adjustment.

8. Control work:

During construction, the unit has directly controlled over 100% of volume. Project manager and Viet-Lao Joint Stock Company have directly controlled over the quality of work and control landmarks (enclosed herewith some images) after finishing the field trip.

Office materials include book recording detailed measurement results, topographic drawings, table of adjustment calculation results, list of coordinates of control points, increase density of already examined geological engineerings before submit for approval.

9. The results of adjustment calculation:

Table III.1 – 9 : The results of adjustment calculation of triangulation class IV in the table 1

Point name	North	N error	East	E error	Elevation	E error	Fix
GPS 6	1656477.530	0.007	758797.036	0.014	971.130	0.006	
GPS 1	1658761.068	0.009	757577.447	0.011	984.810	0.006	
GPS2	1658829.726	0.007	759146.294	0.004	1267.41	0.006	
GPS-3N	1625161.020	0.000	775331.600	0.000	1081.00	0.000	N E e
GPS3	1657937.582	0.010	759864.585	0.009	1330.98	0.009	
GPS4	1656416.094	0.005	758003.132	0.011	975.183	0.006	
GPS5	1655620.836	0.011	759378.468	0.011	1063.17	0.013	
GPS6	1656477.563	0.005	758797.007	0.007	971.298	0.006	
Cap1-I2	1657369.615	0.009	758873.934	0.008	1100.56	0.019	
Cap1-I1	1657949.283	0.008	757824.484	0.006	952.004	0.007	
Cap1-I4	1655926.374	0.012	758384.252	0.011	885.625	0.016	

T23	1656928.051	0.013	758544.085	0.008	992.821	0.006
CAP1-I4	1655926.479	0.012	758385.468	0.007	885.799	0.006
DC1	1637489.147	0.006	768108.153	0.009	307.966	0.005

The calculation results of triangulation survey grid II which met the technical norms in the table III.1 – 2

No	*Name Line*	Length of line	Measured mβ"	Permitted mβ"	Measured m_s/s	Permitted m_s/s	Measured fh (m)	Permitted fh (m)
1	*CII1-CII5*	3,571	1,34	10"	1/33.200	1/5000	0,008	0,018
2	*CII6-CII14*	5,146	2,64	10"	1/21.800	1/5000	0,005	0,024

The calculation results of control survey grid II that met the technical norms in the table III.1 – 3

No	Name line	Length of line	Error					
			Measured mβ"	Permitted mβ"	Measured m/s	Permitted m_s/s	Measures fh (m)	Permitted fh (m)
1	A1 - A3	1.7	-10.1	30	1/22.500	1/1000	0.135	0.260
2	A4 – A7	1.5	5.3	30	1/15.400	1/1000	-0.196	0.245
3	A8 – A13	2.5	6.4	30	1/18.200	1/1000	-0.091	0.316
4	A14–A 16	1.8	-7.3	30	1/27.000	1/1000	0.125	0.268
5	B1 – B4	2.2	-2.9	30	1/12.000	1/1000	0.100	0.297
6	B5 – B10	1.3	8.3	30	1/14.000	1/1000	0.120	0.228

In short: The geodesic data are adequate and have ensured the accuracy in accordance with procedures issued by the General Department of Geology of Vietnam in 1990, which can be used for exploration, calculation of gold reserves and further mining design.

III. 2. GEOPHYSICAL WORK

III.2 – 1. The aim and task:

- To determine location and depth of gold-bearing mineralization zones, especially that of rich ore bodies.

- To determine geological factors such as boundary between rocky beds, magmatic massifs, geological faults, etc related to gold-bearing mineralization zones.

- To select perspective sites for orientating design for drilling and engineering works .

III.2 – 2. Technical methods for survey:

2 – 1. Network of measurement points:

The IP sounding was carried out on 47 lines, from line 2 to line 30A with average length of a line being 700m. from line 2 to line 12, the space between lines is 100m, while from line 13 to line 30A, the space between lines is 50m. On all survey lines, the 2-dimension equipment was used with spaces between measurement points are 50m and 10m (space 50m is used for the whole length of the line, while space 10m is used for fragments of lines where is fixed as ore-bearing mineralization zone)

2 – 2. Machine and equipment:

Machine used in IP sounding method is multipole detector (geophone) Elrecpro, generation source is VIP 3000 produced by France. Conductor wires connected electrode with geophone are electroprospecting conductor wires JCP manufactured by Russian Federation. The machines and equipments are examined to ensure in accordance with the technical norms before measuring .

2 – 3. Measurement techniques:

The IP sounding method was carried out with Pole- Dipole equipment system enclosing equipment of 2 dimensions d=50, n=8 and d=10, n=8, infinite pole was driven into the ground perpendicular with line and 1000m-2000m far from it. The implementation order on the lines is as follows:

- Due to equipment of dimension d=50m, n=8, on the whole length of all lines, the infinite pole was driven into the ground perpendicular with the line and 2000m far from it.

- After primary processing of data received from equipment of dimension d=50, n=8, together with geological observation, on fragments of lines, which are determined to be potential on gold, measurement with equipment of dimension d=50, n=8 will be carry out in order to make clear potential ore bodies.

The measurement is completely automatic with control software Electre II, software examining technical norms of the machine, when conditions of ground touching are met the standards, then the measurement can be operated.

2 – 4. Methods of processing and analyzing the data:

The data obtained from the field trips are controlled and managed by software Electre II. Current and receive electrodes are controlled and displayed values of groud-touch resistance of each electrode. If obtained values are out of reliability, they should be excluded.

The data obtained from IP/resistivity sounding method are interpreted by software RES2DINV produced by Geomoto Software firm (Malaysia). Interpretation process of data is done according to the smoothness-constrained least-squares method. The program allows automatically interpreting in order to establish 2D elecric section for both two parameters: resistivity and IP (IP pseudo-section and Resistivity pseudo-section). In the IP/resistivity sounding method, after interpretation, the physical parameters of rock (resistivity and polarization) become a main information for determination of potential on gold mineralization zones.

The interpretation of data obtained from IP/resistivity sounding method is resulted in giving 2 files of results: profile of equivalent apparent resistivity (ρ_k) and polarization values (η_k). These are image files which can be conversed so that they can be perfomed by such softwares as Surfer, Mapinfor, Autocad.

The data of IP sounding method, after processing, will be interpreted on the basis of characterization of ore-bearing mineralization zones. Accompanying elements, characteristics of surrounding rocks, ore forming origin, etc in combination with observation of exposed on the surface, in difts ore bodies and the experiences on processing of data of some ore points of the same origin and geological characteristics.

The processing of data obtained from IP sounding method is resulted in establishment of geological-geophysical section including ore-bearing mineralization zones, boundary between rock members, geological faults, etc.

III. 3. Volume of implemented works and their quality

3 – 1. Volume of work

The IP resistivity sounding has been carried out on all of 47 observation lines with a total volume of 1399 points, in which:

- With equipment dimension d=50m, n=8: total 658 points.
- With equipment dimension d=10m, n=8 : total741 points.

3 – 2. Quality of work:

The total volume of IP sounding includes 1399 points, in which 1287 measured points and 112 control points. The measurement errors are:

$\delta\eta_k = \pm 5{,}2\%$ (Technical procedures: $\leq \pm 7\%$)

$\delta\rho_k = \pm 6{,}9\%$ (Technical procedures: $\leq \pm 10\%$)

III.4. The results of geophysical survey:

4 – 1. Characteristics of electric parameter of main geological objects:

Geophysical parameters of the geological objects which have mainly been studied are apparent resistivity parameter RHo (ρ_k) and polarization parameter IP (η_k).

The main geological objects in the study area can be distinguished according to geophysical features and groups of quartzite, schist rocks and altered into horn, greenized schist, magmatic rocks, geological faults, especially gold-bearing mineralization zones distributed in greenized schist bed.

The apparent resistivity parameter RHo (ρ_k) and polarization parameter IP (η_k) of geological objects in the whole working area widely variable. These geological objects, especially gold-bearing mineralization zones, quartzite, horny schist are clearly differentiated, as that are observed on every surveying line. The main characteristics of electric parameter of geological objects are as follows:

- Quartzitic rock has highest resistivity and lowest polarization. The values of apparent resistivity ρ_k are concentrated in the interval from 3000Ωm to 30,000Ωm while the values of polarization η_k are from 0.2 % to 1.5 %.

- Group of schists has lowest values of resistivity and low values of polarization which can be seen as lowest in the section. (This group of schists include quartz-sericite schist, clayey schist, etc). The values of apparent resistivity ρ_k are concentrated in the interval from 30Ωm to 300 Ωm, the values of polarization η_k from 0.2 % to 1 %.

- Horny schist has high values of resistivity only lower than that of quartzite and similar to that of magmatic rocks, high polarization with wide vatiable amplituda. The values of apparent resistivity ρ_k are from 1100 Ωm to 7000Ωm, the values of polarization η_k are from từ 1% đến 20%.

- The magmatic rocks have high values of resistivity and very high values of polarozation with wide variable amplitude as that of horny schist. The values of apparent resistivity ρ_k are from 800 Ωm to 10,000Ωm, the values of polarization η_k are from 0.8% to 5% .

- Geological faults are most characterized by variety of very high. polarization values from negative to positive. These values must be excluded during processing, however they are useful in identification their existence and location on the measurement line.

- Gold-bearing mineralization zone lies between quartzite and schist, having average values of resistivity, higher than that of schist much lower than that of quartzite and horny schist, its polarization is higher than that of quartzite, lower than that of schist, especially horny schist. The gold-bearing mineralization zone is very clearly distinguished from surrounding rock on the electric profile. The values of apparent resistivity ρ_k are concentrated in the interval from 300Ωm to 2500 Ωm (at some lines its marginal values near quartzite these values are higher than 2500Ωm, at some lines up to 6000 Ωm),

the values of polarization η_k are from 1 % to 5 %. There are some smaller zones bearing gold-bearing bodies of higher content (at the centers of geophysical anomalies).

4 – 2. The results of geophysical work:

The results of geophysical work are processed at the same time with field survey. The sites of high potential on mineralization and their development depth have been defined on the basis of typical parameters of gold-bearing mineralization zones. Right during the field survey, the data on geophysical measurement obtained from geophysical work are useful for related works such as trenching, field exploration drilling, etc.

The results of IP resistivity sounding, after processing, synthesized and combined, have been expressed in the form of 3 profiles: resistivity profile (Rho profile), polarization profile (IP profile) and geological-geophysical profile. On the geological-geophysical profile, there has been realized boundary between rocky types, gold-bearing mineralization zones, geological faults.

Generally, the following main geological objects have been determined in the study area:

- At the East of the profile, in general, the high mountain part is coincided with quartzite, the distribution area, space location of which are relatively stable at almost all of observation lines (from line 2 to line 26A). at Rho and IP profiles of the lines, this formation ie clearly expressed by high to very high values of resistivity (highest in entire profile), low values of polarization. This formation can be seen as “index horizon”.

- Two gold-bearing mineralization zones have been determined as follows:

+ Gold-bearing mineralization zone 1 locates close to west boundary of quartzite zone, dipping to the East. This mineralization zone is continuously stretched from line 2 to line 27 with a thickness of from 50m to 150m and a width of from 100m to 150m and may be bigger.

+ Gold-bearing mineralization zone 2 is lying parallel with zone 1 at the West, stretching from line 17A to line 30. Its depth and width are strongly varied and had to be narrowed at the places close to the magmatic rocks.

+ Besides 2 mineralization zones of high potential, geophysical data allow to determine the boundary of gold-bearing rock members (mostly greenized schist temporary called greenschist).

- It is determined the location of quartz-sericite schist, horny schist, clayey schist, etc lying at the end of lines and beneath ore zones and quartzitic ones.

- It is determined the location of space location of magmatic massif lying on the surface as well as at depth.

Ther is determined a fault at the West of quartzitic zone adjoining with ore zone. This fault is ore-forming developing nearly to sub-meridional. Besides above-mentione main fault, there are recognized unclear signs of faults at the lines 12, 13, 18, 18A, 25 and 25A, these faults may be of sub-parallel direction which is parallel with observation line. This is necessary to pay attention to this place during investigation.

At the South of the study area, magmatic massif is obviously expressed from line 24A to line 30A and it is exposed on the surface from line 25A to line 29A.

Two potential mineralization zones potential on bearing gold-bearing ore bodies, gold-bearing greenschist, magmatic massif, quartzite have been performed on the plane and drawings.

In short: The geophysical data are very useful in determining gold-bearing mineralization zones, their development width and depth, that serve for location of drilling and engineering works and determination of boundary between rock types, different rocks and geostructural factors. Thus, geological work has completely fulfiled its planned purposes, keeping quality and time.

III.3. GEOLOGICAL INVESTIGATION-EXPLORATION WORK:

The geological exploration work for an area of in Vang Tat was carried out by geological mapping and surveying gold-bearing ore bodies at the scale of 1/2,000 scale with a prospecting network of 20 x 50 (space between points in lines is 20m while the space between line and line is 50m) in accordance with recent procedures in force. Besides, field trips were inserted more denser at places, where appeared evidences of mineralization and geologically exposed bodies serving for geological and mineral resources mapping.

Survey of ore bodies or mineralization occurrences was carried out in accordance with procedures issued by Department of Geology and Mineral of Vietnam. The collection of data from ore outcrops, exploration drifts, trenches has met the technical procedures.

The results of geological work allow to find a mineralization zone in greenschist bed containing 04 ore bodies as the were described in previous part.

Geological work was carried out at the same time with geodesic, geophysical, hydrogeological-geoengineering works in order to guarantee the implementation progress and help each other in achieving high effectiveness in exploration work.

III.4. DRILLING AND ENGINEERING WORKS:

Geological engineering were used in exploration work including clearing outcrops, old drifts and trenches for following the development of ore bodies.

4.1. Outcrops clearing works:

Outcrops clearing is carried out in the geological survey and sampling for mineral resources assessment. Ore outcrops are cleared and sampled which are presented in following table:

No	Outcrop	Coordinates		Collected samples	Total (m^3)
		X	Y		
1	VL. 3009	758,789	1,657,752	11	7.3
2	VL. 5A	758,828	1,657,520	3	9
32	VL. 5B	758,806	1,657,522	2	8
4	VL. 6B	758,792	1,657,320	4	16
5	VL.3204	758,860	1,657,676	10	35
6	VL.3239	758,882	1,657,272	7	16.6
7	VL.3275	758,872	1,657,236	6	21.6
8	VL. 1284	758,590	1,657,040	11	41
9	VL. 1718 A	758,684	1,656,856	12	24.3
10	VL. 4A	758,902	1,656,856	5	30.3
11	VL. 4B	758,940	1,656,782	2	7
12	VL.2	758,638	1,656,884	6	30
13	VL.1	753,136	1,656,220	1	6.6
			Total	***80***	***252.7***

Samples were collected in accordance with recent procedures, minimum length of samples is 1m following apparent length. Total cleared outcrops is 252.74 m^3. Amount of different samples collected is 80.

4.2. Trenching:

Due to the fact that, a part of exploration area was subjected to pilot exploitation in the past, so ore outcrops are mostly clear and exploration-exploitation drifts are much concentrated in the central part and in the South, so far, basically, trenches were dug to control the strike as proposed on the basis of geophysical data.

Trenches are mostly shallow with support (by timbering?) when the depth exceed 3m. Trenches were divided into cavities on the trench lines and were arranged at places where occur anomalies or mineralization occurrences on the surfaces so that information can be obtained for above-mentioned survey work. The volume of work is shown in following table :

No	Trench	Coordinates		Collected samples	Total (m^3)
		X	Y		
1	H.1 -1 – Line 3	758.772	1,658,660		17.5
2	H. 1-2 – Line 3	758.630	1,658,762	4	24

3	H.2 – Line 4	758.704	1,658,060	4	17.0
4	H.5 – Line 5	758.780	1,658,376		10.0
5	H.4 – Line 6	758.784	1,658,474		66.0
6	H.4 – 1 – Line 6	758.734	1,658,078		16.3
7	H.5 – 1 Line7	758.768	1,658,376		21.0
8	H. 5-2 Line 7	758.760	1,658,376		22.6
9	H.5 – 3 Line 7	758.780	1,658,376		21.0
10	H.6 Line 8	758.762	1,658,280	1	39.5
11	H.6- 3 Line 8	758.798	1,658,280		28.5
12	H.7 Line 9	758.730	1,658,176	3	119.0
13	H. 7 – A – Line 9	758.684	1,658,176	1	66.7
14	H.8 – Line 10	758.756	1,658,076	5	109.5
15	H.9 Line 11	758.580	1,657,980	10	62.5
16	H.10 – 1 Line12	758.802	1,657,880		69.65
17	H.1 – Line 19	758.960	1,657,100	2	21
18	H.2 Line 20	758.980	1,657,120		17
19	H.1 Line 27	758.942	1,656,331		16
20	H.2 Line 27	758.939	1,656,320		18
21	H.3 – Line 27	758.939	1,656,309		17
22	H.4 Line 27	758.940	1,656,300		18.5
				30	818.25

4.3. Data collection from drifts:

Update in detail of information is very necessary for establishing shape and gold-bearing rate of ore bodies, so collection data from drifts is focused in exploration lines together with data collected from outcrops, exploration drilling, etc for delineating ore bodies. Total length of drifts from which 75 samples collected for delineation of ore bodies is 362.6m, as that is shown in following table:

No	Drift	Coordinates		Direction (degree)	Collected samples	Length (m)
		X	Y			
1	L. 6-2	758,793	1,657,668	125	24	80
2	L.6 - 5	758,797	1,657,582	140	10	58.6
3	L.6 - 6	758,765	1,657,410	70	33	127.5
4	L.1B	758,976	1,656,454	60	4	74
	Sub L.1B - 1			150	1	9.4
	Sub L.1B - 2			350	3	13.1
			Total		***75***	***362.6***

4.4. Drilling work:

1. Determination of position for geological-hydrogeological exploration drill holes:

Determination of position for geological-hydrogeological-geoengineering exploration drill holes is based on relief, geomorphology, water level of every

sites and through geophysical measurement results together with the data obtained from geological, hydrogeological, geoengineering surveys which ensure exploration network in order to delineate ore bodies and their reserves assessment.

2. Volume of implementation:

According to project approval, the amount of geological exploration and hydrogeological drill holes is 46 drill holes, but in this exploration period, 50 drill holes have been done. Detailed data are shown in the table V-3.

- The amount of drill holes increases more 04 drill holes, but total length of drilling is lessened 566.58m. This decrease is corresponding to real implementation conditions, the reason is that the drilling has met bedrock too early: LK1-T19^{A} (44,88m) LK1-T22 (20,3m); LK2–T22 (29,65m); LK1–T29 (23,8m); some drill holes have to stop early because of finishing control of ore horizon: LK2–T19^{A} (58,4m); LK1-T15(55,32m); some drill holes carried out at the same time and in the same place with drift digging, that caused landslide and by which drill holes can not work continuously as planned: LK2-T16 (35,55m).

Drill holes chosen for field slug test (water withdrawing and pouring) for calculation of hydrogeological parameters have also been calculated and rationally arranged in the whole area, so that they can play a role as representative for geological bodies which can much effect to the hydrogeological-geoengineering conditions of the mine. Drill hole diameter, and design of casing and perforated pipes for test are shown in table II-4.

Table V – 3. Volume of Implemented exploration drill holes

No	Drill hole	Drilling depth (m)		Coordinates	
		Suggested	Done	X	Y
1	LK1-T.13	70.0	54.8	1657744.37	758822.94
2	LK2-T.13	80.0	80.00	1657777.57	758862.06
3	LK1-T.13^{A}	50.0	49.40	1657725.62	758824.16
4	LK2-T.13^{A}	70.0	65.30	1657728.08	758858.13
5	LK1-T.14	65.0	60,0	1657668.01	758833.02
6	LK2-T.14	85.0	85,0	1657680.07	758868.81
7	LK2-T.14^{A}	75.0	74,00	1657625.91	758861.57
8	LK3-T.14^{A}	80.0	80,0	1657629.53	758900.69
9	LK1-T.15	115.0	55,32	1657577.78	758848.30
10	LK2-T.15	115.0	82,80	1657578.06	758864.26
11	LK1-T.15^{A}	70.00	70,00	1657526.44	758801.25

12	LK2-T.15^{A}	100.0	83,70	1657527.12	758844.73
13	LK2-T.16	100.0	35,55	1657475.17	758853.48
14	LK1-T.16^{A}	70.0	58,00	1657427.06	758818.38
15	LK2-T.16^{A}	115.0	106,1	1657426.13	758853.47
16	LK1-T.17	90.0	82,20	1657369.15	758793.94
17	LK1-T.17^{A}	100.0	78,0	1657329.20	758814.26
18	LK1-T.18	70.0	49,90	1657275.84	758878.76
19	LK2-T.18	70.0	62,40	1657277.01	758740.02
20	LK1-T.18^{A}	70.0	61,50	1657234.87	758895.56
21	LK1-T.19	140.0	120,6	1657179.11	758837.09
22	LK2-T.19	70.0	86,81	1657175.59	758780.43
23	LK1-T.19^{A}	70.0	44,88	1657128.46	758641.72
24	LK2-T.19^{A}	70.0	58,40	1657129.56	758687.87
25	LK3-T.19^{A}	92.0	91,79	1657132.32	758814.87
26	LK1-T.20	72.0	70,57	1657079.68	758638.36
27	LK2-T.20	70.0	70,25	1657083.13	758863.94
28	LK1-T.20^{A}	75.0	72,67	1657018.25	758649.26
29	LK2-T.20^{A}	75.0	104,5	1657025.61	758864.04
30	LK3-T.20^{A}	90.0	87,43	1657024.43	758687.00
31	LK1-T.21	75.0	72,80	1656971.98	758656.74
32	LK2-T.21	100.0	99,70	1656974.33	758696.28
33	LK1-T.21^{A}	70.0	67,10	1656927.09	758714.09
34	LK2-T.21^{A}	125.0	124,64	1656927.12	758891.27
35	LK1-T.22	70.0	20,30	1656875.60	758649.87
36	LK2-T.22	100.0	29,65	1656877.50	758700.81
37	LK3-T.22	120.0	117,61	1656879.44	758881.67
38	LK1-T.22^{A}	90.0	83,40	1656826.52	758943.42
39	LK1-T.23	100.0	95,87	1656771.96	758964.11
40	LK1-T.23^{A}	120.0	107,4	1656720.46	758987.33
41	LK1-T.25	50.0	50.05	1656580.00	758822.00
42	LK1-T.25^{A}	50.0	52.37	1656526.45	758853.64
43	LK1-T.26	70.0	74.32	1656493.00	758964.00
44	LK1-T.26^{A}	60.0	64.60	1656426.64	759019.43
45	LK1-T.27^{A}	65.0	37.30	1656332.54	758974.21
46	LK1-T.28^{A}	40.0	38.99	1656234.59	759012.08
47	LK1-T.29	50.0	23.80	1656185.19	759001.86
48	LK1-T.29^{A}	40.0	50.00	1656132.71	758954.17
49	LK1-T.30	80.0	52.56	1656083.80	758973.27
50	LK1-T.30^{A}	70.0	18.91	1656034.08	758980.07
Total		**4029.0**	**3462,.2**		

Table II-4. Test drill holes for calculation of hydrogeological and geo-engineering parameters

No	Drill hole	Depth (m)	Drilling				Casing pipe				Perforated casing pipe			
			Diam-eter (mm)	From (m)	To (m)	Touched (m)	Diam-eter (mm)	From (m)	To (m)	Touched (m)	Diameter (mm)	From (m)	To (m)	Touched (m)
1	LK2-T15^{A}	74,0	150	0,0	54,0	54,0	140	0.0	16.0	16.0	140	16.0	54.0	38.0
			110	54,0	74,0	20,0								
2	LK1-T18^{A}	61,5	150	0,0	61,5	61,5	140	0,0	24,0	24,0	140	24,0	61,0	37,0
3	LK1-T20	70,3	150	0,0	40,0	40,0	140	0,0	8,0	8,0	140	8,0	40,0	32,0
			110	40,0	70,3	30,3								
4	LK1-T20^{A}	72,7	150	0,0	11,8	11,8	140	0,0	4,0	4,0	140	4,0	11,8	7,8
			110	11.8	72,7	60,9								
5	LK1-T23	95,9	150	0.0	47,0	47,0	140	0,0	16,0	16,0	140	16,0	47,0	31,0
			110	47.0	95,9	48,9								
6	LK1-T26	74,3	150	0.0	46,0	46,0	140	0,0	20,0	20,0	140	20,0	46,0	26,0
			110	46.0	74,3	28,3								
Total										**88,0**				**171,8**

3. Drilling rigs and drilling methods:

- The drilling rigs used for project implementation are YTB-50; XJ-100; XJ-180; SKB-4.

- Drilling methods: Rotary drilling with sampling, drilling fluid is clay. Some drill holes go through hard rocks, drilling walls are not collapsed, so the diluted clay is used in drill holes: LK2-T13, LK1-T20. Due to the technical requirement of exploration drilling on high rate of sampling, so some initial drill holes have to ensure sampling rate, they are: LK1-T13^{A}, LK2-T13^{A}, LK2-T15, LK1-T15^{A}, LK1-T17; in other hand, it is necessary to improve drilling methods in order to meet the technical requirements of the project.

4. Quality of data and architecture of drill holes:

- The drill holes were carried out in accordance with the design of the project, their final depth is rational, drilling data were adequately collected and factors were noted carefully as ruled by regulations. In comparison with initial design, some drill holes had to stop early ore lately at inadequate depth because of that the rock horizons are non-ore ore the depth too great with decreasing ore content. The depth adjustment of drill holes during implementation is suitable with practical conditions, which brings high content of ore with stable drilling volume of the project.

Picture II-1:Drilling rig LK 2-T15

Photo: Lương Văn Vấn, 2008

- Hydrogeological test drill holes, after reaming drilling until meeting technical requirements of depth and designed diameter, were subjected to casing and perforated pipes structure on the basis of practical characteristics of drill

holes, serving well for water withdrawing and pouring test. In general, the structure of casing and perforated pipes for drill holes is rational, meeting the requirements of the project.

- Drilling core samples are put in sample boxes in order from the top to the bottom (following the drilling depth). All drilling intervals are described in detail according to regulations. After finishing drilling a technician has directly described and classified into horizons, photographed all samples. Samples were kept in sample storage of the mine for their processing and analyzing in Hanoi.

Picture II-2: Drilling core sample LK 2-T20A
Photo: Lương Văn Vấn, 2008

5. Some difficulties in drilling work:

In general, the implementation conditions are favourable. The Viet-Lao Joint Stock Company has created favourable conditioins in moving drilling rigs to the site and supplying water to the drilling holes, etc. However, the stratigraphy of rock is complicated at some drilling sites and many work types were operated at the same time, that create difficulties for technical drilling (trenching, shooting for rock breaking out, etc) which have led to ground fissuring, landslide, etc (LK1-T15, LK2-T15, LK1-T15^{A}, LK1-T16, LK2-T16).

III.5. SAMPLING, SAMPLES' PROCESSING AND ANALYZING

1.Sampling work

Collection of various samples for exploration of the Vang Tat gold mine was carried out in accordance with technical procedures issued by the Department of Geology and Minerals of Vietnam regarding geological survey, geological prospecting, hydrogeological-geoengineering survey, etc. During

exploration process, amount of various collected samples and their volumes are presented in following table.

Table III.5 – 1. Amount of collected samples

No	Sample types	Amount	Technical norms	Remarks
I	**Geological samples**			
I.1	Trench	30	1 x0.1x0.05 m (L_{max} – 1m)	
I.2	Outcrop	80	1 x0.1x0.05 m	
I.3	Exploration drift	75	1 x0.1x0.05 m	
I.4	Core samples	305	Collected samples cover a length of mineralization zone	
		256	Collected samples should have L max = 1 m in order to determine the thickness of layers intersected in mineralization zone	
I.5	Samples for internal check analysis	66		
I.6	Samples for external check analysis	33		
II	Technical samples			
II.1	Samples for specific gravity	59	Collected raw samples were wrapped in paraffin to keep moisture for analyzing	Samples collected in exploration engineering such as drill holes, trenches, drafts, outcrops in ore bodies
II.2	Physic-mechanic soil samples	6		
II.3	Physic-mechanic rock samples	15	Samples collected based on fixed norms	
II.4	Thin section samples	25	Fresh and altered samples for study	
II.5	Polished section samples	20	Samples were collected for ore representative types in the deposit	
II.6	Technological samples	02	Samples collected for every ore object of the deposit	The weight of every sample is 0.5 ton
III	Water samples			
III.1	Overall water samples	14		
III.2	Microbiological samples	02		

Geological samples were collected in exploration engineering, the maximum length of sample is 1m, the width of sampling trench is 0.1m with a depth of 0.05m. Trenches, drifts, outcrops have been cleared before sampling in

them, the samples were taken perpendicular to engineering, so that one can get real thickness of mineralization ore bodies.

Drill core samples were cut into 4 parts, two parts of opposite angle were taken for processing, the rest parts were kept in storage. The length Lmaxx of drill core sample is 1m. The length of sample controlling mineralization zone is a length of mineralization zone as well.

Water samples were taken and then kept in shady and fresh places and could be sent immediately to analyze basic showings (norms) of the water. *Taken microbe samples should be immediately sent to analytical labs* for analysis of water norms. Water samples were taken and their keeping cans were wrapped by paraffin in order to avoid injection of outer agents.

2. Samples' processing:

Because of that the object is of rare and precious mineral resources, so samples for analyzing chemical composition were taken with a minimum weight of from 3 to 5 kg. Samples were crushed to a grain size of < 1.0 mm, after that they were divided into 4 parts. Two parts of opposite angle were taken and subjected to crush again to a grain size of 0.074 mm. And the process of dividing sample into 4 parts and then taking two parts of opposite angle was repeated until a weight of samples left minimum 0.5 kg. The rest part was kept at the mine.

Mechanic-physical samples were cut till to meet required shine before analyzing.

3. Analysis of different samples:

Samples were analyzed in laboratories following the ISO standards. According to samples' types and analytical requirements, laboratories can be chosen for their analysis. All analyzed samples and chosen laboratories are shown in hereunder table.

TT	Samples for different analysis	Amount	Lab	Remarks
I	Ore samples			
I.1	AAS – Au – Ag	746	Center for Geological analysis and experiment, Department of Geology and Minerals of Vietnam (DGM)	
I.2	AAS – Au – Ag samples for internal check analysis	66		
I.3	ICP – MS (36 elements)	5		Samples for analysis of total ore composition
I.4	Thin sections	25	Vietnam Institute of Geosciences and Mineral Resources (VIGMR)	
I.5	Polished sections	20		
I.6	AAS – Au – Ag samples for external check analysis	66	Center for Analysis and Experiment, South Vietnam Geological mapping division	

I.7	Technological samples	03	National Center for Natural Sciences and Technology	
II	Physic-Mechanical samples			
II.1	Physic-Mechanical samples of soil	6	Lab of Central Regional Hydrogeological-Geoengineering Division	
II.2	Physic-Mechanical samples of rock	15	Khải Hoàn Construction material Company LTD of Gia Lai Province	
III	Water samples			
III.1	Overall water samples	14	Lab of Central Regional Hydrogeological-Geoengineering Division	
III.2	Microbe samples	02	Lab of Gia Lai Department of Science and Technology	
IV	Specific gravity-humidity samples	59	- Center for Geological analysis and experiment, Department of Geology and Mineral of Vietnam - Khải Hoàn Construction material Company LTD of Gia Lai Province	

III.6. MINERAL RESOURCES AND ENVIRONMENT PORTECTION PROBLEMS

The Vang Tat gold exploration area is coincided with a forest of copse wood, thin population, so far, the environment protection problem is of the highest importance.

Exploration process causes factors which have not effected so much to the environment. These agents affected to environment such as noise derived from drilling rigs, sample processing equipments, etc is quite under permitted norms.

The other environmental problem is drill holes, this problem is solved by that, after exploration drilling and sampling the drill holes are coated with concrete in order to protect them against unwanted action, so environment can not be effected. Chemicals used in drilling are mainly clay bentonite – a material that does not cause environment pollution, as for disposal oil from machines, after elimination these oils were burned off in order to keep environment fresh.

Regarding mineral resources, their exploration reached to certain depth to realize certain blocks hosting ores, the deeper horizons should be subjected to further prospecting and evaluation.

Generally, the exploration process does not much effect to the common environment in the study area.