ORE RESERVE ESTIMATION BY USING A GEOSTATISTICAL TOOL AT HEINDA MINE,TANINTHARYI REGION,UNION OF MYANMAR

Mr. Aye Min Tun -

A Thesis Submitted in Partial Fulfillment of the Requirements
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การประเมินปริมาณสำรองด้วยวิธีธรณีสถิติที่เหมืองเฮนดา เขตตะนาวศรี ประเทศเมียนมาร์

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาวิศวกรรมทรัพยากรธรณีและปิโตรเลียม ภาควิชาวิศวกรรมเหมืองแร่และปิโตรเลียม
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
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Thesis Title	ORE RESERVE ESTIMATION BY USING A GEOSTATISTICAL TOOL AT HEINDA MINE,TANINTHARYI REGION,UNION OF MYANMAR
By	Mr. Aye Min Tun -
Field of Study	Georesources and Petroleum Engineering
Thesis Advisor	Assistant Professor PIPAT LAOWATTANABANDIT, Ph.D.

Accepted by the FACULTY OF ENGINEERING, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Engineering

-- Dean of the FACULTY OF ENGINEERING

(Professor SUPOT TEACHAVORASINSKUN, D.Eng.)

THESIS COMMITTEE

-- Chairman

(Professor Punya Charusiri, Ph.D.)

-- Thesis Advisor

(Assistant Professor PIPAT LAOWATTANABANDIT, Ph.D.)

-- Examiner

(Assistant Professor Sunthorn Pumjan, Ph.D.)

-- External Examiner

(Professor Punya Charusiri, Ph.D.)

อาย มิน ทัน - : การประเมินปริมาณสำรองด้วยวิธีธรณีสถิติที่เหมืองเฮนดา เขตตะนาวศรี ประเทศเมียนมาร์. (ORE RESERVE ESTIMATION BY USING A GEOSTATISTICAL TOOL AT HEINDA MINE,TANINTHARYI REGION,UNION OF MYANMAR) อ.ที่ปรึกษาหลัก : พิพัฒน์ เหล่าวัฒนบัณฑิต

เหมืองเฮนดาเป็นผู้ผลิตดีบุกรายใหญ่ในประเทศเมียนมา เหมืองนี้มีอายุมากกว่า 100 ปี เหมืองตั้งอยู่ที่ 14° 8’ เหนือ และ ลองจิจูด 98° 27’ ตะวันออก ประมาณ 45 กิโลเมตรทางด้านตะวันออกของเมืองทวาย ปริมาณสำรองแร่เป็นปัจจัยหลักในการทำธุรกิจเหมืองแร่ วัตถุประสงค์ของการศึกษานี้เพื่อปรับปรุงความถูกต้องการประเมินปริมาณสำรองสินแร่ด้วยวิธีธรณีสถิติ (วิธีคริกกิ้งธรรมดา) เทียบกับวิธีดั้งเดิม (วิธีโพลีกอน)

ในการประเมินด้วยธรณีสถิติ มันเกี่ยวข้องกับการวิเคราะห์ทางแวริโอแกรม การโมเดลแวริโอแกรม และการประเมินทางคริกกิ้ง การโมเดลแวริโอแกรมด้วยวิธีเอ็กโพเน้นเทียนถูกนำมาใช้คำนวนในการประเมินแบบคริกกิ้งธรรมดา ผลลัพท์ที่ได้แสดงให้เห็นว่าการประเมินทรัพยากรแร่ที่เหมืองเฮนดาโดยวิธีคริกกิ้งธรรมดาประมาณ 117,905 ตัน (ดีบุก) และโดยวิธีโพลีกอน 122,460 ตัน (ดีบุก) สำหรับปริมาณสำรองแร่ที่สามารถทำเหมืองได้ที่เหมืองเฮนดาโดยวิธีคริกกิ้งธรรมดาประมาณ 30,368 ตัน (ดีบุก) และโดยวิธีโพลีกอน 32,349 ตัน (ดีบุก) การศึกษานี้ทำการประเมินปริมาณสำรองแร่ใหม่สำหรับเหมืองเฮนดาด้วยวิธีธรณีสถิติ (วิธีคริกกิ้งธรรมดา) ทั้งนี้เพื่อนำผลลัพท์ที่ได้สำหรับการพัฒนาการทำเหมืองและการวางแผนในอนาคตในพื้นที่การศึกษา

สาขาวิชา	วิศวกรรมทรัพยากรธรณีและปิโตรเลียม	ลายมือชื่อนิสิต ....
ปีการศึกษา	2562	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

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KEYWORD: ALLUVIAL TIN, POLYGONAL METHOD, ORDINARY KRIGING, ORE RESERVE, GRADE TONNAGE CURVE

Aye Min Tun - : ORE RESERVE ESTIMATION BY USING A GEOSTATISTICAL TOOL AT HEINDA MINE,TANINTHARYI REGION,UNION OF MYANMAR. Advisor: Asst. Prof. PIPAT LAOWATTANABANDIT, Ph.D.

Heinda mine is one of major tin producers in Myanmar. The mine has been operated for over 100 years. The mine falls at Latitude 14° 8’ N and Longitude 98° 27’ E, approximately about 45 kilometers to the east of Dawei. The ore reserve is the principal factor of mining venture. The aim of this study is to improve the ore reserve estimation by using geostatistical method (ordinary kriging) compared with conventional method (polygonal method).

In geostatistical evaluation, it involved variogram analysis, variogram modelling and kriging estimation. The exponential variogram modelling was used to calculate the ordinary kriging estimation. The results showed that the mineral resource by ordinary kriging method at Heinda mine indicates about 117,905 tons (SnO_2) and the mineral resource by polygonal method is about 122,460 tons (SnO_2). Furthermore, the mineable reserve of ordinary kriging method at Heinda mine indicates about 30,368 tons (SnO_2) and the mineable reserve by polygonal method is about 32,349 tons (SnO_2). This study is the new ore estimation of Heinda mine with geostatistical method (ordinary kriging). Therefore, the result of estimation may be taken in consideration for the better mining development and future’s plan at the study area.

Field of Study:	Georesources and Petroleum Engineering	Student's Signature ....
Academic Year:	2019	Advisor's Signature ....

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Aye Min Tun -

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INTRODUCTION

1.1 Background

Myanmar has both primary and secondary tin deposits and Myanmar was a major tin and tungsten producer since pre-World War II. Tin-tungsten deposits are located at the Sino-Burma Ranges or Shan-Tenasserim Massif from six major geotectonic units in Myanmar, divided by Khin Zaw (1992).

Tin deposits and mines in Myanmar are mostly situated in Tanintharyi Region, Shan State, and Kayah State (Figure 1.1). Among them, Mawchi mine is the famous tin mine located in Kayah State. In Tanintharyi Region, there are many primary and placer tin mines including the famous mines at Hermyingyi, Heinda, Pagaye, Pachaung and Kalonta.

Heinda mine is one of major tin producers in Myanmar. The mine has been operated for over 100 years. The mine lies in Sinbumasu (Shan-Thai) Terrace, which was derived from Gondwana-Land in Devonian age.

Since 1999, Heinda mine has been owned by Myanmar Pongpipat Co., Ltd., which is a Thai company. The geology of the mine is a placer deposit which is the concentration of heavy minerals formed by gravity separation when the heavy minerals were eroded by the weathering and erosion processes. Tin mineral is mainly occurred as the form of cassiterite which occurs in boulder, gravel, sand, and silty clay beds. The associated minerals of the cassiterite are hematite, magnetite, garnet, zircon, and monazite.

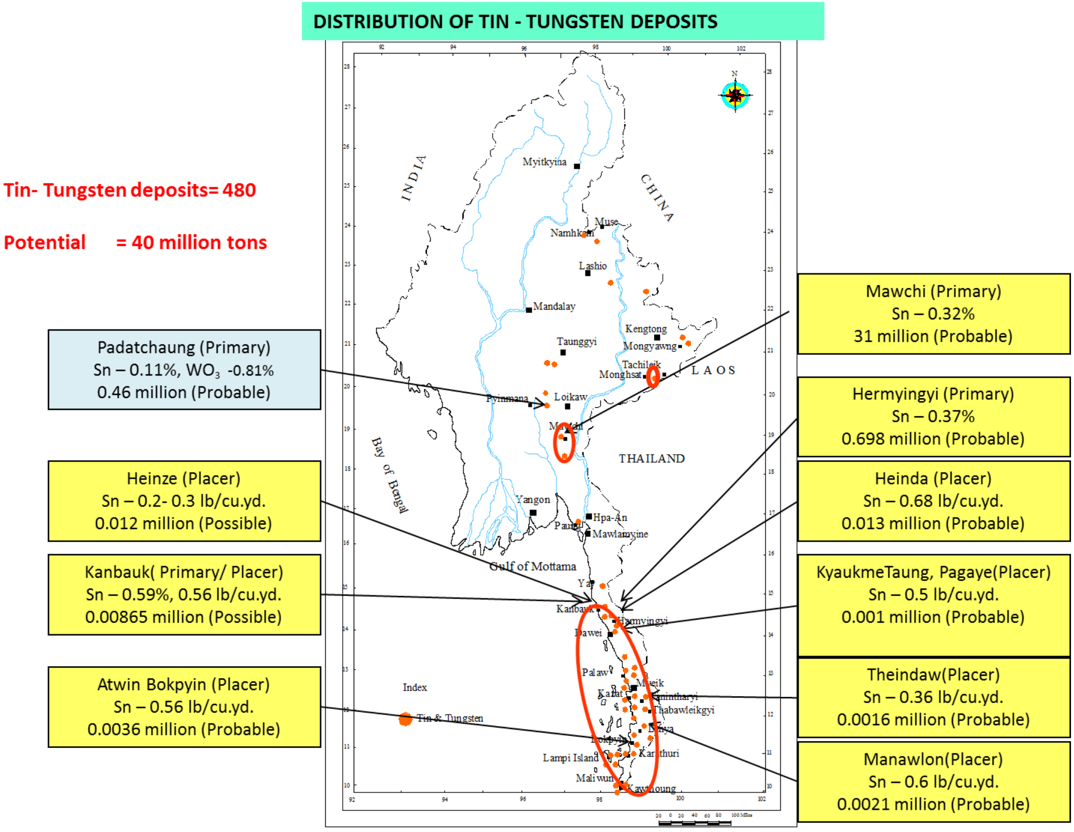


Figure 1.1 Map of Tin – Tungsten deposits in Myanmar

1.2 Location

The Heinda mine is located at Dawei district, Tanintharyi Region, approximately 45 km to the east of Dawei (on the direct distance). The mine falls at Latitude 14° 8' N and Longitude 98° 27' E within the Map reference of U 741 series, sheet edition 5 GSGS 95-J/8, in 1:63,360 scale (Figure 1.2). It is connected to Dawei town by mean of all weathered tar road with the distance of approximately 50 km. There is another branch-road on the National Highway No. 8, approximately 40 km to the south of Thayetchaung, heading for about 80 km along Sosinpya – Myitta road. This road is gravel and it is in a very poor condition. The mining concession covers an area of 8.23 sq. km (2,058 acres) with the present active mining zone of 1.24 sq. km (310 acres). The Heinda mine is situated at Hpolontaung hill, between the elevation of 335 m and 451 m (MSL, Mean Sea Level). The topographic map of study area is shown in Figure 1.3. It is bordered by Byaungbyo stream in the north and Heinda stream in the south. At the western part of the mine, high mountain range orients in the north – south direction with the highest peak of 1,100 m (MSL). Whereas the eastern part and the vicinity of mining area are undulate hilly terrain with the elevation of less than 451 m. The contour map of the study area is illustrated in Figure 1.4.

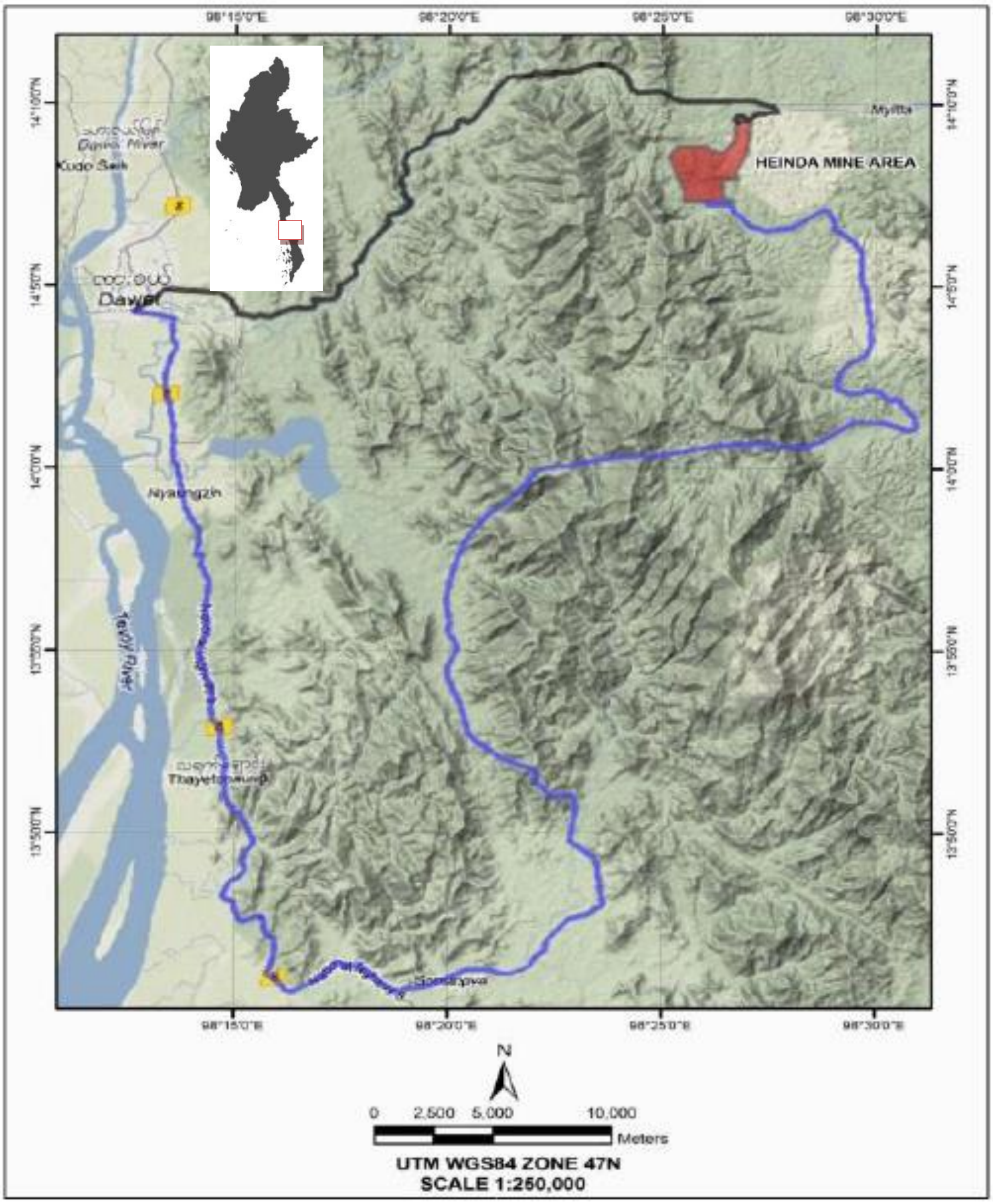
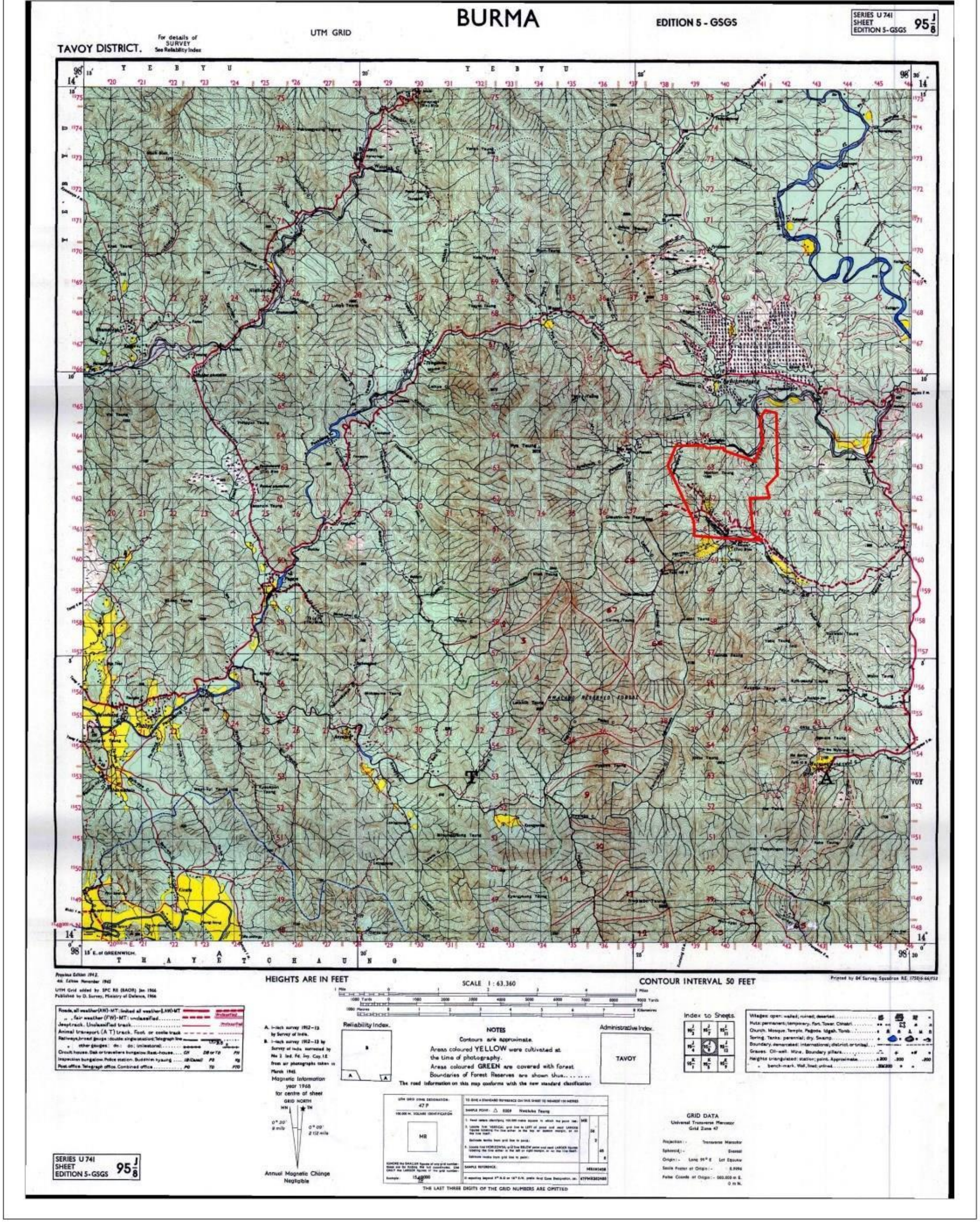


Figure 1.2 Location map of the study area



SYMBOLS

Heinda Mine Boundary

Figure 1.3 Topographic map of the study area

1.3 Regional geology

In the neighboring areas of Heinda-Hpolontaung areas, it can be divided into five rock units as follows,

Formation	Age
Alluvial	Recent
Lateritic Clay Bed	Quaternary
Hpolontaung Formation	Tertiary
Mergui Series	Carboniferous/Permian
Intrusive Igneous Rocks	Tertiary (Eocene to Paleocene)

The regional geological map of the study area (Myint Naing & Aye Min Tun, 2017) is demonstrated in Figure 1.5.

Alluvial

Recent alluvial deposit consists mostly of loose gravel sand and clay occurred around Byaungbyo, Heindu and Heinda Chaung. These alluviums are occurred in the upper portion of lateritic clay beds.

Lateritic clay bed

Lateritic clay bed, that is occurred as the secondary enrichments in which Hpolontaung and Mergui Series rocks were formed by the alluvial erosion in Quaternary age of geological time scale. Lateritic clay bed consists of 4-mm size pebble and up to 256-mm size boulder that are mixed with yellow and reddish-brown colors clay.

Hpolontaung Formation

Tin-bearing Hpolontaung Formation consists of broken fragments of sedimentary rocks, gravel, sands, clays, and clayey sand. In this formation, gravels occur at the base, sands and fine sands occur in the middle, and silty sands occur in the upper portion. The gravel beds are mainly composed of granites, greisen, vein quartz, shale, argillites, and phyllites. Colors of sands and fine-sand layers are generally yellowish brown and silty sand layers are normally bluish brown color. Sometimes, they show reddish brown due to presence of iron oxide and smoky grey to black from having carbonaceous materials.

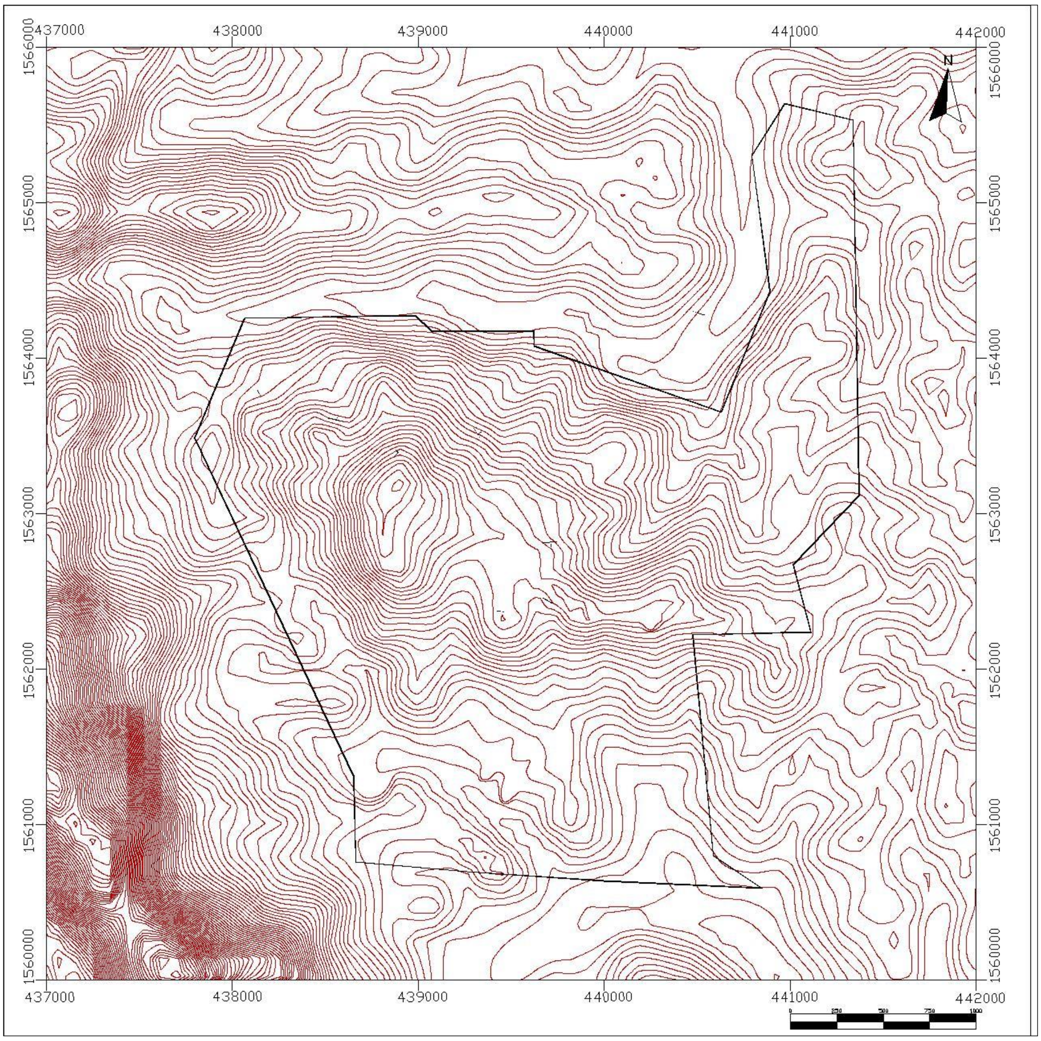


Figure 1.4 Countour map of the study area

Mergui Series

In Mergui Series, widespread occurrences of sedimentary rocks, volcanic rocks and low-grade metamorphic rocks were found along the Tanintharyi Region. In this series, rocks consist primarily of sandstones, mudstone, shale, slates, limestone, volcanic rocks, phyllites, schist, quartzite, and argillites. Mudstone unit is the lowest in the succession where the pebbly mudstone unit is in the upper most part. Mudstone is light grey in color and the color changes into light yellow to yellowish brown when it is weathered. Argillites are divided into two sub-units by their different mineral assemblages. One of them is soft, smoky white in color and is weathered to ash grey color soil. Another sub-unit is black color, soft to rather hard and contains some metamorphic minerals and carbonaceous materials. Quartzite are hard, compact and show various colors of white, pink, and light grey to dark grey. When it is near the granitic body, pyrites, chalcopyrite, and iron minerals occur as small patches in Hermyingyi area. Phyllite, chlorite schist, and slate are also found near the contact with granitic intrusion.

Intrusive igneous rocks

Granitic rocks can mostly be occurred along the mountain flanks of Yenan Taung, Kala Taung, Thayet Taung, Pya Taung, Khat Taung and Latkhot Taung. Depending on the texture and mineral assemblages, it can be grouped into two different type. One is a coarse-grained variety and under microscope. It shows phenocrysts of feldspar with very distinct albite twinning (Khin Mg Nyo, 1979). It contains apart from normal constituents of quartz, feldspar and biotite, mica a little amount of hornblende. The other one is a fine-grained variety and is confined to the southwestern part of the granite body. The occurrence is limited and is formed probably at the marginal area of the igneous area. The pegmatites are common and are found in Peinne Chaung, Taungpilar, Pagaye and Bawabin area.

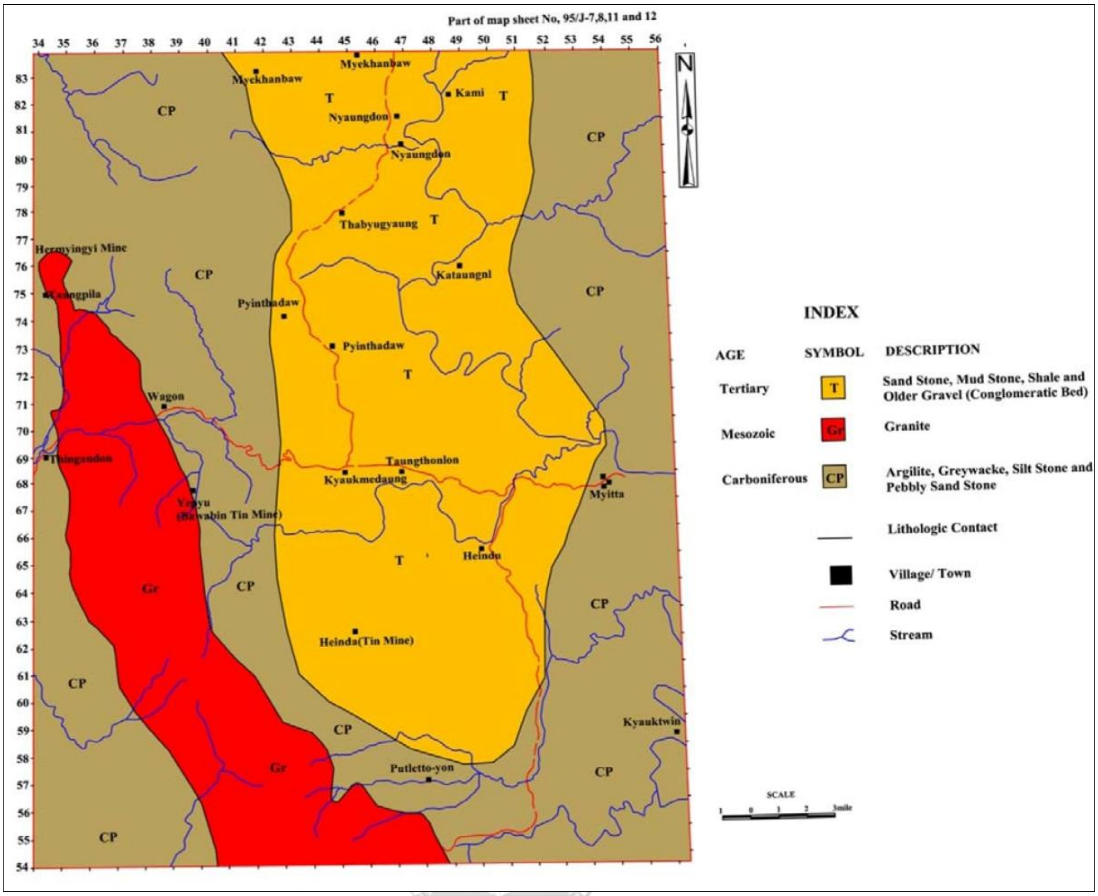


Figure 1.5 Regional geological map of the study area

1.4 Geology of study area

In terms of geology at Heinda mine area, there are mainly three different rock units. These rock units are Unit A, Unit B, and Unit CP-m. Geological map of the study area is illustrated in Figure 1.6 and cross-section of the Heinda area is shown in Figure 1.7. The stratigraphic succession of Hpolontaung Formation is shown in Figure 1.8.

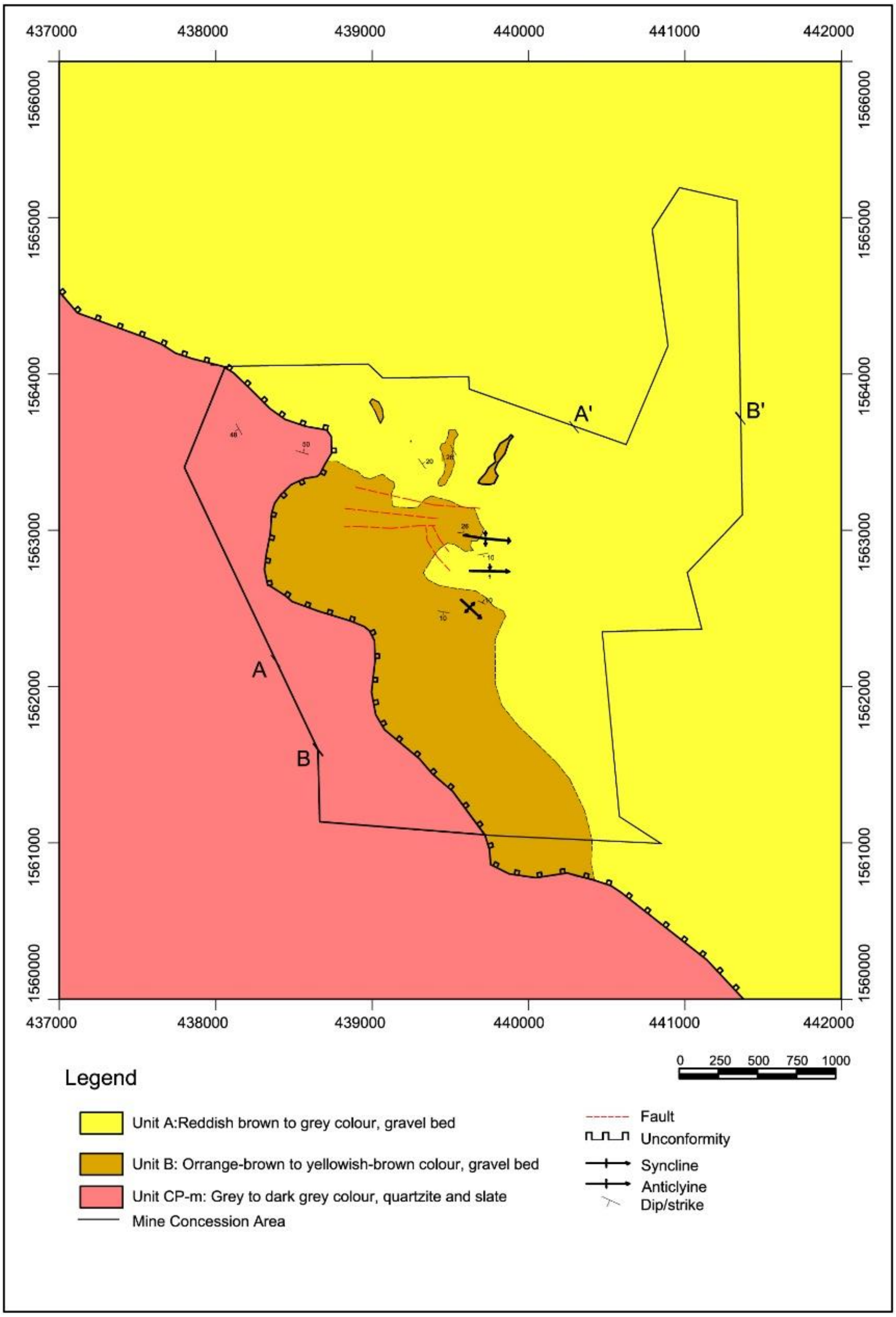


Figure 1.6 Geological map of the study area

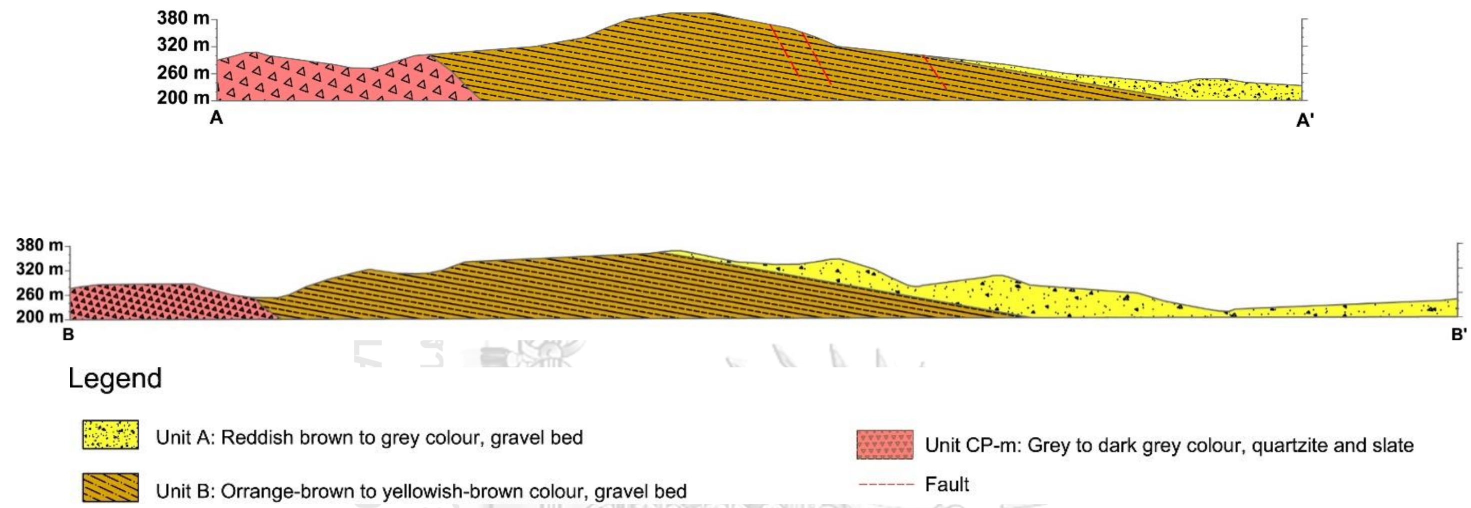


Figure 1.7 Cross-section of the Heinda area

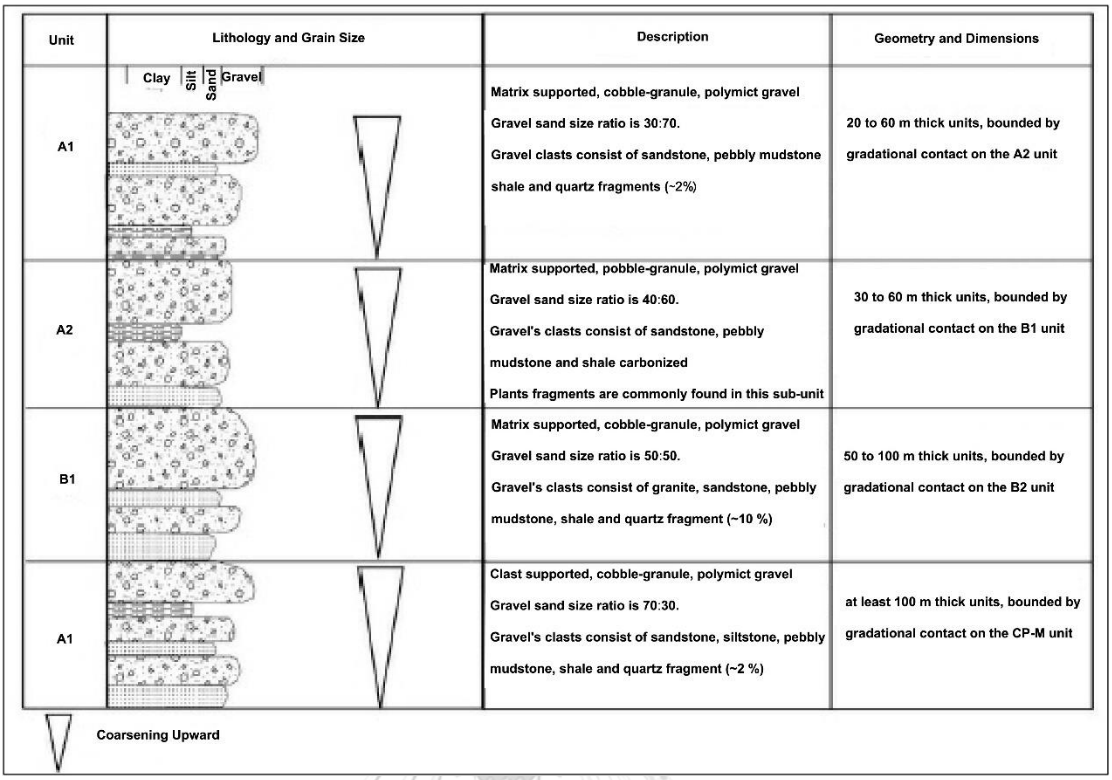


Figure 1.8 Stratigraphic succession in Hpolontaung Formation

Unit A

Unit A occurs widespread in the northern and eastern parts of the mine. It is composed mainly of clayey gravel beds which are interbedded with thin silty clay to medium-grained sand beds. Based on the difference in lithologic composition and clast's size, the unit can be divided into 2 sub-units.

Unit A1: Reddish brown, matrix-supported, polymict, clayey cobble bed

The unit comprises dominantly reddish brown to orange-brown color, gravel which are mostly cobble to granule (size 256-2 mm), sub-rounded to rounded, poorly sorted, matrix supported and polymict in Figure 1.9. The gravel clasts consist of sandstone, pebbly mudstone, shale, and quartz fragments (~2%) with the gravel / matrix ratio of 30:70. The matrixes are composed of clays and fine-grained quartz. It is commonly interbedded with thin bedded silty clay at the top and medium-grained, sandstone at the base. The apparent thickness of this unit varies from 20 to 60 meters. This sub-unit conformably overlies on Unit A2 in the form of gradational contact.

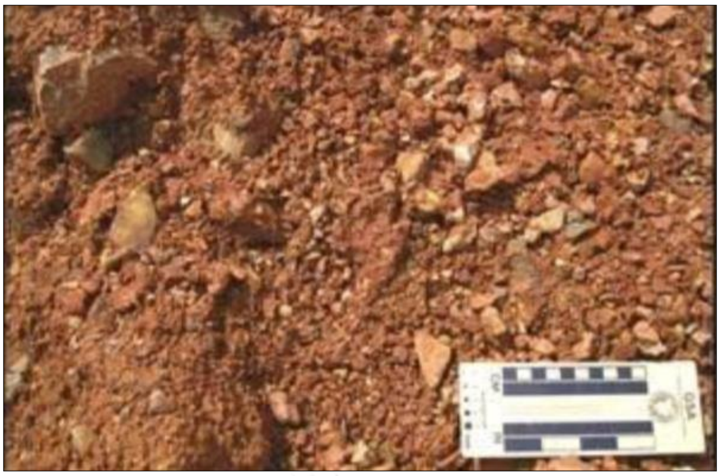


Figure 1.9 Unit A1: reddish brown, matrix-supported, polymict, clayey cobble bed

Unit A2: Grey, matrix-supported, polymict, clayey pebble bed

Apparent characteristics of the unit are grey to dark grey and grayish purple clayey gravel which is pebble to granule in grain size 64-2 mm (Figure 1.10). The gravels are subrounded to rounded, poorly sorted, matrix supported and polymict. The gravel clasts consist of sandstone, pebbly mudstone, and shale. The matrixes are clay and silt size. The gravel / matrix ratio is 40:60. It is commonly interbedded with thick coarse-grained sand beds in the upper part and silty clay beds in the lower part. The apparent thickness of this unit varies between 30 to 80 meters but pinched out in the southeast direction. Furthermore, carbonized plant fragments are commonly found in this sub-unit. Unit A2 is conformably overlain on the Unit B with the gradational contact. The presence of quartz fragments and the larger clast's size are the main features of Unit A1 (the younger unit). The presence of carbonized plant fragments is the signature of Unit A2. In the central part of the mine, there are minor open anticlines and synclines with fold axis plunging to the east. The folding indicated compressive stress regime in the north-south direction after the deposition.

Figure 1.10 Unit A2: grey, matrix-supported, polymict, clayey pebble bed

Unit B

Unit B widely distributes to the central part and partially exposes in small creeks in the north of the Heinda mine. It is composed of silty gravel beds interbedded with sandstone. It can be divided into 2 sub-units.

Unit B1: Orange-brown, matrix supported, polymict, mixed cobble bed

Unit B1 comprises of orange brown to yellowish brown mixed gravel which are mostly cobble to pebble in grain size 256-64 mm (Figure 1.11). The gravels are angular to sub-angular, poorly sorted, matrix supported, and polymict. The clasts compose of granite, sandstone, pebbly mudstone, shale, and quartz fragments (~10%). The matrixes are silt and sand size of quartz with the gravel / matrix ratio of 50:50. It is commonly interbedded with thick coarse-grained sand beds. The apparent thickness of this unit varies from 50 to 110 meters. This sub-unit conformably overlies on Unit B2 in the form of gradational contact.

Figure 1.11 Unit B1: orange-brown, matrix supported, polymict, mixed cobble bed

Unit B2: Yellowish brown, clast support, polymict, silty cobble bed

The unit features as yellowish brown to pale brown silty gravel. The gravel is mostly from cobble to granule (size 256-2 mm), subangular to sub-rounded, moderately to poorly sorted, dominantly clast supported in Figure 1.12. The clasts comprise of sandstone, siltstone, pebbly mudstone, shale, and quartz fragments (~2%). The matrixes are silt and sand size of quartz. The gravel / matrix ratio is 70: 30. It is commonly interbedded with thin silty clay beds in the upper part and thick coarse-grained sand beds in the lower part. Overall grain size distribution has shown that the unit illustrated a coarsening upward character. The apparent thickness of this unit is more than 100 meters. Unit B2 is conformably overlain by Unit B1 and in turn unconformably on the CP-m unit. It is worthy to note that the granite clasts present only in the Unit B1 whereas quartz clasts are present in both sub-units but more abundant (10%) in the upper unit (B1). Unit B is overlain by Unit A with conformable gradational contact but unconformably overlies on the CP-m basement. The orientation is mostly northwest – southeast with dip gently into the northeast and east. According to the investigation by Zaw Win (2001), the gravel unit of "A" and "B" can be correlated to the Hpolontaung beds. The age of the Hpolontaung gravel bed has not been biostratigraphically clarified. Previous investigation gave a late Tertiary age (Bender, 1983). Based on the C-14 dating from two carbonized plant fragments from the upper part of the Unite A, the age has been given as 25,040+/-2,670 and

>30,000 years. Therefore, the Hpolontaung gravel bed age can be defined as upper Pleistocene.

Figure 1.12 Unit B2: yellowish brown, clast support, polymict, silty cobble bed

Unit CP-m

Unit CP-m distributes in western part of the project area. The sequence characterizes as slate and quartzite interbedded with dark grey mudstone, siltstone, and sandstone. The unit features as inclined bed dipping 45 to 50 degrees to the north and northwest. An open-fold with average northeast – southwest orientation of axial plane has been observed in the western part out of the mine area. Fractures of various orientations are well developed within this unit. Approximately 1.5 km to the west of the Heinda mine, a small granite intrusion has been observed. It is white, coarse-grained granite with partly porphyritic texture with feldspar phenocrysts. The rock forming minerals are, in order of abundance, quartz, feldspar and biotite, with locally muscovite and amphibole (Figure 1.13). Based on the investigation of Zaw Win (2001), the granite in Hpolontaung area is defined as a central granite belt of Myanmar which emplaced in lower Tertiary period.

Figure 1.13 Quartzite texture of CP-m Unit

1.5 Mineralization of study area

The Heinda alluvial tin deposit includes in the Hpolontaung Formation which comprises a valley filled with the fluvial sediments tin bearing quartz vein, greisen, and pegmatite. Hpolontaung gravel beds consist of alternating boulder, gravel, sandstone, and silty clay beds. Generally, the strikes of gravel beds are 0° to 50° and the dip amounts are 25° to 45° toward the east and north-east. Boulder gravel beds and pebbly gravel beds are repeatedly divided by red clay bands. The components of the conglomerate attain diameters in the range of 1 m and above. In this area, tin placer deposits are mainly occurred at Hpolontaung gravel beds in the Tertiary age. Cassiterite occurs in consolidated pebble beds and boulders about 200 ft thick. There are mainly three different rock units in the study area.

1.6 Research objectives

The objective of this study is to investigate preliminarily resources assessment and ore reserve by using geostatistical method (ordinary kriging) and conventional method (polygon) at Heinda tin mine, Dawei District, Tanintharyi Region, Union of Myanmar. Furthermore, this study is intended to compute the ore grade distribution and to construct the grade tonnage curve.

1.7 Scope of works

The works consist of literature reviewing, topographic survey, geologic mapping (both regional and within the concession area) and heavy mineral investigation.

In my study, there are the limitations of the data because there have 72 heavy mineral samples data in total 77 samples. Moreover, the elevation of the topography is used from the UTM map sheet No. 1498/08 to draw the contour map of the study area.

The scopes of study are shown as following:

- Statistical analysis
- Geostatistical analysis
- Geological modeling
- Compare ore reserve estimation between with geostatistical method (ordinary kriging) and conventional method (polygonal method)
- Construction the grade tonnage curve from the estimated ore grade distribution and tin reserve

1.8 Statement of problems

The ore reserve is the principal factor of mining development which supplies in economic growth for nation's development. An estimation of ore reserve is necessary for a mining project which is very essential role of mine planning, mine design, mine operation, and financial analysis of a mine. In ore reserve estimation, there are many risks such as variables of quantity and quality of the ore within the calculation and estimation error. This study will focus on the ore reserve estimation. Therefore, the ore reserve estimation using conventional method (polygon) and using geostatistical method (ordinary kriging) are used to estimate the resource and reserve of Heinda tin mine.

1.9 Previous exploration activities

Summaries of exploration activities carried out by various Agencies, Companies, and Government Enterprise are mentioned as below:

- **1934 – 1936**, first time for ore reserves and grade valuation of Heinda alluvial (Hpolontaung) tin deposits by the Anglo-Burma Tin Co. Ltd.

Alluvial Ore	-	8,901,712 cubic meters
Average Tin content	-	551.71 g/cubic meter
Tin concentrate	-	4,873 tons

- **1960 – 1975**, second time ore reserve and grade valuation of Heinda, Hpolontaung tin deposit by the Anglo-Burma Tin Co. Ltd. under the supervision of General Manager Mr. C. J. Wilton

Sunk	-	13 Shafts
Dug	-	300 test pits
Accomplish	-	9 tunnels

Separated ore reserves into 4 blocks

Total ore	-	37,768,178 cubic meters
Average Tin content	-	439 g/cubic meter
Tin concentrate	-	16,565 tons with 72.8% Sn

- **13th January 1962 – 25th February 1962**, a joint team consisting of U Ba Saw Khin and U Kyi Soe, geologists from the Burma Geological Department and Mr. R. C. Raoust, French mining engineer who attached to the Burma Geological Department carried out geological mapping around the Heinda mine and test pitting at the Hpolontaung area. Twenty-two pits were dug and recalculated the ore reserves of the mine together with the previously explored data of shafts, tunnels and test pits that were done by the AngloBurma Tin Co. Ltd. They divided the ore reserves into 5 blocks. Total reserves are:

Total ore	-	39,374,582 cubic meters
Average Tin content	-	830.58 g/cubic meter

Tin concentrate - 32,704 tons

- 1969, the Heinda tailing flat area was also prospected by U Tint Zaw and party from the directorate of Geological Survey and Mineral Exploration. Five banka holes were sunk and possible ore reserves were estimated as below:

Total Ore	-	526,158 cubic meters
Average Tin content	-	225.44 g/cubic meter
Tin concentrate	-	118.62 tons

- April 1970, Professor Dr. Werner Gocht and party from Germany brought 160 channel samples from various place at the Hpolontaung ridge and resurveyed the mine. Basing on the previously exploration data of Anglo-Burma Tin Co. Ltd., and Mr. Raoust, they divided the area into 12 blocks and estimated the ore reserves. Total ore reserves by the German mission show as below:

Total Ore	-	20,470,400 cubic meters
Average Tin content	-	690 g/cubic meter
Tin concentrate	-	14,043 tons

- July – August 1983, U Hla Htay and party from the Anglo-Burma Tin Mining Enterprise accomplished channel sampling along the benches and road cuttings in the northern parts of Hpolontaung Hill and calculated the ore reserves as follow:

Total Ore	-	12,464,510 cubic meters
Average Tin content	-	189.85 g/cubic meter
Tin concentrate	-	2,366 tons

- 1988, U Victor Kay and party from the directorate of Geological Survey and Mining Exploration again explored the Heinda tailing flat. About 21 banka holes were sunk and estimated.

Total Ore	-	2,000,076 cubic meters
Average Tin content	-	237.83 g/cubic meter
Tin concentrate	-	475 tons

CHAPTER 2
THEORY AND LITERATURE REVIEW

2.1 Introduction

"Geostatistics" is the generic name for a family of techniques which are used for mapping of surfaces from limited sample data and the estimation of values at un-sampled locations. It developed almost 60 years ago by Georges Matheron and named in honor of Danie Krige. In 1960 s, the development of geostatistics resulted to evaluate the recoverable reserves in mining deposits as a methodology. The application of geostatistical techniques includes mining, environmental sciences, remote sensing, and ecology (Rossi et al., 1992).

Yunsel (2012) said that the benefits of the using geostatistical method may improve in the assessment of data, sampling strategy, and estimation of values at un-sampled areas to determine quality and mineral reserve characteristics. Furthermore, geo-statistical techniques would provide not only estimations for any point, but also finding the weighting coefficients for a given mining block and data configurations that minimize the error or obtain the associated variance.

There are the following four steps to evaluate ore reserve in geostatistic: (1) compute the variogram of the deposit under study, (2) fit the proper mathematical model, (3) compute all the relevant variances and (4) do the kriging calculations.

2.2 Mineral resources

Mineral resources are defined as natural concentrations of minerals of potential economic interest due to their inherent properties in or on the earth’s crust in such form and quantity and of such a grade or quality that it has reasonable prospects for economic extraction. The location, quantity, grade, geological characteristics, and continuity of a mineral resource are known, estimated, or interpreted from specific geological evidence and knowledge.

Mineral resources are sub-divided, in order of increasing geological confidence, into inferred, indicated, and measured categories. These categories are classified the level of confidence. Inferred mineral resource is the part of a mineral resource for which tonnage, grade and mineral content can be estimated with a low level of confidence. It means that is insufficient to allow the application of technical and economic parameters or to enable an evaluation of economic viability worthy of public disclosure. Indicated resources are simply economic mineral occurrences that have been sampled from locations such as outcrops, trenches, pits and drill holes to a point where an estimation has been made of their contained metal, grade, tonnage, shape, densities and physical characteristics at a reasonable level of confidence. Measured resources are indicated resources that have been an acceptable estimation of the grade, tonnage, shape, densities, physical characteristics, and mineral content of the mineral occurrence at a high degree of confidence.

2.3 Mineral reserves

A mineral reserve is the economically mineable part of a measured or indicated mineral resource demonstrated by at least a preliminarily feasibility study. Estimates of the tonnage and average grade of ore deposits, known as ore-reserve estimates, are made for various purposes. Ore reserve estimates are based upon the results of exploration and development and analyses of the samples derived there from. Ore reserve estimates include the determination of (1) tonnages of ore and (2) average grade or value per ton.

Mineral reserves are sub-divided in order of increasing confidence into probable mineral reserves and proven mineral reserves. A reserve, the part of indicated, is probable when economic extraction can be justified and is of sufficient quality to serve as the basis for decision on the development of deposit. A reserve, the part of measured resources, is proven when economic extraction *is* justified.

2.4 Sampling method (channel)

Channel sampling method can be used in the sediment contained in the surface and, also, in an underground mine. The objective is to cut a linear channel across the vein or orebody to obtain the most representative sample possible for the designated interval. Most of the time, chip channel samples are collected in succession along a sample line that is laid out in advance using a tape measure and is designed to parallel the true width of the deposit. For shallow sediments, chip channel samples are collected along surface trenches. At the hydrothermal sediment mined by underground mining systems, channels made the floors or walls. Sample intervals are set at a specified width, usually ranging from 1 to 20 feet, commonly 5 feet.

2.5 Heavy particle sampling (panning)

Panning is the simple method of separating particles of greater specific gravity (especially gold) from soil or gravels of lighter specific gravity by washing in a pan with water. A typical pan is a rugged, circular metal dish with a flat bottom, and the size of the pan ranges from 10 to 17 in with inclined side at about 45°. The inner surface of a pan is smooth and free from rust and grease. During the panning process, the pan is half-filled with gravel, rocks, and soil. These are collected from places with slow current flow. The pan is then submerged in water to wet the mixture thoroughly. The mixture is, then, stirred and lumps of clay are broken up, from which large stones are collected. The pan, which is still inside water, is provided with gyratory motion and shaking. As a result, heavy particles settle at the bottom, bringing up the lighter materials to the surface. The pan is tilted at intervals to wash off the light surface materials.

2.6 Conventional method

Reserve estimation is used to determine the tonnage and grade of ore deposit. Ore reserve estimations are based on the mineral exploration data and analyses of the collected samples. There are involving the ore volume calculation, ore tonnage calculation and ore grade estimation. The conventional method is used to estimate and define the ore reserve from the exploration data. The principles of conventional method are described as the rule of gradual changes, the rule of nearest points or equal influence and the rule of generalization. In conventional method, there are many different methods: polygonal, cross-sectional, triangular, etc.

2.7 Geological modelling

An ore body definition has three distinct components: the physical geometry of the geological units which host the orebody, the attribute characterization in terms of assays and geo-mechanical properties of all material to be mined, and the value model in terms of economic mining of the deposit (Indranil Roy and B. C. Sarkar., 2000). To determine and define the ore tonnage and grade of a geological deposit, resource estimation is used from the developed geological or block model. There are many advantages used for different scenarios dependent upon the ore boundaries, geological deposit geometry, grade variability and the amount of time and money available. The basic concept of ore body modeling is arranged an array of bricks to conceive the entire ore body in XYZ grid system. Each brick of uniform size representing a small block of material to the values of grade, tonnage and other geological entities are assigned. An ore body modeling project starts with a critical review of existing either drill hole or surface or underground sample data which are set up to suit all the quantitative and qualitative information necessary to build a resource model.

2.8 Statistical analysis

Statistics is the traditional field that deals with the quantification, collection, analysis, interpretation, and drawing conclusions from data (Yoav Benjamini). The mathematical formulation and validation of a methodology, and views simulations and empirical or practical evidence as a less form of validation are emphasized by traditional statistics. Representative sampling assures that inferences and conclusions can reasonably extend from the sample to population. The first in any data analysis involves a computation of basic summary statistics and the construction of histogram for the variables under consideration. Statistics parameters are mean (average), median, mode, variance, standard deviation, skewness, kurtosis, etc.

i) Mean

Mean is the average value of a data set which is the sum of values divided by the number of values. The arithmetic means of samples x_1, x_2, ..., x_n was denoted $\bar{x}$. The equation is followed as:

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = \frac{x_1 + x_2 + \cdots + x_n}{n} \quad (1)$$

Whereby x_i is represented the values of samples and n is the number of samples.

i) Medium

Medium is the middle value of the data samples in which one half is lower values and other half is the higher values of a data samples.

ii) Mode

Mode is the most frequency occurring of data set. The set of data may have either one mode or more than one mode or no mode at all.

iii) Variance

Variance is the expectation of the squared deviation of a random variable from its mean. It measures how far a set of (random) numbers are spread out from their mean.

$$\mathrm{Var(X)} = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2 \quad (2)$$

Whereby x_i is represented the values of samples and n is the number of samples. Moreover, $\bar{x}$ is the mean of samples values.

iii) Standard deviation

Standard deviation, by using the square root of the variance, is a statistic that looks at how far from the mean a group of numbers.

$$\mathrm{s} = \sqrt{Var(X)} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (3)$$

iv) Skewness and kurtosis

Skewness is a measure of symmetry or the lack of symmetry in the distribution of data set. If longer tail has on the left side, it is called negative skewness. If longer tail has on the right side, it is called positive skewness.

Kurtosis is a measure of the respective sharpness of curve in the frequency distribution. Positive kurtosis indicates the relatively peaked distribution and negative kurtosis indicates the relatively flatted distribution. The skewness and kurtosis are defined as equations (4) and (5).

$$\text{Skewness} = \frac{n}{(n-1)(n-2)}\sum_{i=1}^{k}\left(\frac{x_i-\bar{x}}{s}\right) \quad (4)$$

$$Kurtosis = \left\{\frac{n(n+1)}{(n-1)(n-2)(n-3)}\sum_{i=1}^{k}\frac{(x_i-\bar{x})^4}{s}\right\} - \frac{3(n-1)^2}{(n-2)(n-3)} \quad (5)$$

Where, n = number of sample values, x_i = sample values, $\overline{x}$ = mean of sample values, s = standard deviation.

2.9 Structural analysis

In geostatistics, the use of auto-covariance or variogram to characterize the spatial or temporal structure of the data is called structural analysis. The analysis treats a set of spatial data as a sample from the realization of a random process and stresses the structural features.

Variogram is a traditional geostatistical tool that provides quantification of the degree of directional spatial properties in the random variables (Rossi et al., 1992) and gives a nice interpretation of the variance in a second-order stationary process (Schabenberger and Pierce, 2002). Variogram analysis consists of the experimental variogram calculated from the data and the variogram model fitted to the data. A variogram is used to display the variability between data points as a function of distance.

The calculation of semivariogram is defined as,

$$\Upsilon(h) = \frac{1}{2n\,(h)} \sum_{i=1}^{n(h)} (x_i - y_i)^2 \tag{6}$$

Where h is the distance separating sample x_i and y_i, n is the number of sample pairs.

The parameters of variogram are lag, sill, and range.

- Range – The point where the variogram reaches the sill on the lag h axis. Sample points that are farther apart than range are not spatially autocorrelated.
- Nugget – The point where covariance intercepts the ordinate.
- Sill – The value where the variogram first flattens off, the maximum level of covariance. The points above the sill indicate negative spatial correlation and vice versa.

For the sake of kriging (or stochastic simulation), we need to replace the empirical variogram with an acceptable variogram model. Part of the reason for this is that the kriging algorithm will need access to variogram values for lag distances other than those used in the empirical variogram. More importantly, the variogram models used in the kriging process need to obey certain numerical properties, in order, for the kriging equations to be solvable. Using *h* to represent lag distance, *a* to represent (practical) range, and *c* to represent sill, the three most frequently used models are:

1) Spherical Model

$$\Upsilon(\mathrm{h}) = \Upsilon_0 + \mathrm{s}\ [1.5\ (\frac{h}{a}) - 0.5\,(\frac{h}{a})^3]\,, h \le a \tag{7}$$

$= \Upsilon_0 +$ s, h > a.

2) Exponential Model

$$\Upsilon(\mathrm{h}) = \Upsilon_0 + \mathrm{s}\,[1 - \exp\ (-\ \frac{h}{a})] \tag{8}$$

According to Armstrong (1998:37), the range of exponential model is practically defined as 3a at which the 95% of sill is reached if Υ_0 = 0.

3) Gaussian Model

$$\Upsilon(\mathrm{h}) = \Upsilon_0 + \mathrm{s}\ [1 - \exp\left(-\frac{h^2}{a^2}\right)] \qquad (9)$$

Where Υ_0 = nugget effect, s = sill, and a = range. h is the lag distance between sample points. A sill values reached asymptotically at a practical range of $\sqrt{3a}$ (Journal and Huijibregts, 1978:1750).

2.10 Geostatistical analysis

Kriging is a method of spatial interpolation that originated in the field of mining geology, named after South African mining engineer Danie Krige. Kriging is one of several methods that use a limited set of sampled data points to estimate the value of a variable over a continuous spatial field.

Kriging can be understood as a two-step process: first, the spatial covariance structure of the sampled points is determined by fitting a variogram; and second, weights derived from this covariance structure are used to interpolate values for un-sampled points or blocks across the spatial field. There are several sub-types of kriging, including: Ordinary kriging, Universal kriging, Block kriging, Cokriging, Poisson kriging, and more...

2.11 Ordinary kriging

Ordinary kriging is most widely used in kriging methods for decades (Journal & Huijbregts, 1978). This kriging model is the weighted linear combination of the observation. Thus, the optimal predictor will be accepted by minimizing mean squared prediction error and are used to produce the best linear unbiased predictor of the unobserved point. The observed values are first used to estimate the unknown parameters of the process and to compute empirical variogram.

The system of linear equations (Journal & Huijbregts, 1978), called the Lagrange Multiplicator, is shown as a matrix. It can be written as:

$$w = \begin{bmatrix} w_1 \\ . \\ . \\ . \\ w_n \\ \lambda \end{bmatrix} = \begin{bmatrix} C_{11} & \cdots & C_{1n} & 1 \\ \vdots & & \vdots & \vdots \\ C_{n1} & \cdots & C_{nn} & 1 \\ 1 & \cdots & 1 & 0 \end{bmatrix}^{-1} \begin{bmatrix} C_{10} \\ \vdots \\ C_{n0} \\ 1 \end{bmatrix} \quad (10)$$

Where: w is the weighting coefficient, c_{11}....c_{nn} is the variogram values among known simples, c_{10}....c_{n0} is the variogram values between known samples and predicted samples. λ is a Lagrange multiplier that appears due to the unbiasedness constraint $\sum w_i = 1$.

The number of weighting coefficients and control points can be very large. In ordinary kriging calculation, the sum of all weighting coefficients is 1. The kriging estimated values can be calculated by their associated weighting coefficients according to equation, as follows:

$$Z^* = \sum_{i=1}^{n} [w_i . Z_i] \quad (11)$$

Where:

Z^* is the estimated values by kriging at location “i”:

w_i is the weighting coefficient for the location “i”;

Z_i is the known value at location x_i.

The calculation of kriging variance can be defined as,

$$\sigma_{ok}^2 = \sum_{i=1}^{n} \begin{bmatrix} \frac{w_i}{\lambda} \end{bmatrix} \begin{bmatrix} c_{10} \\ \vdots \\ c_{n0} \\ 1 \end{bmatrix} = \sum_{i=1}^{n} \begin{bmatrix} w_1 \\ . \\ . \\ . \\ w_n \\ \lambda \end{bmatrix} \begin{bmatrix} c_{10} \\ \vdots \\ c_{n0} \\ 1 \end{bmatrix} \quad (12)$$

Where: σ_{ok}^2 is the kriging variance.

2.12 Grade tonnage curve

Grade tonnage curves are a visual representation of the impact of cutoff grades on mineral reserves and display the tonnage above the cut-off grade and average grade of a deposit relative to cut-off grade. The grade tonnage curve in a function of cutoff grade is used for the economic and financial analysis to invest a mine. The grade tonnage curve depends on to realize the geology and grade distribution of the deposit. It is used to distinguish for ore deposits either ore or waste. Cutoff grade is regarded the minimum grade required for a mineral or metal to be economically mined (or processed). Cutoff grade considers as ore when the material found above this grade and considers as waste when the material found below this grade. The units of cutoff grade are usually expressed as: g/t (grams per ton), $/t (dollars per ton) and % (percent metal). The changing of cutoff grade depends upon the metal price, exploration and production costs, and mineral processing costs.

CHAPTER 3
RESEARCH METHODOLOGY

3.1 Sample collection and chemical analysis

The mining concession area of Heinda mine which are owned by Myanmar Pongpipat Company Ltd. are 8.23 sq. km (2,058 acres) with the mining license. There were totally 92 samples from 77 field sites that have been collected within the vicinity of the Heinda mine. There were 52 samples have been collected from the gravel unit “A”, 36 samples from the unit “B” and 4 samples from the stream sediments underlain by pebbly mudstone of the CP-m unit. The vertical channel with the size of approx. 20 cm width, 20 cm depth and the length according to the bed’s thickness, has been dug using shovel. The sample (gravel plus sand) was collected. Then, fine grained sand fraction has been collected for approx. 20 liters which passed through screen with 1 cm opening. Heavy mineral samples using panning will be separated by means of heavy liquid (bromoform) and magnetic separator (Frantz Isodynamic Magnetic Separator) in the standard laboratory in Bangkok. The heavy minerals will be separated into five portions: Ferro, strong (0.4 amp), moderate (0.7 amp), weak (1.2 amp) and non-magnetic minerals.

Type and percentage by weight of all observed heavy minerals have been defined under binocular to identify the mineral components and grades of minerals and then, will be analyzed the weight of tin concentrate in gram per cubic meter. 77 heavy mineral samples in total 92 samples are representative samples of the mining concession area and other samples are out of the mining concession area. The exploration data and chemical analysis of Myanmar Pongpipat Company Ltd. will be used to study the ore reserve estimation. According to the chemical analysis, the result shows that cassiterite is mainly associated with hematite, magnetite, zircon, monazite, and garnet. The minimum concentration of cassiterite is 0.61 g/m^3 and maximum concentration is 1,949.65 g/m^3. The average concentration of cassiterite is 205.19 g/m^3.

There are 20 drill holes samples in which the maximum depth of each drill holes is between 12 m and 15 m (Appendix A). The covered area of drill holes is narrow. So, the drill holes data may not represent the whole area of Heinda mine to calculate the mineral resource and mineral reserve. These drill hole data will be used for consideration of the pit limit to calculate the mineable reserve.

3.2 Data preparation

In data preparation, the data is used from the Myanmar Pongpipat company limited. The elevations of the study area will be given from the UTM map sheet No. 1498/08 to draw the contour map of the study area. These elevations were drawn using Autocad software from the UTM to input the Microsoft office excel spreadsheet format. The weights of tin minerals and other minerals in gram per cubic meter are also prepared with the excel spreadsheet format to analyze in statistic and geostatistical method. In the data files, coordinates of samples location, and the weights of tin concentrates in gram per cubic meter with hematite (major associated mineral) and other minor minerals are involved to estimate the ore reserve and ore grade distribution of the concession area (Table 3.1). The location map of the heavy mineral samples is illustrated in Figure 3.1 and Figure 3.2. The ore grade distribution map is demonstrated in Figure 3.3. The elevations and chemical analysis including tin concentrate in gram per cubic meter including other minerals are prepared to study the geological modelling. The contour map, geological modelling, statistical analysis, and geostatistical analysis will be applied by using Microsoft office excel spreadsheet and Autocad software.

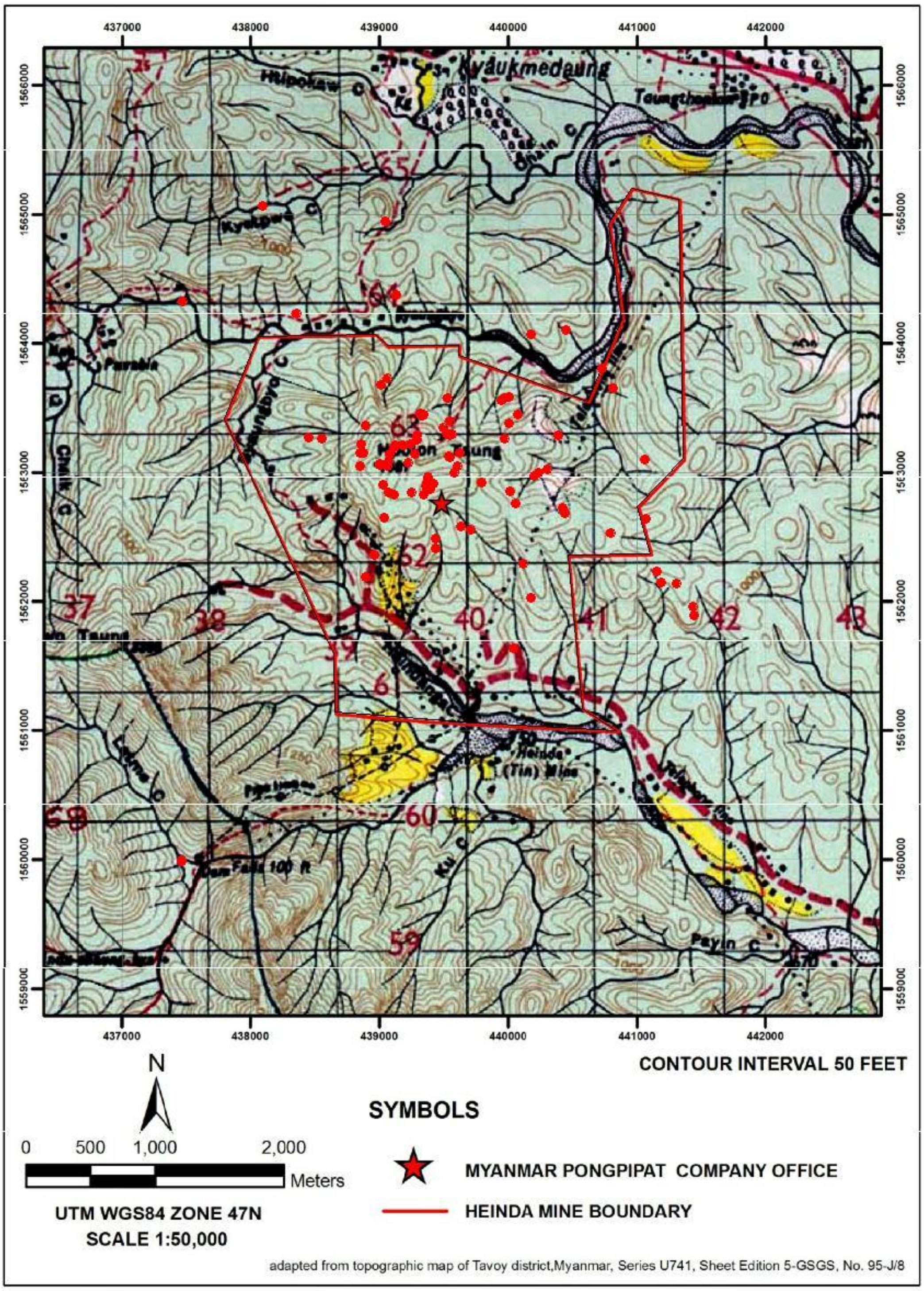


Figure 3.1 Location map of the heavy mineral samples

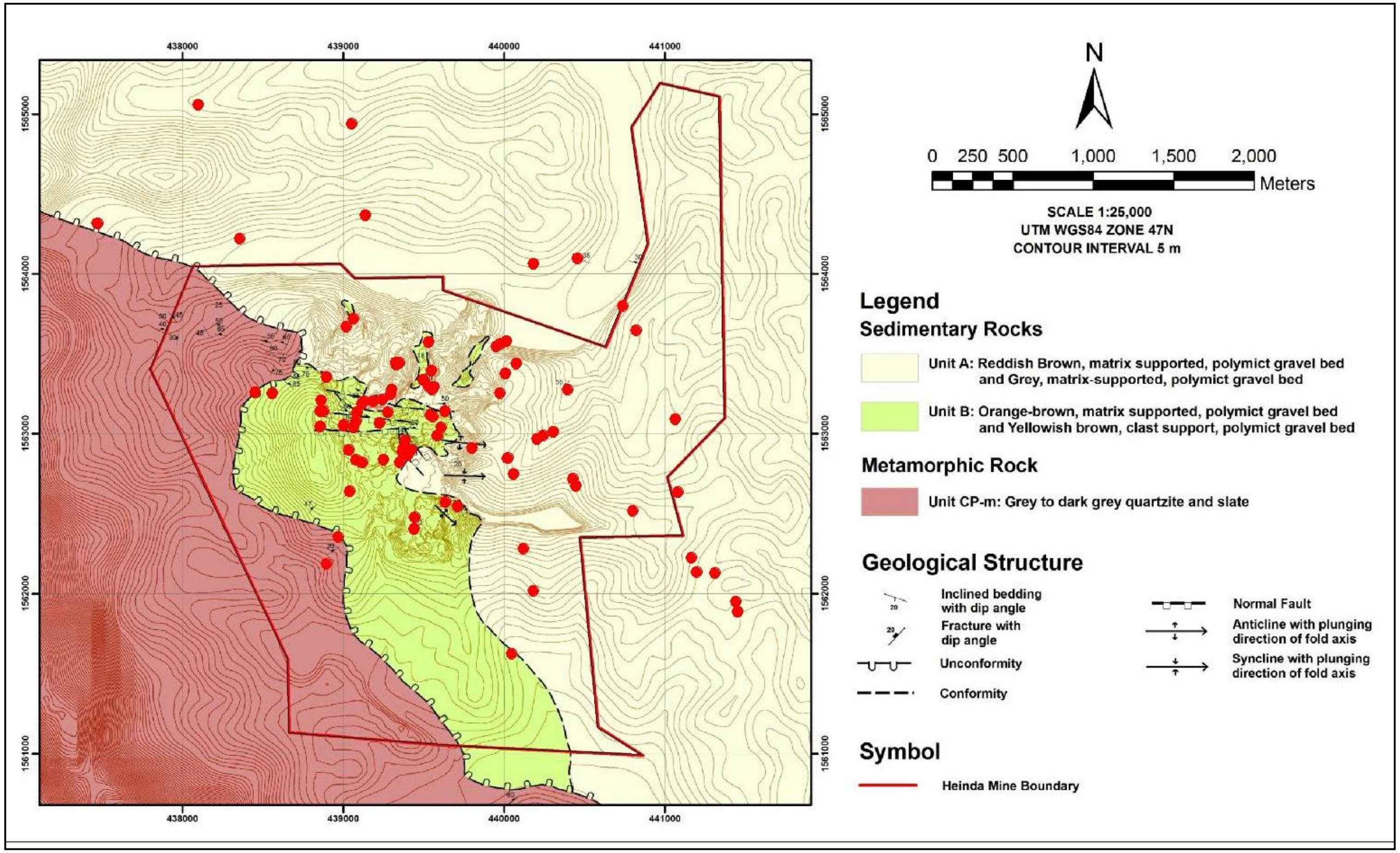


Figure 3.2 Location map of the heavy mineral samples in geological map of the Heinda mine

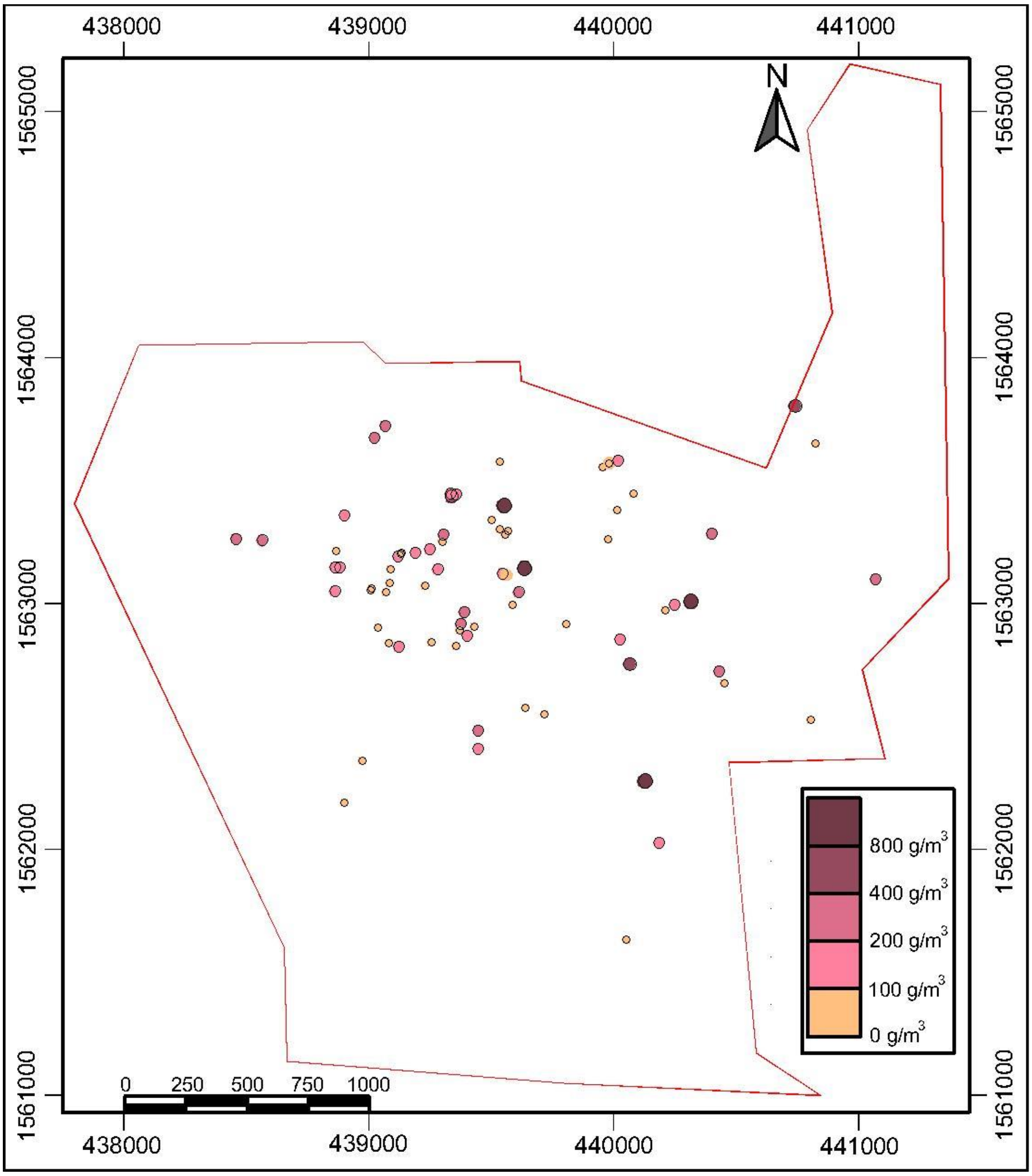


Figure 3.3 The grade distribution of tin concentration at study area

Table 3.1 Concentration results of the heavy mineral samples in gram per cubic meter

Sample No	Easting	Northing	Elevation (m)	Mag g/m^3	Grt g/m^3	Hem g/m^3	Mnz g/m^3	Cst g/m^3	Zrn g/m^3
HD-01	439353	1562825	378	22.50	0.53	96.82	6.65	78.01	1.50
HD-02-1	439401	1562867	365	9.00	0.00	10.60	0.00	123.09	3.40
HD-02-2	439428	1562905	357	1.00	0.14	7.91	0.38	14.10	0.50
HD-03-1	439369	1562890	370	0.50	0.03	1.11	0.29	4.00	0.10
HD-03-2	439375	1562915	364.5	2.00	0.36	10.86	4.86	263.72	2.20
HD-04	439635	1563142	299	52.50	2.69	79.06	29.27	1,831.14	16.30
HD-05-1	439544	1563120	310	3.00	0.02	5.89	1.89	157.71	0.50
HD-05-2	439558	1563113	310.5	4.00	0.22	11.65	1.74	85.77	1.10
HD-06-1	439533	1563299	307	1.00	0.01	1.17	0.31	38.22	1.30
HD-06-2	439555	1563278	308	1.50	0.06	1.07	0.78	39.89	2.20
HD-06-3	439569	1563293	306	0.50	0.36	4.10	0.12	54.70	0.70
HD-07	439551	1563396	304	21.00	0.10	3.90	17.20	1,415.01	17.40
HD-08	439534	1563574	270	0.50	0.08	1.53	0.59	81.97	1.60
HD-09	439389	1562961	360	5.50	0.65	38.63	0.22	245.56	2.90
HD-10-1	439329	1563450	300.5	1.00	0.23	1.56	0.04	142.11	3.60
HD-10-2	439333	1563436	300.7	5.50	0.93	19.15	1.36	777.53	7.50
HD-10-3	439340	1563439	300	2.00	0.15	7.38	0.16	91.09	2.00
HD-10-4	439352	1563447	293	2.00	0.64	3.98	0.39	134.65	1.80
HD-11	439067	1563044	331	0.50	0.04	1.83	0.16	8.85	0.60
HD-12-1	439082	1563080	319	2.00	0.16	5.53	0.65	9.44	0.30
HD-12-2	439087	1563137	313	12.50	0.10	8.66	0.65	84.50	0.60
HD-13-1	439128	1563200	317.5	0.50	0.02	0.69	0.30	140.53	0.50
HD-13-2	439132	1563204	318	1.50	0.10	6.30	0.60	74.03	1.00
HD-14-1	439010	1563060	336	4.50	0.25	16.60	2.94	58.33	3.40
HD-14-2	439007	1563053	339.8	4.50	0.24	10.49	0.04	64.49	1.20
HD-15-1	439121	1562822	389	33.00	0.85	28.54	16.47	137.36	4.80
HD-15-2	439082	1562838	383	2.00	0.04	5.67	2.12	45.62	1.00
HD-16-1	438880	1563145	339.5	2.00	0.40	6.21	0.08	107.71	1.10
HD-16-2	438860	1563146	340.9	1.50	0.35	8.63	0.14	109.20	0.70
HD-16-3	438866	1563212	325	1.00	0.12	6.77	0.54	44.53	1.60
HD-17	438900	1563357	280	0.00	0.07	3.12	1.08	213.72	1.00
HD-18	439444	1562407	365	52.50	0.61	61.68	2.59	179.68	2.40
HD-19	439446	1562482	370	22.50	0.16	51.50	1.31	350.65	3.90
HD-20	439638	1562574	360.5	12.50	0.83	31.72	0.32	38.76	1.40
HD-21-1	439118	1563190	317.8	0.50	0.06	9.23	0.58	97.37	0.80
HD-21-2	439715	1562548	359	14.50	1.00	107.59	0.25	64.21	5.10
HD-22	440449	1562675	302.5	0.50	0.42	3.88	0.92	71.50	0.80
HD-23	440802	1562523	309	1.00	0.12	5.27	0.64	12.29	0.40
HD-25	440823	1563649	217	20.00	0.51	58.49	1.00	17.77	4.30
HD-26	440739	1563802	235	3.50	0.45	14.64	1.04	507.37	7.50

Mag= magnetite, Grt= Garnet, Hem= hematite, Mnz= Monazite, Cst= cassiterite,

Zrn= Zircon.

Sample No	Easting	Northing	Elevation (m)	Mag g/m^3	Grt g/m^3	Hem g/m^3	Mnz g/m^3	Cst g/m^3	Zrn g/m^3
HD-27	441067	1563095	252	1.00	0.26	8.16	0.51	228.35	3.20
HD-28	440024	1562850	320.7	0.00	0.63	13.52	0.23	117.55	4.10
HD-29	440122	1562286	301	27.00	2.19	90.50	0.50	889.64	9.20
HD-30	440063	1562752	339.7	15.50	1.13	64.20	1.97	441.62	6.60
HD-31	440246	1562992	300	1.50	0.15	8.40	0.16	116.87	3.40
HD-32	440208	1562970	305	0.00	0.07	1.61	0.12	10.97	1.70
HD-33	440309	1563017	286.5	15.00	0.93	153.57	0.43	1,949.65	20.20
HD-34	440398	1563280	264	1.00	0.21	5.21	0.52	205.17	3.00
HD-40	440184	1562023	321.8	1.00	0.38	11.52	0.72	351.94	1.90
HD-41	440430	1562721	315	1.00	0.20	4.65	0.48	263.62	7.00
HD-42	440050	1561629	283.6	0.50	0.08	1.54	0.22	50.83	2.80
HD-43	438972	1562359	309.9	0.50	0.11	1.84	0.29	101.44	0.80
HD-44	438899	1562188	281	0.00	0.17	1.09	0.14	0.61	0.40
HD-45	439043	1562642	350.3	3.00	0.29	26.93	0.83	153.65	1.80
HD-48	438861	1563048	324	25.50	0.38	18.29	1.59	190.01	6.20
HD-49	439066	1563721	240	5.50	0.33	18.46	5.83	227.23	7.60
HD-50	438456	1563261	298	1.00	0.12	6.75	0.06	268.18	1.40
HD-51	439037	1562900	360	1.50	0.05	2.76	0.92	20.08	0.70
HD-52	438563	1563254	255	2.00	0.35	5.41	0.15	275.54	4.00
HD-53	439022	1563673	262.5	8.50	1.28	16.36	0.26	257.73	5.90
HD-54	439586	1562993	337	3.50	0.22	15.60	2.61	93.47	1.10
HD-55	439611	1563043	323	1.50	0.68	64.04	4.06	224.82	2.90
HD-56	440012	1563378	260.5	4.50	0.28	13.36	0.50	69.78	0.90
HD-57	439977	1563258	290	0.00	0.04	1.75	0.27	6.24	0.20
HD-58	439304	1563278	314	7.00	0.32	22.29	4.40	321.26	2.70
HD-59	439299	1563250	315.7	2.50	0.03	6.03	0.66	34.34	0.40
HD-60	439247	1563217	330	4.50	0.04	5.79	3.69	106.74	0.70
HD-61	439189	1563205	330.5	4.00	0.06	14.46	7.64	201.65	2.70
HD-62	439280	1563137	338	1.50	0.12	14.53	2.90	145.54	0.90
HD-63	439228	1563069	360	4.50	0.25	6.19	1.05	99.68	1.80
HD-64	440080	1563443	259.5	1.00	0.21	10.58	0.24	69.53	2.50
HD-65	439953	1563551	253	0.00	0.15	2.23	0.28	26.45	0.90
HD-66	439980	1563568	250	0.00	0.04	0.78	0.16	5.83	0.20
HD-67	440018	1563580	245	0.00	0.37	0.35	0.98	148.84	2.00
HD-72	439254	1562840	390	1.50	0.01	2.08	0.54	12.69	0.20
HD-73	439501	1563338	308	1.50	0.15	18.54	2.43	92.40	0.50
HD-74	439804	1562913	318	1.00	0.08	8.06	0.46	13.44	0.50

Mag= magnetite, Grt= Garnet, Hem= hematite, Mnz= Monazite, Cst= cassiterite, Zrn= Zircon.

3.3 Resources and reserve estimation by using conventional method (polygonal method)

Polygonal estimation method is mostly used for tabular deposits that have been collected the samples from drill holes, channel, trench, pit, and stream. This method is used the principle of rule of nearest points. In the polygonal method, there are firstly constructed the connection lines of all sample points. Then, bisector lines are drawn perpendicular to connection lines.

The boundary of ore body is based on the geological aspects and safety factor for the geologist because the western part of Heinda concession area is mostly covered by the meta-sediments and the other fact is based upon the influence of samples. There have 72 polygons for representing samples to calculate the ore reserve of Heinda mine in which 72 samples in total 77 heavy mineral samples are used. The total area of polygons is 4,246,957 m^2 when the mining concession area of Heinda mine covered 8.23 km^2. The contour map of the study area was taken out using with the Autocad software from the UTM map sheet No. 1498/08. The depth of ore body was derived by differing from the highest elevation to the lowest elevation. The highest elevation and the lowest elevation are 390 m and 210 m, respectively.

3.4 Resource and reserve estimation by using geostatistical method (ordinary kriging)

3.4.1 Variogram modelling

In variogram calculation, there are 77 samples of heavy mineral samples used to construct the variogram modelling. Microsoft excel was used to make computing of experimental variogram and the fitting variogram. In addition, Microsoft excel was also used to draw all variograms. The calculation of experimental variogram is shown in Table 3.2. The experimental variogram is illustrated in Figure 3.4. The lag distance and semivariogram between samples points are important to construct the experimental variogram. To calculate the lag distance, the locations of the samples were used. The values of tin concentration were selected to calculate the semi-variance.

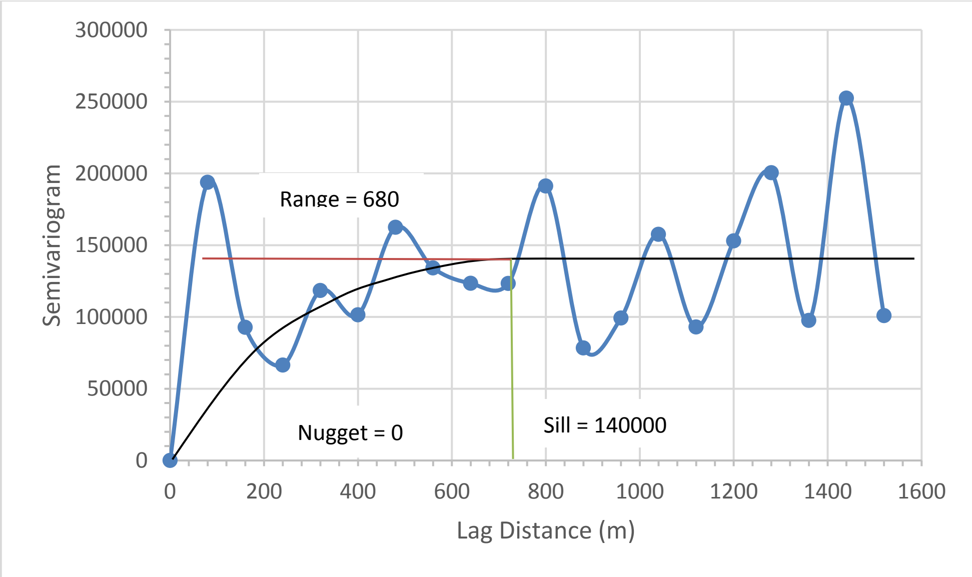


Figure 3.4 Experimental variogram

Before computing the variogram, the data were separated into offset bins for the lag distances of all samples. These offset bins were separated by the lag distances which are defined the offset to the center of bin between minimum offset and maximum offset in bin range. Sill, nugget, and range were provided from the experimental variogram calculation. These parameters were used in fitting variogram and the estimation of unknown sample values by using ordinary kriging. In fitting variogram, there are three fitting models in variograms including spherical model, exponential model, and gaussian model.

Table 3.2 Calculation of semivariogram

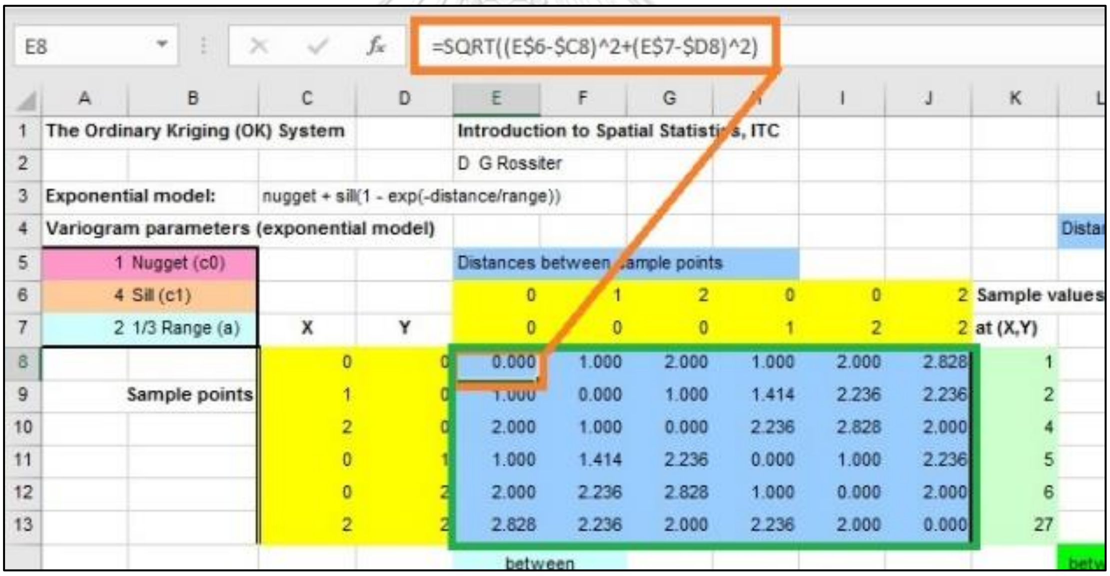
Sum of $(x_i - y_i)^2$	No	Bin	Bin Range		Semivariogram
			From	To	
0	98	0	0	40	0
26,738,166	69	80	40	120	193,755
16,679,316	90	160	120	200	92,663
19,517,863	147	240	200	280	66,387
39,298,512	166	320	280	360	118,369
48,465,532	239	400	360	440	101,392
64,292,085	198	480	440	520	162,354
53,643,691	200	560	520	600	134,109
49,360,872	200	640	600	680	123,402
47,590,327	193	720	680	760	123,291
58,870,385	154	800	760	840	191,138
27,100,355	173	880	840	920	78,325
28,580,272	144	960	920	1,000	99,237
45,053,870	143	1,040	1,000	1,080	157,531
21,384,256	115	1,120	1,080	1,160	92,975
14,983,649	49	1,200	1,160	1,240	152,894
38,880,648	97	1,280	1,240	1,320	200,416
16,764,025	86	1,360	1,320	1,400	97,465
32,308,451	64	1,440	1,400	1,480	252,410
12,304,826	61	1,520	1,480	1,560	100,859

3.4.2 Ordinary kriging

The estimation of unknown samples values by using ordinary kriging was calculated by using Microsoft office excel software. In this study, there are 429 blocks represented unknown samples in which the area of each blocks has 100 m x 100 m. The ordinary kriging method provides not only the estimated values of unknown samples but also the kriging variances. The plotting and mapping of estimated samples and variance of ordinary kriging used with Autocad software. The exponential model in fitting variogram models is used to calculate the ordinary kriging method.

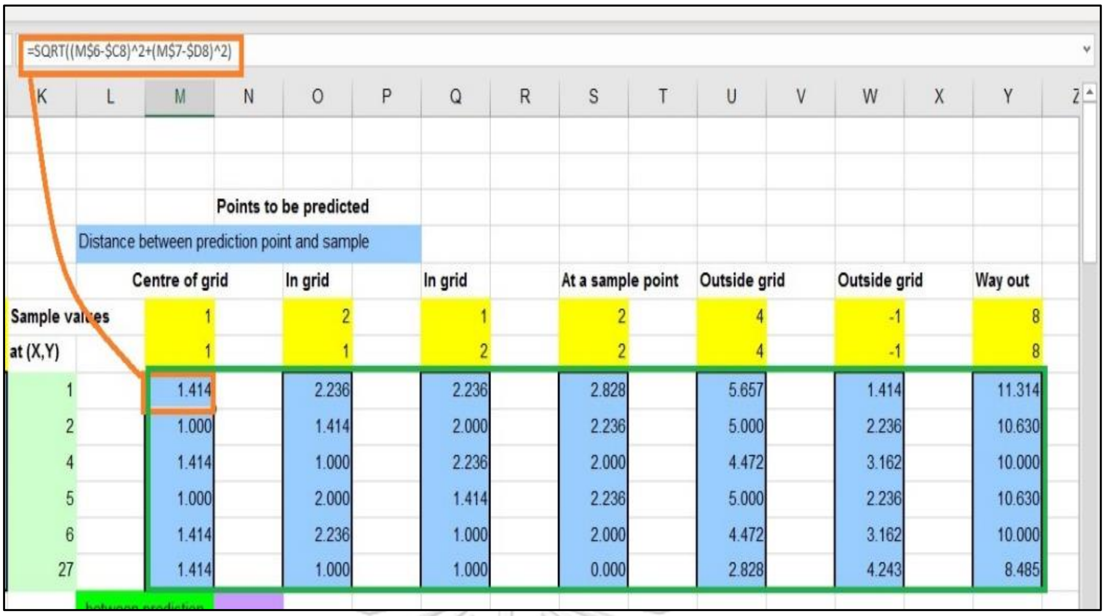
In ordinary kriging calculation, the first step is the calculation of the distances between the known sample points. The second step is also the calculation of the distances between known samples points and unknown samples points. The third step is not only the calculation of covariances known samples points but also the calculation of covariances between known samples points and predicted samples points in matrix form by using exponential variogram values including sill, nugget effect and range. The fourth step is the calculation of weighting coefficient. Finally, kriging values of unknown samples and kriging error are calculated.

In calculation of Microsoft office excel software, there are shown the steps of ordinary kriging calculation (Figure 3.5, 3.6, 3.7, 3.8, 3.9, 3.10, and 3.11). According to a lot of data in my Microsoft office excel software calculation, the calculation methodology of ordinary kriging are presented from the introduction to spatial statistics, ITC (D. G. Rossiter) to get the more understanding and the good views.


E8 =SQRT((E$6-$C8)^2+(E$7-$D8)^2)

	A	B	C	D	E	F	G	H	I	J	K	L
1	The Ordinary Kriging (OK) System				Introduction to Spatial Statistics, ITC							
2					D G Rossiter							
3	Exponential model:		nugget + sill(1 - exp(-distance/range))									
4	Variogram parameters (exponential model)											Dista
5	1	Nugget (c0)			Distances between sample points							
6	4	Sill (c1)			0	1	2	0	0	2	Sample values	
7	2	1/3 Range (a)	X	Y	0	0	0	1	2	2	at (X,Y)	
8			0	0	0.000	1.000	2.000	1.000	2.000	2.828	1	
9		Sample points	1	0	1.000	0.000	1.000	1.414	2.236	2.236	2	
10			2	0	2.000	1.000	0.000	2.236	2.828	2.000	4	
11			0	1	1.000	1.414	2.236	0.000	1.000	2.236	5	
12			0	2	2.000	2.236	2.828	1.000	0.000	2.000	6	
13			2	2	2.828	2.236	2.000	2.236	2.000	0.000	27	

Figure 3.5 Calculation of the distance among known samples

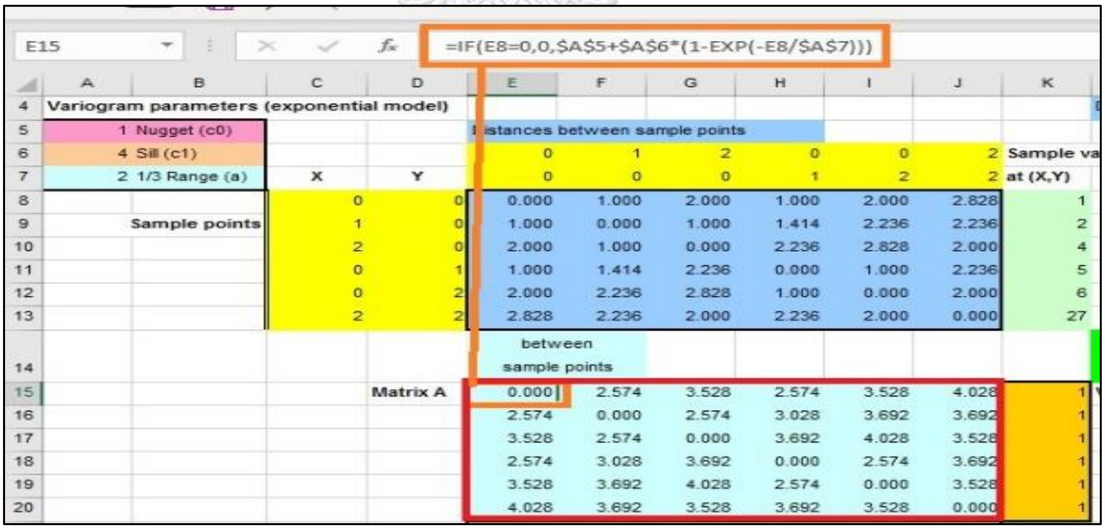


=SQRT((M$6-$C8)^2+(M$7-$D8)^2)

	Points to be predicted / Distance between prediction point and sample						
	Centre of grid	In grid	In grid	At a sample point	Outside grid	Outside grid	Way out
Sample values	1	2	1	2	4	-1	8
at (X,Y)	1	1	2	2	4	-1	8
1	1.414	2.236	2.236	2.828	5.657	1.414	11.314
2	1.000	1.414	2.000	2.236	5.000	2.236	10.630
4	1.414	1.000	2.236	2.000	4.472	3.162	10.000
5	1.000	2.000	1.414	2.236	5.000	2.236	10.630
6	1.414	2.236	1.000	2.000	4.472	3.162	10.000
27	1.414	1.000	1.000	0.000	2.828	4.243	8.485

Figure 3.6 Calculation of the distance between known samples and prediction samples

In Figure 3.5 and 3.6, the calculation of distances between each two samples in green box is needed to follow above method with their corresponding values at that points in Microsoft office excel.



=IF(E8=0,0,$A$5+$A$6*(1-EXP(-E8/$A$7)))

Variogram parameters (exponential model): 1 Nugget (c0); 4 Sill (c1); 2 1/3 Range (a)

Sample points X	Y	Distances between sample points						Sample values at (X,Y)
		0	1	2	0	0	2	
		0	0	0	1	2	2	
0	0	0.000	1.000	2.000	1.000	2.000	2.828	1
1	0	1.000	0.000	1.000	1.414	2.236	2.236	2
2	0	2.000	1.000	0.000	2.236	2.828	2.000	4
0	1	1.000	1.414	2.236	0.000	1.000	2.236	5
0	2	2.000	2.236	2.828	1.000	0.000	2.000	6
2	2	2.828	2.236	2.000	2.236	2.000	0.000	27

Matrix A (between sample points)						
0.000	2.574	3.528	2.574	3.528	4.028	1
2.574	0.000	2.574	3.028	3.692	3.692	1
3.528	2.574	0.000	3.692	4.028	3.528	1
2.574	3.028	3.692	0.000	2.574	3.692	1
3.528	3.692	4.028	2.574	0.000	3.528	1
4.028	3.692	3.528	3.692	3.528	0.000	1

Figure 3.7 Calculation of the coefficient of variance among known samples

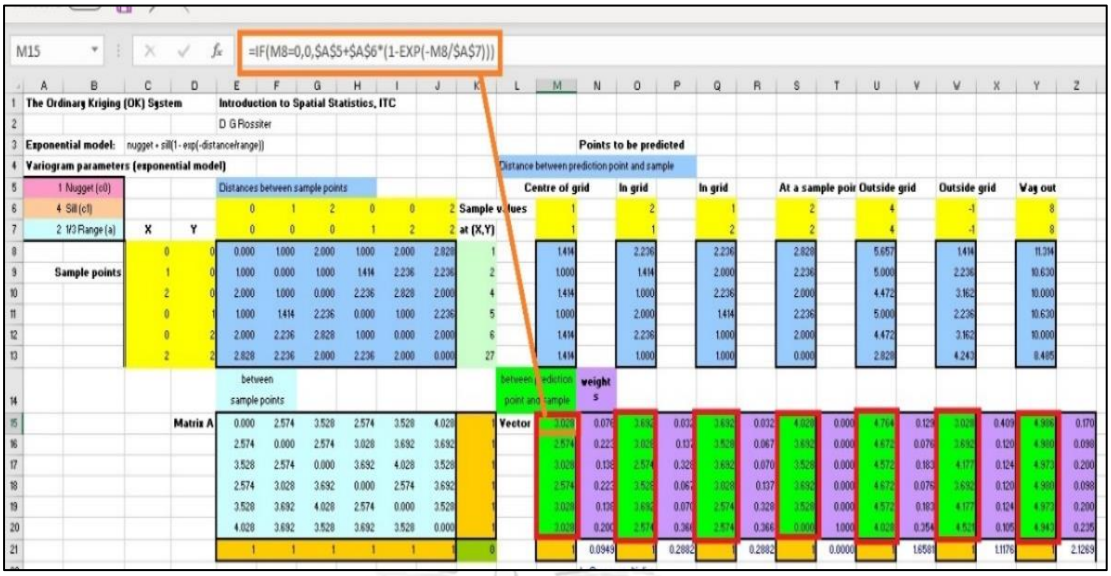


Figure 3.8 Calculation of the coefficient of variance between known samples and prediction samples

In Figure 3.7 and 3.8, the calculation of each coefficient of variances in red boxes is needed to follow above method with their corresponding values at that points in Microsoft office excel. In calculation, A5 is the value of nugget effect, A6 is the value of sill, and A7 is the value of 1/3 of range.

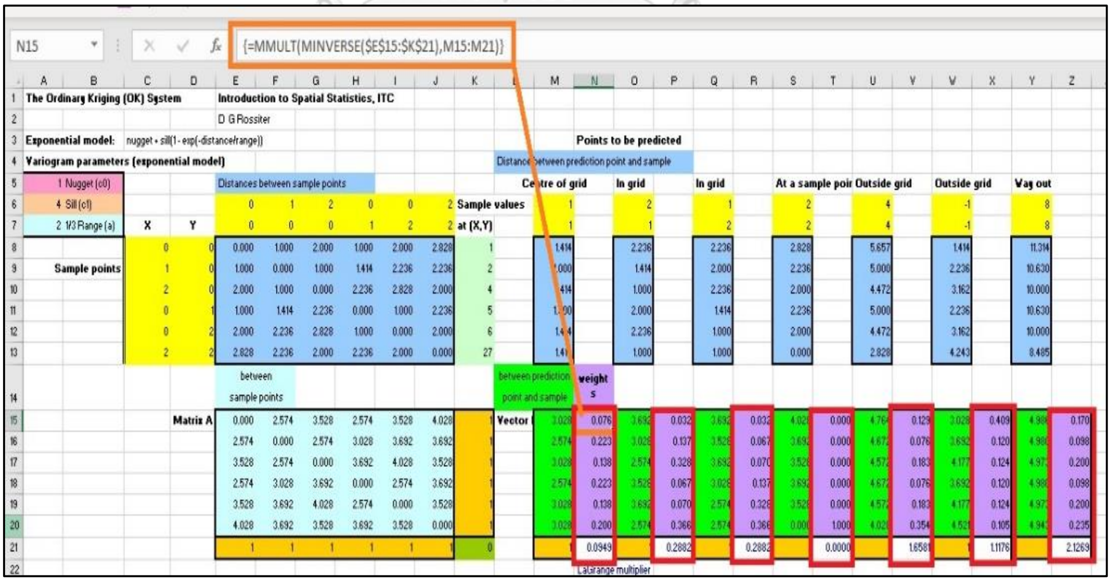


Figure 3.9 Calculation of the weighting coefficient

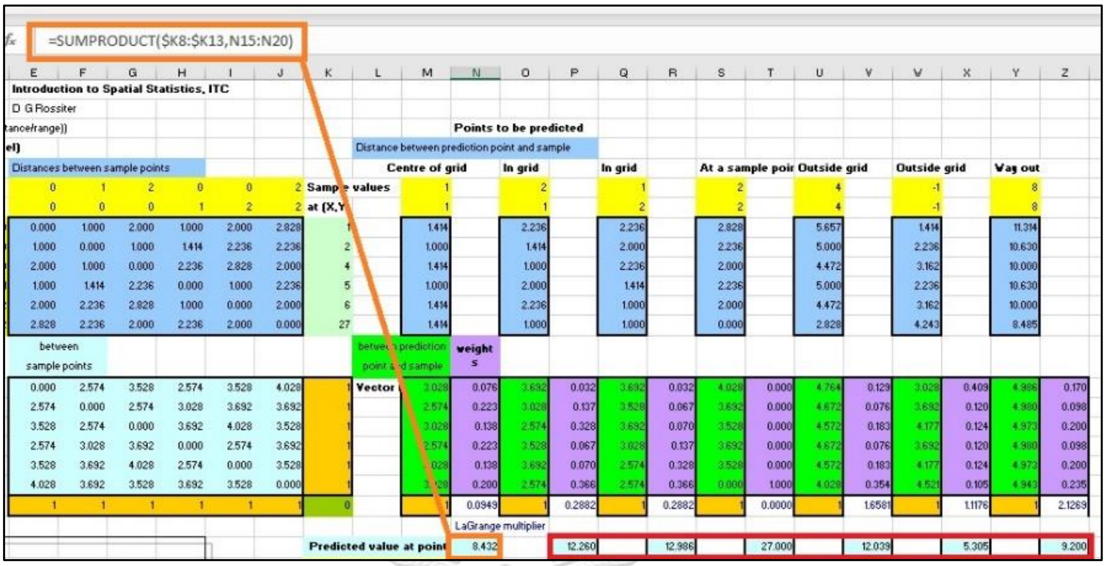


Figure 3.10 Calculation of the kriging predicted values

In Figure 3.9 and 3.10, the calculations for each value in red boxes is needed to follow above method with their corresponding values at that points in Microsoft office excel. In Figure 3.10, K8:K13 are the values of the known samples.

In Figure 3.11, the calculations for each value in red boxes is needed to follow above method with their corresponding values at that points in Microsoft office excel.

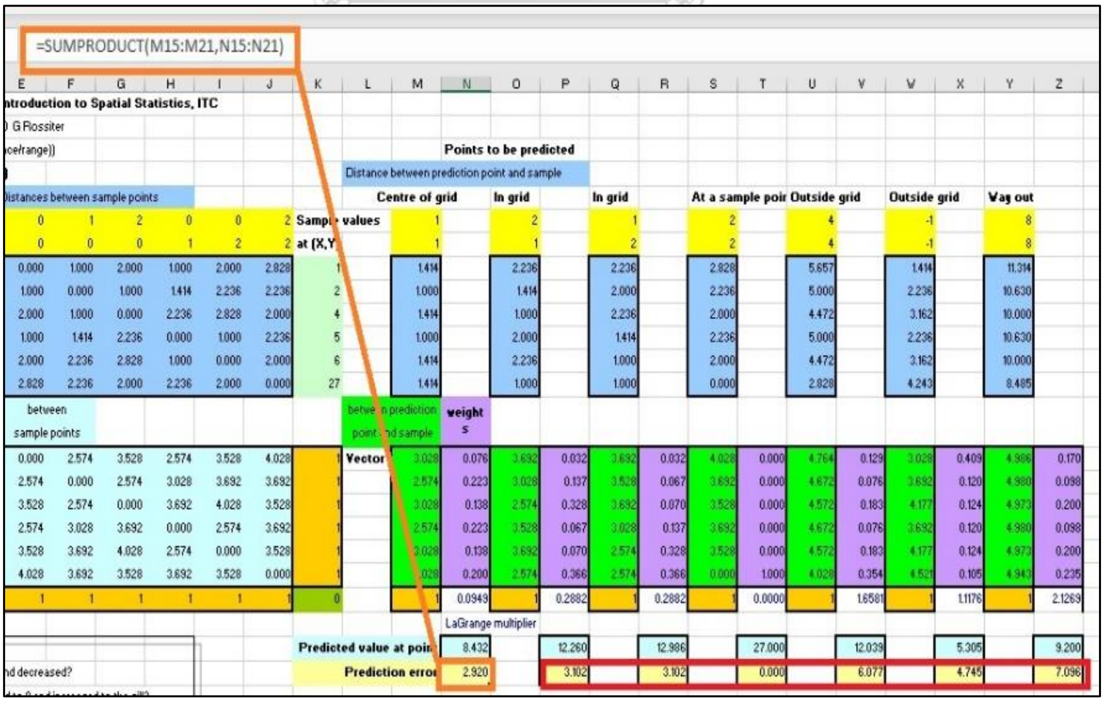


Figure 3.11 Calculation of kriging prediction error

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Resource and reserve estimation by using conventional method

4.1.1 Mineral resource estimation by using polygonal method

In mineral resource estimation by using polygonal method, there were used 72 samples in total 77 heavy mineral samples from the vicinity of Heinda mine. The depth of ore body was ranging from 2 m to 175 m which were differ from the represented elevation to the lowest elevation (210 m) at the Heinda mine. A minimum value of thickness must be considered to the reflection of the economic feasibility of the exploitation. The highest and lowest tin concentrations were 1,949.65 g/m^3 and 4 g/m^3, respectively. The average tin concentration is 211.82 g/m^3. The histogram had been performed and illustrated the grade distribution tin concentrate (Figure 4.1). The location, grade distribution, and polygonal blocks of samples is shown in Figure 4. 2. The coefficient of variation and standard deviation were 58.95 and 359.34. The statistical parameters of 72 heavy mineral samples are illustrated in Table 4.1. The total area of the mineral resources by using polygonal method was 4,246,957 m^2 and the volume of the ore body was 378,562,490 m^3. The specific gravity of cassiterite and recovery factor in Heinda mine were 1.899 and 0.7, respectively. Resource estimation is derived from the volume by applying tin concentration, the specific gravity, and recovery factor. The result of resource estimation by using polygonal method is about 122,460 tons (SnO_2). The calculation of mineral resource is shown in Appendix B.

Table 4.1 Statistical parameters of heavy mineral samples

Mean	211.82
Standard Error	42.35
Median	107.23
Standard Deviation	359.34
Variance	129,127.34
Kurtosis	13.83
Skewness	3.62
Range	1,945.65
Minimum	4
Maximum	1,949.65
Sum	15,250.87
Count	72

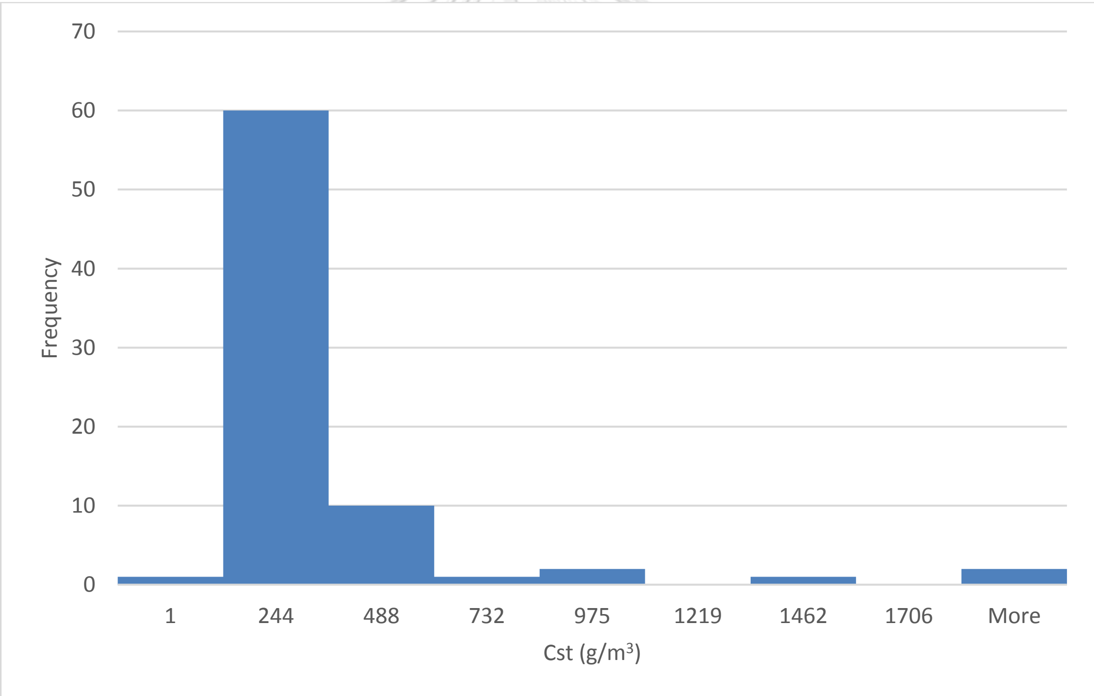


Figure 4.1 Histogram of tin concentration of Heinda mine

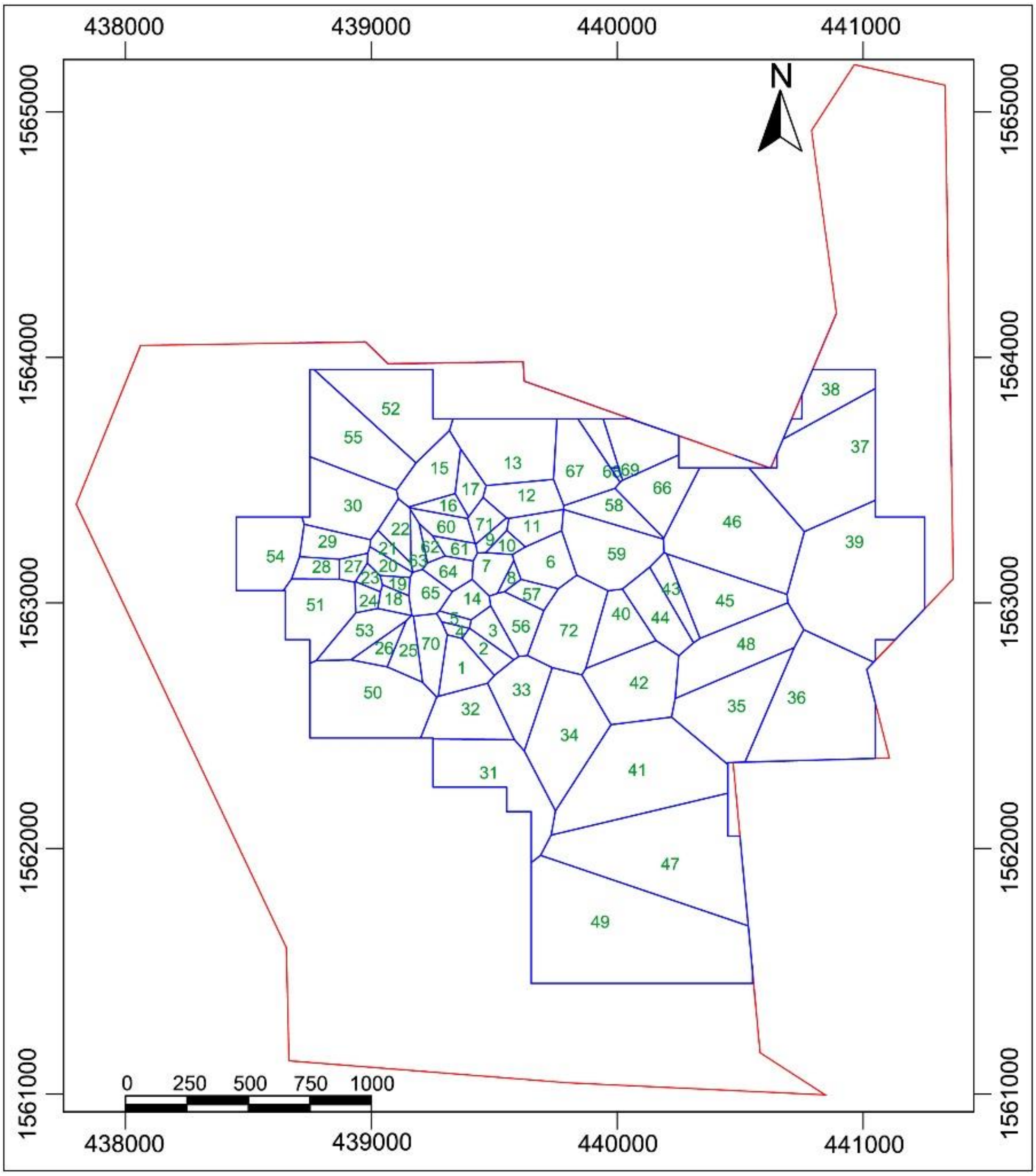


Figure 4.2 Mineral resource boundary by using polygonal method

4.1.2 Pit design and mineable reserve estimation by using polygonal method

The slope of pit is a one factor affecting of the pit size and pit shape. To stable the pit wall, the pit slope is needed to effect for the mining production in mine life. Rocks strength, fault, joint, present of water, and the other geological information are the controlling factors of the evaluation of pit slope. Hassan Z, Harraz (2015-2016) said that rocks must be stronger than sand in which slope angle 45 degree of slope angle is usually maximum slope. The pit limit is controlled by the economic evaluation, geological factors, geotechnical factors, and groundwater condition. Among the elevations of drill-holes data, 300 m is the lowest elevation of the drill holes. The depth of drill holes is between 12 m and 15 m. So, the approximated pit limit is 20 m and the pit slope angle are 45 degree in open pit design.

According to the formula, a rule of thumb is that the catch bench should be 4. m + 0.2 H where H is the height of the bench. This mean when the height bench is 10 m, the catch bench can occur 6 m. In this study, the number of benches was considered at least 2 benches with 10 m of bench height in 63 degree of bench face angle.

There are 72 polygonal blocks of represented 72 samples in total 77 heavy mineral samples to calculate the mineable reserve beyond pit design. The area of mineable reserve calculation is the same both polygonal method and ordinary kriging method. The limitations of the area of pit design are based on the considerations including geological contact, influence of samples, and the concession area of mine. The volume of polygonal method is 154,739,032 m^3. The considerations of volume calculation are pit limit, pit slope angle, the depth of ore body, and the area of each blocks. The mineable reserve by using the polygonal method is 32,349 tons (SnO_2) with the block estimation. The calculation of mineable reserve is shown in Appendix C. The pit design of each blocks is illustrated in Figure 4.3.

In the grade tonnage curve, there are 20 grades ranging from 4 g/m^3 to 1,949.65 g/m^3 (Table 4.2). In the grade tonnage curve, there have no grade in some cutoff grade. The interval of grade is considered about 100 g/m^3 apart of tin concentration. The construction grade tonnage curve is based upon the average grade, tonnage, and cutoff grade (Figure 4.4). The cutoff grades are represented each lowest grade of intervals.

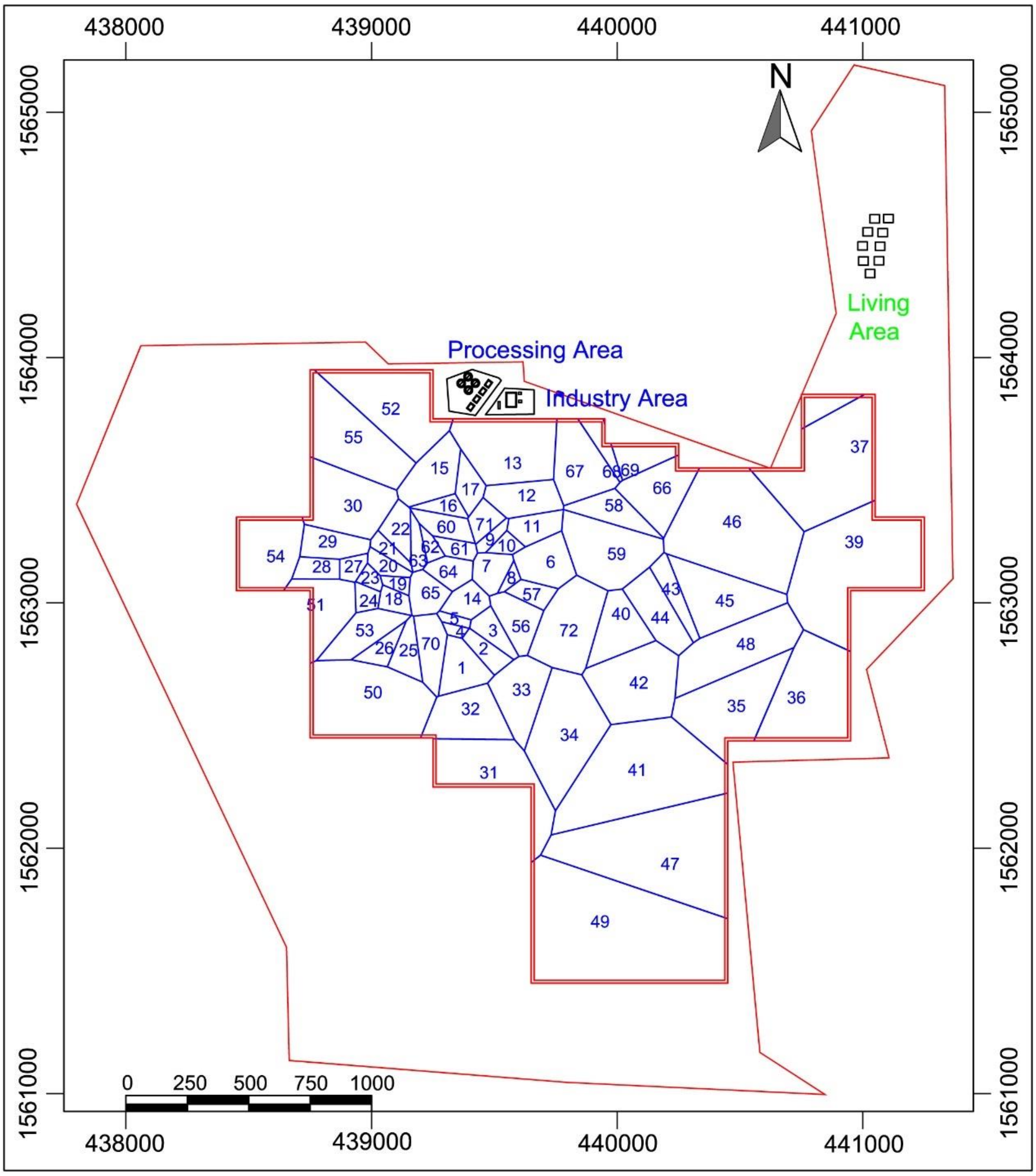


Figure 4.3 Pit design and mineable reserve boundary by using polygonal method

Table 4.2 Calculation of cumulative tonnages and average grade

Interval Tin Concentrate	Cut Off Grade	Tons	Cumulative Tons	Average Grade
4-100	4	3,691	3,691	45.62
100-200	100	16,266	19,957	141.93
200-300	200	4,521	24,479	247.88
300-400	300	1,406	25,885	381.40
400-500	400	1,925.	27,810	441.62
500-600	500	202.	28,012	507.37
600-700	600	0	28,012	0
700-800	700	270	28,283	777.53
800-900	800	603	28,886	889.64
900-1,000	900	0	28,886	0
1,000-1,100	1,000	0	28,886	0
1,100-1,200	1,100	0	28,886	0
1,200-1,300	1,200	0	28,886	0
1,300-1,400	1,300	0	28,886	0
1,400-1,500	1,400	1,395	30,281	1,415.01
1,500-1,600	1,500	0	30,281	0
1,600-1,700	1,600	0	30,281	0
1,700-1,800	1,700	0	30,281	0
1,800-1,900	1,800	698	30,980	1,831.14
1,900-2,000	1,900	1,369	32,349	1,949.65

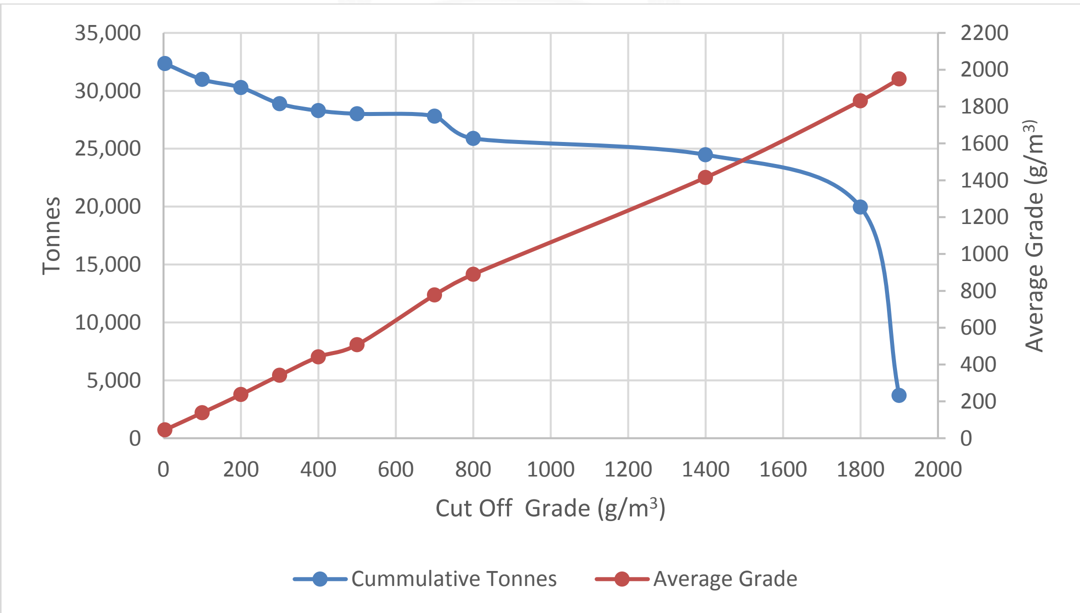


Figure 4.4 Grade tonnage curve by using polygonal method

4.2 Resource and reserve estimation by using geostatistical method

4.2.1 Variogram modelling

In binning, there are 16 lag distances ranging from 0 m to 1,520 m by increasing 80 m apart in lag distances of all samples including known samples and unknown samples. The experimental variogram calculation applied the lag distances and the semivariogram. According to the experimental variogram calculation, the result showed that spatial variation is not the same in all direction. Nugget effect, range, and sill in experimental variogram calculation were 0, 680 and 140,000, respectively (Table 4.3). These factors were used to fit the variogram modelling. Among the fitting models, the result shows that exponential model is good one for the study area (Figure 4.5, 4.6, 4.7, and 4.8).

Table 4.3 Calculation of semivariogram values for variogram fitting models

Sill	Range	Lag Distance (m)	γ(h)	Exponential	Spherical	Gaussian
140,000	680	0	0	0	0	0
140,000	680	80	193,755	41,633	24,592	5,694
140,000	680	160	92,663	70,886	48,500	21,424
140,000	680	240	66,387	91,439	71,040	43,655
140,000	680	320	118,369	105,880	91,529	67,956
140,000	680	400	101,392	116,027	109,281	90,420
140,000	680	480	162,354	123,156	123,615	108,599
140,000	680	560	134,109	128,165	133,845	121,697
140,000	680	640	123,402	131,685	139,288	130,182
140,000	680	720	123,291	134,157	140,000	135,153
140,000	680	800	191,138	135,895	140,000	137,798
140,000	680	880	78,325	137,116	140,000	139,079
140,000	680	960	99,237	137,973	140,000	139,646
140,000	680	1,040	157,531	138,576	140,000	139,875
140,000	680	1,120	92,975	139,000	140,000	139,959
140,000	680	1,200	152,894	139,297	140,000	139,988
140,000	680	1,280	200,416	139,506	140,000	139,997
140,000	680	1360	97,465	139,653	140,000	139,999
140,000	680	1,440	252,410	139,756	140,000	140,000
140,000	680	1,520	100,859	139,829	140,000	140,000

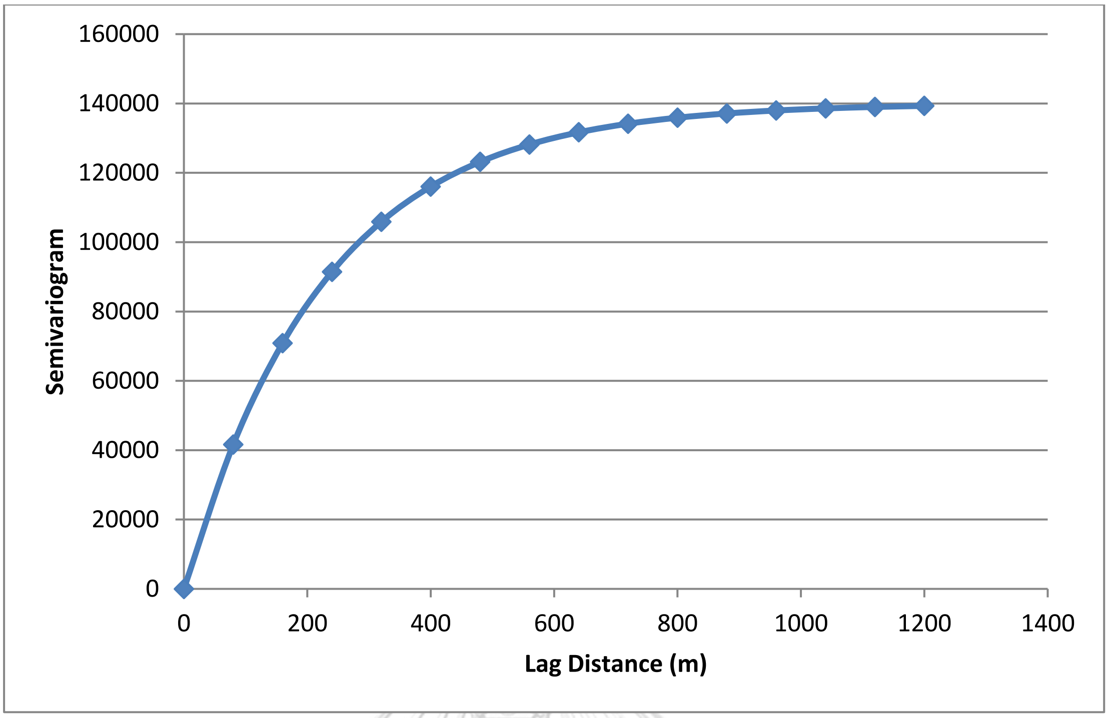


Figure 4.5 Exponential fitting model

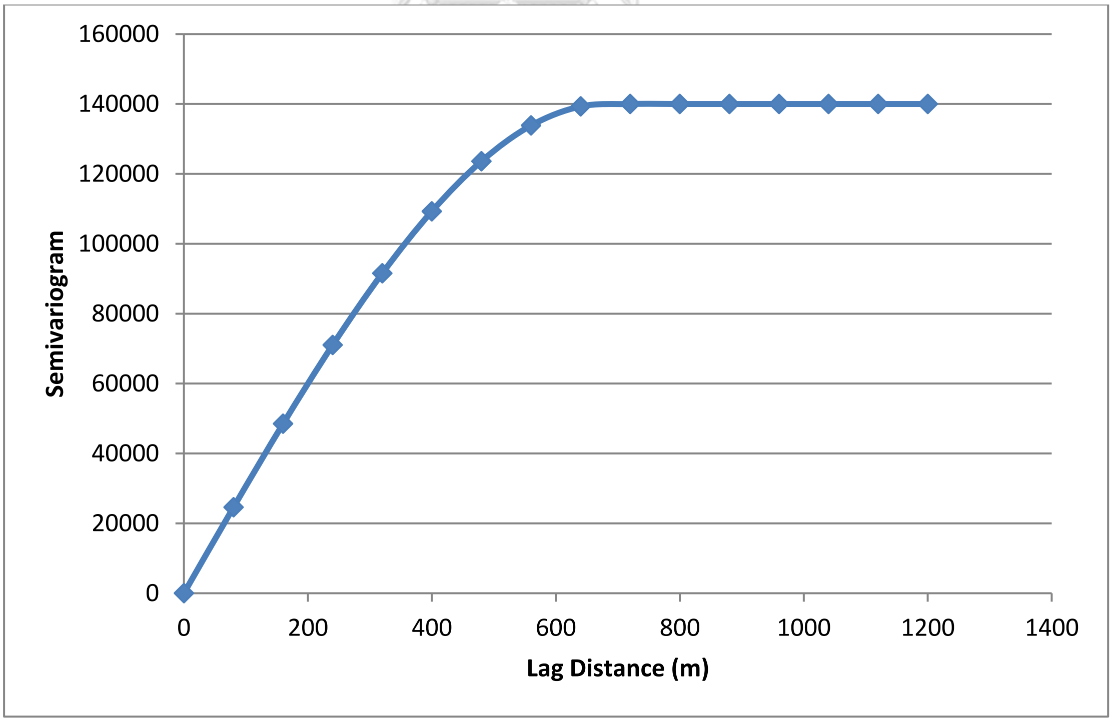


Figure 4.6 Spherical fitting model

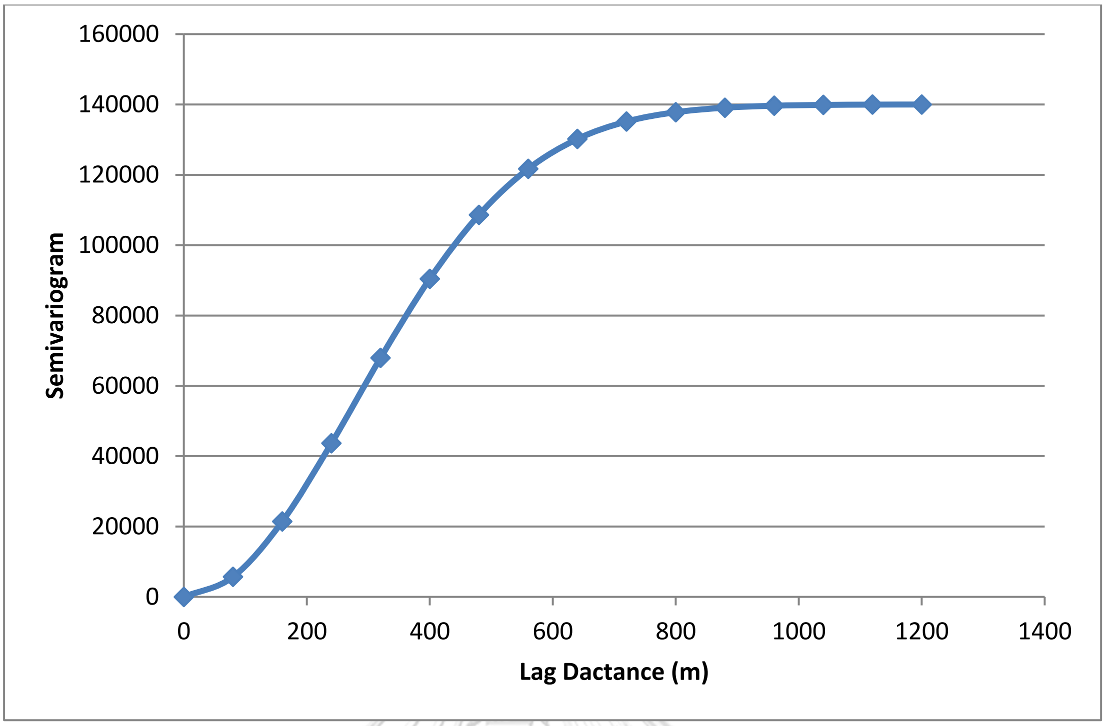


Figure 4.7 Gaussian fitting model

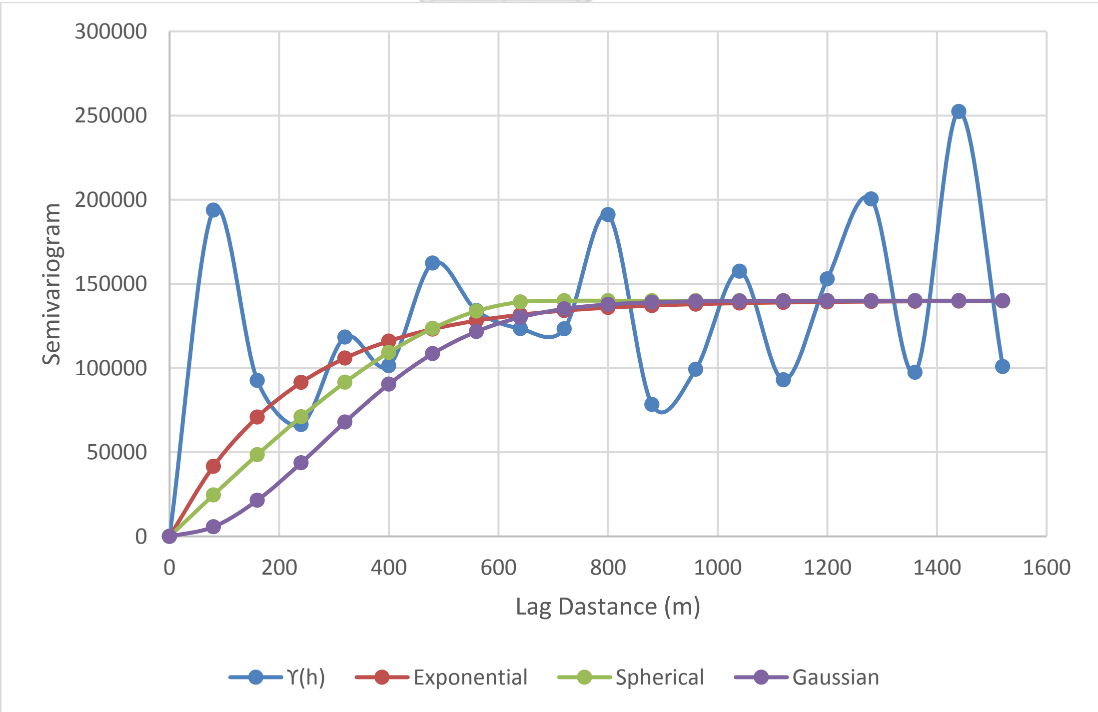


Figure 4.8 Comparison of variogram fitting models

4.2.2 Mineral resources estimation by using ordinary kriging

The estimation of unknown samples values by using ordinary kriging was applied by using Microsoft office excel software. Autocad software was used to plot and draw the map for the ore grade distribution of kriging estimated samples. In this study, there are 429 blocks represented unknown samples in which the area of each blocks has 100 m x 100 m. The ordinary kriging method provides not only the estimated values of unknown samples but also the kriging variances. The exponential model in fitting variogram models is used to calculate the ordinary kriging method.

The estimated average tin concentration by using ordinary kriging is 254.35 g/m^3 and the estimated average kriging variance is 34,360. The minimum and maximum values of tin concentrations are 20.9 g/m^3 and 1,485.55 g/m^3. Moreover, the standard deviation is 185.37 g/m^3. Histogram of estimated samples is shown in Figure 4.9 and statistical parameters are demonstrated in Table 4.4. The grade distribution of estimated samples by using ordinary kriging can be seen in Figure 4.10. Moreover, the kriging variance can also be seen in Figure 4.11. The area of mineral resource using ordinary kriging is 4,246,958 m^2. The volume of mineral resource estimation of kriging estimated samples is 364,031,643 m^3. The tonnage calculation is the results in which the volume is multiplied by the tin concentration, density, and recovery factor. According to the data of Pongpipat Company Ltd., the density of tin concentrate and recovery factor are 1.899 and 0.7. The mineral resources of Heinda mine by using ordinary kriging indicates about 117,905 tons (SnO_2). The calculation of mineral resource by using ordinary kriging method is illustrated in Appendix D.

Table 4.4 Statistical parameters of kriging estimated samples

Mean	254.35
Standard Error	8.94
Median	211.40
Standard Deviation	185.37
Variance	34,360.34
Kurtosis	9.77
Skewness	2.63
Range	1,464.65
Minimum	20.90
Maximum	1,485.55
Sum	109,369.65
Count	429

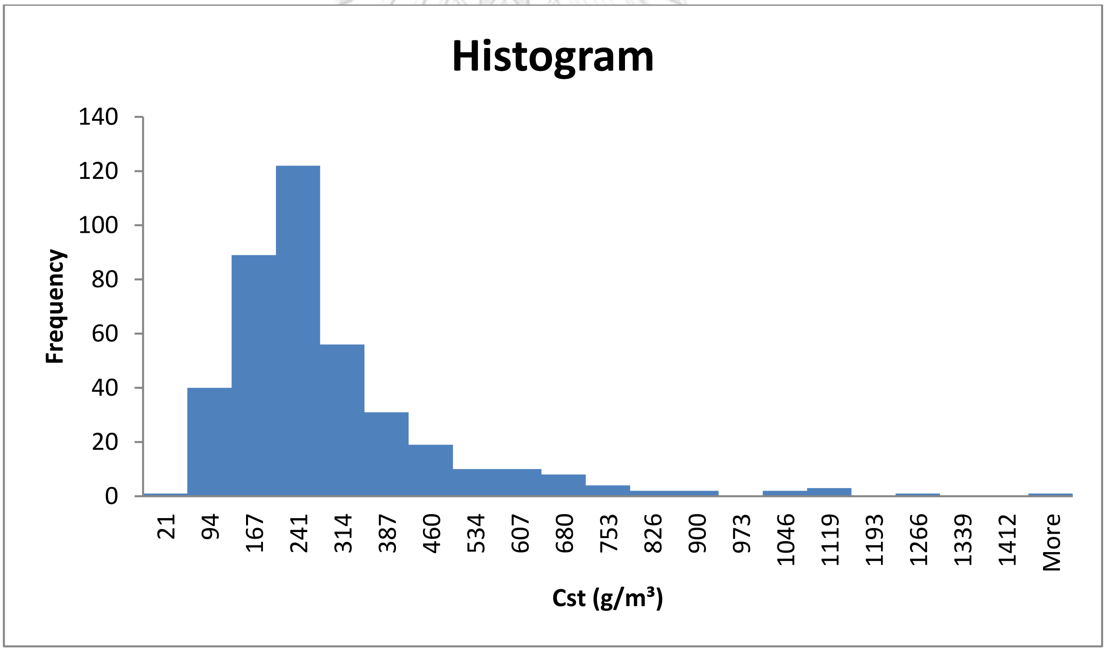


Figure 4.9 Histogram of tin concentration by using ordinary kriging

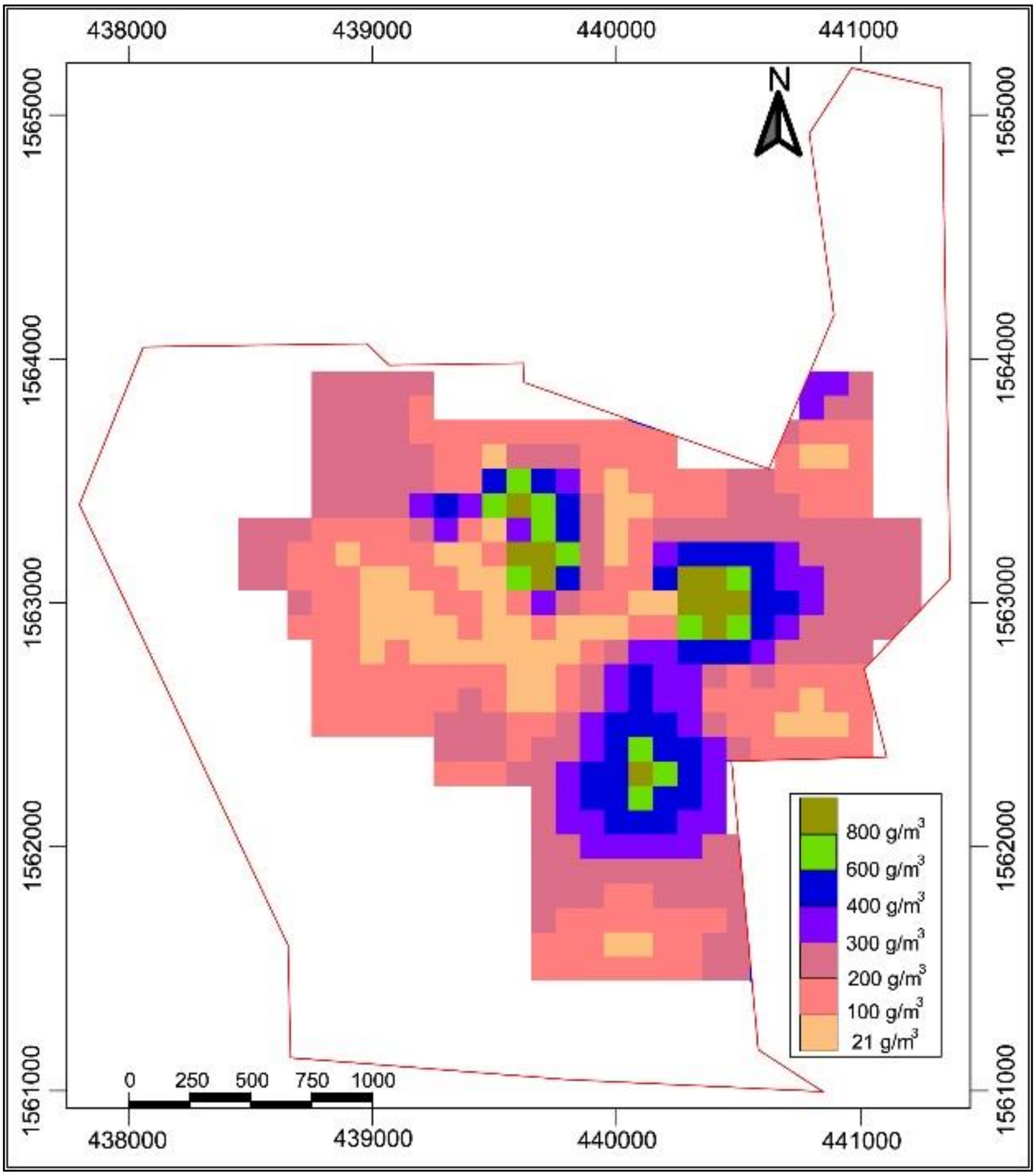


Figure 4.10 Distribution of estimated tin concentration by using ordinary kriging

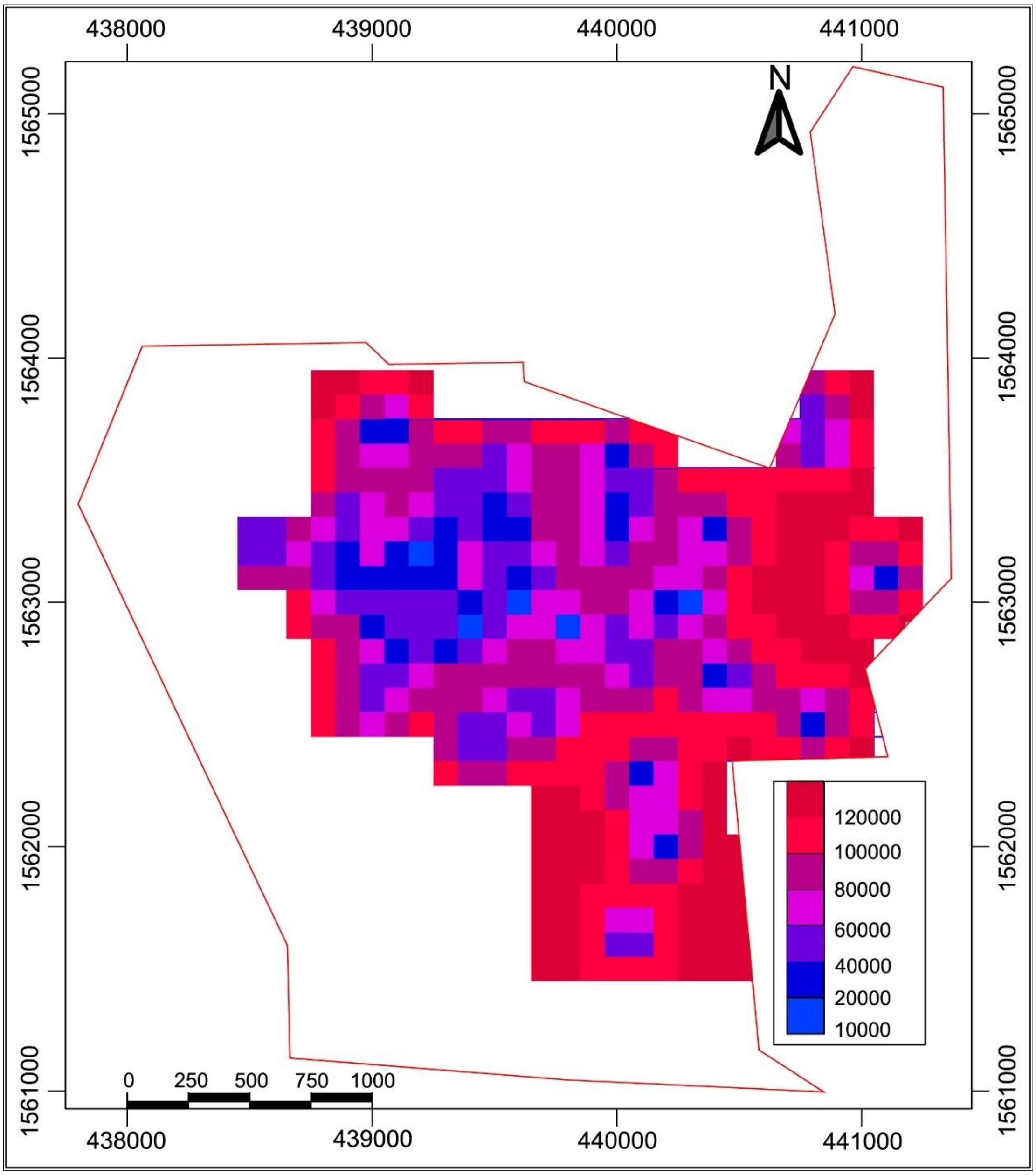


Figure 4.11 Kriging error of estimated tin concentration by using ordinary kriging

4.2.3 Pit design and mineable reserve estimation by using ordinary kriging

The approximated pit limit and slope angle is 20 m and 45 degree in open pit design. In this study, the number of benches was considered at least 2 benches with 10 m of bench height in 63 degree of bench face angle.

According to the ore grade distribution of Heinda mine by using ordinary, the near center of northern part of study area is generally covered above 400 g/m^3 of tin concentration. The center of eastern part and southern part is generally influenced with above 300 g/m^3 of tin concentration at Heinda mine. There are used 401 blocks of kriging estimated samples in total 429 estimated samples to calculate the mineable reserve beyond pit design. The volume of estimated area by using ordinary kriging is 106,724,718 m^3. The mineable reserve by using the ordinary kriging method is 30,368 tons (SnO_2). The calculation of mineable reserve by using ordinary kriging is illustrated in Appendix E. The pit design and the ore grade distribution of kriging estimated samples is shown in Figure 4.12.

In the grade tonnage curve by using ordinary kriging method, there are 15 grades ranging from 20.9 g/m^3 to 1,949.65 g/m^3. In the grade tonnage curve, there have no grade in some cut-off grade. The red line is represented the average grade of tin concentration and the blue line is represented the tonnage of mineable reserve (Figure 4.13). The calculation of cumulative tonnages and average grade is shown in Table 4.5.

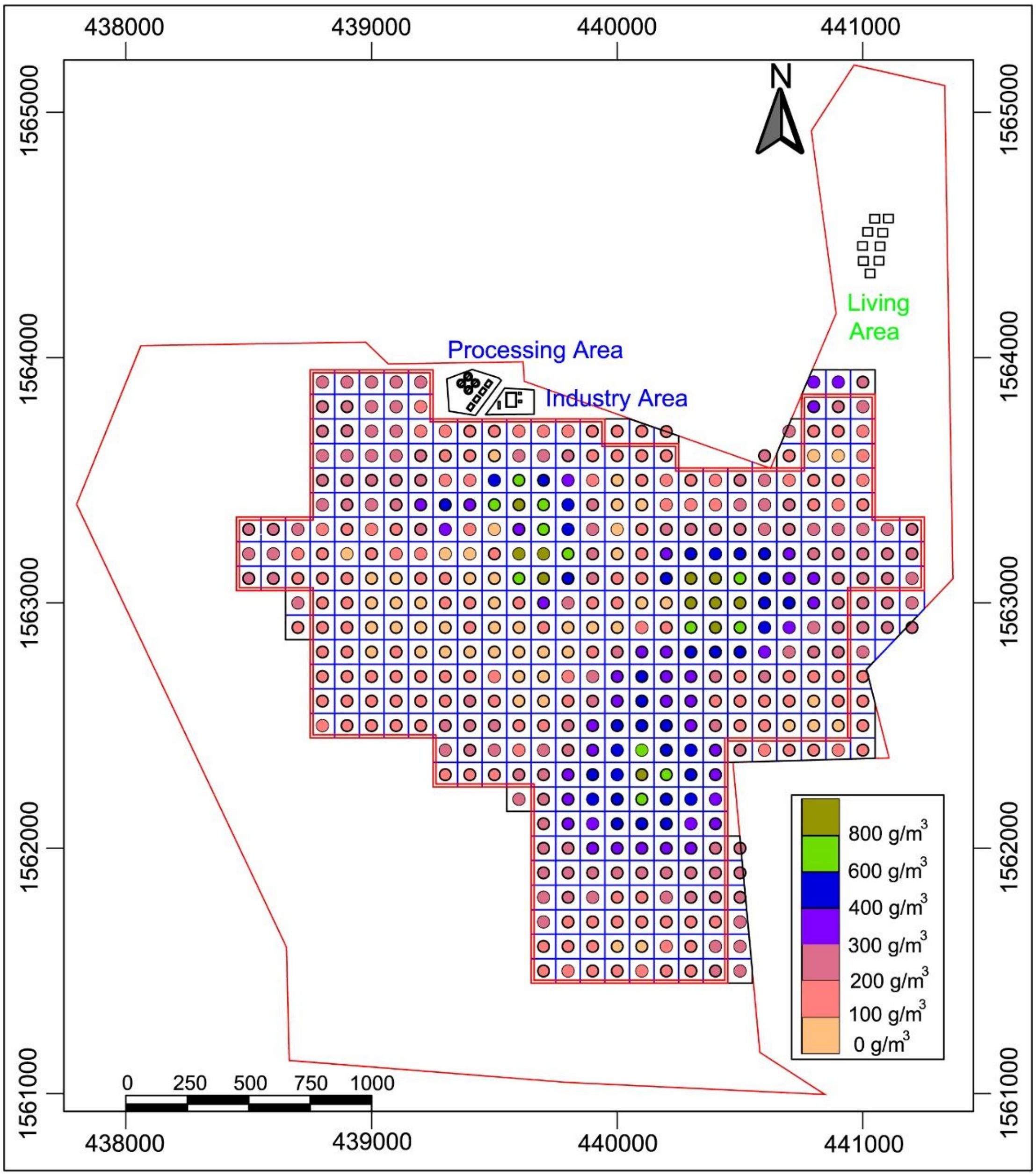


Figure 4.12 Pit design and mineable reserve boundary by using ordinary kriging

Table 4.5 Calculation of cumulative tonnages and average grade

Interval Tin Concentrate	Cut Off Grade	Tons	Cumulative Tons	Average Grade
20-100	20	1,899	1,899	70.93
100-200	100	9,037	10,935	157.20
200-300	200	6,976	17,911	239.78
300-400	300	3,473	21,385	343.05
400-500	400	2,677	24,062	443.52
500-600	500	1,960	26,022	555.62
600-700	600	1,729	27,751	651.19
700-800	700	316	28,067	735.84
800-900	800	845	28,912	827.64
900-1000	900	-	28,912	-
1,000-1,100	1,000	896	29,807	1,040.99
1,100-1,200	1,100	379	30,186	1,104.30
1,200-1,300	1,200	83	30,269	1,251.33
1,300-1,400	1,300	-	30,269	-
1,400-1,500	1,400	99	30,368	1,485.55

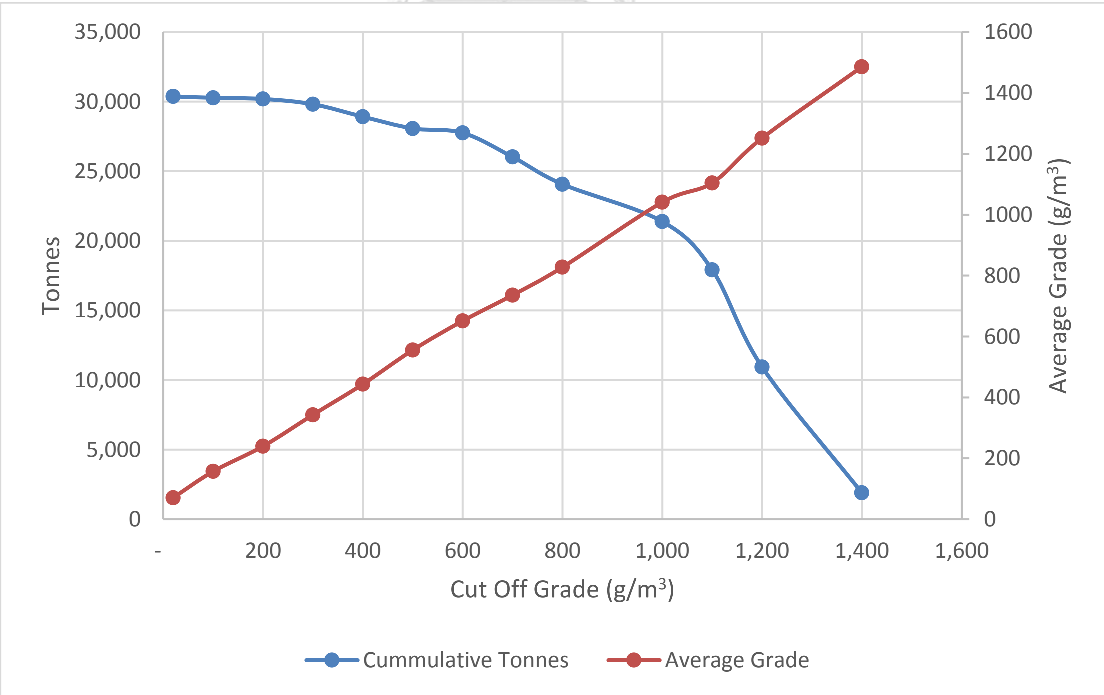


Figure 4.13 Grade tonnage curve by using ordinary kriging

4.3 Comparison between conventional method and geostatistical method

In this study, the mineral resources and mineral reserves are estimated both conventional method (polygonal method) and geostatistical method (ordinary kriging method). In the comparison, the tin grade distribution of ordinary kriging is nearly with the polygonal method and local samples data that it can be seen in the histograms. In this study, the kriging variance provides less than the polygonal variance and local samples variance. The results show that the ordinary kriging gives a smoother map. The average grade of tin concentration of kriging estimated samples is a similar grade with the average grade of polygonal method and local samples data. In the estimation of mineral resource and mineable reserve, polygonal method generates more than the ordinary kriging method. The results show that the ordinary kriging may estimate nearly the local samples data.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study has applied the ore reserve estimation by using ordinary kriging and computing the ore grade distribution from the 77 heavy mineral samples of Heinda mine. Heinda placer tin deposit distributes in the Hpolontang gravel bed. In Hpolontaung gravel bed, cassiterite is mainly associated with hematite, magnetite, zircon, monazite, and garnet. According to the influence of samples, the area of ore body is limited by using the polygonal method. The ore grade distribution of study area is occurred as randomly. The samples are used from the channel sampling. Polygonal method is used the principle of the rule of nearest points. However, polygonal method depends on the influence of the samples and spaces of the samples. The result showed that the mineral resource by using ordinary kriging method at Heinda mine indicates about 117,905 tons (SnO_2) and the mineral resource by using polygonal method is 122,460 tons (SnO_2). Furthermore, the mineable reserve by using ordinary kriging method at Heinda mine indicates about 30,368 tons (SnO_2) and the mineable reserve by using polygonal method is 32,349 tons (SnO_2). This study is the new ore estimation of Heinda mine with geostatistical method (ordinary kriging). So, the result is appeared that it may be taken in consideration for the better mining development and future's plan at the study area.

5.2 Recommendations

In this study, the heavy mineral samples are used to calculate the mineable reserve of ore deposits. These heavy mineral samples were carried out randomly in the vicinity of the study area. So, some samples can be seen so far to the other samples and some samples are very closely to the other samples. The samples collection can be an error in ore reserve estimation and estimation of ore grade distribution.

In this study, the thickness of ore body is defined by the range from the highest elevation of study area to the lowest elevation of of study area. To get the more accuracy of ore reserve, the thickness of ore body is need to more reliable in ore reserve calculation. To generate the conceptual pit design, there are many controlling factors. The influence of samples is also involved the important factor in generating of a pit design.

It is recommended that the sample collection should be carried out systematically within the entire mine area or drill holes programs should be implemented. Drill holes programs and systematic sample collection may improve the accuracy of the ore reserve estimation and estimation of ore grade distribution.

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APPENDICES

Appendix A Concentration results of the drill hole samples in gram per cubic meter

No.	Sample Name	E	N	Elevation (m)	Depth (m)	SnO_2 (g/m^3)
	HD001	439359	1562884	320.14	0.0-12.0	1,169.22
1	HD01/1	-	-	-	0.0-1.5	733.54
2	HD01/2	-	-	-	1.5-3.0	1,416.33
3	HD01/3	-	-	-	3.0-4.5	1,725.26
4	HD01/4	-	-	-	4.5-6.0	2,265.43
5	HD01/5	-	-	-	6.0-7.5	1,044.22
6	HD01/6	-	-	-	7.5-9.0	859
7	HD01/7	-	-	-	9.0-10.5	290.6
8	HD01/8	-	-	-	10.5-12.0	1,019.41
	HD002	439249	1563151	302.32	0.0-12.0	598.69
9	HD02/1	-	-	-	0.0-1.5	747.17
10	HD02/2	-	-	-	1.5-3.0	1,159.94
11	HD02/3	-	-	-	3.0-4.5	509.87
12	HD02/4	-	-	-	4.5-6.0	401.97
13	HD02/5	-	-	-	6.0-7.5	573.49
14	HD02/6	-	-	-	7.5-9.0	576.2
15	HD02/7	-	-	-	9.0-10.5	172.61
16	HD02/8	-	-	-	10.5-12.0	648.25
	HD03	439196	1563153	303.02	0.0-12.0	751.4
17	HD03/1	-	-	-	0.0-1.5	1,119.29
18	HD03/2	-	-	-	1.5-3.0	810
19	HD03/3	-	-	-	3.0-4.5	440.97
20	HD03/4	-	-	-	4.5-6.0	414.15
21	HD03/5	-	-	-	6.0-7.5	454.1
22	HD03/6	-	-	-	7.5-9.0	1,240.72
23	HD03/7	-	-	-	9.0-10.5	846.44
24	HD03/8	-	-	-	10.5-12.0	685.57
	HD04	439149	1563151	303.62	0.0-15.0	367.76
25	HD04/1	-	-	-	0.0-1.5	377.39
26	HD04/2	-	-	-	1.5-3.0	346.14
27	HD04/3	-	-	-	3.0-4.5	320
28	HD04/4	-	-	-	4.5-6.0	423.42
29	HD04/5	-	-	-	6.0-7.5	340.25

30	HD04/6	-	-	-	7.5-9.0	857.7
31	HD04/7	-	-	-	9.0-10.5	239.79
32	HD04/8	-	-	-	10.5-12.0	148.55
33	HD04/9	-	-	-	12.0-13.5	256.62
34	HD04/10	-	-	-	13.5-15.0	
	HD05	439140	1563199	301.40	0.0-15.0	854.76
35	HD05/1	-	-	-	0.0-1.5	3,411.46
36	HD05/2	-	-	-	1.5-3.0	2,259.58
37	HD05/3	-	-	-	3.0-4.5	823.92
38	HD05/4	-	-	-	4.5-6.0	387.3
39	HD05/5	-	-	-	6.0-7.5	270.32
40	HD05/6	-	-	-	7.5-9.0	463.7
41	HD05/7	-	-	-	9.0-10.5	200.92
42	HD05/8	-	-	-	10.5-12.0	387.64
43	HD05/9	-	-	-	12.0-13.5	50.22
44	HD05/10	-	-	-	13.5-15.0	292.54
	HD06	439246	1563200	301.20	0.0-12.0	699.57
45	HD06/1	-	-	-	0.0-1.5	947.09
46	HD06/2	-	-	-	1.5-3.0	271.9
47	HD06/3	-	-	-	3.0-4.5	373.21
48	HD06/4	-	-	-	4.5-6.0	1,337.34
49	HD06/5	-	-	-	6.0-7.5	1,081.89
50	HD06/6	-	-	-	7.5-9.0	808.81
51	HD06/7	-	-	-	9.0-10.5	400.4
52	HD06/8	-	-	-	10.5-12.0	375.97
	HD07	439243	1563249	302.40	0.0-12.0	1,224.67
53	HD07/1	-	-	-	0.0-1.5	1,432.04
54	HD07/2	-	-	-	1.5-3.0	934.29
55	HD07/3	-	-	-	3.0-4.5	423.11
56	HD07/4	-	-	-	4.5-6.0	489.3
57	HD07/5	-	-	-	6.0-7.5	1,262.81
58	HD07/6	-	-	-	7.5-9.0	2125.89
59	HD07/7	-	-	-	9.0-10.5	935.52
60	HD07/8	-	-	-	10.5-12.0	2,194.43
	HD08	439196	1563104	313	0.0-15.0	629.32
61	HD08/1	-	-	-	0.0-1.5	1157.7
62	HD08/2	-	-	-	1.5-3.0	712.34
63	HD08/3	-	-	-	3.0-4.5	319.4
64	HD08/4	-	-	-	4.5-6.0	322.56
65	HD08/5	-	-	-	6.0-7.5	133.9

66	HD08/6	-	-	-	7.5-9.0	1,271.60
67	HD08/7	-	-	-	9.0-10.5	685.01
68	HD08/8	-	-	-	10.5-12.0	262.26
69	HD08/9	-	-	-	12.0-13.5	319.05
70	HD08/10	-	-	-	13.5-15.0	1,109.4
	HD09	439158	1563100	314	0.0-15.0	646.79
71	HD09/1	-	-	-	0.0-1.5	224.84
72	HD09/2	-	-	-	1.5-3.0	726.21
73	HD09/3	-	-	-	3.0-4.5	192.72
74	HD09/4	-	-	-	4.5-6.0	278.39
75	HD09/5	-	-	-	6.0-7.5	764.29
76	HD09/6	-	-	-	7.5-9.0	72.26
77	HD09/7	-	-	-	9.0-10.5	379.07
78	HD09/8	-	-	-	10.5-12.0	1,722.48
79	HD09/9	-	-	-	12.0-13.5	613.16
80	HD09/10	-	-	-	13.5-15.0	1,494.50
	HD10	439192	1563056	313	0.0-15.0	616.55
81	HD10/1	-	-	-	0.0-1.5	216.81
82	HD10/2	-	-	-	1.5-3.0	159.16
83	HD10/3	-	-	-	3.0-4.5	413.72
84	HD10/4	-	-	-	4.5-6.0	707.35
85	HD10/5	-	-	-	6.0-7.5	242.89
86	HD10/6	-	-	-	7.5-9.0	
87	HD10/7	-	-	-	9.0-10.5	437.99
88	HD10/8	-	-	-	10.5-12.0	618
89	HD10/9	-	-	-	12.0-13.5	2,651.93
90	HD10/10	-	-	-	13.5-15.0	101.09
	HD11	439251	1563100	312	0.0-15.0	207.2
91	HD11/1	-	-	-	0.0-1.5	276.8
92	HD11/2	-	-	-	1.5-3.0	310.76
93	HD11/3	-	-	-	3.0-4.5	592.2
94	HD11/4	-	-	-	4.5-6.0	10.66
95	HD11/5	-	-	-	6.0-7.5	21.16
96	HD11/6	-	-	-	7.5-9.0	280.17
97	HD11/7	-	-	-	9.0-10.5	47.62
98	HD11/8	-	-	-	10.5-12.0	86.49
99	HD11/9	-	-	-	12.0-13.5	253.72
100	HD11/10	-	-	-	13.5-15.0	192.45
	HD12	439351	1563100	318	0.0-15.0	577.96
101	HD12/1	-	-	-	0.0-1.5	591.16

102	HD12/2	-	-	-	1.5-3.0	349.95
103	HD12/3	-	-	-	3.0-4.5	1,020.04
104	HD12/4	-	-	-	4.5-6.0	1,139.61
105	HD12/5	-	-	-	6.0-7.5	287.46
106	HD12/6	-	-	-	7.5-9.0	45.41
107	HD12/7	-	-	-	9.0-10.5	157.96
108	HD12/8	-	-	-	10.5-12.0	410.56
109	HD12/9	-	-	-	12.0-13.5	903.05
110	HD12/10	-	-	-	13.5-15.0	874.41
	HD13	439302	1563149	314	0.0-15.0	176.69
111	HD13/1	-	-	-	0.0-1.5	204.37
112	HD13/2	-	-	-	1.5-3.0	568.96
113	HD13/3	-	-	-	3.0-4.5	391.6
114	HD13/4	-	-	-	4.5-6.0	124.34
115	HD13/5	-	-	-	6.0-7.5	109.64
116	HD13/6	-	-	-	7.5-9.0	79
117	HD13/7	-	-	-	9.0-10.5	35.86
118	HD13/8	-	-	-	10.5-12.0	8.67
119	HD13/9	-	-	-	12.0-13.5	102.65
120	HD13/10	-	-	-	13.5-15.0	141.84
	HD14	439297	1563200	317	0.0-15.0	430.22
121	HD14/1	-	-	-	0.0-1.5	503.54
122	HD14/2	-	-	-	1.5-3.0	649.86
123	HD14/3	-	-	-	3.0-4.5	412.81
124	HD14/4	-	-	-	4.5-6.0	370.95
125	HD14/5	-	-	-	6.0-7.5	279.99
126	HD14/6	-	-	-	7.5-9.0	586.76
127	HD14/7	-	-	-	9.0-10.5	1,139.59
128	HD14/8	-	-	-	10.5-12.0	226.64
129	HD14/9	-	-	-	12.0-13.5	65.54
130	HD14/10	-	-	-	13.5-15.0	66.55
	HD15	439254	1563052	317	0.0-15.0	1,288.17
131	HD15/1	-	-	-	0.0-1.5	2,386.44
132	HD15/2	-	-	-	1.5-3.0	705.89
133	HD15/3	-	-	-	3.0-4.5	3,512.44
134	HD15/4	-	-	-	4.5-6.0	2,099.84
135	HD15/5	-	-	-	6.0-7.5	1,567.03
136	HD15/6	-	-	-	7.5-9.0	770.65
137	HD15/7	-	-	-	9.0-10.5	809.86
138	HD15/8	-	-	-	10.5-12.0	267.44

139	HD15/9	-	-	-	12.0-13.5	227.94
140	HD15/10	-	-	-	13.5-15.0	534.21
	HD16	439593	1563194	313	0.0-15.0	860.61
141	HD16/1	-	-	-	0.0-1.5	1,176.02
142	HD16/2	-	-	-	1.5-3.0	1,209.97
143	HD16/3	-	-	-	3.0-4.5	864.34
144	HD16/4	-	-	-	4.5-6.0	832.21
145	HD16/5	-	-	-	6.0-7.5	911.76
146	HD16/6	-	-	-	7.5-9.0	703.07
147	HD16/7	-	-	-	9.0-10.5	1132.2
148	HD16/8	-	-	-	10.5-12.0	808.22
149	HD16/9	-	-	-	12.0-13.5	698.76
150	HD16/10	-	-	-	13.5-15.0	269.55
	HD17	439596	1563300	317	0.0-14.0	1,391.74
151	HD17/1	-	-	-	0.0-1.5	1,414.79
152	HD17/2	-	-	-	1.5-3.0	435.12
153	HD17/3	-	-	-	3.0-4.5	272.6
154	HD17/4	-	-	-	4.5-6.0	1,624.40
155	HD17/5	-	-	-	6.0-7.5	1,524.36
156	HD17/6	-	-	-	7.5-9.0	1,036.79
157	HD17/7	-	-	-	9.0-10.5	2,379.19
158	HD17/8	-	-	-	10.5-12.0	718.64
159	HD17/9	-	-	-	12.0-13.5	2,131.91
160	HD17/10	-	-	-	13.5-14.0	2,379.55
	HD18	439599	1563099	314	0.0-15.0	592.51
161	HD18/1	-	-	-	0.0-1.5	4784.9
162	HD18/2	-	-	-	1.5-3.0	616.525
163	HD18/3	-	-	-	3.0-4.5	775.95
164	HD18/4	-	-	-	4.5-6.0	783.26
165	HD18/5	-	-	-	6.0-7.5	640.26
166	HD18/6	-	-	-	7.5-9.0	783.57
167	HD18/7	-	-	-	9.0-10.5	831.15
168	HD18/8	-	-	-	10.5-12.0	287.42
169	HD18/9	-	-	-	12.0-13.5	120.84
170	HD18/10	-	-	-	13.5-15.0	301.23
	HD19	439502	1563099	319	0.0-15.0	641.17
171	HD19/1	-	-	-	0.0-1.5	1,869.70
172	HD19/2	-	-	-	1.5-3.0	903.79
173	HD19/3	-	-	-	3.0-4.5	992.76
174	HD19/4	-	-	-	4.5-6.0	699.81

175	HD19/5	-	-	-	6.0-7.5	738.52
176	HD19/6	-	-	-	7.5-9.0	68.01
177	HD19/7	-	-	-	9.0-10.5	237.96
178	HD19/8	-	-	-	10.5-12.0	366.32
179	HD19/9	-	-	-	12.0-13.5	205.76
180	HD19/10	-	-	-	13.5-15.0	329.14
	HD20	439349	1563007	324	0.0-15.0	857.05
181	HD20/1	-	-	-	0.0-1.5	1088.07
182	HD20/2	-	-	-	1.5-3.0	428.22
183	HD20/3	-	-	-	3.0-4.5	403.66
184	HD20/4	-	-	-	4.5-6.0	276.89
185	HD20/5	-	-	-	6.0-7.5	1,765.58
186	HD20/6	-	-	-	7.5-9.0	1,474.80
187	HD20/7	-	-	-	9.0-10.5	929.11
188	HD20/8	-	-	-	10.5-12.0	144.31
189	HD20/9	-	-	-	12.0-13.5	718.5
190	HD20/10	-	-	-	13.5-15.0	1,341.38

Appendix B Calculation of mineral resource by using polygonal method

No	Sample No	Easting	Northing	Elevation (m)	Area (m²)	Depth (m)	Volume (m³)	Cst (g/m³)	Specific Gravity	Recovery Factor	Reserve (tons)
1	HD-01	439353	1562825	378	33,109	168	5,562,240	78.01	1.90	0.7	577
2	HD-02-1	439401	1562867	365	15,863	155	2,458,765	123.09	1.90	0.7	402
3	HD-02-2	439428	1562905	357	17,798	147	2,616,306	14.10	1.90	0.7	49
4	HD-03-1	439369	1562890	370	4,090	160	654,400	4.00	1.90	0.7	3
5	HD-03-2	439375	1562915	364.5	5,085	154.5	785,633	263.72	1.90	0.7	275
6	HD-04	439635	1563142	299	39,142	89	3,483,638	1831.14	1.90	0.7	8,480
7	HD-05-1	439544	1563120	310	21,085	100	2,108,500	157.71	1.90	0.7	442
8	HD-05-2	439558	1563113	310.5	5,024	100.5	504,912	85.77	1.90	0.7	58
9	HD-06-1	439533	1563299	307	7,422	97	719,934	38.22	1.90	0.7	37
10	HD-06-2	439555	1563278	308	8,194	98	803,012	39.89	1.90	0.7	43
11	HD-06-3	439569	1563293	306	22,442	96	2,154,432	54.70	1.90	0.7	157
12	HD-07	439551	1563396	304	37,611	94	3,535,434	1415.01	1.90	0.7	6,650
13	HD-08	439534	1563574	270	96,887	60	5,813,236	81.97	1.90	0.7	633
14	HD-09	439389	1562961	360	20,148	150	3,022,200	245.56	1.90	0.7	987
15	HD-10-1	439329	1563450	300.5	46,125	90.5	4,174,285	142.11	1.90	0.7	789
16	HD-10-2	439333	1563436	300.7	11,756	90.7	1,066,269	777.53	1.90	0.7	1,102
17	HD-10-4	439352	1563447	293	18,874	83	1,566,542	134.65	1.90	0.7	280
18	HD-11	439067	1563044	331	11,113	121	1,344,673	8.85	1.90	0.7	16
19	HD-12-1	439082	1563080	319	6,330	109	689,970	9.44	1.90	0.7	9
20	HD-12-2	439087	1563137	313	11,487	103	1,183,161	84.50	1.90	0.7	133
21	HD-13-1	439128	1563200	317.5	9,968	107.5	1,071,560	140.53	1.90	0.7	200
22	HD-13-2	439132	1563204	318	19,607	108	2,117,556	74.03	1.90	0.7	208
23	HD-14-1	439010	1563060	336	6,839	126	861,714	58.33	1.90	0.7	67
24	HD-14-2	439007	1563053	339.8	9,534	129.8	1,237,513	64.49	1.90	0.7	106
25	HD-15-1	439121	1562822	389	20,468	179	3,663,772	137.36	1.90	0.7	669
26	HD-15-2	439082	1562838	383	14,927	173	2,582,371	45.62	1.90	0.7	157
27	HD-16-1	438880	1563145	339.5	9,686	129.5	1,254,337	107.71	1.90	0.7	180
28	HD-16-2	438860	1563146	340.9	15,446	130.9	2,021,881	109.20	1.90	0.7	293
29	HD-16-3	438866	1563212	325	28,666	115	3,296,590	44.53	1.90	0.7	195
30	HD-17	438900	1563357	280	81,234	70	5,686,389	213.72	1.90	0.7	1,615
31	HD-18	439444	1562407	365	108,448	155	16,809,387	179.68	1.90	0.7	4,015
32	HD-19	439446	1562482	370	59,470	160	9,515,278	350.65	1.90	0.7	4,435
33	HD-20	439638	1562574	360.5	55,092	150.5	8,291,346	38.76	1.90	0.7	427
34	HD-21-2	439715	1562548	359	114,057	149	16,994,493	64.21	1.90	0.7	1,451
35	HD-22	440449	1562675	302.5	112,313	92.5	10,388,924	71.50	1.90	0.7	987
36	HD-23	440802	1562523	309	196,735	99	19,476,762	12.29	1.90	0.7	318

37	HD-25	440823	1563649	217	170,582	7	1,194,074	17.77	1.90	0.7	28
38	HD-26	440739	1563802	235	48,579	25	1,214,476	507.37	1.90	0.7	819
39	HD-27	441067	1563095	252	261,303	42	10,974,747	228.35	1.90	0.7	3,331
40	HD-28	440024	1562850	320.7	46,800	110.7	5,180,760	117.55	1.90	0.7	810
41	HD-29	440122	1562286	301	204,097	91	18,572,825	889.64	1.90	0.7	21,964
42	HD-30	440063	1562752	339.7	94,094	129.7	12,203,992	441.62	1.90	0.7	7,164
43	HD-31	440246	1562992	300	21,631	90	1,946,790	116.87	1.90	0.7	302
44	HD-32	440208	1562970	305	44,794	95	4,255,430	10.97	1.90	0.7	62
45	HD-33	440309	1563017	286.5	79,479	76.5	6,080,144	1949.65	1.90	0.7	15,758
46	HD-34	440398	1563280	264	193,215	54	10,433,632	205.17	1.90	0.7	2,846
47	HD-40	440184	1562023	321.8	243,921	111.8	27,270,338	351.94	1.90	0.7	12,758
48	HD-41	440430	1562721	315	94,972	105	9,972,060	263.62	1.90	0.7	3,495
49	HD-42	440050	1561629	283.6	341,408	73.6	25,127,596	50.83	1.90	0.7	1,698
50	HD-45	439043	1562642	350.3	140,357	140.3	19,692,039	153.65	1.90	0.7	4,022
51	HD-48	438861	1563048	324	69,993	114	7,979,158	190.01	1.90	0.7	2,015
52	HD-49	439066	1563721	240	108,257	30	3,247,710	227.23	1.90	0.7	981
53	HD-51	439037	1562900	360	38,496	150	5,774,400	20.08	1.90	0.7	154
54	HD-52	438563	1563254	255	75,131	45	3,380,915	275.54	1.90	0.7	1,238
55	HD-53	439022	1563673	262.5	104,404	52.5	5,481,224	257.73	1.90	0.7	1,878
56	HD-54	439586	1562993	337	32,188	127	4,087,876	93.47	1.90	0.7	508
57	HD-55	439611	1563043	323	14,576	113	1,647,088	224.82	1.90	0.7	492
58	HD-56	440012	1563378	260.5	32,247	50.5	1,628,474	69.78	1.90	0.7	151
59	HD-57	439977	1563258	290	85,845	80	6,867,600	6.24	1.90	0.7	57
60	HD-58	439304	1563278	314	20,475	104	2,129,400	321.26	1.90	0.7	909
61	HD-59	439299	1563250	315.7	11,033	105.7	1,166,188	34.34	1.90	0.7	53
62	HD-60	439247	1563217	330	7,214	120	865,680	106.74	1.90	0.7	123
63	HD-61	439189	1563205	330.5	10,886	120.5	1,311,763	201.65	1.90	0.7	352
64	HD-62	439280	1563137	338	19,037	128	2,436,736	145.54	1.90	0.7	471
65	HD-63	439228	1563069	360	22,985	150	3,447,750	99.68	1.90	0.7	457
66	HD-64	440080	1563443	259.5	55,795	49.5	2,761,853	69.53	1.90	0.7	255
67	HD-65	439953	1563551	253	60,520	43	2,602,375	26.45	1.90	0.7	91
68	HD-66	439980	1563568	250	14,925	40	596,993	5.83	1.90	0.7	5
69	HD-67	440018	1563580	245	48,364	35	1,692,738	148.84	1.90	0.7	335
70	HD-72	439254	1562840	390	30,905	180	5,562,900	12.69	1.90	0.7	94
71	HD-73	439501	1563338	308	15,104	98	1,480,192	92.40	1.90	0.7	182
72	HD-74	439804	1562913	318	81,270	108	8,777,160	13.44	1.90	0.7	157
					4,246,957		378,562,490				122,461

Appendix C Calculation of mineable reserve by using polygonal method

No	Sample No	Easting	Northing	Elevation (m)	Depth (m)	Volume (m³)	Cst (g/m³)	Specific Gravity	Recovery Factor	Reserve (tons)
1	HD-01	439369	1562890	378	98	2,809,225	78.01	1.90	0.70	291
2	HD-02-1	439980	1563568	365	85	17,285,525	123.09	1.90	0.70	2,828
3	HD-02-2	439977	1563258	357	77	630,938	14.10	1.90	0.70	12
4	HD-03-1	439067	1563044	370	90	2,979,771	4.00	1.90	0.70	16
5	HD-03-2	439082	1563080	364.5	84.5	932,289	263.72	1.90	0.70	327
6	HD-04	440208	1562970	299	19	286,976	1,831.14	1.90	0.70	699
7	HD-05-1	440802	1562523	310	30	9,273,587	157.71	1.90	0.70	1,944
8	HD-05-2	439254	1562840	310.5	30.5	1,802,198	85.77	1.90	0.70	205
9	HD-06-1	439804	1562913	307	27	1,245,367	38.22	1.90	0.70	63
10	HD-06-2	439428	1562905	308	28	528,472	39.89	1.90	0.70	28
11	HD-06-3	440823	1563649	306	26	259,168	54.70	1.90	0.70	19
12	HD-07	439037	1562900	304	24	741,720	1,415.01	1.90	0.70	1,395
13	HD-08	439953	1563551	270	5	397,588	81.97	1.90	0.70	43
14	HD-09	439299	1563250	360	80	2,579,760	245.56	1.90	0.70	842
15	HD-10-1	439533	1563299	300.5	20.5	1,629,320	142.11	1.90	0.70	308
16	HD-10-2	439638	1562574	300.7	20.7	261,755	777.53	1.90	0.70	271
17	HD-10-4	439555	1563278	293	13	1,223,222	134.65	1.90	0.70	219
18	HD-11	438866	1563212	331	51	208,590	8.85	1.90	0.70	2
19	HD-12-1	439082	1562838	319	39	198,315	9.44	1.90	0.70	2
20	HD-12-2	440050	1561629	313	33	3,070,583	84.50	1.90	0.70	345
21	HD-13-1	439569	1563293	317.5	37.5	1,679,775	140.53	1.90	0.70	314
22	HD-13-2	439010	1563060	318	38	586,946	74.03	1.90	0.70	58
23	HD-14-1	439715	1562548	336	56	1,097,992	58.33	1.90	0.70	85
24	HD-14-2	439007	1563053	339.8	59.8	570,133	64.49	1.90	0.70	49
25	HD-15-1	440080	1563443	389	109	2,357,779	137.36	1.90	0.70	431
26	HD-15-2	440012	1563378	383	103	651,990	45.62	1.90	0.70	40
27	HD-16-1	440449	1562675	339.5	59.5	9,063,999	107.71	1.90	0.70	1,298
28	HD-16-2	439132	1563204	340.9	60.9	972,297	109.20	1.90	0.70	141
29	HD-16-3	439353	1562825	325	45	500,085	44.53	1.90	0.70	30
30	HD-17	439534	1563574	280	5	353,411	213.72	1.90	0.70	100
31	HD-18	439087	1563137	365	85	11,549,278	179.68	1.90	0.70	2,759
32	HD-19	439558	1563113	370	90	1,713,330	350.65	1.90	0.70	799
33	HD-20	439501	1563338	360.5	80.5	946,358	38.76	1.90	0.70	49
34	HD-21-2	439586	1562993	359	79	540,281	64.21	1.90	0.70	46
35	HD-22	439228	1563069	302.5	22.5	217,935	71.50	1.90	0.70	21
36	HD-23	439247	1563217	309	29	611,465	12.29	1.90	0.70	10

37	HD-25	438880	1563145	217	5	112,210	17.77	1.90	0.70	3
38	HD-26	438860	1563146	235	5	299,922	507.37	1.90	0.70	202
39	HD-27	440246	1562992	252	5	72,880	228.35	1.90	0.70	22
40	HD-28	440024	1562850	320.7	40.7	1,904,760	117.55	1.90	0.70	298
41	HD-29	439401	1562867	301	21	510,024	889.64	1.90	0.70	603
42	HD-30	439352	1563447	339.7	59.7	3,279,390	441.62	1.90	0.70	1,925
43	HD-31	439121	1562822	300	20	3,901,964	116.87	1.90	0.70	606
44	HD-32	439128	1563200	305	25	978,550	10.97	1.90	0.70	14
45	HD-33	439329	1563450	286.5	6.5	528,255	1,949.65	1.90	0.70	1,369
46	HD-34	439280	1563137	264	5	192,483	205.17	1.90	0.70	52
47	HD-40	440018	1563580	321.8	41.8	960,773	351.94	1.90	0.70	449
48	HD-41	439043	1562642	315	35	716,625	263.62	1.90	0.70	251
49	HD-42	439544	1563120	283.6	5	57,435	50.83	1.90	0.70	4
50	HD-45	439444	1562407	350.3	70.3	6,676,532	153.65	1.90	0.70	1,364
51	HD-48	438861	1563048	324	44	2,091,395	190.01	1.90	0.70	528
52	HD-49	439189	1563205	240	5	160,940	227.23	1.90	0.70	49
53	HD-51	440398	1563280	360	80	3,008,880	20.08	1.90	0.70	80
54	HD-52	438900	1563357	255	5	36,070	275.54	1.90	0.70	13
55	HD-53	439611	1563043	262.5	5	429,225	257.73	1.90	0.70	147
56	HD-54	439066	1563721	337	57	6,501,294	93.47	1.90	0.70	808
57	HD-55	441067	1563095	323	43	4,394,477	224.82	1.90	0.70	1,313
58	HD-56	439389	1562961	260.5	5	74,635	69.78	1.90	0.70	7
59	HD-57	439022	1563673	290	10	177,980	6.24	1.90	0.70	1
60	HD-58	440430	1562721	314	34	370,124	321.26	1.90	0.70	158
61	HD-59	439375	1562915	315.7	35.7	719,284	34.34	1.90	0.70	33
62	HD-60	438563	1563254	330	50	6,057,352	106.74	1.90	0.70	859
63	HD-61	439304	1563278	330.5	50.5	5,237,608	201.65	1.90	0.70	1,404
64	HD-62	439446	1562482	338	58	11,133,900	145.54	1.90	0.70	2,154
65	HD-63	440184	1562023	360	80	8,276,066	99.68	1.90	0.70	1,097
66	HD-64	440063	1562752	259.5	5	102,340	69.53	1.90	0.70	9
67	HD-65	440739	1563802	253	5	471,714	26.45	1.90	0.70	17
68	HD-66	439333	1563436	250	5	79,315	5.83	1.90	0.70	1
69	HD-67	440122	1562286	245	5	1,089,955	148.84	1.90	0.70	216
70	HD-72	439551	1563396	390	110	552,640	12.69	1.90	0.70	9
71	HD-73	439635	1563142	308	28	1,542,576	92.40	1.90	0.70	189
72	HD-74	440309	1563017	318	38	282,036	13.44	1.90	0.70	5
						154,739,032				32,349

Appendix D Calculation of mineral resources by using ordinary kriging

Easting	Northing	Elevation	Area (m^2)	Depth (m)	Volume (m^3)	Tin Concentrate (g/m^3)	Density	Recovery Factor	Reserve (tons)
439700	1561500	266.00	10,000	56.00	560,000	199.66	1.90	0.70	149
439800	1561500	269.50	10,000	59.50	595,000	182.51	1.90	0.70	144
439900	1561500	264.00	10,000	54.00	540,000	158.11	1.90	0.70	113
440000	1561500	243.00	10,000	33.00	330,000	133.64	1.90	0.70	59
440100	1561500	235.00	10,000	25.00	250,000	134.23	1.90	0.70	45
440200	1561500	236.50	10,000	26.50	265,000	159.87	1.90	0.70	56
440300	1561500	242.00	10,000	32.00	320,000	185.32	1.90	0.70	79
440400	1561500	248.70	10,000	38.70	387,000	203.38	1.90	0.70	105
440500	1561500	247.00	9,883	37.00	365,687	214.86	1.90	0.70	104
439700	1561600	270.50	10,000	60.50	605,000	199.34	1.90	0.70	160
439800	1561600	273.20	10,000	63.20	632,000	179.62	1.90	0.70	151
439900	1561600	258.50	10,000	48.50	485,000	146.10	1.90	0.70	94
440000	1561600	242.80	10,000	32.80	328,000	93.63	1.90	0.70	41
440100	1561600	241.00	10,000	31.00	310,000	94.58	1.90	0.70	39
440200	1561600	245.00	10,000	35.00	350,000	148.88	1.90	0.70	69
440300	1561600	242.50	10,000	32.50	325,000	184.03	1.90	0.70	80
440400	1561600	250.00	10,000	40.00	400,000	205.04	1.90	0.70	109
440500	1561600	252.30	9,069	42.30	383,631	216.96	1.90	0.70	111
439700	1561700	268.50	10,000	58.50	585,000	205.84	1.90	0.70	160
439800	1561700	273.80	10,000	63.80	638,000	190.33	1.90	0.70	161
439900	1561700	256.30	10,000	46.30	463,000	163.10	1.90	0.70	100
440000	1561700	246.40	10,000	36.40	364,000	125.94	1.90	0.70	61
440100	1561700	245.50	10,000	35.50	355,000	127.47	1.90	0.70	60
440200	1561700	250.40	10,000	40.40	404,000	167.61	1.90	0.70	90
440300	1561700	250.90	10,000	40.90	409,000	197.42	1.90	0.70	107
440400	1561700	253.60	10,000	43.60	436,000	214.74	1.90	0.70	124
440500	1561700	262.80	8,139	52.80	429,750	223.49	1.90	0.70	128
439700	1561800	271.50	10,000	61.50	615,000	218.89	1.90	0.70	179
439800	1561800	267.10	10,000	57.10	571,000	213.85	1.90	0.70	162
439900	1561800	257.50	10,000	47.50	475,000	203.85	1.90	0.70	129
440000	1561800	251.40	10,000	41.40	414,000	193.54	1.90	0.70	107
440100	1561800	254.50	10,000	44.50	445,000	196.06	1.90	0.70	116
440200	1561800	261.80	10,000	51.80	518,000	211.35	1.90	0.70	146
440300	1561800	268.80	10,000	58.80	588,000	225.65	1.90	0.70	176
440400	1561800	263.50	10,000	53.50	535,000	233.13	1.90	0.70	166
440500	1561800	271.90	7,209	61.90	446,243	234.72	1.90	0.70	139
439700	1561900	277.20	10,000	67.20	672,000	235.82	1.90	0.70	211
439800	1561900	263.70	10,000	53.70	537,000	244.42	1.90	0.70	174
439900	1561900	262.20	10,000	52.20	522,000	252.73	1.90	0.70	175
440000	1561900	261.10	10,000	51.10	511,000	259.73	1.90	0.70	176
440100	1561900	267.00	10,000	57.00	570,000	264.12	1.90	0.70	200
440200	1561900	280.40	10,000	70.40	704,000	265.77	1.90	0.70	249

440300	1561900	282.50	10,000	72.50	725,000	265.26	1.90	0.70	256
440400	1561900	263.70	10,000	53.70	537,000	259.36	1.90	0.70	185
440500	1561900	266.70	6,279	56.70	356,019	249.90	1.90	0.70	118
439700	1562000	283.50	10,000	73.50	735,000	253.01	1.90	0.70	247
439800	1562000	271.50	10,000	61.50	615,000	277.49	1.90	0.70	227
439900	1562000	274.50	10,000	64.50	645,000	307.04	1.90	0.70	263
440000	1562000	270.00	10,000	60.00	600,000	334.81	1.90	0.70	267
440100	1562000	275.40	10,000	65.40	654,000	345.66	1.90	0.70	301
440200	1562000	286.10	10,000	76.10	761,000	332.06	1.90	0.70	336
440300	1562000	281.40	10,000	71.40	714,000	318.03	1.90	0.70	302
440400	1562000	271.00	10,000	61.00	610,000	292.74	1.90	0.70	237
440500	1562000	272.20	5,349	62.20	332,702	267.12	1.90	0.70	118
439700	1562100	292.50	10,000	82.50	825,000	265.75	1.90	0.70	291
439800	1562100	284.00	10,000	74.00	740,000	307.87	1.90	0.70	303
439900	1562100	286.80	10,000	76.80	768,000	365.42	1.90	0.70	373
440000	1562100	282.50	10,000	72.50	725,000	430.00	1.90	0.70	414
440100	1562100	281.20	10,000	71.20	712,000	468.70	1.90	0.70	444
440200	1562100	286.10	10,000	76.10	761,000	446.14	1.90	0.70	451
440300	1562100	278.30	10,000	68.30	683,000	389.38	1.90	0.70	354
440400	1562100	278.00	10,000	68.00	680,000	330.04	1.90	0.70	298
439600	1562200	313.40	10,000	103.40	1,034,000	232.12	1.90	0.70	319
439700	1562200	298.20	10,000	88.20	882,000	267.33	1.90	0.70	313
439800	1562200	290.90	10,000	80.90	809,000	325.42	1.90	0.70	350
439900	1562200	292.30	10,000	82.30	823,000	414.44	1.90	0.70	453
440000	1562200	291.70	10,000	81.70	817,000	537.22	1.90	0.70	583
440100	1562200	291.20	10,000	81.20	812,000	650.59	1.90	0.70	702
440200	1562200	292.50	10,000	82.50	825,000	593.25	1.90	0.70	651
440300	1562200	295.00	10,000	85.00	850,000	461.59	1.90	0.70	522
440400	1562200	290.00	10,000	80.00	800,000	358.55	1.90	0.70	381
439300	1562300	301.20	10,000	91.20	912,000	186.58	1.90	0.70	226
439400	1562300	327.60	10,000	117.60	1,176,000	190.69	1.90	0.70	298
439500	1562300	335.00	10,000	125.00	1,250,000	198.33	1.90	0.70	330
439600	1562300	323.80	10,000	113.80	1,138,000	216.52	1.90	0.70	328
439700	1562300	308.00	10,000	98.00	980,000	249.58	1.90	0.70	325
439800	1562300	312.00	10,000	102.00	1,020,000	315.88	1.90	0.70	428
439900	1562300	309.50	10,000	99.50	995,000	424.18	1.90	0.70	561
440000	1562300	298.30	10,000	88.30	883,000	584.35	1.90	0.70	686
440100	1562300	307.70	10,000	97.70	977,000	812.10	1.90	0.70	1,055
440200	1562300	319.10	10,000	109.10	1,091,000	674.54	1.90	0.70	978
440300	1562300	326.00	10,000	116.00	1,160,000	485.69	1.90	0.70	749
440400	1562300	322.00	10,000	112.00	1,120,000	358.30	1.90	0.70	533
439300	1562400	314.00	10,000	104.00	1,040,000	203.86	1.90	0.70	282
439400	1562400	340.00	10,000	130.00	1,300,000	206.07	1.90	0.70	356
439500	1562400	347.40	10,000	137.40	1,374,000	203.06	1.90	0.70	371
439600	1562400	329.50	10,000	119.50	1,195,000	191.36	1.90	0.70	304
439700	1562400	320.00	10,000	110.00	1,100,000	202.81	1.90	0.70	297
439800	1562400	337.60	10,000	127.60	1,276,000	270.76	1.90	0.70	459

439900	1562400	346.00	10,000	136.00	1,360,000	380.72	1.90	0.70	688
440000	1562400	334.00	10,000	124.00	1,240,000	511.23	1.90	0.70	843
440100	1562400	330.40	10,000	120.40	1,204,000	608.68	1.90	0.70	974
440200	1562400	339.50	10,000	129.50	1,295,000	562.52	1.90	0.70	968
440300	1562400	342.70	10,000	132.70	1,327,000	435.41	1.90	0.70	768
440400	1562400	337.30	10,000	127.30	1,273,000	320.28	1.90	0.70	542
440500	1562400	333.00	9,909	123.00	1,218,774	237.20	1.90	0.70	384
440600	1562400	326.20	9,623	116.20	1,118,208	179.82	1.90	0.70	267
440700	1562400	314.70	9,321	104.70	975,861	134.80	1.90	0.70	175
440800	1562400	308.30	9,020	98.30	886,643	109.61	1.90	0.70	129
440900	1562400	304.60	8,728	94.60	825,696	125.76	1.90	0.70	138
441000	1562400	293.70	8,456	83.70	707,762	156.62	1.90	0.70	147
438800	1562500	325.90	10,000	115.90	1,159,000	155.53	1.90	0.70	240
438900	1562500	339.80	10,000	129.80	1,298,000	145.57	1.90	0.70	251
439000	1562500	336.20	10,000	126.20	1,262,000	147.84	1.90	0.70	248
439100	1562500	330.70	10,000	120.70	1,207,000	162.11	1.90	0.70	260
439200	1562500	323.80	10,000	113.80	1,138,000	184.60	1.90	0.70	279
439300	1562500	324.40	10,000	114.40	1,144,000	219.94	1.90	0.70	334
439400	1562500	335.60	10,000	125.60	1,256,000	287.91	1.90	0.70	481
439500	1562500	337.20	10,000	127.20	1,272,000	252.81	1.90	0.70	427
439600	1562500	330.60	10,000	120.60	1,206,000	140.34	1.90	0.70	225
439700	1562500	335.00	10,000	125.00	1,250,000	113.60	1.90	0.70	189
439800	1562500	349.00	10,000	139.00	1,390,000	199.76	1.90	0.70	369
439900	1562500	348.80	10,000	138.80	1,388,000	314.49	1.90	0.70	580
440000	1562500	336.40	10,000	126.40	1,264,000	418.34	1.90	0.70	703
440100	1562500	332.10	10,000	122.10	1,221,000	473.25	1.90	0.70	768
440200	1562500	339.00	10,000	129.00	1,290,000	446.32	1.90	0.70	765
440300	1562500	343.30	10,000	133.30	1,333,000	358.16	1.90	0.70	635
440400	1562500	340.00	10,000	130.00	1,300,000	256.42	1.90	0.70	443
440500	1562500	328.00	10,000	118.00	1,180,000	184.78	1.90	0.70	290
440600	1562500	312.50	10,000	102.50	1,025,000	143.25	1.90	0.70	195
440700	1562500	297.00	10,000	87.00	870,000	95.42	1.90	0.70	110
440800	1562500	298.60	10,000	88.60	886,000	34.06	1.90	0.70	40
440900	1562500	299.30	10,000	89.30	893,000	94.46	1.90	0.70	112
441000	1562500	295.90	10,000	85.90	859,000	145.15	1.90	0.70	166
438800	1562600	348.00	10,000	138.00	1,380,000	167.05	1.90	0.70	306
438900	1562600	361.00	10,000	151.00	1,510,000	156.20	1.90	0.70	314
439000	1562600	353.10	10,000	143.10	1,431,000	154.54	1.90	0.70	294
439100	1562600	333.30	10,000	123.30	1,233,000	159.95	1.90	0.70	262
439200	1562600	333.40	10,000	123.40	1,234,000	169.98	1.90	0.70	279
439300	1562600	333.30	10,000	123.30	1,233,000	190.32	1.90	0.70	312
439400	1562600	334.70	10,000	124.70	1,247,000	211.44	1.90	0.70	350
439500	1562600	336.80	10,000	126.80	1,268,000	175.01	1.90	0.70	295
439600	1562600	336.00	10,000	126.00	1,260,000	79.34	1.90	0.70	133
439700	1562600	335.10	10,000	125.10	1,251,000	58.70	1.90	0.70	98
439800	1562600	318.90	10,000	108.90	1,089,000	147.86	1.90	0.70	214
439900	1562600	322.20	10,000	112.20	1,122,000	260.04	1.90	0.70	388

440000	1562600	302.80	10,000	92.80	928,000	363.52	1.90	0.70	448
440100	1562600	282.00	10,000	72.00	720,000	412.76	1.90	0.70	395
440200	1562600	288.00	10,000	78.00	780,000	385.02	1.90	0.70	399
440300	1562600	305.50	10,000	95.50	955,000	306.17	1.90	0.70	389
440400	1562600	317.00	10,000	107.00	1,070,000	187.65	1.90	0.70	267
440500	1562600	305.90	10,000	95.90	959,000	128.57	1.90	0.70	164
440600	1562600	282.00	10,000	72.00	720,000	136.24	1.90	0.70	130
440700	1562600	272.90	10,000	62.90	629,000	114.52	1.90	0.70	96
440800	1562600	274.60	10,000	64.60	646,000	86.24	1.90	0.70	74
440900	1562600	268.50	10,000	58.50	585,000	115.63	1.90	0.70	90
441000	1562600	270.00	9,561	60.00	573,647	154.71	1.90	0.70	118
438800	1562700	374.00	10,000	164.00	1,640,000	169.45	1.90	0.70	369
438900	1562700	377.00	10,000	167.00	1,670,000	150.43	1.90	0.70	334
439000	1562700	354.50	10,000	144.50	1,445,000	138.56	1.90	0.70	266
439100	1562700	335.40	10,000	125.40	1,254,000	140.44	1.90	0.70	234
439200	1562700	336.20	10,000	126.20	1,262,000	134.35	1.90	0.70	225
439300	1562700	339.80	10,000	129.80	1,298,000	132.88	1.90	0.70	229
439400	1562700	334.80	10,000	124.80	1,248,000	139.19	1.90	0.70	231
439500	1562700	336.70	10,000	126.70	1,267,000	115.91	1.90	0.70	195
439600	1562700	336.00	10,000	126.00	1,260,000	76.35	1.90	0.70	128
439700	1562700	335.10	10,000	125.10	1,251,000	69.87	1.90	0.70	116
439800	1562700	328.90	10,000	118.90	1,189,000	118.38	1.90	0.70	187
439900	1562700	322.20	10,000	112.20	1,122,000	211.13	1.90	0.70	315
440000	1562700	302.80	10,000	92.80	928,000	340.90	1.90	0.70	421
440100	1562700	282.00	10,000	72.00	720,000	412.26	1.90	0.70	395
440200	1562700	288.00	10,000	78.00	780,000	366.64	1.90	0.70	380
440300	1562700	306.00	10,000	96.00	960,000	326.03	1.90	0.70	416
440400	1562700	317.00	10,000	107.00	1,070,000	234.55	1.90	0.70	334
440500	1562700	305.70	10,000	95.70	957,000	174.22	1.90	0.70	222
440600	1562700	282.00	10,000	72.00	720,000	199.99	1.90	0.70	191
440700	1562700	272.90	10,000	62.90	629,000	185.04	1.90	0.70	155
440800	1562700	274.40	10,000	64.40	644,000	165.74	1.90	0.70	142
440900	1562700	268.60	10,000	58.60	586,000	166.38	1.90	0.70	130
441000	1562700	270.00	7,489	60.00	449,321	180.14	1.90	0.70	108
438800	1562800	380.60	10,000	170.60	1,706,000	168.36	1.90	0.70	382
438900	1562800	370.70	10,000	160.70	1,607,000	133.91	1.90	0.70	286
439000	1562800	352.80	10,000	142.80	1,428,000	94.78	1.90	0.70	180
439100	1562800	342.50	10,000	132.50	1,325,000	113.32	1.90	0.70	200
439200	1562800	342.60	10,000	132.60	1,326,000	83.89	1.90	0.70	148
439300	1562800	343.80	10,000	133.80	1,338,000	63.30	1.90	0.70	113
439400	1562800	337.00	10,000	127.00	1,270,000	96.98	1.90	0.70	164
439500	1562800	334.90	10,000	124.90	1,249,000	75.91	1.90	0.70	126
439600	1562800	332.80	10,000	122.80	1,228,000	65.07	1.90	0.70	106
439700	1562800	330.10	10,000	120.10	1,201,000	62.84	1.90	0.70	100
439800	1562800	328.10	10,000	118.10	1,181,000	72.27	1.90	0.70	113
439900	1562800	328.20	10,000	118.20	1,182,000	133.62	1.90	0.70	210
440000	1562800	306.70	10,000	96.70	967,000	221.20	1.90	0.70	284

440100	1562800	280.90	10,000	70.90	709,000	303.61	1.90	0.70	286
440200	1562800	278.30	10,000	68.30	683,000	323.44	1.90	0.70	294
440300	1562800	284.80	10,000	74.80	748,000	428.66	1.90	0.70	426
440400	1562800	297.50	10,000	87.50	875,000	473.71	1.90	0.70	551
440500	1562800	304.20	10,000	94.20	942,000	408.97	1.90	0.70	512
440600	1562800	289.00	10,000	79.00	790,000	335.71	1.90	0.70	353
440700	1562800	273.40	10,000	63.40	634,000	275.91	1.90	0.70	233
440800	1562800	263.10	10,000	53.10	531,000	234.18	1.90	0.70	165
440900	1562800	260.00	10,000	50.00	500,000	213.15	1.90	0.70	142
441000	1562800	264.80	9,878	54.80	541,295	207.50	1.90	0.70	149
438700	1562900	370.20	10,000	160.20	1,602,000	197.56	1.90	0.70	421
438800	1562900	385.10	10,000	175.10	1,751,000	173.31	1.90	0.70	403
438900	1562900	368.00	10,000	158.00	1,580,000	126.19	1.90	0.70	265
439000	1562900	354.90	10,000	144.90	1,449,000	50.62	1.90	0.70	98
439100	1562900	354.80	10,000	144.80	1,448,000	41.80	1.90	0.70	80
439200	1562900	349.30	10,000	139.30	1,393,000	60.31	1.90	0.70	112
439300	1562900	346.40	10,000	136.40	1,364,000	84.16	1.90	0.70	153
439400	1562900	338.30	10,000	128.30	1,283,000	111.23	1.90	0.70	190
439500	1562900	336.40	10,000	126.40	1,264,000	40.23	1.90	0.70	68
439600	1562900	330.80	10,000	120.80	1,208,000	70.96	1.90	0.70	114
439700	1562900	322.00	10,000	112.00	1,120,000	103.04	1.90	0.70	153
439800	1562900	322.10	10,000	112.10	1,121,000	20.90	1.90	0.70	31
439900	1562900	320.20	10,000	110.20	1,102,000	87.80	1.90	0.70	129
440000	1562900	309.00	10,000	99.00	990,000	96.05	1.90	0.70	126
440100	1562900	289.00	10,000	79.00	790,000	113.19	1.90	0.70	119
440200	1562900	275.20	10,000	65.20	652,000	186.44	1.90	0.70	162
440300	1562900	271.70	10,000	61.70	617,000	645.80	1.90	0.70	530
440400	1562900	284.10	10,000	74.10	741,000	827.85	1.90	0.70	815
440500	1562900	290.80	10,000	80.80	808,000	653.86	1.90	0.70	702
440600	1562900	284.80	10,000	74.80	748,000	476.99	1.90	0.70	474
440700	1562900	270.40	10,000	60.40	604,000	358.62	1.90	0.70	288
440800	1562900	256.70	10,000	46.70	467,000	287.19	1.90	0.70	178
440900	1562900	256.80	10,000	46.80	468,000	247.65	1.90	0.70	154
441000	1562900	260.60	10,000	50.60	506,000	228.47	1.90	0.70	154
441100	1562900	273.00	9,790	63.00	616,763	221.25	1.90	0.70	181
441200	1562900	294.60	2,972	84.60	251,461	220.30	1.90	0.70	74
438700	1563000	369.40	10,000	159.40	1,594,000	203.21	1.90	0.70	431
438800	1563000	381.50	10,000	171.50	1,715,000	187.38	1.90	0.70	427
438900	1563000	369.50	10,000	159.50	1,595,000	144.25	1.90	0.70	306
439000	1563000	367.80	10,000	157.80	1,578,000	61.22	1.90	0.70	128
439100	1563000	367.60	10,000	157.60	1,576,000	26.00	1.90	0.70	54
439200	1563000	354.90	10,000	144.90	1,449,000	75.64	1.90	0.70	146
439300	1563000	344.60	10,000	134.60	1,346,000	148.95	1.90	0.70	267
439400	1563000	339.00	10,000	129.00	1,290,000	171.82	1.90	0.70	295
439500	1563000	335.20	10,000	125.20	1,252,000	51.57	1.90	0.70	86
439600	1563000	326.70	10,000	116.70	1,167,000	126.62	1.90	0.70	196
439700	1563000	322.70	10,000	112.70	1,127,000	364.78	1.90	0.70	546

439800	1563000	324.60	10,000	114.60	1,146,000	288.05	1.90	0.70	439
439900	1563000	318.20	10,000	108.20	1,082,000	182.61	1.90	0.70	263
440000	1563000	310.70	10,000	100.70	1,007,000	116.85	1.90	0.70	156
440100	1563000	297.90	10,000	87.90	879,000	83.04	1.90	0.70	97
440200	1563000	277.80	10,000	67.80	678,000	82.36	1.90	0.70	74
440300	1563000	263.50	10,000	53.50	535,000	1,485.55	1.90	0.70	1,056
440400	1563000	267.40	10,000	57.40	574,000	1,251.33	1.90	0.70	955
440500	1563000	272.40	10,000	62.40	624,000	817.79	1.90	0.70	678
440600	1563000	273.50	10,000	63.50	635,000	555.61	1.90	0.70	469
440700	1563000	261.30	10,000	51.30	513,000	402.75	1.90	0.70	275
440800	1563000	253.70	10,000	43.70	437,000	314.92	1.90	0.70	183
440900	1563000	261.30	10,000	51.30	513,000	265.57	1.90	0.70	181
441000	1563000	262.00	10,000	52.00	520,000	239.16	1.90	0.70	165
441100	1563000	271.80	10,000	61.80	618,000	227.06	1.90	0.70	187
441200	1563000	286.30	9,679	76.30	738,473	223.68	1.90	0.70	220
438500	1563100	345.50	10,000	135.50	1,355,000	244.08	1.90	0.70	440
438600	1563100	356.60	10,000	146.60	1,466,000	228.93	1.90	0.70	446
438700	1563100	373.20	10,000	163.20	1,632,000	199.34	1.90	0.70	432
438800	1563100	381.90	10,000	171.90	1,719,000	166.30	1.90	0.70	380
438900	1563100	381.10	10,000	171.10	1,711,000	127.98	1.90	0.70	291
439000	1563100	381.60	10,000	171.60	1,716,000	71.59	1.90	0.70	163
439100	1563100	379.90	10,000	169.90	1,699,000	43.59	1.90	0.70	98
439200	1563100	365.10	10,000	155.10	1,551,000	101.77	1.90	0.70	210
439300	1563100	342.50	10,000	132.50	1,325,000	131.72	1.90	0.70	232
439400	1563100	333.60	10,000	123.60	1,236,000	89.87	1.90	0.70	148
439500	1563100	333.80	10,000	123.80	1,238,000	57.78	1.90	0.70	95
439600	1563100	323.50	10,000	113.50	1,135,000	682.53	1.90	0.70	1,030
439700	1563100	316.70	10,000	106.70	1,067,000	1,022.04	1.90	0.70	1,450
439800	1563100	314.20	10,000	104.20	1,042,000	593.43	1.90	0.70	822
439900	1563100	302.00	10,000	92.00	920,000	297.87	1.90	0.70	364
440000	1563100	291.00	10,000	81.00	810,000	156.14	1.90	0.70	168
440100	1563100	287.00	10,000	77.00	770,000	175.62	1.90	0.70	180
440200	1563100	278.80	10,000	68.80	688,000	441.04	1.90	0.70	403
440300	1563100	266.50	10,000	56.50	565,000	1,066.56	1.90	0.70	801
440400	1563100	253.90	10,000	43.90	439,000	1,049.30	1.90	0.70	612
440500	1563100	260.60	10,000	50.60	506,000	740.42	1.90	0.70	498
440600	1563100	270.10	10,000	60.10	601,000	524.49	1.90	0.70	419
440700	1563100	258.80	10,000	48.80	488,000	391.98	1.90	0.70	254
440800	1563100	247.50	10,000	37.50	375,000	312.28	1.90	0.70	156
440900	1563100	260.20	10,000	50.20	502,000	265.52	1.90	0.70	177
441000	1563100	264.00	10,000	54.00	540,000	239.04	1.90	0.70	172
441100	1563100	263.00	10,000	53.00	530,000	226.29	1.90	0.70	159
441200	1563100	273.40	10,000	63.40	634,000	223.78	1.90	0.70	189
438500	1563200	327.70	10,000	117.70	1,177,000	262.71	1.90	0.70	411
438600	1563200	341.00	10,000	131.00	1,310,000	245.96	1.90	0.70	428
438700	1563200	356.60	10,000	146.60	1,466,000	195.92	1.90	0.70	382
438800	1563200	369.90	10,000	159.90	1,599,000	122.02	1.90	0.70	259

438900	1563200	374.80	10,000	164.80	1,648,000	71.98	1.90	0.70	158
439000	1563200	378.00	10,000	168.00	1,680,000	101.53	1.90	0.70	227
439100	1563200	362.50	10,000	152.50	1,525,000	104.87	1.90	0.70	213
439200	1563200	352.30	10,000	142.30	1,423,000	182.23	1.90	0.70	345
439300	1563200	341.40	10,000	131.40	1,314,000	68.57	1.90	0.70	120
439400	1563200	322.50	10,000	112.50	1,125,000	71.90	1.90	0.70	108
439500	1563200	324.00	10,000	114.00	1,140,000	136.91	1.90	0.70	207
439600	1563200	318.50	10,000	108.50	1,085,000	852.83	1.90	0.70	1,230
439700	1563200	305.80	10,000	95.80	958,000	1,104.30	1.90	0.70	1,406
439800	1563200	299.60	10,000	89.60	896,000	664.00	1.90	0.70	791
439900	1563200	297.90	10,000	87.90	879,000	293.28	1.90	0.70	343
440000	1563200	283.70	10,000	73.70	737,000	99.18	1.90	0.70	97
440100	1563200	276.20	10,000	66.20	662,000	170.59	1.90	0.70	150
440200	1563200	271.50	10,000	61.50	615,000	359.98	1.90	0.70	294
440300	1563200	263.20	10,000	53.20	532,000	554.52	1.90	0.70	392
440400	1563200	250.80	10,000	40.80	408,000	559.60	1.90	0.70	304
440500	1563200	256.30	10,000	46.30	463,000	492.56	1.90	0.70	303
440600	1563200	261.60	10,000	51.60	516,000	411.32	1.90	0.70	282
440700	1563200	254.10	10,000	44.10	441,000	338.12	1.90	0.70	198
440800	1563200	249.00	10,000	39.00	390,000	284.33	1.90	0.70	147
440900	1563200	255.30	10,000	45.30	453,000	249.86	1.90	0.70	150
441000	1563200	251.20	10,000	41.20	412,000	230.65	1.90	0.70	126
441100	1563200	251.50	10,000	41.50	415,000	222.49	1.90	0.70	123
441200	1563200	265.40	10,000	55.40	554,000	221.28	1.90	0.70	163
438500	1563300	308.40	10,000	98.40	984,000	267.99	1.90	0.70	351
438600	1563300	314.80	10,000	104.80	1,048,000	253.96	1.90	0.70	354
438700	1563300	329.00	10,000	119.00	1,190,000	210.26	1.90	0.70	333
438800	1563300	350.50	10,000	140.50	1,405,000	165.12	1.90	0.70	308
438900	1563300	357.70	10,000	147.70	1,477,000	152.43	1.90	0.70	299
439000	1563300	354.30	10,000	144.30	1,443,000	165.92	1.90	0.70	318
439100	1563300	338.40	10,000	128.40	1,284,000	193.68	1.90	0.70	331
439200	1563300	327.80	10,000	117.80	1,178,000	260.21	1.90	0.70	407
439300	1563300	333.50	10,000	123.50	1,235,000	351.73	1.90	0.70	577
439400	1563300	317.90	10,000	107.90	1,079,000	184.53	1.90	0.70	265
439500	1563300	309.10	10,000	99.10	991,000	21.33	1.90	0.70	28
439600	1563300	312.20	10,000	102.20	1,022,000	396.77	1.90	0.70	539
439700	1563300	299.40	10,000	89.40	894,000	733.76	1.90	0.70	872
439800	1563300	300.10	10,000	90.10	901,000	538.69	1.90	0.70	645
439900	1563300	299.50	10,000	89.50	895,000	237.01	1.90	0.70	282
440000	1563300	294.80	10,000	84.80	848,000	45.70	1.90	0.70	52
440100	1563300	282.00	10,000	72.00	720,000	114.81	1.90	0.70	110
440200	1563300	270.50	10,000	60.50	605,000	219.89	1.90	0.70	177
440300	1563300	259.80	10,000	49.80	498,000	267.42	1.90	0.70	177
440400	1563300	247.50	10,000	37.50	375,000	199.78	1.90	0.70	100
440500	1563300	250.60	10,000	40.60	406,000	283.59	1.90	0.70	153
440600	1563300	253.10	10,000	43.10	431,000	296.15	1.90	0.70	170
440700	1563300	253.00	10,000	43.00	430,000	271.78	1.90	0.70	155

440800	1563300	259.00	10,000	49.00	490,000	242.48	1.90	0.70	158
440900	1563300	260.40	10,000	50.40	504,000	222.40	1.90	0.70	149
441000	1563300	255.20	10,000	45.20	452,000	213.86	1.90	0.70	128
441100	1563300	251.10	10,000	41.10	411,000	213.24	1.90	0.70	117
441200	1563300	256.70	10,000	46.70	467,000	216.28	1.90	0.70	134
438800	1563400	327.50	10,000	117.50	1,175,000	215.96	1.90	0.70	337
438900	1563400	336.50	10,000	126.50	1,265,000	224.30	1.90	0.70	377
439000	1563400	330.00	10,000	120.00	1,200,000	226.26	1.90	0.70	361
439100	1563400	329.40	10,000	119.40	1,194,000	257.90	1.90	0.70	409
439200	1563400	323.20	10,000	113.20	1,132,000	347.57	1.90	0.70	523
439300	1563400	316.00	10,000	106.00	1,060,000	552.58	1.90	0.70	779
439400	1563400	301.00	10,000	91.00	910,000	334.60	1.90	0.70	405
439500	1563400	288.00	10,000	78.00	780,000	733.33	1.90	0.70	760
439600	1563400	298.80	10,000	88.80	888,000	1,026.06	1.90	0.70	1,211
439700	1563400	293.00	10,000	83.00	830,000	666.05	1.90	0.70	735
439800	1563400	283.00	10,000	73.00	730,000	430.20	1.90	0.70	417
439900	1563400	269.00	10,000	59.00	590,000	209.25	1.90	0.70	164
440000	1563400	279.20	10,000	69.20	692,000	79.21	1.90	0.70	73
440100	1563400	276.30	10,000	66.30	663,000	87.34	1.90	0.70	77
440200	1563400	263.50	10,000	53.50	535,000	150.95	1.90	0.70	107
440300	1563400	260.90	10,000	50.90	509,000	181.06	1.90	0.70	123
440400	1563400	249.00	10,000	39.00	390,000	185.98	1.90	0.70	96
440500	1563400	244.70	10,000	34.70	347,000	213.78	1.90	0.70	99
440600	1563400	243.60	10,000	33.60	336,000	228.87	1.90	0.70	102
440700	1563400	251.00	10,000	41.00	410,000	216.41	1.90	0.70	118
440800	1563400	263.90	10,000	53.90	539,000	195.29	1.90	0.70	140
440900	1563400	266.10	10,000	56.10	561,000	185.84	1.90	0.70	139
441000	1563400	264.10	10,000	54.10	541,000	190.57	1.90	0.70	137
438800	1563500	317.40	10,000	107.40	1,074,000	235.74	1.90	0.70	337
438900	1563500	323.10	10,000	113.10	1,131,000	240.40	1.90	0.70	361
439000	1563500	313.20	10,000	103.20	1,032,000	246.96	1.90	0.70	339
439100	1563500	314.00	10,000	104.00	1,040,000	258.52	1.90	0.70	357
439200	1563500	316.70	10,000	106.70	1,067,000	269.30	1.90	0.70	382
439300	1563500	302.00	10,000	92.00	920,000	173.83	1.90	0.70	213
439400	1563500	278.40	10,000	68.40	684,000	177.14	1.90	0.70	161
439500	1563500	272.80	10,000	62.80	628,000	454.34	1.90	0.70	379
439600	1563500	286.60	10,000	76.60	766,000	614.70	1.90	0.70	626
439700	1563500	291.30	10,000	81.30	813,000	494.92	1.90	0.70	535
439800	1563500	273.30	10,000	63.30	633,000	319.92	1.90	0.70	269
439900	1563500	250.50	10,000	40.50	405,000	143.85	1.90	0.70	77
440000	1563500	258.60	10,000	48.60	486,000	67.22	1.90	0.70	43
440100	1563500	262.10	10,000	52.10	521,000	105.79	1.90	0.70	73
440200	1563500	247.30	10,000	37.30	373,000	146.70	1.90	0.70	73
440300	1563500	245.00	10,000	35.00	350,000	174.14	1.90	0.70	81
440400	1563500	251.50	10,000	41.50	415,000	191.37	1.90	0.70	106
440500	1563500	247.00	10,000	37.00	370,000	206.16	1.90	0.70	101
440600	1563500	229.40	10,000	19.40	194,000	206.68	1.90	0.70	53

440700	1563500	238.00	10,000	28.00	280,000	179.99	1.90	0.70	67
440800	1563500	255.40	10,000	45.40	454,000	142.77	1.90	0.70	86
440900	1563500	260.70	10,000	50.70	507,000	140.65	1.90	0.70	95
441000	1563500	264.10	10,000	54.10	541,000	165.65	1.90	0.70	119
438800	1563600	315.20	10,000	105.20	1,052,000	242.28	1.90	0.70	339
438900	1563600	321.70	10,000	111.70	1,117,000	247.48	1.90	0.70	367
439000	1563600	304.10	10,000	94.10	941,000	252.46	1.90	0.70	316
439100	1563600	295.80	10,000	85.80	858,000	239.86	1.90	0.70	274
439200	1563600	303.50	10,000	93.50	935,000	207.03	1.90	0.70	257
439300	1563600	294.90	10,000	84.90	849,000	146.25	1.90	0.70	165
439400	1563600	279.00	10,000	69.00	690,000	116.86	1.90	0.70	107
439500	1563600	267.00	10,000	57.00	570,000	92.33	1.90	0.70	70
439600	1563600	273.50	10,000	63.50	635,000	216.59	1.90	0.70	183
439700	1563600	281.60	10,000	71.60	716,000	285.75	1.90	0.70	272
439800	1563600	268.70	10,000	58.70	587,000	224.01	1.90	0.70	175
439900	1563600	242.40	10,000	32.40	324,000	114.56	1.90	0.70	49
440000	1563600	234.80	10,000	24.80	248,000	107.54	1.90	0.70	35
440100	1563600	236.90	10,000	26.90	269,000	155.77	1.90	0.70	56
440200	1563600	228.00	10,000	18.00	180,000	171.16	1.90	0.70	41
440700	1563600	232.70	9,708	22.70	220,377	180.71	1.90	0.70	53
440800	1563600	247.30	10,000	37.30	373,000	79.88	1.90	0.70	40
440900	1563600	251.90	10,000	41.90	419,000	97.83	1.90	0.70	54
441000	1563600	251.00	10,000	41.00	410,000	154.03	1.90	0.70	84
438800	1563700	306.70	10,000	96.70	967,000	242.41	1.90	0.70	312
438900	1563700	310.80	10,000	100.80	1,008,000	246.25	1.90	0.70	330
439000	1563700	292.00	10,000	82.00	820,000	249.86	1.90	0.70	272
439100	1563700	281.80	10,000	71.80	718,000	224.07	1.90	0.70	214
439200	1563700	289.00	10,000	79.00	790,000	193.04	1.90	0.70	203
439300	1563700	287.10	10,000	77.10	771,000	154.42	1.90	0.70	158
439400	1563700	281.00	10,000	71.00	710,000	122.21	1.90	0.70	115
439500	1563700	273.20	10,000	63.20	632,000	110.13	1.90	0.70	93
439600	1563700	264.40	10,000	54.40	544,000	151.13	1.90	0.70	109
439700	1563700	264.50	10,000	54.50	545,000	193.59	1.90	0.70	140
439800	1563700	260.20	10,000	50.20	502,000	184.71	1.90	0.70	123
439900	1563700	234.80	10,000	24.80	248,000	153.29	1.90	0.70	51
440000	1563700	213.70	10,000	3.70	37,000	154.15	1.90	0.70	8
440100	1563700	213.00	8,273	3.00	24,819	177.22	1.90	0.70	6
440200	1563700	211.00	4,819	1.00	4,819	194.02	1.90	0.70	1
440700	1563700	247.20	6,184	37.20	230,057	281.15	1.90	0.70	86
440800	1563700	254.80	10,000	44.80	448,000	173.83	1.90	0.70	104
440900	1563700	258.10	10,000	48.10	481,000	149.37	1.90	0.70	96
441000	1563700	289.30	10,000	79.30	793,000	179.51	1.90	0.70	189
438800	1563800	284.90	10,000	74.90	749,000	239.11	1.90	0.70	238
438900	1563800	269.80	10,000	59.80	598,000	238.77	1.90	0.70	190
439000	1563800	273.90	10,000	63.90	639,000	232.67	1.90	0.70	198
439100	1563800	271.10	10,000	61.10	611,000	216.35	1.90	0.70	176
439200	1563800	232.00	10,000	22.00	220,000	195.26	1.90	0.70	57

440800	1563800	249.70	9,913	39.70	393,532	374.65	1.90	0.70	196
440900	1563800	259.00	10,000	49.00	490,000	261.00	1.90	0.70	170
441000	1563800	265.00	10,000	55.00	550,000	227.95	1.90	0.70	167
438800	1563900	265.00	10,000	55.00	550,000	235.56	1.90	0.70	172
438900	1563900	260.70	10,000	50.70	507,000	233.27	1.90	0.70	157
439000	1563900	255.00	10,000	45.00	450,000	227.24	1.90	0.70	136
439100	1563900	249.80	10,000	39.80	398,000	216.55	1.90	0.70	115
439200	1563900	242.50	10,000	32.50	325,000	202.74	1.90	0.70	88
440800	1563900	226.10	7,708	16.10	124,103	375.06	1.90	0.70	62
440900	1563900	243.80	10,000	33.80	338,000	303.27	1.90	0.70	136
441000	1563900	256.90	10,000	46.90	469,000	259.79	1.90	0.70	162
			4,246,958		364,031,643				117,905

Appendix E Calculation of mineable reserve by using ordinary kriging method

Easting	Northing	Elevation	Depth (m)	Volume (m^3)	Tin Concentrate g/m^3	Density	Recovery Factor	Reserve (tons)
439800	1562900	322	42	421,000	20.90	1.90	0.70	12
439500	1563300	309	29	291,000	21.33	1.90	0.70	8
439100	1563000	368	88	876,000	26.00	1.90	0.70	30
440800	1562500	299	19	186,000	34.06	1.90	0.70	8
439500	1562900	336	56	564,000	40.23	1.90	0.70	30
439100	1562900	355	75	748,000	41.80	1.90	0.70	42
439100	1563100	380	100	999,000	43.59	1.90	0.70	58
440000	1563300	295	15	148,000	45.70	1.90	0.70	9
439000	1562900	355	75	749,000	50.62	1.90	0.70	50
439500	1563000	335	55	552,000	51.57	1.90	0.70	38
439500	1563100	334	54	538,000	57.78	1.90	0.70	41
439700	1562600	335	55	551,000	58.70	1.90	0.70	43
439200	1562900	349	69	693,000	60.31	1.90	0.70	56
439000	1563000	368	88	878,000	61.22	1.90	0.70	71
439700	1562800	330	50	501,000	62.84	1.90	0.70	42
439300	1562800	344	64	638,000	63.30	1.90	0.70	54
439600	1562800	333	53	528,000	65.07	1.90	0.70	46
440000	1563500	259	5	50,000	67.22	1.90	0.70	4
439300	1563200	341	61	614,000	68.57	1.90	0.70	56
439700	1562700	335	55	551,000	69.87	1.90	0.70	51
439600	1562900	331	51	508,000	70.96	1.90	0.70	48
439000	1563100	382	102	1,016,000	71.59	1.90	0.70	97
439400	1563200	323	43	425,000	71.90	1.90	0.70	41
438900	1563200	375	95	948,000	71.98	1.90	0.70	91
439800	1562800	328	48	481,000	72.27	1.90	0.70	46
439200	1563000	355	75	749,000	75.64	1.90	0.70	75
439500	1562800	335	55	549,000	75.91	1.90	0.70	55
439600	1562700	336	56	560,000	76.35	1.90	0.70	57
440000	1563400	279	5	50,000	79.21	1.90	0.70	5
439600	1562600	336	56	560,000	79.34	1.90	0.70	59
440800	1563600	247	5	47,000	79.88	1.90	0.70	5
440200	1563000	278	5	50,000	82.36	1.90	0.70	5
440100	1563000	298	18	179,000	83.04	1.90	0.70	20
439200	1562800	343	63	626,000	83.89	1.90	0.70	70
439300	1562900	346	66	664,000	84.16	1.90	0.70	74
440800	1562600	275	5	50,000	86.24	1.90	0.70	6
440100	1563400	276	5	50,000	87.34	1.90	0.70	6
439900	1562900	320	40	402,000	87.80	1.90	0.70	47
439400	1563100	334	54	536,000	89.87	1.90	0.70	64
439500	1563600	267	5	50,000	92.33	1.90	0.70	6
440000	1561600	243	5	50,000	93.63	1.90	0.70	6
440900	1562500	299	19	181,420	94.46	1.90	0.70	23
440100	1561600	241	5	50,000	94.58	1.90	0.70	6

439000	1562800	353	73	728,000	94.78	1.90	0.70	92
440700	1562500	297	17	170,000	95.42	1.90	0.70	22
440000	1562900	309	29	290,000	96.05	1.90	0.70	37
439400	1562800	337	57	570,000	96.98	1.90	0.70	73
440900	1563600	252	5	50,000	97.83	1.90	0.70	7
440000	1563200	284	5	50,000	99.18	1.90	0.70	7
439000	1563200	378	98	980,000	101.53	1.90	0.70	132
439200	1563100	365	85	851,000	101.77	1.90	0.70	115
439700	1562900	322	42	420,000	103.04	1.90	0.70	58
439100	1563200	363	83	825,000	104.87	1.90	0.70	115
440100	1563500	262	5	50,000	105.79	1.90	0.70	7
440000	1563600	235	5	47,000	107.54	1.90	0.70	7
440800	1562400	308	28	16,980	109.61	1.90	0.70	2
439500	1563700	273	5	47,000	110.13	1.90	0.70	7
439400	1562900	338	58	583,000	111.23	1.90	0.70	86
440100	1562900	289	9	90,000	113.19	1.90	0.70	14
439100	1562800	343	63	625,000	113.32	1.90	0.70	94
439700	1562500	335	55	550,000	113.60	1.90	0.70	83
440700	1562600	273	5	50,000	114.52	1.90	0.70	8
439900	1563600	242	5	49,640	114.56	1.90	0.70	8
440100	1563300	282	5	50,000	114.81	1.90	0.70	8
440900	1562600	269	5	47,000	115.63	1.90	0.70	7
439500	1562700	337	57	567,000	115.91	1.90	0.70	87
440000	1563000	311	31	307,000	116.85	1.90	0.70	48
439400	1563600	279	5	50,000	116.86	1.90	0.70	8
439800	1562700	329	49	489,000	118.38	1.90	0.70	77
438800	1563200	370	90	899,000	122.02	1.90	0.70	146
439400	1563700	281	5	47,000	122.21	1.90	0.70	8
440900	1562400	305	25	14,760	125.76	1.90	0.70	2
440000	1561700	246	5	50,000	125.94	1.90	0.70	8
438900	1562900	368	88	880,000	126.19	1.90	0.70	148
439600	1563000	327	47	467,000	126.62	1.90	0.70	79
440100	1561700	246	5	50,000	127.47	1.90	0.70	8
438900	1563100	381	101	1,011,000	127.98	1.90	0.70	172
440500	1562600	306	26	259,000	128.57	1.90	0.70	44
439300	1563100	343	63	625,000	131.72	1.90	0.70	109
439300	1562700	340	60	598,000	132.88	1.90	0.70	106
439900	1562800	328	48	482,000	133.62	1.90	0.70	86
440000	1561500	243	5	47,000	133.64	1.90	0.70	8
438900	1562800	371	91	907,000	133.91	1.90	0.70	161
440100	1561500	235	5	47,000	134.23	1.90	0.70	8
439200	1562700	336	56	562,000	134.35	1.90	0.70	100
440700	1562400	315	35	20,820	134.80	1.90	0.70	4
440600	1562600	282	5	50,000	136.24	1.90	0.70	9
439500	1563200	324	44	440,000	136.91	1.90	0.70	80
439000	1562700	355	75	745,000	138.56	1.90	0.70	137
439400	1562700	335	55	548,000	139.19	1.90	0.70	101

439600	1562500	331	51	506,000	140.34	1.90	0.70	94
439100	1562700	335	55	554,000	140.44	1.90	0.70	103
440900	1563500	261	5	50,000	140.65	1.90	0.70	9
440800	1563500	255	5	49,640	142.77	1.90	0.70	9
440600	1562500	313	33	325,000	143.25	1.90	0.70	62
439900	1563500	251	5	50,000	143.85	1.90	0.70	10
438900	1563000	370	90	895,000	144.25	1.90	0.70	172
438900	1562500	340	60	562,120	145.57	1.90	0.70	109
439900	1561600	259	5	50,000	146.10	1.90	0.70	10
439300	1563600	295	15	149,000	146.25	1.90	0.70	29
440200	1563500	247	5	49,640	146.70	1.90	0.70	10
439000	1562500	336	56	528,280	147.84	1.90	0.70	104
439800	1562600	319	39	389,000	147.86	1.90	0.70	76
440200	1561600	245	5	50,000	148.88	1.90	0.70	10
439300	1563000	345	65	646,000	148.95	1.90	0.70	128
440900	1563700	258	5	50,000	149.37	1.90	0.70	10
438900	1562700	377	97	970,000	150.43	1.90	0.70	194
440200	1563400	264	5	50,000	150.95	1.90	0.70	10
439600	1563700	264	5	47,000	151.13	1.90	0.70	9
438900	1563300	358	78	777,000	152.43	1.90	0.70	157
439900	1563700	235	5	44,360	153.29	1.90	0.70	9
441000	1563600	251	5	47,000	154.03	1.90	0.70	10
439300	1563700	287	7	66,740	154.42	1.90	0.70	14
439000	1562600	353	73	731,000	154.54	1.90	0.70	150
438800	1562500	326	46	407,225	155.53	1.90	0.70	84
440100	1563600	237	5	47,000	155.77	1.90	0.70	10
440000	1563100	291	11	110,000	156.14	1.90	0.70	23
438900	1562600	361	81	810,000	156.20	1.90	0.70	168
439900	1561500	264	5	47,000	158.11	1.90	0.70	10
440200	1561500	237	5	47,000	159.87	1.90	0.70	10
439100	1562600	333	53	533,000	159.95	1.90	0.70	113
439100	1562500	331	51	476,580	162.11	1.90	0.70	103
439900	1561700	256	5	50,000	163.10	1.90	0.70	11
438800	1563300	351	71	699,924	165.12	1.90	0.70	154
441000	1563500	264	5	47,000	165.65	1.90	0.70	10
440800	1562700	274	5	50,000	165.74	1.90	0.70	11
439000	1563300	354	74	743,000	165.92	1.90	0.70	164
438800	1563100	382	102	1,011,663	166.30	1.90	0.70	224
440900	1562700	269	5	47,000	166.38	1.90	0.70	10
438800	1562600	348	68	639,200	167.05	1.90	0.70	142
440200	1561700	250	5	50,000	167.61	1.90	0.70	11
438800	1562800	381	101	945,640	168.36	1.90	0.70	212
438800	1562700	374	94	883,600	169.45	1.90	0.70	199
439200	1562600	333	53	534,000	169.98	1.90	0.70	121
440100	1563200	276	5	50,000	170.59	1.90	0.70	11
440200	1563600	228	5	44,360	171.16	1.90	0.70	10
439400	1563000	339	59	590,000	171.82	1.90	0.70	135

438800	1562900	385	105	987,940	173.31	1.90	0.70	228
439300	1563500	302	22	220,000	173.83	1.90	0.70	51
440800	1563700	255	5	47,000	173.83	1.90	0.70	11
440300	1563500	245	5	47,000	174.14	1.90	0.70	11
440500	1562700	306	26	257,000	174.22	1.90	0.70	60
439500	1562600	337	57	568,000	175.01	1.90	0.70	132
440100	1563100	287	7	70,000	175.62	1.90	0.70	16
439400	1563500	278	5	50,000	177.14	1.90	0.70	12
441000	1563700	289	9	87,420	179.51	1.90	0.70	21
439800	1561600	273	5	50,000	179.62	1.90	0.70	12
440600	1562400	326	46	27,720	179.82	1.90	0.70	7
440700	1563500	238	5	47,000	179.99	1.90	0.70	11
440300	1563400	261	5	50,000	181.06	1.90	0.70	12
439200	1563200	352	72	723,000	182.23	1.90	0.70	175
439800	1561500	270	5	47,000	182.51	1.90	0.70	11
439900	1563000	318	38	382,000	182.61	1.90	0.70	93
440300	1561600	243	5	50,000	184.03	1.90	0.70	12
439400	1563300	318	38	379,000	184.53	1.90	0.70	93
439200	1562500	324	44	411,720	184.60	1.90	0.70	101
439800	1563700	260	5	47,000	184.71	1.90	0.70	12
440500	1562500	328	48	480,000	184.78	1.90	0.70	118
440700	1562700	273	5	50,000	185.04	1.90	0.70	12
440300	1561500	242	5	47,000	185.32	1.90	0.70	12
440900	1563400	266	5	50,000	185.84	1.90	0.70	12
440400	1563400	249	5	50,000	185.98	1.90	0.70	12
440200	1562900	275	5	50,000	186.44	1.90	0.70	12
439300	1562300	301	21	188,086	186.58	1.90	0.70	47
438800	1563000	382	102	954,100	187.38	1.90	0.70	238
440400	1562600	317	37	370,000	187.65	1.90	0.70	92
439300	1562600	333	53	533,000	190.32	1.90	0.70	135
439800	1561700	274	5	50,000	190.33	1.90	0.70	13
441000	1563400	264	5	47,000	190.57	1.90	0.70	12
439400	1562300	328	48	447,440	190.69	1.90	0.70	113
439600	1562400	330	50	495,000	191.36	1.90	0.70	126
440400	1563500	252	5	47,000	191.37	1.90	0.70	12
439200	1563700	289	9	89,352	193.04	1.90	0.70	23
440000	1561800	251	5	50,000	193.54	1.90	0.70	13
439700	1563700	265	5	47,000	193.59	1.90	0.70	12
439100	1563300	338	58	584,000	193.68	1.90	0.70	150
439200	1563800	232	5	47,000	195.26	1.90	0.70	12
440800	1563400	264	5	50,000	195.29	1.90	0.70	13
438700	1563200	357	77	766,000	195.92	1.90	0.70	199
440100	1561800	255	5	50,000	196.06	1.90	0.70	13
440300	1561700	251	5	50,000	197.42	1.90	0.70	13
439500	1562300	335	55	517,000	198.33	1.90	0.70	136
439700	1561600	271	5	47,000	199.34	1.90	0.70	12
438700	1563100	373	93	876,080	199.34	1.90	0.70	232

439700	1561500	266	5	44,360	199.66	1.90	0.70	12
439800	1562500	349	69	690,000	199.76	1.90	0.70	183
440400	1563300	248	5	50,000	199.78	1.90	0.70	13
440600	1562700	282	5	50,000	199.99	1.90	0.70	13
439200	1563900	243	5	44,360	202.74	1.90	0.70	12
439700	1562400	320	40	400,000	202.81	1.90	0.70	108
439500	1562400	347	67	674,000	203.06	1.90	0.70	182
440400	1561500	249	5	44,360	203.38	1.90	0.70	12
439900	1561800	258	5	50,000	203.85	1.90	0.70	14
439300	1562400	314	34	319,600	203.86	1.90	0.70	87
440400	1561600	250	5	47,000	205.04	1.90	0.70	13
439700	1561700	269	5	47,000	205.84	1.90	0.70	13
439400	1562400	340	60	600,000	206.07	1.90	0.70	164
440500	1563500	247	5	47,000	206.16	1.90	0.70	13
440600	1563500	229	5	47,000	206.68	1.90	0.70	13
439200	1563600	304	24	235,000	207.03	1.90	0.70	65
439900	1563400	269	5	50,000	209.25	1.90	0.70	14
438700	1563300	329	49	460,600	210.26	1.90	0.70	129
439900	1562700	322	42	422,000	211.13	1.90	0.70	118
440200	1561800	262	5	50,000	211.35	1.90	0.70	14
439400	1562600	335	55	547,000	211.44	1.90	0.70	154
440900	1562800	260	5	47,000	213.15	1.90	0.70	13
441100	1563300	251	5	47,000	213.24	1.90	0.70	13
440500	1563400	245	5	50,000	213.78	1.90	0.70	14
439800	1561800	267	5	50,000	213.85	1.90	0.70	14
441000	1563300	255	5	47,000	213.86	1.90	0.70	13
440400	1561700	254	5	47,000	214.74	1.90	0.70	13
438800	1563400	328	48	446,500	215.96	1.90	0.70	128
441200	1563300	257	5	44,360	216.28	1.90	0.70	13
439100	1563800	271	5	50,000	216.35	1.90	0.70	14
440700	1563400	251	5	50,000	216.41	1.90	0.70	14
439600	1562300	324	44	411,720	216.52	1.90	0.70	119
439100	1563900	250	5	47,000	216.55	1.90	0.70	14
439600	1563600	274	5	50,000	216.59	1.90	0.70	14
439700	1561800	272	5	47,000	218.89	1.90	0.70	14
440200	1563300	271	5	50,000	219.89	1.90	0.70	15
439300	1562500	324	44	440,803	219.94	1.90	0.70	129
440000	1562800	307	27	267,000	221.20	1.90	0.70	79
441200	1563200	265	5	47,000	221.28	1.90	0.70	14
440900	1563300	260	5	49,640	222.40	1.90	0.70	15
441100	1563200	252	5	50,000	222.49	1.90	0.70	15
441200	1563100	273	5	44,360	223.78	1.90	0.70	13
439800	1563600	269	5	50,000	224.01	1.90	0.70	15
439100	1563700	282	5	50,000	224.07	1.90	0.70	15
438900	1563400	337	57	565,000	224.30	1.90	0.70	168
440300	1561800	269	5	50,000	225.65	1.90	0.70	15
439000	1563400	330	50	500,000	226.26	1.90	0.70	150

441100	1563100	263	5	47,000	226.29	1.90	0.70	14
439000	1563900	255	5	47,000	227.24	1.90	0.70	14
441000	1563800	265	5	44,360	227.95	1.90	0.70	13
440600	1563400	244	5	50,000	228.87	1.90	0.70	15
438600	1563100	357	77	720,040	228.93	1.90	0.70	219
441000	1563200	251	5	50,000	230.65	1.90	0.70	15
439000	1563800	274	5	50,000	232.67	1.90	0.70	15
440400	1561800	264	5	47,000	233.13	1.90	0.70	15
438900	1563900	261	5	47,000	233.27	1.90	0.70	15
440800	1562800	263	5	50,000	234.18	1.90	0.70	16
440400	1562700	317	37	370,000	234.55	1.90	0.70	115
438800	1563900	265	5	44,360	235.56	1.90	0.70	14
438800	1563500	317	37	351,560	235.74	1.90	0.70	110
439700	1561900	277	5	47,000	235.82	1.90	0.70	15
439900	1563300	300	20	195,000	237.01	1.90	0.70	61
440500	1562400	333	53	31,800	237.20	1.90	0.70	10
438900	1563800	270	5	50,000	238.77	1.90	0.70	16
441000	1563100	264	5	47,000	239.04	1.90	0.70	15
438800	1563800	285	5	46,060	239.11	1.90	0.70	15
439100	1563600	296	16	158,000	239.86	1.90	0.70	50
438900	1563500	323	43	431,000	240.40	1.90	0.70	138
438800	1563600	315	35	330,880	242.28	1.90	0.70	107
438800	1563700	307	27	250,980	242.41	1.90	0.70	81
440800	1563300	259	5	50,000	242.48	1.90	0.70	16
438500	1563100	346	66	581,116	244.08	1.90	0.70	189
439800	1561900	264	5	50,000	244.42	1.90	0.70	16
438600	1563200	341	61	610,000	245.96	1.90	0.70	199
438900	1563700	311	31	308,000	246.25	1.90	0.70	101
439000	1563500	313	33	332,000	246.96	1.90	0.70	109
438900	1563600	322	42	417,000	247.48	1.90	0.70	137
440900	1562900	257	5	47,000	247.65	1.90	0.70	15
439700	1562300	308	28	277,984	249.58	1.90	0.70	92
440900	1563200	255	5	50,000	249.86	1.90	0.70	17
439000	1563700	292	12	120,000	249.86	1.90	0.70	40
439000	1563600	304	24	241,000	252.46	1.90	0.70	81
439900	1561900	262	5	50,000	252.73	1.90	0.70	17
439500	1562500	337	57	572,000	252.81	1.90	0.70	192
439700	1562000	284	5	47,000	253.01	1.90	0.70	16
438600	1563300	315	35	327,120	253.96	1.90	0.70	110
440400	1562500	340	60	600,000	256.42	1.90	0.70	205
439100	1563400	329	49	494,000	257.90	1.90	0.70	169
439100	1563500	314	34	340,000	258.52	1.90	0.70	117
440400	1561900	264	5	47,000	259.36	1.90	0.70	16
440000	1561900	261	5	50,000	259.73	1.90	0.70	17
439900	1562600	322	42	422,000	260.04	1.90	0.70	146
439200	1563300	328	48	478,000	260.21	1.90	0.70	165
440900	1563800	259	5	47,000	261.00	1.90	0.70	16

438500	1563200	328	48	448,380	262.71	1.90	0.70	157
440100	1561900	267	5	50,000	264.12	1.90	0.70	18
440300	1561900	283	5	50,000	265.26	1.90	0.70	18
440900	1563100	260	5	49,640	265.52	1.90	0.70	18
440900	1563000	261	5	47,000	265.57	1.90	0.70	17
439700	1562100	293	13	117,500	265.75	1.90	0.70	42
440200	1561900	280	5	50,000	265.77	1.90	0.70	18
439700	1562200	298	18	171,080	267.33	1.90	0.70	61
440300	1563300	260	5	50,000	267.42	1.90	0.70	18
438500	1563300	308	28	251,965	267.99	1.90	0.70	90
439200	1563500	317	37	367,000	269.30	1.90	0.70	131
439800	1562400	338	58	576,000	270.76	1.90	0.70	207
440700	1563300	253	5	50,000	271.78	1.90	0.70	18
440700	1562800	273	5	50,000	275.91	1.90	0.70	18
439800	1562000	272	5	50,000	277.49	1.90	0.70	18
440500	1563300	251	5	50,000	283.59	1.90	0.70	19
440800	1563200	249	5	50,000	284.33	1.90	0.70	19
439700	1563600	282	5	50,000	285.75	1.90	0.70	19
440800	1562900	257	5	50,000	287.19	1.90	0.70	19
439400	1562500	336	56	556,000	287.91	1.90	0.70	213
439800	1563000	325	45	446,000	288.05	1.90	0.70	171
440400	1562000	271	5	47,000	292.74	1.90	0.70	18
439900	1563200	298	18	179,000	293.28	1.90	0.70	70
440600	1563300	253	5	50,000	296.15	1.90	0.70	20
439900	1563100	302	22	220,000	297.87	1.90	0.70	87
440100	1562800	281	5	50,000	303.61	1.90	0.70	20
440300	1562600	306	26	255,000	306.17	1.90	0.70	104
439900	1562000	275	5	50,000	307.04	1.90	0.70	20
439800	1562100	284	5	50,000	307.87	1.90	0.70	20
440800	1563100	248	5	50,000	312.28	1.90	0.70	21
439900	1562500	349	69	688,000	314.49	1.90	0.70	288
440800	1563000	254	5	50,000	314.92	1.90	0.70	21
439800	1562300	312	32	320,000	315.88	1.90	0.70	134
440300	1562000	281	5	50,000	318.03	1.90	0.70	21
439800	1563500	273	5	50,000	319.92	1.90	0.70	21
440400	1562400	337	57	538,620	320.28	1.90	0.70	229
440200	1562800	278	5	50,000	323.44	1.90	0.70	21
439800	1562200	291	11	109,000	325.42	1.90	0.70	47
440300	1562700	306	26	260,000	326.03	1.90	0.70	113
440400	1562100	278	5	47,000	330.04	1.90	0.70	21
440200	1562000	286	6	61,000	332.06	1.90	0.70	27
439400	1563400	301	21	210,000	334.60	1.90	0.70	93
440000	1562000	270	5	50,000	334.81	1.90	0.70	22
440600	1562800	289	9	90,000	335.71	1.90	0.70	40
440700	1563200	254	5	50,000	338.12	1.90	0.70	22
440000	1562700	303	23	228,000	340.90	1.90	0.70	103
440100	1562000	275	5	50,000	345.66	1.90	0.70	23

439200	1563400	323	43	432,000	347.57	1.90	0.70	200
439300	1563300	334	54	535,000	351.73	1.90	0.70	250
440300	1562500	343	63	633,000	358.16	1.90	0.70	301
440400	1562300	322	42	394,800	358.30	1.90	0.70	188
440400	1562200	290	10	94,000	358.55	1.90	0.70	45
440700	1562900	270	5	50,000	358.62	1.90	0.70	24
440200	1563200	272	5	50,000	359.98	1.90	0.70	24
440000	1562600	303	23	228,000	363.52	1.90	0.70	110
439700	1563000	323	43	427,000	364.78	1.90	0.70	207
439900	1562100	287	7	68,000	365.42	1.90	0.70	33
440200	1562700	288	8	80,000	366.64	1.90	0.70	39
440800	1563800	250	5	44,360	374.65	1.90	0.70	22
439900	1562400	346	66	660,000	380.72	1.90	0.70	334
440200	1562600	288	8	80,000	385.02	1.90	0.70	41
440300	1562100	278	5	50,000	389.38	1.90	0.70	26
440700	1563100	259	5	50,000	391.98	1.90	0.70	26
439600	1563300	312	32	322,000	396.77	1.90	0.70	170
440700	1563000	261	5	50,000	402.75	1.90	0.70	27
440500	1562800	304	24	242,000	408.97	1.90	0.70	132
440600	1563200	262	5	50,000	411.32	1.90	0.70	27
440100	1562700	282	5	50,000	412.26	1.90	0.70	27
440100	1562600	282	5	50,000	412.76	1.90	0.70	27
439900	1562200	292	12	123,000	414.44	1.90	0.70	68
440000	1562500	336	56	564,000	418.34	1.90	0.70	314
439900	1562300	310	30	295,000	424.18	1.90	0.70	166
440300	1562800	285	5	48,000	428.66	1.90	0.70	27
440000	1562100	283	5	50,000	430.00	1.90	0.70	29
439800	1563400	283	5	50,000	430.20	1.90	0.70	29
440300	1562400	343	63	627,000	435.41	1.90	0.70	363
440200	1563100	279	5	50,000	441.04	1.90	0.70	29
440200	1562100	286	6	61,000	446.14	1.90	0.70	36
440200	1562500	339	59	590,000	446.32	1.90	0.70	350
439500	1563500	273	5	50,000	454.34	1.90	0.70	30
440300	1562200	295	15	150,000	461.59	1.90	0.70	92
440100	1562100	281	5	50,000	468.70	1.90	0.70	31
440100	1562500	332	52	521,000	473.25	1.90	0.70	328
440400	1562800	298	18	175,000	473.71	1.90	0.70	110
440600	1562900	285	5	48,000	476.99	1.90	0.70	30
440300	1562300	326	46	460,000	485.69	1.90	0.70	297
440500	1563200	256	5	50,000	492.56	1.90	0.70	33
439700	1563500	291	11	113,000	494.92	1.90	0.70	74
440000	1562400	334	54	540,000	511.23	1.90	0.70	367
440600	1563100	270	5	50,000	524.49	1.90	0.70	35
440000	1562200	292	12	117,000	537.22	1.90	0.70	84
439800	1563300	300	20	201,000	538.69	1.90	0.70	144
439300	1563400	316	36	360,000	552.58	1.90	0.70	264
440300	1563200	263	5	50,000	554.52	1.90	0.70	37

440600	1563000	274	5	50,000	555.61	1.90	0.70	37
440400	1563200	251	5	50,000	559.60	1.90	0.70	37
440200	1562400	340	60	595,000	562.52	1.90	0.70	445
440000	1562300	298	18	183,000	584.35	1.90	0.70	142
440200	1562200	293	13	125,000	593.25	1.90	0.70	99
439800	1563100	314	34	342,000	593.43	1.90	0.70	270
440100	1562400	330	50	504,000	608.68	1.90	0.70	408
439600	1563500	287	7	66,000	614.70	1.90	0.70	54
440300	1562900	272	5	50,000	645.80	1.90	0.70	43
440100	1562200	291	11	112,000	650.59	1.90	0.70	97
440500	1562900	291	11	108,000	653.86	1.90	0.70	94
439800	1563200	300	20	196,000	664.00	1.90	0.70	173
439700	1563400	293	13	130,000	666.05	1.90	0.70	115
440200	1562300	319	39	391,000	674.54	1.90	0.70	351
439600	1563100	324	44	435,000	682.53	1.90	0.70	395
439500	1563400	288	8	80,000	733.33	1.90	0.70	78
439700	1563300	299	19	194,000	733.76	1.90	0.70	189
440500	1563100	261	5	50,000	740.42	1.90	0.70	49
440100	1562300	308	28	277,000	812.10	1.90	0.70	299
440500	1563000	272	5	50,000	817.79	1.90	0.70	54
440400	1562900	284	5	50,000	827.85	1.90	0.70	55
439600	1563200	319	39	385,000	852.83	1.90	0.70	436
439700	1563100	317	37	367,000	1,022.04	1.90	0.70	499
439600	1563400	299	19	188,000	1,026.06	1.90	0.70	256
440400	1563100	254	5	50,000	1,049.30	1.90	0.70	70
440300	1563100	267	5	50,000	1,066.56	1.90	0.70	71
439700	1563200	306	26	258,000	1,104.30	1.90	0.70	379
440400	1563000	267	5	50,000	1,251.33	1.90	0.70	83
440300	1563000	264	5	50,000	1,485.55	1.90	0.70	99
				106,724,718				30,368

VITA

NAME	AYE MIN TUN
DATE OF BIRTH	24 December 1989
PLACE OF BIRTH	Tonywa Thit Village, Sarlingyi District, Sagaing Division, Myanmar
INSTITUTIONS ATTENDED	2018-Present: Studying Master's degree in Georesources Engineering at Chulalongkorn University 2005-2012: Studied Master's degree in Geology at University of Monywa, Myanmar
HOME ADDRESS	Sarlingyi District, Sagaing Division, Myanmar