THE UNION OF BURMA

MINERAL RESOURCES DEVELOPMENT PROJECT FOR PYINMANA EAST

— SURVEY REPORT —

AUGUST 1972

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in compliance with the request of the Government of the Union of Burma for a survey on the development of tin and tungsten resources in the Pyinmana East Area as part of the Mineral Resources Development Project ranked top under the First 4-Year Plan of the government, entrusted the Overseas Technical Cooperation Agency with the implementation of the said survey.

The Agency, for its part, organized a survey team consisting of seven experts, headed by Mr. Kanji Shiobara, a Director and Chief Geologist of Mitsui Mining & Smelting Co., Ltd., and sent it to Burma over a period of 21 days from March 7 to 27, 1972.

In Rangoon the survey team exchanged views with officials of the Mineral Development Corporation which has jurisdiction over the Pyinmana East Area, as well as officials of the Ministry of Mines and Ministry of Planning & Finance. In the field the team conducted investigations of ore deposits and geological surveys for a period of 13 days.

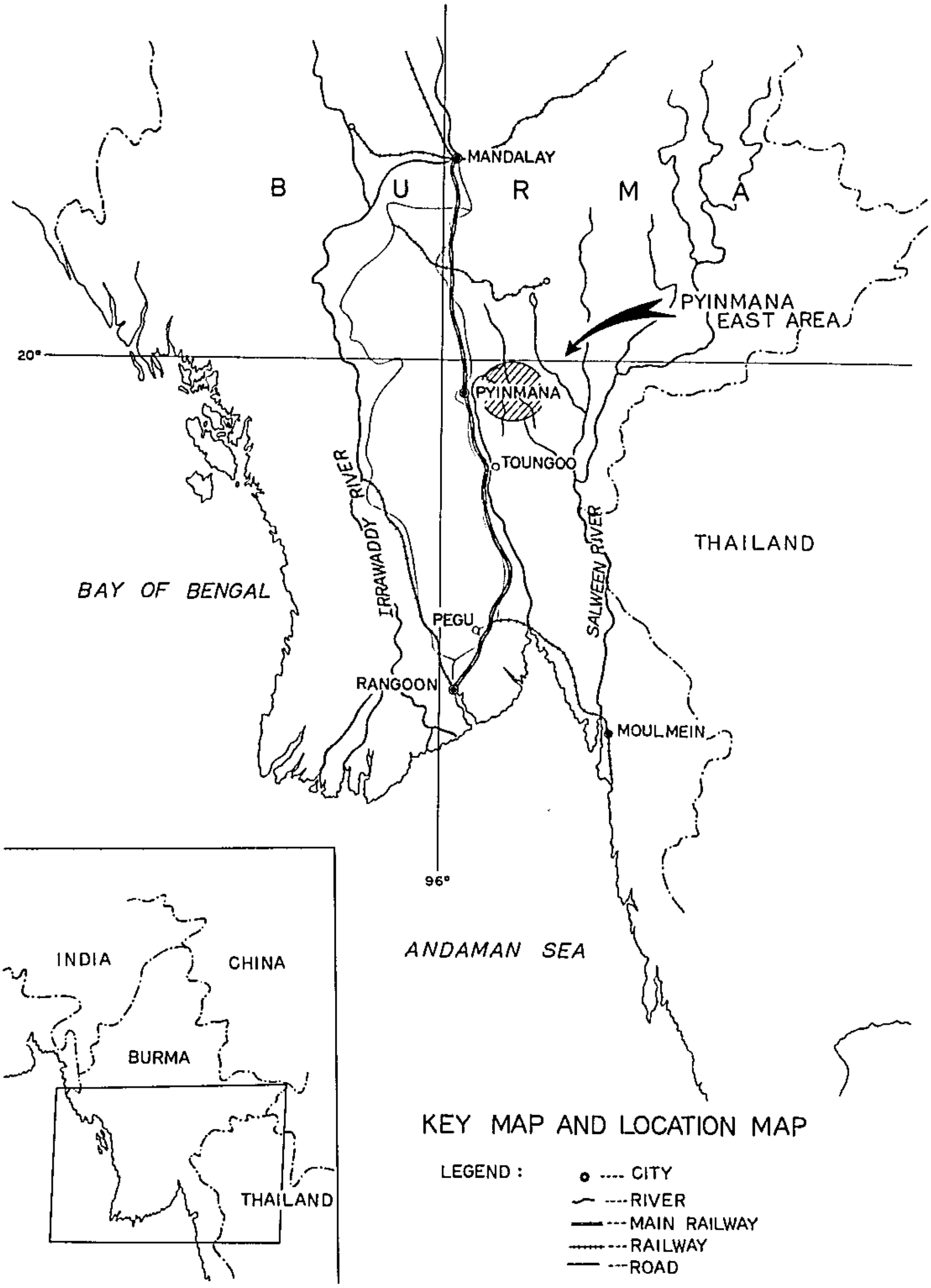
This report is a summary of the findings of the study made on the basis of the data gathered in the field survey and of the results of analysis conducted in Japan on the samples brought from the site.

It is my sincere desire in presenting this report that it will contribute to the development of mineral resources in the Union of Burma and at the same time help promote the economic exchange between our two contries.

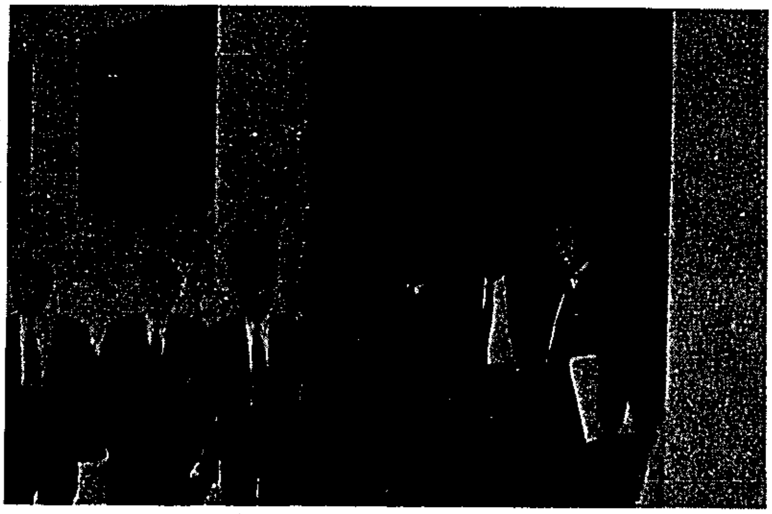
Finally, I should like to take this opportunity to express my appreciation to officials of various agencies of the Government of the Union of Burma, the Ministry of Mines, the Ministry of Planning & Finance and the Mineral Development Corporation for the assistance extended to the survey team during its stay in Burma.

July 1972

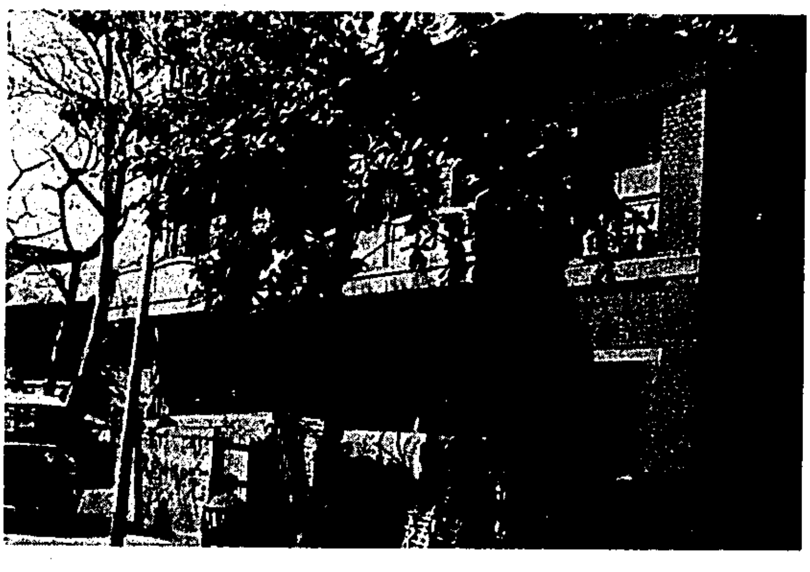
Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency



KEY MAP AND LOCATION MAP



Member of the Japanese Survey Team



Pyinmana branch of M. D. C.

Seipudaung Base

Distant view of Padatgyaung Mine

Distant view of Kalatchaung Mine and No. 4 Mine

Contents

Contents of Figures

1. INTRODUCTION

1-1 Background of Survey

In the pre-war days the Pyinmana East Area was producing 300~600 t of tin-tungsten annually. In the post-war period up to 1967, however, the mines in the area had not been worked because of poor road conditions, rugged terrain, jungles in the area and the lack of geological data.

In 1968, however, MDC established in this area a booking and purchasing office and since then small-scale operations by the Tributor system by local people was resumed. As a result, production of concentrate amounted to 20.93 t in the year 1969-70 and approximately 70 t in the year 1970-71.

Despite the expectation of large ore reserves, no plans for prospecting and production have been made for the Pyinmana East Area because of the lack of sufficient geological data. Under these circumstances, the Ministry of Mines decided to prepare geologic maps and carry out detailed prospecting under the governments Four-Year Plan. In this area only a preliminary survey was conducted by two English geologists for a period of 2 to 3 months in 1971 under the Colombo Plan. The survey was a reconnaisance type and thus the geology of the area was virtually unknown. Under these conditions, the Government of the Union of Burma made a request to the Government of Japan for a detailed survey in October 1971. Later, consultations were held between the MDC and the Japanese Embassy in Rangoon and an agreement was reached on the implementation of the survey during the dry season (March).

1-2 Organization of Survey Team

Chief: Kanji Shiobara (Overall responsibility, geological and ore deposit survey)
Director and Chief Geologist, Mitsui Mining & Smelting Co., Ltd.

Member: Kiichi Kasamatsu (Geological and ore deposit survey)
Directors and Chief of Survey Department, Ohte Development Co., Ltd.

Member: Yoshio Tanaka (Geological and ore deposit survey)
Chief of Prospecting Section, Nittetsu Mining Co., Ltd.

Member: Fumio Kishimoto (Geological and ore deposit survey)
Senior Geologist, Metal Section, Mineral Deposits Department, Geological Survey of Japan, Industrial Science & Technology Agency

Member: Koichiro Daimaru (Geological and ore deposit survey)
Chief of Prospecting Section, Hitachi Mine, Nippon Mining Co., Ltd.

Member: Hironao Suzuki (Coordination)
First Operation Division, Development and Survey Department, Overseas Technical Cooperation Agency

Member: Keiji Omori (Survey of general economic condition and the state of mining industry)
Overseas Mineral Resources Development Group,
Mine Administration Section, Mine and Coal Bureau,
Ministry of International Trade & Industry.

1-3 Survey Schedule

Item No.	Date	Travel	Details
1	Mar. 7 (Tue)	Tokyo - Rangoon	
2	Mar. 8 (Wed)		Consultations with Japanese Embassy staff.
3	Mar. 9 (Thu)		Consultations with officials of the Mineral Development Corporation on details of survey. Preparation for departure for the site.
4	Mar. 10 (Fri)	Rangoon - Pyinmana - Seikphudaung	
5	Mar. 11 (Sat)	Seikphudaung-Padatgyaung	Geological and ore deposit survey in the Padatgyaung district.
7	Mar. 13 (Mon)		
8	Mar. 14 (Tue)	Padatgyaung-No.4 Mine	Geological and ore deposit survey at Kalat Chaung Mine and Steel Mine.
9	Mar. 15 (Wed)		Geological and ore deposit survey at No. 4 Mine.
10	Mar. 16 (Thu)	No.4 Mine-Padatgyaung	
11	Mar. 17 (Fri)	Padatgyaung-Peinnedaik	Geological and ore deposit survey in the Peinnedaik district.
12	Mar. 18 (Sat)	Padatgyaung-Seikphudaung	
13	Mar. 19 (Sun)		Geological and ore deposit survey at Thamaye Mine and Shan Thay Mine.

14	Mar. 20 (Mon)		Summarization of the findings of survey and consultations with the Burmese counterparts.
15	Mar. 21 (Tue)	Seikphudaung-Pyinmana	
16	Mar. 22 (Wed)	Pyinmana-Rangoon	
17	Mar. 23 (Thu)		Report on the findings of survey at the Japanese Embassy, Ministry of Planning & Finance and Ministry of Mines.
18	Mar. 24 (Fri)		Preparation of an interim report of survey with the cooperation of the Japanese Embassy.
19	Mar. 25 (Sat)		Presentation of interim report to the Mineral Development Corporation.
20	Mar. 26 (Sun)		Meeting of the team members to discuss the preparation of a final report. Preparation for departuree for Japan.
21	Mar. 27 (Mon)	Rangoon - Tokyo	

1-4 Acknowlegments

The survey team expresses its profound gratitude to the Government of the Union of Burma for the assistance and cooperation extended through the Mineral Development Corporation during its stay in Burma.

The team is particularly grateful to the Mineral Development Corporation for providing two geologists who joined the team in Rangoon and accompanied it during the entire period of survey, for the participation of staff members from MDC branch office in the Pyinmana East Area in geological and ore deposit surveys and for making transport equipment including jeeps and trucks available to the team.

The Burmese counterparts who have rendered their cooperation in the survey are as follows

2. CONCLUSIONS AND RECOMMENDATIONS

Factors supporting the conclusions on the findings of this survey may be summarized as follows.

The position of tin and tungsten in the mining industry of Burma is such that they constitutes one of the three most important mineral resources of the country together with lead, zinc and silver centered around Bardwin Mine and precious stones including jade produced in northern Burma. The total value of tin - tungsten production in the last fiscal year from October 1970 through September 1971 amounted to about 19 million Kyat (about $3.8 million) and a further increase of the production is expected for the current fiscal year with the target set at 23 million Kyat ($4.6 million).

In terms of volume, the production of tin - tungsten during the last fiscal year totaled 1,802 long tons (l.t.) of concentrate. Against this, the volume of production at the peak just before the outbreak of world war II was approximately 14,000 l.t. Because of the hard blow dealt by the devastation brought about by the war, the post-war rehabilitation made little progress. The production which had amounted to 2,500 - 3,000 l.t. annually up to 1961 began to decline gradually in the following years and the annual production in the three year period after 1966 in particular fell short of the 1,000 l.t. level. Backed by the strong measures taken by the government since then, however, the production exceeded the 1,000 l.t. level in fiscal 1969 and finally attained 1,802 l.t. in the last fiscal year. Production is expected to exceed 2,000 l.t. for the current fiscal year.

The Pyinmana East Area, the object of this survey, used to produce 300 - 600 tons of tin - tungsten in the pre-war days. Its rehabilitation in the post-war period, however, was very slow, and the mining in the form of Tributor system (crude ore purchasing contract with local people) was resumed only in 1968 when M.D.C. established its branch office in this area for booking and purchasing of ores. In the last fiscal year approximately 70 l.t. of tin - tungsten concentrate was produced. The goal for the current fiscal year has been set at 80 l.t., but indications are that the production will be well over the 100 l.t. level and will probably reach 120 l.t..

It may be said, therefore, that the Pyinmana East Area, whose share in the tin - tungsten industry in Burma was 4% in the last fiscal year and will be about 6% in the current fiscal year, does not necessarily hold an important position as far as the present production level is concerned.

The reasons for this low level of production are, first the lack of large alluvial deposits as those seen in the Taboi Magui district because of the influence of topography, second the absence of high-grade and large scale metalliferous veins that allows underground mining such as those seen at Mawchi Mine, and third the rugged terrain, poor road conditions and remote location, these factors make prospecting extremely difficult and the lack of prospecting causes a considerable delay in the exploration and exploitation of new ore deposits. The findings of the survey may be concluded as follows.

1 Of the six mines surveyed, four key mines are located close to the Southern Shan States border. Part of ore deposit is seen in the granite or metasediments intruded by the former in the vicinity of the contact on the western periphery of an intrusive biotite granitic bodies stretching over the state border.

2 The primary ore deposits, however, consist of high temperature type quartz veins containing tungsten and tin, but some contain small quantities of sulphides including molybdenite, pyrite and copper pyrite. As for gangue minerals, the ore is usually accompanied by tourmaline, but magnetite and specularite are also contained.

Veins containing tin and tungsten ore are seen most frequently in the vicinity of the contact and particularly in granite near the contact. They may also be found in some metasediments, but they decrease gradually with the distance from the contact.

Although there are a number of veins, most of them are small in scale with a maximum width of 20 - 30cm and an average width of 10cm. There also are a number of veins having widths of less than 5cm. At times, veins have widths of one meter at the intersections, but such cases are very rare. Because of the small scale and discontinuity of the veins, underground mining of primary the ore deposits cannot be considered.

3 The main object of past operations has been the so-called eluvial deposit formed from the above-mentioned primary ore deposits weathered under the tropical conditions in site.

In this particular area biotite granite and metasediments, country rocks, have been weathered into sands and such conditions make hand digging with a shovel very easy.

Quartz veins containing tin and tungsten ores are highly resistant against weathering and remain in the above-mentioned disintegrated and weathered country rocks in their original primary form.

For this reason, hydraulic mining by monitors utilizing rainwater during the wet season was employed for the mining of this type of ore deposits at the peak of the pre-war days.

4 Because of the steep topography with comparatively rapid currents and narrow gorges, formation of large scale alluvial deposits can hardly be expected. Alluvial deposits of only small scale can be found in the gravel bed at small gorges along the rapid currents. These alluvial deposits are being explored by hand sluicing during the dry season.

5 The greater part of the existing eluvial deposits was already worked in the pre-war days and it is very close to the basement that it will be necessary to shift to underground mining in the future.

In order to realize profitable operation in the future, it will be necessary to make utmost efforts for the discovery and exploration of new ore deposits aiming primarily at eluvial deposits.

6 As for the room for further prospecting, the section north of the already known area at Padatgyaung Mine has not yet been prospected and presents the possibility of new deposits. In general, the section north of the already known deposits along the western edge of biolite granite intrusive

has never been prospected and there are a good possibilities for the discovery of many new eluvial deposits.

On the other hand, the eastern periphery of the granite intrusive has not been prospected so far and prospecting of this section will be indispensable in the future. In view of the question of accessibility, however, it will be more advantageous to start prospecting the western periphery first and then move on to the eastern periphery later.

7 As for mining methods, hand sluicing is employed for the eluvial deposit during the rainy season and hand digging, open-cut mining or shallow underground mining are employed for primary ore deposits. During the dry season, hand sluicing is employed for small alluvial deposits along the streams.

In each of the above cases all operations are carried out manually as seen in hand digging and hand crushing of ores. Separation and extraction are also done by hand sluicing and panning.

8 As for the outlook of future potentialities, discovery of many new deposits can be expected if prospecting is carried out vigorously on the extension of the western edge of granite intrusive in the northern direction. Following the exploration of this section, prospecting of the eastern edges of the same intrusive will be the area with potential of new ore deposits. For this reason, it may be said that the project area, whose production accounts for only a few per cent of the total production in Burma at present, has high potential in increasing its importance depending on the future prospecting.

9 Because of the generally small scale of individual ore bodies the so-called modernized operation with large machinery would not be practical for this mine. In order to improve productibity under the present conditions therefore, it will be more realistic to plan for improvement of efficiency by introducing crushers and grinders to replace the present hand crushing method and tables for gravity separation to replace the present panning method.

These are the conclusions drawn from the findings of the survey. Although it is self-explanatory from these conclusions, recommendations for the future operation may be summarized as follows.

(1) Discovery of new ore deposits through vigorous prospecting

Geological survey and prospecting of the zone north of the western periphery of granite intrusive, particularly the area north of the Paunlaung river, are of prime importance.

As this area has not be surveyed geologically, a survey on the distribution of granite intrusives will be the first requirement, and the tracing of their contact and prospecting of new ore deposits in parallel to this are strongly recommended.

More concretely, clarification of granite distribution as well as tracing of tin - tungsten sources through chemical prospecting and panning of stream sediments in the river area should be attempted.

Following the prospecting of the section north of the western periphery of granite intrusive, it is essential to conduct a geological survey and prospecting on the eastern periphery of the said intrusive. Geological survey and prospecting of the western and eastern peripheries of the said intrusive are the most fundamental and essential operations for the exploitaton of tin - tungsten ore deposits in this area.

For the efficient operation of the above, airborne magnetic prospecting may prove to be effective, but because of the steep topography of the project area, it is advisable to conduct a preliminary test to determine the effectiveness of airborne magnetic prospecting. If it proves effective in determining the distribution of granite, a preliminary geological survey by means of airborne magnetic method or photogeology will be very useful in limiting the range of areal prospecting.

(2) Improvement of the present operating methods

Although the use of a large machinery is not practical in this area, it is most desirable to improve operating efficiency by introducing crushers and grinders which can replace all manual crushing works. The greatest drawback of the present operation is inefficiency resulting from manual crushing operation.

Despite its many advantages, the panning method has a major drawback, a low yield rate of concentrate. It is desirable, therefore, to plan uniformity of grain size and employ the gravity separation method using wilfley tables.

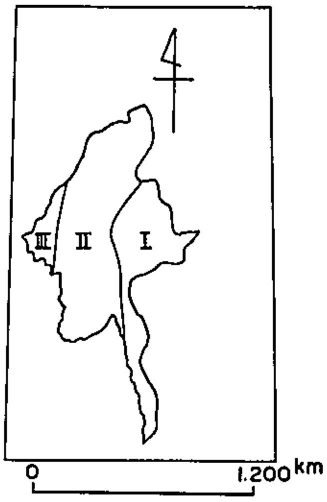
At present, ore is transported as a mixture of tungsten concentrate containing a large quantity of scheelite and wolframite. It would be more advantageous to identify scheelite in using mineralights for separate transportation.

It was found during the survey that the ore produced at Taguntaung Mine has a large content of scheelite.

3. GEOLOGICAL FEATURES OF BURMA

Burma is divided largely into the eastern and western tectonic zones by a large fault which runs from north to south almost parallel to the Sittang river. The eastern zone is a Mesozoic fold province and the western zone is further divided into the Cenozoic fold province and the fore-deep as shown in Fig. 1

Fig. 1 Geotectonic divisions of Burma



I : mesozoic folding province

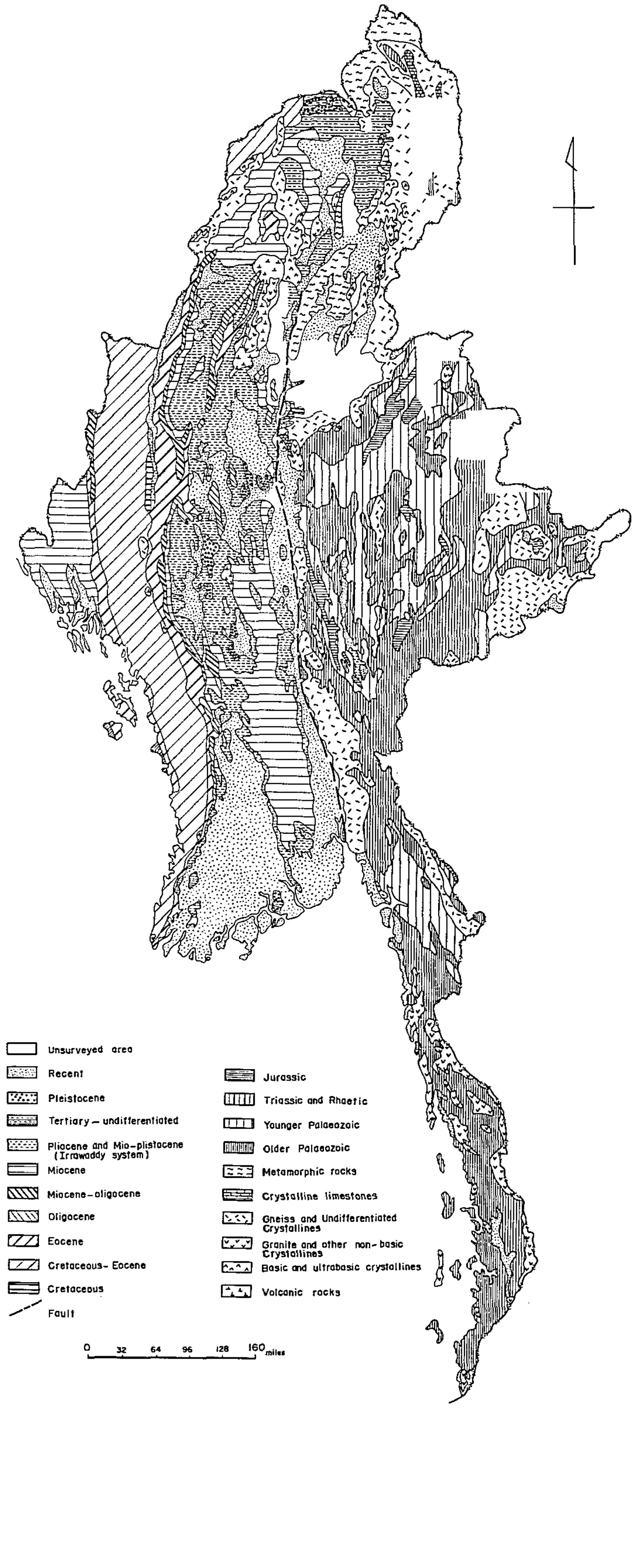
II : cainozoic folding province

III : cainozoic fore deep

MESOZOIC FOLD PROVINCE: This fold province is a tectonic province in which large scale foldings and orogenic movements took place mainly in the Mesozonic era and generally shows a geological alignment of north-south trend (Fig. 2). Its geological features are as follows.

1) Archaeozoic gneisses: These are highly developed metamorphic rocks formed in the oldest time of Burma and distributed in the area extending from the periphery of Shan Plateau to the Tenasserim district and consist mainly of scapolite -garnet- biotite gneiss. They also bear limestone of a high metamorphic grade and are accompanied by granite, nepheline syenite, gabbro and amphibolite and are generally called "Mogok gneisses". They compare with Lewisian gneisses in Scotland and are generally characterized by their high lime content.

Fig. 2 Geological Map of Burma



2) Archaeozoic limestones: These are metamorphic limestones of the Huronian System distributed in Upper Burma and the Mogok district and they may produce fossils of Fusulina elongata, Fenestella, Textularia or Globigerinidae at times. In general, they have a developed continuous strip grown from a crude crystal of calcite and are closely related specially with ruby and saphire deposits.

3) Metamorphic rocks of unknown age: The ages of those Metamorphic rocks distributed in the area extending from the vicinity of Katha in Upper Burma to the north-northeastern border are unknown but are generally believed to be of Archaeozoic era. They consist mainly of biotite gneiss, mica schist and talc schist of various grain sizes ranging from coarse to fine and are characterized by low lime contents compared with Mogok gneisses and a high metamorphic grade compared with early paleozoic strata which will be discussed later.

4) Early Paleozoic formations (Early Devonian formations) These formations are distributed widely in north-south direction from the northernmost to the southernmost of the Mesozoic fold province. With regard to this group, there are many formation names according to their type locality. In general, however, this group may be divided largely into the following series starting from the lower to the upper horizons: Formations that consist mainly of mica schist and are accompanied by many granitic intrusives; quartzite, slate, greywacke, phyllite series (Mawchi series which will be discussed later may be included in this series); sandstone, slate, quartzite, conglomerate, limestone series; and sandstone, maar, Trilobita-containing-graptolites shale series. At the west side of this fold province, there are repeated synclines and anticlines with a relatively steep dip and at the east side anticline with a relatively moderate dip prevails.

5) Late Palaeozoic formations (Late Silurian formations): This is a group consisting of Devonian, Carboniferous and Permian formations and undifferentiated late Silurian beds, distributed in the eastern area of Moulmein and in the Shan Plateau. They may be divided, the lower to the upper formations, into lower plateau limestone, shale, upper plateau limestone and anthracolothic plateau limestone. The coral reef type limestone and shale, comprising part of the above-mentioned limestone, are generally rich in fossils.

6) Triassic system: This Triassic system is distributed mostly in relatively small areas in the vicinity of borders east of Moulmein and east of Lashio. It consists of shale, sandy marl beds of the Rhaetic stage accompanied by a thin layers of limestone and crystalline limestone believed to be either of the Carnic stage or the Norian stage. Under strong influence of folding and compaction, the former contains mainly Pelecypoda fossils and the latter coral reef fossils.

7) Jurassic system: This system is distributed mainly aroung Lashio on the Shan Plateau, in the vicinity of Kalaw on the western edge of the Shan Plateau and in the neighborhood of Mawkmai southeast of Kalaw and consists of non-marine coal-bearing sandstone of Lias (Loi-an series) and limestone

layer and red sandstone bed of the Oolites series. In general, it shows a sharp incline in the west or southeast direction is distributed in or near the axis of anticline as a whole while showing an apparent monoclinic structure.

8) Cretaceous system: The Cretaceous system distributed in the Mesozoic fold province is a shale system (the so-called Namgau shales) belonging to the upper Cretaceous system and is distributed intermittently as a band in the north - northeastern - south - southwestern directions from the east of Sinbo of northern Burma to the west of Mogok. Besides, part of red beds in the vicinity of Kalaw includes a layer that contains some cephalopod fossils, and from this it may be said that the existance of red beds of the upper Cretaceous system in addition to the red beds of the Jurassic system has been established. In addition, there are many stratigraphic classifications independent of geological ages, and a typical example of such classifications within the Mesozoic fold province may be the Mergui series.

Mergui series: This is distributed in Tenasserim peninsula and nearby Mergui Islands and contains no fossils but it consists of crystalline schist, phyllite, shale, sandstone, conglomerate, quartzite, limestone and pyroclastic rocks. Though its accurate geological age is unknown, there are many geolgists who consider it to include formations of Pre-Cambrian to Silurian or Triassic age. In Fig.2 the formation is reclassified according to the latest data and the greater portion of it is included in the "Early Palaeozoic formations".

MAIN IGNEOUS ACTIVITIES IN MESOZOIC FOLD PROVINCE: The main products of magmatic activities of this zone are granite, gabbro and peridotite (and serpentinite), but rhyolites, andisites, diorites, porphyries, porphyrites and basalts are also distributed.

1) Granite: In the Mesozoic fold province, two granite zones, one in the east and the other in the west, are recognized. In the Shan Plateau district one subzone is recognized on the east side of the western granite zone, and the granite existing in the survey area (Pyinmana East Area) is believed to belong to this subzone. The area where granite exists most extensively is the Tenasserim area. In general, granite is found in two main types, one with more or less uniform mineral composition (large contents of quartz, orthoclase, acidic plagioclase and biotite and small contents of amphibole) such as biotite granite and the other with variable contents of tourmaline, muscovite and amphibole and with more diversified mineral composition (biotite granite, two-mica granite, muscovite granite, amphibole granite and tourmaline granite). The former is recognized in the Tavoy area and the latter in the Mergui area. The granite found in the survey area extending from the Padatgyaung Mine to No. 4 Mine falls under the category of the former. These types of granite are believed to be intrusive granitic rocks formed in the late Cretaceous-early Eocene period when the Arakan Yoma was uplifted and trap lava overflowed from the plateau in western India. These rocks are very important as they became the host rock of primary tin and tungsten deposits and the source rock of secondary tin and tungsten deposits. Although the exact period of intrusion of various types of granite and granite porphyry, which are found in the previously mentioned early Palaeozoic formation on a relatively small scale, is unknown, the majority are probably of the same period as that of the formation of this granite.

2) Gabbro: This is distributed intermittently in the area extending from the northern limit (Northeast of Myitkyina) of the previously mentioned western distribution zone of granite to the vicinity of Mandalay in very close proximity of the said granite zone. The gabbro, consisting mainly of olivine, is a block, coarse-grained, compact, holocrystalline rock. It consists mainly of beautiful crystals of olivine, andesine - labradorite and augite and is rich in magnetite and with small quantity of biotite at times. Though the period of formation of this type of rock is believed to be in the pregranite formation period judging from the fact that it co-exists with amphibolite, which will be discussed later, and from the state of its intrusion into various rock layers, the only thing known about it is that its formation is after Archaean. Its formation is generally believed to be in the early Palaeozoic era, but a further study will have to be made on that point.

3) Peridotite: So far, intermittent distribution of perdotite in the area extending from the vicinity of the northeastern border of northern Burma to the line lat. 24 N, very close to the previously mentioned western granite zone has been confirmed. Among many lithofacies including dunite, amphibolite, peridotite, lherzolite and serpentinite derived from these rocks, the serpentinite accounts for the greatest portion. Its intrusion period corresponds to the period of uplift of Arakan Yoma, but it is generally believed that the intrusion occurred in the late cretaceous period from many evidences including the fact that it exists in the lower layer of the Eocene Series in the form of gravel. It is important as the country rock of chromite, iron and precious stone (jade pyroxene) deposits.

CENOZOIC FOLD PROVINCE: This is a Tertiary sedimentary basin surrounded by older formations (mainly Archaeozoic) in the north, older Arakan Yoma (late Cretaceous) in the west and older Shan Plateau (orogenic belt of Mesozoic era) in the east. In this basin each of Tertiary series piles up one another generally in north-south strike and a relatively slow anticline and syncline folding structure was formed by two orogenic movements, one in late Eocene and the other in Pliocene. Also in the center of this basin facing the sea are older Pegu low mountains and hills lying parallel to older Arakan Yoma, which is believed to have divided the basin partially into the east and west portions.

1) Eocene series: This series is distrubuted as a continuous band about 1,200km long along the eastern base of Arakan Yoma. It consists, from the upper horizon, of shale - sandstone layer (227ft), massive sandstone layer (328ft), nummulites containing shale - sandstone layer (658ft) and nummulites limestone (10ft) in the south and nummulites containing shale, conglomerate green shale - sandstone layer (upper part of Eocene series), gravel containing shale - mudstone layer, thick sandstone layer (middle layer), thick shale layer (middle and lower layer) and conglomerate layer (lower layer) in the north. Most of these layers relate conformably with one another and show a fault sporadically along the axes of syncline and anticline. Lower sandstone layers and shale layers often bear coal.

2) Oligocene series and Miocene - Oligocene series: The middle and lower layers of the so-called Pegu System correspond to the Oligocene series and the portions of the Pegu System that are not correlated as upper and lower

layers are regarded as Miocene - Oligocene series. In the Minbu district the Oligocene series may be divided, in terms of type, into neritic sediments, sandstone - shale layer containing some fossils of lepidocyclina (middle layer of Pegu system) and sandstone layer containing some batissa fossils (lower layer of Pegu system).

3) Miocene series: Distribution of this series extends from the eastern base of Arakan Yoma through Pegu plateau to northern Burma. The lower horizon of this Miocene consists of piles of sandstone - gravel layer, shale layer and calcareous sandstone - shale layer including osutoreya with the alternation of shale - sandstone - calcareous thin layer, which contain many fossils of brachiopoda found in the upper strata of the so-called Pegu System forming the lower portion and develops in the vicinity of the right bank of the Irrawaddy river and the right bank of the Sittan river. This is very important as oil producing horizon in Burma. The upper horizon of Miocene series is distributed mainly in the northern limit and in the vicinity of Tertiary sedimentary basin as if it were surrounded by older rock layer groups of upper Burma. Its main part is composed of Tipan series with a typical thickness of 1,200ft which consists of loose ferreous sanstone - sandy shale - mud layer.

4) Pliocene series and Miocene - Pliocene series: These series correspond to the so-called Irrawaddy System which is widely distributed in Tertiary sedimendary basins. They consist of mainly coarse-grained loosely stratified sandstone and are characterized by their content of ferrous, calcareous, siliceous cement and quartz gravel and the existence of petrified wood in large quantities. The maximum thickness reaches 20,000ft.

5) Tertiary system of unknown correlation: This system is distributed in the northern border of the previously mentioned Tertiary sedimentary basin and its vicinity. So far, no detailed correlation has been established in palaeontology. It presents a relatively loose lithofacies by unconformably covering the Mesozoic layer while being covered unconformably by Quaternary System.

6) Quaternary system: This system consists of older gravel layer deposited in old floodplains of Quaternary period or plateau gravel layer which was formed by the rise of the deposited gravel layer, red clay layer, laterite layer and gravel - mud layer deposited in the present river delta. The former belongs to Diluvium and is distributed not only in various places of the Cenozoic fold province but also in Mesozoic fold province sporadically together with Alluvium of the latter.

MAIN IGNEOUS ACTIVITIES IN CENOZOIC FOLD PROVINCE: The existence of a mountain ridge of pre-Tertiary period at the center of Tertiary sedimentary basin has already been mentioned. As part of this mountain ridge, there is an exposure of granite bed in the central section of northern Burma. This granite bed is of the same type and age as those of the granite previously mentioned in the section for Mesozoic fold province. The igneous rock of

Cenozoic era developed in this Tertiary sedimentary basin consists of mainly andesite, basalt and rhyolite, all of which are distributed along a volcanic belt running from north to south slmost through the center of the basin. The periods of major volcanic activities may be classified into four stages; late Eocene, Pliocene, Pleistocene and early Recent - Recent. Besides, there is a volcanic belt believed to be of the same period of volcanic activities on the east side of the central volcanic belt running almost parallel to it. The main volcanic provinces are from south Mt. Popa volcanic province, western Monywa and the Sagaing Central plateau.

CENOZOIC FORE-DEEP: This includes the area west of eastern upper half of Arakan Yoma and the area west of the Cretaceous system distribution zone (refer to Fig. 2). It consist of Cretaceous system, Cretaceous - Eocene series, pliocene series and lower Miocene series. Its characteristics as a fore-deep is distinctly shown by the existence of gneiss as basal rock in the vicinity of the eastern border and the sporadic distribution of plutonic rocks and volcanic rocks such as serpentinite, gabbro and granite only in the eastern slopes of Arakan Yoma (in the vicinity of fore-deep border).

1) Cretaceous system: It is distributed mainly in the Arakan coastal and islands region and in the area west of Gango of Arakan Yoma, forming the basement of Cenozoic fore-deep. It contains ammonite, which serves as an index fossil of upper Cretaceous period, massive sandstone layer which produces some nummulites and sandstone - shale layer (often bearing limestone, and conglomerate). Besides, the lower Cretaceous system also exists in the vicinity of the summits on the Indian - Burmese border.

2) Cretaceous - Eocene series: This series is distributed from north to south in a wide strip while forming Arakan Yoma, leans toward east and extends to the Sagaing district near the border in the north. It is very thick and consists mainly of rhythmical alternation of sandstone and shale. It is flysh with highly developed graded bedding.

3) Eocene series: This series is distributed in a long and narrow strip from the western foot of Arakan Yoma to the Arakan coastal and islands region. It lacks lower and upper Eocene series and consists from top downward of bluish grey shale - mudstone, sandstone containing conglomerate and thin green shale. The former contains a large quantity of foraminifera, lamellibranchiata and gastropoda fossils.

4) Pliocene series: This series is distributed in a long and narrow strip while unconformably overlying the previously mentioned flysh layer in the western foot of northern Arakan Yoma and may by compared with the lower layer of Pegu System.

5) Lower Miocene series: This series is distributed widely in north - south direction on the western side of the previously mentioned Eocene series, and forms the western flank of Burma. It corresponds to the upper layer of Pegu system and consists mainly of sandstone and conglomerate. It is also accompanied by mudstone and contains fossils of marine fauna.

4. SURVEY OF TIN - TUNGSTEN ORE DEPOSITS IN PYINMANA EAST AREA

4-1 Geological Features of Pyinmana East Area.

This area belongs to the previously mentioned "Mesozoic Fold Province" (Refer to geological maps 1.2.3. and 4.). Its geology consists of metamorphic rocks of Archeozoic, Mawchi Series, strata of late Palaeozoic era, plateau limestone, coal measure of Loi-an series and intrusive granites.

1) Metamorphic rocks of Archeozoic: These rocks comprise biotite schist, muscovite schist, graphite schist, gneiss, granulite and gneissose granite and frequent association of such intrusives as granite, gabbro and peridotite in the form of dykes or stocks in one of the special features. Gneiss includes such varieties as scapolite - garnet - biotite gneiss, as well as pyroxene gneiss, pyroxene - scapolite gneiss, diopside gneiss and diopside - graphite gneiss and often alterates in the form of lit - par - lit injection. It is also characteristic that thin layers of Archaean recrystallized limestone accopany gneiss in stripes. This is the oldest rock formation in this area and the distribution of some tin - tungsten ore deposits is also recognized in this metamorphic rock region.

2) Mawchi series: This is a rock formation consisting of mainly quartzite, slate, greywacke, gneiss, sericite schist and green schist, all of which belong to Mergui series and is believed to include pre-Cambrian system through Silurian system. Its strike is generally north - south and usually dips westward but in some cases dips steeply to the east. Its exposure as a basement rock formation of Alluvial tin - tungsten deposit is often recognized in the mine claim being surveyed. Macroscopic and Microscopic properties of some rocks including quartzite are as follows.

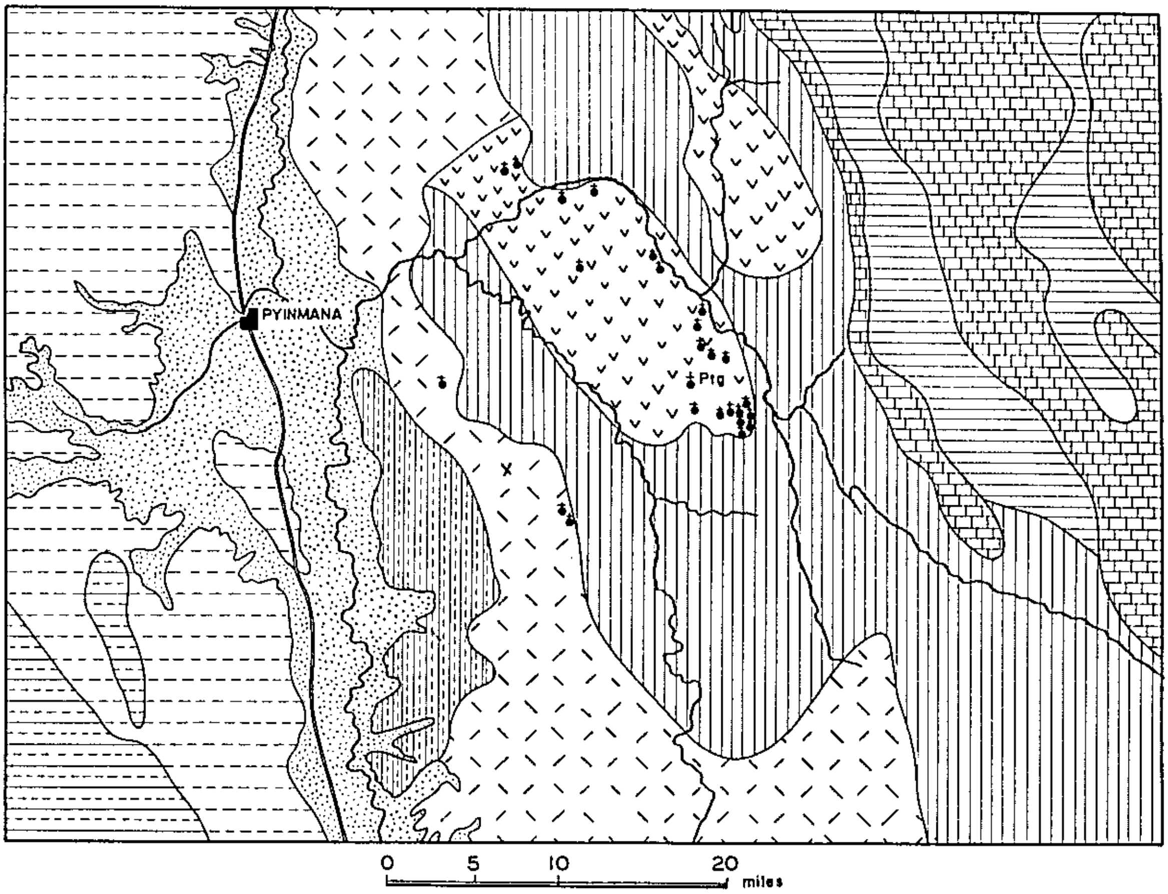
a) Quartzite: This is white compact and solid rock and at times bears light grey stripes.

It consists mainly of quartz and orthoclase and is also accompanied by muscovite, plagioclase and chlorite. Quartz, orthoclase and plagioclase generally have a grain size of 0.2 - 0.05mm and form granoblastic texture. Muscovite (2 - 3% of the entire quartzite) generally has a grain size slightly larger than that of the previously mentioned minerals and also shows allotriomorphic to hypidiomorphic form (Plate 2).

b) Greywacke: This is a greyish-black hard rock and has a look similar to homogeneous slate. Microscopic analysis of this rock show, however, that it is a mass of fragments of the previously mentioned quartzite or crushed tips of feldspar - muscovite - opaque minerals cemented together with such fine cements as mica, feldspar and quartz (Plate 3) and is essentially feldspathic greywacke as far as samples are concerned.

3) Plateau limestone: Plateau limestone distributed in this area is an upper Plateau limestone belonging to the Permian coal system. It has a dark-bluish grey color and contains such fossils as fusulina and productus in large quantity. Its content of dolomite is smaller than that of the lower Plateau limestone.

Fig. 3 Geological Map of Environments of Eastern Pyinmana



Alluvium

Irrawaddy series

Pegu series

Red Bed

Coal measure of Loi-on series

Plateau limestone

Mawchi series

Older palaeozoic bed

Unclassified crystallines, mica-schist, gneiss, gneisso-granitic rocks and other metamorphics with granitic intrusion

Granite

—— pliocene

—— oligocene~miocene

—— triassic and rhaetic

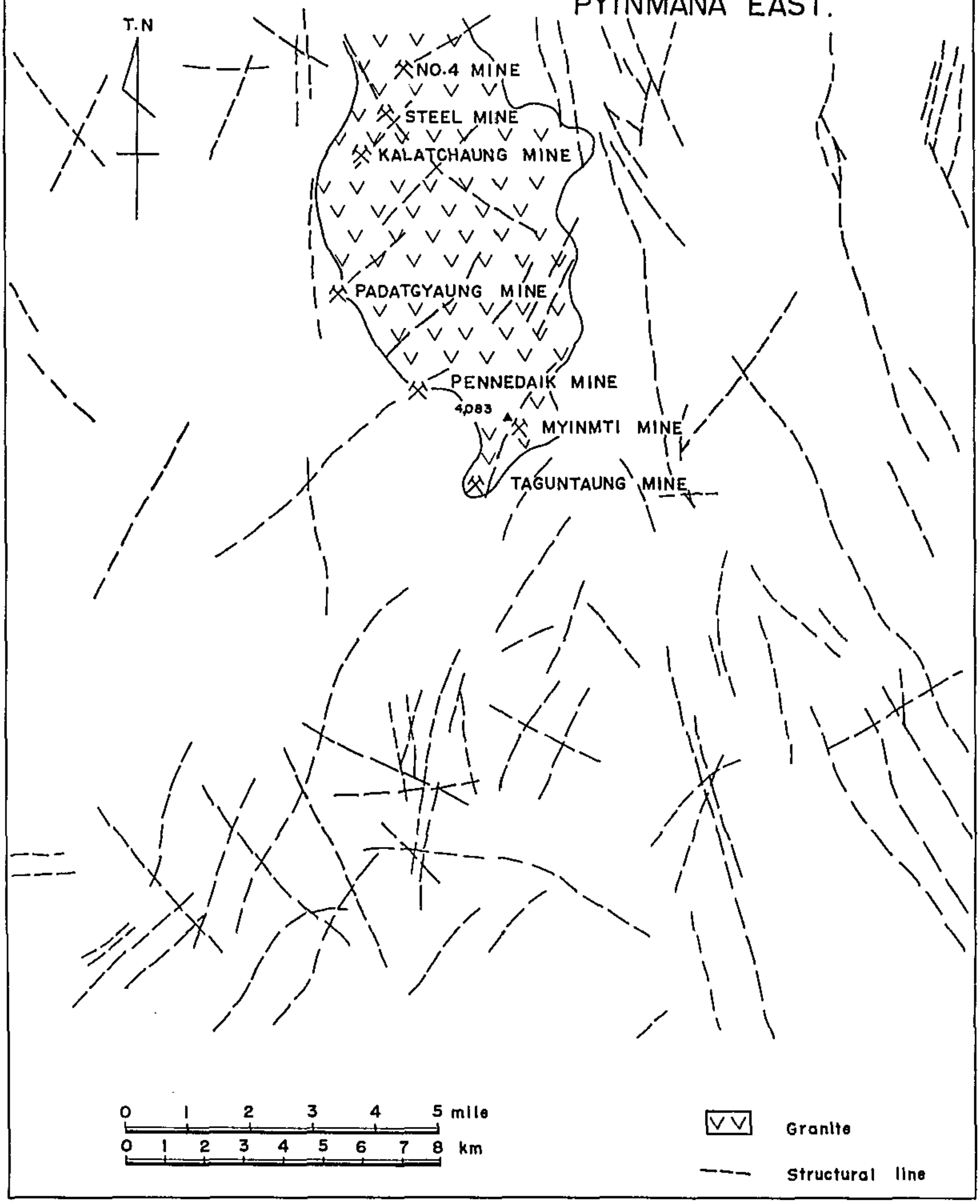
—— jurasic

—— permo-carboniferous

—— sillurian~pre-cambrian

♦ : wolfram x : tin Ptg : Padatgyaung Mine

Fig.4 STRUCTURAL FEATURES OF PADATGYAUNG AREA, PYINMANA EAST.



4) Coal measure of Loi-an series: This measure belongs to Jurassic system and may be divided into the lower measure where the development of shale is dominant, the middle measure where granule quartz like sandstone and red sandstone develop and the upper measure which is rich in coal seam. The upper wall of coal seam is generally rich in fossil flora.

5) Granite: The granite in this area is considered to be of the late Cretaceous period - early Cenozoic era which has intruded Mawchi series. The portion in contact with metamorphic rocks of Archeozoic is considered to form a fault. The granite which is distributed in the said metamorphic rock in the form of a vein or small stock is also considered to have been formed in the same period. Metalliferous vein of tin and tungsten is distributed mainly on the periphery of granite rock on the west side (Fig. 3). As far as hard portion is concerned, it is a homegeneous and holocrystalline biotite granite with less accessary minerals both in type and quantity and with highly stable lithofacies. Its macroscopic and microscopic properties are as follows.

This biotite granite exists generally in a very loose state after weathering and disintegration around primary tin - tungsten - quartz veins. However, a solid sample obtained from the bank of the Paunglaung river northeast of No. 4 Mine shows that it is a typical biotite granite consisting mainly of quartz, orthoclase, plagioclase and biotite.

Of this composition, the ratio of orthoclase to plagioclase is slightly greater than 2 and the plagioclase consists mainly of albite and partly of oligoclase. The biotite (accounting for 7 - 8% of total ingredients) appears brown and green in color under a microscope and shows partial chloritization. Also, the existence of titanite, apatite, zircon and black metallic mineral in very small quantity is recognized. In general, it shows a uniform, holocrystalline and hypidiomorphic granular texture (Plate 1) but hardly shows any myrmekitic or graphic texture. Development of muscovite and sericite is seen specially in the vicinity of primary metalliferous veins and is more conspicuous in the portion in contact with these veins.

No. 4 Mine

4-2 No. 4 Mine

1) Location and communication (See Fig. 7)

(i) The distance between Pyinmana and Seikphudaung is 23.6miles (37.7km) and can be covered in two hours by car. The Paunglaung river which lies in between is without bridges and people, cargoes and vehicles are transported across the river by ferry.

(ii) Of the section between Seikpuhudaung and Padatgyaung with a distance of 23.5miles (37.6km), 21miles (33.6km) are passable by jeep and the remaining 2.5miles (4km) may be covered on foot on a relatively wide path along the mountain sides. A total of 3 1/2 hours, two hours by jeep and 1 1/2 hours on foot, are required to cover this distance.

(iii) Padatgyaung - No. 4 Mine (7 miles or 11.5 km): The mountain path connecting Padatgyaung with No. 4 Mine is fairly steep. There are the previously mentioned Kalatchaung Mine and Steel Mine on the way, and the time for the trip is about 3 1/2 hours. Elevation readings of the barometer are 280 ft (85 m) for Pyinmana, 660 ft (200 m) for Seikphudaung, 3,000 ft (915 m) for Padatgyaun and 1,830 ft (558 m) for the center of the ore deposit at the No. 4 Mine. Access to this mine is very poor.

2) Geology and ore deposits (See Fig.5 and 6)

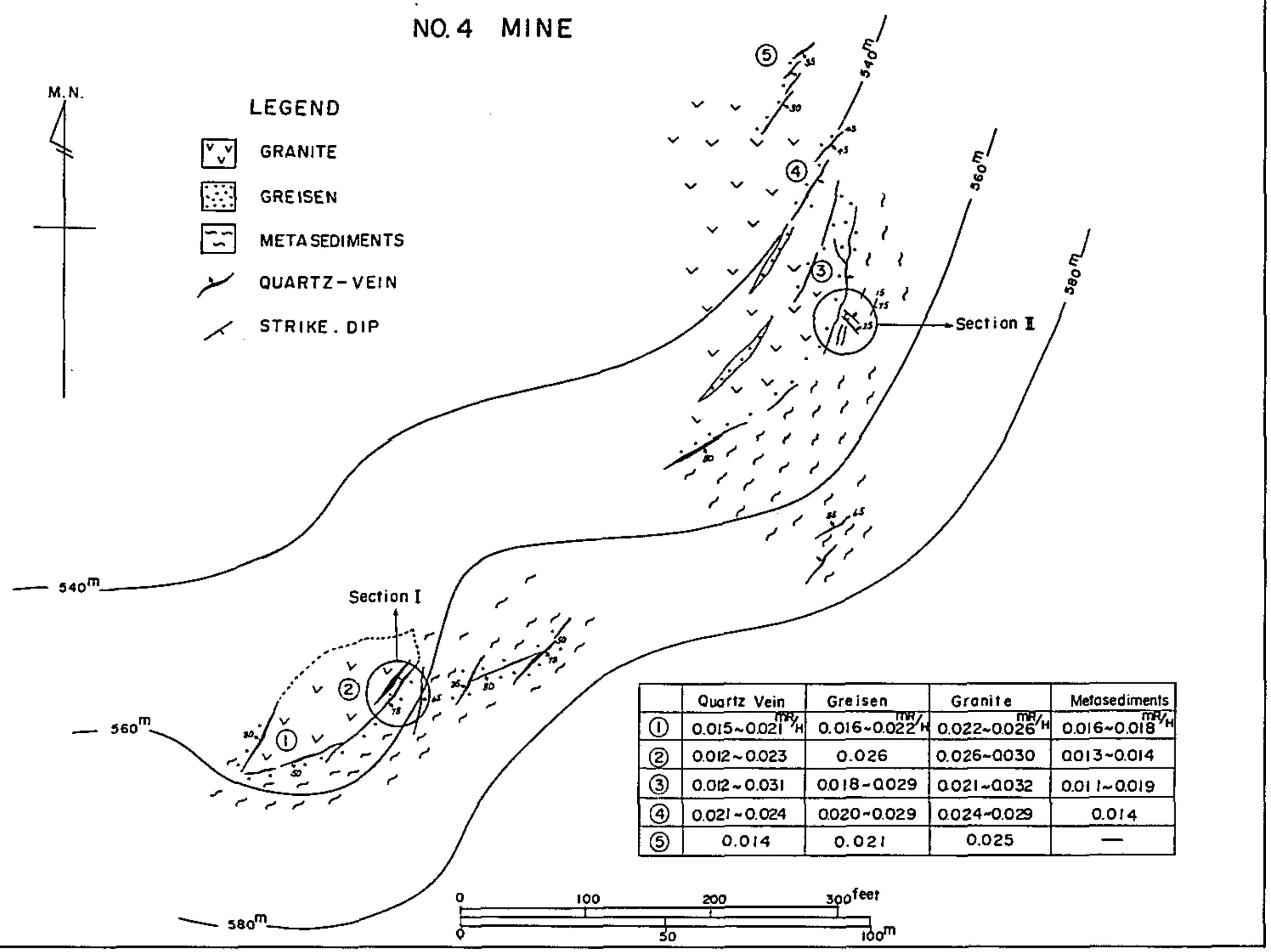
The geology consists of metasediments as the basement and granite which intrude through the basement, and the greisenization is particularly conspicuous in the contact deposit. Both metasediments and granite have been subjected to strong weathering and as a result, the structure of original rocks cannot be determined definitely. However, members of the metasediments are probably slate, sandstone, green rock, etc. Ore deposits include tungsten, tin and molybden veins accompanying quartz veins which are believed to have been formed almost at the same time as the intrusion of granite. Judging from its strong greisenization and association of tourmaline, the deposit is considered to be a typical pneumatolytic deposit. In general, ore deposits occur on the periphery of granite, and the formation of ore shoots is seen more frequently on the granite side. The quartz vein now being prospected consists of individual veins, having lengths of 30 - 160 ft (10 - 50 m) and shows the echelon types arrangement. The quartz veins have a strike of N 10 - 60°E and have either a dip of 30 - 40°E or a steep dip of 70 - 85°E. At present, prospecting is done mainly on the quartz veins with the latter steep dip by drifting and by trenching. The quartz veins have widths of 1/3 - 2 ft (10 - 60 cm) and contain mainly wolframite but are sometimes accompanied by cassiterite or molybdenite. The grain size of wolframite is usually about 5mm and it exists more frequently near the hanging and foot walls of the veins near as small laths or small granules. The occurrence of scheelite is hardly recognized macroscopically and its local occurrence is recognized merely on the edge of wolframite by mineralight.

3) Ore

The main metallic minerals that comprise the ores are wolframite and cassiterite, and accompanied by small quantities of pyrite, bismuthinite, molybdenite, hematite, goethite, and scheelite. The vein is composed mostly of quartz and is also accompanied by small quantities of muscovite and a trace of lipidolite, beryl, garnet and zircon.

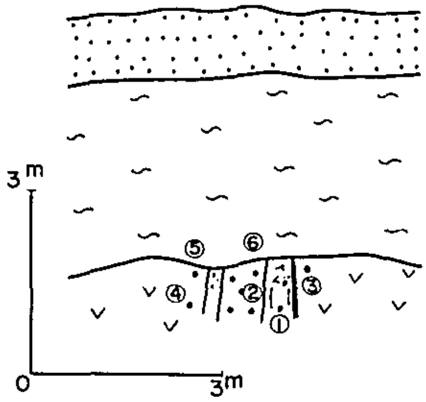
Fig. 5 DISTRIBUTION MAP OF ORE DEPOSITS

NO.4 MINE



	Quartz Vein	Greisen	Granite	Metasediments
①	0.015~0.021 mR/H	0.016~0.022 mR/H	0.022~0.026 mR/H	0.016~0.018 mR/H
②	0.012~0.023	0.026	0.026~0.030	0.013~0.014
③	0.012~0.031	0.018~0.029	0.021~0.032	0.011~0.019
④	0.021~0.024	0.020~0.029	0.024~0.029	0.014
⑤	0.014	0.021	0.025	—

Fig. 6 NO.4 MINE SECTION I

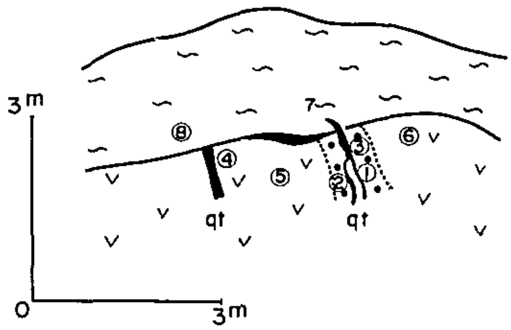


①	0.020~0.023 mR/H
②	0.022
③	0.026~0.030
④	0.026
⑤	0.013
⑥	0.014

LEGEND

- OVERBURDEN
- GRANITE
- GREISEN
- METASEDIMENTS
- QUARTZ VEIN
- WOLFRAMITE
- CASSITERITE

SECTION II



①	0.017 mR/H
②	0.019
③	0.018~0.031
④	0.014
⑤	0.021
⑥	0.032
⑦	0.013~0.017
⑧	0.016

Wolframite occures in quartz veins as comparatively large crystals, which sometimes measures 9 x 3 x 4 cm or more (Plate 4). It is usually disseminated as single crystals and often in the form of laths. Its periphery is often alternated by hematite (Plate 5), or the alteration of hematite into goethite is also recognized at time.

Scheelite exists only in small quantities (its ratio to wolframite is about 0.8) and it sometimes intergrown with wolframite. Tungsten ochre is found stuck to the surface of wolframite but only in very small quantities.

Cassiterite has a variety of colors ranging from colorless, white, lemon-yellow, brown to black and sometimes shows a zonal structure. The grain size is generally in the range of 0.1 - 5mm and the ore exists independently, either in quartz veins or in the adjoining muscovite - lepidolite greisen or is distributed in quartz veins in contact with wolframite or in the form of an intergrowth with wolframite. The ratio of cassiterite to wolframite is approximately 1 : 1 or 1 : 2.

Both bismuthinite and molybdenite is disseminated in quartz veins, but the former sometimes forms its unique felty crystals in small druses. Properties of the ore under microscopes are shown in Plate 6. It is one of the characteristics of No. 4 Mine that its ores are fairly rich in bismuthinite as compared with those of other six mines which will be discussed later.

In addition, the ores of this mine contain more pyrite than those of other mines surveyed, which is disseminated in vein quartz and in the previously mentioned greisen or frequently forms granule masses or at times occurs as relict soil in the mass of goethite.

The content of various elements in the concentrate and the trace element composition of three ore samples from this mine are shown in Table 1 and Table 2.

4) Ore reserves and grade

Prospecting of tungsten - tin quartz veins is being conducted at this mine on a small scale at the periphery of granite by trenching and hand digging. And the comprehensive picture of the total operation cannot be grasped easily. Nevertheless, the possible reserves are estimated as follows from the results of the past surveys and the prospect is not so encouraging.

Estimated concentrate reserves = 150m (total length of strike) x 100m (depth) x 0.3m (width of metal concentration) x 2 (Number of veins) = 25,200tons.

with the estimated grade of WO_3 2%, the amount of tungsten existing will be 504 tons. As for mining conditions, the volume of overburden in combination with metasediments is so great that it will entail a high production cost to obtain concentrates and meanwhile the total mechanization of operation is also difficult.

5) Conclusions

The deposit consist of tungsten, tin and molybden quartz veins developed in granite, particularly on the periphery of its contact with metasediments. The metalliferous vein consists of several echelon veins and lacks a champion vein. Judging from strong variations in vein width and ore grade, much cannot be expected from this mine for future development. As for the method of future prospecting, careful and thorough drifting should be attempted for the periphery of granite, particularly for the quartz vein with steep dip on the side of granite while continuing the present method.

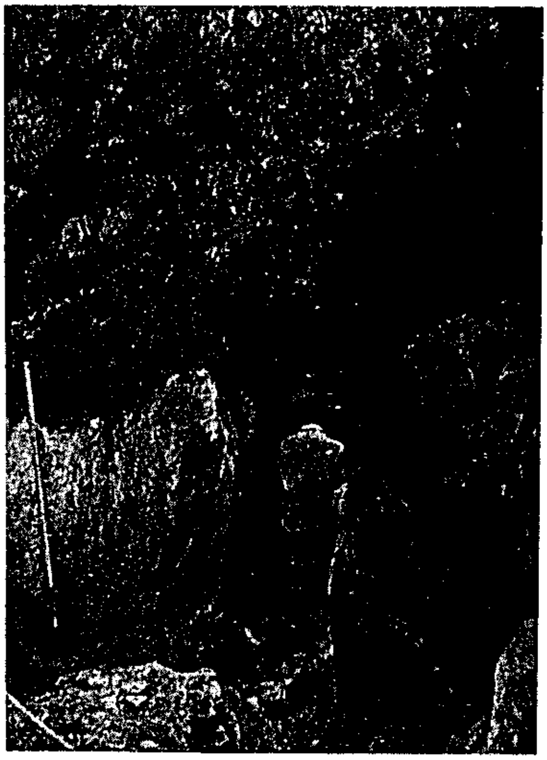
Table 1 Ore Grade of Concentrate Produced at No. 4 Mine (%)

WO_3	Sn	Bi	Mo	Ca	Zr	P	Cu	S
33.0	28.2	0.49	0.18	0.08	0.98	0.004	0.012	0.054

Table 2 Trace Component of Various Ore Samples (%)

Properties of samples / Elements	Quartz veins rich in black cassiterite	Average ores	Vein quartz containing bismuthinite
Ag	$<n \times 10^{-4}$	$<n \times 10^{-4}$	$n \times 10^{-3}$
Al	$n \times 10^{-3}$	$n \times 10^{-2}$	$n \times 10^{-3}$
Ba	-	$n \times 10^{-4}$	-
Be	$n \times 10^{-4}$	-	-
Bi	$n \times 10^{-3}$	$n \times 10^{-2}$	$n \times (10^{0} \sim 10^{-1})$
Co	-	-	$n \times 10^{-4}$
Cr	$n \times 10^{-4}$	-	-
Cu	$n \times 10^{-4}$	$n \times 10^{-3}$	$n \times 10^{-3}$
Fe	$n \times 10^{-2}$	$n \times 10^{-1}$	$n \times 10^{-3}$
Ga	-	$n \times 10^{-4}$	-
Li	-	$n \times 10^{-3}$	-
Mg	$n \times 10^{-2}$	$n \times 10^{-3}$	$n \times 10^{-2}$
Mn	$n \times 10^{-1}$	$n \times 10^{-2}$	-
Mo	$n \times 10^{-4}$	$n \times 10^{-3}$	$n \times 10^{-2}$
Ni	-	-	$n \times 10^{-4}$
Pb	$n \times 10^{-3}$	$n \times 10^{-2}$	$n \times 10^{-1}$
V	-	$n \times 10^{-3}$	-
Zn	-	$n \times 10^{-3}$	-

Steel Mine



4-3 Steel Mine

1) Location and communication (See Fig. 7)

Steel mine is located in Township Yamethin district of Pyinmana city, approximately 25 miles (40 km) east of the center of Pyinmana in a bee-line. The section between Pyinmana and Seikphudaung with a distance of 23.6 miles (37.7 km) can be covered by jeep and ferry service across the Paunglaung river in two hours. The section from Seikphudaung to the end of motorway, a distance of 21 miles (33.6 km), can be covered by jeep in two hours. From this point a walk on a relatively wide mountain path with a total length of 2.5 miles (4 km) takes one to Padatgyaung Mine in about 1 1/2 hours. Steel Mine is located futher north of Padatgyaung Mine, at a point 3 miles (4.8 km) from it in a bee-line. The section having a distance of 3.75 miles (8.7 km) via Kalatchaung Mine is a mountain path and the journey to the mine takes about 3 hours. The elevation of this mine is about 2,100 ft (700 m).

2) Geology

The geology in the vicinity of the mine consists mainly of phyllite, sericite schist and granite, belonging to Mawchi series of older Palaeozoic times. The general strike of sedimentary rocks is approximately N65E with a dip of N 60. Intrusion of biotite granite is believed to have taken place in the late Cretaceous period or early Eocene.

3) Ore deposit (See Fig. 8)

The ore deposit consists of quartz veins developed mainly in the decomposed granite and partly in metasediments and accompanied by tin and tungsten, which may be divided largely into NS trend and EW trend. Champion veins are parallel with the general strike of N30°E and dip of W80°and E70° developed in the granite and integrated into one vein at the lower parts. The vein has widths of 10 - 30cm. As for ore minerals, wolframite occurs in foils or laths of 10 - 25mm forming a high grade ore deposit with the possible grade of WO_3 3 - 4%. In addition, it is accompanied by a trace of scheelite and molybdenite. In general, greisen is developed in widths of 10 - 30cm on the periphery of quartz vein, and its develpment is more conspicuous in the hanging wall. Although the total length of the quartz vein varies, the confirmed length is 36 m and the formation of the vein is considered very stable. Besides, there are several veins of N45°E trend developed in widths of 10 - 20 cm and each of these veins shows the development of greisen on its periphery, which is accompanied by wolframite and scheelite and a trace of molybdenite. The quartz veins of NE trend mentioned above have a maximum length of about 40 m and occurs as an echelon vein, thus forming a stable champion vein. However, those other than the champion vein generally occur as lenticular veins. Although quartz veins of NE trend generally have a dip of N45 - 60°, vein widths of 5 - 20 cm and are accompanied by a trace of wolframite, most of them form barren quartz veins and occur as lenticular veins in the southern district. The quartz vein is developed from granite through metasediments and the mineralization also extends to the metasediments. In general, the echelon quartz veins with NE trend or the quartz vein intruded along the tectonic line almost parallel to the granite bed show the occurrence of wolframite, scheelite and a trace of molybdenite. On the other hand, most of the veins with EW trend crossing the above veins at almost right angles seem to form barren quartz veins.

Fig. 7 MINE LOCATION

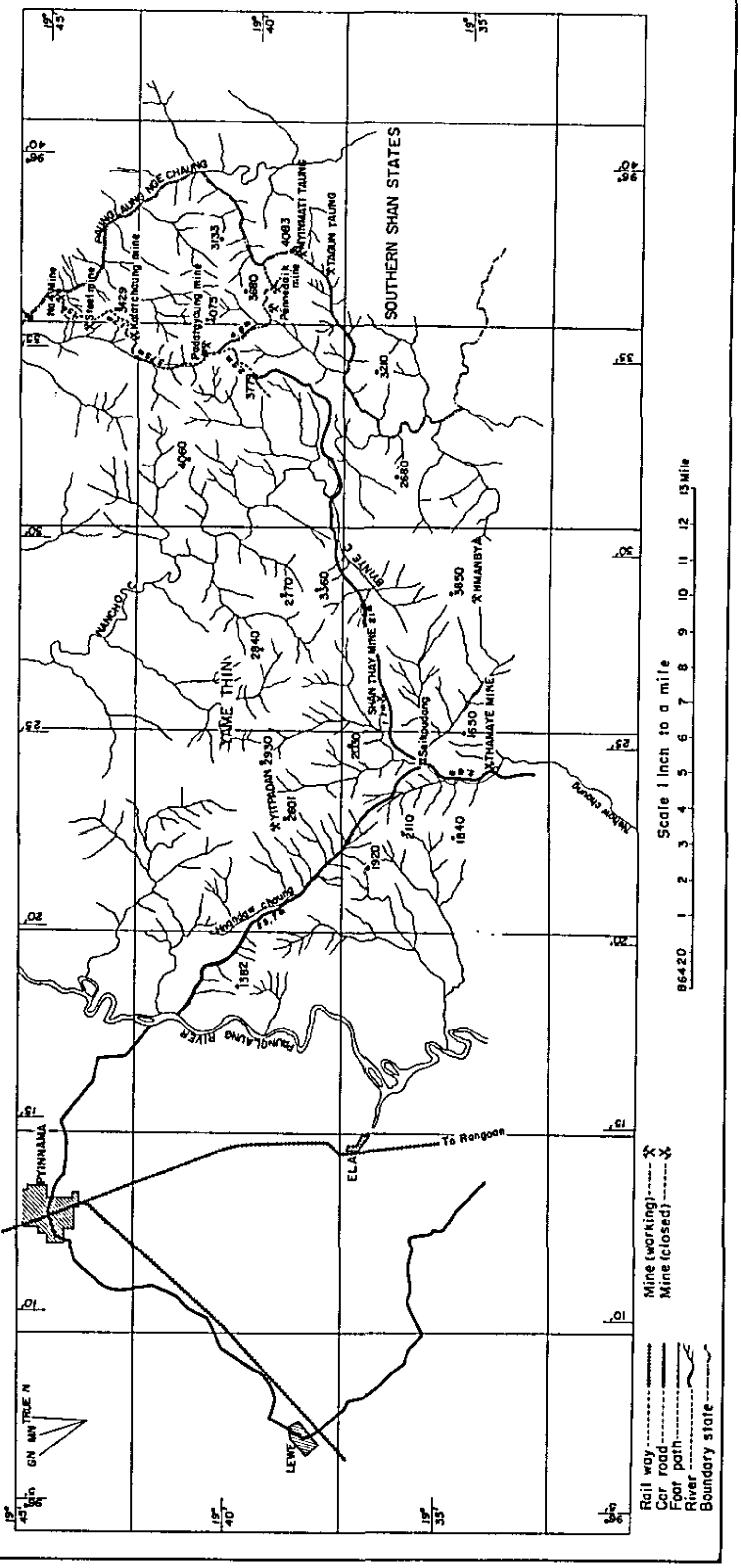
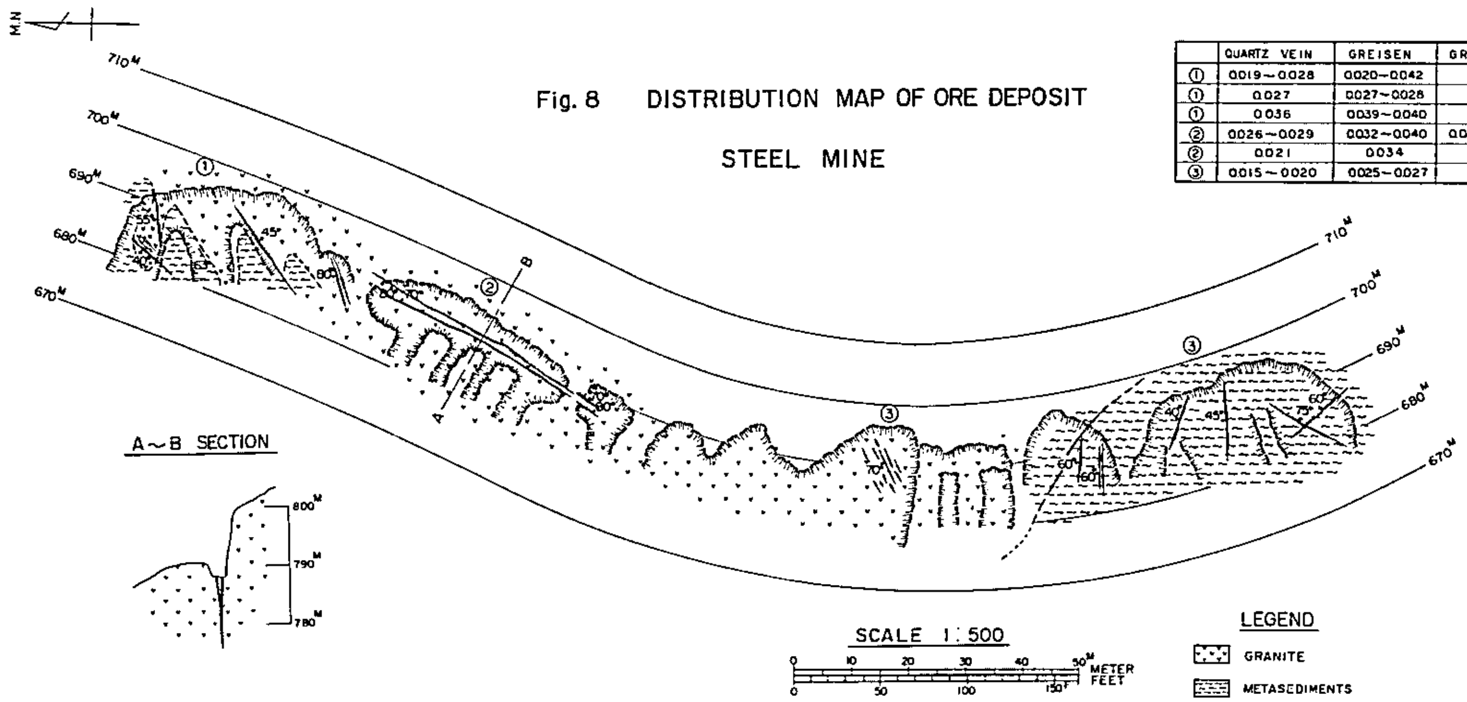


Fig. 8 DISTRIBUTION MAP OF ORE DEPOSIT

STEEL MINE

UNIT: mR/H

	QUARTZ VEIN	GREISEN	GRANITE	METASEDIMENTS
①	0.019~0.028	0.020~0.042	0.020	0.0016
①	0.027	0.027~0.028	—	—
①	0.036	0.039~0.040	0.015	—
②	0.026~0.029	0.032~0.040	0.036~0.043	—
②	0.021	0.034	0.027	—
③	0.015~0.020	0.025~0.027	—	0.0013~0.015



The working face has a length of 220 m in almost north-south direction, widths of 20 m and height of 7 m. At present, high grade portions of quartz veins are being explored by hand digging using the pen-cut mining method. Mining, ore dressing, crushing and panning are all done manually and the production of concentrate amounts to 1 t/m (Fig.8).

4) Ore

Metallic minerals that comprise metalliferous veins are mainly wolframite and cassiterite, with small quantities of molybdenite, bismuthinite, pyrite and scheelite and traces of sphalerite, galena and tungsten ochre are also recognized.

Wolframite occurs between vein quartz or between quartz - muscovite-lepidolite greisen and vein quartz in mass or independently mainly in the form of a lath or at times in the form of dissemination. Its crystals are generally large with the length exceeding 10 cm in some cases, but mostly in the range of 1 - 5 mm. In some cases scheelite occurs very close to wolframite in small quantities (its ratio to wolframite being about 0.6%). There are also cases in which tungsten ochre is found stuck to the surface of wolframite.

Molybdenite is desseminated irregularly between vein quartz (Plate 7), and the maximum size of its crystal measures 7 x 5 mm.

Bismuthinite occurs in small druses as a capillary crystal. Sphalerite and galena are sometimes recognized in the central portion of quartz vein in very small quantities and pyrite is disseminated between quartz veins or in greisen.

Cassiterite occurs between quartz veins or in greisen as euhedral or subhedral crystals (Plate 8) and its size is generally in the range of 1 - 5 mm. In this metalliferous vein the ratio of cassiterite to wolframite (weight ratio) is 1 :5 - 1 : 10.

Results of spectroanalysis of ores which are considered to have a relatively high grade (approximately WO_3 1.5 - 2 %) are shown below.

Table 3 Trace Component of Ores (%)

Sample No. / Elements	No. 31	No. 32	NO. 35

Vein is made up mainly of quartz, followed by muscovite and is also accompanied by small quantities or traces of lepidolite, beryl, tourmaline and apatite. Beryl, tourmaline and apatite are recognized mainly in muscovite - lepidolite greisen.

5) Ore reserves

Ore reserves are estimated only for N35°E champion vein as follows, and estimated reserves for other veins are not mentioned.

Table of Ore Reserves

(l.t.) estimate

Total Length(m)	Depth(m)	Vein width(m)	Specific gravity	Ore reserves	Grade WO_3%	Content (l.t.)
50	30	0.3	2.8	126.0	3.0	4.780

6). Conclusions

The production of this mine which produced 50 tons of concentrate in 1939 is very small present and has reached the limit of open-cut mining. This mine is now considered to be in the state that requires shift to underground mining in the near future. In order to discover new ore deposits, tracing of the extension of the existing deposit and exploration of the periphery of granite body will be necessary. There may not be a great chance of discovering large ore deposits but there is a possibility of finding new deposits of reasonable size. Because of the thick overburden in the area, prospecting by means of surface geological survey alone is considered difficult.

For this reason, use of airborne magnetic and radiometric methods may be useful in determining the state of granite intrusion.

In order to improve the efficiency and to increase production, the present method of using manual methods for mining, crushing and panning should be replaced by the use of small crushers and a gravity separators.

Kalatchaung Mine

4-4 Kalatchaung Mine

1) Location and communication (See Fig.7)

Kalatchaung Mine is a tin - tungsten mine located at a point approximately 20 miles (32 km) east of Pyinmana and its operation is now suspended. Kalatchaung mine is accessible from Pyinmana via ferry service across the Paunglaung river and a road running through Seikphudaung and Padatgyaung. A distance of 44.6 miles (71.3 km) from Pyinmana to a point 2.5 miles (4 km) south of Padatgyaung requires a 4 hour travel by jeep. It takes about an hour and a half to cross the ridge on foot after abandoning the jeep to get to Padatgyaung. A distance of 3.7 miles (6 km) from Padatgyaung along the Sittan river and through a granite mountain area to Kalatchaung mine requires about two-hours on foot.

2) History

The mine is located near the summit of a granite mountain with the elevation of 3,000 ft (910 m) and is said to have been very active around 1940 though on a small scale. The operation continued for some time after the end of World War II, but the exact timing of its suspension is unknown. It is also said that the mine was reactivated for small operation and was completely closed a year or so ago. However, there are many ambiguities on this point. Although the output before the suspension of operation is not known, the grade of concentrate is said to have been 44.46 % for tin and 26.45 % for tungsten. It is also said, on the contrary, that the grade of tungsten was 42 % and that of tin 26 %. Any way, the history of this mine is veiled in mystery.

3) Geology and ore deposits

With the Sittan river flowing north about 1/2 mile (800 m) west of Kalatchaung Mine forming border line, metasediments, which is said to belong to Mawchi series of older Paleozoic, is distributed on the west side of this border line while a granite bed, which is believed to have intruded in the last stage of Mesozoic, extends widely in north-south direction on the east side. Kalatchaung Mine is situated on the western periphery of this granite bed and the whole mining area is composed of white or greyish white decomposed granite.

As shown in Fig. 9, the object of operation then is considered to have been a mineralized zone with a width of about 10 m and a length of 80 m extending in N30°E direction and an eluvial deposit formed in a small valley extending in the east-west direction with point D being the backbone. In this mineralized zone several tin - tungsten quartz veins arranged in echelon with a dip of 80 - 90°NW showing an inflection structure are recognized with a strike of N20°at point A, N30°at point C and N40°in the south. In general, the quartz veins are irregular veins that are subject to frequent expansion and contraction with lengths of 10 - 20 m and widths ranging from 0.1 m to 1m, and its greisenization is also weak.

The section adjacent to the wall consists mainly of white crystal quartz of medium grain size but loose quartz and vein quartz apparently possessing remnant textures of country rock are recognized at places. Against this, the central portion of the vein often consists of milk-white coarse-grained quartz. As for alteration, bands having widths of 1 - a few cm, that have been affected by strong greisenization of muscovite and clay materials, are seen in the section adjacent to the wall and also within the veins. Beyond the section adjacent to the wall where greisenization is narrow but intense, relatively strong silcification is observed, but the greisenization suddenly becomes less apparent and transforms into granite after 2 - 3 meters. Metallic minerals observed include mainly wolframite and cassiterite, and pyrite in rare places, but the occurrence of scheelite was not recognized. These metallic minerals occur frequently in medium-sized quartz crystals or in loose quartz but are seldom seen in coarse-grained granule quartz crystals. For example, wolframite occurs sporadically in loose quartz in the form of a mass or granule having a diameter of about 10 mm or is sometimes disposed along the gash of medium-sized granule crystal quartz in the form of columnar or platy crystals having dimeters of 1 - 2 mm.

As far as the present observation is concerned, the amount of wolframite is far greater than that of cassiterite, and veins with the ratio of W: Sn = 10 : 1 probably are typical.

4) Ore

The main metallic mineral produced in the mine is wolframite which is distributed between vein quartz in laths and dessemination. At times tungsten ochre is found stuck to the surface of concentration of wolframite. Scheelite sometimes occurs close to wolframite or exists within wolframite in irregular forms (Plate 9. A and B). The size of wolframite is variable but is generally small having lengths of about 0.3 - 5 mm.

Cassiterite in the primary ore deposit is relatively small in quantity and its occurrence ratio to wolframite is about 1 : 6 ~ 1 : 10. It occurs mostly as small euhedral to subhedral grains with diameters ranging from 0.1mm to 3 mm and exists as independent dissemination or in close proximity of wolframite (Plate 10).

Development of pyrite and goethite including small druses is recognized sporadically in W - Sn quartz veins (Plate 11).

Gangue mineral is mostly quartz and a small quantity of muscovite and lepidolite and a trace of apatite, zircon, sphene and beryl are also recognized.

Spectroanalysis of a quartz vein mass with a relatively high ore grade of WO_3 2% showed the following results.

Al · Fe · Mg · Mn ..... $n \times 10^{-1}$%, Li · Mo · Zn ..... $n \times 10^{-2}$%, B · Bi · Cu · Ga · Pb ..... $n \times 10^{-3}$%, Ba · Be · Tl · V ..... $n \times 10^{-4}$%, Ag .....$< n \times 10^{-4}$%

Although not confirmed by microscopic observation, it is assumed from these results of spectroanalysis that there is formation of molybdenite, sphalerite, chalcopyrite, bismuthinite, galena and tourmaline in the deposit.

5) Ore reserves

The portion which is considered to have been a stable ore shoot has already been exploited. Estimation of ore reserves in the existing small and variable deposits is difficult for lack of data and therefore will not be attempted.

6) Conclusions

It is assumed that the exploration of Kalatchaung Mine had been carried out on a small scale with the aim of exploring relatively stable ore shoots of eluvial and vein deposits. At present, both greisenization and mineralization are generally poor with irregular veins, and ore shoots occur only locally. Because of this fact, it is assumed that the operation had reached the stage where mining was difficult and closed after attempting several continuous trenches 2 -3 m wide and 2 m deep and some underground prospecting. For this reason, a careful study should be made on the reopening of this mine, and it seems more advantageous to place emphasis on prospecting of new areas.

Fig. 9

GEOLOGICAL MAP SHOWING DEPOSITS

— KALATCHAUNG MINE —

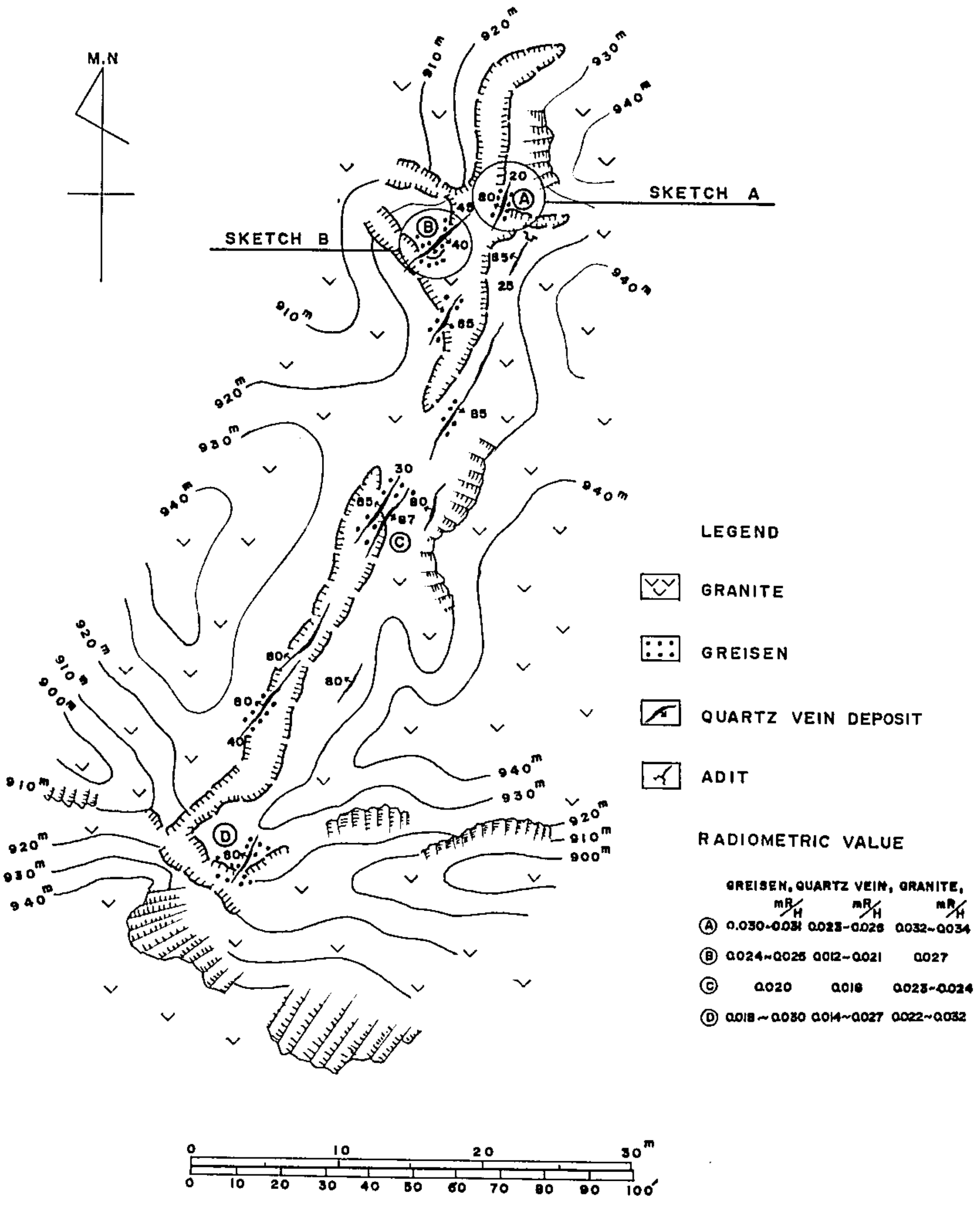
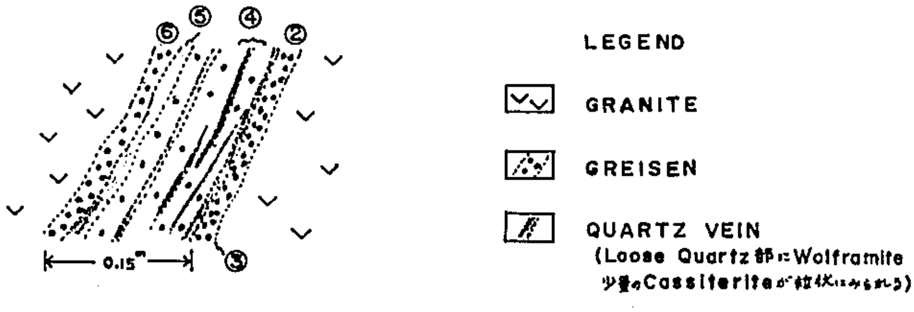


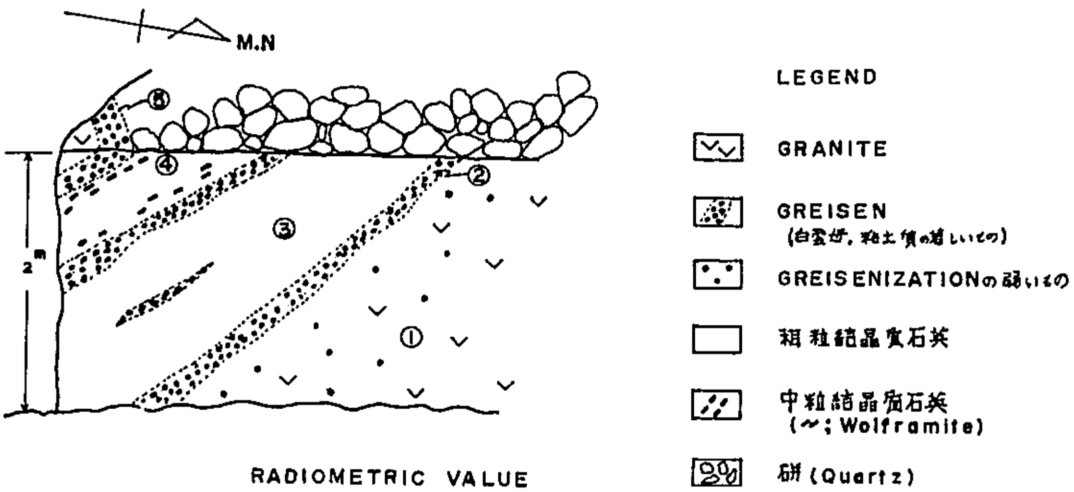
Fig. 10 SKETCH A



RADIOMETRIC VALUE

①	0.032 ～ 0.034 mR/H	②	0.030 mR/H
③	0.024 mR/H	④	0.028 ～ 0.021 mR/H
⑤	0.023 ～ 0.024 mR/H	⑥	0.031 mR/H

Fig. 11 SKETCH B



RADIOMETRIC VALUE

①	0.027 mR/H	②	0.024 mR/H
③	0.012 ～ 0.014 mR/H	④	0.021 mR/H
⑤	0.025 mR/H		

Padatgyaung

4-5 Padatgyaung Mine

1) Location and communication (See Fig. 7)

Padatgyaund Mine is located in Pyinmana, Township, Yamethin District. It is situated at lat. 19°41' N and long. 96°35' E and at a point approximately 24 miles (38.5 km) in a bee-line to the east of Pyinmana city. The means of transportation from Pyinmana to Seikphudaung, a distance of 23.6 miles (37.7 km), is jeep and ferry service across the Paunglaung river. This distance can be covered in two hours. Another two-hour journey in jeep from Seikphudaung, covering a distance of 21 miles (33.6 km), takes one to the end of motorway. A walk from this point along a relatively wide mountain path to Padatgyaung Mine, covering a distance of 2.5 miles (4 km), requires an hour and a half. The elevation of the mine is approximately 2,700 ft (900 m).

2) Geology

The geology in and around the mine consists of phyllite, sericite schist, biotite schist and granite belonging to Mawchi series of older Palaeozoic. The general strike of sedimentary rock is approximately north-south and the dip is 70 - 90° W.

Intrusion of biotite granite is believed to have taken place in late Cretaceous period or early Eocene. The occurrence of this biotite granite extends far in north-south direction almost parallel to the strike of the previously mentioned sedimentary metamorphic rock.

3) Ore deposit (See Fig. 12)

The ore deposit existing in this Padatgyaung Mine consists of three types, namely, tin - tungsten quartz veins (primary deposit) occurring in older granite, eluvial deposits accompanied by tin and tungsten formed secondarily from the above mentioned deposit and alluvial deposits.

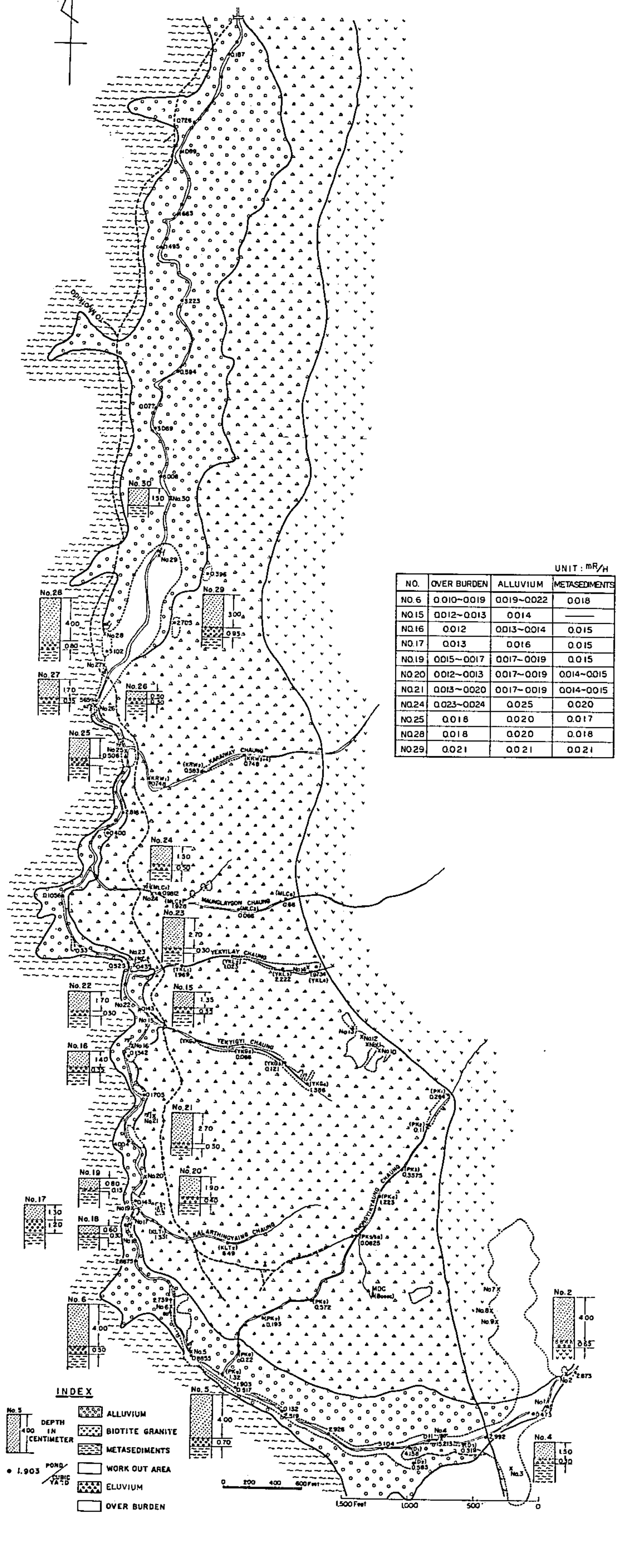
Each of these deposits will be discussed in detail hereinafter (See attached sketches).

(i) Tin - tungsten quartz vein deposits (See Fig. 12).

No. 3 is a tin - tungsten quartz vein deposit occurring in biotite granite near the border of biotite granite and metasediments, with N3°W strike , and W10° dip, the maximum vein width is 100 cm. At the point of about 12 m from the origin the extension starts tapering off to a thickness of about 10 cm and occurs as a lenticular vein. Greisen develops locally only in a thickness of a few centimeters on the periphery of the thick portion of quartz vein. As for ore minerals, wolframite occurs in laths or short prisms and develops particularly in the thick portion of quartz vein and scheelite occurs sporadically in its periphery. Cassiterite also occurs sporadically in small quantities. Estimated grade is WO_3 2 - 3% and Sn 0.5% (Fig.13).

Fig. 12

PADATGYAUNG MINE



UNIT : mR/H

NO.	OVER BURDEN	ALLUVIUM	METASEDIMENTS
NO.6	0.010~0.019	0.019~0.022	0.018
NO.15	0.012~0.013	0.014	——
NO.16	0.012	0.013~0.014	0.015
NO.17	0.013	0.016	0.015
NO.19	0.015~0.017	0.017~0.019	0.015
NO.20	0.012~0.013	0.017~0.019	0.014~0.015
NO.21	0.013~0.020	0.017~0.019	0.014~0.015
NO.24	0.023~0.024	0.025	0.020
NO.25	0.018	0.020	0.017
NO.28	0.018	0.020	0.018
NO.29	0.021	0.021	0.021

No.7 deposit is located at the elevation of 3,530 ft (1,070 m) and comprises quartz veins developed in biotite granite. The strike is generally N20 - 30°E, and the dip is NE 20 - 40°. Several champion veins having widths of 10 - 30 cm and smaller veins are developed. Quartz veins occurring as if to intersect these veins also develp with a strike of N32°W and a dip of NE 10 - 20° and a dozen parallel veins with widths of 5 - 30 cm develop as bands in the southeast direction in the already mined area. As for ore minerals, wolframite is seen in small quantities in the champion vein of NE trend and does not occur in the reticulated veins or quartz veins of NW trend but forms barren quartz veins. Mineralization is hardly recognized and the development of greisen is not recognized at all. As shown in the figure, some quartz veins found in some pits have enlarged parts with width of 60 cm and form ore shoots locally. There also is developed greisen, and wolframite occurs in foils or massed with diameters of about 5 mm or in some parts in laths. There is also occurrence of scheelite in small quantities. All of these form high grade portions and the possible grade is WO_3 2 - 3%. Other champion veins of NE trend are low grade quartz veins with possible grade being in the order of WO_3 0.3%.

No. 8 deposit almost comes in contact with No. 7 deposit in the direction of S 42°E. In this deposit there are 2 or 3 quartz veins developed in biotite granite with a general strike of N18°E and a dip of W 22° forming champion veins. The vein width is 5 - 10 cm and the occurrence is lenticular. Several reticulated veins are recognized, but only several small veins of NW trends are seen crossing the champion veins. As for ore minerals, wolframite occurs in the champion veins locally in the same pattern as that in No. 7 deposit. Although the ore grade of WO_3 2% is expected for the ore shoot, the veins are generally of low ore grade. Occurrence of ore is hardly seen in the reticulated veins and small veins of NW trend, and these form barren quartz veins. Mineralization is recognized only in small extent in quartz veins that form champion veins of NE trend.

The mined section has an elevation of 3,560 ft (1,080 m) and has a length of 60 m, a width of 50 m and a height of 10 m (Fig. 15).

No. 9 deposit almost comes in contact with No. 8 deposit in the direction of S42°E. The deposit consists of quartz veins developed in biotite granite, with a general strike of N18°E, a dip of NE 20° and a vein width of 3 - 7 cm. 2 - 3 veins occur in lenticular form and only a few greisen develop on the periphery of quartz veins. Occurrence of ore minerals is seldom recognized.

The mined section has an elevation of 3,500 ft (1,080 m) and has a length of 40 m, a width of 15 m and a height of approximately 10 m (Fig. 16).

The above is an outline of No. 3, No. 1, No. 8 and No. 9 deposits. Each of these deposits consists of tin - tungsten quartz veins occurring on the western periphery of biotite granite. At present, development of quartz veins becomes weaker as it extends southward from No. 7 deposit toward No. 3 deposit, and there is also less development of mineralization in that direction. Accordingly, grade drops gradually in that direction.

No. 1 deposit consists of a tin - tungsten quartz vein occurring on the border of metasediments and granite, with N40°E strike, SE30°dip, 50 cm width, and 300 cm length. It is a lenticular vein with a greisen having widths of 10 - 15 cm developed in the lower wall of quartz vein. Ore minerals produced are cassiterite and wolframite and ore shoots occur in the thickness of a few centimeters and in concentration in the lower wall of quartz vein. Possible grade of the vein is WO_3 0.5% and Sn 0.5 - 1%(Fig. 17).

(ii) Eluvial deposit accompanied by tin and tungsten (Fig. 12)

This deposit is located on the slope of mountainside at the point 100 - 200 ft (30 - 70 m) west of the granite bed and its elevation is 3,430 ft (1,040 m). The deposit comprises 4 bodies, No. 10 through No. 13, part of which are now in operation.

Outline of each orebody will be discussed below. In each of No. 10, No. 11, No. 12, and No. 13 orebodies there is sediments of granitic, greisen and quartz pebbles in the weathered soil with thickness of 3 - 5 m at the lower portion of overburden which is 1 - 2 m deep. The size of the pebbles varies from 5 m long and 1 m wide to 50 - 60 cm and a few cm, and the show brecciated structures. The ratio of pebbles in the weathered soils is considered to be approximately 50%.

As for ore minerals, wolframite occurs in quartz pebbles sporadically as granules having diameters of 2 - 3 mm or as masses. Scheelite and cassiterite also occur sporadically in small quantities.

Grade of WO_3 2 - 3%, Sn 1% is expected locally in quartz pebbles. Despite the occurrence of high grade ore, estimate of the grade of the total deposit is difficult.

Dimensions of working faces at each orebody are as follows.

No. 10: Length - 40 m, width - 10 m, height - 7 m.

No. 11: Length - 20 m, width - 15 m, height - 10 m.

No. 12: Length - 50 m, width - 50 m, height - 10 m.

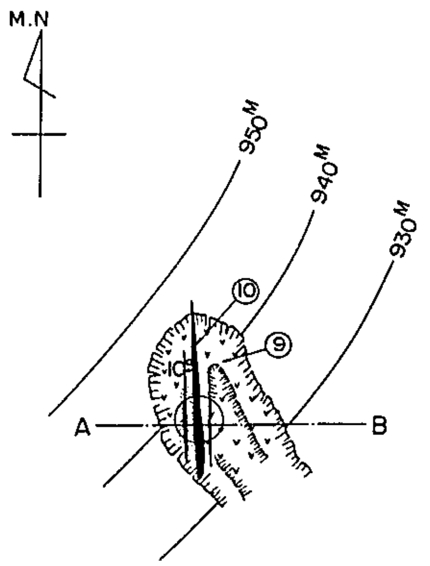
No. 13: Length - 20 m, width 6 - 8 m, height - 5 m.

As for geographical locations of these orebodies they are adjacent to each other and situated in the order of No. 10, No. 11, No. 12, and No. 13 toward north.

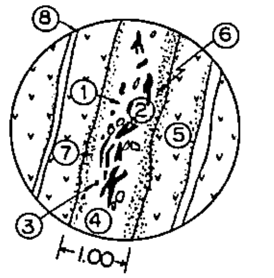
In No. 13 orebody the occurrence of two bands of parallel quartz veins developed in the weathered granite is seen in addition to eluvial deposit. The vein has a strike of N96°E a dip of SE60°and a small width of 1 - 3 cm thus forming a lenticular vein.

As for ore minerals, wolframite occures in small quantity and mineralization of small scale is recognized on the periphery of the vein (Fig.18 - Fig. 20).

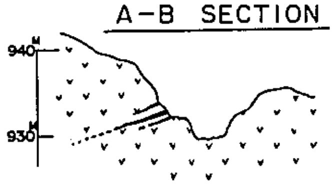
FIG. 13 PADATGYAUNG MINE NO. 3



SKETCH OF VEIN

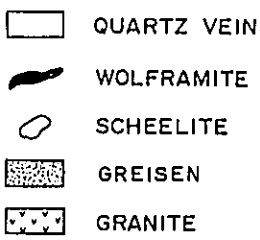


A-B SECTION



①	0.025~0.026 mR/H	QUARTZ VEIN
②	0.029 mR/H	QUARTZ VEIN
③	0.027~0.028 mR/H	QUARTZ VEIN
④	0.019 mR/H	QUARTZ VEIN
⑤	0.030~0.032 mR/H	GRANITE
⑥	0.030 mR/H	GREISEN
⑦	0.031 mR/H	GREISEN
	0.019 mR/H	MUSCOVITE
⑧	0.015 mR/H	QUARTZ VEIN
⑨	0.015~0.016 mR/H	
⑩	0.027 mR/H	GRANITE

LEGEND



SCALE 1 : 500

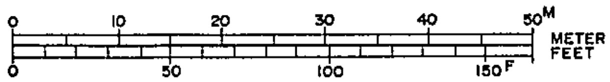
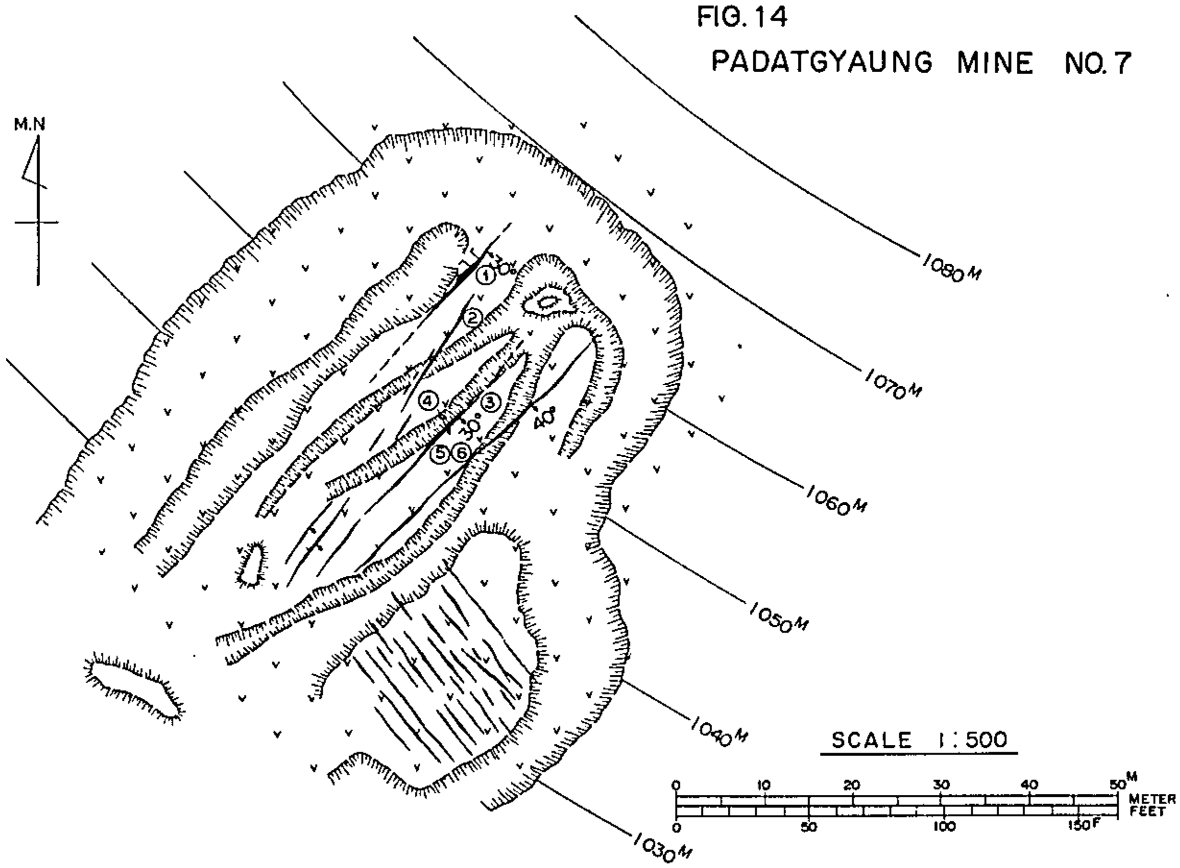


FIG. 14

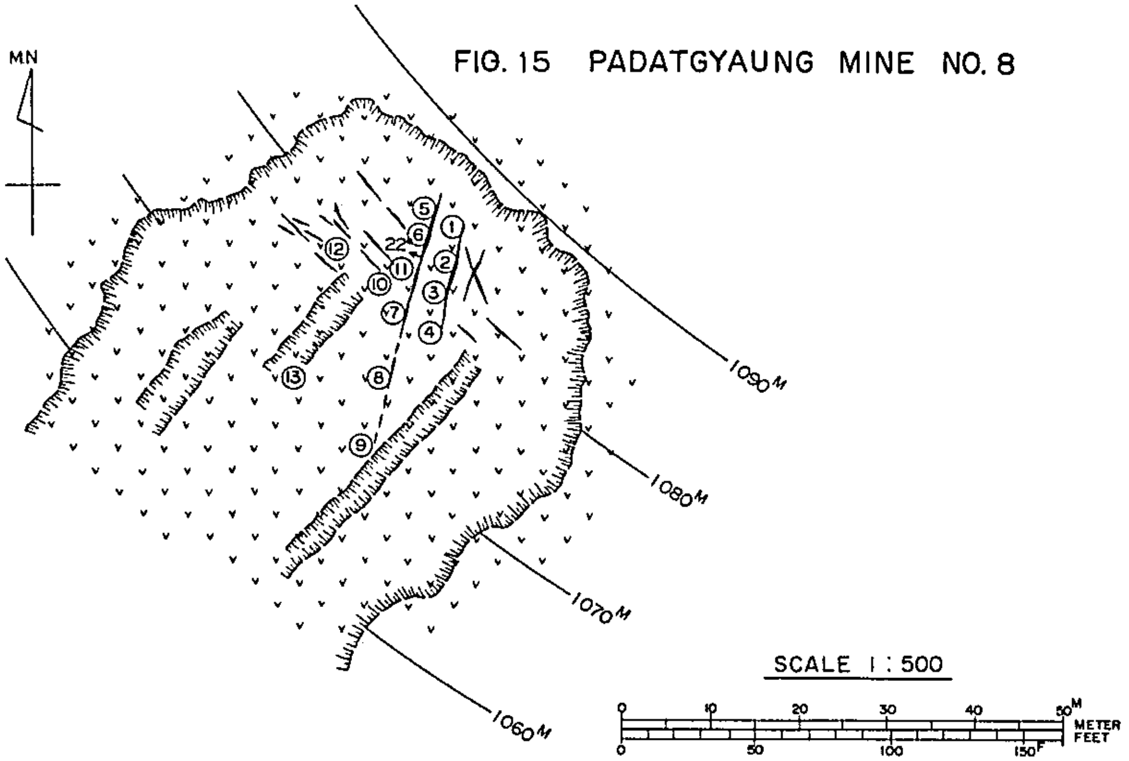
PADATGYAUNG MINE NO. 7



UNIT : mR/H

	QUARTZ VEIN	GREISEN	GRANITE
①	0.017 ~ 0.020	—	0.023 ~ 0.028
②	0.015 ~ 0.018	—	0.024
③	0.021 ~ 0.026	0.025 ~ 0.023	0.025 ~ 0.030
④	0.027 ~ 0.028	0.025 ~ 0.030	0.033 ~ 0.035
⑤	0.016 ~ 0.026	0.024 ~ 0.028	0.030 ~ 0.032
⑥	0.018 ~ 0.019	0.021 ~ 0.022	0.022 ~ 0.026

FIG. 15 PADATGYAUNG MINE NO. 8



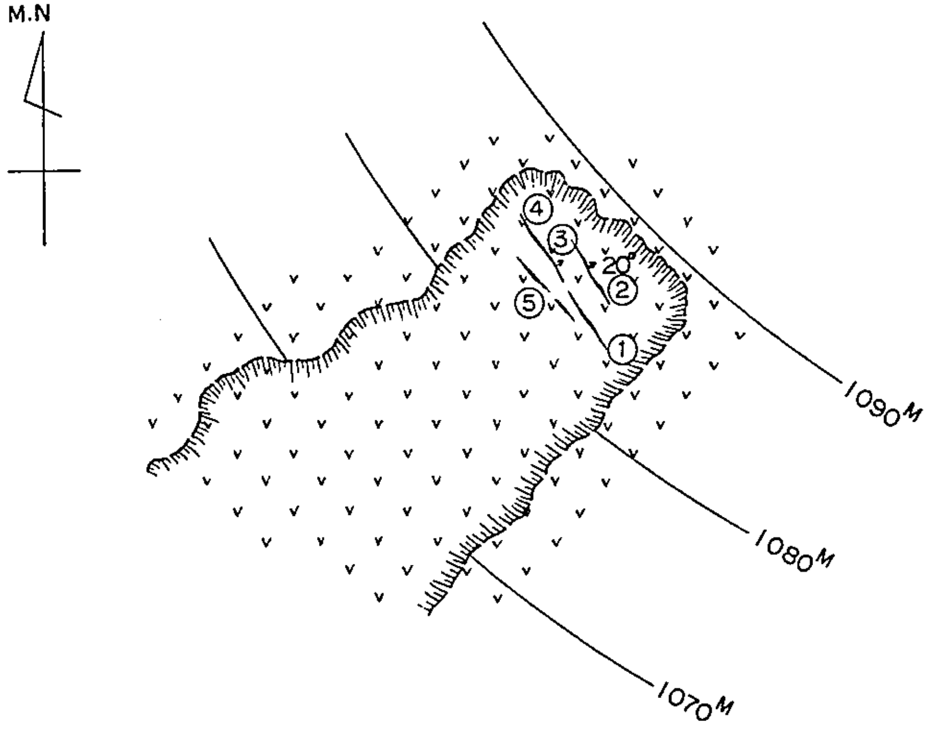
UNIT : mR/H

	QUARTZ VEIN	GREISEN	GRANITE
①	0.021~0.024		0.025~0.030
②	0.024~0.028	0.030	0.032
③	0.027		
④	0.012~0.025	0.021~0.028	0.024~0.033
⑤	0.026	0.038	0.040
⑥	0.027	0.029	0.030
⑦	0.028		
⑧	0.030		
⑨	0.030~0.037		
⑩	0.017~0.026	0.025~0.031	0.029~0.034
⑪	0.030	0.036	0.042
⑫	0.014~0.016	0.026	
⑬	0.014~0.019	0.021~0.025	0.024~0.029

⑩ (60cm)

- → 0.025 mR/H (GRANITE)
- → 0.026 mR/H (GREISEN)
- → 0.034 mR/H (GRANITE)
- → 0.030 mR/H (GREISEN)
- 0.025~0.026 mR/H (WOLFRAMITE) — QUARTZ VEIN
- 0.017~0.019 mR/H (NEAR. BARREN QUARTZ) — QUARTZ VEIN
- 0.026 mR/H (WOLFRAMITE) — QUARTZ VEIN
- 0.029 ~ 0.030 mR/H (GREISEN)
- 0.032 mR/H (GRANITE)

FIG. 16 PADATGYAUNG MINE NO.9



UNIT : mR/H

	QUARTZ VEIN	GREISEN	GRANITE
①	0.027	0.029	0.035
②	0.024	0.027	0.030
③	0.032	0.034	0.036
④	0.024	0.030	0.034
⑤	0.025～0.028	0.029	0.033

SCALE 1 : 500

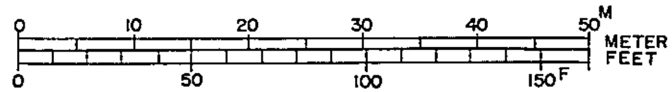
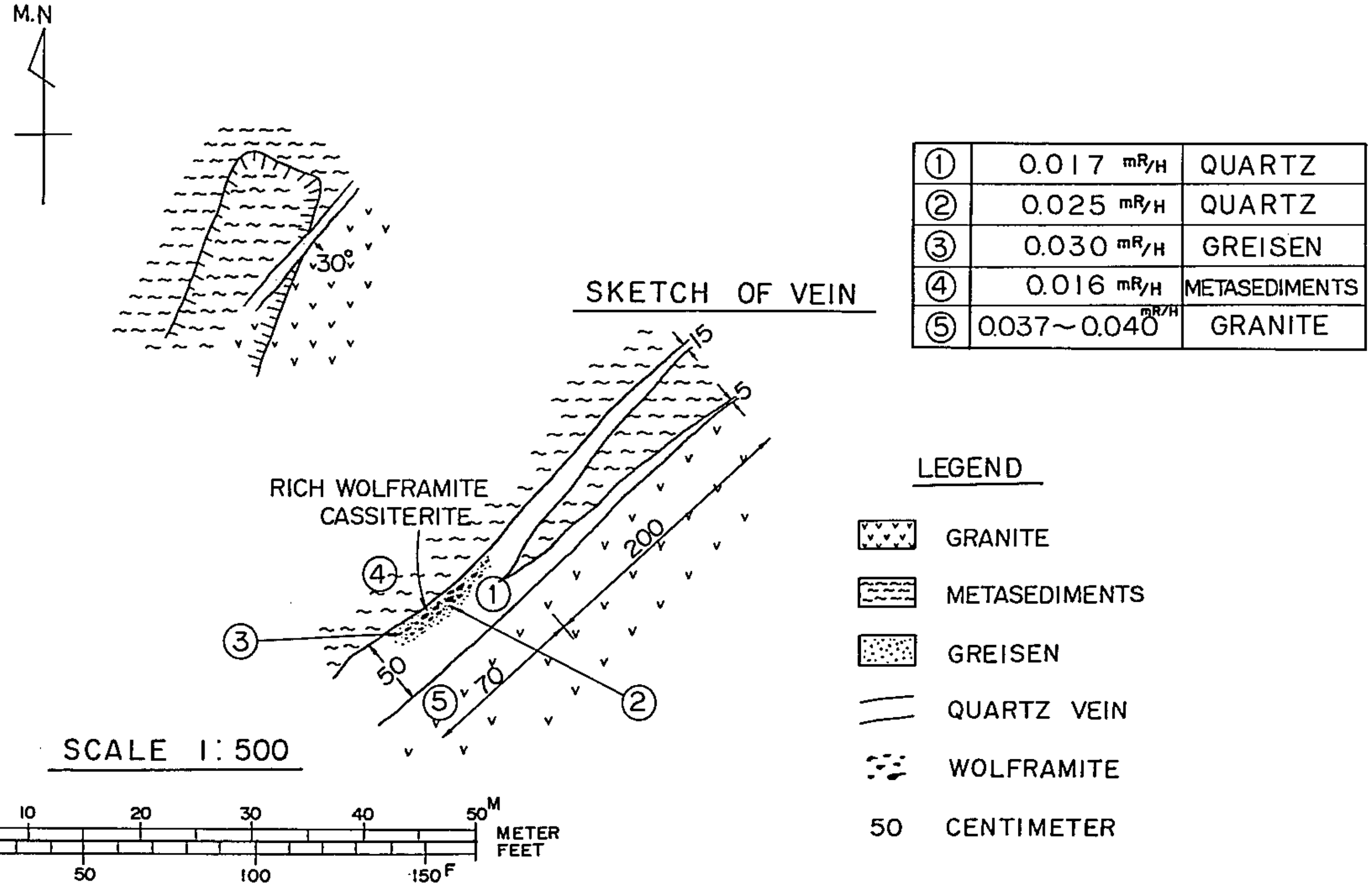
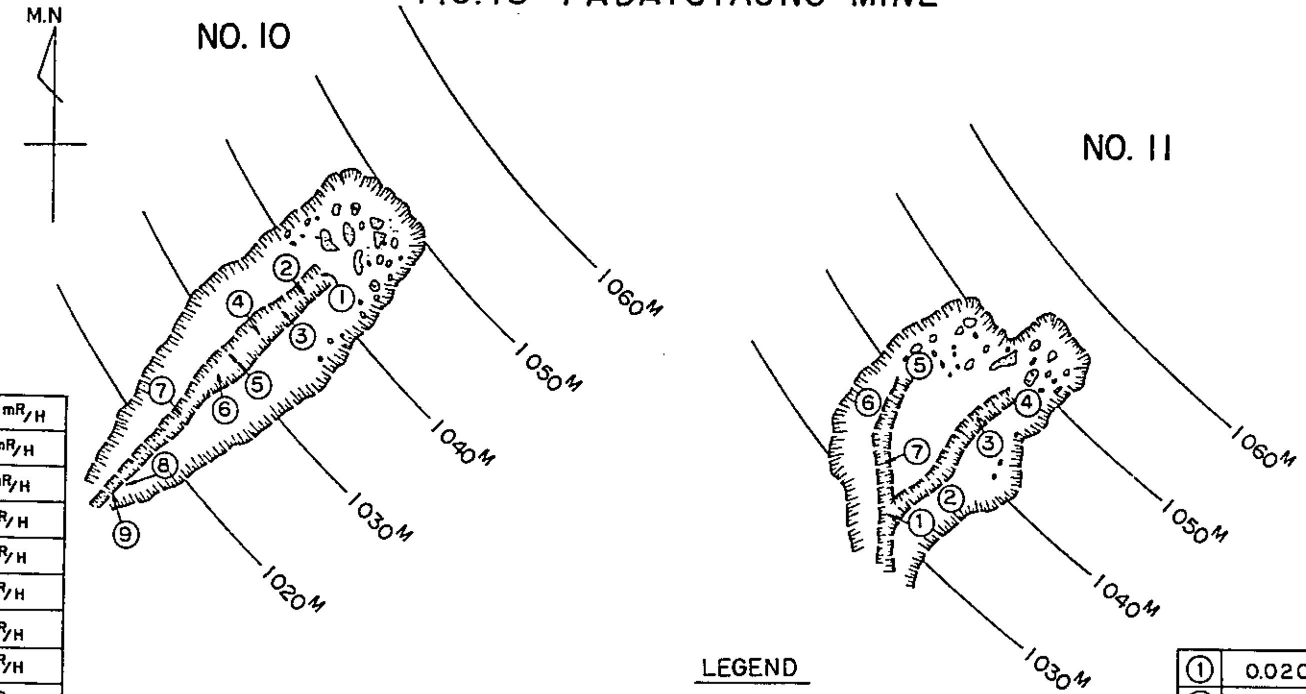


FIG. 17 PADATGYAUNG MINE NO. I



①	0.017 mR/H	QUARTZ
②	0.025 mR/H	QUARTZ
③	0.030 mR/H	GREISEN
④	0.016 mR/H	METASEDIMENTS
⑤	0.037～0.040 mR/H	GRANITE

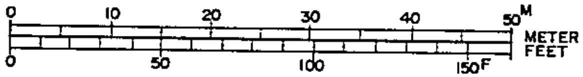
FIG.18 PADATGYAUNG MINE



NO. 10

①	0.021~0.023 mR/H
②	0.025 mR/H
③	0.021 mR/H
④	0.025 mR/H
⑤	0.020 mR/H
⑥	0.021 mR/H
⑦	0.020 mR/H
⑧	0.021 mR/H
⑨	0.030 mR/H GRANITE

SCALE 1 : 500



LEGEND

GRAVEL QUARTZ

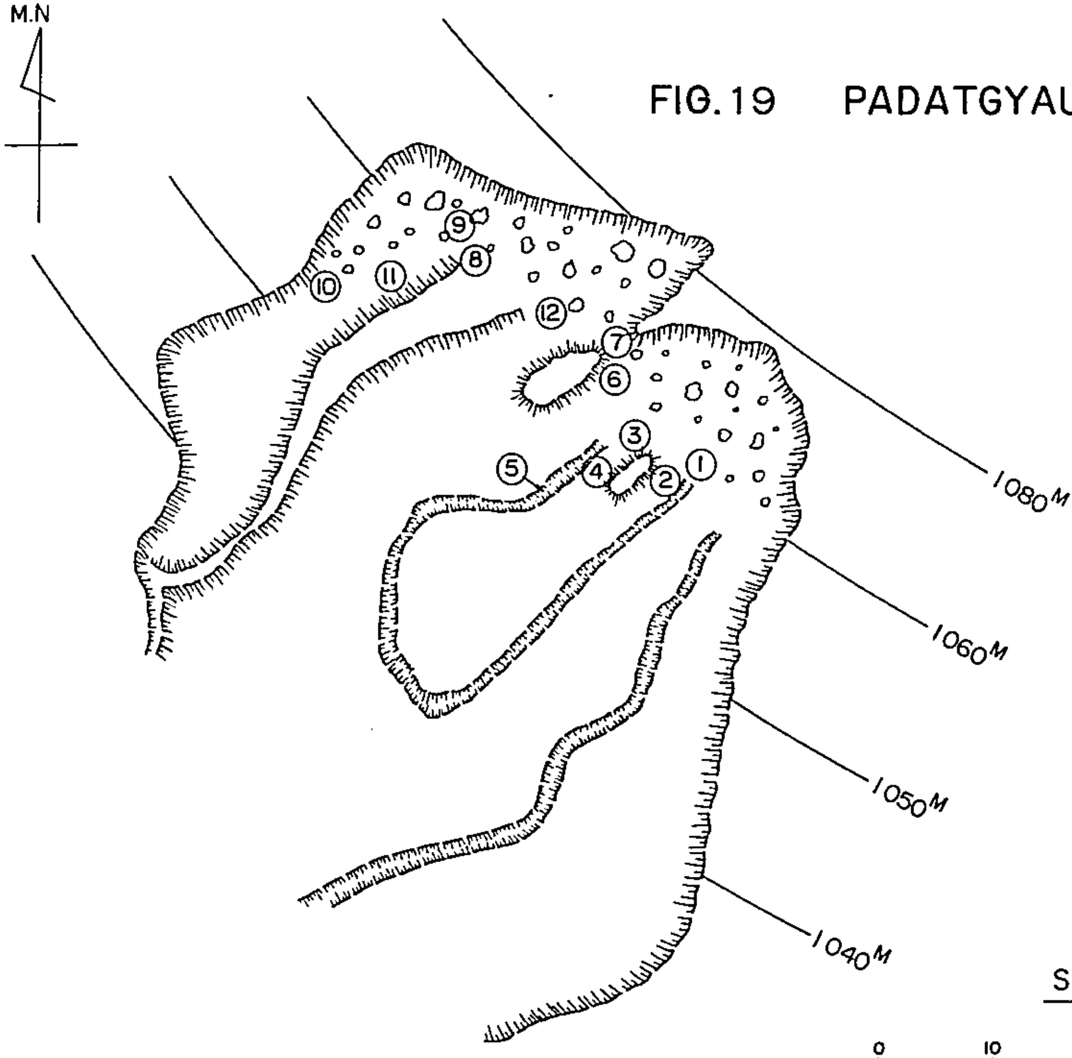
GRAVEL GREISEN

GRAVEL GRANITE

NO. 11

①	0.020 mR/H
②	0.022 mR/H
③	0.019 mR/H
④	0.021 mR/H
⑤	0.024 mR/H
⑥	0.022 mR/H
⑦	0.023 mR/H

FIG. 19 PADATGYAUNG MINE NO. 12



①	0.021 mR/H
②	0.022 mR/H
③	0.014 mR/H
④	0.017 mR/H
⑤	0.021 mR/H
⑥	0.015 mR/H
⑦	0.010 mR/H
⑧	0.024 mR/H
⑨	0.024 mR/H
⑩	0.026 mR/H
⑪	0.026 mR/H
⑫	0.015 mR/H

SCALE 1:500

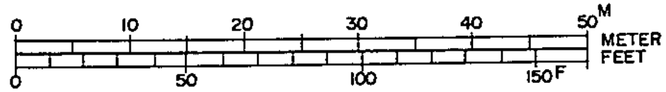
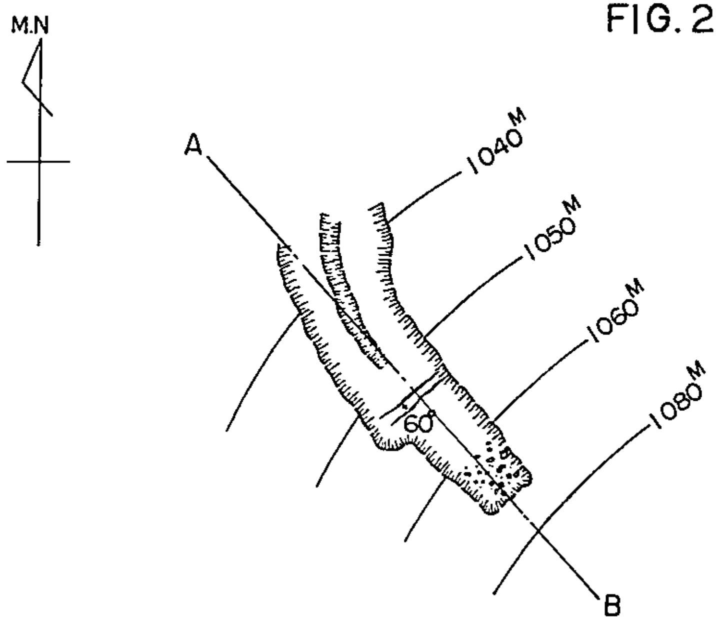
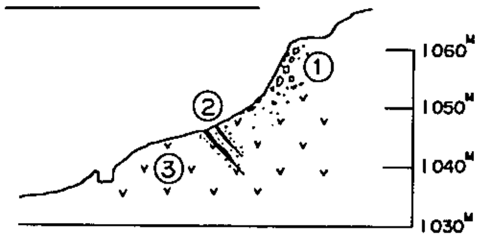


FIG. 20 PADATGYAUNG MINE NO. 13

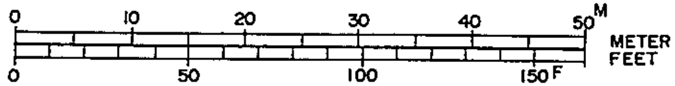


①	0.022～0.025 mR/H	PEBBLE OF QUARTZ GREISEN
②	0.029～0.030 mR/H	GREISEN
②	0.026～0.027 mR/H	QUARTZ VEIN
③	0.032～0.033 mR/H	GRANITE

A-B SECTION



SCALE 1 : 500



The above discussion has been centered on the eluvial deposit. The mining method employed for this deposit is the hydraulic method which removes overburden with hydraulic force, by making good use of the rainy season. As the ores occur in the quartz pebbles, high grade ores are separated by hand, crushed by human power and separated by panning to obtain concentrate. For this reason, the grade of the crude ores and the yield rate are difficult to determine and therefore no attempts were made to estimate ore reserves.

(iii) Alluvial deposit accompanied by tin - tungsten (Fig. 12).

As shown in the attached schetch, the deposit comprises No. 3, No. 7, No. 8 and No. 9 ore-bodies developed along a stream originating in granite, with a total length of 4,455 yd (4,050 m). The range of distribution is very irregular and the widths of the ore-bodies range from 270 yd (240 m) to 33 yd (30 m) (source: maps furnished by M.D.C.). This stream flows west ward parallel to the west side of the granite body with north - south strike, in which the primary and eluvial deposits occur, and develops into a deposit in the basin of a stream flowing northward. This is an alluvial deposit originating from primary and eluvial deposits. As shown in the attached schetch, the average thickness of overburden at each survey point is 2 m and the that of tin - tungsten bearing deposits is 0.45 cm (These values are arithmetic mean values obrained from columnar sections at 20 points). Amount of concentrate, by arithmetic mean of 42 points, is said to be 1,997 lb/yd^3 according to data furnished by M.D.C. (Grade of concentrate by panning is estimated at WO_3 + Sn 65%).

The deposit is a sediment on basement consisting of green schist and biotite schist of Mawchi series. The strike of the sedimentary rock is approximately NS and the dip is W 75 - 90. As shown in Fig. 21, the gravel layer consists of large gravels and sands of barren quartz, granite and greisen. The gravels are generally pebbles of the size ranging from 30 - 50 cm at the maximum and to 3 - 5 cm for the greater part. The ratio of pebble to sand is generally assumed to be 6 : 4.

As for ore minerals, cassiterite and wolframite occure mostly in the sand granule. The greater part of cassiterite are round granules with grain size of 0.5 - 0.7 cm at the maximum and 0.1 - 0.2 cm in general. Wolframite is in the form of granules having a general grain size of 0.2 - 0.3 cm. These ores are being mined at several places by groups of families comprising 2 to 3 members. The pans for panning are made of wood and measure 40 cm in diameter, 5 cm in depth at the center and 1 cm in thickness. It is shaped like an umbrella and carved from wood blocks.

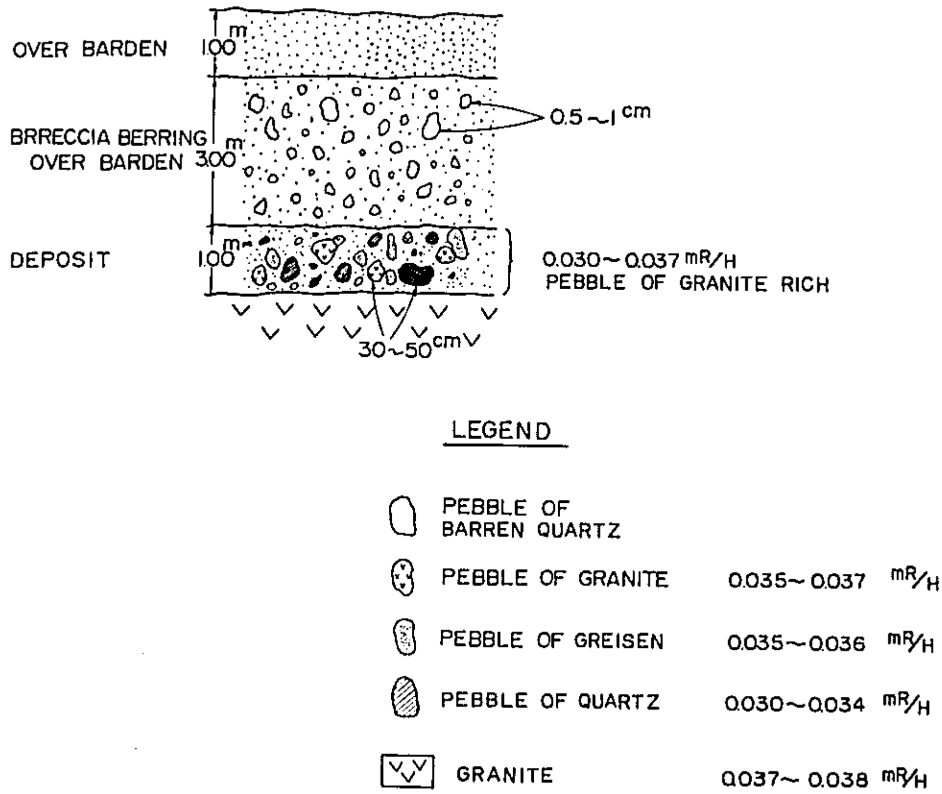
As for ore reserves, the following calculation has been attempted from the average thickness of sand-gravel layer measured during this survey with reference to the distribution range and the amount of concentrate shown in the survey maps furnished by M.D.C.

Ore Reserves Table

	Area(m^2)	Thickness (m)	Volume (m^3)	Volume yd^3	Amount of concentrate per lb/yd^3	Amount of concentrate (lb)	Amount of concentrate (l.t.)
South area	272,448	0.45	122,601	160,362	1,997	320,242	144.108
North area	246,297	0.45	110,833	144,969	1,997	289,503	129.076
Total	518,745		233,434	305,331		609,745	273.184

FIG. 21 PADATGYAUNG MINE NO.2

SKETCH OF ALLUVIAL DEPOSIT



(Note) Since the south section is a mining area where operation is in progress and the north section is a paddy area, estimate of ore reserves was made separately for each section with No. 30 site used as a dividing line.

4) Ore

Primary minerals: These occur in quartz veins and greisen formed on both sides of the veins. Ore minerals are mainly wolframite and cassiterite but are sometimes accompanied by a small quantity of molybdenite and scheelite and also a trace of hematite, tungsten ochre and pyrite.

The gangue is mainly quartz and is sometimes accompanied by lepidolite and muscovite and also a very small quantity of beryl, fluorite, rutile and topaz.

Wolframite occurs as single crystals in the form of laths or as a mass (Plate 12). The largest single crystals measure 7 x 3 x 2cm or more (Plate 13), but in general the length is 0.5 - 5mm. On two occasions its occurrence in contact with scheelite was observed, but in general they occur alternately. It is relatively rich in very fine solid substances. It occurs mainly in quartz veins and is seldom distributed in greisen. When it exists in greisen it is seen in paragenesis with cassiterite and never exist independently.

Cassiterite is distributed both in quartz veins and greisen either as euhedral single crystals, twins, in contact with wolframite or by itself Its color varies and the optical properties under incident light also varies considerably (Plate 14). In this connection, the results of X-ray analysis of several different types of cassiterite with different colors (Table 4) also suggest the difference in the composition and the existence of isomorphism. The grain size of cassiterite in the primary zone is mostly in the range of 0.05 - 3 mm but in some cases it is 2.5 cm or layer. The ratio of cassiterite to wolframite is generally 1 : (4 - 5). According to the results of spectro analysis, the trace components of cassiterite (brown color) are $n \times 10^{-1}\%$ Al and Mg, $n \times 10^{-2}\%$ Fe, $n \times 10^{-3}\%$ Ba, Li, Mn and V, $n \times 10^{-4}\%$ each Be, Bi, Cu, Ga and Pb and $n \times 10^{-4}\%$ Ag.*

Tungsten ochre is found on the surface of wolframite or in its vicinity as a secondary mineral and molybdenite exists mostly around the concentration of wolframite as single disseminated bodies. Consequently, the molybdenite content of the veins trend to become almost proportionate to the grade of wolframite content.

According to chemical analysis, the mean sample taken across the vein of the so-called large outcrop (See Fig. 12) contains 0.90% WO_3, 0.19% Sn, 0.05% Mo, 0.12% Ca, 0.04% P and 93% SiO_2 .

Placer ore: Composition of heavy minerals (speific gravity >3.3) and light minerals (specific gravity≤ 3.3) in the panned concentrates of placer ore are shown in Table 5 and Table 6, respectively (For sampling points, see Fig. 12).

* Nb and Ta are elements determination of which is difficult by spectroanalysis. For this reason, substantial data worth mentioning was not available, though they are believed to be contained.

Table 4

White		Dark brown		Light brown		SnO (synthetic cassiterite) (From ASTM card)	
d (Å)	I/Io	d (Å)	I/Io	d (Å)	I/Io	d (Å)	I/Io
3.344_5	100	3.343_2	100	3.345_7	100	3.351	100
2.638_3	60	2.639_0	54	2.639_7	84	2.644	81
2.363_5	45	2.364_7	50	2.365_9	30	2.369	24
2.307_5	5	2.304_7	6	2.305_8	4	2.309	5
2.115_3	3	2.116_4	3	2.115_7	3	2.120	2
1.763_1	88	1.763_4	66	1.768_5	81	1.765	63
1.759_0	53	1.759_6	44	1.759_0	48	-	-
1.673_7	23	1.674_9	27	1.676_3	25	1.675	63
1.669_0	12	1.670_3	13	1.669_8	14	-	-
1.592_6	6	1.591_1	7	1.590_6	6	1.593	8
1.588_8	3	1.583_6	4	1.587_3	2	-	-
1.497_1	23	1.498_8	10	1.497_1	14	1.498	13
1.493_3	13	1.493_3	7	1.493_8	8	-	-
1.437_5	28	1.438_1	11	1.437_3	16	1.439	17
1.433_9	16	1.434_5	6	1.433_9	10	-	-
1.414_2	21	1.414_8	20	1.414_1	13	1.415	15
1.411_0	11	1.411_4	13	1.410_3	7	-	-
1.321_1	11	1.320_6	11	1.321_2	7	1.322	7
1.317_7	5	1.317_5	5	1.371_9	5	-	-
1.214_0	16	1.214_8	8	1.214_0	14	1.215	11
1.210_7	9	1.211_7	4	1.211_3	7	-	-
1.184_2	2	-	-	1.183_8	4	1.184	3
1.156_6	5	1.153_9	5	1.153_8	7	1.155	8
-	-	1.151_1	2	1.151_3	4	-	-

Table 5 Composition of Heavy Minerals in Panned Concentrate

Mineral \ Sampling ore No. (Fig. 12)	4	15	18	27	29
zircon	+	+++	++	++	+
garnet		++	+++	++	++
magnetite	+	+	+	+	+
ilmenite	+++	++++	+++++	++++	++++
rutile		<+		<+	
cassiterite	+++++	+++++	+++++	+++++	+++++
hematie		+	+	+	+
wolframite	++	++	+	+	+
molybdenite		<+	<+		
pyrite			<+		
topaz	<+				
clinopyroxene		<+	<+		
amphibole		<+			

Approximately 50 to 60% of heavy minerals are cassiterite mainly of white and brown varieties but also smaller amounts of dark brown, light brown, purplish brown, lemon-yellow, bright-yellow and black varieties. Wolframite accounts for only 1 - 2% of heavy minerals but zircon has a fairly large share and often exists as beautiful crystals 0.5 - 2 mm in diameter (Plate 15). Garnet is mainly almandine and occurs mainly as small pink grains.

Table 6 Light Minerals in Panned Concentrate

Mineral \ Sampling deposit No. (Fig. 12)	4	15	18	27	29
Quartz	○	○	○	○	○
Muscovite	○	○	○	○	○
Lepidolite	○	○	○	○	○
Tourmaline		○	○	○	○
Amphibole		○			○
Beryl			○		○
Apatite	○	○	○	○	○

The overwhelming portion (approximately 99%) of light minerals is quartz and the remaining portion is shared by lepidolite and tourmaline. Other minerals are very scarce only a few grains in 5 - 15 gr.

The reason of total lack of biotite despite its distribution comparatively close to the biotite granite is that the biotite is probably cleaved off in small fractions and is easily washed away during panning process.

Results of spectroanalysis of gravels (those accompanied by nied by small quantities of wolframite) contained in placer ore show the trace components contents to be n % Mn, $n \times 10^{-1}$% Fe, $n \times 10^{-2}$ % Al, Cr, Mg, Pb and Zn , $n \times 10^{-3}$ % Bi and Cd, $n \times 10^{-4}$ % Ag, Ba, Cu, Ge and Mo. Content of some elements in tin and tungsten concentrates produced at Padatgyaung and delivered to MDC Padatgyaung Base is shown in Table 7 below.

Table 7 Content Grade of Elements in Mixed Concentrates Produced at Padatgyaung Mine (%)

WO_3	Sn	Bi	Mo	Ca	Zr	P	Cu	S
6.30	67.4	<0.01	0.09	0.06	4.50	0.23	0.002	0.019

The greater part or all of these mixed concentrates are considered to originate in alluvial deposit. High Zr content and comparatively high P content as well as the ratio Snl/W ≒ 13.5 characterize these mixed concentrates. As mentioned previously, Sn exists in the form of cassiterite, W as wolframite (primary minerals contain a small quantity of tungsten ochre and scheelite, but not in these concentrates), Zr as zircon, and P probably in zircon or as apatite. Cassiterite usually contains niobium and tantalum.

Niobium and tantalum content of concentrates produced at this mine is about 0.4% and 0.02 - 0.03%, respectively (because of low sensitivity of Nb and Ta and high detection limit, no readings were obtained from spectroanalysis; wet method should be used for this purpose). Zircon is also contained sufficient quantity for separation and production as a by-product (about 4.5 times higher than the content of zircon in concentrates produced at No. 4 Mine and Steel Mine).

5) Conclusions

Padatgyaung Mine comprises tin - tungsten quartz veins occurring mainly in granite and partly in metasediments intruding the granite near the contact along the western edge of granite body extending in almost north-south direction. The main objects of operation at present are eluvial and alluvial deposits. Most of quartz veins have widths of (10 - 30 cm, and selective mining is being carried out at the section where the probability of occurrence is higher.

Alluvial deposits part of which originated in the primary deposit and are located along a stream are also being mined. Although prospecting of deposits developed on the western side of granitic intrusion may be difficult because of poor exposure, there are possibilities of discovering ore deposits of significant size because the distribution of granite is very extensive. Prospecting has been completed only for a part of this flank. Since the contact on the eastern flank of granite has not yet been prospected, a thorough investigation should be conducted in this section although prospects for large deposits are not very large. Therefore, prospecting is carried out in the order of alluvial, eluvial, and primary deposits, discovery of additional reserves can be expected as there are great potentialities of the existence of ore deposit.

As exposure is very poor, geochemical prospecting of river-bed sediments is considered most appropriate for the discovery of new deposits. Use of airborne magnetic and radiometric methods to determine the state of granite intrusion is also conceivable. In view of the rugged terrain and also of uncertainty as to whether such means are effective or not, a further study should be made on the use of such methods together with the cost involved and other factors.

As for mining method, the present system is considered appropriate in view of the small scale of the deposits. Integration of operation by installing a small crusher and replacing the present panning method by a gravity separator will contribute to the expansion of production. In 1939 this mine is said to have turned out 165 tons of concentrate with grade of WO_3, 32.6% and Sn 45.4%, but the present production is very small.

Pennedaik Mine

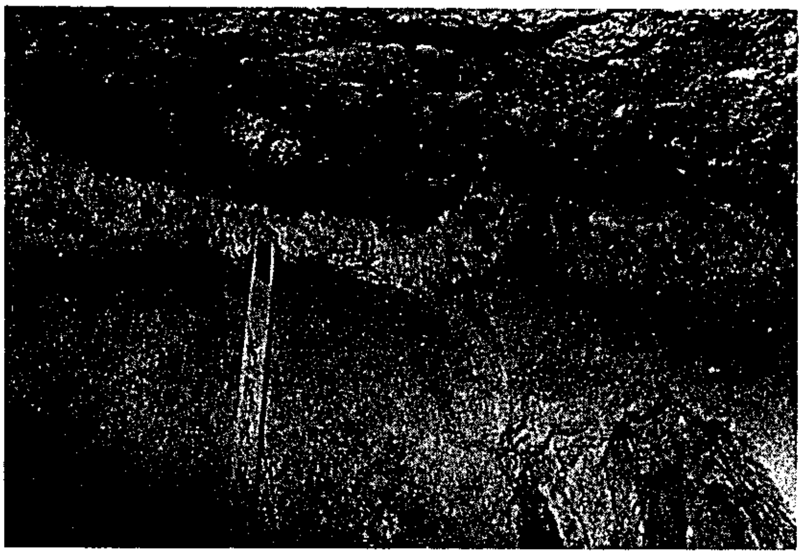
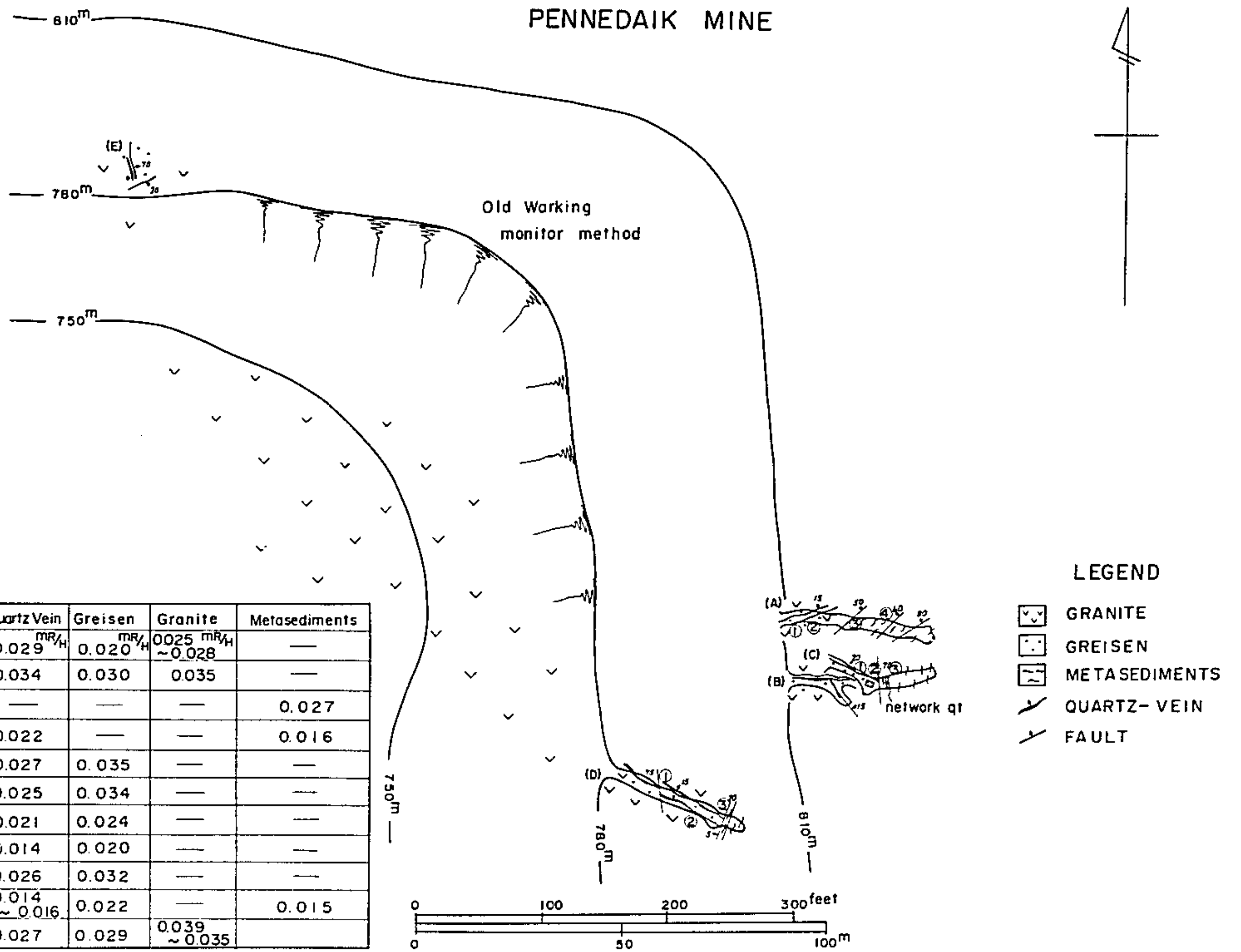


Fig. 22 DISTRIBUTION MAP OF ORE DEPOSITS

PENNEDAIK MINE



		Quartz Vein	Greisen	Granite	Metasediments
(A) Adit	①	0.029 mR/H	0.020 mR/H	0.025 mR/H ~0.028	—
	②	0.034	0.030	0.035	—
	③	—	—	—	0.027
	④	0.022	—	—	0.016
(C) Adit	①	0.027	0.035	—	—
	②	0.025	0.034	—	—
	③	0.021	0.024	—	—
(D) Adit	①	0.014	0.020	—	—
	②	0.026	0.032	—	—
	③	0.014 ~0.016	0.022	—	0.015
(E) Surface		0.027	0.029	0.039 ~0.035	

4-6 Pennedaik Mine

1) Location and access

(i) Pyinmana - Seikphudaung section with a distance of 23.6 miles (37.7 km) can be covered in two hours by car.

(ii) Seikphudaung - Padatgyaung section with a distance of 23.5 miles (37.6 km) can be covered in three and a half hours by car and on foot.

(iii) Padatgyaung - Pennedaik Mine (I) : 6.2 miles (10 km)
Padatgyaung - Pennedaik Mine (II) : 7.7 miles (12.4 km)

A distance of 5 miles (8 km) from Padatgyaung base to Pennedaik camp base can be covered in two and a half hours on foot. The camp is 3,100 ft (945 m) above sea-level, and prospecting is in progress at two sites. One is located at a point about 30 minute walk from the camp and is 2,600 ft (795 m) above sea-level (provisionally designated as Mine (I)) and the other is located at a point about an hour walk to the southwest along the valley and is 2,100 ft (640 m) above sea-level (provisionally designated as Mine (II)). Both locations lack adequate facilities of communication.

2) Geology and ore deposits

As shown in the reference map, Mine (I) comprises old diggings (hydraulic mining) worked by the English, an upper land and four prospecting galleries (called A, B, C and D gallaries for convenience). The geology consists of metasediments and granite. The latter is considered to be either laccolith or stock as in the case of No. 4 Mine. The contact of these two bodies is distinct ant is often accompanied by faults. The granite has undergone intensive weathering and is very frail. As for ore deposit, tungsten and tin quartz veins develop around the contact, particularly on the side of granite. Rocks on the periphery of ore deposit show a remarkable greisenization. Champion veins of tungsten and tin quartz generally show strike of E-W and have dip of 10 - 20°N. In addition, there are massive or sausage type quarty veins and network quartz veins of a width of 2 - 4 inches (5 - 10 cm) near the contact of granite and metasediments, but mineralization is hardly recognized.

	Length of gallery	Remarks			
Pit A	115 feet + 2 (35.0m + 2) 31 cubic meters of collapse	Vein width: 2 8inch (5 20cm)	Drift: 50 feet + 2 (15m + 2)	N70°E 18°s	Low grade
Pit B	43 feet (13.0m)	Vein width: 4 8inch (10 20cm)	Drift: 43 feet (13m)	N70°E 15°N N70°W 10°N	Low grade
Pit C	80 feet (25.0m)	Vein width: 8 12inch (20 30cm)	Drift: 50 feet (15m)	N65°W 20°N	Runs through to the upper part of pit B
Pit D	115 feet (35.0m)	Vein width: 4 24inch (10 60cm)	Drift: 100 feet (30m)	N70°W 15°N	Wolfrawite is scanty

As shown in the table above, significant mineralization is not recognized in the old prospecting galleries. It is assumed, therefore, that prospecting of the upper portion was probably made parallel to the old diggings where the monitoring method was employed. At present, a small scale prospecting is being conducted on a quartz vein with direction of N65°E, 20°S at point (E) shown on the reference map. In this quartz vein wolframite exists with a width of 4 - 5 mm. The quartz veins are small with average width of 6 inches (15 cm) and they are not very satisfactory. The occurrence of cassiterite in the form of irregular granules having grain size of 5 - 8 mm was recognized in the deposited nearby. Judging from the findings of this survey and the past records, the ratio of tungsten to tin is considered to be 1 : 1. Mine (II) is not shown on the reference map, but it is located at a point 1.5 miles (2.4 km) down along a small stream from Mine (I), where the streams meet. Between Mines (I) and (II) biotite granite (indistinct biotite) exists continuously up to the elevation of 2,360 ft (720 m), followed by poor exposures and green rocks, the basement, begin to appear at the elevation of 2,260 ft (690 m). A gravel layer having a thickness of 1 - 1.6 ft (30 - 50 cm) lies over the green rocks. The ore deposits are alluvial, and mining is done by hydraulic elutriation and panning. The gravel layer is thin and has a small depositional surface. For this reason, much cannot be expected from this mine.

3) Ore

Metallic minerals that comprises the ore are mainly goethite, followed by wolframite and scheelite and such minerals as hematite, pyrite, molybdenite, cassiterite and chalcopyrite. A trace of sphalerite and galena is also recognized.

Goethite (Plate 16) occurs in small druses or in small cracks of quartz veins, and those in small druses often show skelton texture. In some cases, the occurrence of euhedral chalcopyrite is recognized in the center of the skeltons.

Lath-shaped wolframite is distributed in relatively small quantity and the length is 0.1 - 2 mm. Macroscopically, veins with possible concentration of wolframite are scarce and scheelite is far less frequent occurring only at 10 spots or so in the entire length of quartz veins in the gallery. The occurrence of scheelite in contact with wolframite was not recognized. The ratio of these two minerals is not accurately known but wolframite is probably the highest as far as the seven mines surveyed are concerned.

Hematite and chalcopyrite are disseminated in quartz veins in small quantities, especially chalcopyrite occurs in minute amount. Pyrite and cassiterite are disseminated independently in the quartz veins. Pyrite sometimes exists in small cracks or within goethite and cassiterite grains and is also distributed in contact with wolframite (Plate 17) or between grain of muscovite masses in very small euhedral or subhedral form (0.01 - 0.2 mm) and in very small quantity (Plate 18).

The greatest part of gangue minerals is quartz which comes in two forms, vein quartz and greisen quartz. Other major components are muscovite and beryl but lepidolite, sphene and apatite are also present in small quantities.

Results of chemical analysis of two samples which were originally expected to have relatively high grade among various veins at Pennedaik Mine are shown in Table 8 below.

Table 8   Analysis of Ore Samples Produced at Pennedaik Mine (%)

Sample No.	WO_3	Sn	P	Ca	Mo	SiO_2
No. 56	0.26	0.01	0.019	0.10	0.01	92
No. 57	0.20	0.01	0.004	0.04	0.03	96

4)   Reserves and grade of ore.

The main ore deposits of Mine (I) have been already prospected during the period of English operation and the upper portion has been explored by underground prospecting. For this reason, much cannot be expected from this mine for increased production in the future.

Gravel layers of the prospecting point at Mine (II) are thin and have small depositional surfaces. For this reason, it may be said that there is no possibility of increased production in the future.

5)   Conclusions

Mine (I) consists of tungsten - tin quartz veins with the champion veins having general strike of E-W and dip of 10 - 20 N and showing better development on the periphery of granite, particularly on the side of granite. The known ore shoots have already been mined. Because of the low dip of champion vein system, both prospecting and mining face problems. Although a number of small quartz veins exist almost parallel to one another, their grade is low and the future prospecting is not so attractive.

Mine (II) comprises alluvial deposits and its small reserves and low grade make it less attractive for future prospecting.

Shan Thaye Mine

4-7 Shan Thay Mine

1) Location and access

Shan Thay Mine consists of an alluvial deposit of tin ore located at a point about 15 miles (24 km) southeast of Pyinmana. Shan They can be reached by ferry across the Paunglaung river and by road via Seikphudaung. A distance of 26.2 miles (41.9 km) up to a point 2.6 miles (4.2 km) northeast of Seikphudaung is passable by jeep, but a distance of 0.5 mile (800 m) beyond this point is a steep descent and must be travelled on foot. The total time required is 2 hours and 40 minutes, which are broken down to 2 hours and 20 minutes by jeep and 20 minutes on foot.

2) Geology and ore deposit

The geology of Shan Thay Mine consists of quartz - sericite - schist, mica - schist, and augen gneiss, which are said to belong to Mawchi series of older Paleozoic, of alluvium and based on granite pegmatite intruding these rocks. The strike of metasediments is NS - N 20 E and the dip is 60 - 70°SE.

Ore deposit is an alluvial deposit developed on the border of metasedimens and alluvium and has a thickness of only about 30 - 50 cm. Panning at several points yielded only cassiterite and the existence of wolframite was hardly recognized. The content of cassiterite is small and the rate of collection is also low. Sketches of points A and B are shown in Fig. 23.

3) Ore

Composition of heavy minerals in panning concentrates of gravel containing ore-minerals are shown in Table 9 below.

Table 9 Composition of Heavy Minerals in Gravel Bed at Shan Thay Mine

Mineral	Sample from downstream	Sample from mid-stream	Sample from upperstream
Zircon	+	+	+
Garnet (Almandine)	++	++	+++
Mognetite	++	++	+++
Sphene	<+	<+	<+
Ilmenite	++++	++++	++++
Rutile	+	+	+
Goethite	++	++	+
Cassiterite	+++++	+++++	+++++
Pyrite	<+	<+	<+
Molybdenite	<+	<+	<+
Wolframite	<+	<+	<+
Hematite	+++	++	++
Clinopyroxene	<+	<+	<+

Fig. 23 SHAN THAY MINE

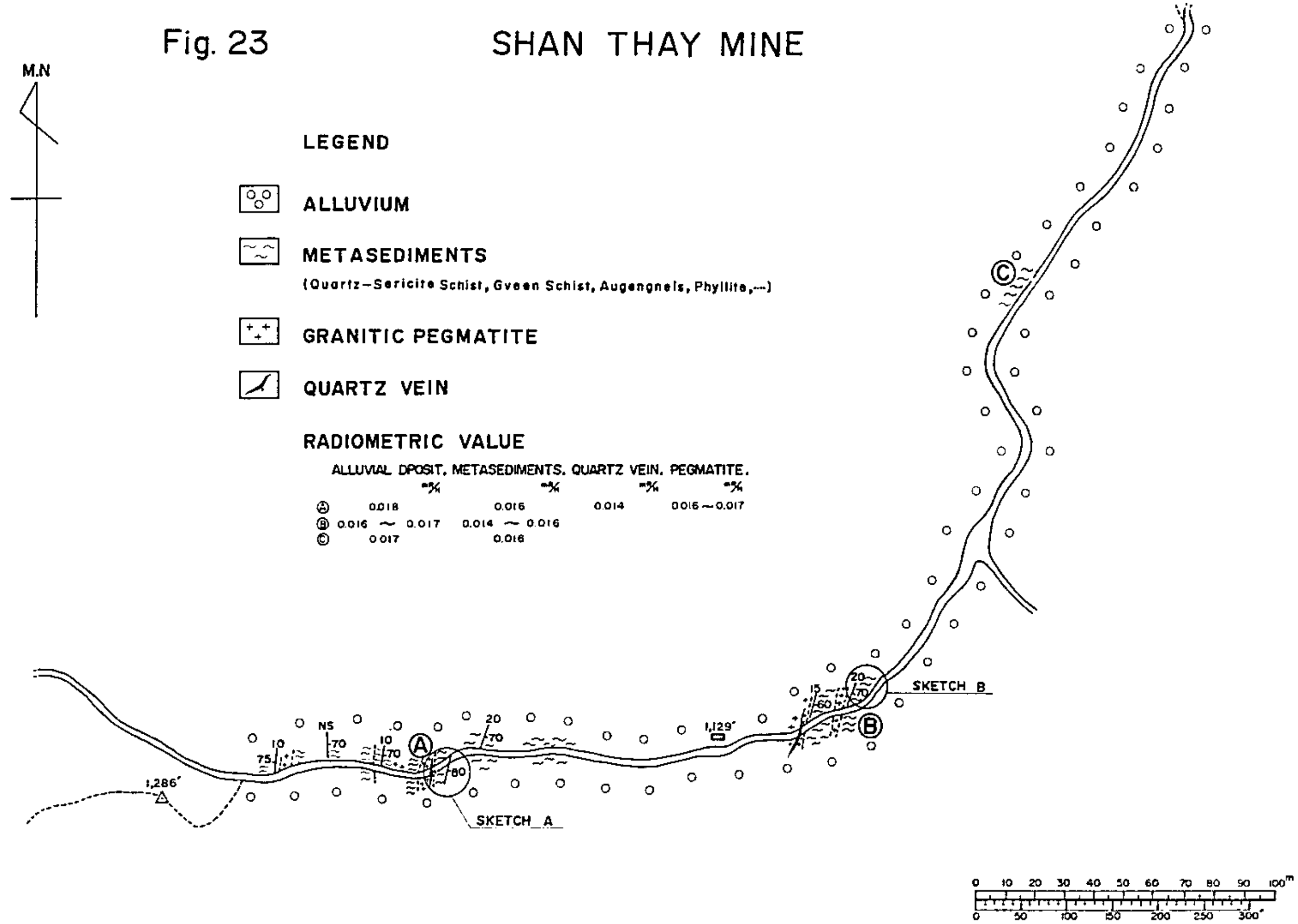
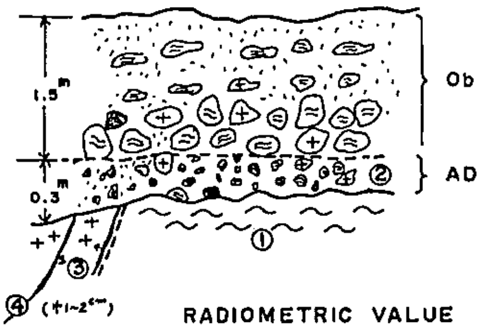


Fig. 24 SKETCH A



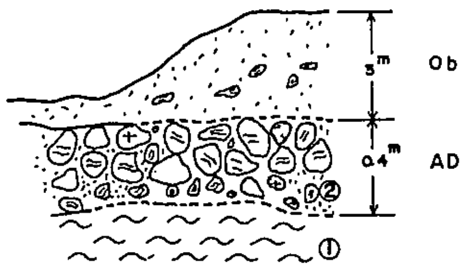
RADIOMETRIC VALUE

① 0.016 mR/H ② 0.018 mR/H
③ 0.017 mR/H ④ 0.014 mR/H

LEGEND

Ob OVERBURDEN
AD ALLUVIAL DEPOSIT
METASEDIMENTS
GRANITIC PEGMATITE
QUARTZ VEIN
PEBBLE OF QUARTZ
PEBBLE OF GRANITIC PEGMATITE
PEBBLE OF METASEDIMENTS

Fig. 25 SKETCH B



RADIOMETRIC VALUE

① 0.014 mR/H
② 0.016 ~ 0.017 mR/H

LEGEND

Ob OVERBURDEN
AD ALLUVIAL DEPOSIT
METASEDIMENTS
GRANITIC PEGMATITE
QUARTZ VEIN
PEBBLE OF QUARTZ
PEBBLE OF GRANITIC PEGMATITE
PEBBLE OF METASEDIMENTS

The grains are moderately rounded and harder minerals show fairly good preservation of external form. Quartz fragments accompanied by euhedral lemon-yellow cassiterite, crystal masses of beryl - muscovite - lepidolite, which are considered to have formed in a greisen body, and small fragments of quartz containing lath-shaped wolframite are recognized as small grains in the previously mentioned panning concentrate. White cassiterite is dominant in this placer ore, followed by that of lemon-yellow and dark brown varieties, as in the case of the placer ore at Padatgyaung Mine. There also is considerable amount of cassiterite of yellow, orange, purplish brown, light-brown, brown or black color. In some cases, a zonal structure comprising stripes of each of these colors is also recognized.

Approximately 85 - 90% of the above mentioned heavy minerals (specific gravity : > 3.3) consists of cassiterite and ilmenite. The largest portion (approximately 95 - 99%) of light minerals mixed in panning concentrates is quartz. Other light minerals are lepidolite, tourmaline, muscovite, amphibole, beryl and apatite.

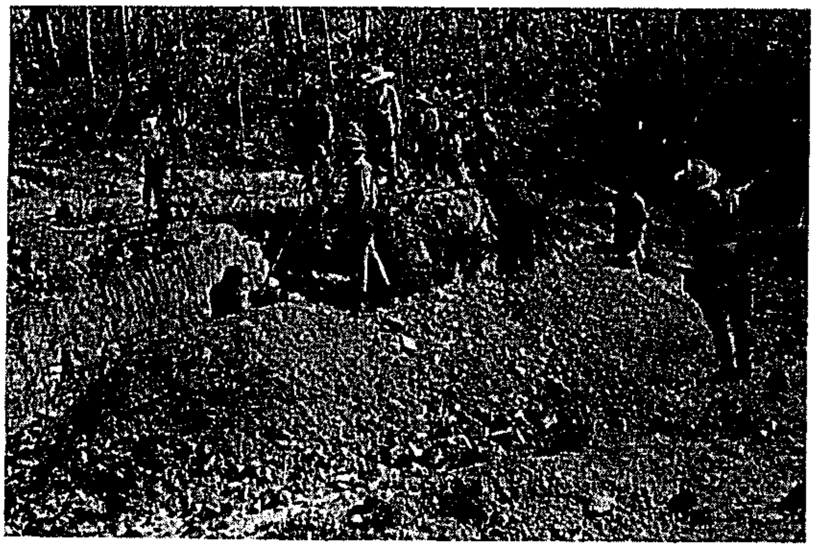
The above facts indicate that the placer tin ore at Shan Thay Mine originated in the gresenized portion of granite or in the cassiterite - (wolframite) - quartz veins in granite or around it.

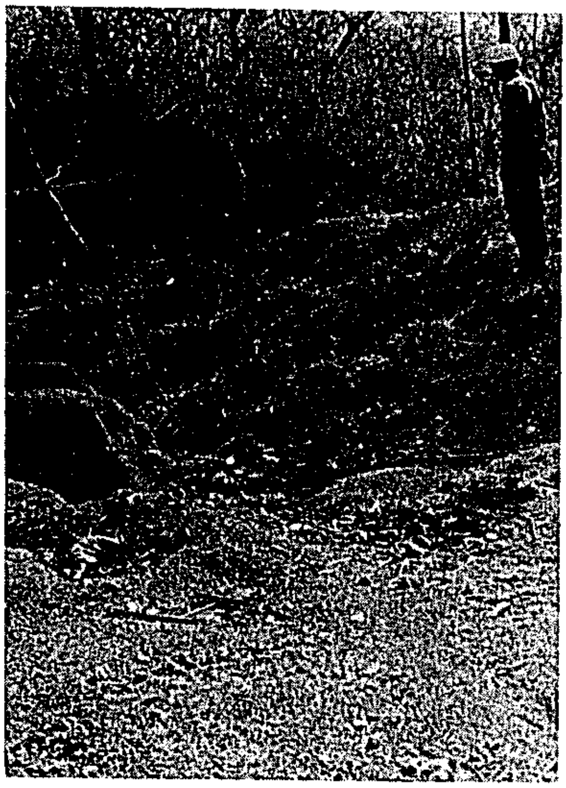
4) Conclusions

Alluvial deposit in the Shan Thay Mine area, because of its limited distribution and low content of cassiterite, is also considered to have a small rate of collection. The granite pegmatite existing in this area is not considered to have any relation with the ore deposit and the origin of this alluvial deposit is considered to exist as exposure further upperstream. It can be said, therefore, that there is room for further prospecting but it is not certain whether any promising ore deposit can be discovered. It is obvious, however, that the area of past operation will not be included in the future development.

Note: In October 1971 Shan Thay Mine produced 50 bis (80 lbs) of concentrate with the grade of tin being 65.44% and that of tungsten 0.29%. This was probably the last operation of the mine.

Thamaye Mine





4-8 Thamaye Mine

1) Location and access

Thamaye Mine is a tin - tungsten mine located approximately 15 miles (24 km) southeast of Pyinmana. Thamaye Mine is accessible from Pyinmana by ferry across the Paunglaung river and by road via Seikphudaung. A distance of 25.4 miles (40.7 km) from Pyinmana to the mine may be covered in two hours and 20 minutes by jeep.

2) History

When this mine was first explored is not known but the latest operation of the mine was suspended in February 1972. The production of concentrate in the years up to the suspension of operation is as follows.

October 1971	220 bis (792 lbs)
November 1971	110 bis (360 lbs)
December 1971	25 bis (90 lbs)
January 1972	5 bis (15 lbs)
February 1972	2 bis (7.2 lbs)

The average grade of concentrates is said to be 3.54% for tin and 59.15% for tungsten.

3) Geology and ore deposit

The geology of the Thamaye Mine area and its neighboring area comprises quartz - sericite schist and mica schist, which are said to belong to the Mawchi series of older Paleozoic. These schists have a strike of N30°- 40°E and a dip of 20 - 30°NW at the point shown in Fig. 26 and a strike of N20 - 40 W and a dip of 30 - 40°S at the point shown in Fig. 27. The relationship between the two points is that the point shown in Fig. 27 is located approximately 110yd (100 m) southeast of the point shown in Fig. 26.

As for the ore deposit, they are tin - tungsten quartz veins occurring almost parallel to the beddings of quartz - sericite schist or mica schist. They often form parallel veinlets of 5 - 20 cm in width in areas 20 - 60 cm wide. Besides, the greater part of it consists of white coarse-grained barren quartz. While the existence of platy wolframite with a thickness of 1 - 2 mm or fine grains of scheelite may be recognized at times, the occurrence of cassiterite is not recognized. The ore shoot runs continuously for only 2 - 3 m and the alteration of the country rock is also very weak. The ore deposit group shown in Fig. 27 corresponds to the lower wall of the ore deposit group shown in Fig. 26.

4) Ore

No metallic minerals other than iron oxides are recognized macroscopically either in the quartz veins or in the greisenized portion near the quartz veins at Thamaye Mine. Under the microscope, however, the existence of a small quantity of fine wolframite and cassiterite is recognized besides secondary iron oxides (limonite) which show colloidal texture (Plate 19).

The greater part of gangue is quartz, followed by muscovite, and a trace of lepidolite, sphene and zircon is also recognized . The quartz is seen in two types. One forms is relatively large crystals that constitutes the main part of metalliferous vein and the other forms relatively small crystals that plays a major role in forming a greisen together with muscovite.

The results of the chemical analysis conducted on the average samples (samples taken from across the vein width) of metalliferous vein show the composition as 0.08% W, less than 0.01% Sn, 0.02% Mo, 0.003% P, 0.12% Ca and 93% SiO_2. The results of spectroanalysis of the same samples show the content of trace components as $n \times 10^{-1}$ % Fe and Mg, $n \times 10^{-2}$ % Al and Mn, $n \times 10^{-3}$ % Bi and Li, $n \times 10^{-4}$ % Ba, Cu, Ga and Pb and $< n \times 10^{-4}$ % of Ag.

5) Conclusions

The operation of Thamaye Mine came to an end after only a small amount of concentrates was produced by trenching after removal of overburden with a bulldozer and underground prospecting by a few short tunnels. The size of ore deposit is very small and the ore shoot extends only several meters in the direction of strike. It is considered, therefore, that this mine cannot be further developed.

Fig. 26

GEOLOGICAL MAP SHOWING DEPOSITS (I)

— THAMAYE MINE —

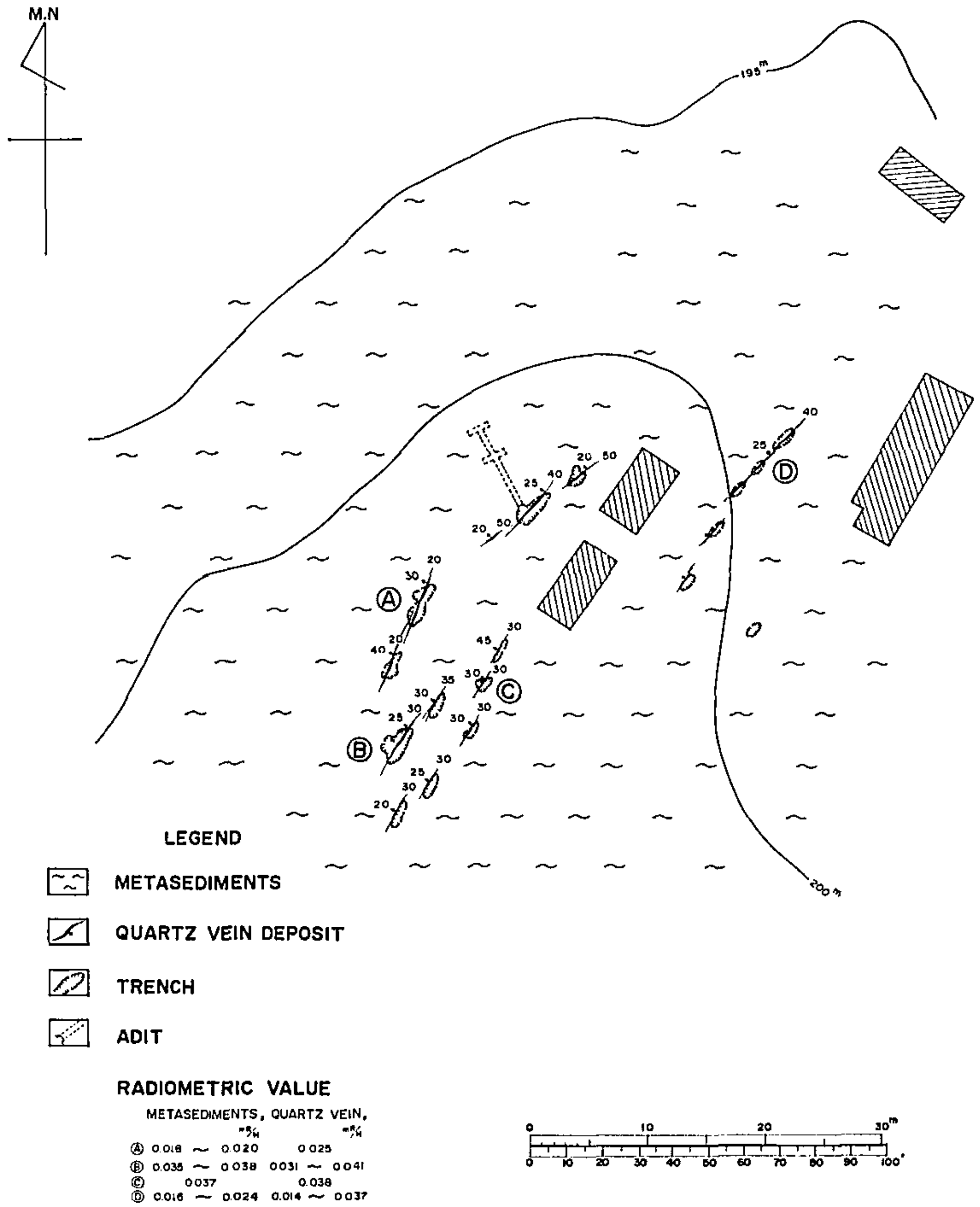
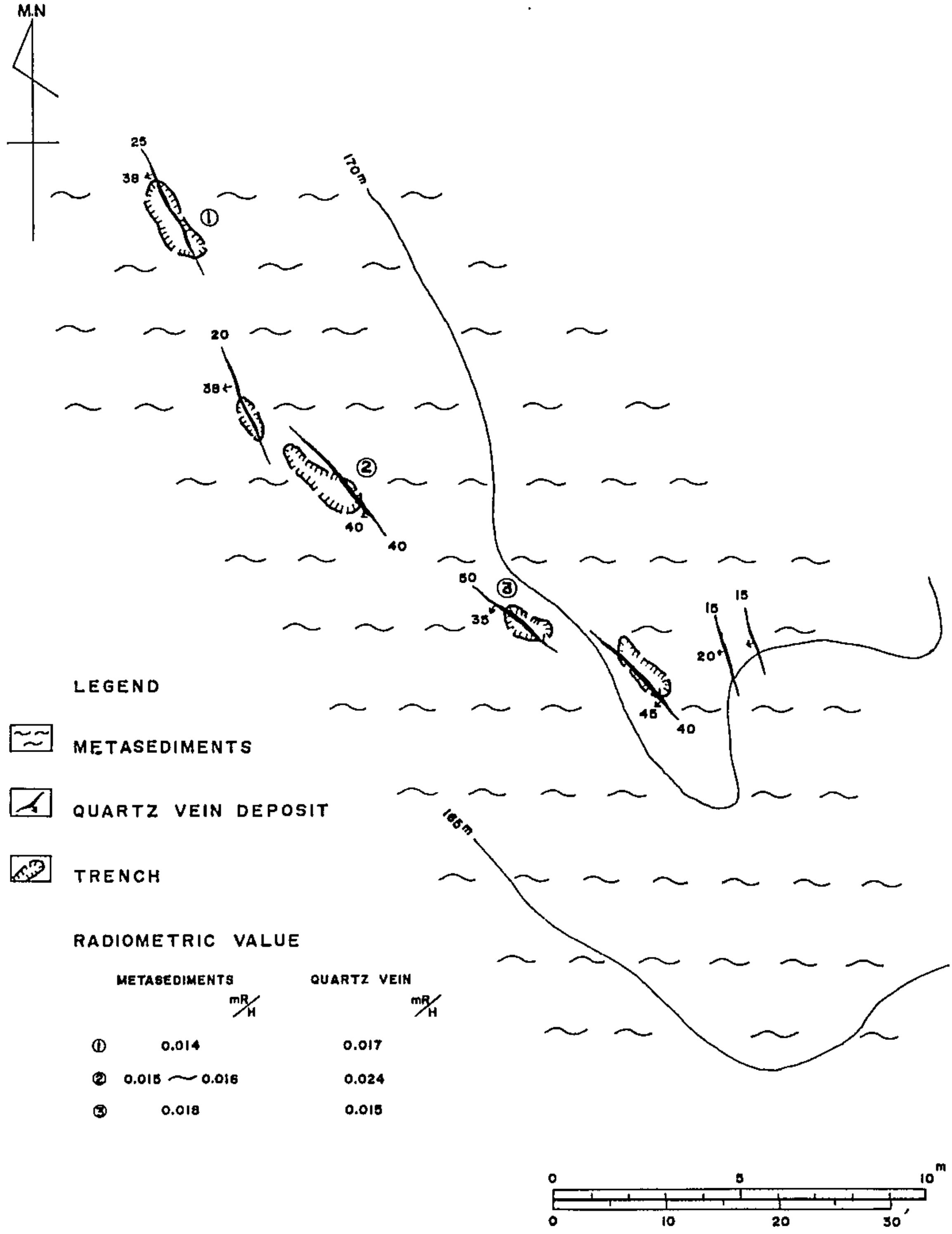


Fig. 27

GEOLOGICAL MAP SHOWING DEPOSITS (2)

— THAMAYE MINE —



4-9 RADIOMETRIC PROSPECTING OF PYINMANA EAST AREA WITH A SCINTILLATION COUNTER

1) Outline of geology and ore deposit

The Pyinmana East Area surveyed consists of widely distributed metasediments belonging to Mawchi series of older Paleozoic age and also has exposures of granite believed to be of late Mesozoic intruding the above metasediments. Overlying these rocks unconformably is a narrow distribution of alluvium and eluvium deposits on the mountain side or in lowland along rivers and streams.

The tin -tungsten ore deposits being mined in this area are alluvial deposits and eluvial de posits formed near the boundary of alluvium or eluvium and basement rocks. The bsement is metasediments and granite. Vein deposits in the granite or metasediments are the source of alluvial and eluvial deposits.

2) Purpose of survey

In order to determine the effectiveness of scintillation survey for the detection of new tin - tungsten ore deposits existing in the Pyinmana East Area and in the development of the mines now being prospected, a preliminary survey was conducted using a TCS-123 Type portable scintillation survey meter developed by the Medical and Physical Science Laboratory of Japan Radio Co., Ltd.

For measurements of the level of radiation, field observations and sketching, special emphasis was placed on the following during the survey.

a) Whether there are any specific features seen in the level of radiation in metasediments, granite, eluvium and alluvium.

b) Whether any difference in the level of radiation according to the type of sedimentary rock, difference in sedimentary environment and the extent of alteration or mineralization recognized in the same rock body is useful for prospecting.

c) Determination of specific features in the level of radiation depending on the type of ore deposit such as vein deposit, eluvial deposit and alluvial deposit and of characteristics of ore shoot, low ore grade portion and barren quartz in relation to the level of radiation.

d) How the measurement, observation and recording should be carried out in the field to avoid difficulty in the interpretation of data since it is very probable that the systematic and appropriate distribution of measuring points is not always possible due to the differences in the duration of survey, condition of each mine and also due to the fact that the ore shoots have already been explored.

3) Adjustment of equipment and method of measurement.

This scintillation survey meter can be adjusted to within the range of 0.010 mR/h - 5.0 mR/h by use of a five-stage transfer.

For background, a value of 0.010 mR/h was selected from several values ranging from 0.009 mR/h to 0.010 mR/h measured on the floor at the Padatgyaung Camp and the standard sample (0.380 mR/h) was stuck fast to the measuring window of the scintillation survey meter and adjusted so that level of its radiation would show 0.390 mR/h. As a result, the value measured in the field always includes the background value of 0.010 mR/h. Besides, the time constant for field measurement was fixed at 8 seconds and the mean of measured values at several neighboring points was used as the measured value of the object at the specific point. Occasionally, there are cases in which radon remains in the old mines, trenches or pits. In such cases, the measured value is sometimes much higher than the level of radiation of the object being surveyed. Special attention was paid to this point during the survey and the measurement of the points where there were possibilities of radon was avoided as much as possible. Yet, it was unavoidable to record some doubtful figures. In each of such cases, re-measurement was made in the atmosphere near the object to ascertain the effect of radon. However, all available data except for extreme cases are given in Table 10.

Some of the alluvial deposits and sedimentary rocks at Pennedaik Mine and Shan Thay Mine showing values of 0.006 mR/h – 0.008 mR/h, which are lower than the background value, were not recorded.

4) Classification of measurement data

Table 10 shows measured values for each mine, selected from among over 300 measured values. It cannot be said, however, that there was appropriate and systematic distribution of measuring points among the seven surveyed areas, namely, No.4 Mine, Steel Mine, Kalatchaung Mine, Padatgyaung Mine, Pennedaik Mine, Thamaye Mine and Shan They Mine.

Because of insufficient data, therefore, it was considered that detailed classification of measured values for specific study would only complicate the procedure and might lead to misinterpretation of the data. Therefore, the following classification was adopted in order to determine the general trend semi-quantitatively in line with the object of this survey.

a) Granite

Granite was divided largey into two groups, G1 and G2.

G1 : Mean value of the levels of radiation presumed to have been added to the original level of radiation in granite in the specific area by the efect of alteration or mineralization.

G2 : Mean value of the levels of radiation presumed to be inherent to granite in the specific area.

b) Greisen

Greisen was divided largely into two groups, GS1 and GS2.

GS1 : Mean value of the levels of radiation in greisen which is presumed to have been subjected to relatively strong greisenization in the specific area.

GS2 : Mean value of the levels of radiation in greisin which is presumed to have been subjected to relatively moderate greisenization.

c) Vein deposit

Vein deposit was divided largely into two groups, V1 and V2.

V1 : Mean value of the levels of radiation in ore shoots usually containing wolframite, scheelite and cassiterite and occasionally molybdenite.

V2 : Mean value of the levels of radiation in barren quartz or low ore grade portions.

In terms of gangue, white or milky-white, coarse-grained quartz may be considered to come under V2 group and white or grey medium-grained quartz (Loose quartz or vein quartz which is considered to possess remnant textures of the country rocks may be included in part) can be considered to come under V1 group.

d) Alluvial deposits.

Because of the fact that the data was limited to Padatgyaung Mine and Shan Thay Mine and that the number of measuring points was small compared with the extent of area, it was not possible to determine the trend as close as that of the vein deposits. However, the deposits were also divided largely into two groups, AD1 and AD2.

AD1 : Mean value of the levels of radiation in the deposit located close to the eluvial deposit of granite zone or in the deposit having similar gravel composition.

AD2 : Mean value of the levels of radiation which are considered to be inherent to alluvial deposit in the specific area.

e) Eluvial deposit

Since the level of radiation in the eluvial deposits is considered to vary greately because of the value of igneous bodies distributed in the area, it was meaningless to attempt classification of this type under the existing condition of this survey. Accordingly, the mean value of the levels of radiation is given under one category - ED, for reference.

f) Metasediments

As the level of radiation showed almost constant values in the survey area, the values obtained are indicated by symbol MS.

g) Soil

Almost constant values were always obtained despite a fewer number of measuring points. The mean value is indicated by symbol S.

5) Analysis of data

Fig. 28 may be summarized as shown in Table 10 with the following results.

a) Vein deposit areas

The level of radiation in vein deposit areas is always highest in granite and declines in greisen, vein deposit, metasediments soil in that order. A comparison of G1, GS1 and V1 groups with G2, GS2 and V2 groups shows that the former has higher levels of radiation than the latter, and that between groups, granite gives the highest and vein deposits the lowest level.

Although the metasediments may give high values within the range of a few centimeters from the contact with granite, greisen and vein deposits on rare occasions, it always gives the level of raditian that is lower than that of V2 group and shows a stable tendency (approximately 0.016 mR/h).

Between the six mines, the group of Steel Mine, Padatgyaung Mine and Pennedaik Mine shows a higher level of radiation than the group of No. 4 Mine and Kalatchaung Mine. Ore deposits in the metasediment area such as Thamaye Mine has a tendency to show even smaller values. The level of radiation in the granite zone such as the highly radioactive zone at Steel Mine exceeds the original level by 0.008 mR/h - 0.013 mR/h when subjected to alteration and mineralization. In the low radioactivity zone such as Kalatchaung Mine the increase is only 0.004 mR/h - 0.007 mR/h. In the metasediment areas what may be considered to be the alteration related to mineralization is hardly seen and where it exists on rare occasions, the size is only a few millimeter to a few centimeters with the increase in the level generally being within the range of measuring error. The foregoing is the general tendency of country rocks, but as far as the vein deposits are concerned, the difference in the level of radiation between V1 and V2 is in the order of 0.010 mR/h irrespective of the variation in country rock. As it is evident from the above fact, it seems to have a fairly stable tendency in the mean value of its radiation.

b) Eluvial deposits

Due to the fact that its existence is limited to the Padatgyaung district with the resultant limit in the number of measuring points and that the greater part of the deposit is located close to a granite exposure zone, the mean value is 0.025 mR/h which is close to the value obtained in G2.

c) Alluvial deposits

Alluvial deposits with the exception of those existing very close to eluvial deposits and those which have granite as their base shows a fairly constant level of radiation in the range of 0.014 mR/h - 0.016 mR/h.

d) Granitic pegmatite

The pegmatite intruding almost parallel to the bedding of metasediments recognized in the Shan Thay area shows such a low reading as 0.017 mR/h even after repeated measurement. It is difficult, therefore, to determine whether it is a part of granite closely related to vein deposits or it is the one with a completely different episode of intrusion unless extensive geological surveys are conducted.

e) Distribution and the level of radiation of vein deposits in the granite zone.

Starting from north the mines are distributed in the order of No. 4 Mine, Steel Mine, Kalatchaung Mine, Padatgyaung Mine and Pennedaik Mine. In terms of the level of radiation, mines with high levels of radiation and those with low levels of radiation are aligned alternately. From this, the question arises as to whether the area including Padatgyaung and Pennedaik should be regarded as an extensive high radiation zone or whether there is a low radiation zone equivalent to Kalatchaung Mine between these two mines. Similarly, as the northern section of Padatgyaung Mine seems to transform into low radiation zone gradually, it is not certain whether there is a high radiation zone like Steel Mine undetected between Padatgyaung Mine and Kalatchaung Mine.

6) Conclusions

In conducting scintillation surveys for prospecting and exploration of tin - tungsten ore deposits in the Pyinmana East Area it is essential to divide the survey largely into two types, preliminary survey and detailed survey.

a) Preliminary survey

The preliminary survey conducted this time is not considered sufficient due to various restrictions. If a survey is conducted by systematically selecting measuring points according to the field conditions, more valuable data useful for delineating the range of potential vein deposits in the granite zone will be obtained. This method, however, is not considered suitable for prospecting of vein deposits in the alluvial deposits, eluvial deposits and metasediments. On the other hand, there arises the question as to whether the granite pegmatite should be simply regarded as a part of granite closely related to ore deposit as in the case of Shan Thay Mine. The method, therefore, is considered highly effective for an extensive survey of the source of alluvial deposit for classification of igneous rocks.

b) Detailed survey

Although it is possible to predict the size of vein deposit, extent of alternation and type of rocks from the measured values of the granite zone, it is essential for that purpose to select measuring points systematically and gather accurate observation data on each occasion corresponding to the progress of prospecting and exploration while providing sufficient time for the compilation of data, otherwise it is very probable to reach erroneous conclusion. Tracing from alluvial deposits to eluvial deposits and further to residual deposits in pursuit of vein deposits with high potentialities is far more difficult than prospecting of granite zone and requires more data.

As the level of radiation decreases in inverse proportion to the square of measuring distance, special care must be taken to avoid interposition of soils or overburden, otherwise analysis of data will be extremely difficult and further classification of data suitable for detailed survey will be impossible.

In short, scintillation survey will be useful to the extent that it provides information on prospecting as to the possibilities of the existence of a high radiation zone like the Steel Mine between Padatgyaung and Kalatchaung Mines in the granite zone and low radiation vein deposits like the No. 4 Mine between Padatgyaung and Pennedaik Mines.

Table 12 Results of radiometric survey

PADATGYAUNG MINE (①; Ref. Fig. 6)

Locality	Alluvium	Placer	Eluvium	Eluvial deposit	Metasediments	Greisen	Quartz vein	Granitic rocks	Remarks
	mR/H	mR/H	mR/H	mR/H	mR/H	mR/H	mR/H	mR/H	
①					0.018	0.030	0.017-0.025	0.037-0.040	Vein width 50 cm minute crystals of wolframite and cassiterite in the hanging wall.
②	0.034-0.053								Arkose sands and granitic pebbles.
	0.034-0.037								Mainly granitic pebbles. 0.035-0.036 mR/H for greisen pebbles.
		0.030-0.034						0.037-0.038	Eluvial deposit. Granitic basement. 0.034-0.037 mR/H for panned concentrates.
③						0.027-0.031	0.015-0.019 0.025-0.029	0.027 0.030-0.032	Vein width 100 cm. 20-30 cm from the vein greisenized & contains many large wolframite crystals and also some cassiterite.
④			0.021-0.024	0.021-0.024					Majority of pebbles granitic and quarty. Concentrate (W:Sn = 2:1) 0.020 mR/H.
⑤	0.024	0.022			0.020				Many barren veinlets in schist.
⑥	0.010-0.019	0.017-0.022			0.018				0.030 mR/H in parts rich in grainitic pebbles and sand.
⑦							0.015-0.020	0.023-0.028	Low grade, barren guarty.
						0.025-0.028	0.021-0.026	0.025-0.030	Concentration of small veinlets in granite.
						0.026-0.030	0.027-0.028	0.033-0.035	Deposit cosist of aggre gate of quarty veinles in greisen. Minute grains of wolframite scattered.
						0.020-0.024	0.016-0.026	0.030-0.032	Wolframite observed near the walls.
						0.021-0.022	0.018-0.019	0.022-0.026	
⑧				0.030-0.037		0.026-0.036	0.014-0.016	0.030-0.040	High due to larger content of granite pebbles in residual deposits.
						0.029-0.038	0.026-0.030	0.032	Minute wolframite crystals in parallel veinlets.
						0.037	0.021-0.024		
						0.030-0.035	0.027-0.028	0.030-0.037	Many wolframite grains in veinlets.
						0.026	0.014-0.016		Barren veinlets.
						0.036	0.030	0.042	Minute wolframite crystals nears the wall.
						0.025-0.031	0.017-0.026	0.029-0.034	Vein width 60 cm, abandoned adit, wolframite concentrated near the hanging wall. 0.017-0.019 mRH for barren quarty.
						0.021-0.025	0.014-0.019	0.024-0.029	

(9)						0.029	0.027	0.035	Veinlet 2 m within the foot wall, minute pyrite grains.
						0.027	0.024	0.030	"
						0.030-0.034	0.024-0.032	0.034-0.036	Veinlet, include pyrite and wolframite.
						0.029	0.025-0.028	0.033	
(10)				0.020-0.025				0.030	8 measurements in a distance of 40 m near residual deposit. Wolframite not recognized, many coarse-grained crystalline quarty pebbles.
(11)				0.019-0.024					7 measurements.
(12)			0.014-0.022					0.024	12 measurements.
			0.010(Soil) 0.024-0.025	0.016-0.026					Higher than 0.022$^{mR/H}$ for pebbles with wolframite.
(13)			0.022-0.025	0.015-0.016		0.022	0.015	0.025	Greisen of quarty pebbles, 0.015-0.016 are barren quarty pebbles.
						0.029-0.030	0.026-0.027	0.032-0.033	2 veins of 15 and 20 cm in width within 3 m.
(14)	0.012(Soil)			0.018-0.023	0.015-0.016				
(15)	0.012(Soil) 0.013(Sand)	0.014-0.016			0.015				Basement close to granite, high radio activity for granite and greisen pebbles and low for quarty pebbles.
(16)		0.013-0.014			0.015				Amount of granitic pebbles relatively small.
(17)	0.013(Soil)	0.016			0.015				"
(18)	0.014	0.019							Alluvium; medium-five grained. 5-10 cm pebbles in deposit.
(19)	0.015(Soil) 0.017-0.019	0.017-0.019			0.015				Wolframite ⩽ cassiterite for panned concentrates.
(20)	0.013(Soil) 0.012-0.014	0.014-0.018			0.013				Wolframite < cassiterite for panned concentrates.
(21)	0.015-0.020	0.017-0.019			0.014-0.015				Panned concentrate almost all cassiterite.
(22)		0.015-0.018			0.013-0.015				"
(23)	0.024	0.018-0.019			0.020				Amount of granitic pebbles and sands increases.
(24)	0.023-0.025				0.019				Basement argillized mica-schist?
(25)	0.018	0.020			0.017				Wolframite < cassiterite for panned concentrates.
(26)		0.017-0.019			0.013-0.015				
(27)		0.020			0.016				
(28)	0.018	0.019			0.018				Minute grains of chalcopyrite and pyrite in silicified boulders.
(29)	0.022	0.021			0.021				

STEEL MINE (①; Ref. Fig. 6)

Locality	Alluvium	Placer	Eluvium	Eluvial deposit	Metasediments	Greisen	Quartz vein	Granitic rocks	Remarks
①	mR/H	mR/H	mR/H	mR/H	0.016 mR/H	0.020 mR/H	0.019 mR/H	0.020 mR/H	Vein width 5-10 cm.
						0.027-0.028			Greisenization intense for 50 cm width, Barren quarty veinlets.
						0.040-0.042	0.028		Quarty veins (2-3 cm wide) in greisen. Some minute wolframite grains.
					0.014	0.027-0.028	0.027		Quarty veins (4-5 cm) in greisen, barren by unaided eyes.
					0.015	0.039-0.040	0.036		Probably the reading of greisen, because of the many thin quarty veinlets in 30 cm width. 0.026 of the sediments is probably due to silicification.
②						0.040	0.029	0.038-0.043	Vein 30 cm wide. Scheelite scattered near wolframite.
						0.032-0.034	0.026	0.036	50-70 cm wide vein, ore shoot.
						0.035-0.038	0.028	0.037-0.040	"
						0.034	0.021	0.027	Veinlets in abandoned adit(?). 1-3 mm wolframite observed.
③					0.015	0.025-0.027	0.020		Veinlet.
					0.013	0.027	0.015-0.016		Aggregate of veinlets in 30-120 cm zone.
						0.024	0.016		Block?
					0.014	0.026	0.015		Barren veinlet.

NO. 4 MINE (①; Ref. Fig.)

Locality	Alluvium	Placer	Eluvium	Eluvial deposit	Metasediments	Greisen	Quartz vein	Granitic rocks	Remarks
①					0.016	0.016-0.024	0.015-0.020	0.022	2 veins (10 and 60 cm wide). Minute wolframite and scheelite observed, at places only pyrite observed.
					0.018	0.022	0.020-0.021	0.026	Aggregate of veinlets in 30 cm zone of greisen.
②					0.013-0.014	0.026	0.012-0.023	0.026-0.030	Veinlet include minute wolframite grains.
					0.013-0.014		0.016-0.018		Several veins in echelon arrangement in 150 cm distance.
③					0.011-0.017	0.018	0.017-0.020		Aggregate of veinlets in 100 cm distance. (0.030mR/H in wolframite concentrated parts)
						0.019	0.018	0.021	Barren veinlet.
					0.019	0.029	0.012-0.031	0.032	0.031mR/H in parts where wolframite and cassiterite observed.
④						0.022-0.029	0.024	0.028	Wolframite observed in minute quantity. Vein width 25 cm.
					0.014	0.020		0.024	
						0.025-0.027	0.021-0.024	0.027-0.029	Mineralized zone 15 and 20 cm wide occurs paralled within 100 cm.
⑤						0.021	0.014	0.025	Wolframite, cassiterite, molybdenite, Bi-mineral(?) observed in quarty-rich portion near the wall, greisenized, 0.030mR/H.

THAMAYE MINE

THAMAYE MINE (1) (Ⓐ; Ref. Fig. 6)

Locality	Alluvium mR/H	Place mR/H	Eluvium mR/H	Eluvial deposit mR/H	Metasediments mR/H	Greisen mR/H	Quartz vein mR/H	Granitic rocks mR/H	Remarks
Ⓐ					0.018-0.020		0.025		Vein width 30 cm, minute wolframite grains observed
Ⓑ					0.038 0.035		0.040-0.041 0.031-0.035		0.030-0.040 mR/H in air of the adit Rn effect.
Ⓒ					0.037		0.038		"
Ⓓ					0.017		0.014		Barren quarty veins 1-4 cm wide.
					0.024		0.025		Strongly altered for several cm, veinlets, wolframite observed in hanging wall.
					0.016		0.014		Barren quarty veinlets.
					0.023		0.037		Strongly altered for several cm, vein width 10-13 cm Wolframite grain scattered.

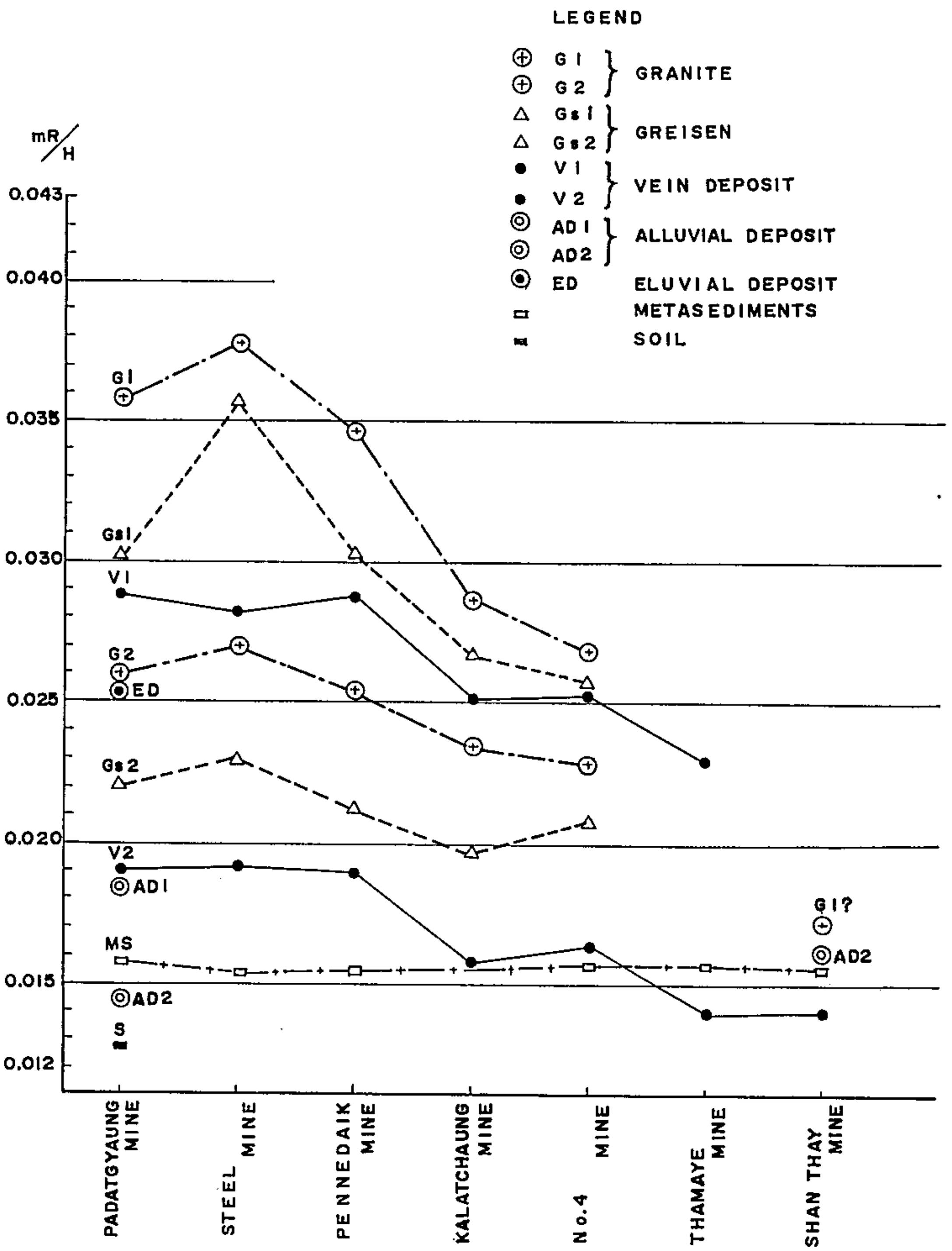
THAMAYE MINE (2) (①; Ref. Fig.)

Locality	Alluvium	Place	Eluvium	Eluvial deposit	Metasediments	Greisen	Quartz vein	Granitic rocks	Remarks
①					0.014		0.017		Barren quarty vein 10-20 cm wide.
②					0.015-0.016		0.024		Vein width 70 cm, small amount of wolframite in foot wall.
③					0.018		0.015		Barren quarty vein 40 cm wide.

Locality	Alluvium	Placer	Eluvium	Eluvial deposit	Metasedi-ments	Greisen	Quartz vein	Granitic rocks mR/H	Remarks
	P E N N E D A I K M I N E (Ⓐ; Ref. Fig. 6)								
	mR/H	mR/H	mR/H	mR/H	mR/H	mR/H	mR/H		
Ⓐ						0.020	0.029	0.025-0.028	4 m from adit entrance.
						0.030	0.033-0.034	0.035	Many wolframite grains, 4-9 m from adit entrance, Rn effect.
					0.027				15 m from adit entrance. Rn effect.
					0.016		0.022		25 m from adit entrance.
Ⓒ						0.035	0.027		10 m from adit entrance. Rn effect.
						0.034	0.025		15 m from adit entrance. Rn effect.
						0.024	0.021		18 m from adit entrance.
Ⓓ						0.020	0.014		8-10 m from adit entrance. Scheelit observed in ceiling.
						0.032	0.026		13 m from adit entrance. Rn effect.
					0.015	0.022	0.014-0.026		15-16 m from adit entrance.
Ⓔ						0.029	0.027	0.033-0.036	Wolframite and cassiterite observed in greisen.
	S H A N T H A Y M I N E (Ⓐ; Ref. Fig.)								
Ⓐ		0.018			0.016		0.014	0.016-0.017	Several readings for pegmatitic granite. Reddish brown barren quarty veinlets observed.
Ⓑ		0.015-0.017			0.014				
Ⓒ		0.016			0.016				
	K A L A T C I I A U N G M I N E (Ⓐ; Ref. Fig.)								
A						0.030-0.031	0.023-0.026	0.032-0.034	Aggregate of parallel veinlets in 10-15 cm minute crystals of wolframite and cassiterite.
Ⓑ						0.024-0.025	0.021 0.012-0.014	0.027	
Ⓒ						0.020	0.018	0.023-0.024	
Ⓓ						0.018-0.025	0.014-0.015	0.022-0.030	Aggregate of veinlets.
						0.030	0.027	0.032	Wolframite, cassiterite and pyrite observed.

Fig. 28

RELATION BETWEEN RADIOMETRIC VALUE TO DIFFERENT ROCK TYPES



4-10 Scheelite in the concentrates of each mine

Average contents of scheelite in concentrates from each of Padatgyaung Mine, No. 4 Mine, Steel Mine and Taguntaung Mine (See Fig. 11) and the content of various constituents of the concentrates from Taguntaung Mine, both stored at MDC's Padatgyaung base, are shown in Table 11 and Table 12 .

Table 11 Scheelite Contents (Actual value in separation) in Concentrates

Name of mine	Average contents(%)	Ratio to wolframite(%)
Padatgyaung mine	Neglisible	-
No. 4 mine	0.20	0.8
Steel mine	0.25	0.9
Taguntaung	1.20	3.0

Table 12 Analysis of Concentrates from Taguntaung Mine (%)

Nb	Ta	Zr	Th	P	W	Sn
0.08	≦0.01	1.03	0.09	0.03	42.3	13.5
S	Cu	Mo	Bi	B	Be	Ca
0.32	0.009	0.36	0.58	0.26	≦0.01	0.25

As is evident from the above Table, the average content of scheelite in concentrates from Taguntaung Mine is higher than that from other three mines (Seven mines with the addition of Kalatchaung, Pennedaik, Shan Thay and Tamaye mines when the results of field survey are taken into consideration) and it is five times greater than that of Steel Mine which was considered to have the highest scheelite content among the seven mines. The value of average content itself should not be ignored either.

It is advisable, therefore, to employ non-mixture treatment for ore separation at the mine. Since the content of Zr and Bi is comparatively high as shown in the table of analysis and they exist in the form of zircon and bismuthinite, it is advisable to plan recovery of these elements at the same time. One of the features of concentrates from Taguntaung Mine is that Th occurs as monazite and shows a considerably high reading of radioactivity 0.1 mR/h. Recovery of this monazite is also one of the problems to be given further consideration.

References

1) Brown, J.C. (1924) : A geographical classification of the mineral deposits of Burma : Rec. Geol. Surv. India, v. 56.

2) Chibber, H.L. (1934) : Geology of Burma : London.

3) Chibber, H.L. (1934) : The mineral resources of Burma : London.

4) Chibber, H.L., translated by Nanyo Kyokai (1942) : Mineral Resources of Burma, Nihon Hyoron Sha. (in Japancese).

5) Kinoshita, K (1944) : Minerals and Mining in Southern Areas. Ida Shoten (in Japanese).

6) Krishnan, M.S. (1949) : Geology of India and Burma : Madras.

7) Institute of Developing Economies ed. (1962) : Resources structure of Southeast Asia. (in Japanese).

8) Muraoka, M. (1962) : Mining in the Union of Burma - with Special Reference to antimony. Mining Geology v. 12, No. 54 (in Japanese).

9) Mineral Resources of Burma. (2 volumes) (in Japanese).

10) U Aung Khin and U Kyaw Win (1968) : Preliminary studies of the paleogeography of Burma during the Cenozoic : Union of Burma Journal of Science and Technology, v. 1. No. 2.

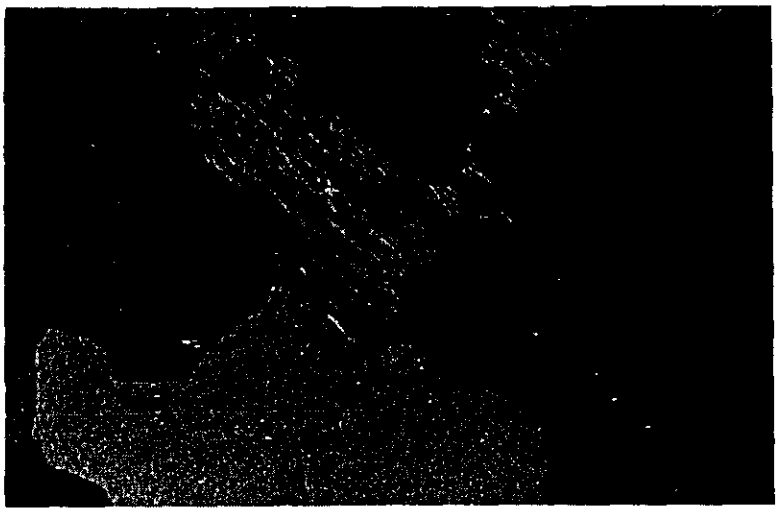
11) Maung Thein and Ba Than Haq (1969) : The prepaleozoic and paleozoic stratigraphy of Burma — a brief review : Union of Burma Journal of Science and Technology, v.2, No.3.

12) Ohmachi, H., et al (1971) : Report on Preliminary Survey for Mineral Resources in the Republic of Burma. Overseas Technical Cooperation Agency.

13) Ohmachi, H., et al. (1971) : Recent Mining Activities in the Union of Burma. Sekai Keizai Shuho, Nov. issue. (in Japanese).

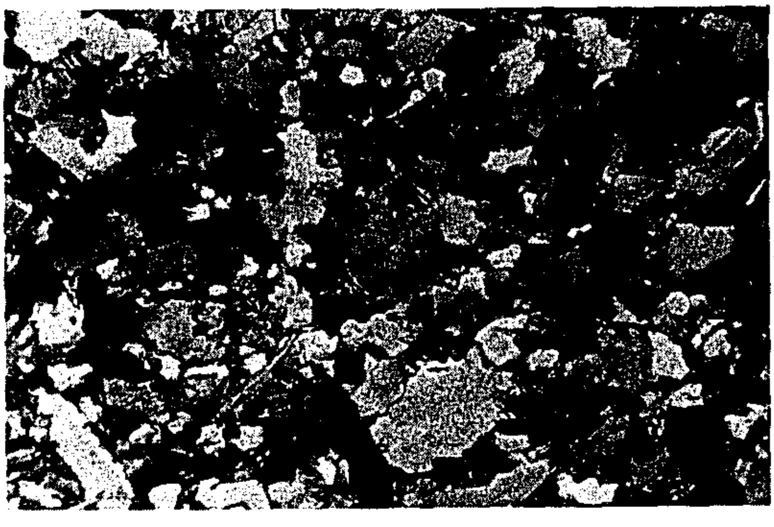
14) Government of the Union of Burma (1972) : Report to the people on the financial, economic and social conditions : Rangoon.

Plate 1. Photograph of biotite-granite, Located
Paunglaung river-side, under microscope



0 2 mm : cross nicols

Plate 2. Photograph of quartzite in Mawchi Series
under microscope



0 0.5 mm : cross nicols

Plate 3. Photograph of greywacke in Mawchi Series under microscope

0 2mm : open nicols

Plate 4. Large crystal of wolframite in quartz vein, No. 4 Mine

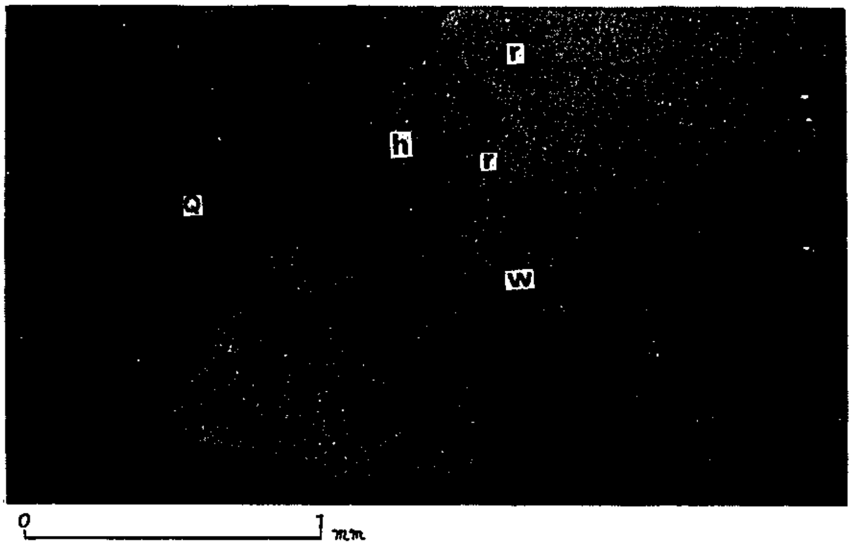
Field photograph

W: wolframite

Q: quartzite

Plate 5. Wolframite, replaced by hematite, No. 4 Mine

Reflected photograph



W: wolframite

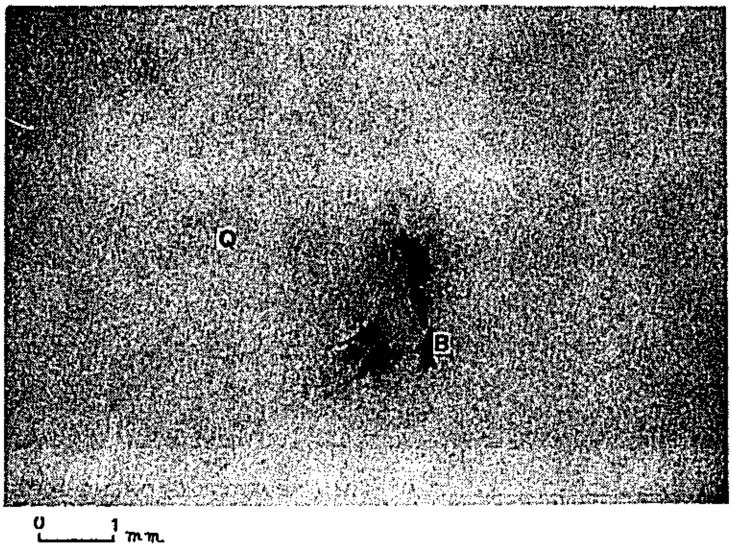
h: hematite

r: reaction unknown-mineral

Q: quartz

Plate 6. Bismuthinite in small cavity of quartz-vein, No. 4 Mine

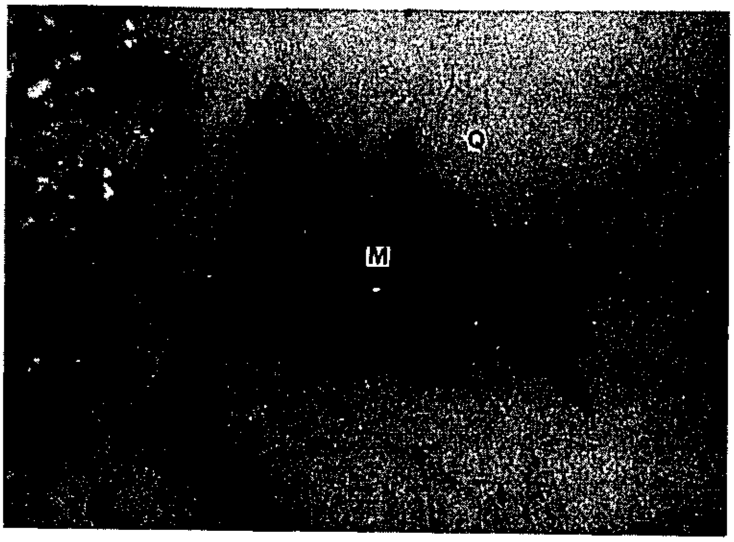
Magnified photograph of polished section



B: Bismuthinite

Q: quartz

Plate 7. Molybdenite in quartz-vein, Steel Mine



0 1 mm

Magnified photograph of polished section

M: Molybdenite

Q: quartz

Plate 8. Cassiterite with zoning textures, Steel Mine

0 1 2 mm Thin section: crossed nicols

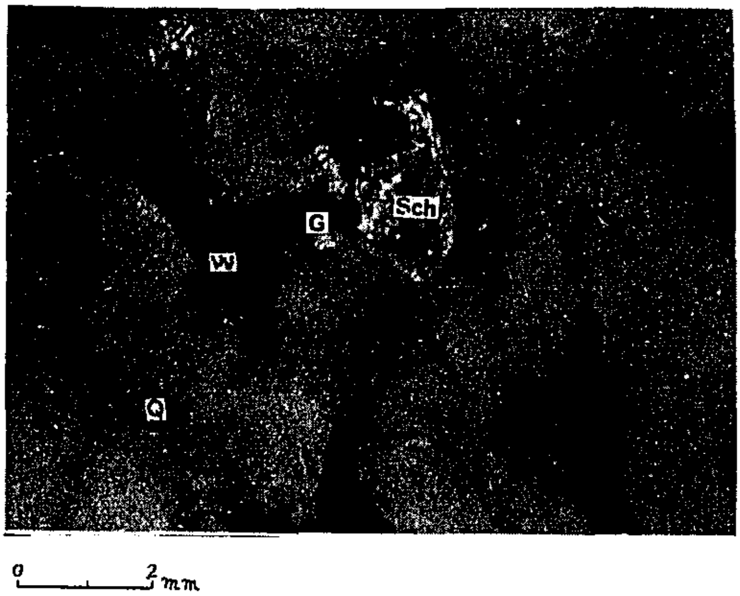
C: zoning part of cassiterite

Q: quartz

M: muscovite

Plate 9. Scheelite and wolframite of polished section, Karatchaung Mine

A. Magnified photograph of polished section



W: wolframite

Sch: Scheelite

Q: quartz

G: Goethite

B. Reflected photograph: // el nicols

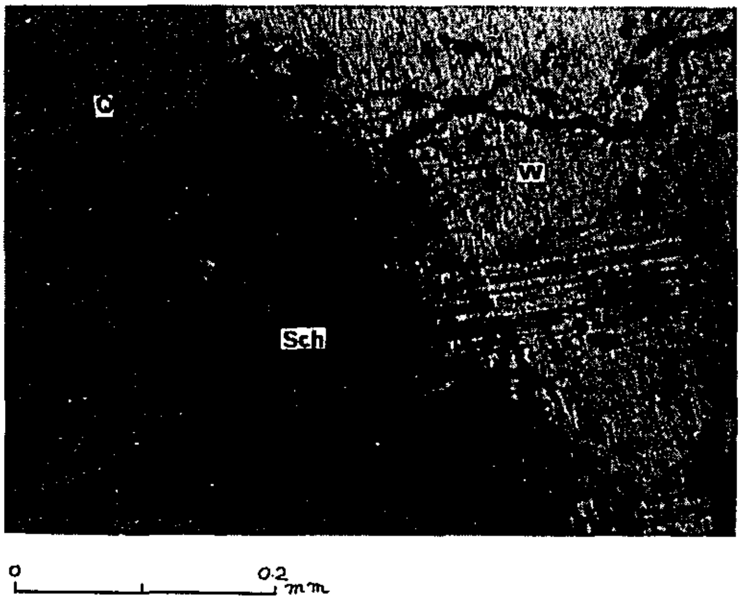
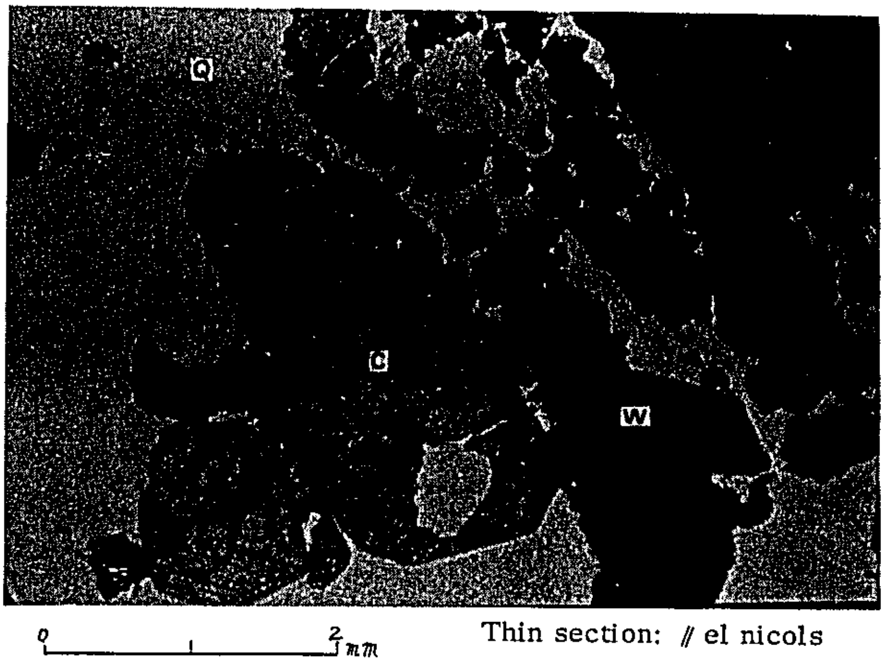


Plate 10. Cassiterite with wolframite of Karatchaung Mine under microscope



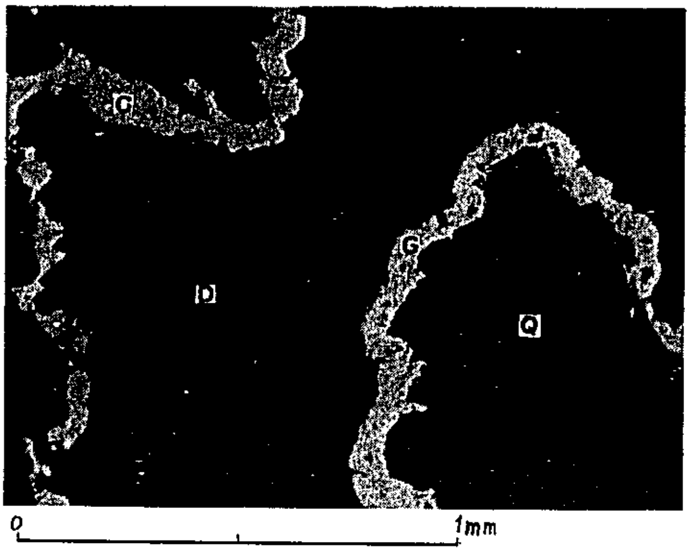
Thin section: // el nicols

C: cassiterite

W: wolframite

Q: quartz

Plate 11. Goethite of cavity-wall under microscope, Karatchaung Mine



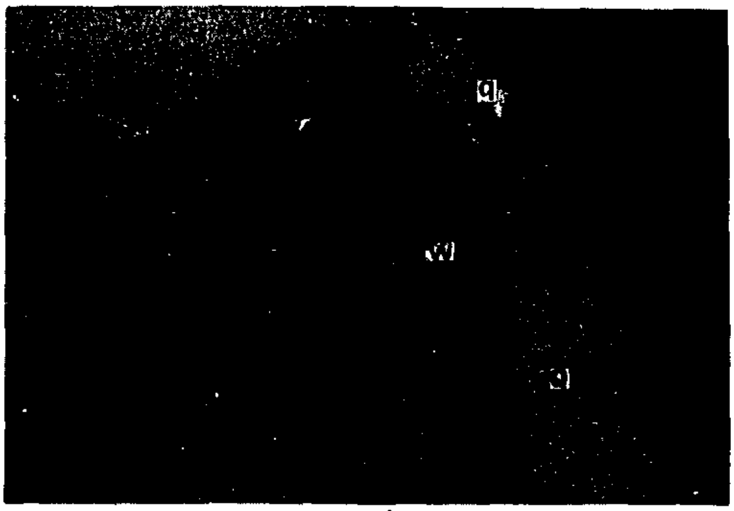
G: goethite

Q: quartz

D: Cavities

Photograph of reflection by polished section: // el nicols

Plate 12. Wolframite in quartz-vein



0 1 cm

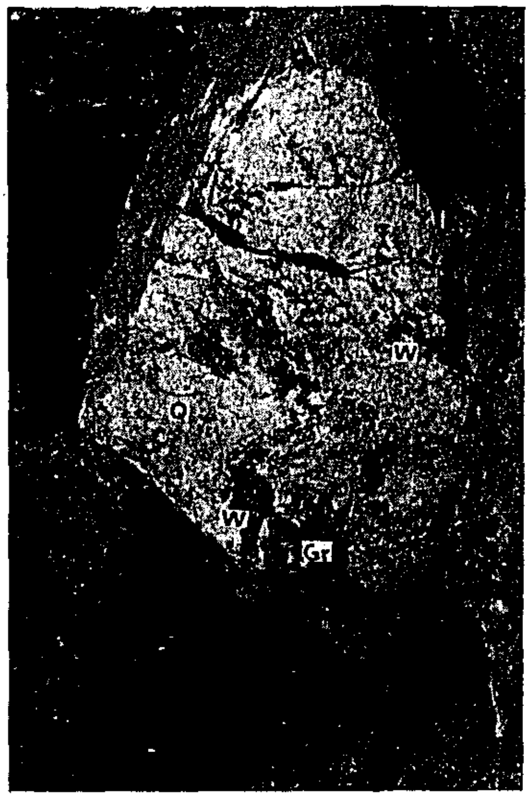
Magnified photograph of polished section

W: wolframite

Q: quartz

q: reflection by cleavage of quartz

Plate 13. Wolframite-quartz vein at No. 7 point of Padatgyaung Mine



0 50 cm

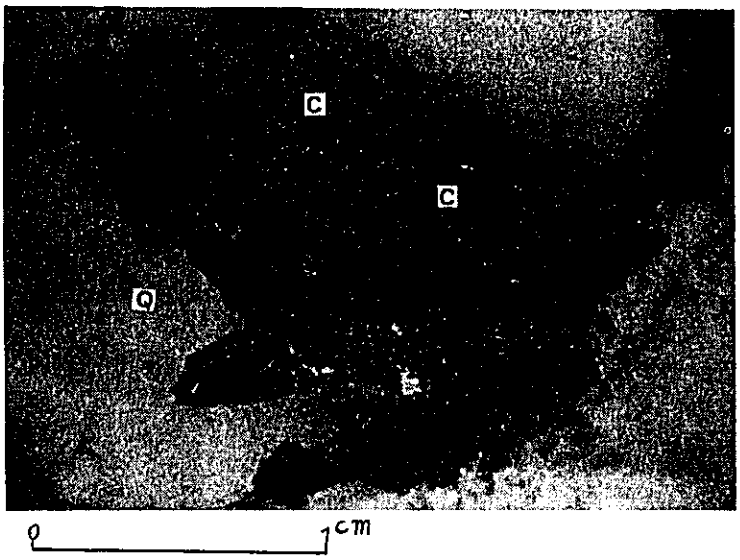
Field photograph

W: wolframite

Q: quartz

Gr: greisen

Plate 14. Cassiterite in quartz-vein, at Padatgyaung Mine

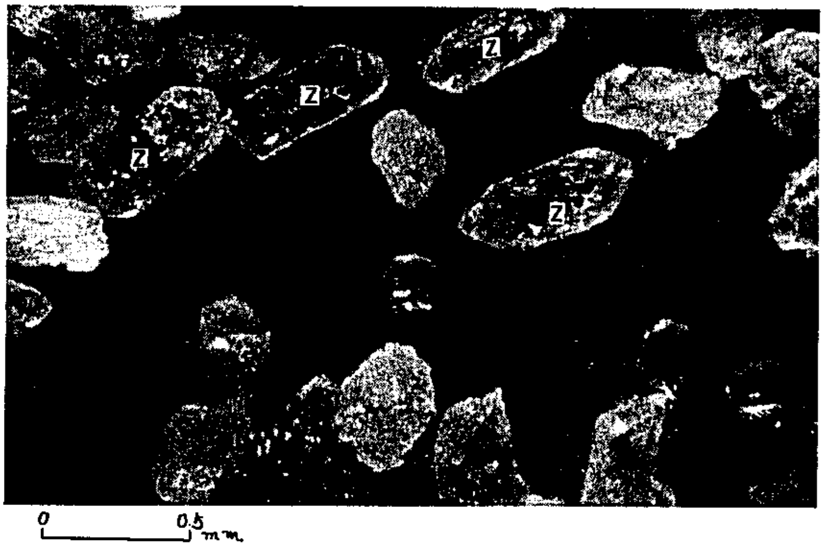


Magnified photograph of polished section

C: cassiterite

Q: quartz

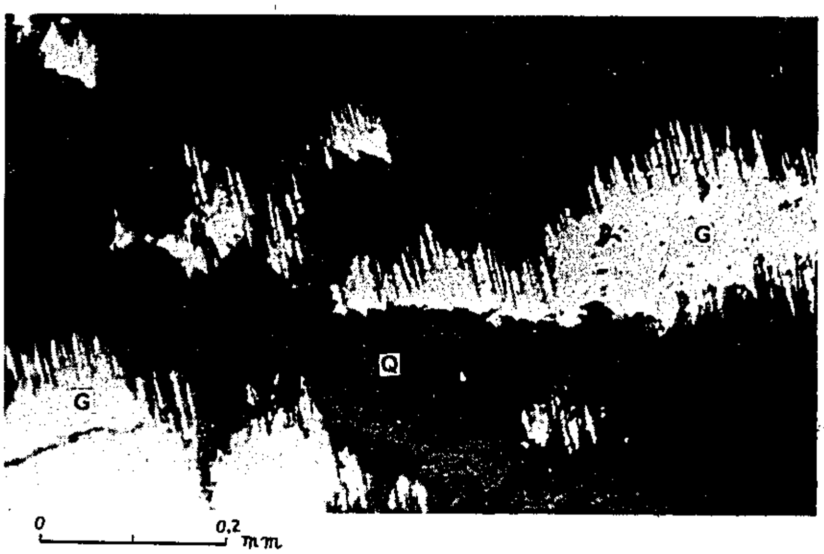
Plate 15. Zircon sand in concentrates from panning of the placer, at Padatgyaung Mine



Magnified photograph, used oblique white-light

Z: zircon

Plate 16. Goethite in small cavities under microscope



Photograph by reflection of polished section: //el nicols

G: goethite

Q: quartz

Plate 17. Wolframite and cassiterite in quartz-vein under microscope, Pennedaik Mine

Thin section: //el nicols

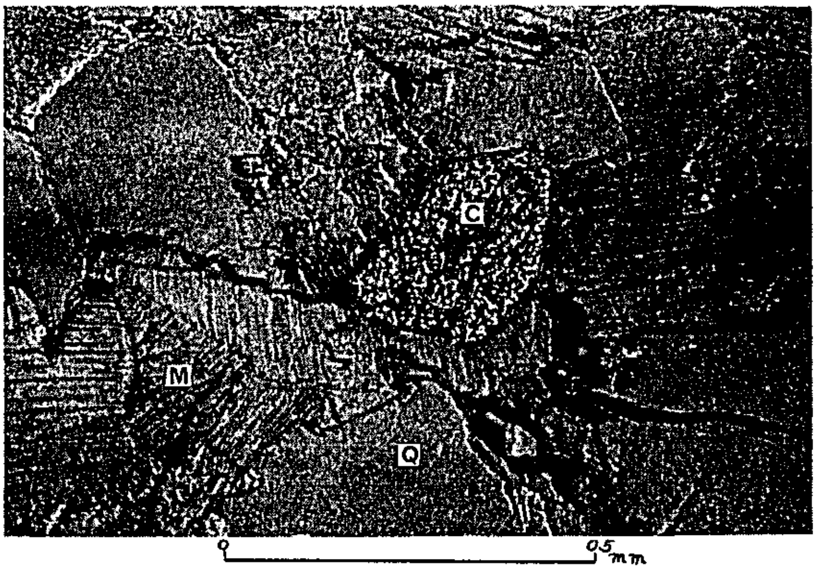
C: cassiterite

W: wolframite, partly goethitized

Q: quartz

G: Goethite

Plate 18. Cassiterite in quartz-muscovite greissen of Pennedaik Mine, under microscope



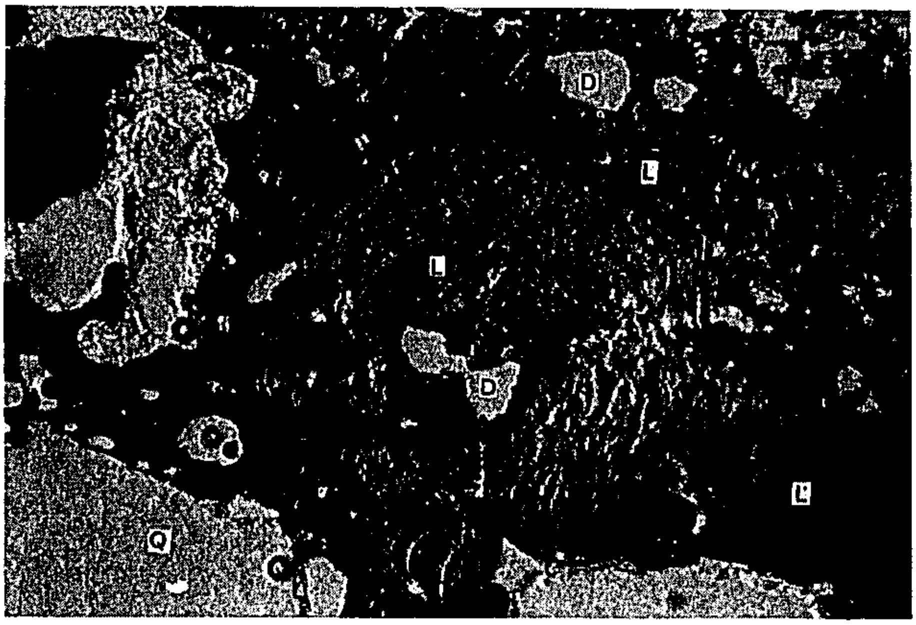
Thin section: // el nicols

C: cassiterite

M: muscovite

Q: quartz

Plate 19. Colloidal limonite under microscope, Thamaye Mine



0 1 mm

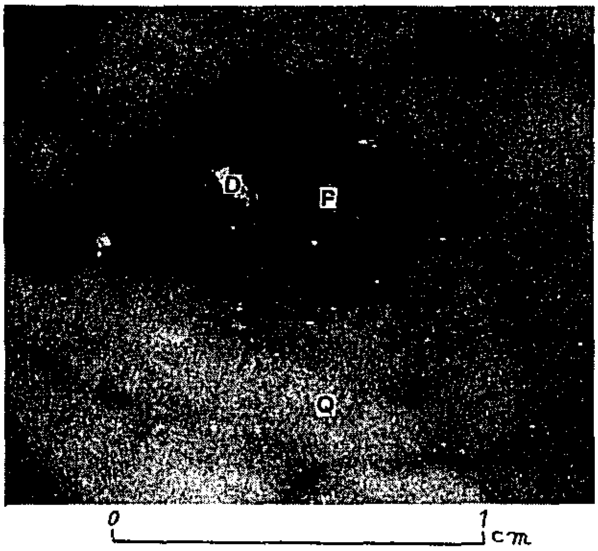
Thin section: // el nicols

L: limonite

Q: quartz

D: cavities

Plate 20. Pyrite in quartz-vein from Thamaye Mine



Magnified photograph of polished section

P: pyrite

Q: quartz

D: cavities