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REFERENCE: EC 132/226/2 BURMA (12)

I have the honour to refer to the project "Geological Survey and Exploration (BUR-72-002)" undertaken in Burma with the assistance of the United Nations Development Programme, for which the United Nations served as executing agency, and to transmit a technical report of the United Nations entitled "Geology and exploration geochemistry of the Shan Scarps area, east of Kyaukse, Thazi and Tatkon, central Burma", Technical report 3 (DP/UN/BUR-72-002/12).

The report details the geological mapping and reconnaissance geochemical exploration undertaken during 1976-77 over an area of 4,650 square kilometres in the Shan Scarps Area of central Burma. One of the significant results of the geological mapping was the identification of six Mesozoic formations which has led to a new interpretation of the Mesosoic geological history.

Geochemical exploration demonstrated the presence of mineral occurrences of several distinct types and it is important to note the close lithological control which appears to be exerted on mineralisation. The results of stream sediment sampling indicated four areas where follow-up investigations were subsequently undertaken; these investigations are detailed in Technical Report No. 6.

We should appreciate your informing us, through the Office of the Resident Representative of the United Nations Development Programme, of your Government's comments on the report.

This report represents technical contributions prepared with the co-operation of the United Nations Development Programme. In conformity with the agreement governing such co-operation, the report should be available for utilization by all interested parties. We should, therefore, appreciate your Government's agreement to the derestriction of the report so that it may be placed on open file and made available to all interested parties. Your Government's concurrence to derestriction will be assumed, unless you inform us, within six months of the date of this letter, that you wish the report to remain restricted.

Accept, Sir, the assurances of my highest consideration.

for [signature]

Findley Burns, Jr.
Director of Operations
Department of Technical Co-operation
for Development

DP/UN/BUR-72-002/12

BURMA

RESTRICTED

GEOLOGICAL SURVEY AND EXPLORATION

Technical report 3

Geology and exploration geochemistry of the Shan Scarps area, east of Kyaukse, Thazi and Tatkon, central Burma

UNITED NATIONS

NOTES

Abbreviations used:

DGSE - Department of Geological Survey and Mineral Exploration

m.y. - million years

ppm - parts per million

The designations employed and the presentation of material in this report do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

As of 1 October 1978, the rate of exchange was 6.72 kyats (k) to the US dollar.

DP/UN/BUR-72-002/12

PREFACE

This report, "Geology and Exploration Geochemistry of the Shan Scarps Area, East of Kyaukse, Thazi and Tatkon, Central Burma", covers the work of the following international experts, among others: J.V. Huhta, Project Manager; A.H.G. Mitchell, Chief Geologist; P. Carrel, Economic Geologist; F. Sumi, Geophysicist; and B. Zitek, Chief Geochemist; in cooperation with numerous Burmese experts, including U Kyi Soe, Project Co-Director (see annex 4).

ABSTRACT

Geologic mapping and reconnaissance geochemical exploration were undertaken in the 1976-1977 field season over an area of 4,650 sq km in the Shan Scarps area of Mandalay Division and the Southern Shan State, on the western margin of the Eastern Highlands of Burma. Geochemical sample maps and four geological maps for colour printing were produced, three at 1:100,000 scale and one covering the entire area at 1:250,000 scale.

The geologic mapping was supported by 20 palaeontological determinations from within the area, and two radiometric age determinations from a map sheet immediately to the south, investigated in the 1977-1978 field season. The rocks present include every geological period from Precambrian to early Tertiary, but results were of particular significance with regard to the Mesozoic geology and structure. Six Mesozoic formations were identified leading to new interpretations of the Mesozoic geological history, a zone of imbricate thrusts was mapped for the first time in the Eastern Highlands, and evidence was found for early Mesozoic and early Tertiary metamorphic episodes.

During geologic reconnaissance 2,880 stream sediment samples were collected and a total of 19,420 determinations were made for the elements Cu, Pb, Zn, Ag, Mo, Sb, Sn, and W. Results indicated four areas in which follow-up investigations were subsequently undertaken.

The results demonstrated the presence of numerous mineral occurrences of several distinct types within the area, and indicated the close lithological control on mineralization. Specific types of mineralization include Cu in lower Ordovician rocks, Ba-Pb veins stratabound in mid-Ordovician limestones, Sb in carbonaceous shales, Sn-W-Mo in late Cretaceous to Eocene granite, minor Pb veins in a variety of lithological units and Au associated with diorite plutons.

The emplacement of plutons, Sn-W-Mo, Au and Sb mineralization, and deposition of the late Mesozoic to early Tertiary sedimentary and volcanic rocks and subsequent thrusting and metamorphism took place on continental crust 300 km landward of a subduction zone. However, the complexity of the Jurassic to Oligocene geological and metallogenic events preclude comparison with a simple plate margin model of Andean type.

CONTENTS

Page

Annexes

Tables

Page

Figures

INTRODUCTION

Background

The Geological Survey and Exploration Project (Bur-72-002), for which the United Nations was the executing agency, became operational in January 1974. The Government co-operating agency was the Department of Geological Survey and Mineral Exploration (DGSE) of the Ministry of Mines.

The total United Nations Development Programme (UNDP) contribution, according to the revised budget, is estimated at $US 1,888,752, and the government contribution at kyats (k) 5,120,600, partly in cash and partly in kind. The latest (as of October 1977) revision extended the project through June 1978.

The main objective of the project was to carry out systematic regional geochemical exploration and geologic mapping of selected areas followed by detailed investigations in areas of special interest. Between 1974 and late 1977, approximately 15,525 square miles (40,210 sq km) were surveyed by the project.

This report and relevant geologic maps (figs. 15, 16, 17 and 18, deleted) describe the results of geological mapping and reconnaissance geochemical exploration in part of the Shan Scarps area in central Burma. The area comprises six one-inch to one-mile (1:63,360) scale topographic map sheets (93 C/6, 10; 94 D/5, 6, 7, 8), each of approximately 690 sq km, and the northern three-quarters of a seventh sheet (93 C/7), a total of [illegible],656 sq km, distributed in a north-south belt bounded by lat. 20°0', and 2[illegible]°45'N, and long. 96°15' and 96°[illegible]5'E (figs. 1 and 3). Field work in the southern third of C/8 and in 94 A/5, south of D/8, was completed as this report was being written, and some of the geological results are included in the text.

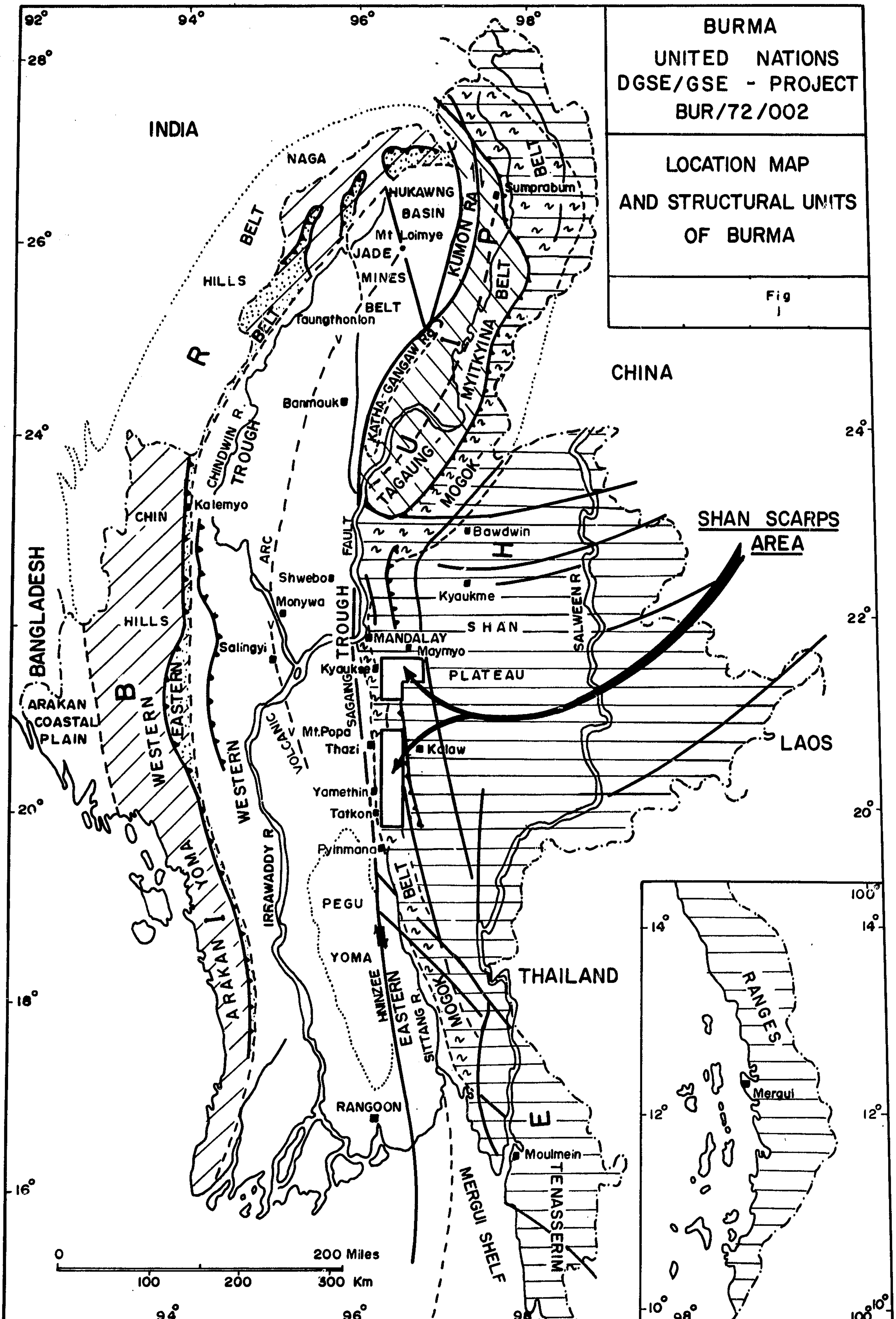
The western part of the area lies within the Mandalay Division administrative district and the eastern part within the Southern Shan State. The area was selected to include the belt of pre-Tertiary rocks east of the alluvial plain and west of the region recently investigated by the DGSE. The area in the centre of the belt (most of C/8) not investigated by the project, was recently geologically mapped and prospected (Garson et al., 1974)

Three colour-printed geological map sheets at 1:100,000 scale are relevant to this report: figure 16, the Pyaukseikpin-Myogyi sheet east of Kyaukse (comprising topographic maps C/6, 7 and 10); figure 17, the Yinmabin-Lebyin sheet east of Thazi (D/5 and 6); and figure 18, the Indaing-Kintha sheet east of Tatkon (D/7 and 8). These sheets are combined, together with the area described by Garson et al. (1974, 1976) and the southern part of C/8, on a four-miles to one-inch scale colour-printed geological map: figure 15, Geology of the Shan Scarps east of Kyaukse, Thazi and Tatkon, central Burma. (All of these maps have been deleted.)

Communications

With the exception of C/10, which is further east, the area lies between 5 and 30 km east of the Rangoon-Mandalay motor road and not more than 30 km east of the Rangoon-Mandalay single-track railway. The road and railway from the rail junction at Thazi in the west to Kalaw in the east pass through the area (see fig. 3).

A few all-season dirt roads extend eastwards from the Rangoon-Mandalay road into the western part of the area, where there are also a number of tracks open to 4-wheel-drive vehicles in the dry season. The Doktawaddy River in the northernmost part of the area can be navigated by motor boats, although progress upstream is difficult. Part of the area can be reached by footpaths, but the northeastern sheet (C/10) and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LOCATION MAP
AND STRUCTURAL UNITS
OF BURMA
Fig 1
INDIA
CHINA
BANGLADESH
LAOS
THAILAND
SHAN SCARPS AREA
NAGA HILLS BELT
HUKAWNG BASIN
Mt Loimye
JADE MINES BELT
Taungthonlon
KUMON RA
Sumprabum
MYITKYINA BELT
KATHA-GANGAW RG
TAGAUNG
MOGOK
Banmauk
CHINDWIN R.
TROUGH
CHIN HILLS
Kalemyo
ARC
FAULT
Bawdwin
Shwebo
Monywa
Kyaukme
SHAN PLATEAU
MANDALAY
Maymyo
Kyaukse
SALWEEN R.
Salingyi
SAGAING
TROUGH
VOLCANIC
Mt.Popa
Thazi
Kalaw
Yamethin
Tatkon
Pyinmana
ARAKAN COASTAL PLAIN
WESTERN
EASTERN
WESTERN
YOMA
ARAKAN
IRRAWADDY R
PEGU YOMA
BELT
HWINZEE
EASTERN
SITTANG R.
MOGOK
RANGOON
Moulmein
TENASSERIM
MERGUI SHELF
RANGES
Mergui
0
200 Miles
100
200
300 Km
92°
94°
96°
98°
28°
26°
24°
22°
20°
18°
16°
14°
12°
10°
100°

parts of the southernmost three sheets are very inaccessible with neither paths nor villages.

Settlement and agriculture

In the areas of low relief in the west there are numerous Burmese villages, and most of the ground is cultivated, producing rice, sugar cane and vegetables. In the mountain ranges in the east, scattered hill-top villages are inhabited mostly by Burmese-speaking Shans, Danus and Karens. Agriculture here is largely limited to hill rice and vegetables, and teak, other hardwoods and bamboo are extracted.

Climate

The western part of the area lies within the driest part of Burma, with 40 to 60 inches rain falling in the southwest monsoon mostly between June and October. In the east rainfall is higher, probably exceeding 80 inches. In the hot season from March to May, maximum daily temperatures on the plain in the west exceed 100^{o}F, but are at least 10^{o} cooler in the hills. In the cooler season from November to February, maximum temperatures are at least 15^{o} lower and rare night frosts occur on ridges about 4,000 ft elevation.

Previous work

The central part of the area and its surroundings (C/6, 7; D/5, 6) have probably received more attention from geologists than any other part of Burma, owing to its accessibility and the presence of rocks of most geologic periods from Precambrian to Jurassic (fig. 2).

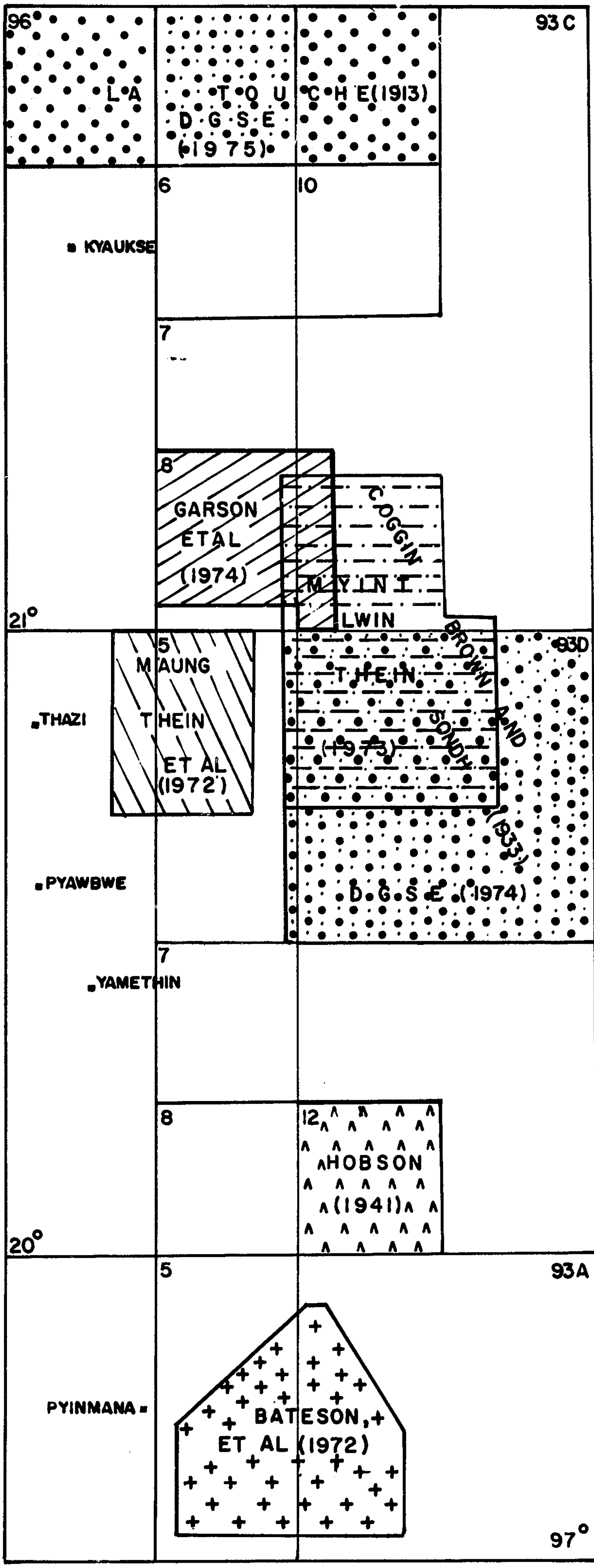
The first recorded geological observations were by Fedden (1865), who described the rocks seen during his journey northeastwards from near Yamethin to the Salween River in the Northern Shan State. Middlemiss (1900) carried out the first systematic geologic survey between 1893 and 1900, and described in some detail the rocks adjacent to the Kalaw-Thazi road and in the scarps to the north. The most detailed report yet published on the stratigraphy of the region was that by La Touche (1913) who described the Northern Shan State immediately north of the project area. Geologic mapping in the easternmost part of D/5 and 6 was undertaken in 1928-1931 by Coggin Brown and Dondhi (1933), who published a one-inch-to-four-miles scale geologic map.

The stratigraphic position and palaeontology of Mesozoic rock units were discussed by Fox (1930), although his conclusions were subsequently disputed. Chhibber (1934a, b) referred to the area in his two books on the geology and mineral deposits respectively of Burma, and Pascoe (1959) included more detailed reviews of the geology in and adjacent to the area. Hobson (1941) described the geology of the southern part of the area. The geology of the area was summarized in papers describing the metamorphic rocks in the Kyaukse district west of C/6 by Tha Hla and Ba Than (1960), Maung Thein and Soe Win (1969), and in a review paper by Ba Than Haq and Maung Thein (1970).

Results of geologic mapping and an investigation of mineral occurrences on sheet C/8, between the northern and southern parts of the area, carried out in 1970 are available in an unpublished report on the mineral occurrences (Garson et al., 1972), a one-inch-to-one-mile-scale colour-printed geologic map (Garson et al., 1974) and a memoir on the geology (Garson et al., 1976). The most important geological results of this work were the establishment of a stratigraphy within the upper Palaeozoic-lower Mesozoic 'Plateau Limestone' and the recognition of a Mesozoic flysch-type unit.

Results of geologic mapping of the eastern margin of sheets C/8 and D/5 and an approximate half degree square area to the east, carried out between 1968 and 1970 by staff and students of Rangoon Arts and Science University (RASU), resulted in significant revisions to the lower Palaeozoic stratigraphy of the region (Myint Lwin Thein, 1973). Geological mapping of part of D/5 and the northernmost part of D/6 was carried out by students of the Geology Department, RASU, between 1969 and 1975 (Maung Thein et al., 1972). Dr. Myint Lwin Thein (personal communication, 1977) and staff from the same Department mapped part of D/6 near Lebyin in 1976.

Tungsten mineralization in the area was referred to in Coggin Brown and Heron (1919, 1923) and Dutt (1942). Investigation of mineral occurrences in the western part of D/6 was carried out by students and staff of the UNDP-assisted Post Graduate Training in Mineral



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AREAS OF PREVIOUS WORK

Fig 2

Exploration Project in 1973-1976 (unpub. repts). Government departments have produced unpublished local small-scale geological maps for engineering purposes in the Lebyin area (D/6) and around a dam site (C/6) and unpublished reports by DGSE on the Lebyin antimony mine include notes on the geology. An unpublished geological map of part of D/6 was produced following investigation of coal seams by a Japanese team (Coal Research Institute, 1958).

I. FIELD OPERATIONS AND METHODS

Camps, transport and personnel

The area was divided into three districts, in each of which a group of geologists worked throughout all or most of the field season. One or more base camps were established in each district, and traverses of up to 10 days were undertaken from the base, using village accomodation where available and tents elsewhere. Transport was partly by bullock carts, but in less inhabited areas extensive use of porters was necessary to move camps.

In the northern district comprising three map sheets (C/6, 7, 10), field work was carried out by six geologists between late November 1975 and late May 1976, with an additional two geologists from the beginning of January 1976. A base camp was maintained at Myogyi throughout the season.

Sheets D/5, 7 and 8 formed a second district. Field work was carried out by eight geologists between late November 1975 and late May 1976, with two geologists responsible for each sheet. Base camps were established at Thazi, west of D/5, and at Tatkon, west of D/8 on the Mandalay-Ran on motor road.

On sheet D/6, field work was undertaken between early January and late May 1976 by a team of six geologists, using the base camp at Thazi. Results of further field work in parts of D/6 carried out in early 1977 as part of follow-up-investigations are included in the report and on the geologic map. Field work in the southern part of C/8, and in A/5 which is not included on the geologic maps, was carried out in the 1977-1978 field season.

Geologic mapping

In each district the team comprised a supervising geologist in charge of geochemical sampling, a mapping geologist responsible for the geological map and traverse geologists. Each geologist worked as a separate field party accompanied by one or more labourers. Geological observations and collections of geochemical samples were carried out by all geologists; critical localities, type sections and areas away from streams were examined by the mapping geologists. Traverses were mostly along streams, and to a lesser extent along paths and over exposed rock on mountain slopes.

Field data from the regional mapping were plotted on 1-inch-to-1-mile-scale drainage sheets prepared from the topographic maps. Results of detailed mapping, carried out in specific areas as part of the mineral exploration follow-up work in 1976-1978, were incorporated into the geological maps. Limited use was made of air photographs in the field because of a shortage of both trained photogeologists and air photographs, and photo-interpretation was carried out largely in Rangoon after the field work by a mapping geologist with the cooperation of the chief photogeologist of DGSE. Air photographs were mostly 1:50,000 scale and locally 1:20,000 scale. The photo-interpretation maps were combined with field data maps and drawn by project draftsmen to produce 1-inch-to-1-mile geological maps. These maps were reduced photographically and then redrawn to make the 1:100,000 scale geological maps (figs. 16, 17 and 18). The 1:100,000 scale maps were reduced photographically, simplified and redrawn to form the 4-miles-to-one-inch-scale map (fig. 15). (All of these maps have been deleted.) The geology of the northern part of C/8, and southern margin of C/7, modified from Garson et al. (1974) to include new evidence from the adjacent sheets, is included on figure 15.

Reconnaissance geochemical sampling

Stream sediment geochemical samples

were collected mostly by traverse and supervising geologists, the position of their traverses being determined by the sampling programme. Mapping geologists also collected samples where convenient and in inaccessible areas. Details are given in chapter VII.

Report preparation

This report was prepared in Rangoon by the chief geologist and chief geochemist between January and June 1978. It is based partly on data collected and unpublished reports prepared by each of the three national geologist teams. The geologic chapters rely heavily on observations and interpretation made by the chief geologist, and the geochemical part on work by the chief geochemist. The maps, figures and other illustrations were drawn by the project's draftsmen, who are seconded to the project from the DGSE. The material used in report preparation is filed with DGSE.

II. REGIONAL GEOLOGICAL SETTING

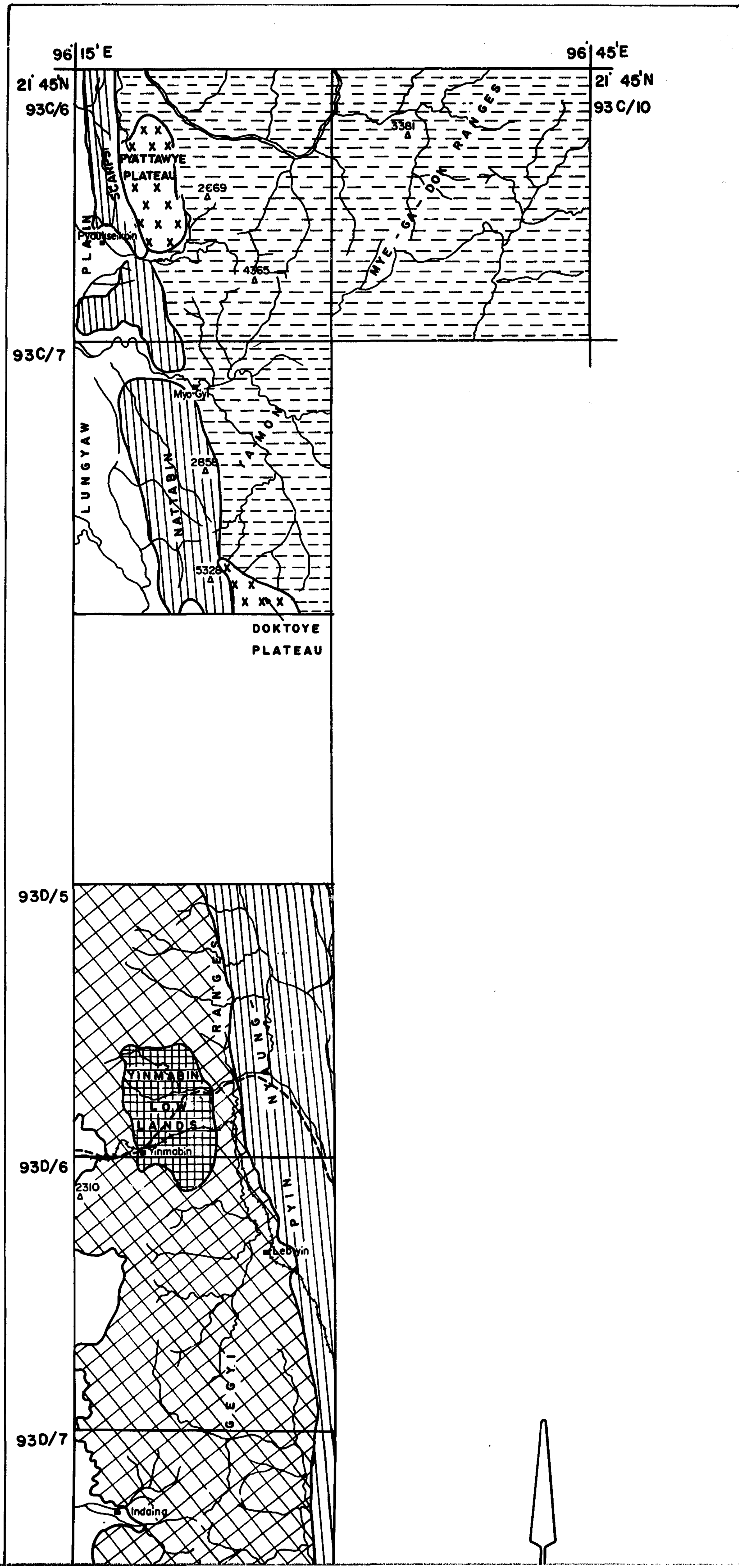
The area lies along the western margin of the Eastern Highlands of Burma (fig. 1). It comprises, from northeast to southwest, the western margin of the Shan Plateau, a segment of the Shan Scarps forming a belt of steep N to NNW-trending linear valleys and ridges and a mountainous area to the west lying within the north-trending Payangazu-Thandaung Hills, between the Scarps and the Cenozoic sediments of the Central Lowlands (fig. 3). The Shan Scarps extend southwards from Mandalay along the Shan State-Burma boundary, adjacent to the Shan Plateau to the east (see fig. 7).

The Plateau, which extends eastwards to the Thai-Laos-China borders, comprises gently undulating areas mostly underlain by Permo-Triassic dolomites at elevations of 3,000 to 5,000 ft, separated by ridges and dissected valleys underlain by thick Precambrian, Palaeozoic and in places Mesozoic successions of sedimentary and minor volcanic rocks, of which the pre-Mesozoic rocks are locally metamorphosed. Within the map area in and east of the Shan Scarps, most of the rock units found on the Plateau are present. In the western part of the area, within the Payangazu-Thandaung Hills west of the Shan Scarps, granitic and metamorphic rocks form part of the Mogok Belt, extending south-southeastwards from west of Mandalay through Thandaung into the Tenasserim Ranges of southern Burma.

The Mogok Belt, of high-grade metamorphic rocks, continues north from Mandalay and then northeastwards along the northern margin of the Shan Plateau; it is bordered on the northwest side by a tectonically complex zone of ultrabasic and volcanic rocks and mid-cretaceous limestones forming the Tagaung-Myitkyina Belt. West of this, the Gangaw-Katha Range comprises a narrow belt of schists, quartzites and amphibolites. Further west, the Jade Mines belt with ultrabasic rocks, metamorphic rocks including glaucophane schists, and mid-Cretaceous limestones, extends across the northern part of the Central Lowlands.

West of the map area the Central Lowlands, comprising the Eastern Trough, Burma Volcanic Arc and Pegu Yoma, and Western Trough, lie between the Eastern Highlands and the Indoburman Ranges. The narrow Eastern Trough is underlain largely by late Tertiary sediments. The Burma Volcanic Arc, a medial ridge within the Central Lowlands, is defined by the presence of late Cenozoic volcanoes, but includes mid-Cretaceous granitic plutons intrusive into submarine andesitic lavas, dacites and sedimentary rocks, upper Cretaceous to lower Eocene conglomerates, and Eocene and Oligocene volcanic rocks; small exposures of gneiss, schist and amphibolite are also present (Technical Reports Nos. 2 and 5). To the south the trend of the Arc continues through the Pegu Yoma range, comprising folded sediments of Oligocene to Miocene age with rare dolerite sills. The Western Trough is underlain by at least 8,000 m of late Cretaceous and Cenozoic sedimentary rocks mostly occupying a broad syncline, but cut by east-dipping thrusts in the west and locally by west-dipping thrusts in the east. Mid-Cretaceous limestones are present locally in the west at the base of this succession. A major fault, the Hinzee-Sagaing Fault (Dey, 1968; Win Swe, 1970), extends northwards from the eastern side of the Pegu Yomas, and lies a few kilometres west of the project area; it continues northwards as the Mogaung Fault, west of the Katha-Gangaw Range, into northernmost Burma. There is some evidence of Cenozoic dextral strike-slip displacement along the Fault of more than 300 km, and Quaternary basalts at four localities suggest recent movement.

West of the Central Lowlands, the Indoburman Ranges consist of an eastern and western structural unit (<u>Technical</u>


96° 15' E
96° 45'E
21° 45'N
21° 45'N
93C/6
93 C/10
93C/7
93D/5
93D/6
93D/7
PYATTAWYE
PLATEAU
SCARPS
PLAIN
Pyaukseikpin
2669
4365
3381
MYE - GA - DON RANGES
Myo-Gyi
LUNGYAW
NATTABIN
YAMON
2856
5328
DOKTOYE
PLATEAU
RANGES
YINMABIN
LOW
LANDS
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PYIN
2310
Lebyin
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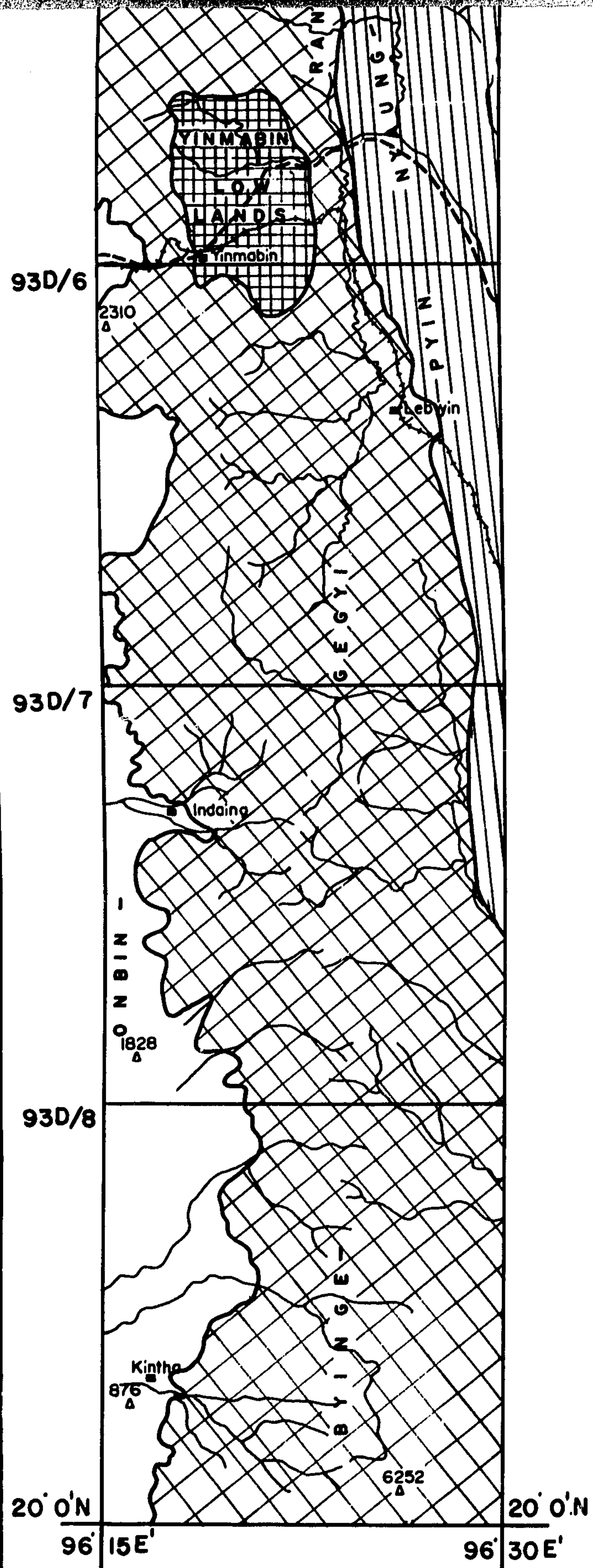

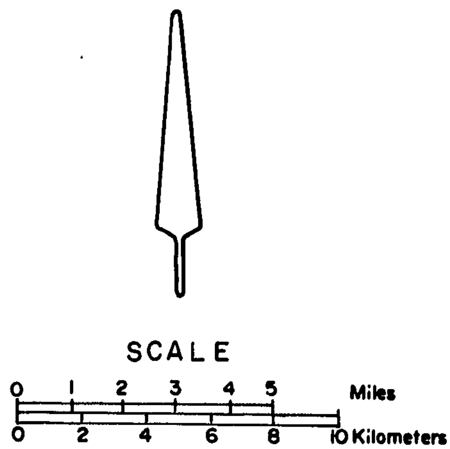

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SHAN SCARPS AREA

PHYSIOGRAPHY

Fig 3

Report No. 4). The relatively narrow Eastern Belt consists of late middle to early upper Triassic flysch-type sediments, tightly folded and in places metamorphosed, and overlain by local pillow lavas and serpentinite sheets. The Eastern Belt rocks are thrust westwards over the more extensive Western Belt, consisting of upper Cretaceous to middle Eocene flysch-type sediments and olistostromes, folded in the Chin Hills and highly folded and thrust in the Arakan in the south.

The crust beneath the Eastern Highlands is evidently continental. Metamorphic rocks, probably metamorphosed in the early Mesozoic, extend westwards beneath the Eastern Trough to west of the Volcanic Arc. The western part of the Western Trough is underlain by upper Triassic flysch-type sedimentary and metasedimentary rocks with an unknown basement.

III. PHYSIOGRAPHY

With the exception of the dissected mountain ranges in the northeast of the area, the major physiographic features trend NNW (fig. 3), generally decreasing in elevation from the Plateau in the east to the Plain in the west. The mountainous features between the Plateau and Plain also decrease in elevation towards the north-northwest.

Onbin-Lungyaw Plain

The westernmost part of the area is occupied by the eastern limits of a plain which extends westwards to the Sittang and Panlaung Rivers. The plain decreases in elevation from around 400 ft in the north to 300 ft in the south, but rises to the east, where it merges into alluvial fans and steep hill slopes. It is drained by short westward-flowing streams and by rivers originating in the ranges to the east.

Byinge-Gegyi Range

The southwestern part of the area is occupied largely by a NNW to N-trending belt comprising the Byinge-Gegyi Range, named from peaks at elevations of 6,252 and 4,422 ft, respectively. The Range lies between the Onbin Plain to the west and the Shan Scarps to the east, and forms part of the Payangazu-Thandaung Hills, which extend southwards from north of Yinmabin to east of Rangoon. It is underlain by granitic rocks, a narrow belt of metamorphic rocks to the west, and an extensive and monotonous succession of folded greywackes within which there is little relationship of topography to structure. Drainage is dendritic with streams flowing east and west from a watershed near the middle of the Range.

Pyin Nyaung-Nattalin or Shan Scarps

This belt lies immediately east of the Pyaukseikpin Plain in the north, where it has a northerly trend, and east of the Byinge-Gegyi Range in the south, where the trend is NNW. It coincides with a number of major N to NNW-trending high-angle faults which separate narrow zones of contrasting lithology. It is mostly underlain by steeply-dipping and fault-bounded Ordovician and Permo-Triassic dolomites and limestones forming ridges up to 4,000 ft elevation, separated by areas of Mesozoic clastic sedimentary rocks. The steep slopes and rugged relief of the belt, which lies more or less along the western margin of the Southern Shan State, explain the origin of the term Shan Scarps.

A number of rivers cut obliquely through the Scarps along N30°W-trending valleys. The Kalaw-Thazi motor road and railway line each follow valleys of this trend; together with the Mandalay-Maymyo road and railway north of the area, these form the only links for motor transport between the Shan Plateau and Central Lowlands of Burma in the 700 km of mountain ranges extending from east of Mandalay to east of Rangoon.

Pyattawye-Doktoye Plateau

The Pyattawye Plateau, near the northwestern corner of the area, is largely underlain by Ordovician limestone occupying a NNW-trending syncline. Erosion has produced a sub-horizontal plateau at an elevation of around 2,000 ft, with an irregular karstic topography. Drainage is partly internal through sink holes, but mostly radial. The Doktoye Plateau, in the south of 93 C/7, is a small, southward-sloping area of karstic topography, with a maximum elevation of 5,755 ft at its northern margin, where it terminates in a north-facing scarp above the more dissected Ya-mon Ranges. It is underlain mostly by Ordovician limestones with minor carbonates of Permo-Triassic age. Both plateau areas lie within the western margin of the extensive Shan Plateau.

Ya-mon-Myegadok Ranges

In the north of the area mountain

ranges with high relief occupy the eastern part of C/6 and 7 and all of C/10. The highest peak is Myegadok Taung in the northeast of C/10; numerous peaks are above 4,000 ft, with major stream valleys below 1,000 ft, but in general elevations decrease westwards to a minimum immediately east of the Nattabin Scarps.

The ranges are underlain almost entirely by Precambrian folded flysch and greywackes, which in the east are metamorphosed to schist. Throughout most of the Ranges there is no distinct structural trend, and the Myitnge, Zawgyi and Thanbo Chaungs with a characteristic dendritic drainage pattern flow westward to and through the Scarps. However, in the west of map C/7, both structure and drainage show a NW to NNW trend. The Ya-mon-Myegdoke Ranges are normally considered to form part of the Shan Plateau.

IV. STRATIGRAPHY OF SEDIMENTARY AND METAMORPHIC ROCKS

Sedimentary and volcanic rocks are grouped into stratigraphic units and described in order of decreasing age, with the exception of those metamorphic units which cannot obviously be related to the rocks in the stratigraphic column and are described separately.

The names of the lower Palaeozoic stratigraphic rock units are based largely on those of La Touche (1913), with some modifications after Myint Lwin Thein (1973). The names of upper Palaeozoic to lower Mesozoic units are based mainly on those of Garson et al. (1974, 1976). These authors and also Amos (1975) have considered the terminology of the rock units in some detail, but the ages of and correlations among the post-Devonian rocks are discussed here because the mapping has yielded new information resulting in significant changes to much of the previously accented stratigraphy. The unit names should be regarded as informal because measured type-sections have not been established.

A simplified geological map of the area is given in figure 4, and a schematic stratigraphic column in figure 5. Schematic stratigraphic relationships among rock units are shown in figure 6.

Chaung Magyi Group

Definition and distribution

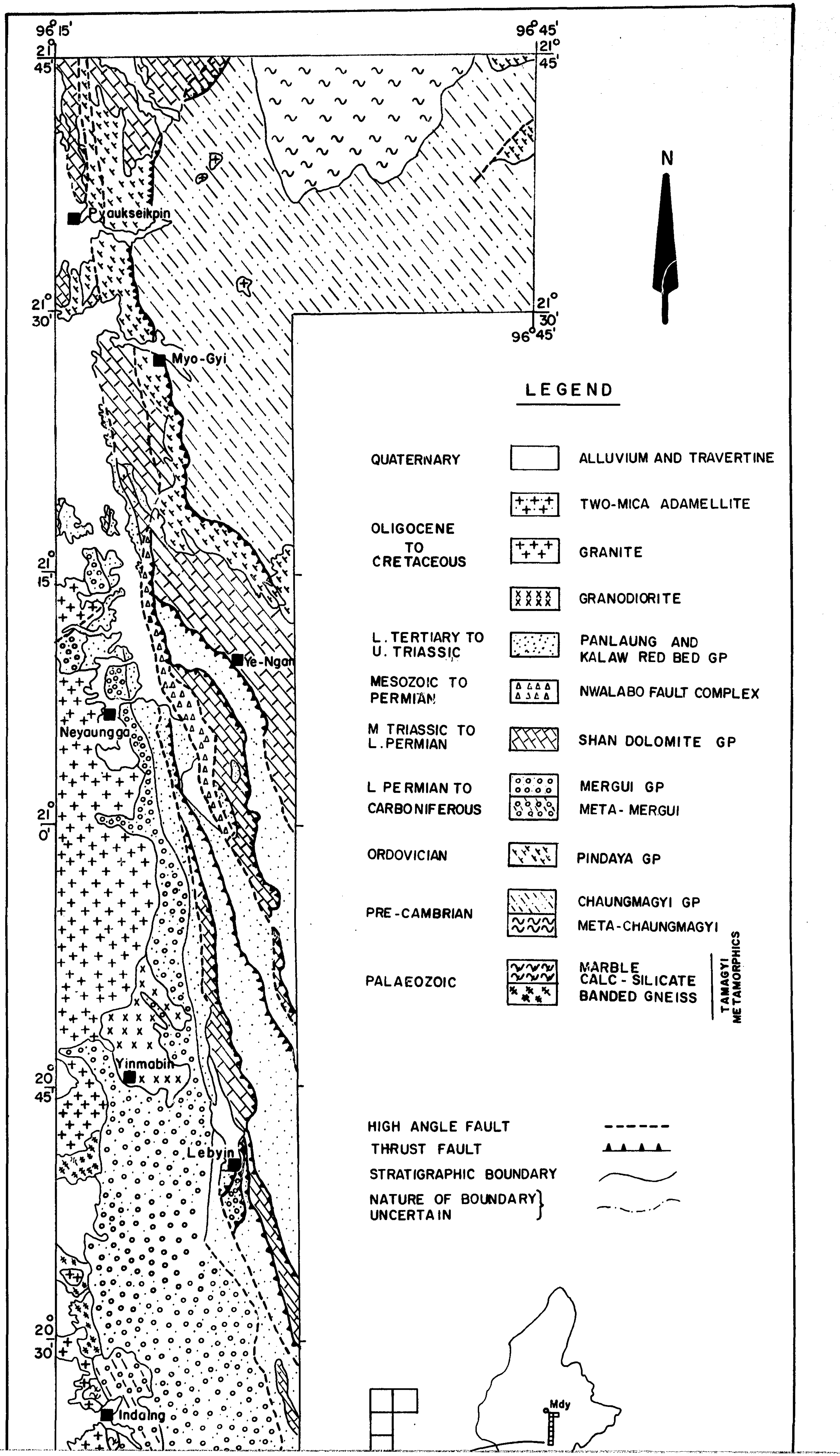
A thick folded and in places metamorphosed succession of greywackes and mudstones in the north of the area is termed Chaung Magyi Group from the lithologically similar Chaung Magyi Series described by La Touche (1913), from northeast of Mandalay. Although the Group is restricted to the northern three map sheets, occupying the eastern part of C/6 and 7 and nearly all of C/10, it underlies a larger area than any other rock unit and has a stratigraphic thickness of at least 3,000 m. It coincides approximately with the Ya-mon-Myegadok Ranges.

Lithology

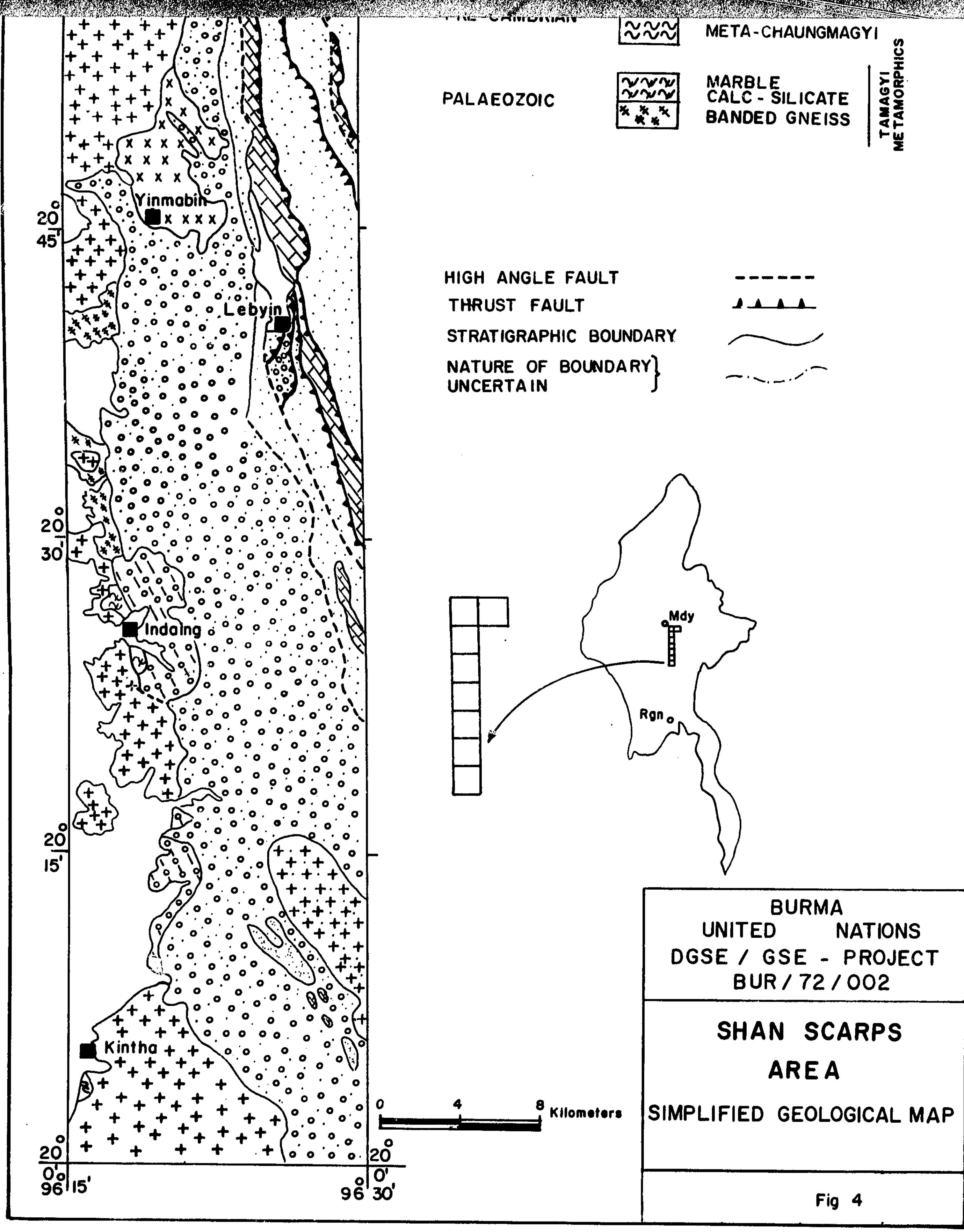
The predominant rock type is a monotonous alternation of fine-grained grey to greenish sandstones and black mudstones or siltstones, mostly in beds less than 50 cm and commonly less than 20 cm thick. Most sandstones are micaceous greywackes although some better-sorted quartzose sandstones also occur. Sole marks have not been observed, but sedimentary features including parallel bedding, sharp bases to sandstones, load casts and parallel and cross-lamination within sandstone beds indicate a turbidite facies, and rare highly convolute beds transitional to slumps occur.

In the west the succession is mostly unmetamorphosed with cleavage absent or weak; where better developed, the cleavage is mostly parallel to bedding, forming slates. Locally the rocks are phyllitic, and towards the north there is a transition from silvery grey phyllitic mudstones with interbedded thicker greenish micaceous greywackes into semi-schists and schists.

The schists show compositional layering which is probably relict bedding. Dark grey to almost black fine-grained biotite-quartz-schists and green to white micaceous quartzites are most abundant, interbedded with coarser-grained biotite and biotite-garnet schist; these can be interpreted as metamorphosed greywackes, sandstones and mudstones. Garnet-bearing schists suggest that these are surrounded by biotite-schists, but the actual boundary has not been defined. Relict cross-bedding and cross-lamination is sometimes visible and indicated by variations in the relative amounts of quartz and biotite in the layers. Veins of milky quartz are abundant both parallel to and cutting the bedding. The northern part of the area occupied



96°15'
96°45'
21° 45'
21° 30'
21° 15'
21° 0'
20° 45'
20° 30'
N
Pyaukseikpin
Myo-Gyi
Ye-Ngan
Neyaungga
Yinmabin
Lebyin
Indaing
Mdy
LEGEND
QUATERNARY
ALLUVIUM AND TRAVERTINE
TWO-MICA ADAMELLITE
OLIGOCENE TO CRETACEOUS
GRANITE
GRANODIORITE
L. TERTIARY TO U. TRIASSIC
PANLAUNG AND KALAW RED BED GP
MESOZOIC TO PERMIAN
NWALABO FAULT COMPLEX
M TRIASSIC TO L. PERMIAN
SHAN DOLOMITE GP
L PERMIAN TO CARBONIFEROUS
MERGUI GP
META- MERGUI
ORDOVICIAN
PINDAYA GP
PRE-CAMBRIAN
CHAUNGMAGYI GP
META-CHAUNGMAGYI
PALAEOZOIC
MARBLE
CALC - SILICATE
BANDED GNEISS
TAMAGYI METAMORPHICS
HIGH ANGLE FAULT
THRUST FAULT
STRATIGRAPHIC BOUNDARY
NATURE OF BOUNDARY UNCERTAIN


META-CHAUNGMAGYI
PALAEOZOIC
MARBLE
CALC - SILICATE
BANDED GNEISS
TAMAGYI METAMORPHICS
HIGH ANGLE FAULT
THRUST FAULT
STRATIGRAPHIC BOUNDARY
NATURE OF BOUNDARY UNCERTAIN
Yinmabin
Lebyin
Indaing
Kintha
Mdy
Rgn
20° 45'
20° 30'
20° 15'
20° 0'
96° 15'
96° 30'
0
4
8 Kilometers
BURMA
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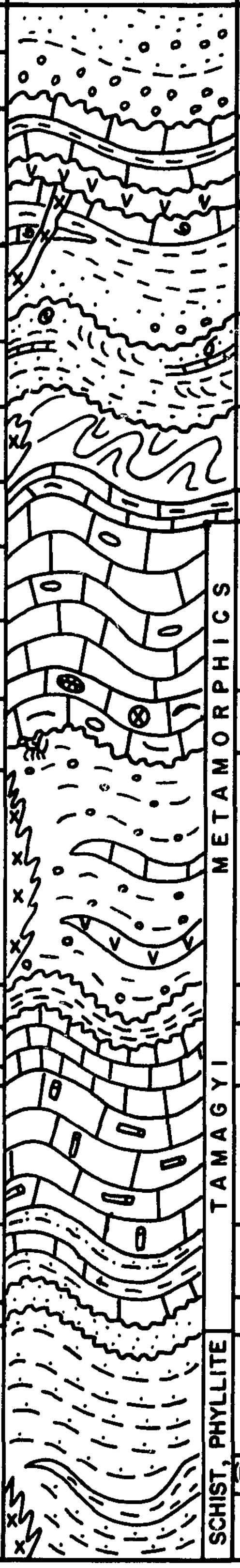
SHAN SCARPS AREA
SIMPLIFIED GEOLOGICAL MAP
Fig 4



SYSTEM	SERIES	FORMATION (MEMBER)	GROUP THICKNESS (METRES)	INTRUSIVE ROCKS	DESCRIPTION
TERTIARY / CRETACEOUS	L / U	KALAW CONGLOMERATE	KALAW RED BED > 2000		Basal polymict conglom and boulder bed commonly calcareous passing up into interbedded red-purple cross-bedded sst, sh and conglom. Clasts of dolomite, lst, quartzite, phyllite, dacite, leucogranite, red and grey mudst and sst.
CRETACEOUS	?L	TELU LIMESTONE			White, grey and pink micritic lst, rarely cherty, in part calcirudite; local interbedded clastic red beds.
		PATCHAUNG VOLCANICS			Dacite, andesite, coloured tuffs and purple lava flows; minor coarsely porphyritic potassic rhyolites; carbonate common as veins and locally as groundmass; interbedded siltstones.
JURASSIC	U	KYAUKHSU TAUNG	PAN LAUNG > 3000	GRANODIORITE DYKES	Quartzose conglom, sst, overlain by carbonaceous locally pebbly sh and sst passing up into muddy lsts with shell fragments and interbedded sh.
	M	LOI - AN			Well-laminated fossiliferous siltst-sst-sh, abundant concretions. Rippled sst-siltst with interbedded coals, channel-fill quartzose, ferruginous cross-bedded sst, rare quartz pebbles, sh. Thin calcarenite-calcirudite lsts in upper part.
TRIASSIC	U	MA - U - BIN		DIORITE	Quartzose and calcareous sst turbidites with local grit and mudflake conglom, common sole mark, rare slumps. Includes muddy limestone and limestone turbidites east of Pinmon. Tightly folded, common overturned beds.
	M	NATTEIK LST.	SHAN DOLOMITE 2500		Well-laminated calcarenite and calcilutite. Probably dolomitised and included in Nwabangyi Dolomite.
TRIASSIC / PERMIAN	L / U	NWABANGYI DOLOMITE			Structureless to well-laminated dolomite and dolomitic lst with brecciated texture when weathered. Local abundant foraminifera.
PERMIAN	L	THITSIPIN LIMESTONE			Blue-grey well-bedded calcarenite and calcilutite, locally abundant foraminifera ar' corals; local basal conglom transitional to marble in . ast of C6.
CARBONIFEROUS			MERGUI >2500	GRANITE ADAMELLITE GRANODIORITE (CRETACEOUS-OLIGOCENE) IN MERGUI GP AND TAMAGYI METAMORPHICS	Predominantly argillaceous or pelitic. Thick structureless pebbly mudst, pebbly siltst and minor pebbly sst with clasts of quartzite and rare lst; interbedded with black mudst, laminated mudst-siltst, rare slumps, and white quartzose sst units up to 20m thick. Includes rare thin red to grey lst, green volcanic rocks. Folded and locally metamorphosed to phyllite, spotted slate and semi-schist transitional to interbedded biotite schists and white quartzites with minor marble and calc-silicate granulites.
DEVONIAN	L	ZEBINGYI ?			Calc sh, silty calcarenite, fine gr calcirudite; abundant brachiopods.
SILURIAN	L	NYAUNGBAW LIMESTONE	PINDAYA 3200		Grey to red and purple thick-bedded argillaceous lst with 'phacoidal' weathering pattern; interbedded red sh and calcareous siltst, local Orthoceras.
ORDOVICIAN	U / M	NAUNGKANGYI			Blue-grey argillaceous lst with yellow to buff silty partings. Thick bedded to massive but local silty laminations, cross-bedded sandy calcarenites and marls.
	L	NGWETAUNG			Brown ferruginous siltst and calcareous siltst interbedded with silty lst and micaceous calcareous sst; mostly thin bedded, cross-laminated; minor quartzites. Widespread burrows and stylolites.
CAMBRIAN		PANGYUN			White to purple quartzite and quartzose sst. Very limited area on C6.
PRECAMBRIAN	LATE PROTEROZOIC		CHAUNG MAGYI >2500		Grey to green micaceous greywacke and quartzose sst, thin turbidite sst and black lam mudst. Folded and locally metamorphosed to phyllitic mudst and chloritic greywackes, transitional to semi-schists and to biotite-quartz and biotite-garnet schists with probable primary compositional layering.
		(MYOGYI SLATE)			Black pyritic mudst and slaty mudst.
				GRANITE	

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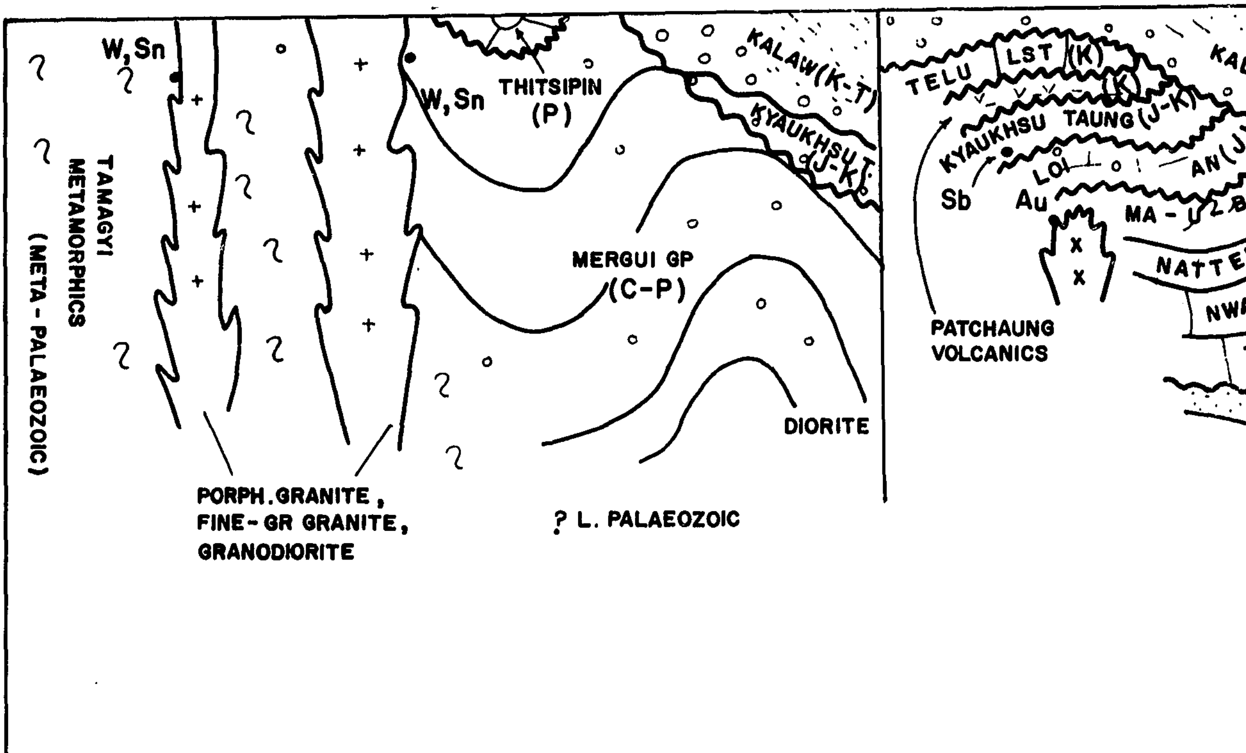
SCHEMATIC STRATIGRAPHIC COLUMN

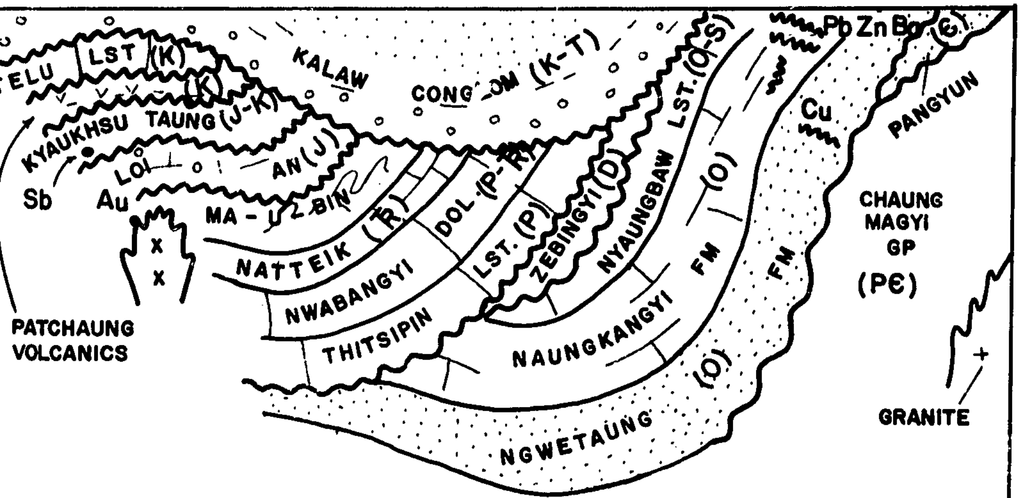
Fig - 5



BURMA - UNITED NATIONS DGSE / GSE - PRO

SCHEMATIC RELATIONSHIPS AMONG STRATIGRAPHIC

Fig - 6



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STRATIGRAPHIC UNITS, SHAN SCARPS

Fig - 6

by schists was not mapped in detail owing to difficult access, but widely spaced traverses showed scattered pegmatites within the metamorphic rocks.

Myogyi Slate

A NW-trending belt of black slaty mudstone lying east of Myogyi village is here termed the Myogyi Slate. It is considered to be interbedded with the greywackes and mudstones of the Chaung Magyi Group, and occupies a stratigraphic position at least 1,000 m below the top of the Group. The Myogyi Slate is visible on air photographs and was intersected by three field traverses. Its maximum thickness is about 1,200 m. The characteristic lithology is black mudstone, phyllitic mudstone and slate with cleavage mostly parallel to bedding. Minor pyrite and chalcopyrite are present in the Slate northeast of Myogyi.

Structure and thickness

Bedding is visible on air photographs in only a few localities, and with the exception of the Myogyi Slate there are no recognizable sub-units. Dips recorded in the field indicate that in the west the Group is folded about broad N to NW-trending areas with a wavelength of at least 7 km and limbs dipping at up to 80°. The minimum stratigraphic thickness here is around 2,700 m. On sheet C/10 the structure of the sedimentary rocks and phyllites is less regular, and in the absence of distinct way-up criteria the younging direction of steeply dipping beds cannot be determined. In the schists the attitudes of compositional layering indicate that they possibly form a domal structure, but this is complicated by small-scale folds and locally kink folds with a tectonic foliation across the compositional layering.

Correlation and age

The Group, which is unfossiliferous, occupies an extensive area in the Northern Shan State, east and northeast of C/8, where it underlies the Bawdwin Volcanics and Pangyun Formation of probable Cambrian age; the presence here of animal burrows in the inferred uppermost part of the Group suggests a latest Precambrian age (Mitchell et. al., 1977). The age of the metamorphism is uncertain; it is probably of the same age as the first metamorphism affecting the Mergui Group, in which case it is post-middle Triassic and pre-upper Cretaceous.

Pangyun Formation

Small areas consisting largely of quartzite in the north of C/6 resemble in lithology part of the Pangyun Series, formerly the Pangyun Beds described in an unpublished report by Maclaren, which overlie the Chaung Magyi Group near Bawdwin in the Northern Shan State (Coggin Brown, 1918). The quartzites are surrounded by unmetamorphosed rocks of the Chaung Magyi Group, except at one locality where they are also adjacent to Silurian rocks. They form steep slopes, and are well exposed with a thinner soil cover than the surrounding rocks of the Chaung Magyi Group. The beds dip west at a high angle and strike mostly NW; the stratigraphic thickness of the unit does not exceed 100 m.

The predominant lithology is purple to white or grey quartzite and quartzose sandstone often showing ferruginous specks or small patches, giving it a spotted appearance. The quartzites are interbedded with chloritic greenish sandstone, mudstone and slaty shale.

The quartzites resemble the purple to white quartzose sandstones and quartzites of the western outcrops of the Namhsim Series of La Touche (1913), which he considered to be of Silurian age, recognized as equivalent to the Pangyun Series of Coggin Brown (1918) and termed Pangyun Formation by Mitchell et al. (1977). The quartzites also are equivalent to part of the Molohein Group of Myint Lwin Thein (1973) immediately east of the area. The Pangyun Formation and Molohein Group are at least partly of Cambrian age.

Pindaya Group

Rocks of Ordovician age are collectively termed the Pindaya Group, the name applied to the similar succession lying in and east of C/7 and 8 by Myint Lwin Thein (1973) and formerly termed Pindaya Beds or Mawson Series (Coggin Brown, 1931; Coggin Brown and Sondhi, 1933). The names of the three formations comprising the Group are based on the older terms of La Touche (1913) defined in the region immediately north and northeast of the area, and on the unpublished geological maps of the same region recently prepared by

DGSE following re-mapping in 1974-1976. Within the area the Group is confined to a NNW-trending belt on C/6 and 7, largely bounded on the east by a thrust and on the west by high-angle faults.

Ngwetaung Formation

Definition, distribution and topographic expression. A succession of brown calcareous siltstones and silty limestones in the west of C/6 and C/7 is named from the lithologically similar Ngwetaung Sandstones of La Touche (1913) exposed about 20 km north of C/6. It mostly forms low ranges and hill slopes beneath stratigraphically higher carbonate units. Dips are mostly west or northwest at between 50 and 80°, and the Formation occupies the eastern limb of faulted north-trending synclines. Its maximum stratigraphic thickness is estimated at about 900 m.

Lithology. The Formation comprises mostly ferruginous and calcareous siltstones interbedded with silty limestones and micaceous calcareous sandstones. Exposures are characteristically buff to yellow in colour, but when fresh the siltstones are blue-grey to yellow or pink. The sediments are thin-bedded or laminated and commonly show parallel and cross-lamination, although this is sometimes masked by ferruginous and carbonate veinlets. In the western part of C/6 quartzites are locally present within the siltstones. On Kalagwe Taung, west of Pyaukseikpin, the unit is metamorphosed to calc-silicate rocks, marble and quartzites, and overthrust by marble and calc-silicate of the Thitsipin Formation. It extends west of C/6 to form much of the Kyaukse Hill range.

Stratigraphic position, correlation and age. Although the contact of the Ngwetaung Formation with the underlying Chaung Magyi Group is everywhere obscured by debris from the steep scarp slope in the topographically higher Naungkangyi Formation, the presence to the north of younger Ordovician units adjacent to the Chaung Magyi Group suggests a thrust contact. The Formation can be traced southwards into C/8 and eastwards into C/11, where it was termed the Lokepyin Formation by Myint Lwin Thein (1973) and the Ngwetaung Formation by Garson et al. (1974). Most authors have placed the Formation in the lower Ordovician, but Thaw Tint and Hla Wai (in Win Swe pers. commun, 1978) have recently described Cambrian fossils from the Formation in the type-area.

Naungkangyi Formation

Definition, distribution, topographic expression and structure. This Formation is named from the Lower Naungkangyi Stage of La Touche (1913) described from the Northern Shan State near Maymyo. It is defined by the presence of characteristic argillaceous limestones and is restricted to the western part of sheets C/6 and the east of C/10. In many places Naungkangyi limestones form the upper parts of north-trending ranges with steep scarps above the gentler slopes underlain by the Ngwetaung Formation. The Formation underlies the Pyattawye and Dokto-ye Plateau on sheets C/6 and C/7 respectively, where it shows a characteristic karst topography. Dips are mostly westerly at 30 to 70°, although beneath the Pyattawye Plateau and the small area to the south the Formation occupies a north-trending syncline truncated in the west by a fault. The maximum thickness of the Formation is around 1,100 m.

Lithology. The predominant lithology is a blue-grey argillaceous limestone with yellow to buff-coloured silty partings. It is mostly medium to thick-bedded, with faint silty laminations and local cross-bedding, but in places it is structureless. The less argillaceous beds of blue-grey limestone are calcarenites with abundant crinoid and shell fragments, partly recrystallised to sparry calcite. Locally soft weathered calcareous siltstones and marls are interbedded with the limestone. Dolomite with a characteristic weathered surface is present in places as bedded units and as patches probably related to faults, cutting the bedding. Burrows are widespread, forming silt-filled tubes up to a centimetre diameter, both along and across the bedding. Stylolites are conspicuous, mostly approximately parallel to the bedding and appearing as thin wavy laminations of yellow to brown argillaceous material. The Formation has been described in detail from adjacent map sheets by Myint Lwin Thein (1973) and Garson et al. (1976).

Stratigraphic position, correlation and age. The Naungkangyi Formation passes gradationally down into the Ngwetaung Formation. It is approximately equivalent to the extensive Lower Naungkangyi stage of La Touche (1913) in the Northern Shan State, the Wunbye Formation of Myint Lwin Thein (1973) to the east, the Dokto-ye Limestone Formation of Garson et al. (1974) on C/8, and to the Taungyun Formation within the Naungkangyi Stage north of Kyaukme in the Northern Shan State (Mitchell et al., 1977).

Nyaungbaw Formation

Red and grey limestones and calcareous mudstones are restricted to the northern part of C/6. They are here termed Nyaungbaw Formation because of their similarity to rocks of the type-area north of the project area described by La Touche (1913). The maximum thickness of the unit is about 600 m.

The Formation consists of grey to red and purple coloured thick-bedded argillaceous limestones with a characteristic surface texture commonly termed 'phacoidal' and related to stylolites of argillaceous material, interbedded with red shale and calcareous siltstone. The lithology of the Formation has been described in detail from adjacent areas by previous authors.

The Nyaungbaw Formation includes the Orthoceras Beds of Coggin Brown and Sondhi (1933), and is similar in lithology to the Linwe Formation of Myint Lwin Thein (1973) and to the Linwe Formation and probably part of the underlying Kinle Siltstone Formation of Garson et al. (1974, 1976). It is of Upper Ordovician and Lower Silurian age, and older than the Panghsa-Pye graptolite band of Llandovery (lower Silurian) age to the north and east of the area.

The Formation lies adjacent to the Chaung Magyi Group in the northeast of C/6. The contact is obscured by travertine and boulders, and although the bedding attitude suggests an unconformity, elsewhere the Nyaungbaw Limestone is conformable on the Naungkangyi Formation. The base of the Nyaungbaw Limestone in this area is therefore probably a northwesterly dipping thrust.

Zebingyi (?) Beds

A thin unit of calcareous shale and silty well-bedded calcarenite and fine-grained calcirudite is present south of Pyaukseikpin on C/6. The succession, less than 30 m thick, is overlain unconformably by Kalaw Conglomerate (see fig. 9a) and overlies quartzites, phyllitic mudstones and calcareous sediments of the Ngwetaung Formation. Sample C/6 790 124 yielded brachiopods probably related to Plectodonta, indicating an age within the range upper Ordovician to lower Devonian (annex III). The unit is possibly equivalent to either the Namhsim Formation or Zebingyi Beds of the Northern Shan State; it is tentatively referred to the Namhsim Formation on the 1:100,000 scale geological map (fig. 2), but to the Zebingyi Beds on the later ¼ inch compilation (fig. 15).

Mergui Group

Definition, distribution, topographic expression and structure

This unit consists of a thick succession of mudstones, siltstones, greywackes and sandstones and small areas of schists and quartzites interpreted as their metamorphosed equivalents, occupying the western part of D/5, 6, 7 and 8, where it underlies much of the Byinge-Gegyi Ranges. Pebbly facies resemble those of the Mergui Series of Oldham (1856) in the south of Tenasserim, and the unit is here redefined as a Group. Major north-trending folds with a wavelength of 5 to 9 km are visible on LANDSAT imagery, and less distinctly on air photographs, on D/6, but few folds are apparent from field observations. Quartz veins locally are folded on a small scale. Displacement on faults within the Group cannot be determined owing to lack of marker horizons. The maximum thickness of the Group, estimated from D/6 where folds are identifiable, probably exceeds 2,500 m.

Lithology

The predominant rocks are pebbly mudstones, pebbly siltstones and pebbly sandstones, most of which are texturally greywackes, and mudstones. Each of these facies forms units which in places are more than 20 m thick and commonly lack bedding, although parallel and cross-laminated mudstones and siltstones occur locally, and the pebbly facies rarely show lamination. The pebbly mudstones and siltstones, which are in some places calcareous, contain scattered clasts, mostly less than 3 cm diameter, consisting largely of white quartzite and rarely of limestone; one diorite pebble has been observed. Quartzite or highly lithified quartzose sandstones commonly up to 5 m and rarely 20 m thick show sharp stratigraphic contacts with the muddy rocks, and locally the pebbly mudstones contain convoluted or folded blocks of quartzite. Rarely slumped beds are present, for example in the Zemon Chaung (D/8 865 464), and west of Yebu (D/6), where thin quartzites within pebbly siltstones show pull-apart structures and slump balls.

In a few localities red to grey muddy limestones and schistose limestones up to 30 m thick are interbedded with the terrigenous sediments. On D/8 limestone units up to 100 m thick, consisting of poorly-bedded calcarenites with crinoid and shell fragments form steep-sided ridges; they are either interbedded within the Group or are outliers of Shan Dolomite. West of Yinmabin and Pyinyaung (D/5) yellowish-green silicic locally laminated rocks are interbedded with spotted slates and cut by granitic veinlets. The rocks are probably fine-grained basic tuffs and possibly lavas within the Mergui Group, silicified and hornfelsed, and intruded by the granite.

The sedimentary rocks pass laterally into phyllites, spotted slates and quartzites which mostly occur in the west, but these are not everywhere differentiated from sedimentary rocks on the geological map. Adjacent to plutons the sediments are hornfelsed to fine-grained hard dark green to black rocks with fragments clearly visible in the pebbly facies; quartz veins are common. In the Yinmabin Lowlands (D/5), the Group is largely surrounded by granite and locally metamorphosed to schist, with gneissic bands forming the Yinmabin Metamorphics of Maung Thein et al. (1972).

In the west of D/7 and 8 areas of interbedded biotite schists, quartzite and minor quartz-mica schist are interpreted as metamorphosed greywackes and quartzose sandstones of the Mergui Group. These are well exposed east of Indaing (D/7), where thin bands of marble and calc-silicate rock occur within the schists, the compositional banding dipping regularly westwards. Although the schists are restricted to the western part of the Group adjacent to plutons, there is no obvious genetic relationship between the plutonic and metamorphic rocks.

Stratigraphic position, correlation and age

The stratigraphic base of the Mergui Group has not been observed. The Group passes westwards into metamorphic rocks and is bounded on the east by Mesozoic rocks; the latter locally overlie the Group unconformably and elsewhere are overthrust by it. The Group shows lithological similarities with both pebbly schists within the Nancho Group and with the Kankalin Formation of Bateson et al. (1972) east of Pyinmana. It can be correlated on the basis of stratigraphic position and lithology with the Taungnyo Series of Leicester (1930), renamed Taungnyo Group by Brunnschweiler (1970), with the Martaban Series of Oldham (1856) in northern Tenasserim, with the Phuket Group of Garson et al. (1976) and Mitchell et al. (1970) in southern Thailand (table 1), with the Singa Formation of West Malaysia and with Carboniferous rocks near Songhlaburi (15 N, 98 30'E) in western Thailand (Baum et al., 1970). Correlations with South Thailand and Malaysia indicate that the Group is largely of Carboniferous to lower Permian age, but may include upper Devonian and lower Permian rocks. Fossils from several localities in the Group or its stratigraphic equivalent within Burma but outside the project area have all yielded Carboniferous ages (Myint Lwin Thein, pers. commun, 1977); Brunnschweiler (1970). Within the project area, a sample of mudstone from D/8 (910 365) yielded corals and a bryosoa indicating a lower Permian or just possibly a Carboniferous age (annex III).

Shan Dolomite Group

Definition, distribution and structure

Geological mapping in the Neyaungga-Yengan Area of C/8 in 1970 (Garson et al. 1974, 1976) showed that much of the Plateau Limestone of La Touche (1913), considered to be of Devonian to Permian age and forming a widespread unit in the Shan State, contained Lower Permian to Middle Triassic fossils. It is now evident that Devonian carbonates are restricted to the Northern Shan States (La Touche, 1913), where local limestones of Carboniferous age have

Table 1. Stratigraphic correlations, Southeast Asia

		S.SHAN STATE THIS REPORT, AND GARSON ET AL (1976), MYINT LWIN THEIN (1973)	N. SHAN STATE MODIFIED FROM LA TOUCHE (1913); MITCHELL ET AL (1978)	NORTHERN THAILAND BAUM ET AL (1970); PITAKPAIVAN AND PIYASIN (1971)	SOUTHERN THAILAND MODIFIED FROM GARSON ET AL (1975)	WEST MALAYSIA IN GOBBETT AND HUTCHISON (1973)	EASTERN THAILAND PITAKPAIVAN AND PIYASIN (1971)
CRETACEOUS	U M L	KALAW RED BED GP KYAUKHSU TAUNG FM	NAMYAU RED BEDS				
JURASSIC	U M L	LOI AN FM	NAMYAU LSTS		KO YAO FM	GAGAU GP TEBAK FM TEMBELING FM	KHORAT GP
TRIASSIC	U M L	MA-U-BIN FM ? SHAN DOLOMITE GP	NAPENG BEDS PANGNO EVAPORITES ? SHAN DOLOMITE GP		RATBURI LST	SEMMANGGOL FM KERDAU FM GUNONG RABONG FM KODIANG LIMESTONE	
PERMIAN	U L				MOULMEIN LST	CHUPING LIMESTONE	
CARBONIFEROUS	U M L	MERGUI GP		SONGKHLABUR AND MAE HONG SON AREA	PHUKET GP	SINGA FM KAMPONG SENA FM	
DEVONIAN	U M L		WETWIN SH PADAUKPIN LST ZEBINGYI BEDS				
SILURIAN	U L	NAMHSIM FM PANGHSA-PYE GRAPTOLITES	NAMHSIM SERIES PANGHSA-PYE GRAPTOLITES			UPPER SETUL LST MAHANG FM	
ORDOVICIAN	U L	NYAUNGBAW LST NAUNGKANGYI FM NGWETAUNG SST	NYAUNGBAW LST NAUNGKANGYI FM NGWETAUNG SST	LI AREA	THUNG SONG LST	LOWER SETUL LST SUNGEI PATANI LST	
CAMBRIAN	U M L	MOLOHEIN GP	PANGYUN FM BAWDWIN VOLCANIC FM	MAE SARIANG AREA		MACHIN CHAUNG FM PAPULIUT QUARTZITE	
LATE PRE CAMBRIAN		CHAUNG MAGYI GP	CHAUNG MAGYI GP				

also been reported (Win Swe, pers. commun, 1977).

Amos (1975) applied the term Shan Dolomite Group to all carbonates of Devonian to Triassic age, as at that time the Carboniferous age of the terrigenous Mergui Group was not appreciated. It is now evident that the Plateau Limestone comprises rocks of Devonian and also of lower Permian to middle Triassic age, in places separated stratigraphically by the Mergui Group. The Permo-Triassic carbonates were divided into three formations by Garson et al. (1974); these formations can be recognized within the project area, and the Shan Dolomite Group is here redefined to comprise them.

The Group occupies a number of N to NNW-trending belts in the western part of sheets C/6 and 7 and in the east of D/5, 6 and 7, mostly with thrust and high-angle fault boundaries with younger rocks. For example, the NNW-trending belt in the east of D/5 is thrust eastwards over the Kalaw Conglomerate and truncated in the west by a high-angle fault.

Thitsipin Limestone Formation

This is the lowest of the three formations within the Group defined on C/8 by Garson et al. (1976), and can be identified in the project area by its lithology and stratigraphic position. The formation is restricted to the eastern part of C/6. It is folded about north-trending axes and is preserved as north-trending mostly fault-bounded ridges, and as a number of small outliers. Dips are mostly between [illegible]° and 50°, and in the main north-trending ridge are consistently to the west. The probable thickness of the formation on C/6 is about 600 m.

The lithology of the Thitsipin Limestone has been described in detail from sheet C/8 by Garson et al. (1976). The formation consists entirely of limestone, mostly blue-grey well-bedded calcarenite and calcilutite, and is in places richly fossiliferous. Towards the western margin of C/6 the Thitsipin Limestone becomes crystalline, and at Kalagwe Taung consists of fine-grained marble with minor mica and calc-silicate lenses. In the west of D/6 areas of marble associated with schist and gneiss are possibly the metamorphosed equivalent of part of the Shan Dolomite Group.

Seven fossiliferous samples from C/6 all contained either corals or foraminifera of Permian age, and one contained corals indicating an Artinkskian to lower Kungurian age (annex III). These results, together with those determined previously (Garson et al., 1976), indicate that the Thitsipin Limestone is mostly of lower Permian age, but possibly extends into the upper Permian.

Nwabangyi Dolomite Formation

This is the most widespread and thickest formation in the Shan Dolomite Group in the type-area on C/8 (Garson et al., 1976). In the project area, the formation is present in C/7 and the north of C/6. The elongate NNW-trending belts of carbonate extending across D/5 and 6 and the narrow strip in the east of D/5 are shown as undifferentiated Nwabangyi Dolomite-Natteik Formation. While the Natteik Limestone is a distinct litho-stratigraphic unit in the type area, it is possible that the upward stratigraphic limit of dolomitisation which defines the top of the Nwabangyi Dolomite is diachronous (Amos, 1975) and hence the dolomites and dolomitic limestone on D/5 and 6 and in the north of C/7 may include stratigraphic equivalents of the Natteik Limestone. The thickness of the Nwabangyi Dolomite is difficult to determine, but is probably not less than 1,000 m. The Nwabangyi Dolomite typically forms an undulating grass or scrub-covered plateau broken by rounded hills and local craggy knolls. On C/7, east of Lungyaw, the formation is bounded in the west by a major fault and forms a linear west-facing scarp above a faulted segment of sandstones and shales of the Pan Laung Group.

The lithology has been described in detail in the type area by Garson et al. (1976) and Amos (1975). It comprises mostly structureless grey dolomite and dolomitic limestone with a characteristic brecciated appearance which obscures the sedimentary structures. The brecciated dolomite is either very hard or more commonly crumbly and easily shattered into angular fragments by the hammer. In places bedding is visible, mostly within pale grey dolomite with a 'sandy' surface, laminated micritic dolomite or dolomitic limestone, and dolarenites. The dolarenites commonly contain crincid and shell fragments, and the other bedded lithologies locally include abundant foraminifera and relict algal structures.

The belt of undifferentiated Nwabangyi Dolomite-Natteik Limestone on D/5 and D/6 is best exposed in water-polished stream sections; elsewhere, it is mostly brecciated and structureless. For example, in the stream section beside the car road west of Pyinyaung on D/5, the rock throughout the 600 m of stratigraphic thickness consists of thin-bedded and locally laminated dolomite, with alternations of light grey dolarenite and dark grey to black dolomicrite; shell fragments are present locally, mostly as crystalline white carbonate, and patches of calcite are common. The presence of this distinct lamination suggests that the brecciation visible elsewhere is a superficial feature resulting from weathering. Samples of Nwabangyi Dolomite from three localities (C/7 844 906, 846 905, 846 904) each contained a rich fauna of foraminifera and algae of upper Permian (Tartarian) age (annex III).

Natteik Limestone

A unit of calcarenite and calcilutite showing features typical of turbidite facies was described from C/8 by Garson et al. (1976) and termed the Natteik Limestone Formation. A sample (295 472) collected from the type area by Amos (personal communication, 1975) yielded foraminifers of middle or possibly early upper Triassic age (Whittaker, personal commun. 1975). Within the project area a small area of limestone interpreted as an outlier within Nwabangyi Dolomite on C/7 is considered to be part of the Natteik Limestone. The unit consists of well-bedded calcarenite and dark grey calcilutite and dolomicrite dipping regularly westwards with a stratigraphic thickness of at least 400 m. The Natteik Limestone on C/8 was considered by Garson et al. (1976) to lie conformably on the Nwabangyi Dolomite, and although this contact could be reinterpreted as a possible thrust, the palaeontological evidence suggests that the Limestone is younger than the Dolomite.

Stratigraphic relationships, correlation and age

The base of the Thitsipin Limestone has not been recognized. At several localities on C/6 the Limestone lies with a sharp probably thrust contact on older rocks. South of Pyaukseikpin (C/6 790 124), the Thitsipin Limestone is thrust over a limestone boulder bed of the Kalaw Conglomerate, which rests on Silurian rocks (see fig. 9a). Northwest of Pyaukseikpin, it lies on the middle Ordovician Naungkangyi Formation, and in the southwestern corner of the map sheet as well as north of Pyaukseikpin it overlies the lower Ordovician Ngwetaung Formation. At Kalagwe Taung metamorphosed Thitsipin Limestone lies in sharp and probably thrust contact on metamorphosed rocks of the Ngwetaung Formation. Because it has not been proved that these contacts are all tectonic rather than stratigraphic, most of them are shown as stratigraphic on the geological map (figs. 1 and 2).

The Nwabangyi Dolomite in the north of C/6 and south of C/7 rests directly on the Naungkangyi Formation, and also lies adjacent to the Nyaungbaw Formation. The absence here of the Thitsipin Limestone at the base of the Group suggests either that the Nwabangyi Dolomite onlaps across the Thitsipin Limestone onto older rocks, or more probably that it is in thrust contact with the Naungkangyi Formation.

The Group can be correlated with the Moulmein Limestone of Tenasserim, the Ratburi Limestone of Thailand, and the Chuping Formation and Kodiang Limestone of the Langkawi Islands and Kedah in Malaysia (table 1). In the area it ranges from lower Permian to middle Triassic (Anisian or possibly Ladinian) in age (Gramman et al., 1972; Bronnimann et al., 1975; Amos, 1975).

Panlaung Group

Within the Shan Scarps there are thick successions of mostly clastic sedimentary rocks which are younger than the Shan Dolomite and older than the Kalaw Red Bed Group. The successions are mostly fault-bounded and the stratigraphic contacts among them have not been observed. However, traverses in D/5 and in the south of C/8 have led to the recognition of three distinct units, of which two were known previously, and palaeontological determinations provide some evidence of the probable stratigraphic succession. Each unit is here referred to as a Formation within the Panlaung Group, named informally from the river in the middle course of which all the formations lie adjacent to each other. Because the formations are fault or thrust-bounded, their stratigraphic bases and tops are not exposed, with the exception of the top of the Kyaukhau Taung Formation.

Ma-u-bin Formation

Definition, distribution and topographic expression. The name Ma-u-bin Formation was given by Garson et al. (1974, 1976) to a succession on C/8 comprising mudstones and turbidite sandstones with local interbedded limestones. Dutt (1942) extended the term Loi-An Series to include the rocks now termed Ma-u-bin Formation, which are different in lithology and stratigraphic position from the Loi-An Series. The Formation lies immediately east of the Shan Dolomite Group on D/5 and D/6. In the north, much of the Formation occupies an eastward-facing slope beneath a prominent ridge of Shan Dolomite; to the south, on D/6, where it is in places partly hornfelsed and more resistant to erosion, it increases in elevation and relief.

Structure. The Formation in most places is tightly folded, with a wavelength of 5 to 100 m, and many of the beds are overturned, although horizontal bedding is found locally. Cleavage is poorly developed or absent, and most structures show a parallel to disharmonic style of folding, varying from upright to isoclinal and including eastward-facing recumbent folds. In general, the deformation resembles that in the type area at Ma-u-bin (Garson et al., 1976) tentatively interpreted as the result of gravity gliding; alternatively, and more probably, the deformation is the result of eastward thrusting. In spite of the tight folding, the strike is consistently 140 to 160°, slightly oblique to the trend of the belt. Because of deformation the stratigraphic thickness cannot be estimated, although it is unlikely to be less than 700 m.

Lithology. The Formation comprises interbedded sandstones, mudstones and siltstones with local mudflake conglomerates. The most common lithology is an alternation of parallel-bedded grey sandstones and black mudstones, commonly carbonaceous, with sandstones varying from a few centimetres to a metre in thickness in one exposure, and with mudstones mostly thinner than sandstones. Sole marks in the form of flute, groove and load casts are common, and animal trails are visible on some bedding planes. Part of the succession on D/5, for example in the Kanaw Chaung (915 437), consists of muddy calcareous sandstones up to 2 m thick, which are commonly pebbly with sandstone and larger mudstone clasts near the base, and which lie with erosive contacts on underlying sandstones or cross-laminated silty mudstones. A few beds are slumped and interbedded thinner sandstones are also present. A very similar lithology is exposed in the Gegaugh Chaung (970 234) near the unconformable contact with Kalaw Conglomerate.

In the area drained by the Law Chaung on D/6, the succession shows numerous small-scale folds, locally with vertical axes, but most beds are not inverted. The rocks are here mostly silicified and hornfelsed, with greenish to pale grey sandstones and impure quartzites interbedded with black, very hard mudstones giving a pronounced striped appearance. Most beds are from 1 to 20 cm thick, and commonly sandstones show ripple cross-lamination and convolute lamination throughout, with sharp load-cast bases. The Formation is intruded by dykes of felsparphyric hornblende, microdiorite and a diorite stock.

East of the Pinmon Chaung on D/6, muddy calcilutites underlain by pebbly calcareous siltstones form a unit up to 100 m thick; this is stratigraphically overlain to the east by calcareous sandstones and mudstones with rare clastic limestones and stratigraphically underlain to the west by a thin unit of similar rocks. The succession dips west, but youngs east through a stratigraphic thickness of at least 1,000 m. The limestone, termed the Pinmon East Limestone, is intruded by several diorite stocks near Taungbet, and here consists largely of marble.

Thin sections of sandstones from the Formation on D/5 show quartz grains with scattered mudstone pellets in a muddy to locally calcareous groundmass. An impure fine-grained calcirudite from the succession east of the Pinmon Chaung shows in thin section pebbles of limestone, felsparphyric basalt and sandstone. The Formation shows many features typical of a turbidite facies, and the thick sandstones and slump units suggest a proximal or near-source turbidite environment.

Stratigraphic relationships, correlation and age. The contact of Ma-u-bin Formation with the Shan Dolomite Group to the west has not been observed; in the stream section east of Kubyin (D/5), outcrops of dolomite and turbidite beds alternate over a distance of 100 m, probably due to imbricate faulting. The Formation lies to the west of the westward-dipping Loi An Formation, but the intense folding of the Ma-u-bin suggests that this contact is almost certainly tectonic. The Ma-u-bin Formation is overlain in angular unconformity by the Kalaw Conglomerate; the contact is well exposed in the Geyaugh Chaung 500 m from the Kalaw-Thazi road, where red conglomerates dipping west at 55° lie on turbidites dipping east at 80° and younging west.

There is little direct evidence for the age of the Formation within the range post-Shan Dolomite pre-Kalaw Conglomerate. However, the isoclinal folding of the Formation suggests that it was folded before deposition of the relatively undeformed Loi An Formation. Brachiopods from the Formation on C/8 were suggestive of an upper Permian-Lower Mesozoic age (Garson et al., 1976), and since the Formation is evidently post-Shan Dolomite, an upper Triassic age is most probable. There is no known source for the basalt pebbles found in one sample.

If the upper Triassic age for the Formation is correct, it can be correlated (table 2) with the Pane Chaung Group of the Chin Hills (Technical Report No. 5) and with turbidites and cherts of the Ladinian to Carnian Semanggol Formation (table 1) in the Malay Peninsula (Burton, 1973).

Loi An Formation

Definition, distribution, topographic expression and structure. A succession of thin coals, conglomerates, sandstones and shales well exposed in the north of D/5 is equivalent to part of the Coal Measures of Jones (1887) and Cotter (1922), renamed Lai An Series by Dr. Fox in 1929 (in Coggin Brown and Sondhi, 1933). On C/7 ferruginous laminated sandstones and silty mudstones largely mantled in travertine form a narrow N-trending belt in fault contact with the Shan Dolomite Group to the east; although provisionally included in the Ma-u-bin Formation, it is possible that these rocks belong to the Loi An Formation. The topographic relief is lower than in most other units in the area, and adjacent to the Shan Dolomite the Formation is mostly blanketed in travertine. In the northeastern part of D/5 dips are predominantly westward at 20 to 40°; locally small-scale folds are present, but overturned beds have not been observed and the Formation is less tightly folded than the adjacent Ma-u-bin Formation. The thickness of the Formation here is at least 1,200 m.

Lithology. The Formation consists largely of interbedded sandstones, siltstones, limestones and coals or coaly shales. It can be conveniently described in terms of five main facies which with the exception of the concretionary shales are commonly interbedded.

Quartzose and felspathic sandstones occur throughout the lower and middle part of the Formation in units up to 10 m thick. They are white to grey or yellowish, commonly cross-bedded sandstones and gritty sandstones, but in places show ferruginous parallel laminations. The sandstones are mostly interbedded with coals and rippled siltstones. Rarely thin conglomerates with rounded pebbles of quartz are present.

Laminated and ripple-cross-laminated siltstones on weathered surfaces resemble a turbidite facies, with more resistant bands a few centimetres thick alternating with softer layers. However, on fresh surfaces the alternations are seen to consist entirely of interlaminated yellow fine-grained sandstones and grey silty mudstones, the proportion of sandstone laminations being greater in the more resistant bands.

Coals and coaly shales up to a metre in thickness occur mostly in the middle part of the Formation and are commonly interbedded with the rippled siltstones and quartzose and felspathic sandstones.

Limestones occur in units up to 4 m or more in thickness and are largely restricted to the middle and upper part of the Formation. They are mostly bio-calcarenites and silty limestones with locally abundant shell fragments which have not yielded any of determinable age.

Concretionary shales are restricted to the uppermost part of the Formation, where they are up to 200 m thick and lie adjacent to the Ma-u-bin Formation to the west. They comprise grey shaly siltstones and silty mudstones, with scattered spherical nodules up to 6 cm diameter. An abundant fauna is present in some of the concretions, and well-preserved brachiopods are found on the surface of some deeply weathered exposures.

Stratigraphic position, correlation and age. The stratigraphic position of the Loi An Formation has long been in dispute. Cotter (1922) suggested that the Loi An Series east of Kalaw was part of the Kalaw Red Beds. Coggin Brown and Sondhi (1933) considered the Loi An Series to be Rhaetic on the basis of plant remains. A view prevalent in the early 1970's (Dr. Myint Lwin Thein, pers. Commun., 1977), based on the results of mapping of part of D/5 and D/6, was that the coal-bearing succession together with the turbidites of the Ma-u-bin Formation were facies or members of a stratigraphically continuous succession termed the Loi An Group.

Shell fragments from limestones within the Formation have not yielded dateable remains, but an ammonite fragment from within the concretionary shale at the top of the Formation (D/5 937 397) proved to be of lower Oxfordian age (annex III). Part of the Loi An Formation can therefore probably be correlated with the richly fossiliferous limestones (Buckman, 1917; Cowper Reed, 1936) beneath the Namyau red beds in the Northern Shan State.

Kyaukhsu Taung Formation

In the southern part of C/8 an eastward-dipping succession lying in inferred unconformity on rocks of the Mergui Group to the west is well exposed in the Kyaukhsu Chaung, and in streams draining the eastern slopes of Kyaukhsu Taung to the north from which it is named. The succession, here termed the Kyaukhsu Taung Formation, is equivalent to the upper part of the Pan Laung Formation of Garson et al. (1976), now recognized as a composite unit which included part of the Mergui Group.

The Formation is about 1,000 m thick. It comprises a very distinctive pale grey basal conglomerate with rounded pebbles of quartzite, vein quartz and rare mudstone, black limestone and red chert, in a quartzose matrix, interbedded with cross-bedded white quartzose sandstones. The conglomerates and quartzites are overlain by laminated siltstones, mudstones and rare sandstones, with common ripple-marks which pass up into muddy fine-grained black limestones, and calcareous mudstones and shales which are locally pebbly and include shell beds. The top of the Formation consists of a blue-black, fine-grained limestone, mostly well-bedded, which thickens northwards from about 15 m in the north of D/5 to nearly 200 m where described by Garson et al. on C/8.

South of Lebyin on D/6 a succession of shales and thin limestones is considered to be equivalent to the Kyaukhsu Taung Formation to the north. The shales or mudstones are highly carbonaceous and mostly calcareous with interbedded black muddy limestone and include sedimentary breccias with angular fragments of mudstone and limestone up to 5 cm diameter. The sedimentary breccias include slumped beds, but the stratigraphic succession and structure is complicated by thrusts, and sole marks and cross-lamination in a unit to the east suggest that part of the Formation here is overturned.

The quartzose conglomerate at the base of the Formation on C/8 lies adjacent to the underlying Mergui Group, although the actual contact is occupied by a thin band of weathered shale. A sample from limestone near the top of the unit (C/8 865 469) yielded a fauna of Jurassic to earliest Cretaceous age, and fossils from within a shale near Maunggwe (C/8 818 734) were of probable upper Jurassic age (annex III). Previous identifications of fossils from the Formation on C/8 yielded an age within the range of middle Jurassic to lower Cretaceous (Garson et al. 1976). The Formation is therefore considered to be younger than the Loi An Formation, the top of which contains Oxfordian fossils. Hence the base of the Kyaukkau Taung Formation is probably not older than late upper Jurassic. The Formation is overlain with a possible low-angle unconformity by the Patchaung Volcanics on C/8 and D/6.

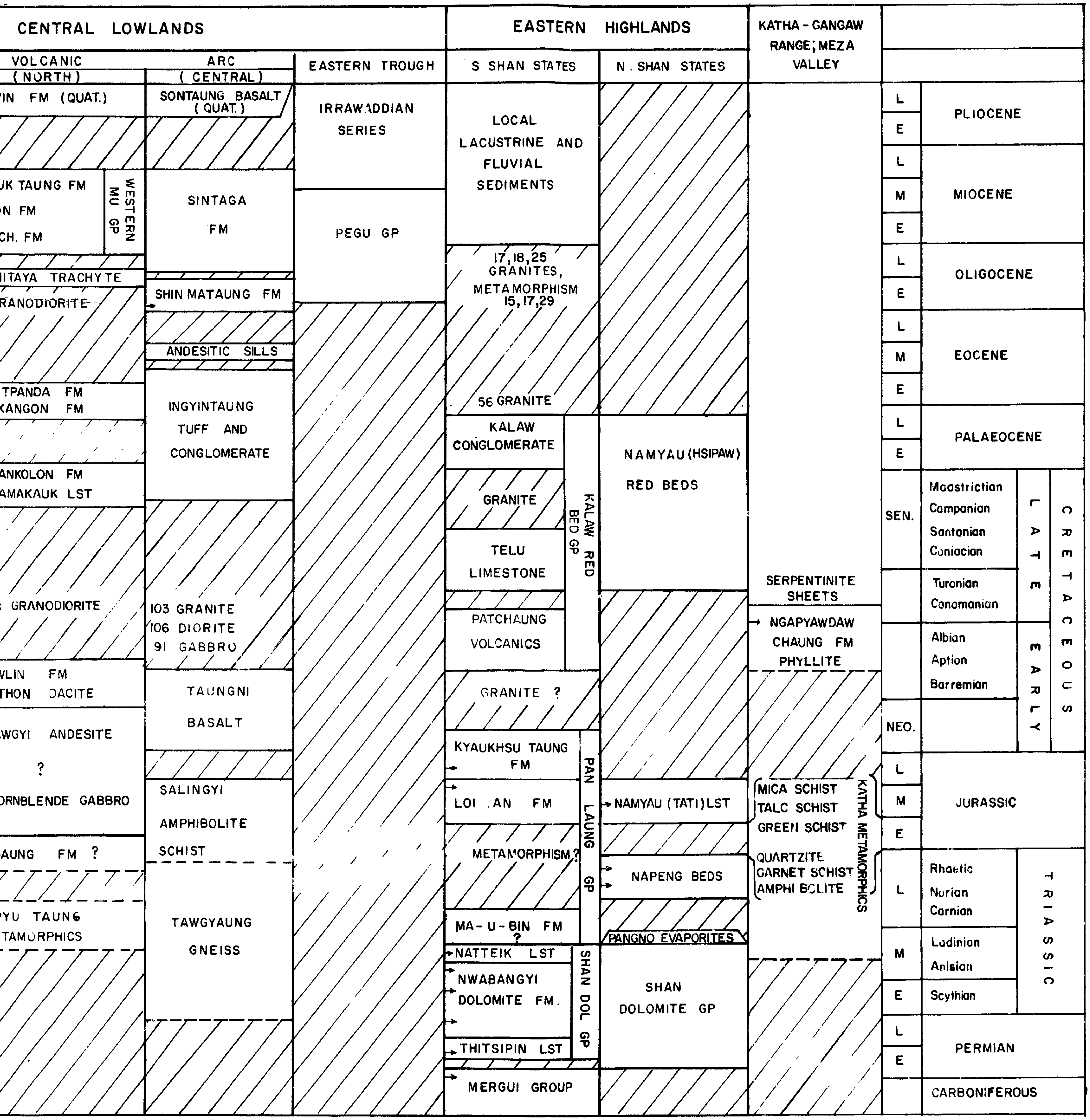
Table 2. Stratigraphic correlatio

SYSTEM	EPOCH STAGE	INDOBURMAN RANGES: WESTERN BELT – ARAKAN	INDOBURMAN RANGES: WESTERN BELT – CHIN HILLS	INDOBURMAN RANGES: EASTERN BELT	CENTRAL LOWLA: WESTERN TROUGH	CENTRAL LOWLA: VOLCANIC (NORTH)	
PLIOCENE	LATE				IRRAWADDIAN SERIES	SADWIN FM (QUAT.)	S
	EARLY						
MIOCENE	LATE	RAMRI AND CHEDUBA I SSTS AND SHS				SUNBAUK TAUNG FM (WESTERN MU GP)	
	MIDDLE	→			→ PEGU GP	GWEGON FM (WESTERN MU GP)	
	EARLY					WABO CH. FM (WESTERN MU GP)	
OLIGOCENE	LATE				→	32 AUKTHITAYA TRACHYTE	
	EARLY					38 33 GRANODIORITE	SH
EOCENE	LATE	TURBIDITES			→ YAW SHALES → PONDAUNG SST		
	MIDDLE	→ OLISTOSTROMES	KENNEDY SST		TABYIN CLAYS → TILIN SST		A
	EARLY	SLUMPS	CHUNSUNG		→ LAUNGSHE SHALES	KETPANDA FM	
PALAEOCENE	LATE	TURBIDITES	→ MUDSTONE-TURBIDITE FM		→ PAUNGGYI CONG.	KANGON FM	
	EARLY				? ? ?		
CRETACEOUS – EARLY – SENONIAN	Maastriction Campanion Santonian Coniacian	→	→ FALAM MUDSTONE-MICRITE FM	PAUNGGYI CONGLOMERATE	→ PAUNGGYI CONGLOMERATE →	NANKOLON FM NAMAKAUK LST	
	Turonian Cenomanian			METAMORPHISM? SERPENTINITE SHEETS		94, 48 GRANODIORITE	103 106 91
CRETACEOUS – LATE	Albian Aptian Barremian			→PAUNG CHAUNG LST.	→ PAUNG CHAUNG LST	MAWLIN FM MAINGTHON DACITE	
– NEOCOMIAN						MAWGYI ANDESITE	
JURASSIC	LATE					?	
	MIDDLE					144,186 HORNBLENDE GABBRO	S A
	EARLY					SHWEDAUNG FM ?	S
TRIASSIC	LATE – Rhaetic, Norian, Carnian			158 SERPENTINITES? METAMORPHISM? PILLOW LAVAS?			
	MIDDLE – Ladinian, Anisian			→ PANE CH. GP KANPETLET SCHISTS		HPYU TAUNG METAMORPHICS	
	EARLY – Scythian						

→ PALAEONTOLOGICAL AGE

56 K/A-RADIOMETRIC AGE, M.Y.

igraphic correlations, Burma



Kalaw Red Bed Group

Definition, distribution, topographic expression and structure

This Group comprises volcanic rocks, micritic limestones and predominantly red to purple or pink clastic sediments lying unconformably on older units. It was defined as a Formation by Garson et al. (1974, 1976) on sheet C/8 and named after the 'Kalaw Red Beds' of Middlemiss (1900), but is here redefined as a Group because it includes at least one and probably two angular unconformities. The Group occurs within a NNW-trending belt extending from C/7 across the eastern part of sheets D/5 and D/6, where it mostly forms hilly areas with well-developed drainage adjacent to higher ridges of the Nwabangyi Dolomite. Adjacent to the Dolomite, it is commonly partly blanketed in travertine.

In the southeast of D/5 the Group forms a southeast-plunging syncline surrounded by the Ma-u-bin Formation. Elsewhere, it is mostly bounded by NNW-trending faults and thrusts and occurs adjacent to the Pan Laung Group. The strike varies from 140^{o} to 180^{o}, with dips mostly between 20 to 40^{o}, although vertical beds are not uncommon; overturned beds are rare. The maximum thickness of the Group is probably at least 2,000 m.

The Group comprises three informally named units. These are, in upward stratigraphic sequence, the Patchaung Volcanics, the Telu Limestone and the Kalaw Conglomerate.

Patchaung Volcanics

A succession of lavas and clastic volcanic rocks up to 700 m thick is well exposed in the stream immediately east of the deserted village of Patchaung in the south of C/8, and in the Kyaukhsu Chaung and Kanaw Chaung in the north of D/5. A similar succession is exposed in a discontinuous belt southwards across D/5 and into D/6; conglomeratic volcanic rocks are also present within the undifferentiated Mesozoic unit in the east of D/7. The Patchaung Volcanics are equivalent to the volcanic rocks which Coggin Brown and Sondhi (1933) recognized within the Kalaw Red Beds.

At Patchaung the succession dips east at 40^{o} to 70^{o}. The lowest bed is a conglomerate with pebbles of limestone and of greenish fine-grained dacitic rocks. This is overlain by volcanogenic green to purple grits and sandstones, which pass upwards into conglomerates with plagiophyric andesite pebbles interbedded with flow-banded rhyolite. The upper part of the Formation comprises a succession of alternating purple plagiophyric andesites, green to purple quartz-porphyry dacites and red to pale grey rhyolites with interbedded volcanogenic sediments and rare white tuffs. The conglomerates are mostly red to purple in colour, and beds of red to purple siltstone and sandstone are interbedded with the coarse-grained sediments. Within the volcanics a local unit of folded sandstone and shale about 10 m thick observed in three-stream sections is presumably interbedded with the volcanic rocks.

Thin sections of lavas from near Patchaung and also south of Telu show vesicular holocrystalline porphyritic hornblende andesite, and rare trachytes with phenocrysts of orthoclase, minor plagioclase and altered mafics. Silitic rocks contain large corroded quartz phenocrysts together with varying proportions of orthoclase and plagioclase with scattered biotite and hornblende in a devitrified groundmass. Northeast of Minpalung on D/5, felspar porphyry has a pale green calcareous groundmass composed of felspar microlites and calcite in apparent optical continuity.

The base of the volcanics is in stratigraphic contact with a limestone at the top of the Kyaukhsu Taung Formation on C/8, where the lowest beds contain pebbles of the limestone. The Volcanics also overlie limestone, probably of the Kyaukhsu Taung Formation, adjacent to the stibnite mineralization at Lebyin on D/6.

Telu Limestone

Pale grey to white or cream and locally pink micritic limestones termed the Pinnacle Limestone Formation formed a mappable unit stratigraphically beneath the Kalaw Red Bed Formation on C/8 (Garson et al., 1972, 1976). Within the project area similar limestones are here informally termed Telu Limestone from the village on the northern boundary of D/5. The unit comprises micritic limestones more than 5 m and commonly up to 30 m thick, interbedded with red sandstones and siltstones and locally with red conglomerates. The maximum thickness of the unit is about 700 m.

The colour of the limestone and characteristic blotchy texture is identical to that described by Garson et al. (1976). It is mostly thick-bedded or unbedded and locally comprises clasts or patches of pink, white or cream-coloured micrite either separated by stylolites or set in a crystalline calcite matrix, resembling a calcirudite. Interbedded red sandstones and shales are commonly calcareous and include lenticular beds of micritic limestone. In a few localities pink to red chert lenses are present in the limestone. Micritic limestones lie in probable stratigraphic contact on the Patchaung Volcanics near Kubyin on D/5 and overlie the Volcanics south of Lebyin on D/6. The contact is probably unconformable. No organic remains have been found in the Limestone.

Kalaw Conglomerate

Red conglomerates, sandstones and siltstones are the most widespread and characteristic lithology in the Kalaw Red Bed Group, and recent mapping in C/8 and near Lebyin has shown that they form the youngest unit. The base of the unit is invariably a conglomerate or boulder bed, mostly red, but locally grey to brown in colour. The composition of the clasts varies widely and is commonly related to the lithology of the underlying unit, although some clasts of red sandstone and siltstone are present in almost all localities.

Angular to sub-rounded pebbles and cobbles of limestone and dolomite are most common and present not only where the unit overlies the Shan Dolomite but also in some areas where it overlies non-calcareous rocks. Elsewhere the clasts are predominantly of the Ma-u-bin Formation, Kyaukhsu Taung Formation, Patchaung Volcanics, Telu Limestone, quartzites of the Mergui Group, or rarely of biotite leuco-granite. The matrix ranges from red or brown sandstone to siltstone and calcareous siltstone. Most of the conglomerates are crudely bedded and locally cross-bedded, and in some places imbrication of the clasts is apparent.

The basal conglomerate, which in places is at least 100 m thick, is overlain by red sandstones and siltstones which are commonly calcareous and cross-bedded and interbedded with conglomerates similar to those near the base. In a few localities, for example east of Telu, fine-grained white tuffaceous sediments occur within a predominantly sandstone sequence. In the Myittha Chaung, on D/6, the basal conglomerate is commonly grey to brown rather than red. Conglomerates up to 4 m thick are well exposed in the river near Pyinyaung Buda (D/6 906 185). They show sharp erosive bases on mudstones and contain angular blocks up to 40 cm diameter of quartzite, phyllite or semi-schist, laminated siltstone, dacitic quartz porphyry and fine to medium-grained biotite leucogranite. Interbedded with the conglomerates are black carbonaceous mudstones and siltstones, including minor mudstone and sandstone laminations with pronounced ripple cross-lamination.

The Kalaw Conglomerate lies with a clearly visible angular unconformity on older rocks. It overlies Silurian or Lower Devonian rocks on C/6 (792 127), the Mergui Group on D/6 (914 086), the Shan Dolomite on C/8 (942 528), the Ma-u-bin Formation on D/5 (920 234), Telu limestone on C/8 (980 487) and north of Lebyin on D/6 (937 065), and what is probably the Kyaukhsu Taung Formation south of Lebyin (D/6 935 044). Immediately east of the Mergui Group on D/5 and 6 the Conglomerate locally contains abundant boulders of rocks resembling the Patchaung Volcanics. The conglomerate is overthrust by the Shan Dolomite on C/6 792 127 (see fig. 9a), C/8 (970 520) and on D/5.

Stratigraphic relationships and age

There are no reports of determinable macrofossils or foraminifera from the Kalaw Red Bed Group. Middlemiss and Sahni (in La Touche, 1913) considered that the red beds were similar in lithology to the purple sandstones and shales of the Namyau Series of the Northern Shan State. The Namyau red beds overlie limestones, later termed Tati Limestone by Brunnschweiler (1970), which contain Bathonian (Middle Jurassic) brachiopods. Although this stratigraphy has been disputed (Sahni, 1937), the red beds of the upper part of the Namyau Series, the Hsipaw Red Beds of Brunnschweiler (1970), are undoubtedly lithologically identical to those of the Kalaw Conglomerate (Mitchell et al., 1977). Possibly also the Kalaw Conglomerate can be correlated with the red carbonate conglomerates and sandstones overlying the Triassic Kamawkala Limestone in Kayah State (Cotter, 1923). The Telu Limestone Member is equivalent to the Pinnacle

Limestone Formation of Garson et al. (1974, 1976) on C/8, and possibly to the Limestones within the lower part of the red beds of the Namyau Series described from the Northern Shan State (La Touche, 1913; Brunnschweiler, 1970; Mitchell et al., 1977).

The stratigraphic relationships observed in the present mapping and described above indicate that the Patchaung Volcanics and Telu Limestone are younger than the Pan Laung Group, and that the Kalaw Conglomerate is younger than all other units in the area. The Group therefore is almost certainly post-Jurassic in age.

The Patchaung Volcanics and Telu Limestone are probably late lower to early upper Cretaceous in age. The Patchaung Volcanics cannot reliably be correlated with any unit of the Volcanic Arc to the west, although they could be equivalent to either the Maingthon Dacite or Kawdaw Dacite in the north of the Arc. Possibly the extensive Kalaw Conglomerate can be correlated with the later upper Cretaceous (Maastrictian) to lower Eocene Paunggyi Conglomerate, widespread in the Western Trough, and the probably equivalent Ketpanda and Ingintaung Formations of the Volcanic Arc (Technical Reports, Nos. 2 and 5).

Tamagyi Metamorphics

Location and definition

Some areas of metamorphic rock can be interpreted on the basis of lithology and gradational decrease in grade of metamorphism as equivalent to specific sedimentary rock units, i.e. meta-Chaung Magyi Group on C/6 and C/10, meta-Mergui Group on D/6 and D/7, and meta-Shan Dolomite Group on C/6, described above. However, in the west of D/6, 7 and 8 there is a narrow north-trending belt of metamorphic rocks, the unmetamorphosed stratigraphic equivalents of which have long been disputed. The rocks comprising the belt are well-exposed in the scarp drained by the Tamagyi Chaung on D/6, from which they are informally named.

Lithology

The Tamagyi Metamorphics in the type area occupy a west-facing scarp about 2,300 ft in height at the eastern edge of the Onbin Plain. On the poorly dissected plateau east of the scarp, mudstones, pebbly mudstones and sandstones of the Mergui Group pass westwards into phyllites and quartzites near the plateau edge. Banded calc-silicate rock dipping steeply west, and locally showing small-scale folds, is in probable stratigraphic contact with the phyllite and extends for about 700 ft down the scarp; at its lower margin, it is in stratigraphic contact with phyllites and quartzites which pass progressively westwards within a kilometre across-strike into sub-vertical micaceous quartzites and biotite schists, and then into biotite augen gneiss and quartzites, augen and banded gneiss and quartzites, and granitic gneiss.

Within the schists and gneiss, minor intrusions conformable with the compositional layering comprise gneissic biotite granite, pegmatites and quartz veins, from a few centimetres to a few metres in thickness. The proportion of igneous rocks increases westwards, and in the westernmost exposures they comprise up to 50 per cent of the rock, forming migmatites. Regional changes in strike indicate that the metamorphic rocks have suffered broad post-pegmatite folding; small-scale folds have been observed in quartzite, but are rare.

The westward change in lithology from phyllite to banded gneiss occurs within less than 2 km and a vertical interval of less than 2,000 feet. The sequence lacks obvious structural breaks and can most simply be interpreted as a progressive westward increase in degree of metamorphism of the mudstone, greywacke and quartzose sandstone sequence of the Mergui Group. The calc-silicate rocks locally show a stratigraphic contact with the phyllite-quartzite succession and can tentatively be interpreted as limestone beds, either within or perhaps stratigraphically overlying the Mergui Group, similar to the unmetamorphosed limestones on D/8.

The Tamagyi Metamorphics extend northwards in a discontinuous belt to the Phaungdaw area, 15 km to the north, where they comprise westerly dipping marble and minor calc-silicate rock with small granitic intrusions, and banded gneiss and schist. The metamorphic belt continues northwards beyond the western margin of the map area and includes the metamorphic rocks at Kalagwe Taung on the western margin of C/6. Southward, metamorphic rocks extend through the north of D/7, where calc-silicate rock and gneiss lie west of schist and

Table 3. Radiometric age determinations

Sample No./Grid ref.	Rock	Method	Age (m.y.)
94 A/5 752 118	Fine-grained biotite granite	K/Ar on biotite	24/5 ±1
94 A/5 835 003	Biotite-quartz-felspar augen gneiss	K/Ar on biotite	29.1 ±1.1

phyllite described above as part of the Mergui Group. On 94 A/5, south of D/8, mapping during the 1977/78 field season indicated that sedimentary rocks of the Mergui Group pass transitionally westwards into schists, gneiss and migmatites.

Correlation and age

Regionally, the Tamagyi Metamorphics lie within the Mogok Belt of metamorphic rocks (Searle and Ba Than Haw, 1964) extending from near Moulmein northwards through Mandalay and Mogok to northern Burma (figs. 1 and 7).

The Tamagyi Metamorphics in the type area are identical to and structurally continuous with those forming the 30 km wide Nancho Group east of Pyinmana, 70 km to the south. The Nancho Group (Bateson et al., 1972), faulted against unmetamorphosed and hornfelsed sedimentary rocks of the Mergui Group to the east, includes pebbly biotite schists interbedded with quartzites, which can be interpreted as metamorphosed rocks of the Mergui Group.

In the west of C/6 at Kalagwe Taung, the lower Permian Thitsipin Limestone and underlying Ngwetaung Formation become metamorphosed, and to the west beyond the area, north of the Kyaukse Range, marbles and limestones within a low-grade metamorphic sequence have yielded late Palaeozoic fossils (Maung Thein and Soe Win, 1969). Therefore probably the metamorphism west of C/6 and hence that affecting the Mergui Group to the south are of post-Shan Dolomite or post-Middle Triassic age.

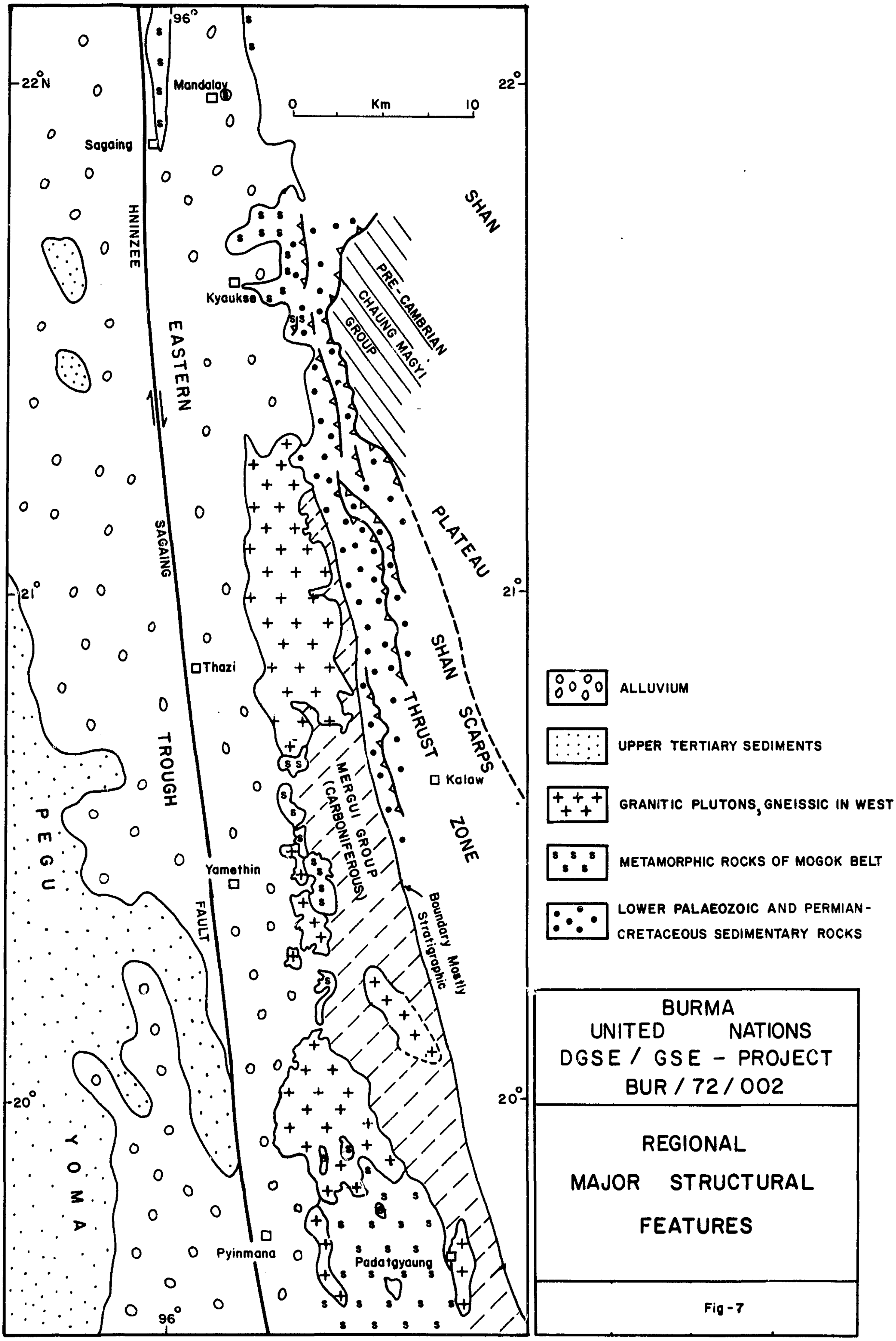
An end-Cretaceous minimum age for at least part of the metamorphism is indicated by the presence of phyllite pebbles in the Kalaw Conglomerate on D/6. Outside the area, a similar minimum age for metamorphic rocks is indicated in the Volcanic Arc at Salingyi and Shinmataung, where gneisses, schists and quartzites are overlain by conglomerates of probable upper Cretaceous to lower Eocene age (Technical Report No. 5).

A K/Ar age determination on biotite from an augen gneiss band within a migmatite zone on sheet 94 A/5 yielded an age of 29 m.y. or later Oligocene (table 3). This is similar to K/Ar ages of granites in the same area, described below. A lower Jurassic age for the earliest metamorphism is suggested by a K/Ar age of 185 m.y. on hornblende from gneiss within the Nancho Group south of 94 A/5; biotite from the same locality yielded a K/Ar age of 55 m.y. (Brook and Snelling, 1976).

Probably the Tamagyi Metamorphics comprise Palaeozoic rocks metamorphosed first in the lower Jurassic, and subsequently intruded by granites and magmatised in the latest Cretaceous to lower Tertiary, with major uplift and cooling in the Oligocene.

Travertine and alluvium

Travertine, probably no older than Pleistocene, forms extensive deposits on the flanks of the north-trending ridges of Shan Dolomite, in particular west of the westernmost Dolomite on D/5 and 6, where it mantles the bedrock, rendering geological mapping difficult. The travertine, deposited by green algae in streams with a high gradient, grows upward rapidly under certain flow conditions resulting in elevation of the watercourse above the surrounding older travertine deposits; consequently the drainage is in a sense locally inverted. Alluvial deposits are extensive in the west of the area. Adjacent to the hills they consist of locally coarse conglomerate aprons, passing westwards into fluviatile sediments of the Onbin-Lungyaw Plain.



96°
22°N
22°
21°
20°
Mandalay
Sagaing
Kyaukse
Thazi
Yamethin
Pyinmana
Padatgyaung
Kalaw
0 Km 10
HNINZEE
EASTERN
SAGAING
TROUGH
FAULT
PEGU
YOMA
SHAN
PLATEAU
SHAN SCARPS
THRUST
ZONE
PRE-CAMBRIAN
CHAUNG MAGYI
GROUP
MERGUI GROUP
(CARBONIFEROUS)
Boundary Mostly Stratigraphic
ALLUVIUM
UPPER TERTIARY SEDIMENTS
GRANITIC PLUTONS, GNEISSIC IN WEST
METAMORPHIC ROCKS OF MOGOK BELT
LOWER PALAEOZOIC AND PERMIAN-CRETACEOUS SEDIMENTARY ROCKS
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FEATURES

Fig - 7

V. INTRUSIVE ROCKS

Plutons

Plutons are present on all the map sheets except C/10, but are abundant only in the southern four sheets, mostly in the west. Seven main types of plutonic rock can be distinguished, and the rocks are described here in approximate order of increasing silica content. The distribution of plutonic rocks within the area is shown on fig. 8. Minor intrusions in the form of dykes largely occur within the plutons. The classification used is based on Williams, Turner and Gilbert (1958).

Diorite

Dioritic rocks form the Kanabaw Diorite pluton in the northwest of D/6, the two small stocks to the south, and the Lawywa Diorite to the northeast and small bodies to the southeast of Lebyin. They are mostly deeply weathered and do not form prominent topographic features. The Kanabaw Diorite shows intrusive contacts with banded gneiss and with sedimentary rocks of the Mergui Group and is also in contact with biotite granite. The Lawywa Diorite and small microdiorite dykes to the south intrude the Ma-u-bin Formation; small diorite stocks intrude the Pinmon East Marble.

The Diorites are mostly medium-grained light grey to greenish-coloured rocks consisting very largely of plagioclase and hornblende with chlorite. Locally more mafic varieties occur, for example near the margin of the Kanabaw Pluton adjacent to the gneiss, and the dykes on D/5 consist of similar mafic rocks. These are mostly coarse-grained hornblende-rich diorites or gabbros locally forming hornblendites. The dykes north of Lebyin on D/6 are porphyritic with a fine-grained holocrystalline groundmass, transitional in texture between microdiorite and andesite.

Hornblende biotite granodiorite

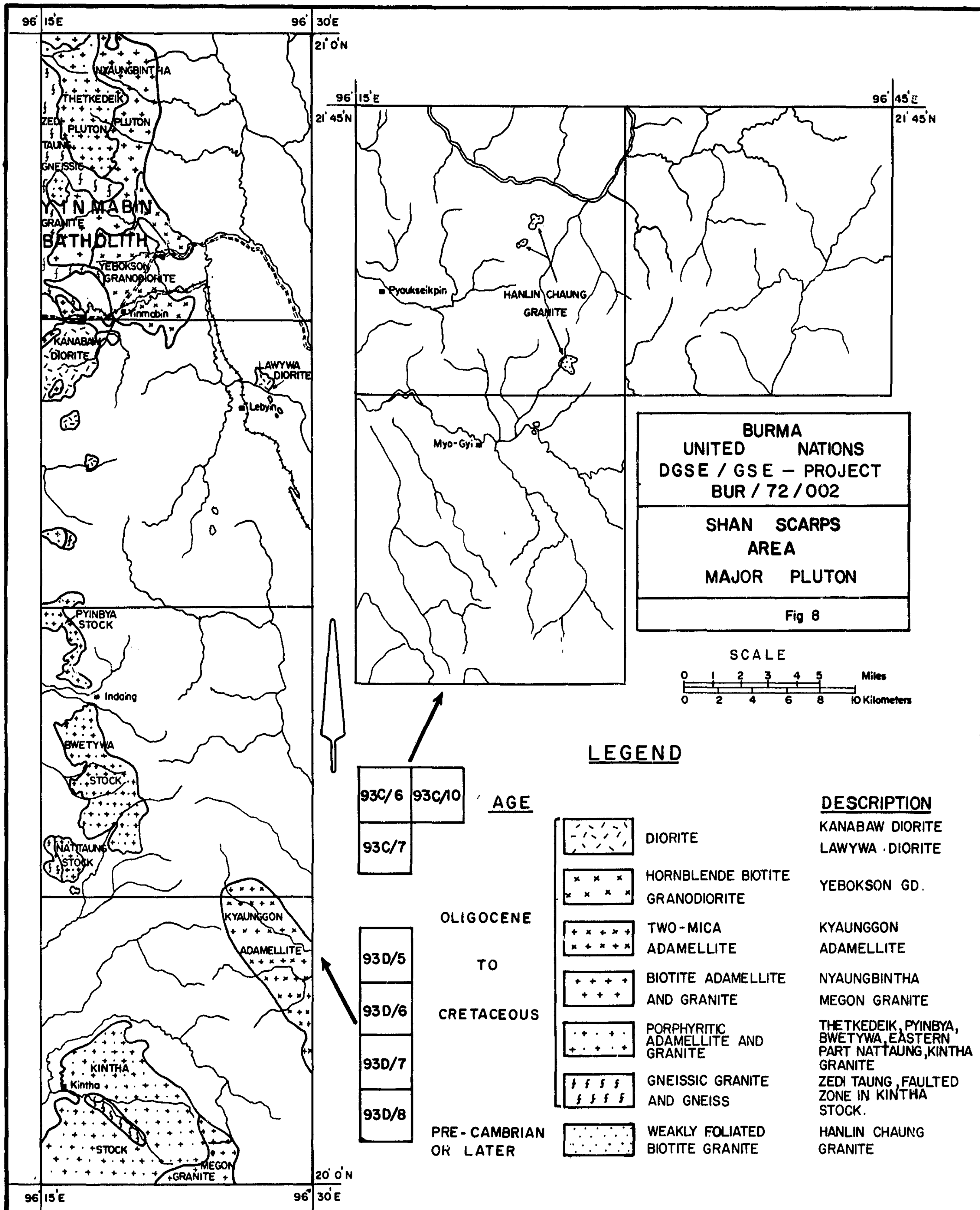
Granodiorite forms the Yebokson Pluton with an area of about 100 sq km on D/5 and in the north of D/6, and small stocks-bordering the pluton southwest of Yinmabin. The granodiorite shows intrusive contacts with the Mergui Group and is in contact with granite of the Nyaungbintha Pluton and the Zedi Taung Gneissic Granite. The rock is medium to coarse-grained, lacks foliation, and consists of hornblende and biotite, mostly with hornblende predominant, plagioclase, quartz and minor alkali felspar; quartz mostly exceeds 20 per cent. In most areas the rock is fresh, but locally it shows a greenish colour due to chlorite which replaces the mafic minerals.

Porphyritic biotite adamellite and granite

This is the most abundant plutonic rock type in the area. It forms most of the large Kintha Stock (250 sq km) on D/8 and the central part of the Yinmabin Batholith on D/5. It occupies mountainous areas, rising above the gneissic granite to the west on D/5 and forming peaks approaching 6,000 ft elevation on D/8. The Kintha Stock is intrusive into the Mergui Group; the presence of small bosses of granite northeast of the main body suggest that much of the Group in this area is underlain by the pluton. In the Yinmabin Batholith the granite passes gradationally westwards into foliated and gneissic granite and eastwards into non-porphyritic granite. The rock is mostly strongly porphyritic and coarse-grained, consisting of biotite, quartz and felspar, with phenocrysts of white to pale grey felspar up to 4 cm long. There is commonly a weak foliation indicated by partial alignment of the long axes of phenocrysts.

Gneissic and foliated granite

Strongly foliated to gneissic granitic rocks form the Zedi Taung Gneissic Granite in the western part of the Yinmabin Batholith and occupy the


96° 15'E
96° 30'E
21° 0'N
NYAUNGBINTHA
THETKEDEIK
PLUTON
ZEDI
PLUTON
TAUNG
GNEISSIC
YINMABIN
GRANITE
BATHOLITH
YEBOKSON
GRANODIORITE
Yinmabin
KANABAW
DIORITE
LAWYWA
DIORITE
Lebyin
PYINBYA
STOCK
Indaing
BWETYWA
STOCK
NATTAUNG
STOCK
KYAUNGGON
ADAMELLITE
KINTHA
Kintha
STOCK
MEGON
GRANITE
20° 0'N
96° 15'E
96° 30'E
96° 15'E
96° 45'E
21° 45'N
21° 45'N
Pyoukseikpin
HANLIN CHAUNG
GRANITE
Myo-Gyi
BURMA
UNITED NATIONS
DGSE / GSE – PROJECT
BUR / 72 / 002
SHAN SCARPS
AREA
MAJOR PLUTON
Fig 8
SCALE
0 1 2 3 4 5 Miles
0 2 4 6 8 10 Kilometers
93C/6
93C/10
93C/7
93D/5
93D/6
93D/7
93D/8
LEGEND
AGE
DESCRIPTION
OLIGOCENE
TO
CRETACEOUS
DIORITE
KANABAW DIORITE
LAWYWA DIORITE
HORNBLENDE BIOTITE
GRANODIORITE
YEBOKSON GD.
TWO-MICA
ADAMELLITE
KYAUNGGON
ADAMELLITE
BIOTITE ADAMELLITE
AND GRANITE
NYAUNGBINTHA
MEGON GRANITE
PORPHYRITIC
ADAMELLITE AND
GRANITE
THETKEDEIK, PYINBYA,
BWETYWA, EASTERN
PART NATTAUNG, KINTHA
GRANITE
GNEISSIC GRANITE
AND GNEISS
ZEDI TAUNG, FAULTED
ZONE IN KINTHA
STOCK.
PRE-CAMBRIAN
OR LATER
WEAKLY FOLIATED
BIOTITE GRANITE
HANLIN CHAUNG
GRANITE

western part of the Nattaung Stock on D/7. The rock shows intrusive contacts with a roof pendant of Mergui Group metasediments northwest of Yinmabin, and intrudes the Mergui Group on D/7. It shows a transitional contact with porphyritic biotite granite to the east on D/5. The rock mostly contains felspar phenocrysts and varies from biotite granite to hornblende biotite granodiorite. Commonly but not invariably there is an increase in the degree of foliation from east to west.

Biotite adamellite and granite

Biotite granite forms the eastern part of the Yinmabin Batholith, occurs as small bodies north of and within the Kanabaw Diorite, and forms the eastern part of the Kintha Stock, where it attains an elevation of 6,172 ft. The rock is characterized on air photographs by a sub-rectangular drainage pattern presumably related to joints. It shows intrusive contacts with the Mergui Group, a sharp contact with the Yebokson Granodiorite and a contact with the porphyritic biotite granite, which is possibly transitional. It is intruded by coarse-grained mafic diorite dykes in the Kunge Chaung on D/5, and locally elsewhere by quartz-felspar dykes, and by quartz veins. The rock is mostly medium to coarse-grained and ranges from granite to adamellite in composition. Local areas of fine to medium-grained white to grey leucogranite with very small biotite flakes are present within the Yinmabin Stock and also form dykes in the Mergui Group near Yinmabin. The leucogranites are similar to clasts in the Kalaw Conglomerate, 12 km southeast of Yinmabin. The Megon Granite in the eastern part of the Kintha Stock is mostly fine-grained; near the tungsten workings it is cut by quartz veins and extensively greisenised.

Two-mica adamellite

Granitic rock with muscovite and biotite forms the NW-trending Kyaunggon Adamellite with an area of 55 sq km on D/8. Small bodies of similar rock occur to the northwest. The stock occupies an area of lower relief than the surrounding host rock and is drained by eastward-flowing streams showing a dendritic drainage pattern. The Kyaunggon stock is intrusive into the Mergui Group and is the only large muscovite-bearing pluton in the area. The rock is mostly medium to fine-grained, with biotite as the only essential mafic mineral and muscovite normally subordinate to biotite. Staining of felspars indicate it is predominantly an adamellite. Aplitic dykes are present locally.

Hanlin Biotite Granite

Three small stocks of foliated granite occur within the Chaung Magyi Group on C/6. They are biotite-hornblende granites with a mostly faint, but locally pronounced foliation, and are mostly greenish in colour owing to secondary chlorite replacing mafics.

Minor intrusions

Acidic dykes are present in most of the plutons, but only a few representative ones are shown on the geological maps. Pegmatite dykes have been mapped at several localities within the schists of the Chaung Magyi Group in the east of C/10, mostly as very coarse-grained muscovite-felspar rocks with minor hornblende. They are widespread in the gneissic zone of the Tamagyi Metamorphics. Pegmatite dykes also occur in the porphyritic and gneissic granite in the west of the area. Dykes of quartz-felspar rock are widespread in the Nyaungbintha Pluton.

Aplitic dykes up to 10 m wide are present in the granitic plutons of the southern four map sheets, and are widespread in the Thetkedeik and Nyaungbintha plutons; they have not been observed in the diorites. They are fine-grained rocks ranging in texture from aphanitic to micrograniitic, with quartz, felspar and in some cases minor biotite. Veins of hydrothermal quartz are associated with greisen in the Megon Granite on D/8. Other minor quartz veins are not shown on the geological maps. Diorite dykes near Lebyin have been referred to above.

Age of plutonic intrusions

Within the project area there is little direct stratigraphic evidence for the age of the various types of plutonic rock. The Hanlin Biotite Granite intrudes only the Chaung Magyi Group and hence may be of any age from Precambrian to lower Tertiary. The other six major types of pluton all intrude the Mergui Group and hence are of post-Carboniferous age. Diorites intrude the Ma-u-bin Formation on D/6 and granodioritic sills intrude the Kyaukhsu Taung Formation immediately beneath the Patchaung Volcanics on C/8. The oldest stratigraphic unit in which granitic detritus is present is the Kalaw Conglomerate, with boulders of grey to white biotite leucogranite.

Limited evidence from outside the project area suggests that the Megon Granite may be of upper Cretaceous to lower Eocene age. The Padatgyaung Granite, 40 km south of the project area, is a biotite and porphyritic biotite adamellite with associated tungsten-tin-molybdenum mineralization, and is thus similar to part of the Megon Granite; four samples from the Padatgyaung Granite yielded a Rb/Sr isochron indicating an age of 56 m.y. and a mean K/Ar age from micas of 55 m.y. or latest Palaeocene (Brook and Snelling, 1976).

North of D/5 the Yinmabin Batholith continues into C/8, where biotite adamellite from the Pyetoye Taung Granite (Garson et al., 1975, 1976) yielded K/Ar ages on Biotites of 51 $\mp$1 and 58 $\mp$1 m.y. and on hornblende of 82 $\mp$2 m.y., while two whole rock samples together gave a Rb/Sr age of 152 $\mp$24 m.y., (Brook and Snelling, 1976). This suggests a possible upper Jurassic to early upper Cretaceous age for the Pyetoye Taung Granite and hence for part of the Yinmabin Batholith. A sample of fine-grained leucogranite from within metamorphic rocks on A/5, south of D/8, yielded a K/Ar age on biotite of 25 m.y. (table 3). This is probably an uplift-cooling age of granite emplaced in the early Tertiary.

In conclusion, there is little evidence that any plutons are older than the Patchaung Volcanics. Some leucogranites pre-date the Kalaw Conglomerate, while radiometric dates indicate that some granitic rocks are of Palaeocene age. As the age of the Kalaw Conglomerate lies anywhere within the range upper Cretaceous to lower Tertiary, it is uncertain whether the Palaeocene granites are younger than those which occur as clasts within the Conglomerate. Probably intrusive activity ranges in age from early Cretaceous to Eocene or Oligocene, although it is not impossible that some leucogranites are as old as early Jurassic.

VI. STRUCTURE

The distribution of rock units in the area is partly determined by at least four episodes of folding. However, the existence within the area of almost the complete range of stratigraphic units found in eastern Burma is probably determined largely by the presence of a major zone of NNW-trending imbricate thrusts cut by high-angle faults, coinciding with the Shan Scarps morphological belt (fig. 9b). The zone extends from the northwestern corner of C/6 to the northeastern corner of D/7. In the south, it is up to 12 km wide and trends 160°, but towards the north the trend changes gradually to 170°, and the zone includes the westernmost exposures of pre-Tertiary rocks protruding through the plain. Beyond the map area, the zone extends northwards through the scarps east of Mandalay and beneath alluvium to the west, and south-southeastwards along the western margin of the Shan Plateau. The high topographic relief within the Shan Scarps Zone is the result of differential erosion of the resistant Shan Dolomite and adjacent mostly clastic sedimentary rocks of the Mergui, Kalaw Red Bed and Pan Laung Groups preserved in thrust and high-angle fault-bounded slices.

Thrust faults

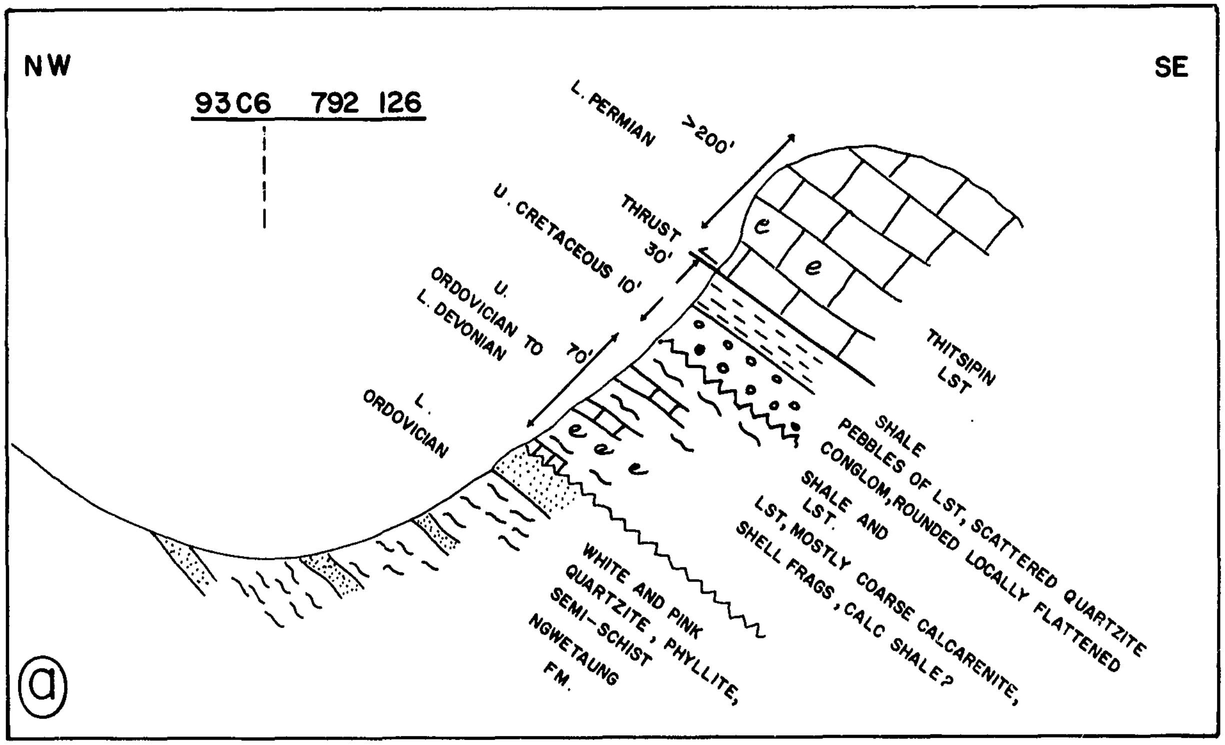
The present mapping showed that eastward-directed overthrusts extend in a narrow zone for 140 km across the northern and central parts of the area. Thrusts in this and adjacent parts of the Shan Scarps and western margin of the Plateau had not previously been described, although Ba Than Haq (pers. commun., 1970) had reported their presence on C/8.

The thrusts largely coincide with the Pyin Nyaung-Nattalin or Shan Scarps morphological zone. Five major thrusts have been mapped from northeast to southwest; these are the Gwe Bin Taung Thrust and its probable southward continuation as the Myogyi Thrust, the Thabye Taung Thrust and a thrust to the east of it, the Kanaw Thrust and the Nyaungbin Taung Thrust, but other shorter thrusts are also present. The thrusts are distributed en echelon, with a trend slightly oblique to that of the Scarps, and forming what appears on a small-scale map (fig. 4) as an imbricate thrust zone. Within the zone local tectonically complex areas, in particular the Nwalabo Fault Complex of Garson et al. (1974, 1976), are probably belts of intense imbricate thrusting (fig. 15).

Along some thrusts older rocks are thrust over younger, but along others the evidence for thrust movement is less direct. In the north of the area (C/6 and 7) rocks forming an east-facing scarp above the Precambrian Chaung Magyi Group are of lower, middle and upper Ordovician age at different localities. As there is no evidence of intra-Ordovician unconformities elsewhere in the Shan States, the middle and upper Ordovician rocks are clearly thrust eastwards over the Chaung Magyi Group.

The stratigraphic units cut by the thrusts range in age from the Precambrian Chaung Magyi Group to the upper Cretaceous or lower Tertiary Kalaw Conglomerate. To the west of C/6 and 7, the thrusts intersect the meta-Palaeozoic rocks, for example on Kalagwe Taung west of Pyaukseikpin. Part of the evidence of thrusting is derived from air photograph interpretation. For example, the thrust at the base of the Shan Dolomite on C/8 truncates the bedding of the Kalaw Conglomerate to the east, and on D/6 the Nyaungbin Taung Thrust at the base of the Dolomite can be seen on air photographs to truncate bedding in the younger Ma-u-bin Formation to the east.

The thrusts shown on the geological maps (figs. 15, 16 and 17, deleted) probably represent only the major faults of this type in the area. Evidence that the base of the Shan Dolomite and top of the Mergui Group are both lower Permian suggests that there may not be a major



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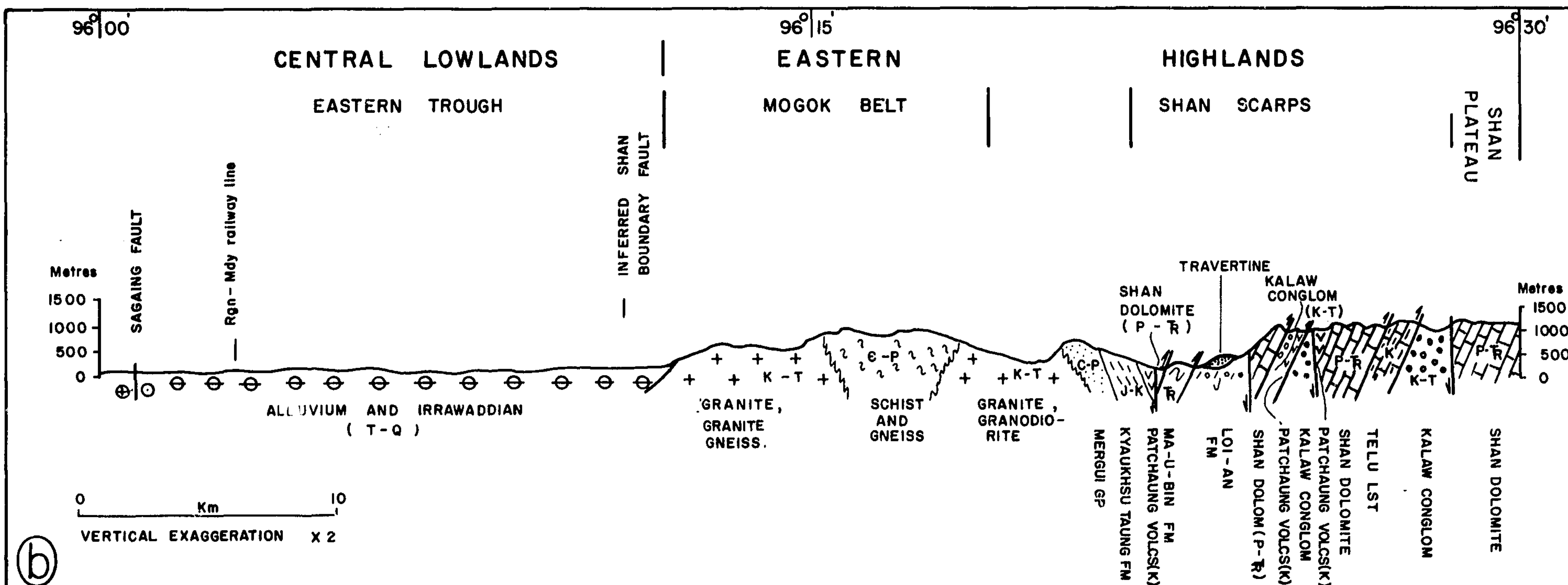
(a) THRUST SOUTH OF PYAUKSEIKPIN

(b) GEOLOGICAL CROSS-SECTION, SAGAING FAULT THROUGH SHAN SCARPS

Fig 9



unconformity between them, and hence that the peaks of Thitsipin Limestone on hills in the west of C/6 may be klippe rather than outliers on the underlying Ordovician rocks.

Significant covergence across the thrust zone is indicated by the difference in the late Palaeozoic stratigraphy to the east and west with up to 2,500 m of Mergui Group sedimentary rocks present to the west, but none to the east. This suggests tectonic juxtaposition of formerly widely separate areas. The latest thrusting clearly post-dates deposition of the Kalaw Conglomerate and hence is probably post-Cretaceous; an early Tertiary, perhaps end-Eocene, age for the latest thrust movements is considered probable. However, the presence of recumbent folds in the Ma-u-bin Formation stratigraphically beneath the gently dipping Kalaw Conglomerate suggests that some thrusting took place in the Jurassic.

High-angle faults

Faults within the Shan Scarps

Within the Shan Scarps on D/5 and D/6 three major high-angle faults are present, downthrowing to the west, and one, along the eastern boundary of the Mergui Group, downthrowing to the east. Two faults can be traced for more than 50 km. The Pan Laung Fault, named by Garson et al. (1974) from C/8, extends from the western part of C/7 to the northeastern part of D/5 for a distance of 75 km, and throughout its length gives rise to a prominent west-facing scarp of Shan Dolomite against which Mesozoic rocks of the Ma-u-bin and Loi-An Formations are downthrown. Similarly the Polaung Chaung and Pyinyaung Faults extend across D/5 southwards into D/6 and northwards into C/8. Most other faults extend only 20 to 40 km as distinct linear features, a few disappearing either within a stratigraphic unit, for example the Taungwundwin Chaung Fault on D/5, or beneath alluvium. Because of angular unconformities at the base of many of the tectonically juxtaposed rock units and because of the structural complexity caused by the thrusts, measurement of displacement along any one fault is difficult. However, vertical movement on the Pan Laung and Polaung Chaung Faults is unlikely to be less than 2,000 m.

The high-angle faults cut the eastward-directed thrusts and hence are probably post-earliest Tertiary in age. They are clearly older than the latest movement (Quaternary) on the N-trending Hninzee-Sagaing Fault to the west of the area, as further south they are cut by NW-trending faults which are themselves truncated by the Hninzee-Sagaing Fault. The main movements on the high-angle faults in the area were therefore probably of early Tertiary, perhaps Oligocene, age. Regional interpretation suggests that the faults pass northwards into northwest-directed overthrusts within the Mogok Belt. An Oligocene age for the faulting is not contradicted by field evidence within the area.

Other high-angle faults

A northwest-trending lineation visible on air photographs extends south-eastwards from Kintha on D/8. The fault lies entirely within granitic rocks, and there is no evidence for the amount or sense of movement. However, a zone of granitic gneiss and local areas of probable mylonite adjacent to the lineation suggest that appreciable movement has occurred along it. A fault of similar trend south of the area (Bateson et al., 1972) is associated with a major zone of mylonite along the boundary between a gneissic granite and metamorphic rocks.

Structural problems related to the Mergui Group

Unresolved structural problems within the area are mostly related to the Mergui Group. It is not clear why the Mergui Group is restricted to the area west of the Scarps zone, and absent beneath the Shan Dolomite Group to the east. Possibly the Mergui Group was originally widespread, and subsequently eroded in the east before deposition of the Shan Dolomite. Later the considerable thickness of Mergui Group preserved in the west was carried eastwards into its present position during eastward-directed thrusting (fig. 6).

The absence of recognizable lower Palaeozoic rocks in the metamorphic zone to the west of the Mergui Group is also a problem. If the Tamagyi Metamorphics are metamorphosed rocks of the Mergui Group as suggested above, it is surprising that older lower Palaeozoic rocks, widespread east of the Shan Scarps, are not exposed in the presumably deep structural level of the metamorphic zone, less than 15 km to the west. This could be explained if the lower Palaeozoic succession and possibly also older continental rocks are absent, perhaps due to non-deposition, everywhere west of the Shan Scarps.

Thus there is considerable evidence for major post-middle Triassic crustal shortening across the Scarps Zone, with tectonic juxtaposition of contrasting pre-Shan Dolomite successions to the east and west. This shortening may have taken place along the mapped post-Jurassic thrusts. However, there is no obvious difference between the Kalaw Conglomerate overlying the Mergui Group west of Lebyin and that overlying Jurassic rocks to the east, and granite pebbles within the Conglomerate near Yebu can be matched with plutons in the Mergui Group immediately to the west. This suggests that tectonic emplacement of the Mergui Group was pre-Kalaw Conglomerate; it could be explained by eastward-directed movement on a thrust now buried beneath the Kalaw Red Bed and Pan Laung Groups.

VII. GEOCHEMISTRY

Introduction

The main purpose of the geochemical reconnaissance survey was the delineation of target areas for follow-up investigations and the elimination of barren ground.

Sampling procedures

The physiographical and geological conditions in the area are sufficiently similar to those in the Pinlebu-Banmauk area (Technical Report No. 2) for the same geochemical reconnaissance survey methods to be used. Within the seven map sheets 2,880 stream sediment samples of fine-grained material were collected during the 1975/76 field season. The samples were taken from the mid-stream part of mostly dry small creek beds in order to avoid bank contamination. Sample locations were plotted in the field on 1:63,360 scale drainage maps; observations including pH, rock exposures, float description and old workings were recorded in the field. The samples were dried, sieved through minus 80-mesh and the fine fraction was collected in 4 x 8 inch pre-numbered paper envelopes, which were forwarded to the DGSE laboratory in Rangoon. The sampling density of 0.6 samples per sq km was effective, as demonstrated by comparison of the geochemical maps (see figs. 19, 20 and 21) with the known mineral occurrences, many of which are very small. In addition, rock samples were collected and sent to Rangoon for analysis.

Laboratory

The elements analysed were based on the known and probable types of mineralization in the northern and southern parts of the area. Samples from the northern part (C/6, 7 and 10) were analysed for Cu, Pb, Zn, Ag and Mo, while samples from the south (D/5, 6, 7 and 8) were analysed for Cu, Pb, Zn, Ag, Sb, Sn and W. Cu, Pb, Zn and Ag were analysed routinely for all stream sediment samples by the AAS method. Mo, W, tungsten and Sb were determined using the classical colorimetric method, and Sn by the plane-grating spectrograph. All analytical procedures are described in annex III of Technical Report No. 6. Table 4 shows the number of laboratory determinations on rock and stream sediment samples.

Table 4. Number of laboratory determinations, stream sediment and rock samples

Element	Stream sediment determinations	Rock determinations
Cu	2,880	78
Pb	2,880	78
Zn	2,880	78
Ag	2,880	78
Mo	2,805	78
Sb	1,682	78
Sn	1,693	78
W	1,722	72

The reliability of analytical results was continuously checked by the DGSE laboratory (1 duplicate in 50 determinations), by a commercial laboratory (Barringer Research Laboratory, Toronto), and by control analyses carried out on six geochemical reference samples (GXR1 - GXR6) prepared by the United States Geological Survey. Table 5 shows the number of checks:

Table 5. Analytical determination checks

	Determinations
Duplicates made by DGSE laboratory	564
Checks by commercial laboratory	1,265
Comparison analyses with USGS standard samples	60

Duplicate determination by the DGSE laboratory

One sample was selected randomly from each batch and analysed in duplicate as a check on reproducibility of analytical work. The duplicate determinations for each element were expressed as a percentage of the original value. These percentages were then averaged, and the standard deviation for the main elements was calculated. The results showed that the 61 duplicate determinations for Cu averaged 98.6 per cent of the original values, with a standard deviation of 0.8 ppm; for Zn, respectively 99.5 per cent and 2 ppm; and for lead, 100 per cent, with a standard deviation of 3.6 ppm. Statistical analyses (Youden method) of replicate determinations of stream sediment samples by the AAS method are shown in table 6.

Table 6. Replicate analytical determination statistics

	n	$\overline{X}$	SD	P(%)
Cu	61	13.64	0.8	11.73
Pb	61	27.7	3.6	25.99
Zn	61	83.5	2.0	4.79
Ag	61	0.85	0.1	24.9

n = Number of replicate determinations.

$\overline{X}$ = Arithmetic mean.

SD = Standard deviation.

p = Precision at the 95 per cent confidence level.

All these checks showed that the results are sufficiently accurate and the reproducibility of the analytical work is quite satisfactory for exploration purposes.

Commercial laboratory determinations

A large number of stream sediment samples were submitted to an outside commercial laboratory. The analyses differed from the DGSE laboratory results because different digesting methods were used. The Barringer Research Laboratory used a perchloric-nitric acid mixture in digestion, while the DGSE laboratory applied nitric acid digestion. For this reason it was not possible to compare the results in the usual statistical way, and the commercial laboratory determinations are expressed simply as an average percentage of DGSE laboratory results as follows: 99 per cent for Cu; 81 per cent for Pb (background correction); 110 per cent for Zn.

Comparison with the RSGS standard samples

This comparison is shown in table 7. The results indicate the reliability of the DGSE laboratory.

Trace elements in rock specimens

The variations in bedrock lithology exert considerable influence on the secondary metal dispersion patterns in stream sediments. In particular, the variety of plutonic rocks, of which seven types were distinguished situated mainly in the western part of the area, have a significant effect on the geochemical landscape. Seventy-eight igneous rock specimens were collected from different lithological types and submitted for trace element analyses (Cu, Pb, Zn, Ag, Ni, Co and Cr by AAS; B, Pb, Zn, W, Bi, Be, Cu, Ag, Au, As, Mn, Sb, Ga, Cr, Ba, Ti, Mo, Y, Cd, La, Sc, Zr, Ni, Co and Nb by emission spectrograph). The number of samples was insufficient for statistical treatment, but the mean of the main trace elements is shown in table 8.

These results show that the diorites are poor in major trace elements, and that relatively high values of Cu, Pb, As, W and Sn are present in the adamellitic and granitic rocks. In particular, the biotite adamellite and granite (Megon type) are associated not only with high values of Pb, W and Sn, but also of Cu, As, Mo, Y, Bi, Ag and Zn. Granitic rocks of this type contain the Megon wolframite mine (D/8) and the tungsten occurrence at Letha Chaung (D/7). Therefore, in the regional exploration special attention was paid to the Megon-type plutons.

Statistical treatment

The geochemical reconnaissance survey produced a large amount of data (nearly 20,000 determinations), requiring statistical treatment. This was done with the co-operation of the United Nations-assisted University Computer Centre, equipped with an ICL 1902 computer. Computer processing of geochemical data required the development of a field data recording system to

Table 7. Comparison of analytical results
samples--Cu, Pb, Zn, Ag, Mo

Number of standard sample	Cu		Pb		Zn	
	DGSE	M	DGSE	M	DGSE	
GXR-1	1,320 1,340	1,107	664 652	725	700 687	7
GXR-2	76 83	78	672 720	700	518 538	5
GXR-3	12 12	16	24 18	30	160 170	2
GXR-4	5,450 5,330	6,470	42 32	50	71 71	
GXR-5	370 356	360	37 22	22	46 45	
GXR-6	65 62	68	102 112	100	104 104	1

<u>Note:</u> DGSE = AAS /C̅u, Pb, Zn, Ag (HNO_3, 300-350° C, 30 mi
Ni-crucible 2 determinations of each sample

M = Median of results quoted by Allcott and Laki
(USGS - open file report).

GXR = USGS geochemical standard reference samples.

nalytical results on six standard reference
., Pb, Zn, Ag, Mo (main elements)

	Zn		Ag		Mo	
M	DGSE	M	DGSE	M	SGSE	M
725	700	770	37.9	29	16	14
	687		21.8		27	
700	518	540	17.5	17	2	1.3
	538		11.6		5	
30	160	208	2.9	2.5	4	6
	170		3.0		5	
50	71	73	5.8	4.0	220	258
	71		5.7		240	
					27	
22	46	47	1.8	1.5	27	30
	45		1.7		28	
100	104	115	1.7	1.5	5	2
	104		1.7		3	

300-350° C, 30 minute)7 Mo - fusion with flux in a
ons of each sample.

y Allcott and Lakin (aqua regia attacks)

reference samples.

Table 8. Mean of trace elements in rock samples

	Rock type	Cu (ppm)	Pb (ppm)	As (ppm)	W (ppm)	Sn (ppm)
1.	Diorite	0.5	2.5	6.0	0	0
2.	Hornblende biotite diorite	6.0	6.5	6.7	0	0.5
3.	Porphyritic biotite adamellite and granite	1.5	8.8	9.0	0.8	3.0
4.	Gneissic granite and granite gneiss	4.0	1.5	10.0	0.2	2.4
5.	Biotite adamellite and granite (e.g. Megon granite)	25.0	44.0	11.3	61.2	25.7
6.	Two-mica adamellite	0.3	5.0	8.3	6.7	0.7
7.	Hanlin biotite granite	13.0	12.0	20.2	10.0	2.0

ensure standardization of factors which might affect the element distribution (bedrock geology, pH value, mineralization alteration). The observations were assigned simple numeric values (1-15, including sample number and co-ordinates) recorded on coding sheets and later transferred to computer cards for subsequent processing.

Before the geochemical data were set in the computer, the samples were divided into three groups based on the geological environment. The first group comprises those dominantly derived from plutonic and metamorphic rocks and sedimentary rocks of the Mergui Group, mostly situated in the southern part of the area (D/5, 6, 7 and 8). The second group corresponds to the area between Group 1 and the Chaung Magyi stratigraphic unit. This area is characterized by a NNW-trending belt of carbonate rocks, forming a special geochemical landscape. The samples taken from the area occupied by the Chaung Magyi rocks comprise a small third group of samples located in the northern three map sheets (C/6, 7 and 10).

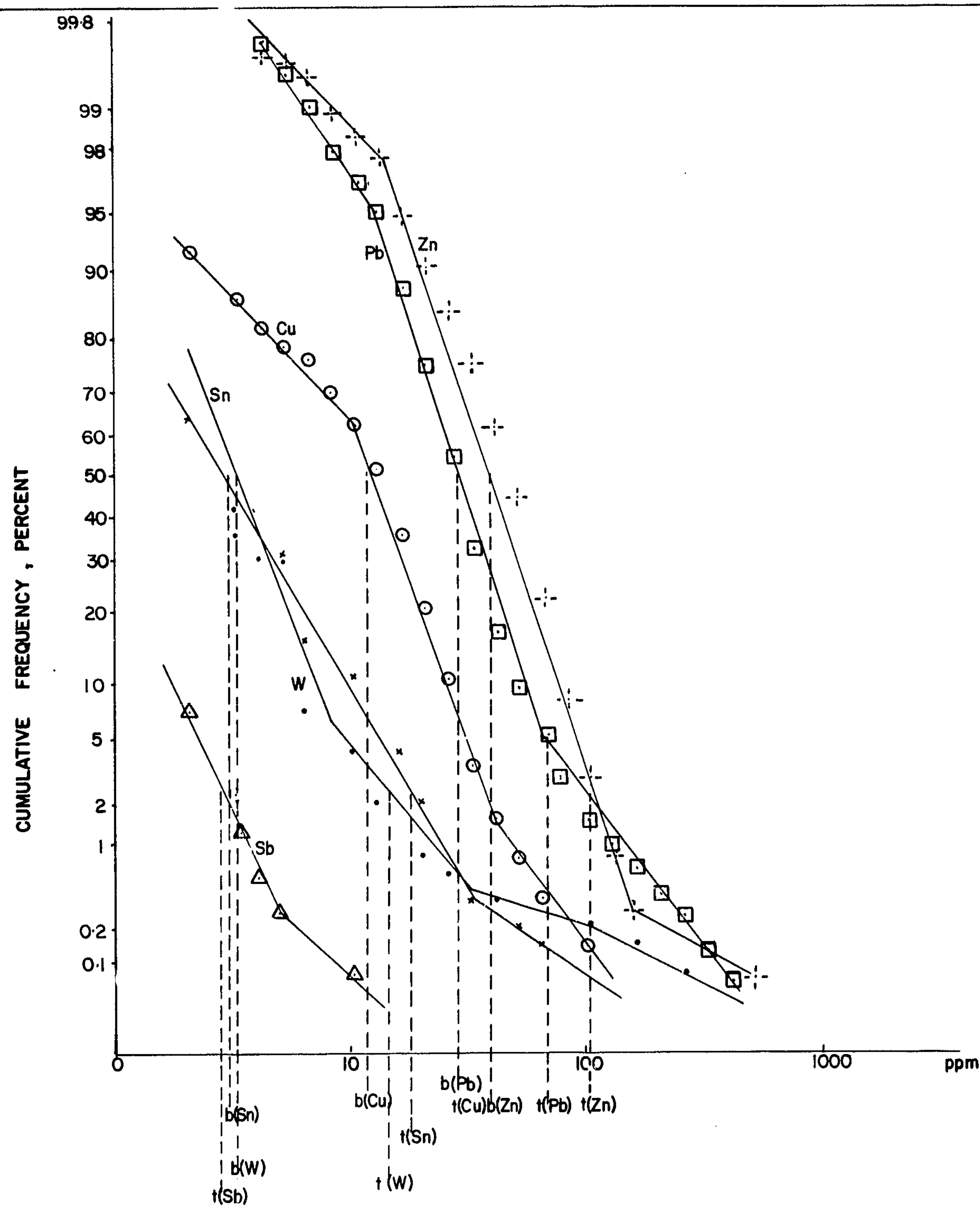
The data obtained from each of these three groups of samples were treated separately. Their cumulative frequency distribution (c.f.d.) plots produced by the plotter CALCOMP Mode-502 are shown on figs. 10, 11 and 12. The distributions are essentially lognormal, but in some cases minor departures from the straight line indicate an excess of high-content samples. The background and threshold values were deduced graphically from the c.f.d. curves. Generally, the median value was accepted as the background value. The threshold value was taken conventionally either at 2.5 per cent on the c.f.d. curve or at the intersection between 2 branches of the curve, provided that this occurred at a level higher than 2.5 per cent. Table 9 summarized the distribution parameters derived from the c.f.d. plots for between 5 and 8 elements in stream sediments of the three main geological environments.

Interpretation of data

For interpretation purposes, values exceeding threshold for Cu, Pb, Zn, Ag, Mo, Sb, Sn and W were marked on the 4-miles-to-one-inch-scale geochemical maps with regional geology as background. The distribution of the eight elements shows the wide variation due to geological control.

Copper

The distribution of Cu (fig. 19) in the three geological environments is marked by well-balanced background values (15 ppm, 18 ppm and 22 ppm). The best grouping of values exceeding threshold is observed on C/6, reflecting the Sabetaung copper deposit. Two less significant higher values (160 ppm) on C/7 are associated with low-grade copper occurrences in the Myo Gyi Slate of the Chaung Magyi Group. The same



	⊙ Cu	⊡ Pb	-¦- Zn	× Sn	• W	△ Sb
No: of Samples	1445	1445	1445	1371	1388	1387
Background Value	15 ppm	30 ppm	50 ppm	5 ppm	4 ppm	—
Threshold Value	47 ppm	74 ppm	118 ppm	23 ppm	14 ppm	3 ppm

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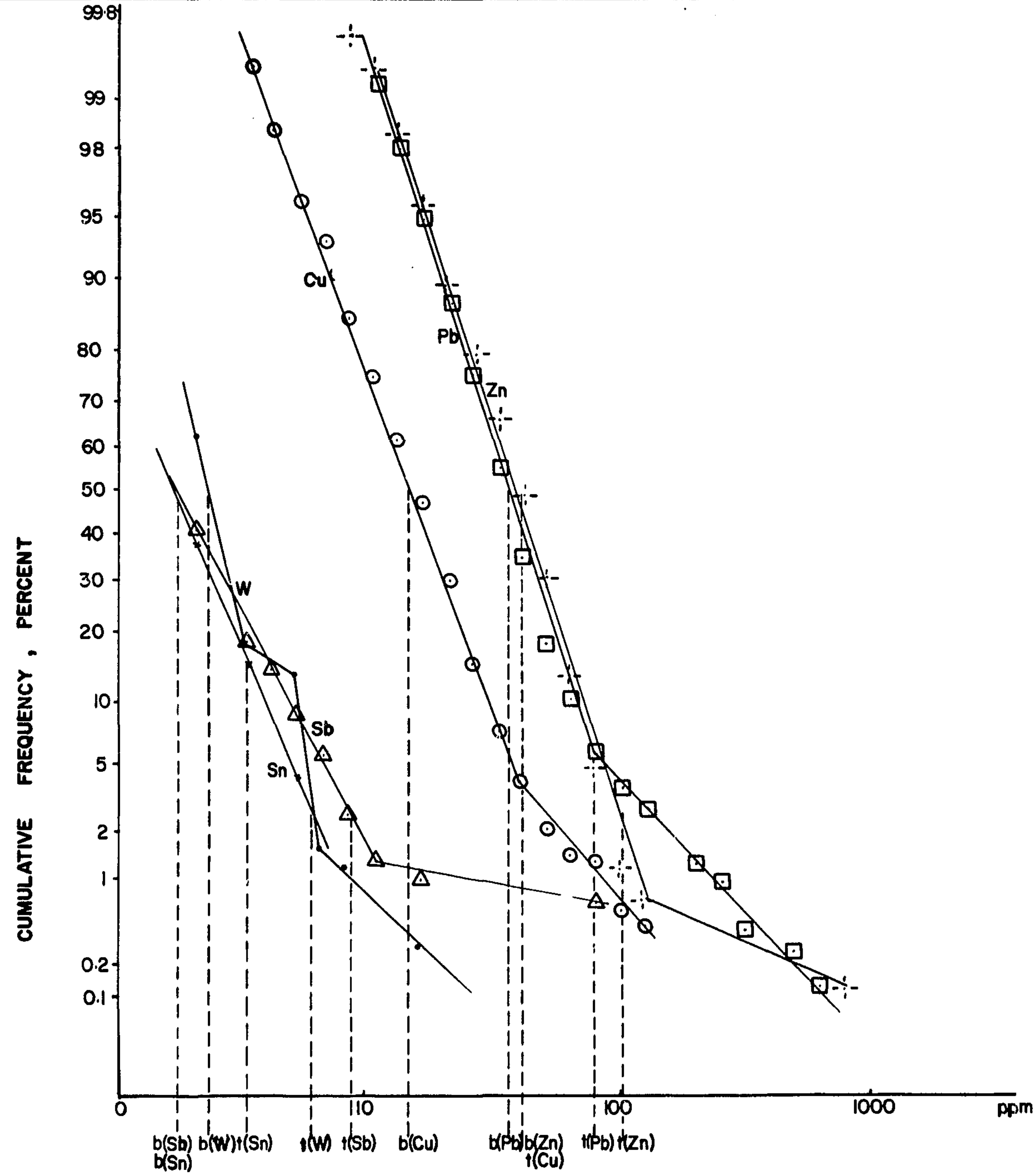
SHAN SCARPS AREA

STREAM SEDIMENTS

CUMULATIVE FREQUENCY

GROUP 1

Fig 10



	⊙ Cu	⊡ Pb	-¦- Zn	• W	△ Sb	x Sn
No: of Samples	729	729	729	335	301	323
Background Value	18 ppm	38ppm	47 ppm	3 ppm	1.9 ppm	1·9ppm
Threshold Value	47ppm	93ppm	105 ppm	7·4ppm	9·0ppm	3·7ppm

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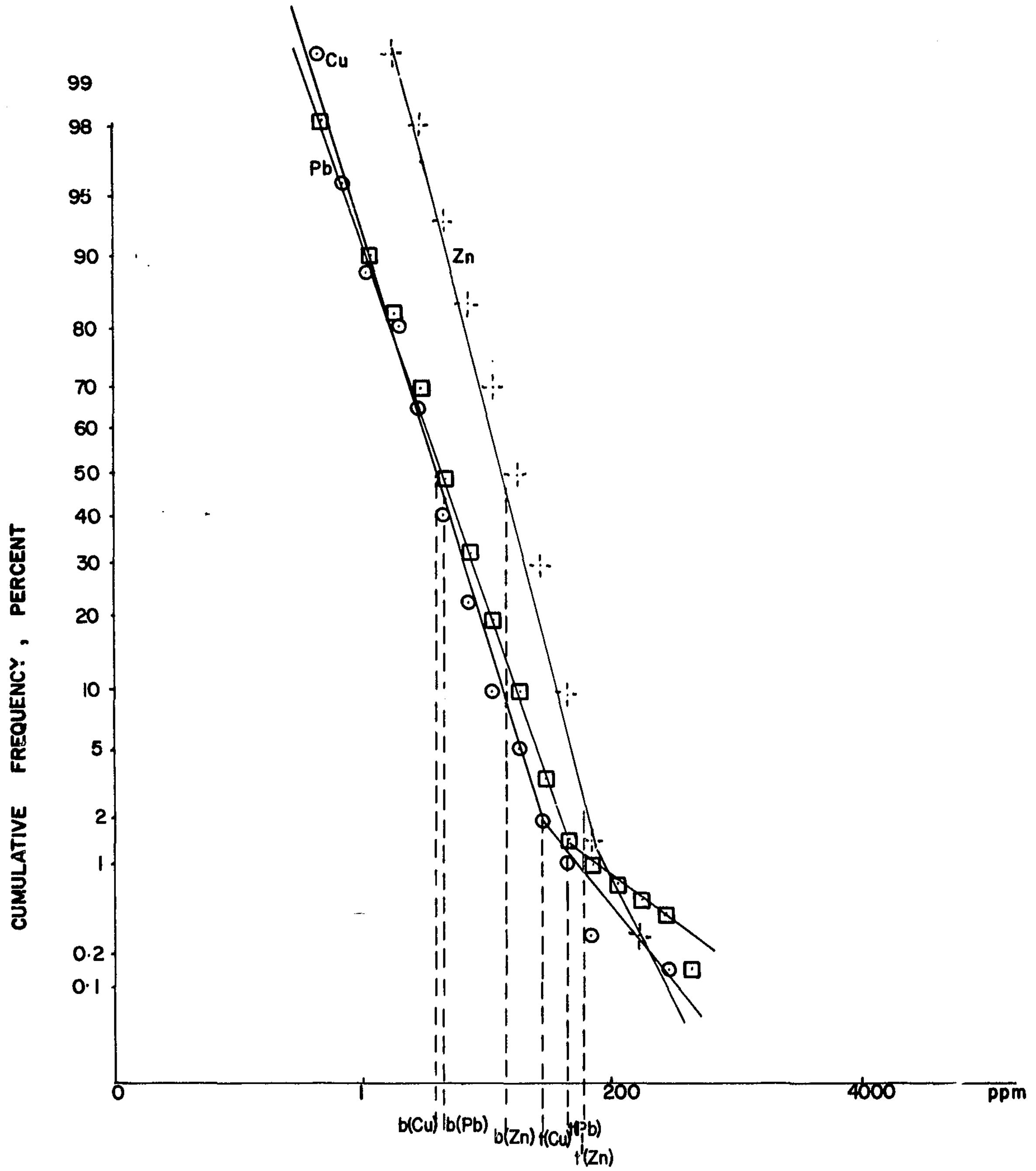
SHAN SCARPS AREA
STREAM SEDIMENTS
CUMULATIVE FREQUENCY
GROUP 2

Fig II



	⊙ Cu	⊡ Pb	-¦- Zn
No: of Samples	706	706	706
Background Value	22 ppm	23 ppm	47 ppm
Threshold Value	59 ppm	72 ppm	90 ppm

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SHAN SCARPS AREA
STREAM SEDIMENTS
CUMULATIVE FREQUENCY
GROUP 3

Fig 12

Table 9. Distribution parameters from cumulative frequency curves

Elements	Number of determinations	Backgroupd (ppm)	Threshold (ppm)	Number of values above threshold
		Group 1		
Cu	1,445	15.0	47.0	12
Pb	1,445	30.0	74.0	42
Zn	1,445	50.0	118.0	14
Mo	1,417	0.9	5.3	19
Ag	1,445	0.3	1.9	2
Sb	1,387	2.7	3.0	16
Sn	1,371	5.0	23.0	5
W	1,388	4.0	14.0	26
		Group 2		
Cu	729	18.0	47.0	15
Pb	729	38.0	93.0	31
Zn	729	47.0	105.0	5
Mo	696	-	4.0	19
Ag	729	-	4.0	5
Sb	301	1.9	9.0	6
Sn	323	1.9	3.7	13
W	335	1.9	7.4	4
		Group 3		
Cu	706	22.0	59.0	6
Pb	706	23.0	72.0	6
Zn	706	47.0	90.0	5
Mo	692	-	9.0	12
Ag	706	-	3.0	4

origin could be attributed to another two anomalous Cu values situated 10 km to the southeast. A Cu anomaly is clearly outlined in the Tamagyi Chaung drainage system (D/6). Also on D/6 another group of anomalous Cu values in Taungbet near Lebyin reflects minor pyrite and chalcopyrite in marble around small diorite bodies. A few isolated higher Cu values were found scattered elsewhere, namely on C/7 and D/8.

Lead

The median value for Pb (fig. 21) is 30 ppm for geological group 1, 38 ppm for group 2 (including the association of Pb-mineralization with middle Ordovician limestone), and only 23 ppm for group 3. Threshold values are respectively 79 ppm, 122 ppm and 55 ppm. The best-outlined anomalous Pb zone appears near Pyattawye (C/6); this zone, with an area of 14 x 7 sq km, includes some known barite occurrences.

Another lead anomaly on C/10 is associated with known galena veins in the Myinbyan mine. The scattered higher Pb values on C/7 could be associated with mineralization, similar to that which occurs near Sakangyi Village. A significant Pb anomaly was discovered on D/6 in the Tamagyi Chaung drainage area (Technical Report No. 6). The Megon Taung Pb anomaly (D/8) is closely related to wolframite occurrences.

Between Megon Taung and Tamagyi Chaung there are numerous anomalous Pb values, either isolated or weakly grouped in a large NW-trending zone 70 km long. Geologically, this zone includes the contact between Mergui Group metasediments in the east and intrusives in the west. The only known Pb occurrence within this zone is a small galena vein in Dathwe Chaung. Among the other anomalous localities without known mineralization are Chaungbya (D/7) and the vicinity of Letnge Chaung.

Zinc, silver and antimony

Zn values (fig. 20) in general are low throughout the area. A few isolated higher values were recorded in C/7, D/7 and D/8. The over-all low content of Zn in the drainage sediments shows that there are unlikely to be any large Zn deposits within the area. Ag (?) values (fig. 19) are generally low (background varies from 0.3 to 0.9 ppm). The few isolated anomalous values are associated with Pb occurrences in the Pyattawye (C/6) and Sakangyi (C/7) areas. Sb distribution (fig. 21) is influenced by the relatively low element mobility. The regional reconnaissance survey resulted in a single anomalous zone at Lebyin (D/6). A few isolated anomalous values in D/8, D/6 and D/5 are not supported by geological observations.

Tin, tungsten and molybdenus

Anomalous values of Sn (fig. 20) as expected are grouped in Megon mine area (D/8). Relatively high values (over 3.7 ppm) are widely spread in the area south of Lebyin (D/6). The highest values of W (fig. 19) are in the first group of samples. Two anomalies were discovered, both in association with wolframite-bearing quartz veins (Megon D/8, Letha Chaung D/7). Other scattered values exceeding threshold are in the western part of D/7. The distribution of Mo (fig. 20) in stream sediments shows a very wide variation. The scattered anomalous values occur mostly on C/6, C/7 and D/8 map sheets. The only well-outlined Mo anomaly covers the southern slopes of Megon Taung (D/8).

Discussion of anomalous areas

In summary, six prominent anomalous zones and some localities of lesser importance were outlined as the result of the stream survey. The six main zones are all supported by geological evidence. They are discussed briefly, in order from north to south, below.

Pyattawya. - A well-outlined large Pb anomaly on C/6 includes in its northern part barite occurrences with a small amount of fine-grained galena and tennantite. The Zn anomaly is distinctly larger than the observed barite area with sporadic sulphide mineralization. Detailed work in the southern portion of this anomaly is therefore suggested to determine whether the mineralized zone extends to the south.

Myinbyan. - The Pb anomaly around the Myinbyan galena mine in the Chaung Magyi Group on C/10 is small. In view of the previous detailed geochemical work by the Department of Geology, Rangoon University, no follow-up is proposed for this remote locality.

Sabetaung. - A Cu anomaly of very limited extent lies in the area south of Pyattawye lead anomaly (C/6) and in the same geological formation (Naungkangyi limestone). The anomaly clearly outlines the known mineralization where quartz veins containing tetrahedrite mineralization were exploited for a short period. Although the copper content was fairly high, mining ceased in the area because of lack of reserves. The small size of the anomaly indicates that additional geochemical or geological work is not justified.

Lebying. - The Sb anomaly confirmed by geology extends throughout the known area of stibnite mineralization and its vicinity on D/6. The various types of mineralization at different localities in a small area (Sb, Au, Cu, Pb-Ba) reflect the complex local geology with post-Jurassic diorite intrusions within folded and thrust late Palaeozoic and Mesozoic sedimentary and volcanic rocks. Although small-scale mining of stibnite in the Lebyin area is continuing, detailed geological, geochemical and geophysical work is recommended.

Tamagyi Chaung. - A Pb anomaly supported by anomalous Cu values lies within sample group 1 on D/6. Five anomalous values, distributed along a northerly trend, occur in the Tamagyi metamorphics. Quartz veins and stringers at one locality in the scarp area carry small amounts of galena. Follow-up work is recommended owing to a well-outlined two-element anomalous zone which is supported by geological evidence.

Megon Taung. - This W-Sn-Mo-Pb anomaly is the southernmost of the anomalies found in the Shan Scarps. It is closely associated with quartz veins in a granitic stockwork and within adjacent Mergui Group metasediments. The quartz veins in both host rocks carry wolframite as the main ore mineral, and molybdenite, pyrite, chalcopyrite, galena and cassiterite were also observed. To find a possible extension of the W-bearing veins, detailed sampling in the northern and southern drainage area of Megon Taung and adjacent hills is recommended.

Conclusions

The stream sediment reconnaissance survey established the following six well-defined anomalous zones supported by geological evidence: Pyattawye (Pb), Sabetaung (Cu), Myinbyan (Pb), Lebyin (Sb), Tamagyi (Pb) and Megon Taung (W, Sn, Mo and Pb). Four of them, Pyattawye, Lebyin, Tamagyi Chaung and Megon Taung, are recommended for follow-up. Results of subsequent work at these four localities are described in Technical Report No. 6. In addition a few anomalies either of small extent or not supported by geological features were found, e.g. Chaungbya (Pb), Letba Chaung (W), Myo Gyi (Cu), Sakangyi (Pb), Taungbet (Cu) and Phaungdaw (Pb). The geochemical methods and analytical procedures used in the regional stream sediment survey as part of the reconnaissance work proved effective and are recommended for further reconnaissance surveys in the neighbouring area.

VIII. MINERAL OCCURRENCES AND DEPOSITS

The area has long been noted for its numerous small mineral occurrences, a number of which either have been or are being worked on a small scale, and many of which were noted by Clegg (1944). A list and brief notes on each mineral occurrence are given in annex II, and their locations are shown on figure 13. Results of follow-up investigations at four of these occurrences, which yielded the well-defined geochemical anomalies described above, are given in Technical Report No. 6. A brief account of the type of mineralization is included below.

Lead

Lead-barite-(zinc) veins in limestone

There are a number of barite veins with a trace of galena at and near Pyattawye on C/7. The veins are probably strata-bound, occurring within the Naungkangyi limestone of middle Ordovician age, and are described in Technical Report No. 6. The Naungkangyi limestone is widespread in the Shan States, and outside the project area mineral deposits within it include the Bawsaing lead-zinc mine in the Southern Shan State where lead carbonates are also present, small barite veins in the Northern Shan State near Maymyo, and barite-galena veins at Doktoye on C/8.

In Thailand and West Malaysia limestones of similar age and lithology to the Shan State contain lead-zinc-barite mineralization. In contrast to the Ordovician limestone, no mineralization is known from the extensive and very thick lower Permian to middle Triassic carbonates in Burma, Thailand or Malaysia.

Lead-quartz-(barite) veins in rocks other than limestone

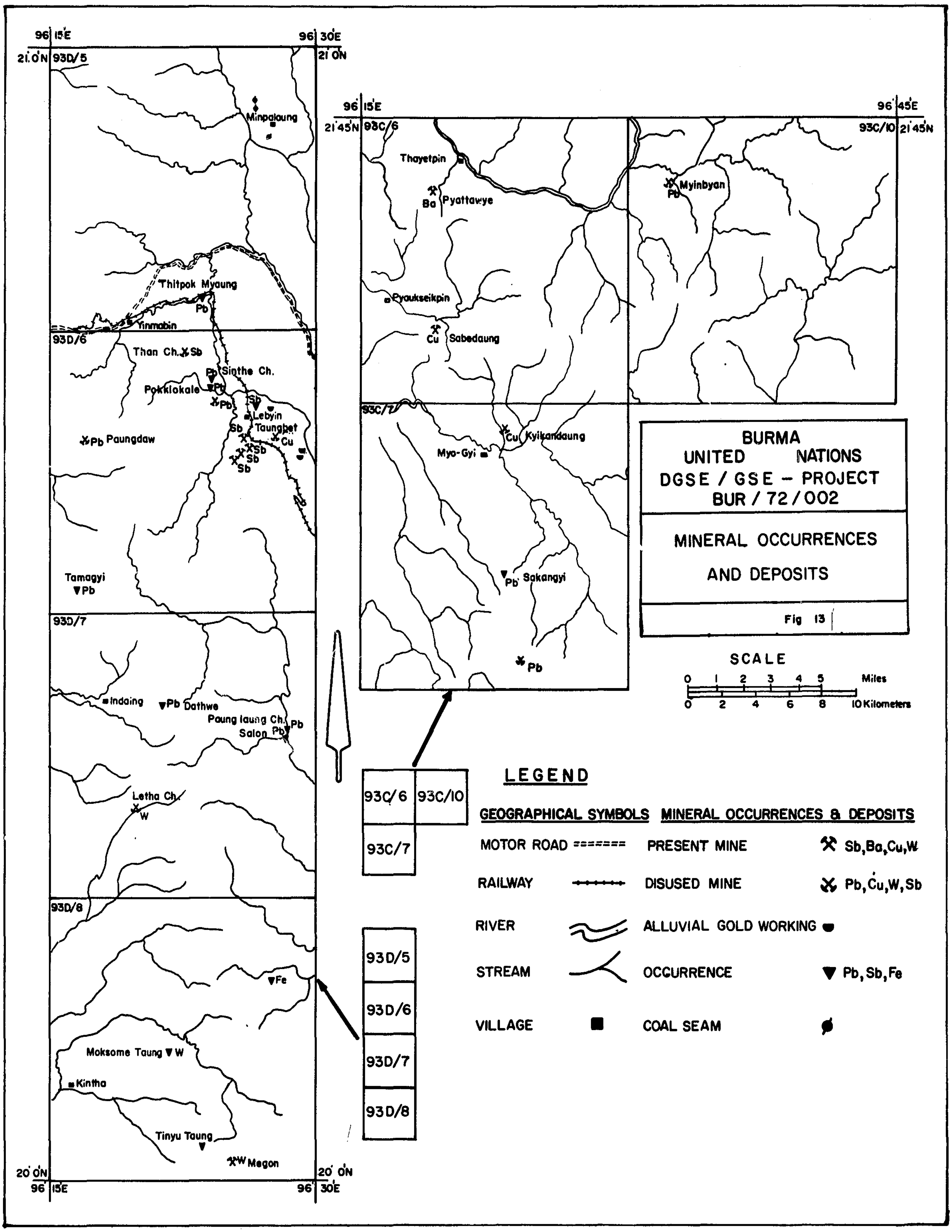
There are six occurrences of galena-bearing veins in rocks of the Mergui Group of Carboniferous to lower Permian age in D/6 and D/7 (Poklokkale, Sinthe Chaung, Salon Chaung, Dathwe Chaung, Thitpok Myaung, and Paunglaung Chaung). Small quartz-galena veins also occur in metamorphic rocks near the western margin of D/6 and D/7. These comprise the veins in calc-silicate rock and marble at Paungdaw, and veins in quartzite within schists and augen gneiss of the Tamagyi Metamorphics, both on D/6. Quartz-galena veins at Myinbyan on C/10 occur within schists of the Chaung Magyi Group. A small barite-galena vein was reported in the 1977/78 field season from a stream draining the Patchaung volcanics in the south of C/8.

Adjacent to the project area on C/8, galena has been reported in diorites and within conglomerates (Garson et al., 1974) of a unit now referred to as the Kalaw Conglomerate. In the Northern Shan Stare there are a number of lead occurrences in the Precambrian Chaung Magyi Group, including those mined on a small scale at Yadanatheingi, and small veins of galena have been reported from Middle Devonian limestones southwest of Yadanatheingi (Mitchell et al., 1977). At the Bawdwin mine, in the Northern Shan State, lead-zinc-silver mineralization in volcanic rocks of Cambrian age has been worked since the 16th century.

There is thus little evident age or stratigraphic control on many of the lead occurrences, with the exception of those strata-bound in Mid-Ordovician limestones. It is probable that there were at least three episodes of lead mineralization in the Shan States, in the Cambrian, Ordovician and post-Jurassic.

Antimony

Stibnite is mined on a small scale from veins and fracture fillings at a number of localities south of Lebyin on D/6. It occurs in silicified zones within tightly folded carbonaceous mudstones and mudstone breccias, possibly forming part of the Kyaukhsu Taung Formation of upper Jurassic age. The mineraliztion, although obviously



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MINERAL OCCURRENCES
AND DEPOSITS
Fig 13
SCALE
0 1 2 3 4 5 Miles
0 2 4 6 8 10 Kilometers
LEGEND
GEOGRAPHICAL SYMBOLS
MINERAL OCCURRENCES & DEPOSITS
MOTOR ROAD
RAILWAY
RIVER
STREAM
VILLAGE
PRESENT MINE Sb, Ba, Cu, W
DISUSED MINE Pb, Cu, W, Sb
ALLUVIAL GOLD WORKING
OCCURRENCE Pb, Sb, Fe
COAL SEAM
93C/6
93C/10
93C/7
93D/5
93D/6
93D/7
93D/8
96 15E
96 30E
96 45E
21 0N
21 45N
20 0N
Minpaloung
Thitpok Myaung
Yinmabin
Than Ch.
Sinthe Ch.
Pokklokale
Lebyin
Taungbet
Paungdaw
Tamagyi
Indaing
Dathwe
Poung laung Ch.
Salon
Letha Ch.
Moksome Taung
Kintha
Tinyu Taung
Megon
Thayetpin
Pyattawye
Pyaukseikpin
Sabedaung
Myinbyan
Kyikandaung
Myo-Gyi
Sakangyi

epigenetic, is stratigraphically controlled, and volcanic rocks and quartzites lying respectively stratigraphically above and below the mudstone unit are not mineralized. The mineralization is probably of early Cretaceous age. North of the Lebyin area, stibnite mineralization is present in sheared boulders in the Than Chaung and in silicified breccia near Yebu. The Lebyin stibnite is one of a number of scattered occurrences in the western part of the Shan State and in Kayah State; at many of these, the host rock is considered to be of Carboniferous age.

Tin-tungsten

Cassiterite and wolframite occur in quartz veins associated with greisen at a high elevation (approx. 6,000 ft) within the Megon Granite on D/8, where they are worked on a small scale on the tributary system. Wolfram-bearing quartz veins are also present within the same granite to the north at Tinyu Taung, where it has been worked on a small scale, and at Moksoma Taung and Letha Chaung. The Megon mineralization lies near the northern end of the belt of granites of probable Cretaceous to Eocene age, which extends southwards through the mineralized granites on 94 A/5 investigated in the 1977/1978 field season, the tungsten occurrences at Padatgyaung, the Mawchi tungsten mine and Tenasserim into southern Thailand (Garson et al., 1975). The northernmost occurrence of tin-tungsten mineralization is near the northern limit of the granite belt on C/8 (Garson et al., 1976). At Padatgyaung, east of Pyinmana, the tungsten and tin is associated with a granite of Palaeocene age, but it is possible that some of the mineralization in the belt is older.

Copper

Only three occurrences of copper are known from the area. At Sabetaung on C/6, copper minerals, associated with quartz veins in calcareous sedimentary rock of probable early Ordovician age, have been worked on a small scale. Southeast of Myogyi on C/7 malachite associated with pyrite occurs in the Precambrian Myogyi Slate; the mineralization is commonly considered to be stratiform but there is no compelling evidence for the mode of occurrence. A trace of copper mineralization is present at Taungbet east of Lebyin on D/6, where minor chalcopyrite and malachite associated with quartz occur within the Pinmon East crystalline limestones of probable Jurassic age.

Gold

There are minor occurrences of alluvial gold to the north and southeast of Taungbet and east of Lebyin on D/6, where they are worked intermittently on a small scale. The gold is evidently derived from nearby small bodies of diorite-intruding limestones and marbles of probable upper Triassic to Jurassic age.

Coal

Coal seams and coaly shales have long been known from the Loi-An Formation of Jurassic age on D/5, and were investigated by a Japanese team 20 years ago (Coal Research Institute, 1958). They extend with decreasing thickness southwards into D/6. Coal from what is considered to be the same stratigraphic unit has been mined intermittently on a small scale from the Loi-An coalfield east of the project area.

Uranium

The lithology of the Loi-An Formation, comprising quartzose sandstones and carbonaceous shales with local channel-fill facies, indicates that it is a possible host rock for sandstone-type uranium mineralization. Rocks of broadly similar age and lithology in the Korat Plateau of Thailand contain small stratabound uranium deposits and are currently being prospected. A ground-based reconnaissance radiometric survey in the Loi-An Formation and adjacent Kalaw Red Bed Group was started during the 1976/1977 field season, but abandoned at the request of the Government.

Raw materials

With the exception of marble on 94 A/5 which is quarried for cement manufacture, the only raw materials extracted within the area are those used for roadstone. Quarries are present in impure marble and calc-silicate rock on D/8, and in the foliated Nattaung granite on D/7. Immediately west of D/5 beryl is extracted from pegmatites broadly similar to those found within the project area, although no beryl has been found in the latter.

Lead isotopes

Samples of galena were collected from 12 mineral occurrences and deposits in Burma and submitted to the Geological Survey of Finland for isotope determinations. Five of these were from localities within the Shan Scarps area, four from localities elsewhere in the Shan States in which some information on the mode of occurrence was available, and one from the Shangalon prospect in the Pinlebu-Banmauk area (table 10). Results are shown on figure 14 and discussed briefly below.

Bawdwin Mine (2)

This sample is from the major lead-zinc-silver mine in the Northern Shan State, in which the sulphides occur within tectonised acidic volcanic rocks of Cambrian age. Although early theories considered the ore to be epigenetic, the mineralization shows many similarities to those found in stratabound ore bodies elsewhere, for example the Kuroko deposits in Japan. The isotope data show that the lead lies close to the two-stage growth curve with μ(238/204 Pb) = 10.1, and slightly above the 500 m.y. isochron, giving an apparent age of about 510 m.y., or late Cambrian. The results thus support the concept that Bawdwin is a syngenetic stratiform ore body, with concordant lead.

Bawsaing Mine (4), Anisakan (8), Doktoye (10)

These samples are from barite-galena veins within middle Ordovician limestones; occurrences of this type are widespread in the Shan States, suggesting that they are probably stratabound in the limestones.

The Bawsaing sample has an apparent age of about 480 m.y., similar to that of the limestone within which it occurs, and also lies close to the μ=10.1 growth line, suggesting that it could have been derived from underlying lead similar to that at Bawdwin with minor addition of younger lead. Results for the Doktoye sample indicate that the lead does not lie near the two-stage growth curve, and at 600 m.y. is apparently older than the Bawdwin sample. The Anisakan Sample has an anomalously young apparent age of about 410 m.y.

Myinbyan (11), Datwe (12), Pokklokale (13), Tamagyi (14) and Paungdaw (15)

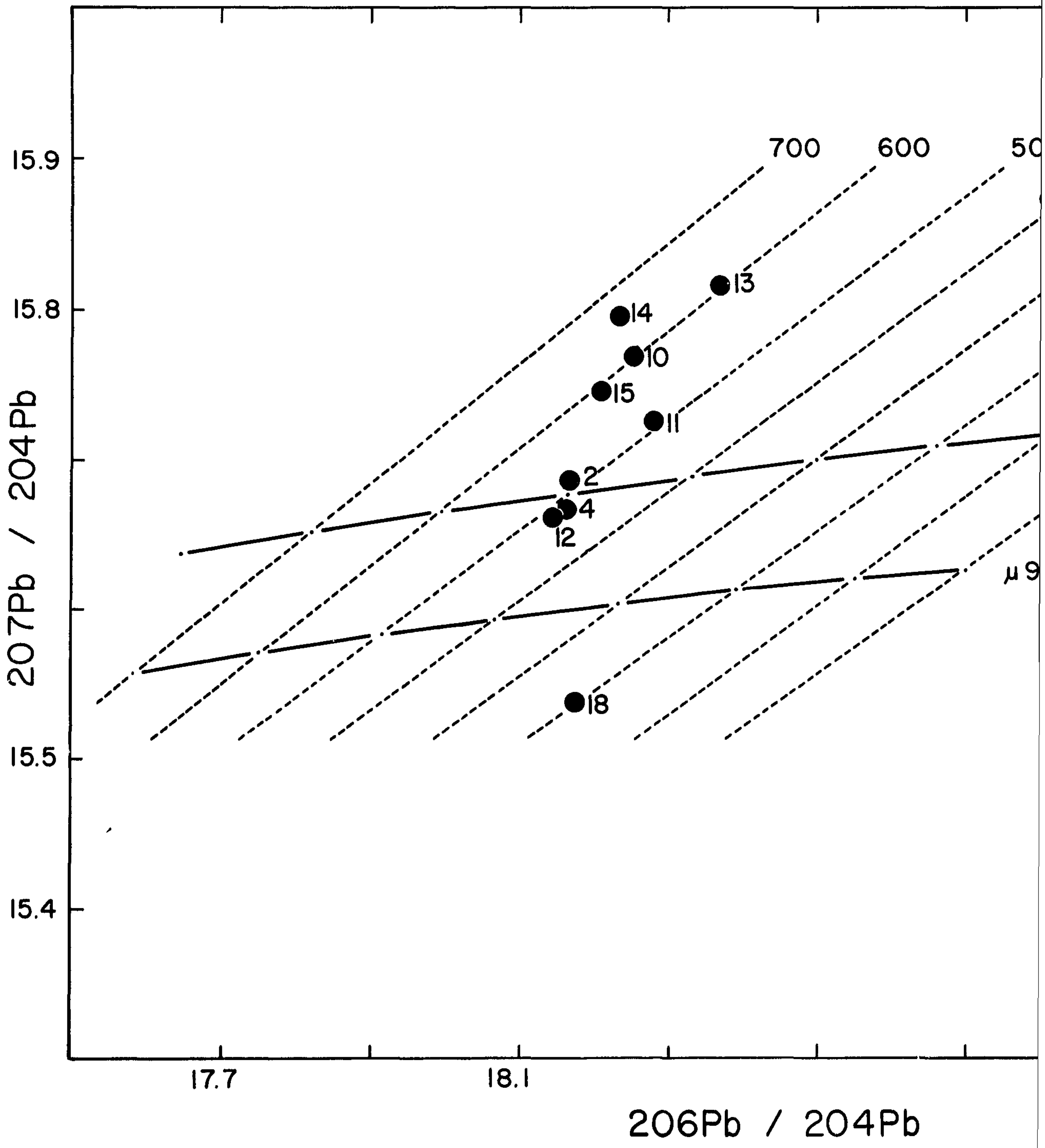
These are all vein-type occurrences, of which Myinbyan lies within Precambrian metamorphics, Paungdaw and Tamagyi in metamorphosed rocks of probable Palaeozoic age, and Datwe and Pokklokale in Carboniferous greywackes. The results show that four samples lie on isochrons between 590 and 660 m.y., and are hence older than the host rocks, whereas Myinbyan lies close to a 500 m.y. isochron, younger than the depositional age of the metamorphic host rocks. With the exception of that from Myinbyan, the samples evidently include some lead older than the Bawdwin 'concordant' lead.

Shangalon

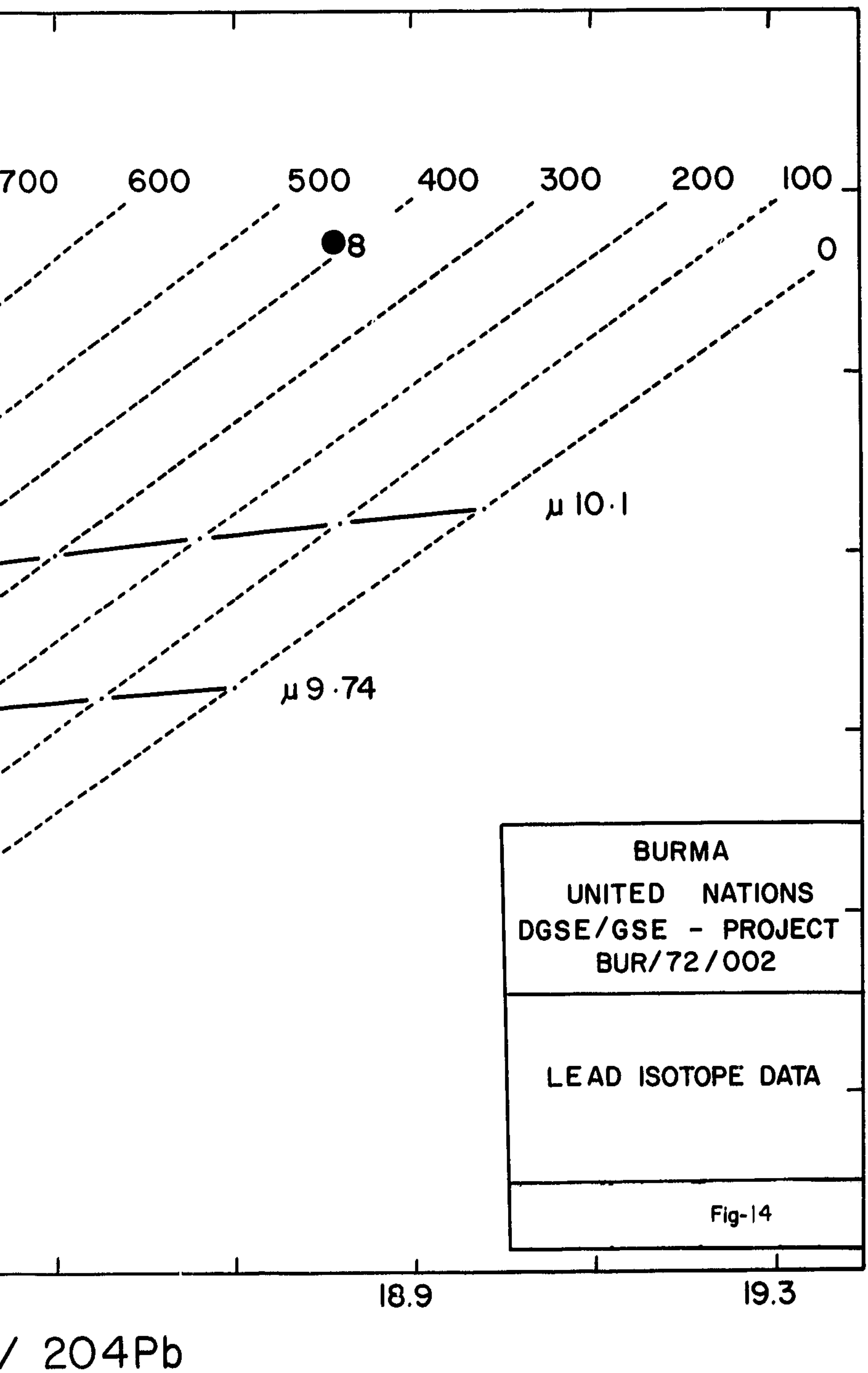
The Shangalon sample is from a galena vein in granodiorite within the Burma Volcanic Arc. The granodiorite yielded an early Oligocene (38 m.y.) K/Ar age (Technical Report No. 2), and the pre-volcanic basement at Shangalon consists of metamorphic rocks, probably metamorphosed in the Mesozoic. The Shangalon lead lies on the 200 m.y. isochron; its apparent age is thus significantly younger than that of the Shan State leads, supporting the geological evidence for the relatively young age of the basement beneath the Volcanic Arc.

Table 10. List of Pb isotope samples

Sample No.	Locality	Region and map sheet	Project Technical Report No.
2	Bawdwin Mine	N. Shan State 93 D/9	-
4	Bawsaing Mine	S. Shan State 93 D/13	-
8	Anisakan	Margin, Shan Plateau 93 C/5	-
10	Doktoye	Mergui, Shan Plateau 93 C/7	-
11	Myinbyan	Shan Plateau 93 C/10	3
12	Datwe	Shan Scarps 93 D/7	3
13	Pokklokale	Shan Scarps 93 D/6	3 and 6
14	Tamagyi	Shan Scarps 93 D/6	3 and 6
15	Paungdaw	Shan Scarps 93 D/6	
18	Shangalon	Volcanic Arc 84 M/10	1 and 2



15.9
15.8
15.5
15.4
207Pb / 204Pb
700
600
50
13
14
10
15
11
2
4
12
18
µ 9
17.7
18.1
206Pb / 204Pb


700
600
500
400
300
200
100
0
8
µ 10·1
µ 9·74
18.9
19.3
/ 204Pb
BURMA
UNITED NATIONS
DGSE/GSE - PROJECT
BUR/72/002
LEAD ISOTOPE DATA
Fig-14

IX. GEOLOGICAL HISTORY

Deposition of the non-volcanogenic flysch-type sediments and interbedded pyritic shale member of the Late Precambrian Chaung Magyi Group was succeeded by folding before accumulation of the quartzites of the Pangyun Formation in the Cambrian. The Pangyun Formation was overlain in probable conformity by the predominantly shelf-type carbonates of the Ordovician to earliest Silurian Pindaya Group, with lead-barites mineralization in the mid-Ordovician carbonates probably taking place soon after sedimentation. As in the Northern Shan State, sedimentation probably continued through the Silurian into the Devonian, indicated by the presence of probable Zebyingyi beds preserved in a thrust slice. The unusual pebbly mudstone and pebbly sandstone facies comprising the Carboniferous to lower Permian Megui Group suggest either a fault-bounded continental margin environment or a very major submarine fan system, although they could also be interpreted as submarine tillites of glacial origin partly reworked by slumping and other mass flow processes. The present restriction of the Mergui Group to the area west of the Shan Scarps suggests extensive pre-Shan Dolomite Group erosion in the east.

The shelf and turbidite carbonates comprising the lower Permian to middle Triassic Shan Dolomite Group were deposited in probable unconformity on the Mergui Group and lower Palaeozoic rocks to the east, although as both the Thitsipin Limestone and the upper part of the Mergui Group are of lower Permian age, there was clearly no prolonged break between deposition of the two units. The Ma-u-bin Formation, comprising non-volcanogenic terrigenous turbidites, mudstones and limestone turbidites with a local basaltic detritus, accumulated probably during the Ladinian to Carnian (late middle to early upper Triassic) and was isoclinally folded, perhaps as a result of eastward-directed overthrusting either in the late Triassic or more probably in the early Jurassic.

The earliest metamorphism of Palaeozoic rocks forming the Tamagyi metamorphics is indicated by the previously determined 185 m.y. K/Ar age on hornblende in gneiss from the southward continuation of the metamorphics in the Mogok Belt east of Pyinmana. This metamorphism was probably accompanied by a major orogeny which post-dated deposition of the Napeng Series of the Northern Shan State. It was possibly accompanied by intrusion of hornblende gabbro in the Volcanic Arc and by either generation or emplacement of ultrabasic rocks preserved in the Chin Hills and Arakan. There is no evidence of pluton emplacement within the area at this time, although the presence of early Jurassic granites cannot be disproved. The Mergui Group lying west of the Shan Scarps was possibly thrust eastwards at this time and tectonically juxtaposed with the Palaeozoic sequence east of the Scarps in which the Group is absent.

Folding and uplift resulted in erosion of the Shan Dolomite Group and Ma-u-bin Formation from the west of the area, and was followed by deposition of the middle to early upper Jurassic Loi-An Formation with coals. Deposition of the Kyaukhsu Taung Formation in the upper Jurassic to lower Cretaceous followed a further period of uplift and erosion, and was succeeded by eruption of rhyolite, dacite and andesite flows and tuffs, probably related to eastward subduction of ocean floor beneath the Chin Hills. The unfossiliferous Telu Limestone accumulated in probable unconformity on the volcanic rocks. Emplacement of some granites and granodiorites, possibly the diorites with local gold mineralization, and perhaps also inferred intrusives to which the antimony deposits are related, preceded deposition of the Kalaw Conglomerate. The Kalaw Conglomerate, lying in angular unconformity on rocks of Cretaceous to Carboniferous and possibly Devonian age, probably accumulated during eastward-directed thrusting in the Shan Scarps, and either preceded or accompanied emplacement of the 56 m.y. Padatgyaung granite and perhaps other tin and wolfram-bearing plutons east of the Mogok Belt.

Granites within the Tamagyi metamorphics were probably also emplaced in the latest Cretaceous to early Tertiary and associated with formation of migmatites and gneisses. Uplift and cooling of these rocks together with the Shan Plateau to the east resulted in Oligocene K/Ar ages on the plutons and gneisses of the Mogok Belt. The uplift was probably accompanied by movement along the high-angle faults in the Shan Scarps. The latest episode of dextral movement on the Hninzee-Sagaing fault, west of the area, took place in the Miocene to Quaternary. The late Mesozoic and Tertiary geological history can be related in only the most general way to its location on a plate margin above the subducting Indian Ocean floor, largely because of difficulties in stratigraphic correlation between the Shan Scarps Area and the Volcanic Arc to the west.

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2. Geology and Exploration Geochemistry of the Pinlebu-Banmauk Area, Sagaing Division, northern Burma. United Nations team (issued)

3. Geology and Exploration Geochemistry of the Shan Scarps Area, East of Kyaukse, Thazi and Tatkon, central Burma. United Nations team (this report)

4. Geology and Exploration Geochemistry of Part of the Northern and Southern Chin Hills and Arakan Yoma, western Burma. United Nations team (in preparation)

5. Geology and Exploration Geochemistry of the Salingyi-Shinmadaung Area, central Burma. United Nations team (in preparation)

6. Mineral Exploration in Selected Areas, Burma. United Nations team (in preparation)

Annex 1

NATIONAL PROFESSIONAL STAFF IN SHAN SCARPS AREA

Chief	U Zaw Pe
Geologists and geochemists	
Map sheets: 93C 6, 7, 10	Khin Maung Aye I, Kyaing Sein, Sein Htun, Htein Win, Than Aung, Nyunt Shwe, Soe Myint IX, Ronald Tun Lin.
Map sheet: 93D 5	Khin Maung Aye II, Tint Naung, Sein Aung Win, Tin Hlaing III, Myint Swe III, Soe Hlaing.
Map sheet: 93D 6	Tin Maung Thein, Htein Linn, Myint Swe III, Khin Maung Aye II, Myint Swe II, Ohn Maung, Myo Myint Swe, Maung Tint.
Map sheets: 93D 7, 8	Sein Aung Win, Ko Ko V, Myint Swe III, Kyaw Sein, Aung Gyi, Saw Naung.

Annex 2

MINERAL OCCURRENCES AND D

Place name and elements		Location and grid ref.	Desc
Lebyin	Sb	93D/6 938031 three km S of Lebyin village	Veins, fr minor dis Jurrassic rocks
Than Chaung	Sb	93D/6 881137 eight km SE of Yinmabin	Minerali silicifie sediment
Paungdaw	Pb, (Zn, Cu)	93D/6 765045	Quartz-ga in marble
Pokklokale Chaung	Pb (BA)	93D/6 907080	Galena-ca veins in
Sinthe Chaung	Pb	93D/6 905126	Scattere probably Mergui G
Salon Chaung	Pb	93D/7 976727	Small ve nations
Thitpok Mysung	Pb (Ba)	93D/5 897196 one km W of Pyinyaung Buda	Quartz-ga in quart Group

Annex 2

OCCURRENCES AND DEPOSITS

ref.	Description	Work done and references
km S	Veins, fracture filling minor dissemination in Jurrassic sedimentary rocks	Tributor mining extracting antimony. Drilling, mechanized trenching geological mapping, geochemical and geophysics, in progress by GSEP; Technical Report No. 6, Clegg (1944).
: km	Mineralized float of silicified sheared sedimentary rock	Detailed survey is being done by DGSE.
	Quartz-galena veins in marble	Detailed exploration and drilling by DGSE in progress.
	Galena-calcite-barite veins in Mergui Group	Previous small-scale extraction.
	Scattered floats, probably from veins in Mergui Group	
	Small veins and disseminations in Mergui Group	
:m W	Quartz-galena stringers in quartzite of Mergui Group	Extracted by private miners pre-1939.

Place name and elements		Location and grid ref.	Descri
Dathwe Chaung	Pb	93D/7 845751 six km E of Indaing village	Quartz-gal within Mer
Sakangi	Pb	93C/7 897 901 NE of Sakangyi village	Galena wit mid-Ordovi limestone
Tamagyi	Pb	93D/6 753 888 W of Natin village	Galena in Tamagyi me
Paunglaung Chaung	Pb	93D/7 978 728	Galena-bea veins in M
Myinbyan	Pb	93C/10 075 300	Quartz-gal Precambria
Sabedaung	Cu	93C/6 834 154 two km SE of Ywathit village	Tetrahedri quartz vei Ordovician
Kyikandaung	Cu	93C/7 905 037 one km NE of Kyungyi village	Azurite an staining i slates
Taungbet	Cu (Au?)	D/6	Trace of c malachite limestone
Megon Mine	W (Mo)	93D/8 910 272	Quartz-wol rite veins
Letha Chaung	W (Sn)	93D/7 836 654	Quartz-wol cassiterit granite
Moksoma Taung	W	93D/8 826 379	Quartz-wol in granite
Tinyu Taung	W	93D/8 888 299	Quartz-wol in granite

Annex 2 (continued)

ef.	Description	Work done and references
E	Quartz-galena veins within Mergui Group	
	Galena within veins in mid-Ordovician limestone	Galena extracted previously by local villagers.
latin	Galena in quartz veins in Tamagyi metamorphics	Detailed investigation by GSEP, Technical Report No. 6.
	Galena-bearing quartz veins in Mergui Group	
	Quartz-galena veins in Precambrian Schist	Previously explored by DGSE.
n ge	Tetrahedrite azurite and quartz veins within Lr. Ordovician carbonates	Exploration work and drilling by DGSE (tunnel, shaft, pits).
n ge	Azurite and malachite staining in Precambrian slates	Investigated by trainees from post-graduate training project.
	Trace of chalcopyrite and malachite in crystalline limestone	Pre-1939 tunnels, small-scale mining. Coggin Brown and Sondhi 1933.
	Quartz-wolframite-cassiterite veins in granite	Small-scale tributor working. Follow-up survey by GSEP, Technical Report No. 6.
	Quartz-wolframite-cassiterite veins in granite	
	Quartz-wolframite stringers in granite	
	Quartz-wolframite stringers in granite	

Place name and elements		Location and grid ref.
Pyattawye	Ba (Pb)	93C/6 839 295
Kyaunggon	Fe	93D/8 955 460
Taungbet	Au	D/6

Annex 2 (continued)

nd grid ref.	Description	Work done and references
295	Barite veins in Mid-Ordovician limestone	Small-scale extraction. Detailed exploration including diamond drilling by Canadian bi-lateral aid, Technical Report No. 6.
460	In adamellite	
	Alluvial gold derived from diorite	Small-scale workings.

Ann

PALEONTOLOGICA

Sample No./grid ref.	Rock unit	Age
1. 93 C/6 838 296	Naungkangyi Lst	M. Ordovician ? L. Cambrian
2. 93 C/6 790 124	?Zebingyi Beds	U. Ordovician L. Devonian
3. 93 D/8 910 365	Mergui Gp.	Permian (? Carboniferous)
4. 93 C/6 791 127	Base of Thitsipin Lst.	Probably L. Permian
5. 93 C/6 845 300	Thitsipin Lst	Permian ? Lower
6. 93 C/6 762 364	Thitsipin Lst	Permian ?Upper

Annex 3

PALEONTOLOGICAL DETERMINATIONS

Age	Reference	Identifications
M. Ordovician	Owen, 1977	Nautiloid provisionally referred to an Ormoceras.
? L. Cambrian	Rosen, 1977	? Syringocnema sp.
U. Ordovician L. Devonian	Cocks, 1977	Plectambonitacid brachiopods probably related to Plectodonta.
Permian (? Carboniferous)	Rosen, 1977	Coral: Tentatively identified as Lophophyllidium (Sinophyllum) pendulum (Grabau); bryozoans: Streblotrypa cf. elegans Sakagami, and ?Fenestella sp.
Probably L. Permian	Elliott and Whittaker, 1977	Recrystallised fusuline foraminifera, probably Schwagerininae and Staffella; smaller indeterminate foraminifera, brachiopod and bryozoan debris, algal oncolite.
Permian ? Lower	Elliott and Whittaker, 1977	Rare smaller foraminifera: Hemigordius, Globivalvulina, Lunucammina (=Geinitzina auct.) and tuberitinids; algal, bryozoa, brachiopod fragments.
	Rosen, 1977	Corals: Pavastehphyllum (Thomasiphyllum) /Iranophyllum/ spongifolium (Smith) and Pseudoromingeria sp.
Permian ?Upper	Elliott and Whittaker, 1977	Smaller foraminifera: Hemigordius, Pachyphloia, Langella, Globivalvulina; algai, brachiopod spines and debris
	Rosen, 1977	Coral Pseudoromingeria sp.

Sample No./grid ref.	Rock unit	Age	Reference
7. 93 C/6 774 251	Thitsipin Lst	Permian	Rosen, 1977
8. 93 C/6 787 274	Thitsipin Lst	Permian (possibly Carboniferous)	Rosen, 1977
9. 93 C/6 789 181	Thitsipin Lst	Palaeozoic, ?Permian	Rosen, 1977
10. 93 C/6 857 256	Thitsipin Lst	L. Permian, Artinskian to L. Kungurian	Rosen, 1977
11. 93 C/7 844 906	Nwabangyi Dolomite	Upper Permian (Tartarian)	Elliott and Whittaker, 1977
12. 93 C/7 846 905	Nwabangyi Dolomite	Upper Permian (Tartarian)	Elliott and Whittaker, 1977
13. 93 C/7 846 904	Nwabangyi Dolomite	Upper Permian (Tartarian)	Elliott and Whittaker, 1977

3 (continued)

	Reference	Identifications
	Rosen, 1977	Coral belonging to the Syringoporida or Auloporida, probably a Pseudoromingeria.
s)	Rosen, 1977	Coral: Probably Pseudoromingeria; Bryozoa: possibly Protoretepora or Polypora.
	Rosen, 1977	Coral: ?Pseudoromingeria.
o n	Rosen, 1977	Corals: Wetzelophyllum jinxianense (Zhao & Chen), Pavastehphyllum (Thomasiphyllum) /Iranophyllum/ arachnoides (Douglas) and Multithecopora sp.
an	Elliott and Whittaker, 1977	Common foraminifera of the family Hemigordiopsidae: Shanita amosi Bronnimann, Whittaker and Zaninetti (in press), Hemigordius renzi (Reichel) (=Hemigordiopsis auct.), Hemigordius spp; Glomospira/ Glomospirella group, Agathammina, Globivalvulina, Paraglobivalvulina, Ichtyolaria, Pachyphloia, ?Robuloides and tuberitinids; algae: Mizzia spp., Tauridium sp., algal oncolites, Permocalculus sp. and a codiacid cf. Aphroditicodium.
an	Elliott and Whittaker, 1977	Foraminifera: Shanita amosi. Hemigordius renzi, Dagmartia sp., indeterminate fusuline; alga Mizzia.
an	Elliott and Whittaker, 1977	Foraminifera: Shanita amosi, Hemigordius renzi, small Hemigorius sp., Glomospira-Glomospirella group, Globivalvulina, Lunucammina (=Geinitzina auct.), fusuline Nankinella, algae Mizzia spp.

Annex 3 (continued)

Sample No./grid ref.	Rock unit	Age	Reference
14. 93 D/5 883 390	Pan Laung Gp.	Post-Palaeo-zoic, probably Jurassic	Morris, N. 1977
15. 93 D/6 981 026	Loi An Fm.	U. Devonian-L. Tertiary, possibly Jurassic	Morris, N. 1977
16. 93 D/6 008 012	Loi An Fm.	U. Devonian-L. Tertiary, possibly Jurassic	Morris, N. 1977
17. 93 D/6 956 091	Loi An Fm.	?Devonian-Recent	Morris, N. 1977
18. 93 C/8 865 469	Kyaukhsu Taung (Lst)	Probably Jurassic-earliest Cretaceous	Whittaker 1978
19. 93 C/8 818 734	Kyaukhsu Taung (Sh)	Jurassic-Neocomian, prob. U. Jurassic	Morris and Palmer in Whittaker 1978
20. 93 D/5 937 397	Loi An Fm.	Lower Oxfordian	Howarth 1978
21. 93 D/5 931 338	Ma-u-bin Fm.		
22. 93 D/5 935 336	Ma-u-bin Fm.		

ex 3 (continued)

	Reference	Identifications
o- ably	Morris, N.J., 1977	Mollusca: ?Costigervillia sp, Modioliform bivalve, Inoceramid-like bivalve, ?Corbulidae, Cerithiacean gastropod (?Procerithiidae).
a- ',	Morris, N.J., 1977	Posidoniid bivalve belong to either Bositra or Posidonia.
a- ',	Morris, N.J., 1977	Posidoniid bivalve belong to either Bositra or Posidonia
	Morris, N.J., 1977	Pectinacean-like bivalve shell
	Whittaker 1978	Foraminifers: Pseudocyclammina, Haplophragmoides spp., miliolaceans and/or Glomospira spp.
	Morris and Palmer in Whittaker 1978	Bivalve Astartidae; Protocardia; gastropod Procerithium
	Howarth 1978	Ammonite Euaspidoceras babeanum (d'Orbigny).

Annex 4

PROJECT PERSONNEL

International staff	Nationality	Arrival date	Departure date	Total m/m served
International personnel				
J.V. Huhta Project Manager	Finland	Jan 1974	June 1978	53
A.H.G. Mitchell Chief Geologist	United Kingdom	Jan 1974	July 1978	55
P. Carrel Economic Geologist	France	Dec 1974	Oct 1976	24
F. Sumi Geophysicist	Yugoslavia	Oct 1974	Mar 1978	40
B. Zitek Chief Geochemist	Czechoslovakia	Feb 1975	Mar 1978	37
T. Davenport Field Geochemist	United Kingdom	Apr 1975	Feb 1976	12
F. Baumann Consultant	Canada	Mar 1976	July 1976	4

Government personnel

U Kyi Soe — Project Co-Director

Geologists

U Zaw Pe
U Danny Sein
U Khin Maung Aye (1)
U Tin Hlaing (2)
U Tin Maung Thein
U Tin Swe
U Kyi Tun
U Soe Thi Ha
U Nyunt Htay
U Myint Swe (2)
U Myint Swe (3)
U Khin Maung Aye (2)
U S. Lwin Than
U Ko Ko (1)
U Aye San
U Kyaw Sein
U Tet Sein
U Sein Tun (2)

Geologists (continued)

U Tint Naung
U Kyaing Sein
U Saw Andrew Htwe
U Ohn Maung (2)
U Ye Maung Tin
U Than Aung
U Htein Win (1)
U Htein Lin
U Tin Than
U Soe Kyi
U Aung Gyi (3)
U Tin Hlaing (3)
U Tin Maung Win (2)
U Shyam
U Sein Aung Win
U Richard Shwe
U Kyaw Win (5)
U Tint

Geologists (continued)

U Myo Myint Swe
U Saw Naung
U Htay Win (2)
U Thein Han
U Ko Ko (5)
U Ba Kyi

Geochemists

U Shwe Gaung Lay
U Kyaw Soe
Daw Khin Khin Win
Daw Thit Thit Hla
Daw Myat Myat Sein

Geophysicists

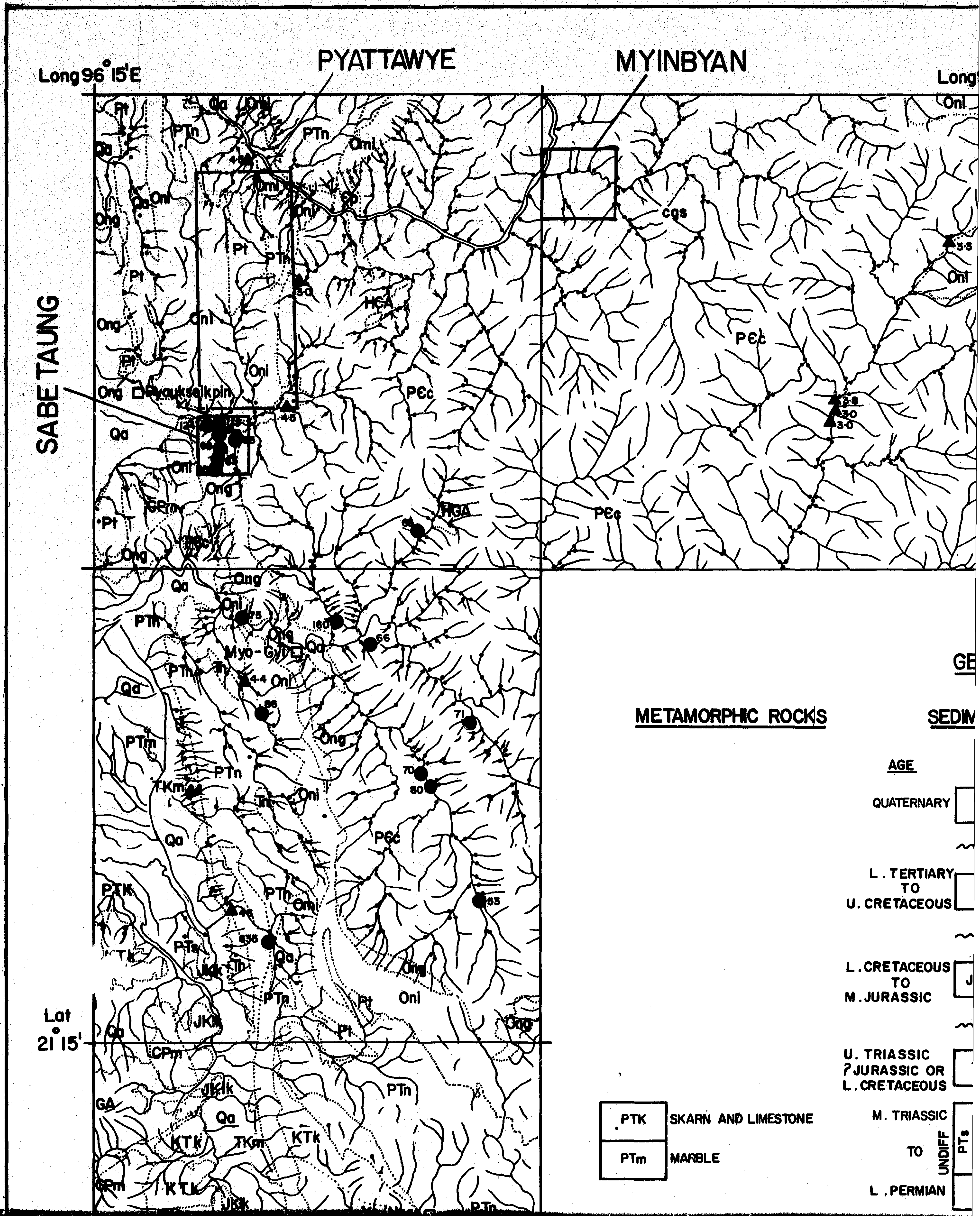
U Tin Myint Oo
U Win Myint
U Nyunt Sein
U Tauk Tut
U Thein Htun
U Mya Thaung
U Khin Maung Htay
U Kyaw Soe

Drilling Engineer

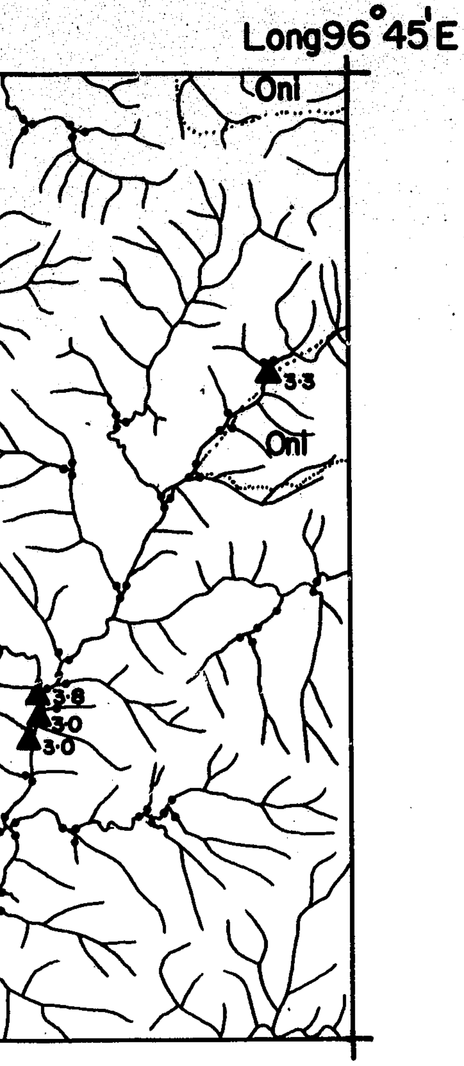
U Ba Soe

Draftsmen

U Maung Maung Nyo
U Tun Aye
U Tun Shin
U Khin Pyone
U Tin Wan
U Hla Than
U Hla Tun
U Khin Sein



PYATTAWYE
MYINBYAN
Long 96° 15' E
Long
SABETAUNG
Lat 21° 15'
Pyaukseikpin
Myo-Gyi
Qa
Pt
PTn
Onl
Ong
Oni
HCA
HGA
PЄc
cgs
CPm
PTm
TKm
PTK
PTs
JKk
KTk
GA
Tn
GE
METAMORPHIC ROCKS
SEDIM
AGE
QUATERNARY
L. TERTIARY TO U. CRETACEOUS
L. CRETACEOUS TO M. JURASSIC
U. TRIASSIC ? JURASSIC OR L. CRETACEOUS
M. TRIASSIC
TO
L. PERMIAN
UNDIFF
PTs
PTK SKARN AND LIMESTONE
PTm MARBLE



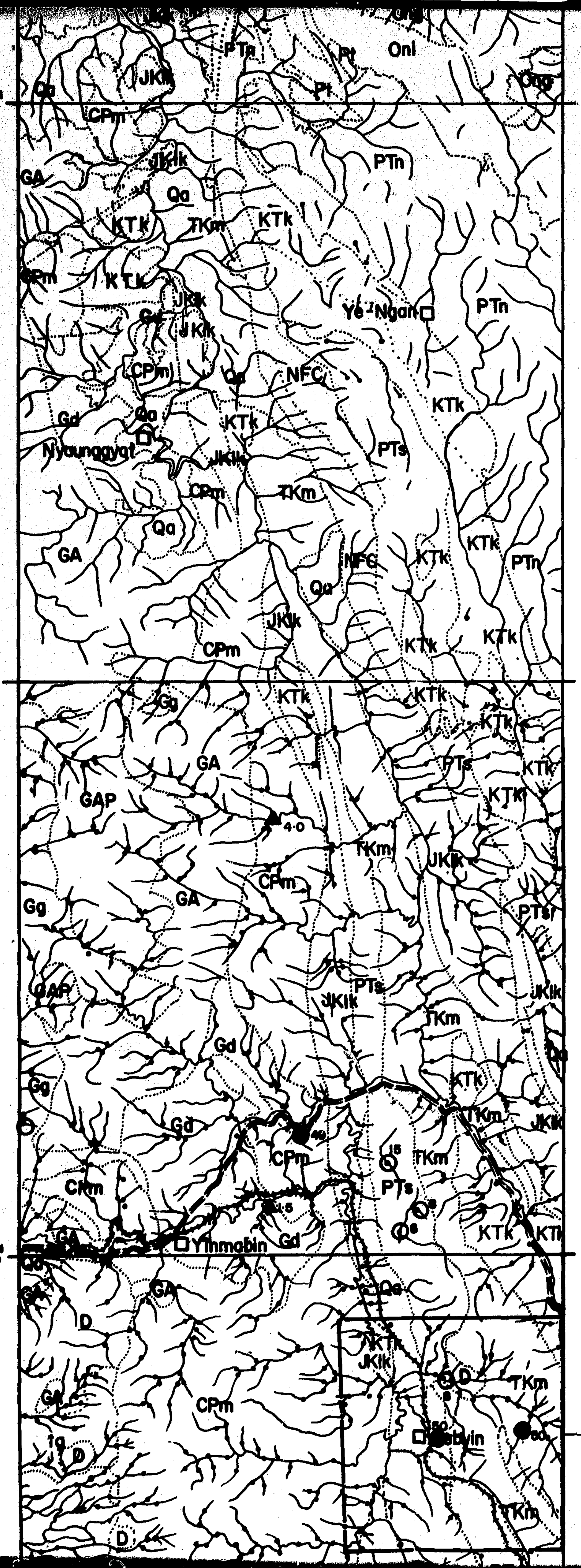
GEOLOGICAL LEGEND

IS

SEDIMENTARY AND VOLCANIC ROCKS

AGE		MEMBER	FORMATION	GROUP
QUATERNARY	Qa	ALLUVIUM AND TRAVERTINE		
	~~	Unconformity		
L. TERTIARY TO U. CRETACEOUS	KTk			KALAW RED BED
	~~	Unconformity		
L. CRETACEOUS TO M. JURASSIC	JKlk		LOI-AN AND KYAUKHSU TAUNG	PANL AUNG
	~~	Unconformity		
U. TRIASSIC ? JURASSIC OR L. CRETACEOUS	TKm		MA-U-BIN	
M. TRIASSIC	UNDIFF PTs — Tn		NATTEIK	SHAN DOLOMITE
TO	UNDIFF PTs — PTn		NWABANGYI	
L. PERMIAN	Pt		THITSIPIN	

E



LEBYIN

L. CRETACEOUS
TO
M. JURASSIC

U. TRIASSIC
? JURASSIC OR
L. CRETACEOUS

PTK	SKARN AND LIMESTONE
PTm	MARBLE

M. TRIASSIC
TO
L. PERMIAN
UNDIFF

ms	BIOTITE SCHIST
mp	PHYLLITE

L. PERMIAN
TO
CARBONIFEROUS

PALAEOZOIC

cm	CALCAREOUS METASEDIMENT
tg	BANDED GNEISS

TAMAGYI METAMORPHICS

UPPER
MIDDLE
LOWER
ORDOVICIAN

CAMBRIAN

cgs	BIOTITE AND BIOTITE-GARNET SCHIST

PRE-CAMBRIAN

UNDIF

L. TERTIARY
TO
U. TRIASSIC

MESOZOIC
TO
PALAEOZOIC

INTR

OLIGOCENE
TO

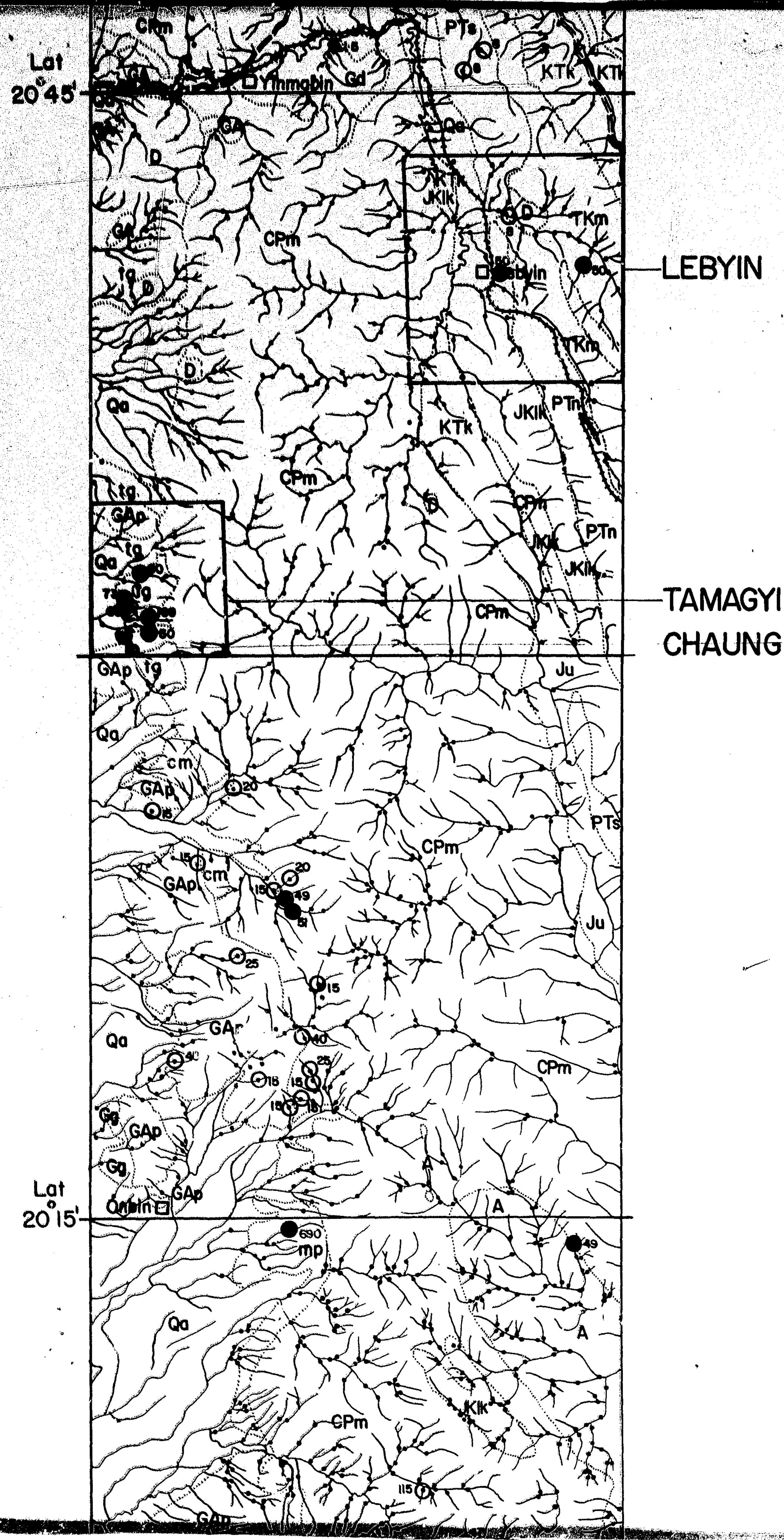
	TO M. JURASSIC	JKlk	AND KYAUKHSU TAUNG	PANLAUNG
	Unconformity			
	U. TRIASSIC ?JURASSIC OR L. CRETACEOUS	T Km	MA-U-BIN	
ONE	M. TRIASSIC	UNDIFF PTs Tn	NATTEIK	
	TO	PTn	NWABANGYI	SHAN DOLOMITE
	L. PERMIAN	Pt	THITSIPIN	
	Unconformity			
	L. PERMIAN TO CARBONIFEROUS	CPm		MERGUI
	Unconformity			
METAMORPHICS	ORDOVICIAN UPPER	Oml	NYAUNGBAW	
	MIDDLE	Onl	NAUNGKANGYI	PINDAYA
	LOWER	Ong	NGWETAUNG	
	Unconformity			
	CAMBRIAN	Єp		PANGYUN
	Unconformity			
CHIST	PRE-CAMBRIAN	PЄc	MYOGYI SLATE (PЄm)	CHAUNGMAGYI

UNDIFFERENTIATED UNITS

L. TERTIARY TO U. TRIASSIC	Ju	UNDIFFERENTIATED KALAW AND PANLAUNG GROUPS
MESOZOIC TO PALAEOZOIC	NFC	NWALABO FAULT COMPLEX MOSTLY NWABANGYI DOLOMITE

INTRUSIVE ROCKS

	D	DIORITE
	Gd	HORNBLENDE-BIOTITE-GRANODIORITE
	A	TWO-MICA ADAMELLITE
OLIGOCENE TO	GA	BIOTITE ADAMELLITE AND GRANITE



INTRUSIVE ROCKS

OLIGOCENE TO CRETACEOUS

D	DIORITE
Gd	HORNBLEN
A	TWO-MICA
GA	BIOTITE A
GAp	PORPHYRIT
Gg	GNEISSIC
Gm	GRANITE (

PRE-CAMBRIAN OR LATER

HGA	HANLIN B

GEOCHEMISTRY

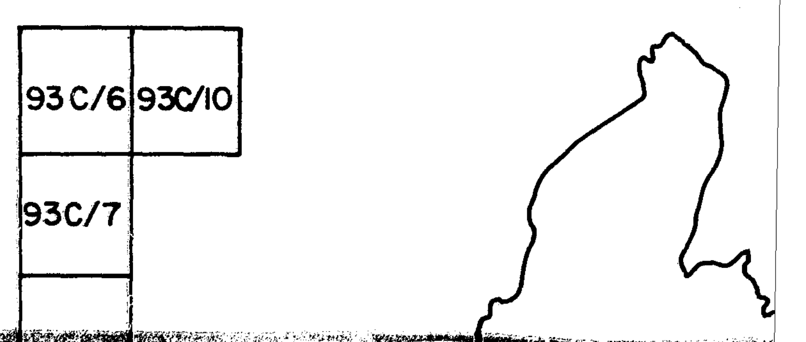
· SAMPLING SITE

● Cu - VALUES ≥ THRESHOLD (GROUP

○ W - VALUES ≥ THRESHOLD (GROUP

▲ Ag - VALUES ≥ THRESHOLD (GROUP

SABETAUNG = ANOMALOUS ZONES, I



ITRUSIVE ROCKS

D	DIORITE
Gd	HORNBLENDE - BIOTITE-GRANODIORITE
A	TWO-MICA ADAMELLITE
GA	BIOTITE ADAMELLITE AND GRANITE
GAp	PORPHYRITIC BIOTITE ADAMELLITE AND GRANITE
Gg	GNEISSIC GRANITE
Gm	GRANITE GNEISS AND MYLONITE
RIAN ER HGA	HANLIN BIOTITE GRANITE

THRESHOLD (GROUP I = 47 ppm , GROUP 2 = 47 ppm, GROUP 3 = 59 ppm)

THRESHOLD (GROUP I = 14 ppm, GROUP 2 = 7.4 ppm ,)

THRESHOLD (GROUP I = 1.9 ppm , GROUP 2 = 4 ppm , GROUP 3 = 3 ppm)

ANOMALOUS ZONES, FOLLOW - UP TARGETS

0 2 4 6 8 10 12 14 MILES

0 4 8 12 16 20 24 KILOMETERS

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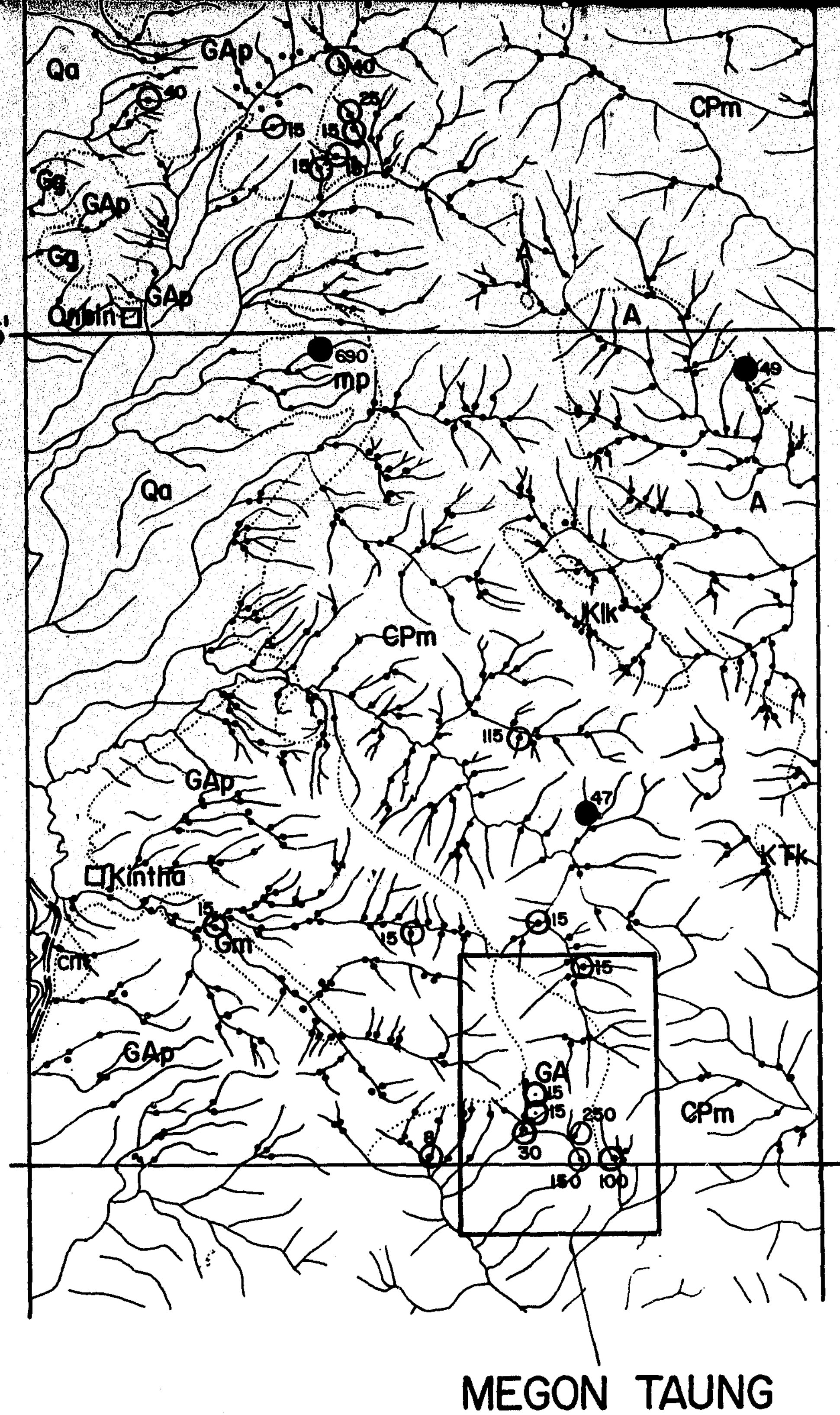
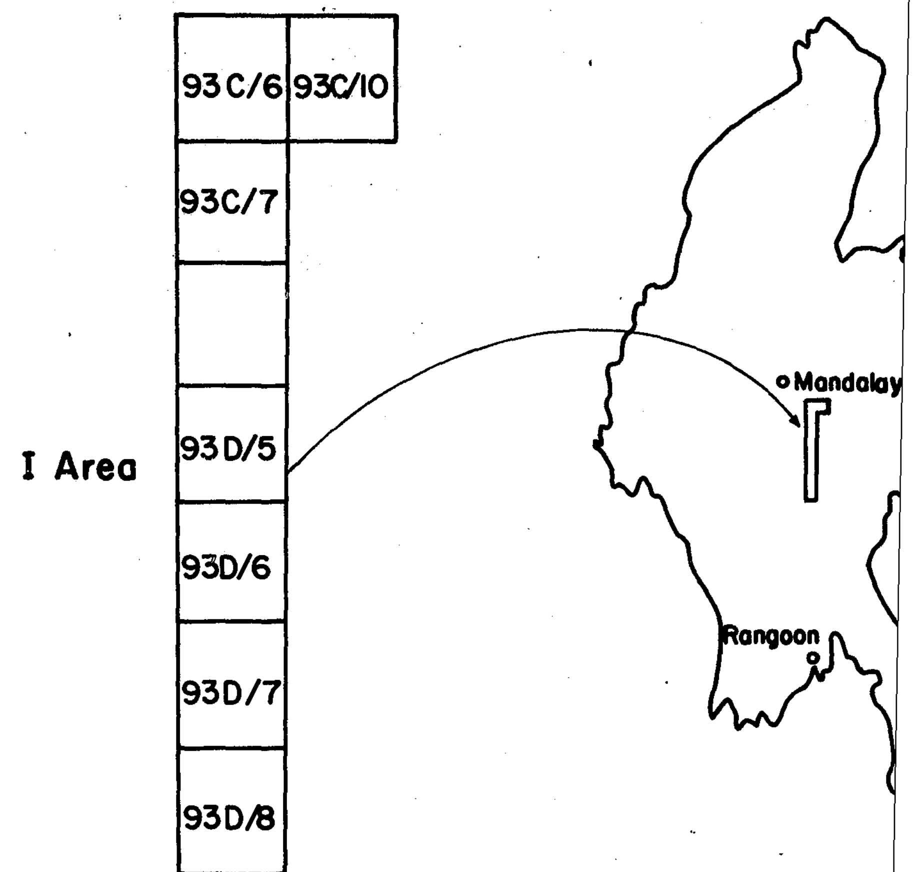
▲ Ag - VALUES ≥ THRESHOLD (GROUP

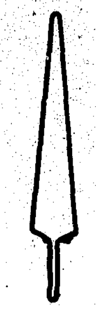
SABETAUNG = ANOMALOUS ZONES,

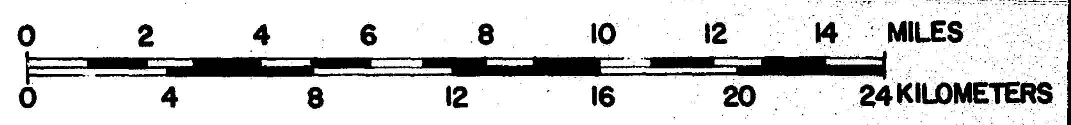


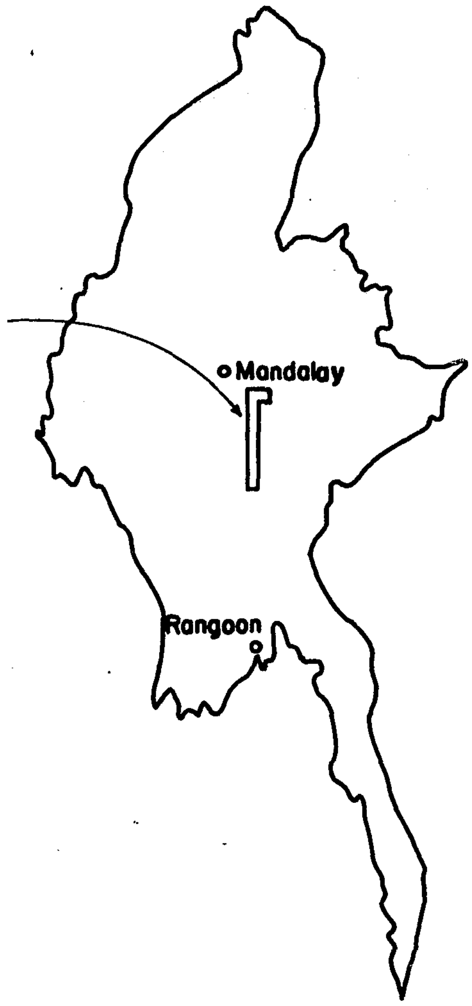


THRESHOLD (GROUP 1 = 1.9 ppm , GROUP 2 = 4 ppm , GROUP 3 = 3 ppm)

ANOMALOUS ZONES, FOLLOW - UP TARGETS







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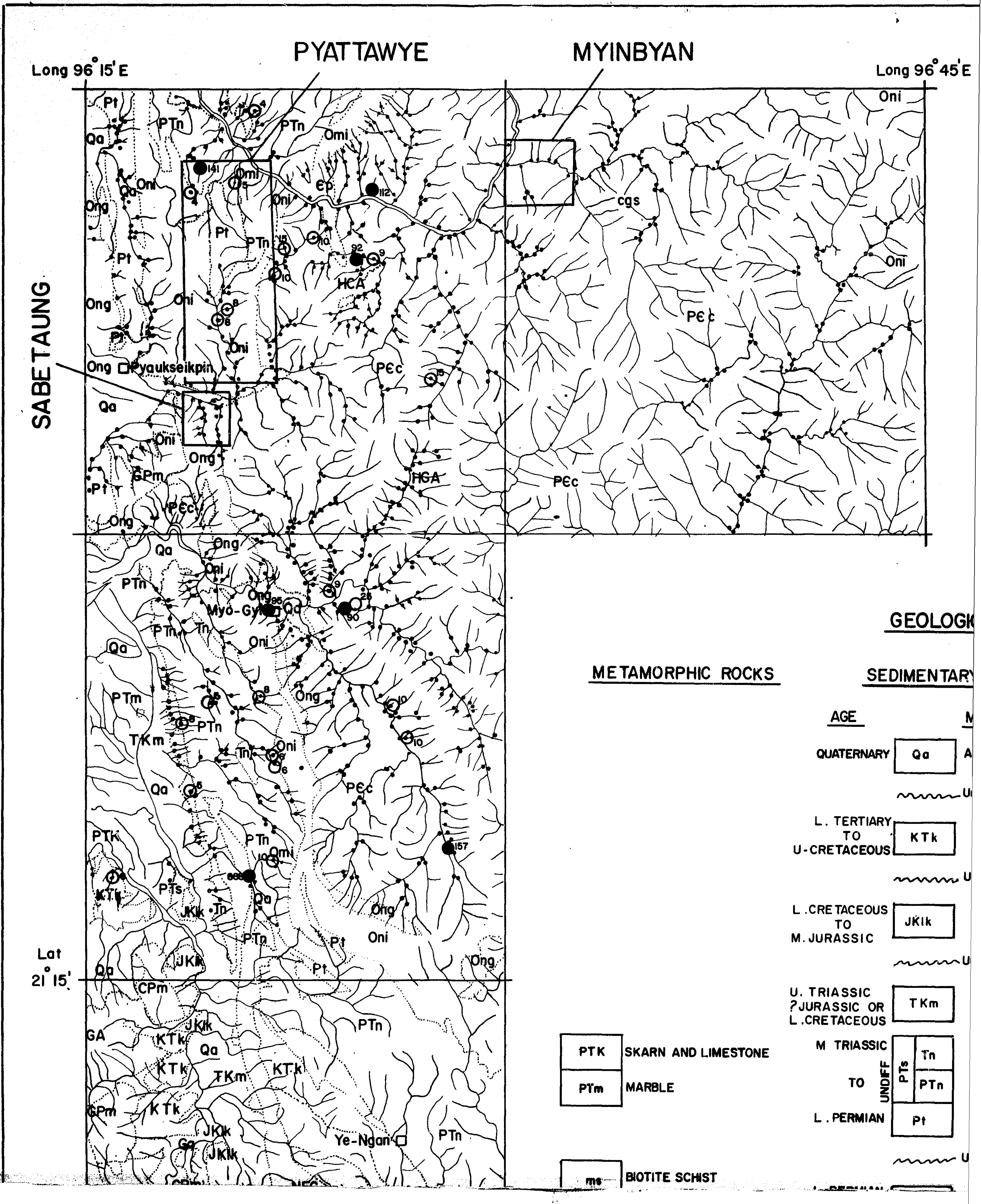
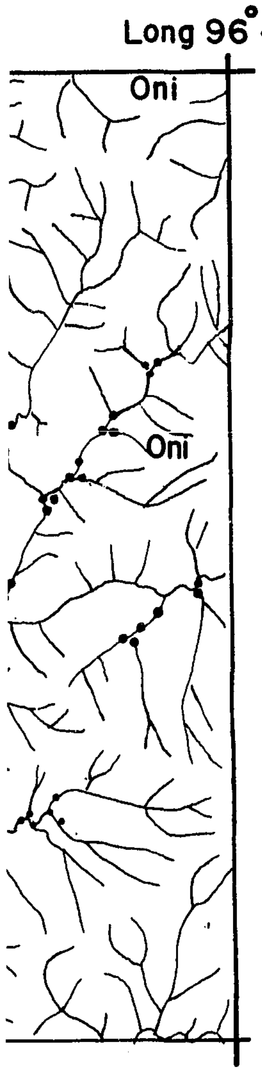
SHAN SCARPS AREA

STREAM SEDIMENTS RECONNAISSANCE

Cu - W - Ag

Fig. 19

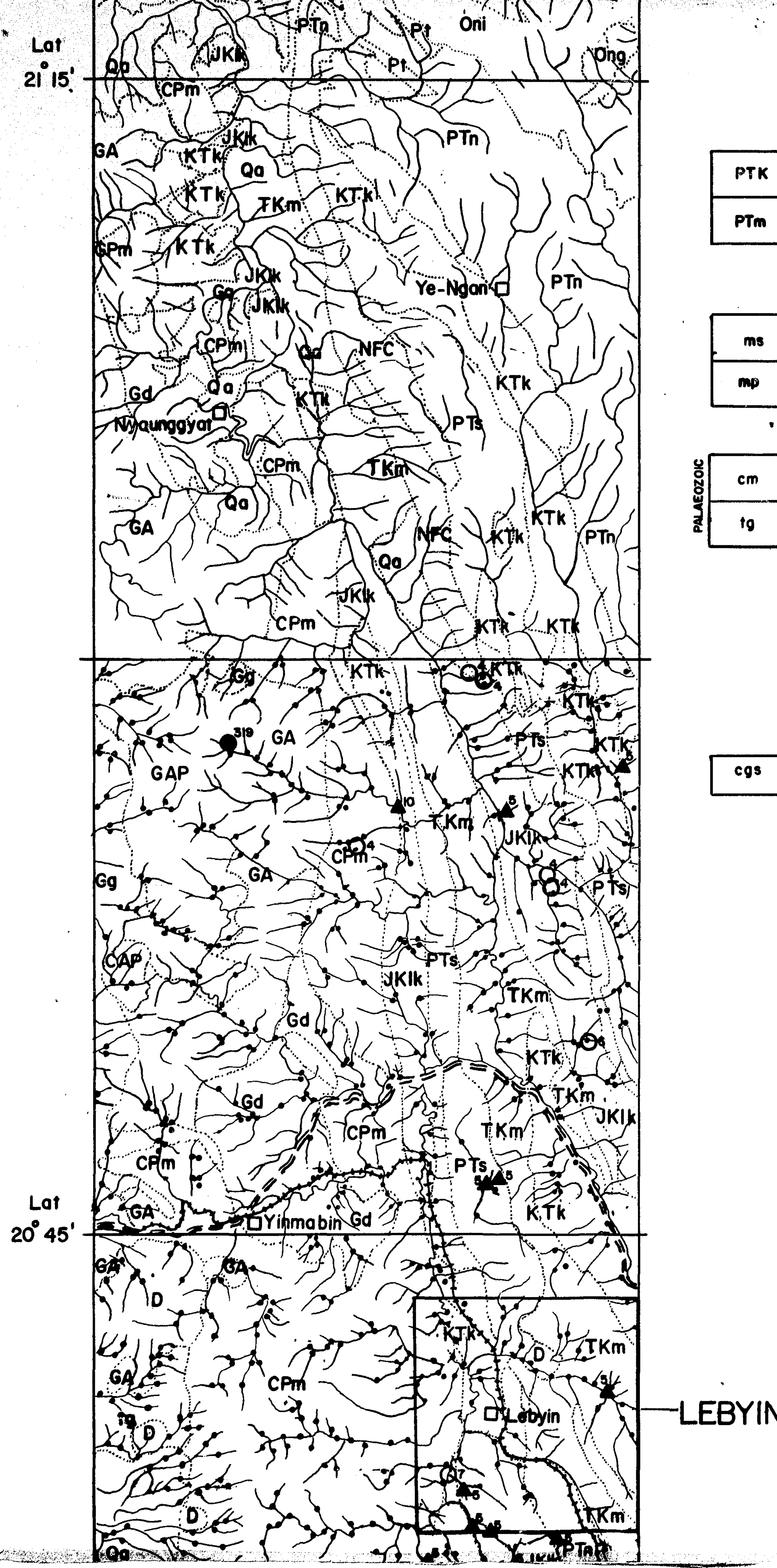

PYATTAWYE
MYINBYAN
Long 96° 15' E
Long 96° 45' E
SABETAUNG
Lat 21° 15'
Pyaukseikpin
Myo-Gyi
Ye-Ngan
GEOLOGI
METAMORPHIC ROCKS
SEDIMENTARY
AGE
QUATERNARY
Qa
L. TERTIARY TO U-CRETACEOUS
KTk
L. CRETACEOUS TO M. JURASSIC
JKlk
U. TRIASSIC ?JURASSIC OR L. CRETACEOUS
TKm
M TRIASSIC TO L. PERMIAN
UNDIFF
PTs
Tn
PTn
Pt
PTK
SKARN AND LIMESTONE
PTm
MARBLE
ms
BIOTITE SCHIST



GEOLOGICAL LEGEND

SEDIMENTARY AND VOLCANIC ROCKS

AGE		MEMBER	FORMATION	GROUP
QUATERNARY	Qa	ALLUVIUM AND TRAVERTINE		
	Unconformity			
L. TERTIARY TO :RETACEOUS	KTk			KALAW RED BED
	Unconformity			
RETACEOUS TO URASSIC	JKlk		LOI-AN AND KYAUKHSU TAUNG	PANLAUNG
	Unconformity			
'RIASSIC RASSIC OR RETACEOUS	TKm		MA-U-BIN	PANLAUNG
M TRIASSIC	UNDIFF PTs Tn		NATTEIK	
TO	UNDIFF PTs PTn		NWABANGYI	SHAN DOLOMITE
L. PERMIAN	Pt		THITSIPIN	
	Unconformity			



PTK	SKARN AND LIMESTONE
PTm	MARBLE

ms	BIOTITE SCHIST
mp	PHYLLITE

PALAEOZOIC — TAMAGYI METAMORPHICS

cm	CALCAREOUS METASEDIMENT
tg	BANDED GNEISS

cgs	BOTITE AND BOTITE-GARNET SCHIST

TO M. JURASSIC	JKlk
U. TRIASSIC ?JURASSIC OR L. CRETACEOUS	TKm
M TRIASSIC TO L. PERMIAN (UNDIFF PTs)	Tn / PT / Pt
L. PERMIAN TO CARBONIFEROUS	CPm
UPPER ORDOVICIAN	Omi
MIDDLE ORDOVICIAN	Oni
LOWER ORDOVICIAN	Ong
CAMBRIAN	Єp
PRE-CAMBRIAN	PЄc

UNDIFFERE

L. TERTIARY TO U. TRIASSIC	Ju
MESOZOIC TO PALAEOZOIC	NFC

INTRUSIVE

	D
	Gd
	A
OLIGOCENE TO	GA

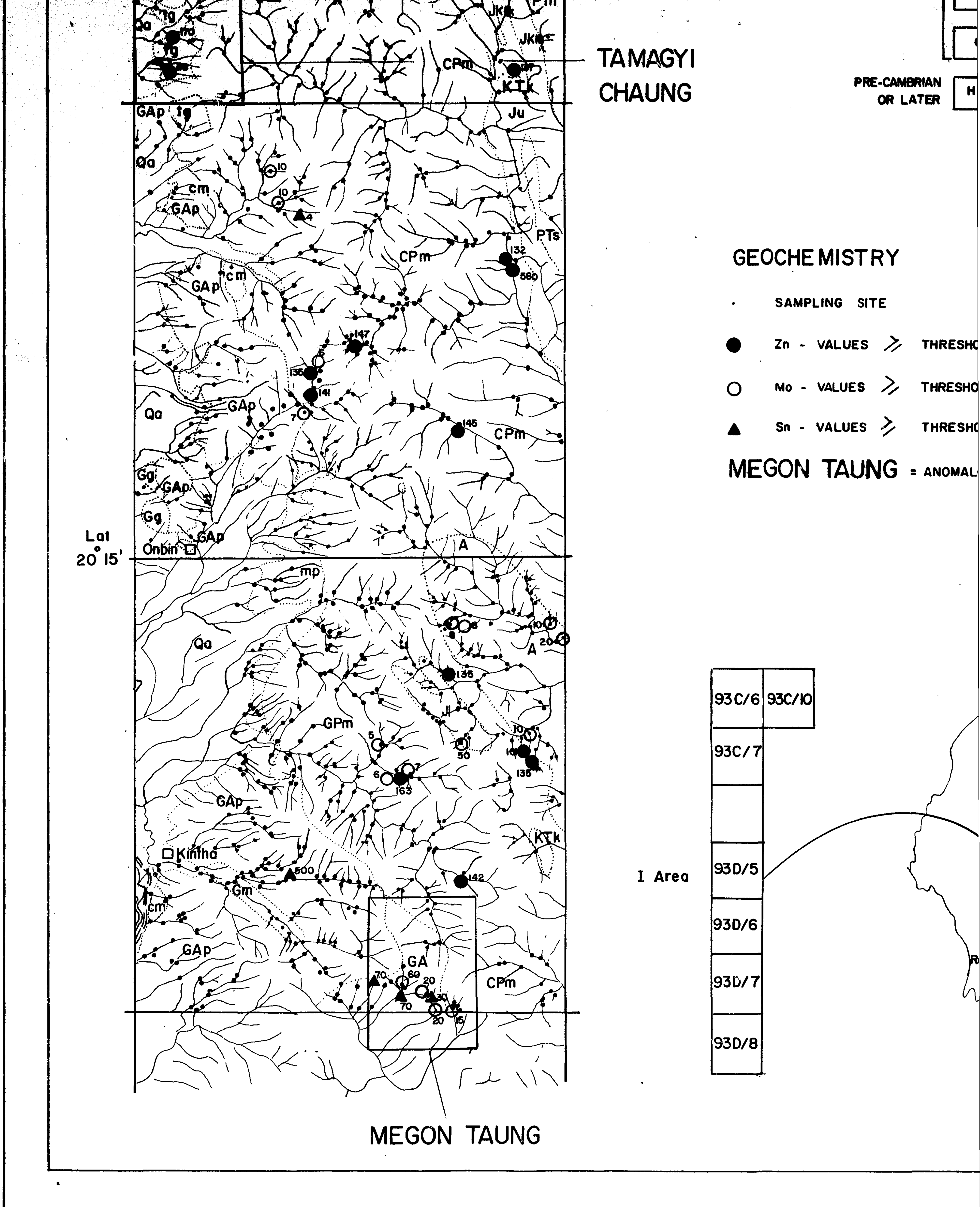
TO M. JURASSIC	JKlk	AND KYAUKHSU TAUNG	PANLAUNG
Unconformity			
U. TRIASSIC ?JURASSIC OR L. CRETACEOUS	TKm	MA - U - BIN	
M TRIASSIC	UNDIFF PTs Tn	NATTEIK	SHAN DOLOMITE
TO	PTn	NWABANGYI	
L. PERMIAN	Pt	THITSIPIN	
Unconformity			
L. PERMIAN TO CARBONIFEROUS	CPm		MERGUI
Unconformity			
UPPER ORDOVICIAN	Omi	NYAUNGBAW	PINDAYA
MIDDLE ORDOVICIAN	Oni	NAUNGKANGYI	
LOWER ORDOVICIAN	Ong	NGWETAUNG	
Unconformity			
CAMBRIAN	Єp		PANGYUN
Unconformity			
PRE-CAMBRIAN	PЄc	MYOGYI SLATE (PЄm)	CHAUNGMAGYI

UNDIFFERENTIATED UNITS

L. TERTIARY TO U. TRIASSIC	Ju	UNDIFFERENTIATED KALAW AND PANLAUNG GROUPS
MESOZOIC TO PALAEOZOIC	NFC	NWALABO FAULT COMPLEX MOSTLY NWABANGYI DOLOMITE

INTRUSIVE ROCKS

	D	DIORITE
	Gd	HORNBLENDE-BIOTITE-GRANODIORITE
	A	TWO-MICA ADAMELLITE
.IGOCENE TO	GA	BIOTITE ADAMELLITE AND GRANITE


TAMAGYI
CHAUNG
PRE-CAMBRIAN
OR LATER
GEOCHEMISTRY
SAMPLING SITE
Zn - VALUES ≥ THRESHO
Mo - VALUES ≥ THRESHO
Sn - VALUES ≥ THRESHO
MEGON TAUNG = ANOMAL
Lat
20° 15'
Onbin
Kintha
Qa
GAp
cm
CPm
Gg
Gm
GPm
GA
KTk
Ju
PTs
mp
A
93C/6
93C/10
93C/7
93D/5
93D/6
93D/7
93D/8
I Area
MEGON TAUNG

	Gm	GRANITE GNEISS AND MYLONITE
PRE-CAMBRIAN OR LATER	HGA	HANLIN BIOTITE GRANITE

MISTRY

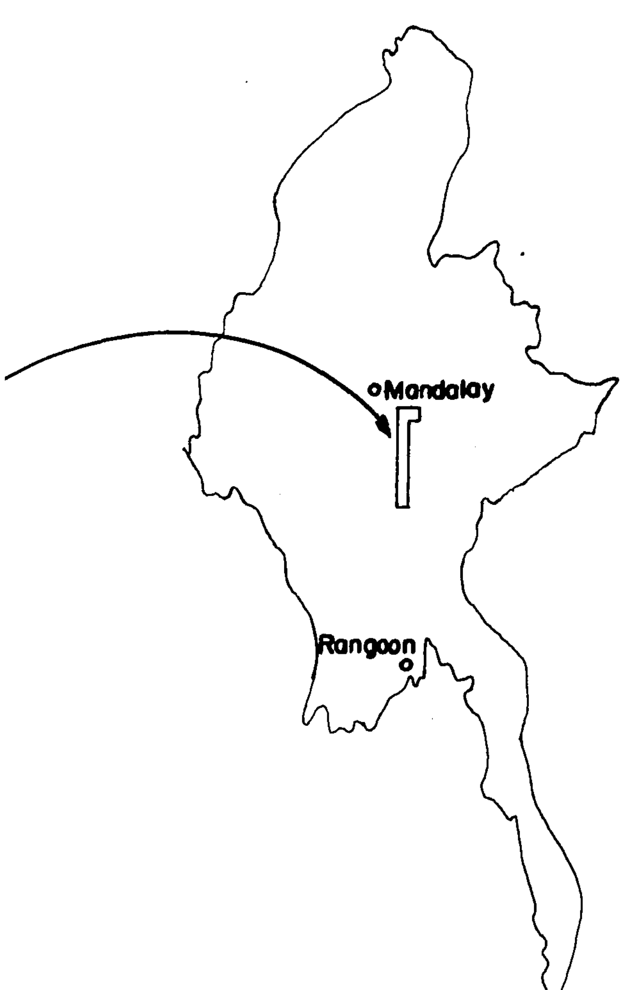
ING SITE

'ALUES ⫸ THRESHOLD (GROUP 1 = 118 ppm, GROUP 2 = 105 ppm, GROUP 3 = 90 ppm)

'ALUES ⫸ THRESHOLD (GROUP 1 = 5.3 ppm, GROUP 2 = 4 ppm, GROUP 3 = 9 ppm)

'ALUES ⫸ THRESHOLD (GROUP 1 = 23 ppm, GROUP 2 = 3.7 ppm)

TAUNG = ANOMALOUS ZONE, FOLLOW - UP TARGETS



0 2 4 6 8 10 12 14 MILES

0 4 8 12 16 20 24 KILOMETERS

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UNITED NATIONS

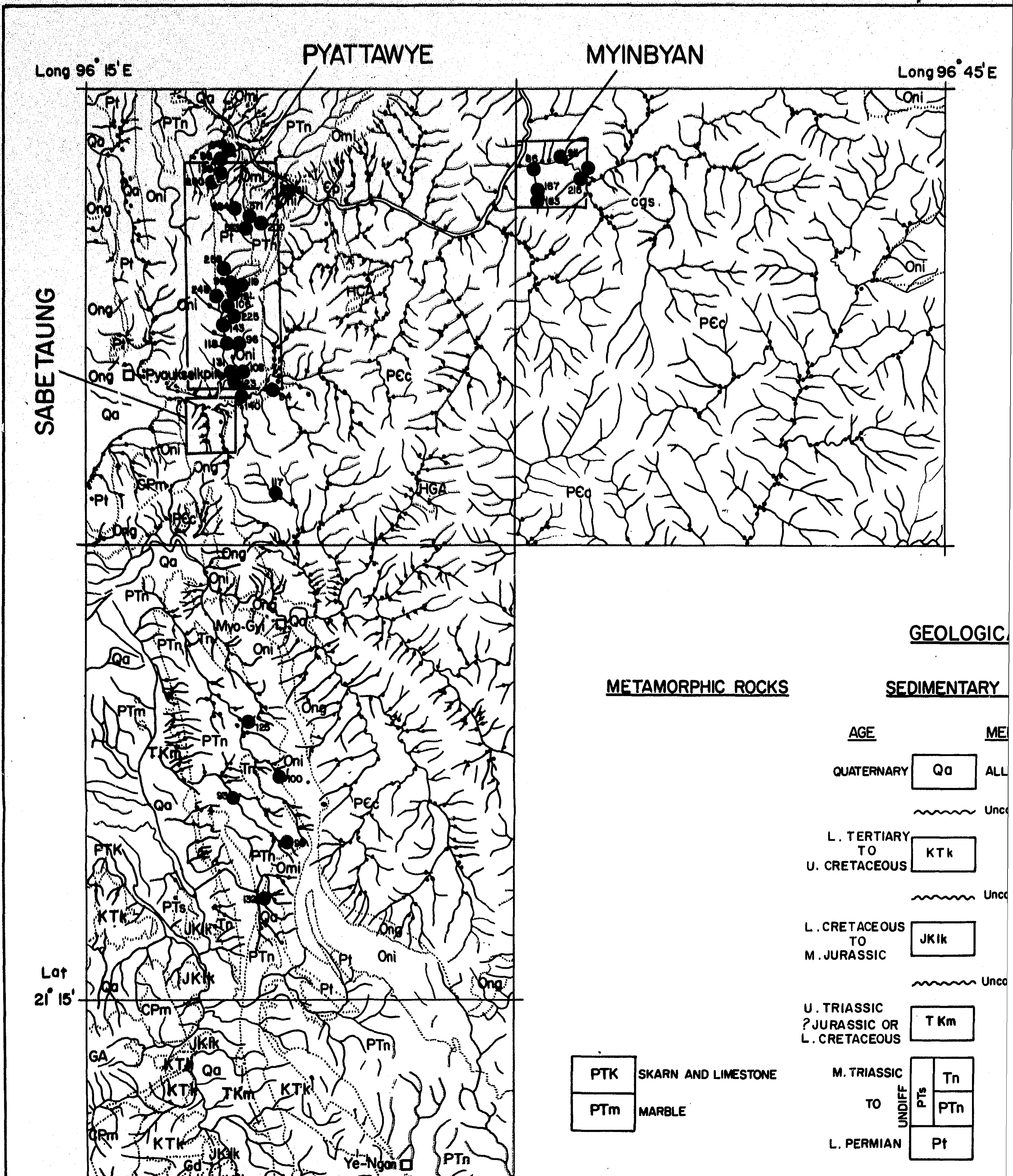
Bur/72/002 Geological Survey and Exploration Project

SHAN SCARPS AREA

STREAM SEDIMENTS RECONNAISSANCE

Zn - Mo - Sn

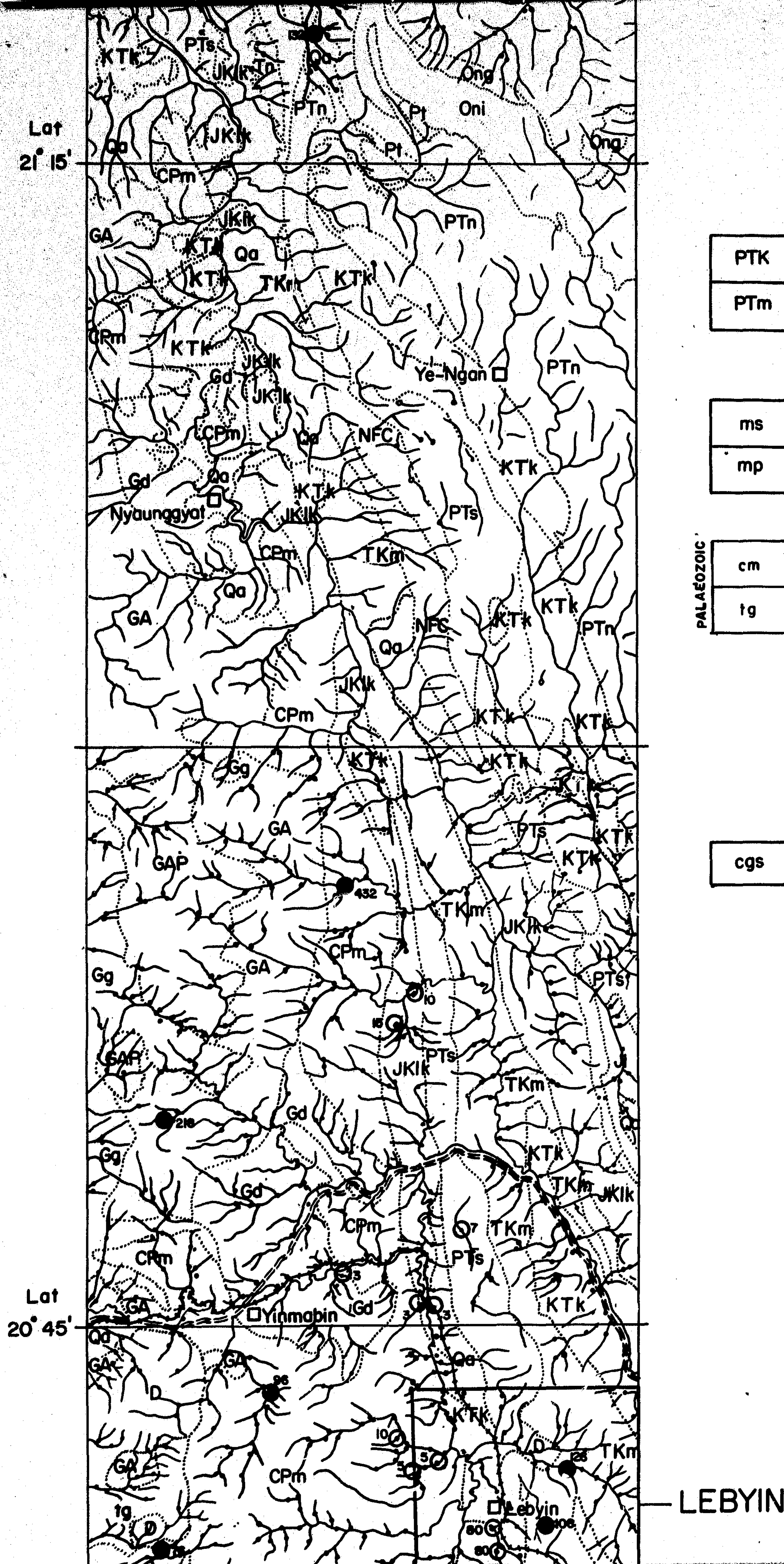
Fig. 20


PYATTAWYE
MYINBYAN
SABETAUNG
Long 96° 15' E
Long 96° 45' E
Lat 21° 15'
Pyauksetkpin
Myo-Gyi
Ye-Ngan
GEOLOGIC
METAMORPHIC ROCKS
SEDIMENTARY
AGE
QUATERNARY
Qa
Unco
L. TERTIARY TO U. CRETACEOUS
KTk
L. CRETACEOUS TO M. JURASSIC
JKlk
U. TRIASSIC ?JURASSIC OR L. CRETACEOUS
TKm
M. TRIASSIC TO L. PERMIAN
UNDIFF
PTs
Tn
PTn
Pt
PTK
SKARN AND LIMESTONE
PTm
MARBLE

GEOLOGICAL LEGEND

SEDIMENTARY AND VOLCANIC ROCKS

AGE		MEMBER	FORMATION	GROUP
ATERNARY	Qa	ALLUVIUM AND TRAVERTINE		
		Unconformity		
TERTIARY TO TACEOUS	KTk			KALAW RED BED
		Unconformity		
TACEOUS TO ASSIC	JKlk		LOI - AN AND KYAUKHSU TAUNG	PANLAUNG
		Unconformity		
ASSIC SSIC OR TACEOUS	TKm		MA-U-BIN	PANLAUNG
TRIASSIC TO PERMIAN	UNDIFF PTS Tn		NATTEIK	SHAN DOLOMITE
	UNDIFF PTS PTn		NWABANGYI	SHAN DOLOMITE
	Pt		THITSIPIN	SHAN DOLOMITE
		Unconformity		



PTK	SKARN AND LIMESTONE
PTm	MARBLE

ms	BIOTITE SCHIST
mp	PHYLLITE

PALAEOZOIC — TAMAGYI METAMORPHICS

cm	CALCAREOUS METASEDIMENT
tg	BANDED GNEISS

cgs	BIOTITE AND BIOTITE-GARNET SCHIST

L. CRETACEOUS TO M. JURASSIC	JKlk
U. TRIASSIC ?JURASSIC OR L. CRETACEOUS	TKm
M. TRIASSIC TO (UNDIFF PTs)	Tn
	PTn
L. PERMIAN	Pt
L. PERMIAN TO CARBONIFEROUS	CPm
UPPER ORDOVICIAN	Omi
MIDDLE ORDOVICIAN	Oni
LOWER ORDOVICIAN	Ong
CAMBRIAN	Єp
PRE-CAMBRIAN	PЄc

UNDIFFERENT

L. TERTIARY TO U. TRIASSIC	Ju
MESOZOIC TO PALAEOZOIC	NFC

INTRUSIVE R

D
Gd

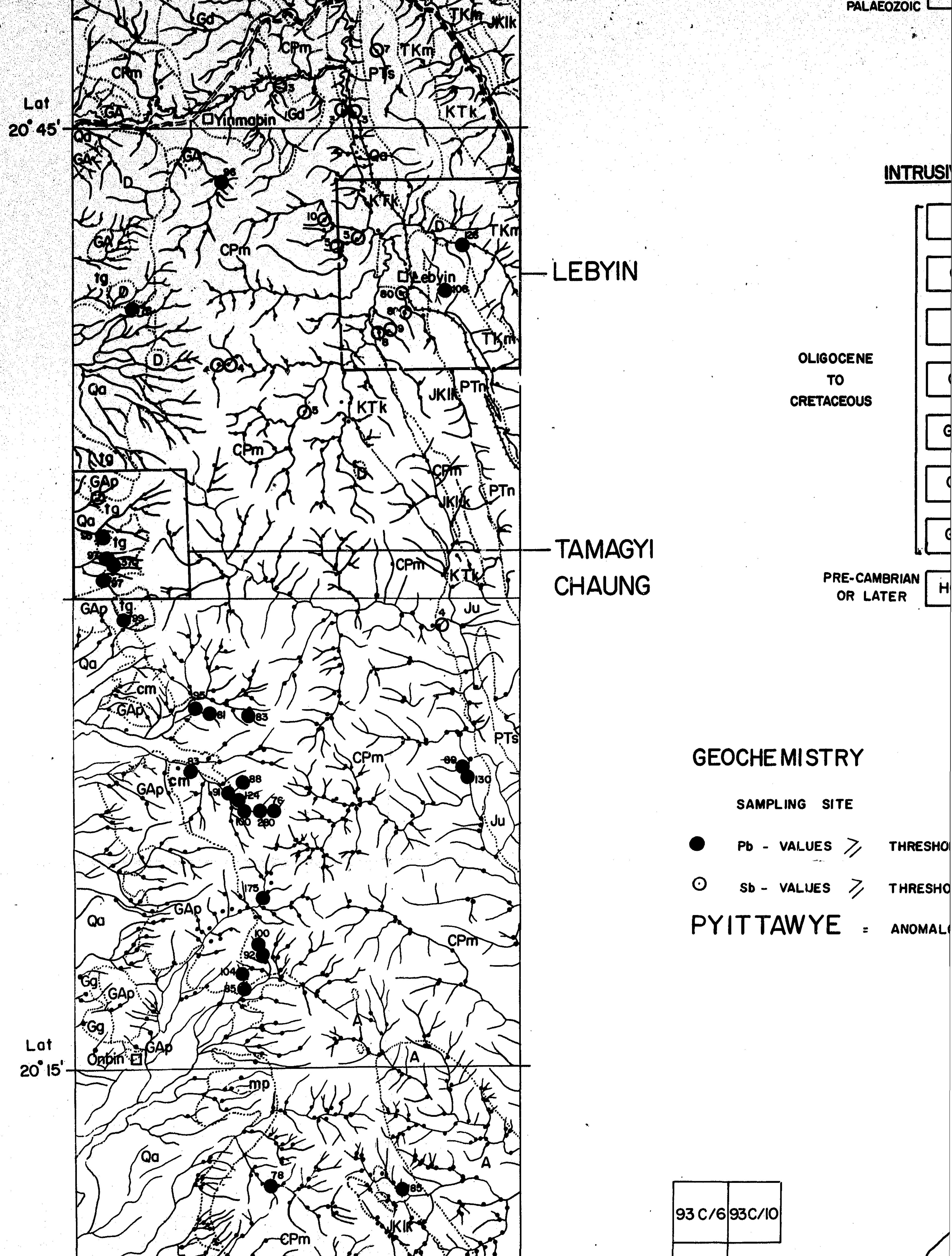
	Unconformity		
.CRETACEOUS TO .JURASSIC	JKlk	LOI - AN AND KYAUKHSU TAUNG	PANLAUNG
	Unconformity		
. TRIASSIC JURASSIC OR . CRETACEOUS	T Km	MA-U-BIN	PANLAUNG
M. TRIASSIC TO L. PERMIAN (UNDIFF PTs)	Tn	NATTEIK	SHAN DOLOMITE
	PTn	NWABANGYI	
	Pt	THITSIPIN	
	Unconformity		
L. PERMIAN TO ARBONIFEROUS	CPm		MERGUI
	Unconformity		
UPPER ORDOVICIAN	Omi	NYAUNGBAW	
MIDDLE ORDOVICIAN	Oni	NAUNGKANGYI	PINDAYA
LOWER ORDOVICIAN	Ong	NGWETAUNG	
	Unconformity		
CAMBRIAN	Єp		PANGYUN
	Unconformity		
PRE-CAMBRIAN	PЄc	MYOGYI SLATE (PЄm)	CHAUNGMAGYI

UNDIFFERENTIATED UNITS

L. TERTIARY TO U. TRIASSIC	Ju	UNDIFFERENTIATED KALAW AND PANLAUNG GROUPS
MESOZOIC TO PALAEOZOIC	NFC	NWALABO FAULT COMPLEX MOSTLY NWABANGYI DOLOMITE

INTRUSIVE ROCKS

D	DIORITE
Gd	HORNBLENDE - BIOTITE - GRANODIORITE


PALAEOZOIC
Lat
20° 45'
Yinmabin
INTRUSIV
LEBYIN
Lebyin
OLIGOCENE
TO
CRETACEOUS
TAMAGYI
CHAUNG
PRE-CAMBRIAN
OR LATER
GEOCHEMISTRY
SAMPLING SITE
Pb - VALUES
THRESHO
Sb - VALUES
THRESHO
PYITTAWYE
= ANOMAL
Lat
20° 15'
Onbin
93 C/6
93C/10

IO
PALAEOZOIC | NYG | MOSTLY NWABANGYI DOLOMITE

INTRUSIVE ROCKS

OLIGOCENE TO CRETACEOUS	D	DIORITE
	Gd	HORNBLENDE - BIOTITE - GRANODIORITE
	A	TWO - MICA ADAMELLITE
	GA	BIOTITE ADAMELLITE AND GRANITE
	GAp	PORPHYRITIC BIOTITE ADAMELLITE AND GRANITE
	Gg	GNEISSIC GRANITE
	Gm	GRANITE GNEISS AND MYLONITE
PRE-CAMBRIAN OR LATER	HGA	HANLIN BIOTITE GRANITE

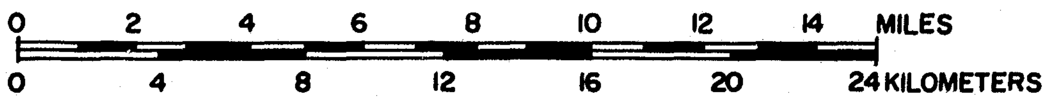
ISTRY

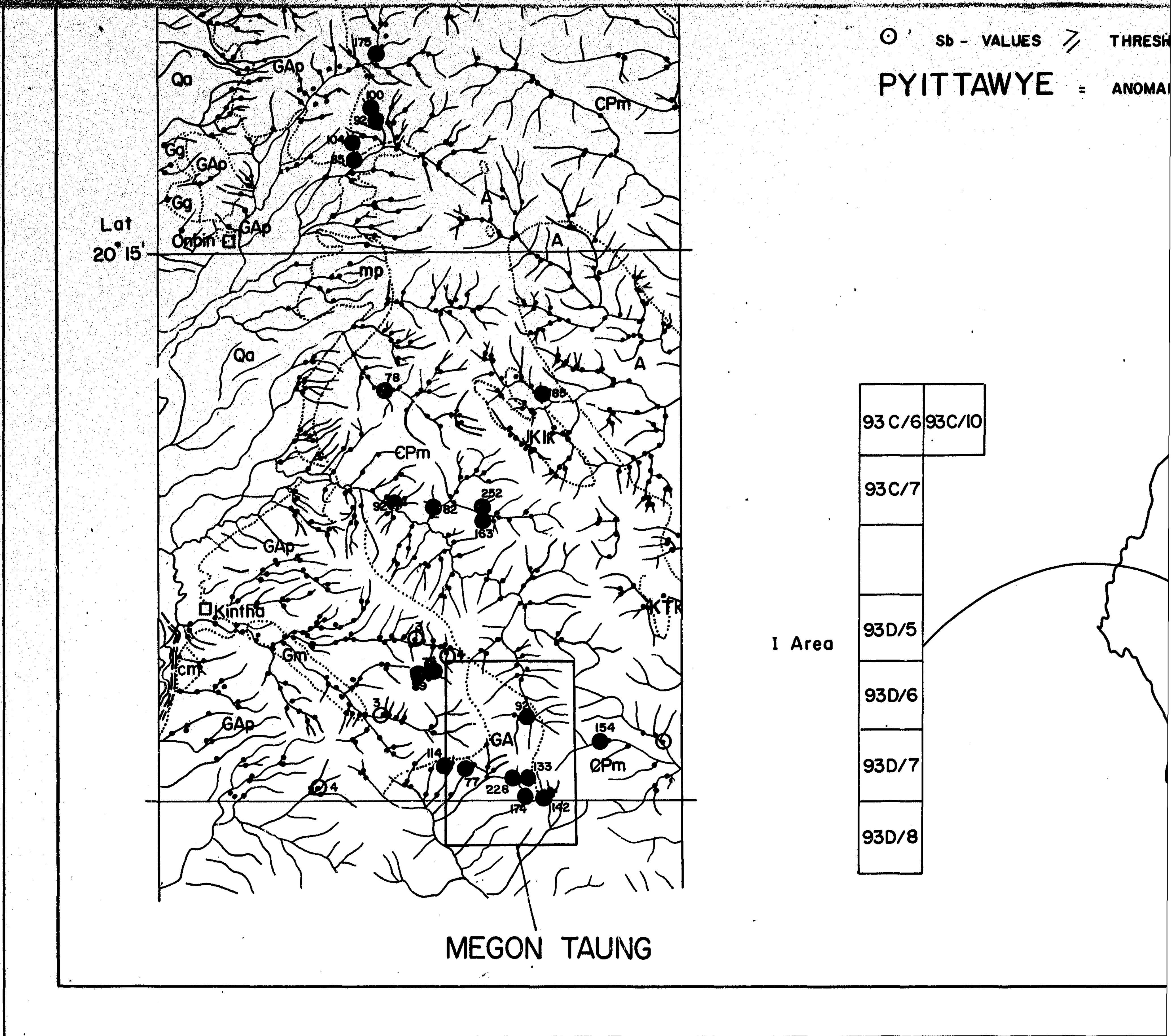
NG SITE

ALUES ≥ THRESHOLD (GROUP I = 74 ppm , GROUP 2 = 93 ppm, GROUP 3 = 72 ppm)

ALUES ≥ THRESHOLD (GROUP I = 3 ppm, GROUP 2 = 9 ppm)

WYE = ANOMALOUS ZONE , FOLLOW - UP TARGETS

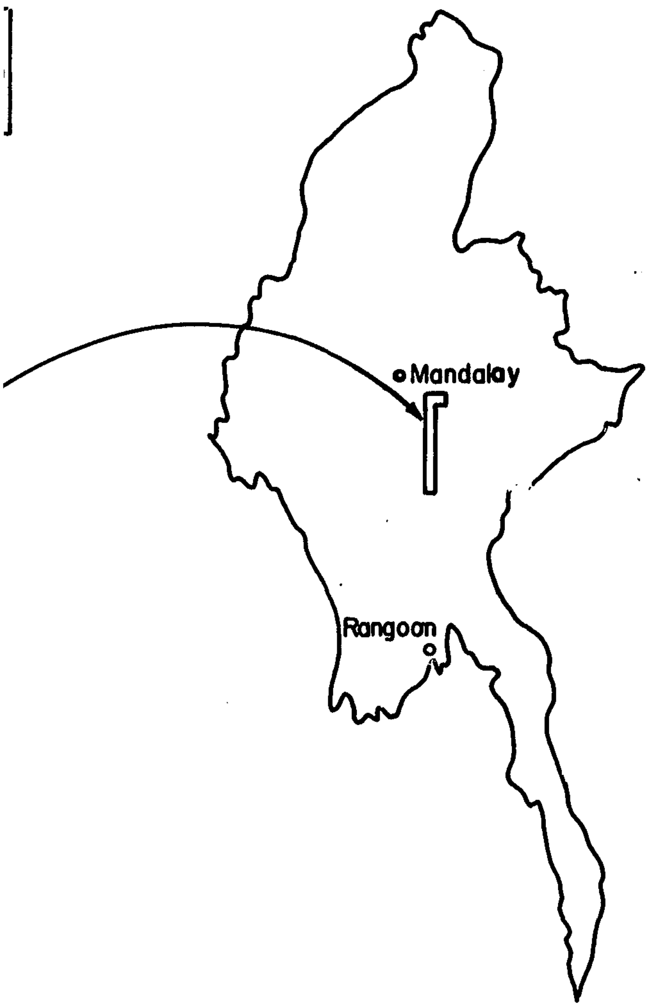




Sb - VALUES
THRESH
PYITTAWYE
= ANOMA
Lat
20° 15'
Qa
GAp
Gg
Onbin
mp
CPm
A
JKlk
Kintha
Gm
cm
GA
KTk
MEGON TAUNG
93 C/6
93C/10
93C/7
93D/5
93D/6
93D/7
93D/8
I Area

VALUES ⫽ THRESHOLD (GROUP I = 3 ppm, GROUP 2 = 9 ppm)

WYE = ANOMALOUS ZONE, FOLLOW - UP TARGETS



0 2 4 6 8 10 12 14 MILES

0 4 8 12 16 20 24 KILOMETERS

BURMA

Department of Geological Survey and Mineral Exploration

UNITED NATIONS

Bur/ 72 /002 Geological Survey and Exploration Project

SHAN SCARPS AREA

STREAM SEDIMENTS RECONNAISSANCE

Pb - Sb

Fig. 21