J. Myanmar Acad. Arts Sci. 2020 **Vol. XVIII. No.5A**

STRUCTURAL CONTROLS ON LEAD MINERALIZATION AT LINWE AREA, YENGAN TOWNSHIP, SHAN STATE (SOUTH)

Tun Naing Zaw[1], Day Wa Aung[2], & Swun Wunna Htet[3]

Abstract

The study area is located about 1.5km northeast of Ye-ngan Township, Shan State (South).It is also situated within Latitude21 12 30 N to21 14 30 N and longitudue96 31 30 E to 91 34 00E.It covers about 4.6 kilometers. The area is covered by the Paleozoic units namely, Lokepyin Formation, Wunbye Formation, Nan-on Formation, and Tanshauk member of the Pindaya Group of Ordovician age, the Linwe Formation of the Mibayataung Group of Silurian age, the Thitsipin Formation of Permian age, and the Nwabangyi Dolomite Formation of Early Triassic age. Structurally, the area is significant due to the recognition of genesis of fault system which is previously not known from the area. The present study provides reevaluation of the structural geology of the research area. Resent study in the Linwe area, has significantly improved our knowledge of recognizing a lead mineralization in phacoidal limestone of Linwe Formation (Early Silurian) mainly occurred in nearly NW-SE trending fault zone. Linwe lead occurrence (latitude 21 13 16 N longitude 96 32 23E) is situated at half mile northwest of Linwe monastery. The mineralization of the Linwe area is found to be definitely structurally controlled. The galena is observed to have mostly occurred in fault with brecciated zone. In the alteration map by ASTER data, many cyan tint pixels (alterations) are observed which the evidences of possible locations of mineralization area. The common wall rock alteration of Linwe lead mineralization may be dolomitization and the formation of sanded dolomite based on the alteration map by using aster and Landset 8 images. Most of the Linwe ore bodies have been followig NW-SE trending faulted stream that is pre mineralization fault. On the surface, the mineralization can be followed the brecciated zone.Styles of mineralization occur as fracture filling and solution collapse breccia. Lead mineralization fill in cracks of deformed calcite crystals. Texture of lead sulphide minerals are mostly related to open-space filling of breccia's and fractures. This fault zone and lead mineralizatioin were previously mapped and designated by Tun Naing Zaw et.al., (2017).Lead deposit in the Linwe Formation is hosted by sedimentary rock deposited during the later stage of at least two overprinting extensional events.Hydrothermal activity and alteration also acted as a heterogeneity focusing of dilational deforation and final stage of mineralization.Reactivated fault thereby accounting for the longevity of the hydrothermal system responsible for the alteration and mineralization at Linwe Formation.Analysis of the kinematic controls on lead mineralization in Linwe Formation is structurally controlled may enable other prospective structures in the near Linwe area to be identified.Need to seek possible means and ways for further exploration of Pb mineral deposits in the Linwe area.

Keywords: Phacoidal limestone, ASTER data, sanded dolomite, fracture filling, solution collapse breccia, brecciated zone

Introduction

For many years, no lead mineralization in Linwe Formation has been reported in Linwe-Pegin area, Ye-ngan Township, Shan State (South). Lead mineralization has been found in grey coloured nodular limestone which is exposed in southwestern part of Linwe village. This lead mineralization occurred in NW-SE trending fault zone. (Figure 1) This fault zone and lead mineralizatioin were previously mapped and designated by Tun Naing Zaw et.al., (2017) as a possible structural control. The study aim to determine whether primary syntectonic mineralization or secondary tectonic mineralization are involved in the formation of economic mineralization.

[1] Dr, Lecturer, Department of Geology, University of Yangon
[2] Dr, Professor and Head. Department of Geology, University of Yangon
[3] 3rd year Honours student, Department of Geology, University of Yangon

Location

The research area is situated in Ye-ngan Township, Shan State (South) and bounded between latitudes 21º 12' 30" N - 21º 14' 30" N and longitudes 96º 31' 30" E - 96º 34' 00" E. The area falls within the geographic limit of topographic map No. 93 C/2 on the scale of one-inch to one mile. It also covers about 4.6 square kilometers.Figure (1).

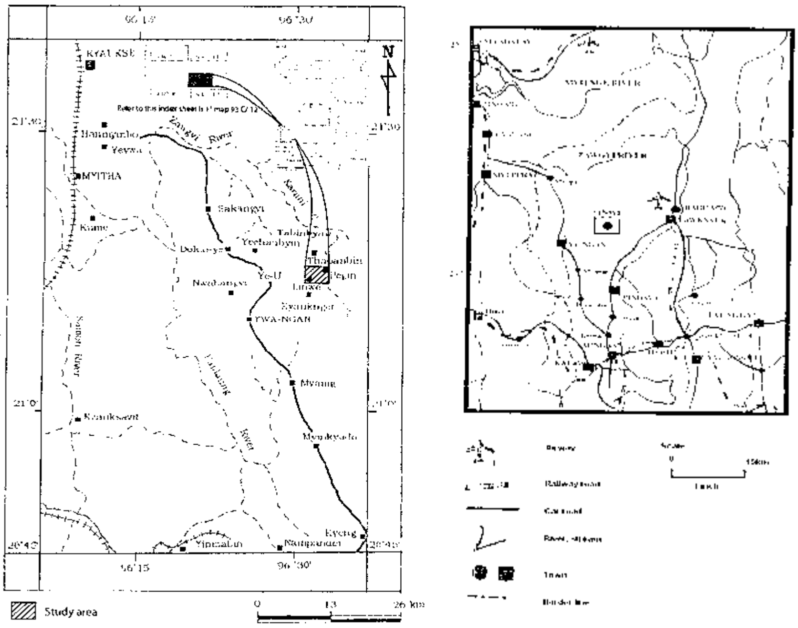


Figure 1 Location map of the study Area

Previous Studies

Geologists of Geological Survey of India (1864-1865) had firstly made the systematic geologic works as a regional geology of the Southern Shan State including Pindaya Township and Ye-ngan Township.

The geology of Linwe-Pegin area was investigated by several geologists (from 1897 to 1976) on various aspects of its stratigraphy , paleontology and economic aspects. From 1976 to present day, the geology of the research area was continuously studied on purposes of completing student's basic training course as well as aiming of higher degree, such as Master of Science (M.Sc), Master of research (M.Res) and doctoral research (Ph.D).

Materials and Methods

(1) Remote Sensing

i. Landsat-8 OLI/TIRS Level-1 Data Products are applied for the general evaluation of the study area and alteration zones. Details of the Landsat scene are as follows:
   Landsat Product ID= LC08_L1TP_133045_20190212_20190222_01_T1
   Row/Path = 133/045
   Data Acquired = 5:27:43
   Cloud Cover = 0.01
   Image Quality = 9 for both OLI and TIRS sensors
ii. SRTM 1-Arc Second Digital Elevation Model
   Product Name = n21_e096arc_v3

(2) Spatial Data

Topographic map, the scale of one-inch map sheet no. () is used as base map for geographic database of the research area. UTM (quarter-inch) and topographic map (quarter-inch) scale are used to identify the significant topographic criteria.

(3) Software

Microsoft Excel 2013 for geostatistical analysis

Global Mapper v.18 (64 bit)

ArcGIS 10.6

ENVI 4.8.

(4) Technical Methods

Using ArcGIS 10.6, band rationing and band combinations of Landsat images are proceeded to export the alteration distribution map. In some cases, geo-statistical procedures are applied using threshold equations to map the alteration anomaly zones for further analysis.

(5) Laboratory Methods

Satellite data of Landsat 7 Thematic Mapper TM were selected form the research. These data are recorded on seven bands with Landsat 7 satellite, the study area is fell within path/row (132/45) with 30 meters ground resolution. Visual image interpretation and digital image processing were applied for classifying images in a base of land cover/land use and to enhance image quality.

In this research, ground control points were selected by following permanent features evenly distributed throughout the area and identified easily both in image and topographic maps. The Universal Transverse Mercator (UTM) projection method is employed in the research area. The scale of Topographic maps used this research area was one-inch.

In this research, the false colour composite (R: G: B=4:5:3) was made for land use/land cover interpretation. TM images are analyzed to identify the major structural patterns and lithology by using ENVI 4.8.

The detailed stratigraphic measurement was made of the, the Linwe Formation.

Rock samples and ore samples were collected at stratigraphic horizon along the measured sections of Linwe Formation.

Identifying the rocks thin sections with low-powdered petrographic binocular microscope and ore polish sections with ore microscope.

Regional Stratigraphy

The stratigraphic sequence of the Paleozoic rocks are exposed in the present area. The area is composed of rocks of Ordovician to Permian except the Devonian age. Most units are mainly composed of carbonate and subordinately of clastic sedimentary rocks. Myint Lwin Thein (1973) classified the Lower Paleozoic rocks of the western part of the Southern Shan State as a Ordovician rocks (the Pindaya Group) including three formations and one member such as Lokepyin Formation (Early Ordovician), Wunbye Formation (Middle Ordovicia), Nan-on Formation (Late Ordovician) and Tanshauk Member (Late Ordovician). Myint Lwin Thein (1973) had also classified the Silurian rocks as the Minbayataung Group with two formations and one member such as Linwe Formation, Wabya Formation of the Early Silurian age and Taungminggyi Orthoquartzite Member (Late Early Silurian) age. Figure (2).

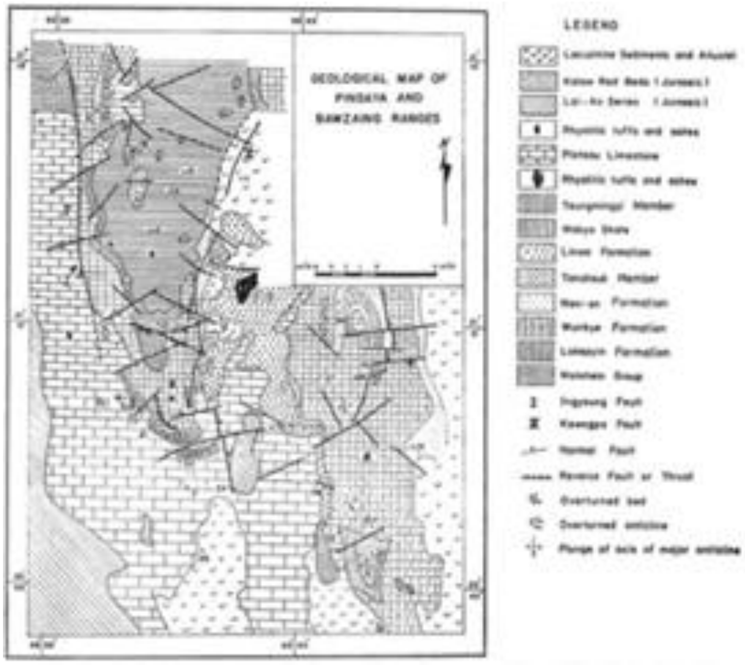


Figure 2 Regional Geological Map of the Study Area((Myint Lwin Thein, 1973)

Regional Structures

The Pegin-Linwe area forms part of the Western Limb of south plunging anticline of Pindaya Range. The regional structural trend is nearly N-S and they are sub-parallel to the topographic trends and minor structural alignments nearly coincide with the major trend. Faults are well developed in the present area, including longitudinal fault and cross fault. The major faults are generally trending in N-S direction. Karani fault is trending in NNW-SSE and occurred at northeast of the study area. Ingyi-Ingyaung fault is trending in NNW-SSE and occurred at western part of study area. Linwe-Pegin fault is nearly N-S in direction and pass through from north (Pegin Monastry) to south (Linwe monastery).Figure (13).

Rock Units in the Study Area

General Statements

The study area is mainly composed of Ordovician to Permian rocks. Most of the type sections are classified by Pascoe (1959), Myint Lwin Thein (1973), Mitchell, A.H.G (1976).

Lokepyin Formation

The Ordovician rock of Lokepyin Formation is mainly made up of yellowish to buff color siltstone which are well exposed at western part of the study area. Figure(3).


Figure 3 Siltstone beds and Orthid brachiopods under Shwe Guu Pagoda in Ingyi Village

Wunbye Formation

Wunbye Formation is mainly composed of limestone with silt patches limestone, dolomite, oolitic limestone, micritic limestone and yellowish siltstone. Barrow structures are also distinct. This formation is well exposed at central port ion of the study area. Figure (4)


Figure 4 Burrowed Limestone of Wunbye Formation at Location 062715, (Photo Facing 278) and Actino*ceras*

Nan-on Formation

Nan-on Formation is especially composed of yellow to buff, subindurated to soft, thin to medium bedded , fossiliferous calcareous siltstone and shale and this formation is exposed at central portion of the study area. Figure (5)

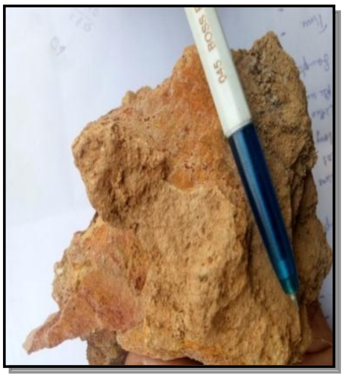



Figure 5 Yellow to Buff colored siltstone with *Spiriferina* Braphiopod of Nan-on Formation(N 21 º14’ 31”, E 96º 33’ 37”)

Tanshauk Shale Member

The Tanshauk Memberis a marker bed lying between the Nan-on Formation and the Linwe Formation of Mibayataung Group. This unt is well exposed at Tanshauk village and vicinity of Nan-on village. Figure (6)

Figure 6 Purple color shale and Star shape stems of Tanshuak Member at location:N 21˚ 14' 56″,E 96˚ 33' 48″, (photo facing – 68)

Linwe Formation

The Linwe Formation is composed of purplish and grey phacoidal limestone and buff to grey micaceous siltstone. Figure (8)

This unit was named after Linwe village, Ye-ngan Township, Shan State (South) by Myint Lwin Thein (1973).

Type Section

The type section of the Linwe Formation is located W of Linwe monastery, Linwe village, Ye-ngan Township, Shan State (South)

Distribution and Thickness

This unit is widely distributed in Kyauktaw, Pegin, Linwe, NE of Tanshauk, Nan-on and N of Hsin-Sa-Pya villages. We measured the exposed stratigraphic thickness of mineralized limestone unit of Linwe Formation (from 078729to 087729) and (from 074723to 087729) (Figure 7).

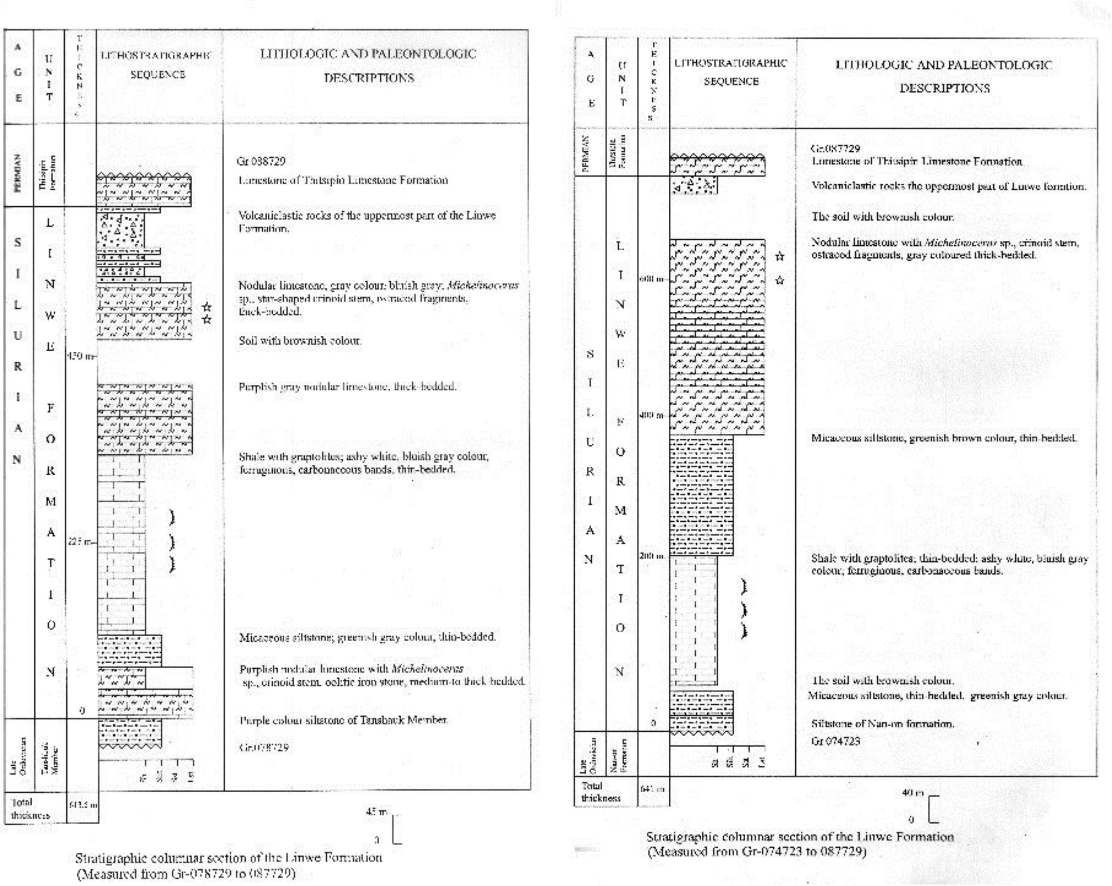


Figure 7 Stratigraphic Measured Sections of Linwe Formation

Lithology

It chiefly consists of medium to thick-bedded, grey-coloured limestone with nodular appearance (phacoidal texture, Fig-), micaceous shale, graptolite-bearing shales (Fig-), micaceous siltstones and black shales are occurred as minor amounts. Wavy bedding nature is common in phacoidal limestones. Coal seams with minor sulfur are found in the Linwe shale unit Figure (10).

Fauna Content and Age

A large number of graptolites are found (Figure-). *Michelinoceras sp.* and crinoid stems are common. Trilobites are found in micaceous siltstone .Figure(12). According to these fossils, it suggests the age of Early Silurian.

Stratigraphic Relationship

The Linwe Formation underlines conformably with Tanshauk Member and it overlies faulted contact with the Mixed Clastic Carbonate.

Correlation

This unit is correlated with Nyaungbaw Formation of Shan State (North).

Depositional Environment

The Linwe Formation might be deposited under shallow warm marine conditions.

Figure 8 Grey-Coloured Phacoidal Limestone Found in Linwe Formation (Location: 082723) (Facing: 290°)

Figure 9 *Michelinoceras* Fossil Found in the Phacoidal Limestone of Linwe Formation (Location: in front of Linwe Monastery) (Facing: 86°) (Location: 082712) (Facing: 349°)

Figure 10 Coal Seams with Minor Sulfur in the Shale of Linwe Formation (Location: 076712) (Facing: 260°)

Figure 11 Graptolite-Bearing Shale Outcrop of the Linwe Formation (Location: 082712, Mwe-Taung)

Figure 12 Trilobite found in micaceous siltstone unit of Linwe Formation (Kyauk Taw Village)

Thitsipin Limestone Formation

The Thitsipin Limestone Formation is exposed at the east of Linwe, Pegin and east of Tanshauk village. The Thitsipin Limestone consists of light to darkgray, bedded to massive limestone and wackestone with abundant of coral fossils, brachiopods, fusulinids and bryozoan. Figure(13). Locally has been dolomitized and it is intensively brecciated.

Figure 13 Limestone outcrop of Thitsipin Formation (N21° 11’ 31”, E96° 24’ 31”)

Nwabangyi Dolomite Formation

It is characterized by brecciated dolomite which is light to dark bluish colour, massive to poorly bedded, and highly brecciated. Figure (14)

Figure 14 Criss-cross joints on dolomite of Nwabangyi Formation (N21° 11’ 34”, E96° 24’ 34”)

Structures of the study area

Pegin-Linwe fault, Thisipin-Karani fault and Ingyi-Dalabin fault are longitudinal faults of the study area .The general trend of these major longitudinal faults is NNE-SSW and NNW-SSE in direction. Figure (15)

Ingyi-Dalabin fault

In the study area, Ingyi-Dalabin fault which is longitudinal fault, is the largest fault. It is trending in N-S direction, NNW-SSE and known as dextral strike-slip fault.

Thisipin-Karani fault

This fault is striking nearly N-S, trending northwards to Thitsipin and southwards to Hsinsapya village. It has NNW-SSE trending fault system. This fault is reactivated as dextral strike-slip fault.

Linwe-Pegin fault

It is passing through the east of Linwe pagoda from the south and east of Pegin monastery to the north . It is NNE-SSW structural trend. It is the contact fault sbetween Plateau Limestone group and Linwe Formation.

NW-SE trending cross fault

In the eastern part of Linwe area, en echelon NW-SE trending major cross faults are observed and some are reactivated and some are concealed with limestone breccia and gauge. Lead mineralization occurred at the NW-SE trending cross fault near the ½ mile northwest of Linwe Monastery (Location: Latitude 21°13′16″, Longitude 96°32′23″.Figure(15).

Joints

Detailed measurements of joints are made in Pegin-Linwe area. A statistical analysis of joints of Linwe Formation is shown as a joint rose diagram. Figure (16)

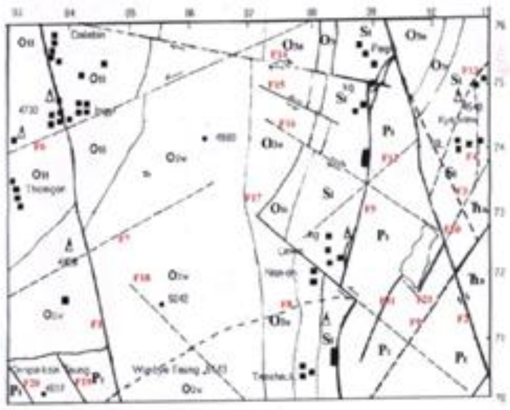
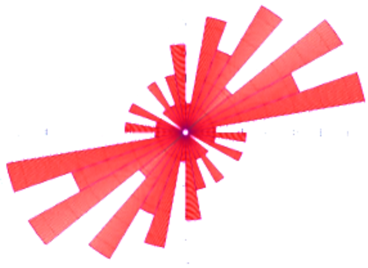


Figure 15 Fault Distribution Map of the Study Area



Calculation Method ... Frequency
Class Interval .... 10 Degrees
Filtering .... Deactivated
Data Type .... Bidirectional
Rotation Amount ...... 0 Degrees
Population 46
Maximum Percentage ... 13 Percent
Mean Percentage ...... 5.9 Percent
Standard Deviation ... 3.69 Percent
Vector Mean .... 46.52 Degrees
Confidence Interval .. 33.51 Degrees

Figure 16 Joint Rose Diagram of Linwe Formaion

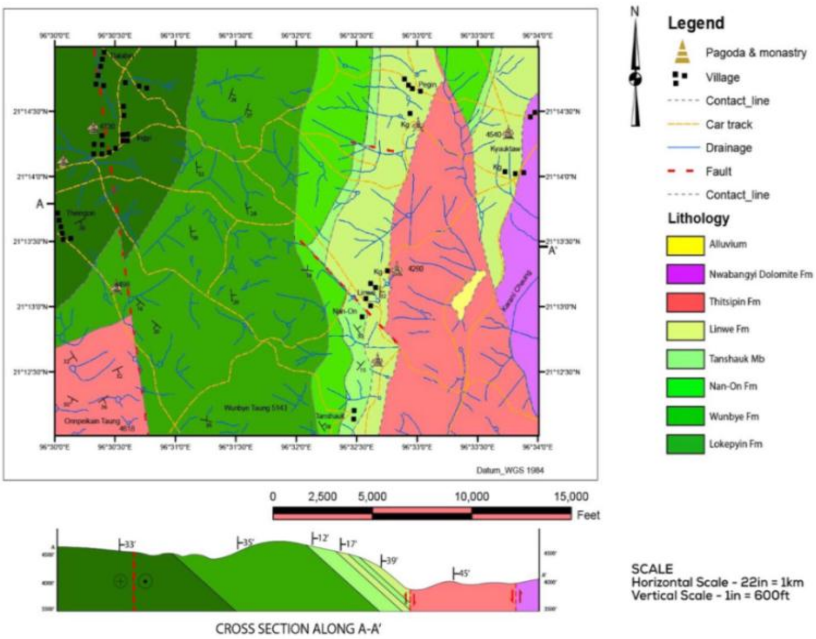


Figure 17 Geological Map of Linwe-Pegin Area

Results and Discussions

For the purpose of detection of mineralization in the study area, it is essential to evaluate the alterations produced by mineralization. In this case, both Landsat-8 and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) images are used for alteration zone detection. The raw data of those two image types are radiometrically corrected separately, later these two processed are compared for confirmation of detection of alteration zones in the study area.

Landsat-8 OLI images are converted from their digital numbers to TOA (Top of Atmosphere) reflectances using the equation:

$$\rho\lambda' = ML * Qcal + AL$$

Where: $\rho\lambda'$ = TOA Planetary Spectral Reflectance, without correction for solar angle. (Unitless)

$M\rho$ = Reflectance multiplicative scaling factor for the band (REFLECTANCE_MULT_BAND_n from the metadata).

$A\rho$ = Reflectance additive scaling factor for the band (REFLECTANCE_ADD_BAND_N from the metadata).

Qcal = Level 1 pixel value in DN

Next, using the solar elevation angle information from the metadata, the conversion of TOA reflectance is calculated as follows:

$$\rho\lambda = \frac{\rho\lambda'}{\sin(\theta SE)}$$

Where: $\rho\lambda$ = TOA planetary reflectance

$\rho\lambda'$ = TOA Planetary Spectral Reflectance

θSE = Local sun elevation angle; the scene center sun elevation angle in degrees is provided in the metadata

The following combination band ratios: Band 4/ Band 2 (Ferrugination), Band 5/ Band 6 (Fe+Mg) and Band 6/ Band 7 (OH-bearing and carbonate minerals) are continued to pansharpen using 15-meter resolution panchromatic Landsat-8 images for better visualization of alteration map.

For the ASTER images, the images are preprocessed and rescaled to 30-meter resolution and the following band combination of Band 6 (SWIR), Band 2 and Band 1 (2 VNIRs) is processed for gossan/alteration/host rock delineation.

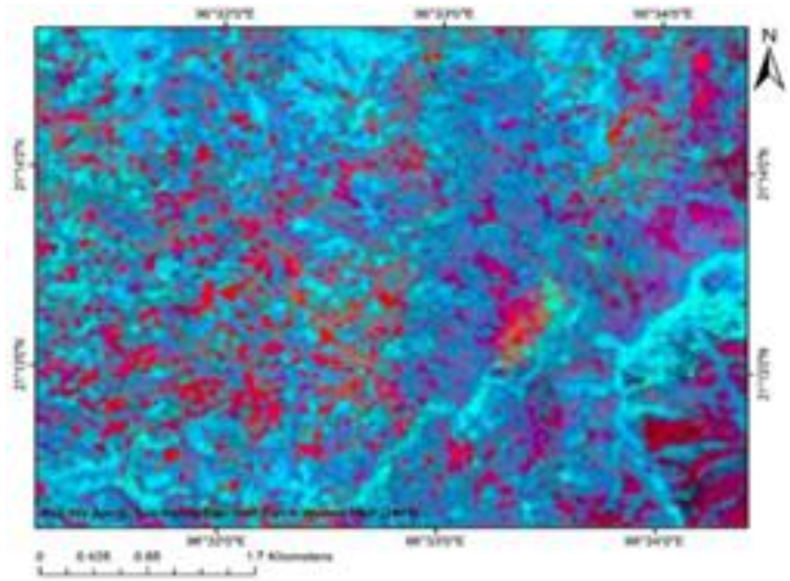


Figure 18 Alteration map by band combination of 4/2, 5/6,6/7 of the study area using Landsat-8 (red = Fe, green = Dolomitization or formation of sanded dolomite, blue=limestone)

According the alteration map by Landsat-8 images, many ferruginations are observed due to alteration of limestones into laterites. Most of the study area is covered with limestone area (more obvious in eastern part of the area which indicates the Nwabangyi Dolomite Formation). The green colour, a signature of Mg, shows dolomitization, thus also gives the evidence of the presence of mineralization).Figure (18).In the alteration map by ASTER data, many cyan tint pixels (alterations) are observed which the evidences of possible locations of mineralization area. The gossan shows with white or grey tint colour. And the rest of the area is host rock of brown colour. Figure (19)

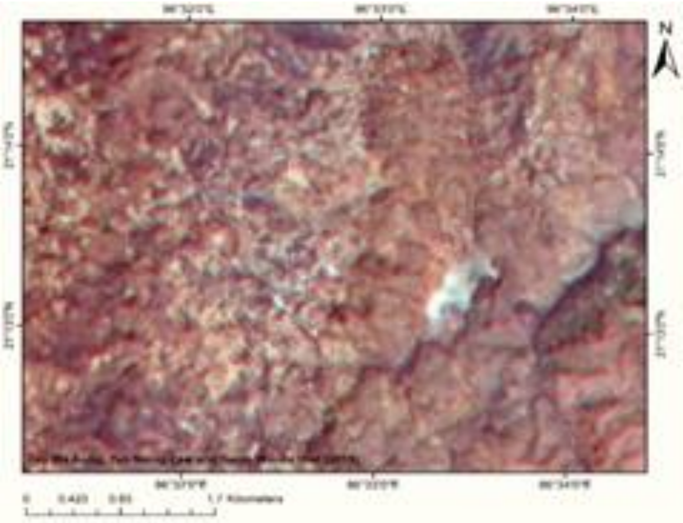


Figure 19 Alteration map by band combination of 6, 2, 1 of the study area using ASTER L1 products (cyan= alteration, brown = host rock, grey tint = gossan (Fe)

Linwe Village Lead Occurrence (New Finding)

Lead Occurrence (1)

This lead occurrence is situated at ½ mile northwest of Linwe Monastery (Location: Latitude 21°13′16″, Longitude 96°32′23″. This occurrence of lead mineralization is assumed to be new finding of lead occurrence as there has been no data mentioned or proof about the existence of this occurrence. There are many cross faults with trending direction N10W and S10E in the studied area. Linwe Formation and Nan-on Formation are cut by minor fault (NW-SE trending cross fault) which is faulted stream. Lead mineralizations observed at Linwe phacoidal nodular limestone that is well exposed along the NW-SE trending faulted stream. Figure (15)and Figure (20).

Figure 20 Occurrence of Lead mineralization in Linwe Village at Lat 96˚32’ 23’’, Long 21˚13’ 16’’ , Linwe Formation

Lead Occurrence (2)

In the northwestern part of Linwe village, lead mineralization in phacoidal limestone unit of the Linwe Formation observed at GPS locations 21° 12' 49" N ,9° 32' 45"E(4070'), 21° 12'54"N 96° 32'42"E (4390'), 21°12'59"N96°32'42"E(4150') and21°12'60"N96°32'43"E(4210') near the NW-SE trending cross fault zone. In these outcrops , mineralized phacoidal limestone s are highly brecciated and highly weathered and altered.Figure (21)

Figure 21 Lead mineralization in Linwe Phacoidal limestone

Position of Ore Bodies to the Host Rock

The Wunbye deposit can be regarded as stratabound and the deposit is found to be definitely stratigraphically controlled at Wunbye hill, Ywangan township ,Shan State(South). The galenais observed to have mostly occurred in the lower Wunbye Formation whereas galena associated with barite commonly occur in middle Wunbye Formation.But the Linwe ore bodies are highly concordant and crosscuts the regional strike of Linwe Formation at high angle. The mineralization controlling fracture has been NW-SE in direction. Most of the Linwe ore bodies have been followig NW-SE trending faulted stream that is pre mineral fault. On the surface, the mineralization can be followed the brecciated zone. The ore are disseminated, fracture fillings with no significant replacement of the host rock. The mineralization is structurally controlled with individual district , which is Linwe village at Linwe Formation.

Style of Mineralization

In the occurrences of lead mineralization in two new findings, there are four style of mineralization such as (i) dissemination (ii) fracture –fillings (iii) replacement and (iv) solution collapse breccias. Figure (22)

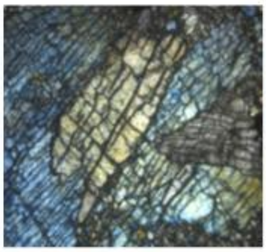
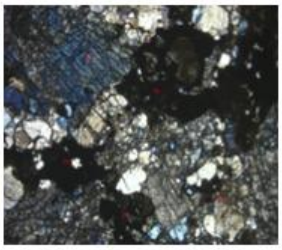
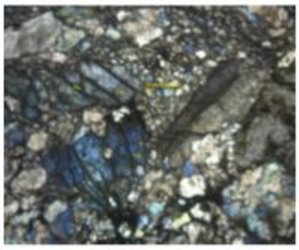

(i) dissemination (ii) fracture –fillings


(iii) replacement (iv) solution collapse breccias

Figure 22 Lead in Linwe Phacoidal Limestone

Petrography of Linwe Limestone

Under microscope, this rock is found to be medium grained with crystalline texture. Calcite grains are highly deformed and brecciated. Many cracks are observed in each calcite crystal. Lead mineralization fill in cracks of deformed calcite crystals. Figure (23)

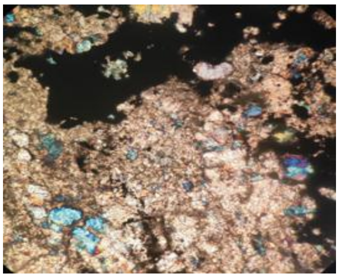




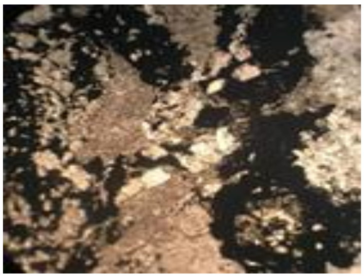
(5X) (Between XN) (5X) Pb –Lead, Ca - Calcite

Figure 23 Thin section of brecciated limestone with lead mineralization

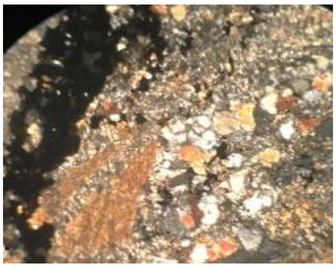
Ore Textures

In the Linwe deposit, the most common textures revealed are (1)open-space filling ,and cavities texture and (2) replacement. Figure(24) .





open-space filling (cavities filling texture)



open-space filling (fracture filling)

Replacement texture (may be ?)

Figure 24 Ore texture of Linwe lead deposit

Conclusions

1. The host rock is confined to the Linwe Formation of Silurian in the middle part of study area especially southeastern part of Linwe monastry.
2. The present study provides reevaluation of the structural geology of the research area. Resent study in the Linwe area, has significantly improved our knowledge of recognizing a lead mineralization in phacoidal limestone of Linwe Formation (Early Silurian) mainly occurred in nearly NW-SE trending fault zone.
3. The mineralization of the Linwe area is found to be definitely structurally controlled
4. The galena is observed to have mostly occurred in fault with brecciated zone. In the alteration map by ASTER data, many cyan tint pixels (alterations) are observed which the evidences of possible locations of mineralization area.
5. The common wall rock alteration of Linwe lead mineralization may be dolomitization and the formation of sanded dolomite based on the alteration map by using aster and Landset 8 images.
6. Most of the Linwe ore bodies have been followig NW-SE trending faulted stream that is pre mineralization fault.

7. On the surface, the mineralization can be followed the brecciated zone. Styles of mineralization occur as fracture filling and solution collapse breccia.
8. Lead mineralization fill in cracks of deformed calcite crystals. Texture of lead sulphide minerals are mostly related to open-space filling of breccias and fractures.
9. This fault zone and lead mineralizatioin were previously mapped and designated by Tun Naing Zaw et.al., (2017) as a possible structural control.Lead mineralization in the Linwe area is epigenetic in origin.
10. Sandy dolomite beds make the orebodies changed to a friable sandy nature and leahing of the carbonate rocks result in thinning of some of the favourable beds to form residual shales in someore bodies, causing fractures into be opened in rocks for ores deposited.
11. Lead deposit in the Linwe Formation is hosted by sedimentary rock deposited during the later stage of at least two overprinting extensional events.
12. Hydrothermal activity and alteration also acted as a heterogeneity focusing of dilational deforation and final stage of mineralization.Reactivated fault thereby accounting for the longevity of the hydrothermal system responsible for the alteration and mineralization at Linwe Formation.
13. Analysis of the kinematic controls on lead mineralization in Linwe Formation is structurally controlled may enable other prospective structures in the near Linwe area to be identified.
14. Need to seek possible means and ways for further exploration of Pb mineral deposits in the Linwe area.

Acknowledgements

We would like to express my thanks to Dr. Phoe Kaung, Rector, University of Yangon , for his permission to summit the research paper. Special hearty thanks are due to Dr. Ohm Thwin, Professor (Retired), Department of Geology, University of Yangon, for his discussions and suggestion. We thank to second year honours students and final year students for their field surveys carried out in the research area. Last, but not the least, we extend our gratitude to the unforgettable villagers and local people of our research area for their valuable helping during the field trip.

References

Amar, B.I., (1975). Stratigraphy of some of upper Paleozoic and Mesozoic carbonate rocks of the Eastern Highlands, Burma, and Newest Stratigraphy. 4(1): 46-70. Stuttgart.

Aleks Kalinowski and Simon Oliver (October 2004). *ASTER Mineral Index Processing Manual, Remote Sensing Application, Geoscience Australia*

Aye Ko Aung, (2006). Revision of the Paleozoic stratigraphy of the Shan State, Dagon University, Department of Geology, 57P, (Unpublished).

Aye Ko Aung, Kyaw Zay Myint, Kyaw Ko Ko and Aung Aye Lin, (2006). A new Carboniferous unit of the western part of southern Shan State, yanmar. Dagon University Research Journal, vol.1, no.1, 8-14.

Borstad Associates, (2008). *Using ASTER in mineral exploration. Unpublished Borstad Associates report*

Brunshweiler, R.O, (1970). Contribution to Post-Silurian Geology of Burma (Northern Shan State and Kayah State) Jour.Geol.Soc. Australia, 17:59- 79

Clegg, E.L.G., (1952). The Cretaceous and associated rocks of Burma. Rec. Geol. Surv. India, vol-49, 1-101.

Das, S, (2004). A manual on clinical surgery. Calcutta, India. South Edition 478P.

Department of the Interior, U.S.Geological Survey, (Version 4.0, April 2019), *Landsat 8(L8) Data Users Handbook*

Folk, R.L, (1989). Practical petrographic classification of the limestone, Bull. Amer. Asso. Petro Geook, V 43-38P.

Hassan Mohy, Islam Abou El-Magd and Fawzy F. Basta (9 December 2015) *Newly Improved Band Ratio of ASTER Data for Lithological Mapping of the Fawakhir Area, Central Eastern Desert, Egypt, Indian Society of Remote Sensing 2016, D.O.I 10.1007/s12524-015-0539-0.*

Jones, E.J, (1887). Notes on Upper Burma. Rea. Geol. Surv. India, 204:170-194, Calcutta

Keller, E.A, (1988), Environmental Geology. Merill Publishing Company, Fifth Edition, 540P.

La Touche, T.H.D, (1913). Geology of northern Shan State. Mem. Geol. Surv. India 39(2):1-379

Mouhssine WAHI, Kamal TAJ-EDDINE and Noureddine LAFTOUHI (2013), ASTER VNIR & SWIR Band Enhancement for Lithological Mapping - A case study of the Azegour Area (Western High Atlas, Morocco), Journal of Environmental and Earth Science, Vol 3, No.12, 2013. ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)

Niyeh, M.M., Jafarirad, A., Karami, J. and Bokani, S.J. (2017) *Copper, Zinc, and Lead Mineral Prospectivity Mapping in the North of Tafresh, Markazi Province, Central Iran, Using the AHP-OWA Method. Open Journal of Geology, 7, 533-558.* *https://doi.org/10.4236/ojg.2017.74037*

Pettijohn. F. J., (1956). Sedimentary Rocks 2nd Edn. Oxford Book Co., 718P

Pour, Amin & Hashim, Mazlan. (2015). *ASTER and Landsat TM Data for Geological Mapping Application: A Case Study from Esfandagheh Ophiolite Complex, South of Iran.*

Second Year Hons Students(2014 intake) 2018. Geological Field Report of Linwe-Pegin Area, Ye-ngan Township, Shan State (South)

Yang, Min & Ren, Guangli & Han, Lin & Yi, Huan & Gao, Ting. (2018). *Detection of Pb-Zn mineralization in west Kunlun using Landsat 8 and ASTER remote Sensing data. Journal of Applied Remote Sensing. 12. 1. 10.1117/1.JRS.12.026018.*