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ABSTRACTS

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The Popa-Loimye Arc, its mineralisation and arc reversal.

Key Note 1

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The Popa-Loimye Arc, named from the southern and northern of its three extinct stratovolcanoes, is the northern continuation of the Sunda arc in Sumatra and is defined by magmatic rocks of Cretaceous to Quaternary age. The main westward-convex part of the Arc (Fig.1a) lies west of the Sagaing Fault and consists of Kawt-a Bum mountain in the north, the Wuntho-Banmauk segment with Taungthonlon stratovolcano at its northern end, and the Monywa-Salingyi and Mt Popa segments to the south. The segments are separated by Tertiary sedimentary cover which also extends from Mt Popa to the Ayeyawaddy delta where subsurface volcanic rocks are known. From Kawt-a-Bum to the delta the arc length is 1150 km but magmatic rocks occupy less than 300 km of this.

Arc stratigraphy is best seen in the 150 km long Wuntho-Banmauk segment (Fig.2) where schist and gneiss underlie the widespread Mawgyi Volcanics consisting of pillowed basalts, andesites and andesitic dykes. Marine volcaniclastics and mudstones of the Mawlin Formation overlie the Volcanics and are overlain unconformably by mid-Cretaceous *Orbitolina* limestone which extends westwards beneath the forearc basin to the Indo-Burman Ranges. The Mawgyi and Mawlin are overlain unconformably by siliciclastics of the Ketpanda-Wabo Chaung Formation with a prominent basal conglomerate of ?early Eocene age. The Mawgyi and Ketpanda-Wabo Formations include dacite bodies and are locally overlain by 33 Ma trachytes. The Mawgyi Formation is intruded by the 70 km long Kanzachaung Batholith consisting of early Upper Cretaceous biotite-hornblende granodiorites and diorites and local Oligocene plutons. To the north in the Pinhinga Plutonic Complex the Mawgyi Volcanics are intruded by granodiorites, diorites and garnet-bearing biotite-muscovite granites some of which are foliated.

In the Monywa-Salingyi segment biotite granites intruding Mawgyi Volcanics occur beneath a folded unconformable cover of late Oligocene to Pliocene clastics. Quartz andesite porphyries and minor rhyolites intrude a mid-Miocene sandstone-shale-basaltic volcaniclastic succession overlain by the Pliocene Irrawaddian Formation and Pliocene-Quaternary K-rich basaltic stratovolcanoes with crater lakes. At Mt Popa the ca 13 Ma Older Volcanics comprising folded latites, rhyodacite lava flows and ignimbrites with interbedded sediments are overlain by Quaternary basalt and basaltic andesite flows and lahars which form the extinct volcano.

Post-Oligocene dextral displacement of ca 400 km on the Sagaing Fault is implied by the probable off-set continuation of the Popa-Loimye Arc beyond Kawt-a-Bum through the Tagaung-Myitkyina belt. Here biotite and hornblende granites intruding pillow basalts and volcaniclastics overlain unconformably by *Orbitolina* limestone may correlate with the Kanzachaung batholith and host rocks west of the Sagaing Fault.

The most important mineral deposits within the arc are those at Sabetaung-Kyisintaung and Letpadaung west of Monywa (Fig.1a) where 7 million tonnes of copper are contained in 2 billion tonnes of ore in which hypogene and supergene chalcocite and covellite veins and hydrothermal breccia dykes are associated with mid-Miocene andesite porphyry intrusions, pebble dykes and eruptive diatreme breccias with pyrite clasts. Alunite, pyrophyllite and abundant pyrite indicate high sulphidation epithermal mineralisation. Kyisintaung and Letpadaung ore bodies are overlain by supergene-leached lithocaps up to 200 m thick with residual-replacement quartz, kaolinitic clays and negligible copper. Copper content and argillisation of host rocks are at a maximum at the water table and decrease downwards while pyrite increases with depth, indicating oxidation and leaching of the highly pyritic deposit above the water table and oxidation and supergene enrichment below. Porphyry copper mineralisation may be present at depth in Miocene intrusions in the Monywa district but perhaps not in those beneath the known deposits.

At Shangalon in the southeast of the Kanzachaung Batholith sheeted pyritic chalcopyrite-bornite-molybdenite quartz veins are hosted by 33 to 38 Ma granitic plutons. Probable VMS-type copper sulphides north of Shangalon occur in fragmental dacitic rocks within the Mawgyi Volcanics. Other copper targets include a quartz-pyrite lithocap at Kyaukpon-Ponkham north of Pinlebu where copper sulphides have been intercepted in an inclined drill hole with no surface copper mineralisation. Similar quartz-pyrite bodies with kaolinitic clays and hydrothermal breccias exposed within 15 km of the extinct Mt Popa volcano contain alunite and a trace of gold. The Popa quartz bodies, like those at the Monywa copper deposits, are hosted by mid-Miocene volcanic rocks.

Gold mineralisation is most abundant as low sulphidation epithermal veins in the Mawgyi Volcanics. The Kyaukpazat underground mine with base metal tellurides within the 60 km-long Shwedaung-Wuntho gold district (Fig.2) operated in the early 1890s. The Mawgyi Volcanics are an important metallotect in which numerous artisanal lode and alluvial gold workings indicate a good potential for commercial scale deposits. Narrow quartz-gold-(copper) veins support widespread artisanal alluvial workings in the Kanzachaung Batholith. Elsewhere in the Arc sediment-hosted epithermal veins occur in Miocene sandstones and mudstones which are either silicified or hornfelsed and intruded by rhyolites. They include veins at Kyaukmyet and Natchetaung near Monywa, at Daungnyu south of Shangalon, and 350 km south of Mt Popa at Myezetaung which has a 20 km long alluvial gold train. At the Kyaukpahto sediment-hosted gold deposit east of the Arc the "basement" rocks are Mesozoic basalts, suggesting that the sediment-hosted vein deposits could be higher-level equivalents of the gold-base metal veins in the older Mawgyi Volcanics.

The deep eastward-dipping seismic zone beneath western Myanmar indicates that the Popa-Loimye Arc faced westwards during recent subduction, and according to most authorities since at least the mid-Cretaceous. We suggest instead that during emplacement of the Kanzachaung Batholith from 110 to ca 90 Ma, the Arc was an east- facing island arc on the West Burma block (Fig.1b) beneath which a Meso-Tethys ocean subducted westwards in a trench near the present Kyaukpyu and Sagaing Faults. During collision ca 90 Ma with the continental Sibumasu or Sunda foreland (Fig.3a), turbidites on the Sibumasu margin were thrust eastwards and form the Pyinyaung Formation in the Paung Laung-Mawchi zone. Collision-related crustal thickening in the foreland could explain the most recent (early Tertiary) metamorphism in the Mogok Metamorphic belt; partial melting of metasedimentary rocks and emplacement of a 70 to 43 Ma eastward-convex belt of reduced peraluminous granites (Fig. 3b) which generated tin and tungsten deposits where they ascended through the carbonaceous Mawchi-Tanintharyi Slate belt; eastward overturning of the regional Ngayan Chaung anticline on the Shan Plateau margin; and isoclinal folding of (?Jurassic) orogenic quartz-gold veins in the Slate belt.

Ar-Ar and K/Ar mica ages of 17 Ma to 30 Ma reported in 1999 from the Mogok Metamorphic belt imply uplift-cooling as rocks ascended through the ductile-brittle transition zone to the surface following intrusion of 16 to 23 Ma undeformed granites and dykes. The westward subduction may have begun before the mid-Cretaceous and generated Neo-Tethys by back-arc spreading and rifting of West Burma from India. *Orbitolina* Limestone west of the Popa-Loimye Arc (Fig.3a) was then deposited
in a back-arc basin during intrusion of the Kanzachaung Batholith.

We propose that by ca 40 or 50 Ma tectonic polarity had reversed (Fig.3b) initiating eastward subduction of Neo-Tethys and generation of the Oligocene granodioritic plutons and Cu Mo veins at Shangalon and later the ca 13 Ma volcanic rocks at Monywa and Mt Popa and the ?late Tertiary Kyaukpon-Ponkham and Popa lithocaps. Sediment-hosted epithermal gold veins in the Arc and epithermal gold veins in the Mogok Metamorphic belt are also probably related to the eastward subduction. Unroofing of Arc granites is indicated by cobbles in Upper Palaeocene conglomerates within the incipient fore-arc basin. Overlying Eocene sediments contain detrital zircons with ages which decrease in abundance from 80 or 90 Ma to ca 50 Ma; younger more abundant zircons can be attributed to the renewed arc magmatism.

Northward movement of western Myanmar accompanying dextral displacement on the Sagaing Fault beginning in the Miocene led to collision of northwestern Myanmar with India in the Naga Hills. East of the Sagaing Fault the former northeastern continuation of the Arc includes copper skarns at Paladokhta and low sulphidation epithermal quartz-gold veins in equivalents of the Mawgyi

Volcanics, but is probably tectonically buried north of Myitkyina. The Mawgyi Volcanics may be oceanic arc rocks above an ophiolite nappe expelled from Meso-Tethys in the Jurassic prior to the start of westward subduction.

Figure Captions

Fig. 1 Sketch maps of the Popa-Loimye Arc (a) in present position and (b) in restored position ca 100 Ma, showing West Burma block and Arc axis (red bars) above the proposed Sagaing-Kyaukpyu Subduction Zone (SKSZ) in (b) and the Andaman-Naga Subduction Zone (ANSZ) in (a). K Kawt-a-Bum, M Monywa-Salingyi, W Wuntho-Banmauk, and Po Mt Popa are arc segments. Mdy Mandalay, My Myitkyina, P Paladokhta, T Taungthonlon.

Fig. 2. Wuntho-Banmauk arc segment and selected mineral deposits and prospects. Location on Fig.1. Re-drawn from Mitchell, A.H.G., 2017, Geological Belts, Plate Boundaries and Mineral Deposits in Myanmar, Elsevier, 509 p.

Fig. 3. Cross-sections through the Arc system (a) immediately following westward subduction and Upper Cretaceous closure of the proposed Sagaing-Kyaukpyu Meso-Tethys and (b) during Miocene eastward subduction of Neo-Tethys including the Bay of Bengal. Granites in the foreland are here related to orogeny during Meso-Tethys closure. After Mitchell, A.H.G. 2017, Geological Belts, Plate Boundaries and Mineral Deposits in Myanmar, Elsevier, 509p.

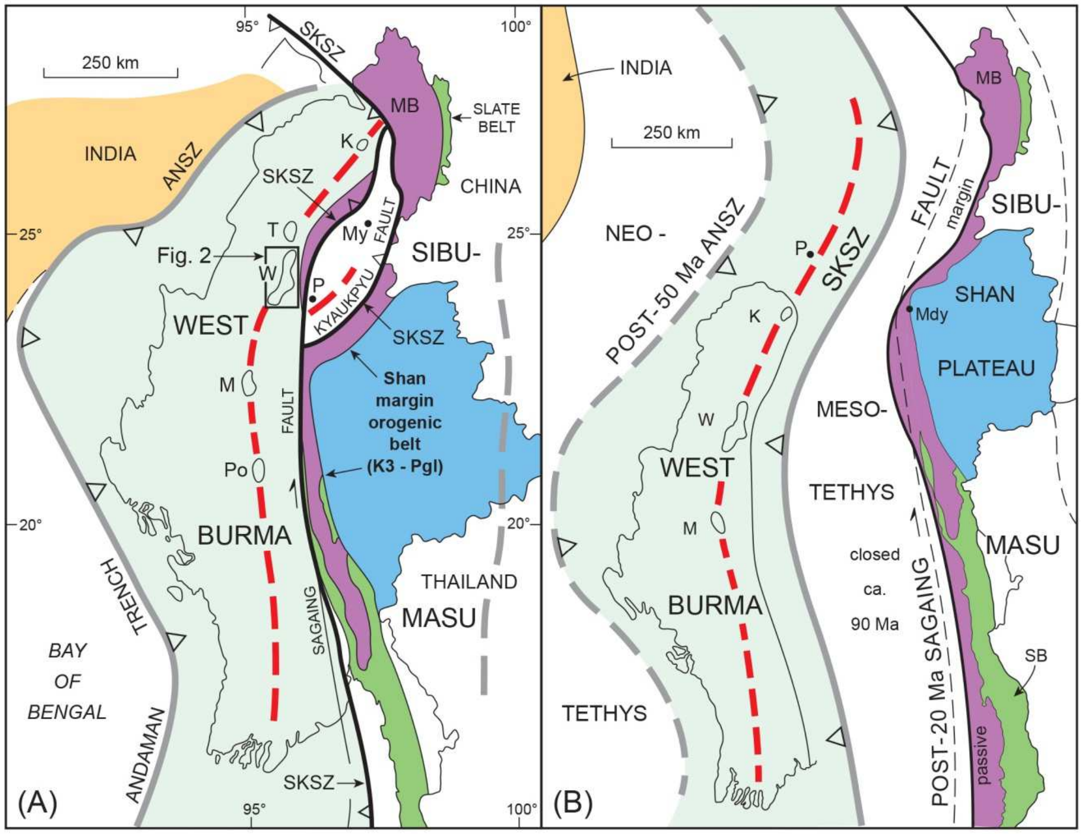
(A)
95°
100°
250 km
SKSZ
INDIA
ANSZ
MB
SLATE BELT
K
CHINA
T
My
FAULT
25°
Fig. 2
W
P
SIBU-
KYAUKPYU
WEST
SKSZ
M
Shan margin orogenic belt (K3 - Pgl)
FAULT
Po
20°
BURMA
TRENCH
SAGAING
THAILAND
MASU
BAY OF BENGAL
ANDAMAN
SKSZ
(B)
INDIA
250 km
NEO -
POST-50 Ma ANSZ
P
SKSZ
FAULT
margin
SIBU-
SHAN
Mdy
PLATEAU
K
W
MESO-
WEST
TETHYS
M
closed
ca.
90 Ma
MASU
BURMA
POST-20 Ma SAGAING
SB
TETHYS
passive

Figure 1

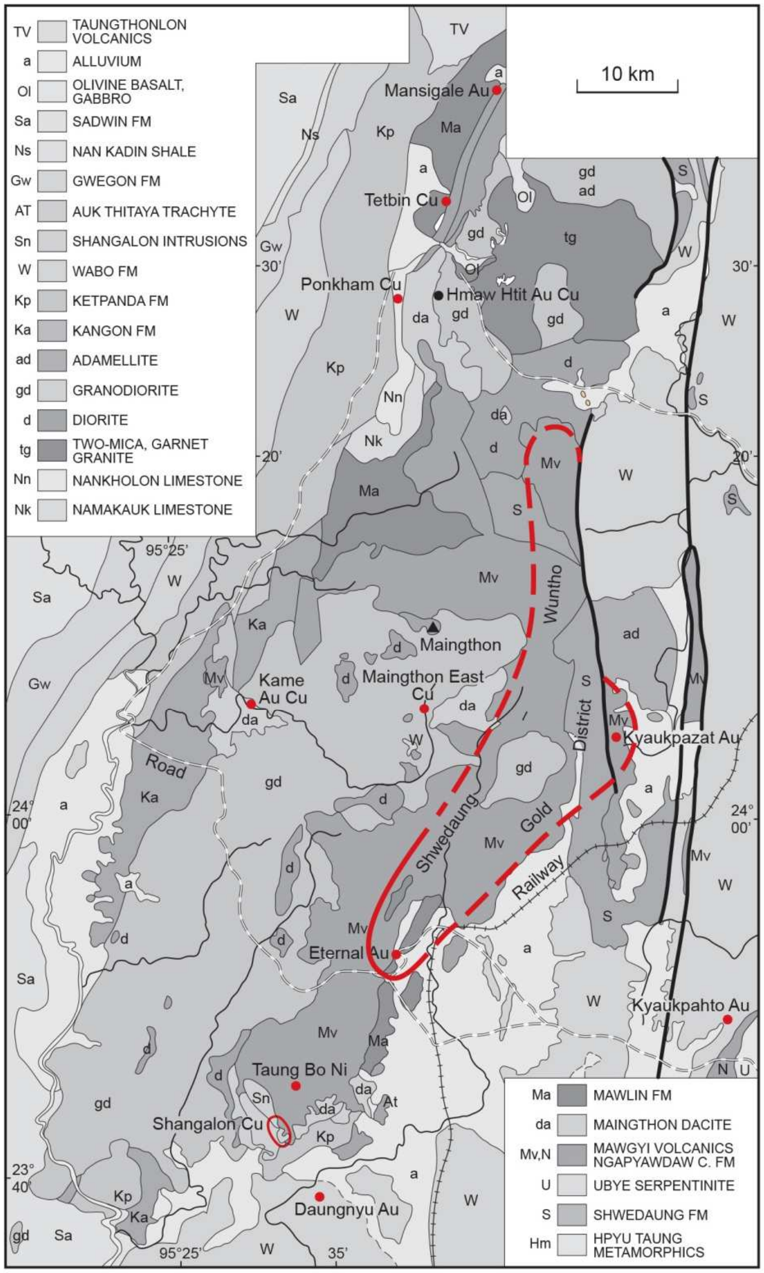
TV TAUNGTHONLON VOLCANICS
a ALLUVIUM
Ol OLIVINE BASALT, GABBRO
Sa SADWIN FM
Ns NAN KADIN SHALE
Gw GWEGON FM
AT AUK THITAYA TRACHYTE
Sn SHANGALON INTRUSIONS
W WABO FM
Kp KETPANDA FM
Ka KANGON FM
ad ADAMELLITE
gd GRANODIORITE
d DIORITE
tg TWO-MICA, GARNET GRANITE
Nn NANKHOLON LIMESTONE
Nk NAMAKAUK LIMESTONE
10 km
Mansigale Au
Tetbin Cu
Ponkham Cu
Hmaw Htit Au Cu
Maingthon
Maingthon East Cu
Kame Au Cu
Kyaukpazat Au
Wuntho
District
Shwedaung
Gold
Road
Railway
Eternal Au
Kyaukpahto Au
Taung Bo Ni
Shangalon Cu
Daungnyu Au
95°25'
35'
30'
20'
24° 00'
23° 40'
Ma MAWLIN FM
da MAINGTHON DACITE
Mv,N MAWGYI VOLCANICS NGAPYAWDAW C. FM
U UBYE SERPENTINITE
S SHWEDAUNG FM
Hm HPYU TAUNG METAMORPHICS

Figure 2

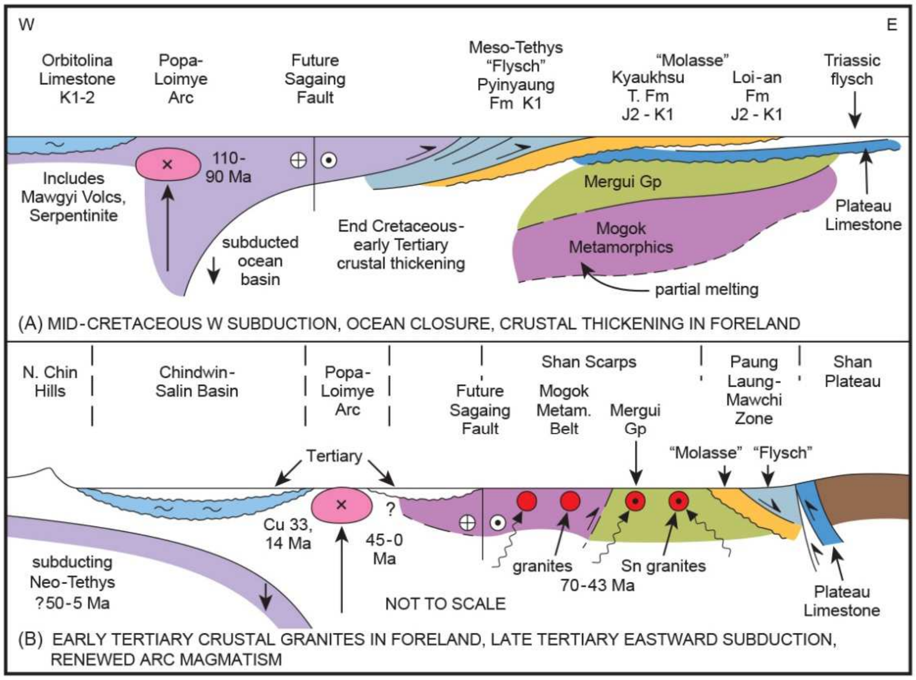
W
E
Orbitolina Limestone K1-2
Popa-Loimye Arc
Future Sagaing Fault
Meso-Tethys "Flysch" Pyinyaung Fm K1
"Molasse"
Kyaukhsu T. Fm J2 - K1
Loi-an Fm J2 - K1
Triassic flysch
110-90 Ma
Includes Mawgyi Volcs, Serpentinite
Mergui Gp
Plateau Limestone
subducted ocean basin
End Cretaceous-early Tertiary crustal thickening
Mogok Metamorphics
partial melting
(A) MID-CRETACEOUS W SUBDUCTION, OCEAN CLOSURE, CRUSTAL THICKENING IN FORELAND
N. Chin Hills
Chindwin-Salin Basin
Popa-Loimye Arc
Shan Scarps
Future Sagaing Fault
Mogok Metam. Belt
Mergui Gp
Paung Laung-Mawchi Zone
Shan Plateau
Tertiary
"Molasse"
"Flysch"
Cu 33, 14 Ma
?
45-0 Ma
subducting Neo-Tethys ?50-5 Ma
granites 70-43 Ma
Sn granites
NOT TO SCALE
Plateau Limestone
(B) EARLY TERTIARY CRUSTAL GRANITES IN FORELAND, LATE TERTIARY EASTWARD SUBDUCTION, RENEWED ARC MAGMATISM

Figure 3

Key Note 2

Miocene Magmatism And Its Implications For The Metallogeny Of Myanmar

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Collision of India and Asia during the Himalayan orogeny in the early Eocene (55 to 45 Ma) is generally considered to have marked the end of northward subduction of Neo-Tethys beneath the Asian plate. Many tectonic and petrogenetic models consider that subduction related melting effectively ceased at around this time, with subsequent magmatic activity attributed to a variety of processes that include crustal thickening, exhumation and slab roll-back and/or detachment. The Gangdese arc represents a trans-Himalayan magmatic belt to the north of the Indus-Yarlung suture that extends from Kohistan to eastern Tibet, forming largely as a result of the subduction of Neo-Tethys beneath Asia. Its pre-collisional development is essentially devoid of significant mineralization – however, post-collisional magmatic activity, extending intermittently from the Palaeogene to recent times along this zone, is linked, enigmatically, to the formation of some of the great Cu-Mo-Au porphyry-epithermal deposits of the World. These major deposits are not distributed equitably with respect to either space or time. The Lhasa Terrane of eastern Tibet is particularly well endowed with world class porphyry systems such as the giant Qulong Cu-Mo deposit (2.2 billion tonnes at 0.5% Cu and 0.03% Mo), the Jiama Cu-Mo-Au porphyry and several lesser occurrences (e.g. Bairong, Tinggong, Chongjiang). These deposits are Miocene in age with the Qulong deposit, for example, hosted in calc-alkaline granodiorite and porphyry intrusions ranging in age from 17.2 to 15.3 Ma (U-Pb zircon dates) and the associated molybdenite mineralization dated by Re-Os systematics at 16.1 Ma (Li et al., 2017). West of the Western Syntaxis, in Iran and Pakistan, similar giant Miocene-aged porphyry Cu-Mo systems are preserved, such as Sar Cheshmeh (13.6 to 12.5 Ma; Boomeri et al., 2010) and Reko Diq (10-14 Ma; Razique et al., 2014). Although Neogene magmatism appears to have been specifically implicated in the formation of the giant porphyry deposits of the region, other, lesser occurrences also formed during the Palaeogene – examples include the Yao'an, Beiya and Machangqing porphyry-skarn Cu-Au systems in western Yunnan dated at 37-33 Ma (Lu et al., 2013) and the Yaguila (Palaeocene), Sharang (Eocene) and Jiru (Eocene) porphyries of the Lhasa Terrane (Wang et al., 2014a,b). It is evident that porphyry style Cu-Mo-Au mineralization is a feature of the post-collisional magmatic phase of the Himalayan orogeny and this observation is likely to have significant implications for the metallogeny of Myanmar, both along the Popa-Loimye arc and elsewhere.

The Popa-Loimye arc (Mitchell, 2017), also known as the Burman or Inner Volcanic Arc, extends for some 1100 km from Kawt-a-Bum in the north to the Ayeyawaddy delta in the south, although it is well exposed for only a fraction of its extent. It is essentially calc-alkaline (I-type) in character and contains several known porphyry and epithermal occurrences, including the giant Letpadaung high-sulphidation Cu deposit (Figure 1) near Monywa and the Shangalon Cu-Mo-Au porphyry system (Figure 2). The volcanism that initiated arc construction (the basaltic-to-andesitic Mawgyi Group) is early Cretaceous or older in age and in the Wuntho-Shangalon area these volcanics are cut by granite plutons that have been dated at 98 Ma and 33 Ma (Mitchell, 2017). Porphyry style mineralization at Shangalon is hosted in granodiorite of the latter age.

Figure 1: View of the Letpadaung pit – a high-sulphidation epithermal Cu-rich system showing the contact between upper oxidized and underlying hypogene zones.

The Monywa segment of the arc also comprises high-potash calc-alkaline plutons dated at 105 Ma to 91 Ma, but the high-sulphidation copper mineralization at the Sabetaung pit is believed to have formed at, or just after, 13.6 Ma, the U-Pb zircon age of an intrusive andesite porphyry dyke. North of Monywa young basaltic flows and craters preserve the youngest magmatic activity along the Popa-Loimye arc, dated at 0.72 Ma (Mitchell, 2017). The arc therefore records an extended period of easterly directed subduction from the present Andaman suture that commenced in the mid- Cretaceous and continued through the Cenozoic, encompassing both pre- and post collisional stages of the Himalayan orogeny.

Figure 2: View of the copper vein stockwork in the 33 Ma old Shangalon granodiorite – a porphyry-like Cu-Mo-Au system that also contains possible low sulphidation epithermal Au mineralization.

The correlation of long-lived tectonic and magmatic activity in Myanmar with post-collisional processes elsewhere in the Himalaya, and in particular in the Lhasa Terrane, warrants careful consideration given the importance of these processes in a metallogenic context. In addition to the

Popa-Loimye arc, Palaeogene and Neogene granite magmatism is recorded elsewhere in Myanmar (Gardiner et al., 2016), specifically in the Mogok metamorphic belt. In the Mogok belt, for example, Miocene aged granites, such as the ca. 18 Ma Tabeikkyin biotite microgranite, are spatially associated with known Cu-Au mineralization (Aung Zaw Myint, per.comm.). In addition, the Mogok belt has been intruded by a variety of post-collisional intrusions that include leucogranites at 45 Ma and 24 Ma and the Kabaing granite at 16 Ma – polyorogenic processes are also suggested by Ar-Ar biotite ages at 16 Ma, phlogopite ages at 17-19 Ma and U-Pb zircon inclusions within ruby at 32 Ma, all of which indicate Eocene – Miocene activity in the region (Kyaw Thu and Khin Zaw, 2017).

The tectonic framework for extended post-collisional magmatism in north-central Myanmar and eastern Tibet (Lhasa) remains equivocal and definitive statements require considerable additional study. Although the processes associated with the two regions may differ, it is pertinent to speculate on hypotheses that may link them. Two models appear favourable in the current context:-

Model 1 (Murphy and Yin, 2003) – Time constrained tectonic restoration of part of southwest Tibet orthogonal to the Indus-Yarlung suture over the period from the early Cretaceous to mid-Miocene suggests that oceanic lithosphere existed south of the suture well into the Oligocene. Murphy and Yin suggest that the under-thrusted portion of the Indian continent did not reach the Indus-Yarling suture until the early Miocene. This is consistent with the observation that some of the calc-alkaline magmatism in, for example the Kailas complex and parts of Ladakh and eastern Tibet, did not cease at 50 Ma but extended through the Palaeogene-early Neogene periods and was the product of melting due to subduction of oceanic crust.

Model 2 (Mitchell, 2017) – reconstructing the tectonic evolution of northwest Myanmar led to the suggestion that northward movement of the Burma platelet, and closure of this portion of Neo-Tethys, occurred after the early Eocene collision of India with Asia. As with Model 1, this scenario envisages continued Neo-Tethyan subduction in post-Eocene times and eventual collision of the Burma platelet in the Miocene with the so-called 'foreland spur' of continental India to form the Naga Hills (Figure 3). Subduction related melting rather than delamination or roll-back could, in this case, explain post-collisional, calc-alkaline magmatism and mineralization in northern Myanmar and eastern Tibet.

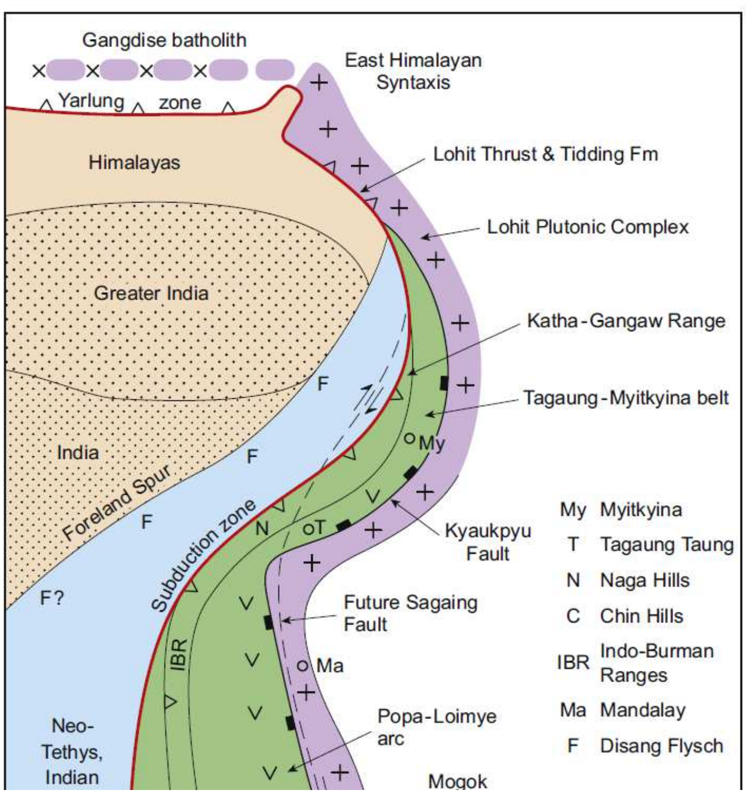

Figure 3: Sketch map of northwest Myanmar in the early Eocene and at the time of initial India-Asia collision. The red line is the edge of the Indian plate along which north, northeast and east directed subduction is occurring. It is suggested that continued subduction of Neo-Tethys (in blue) in this region could have continued until Miocene times, giving rise to so-called 'post-collisional' subduction related magmatism and mineralization (after Mitchell, 2017)

Post-collisional magmatism has occurred in many parts of the Himalayan orogenic belt, extending intermittently through the Palaeogene and Neogene periods, and even into more recent times. The Miocene in particular is associated with intrusions that have yielded prolific porphyry and epithermal mineralization, related in part to fertile magmas that are both more hydrous and more oxidized than typical melts (Wang et al., 2014a,b). Understanding the tectonic framework for this event, as well as the distribution of magmatism and the nature of the ore-forming process, will be crucial to the future development of the mineral potential of Myanmar.

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Key Note 3

UNESCO Global Geoparks: the development in the Asia Pacific Region

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Vice President, Global Geoparks Network;
Vice Chair, UNESCO Global Geoparks Council.
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UNESCO Global Geoparks (UGGp) is a brand new UNESCO's program under the International Geosciences and Geoparks Program (IGGP) established in 2015 to encourage important geological landscape to be developed as balance conservation and tourism area in a sustainable manner.UGGp is defined as single and unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development.The major components of UGGp are: a) uses geological heritage, in connection with other area's natural and cultural heritage, to enhance awareness and understanding of key issues facing society; b) give local people a sense of pride in their region and strengthen their identification with the area; and c) creation of innovative local enterprise, new jobs and skills to stimulate new sources of revenue through geotourism. This program evolved through UNESCO's initiative in 2004, where Global Geoparks Network (GGN) were established to help member countries to create their national geoparks and subsequently become a member of GGN. Until today, GGN has established 127 UGGp in 35 countries. This presentation will highlight the history, philosophy, characteristics and strategy for development of UGGp, particularly in the Asia Pacific region.

Keywords: global geopark, geosite, geopark development, Asia Pacific.

Key Note 4

Life of mine planning for improved environmental management

Dr Greg Maddocks

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Globally there is increasing pressure on mining companies from project stakeholders to provide improved social and environmental outcomes from exploration all the way through to mine closure. Adverse impacts to land and water resources from mining projects are of particular concern to project stakeholders. Acid and metalliferous drainage (AMD) is one of the major impacts that can occur from mining. AMD has the potential to damage receiving land and water resources. If the geological materials and mine waste produced from mining projects are managed appropriately the potential adverse impacts can be minimised. Because the materials that cause AMD are from the deposit the methods to sample, analyse, characterise and classify the materials into beneficial and deleterious material classes should be a simple extension of the exploration and resource evaluation programs. This presentation will provide (1) instruction on how AMD investigations can be undertaken by geologists and geoscientists, and (2) show how the data from AMD investigations can be used to evaluate mining options and then select a life of mine plan that can be implemented and have minimal potential for environment harm.

Key Note 5

Geology in Underground Mining

Kar Winn
President (Myanmar Geologist Society Singapore) / Professional Geologist (Geomotion Singapore P/L)

Thorough understanding of the Geology of the planned area for underground mining will provide economical design and safe working environment. Geologist's role is crucial from the beginning stage of area site investigation, geological model design, in-situ stress measurement and so on. During the construction period, his role continuously plays important in face geological mapping, Q and RMR calculation, GSI value determination, judgement in support application, observation in hydrogeological condition, instrumentation monitoring works, etc. The speaker will share his design and construction experience gained in two underground rock excavation projects in Singapore.

Key Note 6

Tibet and Beyond: Collision Zone Magmatism in the Eastern Tethyan Orogenic Belt

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Asia that comprises numerous ancient cratonic blocks and young mobile belts is the largest composite continent on Earth. It was enlarged by assembly of dispersed terranes that, in association with opening and closure of the Paleo-Asian and Tethys oceans, led to significant continental growth. The Central Asian orogenic belt (CAOB), for instance, is celebrated for its accretionary tectonics and production of massive juvenile crust in the Phanerozoic or, predominantly, in the Paleozoic. The Tethyan domain consisted of two major oceans, i.e., Paleo-Tethys in north and Neo-Tethys in south, separated by a strip of continents/terrains called the Cimmerian Continent, most of which had begun splitting from the northern margin of Gondwanaland during Triassic time. Elimination of the Tethys oceans by collisions of the Cimmerian continental fragments and subsequent Gondwana-derived terrains with Eurasia resulted in a double, largely over-printed orogenic system, the Alpine-Himalayan or Tethyan orogenic belt.

Here I present a synthesis of geochemical data of collision zone magmatism from Asia, particularly from Tibet and “CIA” (Caucasus/Iran/Anatolia) in the eastern Tethyan orogenic belt (ETOB) that has traditionally been regarded as a typical collisional system. The dataset suggests that, before the terminal collisions, the entire region was characterized not only by Tethyan subductions but also by accretionary orogenic processes that produced a vast amount of juvenile crust from the Jurassic to Eocene or, in places, to Oligocene. Consequently, both the CAOB and ETOB appear to have evolved through time from an accretionary into a collisional system. The synthesis further indicates that, in contrast to generating massive juvenile crust in the earlier, accretionary stages of orogenic development, crustal recycling plays a more substantial role in the subsequent, collisional stages. The latter involves addition of older continental crust materials into the upper mantle, which in turn melted and caused compositional transformation of the juvenile crust formed in the accretionary stages. Similar features are observed in young volcanic rocks from eastern Taiwan, i.e., the northern Luzon island arc and part of the complex tectonic system in Southeast Asia, where active orogenic processes are operating and thus may evolve one day to resemble the CAOB or ETOB by collision with the northward advancing Australian continent.

Slope flows on Rakhine shelf

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Rakhine shelf is on 2 to 5 degree gradient sea bottom ground of (52800 sq km) standing between 7400 km coast line and the steep continental slope facing Bay of Bengal. From far north of Sylhet trough (Bangaladesh) and India Naga thrust belt productive folds of Tripura come down across Myanma –Bangaladesh border as Pliocene infilled trends of Mayu-Paletwa-Myohaung. At the start of coast , rifted Miocene core as peninsular island trends of Pharonga(colonial word Boronga) All structural fold lines running parallel to uplifted Rakhine hills. (colonial word Arakan) Behind the shelf coast line Rakhine hill ranges forming into for 's' shaped curve . The elevation are from low hills (100m) in southern tip Mawdin to (920 m) in higher terrain peaks beside the two Padan-Ann and Padaung –Taungup pass roads.

Since half century years before , MOGE (Myanma Oil and Gas Enterprise) geologic mapping followed in traverses on Rakhine ranges,Mayu-Paletwa - Myohaung folds , three peninsular trends of Pharongas Yanbye ,Manaung(colonial word as Ramree and Cheduba) islands down to southernmost tip area Mawdin - Hainggyi. The westward thrusted high Rakhine ranges end up against the Mayu-Paletwa folded synclinal trough belt by regional Myohaung or Myauku fault. The bay start from here and along all the coastal lines exposed by flysch type Eocene pelagic sediments forming into mélange outcrops.The main erosional amphitheater bay from Ngapali , Gwa to Chaungtha is notable and at few places protruded only by inlet forming Miocene folds.The regular structural trend from Pharongas disappear at peninsular Yanbye and Manaung island cross arch trend. Both Manaung and Yanbye are actually the two adjacent trends of mélange Eocene sediments with volcanic and autochthonous blocks of Globotruncana bearing limestones in various sizes exposed .Sepentine intrusion is on Manaung highest peak. Miocene Laikkamaw with Maragyun(2135 m succession) partly onlapping edges onto peneplained Eocene Sinbok surface of Yanbye and Manaung islands. Picturesaque view on hill ring of Oligocene ? Yechangyi and several similar patches stand out on the level ground of meandering rivers and tidal swamp still remain as conceptual challenges.

Productive source rich Bangal sediments (Miocene Bhubans) were compared with Miocene outcrops of Pharonga-Yanbye (colonial word Ramree)-Manaung area.Miocene exposure provinces like Pharongas,Yenandaung (mean oil hill) area extracted oil by indigenous bamboo/wood drillings up to present days. Yearly maximum 2500 in Ramree Yenandaung +1500 barrels in Boronga east before 1900 dwindled down within three decade were exported .Moreover, the area spreading over the region has several places of timely spewed mud volcanoes ,oil seeps and gas shows.There were even historic events of mud volcanoes violent explosion associated with gas flame as high as 100 meters ,sudden flooding accompanying with mud volcano activity onto nearby rice fields with oil, erupted mud flow accidentally buried alive on nearby ploughing farmer. MOGE and later China International company(CNOOC) tried to extract some production in the area but the program run out by reservoir sand lacking and drill well stuck problems.

Lead by geoscientists from ENS (Ecole Normale Superieure) Yangon.Mandalay and Dagon Universities, MOGE ,with financial support from TMEP(Total Myanmar Exploration and Production) GIAC (Geodynamics of India- Asia Collision) joint project study was launched in(1998-1999) together with r.v.Marion Dufresne swath bathymetry and seismic reflection profile mapping (in second phase) cruise within Myanmar Economic Exclusive Zone (EEZ) of Production Sharing Concession deep blocks. The study indicated continental slope with the protruding buttress end near Manaung with three southern evalanche debris flows over the oblique rift fault formed after plate collision in Bengal sea deep.

Earliest country offshore concession opening was in (1974-76) .lead by well known International oil companies covered by multicoverage seismic profiles and drilled unsuccessfully 9 wells (including 2 wells in Sittwe and A2 block) in different blocks along structural folds closer to the shore line. MOGE with CGG in 1993 made Non-Exclusive high resolution seismic survey lines over the whole shelf. with significant DHI reflection lines,two International companies in Rakhine shelf and the other in Moattama shelf , emphasize on more 2D-3D seismic surveys in the blocks and later discoveries made. Rakhine discovery is on Pliocene turbidite slope front fan accurately resolve and image by seismic surveys. The prospective turbidite fans continue to extend to adjacent and to other blocks on shelf as well as towards continental slope .Through out Rakhine high terrain sediment bypassing and erosion carried out through Pleistocene to Pliocene time and deposited as turbidite flows.Gravity mass transport processes are always dominant feature in slope flow system.

Free air satellite gravity map showing , not by edge effect, the large three depression basins along the continental steep slope. Between the mouth of largest rivers Ganges, Bhramaputra and the longest Bengal fan there lies swatch of no ground which extending to east as Rakhine shelf. With transpression from east ,volcanic rocks are lifted up under Pharonga sea. Distribution of vocanic rocks over the shelf and all coastal land area can be detected by Free air gravity. With further manipulation on density effect Bouguer gravity can even delineated the underlying shelf sea bottom configuration like sediment filled ridges ,gorges, and basin depression.

Integration with interpretted Non Exclusive profile result bringing light on the shelf architecture configuration with delineation on major ridge trends, slope flows on the shelf , breached slope flows over continental slope, main slope flow ways , delta mouth aprons, terrace canyon for feeding sediments supply , volcanic intrusion ,rift zone and resistant remnant ophiolites pillar , spewed outcrop on continental slope.

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Roles of CCOP on Promoting the Geoscience Cooperation in Southeast Asia

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The ongoing globalization of economic activities in Southeast Asia has led to heightened awareness of and concerns about the challenges it poses to the international environment. With increased access to information on a timely basis, effects of on utilization of geo-resource and management of geo-hazards have become ever more apparent. These transboundary challenges highlight the need for decision-making processes that go beyond the borders of individual states. They illustrate the necessity of creating administrative structures designed to nurture environmentally sustainable geo-resource utilization and socially acceptable development that function on many levels.

On the one hand, national governments of natural resources and environment occupy a central position within almost all decision-making processes in Southeast Asia; their participation is needed for any viable long-term solution to the area's environmental problems. On the other hand, the role of regional organizations is increasing as they begin to provide more effective channels for cooperation and collaboration among a number of stakeholders. The roles of the regional intergovernmental scientific organizations/ institutions are to address the following questions: 1) what are the most pressing transboundary issues in SEA region? 2) What are the regional forces at play, and how are they responding? 3) What are the gaps in the current governance practices? 4) What are the most promising approaches that could enhance governance at the regional level?

Strategy to deal with transboundary issues in geo-resources utilization, geo-hazards mitigation and environment protection is to foster collaboration by the member countries, based on regional network to influence national networks among geoscientists, decision-makers/planers and stake holders in the benefited/affected areas. The influence is exercised by facilitating neutral platforms for regional and country dialogues on topics; conducting capacity building activities for all member countries to enhance commonsense awareness and strengthen management/research skills; coordinating collaboration by member country for building database, harmonized maps and monitoring system. The database includes a mechanism for sharing knowledge and information on geo-resources management and geo-hazard mitigation through websites.

As a unique intergovernmental organization whose mission is to facilitate and coordinate the implementation of applied geoscience cooperation in East and Southeast Asia for improvement of life quality, the Coordinating Committee for Geoscience Programmes in East and Southeast Asia

(CCOP) promotes capacity building, technology transfer, exchange of information and institutional linkages for sustainable geo-resource development, geo-hazard mitigation and protection of the environment, develop transboundary database and management of geo-information.

For enhancing capacity for management and development of transboundary areas, CCOP is implementing programmes related to Joint Development Area on oil and gas, mineral resources, groundwater management, active fault, as collaborative efforts by Member Countries. CCOP also acts as forums for member countries to gain commonsense knowledge, learn international/regional standards (e.g. UNFC classification, WebGIS based mapping) and share best practices of mineral resource using, mine rehabilitation, geo-park development, solving national issues of mine pollution/groundwater contamination/landslide watch, etc.

Currently CCOP-GSJ/AIST program “Development of Geoinformation Sharing Infrastructure (GSi) for East and Southeast Asia”, the database and maps are being collaboratively established by member countries covering many topics, for example, transboundary groundwater resources (UNESCO), geo-hazards (G-Ever Project), karst geology (IRCK) and shale-gas basin mapping (UnCon Project). Both technical trainings, in Japan and in Member Countries, and server installations were assisted by GSJ and CCOPTS since 2014.

Regarding the transboundary mapping of geoscientific subjects, the OneGeology Program, a global initiative which is initially improving the accessibility of a fundamental geoscience dataset was started since 2006. At present, the harmonized 1:2M geological map of CCOP and the 1:1M geological maps of China, Indonesia, Japan, Republic of Korea, Lao PDR, Malaysia, Myanmar, Philippines and Thailand, are accessible from the 1G Portal, http://portal.onegeology.org/. So far, CCOP has published 1:2M digital seamless geology in CCOP region and now cooperating with ASEAN Secretariat and GSJ/AIST to implement the Harmonized Geology Project with participation by 10 countries: Brunei, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Lao, Singapore, Thailand and Vietnam. Goals of the projects are: Standardization of Geology Legend; Compilation of 1:1M seamless geology; and Development of Data Management System by free and open sources as WebGIS.

CCOP has made solid and steady growth since its establishment in 1966, four in the beginning and now 14 Member Countries, and still has room for further progress in facilitating the collaboration by member countries in solving transboundary issues based on geosciences. For future strategic orientation, CCOP is developing to be a regional data-knowledge center of geoscience and play the most important role to solve societal issues for geo-resources, geo-environment and geo-hazards for sustainable development of this region and beyond.

Tectonics & Mineralization Paper -1

Granite-related W (-Sn) -Mo mineralization in Padatgyaung-Myinmahti area, central Myanmar

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Padatgyaung-Myinmahti area is located 80km E from Nay Pyi Taw and lies at the eastern margin of the Shan Plateau. W (-Sn) -Mo mineralization is spatially associated with the biotite granite of Early Eocene age and low-grade metasediments of Carboniferous to Early Permian Mergui Group. The biotite granite is slightly weathered and intensively greisenized in some places. Quartz veins generally trend N-S and NE-SW with steep dipping (80° -90°). Wolframite and molybdenite is prevalent in both quartz vein and greisen whereas cassiterite is common only in greisenized zone. Greisenization of granite associated with tin-tungsten mineralizations are represented by the mineral assemblage of quartz, muscovite, molybdenite, cassiterite, wolframite with rare fluorite. Quartz veins with wolframite and molybdenite are associated with a biotite granite and metasediments, which has a low Sn content. The quartz veins contain minor amount of galena, pyrite, chalcopyrite, sphalerite, arsenopyrite, bismuthinite, scheelite, bornite and covellite. Wolframite composition ranges from hubneritic to ferberitic composition. Geochemical data indicates that the granites are peraluminous and highly fractionated, and characterized by high SiO_2 with A/CNK [molecular Al_2O_3/ $(CaO+Na_2O+K_2O)$] values of (>1.1). Granite lies in the fields of syn-collision (Syn-COLG) and highly fractionated melt system with enrichment of HREE and Y indicating TG to have within-plate granite (WPG) affinity. Trace element geochemistry, distinct negative anomalies of primitive-mantle normalized Ba, Sr, Ti, Nb and the positive Pb, Rb, Y anomalies reveal that distinct crustal sources have been involved in the formation of granite.

Keywords: Granite; W-Sn-Mo; Padagyaung-Myinmahti; geochemistry.

Tectonics & Mineralization Paper -2

Cordierite-bearing paragneiss and cordierite-free garnet-biotite paragneiss samples from the middle segment of the Mogok metamorphic belt, central Myanmar

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The Mesozoic to Cenozoic tectonic evolution of Southeast Asia is characterized by the closure of the Tethys ocean and subsequent collision of the Indian microcontinent with Eurasia. Progressive convergence between these two continental plates resulted in the development of Cenozoic high-temperature metamorphism and related magmatism in central Myanmar. The Cenozoic Mogok metamorphic belt, located at the western margin of the Shan-Thai Block forms a prominent part for understanding the continental evolution of Southeast Asia, and records subduction- and collision-related events between the Indian and Eurasian plates. It lies along the western margin of the Shan Plateau in central Myanmar and continuing northwards to the eastern Himalayan syntaxis, extending up to 1500 km. This belt consists of gneiss, schist, quartzite, marble, calc-silicate rock, and locally migmatite with various types of granitoid intrusions. Previous geochronological studies, based on U–Th–Pb and Ar–Ar dating, indicates that an assemblage of the Mogok high-grade metamorphic rocks formed during the Paleogene to early Neogene in association with the India–Eurasia continental collision.

Cordierite-bearing paragneiss and cordierite-free garnet-biotite paragneiss in association with marble, and calc-silicate rock dorminate in the middle segment of the Mogok metamorphic belt from the Mandalay to Mogok regions. The typical mineral assemblage of the paragneisses is characterized by garnet + biotite + plagioclase + K-feldspar + quartz with minor rutile, ilmenite, graphite, monazite and zircon, and cordierite and spinel are included in some samples. Conventional geothermobarometers yield pressure–temperature (*P–T*) conditions of 0.60–0.84 GPa/780–860 °C as the peak granulite facies metamorphism. The *P-T* pseudosection analyses of the inclusion phases in garnet and matrix assemblage suggest prograde path from700–730 °C to 710–765 °C at 0.68–0.78 GPa.

The TiO_2 content of biotite coexisting with rutile and/or ilmenite reaches 6.9 wt% and implies high-temperature conditions up to about 820 °C by employing the Ti-in-biotite geothermometer. The compositional relationships between Ti content and other components, total cation, total divalent cation, Si, and Al, suggest that the Ti-vacancy exchange vector of Ti□R_{-2} might be the most effective mechanism to control Ti-substitution into biotite that coexists no Al_2SiO_5 phase under high-temperature conditions. The Zr-in-rutile geothermometer yield temperature conditions of 845 ± 26°C. These paragneisses were extensively recrystallized under lower-amphibolite facies (about 0.40–0.55 GPa/620–640 °C) during the exhumation and hydration stage.

The comparisons of the present data and *P–T* conditions reported in literature suggest that

(1) the metamorphic conditions of the Mogok metamorphic belt vary from the lower amphibolite- to granulite facies, (2) metamorphic grade seems to increase from east to west perpendicular to the north-trending extensional direction of the Mogok belt, (3) granulite facies rocks are widespread

in the middle segment of the Mogok belt, and (4) the granulite facies rocks were locally re-equilibrated at lower amphibolite facies conditions during the exhumation.

Keywords: Paragneiss, Granulite, *P-T* conditions, Mogok metamorphic belt, Metamorphic grade.

Quantifying The Rise Of The Gangdese – Himalaya Orogen And Implications South Asia Monsoon

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Quantifying the rise of the Gangdese-Himalaya orogen since the onset of the India-Asia collision is critical for understanding the coupling between tectonics and climate. We reconstruct the rise of a segment of the Gangdese and Himalaya orogen, using paleoaltimeter based on paleoenthalpy encoded in fossil leaves and oxygen and carbon isotopic compositions from paleosols, lacustrine calcareous carbonates and marls. In Gangdese mountain, we presents new oxygen and carbon isotopic compositions from well dated Tertiary paleosols, lacustrine calcareous carbonates, and marls from the Nianbo (60–54 Ma) and upper Pana Formations (51–48 Ma) of the Linzizong Group in the Linzhou (Penbo) Basin. The paleoelevations are reconstructed using the corrected most negative paleosurface water $\delta^{18}O_{psw}$ values. These imply that the Linzhou area had attained an elevation of 4500±400 m during the period of the Indo-Asian collision, i.e., achieved a near-present elevation (4000m), and may form an Andean-type mountain range stretching the Gangdese arc before collision. The Gangdese Mountains probably maintained high elevations since at least the Paleocene and could play a crucial role in the climate change in the interior of the Tibetan Plateau during the Early Cenozoic. In Himalaya orogen, well preserved fossil leaves from two new assemblages in southern Tibet (Liuqu and Qiabulin) and four previously known floras from the Himalaya foreland basin were found. U-Pb dating of zircons constrains the Liuqu flora to the latest Paleocene (ca. 56 Ma) and the Qiabulin flora to the earliest Miocene (21–19 Ma). The proto-Himalaya grew slowly against a high (~4 km) proto–Tibetan Plateau from ~1 km in the late Paleocene to ~2.3 km at the beginning of the Miocene, and achieved at least ~5.5 km by ca. 15 Ma.

The Gangdese and Himalaya Mountains had archived present elevation in 56-54 Ma and 24-15 Ma respectively. A persistence of monsoon-like rainfall seasonality to the south of the Himalaya-Tibet edifice since the Paleogene (56 Ma) result from the uplift of the Gangdese. Contrasting precipitation patterns between the Himalaya-Tibet edifice and the Himalaya foreland basin for the last ~56 Ma show progressive drying across southern Tibet, seemingly linked to the uplift of the Himalaya orogen. The amount of precipitation just north of the present Himalaya gradually decreased from 103 cm in the late Paleocene, through 90 cm in the earliest Miocene, to 68 cm in the middle Miocene, and to the present 33 cm at Lhasa. In contrast, the low altitude sites to the south of the Himalaya-Tibet orogen show that summer rainfall has remained in a relatively stable range between 96 cm and 118 cm since ca. 56 Ma.

The first portable seismic array in Myanmar and the crust and upper mantle structures beneath north central Myanmar

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The Eastern Himalaya Syntaxis (EHS) is an ideal natural laboratory to study the spatial-temporal transition from oceanic subduction to continental subduction during the Neo-Tethyan subduction. As an important part of the eastern Himalaya syntaxis, the seismic velocity structures and physical properties of the lithosphere beneath the Indo-Burma Range and the West Burma Block would help us further undertand its dynamic process.

Since June, 2016, we have executed the China-Myanmar Geophysical Survey in the Myanmar Orogen (CMGSMO) and deployed the first portable seismic array in north central Myanmar in cooperation with the Myanmar Geosciences Society (MGS). This array contains 70 stations with a dense-deployed main profile across the Indo-Myanmar Range, the Central Basin and the Shan State Plateau along latitude of ~22° and a 2-D network covering the Indo-Myanmar Range and the western part of the Central Basin. All field work will be finished in January 2018 and most of the stations have seismic recordings of 12-18 months.

The preliminary results of the receiver function common conversion point (CCP) stacking showed obvious variations of the crust and the uppermost mantle structures from the Indo-Myanmar Range to the Central Basin and the Shan State Plateau. The crust structure beneath the Central Basin is characterized by a thick sedimentary cover and a shallow Moho, which is a common characteristic in extension tectonic setting. The Moho beneath the Shan State Plateau is relatively flat and has a crustal thickness of ~30 km, similar as those beneath the southern Yunnan Province. The lithospheric structure beneath the Indo-Myanmar Range is more complex than that beneath the Central Basin and Shan State Plateau. Ongoing study of the detailed crustal and uppermost mantle structures beneath the study region, applying an imaging technique to model the CCP stacking profile, will descript the development of the Neo-Tethyan subduction and understand related evolution dynamics.

This study is supported by the National Natural Science Foundation of China (grants 41490612).

High-grade Epithermal Veins in the Kwin Thone Ze Districtm Shante Gold Province, Mogoke Metamorphic Belt, Central Myanmar

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The Kwinthoneze Sub-district is a 200 km^2 NNW- trending area situated in the Mogok Metamorphic Belt immediately east of the Sagaing strike-slip fault. The Sub-district lies north of Singu in the southwestern part of the Shante Gold district which includes the Myole-Thayetsu Sub-district northwest of Mogok. In the Kwinthonze Sub-district gold mineralisation is worked in veins to depths of about 300 m. The veins are hosted by diopside phlogopite graphite marbles with occasional spinel, and by interlayered sillimanite schists and migmatites, calc-silicates, and to a lesser extent by ca 17 Ma granites, indicating that gold mineralization is mid – Miocene or younger. Veins are described here from the Kandaung, Shante, Donwe and Sharchat deposits, but at least 10 other deposits were recently in production. In the Kandaung veins, there are Kandaung West (A2 or Claim 127) vein and Kandaung (2A) vein, about 2.1 km apart. Kandaung West (A2 or Claim 127) vein strikes north-northeast and dips moderately east-southeast. Kandaung (2A) vein strikes north-northwest and dips moderately east-northeast with associated overlying black shear zone that is either manganese or graphite. Shante vein strikes north-northeast and dips moderately east-southeast. Donwe vein strikes north-northwest and dips moderately east-northeast. Sharchat vein strikes north-northwest and dips moderate to steeply northeast in granite intrusion which has a 17 Ma Zircon U-Pb age. Among workings in the Sub-district, all have base metal sulphides and pyrite. Galena is the most common base metal sulphide, occurring in veins and as pods of massive sulphide but in a few veins copper sulphides predominate. Pyrrhotite is widespread in some deposits, for example Shante. Tellurides occur in metallurgical test samples from Kandaung West (A2 or Claim 127) vein system. University studies have identified adularia in some deposits, indicating low sulphidation or adularia-quartz epithermal mineralisation. This is supported by the presence at Donwe of hydrothermal breccias, crustiform veins and possible geyserite. However the pyrrhotite may indicate that some deposits include gold skarns. The heat source is thought to be younger and deeper than the granites but could be represented by very rare hornblende biotite dykes or lamprophyres. Cumulative production in the Sub-district is probably a few tens of tonnes of gold.

Acid, Intermediate and Basic-Ultramafic Igneous Rocks from Bilin area, Mon State

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The study area is situated in northern part of Mon state; about 106 miles from Yangon and about 60 miles from Mawlamyine. Geologically, the study area falls in the southern part of the Mogok Belt that runs as a narrow linear belt trending NNW-SSE in the western marginal zone of the Shan-Tanintharyi region. The study area covers about nearly 70 square miles. In the area, Carboniferous clastic rocks are intruded by various kinds of igneous rocks forming regional, thermal and locally cataclastic metamorphic rocks. Six units of igneous rocks and three units of metamorphic rocks occur in the area.

Host rocks of the area are found in the western part of the area near Alugalay village represented by metasedimentary rocks of quartzite, slate, phyllite, spotted phyllite and biotite gneiss. They are assumed as metamorphosed Taung Nyo Series of Carboniferous age. They trend NNW- SSE with dip amount of 35° to 40° to the west.

The majority of rocks occurring in the area are igneous rocks. Three major rock types are leucogranite, biotite-hornblende diorite, and basic-ultramafic rocks. Leucogranite is the most abundant rock type and occurs in the eastern, northeastern and northern parts of the area as high mountains. Biotite- hornblende diorite and basic-ultramafic rocks are less important and occur in the western and northwestern parts of the area as hillocks. The other igneous rocks occur as dykes, veins and small patches.

The acid igneous rocks of the area are: garnet bearing pegmatite, leucogranite, biotite granite, greisen (coarse-grained), aplite, microgranite, micro graphic-granite (medium-grained), and porphyritic rhyolite, banded rhyolite with flow structure (fine-grained). Garnet bearing granites occur in adjacent north of the study area.

The intermediate igneous rocks of the area are: biotite-hornblende diorite (coarse-grained) and porphyritic andesite (medium-grained).

The basic-ultramafic igneous rocks found in the area are pyroxenite (coarse-grained), dolerite (medium-grained) and spessartite (lamprophyre).

According to available field occurrences, biotite hornblende diorite is regarded as the oldest and basic – ultramafic is younger than the leucogranite.

The igneous rocks occurring in this area are assumed as both I-type and S-type. It is suggested that the intrusion of igneous rocks occur in multiple phases in Cretaceous- Paleocene.

Tectonics & Mineralization Paper -7

Preliminary 3D velocity structure of the Central Myanmar Basin

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The geometry and velocity structure of the Central Myanmar Basin is critical to understand the tectonics in Myanmar. In addition, most of the Myanmar population lives within this basin, with several major cities, including the capital, located along the active strike-slip Sagaing fault that lies to the eastern edge of the basin. Therefore, better understanding of the basin structure is also crucial for the future seismic hazard preparation. In the central of the basin, the sediment thickness is at least 15 km as inferred from the interpretation of sparse seismic reflection profiles. However, insufficient seismic observations have precluded an integrated constraining the sedimentary structure of the basin. Here, we present our preliminary results of the crustal-scale seismic structure of the Central Myanmar Basin based on a joint inversion of Rayleigh wave ellipticity and receiver functions from the newly updated Myanmar National Seismic Network (MM, 9 seismic stations) and Earth Observatory of Singapore – Myanmar Seismic Network (EOS-MM, 29 seismic stations). We observed an up to 18 km basin-fill in the central Burma. Our results also reveal the 3D geometry of the Central Myanmar Basin. We then used the 3D seismic waveform simulation of a regional earthquake (2017 Mw 5.1 Taik-Kyi) to verify our newly updated 3D basin structure, which can greatly improve the surface waveform fits than the 3D CRUST 1.0 model.

Geotechnical Conditions And Lessons Learnt From Dam Foundations, Tunnels And Slopes In Different Formations Along The Western Ranges, Magway And Sagaing Regions

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Geotechnical investigations and Characterization of tunnels, dam sites and slope in different formations along the western ranges are carried out in order to evaluate geotechnical information and problem associated with foundations. Most of the rocks are related to subduction zone and they show different deformation pattern as well as squeezing nature and unstable slope condition. This paper includes "Major geotechnical conditions and lessons learnt from Manipur Multipurpose Dam Project and Tunnel, Yazagyo Multipurpose Dam Project, Bu Multipurpose Dam Project, Upper Bu Multipurpose Dam Project, Mone Multipurpose Dam Project and Tunnel, Myittha Multipurpose Dam, Ponnya Taung Railway Tunnel, and Slope Stability Analysis of Kyaw-Yemyatni Railway Line."

Manipura Multipurpose Dam and Tunnel Project is situated on the Manipura River. The rocks of the project area include three different units: Falam Mudstone-Micrite, Chunsung Mudstone-Turbidite and Exotics (micritic limestone). According to litholgy, borehole data and water pressure test, foundation conditions and types are described and discussed. The geotechnical parameters for Manipura Diversion and Power Tunnels are classified on the basis of available data as these tunnels are under constructions. The present available data indicate that the rocks of both diversion and power tunnel alignment fall in "poor" rock mass class.

Yazagyo Multipurpose dam project is located on “Neyinzayar Chaung”. Three types of rock units: Pane Chaung Formation, Yazagyo Metamorphics and Intrusive rock unit (Dolerite and Serpentinite) are observed. The landslide body of the right abutment consists of much volume of loose fragments and residual soil which extend up to the entire bank of the river. Such kind of compressible ground is evaluated. Installation of well-designed retaining walls and bending the dam alignment by using turning point are also discussed.

Bu Multipurpose Dam Project is selected on the upstream of Mone Chaung near Bu Village. Two lithostratigraphic units, Paunggyi Formation and Sin Chaung Exotics Zone are observed. According to the borehole data, the interpretative profile along the main dam axis is made up of indurated shales with occasional occurrence hard blocks or boulder. The characterization of Bu Dam and highly to moderately pervious condition are also described and discussed.

Upper Bu Dam site and its appurtenant structures are located on the contact zone between Serpentinite and Paunggyi Formation. Field investigation indicated that about 70% of the proposed dam base area is to be founded within massive serpentinite and sheared serpentinite (bimrock). Moreover, multi-landslides occurred at the upper portion of the right abutment. This was rejected to construct and implement due to the adverse foundation condition after the detailed observation.

The alignments of Mone diversion tunnel and power tunnels are selected in a plunging anticline which is composed of Paunggyi Formation; central portion of the tunnel axis is parallel to the general strike of the rocks except in outlet and inlet portals. The alignment of dam axis is situated in Laungshe Formation. For the geotechnical condition of tunnel and dam alignments, the influence of engineering geology on the stability of excavated areas and the problems associated with swelling shales are described and discussed.

Myittha main dam is situated on the Myittha River, 12 miles away to the southwest of Gangaw. Main dam and its appurtenant structures are sited in Pane Chaung Formation. According to the boreholes data, the bedding trend is quite different in the left and the right banks. In the right bank, layers run across the dam axis with a high angle, and dipping to the hill side whereas, in the left bank, layers lie almost flat near the river and a little dipping to the hill side (west). This structural difference rock mass grades are also describe and discussed.

The rocks exposed in Ponnya Taung Tunnel area belong to the Pondaung Formation. The geotechnical parameters for Mone Tunnel are also analysed. Geotechnical condition along the tunnel

alignment was identified and classified into structural regions. Squeezing nature for each structural regions are evaluated.

Analysis of Slope Stability along Kyaw-Yemyatni Railway Line is evaluated using finite method and Slope Mass Rating (SMR) to match real condition in the field. Both outcome results are coincided and also indicate the instability nature of the slope along the railway line. Finally, zone map has been prepared using two methods mentioned above.

It is learnt that engineering geological mapping of the tunnel and dam site is not properly done to identify and record the lithology and structural set-up including all the visible geologic defects at the surface. It is hoped that this paper will highlight the important role of geological structures and geotechnical parameters in civil engineering construction of infrastructures such as tunnels, dams and slopes, etc.

Key words: geologic defects, geotechnical parameters, investigation, landslides, sheared serpentinite (bimrock), squeezing nature

Maar lakes and preliminary study on high resolution paleoclimatic change in Myanmar

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Maar lakes in Myanmar are invaluable archives for understanding climate variabilities on different timescales, from years to decades to millennia. We present a preliminary result of paleoclimatic change from annually laminated sequence in Maar Lake Twintaung, Myanmar. On the centuries-millennia timescales, compound-specific carbon isotope composition of n-alkanes and sedimentary magnetic susceptibility reveal a gradually decreased monsoonal rainfall from 7990 to 1900 years BP, then to a large variable period from 1900 years BP to the present. On the annual to decadal annuals timescales, high resolution elemental data show distinct interannual and decadal variabilities that link with El Niño–Southern Oscillation (ENSO)-like and Indian Ocean Dipole (IOD)-like variability at periods of 2–7 years. Especially, ENSO-like variabilities were significantly changed around AD 1750, a weaker variabilities between AD 1475 and AD 1750, and an enhanced variabilities after AD 1750. Dynamically, the regional monsoonal rainfall recorded in maar lake Twintaung are likely coupled with several processes such as ENSO, tropical sea surface temperature and anthropogenic forcings.

Key Words: Maar Lake; Carbonate varves; Indian Summer Monsoon; centennial to millennial timescales, annual timescales ENSO

Geotechnical,Geohazards & Geopark Paper -3

Geoheritage and Geoparks in China

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Geoparks, as an innovation for the conservation of geological heritage, play an important role in the development of many parks and protected areas. As defined by UNESCO, “a Geopark is an area with a geological heritage of significance, with a coherent and strong management structure and where a sustainable economic development strategy is in place . . . geological heritage and knowledge are shared with the broad public and linked with broader aspects of the natural and cultural environment, which are often closely related or determined to geology and landscape.”

China, with its vast territory and complex geological & geomorphic features, has received the designation of the UNESCO Global Geopark for thirty-five areas of outstanding geological heritage, and is the world’s leading country.

The aim of this paper is to present a comprehensive overview of geoparks in China, and to provide insights for possible creation of geoparks in Myanmar. This paper reviews the establishment and development of geoparks in China, evaluates goals, values, impact and conservation effectiveness in the geoparks. Therefore, establishing geoparks in Myanmar may stimulate the creation of innovative local enterprises, new job opportunities, and generate new resources of revenue stemming from geotourism.

Geotechnical,Geohazards & Geopark Paper -4

Controls on the terrace system of Lower segment of Irrawawaddy river, Central Myanmar Basin

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Development of river terraces is mainly controlled by changing tectonic and climate conditions, therefore they can be used as archives for paleotectonic and paleoenvironmental reconstruction.

The Ayeyarwady is Myanmar's largest river, flow from north to south for a distance of (about 2170 km long) with a total drainage area of about 411,000 km². There are composed of at least defined three defiles, five terraces and nine major distributaries. The course of the Ayeyarwady can be divided into three parts (segments): *the upper, the lower*, and *the delta*. The *upper segment* extends from the confluence of the Mai Kha and the Mali Kha down to the confluence with the Chindwin River near Pakokku. The Lower segment is demarcated from the confluence with the Chindwin and the big river winds through the central lowland of Myanmar until it reaches the tip of the delta above Hinthada. There are at least *nine major distributaries* by which the Ayeyarwady empties its sediment-laden waters into Andaman Sea via the Gulf of Mottama.

At least *five river terraces* have been recognized along the Lower segment of Ayeyarwady, particularly between Nyaung-Oo, Chauk,and Yenangyaung. De Terra (1939) and De Terra & Movius (1943) identified those five levels in a terrace system above the river: **T1** (30-60)m, **T2** (55-76)m, **T3** (27-33)m, **T4** (17-20)m, **T5** (12)m during middle Pleistocene to Recent.

The Irrawaddy River continued to cut a wide valley after the middle Pleistocene, later filled in part by deposits of Terraces. The terrace sequences are associated with thick Quaternary valley fills and a total incision depths of about (76) m. Terrace elevation shows a gradual increase downstream from North to South. Each terrace, from lowest (T1) to highest (T5), has its own sediment package, characterized by low sinuous, shallow bathymetry, sandy braided river (Naing Maw Than 1993).

In Upper Pleistocene, a thick sequence of terrace T2 was formed during the heavy rainfall period of Upper Burma (Myanmar) in two to three times that of current times encountered with the *Third Glacial Stage* of the Himalayas. Terrace T3 have been occurred a wide level and it is thought to be the counterpart of the *Third Interglacial* in the Himalayan sequence. Terrace T4 was formed during the Fourth Pluvial Stage belonging to the late Upper Pleistocene.

The transition from aggradation to incision occurred during T2 to T3 stage, that may have been caused in large part by precipitat ion-starvation. A combination of high sediment availability and increased precipitation make result in substantial aggradation of the valley floor followed by incision of T3 in interglacial stage.

The study area belongs to eastern flank of synclinorium in the Central Myanmar Salin basin and regional aggradation probably related with tectonic controls particular in early stages.

With further works over a wider region and chronologies of terrace system enables construction of a more complete terracing history, which can be better correlated to climate history of central Myanmar basin.

Key Words, Irrawawaddy, Central Myanmar Basin, Salin, Terrace system

Early Permian (Cisuralian) brachiopod fauna from the Yinyaw beds in the Yinyaw area, Pekon Township, southern Shan State, Myanmar

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The Yinyaw beds are very well exposed near the Yinyaw village, 23 miles west of Moebye, Pekon Township in the southern Shan State. They contain very abundant brachiopod fossils. After a preliminary examination, we identified the brachiopods: *Retimarginifera alata, Neospirifer fasciger, Spinomartinia prolifica, Phricodothyris* sp., *?Derbyia* sp., *Stereochia koyaoensis, Stenoscisma qasimultabilis, Transennatia* sp., *Martiniopsis* sp., *Spiriferella salteri, Costatumulus?* sp. Based on these brachiopods, the present fauna probably indicates that the Yinyaw beds may be of late Early Permian age. Of the brachiopods, *Spinomartinia prolifica*, *Retimarginifera alata*, *Stereochia* sp., etc. are also present in the Lebyin Group at Ngayanchaung of the Lebyin area and the Taungnyo Group in the Kya In Taung, northern part of Zwekabin range, thus, it is clear that the Yinyaw beds are equivalent to the upper part of the Lebyin and Taungnyo groups.

Keywords: Early Permian**,** brachiopods, Yinyaw beds, southern Shan State, Myanmar

Sequence Stratigraphy Of The Neogene Sediments Exposed In Myothit – Taungnyo Area,Magway Region And Nay Pyi Taw Council

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The study area is situated in south-east of Myothit Township and south-west of Taungnyo Township, Magway Region and Nay Pyi Taw Council Area. The study area is located in the eastern part of the Central Cenozoic Belt and the middle part of the Pegu Yoma. Pegu Yoma is a morphological and geological unit about 400 miles long and 40 miles wide which generally strike NNW-SSE. The study area lies between the Sagaing Fault in the east and the Central Volcanic Line in the west of the area.

The study area mainly consists of the siliciclastic rocks belonging to the upper Pegu Group (Middle Miocene). The clastic rocks are mainly observed and classified into three formations based on the lithologic characters and paleontological evidences. Three stratigraphic units are the Moza Formation, the Khabo Sandstone (Middle Miocene) and the Irrawaddy Formation (Late Miocene to Pliocene). The two sequences of the Moza Formation and the Khabo Sandstone are mainly consisted of tide-dominated estuary deposists well exposed in the west and unconformably overlain by fluvial deposits of the Irrawaddy Formation in the east.

In the study area, 12 detail sections are measured along car road and stream section. There are four major marine transgressions interrupt this generally regressive succession. The present study area was influenced by tidal and fluvial currents, therefore, the sequence stratigraphic interpretations are devoted mainly to shallow marine and brackish water deposits of the Moza Formation and Khabo Sandstone.

The sequence of the study area, The system consists of tide-generated deposits attributed to channel, bay-fill, tidal delta, shoal and sand-flat depositional setting. The planar cross-bedded subtidal sand-bar facies of the Moza Formation are found the early transgressive system tract in the tide-dominated estuarine incised-valley system. The fast to slow relative sea-level rise, as evidenced by progradation of sandwedges in the Khabo Sandstone estuarine environment, caused changes to the basinward-stepping stratigraphy.

Lithofacies Analysis of Middle Miocene Balikpapan Formation, Samarinda Area, Lower Kutai Basin, Indonesia

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Rock units of Middle Miocene Balikpapan Formation are well exposed in a section near Samarinda city, East Kalimantan, Indonesia. Geologically, it lies within the Lower Kutai Basin. The succession is characterized by thick sandstone bodies alternating with shales and coal beds. This succession is a part of the Samarinda Anticlinorium and located between Separi Anticline and Prangat Thrust. The outcrops constituting the succession are currently, easily accessible and are situated close to the main road to Samarinda, near and around the new stadium built in 2007. The present study was aimed in order to interpret sedimentary facies, enabling the geology to be recorded and to make measure sections. The sediments were examined at 10 sites and the study stratigraphic section shows 250 m (not included soil interval) of vertically stacked sediments constituted by three main lithologies: (1) thick sand bodies (0.5 to 14 m), (2) shale intervals (0.5 to 6 m thick) and coal layers (0.5 to 1.5 m thick). Locations of the stratigraphic sections were recorded with the aid of Global Positioning System (G.P.S) receiver. The sedimentary structures and tectonic deformation were examined and recorded. Dip and strike of the strata was measured using Brunton compass. Topographic map, satellite image of the area, measuring tape, camera, hand lens and geologic hammer were used as additional field equipments. The thickness of the sections was directly measured by using Jacob Staff. The stratigraphic sections were supplemented by photographs of sedimentary structures and outcrop nature. A total of 10 locations were obtained for the composite columnar section. The stratigraphic columns were reproduced using Corel DRAWX3 software. The sandstones are interpreted as fluvial channels and their associated crevasse splays environment. The shales are interpreted as a flood plain setting. The coal layers are interpreted as a continental swamp environment. From the outcrop observation, a total of six different facies can be discriminated base on their predominant physical characteristics. They are conglomerate and sandstone facies (Cst), coarse to medium-grained sandstone with trough cross-bedding facies (St), fine-grained sandstone with current ripples facies (Fsr), thinly interbedded siltstone and mudstone facies (Fsc), mire (coal) facies (M), Mudstone facies (Ms) and Carbonate facies (Cc). The sediment in the research area shows at its bottom a very rapid shift of facies from open marine shelf to continental fluvial environment. The coal beds are landwards correlative surfaces of maximum flooding surfaces. The coals of the Samarinda area are forming from "abrupt marine regression", where sea level dropped suddenly allowing for possible subaerial exposure and then peat formation during subsequent transgression. Both plant roots and burrows are relatively common in the sediments, particularly below coal seams, indicating that the coals probably accumulated from autochthonous vegetation and not from transported organic matter.

Keywords: Sedimentary Facies, Balikpapan Formation, Samarinda, Kutai Basin

Geology and Discoveries on Primary Gold Mineralization at Kalein Area, Shwegyin Township, Bago Region

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The research area, Kalein is located about 8 kilometers in the eastern part of Shwegyin Township, Bago Region. This area is one of the economically highly potential of the gold district of the primary and secondary gold occurrences in Myanmar. The area lies within the Mogok Metamorphic Belt (MMB) that developed late Oligocene to early Miocene. The MMB represents an important exploration target because of the gold districts of Thebeikkyin, Phayaung Taung and Modi Taung to the south. The regional geology of the study area is characterized by Paleozoic metasedimentary rocks and Mesozoic granites. The low-grade metasedimentary rocks are highly foliated, unfossiliferous, extensively intruded by granite and they show effects of contact metamorphism at places. It is very interesting to note that the appearances and zonation of primary mineralization by the field observation and the secondary deposits or alluvial deposits are also interested in this area. The alluvial deposits were not tested in this time but it may be an interested potential area by the local information and the good potential around this area. Gold generally occurs as a minor constituent in the stream sediment in the area and the local people panned the placer gold in the last thirty years. Gold-sulphides mineralization occurs small veinlets from near the Kalein worksite area. Gold mineralization is mostly hosted into the alteration zone of meta-sedimentary rock of Mergui Group. The nature and occurrences of gold and sulphide minerals strongly suggest that mineralization is formed by hypogene process because sulphide minerals are dispersed through the oxidized zone. Mostly gold occurs as free grain in oxidized zone. The oxidized gold nuggets are found many places in this research area. The primary sources of high gold values from underground mineralized quartz veins are found at the 35-meter depth in vertical shaft and which are clearly associated with book-and-ribbon textures, most high-grade zones are not surprisingly in veins with these fractures, although some veins of anhedral quartz associated with gold also have values averaging above 20 ppm. The Kalein area has many features typical of mesothermal related gold mineralization. Biphasic inclusions formed by primary growth zone that is formed on the parent crystal, isolated, sometimes in groups), and secondary to the main minerals quartz and general calcite. In fluid inclusions derived from water-rich epithermal environment and has a low salinity. With a relatively low salinity, samples are on-mesothermal to epithermal environment.

Keywords: fluid inclusion, gold mineralization, mesothermal, Shwegyin

Orogenic Gold Mineralization in Kyaukkyi Area, Bago Region, Myanmar

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The orogenic gold mineralization at Kyaukkyi area is located in the northern part of the Bago Region, Myanmar. Tectonically, the area lies between the two major dextral Strike Slip Faults zone of Sagaing Fault and Papun Fault. The Gold mineralization is hosted by a Carboniferous sequence of Mergui Group that is dominated by deformed greenschist, phyllite, mudstone, quartzite, that exhibits a low grade greenschist facies metamorphism, and which is intruded by the granitic rocks of Mesozoic in age. Gold mineralization at Kyaukkyi area occurred over a prolonged deformation of dextral strike slip shear zone, but is closely related to alteration, retrograde greenschist-facies assemblages, and ductile and brittle deformation. The presence of deformed Au-bearing quartz veins, and their concordant and discordant relation with respect to the main mylonitic foliation and the shear zone. The Au-hosting shear zones are characterized by extensive development of heterogeneous mylonitic rocks that enhanced the permeability within the shear zones. This gave rise to further extensive dilatancy within major dilational jogs and produced a suitable structural regime for vein-hosted Au mineralization. The epigenetic Au mineralization resulted from metamorphic hydrothermal fluids circulating through major shear zones and associated structures during the late stages of orogeny. The investigation of this research shows that granitic intrusions have no genetic link with gold mineralization. The origin of gold mineralization of this research area cannot be intrusion-related. Metamorphic devolatilization and fluid flow is suggested for the genesis of the gold occurrences in both ductile and post-transpressional brittle structures. Fluid inclusion data and mineral identification result by Laser Raman recommends that the type of gold mineralization at kyaukkyi area is Mesothermal Type deposit.

Keywords: Orogenic, Dextral Shear Zone, Fluid Inclusion, Kyaukkyi, Myanmar

Tectonics & Mineralization Paper -10

Cenozoic magmatism, mineralization and tectonic setting at Shangalon Au-Cu district, north of Wuntho-Popa Arc, Myanmar

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The Shangalon Au-Cu ore district lies 170 km from north of prominent Monywa high sulfidation epithermal deposit, northern part of Wuntho-Popa arc, within central volcanic arc of Myanmar. The Shangalon mineralization hosted in the pluton mainly comprising diorite and granodiorite which intruded by tonalite-porphyry and diorite-porphyry. The early quartz diorite and diorite is a zone of highly developed stockwork and sheeted quartz-sulfide vein-let associated with disseminated and vein type high-grade copper mineralization such as chalcopyrite, pyrite, minor bornite and uneconomic molybdenite with intensive alteration. The barren crenulated quartz layer (USTs) set in aplitic rock comprise vapor rich and NaCl rich inclusions. The wispy sec-biotite (EB) vein with A vein were the first in Shangalon. The amphibole are pervasively replaced by secondary biotite also coexists with magnetite and rutile which is typically disseminated as a potassic alteration. The quartz-carbonate veins with tennantite-tetrahedrite are associated minor galena and sphalerite as a transitional zone between porphyry and epithermal. The open space veins, chalcedonic veins and barren breccia occurs the outside zone of main mineralization.

The U-Pb zircon age of tonalite-porphyry and diorite-porphyry yield 37.4 $\pm$ 0.3 Ma and 37.8 $\pm$ 0.4 Ma respectively, while the main mineralization related diorite and granodiorite yield 38.0 $\pm$ 0.4 Ma, and 36.9 $\pm$ 0.2 Ma respectively. The main Au-Cu mineralization in Shangalon is porphyry-style mineralization related with Eocene (ages from ca. 38 to 36 Ma) diorite to granodiorite with SiO_2 contents ranging from 50.66 wt% to 65.91 wt.%, belonging to calc-alkaline to high calc-alkaline. The trace elements of plutonic and volcanic rocks from Shangalon are marked by enrichments in LREE and depletions in HREE patterns in the rare earth (REE) diagram, and most are accompanied Eu anomalies (Eu/Eu* = 0.40-1.22). In the primitive diagram, significant enrichments in LILEs (Cs, Rb, Ba, Tha and K) and depletions in HFSEs (Nb, Ta and Ti with high peak of Pb). These characteristics are similar to those of representing a typical arc-like geochemical feature. Their Sr and Nd isotopes present initial Sr ratios from 0.70528 to 0.70823 and ε_{Nd} values from +1.87 to -4.62, which could be the partial melting of the mantle wedge followed by crustal contamination and/or magma mixing, with the calculated T_{DM}^{C} model ages between 0.70 and 1.20 Ga. The Hf isotopes young-aged zircons from these volcanic-plutonic rocks show the wide variation of εHf (t) values from +0.66 to +14.26.

Our geological and geochemical study reveals the mineralization style in Shangalon may probably be related to transitional zone between the deep root of epithermal-type mineralization and the top portion of the beneath porphyry Cu-Au system. And the multi-phase high-grade Au-Cu mineralization could be controlled by the arc magmatism related to the Neo-tethyan oceanic subduction.

Tectonics & Mineralization Paper -11

Kinematics, geodynamics and paleoseismology of the sinistral faults on the Shan Plateau, SE of the eastern Himalayan syntaxis

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Characterizing the 700-km-wide system of active faults on the Shan Plateau bounded by the Red River and Sagaing faults, southeast of the eastern Himalayan syntaxis (EHS), is critical to understanding the geodynamics and seismic hazard of the large region that straddles neighboring China, Myanmar, Thailand, Laos and Vietnam. Here we evaluate the fault styles and slip rates over multi-timescales, reanalyze previously published short-term GPS velocity field and evaluate slip-rate gradients to interpret the regional kinematics and geodynamics that drive the crustal motion. Geomorphic mapping of the sinistral-slip fault zones using SRTM 30-m DEM and ALOS 5-m DSM, together with previous paleoseismological and geomorphic studies and the seismicity of the Shan Plateau region, suggest that all sinistral-slip faults on the Shan Plateau have been active at least since their initiation of sinistral slip. Relative to the Sunda plate, the GPS velocities across the Shan Plateau show a broad arcuate tongue-like crustal motion with a progressively northwestward increase in sinistral shear over a distance of ~700 km followed by a decrease over another ~100 km towards to the EHS. The cumulative GPS slip rate across the entire sinistral-slip fault system on the Shan Plateau is ~12 mm/yr, consistent with the cumulative long-term geologic rate averaged over ~10 Ma. Our observations of the fault geometry, slip rates and the arcuate southwesterly-directed tongue-like pattern of GPS velocities across the region suggest that the fault kinematics is characterized by a regional southwestward distributed shear across the Shan Plateau, as compared to block-like rotation and indentation north of the Red River fault. The fault geometry, kinematics and the regional GPS velocities are difficulty to reconcile the regional bookshelf faulting between the Red River and Sagaing faults and localized crustal channel flows beneath this region. The crustal motion and fault kinematics can be driven a combination of basal traction of a clockwise, southwestward asthenospheric flow around the EHS and gravitational/indenting forces sourced from north of the Shan Plateau region.

To better understand the millennial slip rates and earthquake recurrence intervals of the sinistral faults, we chose the Jinghong fault, one of the primary faults on the Shan Plateau, as an example. High-resolution topographic and stratigraphic studies on several offset sites along this fault, provide an upper bound of the fault slip rate of 2-3 mm/yr. Three excavations along the NE section of the fault constrain the time of last ground-rupturing earthquake to be between ~500 and ~1000 years ago.

Geochronology of the Myanmar ophiolites and its implications for tectonic framework

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Southeast (SE) Asia comprises a giant 'jigsaw puzzle' of continental terranes (e.g., Indochina, Sibumasu and West Burma) that amalgamated during the Mesozoic after rifting and separation from Gondwanaland during the Paleozoic to Mesozoic. Rifting and suturing of these continental terranes was accompanied by the opening and closure of three successive Tethys oceans, i.e., the Paleo-Tethys, Meso-Tethys and Neo-Tethys, since the Paleozoic. Thus, the Tethyan evolution is essential to the geological history of SE Asia. Sutures of the Tethys oceans have been well established in the Tibetan Plateau. The Paleo-Tethys suture is marked by the Carboniferous Longmu Co-Shuanghu belt, which continues southeastward to the Bentong-Raub suture in Malaysia through the ophiolite belt lying east of Myanmar. The Neo-Tethys suture is represented by the Yarlung-Tsangpo belt, which connects with the ophiolite belt along the eastern Indo-Burma Range. The Meso-Tethys suture is best exposed along the Bangong-Nujiang suture in central Tibet, but its occurrence in SE Asia remains unclear. For example, crucial ophiolites that outcrop within Myanmar have been poorly studied. In the past several years, we have conducted a combined analysis of zircon SIMS U-Pb ages and Hf-O isotopes of two Myanmar ophiolites, namely, the Kalaymyo ophiolite and the Myitkyina ophiolite, from the Western and Eastern Belts, respectively. Our results show that the Kalaymyo ophiolite has an Early Cretaceous age (ca. 127 Ma), coeval to Neo-Tethyan ophiolites along the Yarlung-Tsangpo Suture. In contrast, the Myitkyina ophiolite was formed during the Middle Jurassic (ca. 173 Ma) and thus the Eastern Belt is the southern continuation of the Meso-Tethyan Bangong-Nujiang Suture in the Tibetan Plateau. Consequently, we argue not only that the two Myanmar ophiolite belts belong to two different sutures of the Meso-Tethys and Neo-Tethys, but also that the boundary between the Sibumasu and West Burma blocks is a Jurassic suture rather than a transcurrent shear zone. These geochronological data of ophiolites provide important temporal constraints on the tectonic framework of Myanmar geological evolution.

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Fluid processes in the forearc mantle as constrained by jadeitites and associated serpentinites, Myanmar

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Subduction-zone fluids are critical for transporting materials from subducted slabs to the mantle wedge. The sources and properties of subduction-zone fluids are mainly identified by the trace element and isotopic compositions of arc magmas, making fluid processes and properties in the forearc region unclear. Mg-rich jadeitites from Myanmar are unique samples that record fluid compositions and reactions in the forearc subduction channel. Here, we present mineralogical, petrological and Mg isotopic data of the Myanmar jadeitites and associated rocks to understand the fluid processes in the forearc mantle. Two types of jadeitites exhibit distinct textures and Mg isotopic compositions. The white jadeitites precipitated from Na–Al–Si fluids show rhythmic zoning and low δ^{26}Mg, varying from -1.34‰ to 1.03‰, whereas the green jadeitites have relatively higher δ^{26}Mg (-0.91‰ to -0.11‰) due to metasomatic reactions between fluids and Cr-spinel. The amphibole-rich blackwall on the contact boundaries between jadeitites and serpentinites also exhibits low δ^{26}Mg values (-1.17‰ to -0.72‰). Therefore, the jadeite-forming fluids are not only rich in Na–Al–Si–Mg but also light in Mg isotopes. Our observations indicate that the fluids were likely derived from multiple sources in the oceanic subduction channel. The enrichment of Mg in the fluids is better explained by the dehydration of brucite and antigorite in serpentinite at the slab–mantle interface, as evidenced by the formation of metamorphic olivine (Fo96-97) in the country serpentinites. The light Mg isotopes in the jadeite-forming fluids are likely attributed to the dissolving carbonates from sediments or serpentinites. In this regard, some carbonates (calcite) can be released from subducted slabs via dissolving processes. Therefore, the white jadeitites were directly precipitated from a mixture of Na–Al–Si-rich fluids (from subducted sediments and oceanic crust) with Mg-rich fluids from serpentinites. Such Na–Al–Si–Mg-rich fluids would react with Cr-spinel to create isotopically heterogeneous Mg in the green jadeitites. Therefore, the subduction of serpentinites, fluid mixing and metasomatism in the forearc subduction channel are potentially important processes in creating the Mg isotope heterogeneity of the mantle.

Mesozoic-Cenozoic Magmatism Of Central Myanmar Arc: Implication For Tectonic Evolution In Myanmar

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Myanmar can be traditionally regarded as the accreted continental blocks, and tectonically into four belts, Shan-Thai block, Central Myanmar Belt (CMB), Indo-Myanmar Ranges (Suture), Rakhine Coastal Belt. Central Myanmar Arc (CMA) in Central Myanmar Belt (CMB) occupies Cretaceous to Quaternary age of plutonic and volcanic rocks extending from the northern continuation of the active Sunda-Sumatra arc into the Eastern Himalaya Syntexis (EHS). Research field is focused on the magmatic rocks in Monywa and Kawlin area in CMA, volcano-plutonics expose in north-south trending terrain where is bounded by the dextral Sagaing Fault in the east and Kabaw Fault in the west. Total forty two samples of older granitoid and younger volcanic rocks are collected and analyzed.

Mid-Cretaceous granitoid in CMA, Twelve samples in Kawlin and Monywa area are done for U-Pb zircon ages that give 105 to 89 Ma. The mid-Cretaceous meta-aluminous I-type series granodiorite with minor gabbro dyke, derived from the magma generated in water-rich environment (i.e., in an arc setting). The isotopic compositions (I_{Sr}) of the granitoid have from 0.704 to 0.706 and a relatively young model age (TDM= ca.1Ga) with a relative high values of ε_{Nd} (+4.12 to +5.29) in granitoid of Salingyi (Monywa area), the magma could be derived from the high percent of mantle contributions and a low values of ε_{Nd} (-0.89 to +2.95) in that of Kawlin that could be had from the mantle contributions with an insignificant crustal contamination. Therefore, we suggest that the granitoid should have been derived from the partial melting of juvenile crust related to Neo-Tethys subduction under Myanmar micro-plate.

The volcanic rocks are mainly high-K calc-alkali andesite and alkali dacite, and U-Pb zircon ages of seven samples are ranging from 20 to 12 Ma. The low initial ratio of Sr (I_{Sr}= 0.7047 to 0.7049) and ε_{Nd} (+0.83 to +2.25) with a low TDM (<1 Ga) of mid-Miocene volcanics are indicating isotopically a juvenile/depleted mantle. Both high-K calc-alkali and alkali basalts and andesite in Quaternary age have a relatively low initial ratio of Sr (I_{Sr}= 0.7043 to 0.7047) and ε_{Nd} (+2.27 to +4.28) with a low TDM (< 1 Ga) imply that juvenile mantle origin and may be more primitive than mid-Miocene volcanics. Decrease in the I_{Sr} values and increase in the Epsilon Nd values indicate that closing to Depleted Mantle (DM) reservoir due to subducted slab rolling-back and break-out through Miocene to Quaternary period in CMA.

The main magmatism in CMA was initiated during mid-Cretaceous, and then, followed by the late sequence in early Oligocene, mid-Miocene and Quaternary. Therefore, the magmatism in CMA and Mogok Metamorphic Belt of Myanmar may have been contemporary from Cretaceous to Eocene period due to oblique subduction of Neo-Tethys and then, offset by dextral movement along the Wharton-Sagaing Fault related to northward movement of India plate. The notable cessation of magmatism in CMA was formed due to flat-slab subduction during Late Cretaceous to Paleocene. Miocene to Quaternary volcanism occurred due to subduction slab rolling-back and break-out during opening the Cenozoic Basins in Central Myanmar Belt.

KEY WORDS: Myanmar, Subduction Related, Magmatism in Central Myanmar Arc (CMA), Plutonics and Volcanics, Tectonic Evolution, Cretaceous and Miocene to Quaternary

Mineral Resources of Myanmar: Past , Present and Future

Kyi Tun

Myanmar is endowed with many mineral resources and has a long history of mining. The country is still under explored and underdeveloped of its various commodities. Precious metals (gold, silver and platinum), gemstones (ruby sapphire and jade), tin tungsten, copper, lead, zinc , nickel, chromium and antimony are important. Limited resource of iron and brown coal are also important for local industries. Granites , limestones and gypsum are abundant aggregate resources for new development projects and cement industry.

The history of mining can be divided into seven periods, viz. (1) Pre-colonial period (2) Colonial period (1885 to 1947) (3) Post Independence period (4) First military government (1962 to 1988) (5) second military government (1988 to 2010) (6) Transitional government period (2010 t0 2015) and (7) NLD government (2016 to present).

Mineral resources are dynamic, It change with time and depend on the politics, economics, technology and infrastructure development of the country. Mineral resources of Myanmar also change with time and many lessons can be learnt from the past mining history to develop the prosperous mining industry for the blessing to the country of .Myanmar and its people

Structural Deformation of Meiktila Area, along the Mandalay-Naypyidaw Express Car Road

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The Meiktila area is composed of mollassic clastic sedimentary rocks of upper Pegu Group (Miocene) and Irrawaddy Formation (Miocene to Pliocene). The present area is located at the northern most continuation of the Bago Yoma. The outcrops are well exposed in the area especially along the Mandalay-Naypyidaw express road that cut across the regional structural trend. The study area occupies the western part of Sagaing fault, dextral strike slip fault. The major fold system of the area is an anticlinorium and synclinorium, that running NNW-SSE trending. The major longitudinal fault is east dipping dextral strike slip fault that related to the Sagaing fault. Numerous cross faults are interpreted as normal faults and the NW-SE trending faults are similar to east-vergent, Tuyintaung-Gwegyo thrust. Differential erosion of soft Tertiary sandstones and shales and more resistant medium to thick bedded sandstone of Kyaukkok Formation create an irregular topography of rolling to steep hills topography. Obogon and Kyaukkok Formation are exposed at the axis of anticline and east-west cross faults cut of the structure.

Keywords: Structural deformation, Meikhtila area, fold system, NNW-SSE direction, cross fault, NW-SE trending

Geology and Petrology of the Metamorphic and Igneous Rocks of the Kuki Area, Layshi Township, Sagaing Region

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The Kuki area which is the southern part of the Naga Hill of the northern part of Indoburman Range lies about 30 km southwest of Layshi Township. The serpentinized dunite occurs as minor outcrop which is only exposed in the western part of the study area. The Research area is mainly composed of quartz-mica schist which may probably derived from Si-rich pelitic rock, graphite schist derived from carbon rich pelitic rock, actinolite-chlorite schist derived from basalt, glaucophane schist derived from basalt, and partial foliated or non-foliated serpentinite derived ultramafic rocks (especially preridotite). Serpentinite is mainly composed of serpentine minerals (especially antigorite, lizardite and chrysotile). The grade of metamorphism generally increases to the east according to mineral assemblage and dipping of these rock units which is west. The study area is mainly suffered by the regional metamorphism. The presence of Ca-rich garnets within the serpentinite bodies may be regarded as indicator of contact metamorphism. Therefore the metamorphism may be low to high grade metamorphism. The general trend of the rock units is NNE-SSW. The minor folds are mainly found in the glaucophane schist and graphite schist. The minor normal faults are chiefly found in the quartz-mica schist (especially south of the Kuki hospital in which the fault rock can be observed along the fault plane). One and only left lateral strike slip fault can be observed as an off set of rock units in the stream section which flow from New Ko Kaing Lone village. Regional structural analyses indicate that the regional force may derive especially from NW-SE.

Keywords: Kuki, Indoburman Range, Layshi Township, serpentinized dunite, pelitic rock, preridotite, glaucophane schist

Mineral Chemistry and *P-T* evolution of High-grade Gneiss and Granulite from the Mount Loi-Sau and its Environs, Mogok and Momeik Townships, Mandalay Region and Shan State (North)

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Abstract

At the remote area between Mogok and Momeik Township, high-grade gneiss, felsic and mafic granulitic rocks are exposed. Such rocks are characterized by a mineral assemblage that was developed under high-grade metamorphic conditions. Chemical analyses of minerals indicate that Fe and Mg act as a principal role in composition of garnet to define the grade and pressure and temperature of the research area. The more pyrope content the rock has, the temperature become higher and also the higher anorthite content favour the greater temperature. Ilmenite and hercynite are also diagnostic minerals of some acid granulitic assemblages. Petrochemically, high-grade gneiss in the research area have reached up to granulite facies, characterized by the mineral assemblages Qz+Pl+Afs+Bt+Sil+Grt+Hc+ Ilm+Cpx+Opx in the MnO-Na_2O-CaO-K_2O-FeO-MgO-Al_2O_3-SiO_2-H_2O (MnNCaKFMASH) system. The occurrence of hercynite and pyroxene-bearing high-grade gneiss explained *P-T* conditions of 6.5-9.3 kbar, 740-810ºC, whereas hercynite bearing sillimanite-garnet-biotite gneiss experienced at 6.2-8 kbar, 750-790ºC. The *P-T* condition of granulitic rocks should probably be greater than that of the high-grade gneisses of the research area and the *P-T* path of these rocks can be estimated as counter-clockwise, according to the mineral assemblages: Opx+Afs+Bt+Chl+Pl+Grt+Qz+Rt+Sil+Spr+Opq+Hc+Ser+Zrn+Ilm of felsic granulite and Cpx+Bt+Pl+Afs+Qz+Opx+Spn+Opq+Atg of mafic granulite. Remarkably, the presence of ultra-high temperature minerals such as hercynite and sapphirine indicate that these rocks were experienced under ultra-high temperature metamorphism in the granulite facies.

Keywords: high-grade gneiss, granulite, hercynite, sapphirine, ultra-high temperaıure

Jadeitite and associated high-pressure metamorphic rocks of Natmaw Area, Hkamti Township, Sagaing Region, Northwestern Myanmar

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Natmaw (also called Nammaw, Namhmaw) lies about 80 km southeast of Hkamti in Sagaing Region. It is bounded by Latitudes 25° 53' 13.79″N and 25° 57' 05.73″N and Longitude 95° 55' 20.78″E and 95° 58' 14.23″E, in part of one inch topographic map sheet number 83 O/13. The total area coverage is about 52.84 km^2. The lithologic units that exposed in the study area are granodiorite, serpentinized peridotite, eclogite, complex schists, sandstone and shale interbedded unit, sandstone and conglomerate interbedded unit and Alluvium. Schist unit is the second most abundant unit next to the serpentinized peridotite. The schist unit includes graphite schist, mica schist, chlorite schist, epidote schist and glaucophane schist (blue schist). Jadeitite is found in serpentinite mélange associated with high-pressure low-temperature (HP/LT) metamorphic rocks, such as eclogite and blueschist. The serpentinized peridotite is host rock for primary jadeitite dikes or veins in Natmaw area which are associated with albitite, albite-jadeite and amphibolite and blackwall unit. Jadeitite dikes or veins are surrounded by black wall zone (such as chlorite zone, amphibolite zone) which is similar to that of Tawmaw jadeitite dikes. Jadeite is the principal constituent mineral in jadeitite and accessory minerals include amphiboles (glaucophane, actinolite and tremolite), kosmochlor, omphacite, albite, phlogophite and chromite. A small block of eclogite and garnet amphibolites are found at the Makyan up stream near the jadeitite body. The main constituent minerals are omphacite and garnet porphyroblasts with minor amphiboles (glaucophane) and greenish micas and epidote in eclogite and glaucophane, garnet, hornblende and actinolite in amphibolite. P-T condition of Natmaw jadeitite and associated metamorphic rocks (glaucophane and amphibolite) can be compared with similar lithological and mineralogical characteristics of the previous research works from Pharkant-Tawmaw jade mines area. An occurrence of associated eclogitic rock from the study area can be used to estimate that these rocks were experienced at the *P-T* condition of 1.6-2.1GPa and 470 -550°C.

Keywords: Natmaw, Hkamti, Jadeitite, jadeite, eclogite, omphacite, garnet, glaucophane, albitite

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Cenozoic Deformation Study on Part of Suture Zone between Sagaing Fault and Shan Scarp

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The present day Myanmar Tertiary is underlain by at least two formely independent microcontinental fragments. The west Myanmar Block and the western part of Shan-Thai block or more broadly Sibumasu block (Win Swe 2012). The West Myanmar Block has been also described as a fore arc sliver bounded on the west by a strike slip fault (Sagaing Fault)(Curray et al 1979; Pivnik et al 1998; Nielsen et al. 2004). Shan Scarp Shear Zone which clearly divided from memtasedimentary rocks of Mergui Group and sedimentary units of Shan Plateau (part of Shan-Thai block or Sibumasu terranane) region. For the Shan Boundary (a possible suture between Sibumasu and West Burma blocks) the age of closure of Meso-Tethys was in the Early Cretaceous, but for the Bangong-Nujiang suture in the Late Jurassic- earliest Cretaceous (Metcalfe, 1999). The age of Meso-Tethys therefore ranged from late Early Permian to Early Cretaceous. In order to constrain the age of Meso-Tethys (P. Li et al. 2004).

The study area is between eastern Sagaing Fault Zone and western Shan Scarp (Shear Zone). It's also lie betweegn West Myanmar Block and Sibumasu (Shan-Thai Block). Tectono stratigraphically, juxtaposition of Mogok Metamorphic Belt-Tin bearing Central Granitoid Belt - metasedimentary rocks of Mergui Group and sedimentary rocks of Cambro-Cretaceous Limestone Plateau sequence of Shan-Thai Block (Chhibber 1934; Mitchell et al 2002) show nearly N-S linear array. Crustal thickening and heating from India –Asia collision (including West Myanmar block-Shan Thai collision) of continental crust associate with subduction related I type granites and followed by early to late Cretaceous S –type granites plutons due to initial collision. Late Paleocene to early Eocene, continuous E-W compressional field occurred and the intense deformation time of collision lead to forceful injection of tin bearing granitoid intrusions along the western margin of Shan Plateau. The episodes of metamorphism and magmatism are also the episodes of deformation.

The deformation study, strike slip related faults on the satellite image are discrete with sharp, straight and branching patterns. Under the early compressional field generated regionally fold and thrust belt in the area which are evidenced by vertical σ_3 position. From the fold axis analysis, although the plung of fold axes are varied, they fall under E-W to ENE-WSW compressional field. Another tectonically thrust evidence are in the east of Panlaung Fault as where the tightly folded nature of Shwemibon Formation overthrust by horizontal bedded nature Loian Formation with SE dipping NW verging. The deformation fabrics of microtectonic study show the progressive uplifting of lower crustal level to upper crustal level in the western Shan Plateau region.The kinematic analysis revealed earliest vertical σ_3 is changed to orthogonal horizontal position during transtension that would be collapse of high angle thrust belt. From middle Miocene to present, the continuous transpression was evidenced by the stress field transition of σ_3 unchanged while σ_1 and σ_2 exchanged (vertical σ_2 position) due to continuous crustal block rotation and northward migration of India Plate.These transpressional deformation revealed the activation of lateral slip faults. The active deformation structure of Shan Scarp (Shan Scarp Fault Zone) may change to stable position probably after cooling stage of both exhumation and forceful injection of granitoid intrusion, as while the Sagaing Fault is still active lead to north ward motion of West Myanmar block by the opening spreading center in the Andaman sea.

Geology and Mineral Aspect of the Part of the Hukawng Basin and Kumon Range, Kachin State

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The area lies at the northwestern part of Kachin State except the northern most part along the east – west running Tarung Hka (Hka means stream or river) valley is situated in Sagaing Region .The mention area of 9013km^{2}was mapped from 3rd week of December 2003 to 1st week of June 2004 .The guide maps are one inch to four mile scale topographic maps of 92 A,B,E and F .It lies between 96°30′00″ to 97°30′00″ East Longitude and 26°02′30″ to 27°12′30″ North Latitude.It is very remote and sparsely populated region with rugget terrains.The area occupies part of the Hukawng Basin which forms as a broad valley in the upper reaches of the Chindwin River where the river is named Tanai Hka. The assigned area in the north and northeast of the basin is bounded by the upper Triassic Ngu Hka Formation and minor ophiolite fragments.The northern edges of the basin are built up of Tarung Hka Formation of Eocene age with tectonic contact with the Triassic rocks in the north .In the south of the Eocene Formation named Ahauk Hka Formation is overlain by the Oligocene, Miocene and Pliocene Formations in the south and southeast of the limbs of regional southwest plugging syncline.In the east of Hukawng Basin,Kumon Range forms as the eastern wall with the peaks of more than 1219 meter to 3048 meter high.The Range is bounded in the east by the Namyin Fault and in the west by Taikri Fault both of which are the splays of Sagaing Fault.The Taikri Fault merges northward with the Kadup Hka Fault.The Western margin of the Range is faulted with the Oligocene sediments of Langnem Bum Formation.To the north of the Kumon Range ,the contact of metamorphic rocks and Triassic Ngu Hka Formation is inferred and at the northern most of Kumon Range those metamorphic appear to plunge north westward under the Ahauk Hka Formation of Eocene age.The Lower eastern slope of Kumon Range,Oligo – Miocene stratas lie stratigraphlly on the metamorphic rock. The Namyin Fault, east of Kumon Range runs N-S and northern end of the fault passes into the northwest trending Nam Yak Thrust with Chaun Kan Gneiss in the hanging wall.The gneiss may be the same as Mishmi Gneiss in Lohit River about 100km northwest of the Chaun Kan Pass.The Hpung Ma Schist and Noi Lagong Conglomerates with ultramafic rocks may be the same lithology as Tiddim Suture Zone on the north in India.

Kaw –Ta Bum ,a strato volcano 1404meter (4606 feet) on the eastern margin of the valley,west of the Kumon Range is built up of rhyolite, andesite and microdiorite with basaltic dykes and it is considered to be of Cenozoic age.It may be northern most hill of the Central Volcanic Arc of Myanmar. Orbitolina Limestones of mid- Cretaceous age are noticed at Kadup Hka Fault immediately east of Kaw –Ta Bum hill and about 25km south of the hill same limestone hill named Piyang Bum (544meter) is situated at the same fault. The largest granitic stock in the area about 8sq-km is situated at the northeast corner of the mapped area.There are biotite granite,two mica granite and hornblende biotite granite .Pegmatite dykes are intruded in granite and dioritic and grabbroic xenoliths in granite are noticed at some places.The granite is well foliated at the contact with schist in the west. Small patches of gneissic granite,coarse granite and feldspar porphyritic granite are cropped out at north western end of Kumon Range in Ngu Hka Formation.The granites may be Upper Triassic or older in age.

For mineral prospecting,the traverses had done mainly along the creeks and 210 stream sediment samples and 158 pan concentrates are collected within 9013km^2.The gold,copper,lead and zinc assays of the stream sediment samples show 0.02ppm to 1.75ppm,5ppm to50ppm, 3ppm to170ppm and 13ppm to 388ppm respectively.Gold is only detached at the streams across Tertiary strata and around Kaw –Ta Bum Hill.The noticeable feature is no trace of gold is observed at the streams across Kumon Metamorphics.Visible gold and PGM group minerals are encountered in heavy samples around Kaw –Ta Bum hill where pleacer gold workings are very common.An area of

103.6sq.Kilometer around the Kaw-ta Bum hill is the first priority area to check the potential of the placer gold and Kadup Hka stream valley is the only favorable area for the source of primary gold.

Some coal seams less than half meter thick are noticed within the Oligo-Miocence clastic strata however they do not appear to be economically significant .For raw material Piyan Bum limestone beside Tanai Chaung is texturally and chemically attractive for cement factory.

Keywords: Hukawng Basin,Tanai Hka,Ngu Hka Formation,Tarung Hka,Ahauk Hka Formation,Kumon Range,Namyin Fault,Taikri Fault,Sagaing Fault,Kadup Hka Fault,Langnem Bum Formation,Chaun Kan Gneiss,Mishmi Gneiss,Lohit River,Hpun Ma schit,Noi Lagon Conglomerates,Tiddin Suture Zone,Kaw-ta Bum,Central Volcanic Are,Orbitolina Limestone

Seismicity and Active Tectonics in Kabaw Valley Fault Zone and Surrounding Regions, Western Myanmar

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Tectonic processes in Indo-Myanmar subduction system include oblique subduction to collision tectonic process. This process resulted highest tectonic activity in the region. Thus, seismotectonic maps are prepared using remote sensing and GIS techniques, based on regional tectonics, geology, seismicity and active faults. The main objectives are to compare the faulting and spatial distribution of earthquakes with instrumental seismic data and to understand the relationship between the earthquakes and active tectonics of the region. Linear features are extracted using PCI Geomatic (remote sensing) based on the ALOS PALSAR data and orientations are analyzed by rose diagram. The earthquake data from USGS catalog, magnitudes (M>4) are plotted and analyzed using spatial analysis tools of ArcGIS (point density and kernel density analysis), to obtain the spatial variation of earthquake epicenters. The structural lineaments can be traced on satellite images for some parts which indicates that the northeast to southwest striking features under the collision tectonic setting, suggest the major compressive force probably acting in a nearly EW direction. Kabaw Fault, main seismotecotnic structures, is running along the east side of the Indo-Myanmar ranges which probably to produce moderate to strong earthquake in the future. There are also some active faults in the border that have caused many earthquakes in these regions. A lot of fault plane related to strike-slip movements observed in the western part of Kabaw valley which is also a remarkable area for studying morphotectonics processes. Because active tectonic processes have a direct effect on the geomorphology in the region. Overall, results of a comparative study of seismicity and active faulting of the region are presented, based on an interpretation of satellite imagery. The seismic density evaluation showed high density value from Homalin to Gangaw along the river, eastern part of Indo-Myanmar ranges, suggesting the movements are continuing. This study can further improve the understanding of tectonic activity. Future research should therefore concentrate on the brittle tectonic analysis of the region.

Keywords – Kabaw Fault, morphotectonics, active tectonic processes, seismic density evaluation, brittle tectonic

Shear Hosted Mesothermal Gold Deposit, Kyaukphyuchaung Area, Banmauk, Northern Myanmar

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The Kyaukphyuchaung gold mineralization is mainly confined to gold-sulphide bearing quartz veins in schistose rock and andesitic rock of Upper Triassic to Lower Cretaceous by forming stockwork/ network, lense types and sometimes lode type. The gold mineralization occurs in NNW-SSE shear zone probably related to the movement of Taungchaung fault and / or Chutkon-Legyin fault system. The mineralized quartz vein yields white, milky grey, grey and has greasy texture, sometimes book and ribbon texture and vuggy quartz, Silicification, Chloritization, Pyritization and clay - alternation are recorded in the Kyaukphyuchaung area. Pyrite is most abundant mineral with minor amount of chalcopyrite. Most of the mineralized quartz veins are formed as irregular, pervasive, discontinuous vein system and intermittently exposed along the NNW-SSE trending shear zone. Recent geological investigation and petrological analysis indicate that the gold mineralization at Kyaukphyuchaung is shear related mesothermal gold deposit.

Keywords: Kyaukphyuchaung Gold Deposit, shear related, discontinuous vein system, mesothermal.

Petrochemical characteristics and Geochronology of the Igneous Rocks in Bilin and its Environs, Bilin Township, Mon State

Mya Moe Khaing

The research area is located in Bilin Township and its vicinity, Mon State. It lies between Lattitude 17˚12′45″ N to 17˚21′45″ N and Longitude 97˚09′00″ E to 97˚14′45″ E. The total area coverage is about 116.5 km^2. Four igneous rock samples were sent to ALS laboratory of Geological Survey of Japan and analysed by XRF and LA-ICP-MS. Eight igneous rock samples from the research area were analyzed at DSSTRC (Defence Service Science and Technology Research Centre) in Pyin-Oo-Lwin Township and seven samples were sent to Department of Geology, Mandalay University for XRF analysis. Geochemically, biotite granite, biotite-muscovite granite and biotite microgranite show chemical composition (weight percent) of SiO_2 (69.4 - 75.96), Al_2O_3 (13.34-16.8), TiO_2 (0.154-0.284), Na_2O+K_2O (7.765- 10.31), Fe_2O_3+MgO (1.149-2.64), MnO (0.039-0.151), CaO (0.897-3.14) and P_2O_5 (0.027-0.159), suggesting calc-alkaline series and are predominantly peraluminous; alumina saturation index (ASI) A/CNK ranging from 1.054 to 1.524 and A/NK ranging from 1.384 to 1.879. Diorites and microdiorite exhibit SiO_2 (52.3-55.95), Al_2O_3 (17.69-22.3), TiO_2 (0.738-0.973), Na_2O+K_2O (4.95-6.364), Fe_2O_3 +MgO (9.211-13.35), MnO (0.121-0.359), CaO (5.435-7.51) and P_2O_5 (0.285-0.602); related to SiO_2 content indicate that the diorite and microdiorite are calc- alkaline series with alumina saturation index A/CNK ranging from 1.30 to 1.80 and A/NK ranging from 2.77 to 4.5. According to Harker's variation diagrams, TiO_2, Al_2O_3, Fe_2O_3, MnO, CaO, MgO and P_2O_5 are negatively correlated with SiO_2 and then Na_2O, K_2O are positively correlated with SiO_2 showing a significant role of fractional crystallization in the evolution of magma. Result from geochemical analysis, biotite-muscovite granite and some biotite granites have high sodium content, normatic corundum ranges from 0.831 to 0.974 and biotite microgranite is low in sodium content. SiO_2 Vs A/CNK and A/CNK Vs A/NK diagrams show that the granitic rocks contain both I and S-types consistent with Chappell and White (1994). Based on the tectonic discrimination diagram of Maniar and Piccoli (1989), the granitic rocks fall within the IAG+CAG+CCG field. In Y Vs Nb diagram; all the granitic rocks fall in the field of Syn-COLG and VAG. Y+Nb Vs Rb diagram indicates that all granites fall in the VAG field. U-Pb zircon dating of the biotite granite from the northern part of Lakhin pogoda (Myinthar Range) gives age of 51.9$\pm$0.7 Ma. The result from zircon crystallization suggests that the biotite granite was emplaced in Eocene.

Key words; calc-alkaline, peraluminous, I-type, S-type, COLG, VAG, fractional crystallization

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Geology and Mineral Resources of Hopang Area, Northern Shan State, Myanmar

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The investigated area is situated in Hopang Township, Wa Self-Administered Division in northern Shan State, Myanmar. The area is bounded by Latitude 23º 19' 00" - 23º 26' 30" N and Longitude 98º 42' 30" - 98º 48' 00" E. It covers a surface area of about 48 square miles. The present area is generally mountainous region forming the rugged terrain in the northern part of the Shan Highland. The mountain ranges are trending roughly NE-SW to NNE-SSW direction. They are highly dissected by deep valleys and steep mountains.

The study area is composed of Upper Precambrian metasedimentary rocks, Paleozoic and Mesozoic units of carbonates and minor clastic sedimentary rocks, metamorphic rock and igneous rocks. Chaung Magyi Group (Late Precambrian) contains low grade metasedimentary rocks of slaty phyllite, metagreywackes, quartzites with sandstones, siltstone and siliceous shales. Pangyun Formation (Late Cambrian) consists of unfossiliferous brorwnish red, thin-to medium-bedded micaceous sandstones, micaceous quartzites, tuffaceous sediments and reddish brown shales. Sitha Formation (Middle Ordovician) composed of blue-grey limestone containing numerous cylindrical sinuous burrows filled with brown calcareous silts in lower part and bluish grey limestone with irregular silt parting and buff coloured silty limestone in upper part. The lower part of Nyaungbaw Formation (Silurian) is composed of thin-to medium bedded, pinkish, yellow to chocolate brown argillaceous limestone and white to buff silty shale and marl. The upper part is made up of lightly grey, earthy crinoidal limestone, calcareous shale and brownish sandstone. Plateau Limestone (late Early Permian to Middle Permian) is composed of light grey to grey, hard and compact, well bedded containing fusulinids, gastropod and large solitary and compound coral. Nwabangyi Dolomite Formation (Late Permian to Early Triassic) is mainly composed of light grey to grey, thick-bedded to massive, highly brecciated dolomites and dolomitic limestone. Hsipaw Red Beds (Late Jurassic) can be subdivided into siltstone member and conglomerate member.

Marble unit (probably Permian) of the study area contains crystalline white marble and forsterite marble. Porphyritic biotite granite (? Triassic) composed of medium-to coarse-grained crystals with the phenocrysts of up to 5cm long, containing biotite, potash feldspar, plagioclase and quartz.

Lead-zinc-copper mineralization are occurred in the carbonate unit of Permian Plateau Limestone and some places the lead occurred area contacted with Chaung Magyi Group and Plateau Limestone. The mineralization of Hpalin mine is associated with the granite in this area. The major constituent of Hpalin mine is galena, sphalerite and pyrite. Accessory minerals are chalcopyrite, bornite, chalcocite, chrysocolla and laurionite. Secondary minerals in oxidizing zone are azurite, malachite and limonite. The gangue consists of epidote, fluorite, garnet, wollastonite, biotite, calcite, dolomite and quartz. Mineral paragenesis in Hpalin skarn deposit is grouped into two stages, i.e. prograde and retrograde. Prograde stage formed as the temperature of more than 300˚C represented by garnet (andradite), quartz, pyrite, chalcopyrite and possibly magnetite which occurred in both quartz monzonite and wall rocks limestone. Retrograde stage is typified by epidote, chlorite, quartz, calcite and sericite as well as pyrite chalcopyrite, galena, sphalerite, hematite, and argentite.

In (TAS) diagrams, the plutonic rocks of the Hopang area fall in quartz monzonite field. The igneous rocks of the study area possess to acidic composition peraluminous nature and calc-alkaline series. The geochemical evidence and constraints from experimental petrology have confirmed that most large-volume peraluminous granite originate mainly form melting of crustal rocks during continental collision. Sandstone samples of Hsipaw Red Beds fall within the field of continental arc and sandstone samples of the Pangyun Formation fall in the active continental margin.

Tectonically, Myanmar can be divided into four major geological provinces from west to east: the Indo-Burman Ranges, the Wuntho-Popa Arc, the Mogok-Mandalay-Mergui Belt, and the Shan Plateau (Gardiner et.al, 2016). The study area falls in Shan Plateau of eastern Myanmar. The S-type granite plutons, which outcrop towards the center and east of the Shan Plateau are interpreted as a northwards extension of the Central Province of (Cobbing et.al.1992), running through Thailand and Malaysia. Two principal collisional events dominate the Mesozoic-Recent geological history of Myanmar. The earlier Late Triassic closure of Palaeo-Tethys (Sone and Metcalfe, 2008), involved the collision of Sibumasu with the Indochina terrane, and resulted in the Indosinian Orogeny. The later closure of Neo-Tethys and the initiation of the Himalayan Orogeny have been dated at ca 50 Ma (Searle et.al, 2011).

Characteristics and genesis of Gold Mineralization at That-Kal Byant area, Thabeikkyin Township, Mandalay Region

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Geologically, the study area is situated along the western margin of the Shan- Thai block, composed mainly of high grade Mogok Metamorphic Belt, about 115 kilometer far from north of Mandalay and 97 kilometer far from south west of Mogok, Mandalay Region. The research area is located southeastern part of the Thabeikkyin Township, Mandalay region, which are locally intruded by biotite microgranite, pegmatite and aplite. Dykes and veins are considered to have originated during the later stage of the granitic intrusions.Gold mineralization styles are wide spread occurrences of Placer Gold, Sediment hosted oxidized Gold mineralization along the fractures within the marbles and Massive sulphide.

Hydrothermal alteration included Calc- silicate alteration, propylitization, sericitization, argillitization and minor hematization. In the study area, Gold mineralization occurs as replacement in the carbonates (marbles) as well as veins and stock work structures. Gold-bearing sulfide mineralizationoccurs replacement type,disseminate in the marble and gold-bearing quartz sulfide veins and their wall rock alteration zones in the underground mine section of depth and in secondary enrichment gossans zone of upper portion.

Common ore minerals in the That-Kal Byant area included chalcopyrite ($CuFeS_2$), galena (PbS), sphalarite (ZnS), pyrite (FeS_2), gold (Au) ± silver(Ag) and Fe-oxides minerals, such as (hematite, magnetite and goethite). Common ore textures regarded as replacement, exsolution, and banded nature. The paragenesis of the ore minerals indicate that galena, pyrite, sphalarite and chalcopyrite were developed in the early stage of ore deposition and hematite, electrum, quartz and calcite are late stage. Pyrite seems to be deposited first along the fractures, followed by sphalerite, chalcopyrite and galena are deposited. Gold and silver mineralization was probably related to deposition during these mineral assemblages. Iron oxides mineral, such as hematite, magnetite and goethite were formed during the later phase of ore deposition as supergene minerals. The gold mineralization in the study area may have been apparently controlled faults related to the regional structure, a well-known dextral Sagaing strike-slip fault and local structure of cross fault.

Keywords: Shan-Thai block, Mogok Metamorphic Belt, Sagaing strike-slip fault

Geochemistry and Petrogenesis of Proterozoic Rock Unit Hosting Gold Mineralization in Phayaung Taung area, Central Myanmar

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The Phayaung Taung gold deposit is located at 30 km northeast of Mandalay in Central Myanmar. The mineralization is hosted by Proterozoic basement meta-sedimentary unit such as quartzite and phyllite. This unit is conformably overlaid by the metamorphosed rocks of the Mogok Belt which intruded by the igneous rocks such as diorite and pegmatite (Mesozoic age, I- type, calc-alkaline grantiods series).

In petrological studies of both Proterozoic to metamorphosed rocks of Mogok Belt, low to medium grade metamorphosed minerals such as chlorite, epidote, muscovite, biotite, garnet, staurolite and sillimanite which can be identified in the analyzed samples. It suggested the rocks formed by the greenschist to amphibolite facies metamorphosed events. Geochemical studies indicate that the correlations of TiO_2, Na_2O, K_2O and FeO had the negative correlation with SiO_2.There is no correlation between SiO_2 and CaO, Na_2O, P_2O_5, SiO_2 and MgO. Al-Ti-Zr plot can provide to classify the original unmetamorphic rocks called protolith. The protolith of these rocks was clastic sedimentary rock such as sandstone, mudstone/ shale interbedded units. As chemical index of alteration (CIA) value; $100[A1_2O_3/ (A1_2O_3+CaO^*+ Na_2O +K_2O)]$ of these meta-sedimentary rocks was high (CIA >70). The correlation results regard the host rocks were probable related to strong deformation and chemical weathering events after deposition in the paleo- geologic time.

High CIA value of the mineralization hosted Proterozoic rocks is also suggesting the rocks were happened by deeply chemical and physical weathering conditions; prior to being hydrothermally altered adjacent to the quartz veinlets/ lode during the mineralization. TiO_2- (Fe_2O_3+MgO) and Al_2O_3/SiO_2 - (Fe_2O_3+MgO) discrimination diagrams suggest the depositional tectonic environment of these sediments taken place in an active continental margin with continental arc tectonic regime. The Proterozoic- Paleozoic stratigraphy might be therefore faced the regionally metamorphic events which mainly supported by collisional tectonic events of two continents. The gold mineralization related to magmatic activities formed along the regional scale deformational zones within Proterozoic rock unit, and it's as structural controlled shear zone hosted- mesothermal, orogenic gold quartz vein system.

Keywords: Collisional tectonic events, Meta-sediments, Paleozoic, Proterozoic, Protolith, Orogenic gold.

Tectonics & Mineralization Paper -28

Petrological and Geochemical Studies of Chromitite of the Bhopi Vum Area, Tiddim Township, Chin State

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The study area is situated about 16 miles east of Tiddim. It covers a surface area of about 96 square miles. Peridotites, plagiogranite, mafic intrusives, mafic volcanics, pelagic sediments and podiform chromitites are the dominant lithologic units of ophiolite (Jurassic age) in the study area. In the Bhopi Vum massif, a total of 12 chromite occurrences have been found. The host rock is usually dunite. Podiform chromitites in Bhopi Vum Area are typically lens shaped, although many occur as tabular like bodies and have an average grade of 48 wt % Cr_2O_3. Massive chromitites, nodular type, leopard, schlieren type, disseminated and spotted type are also occurred. The chromitite comprises of predominately chromite with subordinate amounts of olivine, minor serpentine and chlorite. Chromite ores exhibit various textures such as cumulus, chain, cataclastic, pull-apart and exsolution. The chromitite of the studied area are clearly low and uniform in Al_2O_3 and higher Cr_2O_3 and plots in the field of podiform chromitite. Chromitite of study area fall within mantle chromitite field, in the arc and suprasubduction zone fields. Podiform chromitites form by crystallization of mafic magmas in the upper mantle. The interplay of melt-rock reaction, chromite fractionation and magma mixing would lead to many fluctuations in melt composition, producing both massive and disseminated chromitites within a single podiform body. Nodular ores probably form by a combination of chromite precipitation and convective overturn of magma pocket.

Keywords: podiform chromitites, nodular, leopard, schlieren, cumulus, cataclastic, pull-apart, exsolution, suprasubduction zone, melt-rock reaction, fractionation, magma mixing, magma pocket.

A Significant Role of SiO_2, Al_2O_3, Na_2O, K_2O and CaO proportions in genetic types and classification of some granitic rocks in Kyaing Tong Area, Eastern Shan State, Myanmar

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Seven representative samples were choice to analyze the geochemical data of granitic rocks from Kyaing Tong batholith. It is mainly composed of leucogranite and biotite granite and granodiorite. SiO_2 contents are range from 73.23 to 74.73 wt (%) in leucogranite, (65.83%-68.77%) in biotite granite and (65.73 - 66.49%) in granodiorite. Na_2O contents are (1.4 to 3.65 %), (1.77-1.81%) and (1.3 to 1.61%) in leucogranite, biotite granite and granodiorite respectively. K_2O contents are (4.01 to 6.31%), (3.64-3.95%) and (3.24 to 5.52%) in leucogranite, biotite granite and granodiorite respectively. CaO contents in leucogranite range from 0.31 to 0.52%, (1.92-3.06%) in biotite granite and (3.4 t- 3.76%) in granodiorite. Although total contents of (Na_2O+K_2O) % in leucogranite is more constituent than in granodiorite, total (CaO+ Na_2O+K_2O) % in leucogranite is lesser constituent than in granodiorite. According to Chappell & White (2001), molecular values of A/CNK ratio is less than 1.1 limited values in granodiorite while greater than 1.1 limited values in both leucogranite and biotite granite. The composition of quartz and feldspar proportions is very important to identify the nomenclature and igneous classification of granitic rocks. Geochemical data proved to be useful in distinguishing parental magma, genetic types from I-type or S-type and granitic rock classifications.

Keywords: *SiO_2, Al_2O_3, Na_2O, K_2O and CaO proportions, genetic types, classification of some granitic rocks, Kyaing Tong*

Geotechnical,Geohazards & Geopark Paper -8

Initiation and Evolution of Forearc Basin in Central Myanmar

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The Central Myanmar forearc basin records marine Upper Cretaceous to Eocene and overlying Oligocene to Pliocene continental sedimentation along the western margin of Asian plate. We present new measured stratigraphic sections, sandstone petrographic and U-Pb detrital zircon data of Upper Cretaceous-Eocene sedimentary rocks from the Central Myanmar forearc basin. The Kabaw Formation is exposed along the eastern flank of the Indo-Burma Ranges. In Kalay, the Kabaw Formation is composed of shale, muddy limestone in the lower part and mudstone and sandstone in the upper part. Bivalvia and gastropods fossils indicated Cenomanian-Turonian in age. Sandstones includes significant populations of late Cretaceous (103-70 Ma) detrital zircons. In Minbu, however, the Kabaw Formation is composed of ~20 m matrix-supported conglomerate. The conglomerate clasts are mainly of angular to subangular schist and subordinate quartz and sandstone. Major age populations lie in the ranges of 260-223Ma, 600-500Ma and 1100-900Ma which is similar with that of Burma plate. In the Upper part, pebbly sandstone, sandstone and mudstone deposited over the conglomerate. Major age populations lie in the ranges of 103-70Ma that is consistent with the age spectra of Kalay section. The Paunggyi Formation (or Paunggyi Conglomerate) lies uncomfortably on the Kabaw Group. In Minbu, the 90 m thick Paunggyi Formation consists mainly of conglomerate, massive laminated sandstone, thin to medium sandstone and mudstone and tuff layers. Graded bedding, crossbedding and erosional surface are observed. U-Pb dating of zircon from tuff indicate early Paleocene (64-60 Ma) in age. Major age populations of detrital zircon were identified in the ranges of 100–60 Ma. The Eocene strata including Tilin, Tabyin, Pondaung and Yaw Formations are composed mainly of sandstone and mudstone. In Yaw Formaion, the presence of bituminous coal indicate transition from marine to terrestrial. Major age populations in these formations are between 100–36 Ma and 600–500 Ma. These late Cretaceous-Eocene detrital zircon ages from Upper Cretaceous-Eocene strata overlap with igneous crystallization ages from the Central Arc. Based on stratigraphic and detrital zircon age data, we propose a model that the forearc basin initiated in Cenomanian time due to the formation of trench-slope break. The schist-rich Kabaw conglomerate indicated the basement of the forearc basin is the Burma plate. The Central Myanmar forearc basin can be correlated to time-equivalent Xigaze forearc basin in South Tibet. Correspondingly, the Gangdese arc is the correlative of the Central Arc in South Tibet.

Measurement and modeling of ground motions in Myanmar for seismic hazard assessment

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An important first step in assessing the seismic hazard for any region is the selection or development of appropriate ground-motion prediction equations (GMPEs) that adequately describe the expected shaking from a specified earthquake. In this study, we apply the log-likelihood method of Scherbaum et al. (2004) to analyze residuals between predictions from a suite of GMPEs developed for tectonically active regions and ground-motion observations recorded by the Myanmar National Seismic Network (MNSN). Following major upgrades beginning in January 2016 (Hrin Nei Thiam et al., 2017), the MNSN now comprises >12 real-time broadband and/or strong-motion stations distributed throughout the country. During its first two years of operation, the upgraded MNSN recorded multiple M≥4 events per month, including two deep M6.8 earthquakes near Chauk and Kale in 2016, and the M5.1 Taikkyi earthquake in 2017. We will briefly discuss ongoing work to evaluate the suitability of low-cost, low-power Raspberry Shake instruments to augment monitoring by the MNSN.

We measure peak ground acceleration (PGA) for M≥3.5 events within Myanmar and within 300 km of MNSN stations. We compare these PGA measurements with predicted ground motions from GMPEs developed for tectonically active regions as part of the NGA West and NGA West-2 model suite, including Chiou and Youngs (2008), among others. V_{S30} for MNSN stations is estimated from topographic slope using the proxy method of Wald and Allen (2007), and site amplification factors are calculated using the relationships of Seyhan and Stewart (2014). The results of this analysis will be used to inform decisions regarding the configuration of real-time ShakeMaps, produced by the Myanmar Department of

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Fossil wild boars of Myanmar and their significances before/after the late Miocene faunal turnover in Asia

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The Late Miocene faunal turnover in Asia greatly affected on the occurrence and habitat of the fossil wild boars of Myanmar. Up to date, 9 genera for 13 species of fossil wild boars have been discovered from the Neogene sediments of central Myanmar. The diet of wild boar essentially relies on their environment, and differences in diet are always accompanied with differences in habitat. Middle Miocene to early Late Miocene form of Myanmar, *Listriodon*, *Tetraconodon*, *Hippopotamodon* and *Parachleuastochoerus*, have relatively smaller third molars, suggesting distinct closed forest inhabitants. The Late Miocene to Early Pliocene, *Propotamochoerus* spp., are more open forest inhabitants compared to the genera from the Middle Miocene and their diet varies from frugivorous to folivorous. The Pliocene *Sivachoerus* of Myanmar has large and complex third molars, suggesting it is a predominantly folivorous in open forest habitats. The paleontological records of Myanmar wild boars suggests that the predominantly frugivorous forest dwellers were mostly extinct after the Late Miocene faunal turnover, and the first folivorous open habitat species alternatively appeared in the early Late Miocene. In the Pliocene, it was replaced by predominantly folivorous species in more open habitats. After the Pleistocene, hyperbrowser/frugivore species in closed forest habitants have exclusively survived in Myanmar.

Key words: Fossil wild boars, frugivorous to folivorous, Late Miocene faunal turnover

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Stratigraphy Of Linwe Formation (Early Silurian) Of Konlon And Thayetpya In Pindaya Plain, South Shan State, Myanmar: Pseudo-Bedding Produced By Burial Diagenesis

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Lithofacies of the **Linwe Formation** exposed in **Thayetpya** and **Konlon** areas are studied. Limestones with interbedded marl, limestones with flaser bedding, limestones with argillaceous seams and limestones with pressure-solution seams are dominant lithofacies in the Thayetpya area. Limestones with micaceous siltstones interbeds, limestones with argillaceous layers and limestones with pressure-solution seam lithofacies are observed in the Konlon area. Moreover, limestones of Thetyetpya area are beds at lower horizon and homogeneous and lack lithological changes in upper part of the section. In Konlon area, layered limestones are relatively homogeneous and lack lithological changes or sedimentary structure.

Beds were deposited under essentially constant physical conditions and their internal compositions are not the same; sometimes large fossil fragments occurred and others are homogeneous. Thin section across the planes showed that they have been made visible by the weathering of several millimeter of insoluble residue. The faint unweathered traces of surfaces were lithological contact points to depositional origin. Pressure-dissolution could not have produced the grain truncation because stylolitic seams would have truncated grains in both sediments adjacent to the surfaces. Bedding planes between beds of initially different texture are the sites of a porosity instability that can lead to the formation of stylolites within each bed. Thus there is the possibility that parallel, evenly-spaced surfaces were totally diagenesis in origin. It can produce relatively homogeneous limestones during burial diagenesis.

Keywords: Early Silurian, lithofacies, pressure-dissolution

Mapping the macroseismic effects of the Mb 6.5 Bagan earthquake in 1975, Central Myanmar: the new synthesis on felt intensity assignment

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Historical and archeoseismological records suggest the ancient city of Bagan which was the royal capital of Myanmar between the 11th and 13th centuries, is highly susceptible to earthquakes. Among the earthquakes preserved in these records, the ML 6.8 Bagan earthquake of 1975 is among the most noteworthy in the region. A comprehensive seismological study of this earthquake was not carried out due to the lack of instrumental data from Myanmar. Early efforts to map the macroseismic effects of the Bagan earthquake indicate most of the destructive effects were in the vicinity of Bagan and its surrounding region. The source of earthquake was thought to relate to the NNW-SSE directed, active inversion of shallow crustal structure, Gwegyo thrust which is well exposed at Tuyin Hill to the east and west dipping fault plane buried underneath sandy alluvium of the Bagan. In August 2016, Mw 6.8 Chauk earthquake hit central Myanmar and its epicentre was located at the similar distance from Bagan as 1975 earthquake. The post-earthquake field reconnaissance and damage assessment of the Chauk earthquake suggests that Bagan experienced moderate shaking intensities, and that the damage pattern within Bagan and its surrounding areas were also similar to the 1975 event. The intention of the present study was to revise the macroseismic effects of 1975 Bagan earthquake by revisiting reports of damage from previous studies (e.g. Shwe Gaing Thar, 1976; Min Htwe Naung, 1987), and combining these with data collected from India and Bangladesh. We also conducted a field survey data to interview local people who felt the Bagan earthquake in 1975. We then compared the damage and intensity distribution from the 1975 earthquake with the damage pattern and intensity distribution of the Chauk earthquake of 2016. In this present macroseismic study, we use the European Macroseismic Scale (EMS-98). Our new macroseismic map provides an improved spatial coverage across the Myanmar-India-Bangladesh region and shows good correlation with Mw 6.8 Chauk earthquake of 2016. Our new macroseismic assignment suggests that the ground motion of Mb 6.5 Bagan earthquake of 1975 is most likely to be subduction zone earthquake.

Key Words: Macroseismic mapping, felt intensity, damage pattern, Bagan earthquake

Provenance Study of Siliciclastic Rocks Exposed in Okhmintaung Type Section Area, Magway Region

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The study area occupies a small segment of the southwestern part of the Minbu Basin. The lithostratigraphic units in Okhmintaung Type Section area are Late Eocene age of Yaw Formation to Kyaukkok Formation of Middle Miocene in age. Quartz, feldspar and rock fragments are the dominant framework components of the studied specimens. Okhmintaung sandstones are mineralogically and texturally immature and have been classified as sublitharenite on the basis of QFR diagram. Quartz in Okhmintaung sandstone samples is of monocystalline and polycrystalline nature and feldspars are represented mainly by orthoclase and plagioclase. A wide variety of lithic fragments like granite, schist, shale, siltstone, quartzite, chert and gneiss have been recorded in these sandstones. QtFL and QmFLt plots indicate derivation mainly from recycled orogen including foreland uplift of subduction complex (western range) and mixed magmatic arc and Northern Myanmar Provenance. Heavy minerals present in the Okhmintaung sandstones are zircon, tourmaline, rutile, hornblende, glauconite, hypersthene, kyanite, sillimanite, staurolite, topaz, garnet and opaque minerals. On the basic of petrographic study and heavy mineral analysis, all the sediments of the Okhmintaung Formation fall in the field of the recycled orogen. The source areas of the Okhmintaung Formation from the Onh min taung Ridge were probably derived from the Magmatic-Arc provenance and Recycled-Arc provenance.

Keywords— Okhmintaung sandstones, sublitharenite, recycled orogen, Magmatic-Arc

Diamictite Horizon of Taungnyo Formation in Mawlamyine-Mudon Area, Mon State

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The study area is situated in Mawlamyine and Mudon Townships, Mon State. It is mainly composed of Early Carboniferous to Early Permian clastic sedimentary rocks. There are three sub-units (C_1-P_1t^1, C_1-P_1t^2 and C_1-P_1t^3) with stratigraphic thickness of 22.68m, 126.7m and 108.22m respectively. C_1-P_1t^1unit consists of thick-bedded to massive sandstones and mudstone, C_1-P_1t^2 units are medium to thick-bedded sandstone interbedded with shale and mudstone, pebbly mudstone, pebbly greywacke, gritty sandstone and conglomerate and C_1-P_1t^3unit is thin to medium-bedded sandstone and shale. The significant feature of Taungnyo Formation is the presence of pebbly mudstones and wacke which look like diamictite. Pebbly mudstone and wacke consists of pebbles and disorted clasts of sandstone and mudstones dispersed in silty-mud matrix. Pebbles are subangular to well rounded, and sizes range from 1cm to 5cm in diameter. Some pebbly mudstone deposits possess large rock blocks with sizes ranging from about cobble to boulder. Clasts are randomly oriented. Pebbles are larger in southern part than northern portion of the study area. It is widely distributed throughout the study area. The origin is the rapid deposition of sands and gravels on top of very watery, uncompacted mudstone higher in amount of matrix. They were probably formed by subaqueous debris flows. These deposits represent high velocity plastic mass-flow downslope movement under the influence of gravity and would be considered as turbidites. Taungnyo Formation is correlated with Lebyin Group, Mawchi Series and also a part of Mergui Series of Taninthayi Region. Mergui Group is a part of Slate Belt of MMM Group and which is correlated with Kaeng Krachan or Phuket Group of western Thailand. Kaeng Krachan or Phuket Group can be stratigraphically correlated with the Singa Formation of Malaysia, Bohorok and Mentulu Formation in Sumatra of Sibumasu Block in which diamictites occur widely throughout.

Keywords - Taungnyo Formation, diamictite horizon

A Report on Upgraded Seismic Monitoring Stations in Myanmar: Station Performance and Site Response

Hrin Nei Thiam[1], Yin Myo Min Htwe[1], Tun Lin Kyaw[1], Pa Pa Tun[1], Zaw Min[1], Su Hninn Htwe[1], Tin Myo Aung[1], Kyaw Kyaw Lin[1], Myat Min Aung[1], Jason de Cristofaro[2], M. Franke[3], S. Radman[3], E. Lepiten[4], Emily Wolin[2], and Susan E. Hough[2]

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Myanmar is in a tectonically complex region between the eastern edge of the Himalayan collision zone and the northern end of the Sunda megathrust. Until recently, earthquake monitoring and research efforts have been hampered by a lack of modern instrumentation and communication infrastructure. In January of 2016, a major upgrade of the Myanmar National Seismic Network (MNSN; network code MM) was undertaken to improve earthquake monitoring capability. We initially installed five permanent broadband/strong-motion seismic stations and real-time data telemetry using newly improved cellular networks. Data are telemetered to the MNSN hub in Nay Pyi Taw and archived at the Incorporated Research Institutions for Seismology Data Management Center. During 2017, the system was expanded with the establishment of real-time telemetry from additional stations. For example, a deep Mw5.0 earthquake on 28 December 2017 was well recorded at 10 stations within Myanmar. The network software can be expanded easily to include other stations that are equipped with compatible telemetry. In 2017 the network software was updated to produce real-time ShakeMaps for significant earthquakes. In this report we analyze station noise characteristics and site response using noise and events recorded by the initial five monitoring sites over the first six months of station operation. Background noise characteristics vary across the array, but indicate that the new stations are performing well. During its first year of operation, MM stations recorded more than 20 earthquakes of M ≥4.5 within Myanmar and its immediate surroundings, including a M6.8 earthquake located northwest of Mandalay on 13 April 2016, and the M6.8 Chauk event on 24 August 2016. We use this new dataset to calculate horizontal-to-vertical spectral ratios, which provide a preliminary characterization of site response of the upgraded MM stations.

The Inventory Of Preliminary Geological Sites Assessment In Myanmar

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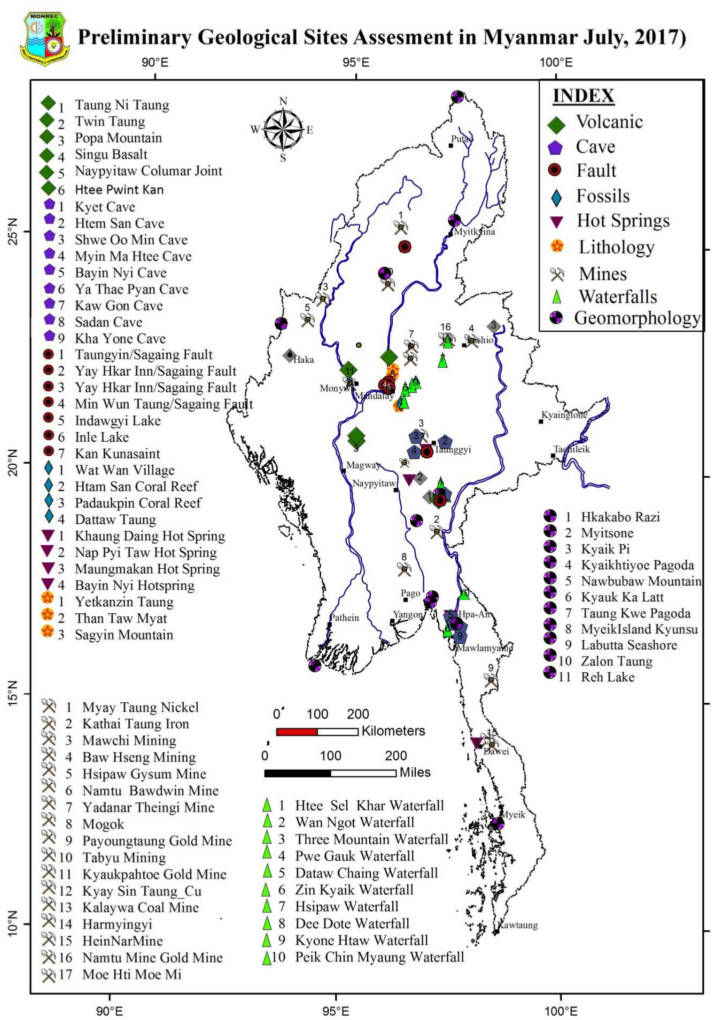
The present study is mainly focuses on different geological sites inventory data in Myanmar. Myanmar has not been systematically collected inventory of geo-conservation potential database. It is also expected that this work will contribute to create an increasing public awareness on geological heritage, as an important natural resource with major strategic importance. The geological sites were classified as lithological sites, geological or geomorphological landscapes, caves and grottos, mineral sites, historical mine sites, fossil sites, geo-hazard sites and geological environments that support an ecosystem and meteorite impact sites. This preliminary study includes 70 geological sites for preliminary assessments and we describe some of geological sites in Myanmar.

Keyword: Framework list, Geological sites in Myanmar, Issue and challenge



Mount Popa Geopark and Potential Geoparks in Myanmar

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UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. With the above objectives in mind Myanmar Geosciences Society (MGS) has been endeavouring to establish UNESCO Global Geoparks in Myanmar. Based on the available information obtained by Department of Forestry there are ten potential areas for Geopark spreading all over the country. Of those the Mount Popa area is the most suitable location to establish and propose for a first UNESCO Global Geopark in Myanmar.

Mount Popa forms a conspicuous landmark in the heart of the dry belt of central Myanmar forming the largest and southernmost volcano of the group of Lower Chindwin volcanic belt. The area occupies about 315 square miles (816 sq.km) and lies between 20° 40’ and 21° 3’N Latitude and 95° 6’ and 95° 22’E Longitude. The main mountain originally had a circular crater, but the whole of the north-western side was blown up, probably due to the final volcanic outburst, which suggests that the last eruption must have projected its discharge inclined to the sides of the volcano in that direction. The present mountain is therefore, shaped like a horse-shoe and it is possible to walk into the crater through the northern wall.

Two major sedimentary units occur in conformable sequences. The lower unit of Miocene age constitutes the upper part of the Peguan Super Group of Central Myanmar and consists of interbedded shales and massive, often calcareous sandstones. The overlying Irrawaddy Formation is of Pliocene to Lower Pleistocene age and consists of poorly lithified cross-bedded, fluvial sandstones with a few conglomerates and siltstones.

There are of two volcanic rocks in the Popa area. The older volcanic unit covers southern part of the Mount Popa volcano. Small flows occur locally in the topmost beds of the Miocene, but the majority occur within the Pliocene Irrawaddy Formation. The younger volcanics cover an area of 153 sq.km, comprising a near vertical composite cone (57sq.km) rising 1,150 m above the surrounding plain forming a wide spread lava plateau (60 sq.km).

Since 1920 an area of 2961 acres was demarcated as National Forest in the Mount Popa area and extended up to 49.63 sq. miles (31763.5 Acres) in 1982. The Popa Mountain Park has been established by the aid of UNDP in 1993. In 2007 Forestry Department has formed National Institute of Biological Resources and International Cooperation Unit for the Biodiversity and Environmental Conservation so as to carry out research works.

Floras are mainly of teak, Pyinkado and Tamalan and various varieties of bamboos. Faunas include mainly of jungle pigs, cats, monkeys, mammals, reptiles, and 45 species of birds.

The type of soils are vertisols, acrisols, ferrasols, and nitosols. According to archaeological data it has been known that the Popa region was inhabited by the human since 10000 years ago. The estimated population in this region is currently about 40000 in 32 villages.

The Mount Popa area has a remarkably rich geodiversity that includes varied geology, landforms, and assemblages of associated features and processes. Some geological features can even be considered as world-class. Because geodiversity has a range of values in many ways and as it is now threatened by human activities and urban development, geoconservation is essential for the well being of present and future generations. Geodiversity and geoconservation deserve more attentions in Myanmar.

The cultural and religious heritage of the Mount Popa Geopark include astrology, alchemy and the worship of Nats. Astrology to the Burmese meant not only the methods of tracing the courses of the planets and their influence on mortals, but also the ritual by which the planets were appeased and made to withdraw their influence and impact.

The most important of the thirty-six nats are the Lord of the Great Mountain and his sister Lady Golden-Face, whose abode was on the Mount Popa, an extinct volcano in central Myanmar. They became, in the ninth century, the guardian gods of the city of Bagan and its kings. There was an annual Nat feast on Mount Popa itself, at which hundreds of animals were offered as sacrifice to the Lord of the Great Mountain and Lady Golden-Face.

The mount Popa Global Geopark Development committee has formed in December 2016 and conducted frequent field activities and discovered the petrified forest in the sandstone of Irrawaddy Formation mainly west and southwest of Mount Popa around Thanbo Village. Some of the fossils of mammals especially jaws and bones of ancient elephants, deers etc. are found. Some of old iron smelters in Bagan Dynasty are discovered as a natural heritage of various species of birds such as owls, swallows, sparrows, parrots that are living together on the sandstone cliff of Irrawaddy Formation north of Thanbo Village.

Conservation activities for natural spring water, consuming by the local people; forest, landscape and sustainable development of economic activities including geotourism and research and training programmes for geology, palaeobotany, palaeozoology, biodiversity and management of Geopark are currently being carrying out in collaboration with Forestry Department, Goelogy Department of Yangon University, local NGOs and UNESCO.

Geotechnical,Geohazards & Geopark Paper -18

Geotourism and geoparks: geoscientists' roles in alleviating poverty in destitute areas of China

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New opportunities are opened for geoscientists in the past decade in developing geotourism and geoparks. In China, geotourism and geoparks have been used as a strategy to alleviate poverty in destitute areas. These areas are mostly located in China's central west and southwestern regions where 43 million people are still living on less than USD 1.90 per day. Both central and local governments are determined to address and eradicate this problem within the coming decade. Geoscientists play a significant role in identifying geoheritages with high scientific and tourism values through geological surveys and inventory establishment. The data are used for geotourism and geopark planning and design. Geo-trails and a complete interpretation system including visitor centres and museums are set up to enhance attractions of the sites. Geoscientists are also heavily involved in preparing short and long terms conservation plans of protecting geological heritages for sustainable utilization of the geological resources. By following the criteria and requirements of UNESCO Global Geopark, 35 of the 204 Chinese national geoparks have acquired global status since 2004. The UNESCO Global Geopark branding is a quality assurance enhancing the attraction of these areas. As a result, tourism grows, new businesses and jobs are created and incomes of local residents improved. With a total tourism revenue of USD 90 billion generated by Chinese geoparks since the year 2000, each Chinese geopark is estimated to worth USD26 million per year. In terms of job creation, 464,000 direct jobs and 2.6 million indirect jobs are created by geoparks and associated geotourism up to the year 2017. This paper begins by explaining the meanings and objectives of geotourism and geoparks. It follows by discussing about their development and economic impacts in China. It finally introduces the available opportunities and roles of geoscientists in this new, rapidly growing global movement.

Keywords: geotourism, geoparks, geoheritage, UNESCO, interpretation
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The Updated Seismic Models of Myanmar

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The first seismic hazard map of Myanmar was developed by Gorshkov in 1959. In 1985, Maung Thein proposed the new seismic hazard model of Myanmar and he updated his seismic hazard models in 2001, 2003 and 2005. All of these hazard models can be said as deterministic seismic hazard models and the hazard is presented in terms of modified mercalli scale and later together with peak ground acceleration (pga). Myo Thant et al. (2012) conducted the probabilistic seismic hazard assessment (PSHA) for Myanmar and they prepared PSHA maps of Myanmar in terms of peak ground acceleration (pga); spectral acceleration (sa) at the natural periods of 0.2 s and 1.0 s; peak ground velocity (pgv). In developing those maps, the seismic sources are modeled as areal seismic sources for the subduction zone domain of Indian-Australia Plate beneath Burma Plate, in the west of country and the collision zone domain of Indian-Australia Plate and Eurasia Plate, in the north-west. Moreover, the Eastern Highland region is also modeled as the areal seismic sources due to the unavailability of the sufficient fault parameters, even though there are several strike-slip faults in that region (e.g. Moemeik Fault, Nampon Fault, Shweli Fault, Kyaukme Fault, and Nam Ma Fault, etc.). We remodel 2012 seismic sources, especially the areal seismic sources of subduction and collision zones, and Eastern Highland, the new probabilistic hazard models are proposed for Myanmar.

The seismic hazard assessment is carried out for 10% and 2% probability of exceedances in 50 years as the previous one. The resulted seismic hazard maps of Myanmar are peak ground acceleration (PGA) maps, spectral acceleration (SA) maps for the period 0.2 s and 1.0 s, and peak ground velocity (PGV) maps. Currently we will introduce the probabilistic seismic hazard maps in terms of peak ground acceleration and spectral acceleration (0.2 s and 1.0 s) for 10% and 2% probability of exceedance in 50 years. Moreover, we also conducted the deterministic seismic hazard assessment (DSHA) for Myanmar.

Keywords: probabilistic seismic hazard assessment, ground acceleration, spectral acceleration, peak ground velocity, deterministic seismic hazard assessment

Determination of Site Effects by Microtremors Survey in Hlaing Township, Yangon for Future Seismic Risk Assessment

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Site effect is one of the major issues during an earthquake especially for the cities which are situated in young sedimentary rock and recent alluvium area like Yangon. Most of the townships of Yangon is located in soft alluvial plain which is mainly composed of sand, silt and clay, underlain by young sedimentary rock. Moreover, the seismogenic Sagaing fault is passing through about 40 km east of Yangon and it had experienced several earthquakes in the past. Studied area, Hlaing township is one of the major townships of Yangon with high population. To understand the potential site effects in Hlaing township during an earthquake, the microtremors survey and analysis had been conducted at 84 sites. The analysis reveals that the fundamental frequency of horizontal to vertical spectral ratio (HVRs) of microtremors is generally ranging from 1.2Hz to 2.9 Hz, while the peak amplitude is between 1.0 and 5.0. Based on the inversion of fundamental frequency and peak amplitude of microtremors HVRs, the sediment thickness is between 40m to 260m in general and the shear wave velocity of upper 30m depth (V_s^{30}) is ranging from 140m/s to 600m/s. The outcomes of this research are major input parameters for future seismic risk analysis and development of township level earthquake resilience system for Hlaing township.

Keywords: site effect, microtremors, HVRs, fundamental frequency, sediment thickness, V_s^{30}

Acquisition of Ground Information by Microtremors Survey in Central Business District, CBD, of Yangon for Future Seismic Hazard Mitigation

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Yangon is one of the most populated and socio-economically important cities in Myanmar. Unfortunately, it is located in the seismic prone area and high damage and losses will have been observed if there is an earthquake in future. The seismogenic Sagaing fault is passing through about 40 km away from Yangon and it had experienced several earthquakes in the past. Studied CBD area; Botahtaung, Pazundaung, Kyauktada, Pabedan, Lathar and Lanmadaw townships, are located mostly in soft alluvial plain which is mainly composed of sand, silt and clay and where strong ground motion and high amplification of local sediments can be expected. To minimize the seismic hazard, the microtremors survey and analysis had been conducted at 164 sites in CBD area. The microtremors (ambient seismic noises) are low amplitude vibrations generated by natural disturbances. The analysis highlights that the fundamental frequency of horizontal to vertical spectral ratio (HVRs) of microtremors is generally ranging from 1Hz to 2.7 Hz, while the peak amplitude is between 1.2 and 5.2 while peak amplitudes are between 1.3 to 4.2. Based on the fundamental frequency and peak amplitude of microtremors HVRs, the sediment thickness, shear wave velocity of upper 30m depth (V_s^{30}), soil class and the potential engineering bedrock had been determined for future seismic hazard analysis and mitigation in Yangon.

Keywords: microtremors, spectral ratio, fundamental frequency, peak amplitude, sediment thickness, V_s^{30}

Strength and Stiffness Parameters determined from Cone Pressuremeter Tests at Changi East Reclamation Project

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As a part of infrastructure developments, large scale land reclamation was carried out in Singapore involving creation of 2000 hectors of land at foreshore location East of Singapore. The project is named as Changi East Reclamation Projects. The land was created in the sea by placing hydraulically filled sand on to the soft seabed marine clay. Various types of ground improvement techniques including prefabricated vertical drains with surcharge preloading and deep compactions have been used to improve the soft marine clay and reclaimed sand respectively. As a part of geotechnical characterization, various in-situ tests were conducted at the project area including cone penetration tests, pressuremeter tests, cone pressuremeter test and dilatometer tests. The cone-pressuremeter test is an in-situ testing method used to measure both the soil strength and stiffness parameters. The cone-pressuremeter combines the advantages of a conventional pressuremeter test and a CPT. CPT probe provides a continuous profile of the soil by measuring the stress on the tip, the sleeve friction and the porewater pressure. Pressuremeter allows the assessment of the soil strength and stiffness at selected depths. This paper presents the results of cone pressuremeter tests conducted at the Changi East Reclamation project. Pressuremeter tests were conducted on both reclaimed sand and underlying soft marine clay. The results from the cone pressuremeter tests are compared with other specialized tests and the results are found to be in good agreements.

New technologies in the energy industry. The use of unmanned aerial vehicles

Karol Cheda

Unmanned Systems Manager
Research and Development Division

(No abstract has been submitted)

Characteristics of Okhmintaung Sandstones in Nyaungnigyin Area, Chauk and Nyaung U Township

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Nyaungnigyin Area is located about 12 km westward from Kyaukpadaung and 17 km eastward from Chauk. It is the southern part of Gwegyo– Tawintaung Range. It also lies between North Latitude 20° 50′ to 20° 53′ and East Longitude 94° 58′ to 95° 01′. The study area comprises mainly Oligocene and Pliocene sediments which are, in ascending order, Shwezettaw Formation, Padaung Formation, Okhmintaung Formation and Irrawaddy Formation. Okhmintaung Formation is well exposed on the western part of the study area. It is mainly composed of buff-coloured massive sandstone and subordinate bluish grey clay with intraformational fossiliferous conglomerate bands. Based on fossil assemblages, Okhmintaung Formation may be regarded as of late Oligocene in age. The purpose of present study is to determine the reservoir quality based on the characteristics of sandstones. The sieving analysis was carried on to know the textural characteristics of sandstones. The petrophysics properties of sandstones were derived from the porosity analysis. The mean size of Okhmintaung sandstones are ranging from 2.16 to 3.26 and standard deviations are 0.95-1.23. The average mean value and standard deviation interpreted, Okhmintaung sandstones are composed mainly of poorly to moderately well sorted, fine grains. Based on the relationship between petrophysic properties and textural characteristic, Okhmintaung sandstones are from 29% to 37% of porosity and from 400 to 10000 mD of permeability. However, the effective porosities of Okhmintaung sandstones are ranging from 28.99% to 40.69%. The characteristics and porosity value pointed to Okhmintaung sandstones have very good reservoir quality.

Keywords: sandstone, textural characteristic, porosity, reservoir

Geotechnical,Geohazards & Geopark Paper -25

Geological structures and Relating Petroleum Occurrences of Kyaukmyaung Area, Minhla Township, Magway Region

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The study area is famous for its petroleum accumulation and we focus our study on the structural features in the area. The main scope of this research is to establish a modified geological map and to correlate geological structures with the petroleum occurrences of Kyaukmyaung area. To complete the need, geomorphologic studies and marking structural features such as folding, faulting and jointings were carefully done. Furthermore, a detail field study was carried out to locate the actual places where petroleum is accumulated and a few interviews with both local and government petroleum explorers. As a result, the modified geological map has completed and it could also be interpreted that the occurrences of petroleum is significantly related to the major structural features of the research area. The research area can be said to be influenced by a counter-clockwise rotational compressive stress of NE-SW direction to nearly NNE-SSW direction. Secondly, a detail lithologic study was done to investigate the stratigraphy of the area. The research area mainly consists of Tertiary sedimemtary rocks where of Oligocene-Miocene units of Pegu Group and Pliocene Irrawaddy Formation.

Keywords: Kyaukmyaung area, structural features, occurrences of petroleum, compressive stress, Tertiary sedimemtary rocks

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Multichannel Analysis of Surface Wave method for geotechnical site characterization in Yogyakarta, Indonesia

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On May 27th 2006, Yogyakarta earthquake happened with 6.3 Mw. It was causing widespread destruction and loss of life and property. Shear wave velocity is one of the most influential factors of the ground motion. The average shear wave velocity for the top 30 m of soil is referred to as Vs30. In this study, the Vs30 value was calculated by using multichannel analysis of surface waves (MASW). The Multichannel Analysis of Surface Waves (MASW) method was introduced by Park et al. (1999). Multi-Channel Analysis of Surface Waves (MASW) is non-invasive method of estimating the shear-wave velocity profile. It utilizes the dispersive properties of Rayleigh waves for imaging the subsurface layers. MASW surveys can be divided into active and passive surveys. In active MASW method, surface waves can be easily generated by an impulsive source like a hammers, sledge hammer, weight drops, accelerated weight drops and explosive. Seismic measurements were carried out 44 locations in Yogyakarta province, in Indonesia. The dispersion data of the recorded Rayleigh waves were processed by using Seisimager software to obtain shear wave velocity profiles of the studied area as shown in figure 1. The average shear wave velocities of the soil obtained are ranging from 200 ms^{-1} to 900 ms^{-1}, respectively.

Keywords: seismic measurements, *shear wave velocity, Multichannel Analysis of Surface Wave (MASW)*

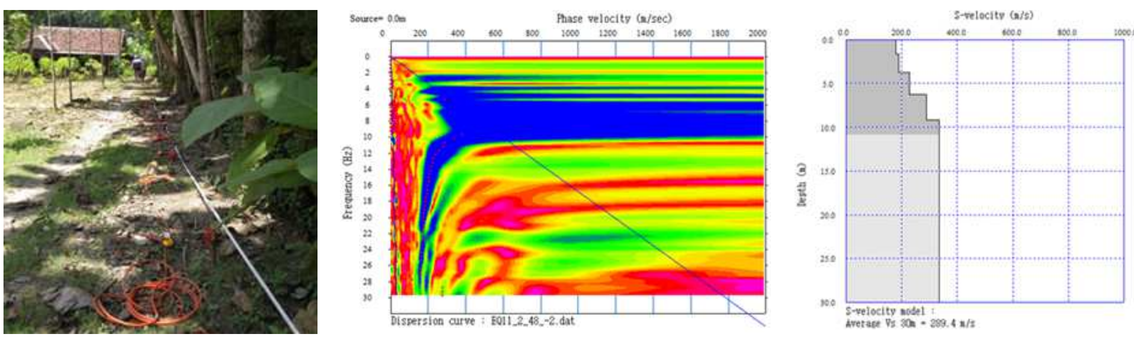

Figure.1 Data acquisition and processing of MASW data

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Calculation of Ground Motion by Using the Multiple Transfer Function Method in Yogyakarta City, Central Java, Indonesia

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Indonesia is repeatedly unsettled by severe earthquake related disasters, which are geologically coupled to the 5-7 cm per year tectonic convergence of the Australian plate beneath the Sunda plate. Yogyakarta city, the capital of Yogyakarta Special Province, is situated at the southern part of the volcanic arc island of Java. The city and the province accordingly are prone to geohazards especially earthquakes as well as geological problems. The 27th May 2006 earthquake hit the Provinces of Yogyakarta and Central Java at 5:53 a.m. local time, with its epicenter estimated at about 30 km south of Bantul district in Yogyakarta Province. The magnitude scale reached M_W 6.3. Subsequently, about 750 aftershocks have been reported, with the largest intensity recorded at 5.2. Based on latest available information, more than 5,700 precious human lives have already been lost. About 9,000 individuals are estimated to have been injured, though estimates vary up to 20,000 individuals. About 200,000 people are estimated to have been displaced and rendered temporarily or permanently homeless. The purpose of this research is to simulate the prominent periods of the strong ground motions in the Yogyakarta city by utilizing the multiple transfer function model. There are 12 bore-hole sites in the research area to calculate the V_{S30} values. The period values are varying from 0.44 to 0.50 sec and 0.45 to 0.67 sec. The period map illustrates that significant amplification occurs in the research area. This research indicates that the periods are useful parameter for characterization of ground motion simulation. Finally, the period map of the transfer function method will relate to the damage area of the research city for the future earthquake.

Keywords: Multiple Transfer Function Method, Periods, Strong Ground Motion and Yogyakarta city.

A Study on Surface Sediments Distribution of Ayeyarwady Continental Shelf

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The study area is located in northern part of Andaman Sea; bounded by latitude 13º 25´ N and 15º 40´ N and longitude 93º 15´ E and 97º 45´ E occupies the south and southwest oceanic area of Myanmar. Ayeyarwady continental shelf is part of an area of a complex geological setting in Andaman basin, located in the south of Ayeyarwady delta surrounded by land area in north and east. In the present study, sediments facies, the textural characteristics and grain size distribution were systematically studied. From the facies analysis clayey silt facies occupied the gulf of Martaban is deposited by the sediment delivered from Ayeyarwady, Sittaung and Thanlwin rivers settle out from suspension in relatively low energy condition. The sand dominant facies occupied in the southwestern part of Ayeyarwady continental shelf can be interpreted as relict sediment deposited in a variety of shallow water area during the sea level Lowstand generating the alluvial, coastal plain and shoreline environments. This is obvious that the rapid raise of sea level during the Holocene causes these environments to be submerged and hence most of the seabed sediment appeared unrelated to their new, shallow shelf environments. Clayey sand facies occupied in the southwestern part of Ayeyarwady continental shelf were deposited by Ayeyawady River or redistribution of relict sand. Sand-silt-clay facies deposited with intense bioturbation forming a mixed sediments on Ayeyarwady continental shelf are the sediment of prodelta area. The sand silt clay facies is caused by intense bioturbation in that area by. Clayey silt facies occupies the south of Martaban canyon area which represent the pelagic sediment settled out from suspension.

Sedimentology Of Letkat Formation In Southern Chindwin Basin, Sagaing Region, Myanmar

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The present research would offer the sedimentology of the clastic sedimentary rock unit of Letkat Formation (Early Miocene) exposed in the southwestern Chindwin Basin, situated in Kalewa-Mawleik Townships, Sagaing Region, Myanmar. The study is mainly focus on petrography and provenance study and outcrop-based sedimentary facies analysis. Stratigraphically, the upper member of Letkat Formation of Thitchauk Conglomerate comprises quartz pebble conglomerate and clean quartzose sandstone with large-scale cross-stratifications. The lower Nwa Taung Sandstone member is composed of sandstone with some shale intercalations or partings between massive sandstone beds which are mostly fine to medium-grained, gray sandstones with medium to large scale cross-stratifications, wood chips, mud clasts, and quartz pebble conglomerate pockets or stringers are common. Petrographically, the Letkat sandstones mainly composed of detrital grains including abundant altered feldspar grains with few volcanic lithic grains and metamorphic grains; schist fragments and abundant undifferentiated altered grains cemented with chemical cement, lithic arkose to arkose in composition with a significant diagenetic imprint. By the provenance study, the data plot fall in the field of recycled orogenic and transitional continental and the dissected arc, mix and transitional continental provenance. By the sedimentary facies analysis, there are eight lithofacies such as trough cross-stratified sandstone (St) with basal erosional surface facies (Se) and lags, pebbly gritty sandstone facies (Gm), sand-mud interlayer facies (Fl), thinly laminated fine sandstone facies (Sl), planar cross-stratified sandstone facies (Sp), horizontal to low-angle stratified sandstone facies (Sh), massive, variegated silty clay facies with fine-grained sandstone facies (Fsc) and bluish grey silty shale with silt and sand lens facies (Fsc) are recognized in the Letkat Formation which was deposited in a braided fluvial system.

GEOMYANMR 2018

31 January 2018 (Wednesday)

8:00	9:00	**Registration**
9:00	9:30	**Opening Ceremony**
9:30	10:00	**Coffee Break**

KEY NOTE PROGRAM

Key Note Chair Person -

Time		**Title**	**Speaker**
10:00	10:30	The Popa – Loimye Arc and it's mineralization	Dr.A.H.G.Michell
10:30	11:00	MIOCENE MAGMATISM and its implications for the Metallogeny of Myanmar	Mr.Laurence Robb
11:00	11:30	UNESCO Global Geoparks: the development in the Asia Pacific Region	Dr. Ibrahim Komoo
11:30	12:00	Life of mine planning for improved environmental management	Dr.Greg Maddocks
12:00	13:00	**Lunch Break**	

Key Note Chair Person -

13:00	13:30	Geology in underground mining	U Kar Winn
13:30	14:00	Tibet and Beyond: Collision Zone Magmatism in the Eastern Tethyan Orogenic Belt	Prof. Sun-Lin Chung

ORAL PRESENTATION SECTION
Chair: , Co Chair:

14:00	14:25	Slope flows on Rakhine shelf	Win Maw
14:25	14:50	Role Of CCOP On Promoting The Geosciences Cooperation In Southeast Asia	Dr. Adichat Surinkum
14:50	15:20	**Coffee Break**	

Section - A Tectonic and Mineralization

Chair: , Co Chair:

15:20	15:40	Granite-related W (-Sn) -Mo mineralization in Padatgyaung-Myinmahti area, central Myanmar	Aung Zaw Myint
15:40	16:00	Cordierite-bearing paragneiss and cordierite-free garnet-biotite paragneiss samples from the middle segment of the Mogok metamorphic belt, central Myanmar	Ye Kyaw Thu
16:00	16:20	Quantifying the rise of the Gangdese – Himalaya Orogen and Implications South Asia Monsoon	Prof. Ding Lin
16:20	16:40	The first portable seismic array in Myanmar and the crust and upper mantle structures beneath north central Myanmar	Yumei He
16:40	17:00	High-grade epithermal veins in the Kwin Thone Ze District, Shante Gold Province, Mogok Metamorphic Belt, central Myanmar	Kyaw Min Htun
17:00	17:20	Acid, Intermediate and Basic- Ultramafic Igneous Rocks from Belin area, Mon State	Tin Tin Latt
17:20	17:40	Preliminary 3D velocity structure of the Central Myanmar Basin	Xin Wang

Section - B Geotechnical,Geohazards and Geopark

Chair: , Co Chair:

15:20	15:40	Geotechnical Conditions And Lessons Learnt From Dam Foundations, Tunnels And Slopes In Different Formations Along The Western Ranges, Magway And Sagaing Regions	Dr. Kyaw Htun
15:40	16:00	Maar lakes and preliminary study on high resolution paleoclimatic change in Myanmar	Prof. Guo Qiang Chu
16:00	16:20	Geoheritage and Geoparks in China	Kejian Xu
16:20	16:40	Controls on the terrace system of Lower segment of Irrawawaddy river, Central Myanmar Basin	Naing Maw Than
16:40	17:00	Early Permian (Cisuralian) brachiopod fauna from the Yinyaw beds in the Yinyaw area, Pekon Township, southern Shan State, Myanmar	Kyi Pyar Aung
17:00	17:20	Sequence Stratigraphy of the Neogene Sediments exposed in Myothit-Taungnyo area, Magway Region and Nay Pyi Taw council	Thant Zaw Moe
17:20	17:40	Lithofacies Analysis of Middle Miocene Balikpapan Formation, Samarinda Area, Lower Kutai Basin, Indonesia	Chaw Thuzar Win

1 February 2018 (Thursday)

Section - A Tectonic and Mineralization

8:00	9:00	**Registration & Coffee**

Chair: , Co Chair:

Time		Title	Speaker
9:00	9:20	Geology and Discoveries on Primary Gold Mineralization at Kalein Area, Shwegyin Township, Bago Region	Kyaw Lin Zaw
9:20	9:40	Orogenic Gold Mineralization in Kyaukkyi Area, Bago Region, Myanmar	May Thwe Aye
9:40	10:00	Cenozoic magmatism, mineralization and tectonic setting at Shangalon Au-Cu district, north of Wuntho-Popa Arc, Myanmar	Thiri Ye Htut
10:00	10:20	Kinematics, geodynamics and paleoseismology of the sinistral faults on the Shan Plateau, SE of the eastern Himalayan syntaxis	Xuhua Shi
10:20	10:40	Geochronology of The Myanmar Ophiolites and its Implications for Tectonic Framework	Prof. Chuan Zhou Liu
10:40	11:00	Fluid Processes in the forearc mantle as constrained by Jadeitites and associated serpentinites Myanmar	Prof.Chen Yi
11:00	11:20	Mesozoic-Cenozoic Magmatism Of Central Myanmar Arc: Implication For Tectonic Evolution In Myanmar	Than Zaw
11:20	11:40	Mineral Resources of Myanmar : Past, Present and Fucture	Kyi Tun
11:40	12:00	Structural Deformation of Meiktila Area, along the Mandalay-Naypyidaw Express Car Road	Saw Ngwe Khaing
12:00	13:00	**Lunch Break**	

Chair: , Co Chair:

13:00	13:20	Geology and Petrology of the Metamorphic and Igneous Rocks of the Kuki Area, Layshi Township, Sagaing Region	Zaw Htike
13:20	13:40	Mineral Chemistry and *P-T* evolution of High-grade Gneiss and Granulite,from the Mount Loi-Sau and its Environs, Mogok and Momeik Townships, Mandalay Region and Shan State (North)	Wai Yan Lai Aung
13:40	14:00	Jadeitite and associated high-pressure metamorphic rocks of Natmaw Area, Hkamti Township, Sagaing Region, Northwestern Myanmar	Cho Cho
14:00	14:20	Cenozoic Deformation Study on part of Suture Zone between Sagaing Fault and Shan Scarp.	Sandy Chit Ko
14:20	14:40	Geology and Mineral Aspect of Part of the Hu Kawng Basin and Kumon Range, Kachin State.	Nyunt Htay

14:40	15:00	Seismicity and Active Tectonics in Kabaw Valley Fault Zone and Surrounding Regions, Western Myanmar	Kaung Si Thu
15:00	15:30	**Coffee Break**	

Chair: , Co Chair:

15:30	15:50	Shear Hosted Mesothermal Gold Deposit,Kyaukphyuchaung Area, Banmauk, Northern Myanmar	Han Naing Zaw
15:50	16:10	Petrochemical Characteristic and Geochronnology of the Igneous Reocks in Bilin and its Environs, Bilib Township, Mon State	Mya Moe Khaing
16:10	16:30	Geology and Mineral Resources of Hopang Area, Northern Shan State, Myanmar	Zar Ni Swe
16:30	16:50	Characteristics and genesis of Gold Mineralization at That-Kal Byant area, Thabeikkyin Township, Mandalay Region	Myo Myint Myat
16:50	17:10	Geochemistry and Petrogenesis of Proterozoic Rock Unit Hosting Gold Mineralization in Phayaung Taung area, Central Myanmar	Win Phyo
17:10	17:30	Petrological and Geochemical Studies of Chromitite of the Bhopi Vum Area,Tiddim Township, Chin State	Tun Tun Min
17:30	17:50	A Significant Role of SiO_2, Al_2O_3, Na_2O, K_2O and CaO proportions in genetic types and classification of some granitic rocks in Kyaing Tong Area, Eastern Shan State, Myanmar	Khine Zar Wai
18:30	21:30	**GEOMYANMAR2018 GALA DINNER AT POOL SIDE, SEDONA HOTEL**	

1 February 2018 (Thursday)

Section - B Geotechnical,Geohazards and Geopark

	Time	Title	Speaker
8:00	9:00	**Registration & Coffee**	

Chair: , Co Chair:

9:00	9:20	Initiation and Evolution of Fore arc Basin in Central Myanmar	Prof. Fulong Cai
9:20	9:40	Measurement and modeling of ground motions in Myanmar for seismic hazard assessment	Yin Myo Min Htwe
9:40	10:00	Fossil wild boars of Myanmar and their significances before/after the late Miocene faunal turnover in Asia	Thaung Htike
10:00	10:20	Stratigraphy of Linwe Formation (early Silurian) of Konlon and Thayetpya in Pindaya Plain, South Shan State, Myanmar: pseudo-bedding produced by burial diagenesis	Yin Min Htwe
10:20	10:40	Comparison of Arsenic Adsorption from Groundwater on Lignite and Bentonite	Kyu Kyu Mar
10:40	11:00	Provenance Study of Siliciclastic Rocks Exposed in Okhmintaung Type Section Area, Magway Region	Paing Soe
11:00	11:20	Diamictite Horizon of Taungnyo Formation in Mawlamyine-Mudon Area, Mon State	Moe Moe Lwin
11:20	11:40	A Report on Upgraded Seismic Monitoring Stations in Myanmar: Station Performance and Site Response	Hrin Nei Thiam
11:40	13:00	**Lunch Break**	

Chair: , Co Chair:

13:00	13:20	The Inventory Of Preliminary Geological Sites Assessment In Myanmar	Myint Soe
13:20	13:40	Mount Popa Geopark and Potential Geoparks in Myanmar	Than Htun
13:40	14:00	Geotourism and geoparks: geoscientists' roles in alleviating poverty in destitute areas of China	Dr Young NG
14:00	14:20	The Updated Seismic Models of Myanmar	Myo Thant
14:20	14:40	Determination of Site Effects by Microtremors Survey in Hlaing Township, Yangon for Future Seismic Risk Assessment	Tun Naing
14:40	15:00	Acquisition of Ground Information by Microtremors Survey in Central Business District, CBD, of Yangon for Future Seismic Hazard Mitigation	Su Thinzar
15:00	15:30	**Coffee Break**	

Chair: , Co Chair:

15:30	15:50	Strength and Stiffness Parameters determined from Cone Pressuremeter Tests at Changi East Reclamation Project	Soe Moe Kyaw Win
15:50	16:10	New technologies in the energy industry. The use of unmanned aerial vehicles.	Karol Cheda
16:10	16:30	Characteristics of Okhmintaung Sandstones in Nyaungnigyin Area, Chauk and Nyaung U Township	Paike Htwe
16:30	16:50	Geological structures and Relating Petroleum Occurrences of Kyaukmyaung Area, Minhla Township, Magway Region	Han Myo Hset
16:50	17:10	Multichannel Analysis of Surface Wave method for geotechnical site characterization in Yogyakarta, Indonesia	Nwai Le Ngal
17:10	17:30	Calculation of Ground Motion by using the Multiple Transfer function Method in Yogyakarta City, Central java, Indonesia	Zaw Lin Kyaw
17:30	17:50	A Study on Surface Sediments Distribution of Ayeyarwady Continental Shelf	Ko Yi Hla
17:50	18:10	Sedimentology Of Letkat Formation In Southern Chindwin Basin, Sagaing Region, Myanmar	Moe Zat
18:30	**21:30**	**GEOMYANMAR2018 GALA DINNER AT POOL SIDE, SEDONA HOTEL**	

2 February 2018 (Friday)

Time		Title
8:00	9:00	**Registration**
9:00	11:30	**MGS 14th Annual General Meeting & Paying Homage Ceremony**
11:30	13:00	**Lunch**
14:00	18:00	**Acid & Metalliferous Drainage (AMD) Short Course by Dr. Greg Maddocks (Principal Hydrogeochemist, RGS Environmental Pty. Ltd.)**

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