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ABSTRACTS

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A REVIEW OF PALEOZOIC STRATIGRAPHY IN THE WESTERN PART OF SOUTHERN SHAN STATE, MYANMAR

Aye Ko Aung
Department of Geology, Dagon University

EXTENDED ABSTRACT

The Paleozoic stratigraphy of the western part of southern Shan State, Myanmar is reviewed with some recent findings in the area. The rocks of Precambrian and Paleozoic rocks, in exception of the Carboniferous, are well exposed in Ywa-ngan Township, the westernmost township of the Southern Shan State. This study is based on the earlier work of Myint Lwin Thein (1973) in review of the Lower Paleozoic rocks and, follows Garson et al. (1976) for the Permo-Triassic rocks. A useful conodont, *Ozarkodina remscheidensis* is recovered from the upper part of the Linwe Formation, east of Pegin village which indicates the age of Late Silurian Ludlovian to Early Devonian late Lochkovian age (Maung Maung and Aye Ko Aung, 2012). A Middle Permian Murgabian to Capitanian phillipsid trilobite is reported for the first time from the Thitsipin Limestone outcrop of Linwe pagoda hill (Aye Ko Aung, 2005). It is closely similar to a trilobite species of same age, *Pseudophillipsia* sp. from the Bara area, Pahang State, east Malaysia (Shafeea Leeman and Sone, 2002). Similarly, a colonial waagenophyllid rugose coral species, *Waagenophyllum yini* FONTAINE of Middle Permian Capitanian from the Thitsipin Limestone of the Linwe area is closely coeval with that of Bukit Kapayang, Kampong Awah area, Pahang State (Aye Ko Aung and Mustaffa Kamal Shuib, 1913). Two Devonian units are recognized in the Myogyi area, the Zebingyi Formation of Early Devonian (Pragian-Emsian) and the conformably overlying unnamed unit of Late Devonian (Frasnian). The unnamed Devonian unit is here proposed as a part of the “Maymyo Formation”, which include the Padaukip Limestone and Wetwun Shale (Aye Ko Aung, 2005, 2012), and Aye Ko Aung and Cocks (2017). The new Devonian unit consists of alternating purplish-red, unindurated calcareous siltstone and medium-bedded light grey argillaceous limestone with some ammonoids, gastropods, nautiloids, and ostracods (Ko Ko Myint, 1989). Two species of Frasnian ammonoids have been collected, identified as *Beloceras shidianese* YANG, 1984, and *Tornoceras* cf. *contractum* GLENISTER, 1958 (Aye Ko Aung et al., 2011). The types of *Beloceras shidianese* are from the Baoshan District of western Yunnan, which is rather close to Myanmar. *T. contractum* is restricted to the lower Frasnian to middle part of the middle Frasnian in the Canning Basin (Becker and House, 2009). Further precision of the age of the ammonite level can be expected from future conodont investigations and additional collections.

In addition to that, some rock units are recognized in the western part of the area, such as, the Chaungmagyi Group of either Neoproterozoic or Cambrian age (Dew et al., 2019) in Myogyi and Yechanpyin areas, Ywa-ngan Township. The later is firstly surveyed to consider the contact between Precambrian Chaungmagyi Group and Cambrian Molohein Group whether it is stratigraphic or structural. The Chaungmagyi Group in the core of “Yechanpyin Anticline” comprises, in order of abundance, yellowish brown sandy phyllite, green chlorite phyllite, greywacke, siltstone and purple quartzite. Scattered quartzfeldspathic veins are frequent. The group passes upward into the Cambrian Molohein...
sandstone and no signs of break in sedimentation is recognized in the Yechanpyin area.

The present work also deals with the Precambrian to and Paleozoic rock sequence, freshly exposed along Han Myint Mo – Myogyi – Ywangan road section. The road, 67.2 kilometers (42) miles in length, lies jointly in Mandalay Region to the west and southern Shan State in east. It was reconstructed in two years (1916 to 1918), under Regional Development Project for Poverty Reduction funded by Japanese Oda Loan as a friendship and cooperation between Japan and Myanmar. The beds are more or less dipping with high angles and the strike of the bed is almost parallel to the road. The formation names of Lower Paleozoic rocks exposed along the road is adopted from Myint Lwin Thein (1973). The section starts low in the Middle Ordovician limestone of the Wunbye Formation which is dominated by the mixed limestone-shale succession. In south and southwest of Myogyo Dam, the individual beds can be followed for several kilometers along the road. The base of which is covered in the plain adjacent to the bituminous road. The Wunbye limestones are extensively used as road and construction material for nearby Myogyi Dam. It is followed by the Upper Ordovician Nan-on Formation, mainly consists of siltstone, shale, and limestone. The whole unit is slightly metamorphosed due to the minor tectonic activities.

The Nan-on Formation is conformable with the overlying Linwe Formation of Silurian age. It comprises yellowish brown limestone, dark in color when fresh. Medium-to thick-bedded, with thin bands of calcareous shale, the sequence is lightly metamorphosed and slightly folded in places. The lower Paleozoic sequence is over thrust by the Chaung Magyi Group which was excluded from the Paleozoic by Aye Ko Aung and Cocks (1917), and assigned an entirely Precambrian age. In the area between Myogyi and Sakangyi, the Chaung Magyi Group comprises, in order of abundance, yellowish brown sandy phyllite, chlorite phyllite, metagreywacke, slate, quartzite and siltstone. The sequence is similar to that of the type section, along the east bank of Chaung Magyi river north of Sedawgyi, Madaya Township, Mandalay Division mapped by Aye Ko Aung (1980). The only difference is that, a good datum unit of purple conglomerate beds (80m in thickness), overlying upon the Chaung Magyi quartzite is absent in this section. In addition to that, the purple conglomerate bed is recognized in four areas: Bawdwin Mine area (BGR, 1976; Brinkmann and Hinze, 1981; Hopwood, 1985; Gardiner et al., 2017; Hsinmango hill, Satthe village, and Sugyi hill, in Ywangan Township (Myint Lwin Thein, 1973). The stratigraphy of poorly dated Chaung Magyi Group required an extensive revision in a matter of urgency.

REFERENCES


REFERENCES


Aye Ko Aung, 2010b. New Early Permian rugose corals from Myanmar (in prep.).
Kyi Kyi Maw and Aye Ko Aung, 2009. Revision on the stratigraphy of PermianThitsuipin Limestone, Myanmar (in prep.).
MONDAUNG-LAWA AND POPA-LOIMYE ARCS AND OTHER BELTS, THEIR MINERAL DEPOSITS AND TECTONIC SETTINGS

A.H.G. Mitchell1, Kyaw Min Htun2 and Myin Thein Htay2

1 Myanmar Precious Resources Group and 20 Dale Close, Oxford OX1 1TU, UK; 2 Myanmar Precious Resources Group, Room 302, Shwe Than Lwin Condo, New University Avenue road, Aye Yeik Thar St, Bahan Township, Yangon, Myanmar

ABSTRACT

Recent identification of the Mondaung-Lawa magmatic arc necessitates revisions to inferred post-Triassic tectonic plates and their mineralisation in Myanmar west of the Salween (Figs.1, 2). Restoration of the long-proposed ca 400 km dextral displacement on the Sagaing Fault allows pre-Oligocene continuity of the IndoBurman Ranges and Central Basin with the Tagaung-Myitkyina Belt and KathaGangaw Range. We relate the Modi Taung orogenic gold mineralisation in the Shan Scarps to end-Jurassic or possibly early Jurassic tectonic burial and metamorphic dehydration of the Mergui Group beneath a nappe of Mogok Metamorphics and overlying Sibuma crust, a setting analogous to Au mineralisation in the Monte Rosa nappe or Tauern window in the Italian and Austrian Alps. The early Cretaceous (127 to 113 Ma) Mondaung-Lawa arc includes numerous rhyodacitic intrusions and Yebokson Granodiorite in the Shan Scarps, and the Law Chaung diorites on the adjacent Shan Plateau. The arc hosts productive Au-Cu skarns and a magnetite prospect on the Plateau margin, skarns at Mondaung, and Cu skarns at Paladokhta. It probably includes I-type granitoids west of Mondaung, continues southwards along the Tanintharyi coast to Phuket, and appears in Tengchong, its basement defining a Mergui-Tengchong Block. The arc formed above eastward-subducting Neo-Tethys which closed when the Victoria-Katha Block and its Triassic flysch underthrust ophiolite and the Mergui-Tengchong Block, before deposition of mid-Cretaceous Orbitolina Limestone over the subduction zone. The metamorphic Jade Mines Uplift (Fig.1) is probably part of the Victoria-Katha Block, interpreted as a window beneath jadeite-bearing Neo-Tethys serpentinite mined at Hpakant and near Khamti. The jadeite veins, possibly products of early Cretaceous hydrothermal fluid expelled from the subducting Block, may have ascended within their ductile serpentinite host rock along the former subduction zone. Indian Ocean lithosphere subducting west of the Victoria-Katha Block generated 106 to 90 Ma and 38 to 33 Ma granodiorites and diorites, 50 and 70 Ma andesite dykes, and 14 Ma latites and Pliocene-Recent stratovolcanoes. Within this Popa-Loimye arc pre-Albian pillowed basalts and andesites, the Mawgyi Volcanics, form an epithermal gold metallocotect with sub-sea floor volcanogenic Cu sulphides also found in the Indo-Burman Ranges. Like the orogenic Au and many Sb deposits, the epithermal gold may be situated above structural highs. The giant high sulphidation epithermal chalcocite Cu deposits at Monywa with 14 Ma mineralised quartz andesites lie on the arc axis. In the Shan Scarps and Tanintharyi reduced 72-44 Ma granites intruding the argillaceous Mergui Group contain more than 400 Sn-W-(Ta) deposits. We suggest that hornfelsed slates above granite apices blocked ascent of magmatic hydrothermal fluids, depressing the magma surface and increasing hydrostatic pressure. This ruptured the hornfels,
resulting in mineralised veins and Sn-Ta-bearing pegmatites in and above the granites, while similar granites in the fracture-permeable Mogok Metamorphics lack Sn-W. Instead of back-arc extension during mineralisation, we favour 1980s proposals of east-directed thrusting and crustal melting, as Southeast Asia rotated clockwise. Older higher-level since-eroded granites could explain some of the high-temperature Tertiary metamorphism in the Mogok Belt. In the Shante gold district migmatite and spinel-ruby bearing marble of the Mogok Belt host base metal-rich pyrite-pyrrhotite and telluride-bearing veins with chalcedonic hydrothermal breccias and reported adularia. Commonly exceeding 500 m down-dip, the epithermal veins post-date mid-Tertiary cooling ages on micas and the 16 Ma Shar Chat granite. They imply younger intrusive heat sources beneath the latest Oligocene-early Miocene Payangazu-Kabaing belt of partly crust-derived dykes and granites.

Fig. 1. Map with locations A, B, C, D for Fig. 2 cross-section. Offset between lines A and D on Sagaing Fault is ca 500 km. CB Central Myanmar Basin, IBE and IBW, Indo-Burman Ranges Eastern and Western Belts, IO Indian Ocean, IOS Indian Ocean suture zone, J Jade Mines Uplift, KG Katha-Gangaw Range, MMB Mogok Metamorphic Belt, MTB Mergui-Tengchong Block, PLA Popa-Loimye arc, PT Palaeo-Tethys suture zone, SF Sagaing Fault, SP Shan Plateau, SS Shan Scarp, SSS Shan Scarps, TM Tagaung-Myitkyina Belt. Broken orange line Mondaung-Lawa arc, black dots Payangazu-Kabaing intrusions.
Fig. 2. Schematic cross-section from Naga Hills through Hpakant to Sagaing Fault and continuation through Shan Scarps and Shan Plateau, 500 km dextral offset on Sagaing Fault restored. Blocks or terranes in block capitals. S, I are S- and I-type granites. NCT Ngayan Chaung Turbidites, P Plateau Limestone and Yinyaw Beds, PMZ Paung Laung-Mawchi zone; 1, 2 etc sequence of thrusts. Location on Fig. 1.
INTEGRATING BIOLOGICAL AND PHYSICAL CHANGES DURING THE LATE CAMBRIAN AND INTO THE ORDOVICIAN DIVERSIFICATION: PATTERN AND PROCESS

Hughes Nigel C.\textsuperscript{1}, Wernette Shelly J.\textsuperscript{1}, Myrow Paul M.\textsuperscript{2}, McKenzie N. Ryan\textsuperscript{3}, Sardsud Apsorn\textsuperscript{4} and IGCP 668 members

\textsuperscript{1}University of California, Riverside, nigel.hughes@ucr.edu
\textsuperscript{2}Colorado College, USA
\textsuperscript{3}University of Hong Kong, China
\textsuperscript{4}Department of Mineral Resources of the Kingdom of Thailand, Thailand

IGCP668 focuses on regionally localized but globally Earth-Life interactions at a critical and poorly resolved interval of Phanerozoic time: the transition from the later Cambrian into the early Ordovician up to the establishment of the “Great Ordovician Biodiversification Event”. Recent work has shown that the late Cambrian, with its repeated episodes of evolutionary “boom and bust” is also a time in which the Earth was generating large amounts of zircon grains from felsic igneous activity. Such a high zircon yield is an unexpected result because that late Cambrian is one of the most poorly dated intervals of the Phanerozoic in terms of absolute dates. Because felsic yields abundant zircon grains, the Cambrian might be expected to have few such grains. This conundrum is resolved by the fact that the source of the high late Cambrian zircon yield was concentrated around the equatorial Gondwanan margin, much of which has been destroyed in subsequent tectonic activity, such as building the Himalaya and Tibet. Fortunately, there is one area in which this record is preserved such that datable ashes and faunas of invertebrate fossils are interbedded. That region is the Sibumasu/Shan-Thai block. Hence the primary tasks of IGCP668, with its particular focus on the integration of biotic and physical events, are firstly to resolve the geochronology of the late Cambrian and correlate this regionally and globally, and secondly to assess associations between the patterns of evolution witnessed and the episodes of intense igneous activity.
MAGMATIC-HYDROTHERMAL TIN DEPOSITS WITH SPECIAL REFERENCE TO TIN MINERALISATION IN SOUTH EAST ASIA

Laurence ROBB
Department of Earth Sciences, University of Oxford, UK

Once the principal tin producer of the World with an annual production in the period 1950-1980 that typically exceeded 50 000 tonnes, Malaysian output over the past 2 decades has declined to less than 5000 t per annum. By contrast, global tin production over the past decade has remained relatively constant at around 300 000 to 350 000 tonnes and is dominated by China and Indonesia. The SE Asian granite tin belt (Figure 1) is undoubtedly the most prolific tin metallotect on Earth. The tin belt forms part of an extensive magmatic arc that was emplaced as 4 principal belts that young towards the west as the Tethyan Ocean was progressively subducted beneath SE Asia from late Permian through to Eocene times. In Peninsula Malaysia two major belts are recognized, the Permo-Triassic Eastern Belt (260-230 Ma) which is predominantly I-type, and the upper Triassic Main Range (220-210 Ma), which is largely S-type (Figure 1). Elsewhere in SE Asia, the granites of Myanmar are represented by the upper Cretaceous-Eocene, S-type Mogok-Mandalay-Mergui (MMM) belt in the east and the I-type Wuntho-Popa arc emplaced over a similar time span to the west (Figure 1). Tin mineralization is widely distributed throughout the SE Asian granite belts, albeit largely focused in the S-type dominated Main Range and MMM belts – mineralization is associated with granites that are highly fractionated and yield evidence of pronounced fluid saturation and magmatic-hydrothermal activity that is focused in the roof zones of the intrusion.

Figure 1: The granite tin belts of SE Asia
Granitophile metals such as Sn and W are typically incompatible and tend to concentrate in residual granite melt fractions. Metals are, thus, significantly fractionated into the fluid phase from an already enriched residual melt, with fluids concentrating into the apical portions of the granite intrusion, or egressing into the surrounding host rocks, to form sheeted vein systems or disseminated deposits in the altered, upper portions of granite plutons and surrounds.

Likely scenarios for the future development of tin mining in SE Asia will focus on the discovery and evaluation of primary granite related magmatic-hydrothermal deposits with a less invasive environmental footprint than traditional alluvial and eluvial operations. Crustally-derived granitoids of peraluminous affinity, such as the MMM belt of Myanmar, are typically very prospective for tin mineralization. Such belts will continue to attract the attention of companies that seek high-tonnage ore deposits comprising either closely-spaced vein swarms or disseminated granite cupolas, both amenable to open-castable, bulk-mining technologies. Deposits of this type abound in Myanmar and their identification and...
evaluation could propel the country into one of the top-ranked global tin producers – development of such deposits will, however, need to be accompanied by the transition from an artisanal mining mindset to one that encourages large-scale exploration and evaluation methodologies.
INTRODUCTION TO INTERNATIONAL ASSOCIATION FOR ENGINEERING GEOLOGY AND THE ENVIRONMENT (IAEG)

Bo-An Jang
Professor in Department of Geophysics, Kangwon National University, Republic of Korea
Vice president of IAEG for Asia

International Association for Engineering Geology and the Environment (IAEG) started the very first meeting in New Delhi on 12 December 1964, with the topic of “Quarry materials and other mineral products used in engineering”. IAEG was affiliated to the International Union of Geological Sciences (IUGS) on 23 August 1968 in Prague. The first bulletin was published in 1970 with title of “Bulletin of the International Association of Engineering”. The statutes were published in the first issue of the bulletin. At present, IAEG becomes a worldwide scientific society with more than 4,000 members and 63 nations and national groups. IAEG publish 4 issues of “Bulletin of Engineering Geology and the Environment” in a year and the impact factor is 2.138. The official languages are English and French. Asian regional conference and European regional conference are held every 2 years, and IAEG congress every 4 years. IAEG awards Hans Cloos Medal for the outstanding engineering geologist, Richard Wolters Prize for young professional and Marcel Arnould Medal for IAEG member who has made a significant contribution to the engineering geology profession in their region and given outstanding service to the Association.

The five biggest national groups are China, Germany, New Zealand, Australia and United Kingdom. Seven national groups are reactivated and 9 national groups including Myanmar joined as new national groups within 5 years. Asia is the most potential and challenging region and membership in Asia grows rapidly. Therefore, IAEG just set up 2 vice presidents in Asia since 2019. Eighteen national groups with over 1,300 member in Asia joined in IAEG. The first IAEG Asian regional conference was held at Tokyo, Japan in 1997 and 12th Asian regional conference was held at the Jeju island, Korea in this year.
MICRODIAMOND IN OPHIOLITE

Jingsui Yang1,2, Dongyang Lian1, Paul Robinson1, Weiwei Wu1

1. School of Earth Sciences and Engineering, Nanjing University, Nanjing, 210023, China
2. Center for Advanced Research on Mantle (CARMA), Chinese Academy of Geological Sciences, Beijing, 100037, China

More and more occurrences of microdiamond (less than 1 mm) have been reported on Earth. They were early known in kimberlite and lamproite in addition to macrodiamonds (> 1 mm). Recently they were also confirmed to occur in mantle peridotites and podiform chromitites in 14 ophiolites in different part of the world. Besides, microdiamonds were also reported from mafic or ultramafic rocks in Paleoproterozoic greenstone orogenic belts, Archean komatiite, in Phanerozoic mafic intrusions and in island arc volcanic rocks, and in modern oceanic island.

Microdiamonds are euhedral, and on the basis of nitrogen (N) defects these microdiamond are categorized as Type Ib–IaA. On the C and N isotopic compositions, microdiamonds are consistent with two types of source of carbon, i.e., sedimentary source or mantle source. Inclusions in diamond are unusually enriched in Mn, Ni and Co, and suggests from a subducted normal MORB.

In ophiolites, occurrences of ultrahigh-pressure and super-reduced minerals in chromite and peridotite, collectively confirms extremely high pressures (300 km to ≥660 km) and super-reducing conditions in their environment of formation in the mantle. New Infrared (IR) spectra data reveal that these diamonds contain fluid inclusions, e.g., water, carbonates, hydrocarbons, and solid CO2. The higher IR peak position of solid CO2 inclusion caused by intense internal pressure provide evidence that fluid inclusions have been trapped during diamond growth (Moe et al., 2018). Crystallization of diamond from a C-rich fluid encapsulates the observed inclusions. These prove that diamond formed in carbon-riched fluid which differ significantly from most gem-diamond in kimberlite. Many types of microdiamond (less than 1 mm), in addition to macrodiamonds, occur within kimberlite and lamproite. In which some fibrous cuboid diamonds and coated cuboid diamonds also contain abundant hydrocarbons and water, which suggest these dimonds may have grown through carbon-riched fluids or volatile-rich melts as well. Besides, microdiamonds have been reported from volcanic basalt and diabase dikes in oceanic basins and cratons. The features and carbon isotopes of these microdiamonds indicate that their formation is most likely related to carbon-riched fluids from deep recycled subducted slabs. Carbon-bearing fluids and melts may have been formed in the mantle transition zone, in the lower mantle or even near the core mantle boundary. Fluids or melts may rise along with deep plumes through the lower mantle and reach the MTZ under both oceanic and continental crust. Ophiolites since they represent widely distributed ancient oceanic crusts on land, may act as a major output of global scale recycled deep subduction materials, and provide us most important geological record for studying deep mantle circulation and deep Earth dynamics.
IMAGE PROCESSING TOOLS FOR IMPROVED VISUALIZATION AND ANALYSIS OF REMOTELY SENSED IMAGES FOR AGRICULTURE AND FOREST CLASSIFICATIONS

G. R. Sinha, Ph.D.
Professor, Myanmar Institute of Information Technology (MIIT) Mandalay
(Adjunct Professor, International Institute of Information Technology (IIIT) Bangalore, India)

Email: gr_sinha@miit.edu.mm, drgrsinha@ieee.org
Phone: +95-9773613344

This lecture suggests Image Processing tools for improved visualization and better analysis of remotely sensed images. There are methods already available in literature for the purpose but the most important challenge among the limitations is lack of robustness. We propose an optimal method for image enhancement of the images using fuzzy based approaches and few optimization tools. The segmentation images subsequently obtained after de-noising will be classified into distinct information and the appropriate conclusions would be drawn with regard to forest, agriculture, environmental effect, and crop assessment etc. The tools and techniques are useful for Scientists, Researchers and Academicians working in the area of remote sensing, weather forecasting, crop assessment etc.

About the Speaker

Dr G R Sinha is Adjunct Professor at International Institute of Information Technology (IIIT) Bangalore and currently deputed as Professor at Myanmar Institute of Information Technology (MIIT) Mandalay Myanmar. He obtained his B.E. (Electronics Engineering) and M.Tech. (Computer Technology) with Gold Medal from National Institute of Technology Raipur, India. He received his Ph.D. in Electronics & Telecommunication Engineering from Chhattisgarh Swami Vivekanand Technical University (CSVTU) Bhilai, India. He is Visiting Professor (Honorary) in Sri Lanka Technological Campus Colombo for one year 2019-2020.

He has published 243 research papers, book chapters and books at International and National level that includes Biometrics published by Wiley India, a subsidiary of John Wiley; Medical Image Processing published by Prentice Hall of India and 05 Edited books on Cognitive Science-Two Volumes (Elsevier), Optimization Theory (IOP) and Biometrics (Springer). He is active reviewer and editorial member of more than 12 Reputed International Journals such IEEE Transactions on Image Processing, Elsevier Computer Methods and Programs in Biomedicine, Springer Journal of Neural Computing and Applications etc. He has teaching and research experience of 21 years. He has been Dean of Faculty and Executive Council Member of CSVTU and currently a member of Senate of MIIT. Dr Sinha has been delivering ACM lectures as ACM Distinguished Speaker in the field of DSP since 2017 across the world. His few more important assignments include Expert Member for Vocational Training Programme by Tata Institute of Social Sciences (TISS) for Two Years (2017-2019); Chhattisgarh Representative of IEEE MP Sub-Section Executive Council (2016-2019); Distinguished Speaker in the field of Digital Image Processing by Computer Society of India (2015).
He is recipient of many awards and recognitions like TCS Award 2014 for Outstanding contributions in Campus Commune of TCS, Rajaram Bapu Patil ISTE National Award 2013 for Promising Teacher in Technical Education by ISTE New Delhi, Emerging Chhattisgarh Award 2013, Engineer of the Year Award 2011, Young Engineer Award 2008, Young Scientist Award 2005, IEI Expert Engineer Award 2007, ISCA Young Scientist Award 2006 Nomination and Deshabandhu Merit Scholarship for 05 years. He served as Distinguished IEEE Lecturer in IEEE India council for Bombay section. He is Senior Member of IEEE and Fellow of IETE India.

He has delivered more than 50 Keynote/Invited Talks and Chaired many Technical Sessions in International Conferences across the world such as Singapore, Myanmar, Sri Lanka, Bangalore, Mumbai, Trivandrum, Hyderabad, Mysore, Allahabad, Nagpur, Yangon, Meikhtila. His Special Session on “Deep Learning in Biometrics” was included in IEEE International Conference on Image Processing 2017. He is also member of many National Professional bodies like ISTE, CSI, ISCA, and IEI. He is member of various committees of the University and has been Vice President of Computer Society of India for Bhilai Chapter for two consecutive years. He is Consultant of various Skill Development initiatives of NSDC, Govt. of India. He is regular Referee of Project Grants under DST-EMR scheme and several other schemes of Govt. of India. He received few important consultancy supports as grants and travel support.

Dr Sinha has Supervised Eight (08) PhD Scholars, 15 M. Tech. Scholars and has been Supervising 01 more PhD Scholar. His research interest includes Biometrics, Cognitive Science, Medical Image Processing, Computer Vision, Outcome based Education (OBE) and ICT tools for developing Employability Skills.
MINERAL SYSTEMS CONCEPT FOR UNLOCKING MYANMAR’S MINERAL RESOURCES

Kyi Htun
Independent Geologist
Joint Secretary, Myanmar Geosciences Society

ABSTRACT

Mineral systems is defined as all geological factors that control the generation and preservation of mineral deposit and stress the process that are involved in mobilizing ore components from a source, transporting and accumulating them in more concentrated form and then preserving them throughout the subsequent geological history (Waybore, 1994). There are five fundamental factors required for the development of a viable ore body are (1) Fertility (2) Active fluid (3) Fluid focusing architecture (4) reactive site and (5) exhumation and preservation. Exploration targeting is based on the identification of above five factors that can be mapped either directly or indirectly from available datasets. These factors require translation into observable geoscience datasets at the appropriate scales to generate exploration targets. Mineral systems approach to exploration targeting defines mineralization search space through conceptual model of how mineral endowment is concentrated within geological systems. Mineral systems concept need to be fully integrated into Myanmar mineral exploration landscape. Mineral systems incorporate broad and wider geological process that responsible for economically concentrate minerals. Myanmar is located in important geodynamic setting. Formation of Paleotethys, Mesothys, and Neotethys between Eurasia and Gondwana and subsequent closing of these Tethys made the present Myanmar landscape and responsible for the Myanmar’s mineral endowment. Unlocking these mineral resources requires 4D geodynamic evolution history integrating with all available geosciences data (direct or indirect) to define and generate targets for efficient mineral exploration in the country leading to discovery.

UPDATED GEOLOGY AND MINERALIZATION CONTROLS OF MOHOCHAUNG PB-ZN-AG DEPOSIT.

Aung Kyin ¹, Tin Htut ² and Hkang Ma Yaw ³.
1. Consultant Geologist., 2. Consultant Geophysicist, 3 Senior Geologist (Mohochaung Mine)

ABSTRACT

Mohochaung area is extremely rugged and the highest peak in this area is Mohochang (Chinese word: Elephant head) 6437 ft. (1962 m) and formed by the Precambrian Chaung Magyi (CMG) rocks. Silver mining had been started by the Chinese as early as the 15th century. The Chinese mined the ore mainly for it's silver content and left behind large amounts of lead slags.

The most important Sediment-hosted Pb-Zn deposits are hosted in clastic-dominated sedimentary rock sequences (CD Pb-Zn) that are traditionally called sedimentary exhalative (SEDEX) deposits, and those in carbonate-dominated sequences that are known as Mississippi Valley-type (MVT) Pb-Zn deposits occurs in platform carbonate sequences, typically in passive-margin tectonic settings, David. L. et. al (2010). Mohochaung Pb-Zn-Ag Deposit included in (CD Pb-Zn) type.

Sandstone-hosted lead-zinc deposits, that occur along the present erosional front of the Shan Plateau (Sebumasu), contain galena and sphalerite cementing fractures and pore space. Mappable lithologic units can be described as: - 1. Greenish gray slightly metamorphosed metasediments: chloritic schist, phyllite etc. and cross laminated sandstones ((Map Unit-1); 2. limonitized disturbed silty sandstone (Map Unit-2); 3. Highly altered white sandstone/ shale (Map Unit-3) and 4. variegated color shale and siltstones (Map Unit-4). Host rocks (CMG) deposited in combined continental and marine environments.

The rocks of the CMG series are overlain unconformably by the Pangyun beds. The Pangyun formation contained purple shales and thinly bedded, purple sandstones and sometimes grading to greenish purple and greenish gray in color. Unlike the Pangyun formation in Bawdwin area, it does not act as a host rock for mineralization. A Late Cambrian-Early Ordovician age for the Pangyun Formation is assumed on the basis of the presence of Upper Cambrian trilobites (Myint Lwin Thein 1973).

Metalliferous fluids emerging from reactivated basement faults mixed with fluids in the sedimentary cover, which resulted in metal precipitation. The lead-zinc deposits in sandstones (Map unit-3, highly altered white sandstone/ shale) were formed by these processes, occur selectively under the impermeable capping (Map unit-4, variegated color shale and siltstones).

The Tawngpeng granite intrusion is not far away from the Mohochaung deposit. Tawngpeng granite is an elongated rock body that runs NE-SW along the CMG contact in
the north-west margin. The granite in hand specimens is a two mica granite. Some small local igneous bodies (dolerites, microdiorites) are post Tawngpeng granite of basic intrusive. It is possible that the mineralization fluids come up from the deeper west and deposited in the more pervious white sandstone units (Map unit-3) conformably while the upper silt and shale units behave as impervious cappings. A thermal overprint was imposed on the mineralization and this overprint may have been caused by intrusion of the nearby Tawngpeng Granite or by orogenic hydrothermal fluids related directly to the tectonic event. Although major folding is not observed in the area, some minor undulating folds are frequently found. Mohochaung lead-zinc ore contains galena, sphalerite, pyromorphite in the some oxidized zone, pyrite, a little chalcopyrite quartz, calcium, magnesium and iron carbonates. Locally limonite and hematite veins/ floats are abundant. The limonitic gossan contains average of 1.62 % Pb and 1.49 % Zn. In some places quartz and late phase prochlorites (ripidolite) are also found together.

Modification to the host by silicification, seritization, kaolinization and limonitization are also observed. The host, white sandstone (CMG Map Unit-3), becomes coarser, siliceous, micaceous and hardened near ore body. Earlier limonitization is observed conformable with the host. They may be contemporaneous deposition of FeOx rich sediments. However, in general, highly disturbed and crushed limonitized beds appear to be modified by the earlier hydrothermal precursor fluids. Thin limonite veins lets in joint cracks of greenish gray CMG sandstone clearly demonstrate the secondary nature of FeOx remobilization. Although there are earlier FeOx alterations in CMG rocks, some of the hematite gossan boulders and veins, very close to the ore veins, are definitely contemporaneous deposition of lead-zinc mineralization. These hematite veins as well as the quartz veins are always found discordant to the CMG host.

Sometimes, the rich ore pockets are observed inside the fault related tensional shear zones of fault intersection area (Kachin Adit No.-l). Therefore, the N-S structures are pre-mineralization faults and the E-W structures are pre and post mineralization faults of many episodes. It seems that mineralization fluids penetrated along the pre-mineralization fault systems and deposited rich are pockets at the site of favorable intersecting shear fracture zone of NS and EW direction. This observation envisaged that the thinner PbS stringers and vein lets (about 5 to 10 cm) flow out from the main shear fracture zone and deposited conformably with the adjacent sandstone strata. As such, these PbS interlayers in sandstones are quite different from the stratiform ore type and they always pinch-out and eventually disappear at some distance.

The Mohochaung ore body is rich in iron and is commonly associated with limonitic gossan. As the gossans are the oxidized outcropping cellular mass of limonitic material and gangue that overlies sulphide ore shoots. In Mohochaung, gossan extend some distance beneath the surface, as far down as the ground-water table, and in some cases the gossan ore contain 1.56%, 1.87 and 1.45% Pb and 1.36%, 1.69% and 1.42% Zn. Therefore, the hematite gossan boulders and veins found in the area are related to the ore forming hydrothermal solution. They are believed to be deposited by the precursor mineralized hydrothermal fluids before the formation of lead-zinc mineralization in the area. The average highest and lowest grade of Pb and Zn content in the Mohochaung Mine ore are: 14.7 % Pb - 3.3% Zn and 1.6% Pb -1.5% Zn.
Sibumasu rifting off from Gondwana in the Late Carboniferous-Early Permian (Metcalf, 2006). In early Palaeozoic, Cambro-Ordovician magmatism was associated with having been sited above an Andean-type subduction setting (e.g., Cawood et al., 2007; Metcalfe, 2011; Zhu et al., 2012).

Sediment-hosted deposits have a genesis related to the circulation of low-temperature brines (Leach et al. 2005). Tawngpeng granite is believed to be included in the above Andean-type subduction setting and it may have been responsible for combination of thin-skin folding and thrusting and/or orogenic uplift and gravity–driven connate fluid flow into the Cambro-Ordovician Mohochaung deposits now located within Sibumasu. The possible 500 Ma age is proposed for Taungpeng granite by Mitchell, A.H.G. (2018).

Between 0.8 Ga and the end of the Proterozoic at 0.5 Ga was a time of major changes in the redox state of the atmosphere and hydrosphere in earth history, referred to as the Second Great Oxygenation Event (e.g., Holland, 2005; Hazen et al., 2008). Perhaps Cambro-Ordovician Mohochaung CD deposit may have deposited in this redox states.

**Keywords:** Sedimentary Exhalative (SEDEX) deposits, Clastic-Dominated Lead-Zinc (CD Pb-Zn) ores, Mississippi Valley-type (MVT Pb-Zn), Sibumasu, Passive margins tectonic setting, Back-Arcs, Continental Rifts, Sag Basins, Chaung Magyi (CMG), Pangyun,
SEISMIC STRUCTURES BENEATH CENTRAL MYANMAR: FROM THE CRUST TO THE MANTLE TRANSITION ZONE

Yumei He, Tianyu Zheng, Shun Yang, Xiaofeng Liang, Chit Thet Mon, Myo Thant, Kyaing Sein

ABSTRACT

Myanmar, located at the northwestern margin of Southeast Asia, has undergone oceanic closure of the Tethys and continental collision and subduction between the Indian and Eurasian plates. Fine deep seismic structures beneath Myanmar is crucial to understand the Tethys tectonic evolution. The data obtained from a densely spaced seismic array in the central Myanmar have enabled the study of crustal and upper mantle structures in unprecedented detail.

In this study, we use receiver function (RF) imaging to find direct structural evidence of present-day subduction of complete Indian continental crust beneath Myanmar. RF study reveals an east-dipping low velocity structure beneath central Myanmar, with an average thickness of ~31 km and a dip of ~18° extending to a depth of 100 km. We propose that the results reveal a continental subduction regime resulting from continental collision with lateral extrusion.

Tomographic images of P- and S-wave velocity perturbation in the upper mantle beneath Myanmar region further illustrate parallel east-dipping subducted Indian and Meso-Tethyan oceanic plates below 100 km. In the upper mantle, finite-frequency tomography reveals two parallel east-dipping high velocity anomalies beneath the Indian Burma Ranges (HV1) and the Sagaing fault (HV2). Based on its morphology, velocity structural features and the distribution of Benioff seismicity zone, the HV1 is interpreted as the subducted Indian oceanic slab while the HV2 is proposed as a remnant of the Meso-Tethyan oceanic slab. The characteristics of the parallel east-dipping Indian and Meso-Tethyan oceanic slabs, as well as the possible existence of the Meso-Tethyan oceanic slab in the upper mantle provide a significant evidence of Tethyan one-way subduction.
ABSTRACT

Yangon City is the former capital of Myanmar and the total population is about 6 millions. Based on the previous earthquake experiences such as the magnitude 7.3, 1930 Bago earthquake that caused 50 casualties and several buildings damaged, Yangon City can be regarded as it belongs to the high seismic hazard zone. Moreover, several seismogenic sources such as some of the small scale faults in and around the city, the subduction of India Plate underneath Burma Plate which is the platelet of Eurasia Plate; and the N-S running, right-lateral strike-slip Sagaing Fault which is around 25 km in east of the city can contribute the significant seismic hazards to the city. Therefore, we carried out site specific probabilistic seismic hazard assessment for the city in 2014. During recent years, we have obtained the more information related to the seismic sources and site geology, and modified the seismic sources from both the subduction zone of Indian Plate underneath Burma Plate; and the active crustal faults. We also modified the site geology map of Yangon city based on the geological information, geotechnical parameters and those obtained by the microtremor HVRs analysis. Based on the updated information, we modified the probabilistic seismic maps of Yangon, developing the new probabilistic seismic hazard maps of the city for 10% and 2% probability of exceedance in 50 years. The seismic hazards are presented in terms of peak ground acceleration (PGA), peak ground velocity (PGV), and spectral acceleration at the periods of 0.2 s and 1.0 s. With regards to PGA of the city, the highest seismic hazard areas belong to the eastern part of Yangon with the values of 0.3-0.45g for 10% probability of exceedance in 50 years and 0.45-0.7 g for 2% probability of exceedance in 50 years.

Keywords: 1930 Bago earthquake, Sagaing Fault, probabilistic seismic hazard assessment, seismogenic sources, peak ground acceleration, peak ground velocity, spectral acceleration.
THE SHORT RUPTURE INTERVAL OF THE WESTERNMOST NAM MA FAULT IN THE PAST MILLENNIUM

Yu Wang\textsuperscript{1,2}, Lin Thu Aung\textsuperscript{2}, Xu-Hua Shi\textsuperscript{3}, Saw Ngwe Khaing\textsuperscript{4}, LiLi Weldon\textsuperscript{5}, Soe Min\textsuperscript{6}, Tim Dawson\textsuperscript{7}, Yann Gavillot\textsuperscript{8}, Aron Meltzer\textsuperscript{2,9}, Ray Weldon\textsuperscript{5}; Myo Thant\textsuperscript{10}, Nam Ma fault survey team

1 Department of Geosciences, National Taiwan University, Taiwan
2 Earth Observatory of Singapore, Nanyang Technological University, Singapore
3 School of Earth Sciences, Zhejiang University, China
4 Department of Geology, Hinthada university, Myanmar
5 Department of Earth Sciences, University of Oregon, USA
6 Department of Geology, Taungoo University, Myanmar
7 California Geological Survey, USA
8 College of Earth, Ocean and Atmospheric Sciences, Oregon State University
9 Asian School of the Environment, Nanyang Technological University, Singapore
10 Department of Geology, Yangon University, Myanmar

ABSTRACT

We present preliminary paleoseismological investigation results for the westernmost section of the 220-km-long Nam Ma Fault, which ruptured during the M\textsubscript{w} 6.8 Tarlay earthquake on 24 March, 2011, close to the Myanmar-Thailand border. During our paleoseismological training course in 2017, we analyzed two hand-dug trenches, Trenches 1 and 2 (T1 and T2), across the 2011 Tarlay earthquake surface rupture west of Kya Ku Ni village. T1 is located at a small sag pond developed from the recent fault surface rupture. Both east and west walls of T1 show several abrupt changes in its sedimentation sequence, suggesting multiple rupture events occurred in the past. Combining the stratigraphic and radiocarbon-dating analyses from both T1 and T2, we infer at least 3 rupture events were recorded during the past Millennium, including the most recent Tarlay earthquake of 2011 (E1). The preceding event (E2) occurred sometime between late-1300s and early 1400s C.E. based on radiocarbon analysis. An earlier rupture event (E3), inferred from stratigraphy at the base of T1 and T2, likely occurred prior to 973 C.E. when the sediment in T2 changed from channel gravels to overbank deposits. The short recurrence interval between the 2011 and its preceding events is consistent with our earlier interpretation that the westernmost Nam Ma fault ruptures once at least every 1000 years on average, based on the nearly 2-meter coseismic slip recorded during the Tarlay earthquake, and the ≥2 mm/yr average fault slip-rate inferred from the ~12-km Maekong River offset.
ACTIVE TECTONICS AND PALEOSEISMIC STUDIES AT THE CENTRAL SEGMENT OF SAGAING FAULT, NAY PYI TAW, MYANMAR

Saw Ngwe Khaing¹*, Tun Tun Min¹, Kaung Si Thu², Than Soe³, Han Myo Hset¹, Soe Min³, Myo Thant⁴

¹Department of Geology, Hinthada University,  
²Department of Geology, Pathein University, Myanmar,  
³Department of Geology, Taungoo University, Taungoo, Myanmar,  
⁴Department of Geology, University of Yangon, Myanmar  
*sawngwekhaing@gmail.com

ABSTRACT

The study area is located at the Central Myanmar, along the Sagaing Fault, near Nay Pyi Taw. It is also close to the eastern limb of the Bago Yoma anticline. The active fault mapping, fault trace, vertical separation and active fault criteria are well observed in this area. The active tectonics evidences are offset streams, fault scarps and pressure ridge. These can be found in the various types of images and also in the field. The area divided into five sections and according to their segment was made active fault mapping. Highest vertical movement is about 3.2 m at section 4. It can be used as site selection for paleoseismic study and offset mapping. According to the paleoseismic study, there have four events observed. The youngest event formed at the historical time of the human life, probably between 200 ±25 and 250 ±35 BP. The total length of seismic gap of central Sagaing Fault section is about 180 km in length. The fault has accumulated elastic strain is about 4.0 m during the past about 200 years. Therefore, the next large earthquake is expected to strike the area in the near future.

Keywords: active tectonics, offset streams, Sagaing Fault, paleoseismic, Nay Pyi Taw
METAMORPHISM RECORDS CHANGES IN SUBDUCTION DIP ANGLE OF THE INDIAN PLATE

Yi Chen\textsuperscript{1,2}, Si Chen\textsuperscript{1}, Qiuli Li\textsuperscript{1}
\textsuperscript{1}State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
\textsuperscript{2}Chinese Academy of Sciences Center for Excellence in Tibetan Plateau Earth Sciences, Beijing 100101, China

ABSTRACT

Ultrahigh-pressure (UHP) and high-pressure (HP) rocks that occur in the Himalayan orogen have been conventionally regarded as a result of different subduction angles between the western and eastern syntaxes. Here we present a combined analysis of zircon geochronology and geochemistry of eclogites and gneiss in the Stak massif, western Himalaya. Metamorphic zircons equilibrated with garnet and omphacite show flat heavy rare earth element patterns without Eu anomaly, and thus yield similar eclogite-facies ages of ca. 31 Ma. This HP eclogite-facies metamorphism is at least 15 Ma younger than those measured in the western Himalayan UHP eclogites, but broadly contemporaneous with other Himalayan high-pressure rocks. Therefore, all the Himalayan HP rocks record higher geothermal gradients and younger ages than those of UHP rocks. Our new data, combined with the magmatic lull observed in the Kohistan-Ladakh-Gangdese arc and with the convergent rate of the Indian plate, suggest a change in subduction dip angle through time. Consequently, in our view, the entire Indian continental plate experienced a coherent shift from steep to low-angle subduction after the breakoff of the Neo-Tethyan slab since middle Eocene.

Keywords: UHP metamorphism, eclogite, subduction dip angle, Indian Plate
DIAMOND PROSPECTING IN MYANMAR WITH EMPHASIS ON MOMEIK AND THEINDAW AREA

Nyunt Htay
CEC Member, Myanmar Geosciences Society (MGS)
E-mail: nyunthtay1970geol@gmail.com

EXTENDED ABSTRACT

The occurrence of placer diamond in Myanmar has been known since 1959 at Momeik Township in the Northern Shan State of Myanmar and the occurrence extends to the south from east of Taungoo, through Tanintharyi strip to Phuket area in Thailand, approximately 965 km in length.

The integrated diamond exploration programme in Momeik area was started in 1972 onwards with the objective to prove the occurrence of diamond reported from Kyeindaw area in Momeik Township. The prospecting has been carried out by the Ministry of Mines, up to 1992.

About 450 km south of Momeik, some placer diamonds are noticed at Myatsawnyinaung, 10 km SE of Taungoo. According to local gold panners, 17 diamonds total 19.72 carats (cts) in weight were collected within 22 years from 1985 to 2007 with the biggest stone is 4.08 cts in weight. In 1987 - 88, the prospecting team of the Department of Geological Survey and Mineral Exploration (D.G.S.E) under Ministry of Mines found two small diamonds (0.05 ct and 0.35 ct) by washing 89 test pit samples from older alluvium comprises of gravels, silt, and lateritic soil. In Tanintharyi Region, Kyaukmetaung area of Dawei Township is the northern most known placer diamond in older alluvium and it is about 150 km north of Theindaw Mine. In the area, six small diamonds (total 1.775 cts) were discovered by local tin miners in 1981. In 1985, three small diamonds (total 2.8 cts) were collected by exploration team of D.G.S.E in the same area. In 1985, diamonds were discovered with alluvial tin at Theindaw Mine, 96 km east of Myeik beside Tanintharyi River. Among the placer diamond occurrences, Theindaw mine is noticed for the significant diamond recovery with tin.

Probably be new finding areas for placer diamond are noted at Nambyu Chaung, 25 km southwest of Tanai at Hukawng Valley in northwestern Myanmar and at Thanlwin River, east of Mong Hsu Ruby Mine in Shan State. Some diamonds are noticed at active stream gravel bed while washing for gold underlain by Tertiary Stratas at Nambyu Chaung and at Thanlwin River, very few diamonds are encountered while washing the active sand bar for rubies which is closed to the mouth of the stream flows from Mong Hsu Range.

Mohauk- Kyeindaw Area, 16 km west of Momeik, lies at east-west running Momeik - Twininge Fault. The rocks in the region mainly composed of gneisses, schist, granulites, migmatites, quartzite, calc-silicate and marble of Mogok Group in Paleozoic and possible Precambrian age, into which young granite so called Kabaing Granite of 15 Ma in age and alaskite- syenite suite, have intruded. Ultramafic rocks of possible ophiolitic origins are also covered the metamorphic rocks of Mogok Group around Pyaung gaung –
Tinyu taung area. Some Quaternary basalts are occurred along the Momeik-Twinngge Fault at some places. The diamondiferous gravel beds, 1 m to 2.5 m in average thickness are exposed in Bawday area 2 km north of Mohauk village and at the area, nearly 6 km northwest of Kyeindaw village where the first placer diamonds were noticed. These gravel beds also contain small quantity of ruby, sapphire and gold. The majorities of the gravel are schistose quartzite/quartz schist and brecciated quartz tourmaline rock which are scattered near Mohauk gem area. DGSE in conjunction with the Geological Department of the University of Rangoon carried out the prospecting so called Special Mineral Project from 1971 to 1973. From 1978 to 1981, D.G.S.E carried out the project and handed over the project to Myanmar Gem Enterprise (M.G.E) in 15th December 1981. The project was transformed by MGE to DGSE again in 31st March 1989. It was carried out till 1992 and so far have been not discovered a primary diamond. From 1978 to 1988, 41 diamond drill holes all in Tertiary strata were completed with 61 meter in average depth. At the Momeik valley, 291 stones, weighting about 200 cts were collected. They are mainly light yellow with a brownish tinge, with a few colourless ones ranging 0.3 ct to 7 cts which all are gem quality. The crystal forms are mainly octahedrons and dodecahedrons. Out of hundreds of stream sediment samples, 4 samples contain possible indicator minerals as chrome diopside and picroilmenite according to Dr. K. J. Stracke of De Beers Co in 1974.

Theindaw Mine Area, 96.5 km due east of the Town of Myeik previously known as Mergui, is at the Tanintharyi coastline in southern Myanmar. The mine site is situated at about 3 km north of Theindaw village beside Tanintharyi (Tenasserim) River. According to the records of Geological Survey of India (GSI), the area has been explored for tin-tungsten deposits since 1928. In 1936, Tavoy Tin Dredging Company started dredging for tin along Theindaw stream which is the eastern tributary of Tanintharyi River and the operation had been terminated in 1958 after receiving 824 tons of tin concentrates but no diamond had been reported for the operation. State owned No (2) Mining Enterprise (ME.2) started alluvial tin mining near Theindaw village in 1983. In July 1985, ME.2 noticed 7 diamonds for the first time while dressing the placer tin from Work Site B and after that mining target was changed to focus on diamond but the mining operation terminated in 1989. At the end of 1999, Myanmar Tin-Tungsten Co., Ltd. (MTT) was awarded large scale joint venture mining lease from the Ministry of Mines. MTT conducted for diamond production in the early period and change to tin mining up to now. The Tanintharyi region of southern Myanmar is underlain by metasedimentary rocks belonging to Mergui Group of Permo-Carboniferous age. In places, metasediments are overlain by isolated patches of limestone so called Moulmein Limestone of Permian age but not crop out at Theindaw mine area. Granites and associated tin and tungsten - bearing veins of Late Mesozoic extensively intruded into the sediments. Theindaw area of the present study is built up of the metasediments of Mergui Group with lamprophyre dykes. Structurally, the metasediments are folded with the axis along the Tanintharyi River. The Tanintharyi River valley shows an example of the Tertiary basin of the typical fluviatile feature. The clasts composed in the gravels of the Tertiary sediment include metasediments of Mergui Group, intruded granitic rocks, acid volcanic rocks, basic dykes, tuff and vein quartz detritus. A total of 2752 gem quality diamonds weighing 2010.75 cts have been recovered from placer mining from 1985 to 1996. The largest diamond discovered is 10.13 cts while the average diamond weight ranges around 0.70 ct. About 60% of the stones fall in a 0.04 to 1 ct range. The average size is based on arithmetic calculation, not a histogram of actual physical size. Reserves reported for the diamond and tin-bearing alluvial deposit by the Ministry of Mines.
is about 9 million cubic yards of 13.88 million tons. The ground value of the diamond is estimated to be 0.29 ct per ton. Only about 5% of the total reserves had been worked at present.

For the source of Myanmar diamond, some attempts have been done by the geologists of the diamond companies in abroad since 1974. In 1997, two lots of diamonds comprising 26 stones from the Momeik area and 111 stones from Theindaw area ranging from 3.5 cts to less than 0.003 ct have sent to CSIRO in Australia to study the growth processes and data history of diamonds. According to the CSIRO, the Myanmar diamonds appear to be more characteristic of diamond suites from lamproites than of those from kimberlites and the diamonds have passed through a secondary (sedimentary) collector before being deposited in their current environment (Win et al., 2001).

The diamond occurrences from Taungoo in the north to Theindaw in the south lying at the same geo-tectonic belt of SIBUMASU terrane in about 965 km (600 miles) extent is thought to be the derivation of glacial marine sediments (diamictites) of the western Kimberlay region of north-western Australia (Griffin et al., 2001). It is difficult to explain about the source of the diamonds of Momeik, Nambyu and Thanlwin River. Myanmar diamonds found as headless placer are derived from normal mantle source and no evidence of subduction processes are found (Griffin et al., 2001) though microdiamonds are confirmed in ophiolitic rock of Myitkyina, the Capital of the Kachin State, Myanmar (Yanhong Chen et al., 2018).

Keywords; Nambyu Chaung, Mong Hsu Range, GSI, Tin-dredging, lamprophyre dyke, fluviatile feature, CSIRO, lamproite, kimberlite, geo-tectonic belt, SIBUMASU terrane, diamictites, headless placer, mantle source, subduction process, microdiamonds, ophiolitic rock.

References
FIRST REPORT OF DIAMOND IN KALAYMYO PERIDOTITE FROM THE INDO-MYANMAR OPHIOLITIC BELT, WESTERN MYANMAR

Fei Liu¹, Jingsui Yang¹,², Dongyang Lian², Kyaing Sein³, Xiaolu Niu¹, Guangying Feng¹

¹ CARMA, Key Laboratory of Continental Tectonics and Dynamics, Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, P.R. China
² School of Earth Sciences and Engineering, Nanjing University, Nanjing, 210023, China
³ Myanmar Geosciences Society, 303 Mes Building, Hlaing University Campus, Yangon, Myanmar

ABSTRACT

Kalaymyo ophiolite that crops out in the central part of the Indo-Myanmar Range (western Myanmar), has been regarded as the southern continuation of the Neo-Tethyan ophiolites occurring along the Yarlung Zangbo suture zone in southern Tibet (Sengupta et al., 1990; Mitchell, 1993; Liu C., et al., 2015; Niu et al., 2018). The ophiolite mainly consists of peridotite, gabbro, dolerite, amphibolite and pillow basalt, spatially associated with early Cretaceous oceanic marine sedimentary-volcanic sequences and tectonically overlying mica schist, gneiss, and pegmatite (Mitchell, 1993; Niu et al., 2018). 127-126 Ma rodingites are observed as irregular pods within the serpentinitized peridotites (Liu C., 2015). The Kalaymyo peridotites are dominantly composed of harzburgites and lesser amounts of lherzolite and dunite. The harzburgites are composed of olivine (Fo = 89.8–90.5), orthopyroxene (Mg# = 89.6–91.9), clinopyroxene (Mg# = 90.9–93.6) and spinel (Mg# = 67.1–78.9; Cr# = 13.5–31.5). They have relatively homogeneous whole-rock compositions with Mg# = 90.1–90.8 and SiO₂ = 41.5–43.65 wt.%, Al₂O₃ = 1.66–2.66 wt.% and CaO = 1.45–2.67 wt.% The peridotites display Light Rare Earth Element (LREE)-depleted chondrite-normalized REE patterns with (La/Yb)CN = 0.04–0.21 and (Gd/Yb)CN = 0.40–0.84, and show a slight enrichment from Pr to La with (La/Pr)CN mainly in the range of 0.98–2.36. These mineralogical and geochemical features collectively suggest that the Kalaymyo peridotites represent residual upper mantle rocks after low to moderate degrees (5%–15%) of partial melting at a mid-oceanic ridge environment. Mineral separation from ~500 kg harzburgites has yielded a range of exotic minerals, including diamond, moissanite, native elements, metallic alloys, and some crustal minerals (i.e., zircon, quartz, amphibole, and rutile), the collection similar to those peridotites from Luobusa (China), Myitkyina (Myanmar), Ray-Iz (Russia), Mirdita (Albania), Pozanti-Karsanti (Turkey), etc. Widespread occurrence of diamonds and other exotic minerals in ophiolitic massifs implies a significant deep-earth dynamic process.

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References
GENESIS OF SUPER-DEEP DIAMOND BY IRON-ASSISTED MAGNESIUM CARBONATE REDUCTION

Jing Gao¹, Bin Chen², Xiang Wu³

¹ State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
² Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, Honolulu, HI, 96822, USA
³ State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences (Wuhan), Wuhan 430074, China

ABSTRACT

Diamond genesis constitutes an important part in deep Earth carbon cycle. Super-deep diamonds, representing only 6% of the global diamond population, host inclusions with phase assemblages requiring a sublithospheric origin (>300 km). Being the windows of the deep Earth, super-deep diamonds with their distinctive micro-inclusions provide direct insights into the mineralogy, petrology, geochemistry and geodynamical process within the Earth, and moreover, indicate their genesis pertinent to the crust carbonates that melt under Fe⁰-buffered reduced conditions. Several genetic mechanisms have been proposed, i.e., decomposition of carbonate, self-reduction of ferromagnesian carbonate and redox reaction of carbonate-Fe system but they remain elusive in unlocking the carbon reduction pathways. Our pilot experiments have evidenced the formation of diamonds from MgCO₃-Fe⁰ system in a laser-heated Diamond Anvil Cell device at ~25 GPa and ~1800 K. Detailed experimental investigations of redox mechanism of MgCO₃-Fe⁰ coupling have been conducted in a Multi-Anvil Apparatus. The experimental conditions were set along the oceanic lithosphere subduction paths in the pressure-temperature range of 10-24 GPa and 1200-2000 K, covering the formation region of most super-deep diamonds. Our results demonstrate that the reduction course of carbon to form diamond is “MgCO₃→Fe-C→graphite→diamond”, during which carbon isotope fractionation occurs to allow Fe-C to preferentially sequester ¹²C and finally nucleate diamonds with low δ¹³C values compared to the parental carbonate. Furthermore, magnesium index (mg=Mg/(Mg+Fe)at.) of the reaction product (Mg,Fe)O demonstrates a positive correlation with temperature, which can be applied to constrain the formation environment of super-deep diamonds including (Mg,Fe)O associations. Our results not only provide a basic mechanism for super-deep diamond genesis, but also shed new lights on the interactions at slab-mantle boundary.

Keywords: super-deep diamond; carbon isotope fractionation; (Mg,Fe)O; Deep Earth Cycle Carbon
DIAMONDS AND OTHER EXOTIC MINERALS IN THE POZANTI-KARSANTI CHROMITITES IN TURKEY: IMPLICATIONS FOR THE DEEP ORIGIN

LIAN Dongyang1,*, YANG Jingsui1,2, WU Weiwei3 and XU Zhiqin1

1 School of Earth Sciences and Engineering, Nanjing University, Nanjing, 210023, China
2 Center for Advanced Research on Mantle (CARMA), Chinese Academy of Geological Sciences, Beijing, 100037, China
3 College of Marine Science and Technology, China University of Geosciences, Wuhan, 430074, China

Corresponding author’s E-mail: Dongyang Lian (ldy199008@163.com)

ABSTRACT

The Pozanti–Karsanti ophiolite situated in the eastern Tauride belt, southern Turkey, is a well preserved oceanic lithosphere remnants comprising, in ascending order, mantle peridotite, ultramafic and mafic cumulates, isotropic gabbros, sheeted dikes and basaltic pillow lavas. Two types of chromitites are observed in the Pozanti–Karsanti ophiolite. One type of chromitites occurs in the cumulate dunites around the Moho and the other type of chromitites is hosted by the mantle harzburgites below the Moho. The second type of chromitites has massive, nodular and disseminated textures. We have conducted the mineral separation work on the podiform chromitites hosted by harzburgites. So far, more than 200 grains of microdiamond and more than 100 grains of moissanite (SiC) have been separated from the podiform chromitite. These minerals have been identified by EDS and Laser Raman analyses. The diamonds and moissanite are accompanied by large amounts of rutile. Besides, Zircon, monazite and sulphide are also very common phases within the separated minerals. The Pozanti-Karsanti diamonds were investigated for morphology, color, cathodoluminescence, nitrogen content, carbon and nitrogen isotopes, internal structure and inclusions. The diamonds recovered from the PKO are mainly mixed-habit diamonds with sectors of different brightness under the cathodoluminescence images. The total $\delta^{13}C$ range of the PKO diamonds ranges between $-18.8 \%$ and $-28.4 \%$, with a principle $\delta^{13}C$ mode at $-25 \%$. Nitrogen contents of the diamonds range from 7 to 541 ppm with a mean value of 171 ppm, and the $\delta^{15}N$ values range from $-19.1 \%$ to 16.6 \%, with a $\delta^{15}N$ mode of $-9 \%$. Stacking faults and partial dislocations are commonly observed in the Transmission Electron Microscopy foils whereas inclusions are rather rare. Combinations of $(Ca_{0.81}Mn_{0.19})SiO_3$, NiMnCo-alloy and nano-sized, quenched fluid phases were observed as inclusions in the PKO diamonds. We believe that the $^{13}C$-depleted carbon signature of the PKO diamonds derived from previously subducted crustal matter. These diamonds may have crystallized from C-saturated fluids in the asthenospheric mantle at depth below 250 km which were subsequently carried rapidly upward by asthenospheric melts.

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QUATERNARY VOLCANISM IN MYANMAR: A RECORD OF INDIAN SLAB TEARING IN A TRANSITION ZONE FROM OCEANIC TO CONTINENTAL SUBDUCTION

L.Y. Zhang¹,2†, W.M. Fan¹,2,3, L. Ding¹,2, M. N. Ducea⁴,5, A. Pullen⁶, J.X. Li¹,2, Y.L. Sun¹,2, Y.H. Yue⁷, F.L. Cai¹,2, C. Wang¹, T.P. Peng²,7, Kyaing Sein⁸

1. Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China
2. Center for Excellence in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, Beijing 100101, China
3. University of Chinese Academy of Sciences, Beijing 100049, China
4. Department of Environmental Engineering and Earth Sciences, Clemson University, Clemson, South Carolina 29634, USA
5. State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China
6. Myanmar Geosciences Society, Yangon, Myanmar
* Corresponding author. E-Mail: zly@itpcas.ac.cn

ABSTRACT

The largest discontinuity during most orogenic evolution is probably the transition from oceanic to continental subduction. Subsequent slab detachment in particular is expected to mark a fundamental change in magmatism and deformation within an orogen. By looking at an example from an active slab detachment it is possible to critically evaluate ancient slab detachment events. To that end, we are capable of better understanding the deep mantle structure during detachment, the nature of the resulting melts and the relationships between magmatism and regional deformation patterns with greater precision. The Burmese microplate is located above a tectonic transition from oceanic to continental subduction of the Indian plate. The motion of India relative to Asia results in highly oblique subduction zone. Quaternary volcanism in Myanmar provides an opportunity to constrain the nature of this transitional subduction and the mantle adjunct to it, and to better understand the process of slab detachment processes and its consequences. Here, we report on the Monywa and Singu volcanic centers in central Myanmar. The Quaternary Monywa volcanic rocks are composed of low-K, Medium-K, high-K and shoshonitic basalts with arc signatures. These rocks were generated by small degrees of partial melting of subduction-modified asthenosphere at variable depths from the spinel to garnet stability fields. In contrast, the Singu volcanic rocks indicate formation from melts with rapid ascent and negligible crustal contamination. These rocks show geochemical characteristics similar to oceanic island basalts (OIB) and are interpreted to have been produced by partial melting of a garnet-bearing asthenosphere. Whole-rock Sr and Nd isotopic values for the Monywa rocks plot close to the binary mixing curve between the Indian MORB depleted mantle and pelagic sediments, indicating 8–15% contribution of sediment to the melts. Distinct from a relatively depleted mantle melting of the Monywa rocks, the Singu OIB-like rocks exhibit lower εNd with higher \(^{87}\)Sr/\(^{86}\)Sr values. These values indicate an exotic enriched asthenosphere layer beneath the Burmese microplate which probably flowed from SE Tibet. Combined with results from recent studies, this short-lived, small-scale and low-degrees...
melting Quaternary volcanism in Myanmar was a function of its thermodynamics and positions above a slab window that has resulted from the tearing of oceanic lithosphere from (relatively) buoyant continental lithosphere of the Indian plate.

Keywords: Myanmar Quaternary volcanism; Burmese microplate; Tibet; Slab tearing; Highly oblique subduction; Mantle flow.
EMPLACEMENT OF THE LINCANG BATHOLITH IN THE CHANGNING-MENGLIAN-INTHANON BELT AND ITS TECTONIC SIGNIFICANCE: EVIDENCES FROM MAGNETIC FABRICS AND GRAVITY SURVEY

Yin Wang, Wei Lin
State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

ABSTRACT

The Lincang batholith is a prominent unit in the Changning-Menglian-Inthanon Belt. However, the tectonic regimes associated with the emplacement of the batholith are still controversial. A combine of field structural analysis, anisotropy of magnetic susceptibility (AMS) measurements, and gravity study has been carried out to determine the fabric patterns and shape at depth of the Lincang batholith. The field structural analysis indicates that the Lincang batholith is constrained by a thrust fault to the west and by a NW-SE striking, left-lateral shearing to the east. The western and central parts of the batholith are undeformed, but mylonitized granite is developed at the western boundary of the batholith. At the same time, there is a significant increase of enclaves from western to eastern batholith, and the enclaves are obviously elongated and oriented towards the eastern boundary of the batholith.

The magnetic fabrics in the batholith interior predominantly reflect magma flow structures. A NE-SW trend of magnetic lineations in the batholith interior and a nearly N-S direction of magnetic lineations in its eastern part have been defined. The gravity survey reveals that the Lincang batholith is a wedge-shape in E-W profile, and has a main feeder zone located below its western part.

Integrating the previously published geochemical data and geochronological results, a post-collisional tectonic regime has been established. We concluded that the emplacement of the main part of Lincang batholith happened during 230-220Ma, with a northeastward magma transport. Such feature may indicate a NE-SW trending extension during this period.

Keywords: Changning-Menglian-Inthanon Belt; Lincang Batholith; anisotropy of magnetic susceptibility (AMS).
THE SUBDUCTION OF PALEO-TETHYS ALONG A CONTINENTAL ARC IN EASTERN MYANMAR FROM CARBONIFEROUS TO TRIASSIC: NEW INSIGHTS FROM ZIRCON U-PB AND HF ISOTOPE DATA

Fangyang Hu¹, Fuyuan Wu¹,², Jiangang Wang¹,²

¹ State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
² Innovation Academy for Earth Science, Chinese Academy of Sciences, Beijing 100029, China

ABSTRACT

The eastern Shan Plateau in Myanmar is a crucial region for investigating the evolution of Paleo-Tethys. It is generally believed to be part of the southward extension of the Changning-Menglian Zone. We collected samples of volcanic rocks and gabbroic cumulates in the northern Tachileik, where is the northwestern part of the Sukhothai Arc. Our new data suggested that all the studied samples have typical arc-like geochemical features. The Tachileik basalt, formed at ~340 Ma, has a relatively enriched isotopic composition, indicating they were formed by partial melting of relatively enriched mantle. The andesites-dacites and gabbroic cumulates, however were formed at ~250 Ma, showed clearly depleted isotopic features, suggesting they were derived from partial melting of depleted mantle and experienced infracrustal AFC (assimilation and fractional crystallization) process. The gabbroic cumulates were likely the fractional crystallization products of the coeval arc-like magma. According to our data, we suggest that the Sukhothai Arc is a continental arc as some researchers previously proposed. The Paleo-Tethyan subduction may be initiated at least at ~340 Ma, which is an important transition time of Proto-Tethys and Paleo-Tethys. During ~340-250 Ma, the mantle wedge became gradually depleted through continuous subduction. Therefore, the subduction of Paleo-Tethys in the eastern Myanmar may be activated at early Carboniferous, and then continuing subduction induced the formation of Nan back-arc at late Carboniferous. This provides new insights to the evolution of Paleo-Tethys in the eastern Myanmar and southwestern China.

Keywords: Paleo-Tethys, Sukhothai Arc, Early Carboniferous to Triassic, Zircon U-Pb-Hf isotopes, Volcanic rocks and cumulates.
DROUGHT CYCLES OVER THE LAST 8,200 YEARS RECORDED IN MAAR LAKE TWINTAUNG, MYANMAR

Guoqiang Chu\textsuperscript{a,b,c,*}, Qingzeng Zhu\textsuperscript{a}, Qing Sun\textsuperscript{d}, Youliang Su\textsuperscript{e}, Manman Xie\textsuperscript{a,c}, Than Zaw\textsuperscript{f}, Kyaing Sein\textsuperscript{f}

\textsuperscript{a}Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China;
\textsuperscript{b}CAS Center for Excellence in Life and Paleoenvironment, Beijing, 100044, China;
\textsuperscript{c}Innovation Academy for Earth Science, Chinese Academy of Sciences, Beijing 100029, China;
\textsuperscript{d}National Research Center of Geoanalysis, Beijing 100037, China;
\textsuperscript{e}Institute of Geophysics, China Earthquake Administration, Beijing 100081, China;
\textsuperscript{f}Myanmar Geosciences Society, Yangon, Myanmar.
*Corresponding author.
E-mail address: chugoqiang@mail.igcas.ac.cn.

Keywords: Maar Lake Twintaung, annually laminated sediments; compound-specific carbon isotope; droughts; Holocene Myanmar

ABSTRACT

The tropical Asia land is more prone to suffer catastrophic drought than other regions, due to the high temperature and evaporation, and sensitivity to variable oceanic-atmospheric circulations. As a result of global warming, it is not clear if the increasing droughts will dominate future climate. More regional paleoclimatic data are required to gain an overall view of monsoon variations and understand their teleconnections with dominant modes of internal climate variabilities and external natural forcings. Here, we report a biomarker record from annually laminated sediments spanning the last 8200 years from Maar Lake Twintaung in Myanmar. The sedimentary record of $\delta^{13}C_{27-35}$ mainly derived from leaf wax lipids in the lake catchment. In this C3 plants dominant region, $\delta^{13}C_{27-35}$ is mainly regulated by plant physiological and biochemical responses to drought stress. The $\delta^{13}C_{27-35}$ record reveals distinct decadal- to centennial- scale droughts superimposed on a trend of gradually decreasing summer monsoon. Within the limits of the dating uncertainties, these decadal-to-centennial scale droughts were well correlated with the southward shift of the ITCZ. Most of the droughts are likely linked with external natural forcings such as activer volcanic eruption and solar minima. On a long-term view, a phasic change characterized by a wet middle Holocene and dry late Holocene might be due to a shift of the Indian Ocean Dipole from positive phase during middle Holocene to negative phase in the late Holocene.
LATE TRIASSIC PALEOGEOGRAPHIC RECONSTRUCTION ALONG THE NEO–TETHYAN OCEAN MARGINS, SOUTHERN TIBET AND MYANMAR

Fulong Cai¹, Lin Ding¹, Wei Yao¹
1.Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China

ABSTRACT

Constraining the early Mesozoic paleogeography of the Neo-Tethyan Ocean margins is crucial for understanding the opening history of the Neo-Tethyan Ocean and the paleoposition of the southern margin of Eurasia and the northern margin of India. Upper Triassic strata are well exposed in the Tethyan Himalaya, Lhasa terrane, Indo-Burma Ranges, and Shan Plateau. At present, however, there is little consensus about the paleogeography of these assemblages during Late Triassic time. In an effort to discriminate among the contrasting models of early Mesozoic paleogeography, we conducted sandstone petrologic and U–Pb detrital zircon geochronologic studies on Upper Triassic strata exposed in the Tethyan Himalaya Sequence (THS) and southern Lhasa terrane of southern Tibet, the Indo-Burma Ranges and Shan Plateau of Myanmar.

The Upper Triassic Langjiexue Formation of the THS includes significant populations of Permian to Early Jurassic (291–184 Ma) detrital zircons for which there is no known Indian source. We propose that the Langjiexue formation were derived from continental crustal fragments that were adjacent to the northwestern margin of Australia. The Upper Triassic Mai longgang Formation in the southern Lhasa terrane is dominated by Permian detrital zircons, which were likely derived from proximal Lhasa terrane sources. Upper Triassic Pane Chuang Formation in West Myanmar contain 290–200 Ma detrital zircons, εHf(t) values of −6 to 11, which is indistinguishable with the Langjiexue Formation. The Upper Triassic strata in Sibumasu contain abundant Permian to Triassic detrital zircons that are interpreted to have been derived from the Sukhothai Arc of the western Indochina terrane and obvious 1.8 Ga peak that is most likely derived from Indochina block. The absence of 1.8 Ga peak in the Pane Chuang Formation indicated they have different source rocks.

Based on the detrital zircon age spectra comparisons, our data indicated that the Langjiexue Formation and Pane Chuang Formation are distinct from age-equivalent strata in Lhasa, Indochina and Sibumasu and were most likely derived from the West Papua area. Furthermore, we suggested that the Pane Chaung and age-equivalent strata in the Greater India, Northwest Australia, Northwest Sulawesi, West Sulawesi, Banda Arc and West Papua, comprised a Late Triassic submarine fan along the northern margin of Australia, with the sediment-routing system from the West Papua to the Great India. In contrast, we interpret that the Mai longgang Formation of the Lhasa terrane was separated from Greater India and Australia by the Neo–Tethyan Ocean.
FOUR YEARS OF RESEARCH IN THE BURMESE FOREARC BASIN WITH THE MYAPGR GROUP: INSIGHTS ON THE EOCENE OF MYANMAR

Alexis Licht (1), Guillaume Dupont-Nivet (2,3,4), Jan Westerweel (2), Pierrick Roperch (2), Zaw Win (5), Hnin Hnin Swe (6), Myat Kaythi (6), Tamas Ugrai (1), Virginia Littell (1), Day Wa Aung (6), Huasheng Huang (8), Carina Hoorn (8)

(1) Dept. Earth and Space Sciences, University of Washington, Seattle, United States (1) Department of Earth and Space Sciences, University of Washington, Seattle WA 98195, USA.
(2) Géosciences Rennes, UMR CNRS 6118, Université de Rennes, 35042 Rennes Cedex, France.
(3) Potsdam University, Institute of Earth and Environmental Science, 14476 Potsdam, Germany.
(4) Key Laboratory of Orogenic Belts and Crustal Evolution, Ministry of Education, Beijing, China.
(5) Geology Department, Shwe Bo University, Sagaing Region, Myanmar.
(6) Geology Department, University of Yangon, Pyay Rd, Yangon, Myanmar.
(7) Instituto de Ciencias de la Ingenieria, Universidad de O’Higgins, Rancagua, Chile.
(8) Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, 1098 XH Amsterdam, The Netherlands.

* corresponding author: licht@uw.edu

ABSTRACT

The Myanmar Paleoclimate and Geodynamics research group (MyaPGR group). Founded in Winter 2016, brings together international and Burmese scientists to study the Cenozoic geological record of Myanmar. This talk proposes an overview of the work accomplished so far by our group, covering our projects in paleogeography, paleoclimate, and paleobotany. It will then cover in more details the work achieved on the late Middle to Upper Eocene Pondaung and Yaw Formation of the Burmese Forearc Basin. We will show that this period was associated with deltas and estuaries draining the Wuntho-Popa Arc of central Myanmar, and covered with mangroves and seasonally dry forests thriving under a proto-monsoonal climate. The period is also marked by the emergence of the Indo-Burman Ranges, disrupting river drainages and drastically changing the landscape of central Myanmar.
SEDIMENTARY PROVENANCE AND ROUTING PATHWAYS OF MID-CENOZOIC FORMATIONS OF THE SALIN SUB-BASIN

Amy Gough¹*, Robert Hall¹, and Nils Keno Lünsdorf²

¹Department of Earth Sciences, Royal Holloway University of London, Egham, Surrey, UK
²Department of Sedimentology and Environmental Geology, Centre of Geosciences, Georg-August University, Göttingen, Germany

*Corresponding Author: Amy.Gough@rhul.ac.uk

ABSTRACT

The Central Myanmar Basin (or Central Depression) is an elongated north-south trending basin that extends the length of the country. The basin is bounded to the west by the Indo-Myanmar Ranges, uplifted as a result of the collision between the Indian Plate and the Myanmar Microplate, and to the east by Eastern Myanmar. The Central Myanmar Basin itself is divided into a western and eastern strand by a central north-south trending high, sometimes attributed to a buried magmatic arc. These strands are then further subdivided into sub-basins, including the focus of this study, the Salin Sub-basin.

Approximately 7500 m of sediment was deposited into the deepest part of the Salin Sub-basin during the Mid-Cenozoic. Despite this, there is very little variation in depositional environment, suggesting that subsidence kept pace with sedimentation. This means the subsidence rates of the Salin Sub-basin in the Cenozoic would have been some of the fastest of Southeast Asia. This also raises questions about the source for this large volume of sediment. This work uses a combination of a field study and provenance study to try to locate possible source areas and to unravel sediment routing pathways through the basin, as well as providing key information about the timing of uplift in the areas surrounding the basin. This is achieved through facies analysis of measured sedimentary sections, optical light mineral analysis, heavy mineral analysis using Raman Spectroscopy, and U-Pb dating of detrital zircons using LA-ICP-MS.

The depositional environments of the Mid-Cenozoic are interpreted as broadly south-flowing rivers that ran into large delta systems and shallow marine environments towards the south of the basin. Despite there being very little change in the overall environments, there are evident small-scale sea level oscillations, clearly defined by paralic facies and prograding and retrograding deltaic facies. There is also very little variation in the U-Pb zircon ages throughout the Mid-Cenozoic, with peaks mainly occurring around the Cretaceous-Cenozoic boundary and in the early Cretaceous, with very few zircon ages older than 500 Ma occurring. In contrast to this, the heavy mineral populations show a wide variety, with significant changes in mineral assemblage showing a switch from ultrastable to unstable heavy minerals. This indicates that there was a significant change in source area in the early stages of the Mid-Cenozoic, from further afield to the local Indo-Myanmar Ranges with some minor coeval contribution from the supposed mid-Central Myanmar Basin magmatic arc.
THE INDIA-ASIA COLLISION SEEN FROM MYANMAR

Pierrick Roperch (1), Jan Westerweel (1), Alexis Licht (2), Guillaume Dupont-Nivet (1,3,4), Zaw Win (4), Hnin Hnin Swe (5), Myat Kaythi (5), Tamas Ugrai (2), Virginia Littell (2), Day Wa Aung (5), Huasheng Huang (7), Carina Hoorn (7)

(1) Géosciences Rennes, UMR CNRS 6118, Université de Rennes, 35042 Rennes Cedex, France.
(2) Dept. Earth and Space Sciences, University of Washington, Seattle, United States
(3) Department of Earth and Space Sciences, University of Washington, Seattle WA 98195, USA.
(4) Potsdam University, Institute of Earth and Environmental Science, 14476 Potsdam, Germany.
(4) Geology Department, Shwe Bo University, Sagaing Region, Myanmar.
(5) Geology Department, University of Yangon, Pyay Rd, Yangon, Myanmar.
(6) Instituto de Ciencias de la Ingeniería, Universidad de O’Higgins, Rancagua, Chile.
(7) Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, 1098 XH Amsterdam, The Netherlands.

* corresponding author: pierrick.roperch@univ-rennes1.fr

ABSTRACT

The India-Asia collision remains poorly understood. Today, specialists are torn between two collision models; on the one hand, a simple collision between India and Asia around 60-50 Ma, and on the other hand, a two-stage collision with a trans-Tethyan arc.

As there are not many preserved rocks left in the India-Asia collision zone, researchers are looking to the sides of the zone, particularly in Myanmar's sedimentary basins and magmatic rocks of the late Cretaceous-Tertiary Wuntho-Popa arc.

These rocks are mainly located on a tectonic microplate (Burma Terrane, BT) bounded to the north by the eastern syntax of the Himalayan chain, to the west by the Indian plate, to the south by the oceanic opening in the Andaman Sea and to the east by the Sagaing fault. Despite these characteristics suggesting a complex history with significant tectonic displacements, most geological studies have been done assuming that the BT did not move much and that it had been part of Asia for over 200 Ma. No paleomagnetic data were available to confirm this hypothesis. Paleomagnetism makes it possible, from the recording of the magnetic field preserved in a given rock, to determine at what latitude this rock was located and whether it has undergone vertical axis rotations. The paleomagnetic results, obtained on the Wuntho Cretaceous magmatic arc, allow to place the BT in equatorial position (~5°S) around 95Ma. This arc also records a clockwise tectonic rotation of about 60° since its formation. Paleomagnetic data in sedimentary rocks deposited about 40 Ma ago also show equatorial latitudes but no significant rotation.

These results have several major implications. The equatorial position of the 95 Ma magmatic arc shows that this arc should not be correlated with the magmatism of the
southern margin of the Lhasa microplate (Gangdese rocks) but supports the existence of a trans-Tethyan arc probably connected to that of Kohistan, currently accreted south of the Pamir (see Figure). This reinforces the hypothesis of a first collision of India with a trans-Tethyan arc around 60-50 Ma before a later collision with Asia.

CENOZOIC DEFORMATION HISTORY OF THE BURMA TERRANE CONSTRAINED BY THE SEDIMENTARY RECORD OF THE CHINDWIN BASIN

Jan Westerweel (1,*), Alexis Licht (2), Nathan Cogné (1), Pierrick Roperch (1), Guillaume Dupont-Nivet (1,3,4), Zaw Win (5), Hnin Hnin Swe (6), Myat Kaythi (6), Day Wa Aung (6), Huasheng Huang (7), Carina Hoorn (7)

(1) Géosciences Rennes, UMR CNRS 6118, Université de Rennes, 35042 Rennes Cedex, France.
(2) Dept. Earth and Space Sciences, University of Washington, Seattle, United States (1) Department of Earth and Space Sciences, University of Washington, Seattle WA 98195, USA.
(3) Potsdam University, Institute of Earth and Environmental Science, 14476 Potsdam, Germany.
(4) Key Laboratory of Orogenic Belts and Crustal Evolution, Ministry of Education, Beijing, China.
(5) Geology Department, Shwe Bo University, Sagaing Region, Myanmar.
(6) Geology Department, University of Yangon, Pyay Rd, Yangon, Myanmar.
(7) Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, 1098 XH Amsterdam, The Netherlands.

* corresponding author: jan.westerweel@univ-rennes1.fr

ABSTRACT

The Himalayan-Tibetan orogen, formed primarily due to the India-Asia collision, is often considered as the archetype for continent-continent collision systems. However, the India-Asia collision remains subject to debate, notably in terms of the timing of collision and the paleogeographic evolution. This is partly the result of understudying the western and eastern extend of the collision zone compared to the central orogen. The Burma Terrane (BT) is a microplate at the eastern edge of the Himalayan-Tibetan orogen with a unique tectonic history characterized by a northward translation alongside India, but the relationship between regional phases of uplift and the timing of India/BT indentation into the Himalayan collision zone are poorly understood. These constraints can hence provide important new insights into the evolution of the India-Asia collision.

Here we report new data from sedimentology, paleomagnetism, geochronology (zircon U-Pb, apatite U-Pb and apatite fission track ages) and mineralogy from the late Eocene to early Miocene infill of the Chindwin Basin in the Burmese forearc. This data was then placed in an updated plate tectonic context (Roperch et al., 2020 – this meeting) to yield paleogeographic reconstructions of the BT and the eastern Himalayan orogen.

Our results constrain two depositional hiatuses in the Chindwin Basin of late Eocene – early Oligocene and late Oligocene – early Miocene age. These hiatuses are accompanied by significant changes in depositional environment, sedimentary provenance and magnetic properties. The late Eocene Yaw Formation was deposited in a barrier-bound estuarian
depositional environment during rapid subsidence, locally sourced by the proximal Wuntho-Popa Arc. The late Eocene – early Oligocene unconformity marks the onset of deposition of the fluvial Tonhe Formation and represents the moment of overfilling of the basin. These developments are likely related to the onset of hyper-oblique convergence between the BT/India and Indochina, causing partitioning of the forearc into en echelon pull-apart basins and progressive emergence of the Indo-Burman Ranges, eventually causing the basin to overfill. The second late Oligocene – early Miocene unconformity and subsequent deposition of the Letkat Formation are characterized by abrupt changes to a braided river depositional environment, younger age populations, a higher degree of petrographic maturity and a shift in paleocurrent directions from the SWW to the SSW. This unconformity can be observed across the Burma Terrane and corresponds to uplift of the northern Wuntho-Popa Arc. Furthermore, an early Miocene phase of major thrusting and exhumation in the Himalayan orogen is identical to our geochronology ages. We propose that this second unconformity is the result of ongoing indentation of India and the BT in the eastern Himalayan collision zone.

WEDGE EXTRUSION IN THE INDO-BURMA RANGE ACCRETIONARY COMPLEX
AND IMPLICATION FOR OROGENIC ARCHITECTURE OF NEOTETHYS IN SE ASIA

Ji’en Zhang a, #, Wenjiao Xiao a, Fulong Cai b, Kyaing Sein c

a. Institute of Geology and Geophysics, Chinese Academy of Sciences, China
b. Institute of Tibetan Plateau Research, Chinese Academy of Sciences, China
c. Myanmar Geosciences Society, Yangon, Myanmar

# zhangjien@mail.iggcas.ac.cn

ABSTRACT

The Indo-Burma Range (IBR) of Myanmar consist of serpentinite, greenschist facies basalts and chert, sericite schist, and unmetamorphosed Triassic sandstone, mudstone and siltstone interlayered with chert and high-pressure metamorphic blueschist and eclogite at the Naga Hills, suggesting that it is an accretionary complex. Detailed maps along the Mindat and Magwe sections at the middle part of IBR reveal that the greenschist locates at the core of both sections and the first-rank metamorphic grades increase eastward and westward at their west and east parts, respectively, though these repeated rocks arrange as imbricate thrust stacks. The metamorphic rocks thrust onto Triassic unmetamorphosed sediments at the west boundary and contact as normal fault at the east boundary in the Mindat section, suggesting that these metamorphic rocks in IBR accretionary complex may have exhumed through wedge extrusion. Amphibolite in the Natchaung area, whose protolith is MORB-type basic rock, is a product of metamorphic sole and dated at 115-119Ma, close to the ages of granite and diorite, products of continental arc along the western margin of Shan-Thai Plateau. These facts suggest that the IBR accretionary complex and the Shan-Thai Plateau continental arc compose an Early Cretaceous subduction system, which is a follower of Jurassic subduction zone, constituting with Jurassic accretionary complex, located in the Hpakan area in the north of the Myanmar Central Basin, containing 189-147 Ma high-pressure metamorphic rocks such as jadeite, garnet-mica schist and glaucophane schist, and Myitkyina-Mogok continental margin arc along the eastern margin of the Myanmar Central Basin, containing 177-166 Ma peridotite, andesite, hornblende gabbro, diorite, granodiorite and plagiogranite. This continuous involving subduction suggests that Neotethys extends from the Tibetan Plateau and Myanmar, and continues eastward to Indonesia in the SE Asia.
CULTURE GEOLOGY IN JAPAN AND MYANMAR

Hisashi Suzuki¹# and Teza Kyaw²

¹ Professor, Faculty of Sociology, Otani University, Kyoto, Japan
² Lecturer, Department of Geology, Monywa University

# Corresponding author, e-mail: hsuzuki@res.otani.ac.jp

ABSTRACT

Culture geology was proposed and developed by Prof. Wolfgang Vetters, University of Salzburg, Austria, in 2003. At that time some Austrian geological meetings took up the topics of culture geology energetically, but now such prosperous activities become weak. In Japan, the first topic session “culture geology” was held in the meeting of the Geological Society of Japan in 2014 in Kagoshima. The concept of culture geology in this meeting was explained as “the link between geology and human beings”. Because geologic catastrophes happen in the Japanese islands frequently (e.g. the Tohoku earthquake and the huge tsunami on the March 11th, 2011), public awareness of geological sciences is needed to live on the land along active plate margins.

In comparison of the historical stone buildings in Europa, Japanese traditional architectures are mostly made of woods. But besides historical architectures many interesting geocultures are found in Japan. Natural stones and mountains are widely accepted among the Japanese public as gods with the animistic point of view. The Japanese believe that many gods exist in/on all natural things, e.g. natural stones and mountains as well as big trees and wild animals. Mt. Miwa in Nara prefecture, for example, is a god or a site of god descent of the Ohmiwa shrine. The Yoshino area in Nara prefecture is a famous site of the mountain asceticism by mountain priests of Buddhism (called Yamabushi in Japanese). These religious view of the nature in Japan is a close relationship with natural stones that are the material handled by geology as natural sciences. Geocultures in Japan would be tools connected between geology and the Japanese public.

In case of geocultures in Myanmar we recognise also the close relationship with Myanmar religions. The golden rock of the Kyaiktiyo Pagoda is a famous one of Buddhistic geocultures in Myanmar. The Taung Kalat on the top of Mt. Popa is a sacred place of the Myanmar religion Nat. Many sandstone caves in the Pho Win Taung area include 2588 Buddha statues. Culture geology of Japan and Myanmar resembles each other in 1) tectonic position of the active plate margin, and 2) existence of religious geocultures including Buddhism. Comparative study of culture geology will shed a new light on the relationship between geology and people of each country.
AGE, DEPOSITIONAL HISTORY AND TECTONICS OF THE INDO-BURMAN RANGES

Tin Tin Naing¹, Stuart Robinson¹, Mike Searle¹, Gideon Henderson¹, Ian Millar²

¹University of Oxford, ²NERC Isotope Geosciences Laboratory, British Geological Survey

ABSTRACT

The Indo-Burman Ranges (IBR) run north-south through Myanmar from the Gulf of Martaban in the south to connect with the Himalaya to the north. The provenance and depositional processes of the sedimentary rocks of the IBR discuss the tectonic evolution and provide a synthesis of the geological evolution of Myanmar. The IBR forms an enigmatic mountain belt, comprising a western belt of folded and thrustsed mainly Cenozoic sedimentary rocks, a central zone of highly deformed Triassic turbidites (Pane Chaung Formation) and low-grade metamorphic rocks (Kanpetlet Schist), and an eastern zone comprising a major Neo-Tethyan suture zone. The newly discovered Early Jurassic-Early Cretaceous radiolarian assemblages from ophiolitic mélangé in the Kalemyo area and Late Paleocene-Early Eocene radiolarian ages from the Ngapali mélangé, with ages similar to those of the Indus-Yarlung Tsangpo suture zone (IYTSZ) of south Tibet and Nagaland, reinforces the hypothesis that the Kalemyo-Nagaland and IYTSZ represent a single suture zone that separates the Indian plate to the west (IBR) and Asian plate (Sibumasu) to the east (Central Basin and Wuntho-Popa Arc). The data presented suggest that Triassic turbidites were originally deposited on the northeastern India (Gondwana) margin, not the Asian (Sibumasu) plate, and that a wide Neo-Tethyan ocean separated the IBR from the Wuntho-Popa Arc and the Shan Plateau. The geochemistry of detrital zircons from Upper Cretaceous sediments indicates a subduction related mixed mantle-crust source most likely the suture zone sediments. Similar data from the Paleocene-Eocene flysch sediments suggest derivation from the local sources, such as from the IBR and Wuntho-Popa Arc.
ABSTRACT

Despite decades of research, the mechanisms and processes of subduction initiation remain debated, including where subduction initiation begin and how magmatism responds, and two main conceptual end-member mechanisms are considered as spontaneous and induced subduction initiation (SSI or ISI). Whether SSI or ISI governs plate tectonics on Earth, or both modes can be activated largely depending on tectonic settings, is still a matter of debate. It is significant to note that the net plate convergence during SSI is zero but at least 100 km during ISI. This large plate convergence during ISI should produce a protoarc (which is absent during SSI), although this protoarc would be strongly destroyed by later magmatism and subduction erosion. Fortunately, this diagnostic protoarc survived in western Myanmar where the mid-Cretaceous Wuntho-Salingyi-Popa (WSP) arc are associated with Neotethyan ophiolites. Based on the geochronological, geochemical and isotopic data from Wuntho and Salingyi, the onset of protoarc tholeiites and calc-alkaline arc volcanic rocks (~105 Ma) are significantly older than that of forearc basalts (~93 Ma), but younger than that of those metamorphic soles (~116 Ma) from the Neotethyan ophiolites nearby. The long-term standing at near-equatorial latitudes of Western Burma Block from paleomagnetic results raise the possibility that the WSP arc may have been a segment of the trans-Neotethyan introoceanic arcs at near-equatorial latitudes during mid-Cretaceous. This provides a clue to test the hypothesis that induced subduction initiation by ridge inversion probably prevailed and built SSZ ophiolites within Neotethyan ocean, which may have been triggered by global plate reorganization during mid-Cretaceous.

Key words: Subduction initiation; Ridge inversion; Forearc basalts; mid-Cretaceous; Myanmar; Neotethyan ocean; ophiolites
ABSTRACT

The Lhasa terrane in the Tibetan Plateau was an Andean-type active continental margin before the India-Asia collision. The Xigaze fore-arc basin (XFB) located in the Lhasa terrane preserves a key record of India-Asia convergence and collision. New apatite fission track and zircon (U-Th)/He data from an N-S transect across the preserved fore-arc basin sequence near Xigaze show a consistent northward Late Cretaceous to middle Miocene younging trend, while coexisting apatite (U-Th-Sm)/He ages are all Miocene. Corresponding detrital zircon U-Pb data are also reported for constraining the Cretaceous depositional ages of the XFB sequence in the region. Thermal history modeling indicates that the basin experienced northward propagating episodic exhumation, along with a northward migration of the depocenter and a pre-existing Cenozoic syncollisional basin sequence which had been removed. In the southern part, fore-arc exhumation commenced in the Late Cretaceous (~89 ± 2 Ma). Following transition to a syncollisional basin in the Paleocene, sedimentation in the central and northern Xigaze basin continued until the latest Eocene (~34 ± 4 Ma). Ongoing folding and thrusting (e.g., Great Counter Thrusts) caused by progressive plate convergence during late Oligocene-early Miocene time resulted in regional uplift and considerable basin denudation, which fed two fluvial basins along its northern and southern flanks and exposed the basement ophiolite. Subsequent incision of the Yarlung River resulted in Miocene cooling in the region. Different episodes in the exhumation history of the Xigaze basin, caused by thrusting of an accretionary wedge and ophiolitic basement, can be linked to changes in India-Asia convergence rates and the changing subduction pattern of the Indian and Neo-Tethyan slabs.

Reference

INTER-SEISMIC UPPER-PLATE DEFORMATION OF THE SUNDA MEGATHRUST OFFSHORE WESTERN MYANMAR RECORDED BY CORAL MICROATOLLLS

Sze-Chieh Liu¹, J. Bruce H. Shyu¹, Yu Wang¹, Hong-Wei Chiang¹, Chuan-Chou Shen¹, Lin Thu Aung², Soe Thura Tun³
¹Department of Geosciences, National Taiwan University, Taipei, Taiwan
²Earth Observatory of Singapore, Nanyang Technological University, Singapore
³Myanmar Earthquake Committee, Myanmar Engineering Society, Yangon, Myanmar

ABSTRACT

The Sunda megathrust is one of the major plate boundaries in Southeast Asia, where the Indian-Australian plate obliquely subducts northeastward beneath the Burma microplate at a rate of about 23 mm/yr offshore western Myanmar. The latest historical megathrust earthquake along this convergent plate boundary is the 1762 Arakan earthquake. Although the magnitude and the possible seismogenic structures of this event have been analyzed based on geological records along the coast, constraints on the inter-seismic behavior of this plate boundary are still very limited. Since inter-seismic vertical deformation is a common feature of the upper plate, we utilized coral microatolls as natural tide gauge to analyze relative sea-level history and to obtain information of land-level change before and after the 1762 Arakan earthquake in this study. For Porites corals, the highest level of survival (HLS) is constrained by the level of mean lower water spring. Once the relationship between the HLS and the sea level is established, the morphology of the microatolls can reflect the relative sea-level changes.

We collected slabs from two microatolls that were uplifted and killed by two different historical earthquakes (the 1762 Arakan earthquake and a regional earthquake in 1848) in southwestern Man-Aung Island and northwestern Ramree Island. Our results show that the western Man-Aung coast had been subsiding at a rate of ~4 mm/yr in the 18th century, and the western Ramree coast had been subsiding at a rate of ~6 mm/yr in the 19th century, which is faster than the subsidence rate estimated at St. Martin’s Island, Bangladesh. The higher subsidence rate in western Myanmar indicates the coupling ratio of the plate interface beneath western Myanmar is higher than that in the north. These results enabled us to further understand the seismogenic properties and to calculate possible earthquake recurrence intervals for western Myanmar, and will have important implications for future earthquake hazards of this region.
CONSERVATION OF GEODIVERSITY, BIODIVERSITY AND GEOHERITAGES TOWARDS UNESCO GLOBAL GEOPARKS IN MYANMAR

Than Htun
Myanmar Geosciences Society

ABSTRACT

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 this view in mind Myanmar Geosciences Society has been endeavouring to establish UNESCO Global Geoparks in Myanmar based on the available information from Department of Forestry. There are ten potential Geopark areas spreading all over the country: Mt. Khakaborazi, Puta O, Indawgyi Lake, Mt. Popa, Twintaung, Zwegabin, Manaung Island, Belu Kyun, Pindaya cave and Inle Lake. Of all, Myanmar Geosciences Society started the Mount Popa Geopark which is situated in Mandalay Region in central Myanmar. The all selected areas have significant geodiversity, biodiversity and valuable geo-heritage and intangible heritages. The 5881metre high Karkaborazi, the highest mountain in Myanmar and its environ has been established as the Khakaborazi National Park and facilities for eco-tourism has been successfully implemented in 1998. The Khakaborazi National Park Exhibition Centre in Puta O is a unique place where one will be introduced to the natural environs and various b diversities of the Kachin State. 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. Since 1920 an area of 2961 acres was demarcated as National Forest in Mount Popa area and extended up to 128.54 square kilometers in 1989. 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. The biodiversity of Mount Popa has been done by collaboration with NIBR and National Institute of Biological Research, Incheon, Korea in 2014 and compilation of medicinal plants of Mount Popa in 2016. The Geopark area covers about 1964 square kilometer which is the whole area of Kyaukpadaung Township. Ar-Ar dating of the summit lava dome and the lava flow truncated by the avalanche scar provided zero age- thus they are very young. Buried paleosol under the avalanche deposit provided C14 calibrated ages 17660-17220 BP, 12820-12650 and 8590-8400BP. The paleosol contains thin layers of fine-grained ash indicating eruptions of Mt. Popa in the beginning of Holocene. Paleosol on top of the volcanoclastic fan provided a calibrated C14 age of 2740-2640 BP. The uppermost paleosol contains no ash layers, thus there are no geological evidences of explosive eruptions of the volcano in the end of Holocene. Latest period of volcanic activity of Mount Popa took place in the beginning of Holocene. It included several mild explosive eruptions probably of Vulcanian type ~12700 – 8500 BP, followed by strong magmatic eruption with deposition of the pyroclastic flow (A. Belausov et.al, 2012). 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. Regarding archaeological heritage a lot of ancient traditional iron furnace in Bagan Dynasty are discovered near Thanbo village. King Anawrahtar, when his brother King took power at Bagan, he based at Popa village and gathered soldiers and trained the secretly to take the thrown. He made weapons with iron concretions from Irrawaddian Sandstone by using furnace. He used horses and elephants in fighting and there is royal elephant pasture near Shwezitaing Village. According to archaeological data it has been known that the Popa region was inhabited by the human since 10,000 years ago. The Mount Popa region is at the heart of famous Anyathian culture in Myanmar. The estimated population in this region currently is about 291,561 in 339 villages.

CV of Than Htun

Than Htun received B.Sc.(Geology) Degree from Arts and Science University, Mandalay in 1972. He joined Department of Geological Survey and Mineral Exploration (DGSE) under Ministry of Mines in 1972. He served as an exploration geologist in DGSE and got UN fellowship award to study Offshore Exploration for Tin in Banka and Billiton islands in Indonesia and Phuket Island in Thailand. He has been working as chief geologist in offshore exploration for tin in Tanintharyi Offshore areas under UNDP project from 1977 to 1987. He carried out gold, manganese and tin exploration near China and Myanmar border for Border Areas Development Programme. He is one of the pioneers who found New Mong Hsu Ruby Deposit in Shan State in 1993-1995. He got an opportunity to study Remote Sensing and Satellite Image Analysis in Mineral Exploration in Tokyo under AOTS Programme in 1998. He served as Secretary of Foreign Joint Venture Committee in DGSE and took care various mineral exploration activities collaboration with foreign companies and DGSE from 1995 to 2005. After retirement from DGSE in 2005 he joined Foreign exploration companies and carried out gold and tin exploration in Upper and Lower Myanmar. At present he is the secretary and Chairman of Geopark Establishment Committee of Myanmar Geosciences Society and a member of National Geopark Executive Committee.
A STUDY OF PEZZOTTAITE FROM PYIN GYI TAUNG, MANDALAY REGION, MYANMAR

Kyaw Thu¹*, Shang I (Edward) Liu²

¹* MACLE Gem Trade Laboratory, Yangon, Myanmar; macle45@googlemail.com
² The Gemmological Association of Hong Kong, Hong Kong; gemedward@hotmail.com

ABSTRACT

Pyin Gyi Taung is located 6km E of Let Pan Hla, Singu Township, Mandalay Region. There are many LCT type pegmatite distributed over this mountain range producing mainly rubellite (elbaite variety). Recently, the discovery of "mushroom" (and "wheat sheaf") tourmaline in this area has aroused one of the author's interest to investigate the unusual pink "beryl". Finally, they are identified to be Cs-, Li-rich beryl and few of them are pezzottaites.

Pyin Gyi Taung area lies in the southern continuation of Mogok Metamorphic Belt (MMB) (Latitude 22°33'52"N and Longitude 96°07'58"E, 466m at elevation). It comprises mainly marble and calc-silicate rocks which intruded by rubellite bearing pegmatite dykes. The prominent pegmatite occur as concordant to discordant dykes trending in nearly E-W to NE-SW directions and dipping at 40°-80°. Most dykes occur in tabular and mostly irregular with long narrow branches. The width of pegmatite dykes are 1m to 10m and the length measures about 7m to 50m. Radiometric dating by zircon U-Pb method using LA-ICP-MS indicates that the age of pegmatite is 24.56 Ma (Phyu Phyu Lwin, 2012). These pegmatites are classified as zoned pegmatite, rare-element type and complex lepidolite subtype that are generated by pneumatolitic action, and eventually hydrothermal fluid metasomatic alteration. Recently, they discovered goshenite and pink "beryl" with rock crystal and green tourmaline in some small pockets near the surface. The materials occur in shade of pale pink to milky white colour and sub transparent to translucent with plenty of visible inclusions. X-ray single crystal diffraction revealed that sample MP1 consists of both pezzottaite and Cs-, Li-rich beryl, whereas the other three samples are Cs-, Li-rich beryl. Chemical analysis of pezzottaite has high Cs contents (Cs₂O up to 14.85 wt.%). BSE imaging shows that the distribution of Cs contents in sample MP1 is uneven and increase discontinuously from colourless prism and core of Cs-, Li-rich beryl (Cs₂O=5.67 wt.%) to pink pezzottaite termination (Cs₂O=14.41 wt.%). A thin milky layer which contains less Cs contents (Cs₂O=3.64 wt.%) has been found below the pink layer. Distinct compositional discontinuities reflect fluctuations in fluid chemistry and changing in driving force during the multiple stages of crystallization. Both pezzottaite and Cs-, Li-rich beryl exhibit similar Raman spectrum with distinct bands at 112 cm⁻¹ and 1100 cm⁻¹, which has not been observed in common beryl. Homogenization temperature of fluid inclusions in Madagascar pezzottaite are formed in the range of 180-340°C (Liu et al., 2006). This temperature is in line with the formation temperature of some pegmatite 210-410°C in Myanmar (Khin Zaw, 1998). The order-disorder (Be and Li ions arrangement in tetrahedral sites) transformation in the beryl structure was suggested to be happened mainly at relatively low temperature around 180-260°C where pezzottaite and Cs-, Li-rich beryl crystallized syngenetically. Since “mushroom” tourmaline has only been found in those pezzottaite mines in...
Madagascar, Momeik and Pyin Gyi Taung, Myanmar, its textural and compositional changes at different parts of the stone reflects the changes of crystallization conditions during late stages of evolution of this complex type rare element miarolitic pegmatite (Lussier et al., 2008).

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References


PETROGENESIS OF IGNEOUS AND METAMORPHIC ROCKS EXPOSED AROUND THE ROAD SECTION FROM WASHAUNG VILLAGE TO SADON VILLAGE, WAINGMAW TOWNSHIP, KACHIN STATE

Me Me Aung¹, Dwe Aung², Thein Win Tun³, Htet Htet Wint War⁴

1. Professor, Department of Geology, Myitkyina University
2. Assistant Lecturer, Department of Geology, Myitkyina University
3. (& 4) MSc Students, Department of Geology, Myitkyina University

ABSTRACT

The Washaung and Sadon villages are situated about 5 miles (8km) and 14 miles (23km) respectively from east of Myitkyina Township. The study area falls within the eastern part of Kachin State which is one important segment of SE Asia consequently this area is interesting not only for petrology but also for tectonic point of view for many decades. The main purpose of this research is petrogenesis of igneous and metamorphic rocks. The igneous rocks comprise pegmatite/aplite, hornblende granite, granodiorite, diorite, dolerite, lherzolite and pyroxenite. The constituent metamorphic rocks are amphibolite, hornblende-biotite gneiss, biotite gneiss and migmatitic gneiss. Their general trend is nearly N-S with eastern and northeastern dip. Field criteria, petrographic data and previous published literature jointly suggest the igneous rocks from the study area may be formed as continental arc which related to India-Eurasia subduction during the Mesozoic and Early Cenozoic time. The magma source may commence the partial melting of subduction oceanic plate and followed by assimilation and the solidification of a gabbroic crustal underplate process may take place at the base of the crust. Subsequent partial melting of this mafic underplate may effect from heat carried upward by subsequent basaltic magma. Fractional crystallization and contamination occurred when it pass through the crust. Some granite and pegmatite probably formed by partial melting of lower or middle crust. For metamorphic rocks, the protolith age may be Lower Paleozoic and Jurassic, and the time of metamorphism may be Cretaceous in age. The igneous are estimated to be Mid Jurassic to Cretaceous in age.

Key words: petrogenesis, continental arc, protolith
COMPARATIVE STUDY OF CHROMITE MINERALIZATION BETWEEN TAGAUNG AND MYITKYINA AREAS WITHIN TAGAUNG-MYITKYINA BELT, MYANMAR

Hnin Min Soe
(Professor, Department of Geology, University of Mandalay)

ABSTRACT

The research areas lie in the Tagaung - Myitkyina Belt, Myanmar. Major objective of this research is comparative study of chromite mineralization between Myitkyina and Tagaung areas within Tagaung-Myitkyina Belt, Myanmar. Chromite deposits can be classified into two categories. They are stratiform and podiform deposits. Stratiform deposits are large, sheet-like bodies in layered mafic to ultramafic igneous complexes. Podiform deposits occur with ophiolite sequence that is fragment of oceanic crust, found on continents mostly because of the oceanic crust was obducted onto the continental crust. Among these two types podiform chromite deposits are observed in these study areas especially Tagaung Taung area. In Myitkyina area chromite occurred as in thin sections only. The ophiolite rock suite of both areas belong to the the Tagaung- Myitkyina Belt of Upper Ayeyarwady Province which extends from the Tagaung area in the south and Myitkyina area in the north. The ophiolitic sequence in these study area dismembered, complete ophiolite suites comprising lherzolite to harzburgite with irregular distribution of podiform chromite mineralization. In Tagaung Taung area podiform chromite ores are main mineralization and they are hosted in serpentinite, serpentinized-dunite and harzburgite. Serpentinization from ultramafic units in the research area is more abundant than Myitkyina area ultramafic units. Focus points on this paper is to know a petrological and geochemical study of chromites at Tagaung Taung area by using XRF, XRD and XGT methods. The ores occurred as irregular pocket or lens-shaped and fracture filling. Nodular structures of chromites ores are common and can be designated that they are not only podiform chromite deposits but also characteristics of Alpine-type ultramafic rocks and primary magmatic feature. Low TiO2 content is the indicators of Boninitic melt as well as primitive parental magma. Comparative study of chromite mineralizations between northern and southern parts of the Tagaung-Myitkyina Belt was attempted. Due to field criteria and analytical results, the considerable amounts of chromite content in the Tagaung area (52.03 - 38.68%) is more abundant than Myitkyina area (0.02 - 0.12%). This different is mainly controlled by primary magma composition. Therefore Tagaung Taung area can be concluded as favourable for chromite mining operation for future workings. Key words: Chromite, Podiform type, Boninitic melt, Low Ti Field, Primary Magma
THE ACTIVE TECTONICS AND CURRENT STATUS OF DAM LOCATION IN SEISMIC ZONE, MYANMAR

Dr Kyaw Htun

Professor and Head (Rtd.), Department of Engineering Geology
Yangon Technological University
ukyawhtun@gmail.com

ABSTRACT

As Myanmar is an earthquake-prone country due to its location in the active Alpide Seismotectonic Belt, there have been at least 45 major earthquakes with Richter Scale \( \geq 6.0 \) within the territory of Myanmar in the past 175 years. Earthquakes in Myanmar have resulted from two main sources namely: the continued subduction (with collision only in the north) of the northward-moving Indian Plate underneath the Burma (Myanmar) Platelet, which is a part of Eurasian Plate and the northward movement of the Burma Platelet from a spreading centre in the Andaman Sea at an average rate of 2.5 to 3 cm/year. Very large over thrusts along Western Fold Belt have resulted from the former movement, and Sagaing Fault and its relative faults from the latter movement. Intermittent jerks along these major active faults have caused the majority of earthquakes in Myanmar. Along these fault zones stand many infra structures and large urban cities where thick populations to live on.

Due to the national requirements of water for irrigation and hydropower for electricity, the expansions of hydropower projects had been implemented in different geologic units and seismic zones. With an intension of mitigating earthquake hazards in Myanmar, Deterministic Seismic Hazard Analysis (DSHA) Zone Map had been constructed since 2005 on the basic of seismotectonic and seismicity of Myanmar. The five seismic zones are demarcated and named in this map (from low to high). According to the Zone Map, 8 numbers of large dams are situated in Zone V (the destructive zone), 45 numbers are in Zone IV (severe zone), 66 numbers are in Zone III (strong zone), and 36 numbers are in Zone II (moderate zone). Safety of dams and their appurtenant structures are critically dependent on their foundation and seismic activities, therefore, the existing dams should be reconsidered whether they had been designed to resist the Maximum Design Earthquake selected for the dam.

Key words: Dam safety, earthquake, fault, hazard, seismotectonics, seismic zone
PETROLOGICAL AND GEOCHEMICAL STUDY OF CHROMITITES FOUND IN WEBULA AND MWE TAUNG AREAS, FALAM AND TIDDIM TOWNSHIPS, CHIN STATE, WESTERN MYANMAR

Tint Swe Myint*
*Lecturer, Geology Department, Kalay University

ABSTRACT

The study area is situated in the northeastern part of the Chin Hills. Chromitite ores are associated with basal assemblages of ophiolitic rocks of Webula and Mwe Taung area. Chromite minerals are dispersed in the peridotite assemblage of dunite, harzburgite and serpentinite. Chromitites are found as lensoid bodies in the dunite and harzburgite. They are observed as irregular disseminated podiforms or sometimes irregular as lenticular shapes and colluvial deposit at the foothill. Chromitites are observed as massive type, spotted type and sub-nodular type. They show brownish grey, euhedral to anhedral, corroded texture to pull-apart texture and sometime cumulate texture. In geochemical data, the Cr₂O₃ contents range from 52 to 40 and Cr:Fe ratio is greater than 3. The Cr₂O₃ content points to metallurgical grade. According to ore textures and geochemical data, the chromitites fall in the podiform and stratiform types of chromium rich type. In chromitite forming ophiolitic magmatism, the magma chamber is subject to tectonic disturbance throughout its evolution. The partially consolidated cumulate pile would possibly undergo slumping, flowage and other process which would disrupt primary cumulate features. Therefore, the stratiform types changed to podiform type. Chromitite samples have low TiO₂ and Al₂O₃ contents show strong affinity with melts from depleted mantle and boninites. The chemical data also indicates that the chromitites are Cr-rich type and derived from superadsubduction zone.

Key wards: ophiolite, podiform, stratiform, depleted mantle and superadsubduction zone
GEOCHEMISTRY OF SANDSTONES OF RED BED UNIT EXPOSED IN HOPANG AREA, IMPLICATION FOR PROVENCE AND TECTONIC SETTING, NORTHERN SHAN STATE, MYANMAR

Zar Ni Swe¹, Si Si Mar²

¹ Lecturer, Department of Geology, Yadanabon University
² Lecturer, Department of Geology, Kyaukse University
Corresponding author: zaniswe78@gmail.com

ABSTRACT

The geochemistry of sandstones has been examined in order to infer paleo weathering, provenance and tectonic settings. Geochemical investigation of 6 sandstones samples were collected and subjected to whole rock geochemistry of major and trace elements. The results show large variation in the major oxides of high SiO₂, Al₂O₃ and CaO with low values of Fe₂O₃, MgO and TiO₂ from the red sandstones of Red Bed Unit. The sandstones were classified as of arkosic and subarkosic sandstones based on major oxide composition. Chemical Index of Alteration values (CIA, 25.12-44.86; mean: 33.59) and Chemical Index of Weathering (CIW, 26.30-49.68; mean: 49.68), indicates low to moderate degree of chemical weathering. Index of Compositional Variation (ICV, 1.61-3.54; mean: 2.59) suggests immature sediments deposited in tectonically active settings. The discriminant function plot indicates intermediate igneous provenance and to some extent the felsic igneous provenance, derived from weathered granite, gneissic terrain. The tectonic setting discriminant diagram log [K₂O/Na₂O] vs. SiO₂ indicates an active continental margin. The geochemical characteristics of the sediments strongly suggest deposition in alluvial fans, lacustrine to fluvial environment.

Keywords: Sandstone Geochemistry, Provenance, Tectonic Setting, Red Bed Unit
OCCURRENCE OF PERMIAN GIANT BIVALVE (ALATOCONCHIDAE) FROM PINDAYA RANGE, SHAN STATE (SOUTH), MYANMAR

Kyi Pyar Aung¹, Yukio Isozaki²

¹ Department of Geology, Banmaw University, Kachin State, Myanmar
Email: kyipyar73@gmail.com

² Department of Earth Science and Astronomy, The University of Tokyo, Meguro, Tokyo 153-8902, Japan
Email: isozaki@ea.c.u-tokyo.ac.jp

ABSTRACT

Alatoconchidae, a unique bivalve family from the Permian, was found in the Guadalupian (Middle Permian) shallow marine limestone in the Pindaya Range of the southern Shan Plateau for the first time in Myanmar. This bivalve family is characterized by a giant body size, by unusual shell form with wing-like flanges, and by coarse-grained prismatic outer layer of the shell wall. The newly found alatoconchids commonly form coquina beds, and co-occur with rugose corals (*Lophophyllidium, Ipcyphyllum* etc.) and bryozoans. Palaeogeographically, they are restricted to low-latitude Tethyan and Panthalassan regions. Alatoconchidae likely became extinct globally at the end of the Guadalupian.

Keywords: Alatoconchidae, Guadalupian, Myanmar, Tethyan, gigantism, extinction
MIDDLE PERMIAN FUSULINE FAUNAS FROM THE THITSIPI FORMATION OF THE SHAN PLATEAU AND THEIR GEOLOGICAL IMPLICATIONS

Yichun-Zhang¹, Kyi Pyar Aung², Shu-zhong Shen³, Hua Zhang¹, Than Zaw⁴,⁵, Lin Ding⁴,⁶, Fulong Cai⁴, Kyain Sein⁵

¹State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology and Center for Excellence in Life and Paleoenvironment, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing 210008, China; yczhang@nigpas.ac.cn
²Department of Geology, Taunggyi University, Shan State (South), Myanmar
³School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, China
⁴Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Beijing 100101, China
⁵Myanmar Geosciences Society, Yangon, Myanmar
⁶Center for Excellence in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, Beijing 100101, China

ABSTRACT

The paleogeography evolution of the Qinghai-Tibet plateau during the Late Paleozoic has been a focus of debates in recent decades. It was widely acknowledged that the rifting of the Cimmerian continents has resulted in the opening of the Neotethys Ocean in the south and narrowing of the Paleotethys Ocean in the north. However, it remains unclear with respect to the opening time of the intervening Bangong-Nujiang Ocean and its southern extensions. According to the original definition of the Sibumasu Block, it includes both the Tengchong and Baoshan blocks in western Yunnan (Metcalfe, 1984). However, it conflicts with the conventional opinion that the Gaoligong Orogen between the Baoshan and Tengchong blocks are the southern extension of the Bangong-Nujiang suture zone. In order to unravel the paleogeographic relationships between the Sibumasu block and the blocks from western Yunnan and Tibet, fieldworks were undertaken in the Shan State of eastern Myanmar in the past three years, which is a main part of the Sibumasu Block.

The fusulines studied came from the Thitsipin Formation from various sections or quarries in the Shan Plateau. The presence of fusuline genera such as Kahlerina, Lantschichites, Neoschwagerina and Sumatrina suggest a Midian (upper Wordian to Capitanian) age. The lower diversity and the presence of some genera, such as Monodiexodina and Eopolydiexodina, suggest that the Sibumasu Block belonged to the Cimmerian Province in paleobiogeography. Most importantly, Eopolydiexodina afghanensis and Jinzhangia shengi are dominant species in the Thitsipin Formation. Those two genera/species were widely reported from the Baoshan Block and the South Qiangtang Block (Cheng et al., 2005; Huang et al., 2009). But, they have not been reported from the Lhasa Block and Tengchong Block yet. Conversely, another Nankinella-Chusenella assemblage have been widely documented from the Lhasa and Tengchong Blocks. But, they are not present in the Thitsipin Formation in the Shan plateau and the Baoshan Block as well. In order to test such hypothesis, we have performed a quantitative analysis on the paleobiogeography of Middle Permian fusulines based on the occurrences of fusuline species from the peri-Gondwanan blocks/terrains. Our results suggest that the Shan Plateau
are much similar to the Baoshan Block and the South Qiangtang Block in the faunal similarities.

Our work suggests the following conclusions. First, the Gaoligong orogen is the southern extension of the Bangong-Nujiang suture zone. Second, the Sibumasu Block should not include the Baoshan and Tengchong blocks in western Yunnan. Finally, the Bangong-Nujiang Ocean might have been present before the Midian to serve as a paleogeographic barrier for the communication of main fusuline assemblages.
RADIOLARIAN AGES OF THE THAT-TU BEDDED CHERT OF TAGAUNG AREA WITH RESPECT TO THE OCEANIC PLATE STRATIGRAPHY

Teza Kyaw¹#, Hisashi Suzuki² and Maung Maung³
1 Lecturer, Department of Geology, Monywa University
2 Professor, Faculty of Sociology, Otani University, Kyoto, Japan
3 Principal, Myingyan Degree College
# Corresponding author, e-mail: tezakyaw1@gmail.com

ABSTRACT

The Tagaung area lies in the Tagaung–Myitkyina belt that extends about 250 km long and 100 km wide in west-central Myanmar. From the Tagaung–Myitkyina Belt the ophiolites with latest Jurassic red claystone with radiolarians (Maung Maung et al., 2011) and Albian–Cenomanian limestones with foraminiferas (Thura Oo, 1993) have been reported. Recently, latest Jurassic (Tithonian) and Early Cretaceous (Hauterivian) radiolarians are demonstrated from the That-tu Bedded Chert (Teza Kyaw et al., 2019 and Suzuki et al., in press, respectively). Here we report new findings of early Cretaceous radiolarians from the That-tu Bedded Chert (sample T-1), indicating an Aptian age as follows: *Hemicryptocapsa verbeeki* (Tan Sin Hok, 1927), *Xitus elegans* (Squinabol, 1903), *Thanarla pulchra* (Squinabol, 1904), *Thanarla elegantissima* (Cita, 1964), *Thanarla brouweri* (Tan Sin Hok, 1927), *Loopus nudus* (Schaaf, 1981), *Pseudodictyomitra carpatica* (Lozyniak, 1969), *Pseudodictyomitra conicostraiata* Dumitrica, 1997.

This new findings extend the stratigraphic distribution of the That-tu Bedded Chert up to the Aptian. Stratigraphic positions of the That-tu Bedded Chert are now the Tithonian of the Upper Jurassic, Hauterivian and Aptian of the Lower Cretaceous. In comparison with the Tithonian red claystone of the Chinghkran area of Myitkyina (Maung Maung et al., 2011), higher stratigraphic levels of the That-tu Bedded Chert are confirmed. Remarkable is the lithologic difference between two areas. Whereas the pelagic chert sequence in the Tagaung area was continued from Tithonian to Aptian time, the hemipelagic red claystone in the Chinghkran area was deposited in Tithonian time. In the viewpoint of the oceanic plate stratigraphy, pelagic chert was deposited on the ocean floor far from the continent under the carbonate compensation depth (CCD), whereas hemipelagic claystone seems to have been deposited on it relatively near the subduction zone. Consequently, two ophiolites of the Tagaung and Chinghkran areas should be separated with each independent oceanic stratigraphy. It is suggested that the name “Ngapyawdaw Chaung Formation” cannot be used for these stratigraphically separated two ophiolites, and the redefinition and/or new names will be needed.

References

MAJOR AND TRACE ELEMENT GEOCHEMISTRY OF GRANITIC ROCKS AT THE SCHWANER MOUNTAINS AREA, SOUTHWEST KALIMANTAN, INDONESIA: PETROGENESIS AND TECTONIC SETTING IMPLICATION

Kyaw Zin Lat
Department of Engineering Geology, Yangon Technological University, Myanmar
Kyawzin.htp@gmail.com

ABSTRACT

Kalimantan island in Indonesia is, apart from his trademark as oil and gas region, known for coal and mineral resources as well. Iron, gold and base metal mineralization occurs association with the Cretaceous – Early Tertiary Schwaner Mountain granitoids. After the deposition of Permo-Carboniferous sediments on a basement complex of crystalline schists and the emplacement of gabbroic plutonic masses, the zone of the Schwaner Mountains had been invaded by large granitic to quartz-dioritic (tonalitic) batholiths. The Schwaner Mountains batholiths include Paleozoic metamorphic rocks intruded by numerous Cretaceous granites and tonalities. The understanding petrogenesis and tectonic setting during the emplacement of the granitic rocks using their inherent major elements and trace elements is the aspiration of this paper. A total of thirty-eight granitic rock samples from two different age units, namely Sukadana Granite and Sepauk Tonalite unit from Ketapang, Nagapinoh and Pontianak area within the Schwaner Mountains area, had been analyzed for their major and trace element geochemistry using XRF (X-Ray Fluorescence Spectrometry). Major element data was used to classify granitic rocks using the CIPW norm calculation, besides, it was also used to determine the affinity discrimination as well, whereas trace elements such as Large Ion Lithophile Element (LILE) and High Field Strength Element (HFSE) was used to figure tectonic environment. All granitic rocks have a comparatively wider range of SiO₂ contents, thus allows identification of various mineral fractionations. Major elements from studied rocks follows smooth trend on Harker-type variation diagrams. All trace elements patterns are characterized by generally enrichment in LILE elements, but generally declining in HFSE elements in the MORB normalized spider diagram. The harmonic negative Nb anomalies of all representative samples suggest that they are the products of subduction-related magmatism. A/CNK vs A/NK diagram shows metaluminous for Sukadana Granite Unit and metaluminous to slightly peraluminous for Sepauk Tonalite Unit. Apart from that, most of the granitic rocks are plotted in volcanic-arc granite fields on Pearce’s diagram. Although granitic rocks have different age, probably they had come from the same magma sources. The geochemical signature of all granitic representative samples suggests that the magmatic activities in the Schwaner Mountains area had been changed from subduction tectonic setting to post-subduction tectonic setting during Cretaceous.

Keywords: Geochemistry, Petrogenesis, Tectonic Setting, Granitic Rocks, Schwaner Mountains, Southwest Kalimantan
QUALITY ASSESSMENT OF GROUNDWATER IN HINTHADA AND ENVIRONS, AYEYARWADY REGION, MYANMAR

Wint Wint Htun¹, and Thet Thet Lwin²
Department of Geology, Pathein University
Department of Geology, Hinthada University

ABSTRACT

The study area is located on the western bank of the Ayeyarwady River. It is situated at the northern part of the Hinthada District, Ayeyarwady Region, Myanmar. The study area is underlain by Alluvium and Irrawaddy Formation. This formation mainly consists of sand and clay of different types. There are several possible explanations for the variation in groundwater composition. Not only determination of hydraulic nature of groundwater is important but also quality requires specifying the actual characteristics of groundwater are important. Twenty five water samples were collected from the study area. Determination of pH, E.C, T.D.S, dissolved cations of Na⁺, K⁺, Ca²⁺, Mg²⁺ and Fe²⁺ and dissolved anions of CO₃⁻, HCO₃⁻, Cl⁻ and SO₄²⁻, are analyzed in the Laboratory of the Health Department of Yangon City Development Committee (YCDC) and Water and Soil Examination Laboratory of Depart of Fisheries, Ministry of Livestock and Laboratory, Thaketa Township, Yangon, Myanmar. pH value in Lat Tha Mar Quarter is higher than World Health Organization (WHO) standard. Calcium ion concentration of Za Kar Quarter and Tar Kalay Quarter are higher than WHO permissible level. Bicarbonate in Za Kar is higher than 200 mg/l. The Chloride contents of Za Kar, Lat Tha Mar and Pan Bal Tan Quarters showed near 500 mg/l. For this study, as a secondary data of Water Resources Utilization Department (WRUD, 2009) and collected water quality data (2012–2013) for groundwater wells spread over the study area were used to understand the groundwater geochemistry. Collected water samples data were analyzed by classification of Kurlov’s Method. The results showed Bicarbonate water type and Chloride water type are most abundant in the study area. Sodium Bicarbonate water types are found in Nyaung Pin, Tar Ngar Sal (north), Za Kar, King, Tar Ka Lay and Lal Di Kwin Quarters. Magnesium bicarbonate water types are found in Yone Gyi, Ka Naung Su and Thone Pin Kwin Quarters. Calcium Chloride types are found in Nyaung Pin, Thone Pin kwin and Tar Kalay Quarters. Sodium Chloride types are found in King and Myawady Quarters. Magnesium Chloride types are found in Pan Bal Tan and Aye Mya Thar Yar Quarters. The determination of groundwater origin, Mg/Ca values measured was less than 4. The Cl/ HCO₃ values ranged between 20 and 30. The Cationic Exchange Value (CEV) values also gave close to zero. Twenty six water samples were collected for Arsenic tested by Wagtech Digital Arsenator. The results (3-9 ppb) of Arsenic are found in Aye Mya Thar Yar, Thone Pin Kwin, Myawady, Ka Naung Su, Tar Kalay, Pa Da Myar, Za Kar and U yin (south). The Arsenic in Lal Di Kwin and King Quarters are 36 ppb and 20 ppb. Arsenic content of the study area is found to be more 50ppb (50µg/l) in the Pan Bal Tan Quarter.

Keywords: quality, water types, groundwater origin.
EARLY JURASSIC (PLIENSBACHIAN–EARLY TOARCIAN) LITHIOTIS-FACIES BIVALVE BUILDUPS WITHIN LATE TRIASSIC–LATE JURASSIC SEQUENCE IN THE HIMALAYAN TETHYS (CENTRAL NEPAL, THAKKHOLA, KALI GANDAKI VALLEY) – STRATIGRAPHY, PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY

Michał Krobicki¹, Krzysztof Starzec¹ & Kabi Raj Paudyal²

¹AGH University of Science and Technology; Mickiewicza 30, 30-059 Kraków, Poland; krobicki@agh.edu.pl, kstarzec@agh.edu.pl
²Tribhuvan University, Central Department of Geology, Kirtipur, Kathmandu 44618, Nepal; paudyalkabi1976@gmail.com

ABSTRACT

In the Thakkhola region (upper part of the Kali Gandaki valley of northern central Nepal) there are classic Jurassic and Cretaceous Eastern Tethys sections with the famous Spiti shales among others, which have been known since the 19th century for the richness of the Late Jurassic ammonites (Oppel, 1863; Uhlig, 1903; Enay 2009). Currently, these are included in the Nupra Formation, which lies directly on the Middle Jurassic (Bajocian–lowermost Callovian) carbonate deposits of the Bagung Formation. These formations are a small fragment of the Late Triassic–Early Cretaceous sedimentary sequence of the highest tectonic unit of the Himalayas, the so-called "Series (zone) of the Himalayan Tethys" (Gradstein et al., 1989, 1991; Upreti & Yoshida, 2005). One of the best places for stratigraphic-sedimentological analysis of Bagung Formation are the western slopes of the Kali Gandaki valley near the village of Jomosom, where there is also the stratotype of directly older unit – the Early Jurassic (Pliensbachian–Early Toarcian) Jomosom Formation. The Bagung Formation is a thin- and medium-bedded limestones, rich in fossils of benthic fauna – including bivalves (mainly oysters), echinoderms (especially crinoids) and gastropods, which in some places form shell beds/coquinas. Their sedimentological character clearly indicates storm conditions (sharp base with lithoclasts and shell fragments – mainly bivalves, with their gradation/fractionation up to the micritic limestones in the topmost part of these beds) and indicate shallow-water sedimentation of repeated storm events that create classic limestone tempestites (cf. Aigner, 1985). These palaeoenvironmental observations find additional confirmation in the analysis of transition between the Jomosom and Bagung formations, which are dominated by oolitic and/or oolitic-biodetric limestones with cross-bedding structures of high-energy sedimentation conditions (Gradstein et al., 1989, 1991). The Jomosom Formation consists also unique Lithiotis-type bivalves biostromes, which have been discovered recently in three sections along Kali Gandaki valley. They indicate probably either lagoonal-type palaeoenvironments or marginal part of such lagoons between nearshore regions and open marine conditions and palaeobiogeographically represent eastern Tethys Lithiotis-facies bivalves belt which occur along peri-Gondwanan margin during Pliensbachian–Early Toarcian times (Krobicki & Golonka, 2009). The continous, deepening upward sedimentary sequence of the uppermost Triassic–Middle Jurassic units constitute a fluvial-paralic of the latest Triassic, the carbonate platform of the Early and Middle Jurassic deposits, and the Late Jurassic
black organic shales with abundant ammonites (Spiti Shales = Nupra Formation) (Gradstein et al., 1989, 1991) of northern Peri-Gondwana margin.


1D SEISMIC RESPONSE ANALYSIS BY EQUIVALENT LINEAR METHOD IN CBD AREA OF YANGON, MYANMAR

1Tun NAING, 2Su THINZAR
1Professor, Department of Engineering Geology, Yangon Technological University, Myanmar
2Assistant Lecturer (Engineering Geology), Department of Petroleum Engineering, Technological University (Mandalay), Myanmar

ABSTRACT

Yangon had experienced several earthquakes in the past because it is located in the moderate seismic prone area and the seismogenic Sagaing Fault is passing through about 40 km away from Yangon in the east. The Central Business District (CBD) area is a major part of Yangon which is mainly located in soft alluvial plain of sand, silt and clay where strong ground motion can be expected. The microtremors survey had been conducted at 164 sites throughout the studied area. One-dimensional seismic response analysis by equivalent linear method had been performed to determine the ground motion parameters based on the shear wave velocity structures and subsurface soil profiles derived from microtremor survey and secondary boring data. The peak ground acceleration (PGA), the peak ground velocity (PGV), the response accelerations and the predominant period are major outcomes. The PGA values are ranging from 0.16g to 0.33g while the PGV values are between 0.75cm/s and 1.75cm/s. The response acceleration ranges from 0.07g to 0.21g at 1.0s and it is ranging from 0.6g to 1.16g at 0.2s. while the predominant period is between 0.25s and 1.65s.

Keywords: response analysis, microtremors survey, PGA, PGV, response accelerations
GEOLOGY AND FLUID INCLUSION MICROTERMOMETRY OF THE KYAIKHTO GOLD DISTRICT, MON STATE, SOUTHERN MYANMAR

Myo Kyaw Hlaing 1, 2*, Kotaro Yonezu 2, May Thwe Aye 1, Koichiro Watanabe 2 And Aung Zaw Myint 1

1*Department of Geology, University of Yangon, Yangon, Kamayut 11041, Myanmar
2Department of Earth Resources Engineering, Kyushu University, Fukuoka 819-0395, Japan

* Corresponding author. E-mail addresses: myokyawhlaing.edu.geol@gmail.com

ABSTRACT

The Kyaikhto gold district is located within the Slate Belt and Mogok Metamorphic Belt of Southern Myanmar. The study area is covered by Carboniferous to Lower Permian metasedimentary rocks consisting of slate, phyllite, and schist of the Mergui Group, intruded by later igneous rocks. Four gold occurrences have been identified in the Kyaikhto district: the Kunzeik in the north, Zibyaung, and Thae Phyu Chaung in the center and Meyon in the south. Gold mineralization in the Kyaikhto district is associated with sheeted, stockwork, dissemination, and sulfide-bearing quartz veins. Ore minerals recognized include sphalerite, galena, chalcopyrite, molybdenite and pyrite with minor native gold and electrum. Two types of fluid inclusions were examined in the quartz samples of the Kunzeik and Zibyaung—Type A: aqueous carbonic fluid inclusions and Type B: aqueous fluid inclusions. At the Kunzeik, Type A fluid inclusions homogenize at temperatures from 296°C to 376°C with low salinities (1.6 - 4.6 wt% NaCl equivalent). The homogenization temperatures of Type B fluid inclusions in vein quartz range from 246°C to 312°C, with salinities of between 1.2 and 10.7 wt% NaCl equivalent. In the Zibyaung, the homogenization temperatures of Type A inclusions vary from 305°C to 378°C, with salinities from 4.6 to 9.6 wt% NaCl equivalent. The homogenization temperatures of Type B fluid inclusions mainly range from 242°C to 298°C, with salinities from 0.9 to 11.8 wt% NaCl equivalent. These characteristics of fluid inclusions are similar to those of orogenic gold mineralization systems.

Keywords: Mineralization, Fluid Inclusion, Orogenic Gold, Kyaikhto District, Southern Myanmar
HAZARD AND RISK ASSOCIATED WITH MYITSONE DAM PROJECT

Dr Chit Ko Ko (Australia) and Dr Maung Thein (Retired Professor)

ABSTRACT

Myitsone Dam Project consists of seven large dams. It has been proposed to build five dams along the Nmai Hka, one on Mali Hka, and one below the confluence of those two rivers supposed to be the birth place of the Mother Ayeyawady. Unfortunately, these proposed dams are associated with multiple hazards, identified as (1) Seismicity, (2) Unfavourable Geological Structure – Sagaing Fault, (3) Reservoir Induced Seismicity or Reservoir Triggered Seismicity, (4) High Precipitation and Climate Change and (5) Landslides, imposing immense risk on the up-stream and down-stream of the Dams. Category 3 Cyclone Nagris storm event on early May 2008 affected more than 50 townships, causing 140,000 death, was the worst hit natural disaster in the history of Myanmar, where the global climate change got a foot print in it. Recent events such as Thabeikkyin earthquake resulting 26 fatalities and destroying numerous buildings instigated a maximum of 102cm lateral movement along the Sagaing Fault, the landslides incidents decimating the Haka town, in the Chin State and Thae Phyu Gone village resulted 75 fatalities, and the Swar dam breach inundating 85 villages, displacing 63,400 people proven that such hazards and threats are real and cannot be underestimated. As for the Myitsone case, focusing on a single hazard alone is unwarranted. A combination of 2 or 3 hazards triggering at the single instant is possible, and cannot be ignored. All the identified hazards are equally important. The impacts on the downstream and upstream of Myitsone Dam are outlined and discussed. Further field studies are suggested to verify and substantiate the identified hazards. More research needs to be carried out on a number of areas by a number of disciplines by brainstorming. At the present level it will be wise to defer this project for at least 15 years or until such time when Myanmar have adequate information, done enough research studies, financial and technical resources, and expertise. Cascade dam strategy is most likely to be unsustainable. Only a single dam should be considered at a time and observed its side effect for a reasonable number of years to reassess the risk, before planning to build another one. A single and multiple dam break studies will be mandatory. It will be beneficial to carry out research study on Swar Dam breach and its consequences for the better understanding of failed dam size and its relationship to destructiveness. Considering the hazards and their likelihood, the stakes appear to be too high for a country like Myanmar even from the perspective of subjective risk assessment. A thorough and rigorous risk assessment including the cost benefit analyses on a multidisciplinary scale is necessary to supplement the decision-making process. Such assessment must be based of the accurate and representative data. Cost and benefit analyses needs to be based on the true cost. The true cost of such project should include the social and environmental cost, and associated opportunity and economic losses.

Key words: Myitsone dams; Earthquake; Sagaing fault; Landslide; RIS or RTS; Precipitation; Climate change; Hazard; Risk.
DEPOSITIONAL HISTORY OF EOCENE SEDIMENTS IN THE NORTHERN PART OF SALIN SUB-BASIN, MYANMAR

Soe Moe Lwin¹, Thant Thu Hein², Thet Paing Soe³, Phyo Nyi Nyi Zaw

¹Myeik University, Department of Geology, Myanmar
²³University of East Yangon, Department of Geology, Yangon

ABSTRACT

We conducted the provenance, tectonic setting and paleoweathering study on Eocene sediments in the northern part of Salin Sub-basin. A total of 45 clastic sedimentary rock samples were collected mostly with an equal interval of space of 20 m. Only 12 representative samples of visibly fresh shales and interbedded sandstones were analyzed for their major and some trace element concentrations. They were examined with Shimatzuu Model ED-720 energy dispersive XRF system with Standard Curves based on International Rock Standards at the Institute of Electron Optics, University Research Center (URC), Mandalay. Formula of Pearson Correlation Coefficient \( r \), Index of Compositional Variation \( ICV \) of Cox et al. (1995) where: \( ICV = \frac{Fe_2O_3 + K_2O + Na_2O + CaO + MgO + MnO + TiO_2}{Al_2O_3} \), Chemical index of Alteration \( CIA = \frac{Al_2O_3}{(Al_2O_3 + CaO* + Na_2O + K_2O)} \times 100 \), and Chemical Index of Weathering \( CIW = \frac{Al_2O_3}{(Al_2O_3 + CaO* + Na_2O)} \times 100 \) are used when geochemical parameters studied. The provenance of the Eocene sediments in study area is the quartzose sedimentary provenance of the sandstones which derived from felsic igneous rocks due to extreme silicate weathering. According to the bivariate diagram (Suttner & Dutta (1986)), these sediments were deposited in fluvial fluctuating on passive margin under semi-arid climate of oxic conditions because of enriched in \( SiO_2 \) but depleted in \( Na_2O, TiO_2, MnO, \) and \( CaO \).

Keywords: Clastic sedimentary rock, Oxic conditions, Extreme silicate weathering, Passive margin
ASSESSMENT OF ACID-MINE DRAINAGE POTENTIAL IN LOIHARYMAR ANTIMONY MINE, HOPONG TOWNSHIP, SOUTHERN SHAN STATE

Nang Sandi Lwin
1 Lecturer, Dr., Department of Geology, University of Taunggyi
Email: lwinsandi84@gmail.com

ABSTRACT

Mining industry has significantly contributed to the prosperity of the nation with economic growth, whereas mining operation has caused Acid Mine Drainage (AMD). AMD is an environmental problem that eventually occurs in sulfide rich mine sites. AMD is characterized by low pH (high acidity), high salinity levels, elevated concentrations of sulfate, iron, and manganese, raised levels of toxic heavy metals. The study area is situated about 8 miles southeast of Hopong Township. It has worked by Ruby Dragon Company since 2004 and produced about 50 Tons per month. The antimony mineralization is observed medium to thick-bedded, grey to bluish grey color sub-phacoidal limestone intercalated with yellowish grey to brown color thin-bedded shale of Linwe Formation. Four ore samples, three tailing samples and three overburden samples were collected from the mine site in order to investigate the AMD in the study area. This research examines chemical composition and the mineralogy of mine wastes and acid-base accounting (static tests) data to understand and predict the acid generating potential of the study area. According to the static tests, the paste pH value measured of the collected samples were > 4.0 and EC value less than 2000 μs/cm, indicating that the study area would be considered low risk of acid forming. In the study area, the calculated neutralization potential ratio (NPR) of ore and tailing samples were NPR < 1 and it would be considered as acid generation (AG), while the overburden samples with value of NPR > 2 would be considered as potential acid consuming (PAC). Therefore, acid generating wastes should be placed into the storage pond as surface shaping and capping with low permeability material and stored saturated condition by keeping it below the water table to prevent oxidation of sulfide minerals.

Keywords: neutralization potential ratio, acid generation, potential acid consuming
NEW ROCK MASS CLASSIFICATION FOR STABILITY ASSESSMENT OF HYDROTHERMALLY ALTERED VOLCANIC ROCKS SLOPE IN GEDONGSONGO, UNGARAN VOLCANO, CENTRAL JAVA, INDONESIA

Khin Nyein Nyein Tun 1, Dwikorita Karnawati 2, Ahmad Rifa'I 3, Hiroyasu Ohtsu 4 and Daywa Aung5

(1) Lecturer, Department of Geology, Yangon University. Email: nyeinnyein11@gmail.com
(2) Professor, Department of Geological Engineering, Faculty of Engineering, Gadjah Mada University, Yogyakarta, Indonesia. Email: dwikoritakarnawati@yahoo.com
(3) Assoc. Professor, Department of Civil and Environmental Engineering, Faculty of Engineering, Gadjah Mada University, Yogyakarta, Indonesia. Email: ahmad.rifai@ugm.ac.id
(4) Professor, Department of Urban Management, Kyoto University Graduate School of Engineering Email: ohtsu.hiroyasu.6n@kyoto-u.ac.jp
(5) Professor, Department of Geology, Yangon University.
Email: daywaaung.geol@gmail.com

ABSTRACT

The research area, Gedongsongo is located on the southeastern slope of Ungaran volcano, Central Java in Indonesia. It is a geothermal field area and composed of andesite and volcanic breccia that altered due to hydrothermal alteration. The alteration rocks were exposed on the surface around the crater with some geothermal manifestations such as steaming ground, fumarole, hot spring and acid surface hydrothermal alteration rocks. The higher elevation of manifestation in the Ungaran geothermal area is covered with thick soil which has more clays as a product of alteration processes. Clay-rich soils formed by hydrothermally induced argillic alteration are the weakest materials that significantly reduced the shear strength, resulting in increased slope instability which may lead to failure. Assessment of rock properties and their variation due to alteration processes play an important role in geothermal area. Thermal water alters volcanic rocks and transforms into hydrothermal rocks and these alteration contributes to changes in physical and mechanical properties. The changes of physical and mechanical properties of volcanic rocks in geothermal areas leads to gradual structural transformation of the hydrothermal system and promotes hazardous geological processes that can result in landslides and hydrothermal explosions (Julia et al., 2014).

Rock slope instabilities are the major hazard for human activities especially in volcanic area where the hydrothermal alteration is dominant and resulting in socio-economic losses. Therefore, it is vitally important to develop the new rock mass classification for the stability assessment of hydrothermally altered volcanic rocks slope in geothermal area. For this purpose, the intensity of hydrothermal alteration was added to the five pre-existing parameters of the basic rock mass rating (RMRbasic) by using Analytical Hierarchy Process (AHP) to develop the new rock mass classification (RMRmodify). According to the Analytical Hierarchy Process (AHP) analysis, alteration intensity is the most influenced parameter by rating 45, condition of discontinuities is the second significant parameter by
rating of 25, RQD and spacing of discontinuities are the third influenced parameters by same rating of 10. UCS and groundwater condition are the least influenced parameters in the new rock mass classification (RMRmodify) by same rating of 5. This research is highly motivated to an improve understanding of rock mechanics in geothermal environment. Moreover, this research is important and strategic for supporting the science and technology development on the landslide risk reduction, through the development of innovative slope assessment on hydrothermally altered slopes.

Keywords: geothermal area, alteration processes, rock slope instabilities, new rock mass classification (RMRmodify), Analytical Hierarchy Process (AHP).
PETROLOGICAL AND GEOCHRONOLOGICAL CHARACTERISTICS OF MIGMATITES AT KYAIKKHAMI-SETSE AREA, THANBYUZAYAT TOWNSHIP, MON STATE, MYANMAR

Thet Paing Kyaw Win 1, Hla Kyi 2, Kyaw Linn Zaw 3

1 Geology Department, Hinthada University, Yangon, Myanmar
2 Applied Geology Department, Yangon University
3 Geology Department, Yangon University, Yangon Myanmar

ABSTRACT

The Kyaikkhami-Setse area is located in Thanbyuzayat Township of Mon State, Myanmar and lies between Kyaikkhami (Amherst) and Setse Township. The area is characterized by medium-grade metamorphic rocks and metasedimentary rocks which were intruded by granitoid rocks. The intrusive rocks are granodiorite, biotite granite, micro biotite granite and leucogranite. Biotite granite is the most predominant granitoid rock types. Dykes and veins of leucogranite, pegmatite and aplite, quartz veins and micro meladiorite are also intruded into biotite granite and metasedimentary rocks. The metasedimentary rocks are migmatite, biotite gneiss, quartz schist, biotite schist, muscovite-biotite schist, andalusite-garnet schist and phyllite-quartzite interbedded unit. Mica gneiss unit is in contact with stromatic migmatite unit. Migmatites were formed as outer zone surrounding granitic pluton and regarded as contact migmatite. Type of migmatite is stromatic migmatite and lit-par-lit injection is well exposed in the study area. The outcrops are well exposed along the beach and off shore reef of low-tide. Lateritization is well developed at the study area. Based on the study of mineralogy and geochemical characteristics, leucosome and mesosome show calc-alkaline fractionation trends and peraluminous. These also show I-type character, Collision Arc Granite as the nature of granitoid source rocks. Garnet bearing leucosome is the typical character of low pressure-high temperature melting of pelitic rocks. Melanosome from neosome is granodiorite like nature. By the study of major and trace elements of the leucosome and mesosome which are mostly similar to I-type granite character and the melanosome slightly show the S-type character probably due to mixing of host rocks. In migmatites, leucosome samples yield 120.8 ± 2.5 Ma (Early Cretaceous) by LA ICP-MS U-Pb zircon age determination. This age implies that timing of the magmatism and mineralization of the granitoid rocks and leucosome were mainly generated by subduction of India Plate and collision between the west Myanmar Terrain and Sibumasu Block during the Early Cretaceous.

Keywords: Kyaikkhami-Setse, stromatic migmatite, paleosome, neosome, melanosome, mesosome, leucosome
ORIGIN AND EVOLUTION OF THE ORE-FORMING FLUIDS IN SHWESIN VEIN SYSTEM, CENTRAL MYANMAR: CONSTRAINTS FROM STRUCTURE, WALL ROCK ALTERATION AND MINERAL CHEMISTRY

Kyaw Linn Zaw\(^1\), Ohn Thwin\(^2\), Jonathan Travnor\(^3\) and Thet Paing Kyaw Win\(^4\)

\(^1\) Lecturer, Department of Geology, West Yangon University
\(^2\) Professor, Department of Geology, Yangon University
\(^3\) CODES, Centre of Excellent in Ore Deposit, Tasmania University
\(^4\) Lecturer, Department of Geology, Dagon University

ABSTRACT

The Shwesin vein system is located 30 km east from Yamethin Township, central Myanmar, within the Mergui Group of the Late Palaeozoic slate belt which is the western edge of the generally N-S trending Mogok Metamorphic Belt. It is characterized by a NW trending topography and steeply dipping (~80°W), multiple quartz vein system which continues to depth, and is low in sulphides. This study was confined to the Shewsin system which has two main types of quartz veins, massive and laminated. Vein stockworks and massive veins are found in the main sedimentary host sandstone and better-defined laminated texture veins in the phyllitic mudstone. The Shwesin system has structurally defined into five stages. 1. Formation of the shear zone, 2. Emplacement of quartz-Au veins through fractures in the shear, 3. Shear zone is offset by both sinistral and dextral conjugate faults, 4. The intrusion of dykes truncating both structures and mineralisation and, 5. Reactivation of the shear zone by a late fault. LA ICP-MS U-Pb zircon study was carried out on the host sandstone unit which gives a pre-mineralization age of 515.9 ± 5.1 Ma (Mid Cambrian). Previous U-Pb and Pb-Pb isotope studies conducted on igneous units that truncate the host rocks and mineralization provide an age of 95 ± 30 Ma and Triassic age. This suggests that mineralization occurred between the Ordovician and Jurassic. LA ICP-MS imaging was also carried out on pyrite grains from the sedimentary host rocks. Textural examination of pyrites and the images together with analysis of the chemical data suggest that there are three types of pyrite. Py1 occurs as spongy core zone and appears to be a sedimentary derived pyrite zoned by a metamorphic formed euhedral pyrite Py2. A third type, Py3 forms as a hydrothermally Au and trace element rich euhedral grain zoned to metamorphic Py2. This information suggests that model of a two stage enrichment process were involved in Au mineralization.

The Shwesin system at can be compared to other similar metasedimentary turbidite quartz-Au vein system in deposits such as Bendigo Goldfield and Macraes Goldfield. All Goldfields have similar gangue, alteration and ore assemblages but with varying concentrations which confirms that all the deposits are similar orogenic Au systems. The main difference with these Goldfields is the age of the host rocks. A general trend of higher Au grades at older ages exists with Au grade decreasing with younger hosts rocks. At Modimomi Taung fluid chemistry and organic carbon content in the host rocks should be studied for further comparative investigations.

Keywords: Mineral chemistry, Ore-forming fluids, Pyrite chemistry, Shwesin vein system
SEQUENCE STRATIGRAPHY BASIN ANALYSIS BY WAVELET ANALYSIS

Sunjay

Geophysicist, sunjaytellus@gmail.com

ABSTRACT

Geophysical well logging (GWL) data is nonstationary in character. It detects cyclicity, trends, sudden changes in sedimentation and stratigraphy. Geophysical well-log (bore-hole) data represent the rock physical properties as a function of depth measured in a well. They aid in demarcating the subsurface horizons, identifying abrupt changes in physical properties of rocks and locating cyclicity in stratal succession. Since wavelet transformations can better identify the abrupt changes in cyclicity common in nature, they become important tools for sequence stratigraphy. Currently spectral decomposition methods (Continuous Wavelet Transform, Matching Pursuit Algorithm decomposition, Discrete Wavelet Transform) are used to detect hydrocarbon zones. The wavelet transform is a multi-scale operator and is well known to point out singularities in the analysed signal. The way in which the wavelet transform analyses the signal can be compared to the geoscientist’s interpretative behaviour in the hydrocarbon upstream industry: both look at the signal at different scales (frequency range), detect breaks “major events” and heterogeneity and characterise trends. In order to measure multi-fractility of any signal the Holder Exponents and Singularity Spectrum attributes are computed. Mathematical transformations are applied to signals to obtain a further information from that signal that is not readily available in the raw signal. Wavelet analysis generates useful information from well-log responses. It is a useful tool for automated cyclostratigraphy. Wavelet analysis is a multiresolution framework and, thus, it is well suited for upscaling rock and flow properties in a multiscale heterogeneous reservoir. Morlet wavelet is best suited to gamma ray logging signal to identify cyclic geological information like sequence stratigraphy. The success and popularity of sequence stratigraphy stems from its widespread applicability in both mature and frontier hydrocarbon exploration basins. Stratigraphic analysis imposed by the lateral extent of sequence-bounding unconformities, which are potentially restricted to the basin margins. Hence, the number of sequences mapped within a sedimentary basin may significantly decrease along dip, from the basin margins towards the basin centre which is deciphered by seismic and sequence stratigraphy. Scale in sequence stratigraphy is very important for high resolution stratigraphic sequence.

Keywords: Sequence stratigraphy, basin analysis, Milankovitch cycles, Geophysical Well Logging, Wavelet transform, Gamma logging,
PREFACE FROM IGCP668 PROJECT PRINCIPAL CO-LEADER

A very warm welcome indeed to this, our annual third meeting of IGCP project 668, here in stunning Yangon and held in association with IGCP679. This meeting follows from the two highly successful preceding gatherings, the first in Thailand. There in Nov-Dec 2019, alongside reporting results and conducting fieldwork, we celebrated the recognition of the newly designated Satun Global Geopark. Our second meeting was at Riverside, CA, USA in June 2019 in association with both our friends in IGCP653 and with the 9th North American Paleontological Convention, which was attended by over 675 persons from 34 countries, and which also featured relevant fieldtrips and workshops. We are indeed grateful to all who have made those meetings so successful, and allowed IGCP members to see new sections and learn new methods of investigation.

This year we have the particular pleasure of meeting here in Myanmar. All will surely join me in thanking our most respected and generous hosts in the Myanmar Geosciences Society, and particularly project co-leader Kyaing Sein, who has done so very much to prepare this meeting, and to all his kind colleagues in the Society. We also particularly thank Dr. Aye Ko Aung, who will lead our field party, and Dr. Tin Aung Myint who is taking on a major role in the coordination of events in Myanmar. As participants will doubtless have noticed that there is no registration fee for this conference – this is solely due to the hospitality extended to all by our Burmese hosts. Please thank them personally for this exceptional kindness.

As I wrote in 2018, IGCP668 draws together persons with a shared interest in learning how the Earth has changed through its long history, and in understanding and expressing the relevance of that history today. Our meeting and excursion focus on a particular region during a particular time in Earth History because of the special geological record of this region, and of its promise for informing us about the timing and cause of important global changes that were happening at that time. We are delighted that our meeting is attended by those with a wide range of geological interests, and also by those skilled in other areas, and particularly those in the art of presenting our findings about the ancient world in exciting ways to a wider audience. This effort assumes particular importance in a time in which our understanding of Earth history is critical for making informed decisions about the planet’s future.

We are pleased that this meeting also includes presentations relative to our sister project IGCP679: Cretaceous Earth Dynamics and Climate in Asia. Several of our presentations address this important and fascinating topic, and we are always delighted to partner with others shared interests.
Our meeting also offers the chance to visit outcrops in the Southern Shan States. These contain a series of rocks from which valiant but unpublished work by several Burmese geologists has revealed Cambrian aged rocks beneath successions long known to be Ordovician and younger. We are again grateful to our kind hosts for arranging this trip to somewhat isolated location, which is a rare privilege. The location of Mt Hsingmango (meaning, I am told “the place where elephants cry”) and the village of Padongaing has special importance, not only because of the fossils occurring there but also because of our geoscience outreach program that will be focused in this region.

The main focus of our project is the integrated record of biological, sedimentological, and tectonic/magmatic events that took place as the world transitioned from the “boom and bust” episodes of evolutionary radiation in the Cambrian and earliest Ordovician into the more sustained and enduring radiation with the Ordovician onwards. The Shan-Thai/Sibumasu block is fortunate to have a uniquely well-preserved record of these events that will help not only to reveal possible interactions between the ancient physical conditions and the contemporary biota, but also allow us to put precise geochronological dates on these.

This third meeting of IGCP668 has attracted attendees from many regional and also far-flung countries. Our backgrounds represent a rich diversity of the globe’s traditions, and we gather together to discover and share what the Earth is telling us about her own story, and seek to understand the relevance of this history to our shared future. On behalf of the IGCP668 leadership committee, may I extend our warmest welcome in the manner of our most kind hosts the Myanmar Geosciences Society: Mingalaba!
THE INCREASING OF COMMUNITY INCOME AND GEOLOGICAL KNOWLEDGE IN SATUN AFTER THE AWARD OF SATUN UNESCO GLOBAL GEOPARK STATUS AND INITIATION OF IGCP668

Apsorn Sardsud

Department of Mineral Resources of the Kingdom of Thailand, Thailand; apsornmini4@gmail.com

ABSTRACT

Satun province is located in the west of peninsular Thailand and has been announced as a UNESCO Global Geopark on April 17, 2018 based on the international geological significance of the late Cambrian U/Pb dates for volcanic ashes and associated trilobites in Tarutao island and the international significance of later lower Paleozoic significance fossils in the mainland of Satun. The international geological significance of Satun UNESCO Global Geopark is directly related to the Cambrian-Ordovician research in the area since the last seven decades from the first study of the oldest trilobites in Thailand which had been studied by Kobayashi in 1957 to recently studied by Prof. Nigel Hughes and his team from University of California Riverside in close cooperation with the Department of Mineral Resources of the Kingdom of Thailand. The results of this study are being revealed after the success of the Satun Global Geopark proposal and are part of the Cambrian-Ordovician studied project awarded from UNESCO as IGCP668 in 2018. After Satun was awarded the UNESCO Global Geopark, Satun has become famous and promoted as the new conservation tourism area in Thailand. Many media outlets from around the world are have been taking note with an effect on increasing the numbers of tourists and thus the people’s and community’s income. This is evident from the trading of Punya Batik, Chim melon, and others that their products are increasing in types, the amounts and also income. On the other hand, after IGCP668 has been awarded from UNESCO, its first meeting was held in Bangkok and along with an excursion to Tarutao island, Satun, Thailand in 2018. Scientists came from nine countries all around the world. From the first meeting, many research subjects have been developing from the collaborations of many researchers and the construction of new research networks such as the research of Ordovician sponge, microbial and conodonts between researchers from China, Japan and Thailand, the extended research for the precisely age dating in Cambrian-Ordovician in Tarutao island. This research will encourage and support the geological knowledge and geological history of this region. It will be not only affect geological knowledge but also will connect to the economy in Satun Global Geopark and will really support the UNESCO vision of the world sustainable development. Satun Global Geopark is thus on track to achieve the Geopark goals.
EXCEPTIONAL FOSSILS FROM THE CAMBRIAN OF NORTH CHINA

Diying Huang

1State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China.

Keywords: Cambrian; exceptional fossils, North China, Lagerstätte

ABSTRACT

Exceptional fossils from the Cambrian of China are mainly from eastern Yunnan and Guizhou provinces, such as the Chengjiang, Xiaoshiba, Guanshan, Kaili, and Balang faunas. In recent years, many promising exceptional sites have also been found on the North China platform, where numerous Cambrian non-mineralized animal fossils are preserved. For example, a large number of eocrinoid fossils were found in Dalian, Liaoning Province; arthropods, palaeoscolecidians, and eocrinoids from Tangshan, Hebei Province; sponges and arthropods from Hebi, Henan Province; arthropods, sponges, chancelloriids, and hyoliths with soft tissues from Linyi, Shandong Province; and large arthropods and hyoliths from Weifang, Shandong Province. These fossil layers generally belong to the slope facies of the continental shelf, and are accompanied by numerous well-preserved trilobites. They provide an important basis for studying the distribution, taphonomy, and early evolution of Cambrian soft-bodied fossils. Integrating biological and physical changes during the late Cambrian and into the Ordovician diversification: pattern and process
STATISTICAL DETRITAL ZIRCON PROVENANCE ASSESSMENT OF NEOPROTEROZOIC-EARLY PALEOZOIC EAST GONDWANA CONFIGURATIONS.

McKenzie, N. Ryan¹, Hughes, Nigel C.², Colleps, Cody L.¹, Wernette, Shelly J.², and Myrow, Paul M.³
¹University of Hong Kong, China ryan00@hku.hk
²University of California, Riverside, USA
³Colorado College, USA

ABSTRACT

Resolving pre-Pangean paleogeographic reconstructions requires integrative perspectives. Early Paleozoic reconstructions for the eastern constituents of the penultimate supercontinent Gondwana have proven complicated with disparate models proposed. Here we present a systematic multi-statistic assessment of detrital zircon U-Pb provenance data acquired from Cryogenian through Ordovician-aged sandstones that were collected from major and minor components of eastern Gondwana. When incorporated with other paleobiogeographic, paleomagnetic, and bedrock geological information, these data allow us to test the placement of Asian terranes such as North China, South China, and Sibumasu along the east Gondwana margins, primarily with respect to the northern margins of India and Australia throughout this interval. Accordingly, we present the seemingly most parsimonious early Paleozoic east Gondwana reconstruction.
ECOSYSTEM RECONSTRUCTION DURING THE CAMBRIAN EXPLOSION: A WORKING HYPOTHESIS

Xingliang Zhang

1Shaanxi Key Laboratory of Early Life and environments, State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University, China; xzhang69@nwu.edu.cn

ABSTRACT

Trophic relationships determine the routes of energy flow and chemical cycling in an ecosystem. In modern marine environments, the trophic level that ultimately supports all others in an ecosystem consists of autotrophs, the primary producers, above which are sequentially herbivores, carnivores and tertiary consumers. Detritivores or decomposers connect all trophic levels. Therefore, primary producers and decomposers play a central role in energy and material cycling, which flow through the trophic levels eventually to detritus and then cycle back to primary producers. Such complexity of marine ecosystems has been built since the Cambrian explosion with advents of diverse metazoans. It was supposed that the early Cambrian marine ecosystems appeared to have been as complex as many modern marine ecosystems, at least in terms of their trophic relationships. It is well right because complex ecological interactions were documented in Cambrian Lagerstätten such as Chengjiang and Burgess Shale. However, ecosystem itself evolved! It was different from time to time, and places to places. Chengjiang ecosystem merely represents a small piece of marine environment at the Cambrian Age 3! How about the ecosystem of the earliest Cambrian? In the past much attention has been paid to evolutionary and ecologic aspects of earliest metazoans that are herbivores and carnivores in Cambrian marine ecosystems. However, much less has been known about primary producers and decomposers in metazoan-dominated ecosystems initially established during the Cambrian explosion, largely because they are microorganisms that have less potential of preservation or discovery. Here we show fossilized microbial colonies from a phosphatic grain-stone bed, immediately below an ash layer dated as ca. 535 Ma in age, in eastern Yunnan, South China. The early diagenetic phosphatization and siliceous cementation are responsible for the preservation of microbial structures. Three types of microbial remains, which are most conspicuous under epifluorescent light illuminations, have been found in our samples: (1) Girvanella that built microbial mats constitute primary producers of the ecosystem; (2) Interweaved microbial filaments (much smaller than Girvanella in diameter) found in cryptic environments (e.g. shell cavities and interstitial spaces) inaccessible to light are possibly mold hyphae and thus likely represent decomposers; Spheroids resembling yeasts are also found in micro-spaces inaccessible to light, and interpreted as decomposers as well. The microbial remains are heavily coated with phosphorous precipitates, and hence are assumed to play a crucial role in phosphorus cycling within the ecosystem. Additionally, on the rock surface, small shelly fossils are extremely abundant. Surprisingly, a giant worm-like organism is present on the surface. It is preserved as elongated and flattened tubes with cross annulations, 1 cm wide and more than 20 cm long, and shows plastic deformations, which can be twisted, folded and bended. Its close association with trace fossils on the same surface suggests the worm is one of the long expected trace maker at the earliest Cambrian. Ecologically, metazoans from this 535 Ma fossil bed are mostly herbivores.
(primary consumers). Secondary and tertiary consumers (carnivores), which are well represented in Cambrian Stage 3 faunas, have not been recognized. Collectively, the information from this earliest Cambrian fossil bed imply that (1) the microbial world constituting producers and decomposers of Cambrian marine ecosystems is recordable and remains to be investigated; (2) The complexity of marine ecosystems during the interval of Cambrian explosion is heterogeneous in time and space. Therefore, to better understand the mystery of the Cambrian explosion, we proposed a project working on Cambrian ecosystem as an integrity including biotic and abiotic components.
CAMBRIAN TRILOBITES OF THE SOUTHERN SHAN STATE, MYANMAR

Wernette Shelly J. 1, Hughes, Nigel C. 2, Myrow, Paul M. 3
1University of California, Riverside, USA; swern001@ucr.edu
2University of California, Riverside USA; nigel.hughes@ucr.edu
3Collorado College, USA; pmyrow@coloradocollege.edu
Keywords: Shan State, Cambrian, Furongian, trilobite, Sibumasu

ABSTRACT

Cambrian trilobites from Myanmar’s southern Shan State have been cited as biostratigraphic evidence in publications since 1973 (Thein), but very little is known about them, and they have never been figured or described in a publication. Through new collections and revision of taxonomy from Myaung Kyi Soe’s unpublished master’s thesis, we present the Cambrian trilobite fauna of the southern Shan State which includes two species of Asioptychaspis, a species of Pseudokoldinioidia, a species of Mictosaukia, three species of Prosaukia, a species of Calvinella, a species of Eosaukia, a species of Aposolenopleura, and an indeterminate tsinaniid which is either Lonchopygella or Dictyella. Though Saukiella has been reported in the area, no collected material can be reasonably assigned to this genus. Eosaukia buravasi is pervasive in the late Cambrian of Sibumasu, and it also occurs in Ao Mo Lae Formation of the Tarutao Group in Thailand; it dates to Cambrian stage 10. Asioptychaspis asiatica occurs in the Liaoning Province of the North China Block. A. asiatica provides a date of latest Jiangshanian. Collections containing A. asiatica and E. buravasi are all from the Molohlein Group, suggesting an age of at least upper Jiangshanian through the end of the Cambrian. Generic and species level analysis supports a paleogeographic affinity closest to the North China Block with secondary affinity to Australia.
LATEST PROGRESS ON THE GSSP CANDIDATE OF CAMBRIAN PROVISIONAL STAGE 10

Shanchi Peng

1 State Key Laboratory of Paleobiology and Stratigraphy, Chinese Academy of Sciences, Nanjing Institute of Geology and Palaeontology, China; scpeng@nigpas.ac.cn

Keywords: GSSP candidate, Cambrian, Stage 10 (Provisional), Wa'ergang section, South China

ABSTRACT

The Wa'ergang section, Hunan, South China has been proposed as candidate stratotypes for the Cambrian GSSP of provisional Stage 10 at FAD of the cosmopolitan agnostoid species Lotagnostus americanus, a level selected as the primary tool for defining the base of the stage by ISCS. Three agnostoid zones are recognition in the boundary interval of the Stage 10 and the FAD of L. americanus is pinned at 29.65 m above the base of the Shenjiawan Formation. This level is close to the lowest known occurrences of two important trilobites, Hedinaspis regalis and Charchaqia norini, both have an intercontinental distribution. Detailed research has resulted also in recognition of four conodont zones, three distinct negative δ13C excursions, and a series of sequence boundaries in the interval of Stage 10. The base of the Proconodontus posterocostatus Zone nearly coincides with the proposed GSSP. Of the three negative δ13C excursions (N1, N2, N3), N1 excursion occurs just above the proposed GSSP, and the N3 excursion correlates with the latest Cambrian TOCE (or HERB) event. A single third-order sequence has been identified. It embraces two fourth-order sequences, each of which is subdivided into six fifth-order sequences. The proposed GSSP lies within the first fifth-order sequence, about 8 m above the conterminous base of the third-order sequence, and the lowermost fourth- and fifthorder sequences.
AN INTEGRATIVE STRATIGRAPHY FOR THE ORDOVICIAN SYSTEM OF CHINA: CORRELATION AND QUESTIONS

Zhang Yuandong¹, Zhan Renbin², Zhen Yongyi³, Fang Xiang⁴
¹Nanjing Institute of Geology and Palaeontology, China; ydzhang@nigpas.ac.cn
²Nanjing Institute of Geology and Palaeontology, China; rbzhan@nigpas.ac.cn
³Geological Survey of New South Wales, Australia; yong-yi.zhen@planning.nsw.gov.au
⁴Nanjing Institute of Geology and Palaeontology, China; xfang@nigpas.ac.cn

Keywords: Integrative stratigraphy, Ordovician, China, framework

ABSTRACT

The chronostratigraphy of the Ordovician System in China is overviewed, with the definition and recognition of the stage boundaries and possible gaps discussed in details. The Ordovician System is now subdivided into three series and seven stages, in ascending order, Lower (Tremadocian, Floian), Middle (Dapingian, Darriwilian) and Upper (Sandbian, Katian, Hirnantian). Three of the seven “Golden spikes” defining the bases of the Ordovician stages were established in South China during 1997–2007. As a regionally applied chronostratigraphy, the Ordovician System was subdivided in China into Lower (Xinchangian, Yiyangian), Middle (Dapingian, Darriwilian) and Upper (Neichiashanian, Chientangkiangian, Hirnantian). Based on the new studies in recent years and distinctions and differences recognized in the development of the Ordovician System in the constituent terranes of China, a new correlation of the major Chinese terranes, e.g. South China, North China (including Tarim and Qaidam) and Tibet–Western Yunnan, has been established. Nevertheless, uncertainties remain on defining the base of the Tremadocian, Dapingian and Katian, and on the correlation between different mega-facies. More specifically, for the Tremadocian, the precise correlation of its base will depend on the better-defined conodont taxonomy, while for the Dapingian and Katian, on the correlation between different mega-facies. It is worthwhile to note that the chemostratigraphic studies of the Ordovician System in China produced the carbonate δ13C curves from the Darriwilian (Middle Ordovician) and Katian (Upper Ordovician), which show significant differences from the composite global curve. Record of the Ordovician isotopic dating is relatively rare in China, with only three reliable ages from Zircons that are all from the upper Katian to Hirnantian of the Upper Ordovician. Studies on the Ordovician magnetostratigraphy of China have been restricted to the Lower Ordovician of North China and are to be strengthened. The analysis of the durational unevenness of the seven stages in the Ordovician supports the possibility to further subdivide the long-durational Tremadocian, Darriwilian and Katian stages, each into two substages.
ABSTRACT

Cambrian and Ordovician strata are well exposed in Sibumasu (Myanmar, Thailand, northwestern Malaysia, and Baoshan [China]). Comparison between the geology of this region and that of the Himalaya is critical in that the two regions may have a shared tectonic history, including a signature of the Cambrian–Ordovician Kurgiakh Orogeny. In northern India, uplift associated with the orogeny was followed by deposition of a thick succession of coarse siliciclastic deposits that can be traced across much of the length of the Himalaya. Denudation of this uplifted region was followed in the Upper Ordovician by a marine transgression and deposition of a mixed siliciclastic–carbonate unit, the Pin Formation. This unit, which spans the Ordovician–Silurian boundary, records deposition in a wave- and storm-influenced setting. Carbon isotopic data from the formation is the highest-resolution (< 0.5 m spacing) data set to date from any location globally through the latest Katian Stage of the Ordovician. Our Gondwanan Pin Formation isotopic curve is nearly identical to one from the western U.S., indicating that the curves likely represent a remarkably faithful representation of the isotopic signature of latest Ordovician to earliest Silurian seawater during a transition into a major icehouse episode. The formation covers a late Katian faunal and climatic shift, known as the Boda event, which is generally interpreted to represent a pre-Hirnantian warming interval. Our data include a long-term positive spike recorded within a thin calcareous-algae-rich shale unit. Directly overlying strata show a very abrupt negative shift (>1.5‰) and then further negative drift of ~1.3‰. Correlations to other sections globally indicate that this positive excursion may represent a mid-Boda cooling episode. Further correlations indicate that the Pin also records a Katian–Hirnantian boundary interval excursion that we call the KaH excursion (= lower HICE), which is potentially a record of initial Hirnantian global cooling. The Hirnantian isotope excursion HICE itself is removed under an unconformity marked by a sandstone unit. Overall, our data provide a definitive isotopic curve and intercontinental chemostratigraphic framework of this biostratigraphically contentious Ordovician-Silurian boundary interval. The study, in combination with previous Himalayan studies of lower Paleozoic sections, also provides a framework for comparison of Cambrian and Ordovician lithofacies from the Himalaya with those of Sibumasu, including the Cambrian-Ordovician boundary section at Taratau Island, Thailand.
?LATE ORDOVICIAN CALCAREOUS GREEN ALGAE (CYCLOCIRINITIDS) AND CHITINOZOA FROM THE TETHYAN SEQUENCE OF SPITI, INDIA AND THEIR IMPLICATIONS

Husain Shabar¹, Anju Saxena, Suyash Gupta, Kamel Jeet Singh
¹Birbal Sahni Institute of Palaeosciences, Lucknow, India; shabbarnaqvi92@gmail.com
Keywords: Ordovician, Chitinozoa, Cyclocrinitids, Tethyan Himalaya, Spiti

ABSTRACT

One of the most complete and spectacular exposure in the world, the Tethyan Himalayan sedimentary sequence, represents the deformed remnants of the northern edge of the Indian subcontinent. The Tethyan realm exhibits phenomenal stratigraphic successions with abundant fossiliferous records. The sequences are preserved in different regions of the Tethyan Himalaya of India, Bhutan, and Nepal. In India, the Early Palaeozoic successions are well exposed in the different areas of the Tethyan Himalaya namely Kashmir, Spiti – Zanskar, Kumaun and Garhwal regions. The most complete succession of the Tethyan Himalayan is exposed in Spiti – Zanskar region. The Spiti valley is a remote part of Himachal Pradesh in the North-Western Himalaya and offers a remarkably thick sequence of sedimentary rocks resting over the Precambrian Crystalline Basement, ranging from Cambrian to Cretaceous in age. The early Palaeozoic successions of the Spiti Basin comprise Parahio (Cambrian), Thango (Early Ordovician), Takche (?Late Ordovician-Early Silurian) and Muth (Late Devonian) Formations. The Takche Formation comprises limestone, marl, dolomite, siltstone, shale, and calcareous sandstone and is readily spotted in the field by its earthy brown/rusty-brown appearance. The Takche Formation conformably overlies Thango Formation and is unconformable with overlying Muth Formation. A sedimentary sequence exposed along the right bank of the Spiti River, near Takche Locality in the Spiti Valley, India was studied for its mega/macro and microfossils contents. Brachiopods, sponges, cyclocrinitids, crinoids, medusoids and tracefossils were recovered from the calcareous grey siltstone unit (Farka Muth member) of the Takche Formation, Takche. In this communication, we are dealing with the records of calcareous green algae – cyclocrinitids and chitinozoans. Recovered cyclocrinitids include Cyclocrinites favus, Cyclocrinites pyriformis, Cyclocrinites sp., Cyclocrinites cf. welleri, Cyclocrinites globosus and Mastopora ?concava. Both C. welleri and C. globosus are documented for the first time from the Tethyan Himalaya, India. Cyclocrinitids are an extinct tribe of Cyclocrininales, a possible sister order of Dasycladales and are considered to be lithophytic. It has been suggested that cyclocrinitids possibly avoided very soft muddy/sandy sea bottoms, typical reef environments and also very shallowly stirred bathymetric regions. They probably inhabited below normal wave base environment due to their frangible nature. Standard maceration technique is employed to retrieve palynomorphs. The retrieved palynomorphs are opaque and dark in colour, indicating high thermal maturity. Chitinozoa dominates the recovered palynomorphs assemblage. The recovered chitinozoans include Chonochitina sp., Cyathochitina sp., Cyathochitina ?calix, Rhachochitina ?tallinnensis, Rhachochitina sp., Armoricochitina sp., Tanuchitina sp., Belonechitina capitata, Belonechitina ?comma, and Desmochitina minor. Belonechitina capitata is the dominant species in the assemblage and has biostratigraphic significance as
it is confined biostratigraphically from upper Darriwilian to lower Sandbian. Based on the occurrence of cyclocrinitids and chitinozoa, it is inferred that deposition of calcareous grey siltstone unit of Takche Formation occurred during early Late Ordovician time in an epineritic zone, relatively shallow, less turbid, and low to moderate hydrodynamic conditions.
CRETAEOUS EARTH DYNAMICS AND CLIMATE IN ASIA

Gang Li

Nanjing Institute of Geology and Palaeontology, China

ABSTRACT

Since the industrial revolution, the increasing usage of fossil energy by humans has led to a continuous increase in atmospheric CO2 emissions, thereby disrupting and unbalancing the global carbon cycle. The direct result is a very rapid global warming. We are now experiencing its likely effects, such as the waning of pole ice caps, rising sea levels, regional changes in precipitation, acidification of the ocean, more frequent extreme weather events (such as heat waves), and expansion of deserts. The development of human civilization urgently requires us to acquire a deeper understanding of the development trend of this rapid climate change and its environmental effects, a topic that in recent years has become a hot issue of common concern from the general public to the scientific community. The Asian continent offers unique opportunities for studying the Cretaceous greenhouse climate and ecosystems. A variety of environments resulted in diverse ecosystems on land and in the oceans. Cretaceous marine strata of the eastern Tethys (India and Tibet of China) and the western Pacific (Japan, South Korea, China and Russia) open an indispensable window for study of the oceanic anoxic events, oceanic oxygen-rich events and rapid climate changes. Cretaceous continental deposits in Asia contain abundant terrestrial organisms that witness the ecosystem evolution and significant rapid climate changes. Various Cretaceous terrestrial lithologic records and large igneous provinces in Asia bear witness to the environmental changes and ecosystem evolution. Cretaceous pedogenic carbonates of paleosols and fossil leaf stomatal index qualitatively depicted the fluctuation and evolutionary trends of the atmospheric CO2 levels. Desert deposits in the interior regions of the continent (Mongolia, China, and Thailand) reveal the shift of subtropical high-pressure belt and dramatic changes in climatic zonation pattern in Asia.

This abstract is part of our collaboration with IGCP679 at this meeting
U-Pb GEOCHRONOLOGY OF THE DECCAN TRAPS AND ITS RELATION TO THE END-CRETACEOUS MASS EXTINCTION EVENT.

Blair Schoene\textsuperscript{1}, Michael P. Eddy\textsuperscript{1}, Kyle M. Samperton\textsuperscript{1,2}, Gerta Keller\textsuperscript{1}, Thierry Adatte\textsuperscript{3}, Syed Fr Khadri\textsuperscript{4}

\textsuperscript{1}Dept. of Geosciences, Princeton University, Princeton, NJ, USA
\textsuperscript{2}Lawrence Livermore National Laboratory, Livermore, CA, USA; ksampert@princeton.edu
\textsuperscript{3}Institute of Earth Sciences, ISTE, Lausanne University, 1015 Lausanne, Switzerland
\textsuperscript{4}Department of Geology, Amravati University, Amravati, 444602, India

ABSTRACT

Understanding the role that flood basalt volcanism plays in mass extinctions requires high-resolution age models for eruption rates from which volcanogenic volatile fluxes can be compared to biostratigraphic and environmental proxy records. We have focused on determining the tempo of Deccan Traps volcanism across the Cretaceous-Paleogene boundary by applying ID-TIMS U-Pb zircon geochronology to ash-bearing horizons between basalt flows. Our main efforts come from the thickest portion of the Deccan Traps, the western Ghats, where we have produced a record of ~25 dates that spans >90\% of stratigraphy with uncertainties typically <\pm 50 \text{ kyr} (2\sigma). These data are used to test existing regional stratigraphic correlations and build an age model for the Deccan eruptions. Our results indicate that the Deccan erupted in 4 pulses lasting ~100-150 kyr each, with major pulses in activity occurring before and after the main phase of extinctions and the Chicxulub bolide impact. We recently have also dated volcanic sections from the northern flank of the Deccan Traps, and show that most of the eruptions occurred during the first pulse of eruptions found in the main volcanic pile. These northern eruptions intruded into and erupted through the Narmada basin, which hosts organic-rich sediment that may provide an extra source of CO\textsubscript{2} that could help explain pre-extinction climate warming observed globally. There are still large uncertainties in volume estimates, volatile content and regional stratigraphic correlations of Deccan lavas that hinder quantitative estimates of volatile release. However, new Hg records from numerous marine stratigraphic sections globally correlate broadly with our eruption records, substantiating both the representativeness of the eruption age model and the use of Hg as a proxy for volcanic eruptions.

This abstract is part of our collaboration with IGCP679 at this meeting.
GUTISHUTI AND THE BIRTH OF THE MOUNTAIN: IGCP668 GEOSCIENCE OUTREACH IN MYANMAR AND IN THE INDIAN SUBCONTINENT

Nigel C. Hughes¹, Marufa A Chowdhury², Sekhar Mukherjee³, Trisha Banerjee⁴, Aye Ko Aung⁵, and Shelly Wernette¹

¹University of California, Riverside, USA, nigel.hughes@ucr.edu
²Visual Artist, Dhaka, Bangladesh
³National institute of Design, Vijayawada, India
⁴Mumbai, India
⁵Myanmar Geosciences Society, Yangon, Myanmar

Keywords: Education, village, children, storybook, animation

ABSTRACT

An important part of IGCP668 involves sharing knowledge and appreciation of the Earth’s natural history with persons living in areas relevant to the project’s focus. We are presently working on a children’s story that explains how fossils of sea creatures can be recovered from mountain tops. Two versions of this story are being developed. The first is an animated movie, called Gutishuti and the birth of the mountain, that is set in the Indian subcontinent and tells of the subcontinent’s movement northwards and the formation of the Himalaya. The second version is a children’s book written in Burmese set in Padongaing village in the Southern Shan States, and also tells of the movement and collision of Sibumasu. The story uses the reawakening of an enrolled trilobite fossil to inform a village girl of the Earth’s natural history written in the rocks, available to all if we open ourselves to it. Telling such stories, which necessarily use a fictional framework to tell a true but unfamiliar narrative, is particularly challenging.
ABSTRACT

Books are important for developing the minds and talents of children, and illustrations reinforce the development of their thinking. Terracotta is an excellent and thought-provoking medium for such artwork. It will make a good connection between the fossils and the clay used for the images. Together the story and artwork will transmit good understanding in a pleasurable way for children. I have had long connection with working with clay, which is the principal medium that I use. Working with different kinds of clay connects me to the fossils in a direct way. I have a big interest in knowing more about fossils that are recovered from the Earth. As part of my on-going work, the artwork that I will make as part of this project will enrich the research work through publishing it as an illustrated story.
A NEW BURGESS SHALE-TYPE FOSSIL LAGERSTÄTTE—QINGJIANG BIOTA (CAMBRIAN STAGE 3) FROM SOUTH CHINA

Dongjing Fu¹, Xingliang Zhang¹ and Robert R. Gaines²
¹State Key Laboratory of the Continental Dynamics, Shaanxi Key Laboratory of Early Life and Environment, Department of Geology, Northwest University, Xi’an 710069, PR China. ²Department of Geology, Pomona College, Claremont, CA 91711, USA.

ABSTRACT

Our understanding of the Cambrian explosion and of the fundamental structure of the tree of animal life rests in large part on evidence from a dramatically enhanced fossil record, characterized by the preservation of entire assemblages of soft-bodied fossils. In the one hundred years since Walcott’s original discovery of the Burgess Shale, exceptionally preserved fossil assemblages have been reported from Cambrian strata of almost every paleocontinent. Nevertheless, only the early Cambrian Chengjiang biota of Yunnan Province has matched the Burgess Shale in total diversity of soft-bodied taxa and fidelity of exceptional preservation. Here, we report the discovery of an extraordinary new early Cambrian Burgess Shale-type (BST) fossil Lagerstätte from the Changyang area of South China, which is characterized by high taxonomic diversity (101 metazoan taxa plus 8 algal forms), an unexpectedly large proportion of new taxa (53.2%), and exquisite preservation of fine aspects of labile tissue anatomy. The taxonomic richness of soft-bodied taxa (85%) approaches the top tier of BST deposits, presently occupied only by the Burgess Shale and Chengjiang biotas. Rarefaction analyses suggest that diversity may surpass all other BST biotas. Novel aspects include high abundance of cnidarians, including both medusoid and polypoid forms, new taxa resembling extant kinorhynchs, and abundant larval or juvenile forms. While approximately coeval to the Chengjiang biota, the Qingjiang biota (518 Ma) appears to have occupied a more distal environmental setting, in which a different early Cambrian ecosystem flourished. The uniqueness of the Qingjiang biota in the taxon composition and preservation quality holds special potential to provide new insights into the evolution of early metazoans and the structuring of Cambrian ecosystems across environmental gradients.
LANDSLIDE HAZARD ZONATION MAPPING USING ANALYTICAL HIERARCHY PROCESS AND GIS TECHNIQUES: A CASE STUDY OF TAUNGGYI – LOILEM HIGHWAY, SOUTHERN SHAN STATE

Kyaw Kyaw Oo¹, Su Su Kyi², Kyaw Swar Myint Thein³, Thae Naung Lwin⁴, Myint Soe¹, Win Win Naing¹, Su Mon Aung¹
1 – Department of Geological Survey and Mineral Exploration
2 – University of Yangon
3 – Asian Institute of Technology
4 – Maubin University
Email: kyawkyawoodgse99@gmail.com

ABSTRACT

Landslide is one of the major environmental hazards in the mountainous regions. In this study, landslide hazard zonation of Taunggyi – Loilem Highway located in about 39 km east of Taunggyi, Southern Shan State. Landslide of this highway mostly occur in heavy rainy season. The study is predicted using Analytical Hierarchy Process (AHP) and Geographic Information System (GIS) tool. The major physical and ecological factors that are considered in landslide hazard mapping are; slope, drainages buffer, lineaments buffer, vegetations cover, road buffer, lithology and existing landslides. The weightage values to the factors used pairwise comparison matrix and standard matrix. Several landslide hazard zones are delineated as very high, high, medium, low and very low by unequal interval classification method in GIS. The final produced map for landslide hazard zonation in mountainous area revealed that: the parameters of slope, lithology have strong correlation and predict 70% of existing instabilities.

Keywords; Landslide, Analytical Hierarchy Process, GIS
ENGINEERING GEOLOGICAL EVALUATION OF SELECTED TOWNSHIPS IN MANDALAY BY GEOTECHNICAL AND GEOPHYSICAL APPROACHES

1Soe Lwin Myint & 2Tun Naing
1Engineering Geologists, Myanmar Geosciences Society
2Professor, Dr, Head of Engineering Geology Department, Yangon Technological University

ABSTRACT

Study area is part of Mandalay City, Mandalay Region. The study area lies in the topographic Map No. 93B/4 and 93C/1, at North Latitude 21° 56′ 45.20″ to 22° 01′ 47.16″ and East Longitude 96° 03′ 36.40″ to 96° 08′ 25.37″. Area of study area is about 56.46 km2. The Main purpose of this research is to evaluate the Engineering Geology of the Mandalay City and to prepare basic Engineering Geological Maps for the part of Mandalay City based on the certain Borehole data and microtremore survey results. The objective of the study was to develop a methodology for engineering geological mapping to support urban planning and development. In the first step, the landforms were mapped from aerial photographs. In the second step, for each landform the nature of surface materials (soil type, soil thickness, soil properties and hydrogeology characteristics) was determined. The dataset include borehole, well logging and microtremore surveying results. Geotechnical and lithological profiles were than be constructed. The resulting engineering geological units are useful for studying concerning geohazards, foundation condition, engineering design calculation and planning.

Keywords: Engineering Geological Mapping, Mandalay City, Mandalay District, Mandalay Region.
GOLD MINERALIZATION F ZI PYUGON AREA, YAMETHIN TOWNSHIP, MANDALAY REGION

1Thein Zaw & 2Aung Zaw Myint
1Economic & Mining Geologist, Myanmar Geosciences Society
2Lecturer, Dr, Geology Department, Yangon University

ABSTRACT

The study area is situated at Modi Taung - Nankwe Gold District, Central Myanmar. Zipyugon gold prospect is located at 39 km east of Yamethin, in the Yamethin Township, Mandalay Region. Eastern Myanmar, or the Eastern Highlands, comprises the Shan Plateau, and the Slate belt and Mogok Metamorphic belt which together form the Karen–Tenasserim block of Bender (1983). Mogok Metamorphic belt occupies the 10–25 km wide western scarp west of the Slate belt and continues beneath the alluvial plain to or beyond the Sagaing Fault. Slate belt in central Myanmar consists very largely of argillaceous rocks correlated with the informally named Mergui Group which forms the belt’s continuation in southern Myanmar. The deposit area is characterized by the Paleozoic of Mogok Metamorphic and Late Carboniferous of Lebyin Group. Silicification, chloritization and pyritization are common alterations associated with gold mineralization. The quartz veins contain the minerals of pyrite, chalcopyrite, sphalerite, gold, galena and oxides minerals. Gold tend to form irregular shaped grains that are dispersed in gangue minerals. By the microscopic studies, the formation of ore minerals sequentially expressed from earlier to later time is pyrite, chalcopyrite, sphalerite, galena and gold. Geochemical data reveals that gold bearing quartz veins of Zipyugon area contains gold (4.63 to 76.55 ppm). Geochemical analysis of Cu, Zn and Bi are positively correlated with Au, Ag and Pb are negatively correlated with Au. The cluster analysis show cupper is closely associated with gold. Cupper is the best path finder element in gold mineralization. By the field evidence, geological and geochemicals indicates that the Zipyugon gold prospect may be regarded as Orogenic Gold Deposit.
CONSTRUCTION OF BORED PILE FOUNDATION FOR HIGH-RISE BUILDINGS IN MANDALAY CITY, MYANMAR

Nwai Le’ Ngai: Lecturer, Applied Geology Department, Yangon University, nwai.nln@gmail.com
Ahkar Moe: Planning & Project Manager, Mandalar Waddy Pile Foundation Co., Ltd

ABSTRACT

Piles foundation are used to transmit the load to underlying bedrock gradually. High-rise structures with pile foundations are subjected to earthquake forces. Mandalay city is located near Sagaing Fault. So, pile foundation are commonly used for tall buildings in this city. This paper is concerned with the construction of bored piles foundation. Firstly, it have to measure the center of pile points based on design drawing. By using total station, it was rechecked the pile points before starting the bored pile construction. After rechecking the pile point, the in-situ bored pile is constructed by digging a hole by rotary method with temporary casing installation. Then, the reinforcement cage installed into the borehole without disturbing the hole. According to holes support requirement, bentonite fluids have been used for the construction of bored piles. The tremie pipe was used for pile concreting. Finally, Pile load test was use for quality assurance of bored pile foundations.

Keywords: bored pile, reinforcement, tremie, load test
PRELIMINARY STUDY ON CHARACTERISATION OF CHROMITE FROM TAGAUNG TAUNG AREA AS AN INDICATOR OF PETROGENESIS AND TECTONIC SETTING OF EASTERN OPHIOLITE BELT, MYANMAR

Cho Nandar Aye¹, Aung Myo Thu¹,²*, Khin Pyone¹, Than Than Nu¹, Jadwiga Pieczonka²

1. Department of Geology University of , Mandalay, Myanmar;
2. AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, al. A. Mickiewicza 30, 30-059 Krakow, Poland
E-mail address – aungmyothu@agh.edu.pl

ABSTRACT

The TagaungTaung ophiolite sequence in eastern ophiolite belt of Myanmar is mostly composed of dismembered, incomplete ophiolitic units of serpentinized dunite, serpentinized harzburgite, partly cumulate peridotite and dolerite dykes (Than Than Oo, 2006; Than Than Oo et al. 2009; Hla Htay et al. 2017). This study of the TagaungTaung chromite mineral chemistry aims to better understand the petrogenesis and tectonic setting of eastern ophiolite belt. The EPMA molar rations of Cr# (100* Cr/(Cr+Al)) and Mg# (100*Mg/ (Mg+Fe²⁺)) is ranging from 17.09 to 94.17 and 55.56 to 79.34, respectively in Tagaung Taung chromites and low Al₂O₃ (2.89 – 14.93 wt.%) suggesting derivation from a supra-subduction zone setting. Calculated melt compositions for TagaungTaung chromitic are (Al₂O₃)ₘₑₜ = 6.2-12.21 wt.%, (TiO₂)ₘₑₜ = 0.02-0.95 wt.% and (Fe/Mg)ₘₑₜ = 0.93-1.76. On the plots of Cr₂O₃ Vs. Al₂O₃ (after Bonavia et al., 1993), the Tagaung Taung chromites have primitive chromite compositions within the range defined by ophiolitic chromitites and the trivalent Cr-Al-Fe³⁺ ternary cation plot of spinels (after Stevens, 1944) showing the ophiolitic affinity of massive chromite and disseminated grains. In a Cr/(Cr+Al) Vs. Mg/(Mg+Fe²⁺) diagram, the chromites fall inside and close to boninite field. Massive chromitite on TiO₂ wt.% Vs. Al₂O₃ wt.% and Fe²⁺/Fe³⁺ Vs. Al₂O₃ wt.% plots showing in the field of supra-subduction zone peridotites. In Cr₂O₃-Al₂O₃ diagram, the chrome spinel data plots in mantle array field, which indicates that the dunite has mantle origin.