Overview on the Geology of the High Speed Railway Line between Mandalay and Lashio Section

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Abstract

Myanmar is a significant tectonic position and also the second largest country in SE Asia. The high speed railway project from Mandalay and Muse under the Belt and Road Initiative is the part of the eastern corridor extension implemented by China. The present paper is about the exposure of the rocks units cropping out along the railway line between Mandalay and Lashio and will aid for selection and construction of the route and better understanding of the back ground geology along the line. In addition, the geo-hazards (including earthquake and landslide) and other environment impacts should be taken into accounts for the safety and standard of railway line, stations, bridges, tunnels, etc.,. Any engineering designs and structures must be constructed in order to resist the magnitude (R.M.8) of earthquake along the line. Care should also be taken for railway route which must be avoided for water resource for the public. Legal enforcement should act to give penalty for those people who carry away valuable minerals and ores from the line or make mineral dressing in situ. In conclusion, seismic, geological and natural hazardous issues might be key burdens to the engineering project implementing along the Muse-Mandalay high speed railway line.

Introduction

Fig. (1) Myanmar Map

Myanmar, the Golden Land, formerly known as Burma, located at the northwestern part of the Southeast Asian is in fact the second largest country in Southeast Asia. It is surrounded by India and Bangladesh to the W, and China, Laos and Thailand to the E. Coastal line is 2100km long and border line is more than 4000km (border with China mostly). Myanmar constitutes seven states and regions. They are Ayeyarwaddy region, Bago region, Magway region, Mandalay region, Sagaing state, Tanintharyi region, Yangon region, Chin state, Kachin state, Kayah state, Kayin state, Mon state, Rakhine state and Shan state (see Fig. 1). From north to south Myanmar extends for some 2200 km from 28° N to 10° N, and from east to west, Myanmar has 950km from 82° 30' to 101˚making the country into a temperate to subtropical climate for the northern part and a tropical climate for the southern part. It is found that climate of Myanmar is controlled locally by geographic position and relief if other factors being equal.

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Muse-Mandalay Railway Project

For many decades, China has also been planning to build the China-Myanmar Economic Corridor (CMEC) to have access to the Indian Ocean. Consequently, a railway line connecting from Muse and Mandalay has been proposed. So, Muse is a significant and key border town in Myanmar on the China-Myanmar border. The proposed project is also a part of eastern corridor extension of the railway projects (Fig. 2) being undertaken in Yunnan Province of China, especially the construction of the Darui railway (short for Dali-Ruili railway) (Source: News from CGTN). China has already made railway lines connecting Kunming, the provincial capital of Yunnan, with Dali which is a major tourist destination in the southwestern Chinese province. The remaining section of the railway connecting Dali and Ruili on the China-Myanmar border is making progressively with the construction of several key bridge and tunnel projects along the route (Singh, 2018).

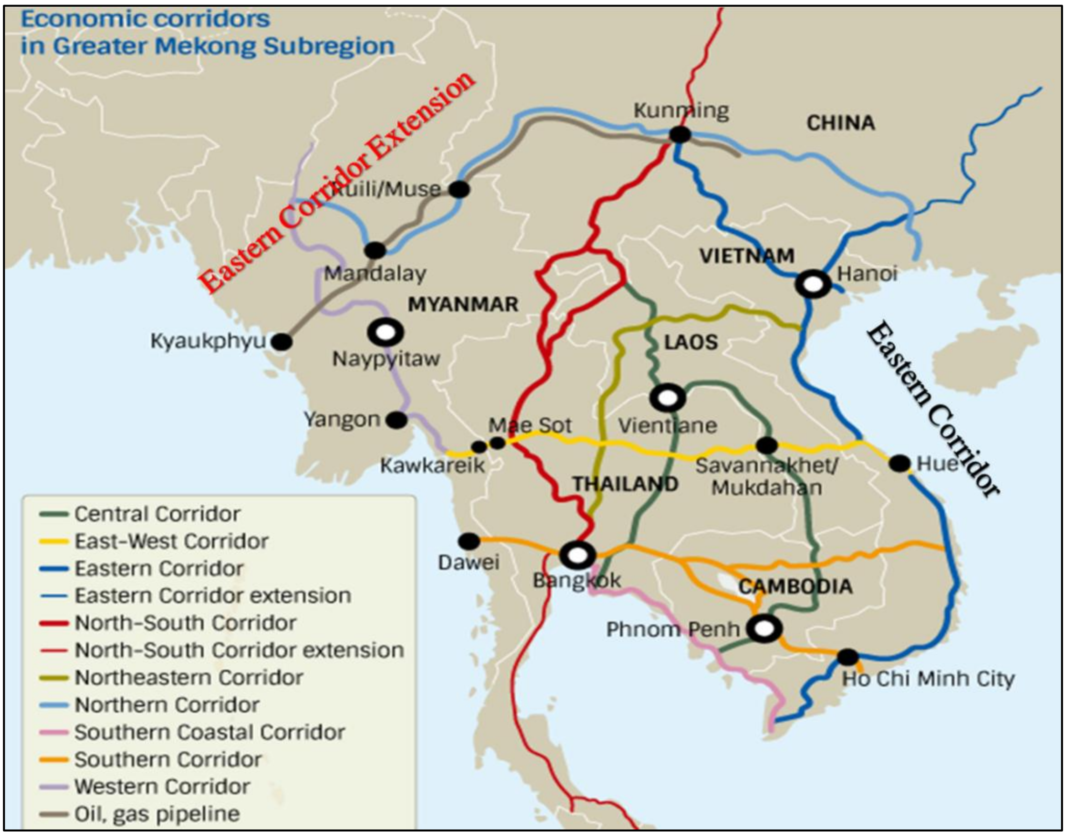

Fig. (2) Economic corridors in Greater Mekong Sub-region. (Source: Internet)

Tectonic Setting of Myanmar

Tectonically Myanmar has a significant position in SE Asia. There is a collision between Indian continental part and Eurasian continent especially in the region of the Himalayas and northern part of Myanmar marking as the Eastern Himalayan Syntaxis and now it has a clockwise rotation and collision. Currently the Indian Tectonic Plate with the rate of 5 cm per year is moving northeastwards, and is also moving past Myanmar on transcurrent faults (Curray et al. 1979). Here it has the oblique collision between Indian subcontinent and the northern part of Myanmar (Fig.3a) (Pluijm, and Marshak, 2003). In other parts of Myanmar, Myanmar Microplate has also oblique subduction with Indian oceanic plate. A Burma (Myanmar) microplate, can be defined between the active Andaman subduction zone to the W and Sagaing fault of Win Swe (1971) to the E. At present the plate is moving with 18 mm per year along the strike slip fault relative to Southeast Asia (Maurin et al. 2010). In short, Myanmar region has encountered one oblique collision (northern part of Myanmar) and one oblique subduction (Myanmar Microplate) with India Oceanic Plate (Fig.3).

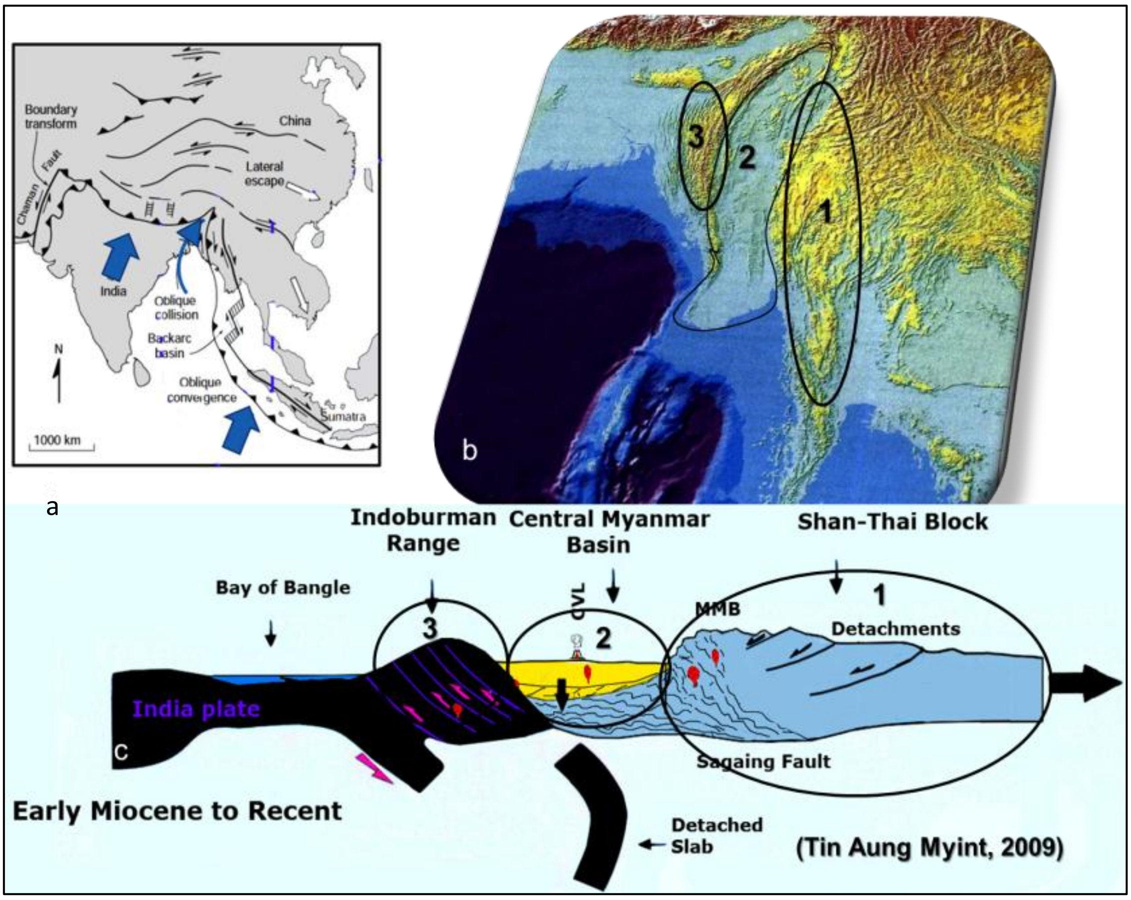

Fig. (3) (a) Tectonic map of Myanmar and surrounding region (Source: Pluijm, and Marshak, 2003). (b) Satellite image of Myanmar and (c) tectonic cross section of Myanmar (GIAC, 1999 & Tin Aung Myint, 2009)

Tectonically as well as geographically, Myanmar is divided into four provinces: 1. Shan- Thai Block, 2. Central Myanmar Basin 3. Western Range (Indoburman Range) and 4. Rakhine Coastal Plain (Fig.3 b & c) (Maung Thein, 1973). In reality, Sagaing Fault which is right lateral strike slip fault is divided Shan-Thai Block also known as Sibumasu Block (part of Eurasian continent) and other three provinces (within Myanmar Microplate). The proposed Muse-Mandalay railway line will mainly pass through the underlying rock units exposed in Shan-Thai Block.

Methods of Study

One inch topographic map of the Myanmar Survey Department, UTM map and Landsat satellite image were used as a base map in the field. The lithologic characters, dip and strike of the beds of various stratigraphic units were studied and plotted on the base map. Tape and compass traverse method and surveying were used in the field.

Literatures concerning about the geology of the northern Shan State along the Muse-Mandalay railway line were done and applied them in the field. Stratigraphic studies and samplings were carried out with the GPS locations in the area. These samples were examined using a polarizing microscope, for the petrographic studies and mineralogical investigations.

Result

General Geology between Mandalay and Lashio Section

Lithologic units exposed along Muse-Mandalay railway are mostly of Paleozoic to Mesozoic clastic and carbonate rocks (See in Table 1 and Fig.4). The occurrence of the rock units along the line are 1. Igneous rocks including rhyolite, tuff and granite?, 2. Metamorphic rocks containing schist, phyllite, and quartzite and sedimentary rocks consisting of carbonate (limestone & dolomite), sandstone, siltstone, clay, shale and evaporite. Among them, limestone is the most abundant rock exposed in the area.

Table (1) Stratigraphic succession of the rock units exposed along Muse-Mandalay High Speed railway line (Compiled by Tin Aung Myint, 2019)

Lithology	Geologic Age
Alluvium	Quaternary
Unconformity	
Namyau Group (Hsipaw Red Beds, Tati Limestone)	Triassic
Bawgyo Group (Napeng Fm & Pannyo evaporate)	Jurassic
Maymyo Formation (Plateau Limestone+ Shan Dolomite)	Mid-Devonian to Triassic
Zebingyi Formation	Early to Middle Devonian
Nyaungbaw Formation	Silurian
Kyaingtaung Formation	Late Ordovician
Sitha Formation	Middle Ordovician
Ngwetaung Group (Pangyun Group)	Cambrian
Granite (granitoid)	Paleozoic ?
Chaung Magyi Group	Proterozoic

Here, the lithology is mainly emphasized on the occurrence of rock units exposed between Mandalay and Lashio section. The generalized geological map of the Myanmar and regional geological map of the Northern Shan State and stratigraphic column of that area are shown in Fig. (4). The oldest one is the Chaung Magyi Group. It is a thick sequence of generally low-grade metasedimentary rocks. The major rock types in an approximate order of abundance are: phyllite, slate (often pyritiferous), metagraywacke, sandy phyllite, mica schist, calc-phyllite, graphite schist,and laminated marble. It occurs in Patheingyi area (Fig. 5a), north of Naungcho, N of Kyaukme and between Namkhan-Muse.

The Cambrian beds are mainly sandstones. They overlie unconformably on the Chang Magyi Group, and underline conformably under the Ordovician beds. The Cambrian rocks are rather limited in distribution (Fig. 5b). It consists of rhyolitic rocks, tuffs and volcanoclastic sediments, purple shales, thinly bedded sandstones, hard greyish green, chololate-coloured micaceous quartzites and grit. The Cambrian succession along railway mainly exposed in two areas: western part (N of Pyinoolwin) and central part (mainly Bawdwin area).

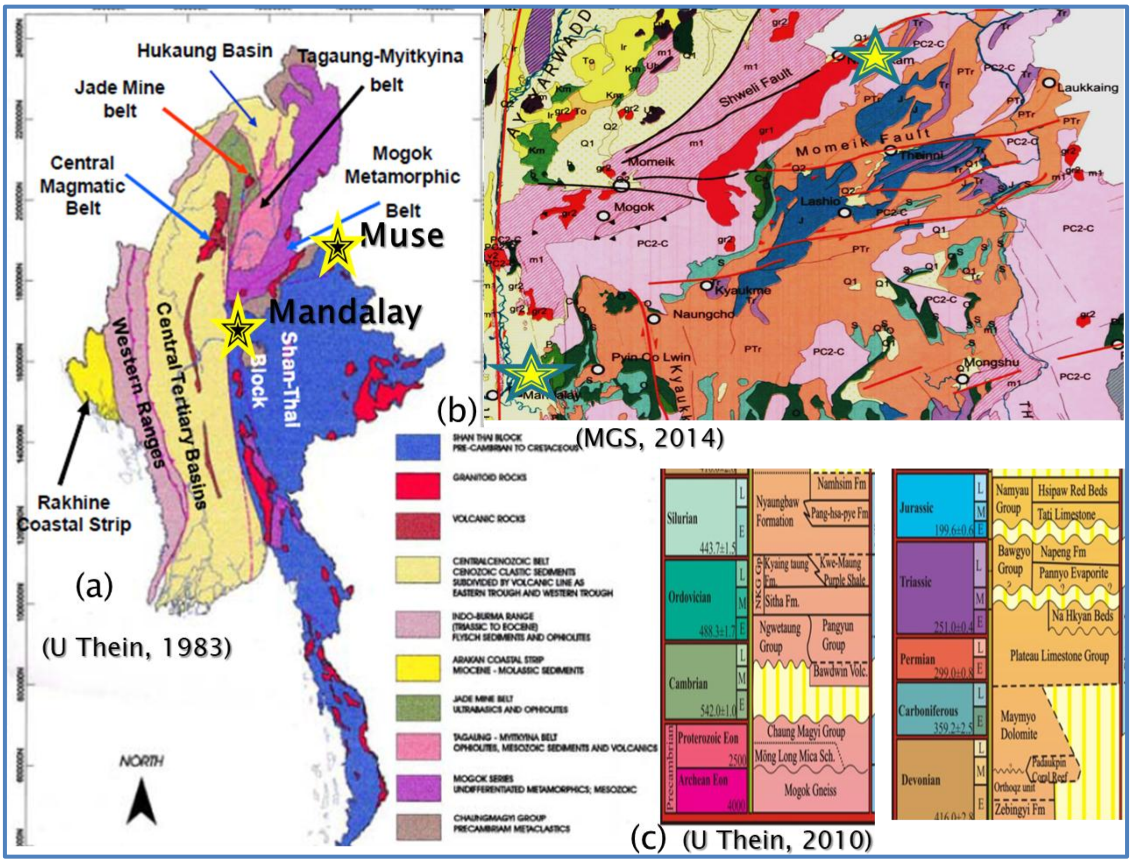

Fig. (4) (a) Generalized geological map of Myanmar (Source: U Thein, 1983), (b) Geological map of Northern Shan State (Source: MGS, 2014) and (c) Stratigraphic column of Northern Shan State (Source; Maung Thein, 2010)

Nothing like the Cambrian system, the Ordovician System is distributed relatively widely in northern Shan State as well as along the railway line. According to La Touche (1913), it is the second most widely distributed rock group, next to Maymyo Formation (formerly known as Plateau Limestone+ Shan Dolomite) in Shan State. Middle Ordovician Sitha Formation is well exposed near Sitha and Thabyegyin villages and Taunggyun area, at east of Sedawlay (especially between First and Third Reversing on Mandalay-Maymyo old railway line), along Mandaly-Pyin Oo Lwin car road (Fig. 5c) and at Kyaukchaw Hill north of Kyaukchaw village, Patheingyi Township, Mandalay. A thick, gorgeously exposed road-cut section occurs along the road down the Gokteik Gorge, east of Naungkhio (Myint Thein, 1983). This formation is composed mainly of medium to thick-bedded (generally1-5ft thick) grey and dark grey blue limestones intercalated with partings, thin beds or subunits of buff-coloured, compact siltstones and marls. Another upper Ordovician Kyaingtaung Formation is composed mainly of thin to medium-bedded, white, yellow, orange, and sometimes purple siltstones, mudstones, and marls with occasional bands or beds of limestone. The beds are often deformed, and with distorted fossils.

The Silurian Nyaungbaw is widely exposed within Pyin-Oo-Lwin Township. Its lower contact with the Nyaungkangyi is conformable. It is mainly exposed Nyaungbaw village (W of Pyin Oo Lwin), S of Pyin Oo Lwin, W of Kyaukme and bent to the NW of Lashio. The

Nyaungbaw Formation is a red brown, purple to blue-grey limestone with claystone sequence which has a strikingly phacoidal (nodular) aspect (Fig.5d).

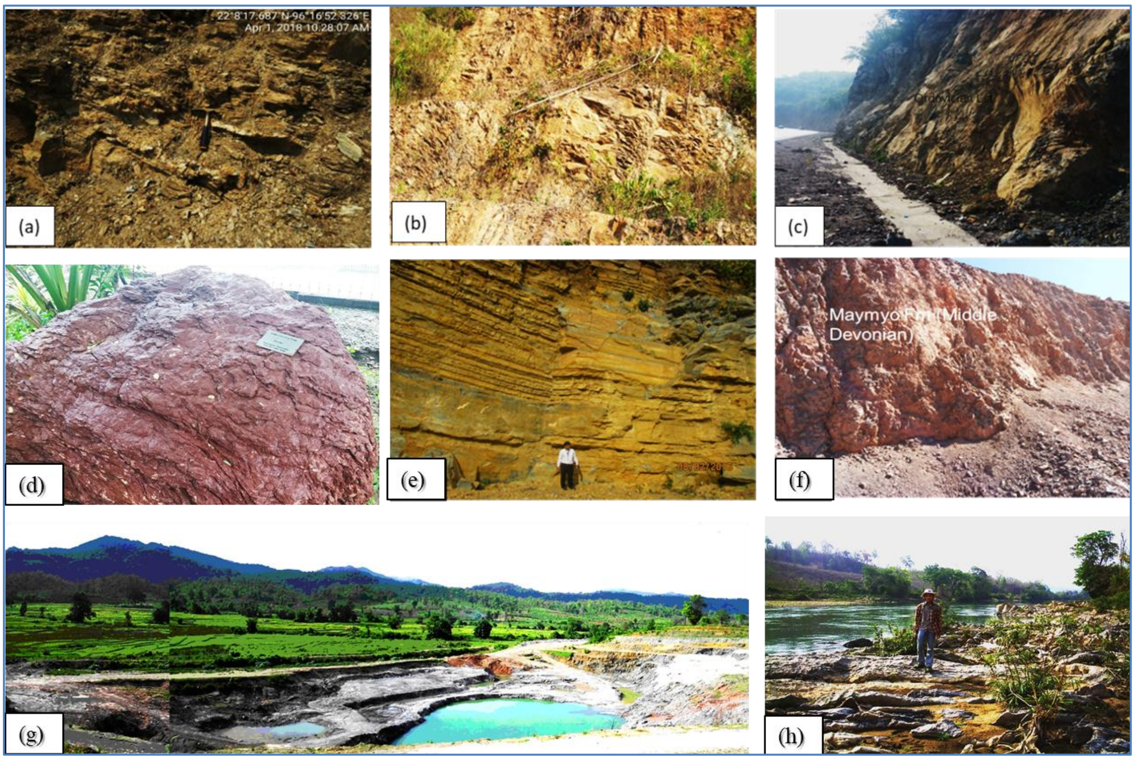

Fig. (5) Lithologic units exposed along Lashio-Mandalay Railway Line. (a) quartzite and phyllite of the Chaung Magyi Group exposed in Kin village in Patheingyi Township, (b) Well bedded Cambrian Pangyun sandstone exposed at Pyinoolwin-Mogok car road (Photo courtesy of Dr Min Nyo Oo), (c) Medium to thick bedded Ordovician Limestone exposed near Mandalay-Pyinoolwin car road, (d) Purple color folded shale showing phacoidal aspect exposed near Nyaungbaw village (e) Thin- to thick beded carbonaceous shale and limestone exposed in Thondaung village, (f) Dolomite and dolomitic limestones exposed north eastern part of Pyinoolwin, (g) Hard and compact, bluish grey, thin- to medium- bedded limestone (Tati Limestone) exposed at southern bank of Namtu River, near Moe- tae village (Grid ref.266236). (Photo courtesy of Dr Khin San) and (h) Panoramic view and exposures of Pannyo Evaporite at Mankong Mine, half mile NE of Mankong Village. (Photo courtesy of Dr Khin San)

The Early to Middle Devonian Zebingyi Beds to a group of limestone and shale occur sporadically along Mandalay -Pyin-oo-lwin old railway line near Zebingyi station and along Kyinganaing stream near Thondaung village (Fig. 5e) and Pathin village. It is largely a calcareous one with admixture of shale.

The Mid-Devonian to Permian Maymyo Formation is the largest outcrop along the Lashio –Mandalay railway secton. The limestone in this formation appears to have passed into finely crystalline dolomites and dolomitic limestones. It occurs Pyin Oo Lwin and its environs (Fig. 5f), Naungcho. between Kyaukme and Lashio, and S of Muse.

Jurassic Bawgyo Group (Especially Napeng Formation) consists chiefly of yellow-to buff- highly fossiliferous siltstone such as (pelecypods, gastropods) variegated shales, clay, arenaceous limestone, calcareous mudstone, argillaceous limestone intercalated with yellowish shale. This unit occurs mainly from E of Kyaume through Lashio, then bends again and passing S of Theinni and finally into south of Muse. Pannyo Evaporite in this group in significant in Hsipaw area (Fig.5h).

Triassic Namyau Group consists of hard and compact, bluish grey limestone (Fig.5g), light grey fossiliferous limestone, cross- bedded arenaceous limestone, highly folded argillaceous limestone and calcareous shale, the red and purple shales, siltstones and sandstones. It is cropping out on both sides of the Namtu River, Kyaukme, northern part of Hsipaw, around Theinni, Nan Pha Ka and Muse towns. The rugged mountainous terrain is covered with relatively dense forest in this area.

It is also found that the granitoid rocks (mostly granite of Paleozoic age?) are found largely along Muse-Namhkam trending NE-SW. It is the huge granite batholith in the area and intruded into the Chaung Magyi Group.

Geological hazards

Myanmar definitely falls in an earthquake prone as it lies within a major earthquake belt, also called the ***Alpine belt***, which is a Tertiary Alpine-Himalayan orogenic belt that extends from northern Mediterranean, through Iran, the Himalaya and Myanmar, to Indonesia for about 15000km. Thus, it is no wonder for Myanmar as a seismic dynamic zone because of collision between India and Himalaya, subduction between Myanmar plate and Indian ocean, and strike-slip faulting along Sagaing Fault that caused many documented earthquakes frequently (Fig.4) (See in Chhibber 1934, Thawbita 1976, Myint Thein, 1983, Wang Yu et al. 2014). Earthquakes by Sagaing Fault are more frequently and hazardously than other earthquakes happened in Myanmar region including the earthquake formed by India subduction (Fig.6). Near the borders with China, Laos and Thailand, the earthquakes are largely linked with other strike-slip faults occurred in the central Southeast Asia region (Fig. 6a). Myanmar is also encountered in other natural hazards, especially storms, cyclones, wildfires, floods, climate change and landslides that often create disasters damaging more proportion than earthquakes.

However, the most probably catastrophic earthquake in Mandalay-Lashio section is Myanmar earthquake (caused by Kyaukkyan Fault) of 23 May 1912. It was the strongest earthquake (with R. M. 8) felt in Myanmar in modern times. Fortunately, it happened away from the populated areas, triggering only moderate damage and destruction. J. C. Brown (1914) suggested that a sudden movement along the Kyaukkyan Fault near Naungcho had caused this earthquake (Fig.7). The well-known Sagaing Fault runs just 14km W of Mandalay, and recurrently make strong earthquakes (with R.M. 7) happened in the region.

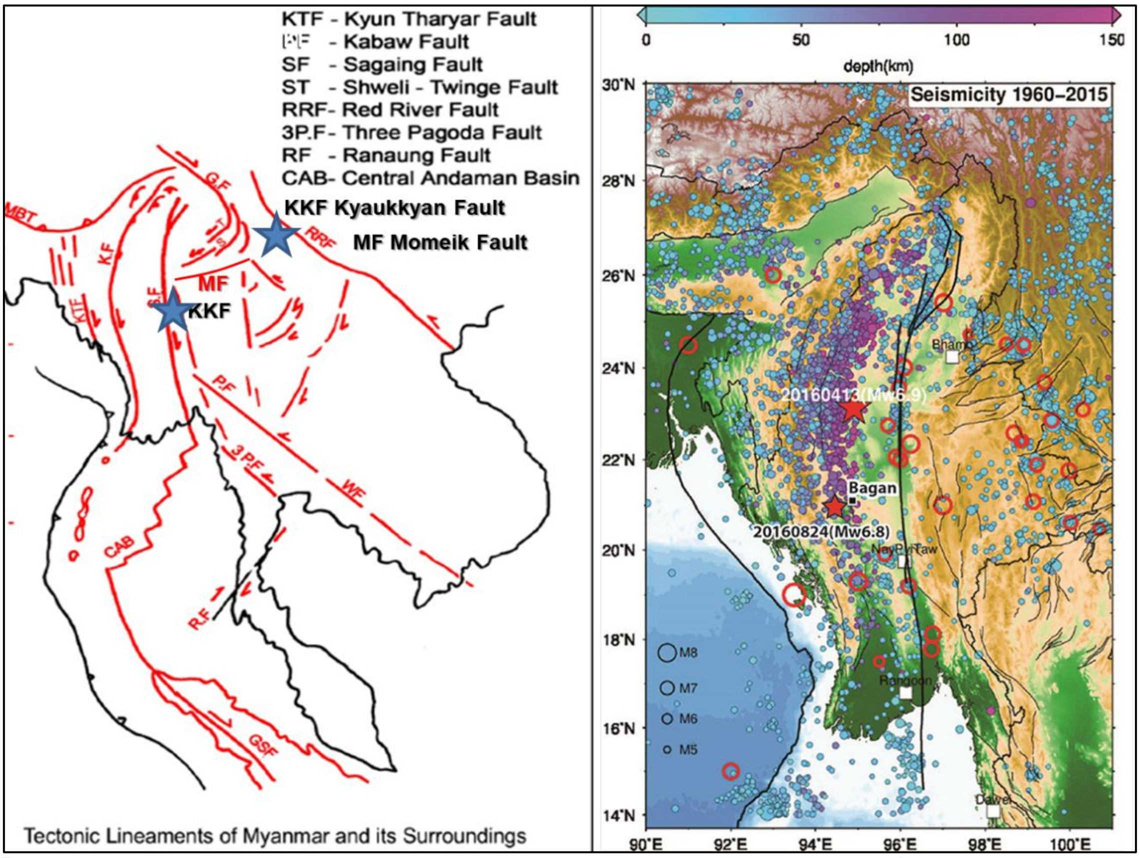

Fig. (6) Tectonic lineaments of Myanmar and its surrounding region (Modified from Hla Hla Aung, 2008) (b) Seismic map of Myanmar (Source: Wang Yu et al., 2014).

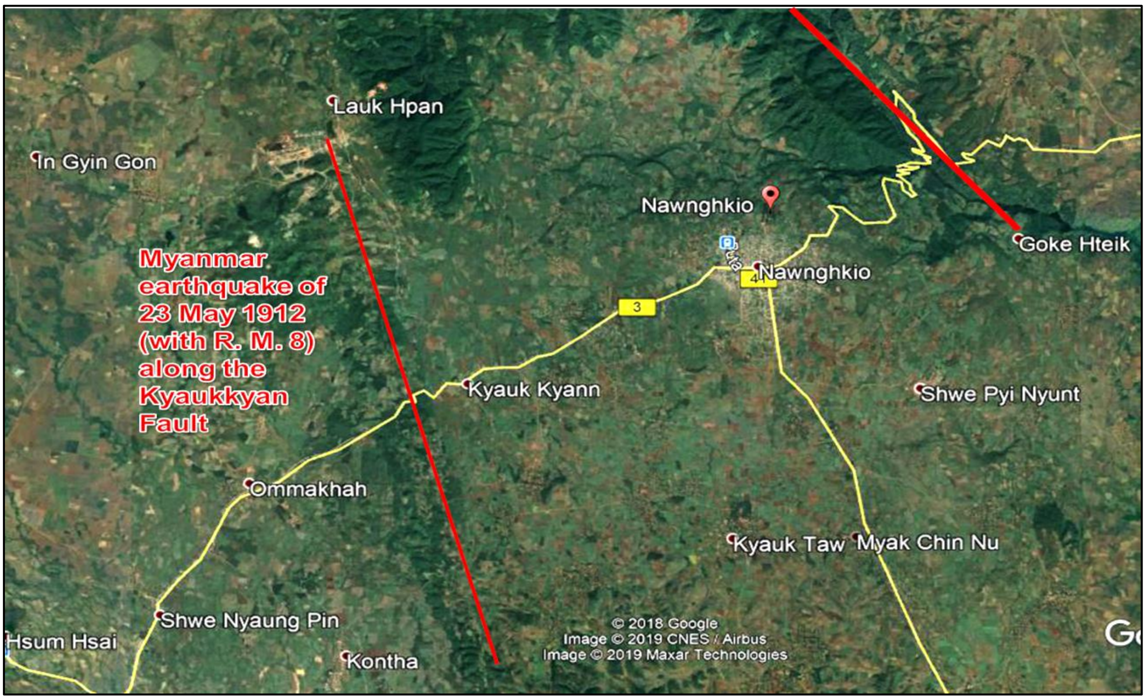

Fig. (7) Satellite image of the Kyaukkyan Fault near Naungcho town. (Source: Google Earth, 2018)

Suggestion

The proposed Railway line is actually located on the Shan-Thai Block and the rocks are mostly of limestones of Paleozoic age forming as some ragged mountain terrains. The majority of carbonate rocks are from Maymyo Formation which has karst topography, cave and sinkhole natures. As the railway line is expected to be 431 kilometres long, it will be needed a significant number of bridges and tunnels. So it is necessary to construct those infrastructures systematically and qualitatively. Another important thing is that as Myanmar itself falls in an earthquake prone and the strongest earthquake (with R. M. 8) happed near Naungcho town, it should be conscious and thoroughly made any structures that must be resisted to the magnitude (> R.M.8) of earthquake. According to seismic record, there was no record for earthquake of Kyaukkyan Fault after 1912. However, the past seismic records and the nature and magnitude of the neotectonic structures (especially active faults) suggest that there is little likelihood of the occurrence of catastrophic earthquakes (with Richter Magnitude > 8.5) in Myanmar in future. Earthquake related landslide and other natural disasters such as storms, cyclones, floods and landslide caused by heavy rains should be aware and taken into account in considering engineering designs. Care should also be taken for railway construction which must be avoided for water resource for the public along the line. Legal enforcement should act to give penalty for those people who carry away valuable minerals and ores from the line or make mineral dressing in situ. In addition to high cost involved, seismic, geological and natural hazardous issues are key burdens to the engineering project implementing along the Muse-Mandalay high speed railway line.

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