THE 30TH EDITION OF

Al HAJAR

APRIL 2021

2001 GSO 2021

20 years of the Geological Society of Oman The story is not over yet!

The GSO unveils the new elected Executive Committee for 2021 & 2022

Coastal terraces as indicators of mountain uplift

Sedimentology of a Fore-arc succession: an example from the Mio-Pliocene Miura Group

Cement and Flux Grade Limestone Blocks of Mallapura-Dudwan Area of Gund Saderkote Bandipora Kashmir India

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ABOUT GSO

GEOLOGICAL SOCIETY OF OMAN ★ الجمعية الجيولوجية العمانية ★ 2001 ★ ٢٠٠١

The Geological Society of Oman GSO was established in April 2001 as a vocational non profitable organizations which aims to advance the geological science in Oman, the development of its members and to promote Oman's unique geological heritage.

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BY THE EDITOR

Dear Readers,

Congratulations on the new GSO Executive Committee 2021 and 2022. Join me to wish a distinguished period during their period of the Society. Also, a big thanks go to the previous Executive Committee 2019 and 2020. They have made a tremendous effort and organized different events to deliver rich programs during the last two years despite their challenges. In addition, we are pleased to say that the Geological Society of Oman has completed its twentieth year since its establishment. We are proud of what the Geological Society of Oman has achieved over the past years. Certainly, the new Executive Committee will continue to do its best of accomplishments and events.

Here, in this edition, we have selected some of our members' research covering different geoscientific themes. We start with the first title about Coastal terraces as indicators of mountain uplift at the coastal stretch between Quriat and Sur. Then, the second title we inform you about the sedimentology of a fore-arc succession is an example from the Mio-Pliocene Miura Group, Jogashima Island, Japan. The last article is about the cement and flux grade limestone blocks of the Mallapura-Dudwan Area of Gund Saderkote Bandipora Kashmir in India and the economic importance of its mining reserve. I hope you will enjoy these articles.

Ramadan Kareem. Stay Safe!

Yousuf Al Darai
Al Hajar Magazine Editor

AL HAJAR EDITORIAL TEAM:

THE ANNUAL GENERAL METTING

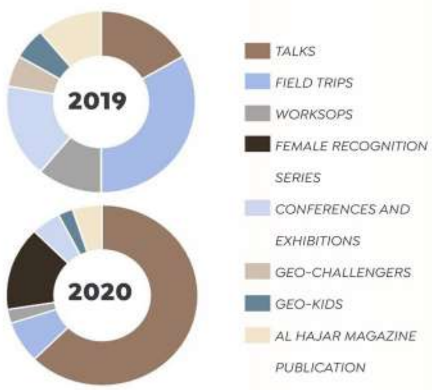
The Geological Society of Oman holds its Annual General Meeting for the year 2021 and unveils the new GSO Executive Election

The Geological Society of Oman (GSO) held its Annual General Meeting (AGM) on March 24th, 2021. Mr Elias Al Kharusi (President of the GSO for 2019-2020) was the moderator of this AGM. He presented the achievements of the Society during the last two years, 2019 and 2020. During the AGM, a summary of the GSO annual report, different Al Hajar publications, a list of activities and events, and the financial review of the Society were presented.

The GSO quarterly publication of Al-Hajar Magazine was published during the past years. Two editions were published in 2019 and two more editions in 2020. The magazine included different articles from GSO members about the geology of Oman and abroad. The support provided by members to enrich the Al Hajar Magazine with articles was appreciated and encouraged to continue to provide value to its readers.

Different activities and events included field trips, talks, and workshops, were organized during the past two years and delivered successfully. Many GSO members and non-members participated and contributed to these successes. Unfortunately, most GSO activities during 2020 faced challenges due to the pandemic, especially GSO field trips. The GSO Committee decided to hold all field trips until things return to normal. However, the GSO talks continued to take place using the different virtual platform in which it enabled to reach to broader audience attracting many interested people globally.

GSO'S ACTIVITIES & EVENTS AT 2019 & 2020



Annual Reports of 2019 and 2020

Among the activities held in 2020 is the celebration of Omani Women's Day, which falls on October 17th every year. The event titled "Omani Geoscientists Female Recognition Series in 2020" hosted GSO female members who have contributed to the success of Oman and in their careers.

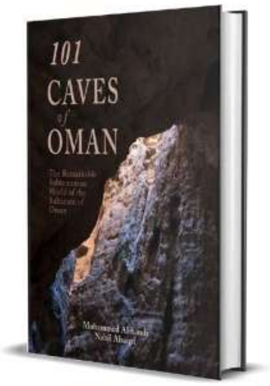
Based on the financial report, the income of GSO was based mainly on the contribution of Energy companies with lesser contribution by membership fee and book sales. These supported the finance of GSO and were used and spent on GSO office renting costs, Employee salary, and printing books to ensure the continuation of its activities.

Dr. Mohammed Al Kindi announced the winners of the Geo-Challengers competition, which was organized in October 2019. The Khuff Team was the winner in first place in this edition of GeoChallenger of 2019. The Geocahllanger competition is organized annually by the Geological Society of Oman for Universities students. They compete on different petrogeology assignments that include outcrop logging, reservoir modelling, volume calculation and presenting the results to the selected committee. This competition helps the student to build the necessary skills to make them ready for future career paths.

Geo- Challengers Competition- 2019

Dr Mohammed Al Kindi also presented a brief content of his upcoming book titled "101 caves of Oman". This book is under final revision by the GSO committee and will be available to those who are interested in future announcements. This work was done by cooperation between GSO with the Omani Caves Exploration Team.

By the end of the AGM, Mr Said Al Mahrooqi -a member of the Election Committee for the year 2021 and 2022- presented the results of the elections on behalf of the election committee. The eight members who won the election results for the GSO Executive Election 2021 and 2022 were Husam Al Rawahi as President of the GSO, Saif Al Azri as Vice President of the GSO, Mazin Al Salmani as Secretary, Amjad Al Shukry as Treasurer, Laila Al Habsi as Executive Director, Yousuf Al Darai as Editor, Issa Al Shibli as Membership Officer, and Sultan Al Khamisi as Committee member.



Proposed edition of Caves of Oman Book will be issued soon

THE GSO EXECUTIVE COMMITTEE 2021 & 2022

Husam Salim Al Rawahi
President

My Name is Husam Al-Rawahi. I am a geologist working in Petroleum Development Oman PDO as Sedimentologist since July 2011. I have completed my BSc in geology at Sultan Qaboos University and my MSc in Petroleum Geosciences at GUtech University. I have been a member of the Geological Society of Oman GSO since 2009 and became a committee member in 2013. I enjoy landscape photography, and I am using this hobby to explore, capture and learn about the geological wonders of Oman. I am one of the authors of the "Oman Enchanting Geology" Book, and I plan to contribute further to the geoscientific community in the future.

Saif Abdullah Al Azri
Vice- President

Saif Al-Azri is Geophysicist by background and my heart with geology. I have undergraduate degree in Geophysics from SQU and MSc in applied geophysics from Curtin University, Western Australia. In my I career I focus on studying Induced seismicity associated to HC production activity. I grew up in a village, my family house is on Hawasina and our garden is on Ophiolite, Jabel AL-Hasah AL-baidhaa "The White Rock Mountain" (as we call it locally) was my first climb, 15 years later I recognize it as Oman's Exotic. I will need your support to organize first international fields tripe for GSO members.

Mazin Khalfan Al Salmani
Secretary

Mazin Al-Salmani, graduated with BSc in Earth Science from Sultan Qaboos University in 2018. And currently I'm pursuing a Master degree in Petroleum Geosciences. I have 3 years hands-on industry experience. One of my important achievements was to be awarded with my team the first place in AAPG IBA competition in 2018 and represented the region in the global finals which were in USA. It's always said that one hand cannot clap, so I'm willing to work with everyone in GSO to make it recognized internationally and to bring our spectacular geology visible globally!

Amjad Nasser Al Shukri
Treasurer

Amjad Al-Shukri, Exploration Geoscientist working for Petroleum Development Oman with 4 years of experience. I have graduated from the University of Leicester with Geology and Geophysics BSc, then proceeded for post-graduate studies and awarded a Masters degree in Petroleum Exploration Geoscience from the University of Manchester. Further, an active participant of the National programs and graduated recently from the National Youth Program as one of the top 100 participants.

Laila Moosa Al Habsi
Executive Director

Laila Al-Habsi, majored in Applied Geology and specialized in mining & extraction of metallic and non metallic deposits. I am also a certified Russian translator. My thesis on chromite mining and PGMs in Oman was awarded the best thesis award and published in Russian. I have also participated in geologic mapping of several landscapes in places such as the Southern Ural mountains and Caucasus mountains. Currently, I works as a geologist in business development for SPMP (Strategic & Precious Metals Processing), the first antimony producer in the region.

Yousuf Ali Al Darai
Editor

I'm Yousuf Al-Darai, Graduated from Sultan Qaboos University in the BSc of Earth Sciences. I'm working right now at the mining sectors under the Earth Sciences Consultancy Centre. Since I was at University and later at GSO I worked with different friends in the contribution with people as well as try to add some value and knowledge of geology sciences for different ages of people and levels. Here in this chance for me at the GSO I will try with the committee members to find a good link to enhance the geology field with interested.

Issa Said Al Shibli
Membership Officer

I am Issa Al-Shibli, I study my MSc in Geosciences at Sultan Qaboos University.
I have experienced oil & gas as a Wellsite Geologist with Petrogas Rima. Currently, I'm serving for Geo-Solutions Engineering in the exploration field of the mining industry as a Field Geologist.
My vision is to enable members to participate in building the futuristic Geological Society of Oman.
Our desire is to change the Society as a focal point, were people are used to share their brilliant ideas, to a better environment that satisfys all our ambitions.

Sultan Mayouf Al Khamisi
Committee Member

My name is Sultan Al-Khamisi, I am a fresh graduated geologist. I have been worked in Discover Geophysical and Physical Consulting Company as field geologist for a period of time, then I moved to work in the Earth Sciences Research Center as research assistant also for a period of time. I have interests in my field as well as other interests. I participated in many field trips and events provided by the Geological Society of Oman and by others. My participation in Geological Society of Oman as committee member came from my passion to contribute to the development of the Society and also to push the wheel of evolution and progress forward to benefit of the entire community.

COASTAL TERRACES AS INDICATORS OF MOUNTAIN UPLIFT

Hoffmann, G.[1,2] *& Falkenroth, M.*[1,2]

1 Environmental Geology, Institute of Geoscience, University Bonn, Bonn, Germany; ghoffman@uni-bonn.de

2 NUG, RWTH Aachen University, Aachen, Germany; michaela.falkenroth@rwth-aachen.de

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INTRODUCTION AND AIMS

Everyone travelling on the highway from Quriat to Sur will recognise a staircase of coast-parallel terraces that shape the steep front of the Hajar Mountains. The observant traveller quickly arrives at the questions how, when and why this striking landscape formed and what it can tell us about the evolution of Oman`s coastline as well as the tectonics of its most prominent mountain range. Needless to say, research efforts in the area focused on just that and resulted in a number of relevant publications (Mattern et al. 2018, Moraetis et al. 2018, Hoffmann et al. 2020). Here we will report on some of these discoveries.

STUDY AREA

The dominating bedrocks of the coastal stretch between Quriat and Sur are limestones (fig. 1). Most of these rocks were deposited during the Paleogene and Neogene and hence after the ophiolite obduction in Late Cretaceous. The unique properties of limestones have implications for the steep and more than 2000 m high mountain front. For instance, the Selma Plateau on top has the entrances of the Majlis al-Jinn (Searle 2019). This is one of the largest cave systems in the world and a striking example of karstification within limestone. The plateau is also characterised by numerous ponors,

The unique properties of limestones have implications for the steep and more than 2000 m high mountain front.

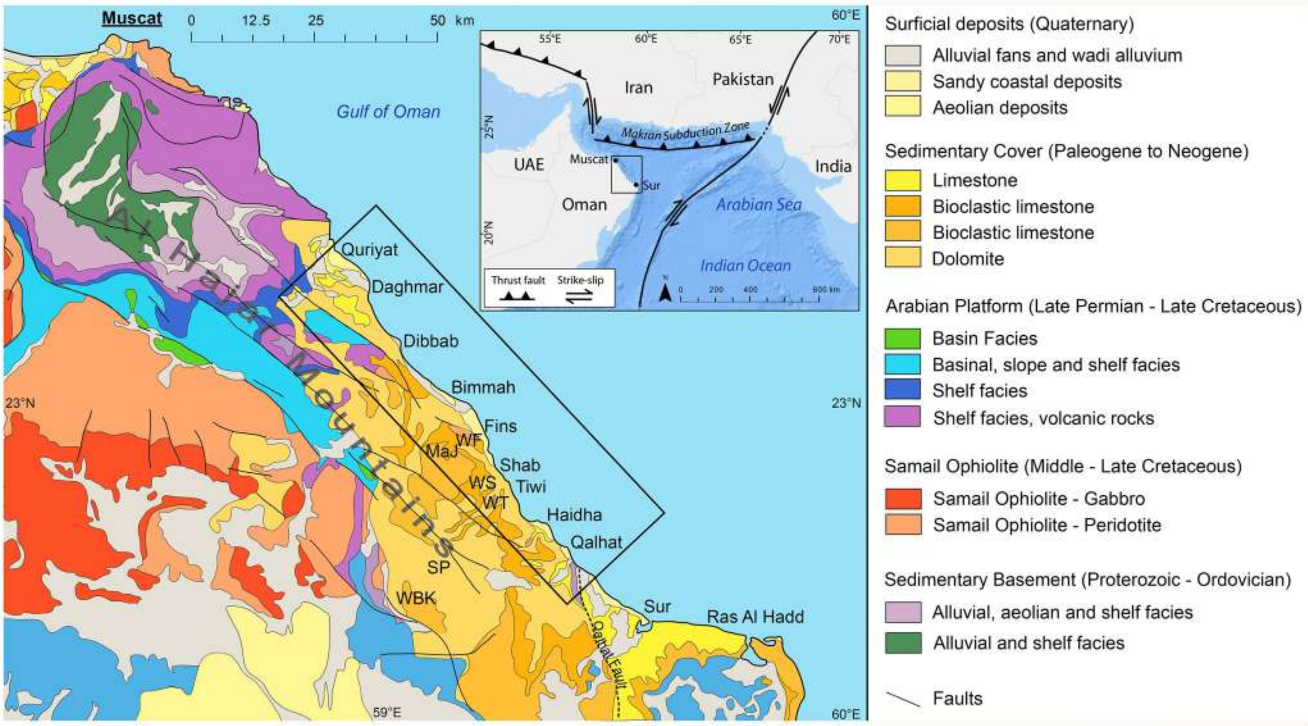

Fig (1). Simplified geological overview of north-eastern Oman. The location of the study area on the coastline between Daghmar and Qalhat is indicated by the black box. The peridotites associated with the Samail Ophiolite are overlain by Paleogene limestone in the study area. MaJ: Majlis al Jinn, WF:Wadi Fins, WS: Wadi Shab, WT: Wadi Tiwi, SP: Selma Plateau, WBK: Wadi bani Khalid. (Inset): Location of the study area, tectonic overview of north-eastern Oman and the Makran Subduction Zone and the bathymetry of the northern Arabian Sea.

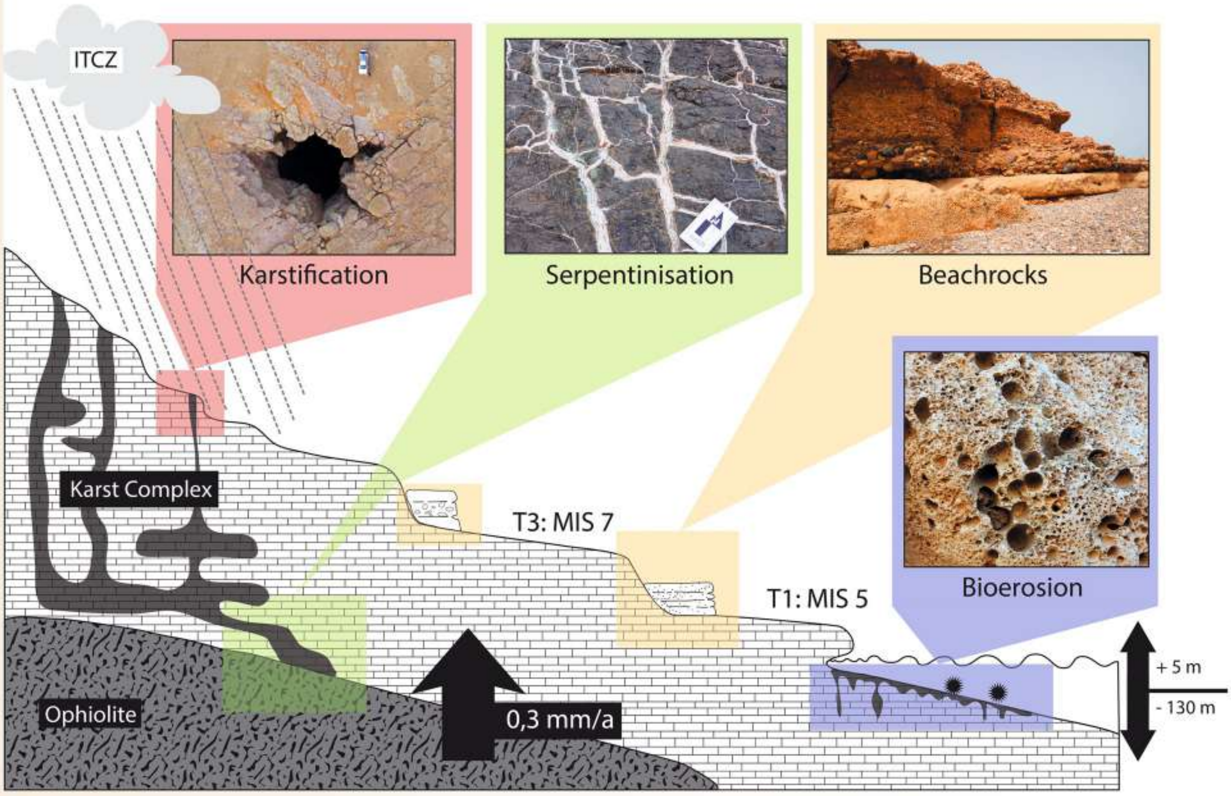

Fig (2). Aerial photography 3 km north of Shab, looking north (upper image) and interpreted drawing (lower image). Typical geomorphic features include the terrace scarps and the terrace treads. The palaeo shoreline-angles are located at the base of the scarps. Note that the tread of T3 is covered with various marine, alluvial and fluvial deposits, while the platform of T4 is erosional without an extensive cover of marine sediments.

openings where surface water enters into the underground karst system. Being semi-arid today, these geomorphological features already indicate that climate must have been wetter in the recent geological past. Another phenomenon of the karst system are the huge wadis, including Wadi Tiwi and Shab on the eastern side and Wadi bani Khalid on the western side of the plateau. These wadis host perennial streams and are part of the open karst system, connected to the ponors on top. The underlying rock unit is exposed in some of these deeply incised landforms. This is the case in Wadi Fins (de Obeso and Kelemen 2018) and in Wadi Tiwi where peridotites of the Semail Ophiolite are outcropping. These rocks are highly serpentinised through the contact with water.

The current coastline in front of the mountains is characterised by cliffs of serval meters to decameters in height. A number of narrow, dominantly sandy pocket beaches are found in between. Commonly an abrasional platform develops within the intertidal zone. This platform is inclined with 1-2° towards the sea and extends up to 150 m seaward. These platforms form due to mechanical abrasion by wave action. Furthermore, bioerosion plays a major role here.

A similar morphology can be observed in the terraces that are defined by a flat terrace tread and a steep terrace scarp (fig. 2). The latter represents a paleocliff whereas the tread is the associated abrasional platform. The transition from the tread to the scarp is known as the shoreline angel and marks the location of the

These platforms form due to mechanical abrasion by wave action. Furthermore, bioerosion plays a major role here.

former beach. The formation of the terraces is related to global sea-level variations during the Quaternary.

METHODS

We conducted extensive topographic, geomorphological and geological surveys. Fieldwork focused on the sediment that accumulated on the terrace treads. These sediments must have formed during or after terrace formation and hence are Pleistocene. An emphasis was put on the mapping of beachrock. These consolidated beach sediments (see Mauz et al. 2015) are important to understand sea-level variability during terraces formation. The beachrocks were examined regarding their sedimentological and petrographical properties (Falkenroth et al. 2019). When mapping the palaeo-shorelines, the highest beachrock occurrence on the individual terrace levels were recorded. These elevations are regarded as minimum values as scree deposits from the palaeo-cliffs often cover the beachrocks. When beachrock occurrence was sparse, for example on the older terrace levels, the highest occurrence of beachrock fragments was mapped. Another focus of the field campaigns was to collect evidence of the tectonic setting of the terraces. For this purpose fault zones were identified and measured. Subsequently lineament and drainage system analyses were carried out (Ermertz et al. 2019).

To unravel geomorphological aspects, such as course and elevation of the paleo shoreline angles the terraces were surveyed with drones and differential GPS (dGPS). The dGPS dataset was verified and improved by remote sensing data using a high-resolution TanDEM-X digital elevation model (DEM). The data was acquired by interferometric radar data from the TerraSAR-X and TanDEM-X satellites. The spatial resolution is 12 m. The relative vertical accuracy ranges between2 m in areas with a slope of less than 20 % and 4 m in areas with a slope larger than 20 %. The relative horizontal accuracy reaches 3 m. The approach results in a comprehensive model of palaeo-shorelines in the study area.

Terrace age was determined by dating the cover deposits. The terraces were dated using the cosmogenic radionuclide 10Be, in locations attributed to palaeo-shorelines. Cosmogenic nuclide 36Cl was used when only carbonatic pebbles were found. Two samples for optically stimulated luminescence (OSL) dating were taken from alluvial deposits, by excavating a c. 80 cm ditch and sampling at night to prevent sunlight exposure.

RESULTS AND INTERPRETATION

The terraced landscape stretches over 72 km along the coastline from Daghmar to Qalhat. Based on drone imagery and an analysis of slope angles within the DEM, nine terrace levels are clearly recognisable. The individual terrace levels show various forms of post-formation alterations, as they are eroded, dissected by fluvial channels, and tilted. The higher terraces are most affected by these processes, confirming that the terrace levels become progressively older with elevation. There are potentially even higher and older terrace levels, but those are very relict and do not allow a reliable, unambiguous lateral correlation.

The terraced landscape is dissected by fault zones into four individual blocks. To the south, the terraced topography terminates at the Qalhat Fault.

Potential remnants of terraces treads are identified up to elevations of 600 m above sea level (a.s.l.). These terraces were labelled T1-T9 where T1 is the youngest. While the lowest three terraces still show a thick sediment cover, the upper ones are ridded from any deposits, except beachrocks, which withstood erosion and are still found up to T7. Our data reveals a general northward inclination of the terraces, resulting in higher elevation of the same terrace level towards the southern part of the study area. The average tilting of the terraces along the entire course is 0.11°. The inclination is not uniform along the coastal stretch under study. The northernmost part of the terraces between Daghmar and Dibbab shows an inclination of about 0.40°. In contrast, in few areas a southward tilting of individual terraces is observed, namely T7 south of Fins, where an inclination of 0.44° was measured. The terrace treads are dipping seawards, with an angle between 0° and 4°, whereby older terrace platforms are steeper. The terraced landscape is dissected by fault zones into four individual blocks. To the south, the terraced topography terminates at the Qalhat Fault.

The ancient city of Qalhat is known as an important trade town. It is a protected archaeological site. The site represents a walled medieval settlement, triangular in shape, confined and protected by natural features such as a wadi, the sea and a steep mountain front. Archaeological remains clearly identify the town as of significance and wealth, a fact which is further stressed by the heavily fortified character of the settlement. The 13th and 14th century CE are known as the golden era when the city was an important administrative and political hub. Evidence for the city´s decline is based on historical and archaeological studies (e.g. Rougeulle et al. 2014). Results published by Ermertz et al. (2019) suggest that the coastal terraces terminate on the Qalhat Fault and that tectonic activity along the fault 500 years ago is possible. Therefore, it is hypothesised that an earthquake along this fault resulted in the destruction of the ancient town of Qalhat. Archeological and historical studies support this assumption.

Sea level studies from the harbour city Sur (roughly 30 km south of Qalhat) show that the crust south of the Qalhat Fault remained stable (Falkenroth et al. 2020). Here, paleo notches were analysed as sea level indicator. The oldest paleo notches stem from the last interglacial sea-level highstand of Marine Isotope Stage (MIS) 5e. This is concluded from cosmogenic nuclide dating of the fanglomerate bedrock in Sur Lagoon. All outcrops of paleo notches around Sur Lagoon were investigated in regards to the faunal distribution and notch shape. The bioerosional notch occurs at the same height around Sur Lagoon indicating that the area remained tectonically stable over the last 125 kyr.

The site represents a walled medieval settlement, triangular in shape, confined and protected by natural features such as a wadi, the sea and a steep mountain front.

As apparent from our data the marine terraces formed through an interplay of sea level change and land uplift. Our dating results show that the terrace surfaces are all Pleistocene in age. The Pleistocene world is characterised by climatic variations between glacials and interglacials and corresponding sea level changes. During this time, sea level highstands produced terrace levels that increase in width the longer sea level remained stable. This, together with the fact that terrace age corresponds with elevation, allows to develop a conclusive age model for each terrace, although the dating results show vast error bars. According to our model T8 formed during Marine Isotope Stage (MIS) 17 and T1 during MIS 5a. Terrace T3, which is the widest and most prominent terrace in the area, was likely formed during MIS 9 and then reoccupied during MIS 7 and MIS 5e. This implies continuous uplift between MIS 5a and MIS 19. Our calculated average uplift rates for the late Quaternary (MIS 5a to MIS 19)range from 0.01 - 0.22 mm/a in the very north,0.25 to 0.68 mm/a in the center, 0.32 to 0.89 mm/a in the southernmost parts of the study area. This uplift is differential as the four distinct blocks move relative to each other.

Now that the formation process of the marine terraces is understood and the timescale is clear, there remains only one further question: How and why does this coastline experience slow but steady uplift although it is located on a passive continental margin.

Previous explanations circle around tectonic forcing, associated with the northward movement of the Arabian plate and its subduction within the Makran Subduction Zone, and usually describe some kind of migrating forebulge (e.g. Abrams and Chadwick, 1994; Rodgers and Gunatilaka, 2002; Yuan et al. 2016). However, in our study (Hoffmann et al. 2020) we presented a different model (fig.3). In our view, the local bedrock lithology of a 2 km thick stack of karstified limestones overlaying peridotites from the ophiolitic complex, is the key to understanding the uplift process. From the deep wadis Fins and Tiwi we know that the peridotites undergo serpentinisation as they come in contact with water. Serpentinisation can increase the volume of a rock body by 50% as the newly formed mineral phases bind large amounts of water (e.g. DeObeso and Keleman, 2018; Coleman and Keith, 1971). Our interpretation is that the vertical movements are caused by several contributory factors. Our results are in agreement with previous studies, suggesting a flexural forebulge as a possible trigger. Ser-pentinisation of peridotites associated with the Samail Ophiolite nappe in combination with karstification of Upper Cretaceous-Palaeogene limestone formations is seen as additional forces for the uplift as they trigger isostatic response and volume increase. These processes are driven by Quaternary climate changes as water is required and where probably intensified during pluvial phases. We speculate that eustatic sea-level changes caused an additional hydro-isostatic effect.

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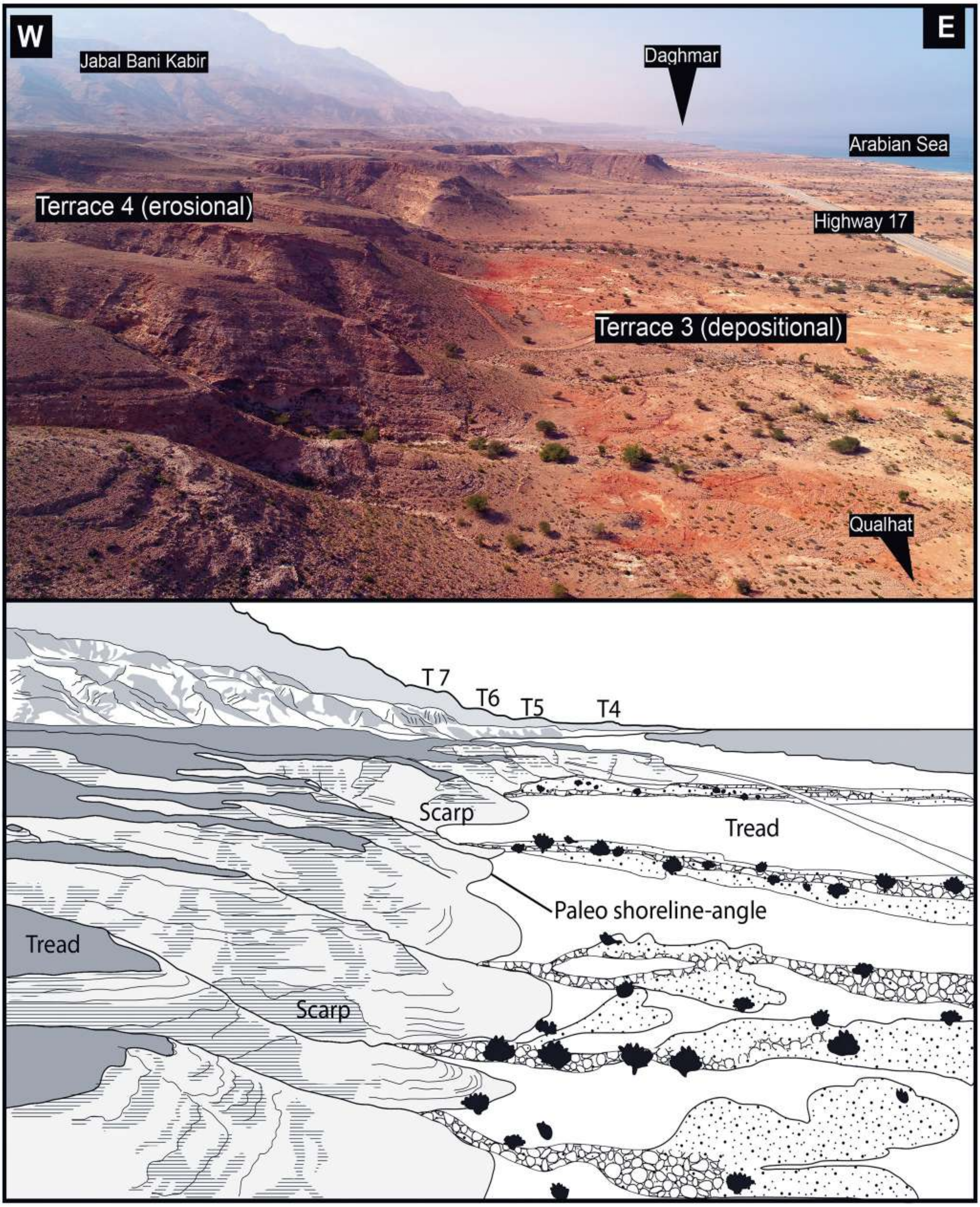

Fig (3). Sketch of the terraced coastal landscape that depicts the most important processes responsible for the formation of the terraces and the uplift. These include the serpentinisation of peridotites and the karstification of overlying limestone formations which are associated with isostatic response. Beachrocks indicate the location of palaeo shorelines and bioerosion is an important process in the formation of the wave-cut platforms that later form the terraces tread. Sea-level oscillation in the order of +5and -130 m cause an additional hydro isostatic factor that influences the observed uplift.

CONCLUSIONS

- The coastal area between Quriat and Qalhat is uplifting
- Field evidence indicates that the area south of Qalhat fault is stable
- Qalhat was likely destroyed by an earthquake
- Beachrock is a powerful tool in sea level studies
- Global climate change has to be considered as a relevant process in vertical crustal movement

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A spectacular huge recumbent fold in Wadi Mayh. Probably folding the Permian-Triassic shelf carbonates in Oman.

Coordinates: 23° 25' 46.7" N, 58° 32' 18.3" E

By: Mazin Al Salmani

Wadi Al-Mayh is part of regional high pressure belt known as Saih Hatat fold-nappe and Saih Hatat consider as one of 3 major culminations in Oman mountains.
It's suggested in published papers and books that the structures in there are result of exhumation processes where it took place during Late Cretaceous after the emplacement of Oman Ophiolite.

Sedimentology of a Fore-arc succession:

AN EXAMPLE FROM THE MIO-PLIOCENE MIURA GROUP, JOGASHIMA ISLAND, JAPAN

Sara Al-Busaidi[1]
Rajat Mazumder[1]
Shinji Yamamoto[2]
Heninjara Rarivoarison[1]
Vivek Malviya[2]
Makoto Arima[2]
Wilfried Bauer[1]

1. Department of Applied Geosciences, German University of Technology in Oman, P.B. 1816, Athaiba, P.C. 130, Muscat, Sultanate of Oman.
2. Graduate School of Environment and Information Sciences, Yokohama National University, Yokohama 240-8501, Japan.

INTRODUCTION

Fore arc basins are marine sedimentary basins which are located in front of volcanic arc towards the trench side. These basins receive sediments from the volcanic arc as well as from oceanic water (hemipelagic sediments) and both are important constituents of the fore arc deposits (Condie, 2016). The fore arc deposits document tectonic processes and consequent sedimentation in the subduction zone (Lundburg and Dorsey, 1988; Soh et al., 1991; Busby and Ingersoll, 1995; Condie, 2016; Pickering and Hiscott, 2016). Deformation and metamorphism often obliterate primary sedimentary structures of the ancient fore arc successions. However, the sedimentological analysis of young un-metamorphosed fore-arc successions preserved on land provide valuable information (Yamamoto et al., 2005; Mazumder et al., 2013, 2018 and references there in).

The Mio-Pliocene Miura Group represents a fore arc succession (Stow et al., 1998; Ogawa et al., 2002; Mazumder et al., 2018) that formed in the Izu-Bonin and the Honsu arc collision zone, Japan (Fig. 1). The Miura Group has been studied by a number of researchers over the last three decades (Soh et al., 1989; Stow et al., 1998; Lee and Ogawa, 1998; Ogawa et al., 2002; Mazumder et al., 2018). The Miura Group is exposed in both Miura and Boso peninsula. This article is a short critical synthesis of the sedimentology of the Miura Group based on the observations made in the Jogashima Island, Miura Peninsula, Japan. This is part of an ongoing research investigation by the Department of Applied Geosciences, German University of Technology (GUtech) on the fore arc sedimentology of active tectonic belts of Japan.

GEOLOGICAL SETTING

The Mio-Pliocene (14-3 Ma, Kaine et al., 1991) Miura Group is a deep to shallow marine volcaniclastic sedimentary deposit that formed in a fore-arc setting in the Izu-Bonin and Honsu arc-arc collision zone (Soh et al., 1991; Stow et al., 1998; Mazumder et al., 2018; Fig. 1A). The Miura Group has been divided into a lower Middle Miocene to early Pliocene Misaki Formation and an upper Late Pliocene Hasse Formation (Soh et al., 1991). Detailed lithostratigraphic analyses have been undertaken by Soh et al (1991), Lee and Ogawa, 1998 and Stow et al (1998). Both the Misaki and Hasse Formations are well exposed in the Miura and Boso Peninsula at a number of places (Stow et al., 1998). The stratigraphic boundary between the two formations is well exposed (Fig. 1B-C) both in the Miura and Boso peninsulas This stratigraphic contact is visible in Jogashima Island as well (Fig. 2). The Misaki Formation constitute the large part of the Jogashima Island (Fig. 1B). Although previous researchers estimated the thicknesses of the Misaki and Hasse Formations around 1200 m and 400 m respectively (Soh et al., 1991; Stow et al., 1998), the actual thickness is difficult to estimate because of post depositional compressional tectonics (mostly low angle thrusts; see Ogawa, 1982; Ogawa et al., 1985, and references therein) that has duplicated the stratal thicknesses (Mazumder et al., 2018). These sedimentary deposits are unmetamorphosed and hence very delicate primary sedimentary features are exceptionally well preserved.

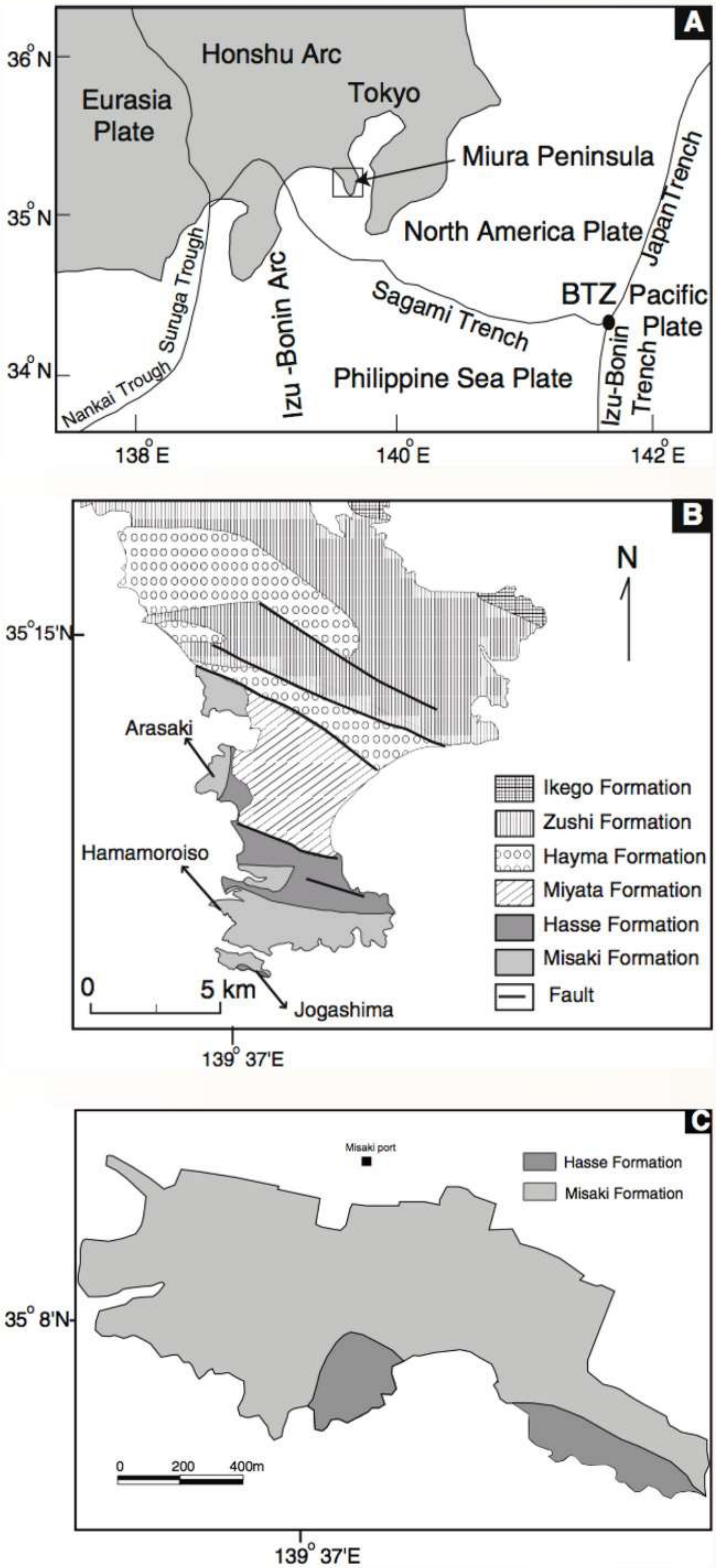

Figure 1: Location map. (A) The Miura Peninsula in its plate-tectonic setting (BTZ= Boso Tripple Junction/Zone; Trench-trench-trench type). (B) Schematic geological map of the Miura Peninsula and Jogashima Island. (C) Outcropping zone of the Misaki Formation in and around Jogashima (after Mazumder et al., 2018).

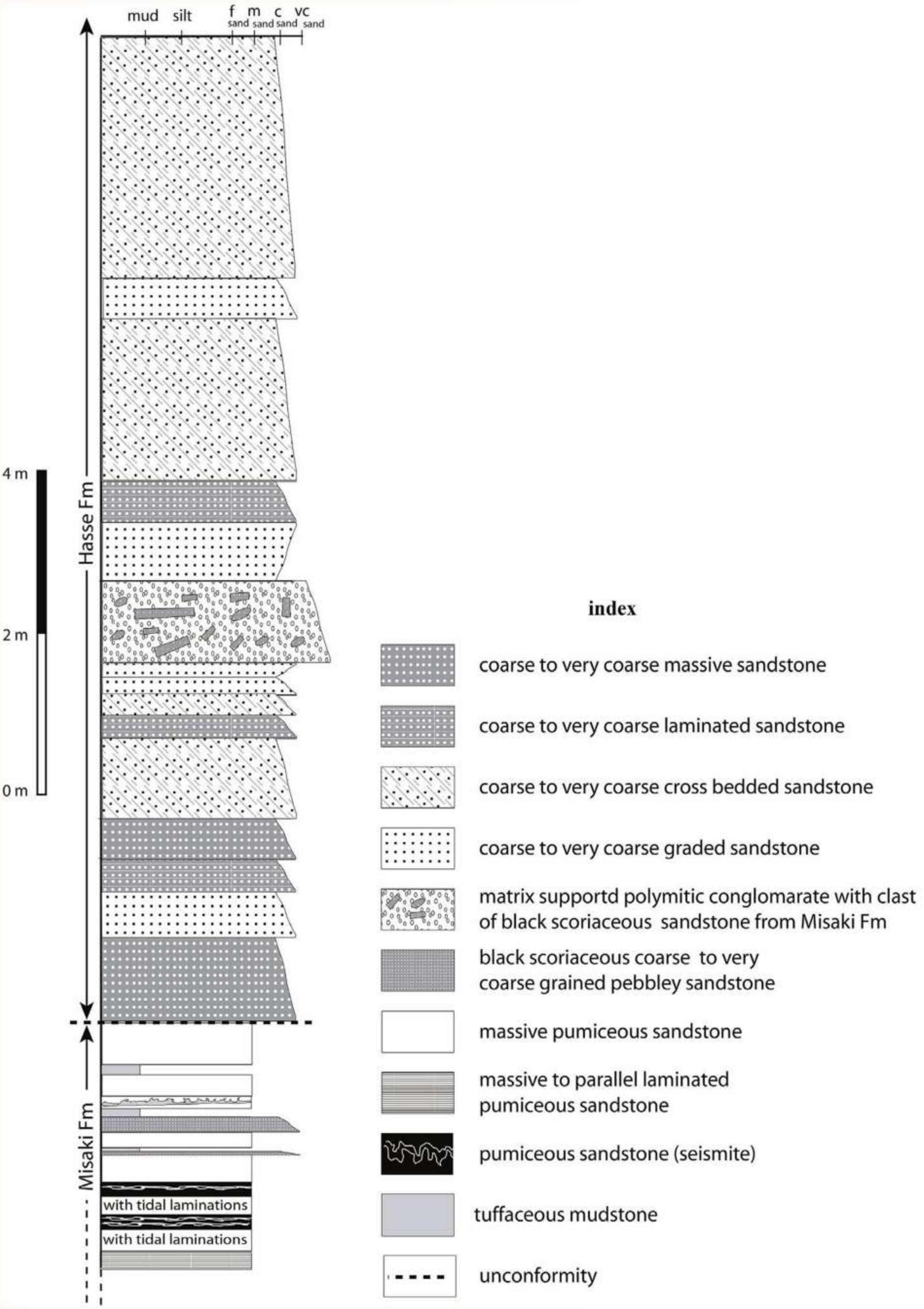

Figure 2: Stratigraphic section showing the lithofacies characteristics of the Miura Group at the Jogashima Island, Miura peninsula.

SEDIMENTARY FACIES CHARACTERISTICS OF THE MIURA GROUP

The sedimentary facies characteristics of the Misaki and Hasse Formations are very different. The sandstones are compositionally as well as texturally immature and made of plagioclase feldspars, clinopyroxenes, occasional hornblende and lithic fragments (Fig. 3A-B). The proportion of lithic fragments is higher in the Hasse Formation. The Misaki Formation is made of three distinct lithofacies: 1. Very coarse to coarse-grained scoriaceous sandstone 2. Pumiceous fine-grained sandstone/siltstone, and 3. Tuffaceous mudstones (Fig. 4A-E) The proportion of lithic fragments is higher in the Hasse Formation. The Misaki Formation is made of three distinct lithofacies: 1. Very coarse to coarse-grained scoriaceous sandstone 2. Pumiceous fine-grained sandstone/siltstone, and 3. Tuffaceous mudstones (Fig. 4A-E). The very coarse to coarse-grained scoriaceous sandstone bears normal grading and parallel lamination (Fig. 4A). At places, the sandstones are devoid of any sedimentary structures (massive). The presence of normal grading and laterally persistent sandstone-mudstone lithofacies association over several hundred of meters with numerous ball and pillow structures (Fig. 4B) indicate that these are turbidite deposits. The volcaniclastic sediments were derived from the arc and were transported by turbidity current to the relatively deeper part of the marine sedimentary basin. This facies is bounded by tuffaceous mudstone or pumiceous sandstone (Figs. 2, 4B). The pumiceous sandstone bears alternate thick and thin sandy laminations bounded by mud drapes (Fig. 4C). Mazumder and Arimad (2013)

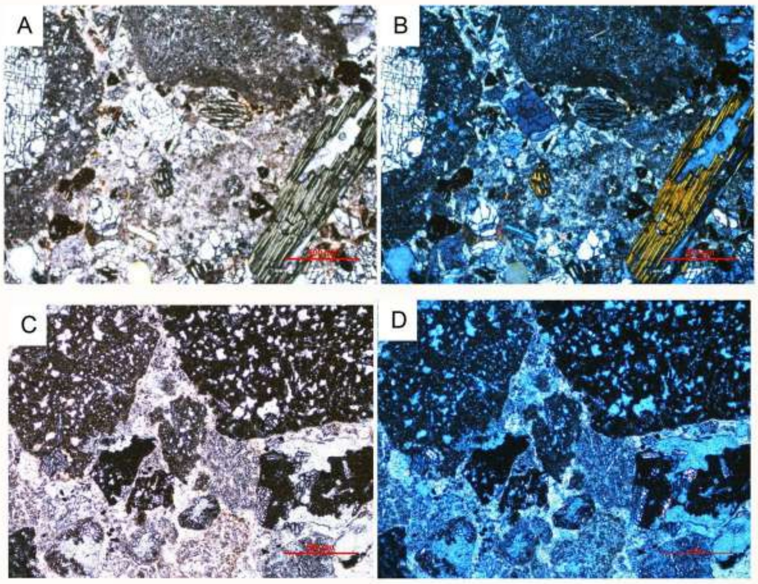

Figure 3: Petrographic characteristics of the Miura Group at the Jogashima Island: Misaki sandstone under plane polarized light (A) and between dross polars (B). Note clinopyroxene grains. Hasse sandstone under plane polarized light (C) and between cross polars (D). Note large lithic fragments.

have interpreted these mud draped sandy laminations as semi-diurnal tidal rhythm (De Boer et al., 1989; Eriksson and Simpson, 2000). The tuffaceuos mudstone facies formed under deeper marine condition as is evident from the presence of foraminifers (Akimoto et al., 1991). The tuffaceous mudstone and the pumiceous sandstones are indigenous sediments that were deposited under deeper marine condition (submarine fan environment; see Stow et al., 1991; Mazumder and Arima, 2013 and references therein). The scoriaceous sandstone facies were formed in a deep water setting but the constituting compositionally immature sediments were derived from the arc (Soh et al., 1989, 1991; Lee and Ogawa, 1998; Stow et al., 1998; Mazumder et al., 2018). The topmost part of the Misaki Formation is characterized by generally massive pumiceous sandstone with occasional large cross-beds (Fig. 4E).

Unlike the Misaki Formation, the Hasse Formation is devoid of mudstone and the Pumiceous sandstone (Fig. 2). The Hasse sandstones are brown colored (Fig. 5A) and sharply overlies the Massive or cross-bedded Misaki sandstone. The Hasse sandstones are very coarse to coarse-grained, often reverse graded (Mazumder et al., 2018; Fig. 5B) or large-scale trough cross-bedded (Fig. 5C). Massive sandstones are also common (Fig. 2). At places, the large scale tabular cross-bedded foresets are overturned and gives rise to recumbent fold geometry.

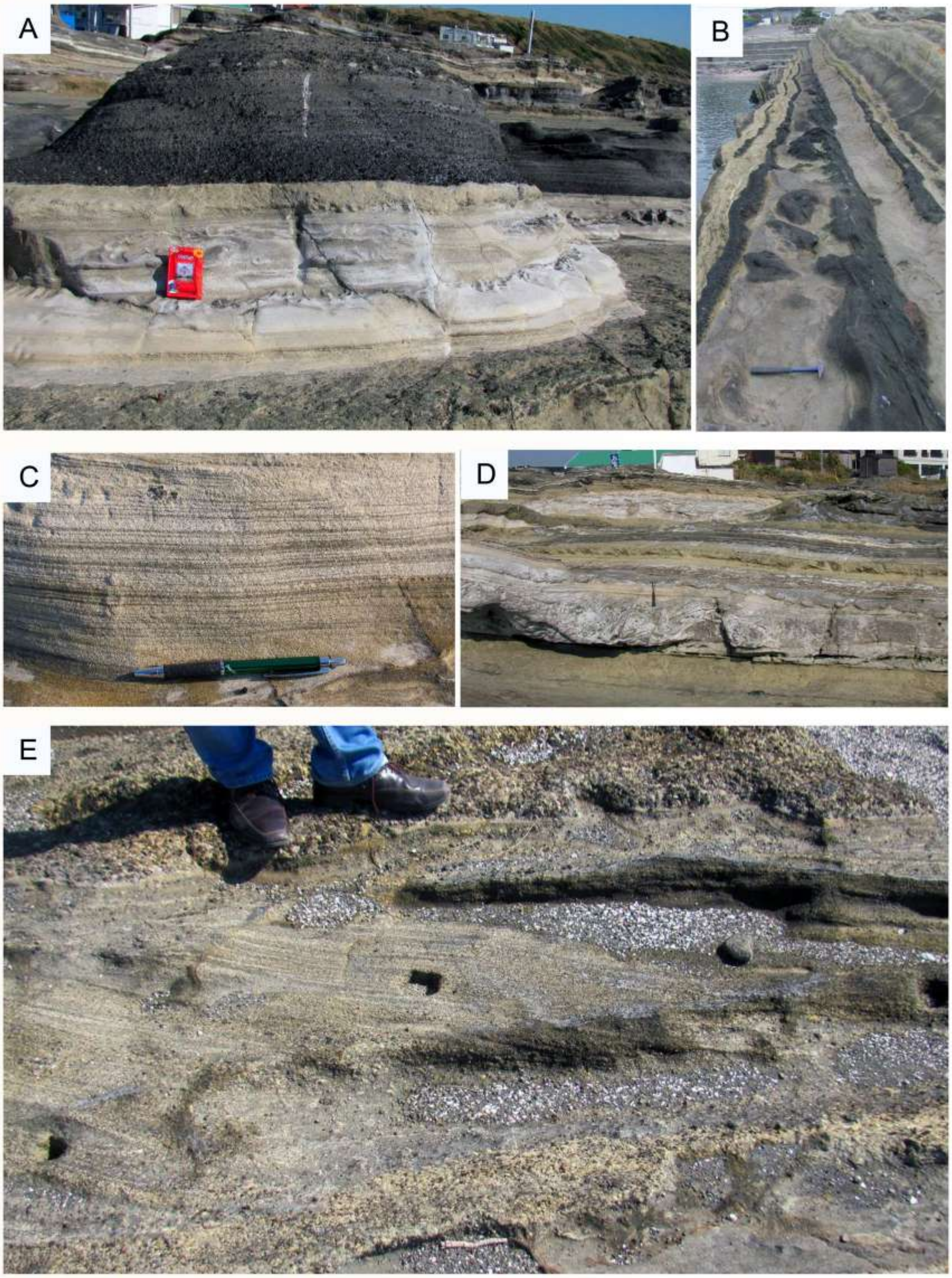

Figure 4: Misaki Formation: (A) very coarse to coarse-grained scoriaceous sandstone with normal grading. The scoriaceous sandstone facies sharply overlies the pale yellow colored tuffaceous mudstone facies. (B) Laterally persistent scoriaceous (dark colored) sandstone interbedded with finer sandstone and mudstone facies. Note ball and pillow structures. (C) Pumiceous sandstone with alternate thick-thin light colored sandy laminae bounded by mud drapes. These are called double mud drape and indicate tidal influence (cf De Boer et al., Mazumder and Arima, 2013). (D) Laterally persistent convolute laminated sandstone bounded by undeformed beds. These have been interpreted as seismites (see Mazumder et al., 2016).

There are matrix-supported conglomerates with clasts made of Pumiceous sandstone facies of the Misaki Formation (Figs. 2, 5D). The clasts are very poorly sorted and highly angular to subrounded (Fig. 5D). These very coarse to coarse-grained sandtone – sandy matrix supported conglomerate association possibly represent the alluvial fan/fan delta deposit; the cross-bedded sandstone possibly represents the fluvial component (cf. Miall, 1996) of the fan complex (Stow et al., 1998; Mazumder et al., 2018).

The Miura Group at Jogashima Island represent a shallowing and coarsening upward stratigraphic succession (Fig. 2). At the lowermost part of the Misaki Formation, the deep water indigenous marine sediments (pumiceous sandstones and tuffaceous mudstone lithofacies) were frequently activated by the supply of volcaniclastic detritus from the arc and got deposited giving rise to the turbidite deposits (very coarse to coarse-grained scoriaceous sandstones). Subsequently, the sea level fall and the depositional setting became progressively shallow as is evident from the upward decrease in proportion of tuffaceous mudstone and pumiceous sandstone facies (Mazumder et al., 2018) and increase in the proportion of coarse-grained massive sandstone and/or occasional large-scale cross beds. The occurrence of alluvial fan/fan delta deposit of the Hasse Formation on top of the deep to shallow-marine deposits of the Misaki Formation indicate rapid fall in the relative sea level across the Misaki-Hasse transition. Mazumder et al (2018) explained that this sharp fall in relative sea level as a consequence of the collision between the Izu-Bonin arc and the Honsu arc.

the large scale tabular cross-bedded foresets are overturned and gives rise to recumbent fold geometry.

The Miura Group is characterized by a number of penecontemporaneous deformation structures like flame structure, dish-and-pillar structures, convolute laminations, load casts, ball and pillow structures, synsedimentary layer confined thrusts, neptunium dykes, slump structures etc.

Most of these structures are found along the selective stratigraphic levels, laterally persistent over two hundred meters and are bounded by undeformed beds.Majority of such penecontemporaneous deformation structures are generated by seismic shocks and hence have been interpreted as seismites (Mazumder et al., 2016). Miura peninsula is one of the most frequent earthquake prone area of Japan and such seismic activity took place in the distant geological past (Mio-Pliocene).

FUTURE RESEARCH DIRECTION

Although the sedimentary facies characteristics and the mode of stratigraphic sequence building of the Miura Group in Jogashima Island is well understood, the provenance characteristics of the Miura Group is yet to be studied. Preliminary petrographic studies reveal, the textural characters of the Miura and Hasse Formations are different. The Hasse Formation bears the clasts of the underlying scoriaceous and pumiceous sandstones and mudstones of the Misaki Formation. However, some clasts found in the Hasse conglomerate are not found in the Misaki Formation. These clasts are derived from elsewhere. No effort has yet been made to compare provenance characteristics of the Miura Group exposed in the Miura and Boso peninsula. Major, trace and REE characteristics of the samples collected from various stratigraphic levels along with paleocurrent data both from the Miura and Boso peninsulas is essential to infer the provenance characteristics and whether there was any provenance switching.

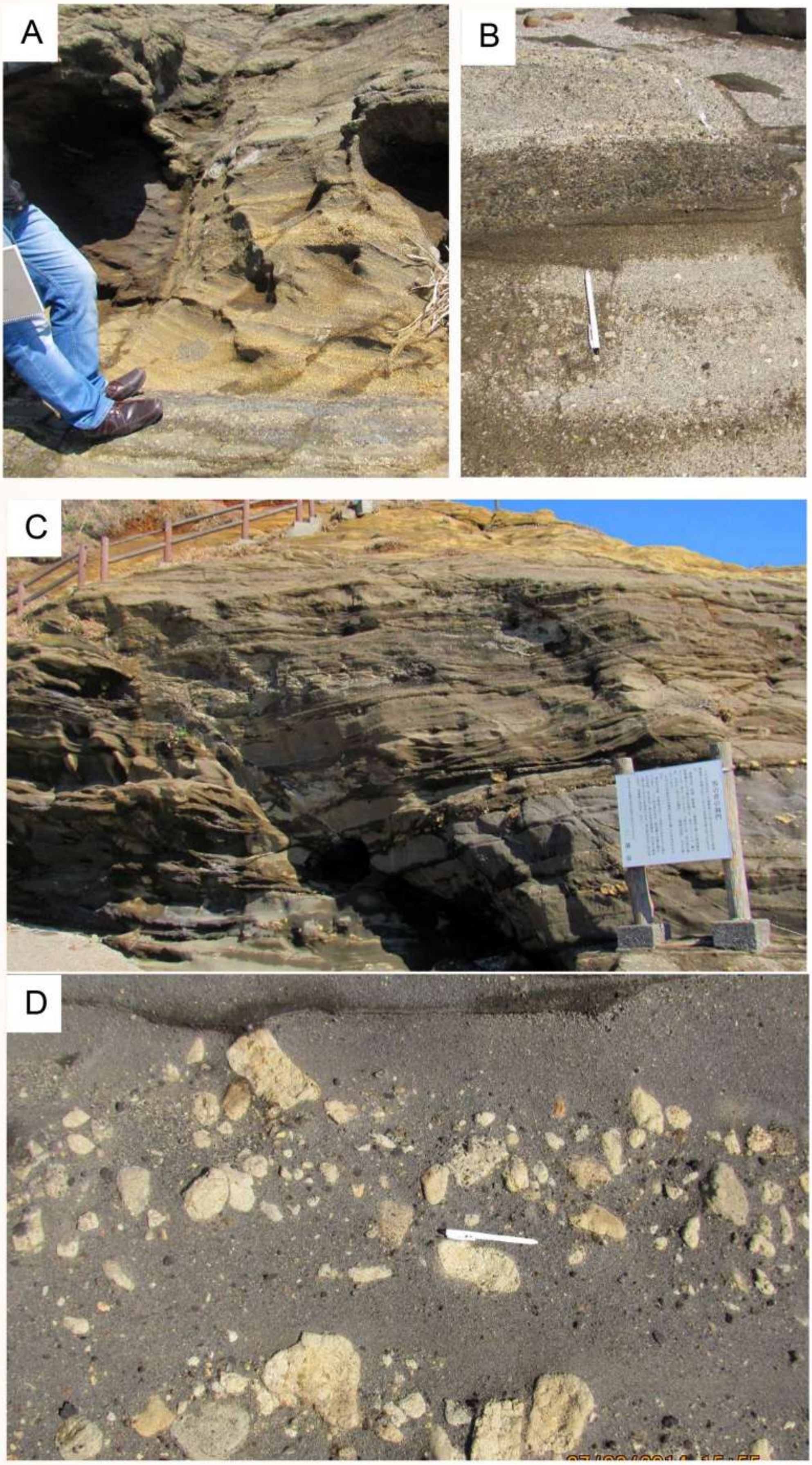

Figure 5: Hasse Formation: (A) Stratigraphic contact between the Misaki sandstone (grey) and the Hasse sandstone (yellowish brown). (B) Reverse graded very coarse-grained sandstone. (C) Large scale trough cross-bedded sandstone overlying tabular massive sandstone beds. (D) Matrix supported conglomerate with poorly sorted angular to subrounded clasts of Misaki sandstones.

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Coordinates: 23° 55' 49.2" N, 56° 53' 15.6" E

Road cut outcrop on the side of the Al-Batinah Expressway in Alkhabourah. These outcrops show highly deformed deep marine sediments (cherts, shale and carbonates) of Hawasina Group that has been thrusted during the Oman Ophiolite emplacement.

By: Mazin Al Salmani

CEMENT AND FLUX GRADE LIMESTONE BLOCKS OF MALLAPURA-DUDWAN AREA OF GUND SADERKOTE BANDIPORA KASHMIR INDIA

Mohsin Noor[1]

[1]*Department of Geology and Mining Srinagar Kashmir India*

INTRODUCTION

The Surface geological mapping of Gund Saderkote limestone deposits were commenced in the month of July 2018 and October 2020, with the purpose to ascertain the grade and tonnage of Saderkote Limestone blocks for their use in cement and steel industry. The Gund Saderkote Limestone blocks are very well exposed in the Mallapura-Dudwan area and is located between the latitudes 34018/13/ to 34018/17/N and longitudes 74039/20/ to 74040/14/E in district Bandipora, Kashmir. The Limestone of Gund Saderkote, Bandipora forms a small portion of a broader path of the Late Triassic Limestone resting on the southern limb of the westerly plunging asymmetrical syncline occupied by flows of Panjal Volcanics of Permo-Carboniferous Age and Late Triassic Limestone (Mohsin Noor 2019). During the field investigation, an area of about 02 square kilometers were brought under surface geological mapping followed by collection of 50 numbers of surface random chip samples to ascertain the grade and tonnage of limestone deposits.

GEOLOGY OF AREA

The Surface geological mapping carried out in the Gund Saderkote area revealed the following lithologies: Quaternary Alluvium, Late Triassic Limestone and Panjal Volcanics of Permo-Carboniferous Age. Generally, the limestone is light gray in colour, well jointed and fossiliferous. Based on the surface geological mapping and geochemical data five (5) potential limestone blocks were demarcated and designated as Kaniwan, Braykujh, Pandov Chul, Malpora A and Malpora B in the Mallapura-Dudwan area of Gund of Saderkote, having limestone either exposed at the surface and in some parts just covered below a thin layer of alluvium. The limestone outcrop present in the area has a thickness of more than 100 meters. The Strike of the exposed limestone outcrops are in northeast-southwest direction. The dip of the limestone outcrop is gentle at an angle of 300–350 inslope due northwest, indicating moderate influence of tectonic activity. Based on these investigations a surface geological map of Saderkote Limestone was prepared (figure 1).

MATERIALS AND METHODS

In order to carry out surface geological mapping of Limestone blocks, the author first consulted Survey of India topographic map (Scale 1:50000) bearing reference no. 43J/12 to finalize the amount of work. Subsequently, the author used imaginary from Google Earth and ASTER 30 digital elevation model (D.E.M) together with the Global Mapper software version (13.2) for generation of various map attributes. To ascertain the grade and utilization prospects of limestone blocks, 50 number of random chip samples were collected across the strike of the limestone beds (i.e., along dip direction of limestone beds) for geochemical analysis/determination of CaO, MgO, SiO2, Al2O3, Fe2O3 and Loss On Ignition (L.O.I). Magnifying hand lens and measuring tape were also used to take measurement of Limestone beds. Only 30 % of the total determined resources have been putted in potential proved reserve category and the remaining have been putted in the probable and possible reserves.

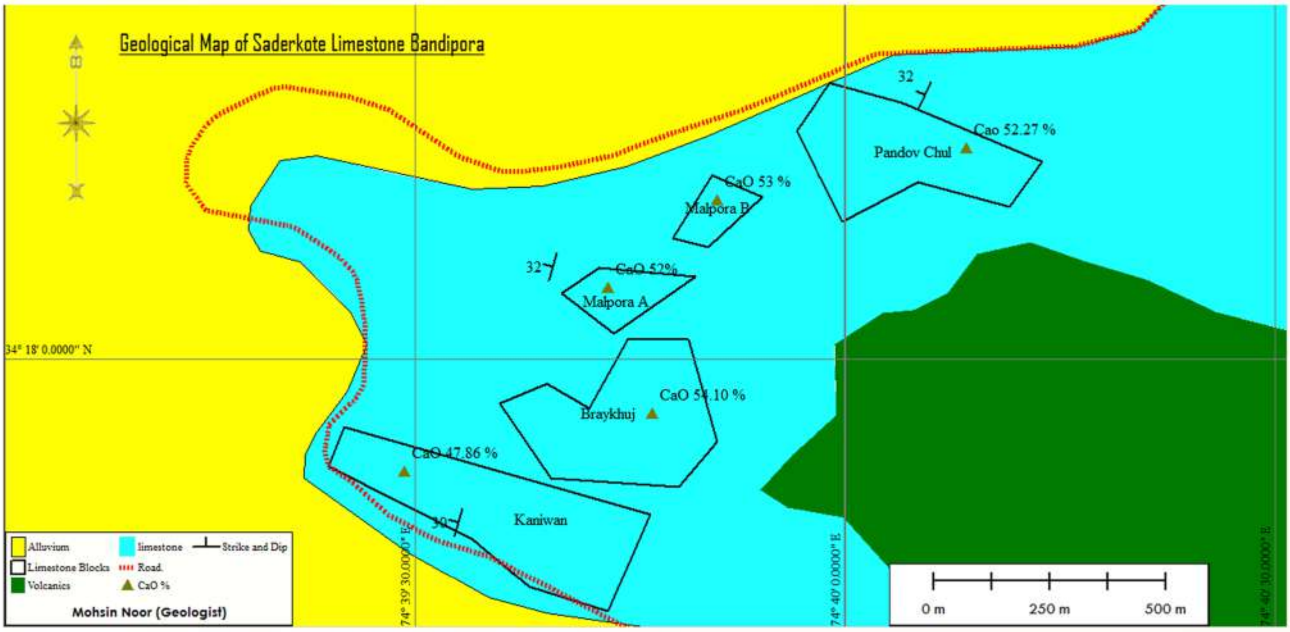

Figure 1. Surface Geological Map of Saderkote Limestone

GEOCHEMISTRY OF LIMESTONE BLOCKS

Analysis of the geochemical results indicated good quality of limestone i.e., Cement and Flux Grade which finds its utility in steel and cement industry. In steel industry, this limestone can be utilized as a flux and in cement industry; it can be utilized as a raw material for making clinker.

Table 1. Geochemistry of Gund Saderkote Limestone Blocks

Geochemical Parameters	Kaniwan	Braykhuj	Pandov Chul	Malpora A	Malpora B
CaO	47.86	54.09	52.27	53.2%	49.49
MgO	2.12	0.74	1.24	0.8 %	1.74
SiO_2	5.53	0.85	1.91	1.3 %	3.86
Al_2O_3	2.34	0.40	0.87	1.80	1.81
Fe_2O_3	1.75	0.33	0.82	1.68	1.67
L.O.I	39.88	43.10	42.41	40.80	40.80
Grade (As per BIS)	**Cement Grade**	**Flux Grade-II**	**Cement Grade**	**Flux Grade-II**	**Cement Grade**

All the five limestone blocks of Gund Saderkote are of Cement Grade and Flux Grade-II as per the Bureau of Indian Standard, New Delhi. The specifications are given in Table 2.

Table 2.

Constituents	Grade-I (%)	Grade-II (%)
CaO	53 (min)	44 (min)
MgO	1.5 (max)	4 (max)
SiO_2	1.5 (max)	6 (max)
Total Acid insoluble (TAI)	2 (max)	10 (max)
Alkali Content	0.2 (max)	0.2 (max)

The Broad chemical specifications of Cement Grade Limestone (Run-on-Mine) for cement manufacturing suggested by the National Council for Cement and Building Material, New Delhi are given in Table 3.

Table 3.

Oxide component	Acceptable range for manufacturing of cement (%)	Limiting values, scope of beneficiation and blending (%)
CaO	44-52	40 (min)
MgO	3.5 (min)	5.0 (max)
SiO_2	To satisfy LSF, Silica	-
Al_2O_3	Modules and alumina	-
Fe_2O_3	Modules	-
Free Silica	<8	<10
TiO_2	<0.5	<1.0
Alkalies	<0.6	<1.0
Total S as SO_3	<0.6	<1.0
Mn_2O_3	<0.5	<1.0

RESOURCES AND RESERVE OF LIMESTONE BLOCKS

Integrated surface geological mapping and geochemical data evaluation have been carried out to determine the potential reserves and resources of each limestone blocks.

Assumption and Methodology

1. In reserve and resource determination, sampled points of limestone beds, thickness of beds and their continuity and area of influence has been taken into consideration.

2. The unit of measurement for length, width and thickness of limestone beds are in meters.

3. Density of the limestone for tonnage calculation has been taken as 2.5.

4. Tonnage = {**A** x **T** x **D**}

Where **A** *is the sectional area of the limestone block.*
T *is thickness and,*
D *is density of mineral/limestone.*
Reserves computed are tabulated as under in Table 4

Table 4.

Block No	Block Name	Sectional Area (A) sq. m	Thickness (T)	Density (D)	Tonnage	Grade
1.	Kaniwan	93123	30	2.5	6984225	Cement Grade
2.	Braykujh	78204	30	2.5	5865300	Flux Grade-II
3.	Pandov Chul	70346	30	2.5	5275950	Cement Grade
4.	Malpora A	17334	30	2.5	1300050	Flux Grade-II
5.	Malpora B	11912	30	2.5	893400	Cement Grade

Total tonnage of 5 blocks = 32 Million Tons.
Potential proved reserves = 9.6 Million Tons.
(Dip down extension (T) of 10 meters from the surface are calculated under proved category)
Resources are to the tune of 22.4 Million Tons.

CONCLUSION

The surface geological mapping and geochemical analysis of surface random chip samples served the purpose in the establishment of grade and tonnage of Gund Saderkote limestone blocks. All the above discussed limestone blocks have commercial value in terms of its suitability in industries like steel and cement as per the Bureau of Indian standards, and National Council for Cement and Building Material, New Delhi, India. The quality based reserve estimation indicated 9.6 million tons of limestone in proved category within a depth of 10 meters from the surface and resource of 22.4 million tons within a depth of 20 meters.

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An aerial photo was taken of wheat fields in the middle of the Ophiolite Mountains, in the state of Mahdah

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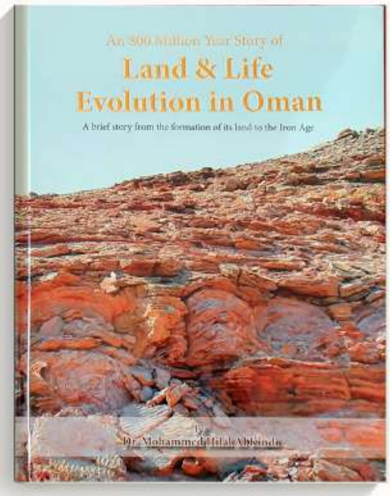

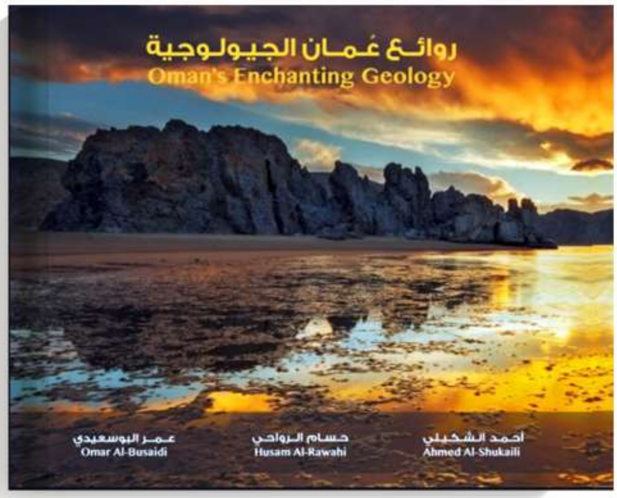

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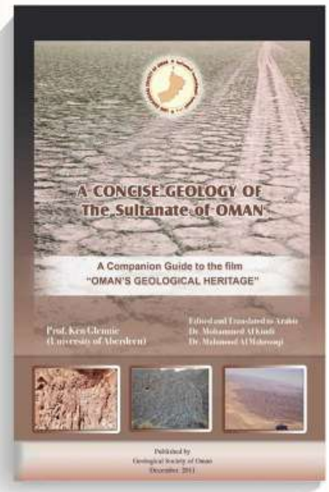

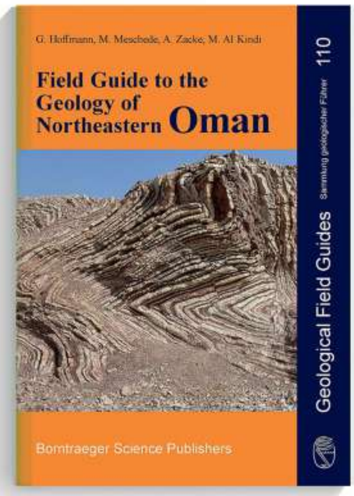

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