Short Note : New Carbonate Outcrops in the Badung Peninsula, Southern Bali

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INTRODUCTION

Recent excavations, facility constructions and road cuts in the Badung Peninsula, southern Bali (Figure 1) have provided additional exposure to the Selatan Limestone Formation. This short note highlights interesting features of the newly discovered outcrops, which are situated near popular touristic destinations including the beaches of the south coast and Garuda Wisnu Kencana Cultural Park (GWK; Figure 2)

Although the geology is relatively simple, the varying facies in the outcrops indicate a range of depositional processes. Overall, the limestone beds are flat. The dips of the layers are less than 10° at different directions. The limestones exposed at the observation locations consist of various types of limestones, which are essentially dominated by mudstone and packstone. Homogenous grains, classified as calcarenite to calcirudite, are also found abundant in several other units.

REGIONAL GEOLOGY

Bali Island is part of the Sunda Volcanic arc. The northern Bali is dominated by Quaternary volcanic and Iaharic deposits (Figure 1A). Several active volcanoes develop in the island, including Mount Batur and Mount Agung, which form the highest elevations in Bali. These volcanoes are generated by magma extrusion, a result of the subduction zone where the Indian oceanic plate plunged underneath the Sunda continental plate. The Badung Peninsula transcended sea level during the Pleistocene time.

The southern tip of Bali, called the Badung Peninsula, is dominated by Mio-Pliocene Selatan Limestone Formation (Figure 1B). The total thickness of the formation is unknown, but it is believed at least a couple hundred meters. The Selatan Formation is rich with corals, but was only observed in locations discussed in this paper. The studied locations were mainly composed of reworked carbonate grains. The upper part of the Selatan Formation is recognised as a vital aquifer in the area (Nielsen and Widjaya, 1989).

OBSERVATION LOCATIONS

1. Melasti Beach

Access to the Melasti Beach was recently opened and the road cuts allowed broad exposure of the Selatan Limestone Formation (Figures 2 and 3A). The total limestone thickness exposed in this beach is <100m, formed as several cliff-edge steps. In the eastern side of Melasti Beach, a limestone unit, which is roughly between 5-20m thick with foreset features, is well-exposed (Figure 3B). The beds are downlapping southwards, under and overlain by parallel beds.

The unit comprises wackestone to grainstone beds, deposited in shallow marine environment. Occasionally coral and shell fragments are found in the beds.

2. Pandawa Beach

Similar to the Melasti Beach, a recently made road cut provides access to another location called Pandawa Beach in the southern coast of Bali (Figures 2 and 3C). The limestones are exposed on both sides of the road. In addition, the beds have different properties, which generate colour variations. The darker colours usually have larger porosity; therefore rainwater is absorbed mainly in these units (Figure 3B). The beds are thicker than 1 meter and relatively flat.

3. Garuda Wisnu Kencana Cultural Park (GWK)

A cultural park was built in the central part of Badung Peninsula in 2000, called the Garuda Wisnu Kencana Cultural Park, or more commonly known as the GWK (Figures 2 and 4). A significant amount of limestones have been excavated to form an open area of traditional attractions such as Balinese dance performances. Some parts of the limestone remained and formed blocks in sizes of 50 x 50 m (Figures 4A and B).

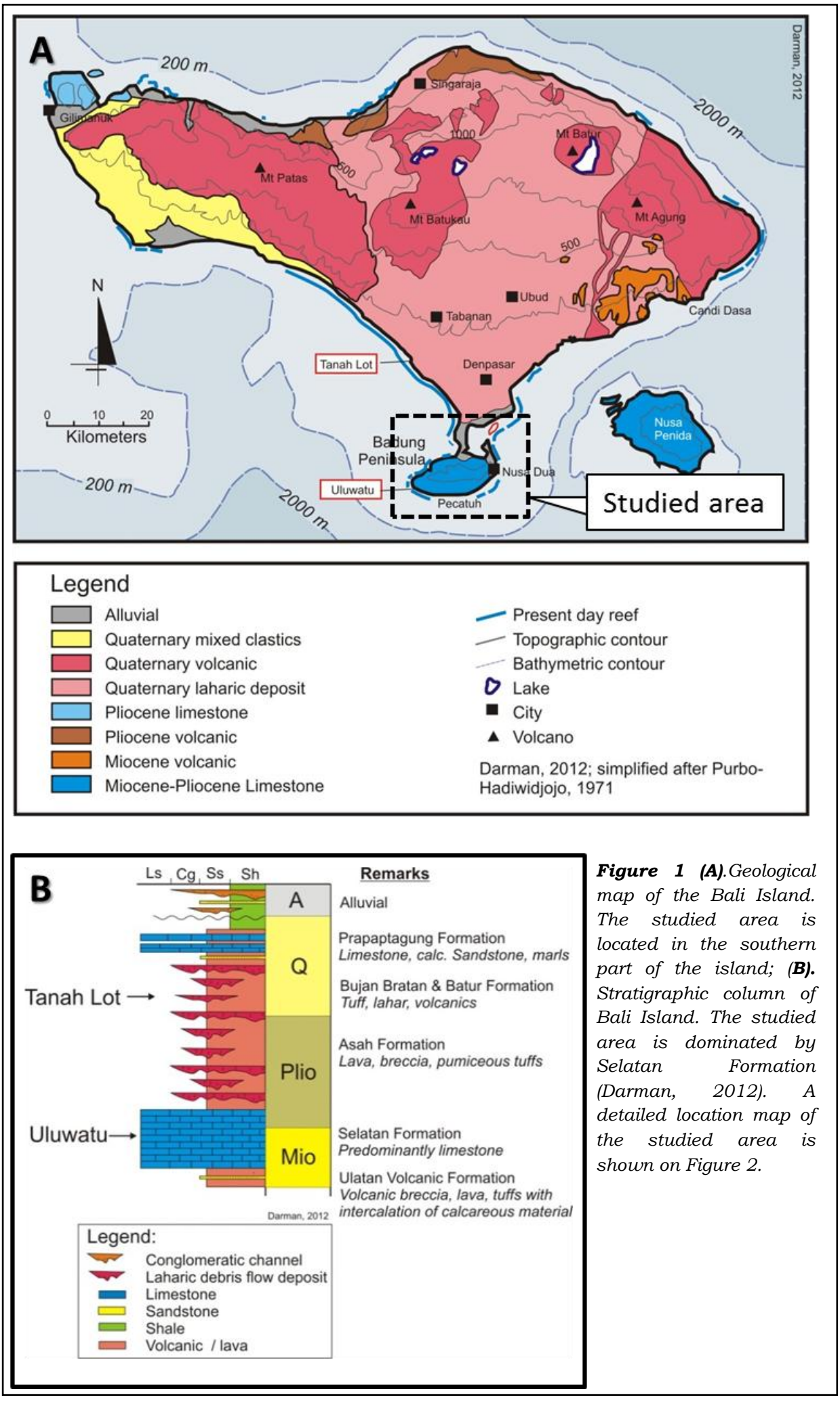


Figure 1 (A)*.Geological map of the Bali Island. The studied area is located in the southern part of the island;* ***(B).*** *Stratigraphic column of Bali Island. The studied area is dominated by Selatan Formation (Darman, 2012). A detailed location map of the studied area is shown on Figure 2.*

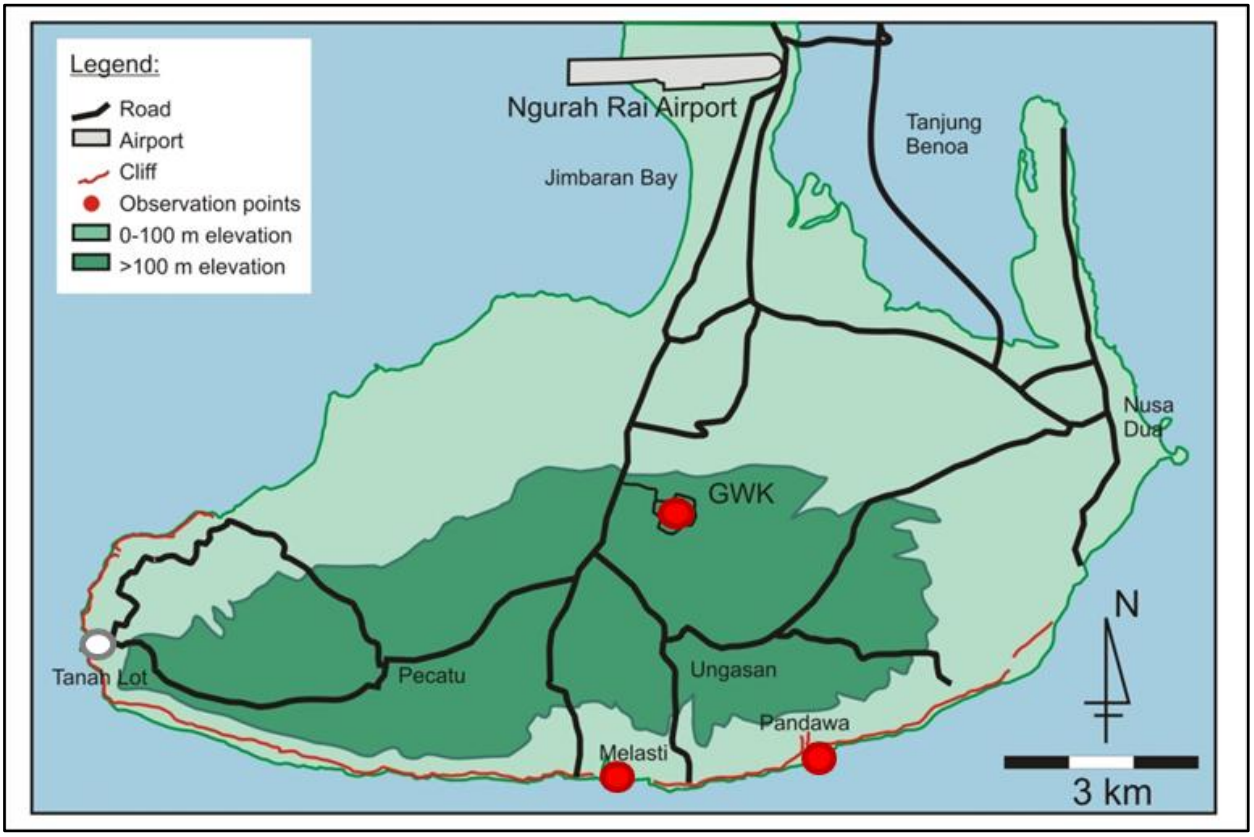


Figure 2. *Location map of the observation points in Badung Peninsula, southern Bali. (GWK = Garuda Wisnu Kencana)*

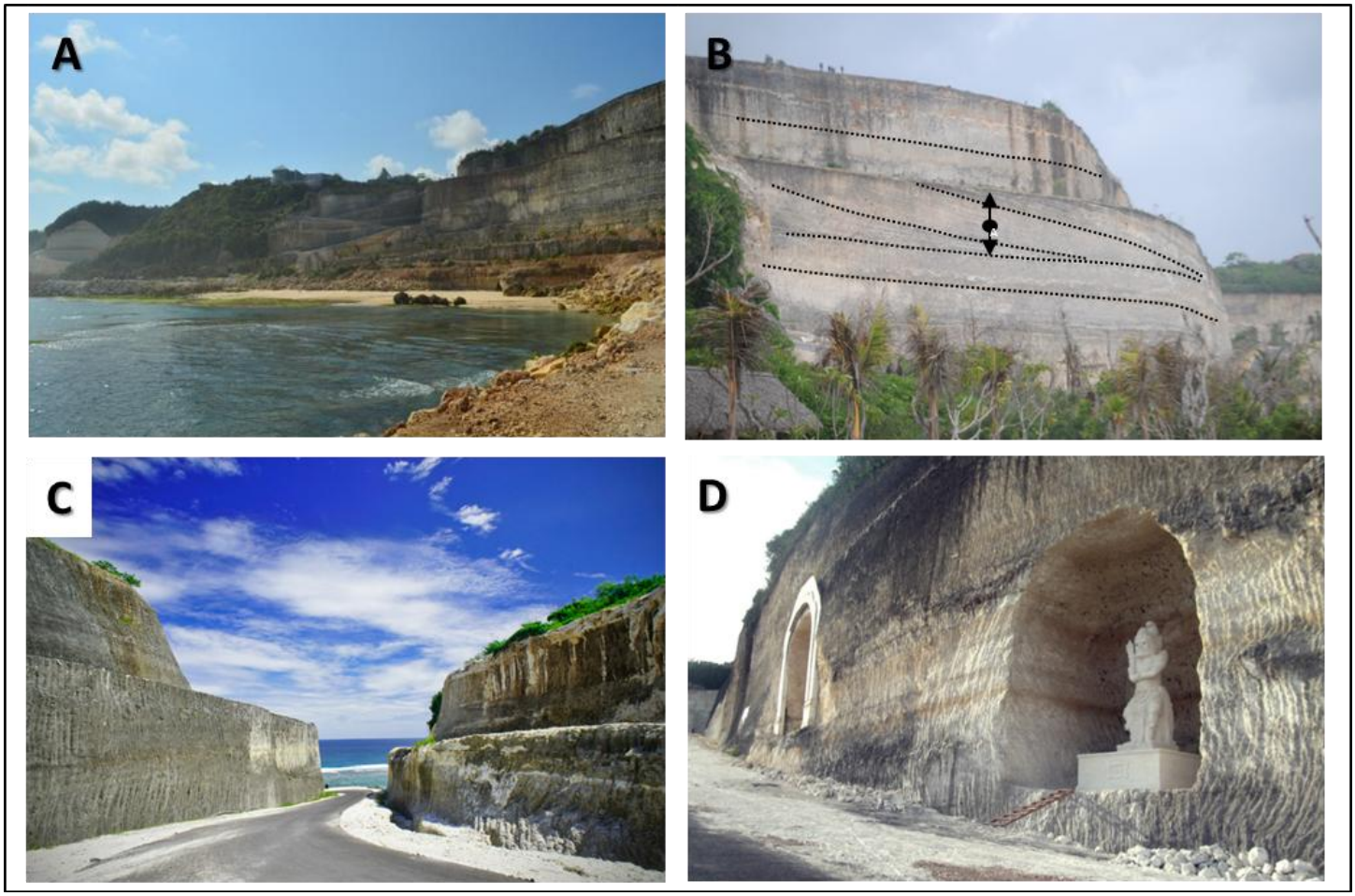


Figure 3. *The beaches in the southern Bali include Melasti and Pandawa Beaches (See Figure 2 for location map).* ***(A)*** *Melasti Beach has been excavated to provide a touristic location, and a unit with foreset feature is well-exposed in the eastern part of this location;* ***(B)*** *This unit is interbedded between carbonates with parallel beddings. The foreset unit is mainly composed of calcarenite-calcirudite. Relatively new road cut near the Pandawa Beach* ***(C and D)*** *also exposes the Selatan Limestone Formation.*

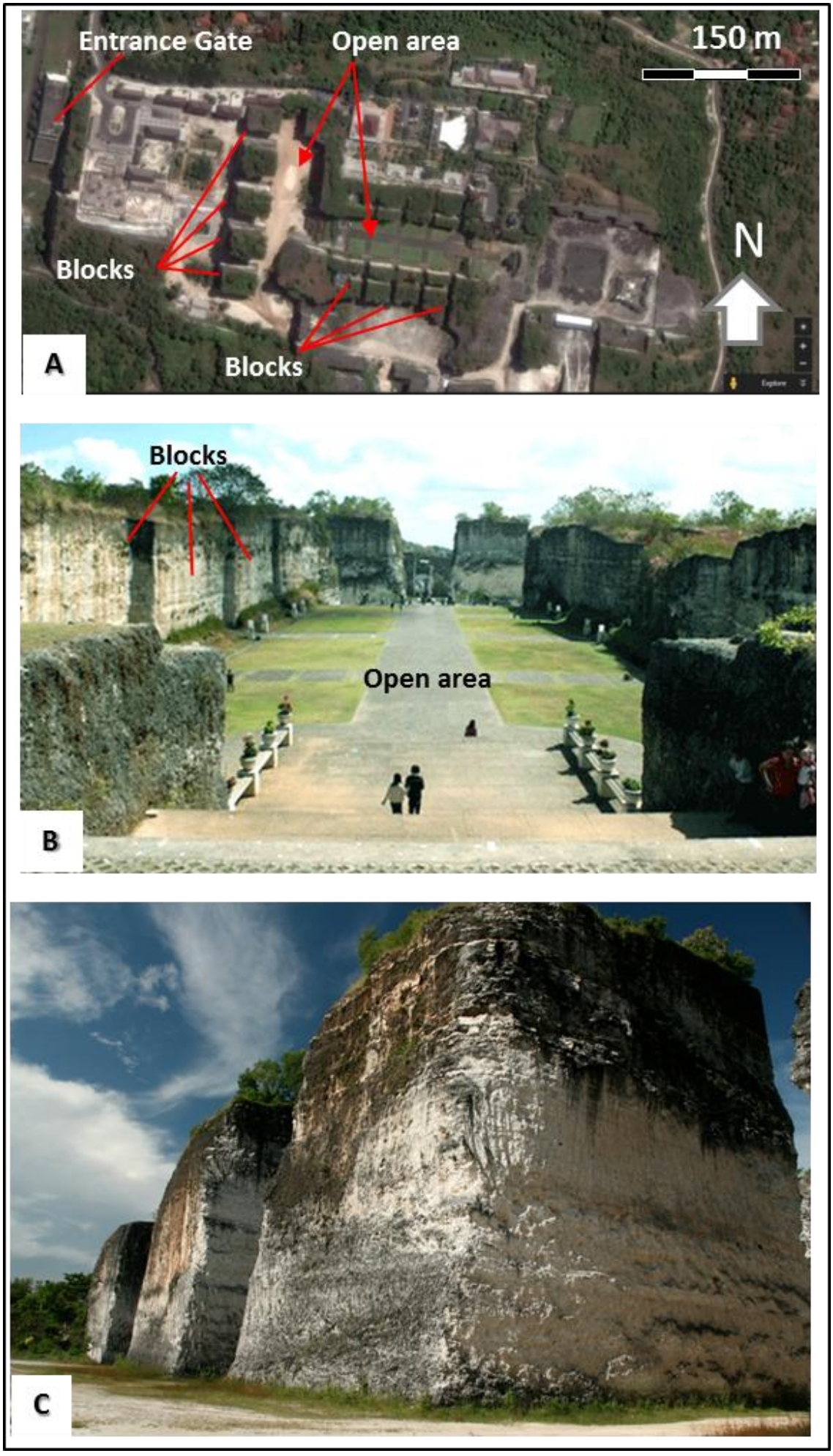


Figure 4. *Garuda Wisnu Kencana Cultural Centre is located in the central part of Badung Peninsula (See Figure 2 for location map). The area has been excavated in part and some were left as blocks, which provide limestone outcrop exposures. The limestone units are dominated by packstone to grainstone units.* ***(A)*** *Google satellite image of GWK, showing the open area and the carbonate 'blocks';* ***(B)*** *The open area and the walls of the limestone blocks;* ***(C)*** *A closer image of the limestone block showing some beddings.*

Layered limestone beds can be thoroughly observed on the wall of the blocks (Figure 4C). They are more than 1 meter thick and the beds are relatively flat with irregular surfaces. The textures of the layers generate colour variations of the general flat beds.

CLOSING REMARKS

The number of new outcrops in Badung Peninsula is quite significant. They are relatively fresh and can be easily observed. These large outcrops give a clear three-dimensional view of the beds. Logistic access and carbonate variations in the area provide an opportunity for detailed mapping, for example, students may engage in a mapping exercise. Lateral facies and lithological variation of the rock units may help as an analog of a oil & gas fields produced from carbonate reservoirs.

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FOSI News

FOSI Goes to Campus

"Have you ever been thinking ahead of time? Do you believe that knowledge and age must grow together?"

Those are the kind of questions being put forward to a group of university students visited by FOSI recently.

It is FOSI's interest to foster scientific spirit in Indonesia for the next 20 years and to see Berita Sedimentologi and Academia grow together, so we start from now. "FOSI Goes to Campus" is our new way to get more interest from the academia. In this program, professionals from different companies share topics about sedimentology to students in various campuses and encourage them to publish their ideas.

The first "FOSI Goes Campus" was on October 31st, 2015. Mohamad Amin Ahlun Nazar, our University Link Coordinator, and Bagus Priyanto (StatOil/AAPG VGP) and Muhamad Rizky Harun (Pertamina EP) visited the University of Indonesia. They presented topics about Deltaic and Deep Water Sedimentology, Sedimentology in Geophysic and Reserve Estimation Workshop.

There were 43 eager young minds from the Geophysic and Geoscience Dept. of University of Indonesia who attended the Course and Workshop, which was held in the Pertamina CEO Room, MIPA UI.

We also believe in "Thinking Differently" in the sense that Indonesia's geological objects are different one to another. This is the reason why during the occasion, FOSI also promoted "Long Term Research Plan" concept. This concept is about how students can do a continuous research in a small group of students from various levels (senior to junior) working together to reveal how modern sedimentology forms and changes by time.

The speakers were invited to give feedback about this activity and their various comments are as follow:

"Sharing to student is challenging, because we have to find the simplest word to describe geological phenomenon, but indeed it is a rewarding experience to share valuable time to student.", said Amin.
"We should do a course together again next time.", said Bagus.

If you are interested to visit campus together with FOSI to inspire and share your daring experience and rich knowledge to the students, or if you are an academia and your campus needs some refreshing workshop/course from professionals, please feel free to speak to us. FOSI would be very happy to work with you to build a stronger relationship between the industry and the academia in Indonesia through our "FOSI Goes to Campus" program.