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The shaping and demise of the Tusan Beach "Drinking Horse", southwest of Miri, Sarawak

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Abstract: The Miri-Bekenu coastline is formed by Neogene clastic rock formations that are poorly consolidated. These formation outcrops are shaped by weathering elements of tropical rainfall, wind and coastal erosion, and deformation processes such as tectonic uplift, structural faulting and folding. The geological monuments of the Miri area such as the iconic Tusan Beach "Drinking Horse" cliff structure generally withstand weathering degradation and coastal erosion poorly. Further to this, housing projects, road constructions and encroaching new plantations had their share in destructing geological landmarks. In this article, we discuss the case study of the "Drinking Horse" starting from its creation, the impact of weathering elements and coastal erosion, plus human interferences that resulted in its ultimate demise. Nonetheless, due to its seaward-dipping sedimentary layers (including thin clay-rich beds), it was predestined for gravity sliding. Coupled with pounding erosion, the cliff inevitably collapsed and any prior preservation effort carried out to protect the structure would have been in vain.

Keywords: "Drinking Horse", Bekenu, Miri, Pantai Bungai, Tusan Beach

INTRODUCTION

The Tusan Beach (coordinates: 04007'32.1" N, 113049'25.9" E) with rocky cliff facing the South China Sea is located in the district of Bekenu, some 40 km SW of Miri accessible via the Coastal Road towards Bekenu (Figure 1). The beach is a popular geotourism site (Andriansyah *et al*., 2016; Kessler & Jong, 2018), as well as for petroleum geology related excursion with excellent exposure of massive sandstone layers often used as analogue for the subsurface petroleum reservoirs (Wannier *et al*., 2011; Kessler & Jong, 2018). On Thursday night, 20th February 2020, the iconic Tusan Beach "Drinking Horse", also famously known as "Horse Head Drinking Water" (Dayak Daily, 2020), a locally well-known tourist hotspot and cherished landmark (Figure 2), unexpectedly collapsed. There is nothing left of the famous sight except for a pile of rubble. In this article, we investigate the factors for the shaping of "Drinking Horse", and discuss the impact of weathering elements and marine coastal erosion that ultimately resulted in its demise.

LOCAL STRUCTURAL SETTING

The prominent "Drinking Horse" cliff structure, formed by Neogene massive channelized sandstone and claystone sedimentary layers, was sculptured by the onslaught of tropical rainfalls, wave and wind erosions, as well as by longshore currents. The cliff section between Miri and Bekenu (Figure 1) has shown itself being particularly vulnerable to erosion for the following reason:

- The formation consists of a sequence of Neogene and poorly consolidated rocks, it dips with a relatively gentle angle of 10° (South of Miri) to a steep vertical 90° (North of Bekenu) facing the South China Sea, with the effect that longshore currents incise the coast layer-by-layer into the rock formation (Figures 3 and 4). Near the Tusan cliff section, including the "Drinking Horse" structure, the seaward dip angle is in the order of 35°; with the strike/dip of the sedimentary layers as measured by Andriansyah *et al*. (2016) reportedly N225°E/35°. Pounded by coastal currents, waves and affected by bio-erosions (Dodge-Wan & Nagarajan, 2019; 2020), as well as scoured by wind and rainfall, the cliff section became unstable. Finally, gravity sliding (thin layers of mudstone between the massive sandstone are also facilitating land-sliding) led to its ultimate collapse. Interestingly, it was reported in the local press that "Building of access road could have hastened Horse's demise" (Borneo Post, 2020), hence human interferences may have had a detrimental impact to the destruction of the cliff section.
- Furthermore, the cliffs are weakened by the effects of structural folding and faulting, with tectonic pulses affecting the area until the Holocene (Kessler & Jong,

Figure 1: Aerial photograph showing the position of the "Drinking Horse" evolved from "Headland 2" on the actively eroding coastline between Miri and Bekenu. Index maps show the location of Tusan and Tanjung Batu beach areas. The seismic section shown in Figure 9 is located offshore of Pantai Bungai.

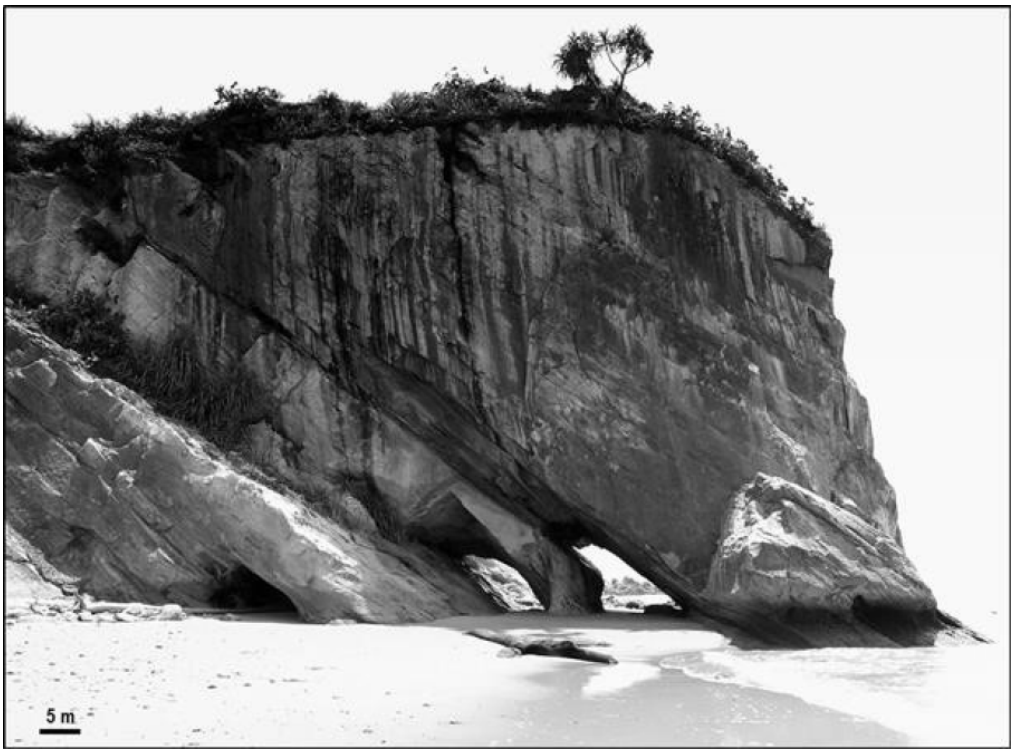

Figure 2: Photo of the "Drinking Horse" taken around 2012. At this time it looked rather like a water-drinking boar. The rock section is formed by 35° N dipping clastics, with a prominent body of mid-size, cross-bedded sandstones with minor interbedded claystones. The roof of the horse is capped by a marine abrasion terrace that originated at the end of the Pleistocene (see Figure 7). Note the bottom part (mouth piece) of the area was affected not only by wave action, coastal current incision, but was also prone to biological weathering by isopod *Sphaeroma triste* (Dodge-Wan & Nagarajan, 2020).

Figure 3: Longshore current and wave actions have eroded the bottom section of the rock face causing the collapse of the overlying section.

Figure 4: The seaward-dipping clay sections form ideal gliding surfaces, and particularly after strong rainfalls the rock face becomes unstable and collapses.

2014a & b; 2015a & b; 2017). The geological map in Figure 5 and the profile sections shown in Figure 6 indicate the amount of tectonism in this rather young and active basin. In the profile of Figure 7, we see the coastal section as being the northern leg of a tectonic zone characterized by strike-slip faulting and thrusting.

- Observing the cliff section over a period of some 12 years, one recognizes how fast the coast is being eroded, in the order of 2 m/year. Looking towards the sea, one notices a shallow greenish shallow-water zone which reaches more than a kilometre out into the sea and indicates a zone of previous

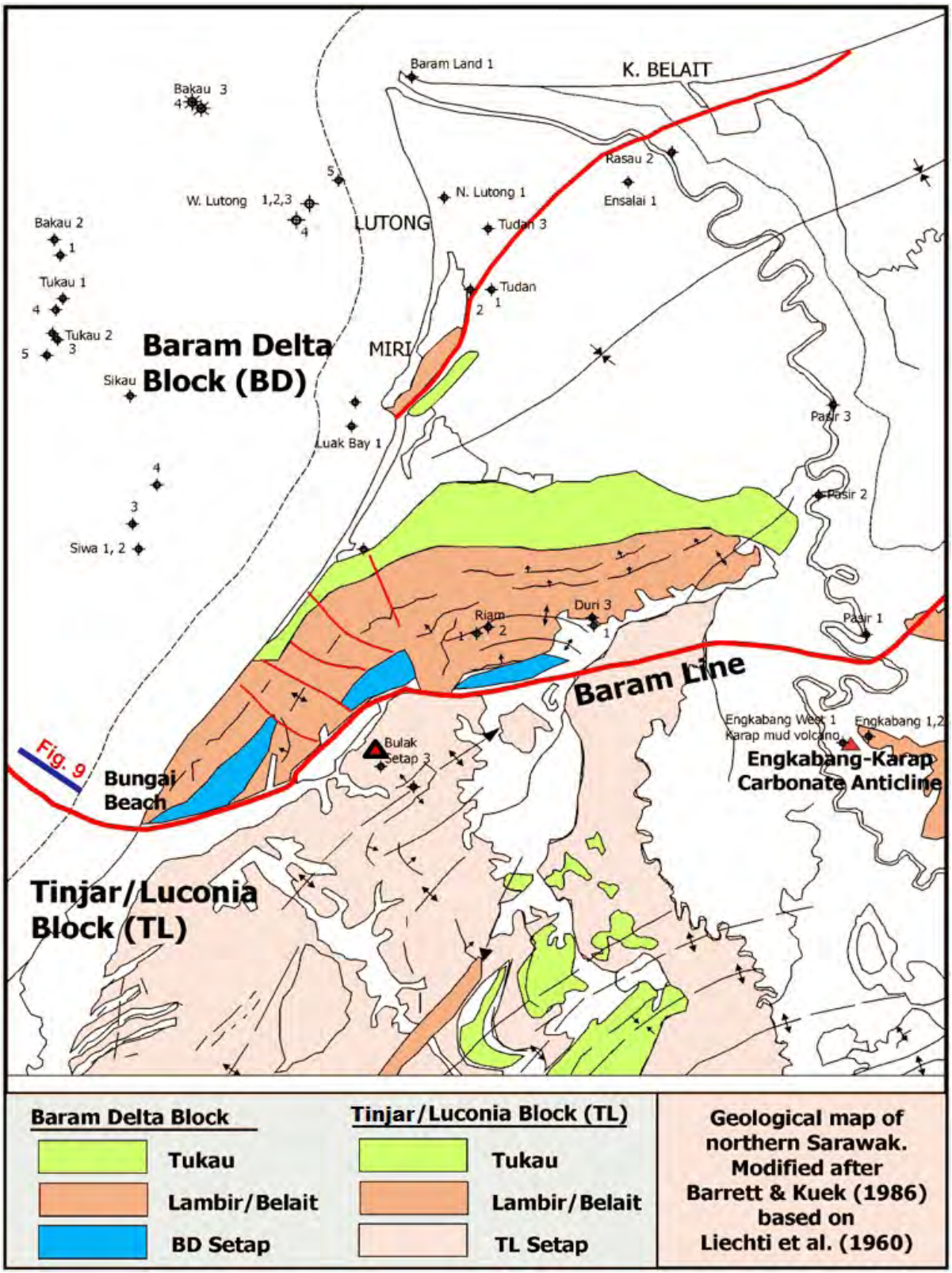

Figure 5: Simplified and updated geological map of northern Sarawak with active thrusting and folding (from Jong & Kessler (2019), modified after Barrett & Kuek (1986) based on Liechti *et al.* (1960)).

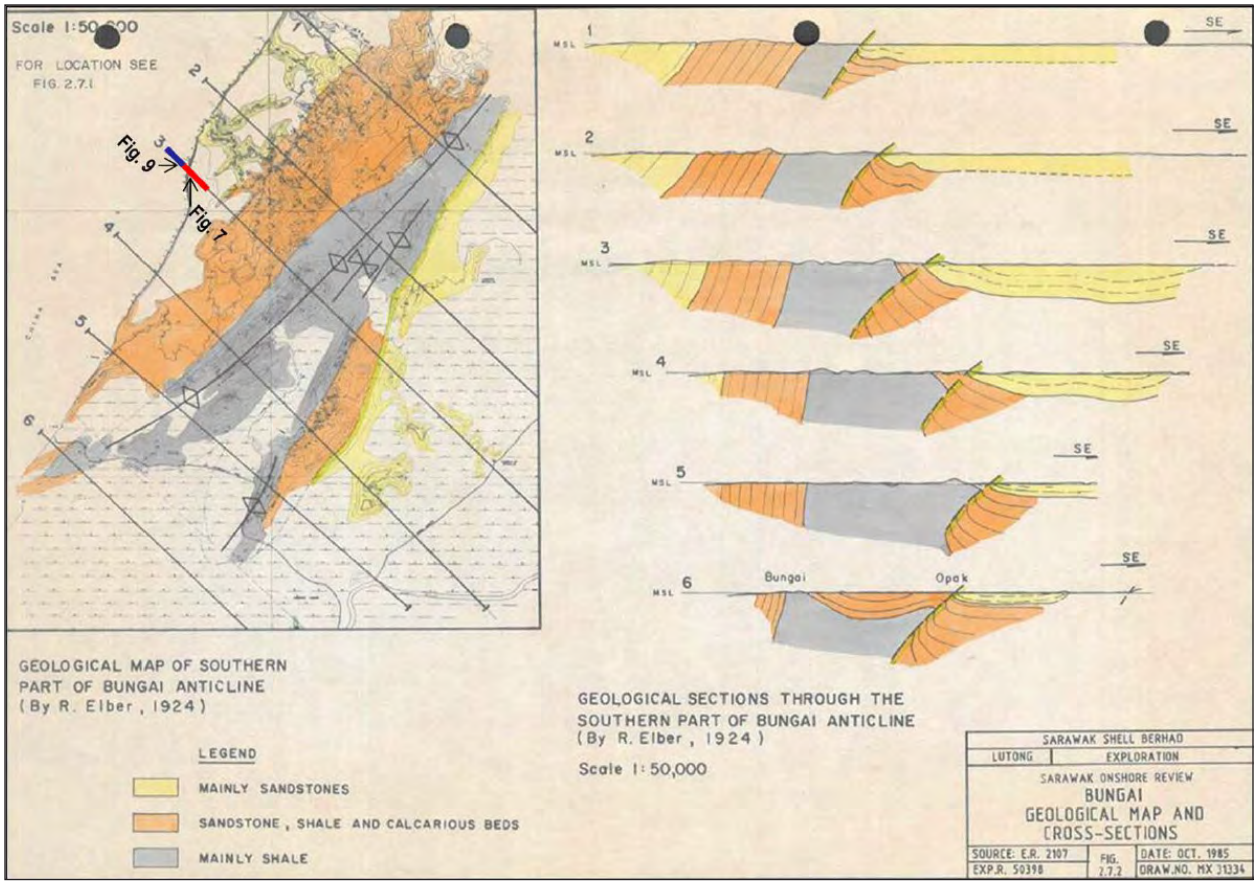

Figure 6: Re-drafted geological sections by Shell of older geological field sections. The "Drinking Horse" lies at the NW end of Profile No. 3 with approximate locations of Figures 7 and 9 indicated (from Barrett & Kuek, 1986).

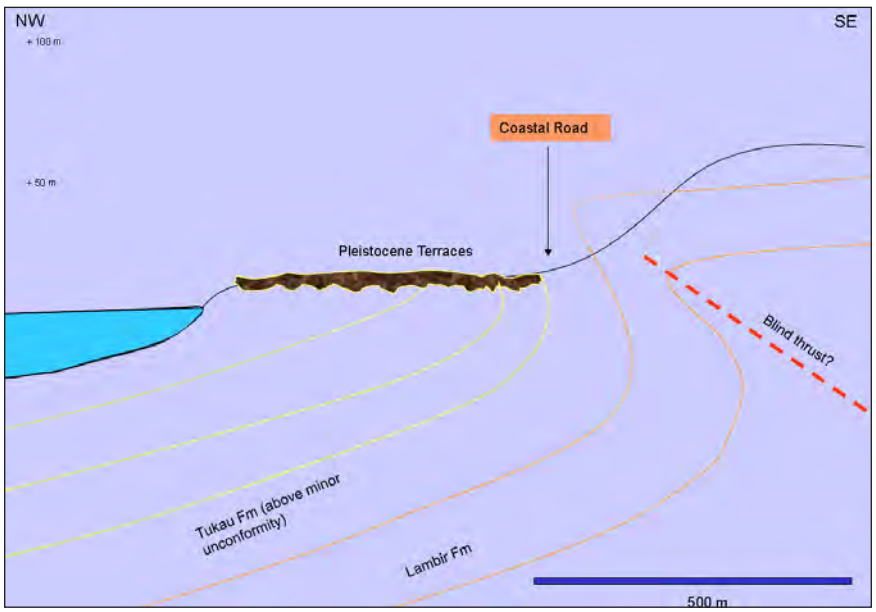

Figure 7: Tectonic profile section in the vicinity of the Tusan cliff area, which shows seaward dipping of the formation underlying the Pleistocene terraces. Note the approximate location of profile section is at the NW end of Profile No. 3 in Figure 6.

abrasion by wave action (Figure 8). Furthermore, on an old seismic line (Figure 9, Line 1141 acquired in the early 60's), we can see abrasion/erosion on the eastern end, and deposition (as onlap) in the NNW.

- The coastline is also characterized by pulses of uplift and the formation of abrasion terraces. The most prominent terrace was formed in the latest Pleistocene, and has been uplifted in the Tusan area by some 20 meters (Kessler & Jong, 2014a). Minor terraces are indicative for an uplift that may even continue to present day (Figure 10).

In summary, we observe a combination of tectonic forces and (the by far more important) combined erosional processes which shaped and continue to shape the morphology of the coastline.

Figure 8: Looking towards the sea from the Tusan cliff area, one notices a shallow greenish shallow-water zone which reaches more than a kilometre out into the sea indicating a zone of previous abrasion and erosion by wave action.

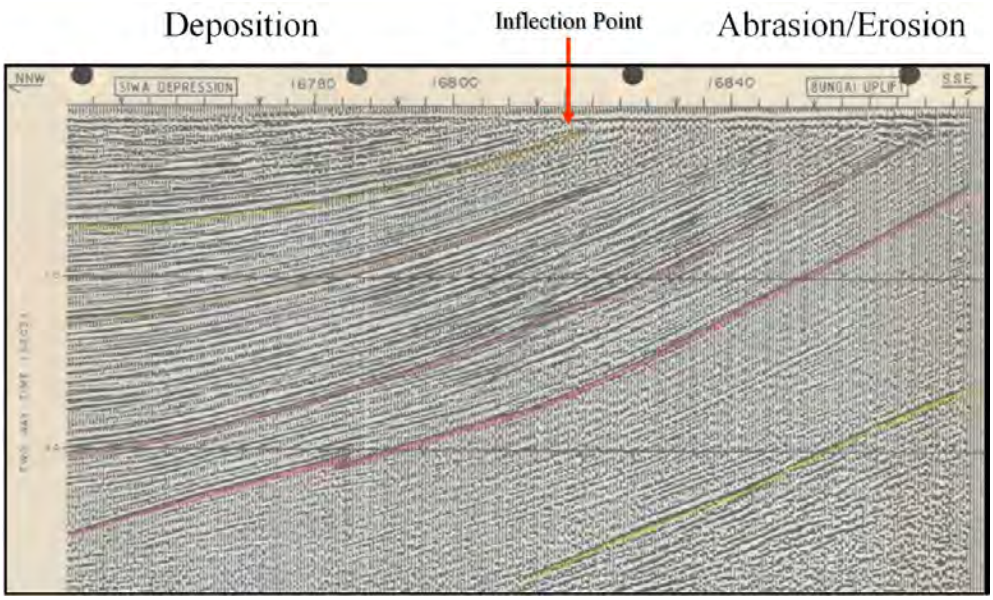

Figure 9: On an old seismic line (Line 114, acquired in the early 60's), we can see abrasion/erosion on the eastern end (Pantai Bungai), and deposition in the NNW basinal area. The abrasion platform of Figure 7 corresponds to the area of truncated seismic event. Note the approximate location of the section at the NW end of Profile No. 3 in Figure 6 (from Barrett & Kuek, 1986).

SHAPING THE "DRINKING HORSE" AND ITS DEMISE

In 2009 (Figure 11), the "Drinking Horse" as we knew it later, did not exist. The so-called "Headland 2" (Figure 1), stood out as a square block mainly formed by sequences of channelized sandstone with interbedded claystone layers. Waves and currents had already carved out a rock pillar, which collapsed around 2010.

Around the same time, longshore currents started to scour the promontory (Figure 12), and created caves which grew in size over time (Figure 13). By 2012, as the erosion processes continued, the caves became bigger and roof sections within the caves collapsed (Figure 13). In addition, the effect of bio-erosion, which is occurring in the Tusan beach area, is also mentioned by Dodge-Wan & Nagarajan (2019 & 2020).

Over the years, more roof section collapsed, and the previous two separate caves had coalesced to form one large cavity (Figure 14). In the picture taken in 2017 (Figure 15), we understand how fragile this geological landmark had become. Then, in early 2020, the inevitable happened - the "Drinking Horse" collapsed overnight on 20th February, perhaps also triggered by road construction to the cliff area (Borneo Post, 2020; Dayak Daily, 2020; Figure 16). Sadly, the lifespan of the "Drinking Horse" was a mere 11 years since its creation in 2009.

Figure 10: The most prominent terrace formed in the latest Pleistocene, and has been uplifted in the Tusan area by some 20 meters (Kessler & Jong, 2014a). Minor terraces are indicative for uplift pulses that may even continue to present day.

Figure 11: In 2009, the "Drinking Horse" as we knew it later, did not exist. The so-called "Headland 2" stood out as a square block mainly formed by sequences of channelized sandstone layers. Waves and currents had already carved out a rock pillar to the right, which collapsed ca. 2010.

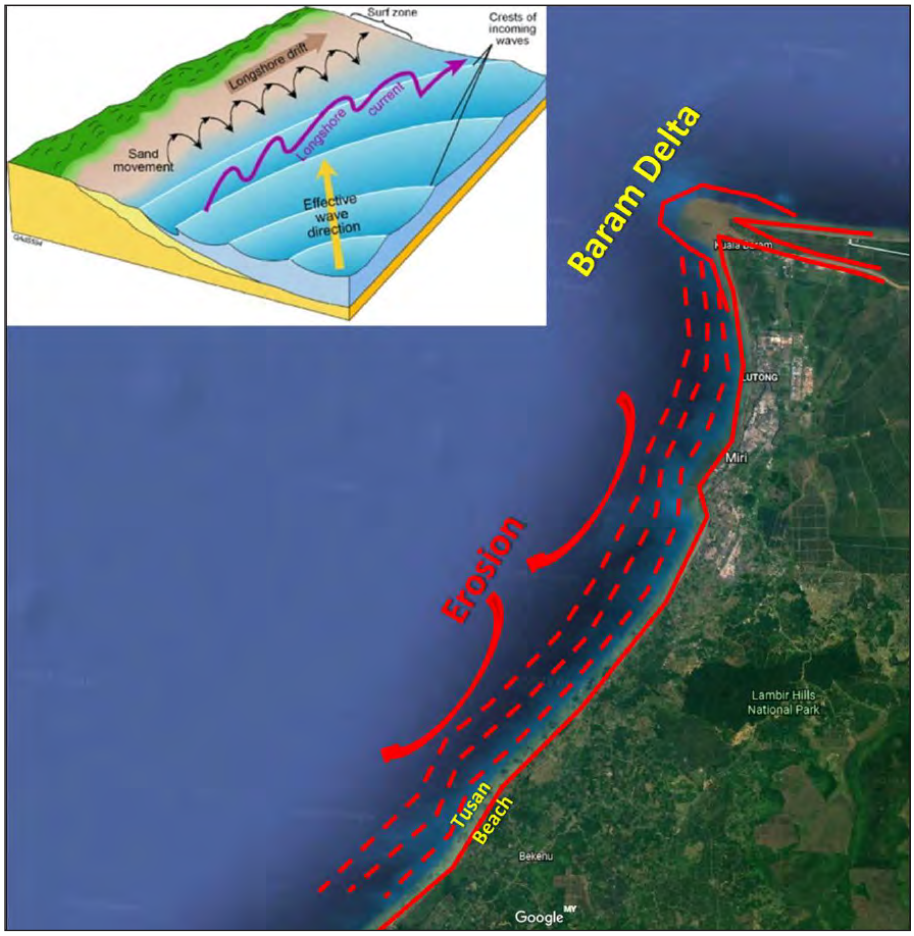

Figure 12: The mechanism of longshore currents resulted in severe coastal erosion along the Miri-Bekenu coastline.

Figure 13: In 2010, longshore currents and bio-erosion started to scour the promontory, and created caves which grew in size over time.

Figure 14: As the coastal and bio-erosion processes continued, the caves became bigger and roof section within collapsed.

Figure 15: Over the years, more roof section collapsed, and the previous two caves had coalesced to form one large cavity. In this picture taken around 2017, we understand how fragile this geological landmark had become (photo credit: Curtin University Malaysia).

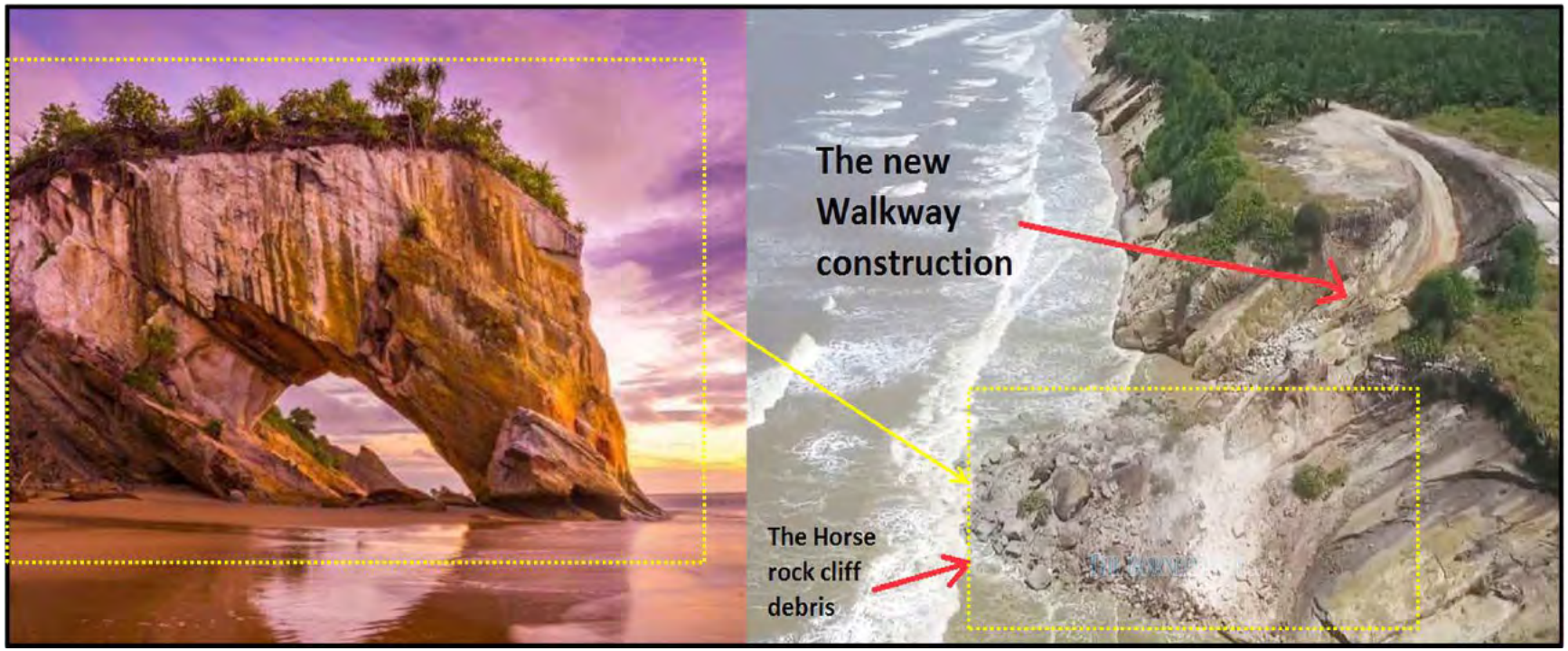

Figure 16: In 2020, the inevitable happened - the "Drinking Horse" collapsed, perhaps triggered by development measures and road construction (photo credit: Left, Curtin University Malaysia; Right, Borneo Post).

DISCUSSION

Could the "Drinking Horse" be saved? Despite the fact that geotourism has benefitted Miri, and likewise local kampung economics to some extent, the area geotourism potential was not recognized for many years. This seems to have changed a while ago, but development plans and actions to save and preserve geological features such as the iconic "Drinking Horse" have come a bit late. As the years passed, one after another geological monuments fell down, or were bulldozed for the sake of housing development and road construction projects, or gave way to new plantations.

Apart from the "Drinking Horse", one good example for this was the destruction of a world-class outcrop in Sungai Rait, which is now inaccessible due to the construction of a chicken farm (Figure 17), in addition to falling prey to degradation by weathering and vegetation. If on same occasions we believe that the geological monuments of the Miri area could have been saved such as the famous Airport Road Outcrop (Wannier *et al*., 2011; Kessler & Jong, 2018), in others such as the "Drinking Horse" it would have been nearly impossible to preserve it. Only the placement of large boulders in a demi-circle could have prevented waves and longshore currents from scouring the monument, however there are no access roads to bring the necessary amount of rock.

As remarked by Kessler & Jong (2018), until today there is little consciousness and conservation effort in respect to the potential touristic values of these geological monuments. Their preservation would require a masterplan spearheaded by the Miri City Council, in collaboration and with the support of the State government and Tourism Board to promote their geotourism potential, in addition to sustainable sponsorship of the local private industries to maintain these geological monuments.

CONCLUSIONS

The morphology of the Miri-Bekenu coastline is formed by Neogene clastic rock formations that are poorly consolidated. These are shaped by coastal and bio-erosions, rainfalls and wind actions, and deformation processes such as tectonic uplift, structural faulting and folding. Geological monuments of the Miri area are prone to rapid erosion. Further to this, housing and encroaching plantation projects had their share in destructing geological landmarks. The call for their preservation is imminent, and would require thoughtful considerations by the Miri City Council to promote their geotourism potential, and with sustainable sponsorship of the local private industries to maintain

Figure 17: The world-class rock escarpment suitable for petroleum geology-related excursion at Sungai Rait (see Kessler & Jong, 2018) has given way to a chicken farm and degraded by weathering and dense vegetation.

these geological monuments. However, in the case of the "Drinking Horse", any effort of protecting was proven to be in vain.

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