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# Jurassic-Cretaceous fluvial channel and floodplain deposits along the Karak-Kuantan Highway, central Pahang (Peninsular Malaysia)

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**Abstract** — A fluvial succession of probable Jurassic-Cretaceous age is well exposed at Km 160 along the Karak-Kuantan highway, central Pahang. Although the exact age of these rocks is unknown, the depositional environment of the rocks, and their relatively unmetamorphosed nature and low structural dips compared to surrounding rocks, suggest that they are equivalent to the 'post-orogenic' continental deposits, generally referred to as the Jurassic-Cretaceous Gagau Group. Such outcrops are rarely found preserved anywhere in Peninsular Malaysia, and if conserved, provides a good locality for the study fluvial deposits. The succession comprises fining-upward channel fill sands and muds, intercalated with red and green overbank and floodplain mudstones. There are four major sandbodies, three of which represent fining upward channel/channel margin sands (>2 m thick), while the fourth consists of at least four tabular/sheet-like sandstones (1.5 m thick) interpreted as crevasse-splay sheet sand deposits. Their facies characteristics suggest that the sediments were deposited in a low-lying meandering channel-floodplain system. The co-existence of red and green mudstones in the floodplain facies suggest that there could be seasonal/climatic fluctuations that affected the geochemical conditions in the basin.

**Keywords:** Jurasssic-Cretaceous, fluvial, channel, floodplain

## INTRODUCTION

Outcrops of Mesozoic rocks are known to occur in isolated localities along the eastern margin of the Central Belt of Peninsular Malaysia (Figure 1). These rocks range from Jurassic to Cretaceous in age, and invariably comprise continental, mainly fluvio-lacustrine sediments and are believed to be deposited in fault-bounded, intermontane basins as a result of extension of the uplifted orogen that was produced by the collision of western and eastern Malaya during the Late Triassic (e.g. Hutchison, 1989). Not much has been published on these rocks, perhaps because of the generally poor exposure.

The Lebuhraya Pantai Timur – Fasa 1 (East Coast Expressway) between Karak and Kuantan cuts through central Pahang. This region is also known as the 'Central Belt', a geological domain underlain by mainly Late Paleozoic and Triassic marine rocks (Semantan Formation and equivalents) that represent the closing stages of the Paleo-Tethys ocean (e.g. Metcalfe, 1988). The Jurassic-Cretaceous rocks overlie the Late Paleozoic sediments with great unconformity, and represent the post-orogenic molasses deposits. At Km 160.8 along that highway, about 4 km east of the Sg. Jempol bridge (see map in Figure 2 for locality), a succession of gently dipping fluvial strata is exposed as a result of the highway construction. This provides an opportunity to study these rarely exposed rocks. The lithologies generally resemble those exposed at Paloh Hinai, about 80 km from Bandar Muadzam Shah, which have been described partly by Abd Hadi & Lee, 1997; Abd Hadi, 1999, 2001). This paper describes this excellent exposure of Jurassic-Cretaceous sediments and interprets the facies and depositional environments.

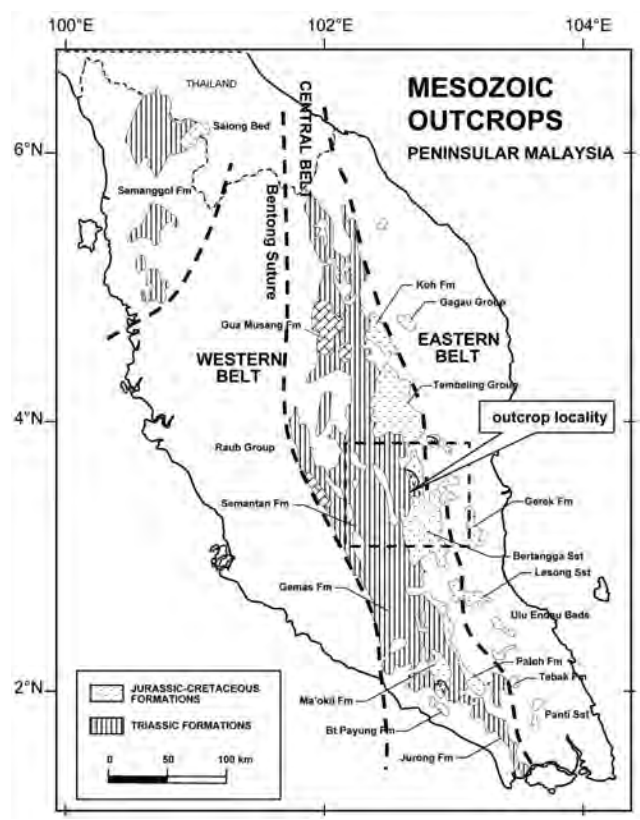


**Figure 1:** Simplified geological map of Peninsular Malaysia, showing the pre- and post-orogenic formations (modified from Geological Survey of Malaysia, 1985). Dashed rectangle is the area of interest in this field trip.

## GEOLOGICAL SETTING

Peninsular Malaysia is divided into three main geological domains, namely the Western, Central and Eastern Belts (Figure 1). These domains differ in several aspects, including lithology, age, tectonics, structure and palaeogeography. The Lebir fault and Bentong Suture define, respectively, the eastern and western margins of the Central Belt, which includes west and central Pahang, eastern Negeri Sembilan, western Johor and the entire state of Kelantan. Lithostratigraphically, it is represented by the Kepis, Lop, Bera, Kaling, Paloh, Ma'Okil, Gemas, Semantan, Tembeling Group and Koh Formations, and the Gua Musang Group and the Bertangga Sandstone. Ages range from Permian to Cretaceous.

As the result of the Indosinian Orogeny, Late Triassic to Jurassic continental deposits representing the post-orogenic stratigraphy lie unconformably on the pre-Triassic rocks, including the Semantan Formation. These relatively mildly deformed Late Jurassic-Early Cretaceous continental deposits represent a phase of continental "molasses" deposition (analogues to the Alpine molasse of Europe). They are referred to as the Tembeling Group, which extends along the eastern margin of the Central Belt, from Gunung Tahan to Bukit Ibam. Local equivalent names include the Gagau Group and Tebak Formation. The Tembeling Group is mildly folded into broad synclines and anticlines, in contrast to the highly deformed Semantan Formation. It may be that the Tembeling Group represents the older parts of the molasses succession in Peninsular Malaysia. Figure 1 shows a map of the post-orogenic deposits in relation to the pre-orogenic deposits.

Based on the earlier geological maps (e.g. Wan Fuad & Purwanto, 2004, Figure 2) the outcrop described in this paper belongs to the Bertangga Sandstone. The lateral (stratigraphic) equivalents of this unit in the region include the Gerek Beds, which are exposed along the Gambang-Bandar Muadzam Shah road, near Paloh Hinai. The age of these deposits have been assigned rather loosely as "Jurassic-Cretaceous" because of the sediments are poorly fossiliferous. They are thought to be equivalent to the Gagau and Tembeling rocks that crop out along the edge of the Eastern Belt of Peninsular Malaysia. The distinguishing feature of these beds is that they are less deformed compared to the Triassic Semantan Formation. They occur generally as moderately dipping strata roughly 50° to the east. Outcrops along the Gambang-Bandar Muadzam Shah road exposing Jurassic-Cretaceous continental deposits have long been known since the road was built in the early 1980s. These outcrops have been the subject of study by academicians, students, and industry geologists, the latter particularly for analogues to fluvial/channel deposits in the subsurface. Isolated outcrops of the Gerek Beds near Paloh Hinai were studied by Abdul Hadi and others between 1997 and 2001, and since 2001 have also been studied by the present author for in-house training material for geoscientists and

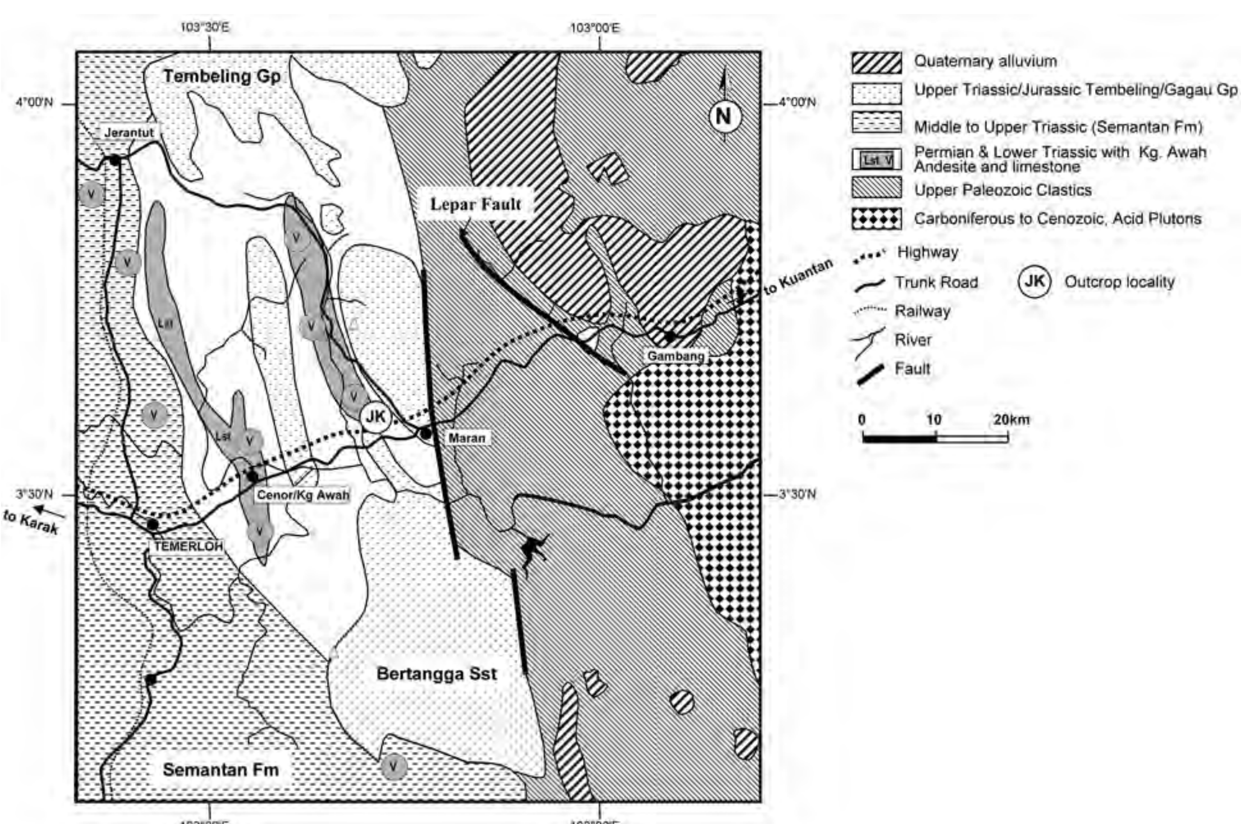


**Figure 2:** Geological map of the Central Belt, between Temerloh and Gambang, showing the main sedimentary formations and volcanic rocks. Modified from Wan Fuad & Purwanto (2004).

engineers. The quality of these exposures has deteriorated very rapidly since, and hence, the relatively new outcrops at Km 160.8 provide excellent new material.

## OUTCROP AT KM160.8, KARAK-KUANTAN HIGHWAY

The fluvial sediments are exposed on the southern side of the highway, while the northern side has been covered with concrete for slope maintenance. The succession comprises a series of fining-upward channel fill sands and muds, intercalated with red and green overbank and floodplain mudstones. There are four major sandbodies, three of which represent fining upward channel/channel margin/overbank facies. The fourth consists of at least four tabular/sheet-like sandstones interpreted as crevasse-splay sheet sand deposits. The erosional nature of the channel sandbodies, cutting down into the underlying mudstones, is clearly observed along the 120 m-long outcrop.

Figure 3 shows a sedimentary log of the whole succession, which has a total vertical thickness of about 40 m. The apparently gently dipping strata (oblique cut of 50 deg dip) enabled the lateral extent and geometry of the sandbodies to be determined (Figure 4). The succession starts at the base (western end) of the outcrop with a 2 m-thick bed of amalgamated cross-bedded, coarse-grained sandstone. The scour-and-fill structures in the trough cross-bedded sands contain mudclasts and pebbles (Figure 5). This seems to be the only occurrence of pebbly sandstone in the outcrop. The pebbly sandstone, which fines upwards into fine-grained parallel laminated and ripple-laminated sandstone, is overlain by a 1.5 m-thick fining-upward, sheet-like, fine-grained sandstone that passes upward into red and green siltstone and claystone (Figure 6). The 1.5 m-thick fine sandstone, which has a partly erosive base, is separated from the underlying pebbly sandstone by a 4 cm-thick red claystone (Figure 6). The red claystone

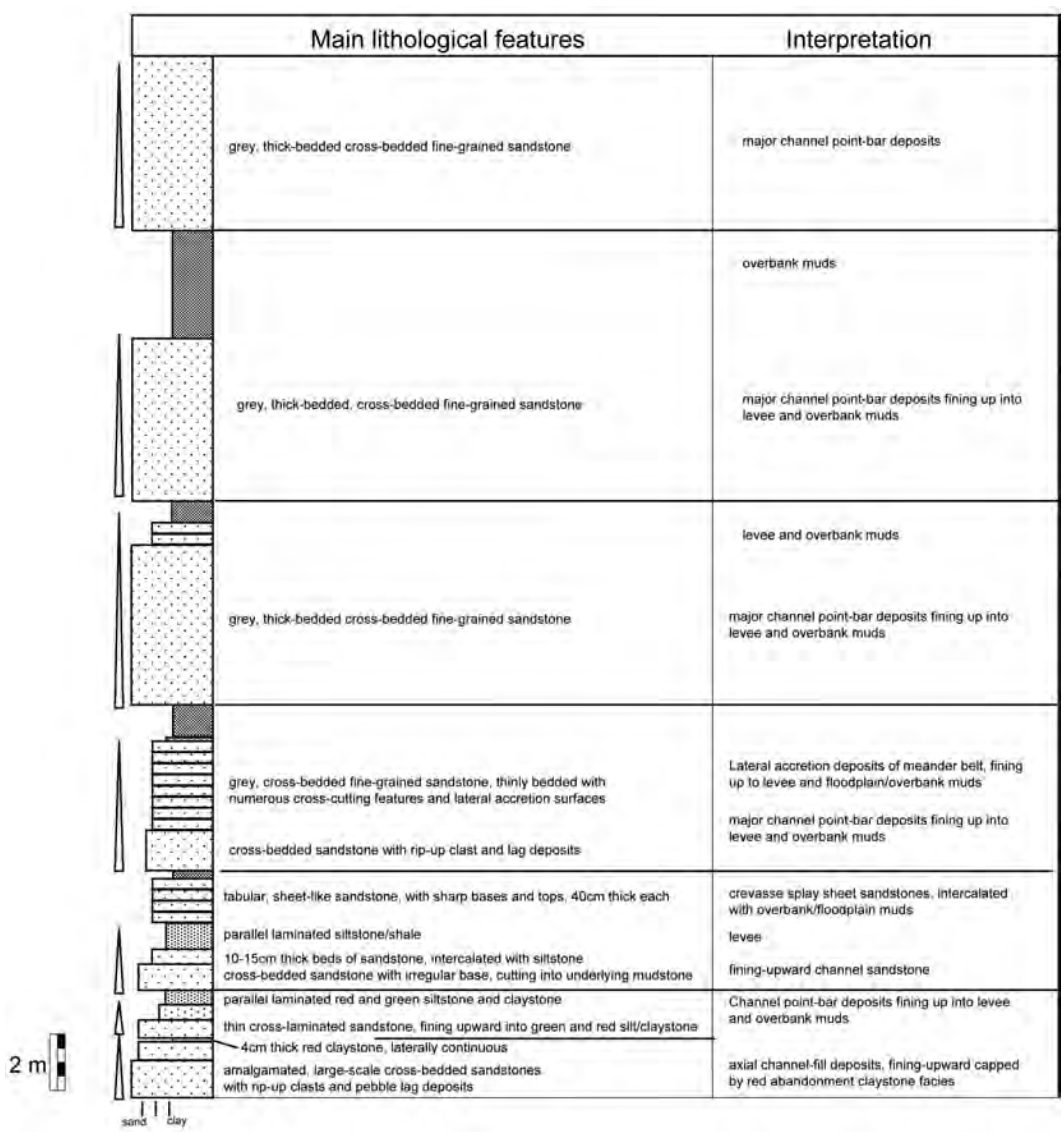


Figure 3: Sedimentary log of the succession exposed at the Km 160.8 outcrop, Lebuhraya Pantai Timur (Karak-Kuantan Highway).

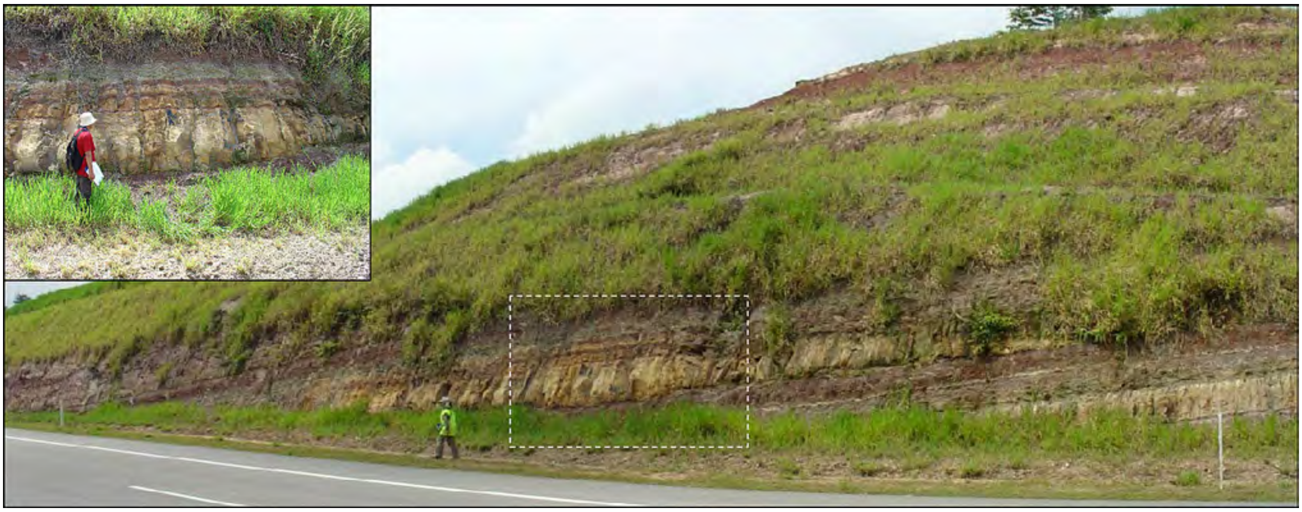

**Figure 4:** Southeastward view of exposure on the south side of Karak-Kuantan Highway, km 160.8. Low-dipping fluvial-floodplain deposits, with a major channel sandbody in the middle of the picture. Inset shows a close-up of the sandbody, with erosive base into underlying floodplain mudstones and showing fining-upward character, grading into laminated and red and green siltstone and claystone. Geologist for scale (1.5 m).

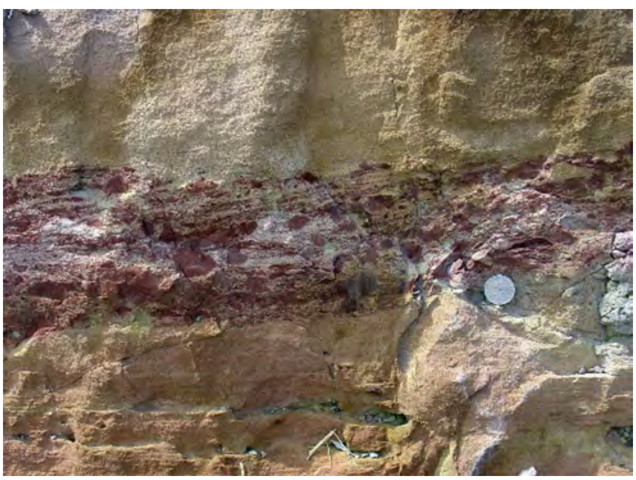

**Figure 5:** Concentration of mudclasts at base of channel scour, in the lowermost channel sandbody.

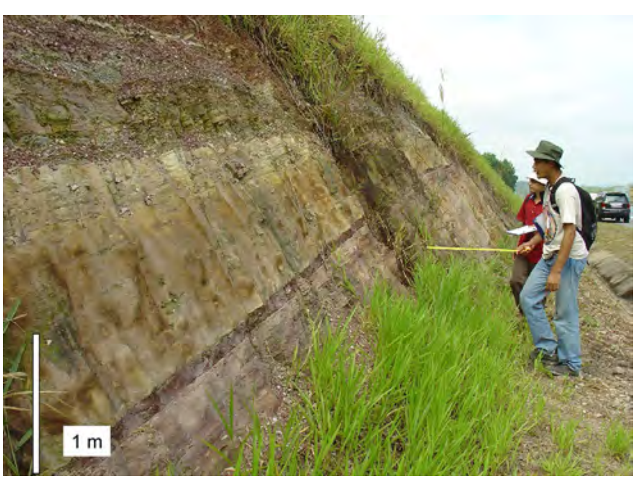


**Figure 6:** Tabular or sheet-like sandstone, with sharp base, and displaying fining-upward character, overlying red claystone and siltstone. Note the thin red claystone layer beneath the sandstone.

appears to be laterally continuous and of uniform thickness throughout the exposure.

An interesting feature of this exposure is the recognition of major bounding surfaces, usually at the bases of the sandstone bodies. These surfaces may be used to define the bases of upward-fining parasequences (Figure 3) which could be interpreted as the deposits of waning current energy in the fluvial system, as in, e.g. lateral point bar accretion and channel abandonment. The erosive bases of the channel sandbodies are well exposed (Figure 7). Although the channel sandbodies in the lower part of the section are well exposed, they are not as thick as the ones in the upper (east) end of the outcrop, where some of the sandbodies are more than 6 m thick. Three such sandbodies are recognized. These are also closely associated with red-coloured mudstone and interlaminated siltstone, which seem to be a characteristic feature of the succession. The thinner channel sandbodies in the lower part of the succession are generally less than 2 m thick and tend to thin laterally quite abruptly (as shown in Figure 4). They pass upward into green and red siltstone and claystone, which represent the interchannel facies within the lower part of the succession. In contrast, the red mudstones are more common as the interchannel facies associated with the thick sandbodies in the upper part of the succession.

Besides the overall channel form and grain-size trends, some sandbodies also exhibit internal stratification that suggests depositional by lateral accretion of point-bar deposits (Figure 8). Some sheet-sandstones interbedded with red and green mudstones could be interpreted as crevasse deposits on the floodplain (Figure 9). These features provide us with some clues as to the type of fluvial system that existed during that time. The generally fine-grained character of the sediments, with abundant overbank facies suggests a low-gradient, meandering channel and floodplain system.

**Figure 7:** Sharp-based, concave-up channel sandbody overlying thin-bedded crevasse splay sheet sands. Note its erosive character, cutting into underlying mudstone (where the geologist is pointing). Geologist for scale: 1.8 m.

## CONCLUSIONS

Based on their general lithological and sedimentary characteristics, the presumed Jurassic-Cretaceous deposits at Km 160.8 are interpreted as the deposit of a meandering fluvial system. Features associated with fluvial deposits include cross-bedding, erosive-based channel forms, pebble ‘lag’ deposits, the presence of lateral accretion surfaces, fining-upward sandstone intercalated with red and green mudstone. Thin sheet-like sandbodies of crevasse splay origin suggests that the system is characterized by high-sinuosity channels with low-gradient and extensive floodplains, where red beds and soil-forming processes were prevalent.

The origin of the red and green coloration is not known. No geochemical analysis have been made at the time of writing. However, since the red claystones and mudstones are the dominant interchannel facies, they could be the result of the prevailing oxidizing environment in the continental setting. The occurrence of both red and green mudstones in the floodplain facies may be indicative of changing conditions that reflect seasonal or climatic fluctuations that affect the sediment. It is therefore possible to use as a criterion, besides sandbody thickness and geometry (based on the limited exposure), the association of red and green interchannel claystones to distinguish between major channel-fill deposits (distributary channels and point bars) and minor channel deposits (e.g. crevasse splay channels). In this example, major channel distributaries are associated with red claystones while minor (crevasse) channels are associated with red and green claystones.

**Figure 8:** Inclined internal stratification surfaces, which could represent lateral point-bar accretion. Geologist for scale (1.6 m).


**Figure 9:** Red and green mudstones overlain by tabular sheet-like sandbodies. The mudstones are interpreted as floodplain deposits whereas the sandstones could be crevasse splays formed during flood events. Geologist is 1.6 m tall.

## ACKNOWLEDGEMENTS

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