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Architecture Elements of the Lemat Formation of the Lubuk Bernai Region, Batang Asam District, Tanjung Jabung Barat Regency, Jambi Province

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Abstract

The study of facies analysis and interpretation of the depositional environment of the Lemat Formation located at Bukit Tiga Puluh aims to clarify the problems found in Paleogene sediments in the South Sumatra Basin. A detailed analysis of the fluvial facies has been carried out in the Lubuk Bernai track. A number of observations, profiling, and measured stratigraphic section have been carried out. The stratigraphy of the study area can be divided into 5 units from old to young, namely the Mentulu-metamorphic sandstone unit, Lemat conglomerate unit, Lemat gravel-sandstone unit, Benakat volcanic-siltstone unit, and the alluvial deposit unit. The stratigraphic relationship between Mentulu metamorphic-sandstone unit and Lthe emat conglomerate unit is nonconformity. The relationship between Lthe emat conglomerate unit and Lemat gravel-sandstone unit and Benakat volcanic-siltstone unit is interfingering. The relationship between alluvial deposit units with Lemat conglomerate units and Lemat gravel-sandstone units is aan ngular unconformity. Analysis of lithofacies and architectural elements of the study area showed a fluvial depositional environment. The resulting architectural elements are 8 associations: SG (sedimentary gravity flow), GB (gravel bedform), SB (sandy bedform), CH (channel), DA (downstream accretion), HO (scour-hollow fill), AC (abandoned channel) and FF (overbank fine). The depositional environment of the Lemat Formation; Lemat conglomerate unit in alluvial fans environment, Lemat gravel sandstone unit in the shallow environment, gravel-bed braided river. In the Benakat tuffaceous-siltstone unit, it was deposited in a flashy, ephermal, sheet flood, sand-bed river environment.

1. Introduction

The South Sumatra Basin is a Tertiary basin located in Jambi and South Sumatra and is a back-arc basin type (figure 1). So far, various studies on the geological conditions of the South Sumatra Basin have been carried out, especially to determine the potential of natural resources in it. Until now, several researchers are still debating the paleogeographic conditions and the tectonic framework of the Lemat Formation. The Lemat Formation is one of the formations that fill the South Sumatra Basin. Consists of sedimentary sequences in the form of sandstone, conglomerate sandstone, and claystone insertion of the brownish-gray or blackish color [1] According to [1] Lemat Formation is not aligned above Kikim Formation. Lemat Formation is included in Lahat Group along with Benakat Formation with an interfingering relationship.

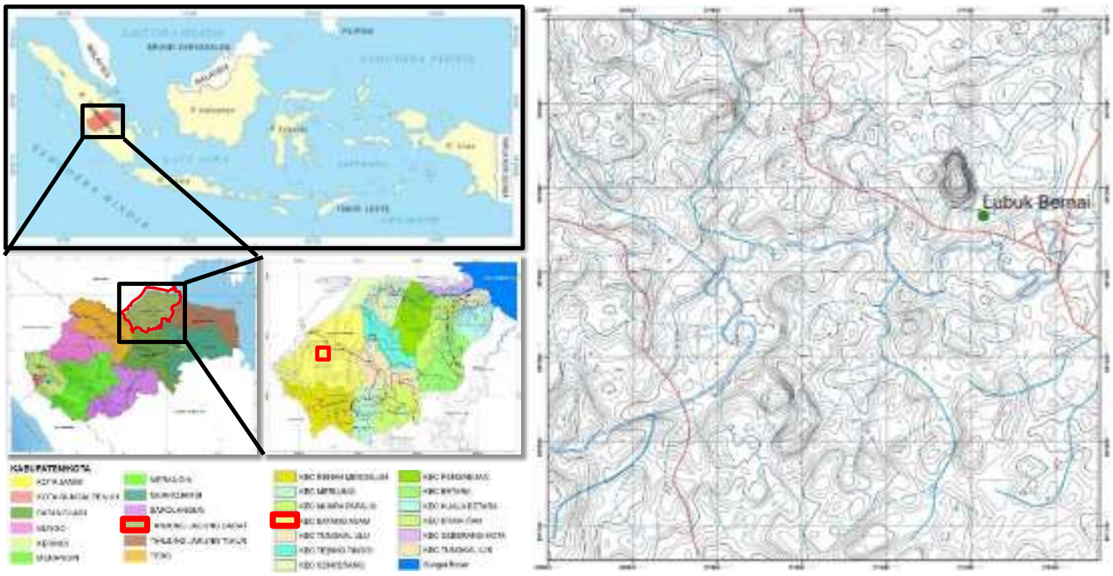

Figure 1. Administration map of Jambi Province and the research area of Kabupaten Tanjung Jabung Barat (left), Topographic map of the research area (Source: SRTM 30m) (right)

Lemat Formation is one of the formations that has an important role in the petroleum system in the South Sumatra Basin. Detailed research on facies analysis, sedimentation process and interpretation of the depositional environment has not been done much. The study of facies analysis and interpretation of the depositional environment of the Lemat Formation located in Bukit Tigapuluh can clarify the problems encountered in Paleogene sediments in the South Sumatra Basin.

Rock composition is a reflection of all kinds of geological processes that occurred at the time of its formation, starting from the geometric character and the environment in which it was deposited, transportation processes, to processes that occur in the basin. Studying rock facies in detail will provide an understanding of the processes that occurred during the rock formation.

This study related with the depositional architectural elements of the Lemat Formation associated with sedimentological and stratigraphic processes of Paleogene sedimentary rocks, Jambi Subbasin. The results of the study will provide an explanation and description of the depositional environmental conditions that occurred during the formation of the Lemat Formation which is reflected in its lithological and facies characteristic.

2. Methodology

This work is based on the results of two (2) months of fieldwork conducted in 2018. The laboratory work is carried out for six (6) months consisting of petrological/petrographic studies, sedimentology, and stratigraphic analysis. Observation maps, visual observations and measured stratigraphic measurements are the main data with the aim of obtaining descriptive and systematic field data. Rock samples made in the form of thin section of rock are samples selected from each rock layer. The selected sample must be fresh so that the components to be observed are clearly visible and easy to describe. To determine changes in facies and depositional environment, lateral and vertical profile correlations were carried out in the context of space and time. The interpretation of the depositional environment system is carried out by identifying the formation facies based on the Miall Classification [2]

3. Results and discussions

The combination of vertical profile analysis with three-dimensional variations in composition and geometry is a new analytical method that divides fluvial deposits into local sequences consisting of one or more frameworks of three-dimensional eight basic architectural elements. The analysis of facies in river depositional systems was proposed by [2] [3] [4] [5] Miall divides the fluvial depositional facies model from paleogeographic map sketches, vertical profiles and block diagrams or a combination of the three.

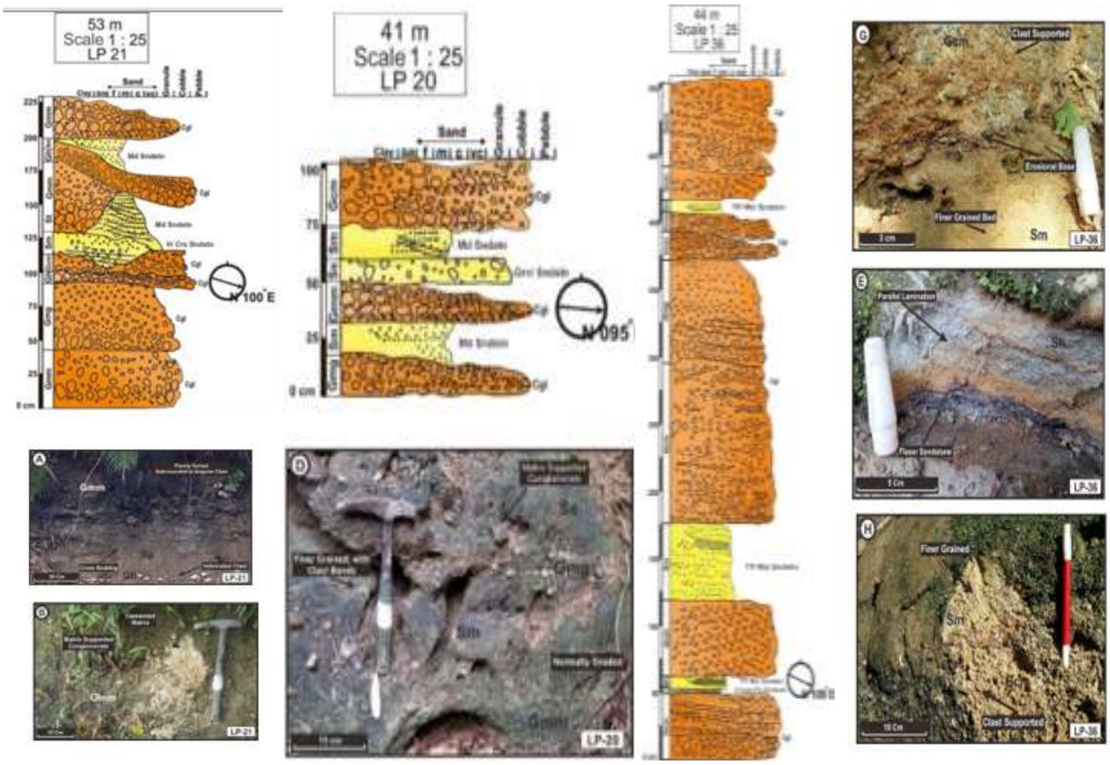

Figure 2. Lithofacies Lemat Conglomerate unit

Determination of the facies of the Lemat Formation by using primary data obtained from the results of field mapping in the form of profiles at each observation location. Determination of facies starts from lithofacies grouping based on differences in grain size, relationship between grains and sedimentary structure and then determines facies associations. Based on the found facies associations, interpretation results regarding the depositional environment and depositional mechanisms of the Lemat . Formation were obtained.

3.1 Lemat Conglomerate Unit

Lithofacies Analysis, there has Found 7 types of lithofacies in the Lemat conglomerate unit. The following is the division of lithofacies based on [3] approach to the Lemat conglomerate unit in the study area (Figure 2).

a. The Gmg facies has a dominant inter-grain relationship which is supported by the matrix. The thickness of this facies in conglomerate units is 15-50 cm. This facies develops in conglomerate and breccia lithology at the bottom of the succession. This facies is interpreted as the result of a low energy debris flow having a high viscosity.

b. The Gmm facies has a thickness of 15 cm-1 m. This facies develops in conglomerate and breccia lithology at the bottom of the succession. This facies has a conglomerate lithology of gravel-cobble sized grains with poor sorting. This facies has a dominant inter-grain relationship which is supported by the matrix. the top of the succession tends to be somewhat finely graded. These facies appear massive, sometimes with lined layers of gravel enclosed within a finer layer. Interpretation based on characteristics of poor sorting and mixing of fine and coarse material, and rarely encountered sedimentary structures, is interpreted as being deposited by gravitational flow, such as from debris flow.

c. Gcm Facies, it is a facies composed of conglomerate and gravel sandstone to pebble with grain relationships supported by grains and has a massive sedimentary structure. This facies has a thickness of 20 cm-2 m. This facies mostly develops in the middle and top of the succession. This facies is interpreted to be deposited in a clastic-rich high energy debris flow.

d. Gp Facies is composed of siliciclastic lithology ranging in size from gravel to cobble with a planar crossbedding sediment structure. The average thickness of this facies is 10 to 30 cm. This facies also develops at the top of the stratigraphic succession. These facies are interpreted as a result of the migration of channel filling processes.

e. Gh Facies is a sedimentary facies composed of sediment grains that are coarser than sand with a plannar bedding sedimentary structure. The thickness of this facies is about 5-10 cm. This facies tends to develop dominantly at the top of the succession. Its presence is also found at the bottom of the succession with a minor amount. These facies are interpreted as lag deposits and longitudinal bedforms of deposition in river systems.

f. Sm Facies has medium sand size with massive structure. The thickness of this facies in conglomerate units is 10-40 cm. This facies develops in sandstone lithology located at the bottom, middle, and top of the Lemat conglomerate unit. It is interpreted that this facies is present in the channel when high debris deposits are transported.

g. Sh Facies has medium-coarse sand size with parallel bed structure. Usually this layer is parallel to the direction of the current. The thickness of this facies in sandstone is 10 cm. This facies develops in sandstone lithology in the middle of the Lemat conglomerate unit.

Architectural Element, the grouping of architectural elements is based on the facies association that has been analyzed. Based on the facies association, there are 5 types of architectural elements in the Lemat conglomerate unit based on [2] classification.

a. Sediment gravity flows (SG), Based on the results of the facies analysis on the Lemat gravel sandstone unit, Gp, Gcm, Gmg facies were found in the SG architectural elements. Elements are narrow, forming elongated lobes. This type can be associated with GB and SB elements. Grading and Inverse grading occur frequently, gravel criss-crossing at low angles may indicate a shift from the debris flow to the transport mechanism of the traction system.

b. Scour Hollows (HO), From the results of the facies analysis, it was found that the Gt, Gmg, Sl, Ss facies in the SG architectural elements in the Lemat gravel sandstone unit. The HO element resembles a small channel, Campbell (1976), with a depth of 20 m and a width of about 250 m, with a curved bottom boundary, concave upwards. Is a channel with the shape of a spade.

c. Channel (CH), In this element, Gmg, Sp, Sl, and Ss facies are found. In the Lemat conglomerate unit, there are 5 channel elements, that is in the middle and the top of the unit. The channel element is a combination of several architectural elements, showing a fining upward pattern and the bottom part is in the form of scouring or grinding.

d. Sandy Bedform (SB), In this element, St, Sm, Sr, and Sh facies are found. In the Lemat sandstone unit, there are 2 sand bedform elements, that is in the middle and top of the unit.

e. Gravel Bedform (GB), The association of gravel bedform (GB) facies is dominated by Gcm facies. In addition, the GB facies association also consists of Gp and Sh facies. The thickness of the GB facies association is 20 meters. The Gcm facies that dominates this interval are interpreted to be deposited with a low energy debris flow. Seeing the association of GB facies which is composed of sand-gravel grain size material, this facies was deposited through a bedload mechanism. Therefore, this interval is interpreted as a dune element in the river flow. What strengthens the notion that this material is a dune element in the river flow is the existence of an ambiguous cross structure that indicates dune migration.

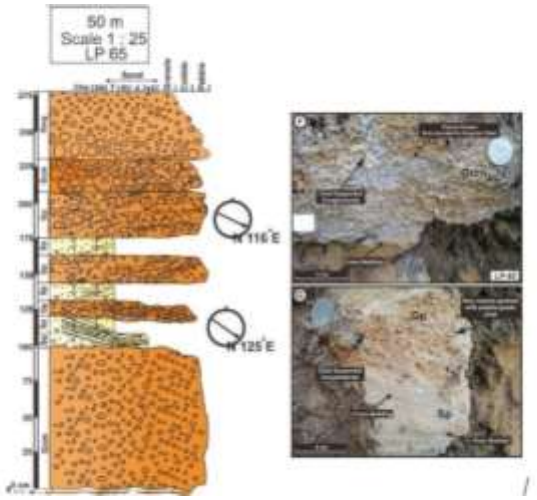

Figure 3. Lithofacies in the Lemat gravel-sandstone unit

3.2 Lemat Gravel-Sandstone Unit

Lithofacies Analysis, there has Found 8 types of lithofacies in the Lemat gravel-sandstone unit. The following is the division of lithofacies based on [3] approach to the Lemat gravel-sandstone unit in the study area (Figure 3).

a. Sm Facies has medium sand size with massive structure. The thickness of this facies in sandstone units is 45-51 cm. This facies develops in sandstone lithology located at the bottom, middle, and top of the Lemat gravel-sandstone unit.

b. Ss Facies has medium grain size with a scour structure. These facies indicate a filling channel. Often found rock lenses underneath. The thickness of this facies in the sandstone unit is 20 cm. This facies develops in sandstone lithology which is at the top of the Lemat gravel-sandstone unit.

c. Sh Facies has medium-coarse sand size with parallel bed structure. Usually this layer is parallel to the direction of the current. The thickness of this facies in the sandstone unit is 30 cm. This facies develops in sandstone lithology which is in the middle of the Lemat gravel-sandstone unit.

d. Sl Facies has a grain size of fine-medium sand with a cross-bedding structure with an angle of <15 o. The thickness of this facies in sandstone units is 15-76 cm. This facies develops in sandstone lithology which is at the bottom and middle of the Lemat gravel-sandstone unit.

e. St Facies has medium sand size with a through cross bedding structure. The thickness of this facies in the sandstone unit is 11 cm. This facies develops in sandstone lithology which is in the middle of the Lemat gravel-sandstone unit.

f. Fsm Facies has a silt size with a massive structure. The thickness of this facies in the sandstone unit is 93 cm. This facies develops in siltstone lithology which is at the top of the Lemat sandstone unit and is in contact with the Lemat gravel-sandstone unit.

g. Gcm Facies, Is a facies composed of conglomerate and gravel-sandstone to pebble with grain relationships supported by grains and has a massive sedimentary structure. This facies has a thickness of 10 cm-1 meter. This facies mostly develops in the middle and top of the succession. This facies is interpreted to be deposited in a clastic-rich high energy debris flow.

h. Gp Facies is composed of siliciclastic lithology ranging in size from gravel to cobble with a planar cross-sediment structure. The average thickness of this facies is 10 to 30 cm. This facies also develops at the top of the stratigraphic succession. These facies are interpreted as a result of the migration of channel filling processes.

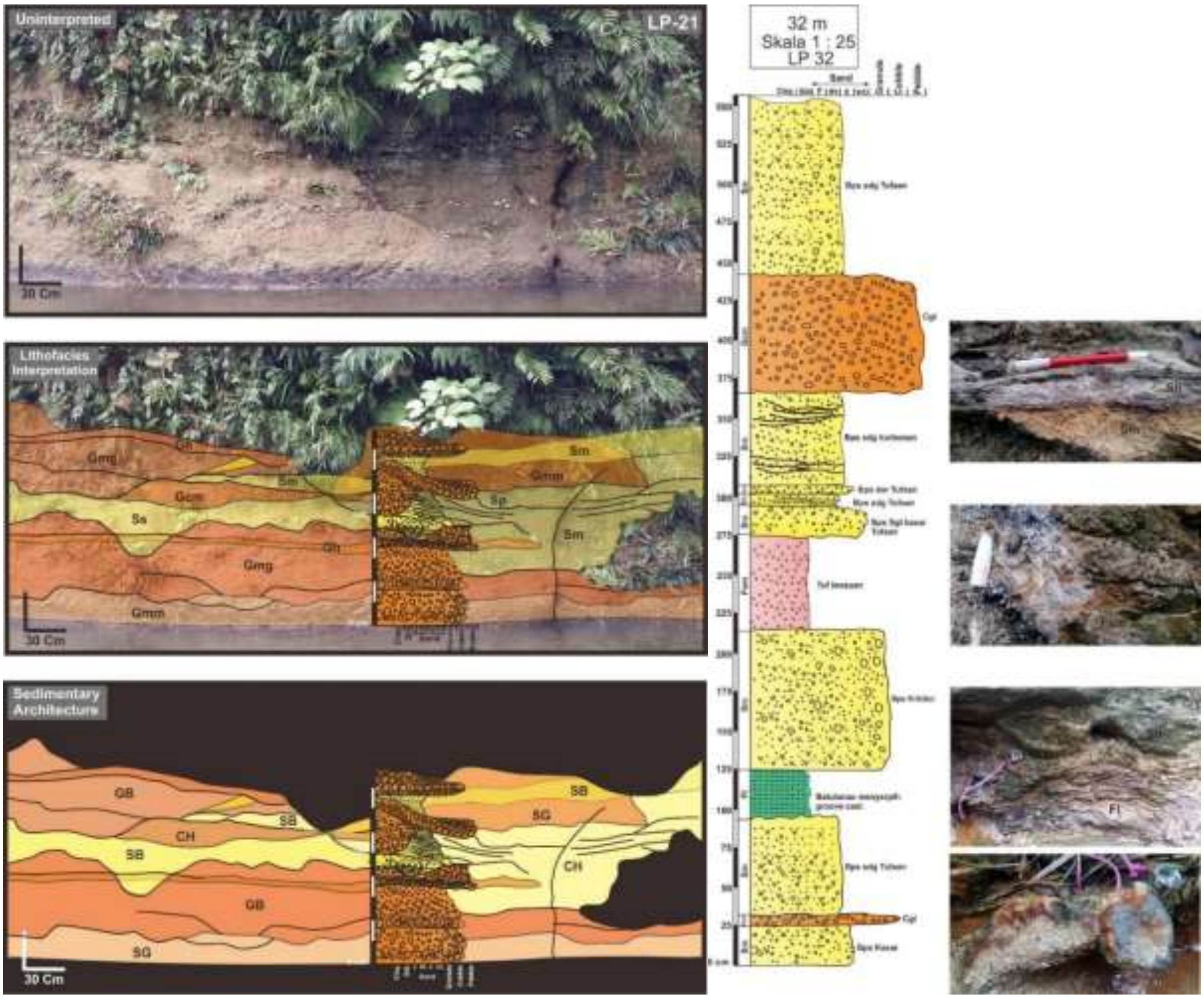

Figure 4. Architecture element of depositional Lemat conglomerate unit (left), Lithofacies in the Lemat gravel-sandstone unit (right)

Architectural Element, the grouping of architectural elements is based on the facies association that has been analyzed. Based on the facies association, there are 3 types of architectural elements in the Lemat gravel-sandstone unit based on [2] classification (figure 4 and 5).

a. Channel (CH), in this element, Gmg, Sp, Sl, and Ss facies are found. In the Lemat gravel-sandstone unit, 5 channel elements were found, that is in the middle and the top of the unit. The channel element is a combination of several architectural elements, showing a fining upward pattern and the bottom part is in the form of scouring or grinding

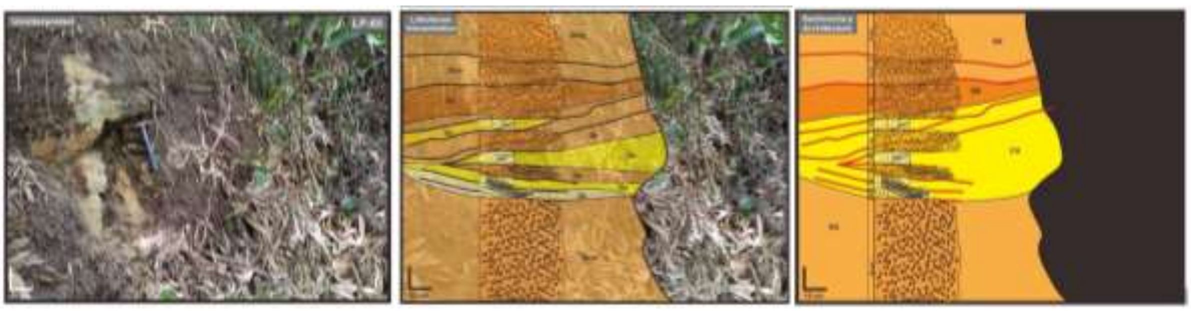

Figure 5. Architectural element of depositional Lemat gravel-sandstone unit

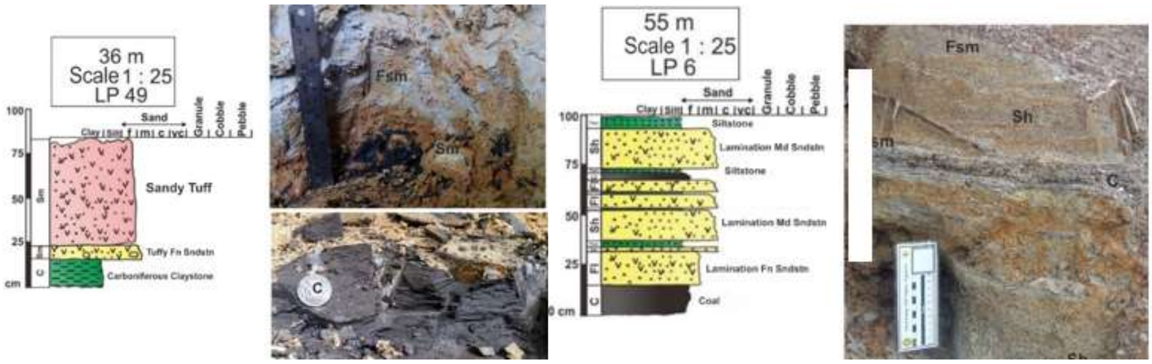

Figure 6. Lithofacies in the Benakat tuffaceous-siltstone

b. Sandy Bedform (SB), in this element, St, Sm, Sr, and Sh facies are found. In the Lemat gravel-sandstone unit, 2 elements of sand bedform were found, that is in the middle and top of the un.

c. Gravel Bedform (GB), the association of gravel bedform (GB) facies is dominated by Gcm facies. In addition, the GB facies association also consists of Gp and Sh facies. The thickness of the SB facies association is 20 meters. The Gcm facies that dominates this interval are interpreted to be deposited with a low energy debris flow. Seeing the association of GB facies which is composed of sand-gravel grain size material, this facies was deposited through a bedload mechanism. Therefore, this interval is interpreted as a dune element in the river flow. What strengthens the notion that this material is a dune element in the river flow is the existence of an ambiguous cross structure that indicates dune migration.

3.3 Benakat Tuffaceous-Siltstone Unit

Lithofacies analysis, there has Found 4 types of lithofacies in the Benakat tuffaceous-siltstone unit. The following is the division of lithofacies based on [3] approach to the Benakat tuffaceous-siltstone unit in the study area (Figure 6).

a. Sm Facies (sandstone massive) has medium sand size with massive structure. The thickness of this facies in sandstone units is 10-22 cm. This facies develops in sandstone lithology located at the bottom and middle of the Lemat tuffaceous-siltstone unit.

b. Sh Facies (Sandstone horizontal), the characteristics of the Sh facies are not much different from the Gh facies. It's just that the grains that dominate in this facies are sand-sized. This facies also has a thickness of 5-30 cm. The development of facies in the path succession is spread evenly from the bottom to the top of the succession. This facies is interpreted as a result of deposition in the plane bed critical flow.

c. Fsm Facies (Fine Silt Mud) is a facies composed of fine-sized lithological alternations, That is silt and clay with a massive structure. The thickness of this layer is about 1-4 cm. This facies predominantly develops in the middle of the succession. Meanwhile, Miall interprets these deposits as the result of deposits in the backswamp area or abandoned channel.

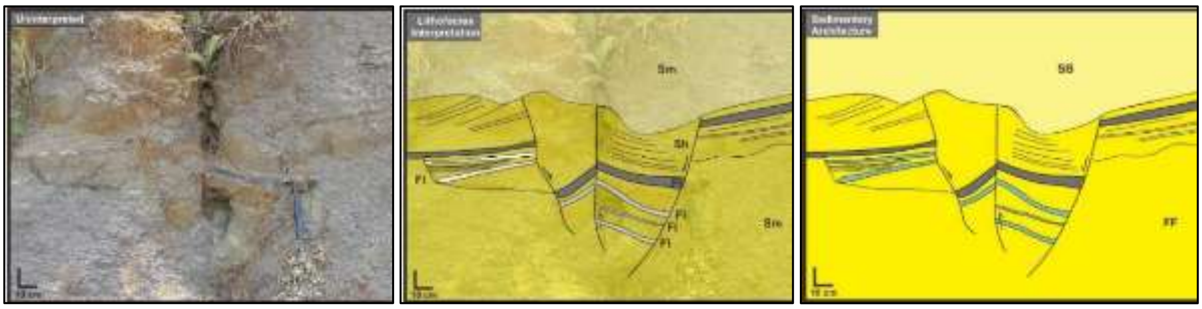
Figure 7. Architectural element Benakat tuffaceous-sandstone unit

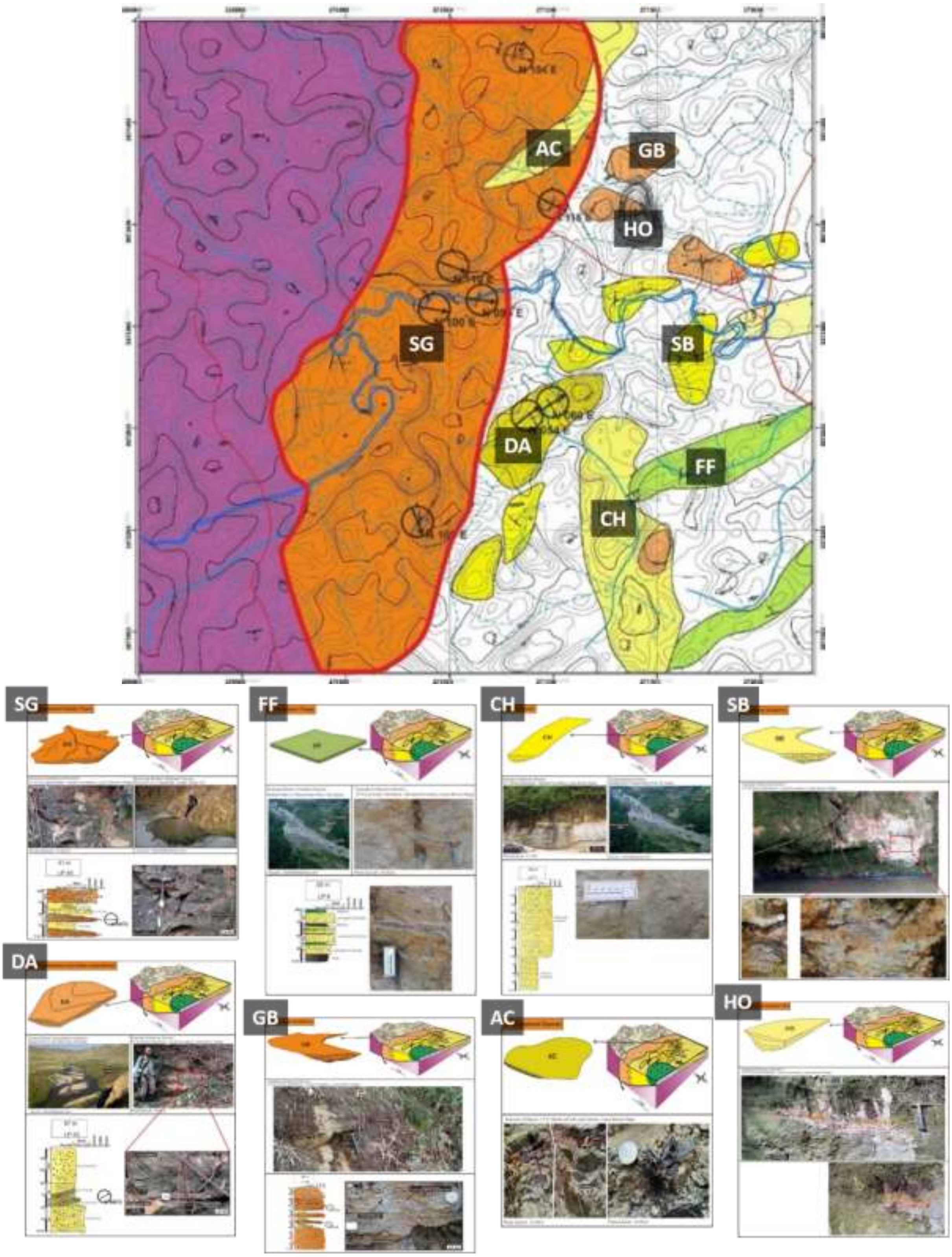

Figure 8. The Architectural elements of the investigation area.

d. C (Carbonaceous Mud), this Fm facies is composed of black claystone and coal lithology with a massive or mudcrack structure. The thickness of this layer can reach 0.2 meters. This facies is dominantly developed in the middle and lower part of the succession in the study area. Facies C is interpreted as the result of overbank deposits or abandoned channel.

Architectural element, The grouping of architectural elements is based on the facies association that has been analyzed. Based on the facies association, there are 2 types of architectural elements in the Lemat tuffaceous-siltstone unit based on [2] classification (figure 7).

a. Architectural element sand bedform (SB), in this element, St, Sm, Sr, and Sh facies are found. In the Lemat siltstone-tuffaceous unit, 2 elements of sand bedform were found, namely in the middle and top of the unit.

b. Architectural element Floodplain (FF), in this element, the FF facies is found, in the form of massive siltstone in the Lemat tuffaceous-siltstone unit. This element characterizes deposition in lagging rivers or back marshes.

4. Conclusion

Based on facies analysis, the stratigraphic sequence of the Lemat Formation indicates a fluvial depositional environment in the braided river system. In this succession, facies obtained include: Gmm (Matrix Supported, massive gravel), Gmg (Matrix Supported, normal grading), Gcm (Clast Supported, massive gravel), Gh (Clast Supported, Horizontal bedding), Gp (Gravel, Corss Stratified), Sp (Cross-bedded sandstone), Sh (Horizontally bedded sandstone), Sl (Low Angle Cross-bedded sandstone), Ss (Scours Sandstone), Sm (Massive sandstone), Fl (Fine Lamination Silt Mud), Fsm (Fine Silt Mud) and C (Carbonaceous Mud) (figure 7).

The resulting architectural elements are 6 associations (table 1): SG (Sedimentary Gravity Flow), GB (Gravel bedform), SB (sandy bedform), CH (Channel), LA (Lateral Accretion), and FF (Overbank Fine). From several architectural elements, it can be interpreted that the depositional environment of the Lemat Formation is: the lower Lemat conglomerate unit deposited in a distal fan or outwash braidplain environment with facies association characteristics of SG (Sedimentary gravity flow), GB (Gravel bars and bedform), SB (Sandy bedform) and fining upward sequence. The Lemat gravel-sandstone unit was deposited in a Shallow, gravel bed braided river environment with facies association characteristics of CH (Channel), GB (Gravel bars and bedform) SG (Sedimentary gravity flow), FF (Overbank fines), SB (Sandy bedform) and sequences fining upwards. Meanwhile, the Benakat siltstone-tuffaceous unit was deposited in Flashy, Ephermal, sheetflood, sand-bed river environments with facies association characteristics of FF (Overbank fines), SB (Sandy bedform) [6 – 19].

Table 1. Architecture Element of Research Area

Architecture Element	Symbol	Facies Association	Interpretation
Channels	CH	Sm, Sp, St, Sl, Gmm, Gcm, Gh	Low sinusity, Braided River Fluvial Channel, multistory channel
Sandy bedforms	SB	Sm, Sh, Ss, Sl, Sp, Gcm	Bar andchannel deposit variation, Bedform dune migration in channel bar or point bar side
Scour-Hollow Fill	HO	Sm, Ss, Sl	Filling Process saw teeth deposit (scouring finer layer) which formed in channel belts
Gravel bars and bedforms	GB	Gh, Gcm	Filling Process saw teeth deposit (scouring finer layer) which formed in channel belts
Sedimentary gravity flow	SG	Gmm, Gmg	Formed by gravity flow deposit, deposit ini alluvial fan system
Downstream-accretion macroform	DA	Gp, Sp, Sh	Channel deposit, Longitudinal bar which migrating
Overbank fines	FF	Fsm, Fl	Overbank deposit and abandoned channel

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