PS Modelling of an Ancient Fluvial Depositional Environment Using 3D-Photogrammetry and Paleohydrology, the Middle Pennsylvanian Allegheny Formation, South-Central West Virginia, USA*

Olu-Segun Abatan[1], Amy Weislogel[1], and B. Mitch Blake[2]

Search and Discovery Article #51466 (2018)**
Posted March 12, 2018

*Adapted from poster presentation given at AAPG Eastern Section 46th Annual Meeting, Morgantown, West Virginia, September 24-27, 2017

[1]Department of Geology and Geography, West Virginia University, Morgantown, WV, United States (olabatan@mix.wvu.edu)
[2]West Virginia Geological and Economic Survey, Morgantown, WV, United States

Abstract

This project uses state of the art 3D photogrammetry combined with paleohydrologic analysis of an ancient fluvial system to better define the facies architecture and facies association of the ancient fluvial channel. Fluvial systems are composed of sedimentary deposits in channelized environments dominated by flowing water. The morphology of fluvial systems is influenced by sediment supply, accommodation space and intensity of flow within the channel. Fluvial geomorphic response to these factors are characterized by a change in channel geometry and the formation of distinct sedimentary features which are distinguished based on geometry, scale and facies. Paleohydrologic analysis employs empirical equations for estimating paleochannel dimensions. The paleochannel dimensions estimated for static modelling, include paleochannel depth and width. 3D photogrammetry is used to construct a 3D photomosaic that captures sedimentary features from an outcrop of an ancient fluvial deposit. This data is then combined with channel dimension information acquired through Paleohydrologic analysis, and data from measured outcrop section, to develop a 3D model of the ancient fluvial depositional environment. The 3D photogrammetry and paleohydrologic analysis were used to investigate and model the Middle Pennsylvanian Allegheny Formation (MPAF). The MPAF is a northwest prograding clastic wedge, which originated from tectonically uplifted highlands along the east-central Appalachian basin. Preliminary sedimentary data showed that sandstone deposits below the Lower Kittanning Coal (LKC) member of the MPAF were more arenitic than the sandstone deposits above the LKC. Preliminary estimates of channel dimensions revealed channel flow depth ranging from 7m to 11m for the MPAF deposits immediately above the LKC and, 7m to 12m for the MPAF deposits immediately below the LKC. The use of 3D Photogrammetry to construct a photomosaic, combined with paleohydrologic analysis of ancient fluvial deposits improves the ability to define accurately, the facies architecture and facies association of the ancient fluvial channel from an outcrop data. The ability to determine the thickness and width of a channel is essential in estimating reservoir extent in exploration and development of petroleum resources of a fluvial depositional system.

Selected References

Bridge, J.S., and R.S. Tye, 2000, Interpreting the dimensions of ancient fluvial channel bars, channels, and channel belts from wireline-logs and cores:

AAPG Bulletin, v. 84/8, p. 1205–1228.

Leclair, S.F., and J.S. Bridge, 2001, Quantitative interpretation of sedimentary structures formed by river dunes: Journal of Sedimentary Research, v. 71/5, p. 713–716.

Cecil, C.B., R.W. Stanton, S.G. Neuzil, F.T. Dulong, L.F. Ruppert, and B.S. Pierce, 1985, Paleoclimate controls on late Paleozoic sedimentation and peat formation in the central Appalachian Basin (USA): International Journal of Coal Geology, v. 5/1, p. 195–230.

Miall, A.D., 2006, How do we identify big rivers? And how big is big?: Sedimentary Geology, v. 186, p. 39–50, doi:10.1016/j.sedgeo.2005.10.001.

Modelling of an Ancient Fluvial Depositional Environment Using 3D-Photogrammetry and Paleohydrology, the Middle Pennsylvanian Allegheny Formation, South-Central West Virginia, USA

WestVirginiaUniversity.

Abatan Oluwasegun O.(1), Weislogel Amy (1), and Blake Mitch (2)

1 – West Virginia University, 2 – West Virginia Geologic and Economic Survey

Grants-In-Aid
FUNDING GEOSCIENCE RESEARCH

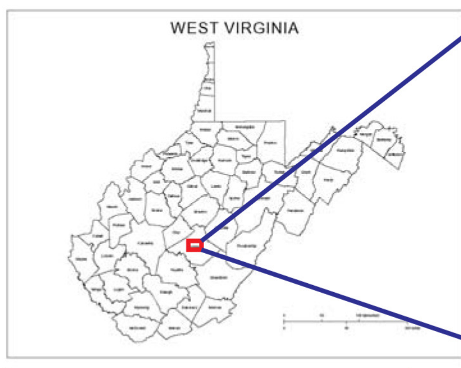
1) Abstract

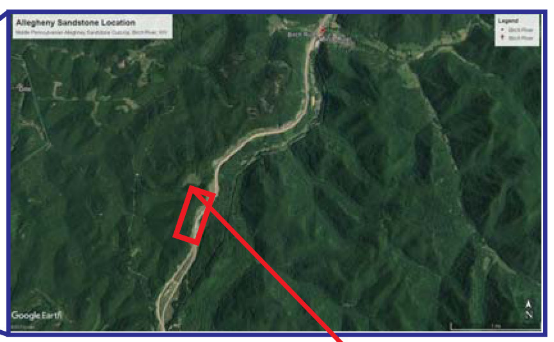
This project uses state of the art 3D photogrammetry combined with paleohydrologic analysis to study the Middle Pennsylvanian Allegheny Formation (MPAF), a north-west prograding clastic wedge in the Appalachian basin. The morphology of fluvial members of the MPAF is influenced by factors such as sediment supply, accommodation space and intensity of flow within the channel. Fluvial geomorphic response to these factors are characterized by a change in channel geometry and the formation of distinct sedimentary features which are distinguished based on geometry, scale, and facies. 3D photogrammetry is used to construct a 3D photomosaic which captures detailed sedimentary features from outcrops. This data is then combined with estimated channel dimension information acquired through paleohydrologic analysis, to construct a static model of the ancient fluvial channel.

Preliminary sedimentary data showed that sandstone deposits below the Lower Kittanning Coal (LKC) member of the MPAF were more arenitic than the sandstone deposits above the LKC. Preliminary estimates of channel dimensions revealed channel flow depth ranging from 3m to 6m for the MPAF deposits above the LKC and, 4m to 6m for the MPAF deposits below the LKC.

The similarity in channel dimensions, even though the fluvial channel above and below the LKC have different mineral composition, suggests input from different sources under similar allogenic factors controlling the channel morphology. Future study involves the development of a stratigraphicframework which would be used to better differentiate the factors that influenced the depositional character of the MPAF.

2) Location and Geologic History



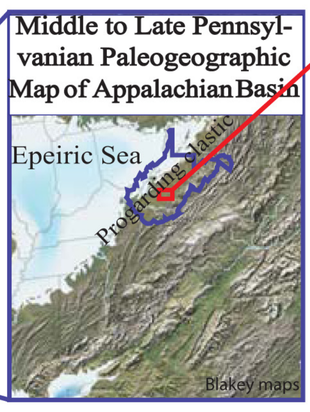


Study Area

-The MPAF is NW prograding clastic wedge in the Appalachain basin
-MPAF members above the LKC are more arenitic compared to MPAF members below LKC
-This study makes use of 3D photogrametry and paleohydrologic equations to analyze depositional features and estimate channel size of MPAF during deposition

Middle to Late Pennsylvanian Paleogeographic Map of North America

Middle to Late Pennsylvanian Paleogeographic Map of Appalachian Basin



3) Methods

Paleohydrologic Equations Workflow

Acquire Data — Direct Measure of cross set thickness (Sm) from outcrop → Estimate Dune Height (hm): hm = 2.9*Sm (Leclaire, 2000) → Estimate Flow Depth (d): d = hm*6 to 10 (Bridge and Tye, 2000) → Estimate Channel Width (Wc): $Wc = 8.88d^{1.82}$ (Bridge and Tye, 2000)

3D Photogrammetry Workflow

Acquire Data — Take Photos from as many viewpoint as possible → Generate 3D Image — Use workflow from Agisoft software → Interprete Sedimentary structures from 3D image

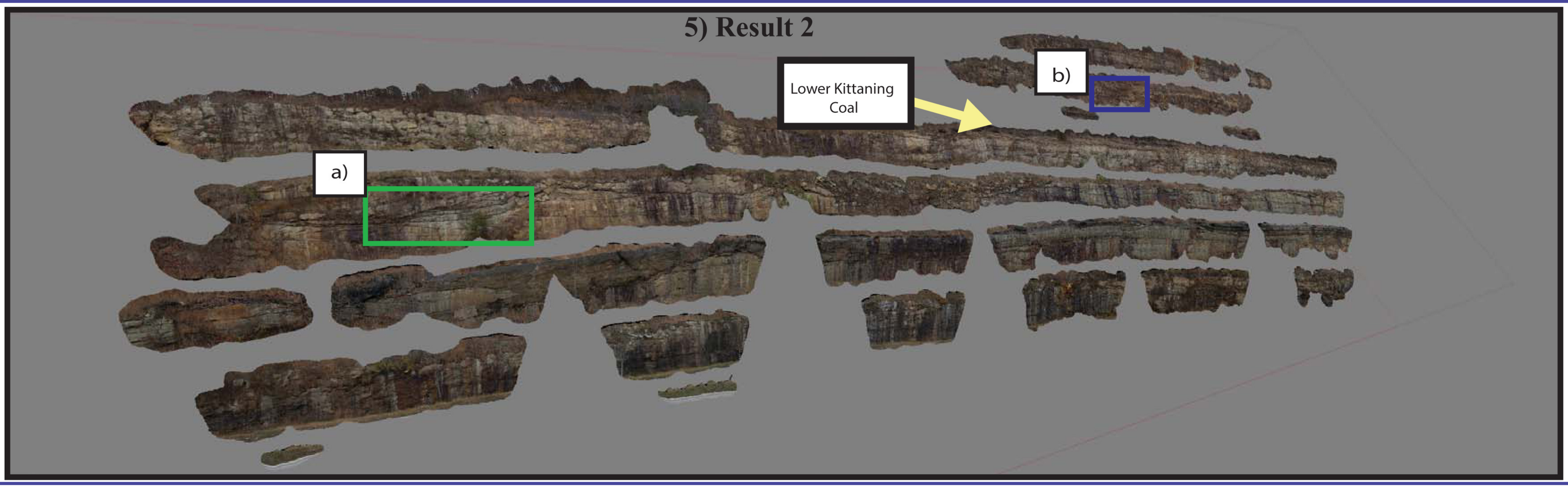
4) Result 1

Table Showing Estimated Channel Dimensions from Paleohydrologic Analysis

Channel ID	Avg. Cross Set Thickness (cm)	Estimated Dune Height (Leclair, 2001) (cm)	Estimated Flow Depth(m) (Bridge and Tye, 2000)	Estimated Channel Width (m) (Bridge and Mckay, 1993)
Channel above LKC	22.41	64.99	3.89 - 6.49	105.69 - 267.12
Channel below LKC	23.47	68.06	4.08 - 6.81	114.77 - 291.57

5) Result 2

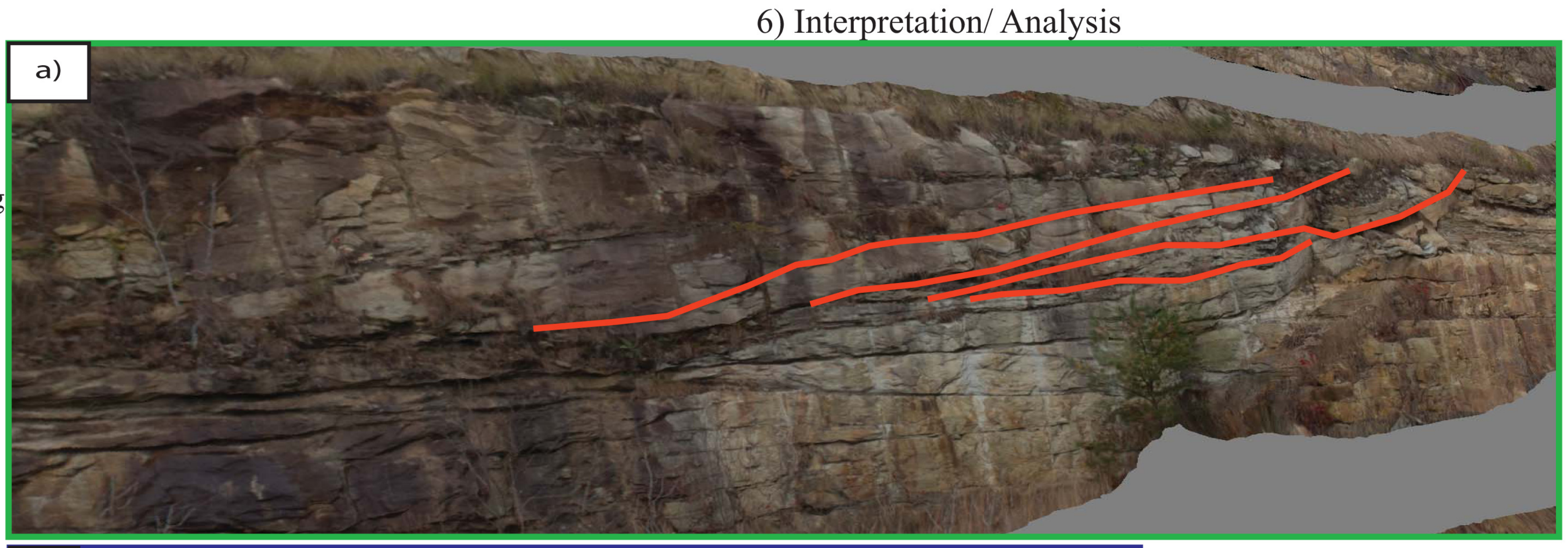
3D Image of MPAF Outcrop Exposure, Birch River, WV



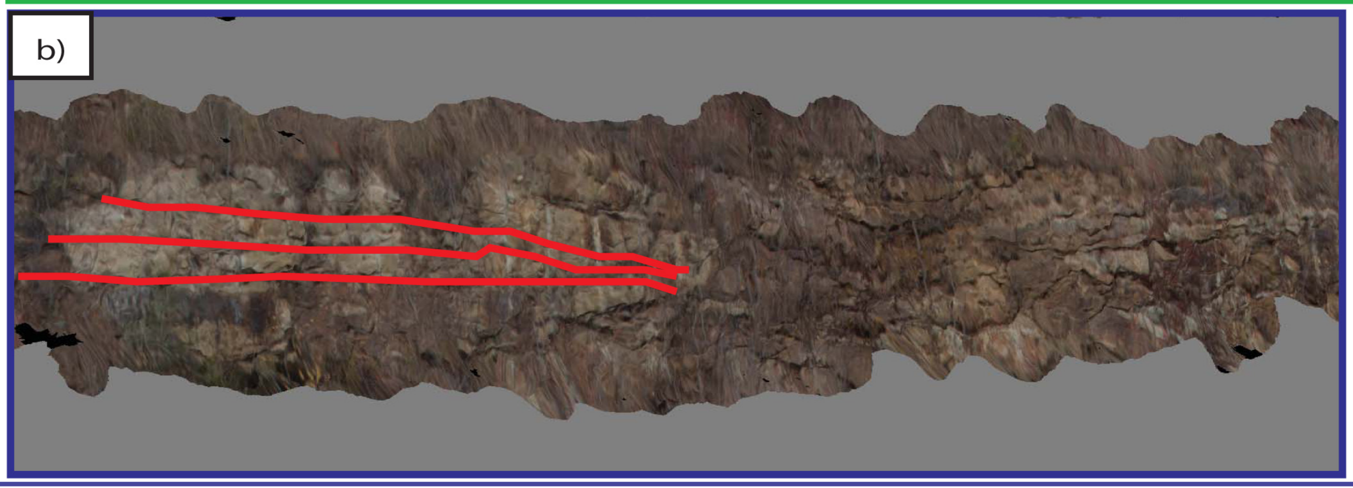
6) Interpretation/ Analysis

Example of interpreted sedimentary feature using 3D Photogrammetry.

a) Interpreted lateral accretion surfaces from MPAF members below the LKC (see location in outcrop image above).

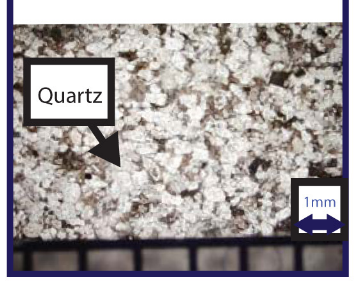


b) Interpreted lateral accretion surfaces from MPAF members above the LKC (see location in outcrop image above).

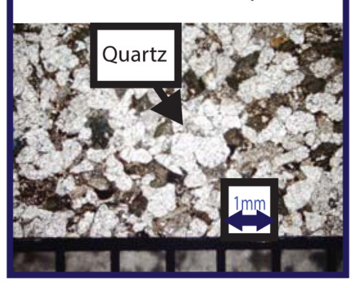


Lateral Accretion Surace

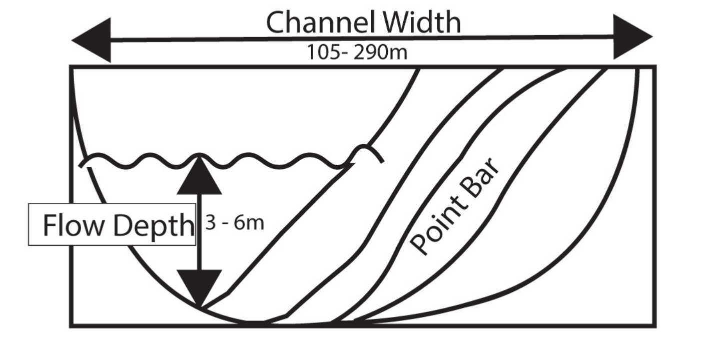
Sandstone sample from MPAF members below the LKC (Magnification 2 x 0.06mm)



Sandstone sample from MPAF members above the LKC (Magnification 2 x 0.06mm)



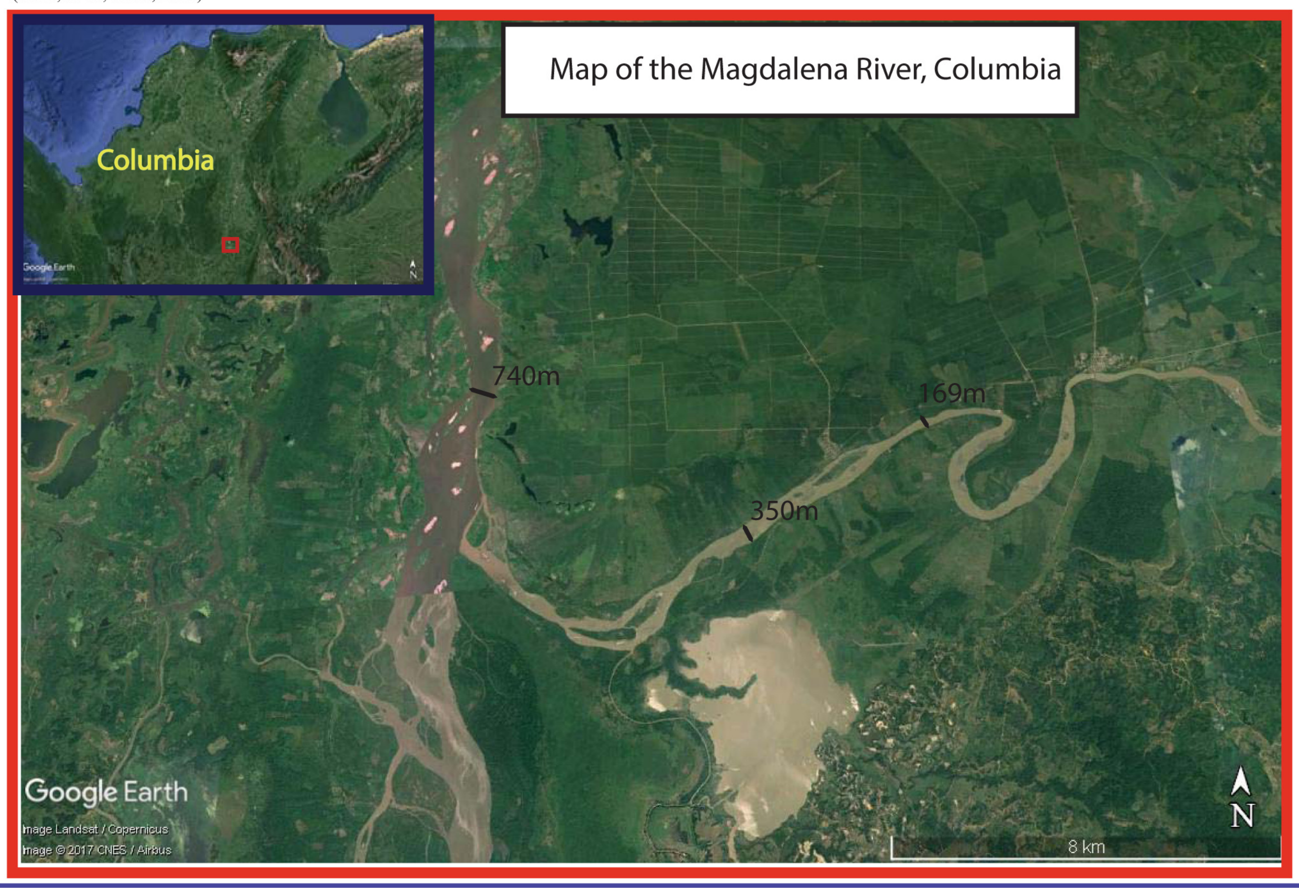
2D reconstruction of fluvial channel based on identification sedimentary features from 3D photos and estimated channel dimensions



7) Interpretation/ Analysis 2

MPAF Modern Analogue, The Magdalena River in Columbia, Comparism of Channel Morphology and Dimentions

(Cecil, 1985; Miall, 2006)



Area of Interest

- Analogue to the MPAF at study location is a tributary channel that feeds into the axial Magdalena River.
-Analogue location is about the same distance to the modern basin as the MPAF was to it's basin coeval deposits in the Appalachian basin. (i.e. ~300km).
-Channel dimensions for the analogue is similar to the estimates for the MPAF (Analogue channel width ranges from 110m to 370m, MPAF channel width ranges from 105m to 290m).
-Swamp areas and large lakes adjacent to the analogue fluvial channel are environments of deposition of lake and coal facies identified in MPAF members.
-The MPAF might be a tributary channel feeding into a larger axial channels that is then discharged into the basin.

8) Conclusions and Future Work

Conclusions

- 3D Photogrammetry was useful in creating outcrop images that improved identification of sedimentary features of the outcrop

- Sandstone deposits of the MPAF above and below the LKC defer in mineralogical composition. This might be due to change in sediment source or addition of new type sediment source

- Even though sandstone deposits of the MPAF above and below the LKC have different mineralogic composition, estimates of paleochannel dimensions both sandstone deposits are similar. This might be because both sandstone where deposited by channels influenced by similar allogenic factors.

-The fluvial morphology of the Magdalena river, a modern analogue, shows the possibility of relatively smaller fluvial channels, which merge with a larger axial channel, having sediment sourced from different areas compared to the large channels

Future Work

- Development of a stratigraphicframework which would be used to better differentiate the factors that influenced the depositional character of the MPAF.

Refrences

Bridge, J. S., and R. S. Tye, 2000, Interpreting the dimensions of ancient fluvial channel bars, channels, and channel belts from wireline-logs and cores: AAPG bulletin, v. 84, no. 8, p. 1205–1228.
Leclair, S. F., and J. S. Bridge, 2001, Quantitative interpretation of sedimentary structures formed by river dunes: Journal of Sedimentary Research, v. 71, no. 5, p. 713–716.
Blakey Maps
Cecil, C. B., R. W. Stanton, S. G. Neuzil, F. T. Dulong, L. F. Ruppert, and B. S. Pierce, 1985, Paleoclimate controls on late Paleozoic sedimentation and peat formation in the central Appalachian Basin (USA): International Journal of Coal Geology, v. 5, no. 1, p. 195–230.
Miall, A. D., 2006, How do we identify big rivers? And how big is big? Sedimentary Geology, v. 186, p. 39–50, doi:10.1016/j.sedgeo.2005.10.001.