

Supplemental Material 1. Full compilation of evidence used to interpret MSB origin. X indicates that a publication cited the specific observation to interpret MSB origin.

MULTISTORY SAND BODY PROPERTIES

Citation	Sheet geometry	Geometry			Story Properties			Architecture			
		Ribbon W:T	Lateral	Vertical	Large area	Varying	Consistent	Upwards increase in story pres.	Paleoflow between stories	Varies	Invariant
1. Intra-channel-belt											
Jensen et al., 2010	X										
Ghosh et al., 2006	X										
Johnson and Pierce, 1990	X										
Kumar, 1993										X	
Tunbridge, 1981											
Gibling and Rust, 1990										X	
Guion et al., 1995			X								
Johnson, S.Y., 1984	X									X	
Labourdette and Jones, 2007				X							
Limarino et al., 2001											
Olsen, 1989	X										
Sadler and Kelly, 1993											X
Diemer and Belt, 1991										X	
Martinsen et al., 1999							X				
Marzo et al., 1988								X		X	
Straffin et al., 1999											
Read and Dean, 1982											
Platt and Keller, 1992											
Chetel and Carroll, 2010	X										
Corbett et al., 2011				X							X
Martinius, 2000			X				X				
Evans and Elliot, 1999											
Kjemperud et al., 2008			X					X			
Leier et al., 2007								X			
Lofgren, 1990								X			X

Matthews et al., 2007				X								
Rygel and Gibling, 2006												
Holbrook, 2001												
Sweet and Soreghan, 2010	X											
Wellman, 1970								X				X
Allen and Fielding, 2007	X											X
Total =32	7	0	4	2	0	0	2	5	0	5	5	5
Percent of 32 papers	22	0	13	6	0	0	6	16	0	16	16	16

2. Avulsion Reoccupation

Kraus, 1997		X										
Mohrig et al., 2000												
Ghosh et al., 2006		X				X						
Gibling and Rust, 1990												
Mjos and Prestholm, 1993						X						
Sarkar, 1988						X						
Jinnah and Roberts, 2011		X										
Michaelsen et al., 2000												
Palmer, 1997						X						
Paredes et al., 2007												
Total = 11	0	3	0	0	4	0	0	0	0	0	0	0
Percent of 11 papers	0	27	0	0	36	0	0	0	0	0	0	0

3. Incised Valley

Arche and Lopez-Gomez, 2005	X											
Hampson et al., 1999b												
Aitken and Flint, 1995												
Hampson et al., 1997							X			X		
Blakely and Gubitosa, 1984		X										
Martinsen et al., 1999												
McCarthy et al., 1999												
Morris et al., 2003												
Hampson et al., 1999a												
Xu et al., 2009								X				
Li et al., 2010												
Total = 11	1	1	0	0	0	1	0	1	1	0	0	0
Percent of 11 papers	9	9	0	0	0	9	0	9	9	0	0	0

Matthews et al., 2007										
Rygel and Gibling, 2006				X			X			
Holbrook, 2001				X						
Sweet and Soreghan, 2010	X									
Wellman, 1970	X									
Allen and Fielding, 2007	X									
Total =32	8	0	2	3	0	1	0	0	2	
Percent of 32 papers	25	0	6	9	0	3	0	0	6	

2. Avulsion Reoccupation

Kraus, 1997			X				X			
Mohrig et al., 2000			X	X			X			
Ghosh et al., 2006										
Gibling and Rust, 1990			X							
Mjos and Prestholm, 1993			X	X						
Sarkar, 1988				X						
Jinnah and Roberts, 2011			X	X			X			
Michaelson et al., 2000							X*			
Palmer, 1997										
Paredes et al., 2007			X	X						
Total = 11	0	0	6	5	0	0	4	0	0	
Percent of 11 papers	0	0	55	45	0	0	36	0	0	

3. Incised Valley

Arche and Lopez-Gomez, 2005										
Hampson, Stollhofen et al., 1999		X								
Aitken and Flint, 1995					X					
Hampson et al., 1997								X		
Blakely and Gubitosa, 1984										X
Martinsen et al., 1999					X					
McCarthy et al., 1999	X									X
Morris et al., 2003										X
Hampson, Howell et al., 1999					X			X		
Xu et al., 2009										
Li et al., 2010										
Total = 11	1	1	0	0	3	0	0	2	3	
Percent of 11 papers	9	9	0	0	27	0	0	18	27	

Matthews et al., 2007										
Rygel and Gibling, 2006										
Holbrook, 2001					X					
Sweet and Soreghan, 2010										
Wellman, 1970										
Allen and Fielding, 2007										
Total =32	0	0	0	1	2	0	0	0	0	3
Percent of 32 papers	0	0	0	3	6	0	0	0	0	9

2. Avulsion Reoccupation

Kraus, 1997						X				
Mohrig et al., 2000							X			
Ghosh et al., 2006										
Gibling and Rust, 1990						X	X			
Mjos and Prestholm, 1993	X									
Sarkar, 1988										
Jinnah and Roberts, 2011										
Michaelson et al., 2000										X
Palmer, 1997										
Paredes et al., 2007										
Total = 11	1	0	0	0	0	2	2	0	0	1
Percent of 11 papers	9	0	0	0	0	18	18	0	0	9

3. Incised Valley

Arche and Lopez-Gomez, 2005*		X								
Hampson, Stollhofen et al., 1999			X						X	
Aitken and Flint, 1995		X	X	X				X		
Hampson et al., 1997								X		
Blakely and Gubitosa, 1984								X	X	
Martinsen et al., 1999										
McCarthy et al., 1999										
Morris et al., 2003								X		
Hampson, Howell et al., 1999								X		
Xu et al., 2009		X								
Li et al., 2010		X						X		
Total = 11	0	4	2	1	0	0	0	6	2	0
Percent of 11 papers	0	36	18	9	0	0	0	55	18	0

	STORY PROPERTIES
--	-------------------------

Citation	Architecture		Sedimentology			Story contacts			Closely spaced, limited extent
	Sheet	Symmetrical	Preserved levee deposits (wings)	Normal grading	Type and abundance of sed structures	Erosional	<i>Mud/pebble-lined</i> Common	Not present	
1. Intra-channel-belt									
Jensen et al., 2010									
Ghosh et al., 2006					X				
Johnson and Pierce, 1990							X		
Kumar, 1993								X	
Tunbridge, 1981	X				X			X	X
Gibling and Rust, 1990							X		
Guion et al., 1995									
Johnson, S.Y., 1984					X				
Labourdette and Jones, 2007					X				
Limarino et al., 2001				X		X			
Olsen, 1989					X				X
Sadler and Kelly, 1993					X	X			
Diemer and Belt, 1991					X	X			
Martinsen et al., 1999									X
Marzo et al., 1988				X					
Straffin et al., 1999									
Read and Dean, 1982									X
Platt and Keller, 1992					X				
Chetel and Carroll, 2010									
Corbett et al., 2011									
Martinius, 2000									
Evans and Elliot, 1999					X				
Kjemperud et al., 2008									X
Leier et al., 2007									X
Lofgren, 1990				X					

Matthews et al., 2007								X			
Rygel and Gibling, 2006											
Holbrook, 2001		X			X						
Sweet and Soreghan, 2010											
Wellman, 1970											
Allen and Fielding, 2007											
Total =32	1	1	0	3	10	3	3	1	2	4	
Percent of 32 papers	3	3	0	9	31	9	9	3	6	13	

2. Avulsion Reoccupation

Kraus, 1997			X								
Mohrig et al., 2000											
Ghosh et al., 2006								X			
Gibling and Rust, 1990											
Mjos and Prestholm, 1993						X					
Sarkar, 1988											
Jinnah and Roberts, 2011								X			
Michaelson et al., 2000								X			
Palmer, 1997						X		X			
Paredes et al., 2007					X			X			
Total = 11	0	0	1	0	1	2	5	0	0	0	
Percent of 11 papers	0	0	9	0	9	18	45	0	0	0	

3. Incised Valley

Arche and Lopez-Gomez, 2005*											
Hampson, Stollhofen et al., 1999											
Aitken and Flint, 1995											
Hampson et al., 1997											
Blakely and Gubitosa, 1984	X										
Martinsen et al., 1999											
McCarthy et al., 1999					X						
Morris et al., 2003											
Hampson, Howell et al., 1999											
Xu et al., 2009								X			
Li et al., 2010											
Total = 11	1	0	0	0	1	0	1	0	0	0	
Percent of 11 papers	9	0	0	0	9	0	9	0	0	0	

	CHANNEL PLANFORM INTERPRETATION			COMPARISON WITH MODERN SYSTEMS	HIERARCHY ANALYSIS
--	---------------------------------	--	--	--------------------------------	--------------------

Citation	Meandering	Braided	Anastomosing		
----------	------------	---------	--------------	--	--

1. Intra-channel-belt

Jensen et al., 2010					X
Ghosh et al., 2006	X				
Johnson and Pierce, 1990		X			X
Kumar, 1993				X	
Tunbridge, 1981					
Gibling and Rust, 1990	X				
Guion et al., 1995					
Johnson, S.Y., 1984	X			X	
Labourdette and Jones, 2007					
Limarino et al., 2001			X		
Olsen, 1989		X			
Sadler and Kelly, 1993					
Diemer and Belt, 1991	X				X
Martinsen et al., 1999					
Marzo et al., 1988					
Straffin et al., 1999		X			
Read and Dean, 1982					
Platt and Keller, 1992	X				
Chetel and Carroll, 2010					
Corbett et al., 2011					
Martinius, 2000				X	
Evans and Elliot, 1999					
Kjemperud et al., 2008					
Leier et al., 2007		X			
Lofgren, 1990					

Matthews et al., 2007		X			
Rygel and Gibling, 2006					
Holbrook, 2001					
Sweet and Soreghan, 2010		X			
Wellman, 1970					
Allen and Fielding, 2007		X			
Total =32	5	7	1	3	3
Percent of 32 papers	16	22	3	9	9

Avulsion Reoccupation

Kraus, 1997				X	
Mohrig et al., 2000					
Ghosh et al., 2006					
Gibling and Rust, 1990					
Mjos and Prestholm, 1993					
Sarkar, 1988					
Jinnah and Roberts, 2011					
Michaelson et al., 2000					
Palmer, 1997					
Paredes et al., 2007					
Total = 11	0	0	0	1	0
Percent of 11 papers	0	0	0	9	0

3. Incised Valley

Arche and Lopez-Gomez, 2005					
Hampson, Stollhofen et al., 1999					
Aitken and Flint, 1995					
Hampson et al., 1997					
Blakely and Gubitosa, 1984					
Martinsen et al., 1999					
McCarthy et al., 1999					
Morris et al., 2003					
Hampson, Howell et al., 1999					
Xu et al., 2009					
Li et al., 2010					
Total = 11	0	0	0	0	0
Percent of 11 papers	0	0	0	0	0

Supplemental Material 1 – References for Supplemental Material 1a

- Aitken, J.F., and Flint, S.S., 1995, The application of high-resolution sequence stratigraphy to fluvial systems: a case study from the Upper Carboniferous Breathitt Group, eastern Kentucky, USA: *Sedimentology*, v. 42, p. 3-30.
- Allen, J.P., and Fielding, C.R., 2007, Sequence architecture within a low-accommodation setting: An example from the Permian of the Galilee and Bowen basins, Queensland, Australia: *AAPG Bulletin*, v. 91, p. 1503-1539.
- Arche, A., and López-Gómez, J., 2005, Sudden changes in fluvial style across the Permian–Triassic boundary in the eastern Iberian Ranges, Spain: Analysis of possible causes: *Palaeogeography, Palaeoclimatology, Palaeoecology*, v. 229, p. 104-126.
- Blakely, R.C., and Gubitosa, R., 1984, Controls of sandstone body geometry and architecture in the Chinle Formation (Upper Triassic), Colorado Plateau: *Sedimentary Geology*, v. 38, p. 51-86.
- Chetel, L.M., and Carroll, A.R., 2010, Terminal Infill of Eocene Lake Gosiute, Wyoming, USA: *Journal of Sedimentary Research*, v. 80, p. 492-514.
- Corbett, M.J., Fielding, C.R., and Birgenheier, L.P., 2011, Stratigraphy of a Cretaceous coastal-plain fluvial succession: The Campanian Masuk Formation, Henry Mountains Syncline, Utah, U.S.A: *Journal of Sedimentary Research*, v. 81, p. 80-96.
- Diemer, J.A., and Belt, E.S., 1991, Sedimentology and paleohydraulics of the meandering river systems of the Fort Union Formation, southeastern Montana: *Sedimentary Geology*, v. 75, p. 85-108.
- Evans, M.J., and Elliott, T., 1999, Evolution of a thrust-sheet-top basin: The Tertiary Barreme basin, Alpes-de-Haute-Provence, France: *GSA Bulletin*, v. 111, p. 1617-1643.
- Ghosh, P., Sarkar, S., and Maulik, P., 2006, Sedimentology of a muddy alluvial deposit: Triassic Denwa Formation, India: *Sedimentary Geology*, v. 191, p. 3-36.
- Gibling, M.R., and Rust, B., 1990, Ribbon sandstones in the Pennsylvanian Waddens Cove Formation, Sydney Basin, Atlantic Canada: the influence of siliceous duricrusts on channel-body geometry: *Sedimentology*, v. 37, p. 45-65.
- Guion, P.D., Banks, N.L., and Rippon, J.H., 1995, The Silkstone Rock (Westphalian A) from the east Pennines, England: implications for sand body genesis: *Journal of the Geological Society, London*, v. 152, p. 819-832.
- Hampson, G.J., Elliott, T., and Davies, S.J., 1997, The application of sequence stratigraphy to Upper Carboniferous fluvio-deltaic strata of the onshore UK and Ireland: implications for the southern North Sea: *Journal of the Geological Society, London*, v. 154, p. 719-733.
- Hampson, G.J., Howell, J.A., and Flint, S.S., 1999a, A Sedimentological and Sequence Stratigraphic Re-interpretation of the Upper Cretaceous Prairie Canyon Member ("Mancos B") and Associated Strata, Book Cliffs Area, Utah, U.S.A.: *Journal of Sedimentary Research*, v. 69, p. 414-433.
- Hampson, G.J., Stollhofen, H., and Flint, S.S., 1999b, A sequence stratigraphic model for the Lower Coal Measures (Upper Carboniferous) of the Ruhr district, north-west Germany: *Sedimentology*, v. 46, p. 1199-1231.
- Holbrook, J., 2001, Origin, genetic interrelationships, and stratigraphy over the continuum of fluvial channel-form bounding surfaces: an illustration from middle Cretaceous strata, southeastern Colorado: *Sedimentary Geology*, v. 144, p. 179-222.

- Jensen, M.A., and Pedersen, G.K., 2010, Architecture of vertically stacked fluvial deposits, Atane Formation, Cretaceous, Nuussuaq, central West Greenland: *Sedimentology*, v. 57, p. 1280-1314.
- Jinnah, Z.A., and Roberts, E.M., 2011, Facies associations, paleoenvironment, and base-level changes in the Upper Cretaceous Wahweap Formation, Utah, U.S.A: *Journal of Sedimentary Research*, v. 81, p. 266-283.
- Johnson, E.A., and Pierce, F.W., 1990, Variations in fluvial deposition on an alluvial plain: an example from the Tongue River Member of the Fort Union Formation (Paleocene), southeastern Powder River Basin, Wyoming, U.S.A.: *Sedimentary Geology*, v. 69, p. 21-36.
- Johnson, S.Y., 1984, Cyclic Fluvial Sedimentation in a Rapidly Subsiding Basin, Northwest Washington: *Sedimentary Geology*, v. 38, p. 361-391.
- Kjemperud, A.V., Schomacker, E.R., and Cross, T.A., 2008, Architecture and stratigraphy of alluvial deposits, Morrison Formation (Upper Jurassic), Utah: *American Association of Petroleum Geologists Bulletin*, v. 92, p. 1055-1076.
- Kraus, M., and Gwinn, B., 1997, Facies and facies architecture of Paleogene floodplain deposits, Willwood Formation, Bighorn Basin, Wyoming, USA: *Sedimentary Geology*, v. 114, p. 33-54.
- Kumar, R., 1993, Coalescence megafan: multistorey sandstone complex of the late-orogenic (Mio-Pliocene) sub-Himalayan belt, Dehra Dun, India: *Sedimentary Geology*, v. 85, p. 327-337.
- Labourdette, R., and Jones, R.R., 2007, Characterization of fluvial architectural elements using a three-dimensional outcrop data set: Escanilla braided system, South-Central Pyrenees, Spain: *Geosphere*, v. 3, p. 422-434.
- Leier, A.L., DeCelles, P.G., Kapp, P., and Ding, L., 2007, The Takena Formation of the Lhasa terrane, southern Tibet: The record of a Late Cretaceous retroarc foreland basin: *Geological Society of America Bulletin*, v. 119, p. 31-48.
- Li, W., Bhattacharya, J.P., and Campbell, C., 2010, Temporal evolution of fluvial style in a compound incised-valley fill, Ferron "Notom Delta", Henry Mountains region, UT (U.S.A.): *Journal of Sedimentary Research*, v. 80, p. 529-549.
- Limarino, C., Tripaldi, A., Marensi, S., Net, L., Re, G., and Caselli, A., 2001, Tectonic control on the evolution of the fluvial systems of the Vinchina Formation (Miocene), northwestern Argentina: *Journal of South American Earth Sciences*, v. 14, p. 751-762.
- Lofgren, D.L., Hotton, C.L., and Runkel, A.C., 1990, Reworking of Cretaceous dinosaurs into Paleocene channel deposits, upper Hell Creek Formation, MT: *Geology*, v. 18, p. 874-877.
- Martinius, A.W., 2000, Labyrinthine facies architecture of the Tortola Fluvial system and controls on deposition (Late Oligocene-Early Miocene, Loranca Basin, Spain): *Journal of Sedimentary Research*, v. 70, p. 850-867.
- Martinsen, O.J., Ryseth, A., Helland-Hansen, W., Flesche, H., Torkildsen, G., and Idil, S., 1999, Stratigraphic base level and fluvial architecture: Ericson Sandstone (Campanian), Rock Springs Uplift, SW Wyoming, USA: *Sedimentology*, v. 46, p. 235-259.
- Marzo, M., Nigman, W., and Puigdefabregas, C., 1988, Architecture of the Castissent fluvial sheet sandstones, Eocene, South Pyrenees, Spain: *Sedimentology*, v. 35, p. 719-738.
- Matthews, W.J., Hampson, G.J., Trudgill, B.D., and Underhill, J.R., 2007, Controls on fluvial lacustrine reservoir distribution and architecture in passive salt-diapir provinces:

- Insights from outcrop analogs: American Association of Petroleum Geologists Bulletin, v. 91, p. 1367-1403.
- Michaelsen, P., Henderson, R.A., Crosdale, P.J., and Mikkelsen, S.O., 2000, Facies architecture and depositional dynamics of the upper Permian Rangal Coal Measures, Bowen Basin, Australia: *Journal of Sedimentary Research*, v. 70, p. 879-895.
- Mjos, R., and Presthom, E., 1993, The geometry and organization of fluviodeltaic channel sandstones in the Jurassic Saltwick Formation, Yorkshire, England: *Sedimentology*, v. 40, p. 919-935.
- Mohrig, D., Heller, P.L., Paola, C., and Lyons, W.J., 2000, Interpreting avulsion process in ancient alluvial sequences: Guadalope-Matarranya system (northern Spain) and Wasatch Formation (western CO): *Geological Society of America Bulletin*, v. 112, p. 1787-1803.
- Morris, J., Hampson, G.J., and Maxwell, G., 2003, Controls on facies architecture in the Brent Group, Strathspey Field, UK North Sea: implications for reservoir characterization: *Petroleum Geoscience*, v. 9, p. 209-220.
- Olsen, H., 1989, Sandstone-body structures and ephemeral stream processes in the Dinosaur Canyon Member, Moenave Formation (Lower Jurassic), Utah, U.S.A.: *Sedimentary Geology*, v. 61, p. 207-221.
- Palmer, B.A., 1997, Sedimentary record of caldera-forming eruptions, Eocene Challis volcanic field, Idaho: *GSA Bulletin*, v. 109, p. 242-252.
- Paredes, J.M., Foix, N., Colombo Piñol, F., Nillni, A., Allard, J.O., and Marquillas, R.A., 2007, Volcanic and climatic controls on fluvial style in a high-energy system: The Lower Cretaceous Matasiete Formation, Golfo San Jorge basin, Argentina: *Sedimentary Geology*, v. 202, p. 96-123.
- Platt, N.H., and Keller, B., 1992, Distal alluvial deposits in a foreland basin setting - the Lower Freshwater Molasse (Lower Miocene), Switzerland: *sedimentology, architecture and palaeosols*: *Sedimentology*, v. 39, p. 545-565.
- Read, W.A., and Dean, J.M., 1982, Quantitative relationships between numbers of fluvial cycles, bulk lithological composition and net subsidence in a Scottish Namurian basin: *Sedimentology*, v. 29, p. 181-200.
- Rygel, M.C., and Gibling, M.R., 2006, Natural Geomorphic Variability Recorded in a High-Accommodation Setting: Fluvial Architecture of the Pennsylvanian Joggins Formation of Atlantic Canada: *Journal of Sedimentary Research*, v. 76, p. 1230-1251.
- Sadler, S.P., and Kelly, S.B., 1993, Fluvial processes and cyclicity in terminal fan deposits: an example from the Late Devonian of southwest Ireland: *Sedimentary Geology*, v. 85, p. 375-386.
- Sarkar, S., 1988, Petrology of Caliche-Derived Peloidal Calcirudite/Calcarenite in the Late Triassic Maleri Formation of the Pranhita-Godavari Valley, South India: *Sedimentary Geology*, v. 55, p. 263-282.
- Straffin, E., Blum, M., Colls, A., and Stokes, S., 1999, Alluvial stratigraphy of the Loire and Arroux rivers (Burgundy, France) [Stratigraphie des alluvions de la Loire et de l'Arroux, Bourgogne, France]: *Quaternaire*, v. 10, p. 271-282.
- Sweet, D.E., and Soreghan, G.S., 2009, Late Paleozoic tectonics and paleogeography of the ancestral Front Range: Structural, stratigraphic, and sedimentologic evidence from the Fountain Formation (Manitou Springs, Colorado): *Geological Society of America Bulletin*, v. 122, p. 575-594.

- Tunbridge, I.P., 1981, Sandy high-energy flood sedimentation - some criteria for recognition, with an example from the devonian of S.W. England: *Sedimentary Geology*, v. 28, p. 79-95.
- Wellman, S.S., 1970, Stratigraphy and Petrology of the Nonmarine Honda Group (Miocene), Upper Magdalena Valley, Colombia: *GSA Bulletin*, v. 81, p. 2353-2374.
- Xu, C., Cronin, T.P., McGinness, T.E., and Steer, B., 2009, Middle Atokan sediment gravity flows in the Red Oak field, Arkoma Basin, Oklahoma: A sedimentary analysis using electrical borehole images and wireline logs: *AAPG Bulletin*, v. 93, p. 1-29.