Mechanism of generation hyperpycnal flow and the features of hyperpycnites

Speaker: Ming-Wei Liao

References

- Mulder, T., Syvitski, J.P.M., Migeon, S., Faugè`res, J.-C., and Savoye, B. (2003) Marine hyperpycnal flows: initiation, behavior and related deposits. A review.

  Marine and Petroleum Geology, v. 20, p. 861–882.
- Bhattacharya, J.P., Maceachern, J.A. (2009) Hyperpycnal rivers and Prodeltaic Shelves in the Cretaceous Seaway of North America. *Journal of Sedimentary Research, v. 79, p. 184–209.*

Outline

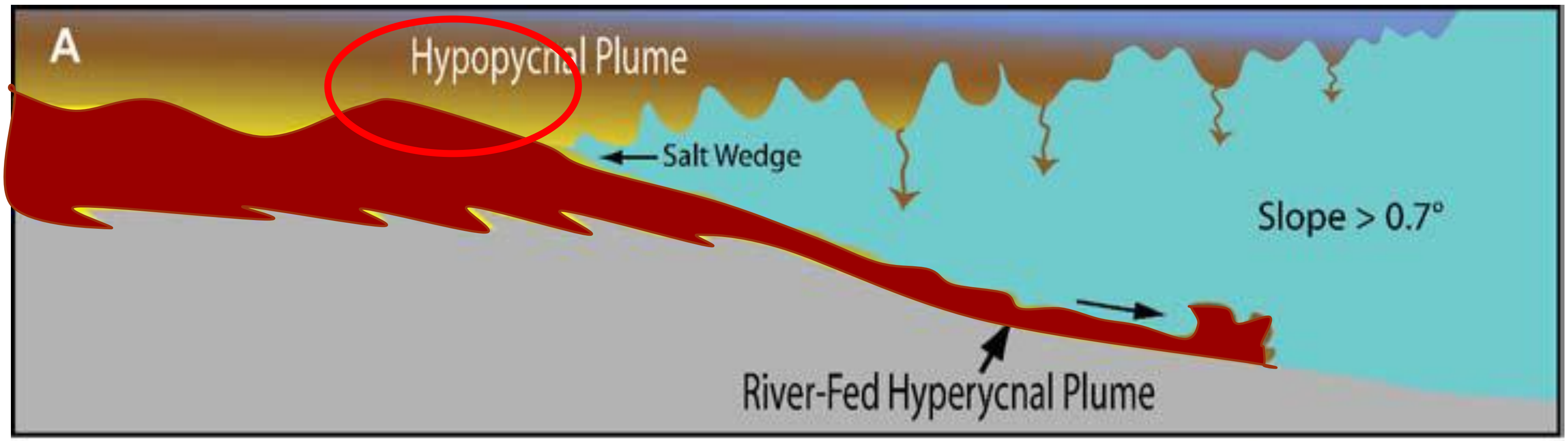
- Introduction
- Criteria for generation of hyperpycnal flow
- Criteria for identification of hyperpycnites
- Discussions
- Conclusions

In Taiwan rivers can generate hyperpycnal flow

Kaoping River

Introduction - hyperpycnal flow

river mouth



A hyperpycnal process means that riverine material is transported directly to the marine environment.

Skeidararsandur (Iceland) The surface flow disappears quickly at the plunging point. Beyond this point, the current will flow along the Atlantic seafloor. Arrow indicates flow direction.

- River flow contributes to 95% of the global sediment flux delivered to the ocean from land.

Global estimates of the flux of sediment from land to the ocean (Syvitski, 2003)

Transport mechanism	Global flux estimate (10^{12} kg $year^{-1}$)	Grade
Rivers: suspended load	18	B^+
Bed load	2	B^-
Dissolved load	5	B^+
Glaciers, sea ice, icebergs	2	C
Wind	0.7	C
Coastal erosion	0.4	D

Criteria for generation of hyperpycnal flow

- Concentration
- High-relief
- Tectonically active mountains
- Humid climates
- Dirty river
- River size
- Dilution of sea-water by fresh water
- Extreme event

Hyperpycal flow experiment

Suspended sediment concentration at river mouth

- The critical concentration for plunging (C_c) varies between 36 and 43 kg m^{-3} ,and depends on the temperature and salinity of seawater near the river mouth.

	Temperature (°C)	Salinity (‰)	Density (10^{-3} kg m^{-3})	C_c (kg m^{-3})
(1)	27	34.75	1.02257	36.25
(2)	24	35.75	1.02424	38.93
(3)	13	35.25	1.02661	42.74
(4)	1	33.75	1.02708	43.49

(1) Equatorial (Lat. <10°); (2) Tropical and subtropical (Lat. 10–30°); (3) Temperate (Lat. 30–50°); (4) Subpolar (Lat. > 50°). Modified from Mulder and Syvitski (1995).

Nine rivers are ‘dirty’ in natural conditions

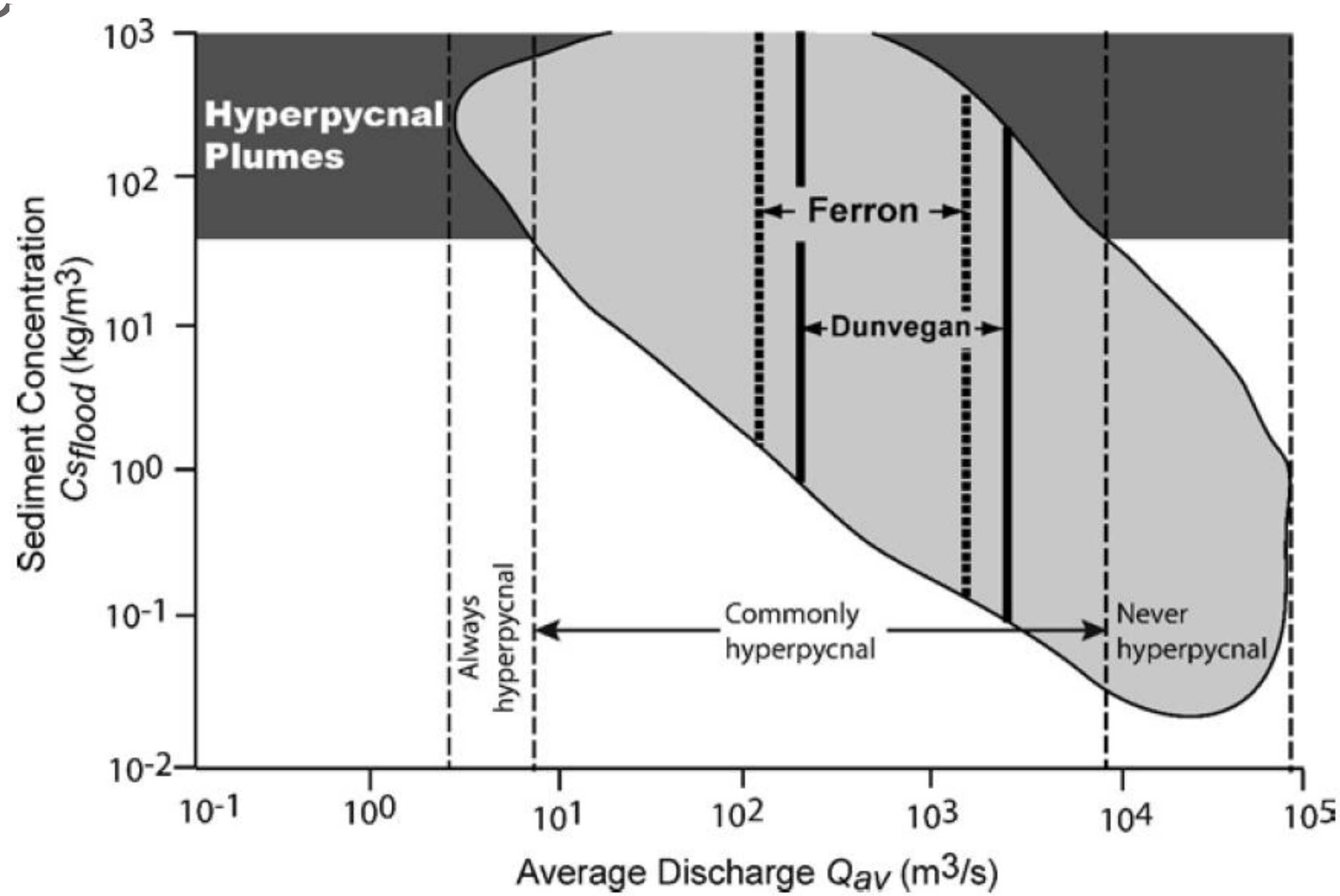
Dirty rivers that may produce one or several hyperpycnal flows each year

River	Q_{av} ($m^3\ s^{-1}$)	$C_{s_{av}}$ ($kg\ m^{-3}$)	C_c ($kg\ m^{-3}$)
Choshui (Taiwan)	190	10.5	38.9
Djer (Algeria)	2	13.4	42.7
Tsengwen (Taiwan)	76	12.9	38.9
Isser (Algeria)	12	15.4	42.7
Rioni (Russia)	5	20.7	43.5
Daling (China)	38	36.0	42.7
Haile (China)	63	40.5	42.7
Huanghe (China)	1880	18.5	42.7
Erhian (Taiwan)	16	25.5	38.9

Average annual suspended particle concentration values (C_{sav}) is close to the critical threshold in concentration (C_c) to generate a hyperpycnal flow. Modified from Mulder and Syvitski (1995).

River size

- Small river



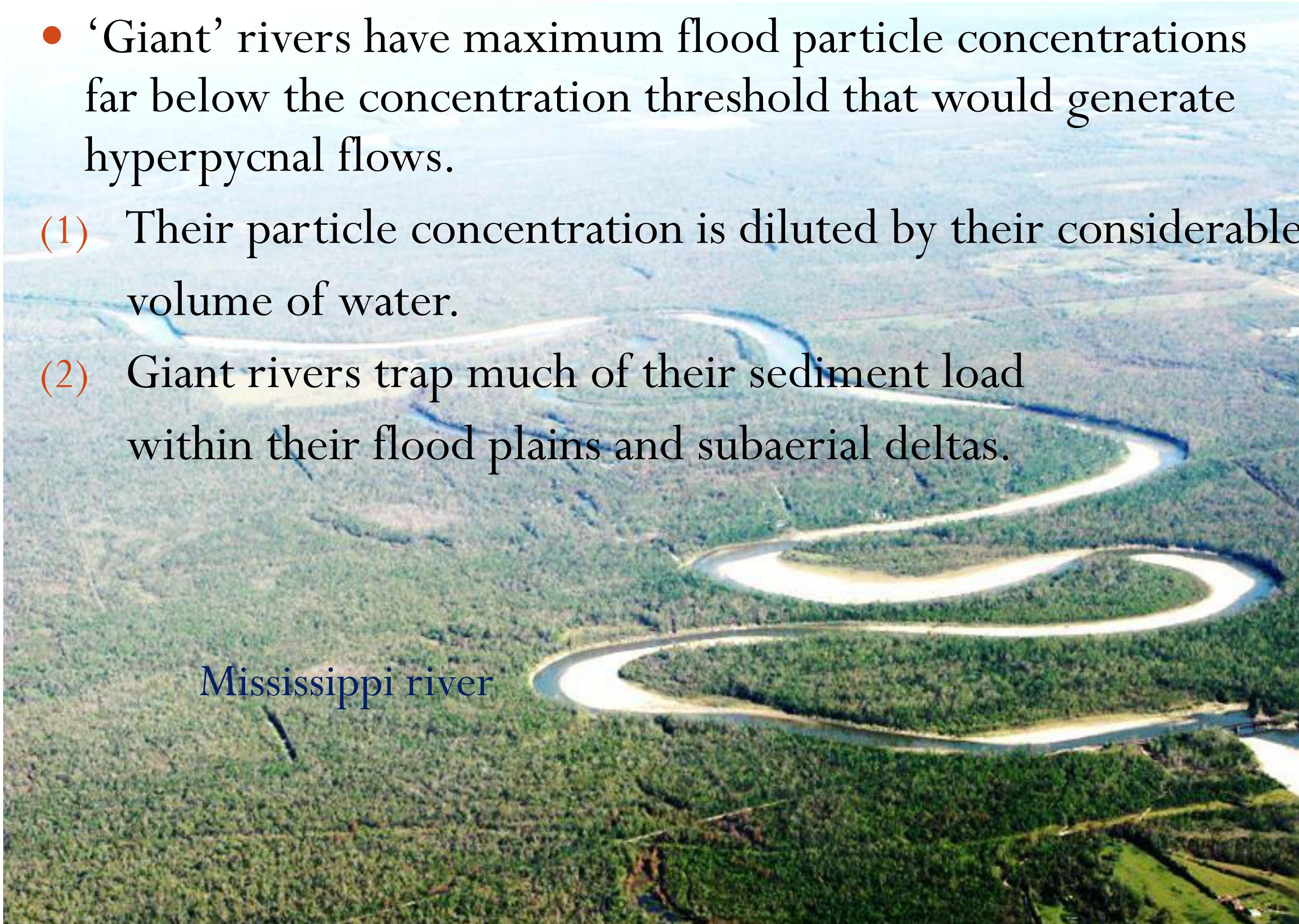
Average discharge of river is less than 6000 m^3/s routinely generate hyperpycnal flows during large seasonal floods.

Giant river

- 'Giant' rivers have maximum flood particle concentrations far below the concentration threshold that would generate hyperpycnal flows.

(1) Their particle concentration is diluted by their considerable volume of water.

(2) Giant rivers trap much of their sediment load within their flood plains and subaerial deltas.



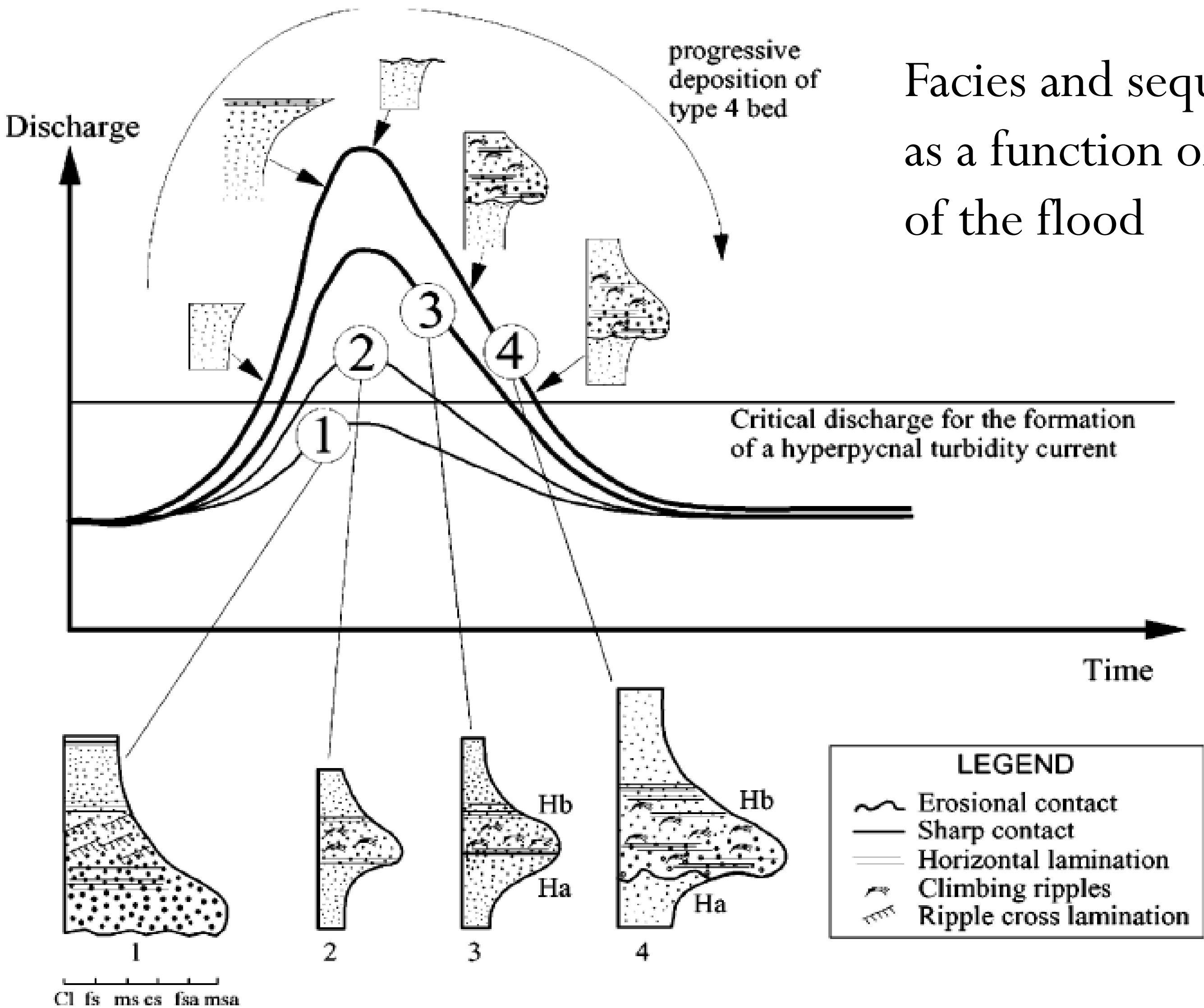
Dilution of sea-water by fresh water

- Dilution of sea-water by fresh water during long duration floods can decrease the concentration threshold to initiate hyperpycnal flows.

Extreme event

- Jökulhaups (glacial flood)
- Dam breaking
- Lahars

Criteria for identification of hyperpycnites

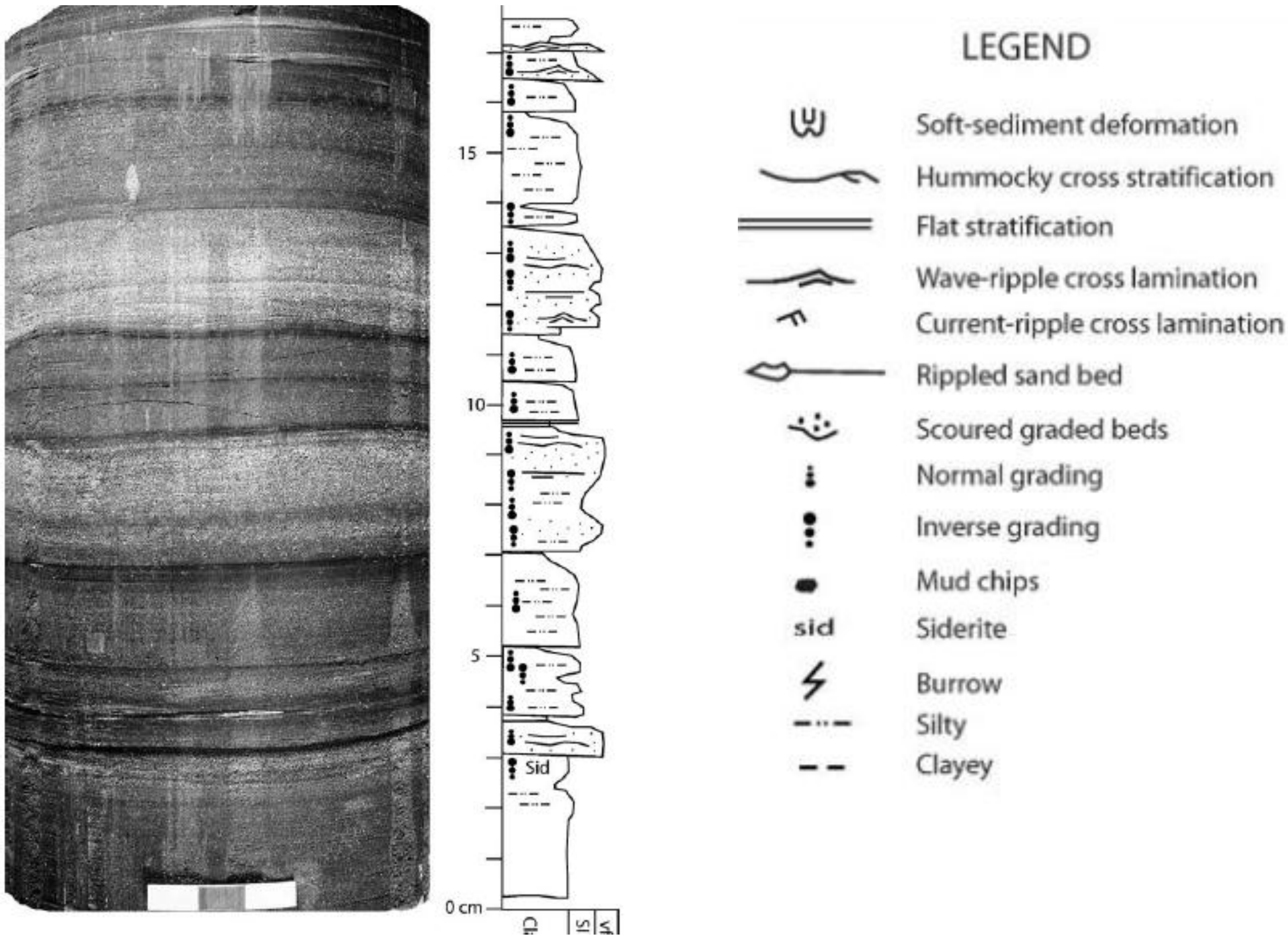


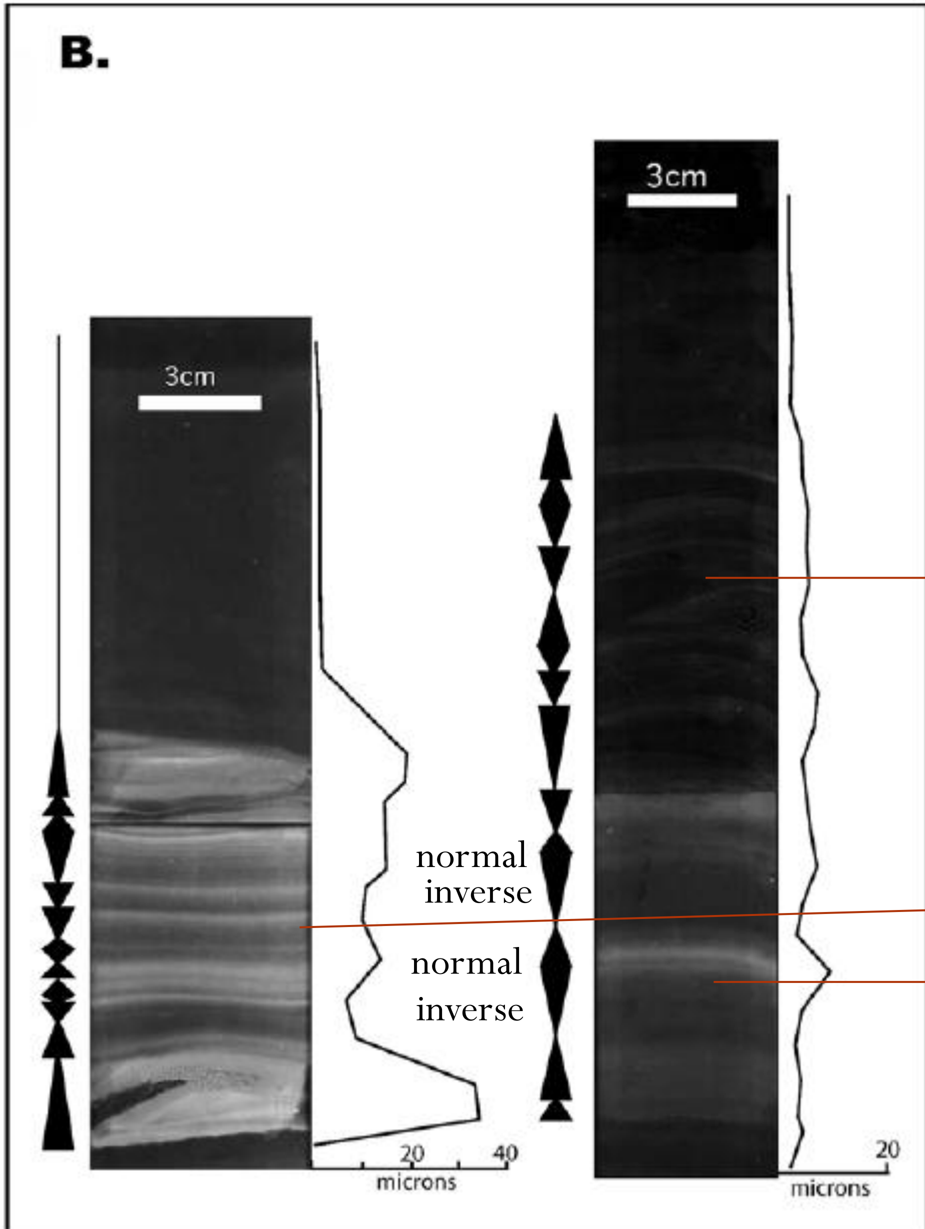
Facies and sequences deposited as a function of the magnitude of the flood

Criteria for identification of hyperpycnites

- Inverse and normally graded beds
- Diffuse bed
- Intrasequence erosion contacts/within-bed scour
- Ripple , climbing ripple
- Continental material
- Flora and fauna is primary allochthonous
- Low bioturbation intensity, few burrowing

Inverse and normally graded beds



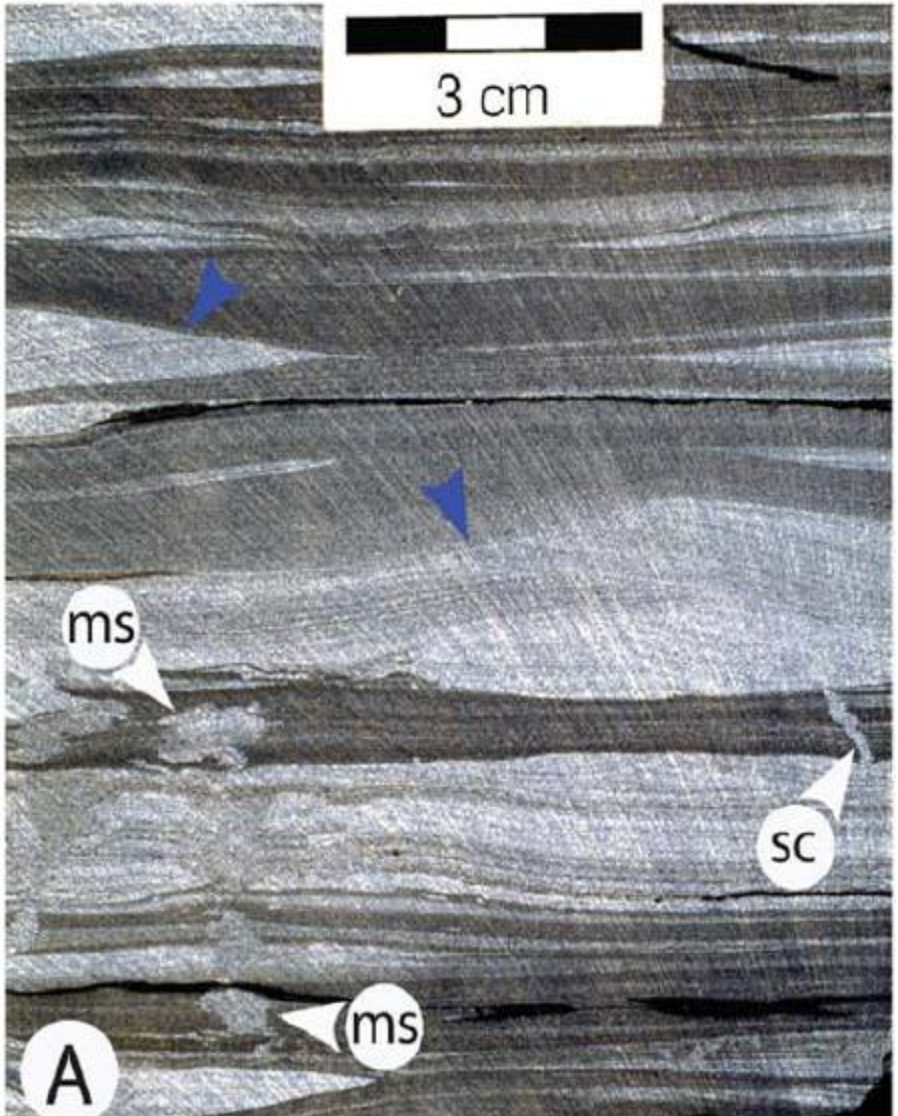


Diffuse bed

Laminae boundary

Inverse and normally graded beds

Intrasequence erosion contacts



Fluid mud

Climbing ripple

Criteria for identification of hyperpycnites

- Continental material
- Flora and fauna is primary allochthonous
- Low bioturbation intensity, few burrowing

Discussions

- How are hyperpycnal flows maintained on the seafloor?

Hyperpycnal flow is maintained along the seafloor because:

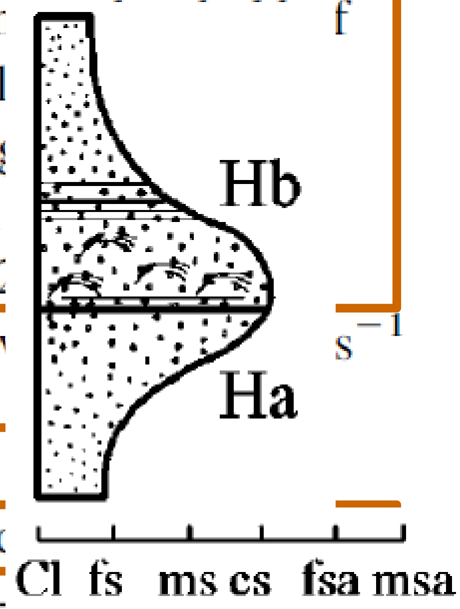
(1) entrainment of sea-water into the flow progressively increases the density of the water phase while dilution of the suspended particle concentration decreases the internal friction and

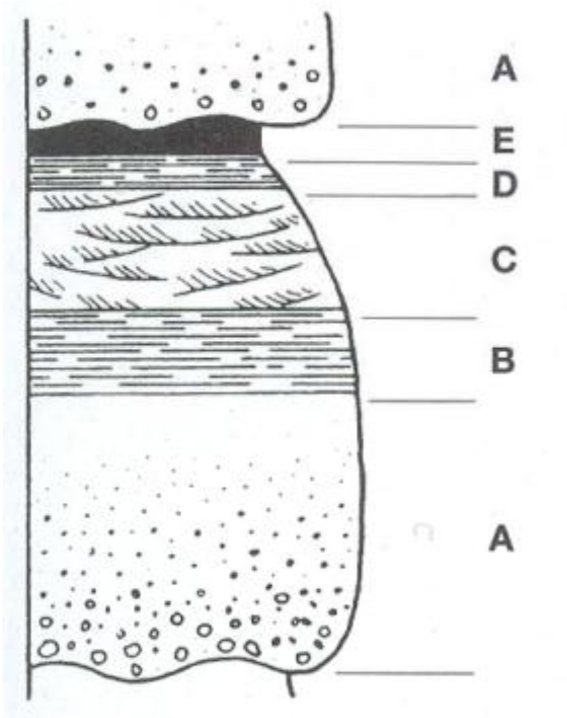
(2) erosion of the seafloor increases flow density.

- Differences with slide-induced flows

Behavior of hyperpycnal and slide-induced flows

Hyperpycnal flows	Surge-induced flow
Minim ... f particl for tri Initial 5(?)–...	d on ... $^{-3}$
Flow ... s^{-1}	s^{-1} lopes
Thick	ned
No in...	ail
Quasi-...	
Duration: minutes to weeks	...ours





Conclusions

- Marine hyperpycnal flows form when fresh watereffluent discharges into the ocean with a suspended mater content of 36–43 kg m^{-3} .
- Hyperpycnal processes could also play an important role in canyon formation and in the origin of meanders in deep-sea channels.
- Shelf mud can be deposited by muddy hyperpycnal process. Sediment accumulation rates of up to 20 cm per year have been recorded in the modern Atchafalaya mud belt,compared to less than 1 cm/year in the more distal offshore.

Thank you!!!

Negtive buoyancy

- Negative buoyancy is when the gravitational pull on a diver is greater than the buoyant force. This means that the diver is being pulled downward, and that the buoyant force is doing negative work (work that is in the opposite direction of the displacement). Positive buoyancy is the opposite situation in which the buoyant force of the diver is greater than the gravitational pull, which makes the diver move upwards.
  Usually, a person's weight is slightly more than the weight of the displaced amount of water. For example, a person who weighs 80kg displaces 79dm2 of water, which weighs 79kg, that is, he has about 1kg of negative buoyancy.
  As for your question whether this negative buoancy is a unique feature for black people, the answer is no. it is related to the person's density.