Estimation of Suspended Sediment Concentrations during Deposition of Turbiditic Structureless Sandstones of the Middle Permian Brushy Canyon Formation, South New Mexico*

Kannipa Motanated[1] and Michael M. Tice[1]

Search and Discovery Article #50681 (2012)**
Posted August 13, 2012

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Long Beach, California, April 22-25, 2012

[1] Texas A&M University, College Station, TX (kmotanat5@neo.tamu.edu)

Abstract

Spatial and size distributions of mineral grains with contrasting densities in massive sandstones (Bouma A divisions) of turbidites from the Middle Permian Brushy Canyon Formation were used to estimate suspended sediment concentrations of the depositing turbidity currents. Semi-quantitative elemental distributions in massive sandstone samples were estimated by x-ray fluorescence analytical microscopy. The results were then used to estimate the spatial and size distributions of zircon and feldspar grains. Hydraulic sorting of these grains resulted in characteristic vertical profiles of zircon grain abundance within the structureless sandstone divisions. Elemental maps show no grading in grain sizes of either heavy or light minerals. However, zircon grain abundance decreased upward within the structureless sandstone divisions relative to that of feldspar grains. These results suggest that zircon grains behaved as hydraulically coarse components of the grain population. Using different models of the effects of hindered settling on mixed grain populations, we estimate a volumetric sediment concentration greater than 20%. This implies that at least some Brushy Canyon Formation A divisions were deposited from hyperconcentrated suspensions.

References

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Haughton, P., C. Davis, W. McCaffrey, and S. Barker, 2009, Hybrid sediment gravity flow deposits-classification, origin and significance: Marine and Petroleum Geology, v. 26, p. 1900-1918.

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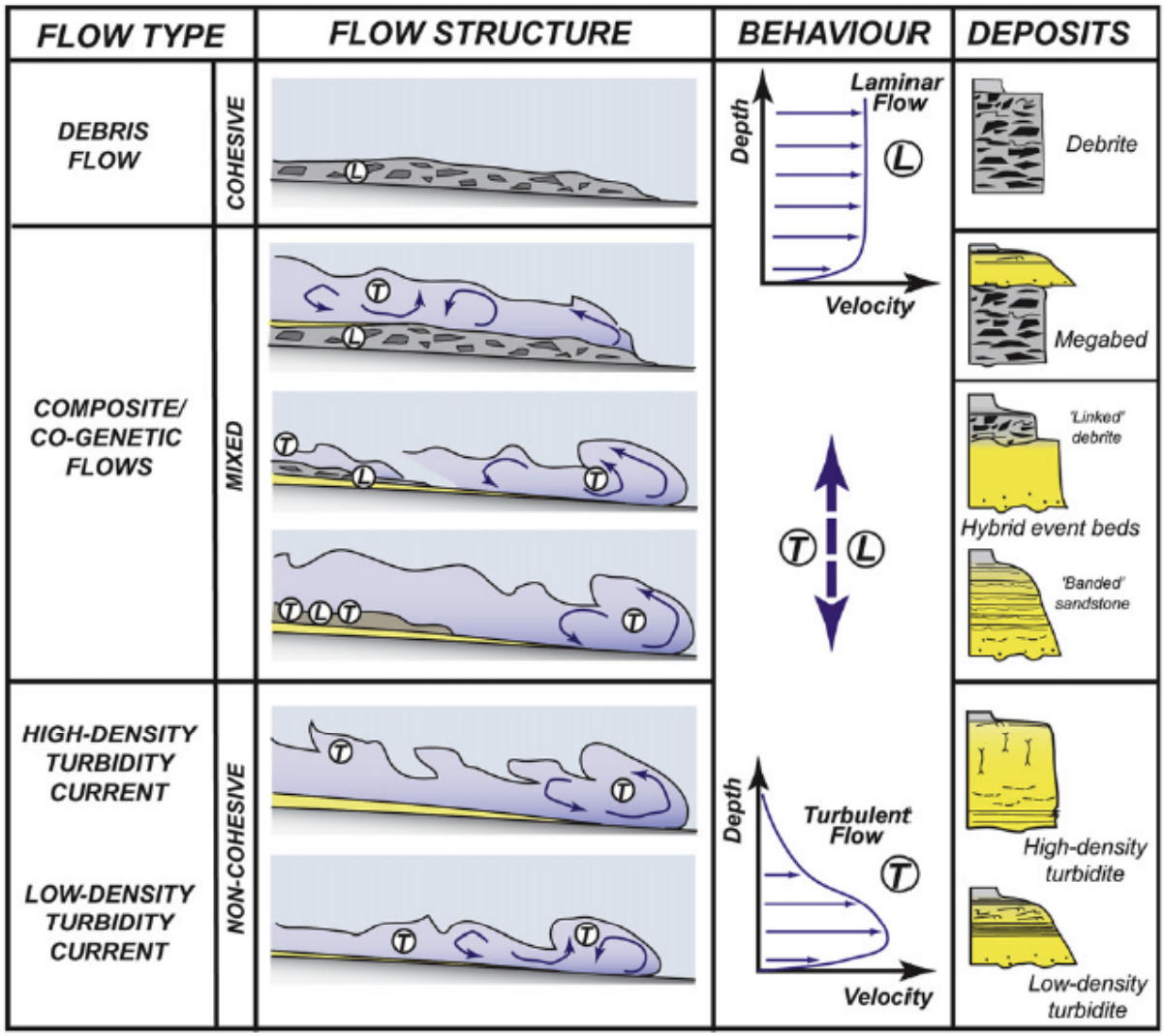
(Abstract ID: 1236965)

Kannipa Motanated
Dr. Michael M. Tice
Texas A&M University

AAPG 2012 Annual Convention & Exhibition,
Long Beach, California
April 24, 2012

MOTIVATIONS



(Haughton et al., 2009)

- Turbidity flow sizes and properties
- Downslope reservoir size

APPROACH

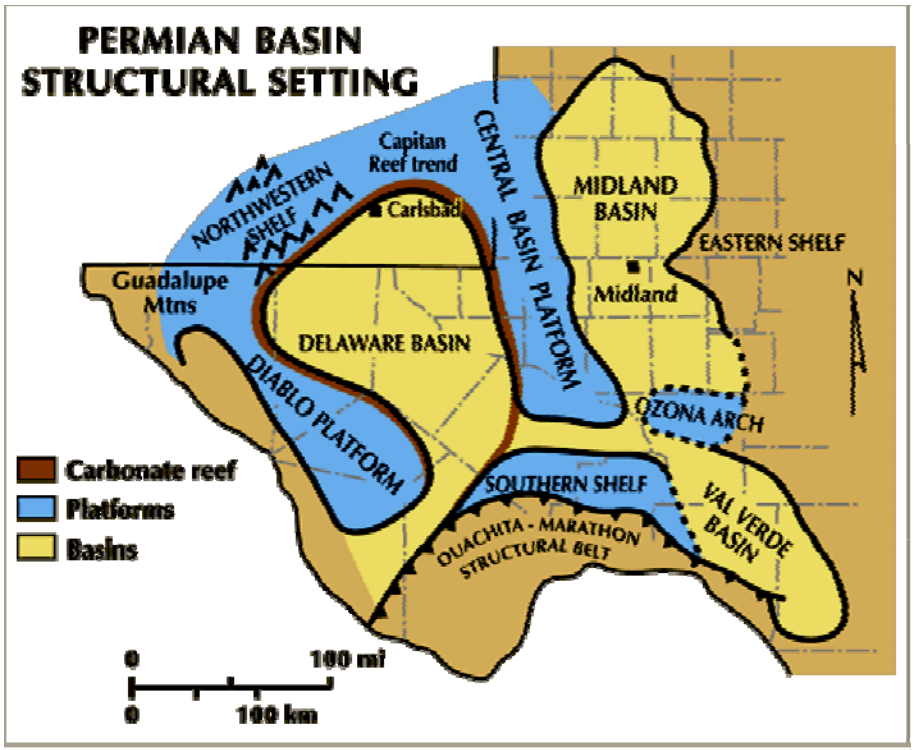
- Forces in infinitely diluted and concentrated suspensions are not the same
- Light and heavy minerals grain will likely settle differently in concentrated suspension
- Zircon and K-feldspar are abundant in core samples
- X-ray fluorescence microscopy (XRF) allows in situ location and measurement
- Apply models of grain settling to infer volumetric concentration from sorting in size data

OUTLINE

- Backgrounds
  - Geologic background
  - Settling velocity models
- Methods
- Results
  - Abundances of heavy and light minerals
  - Size distributions of heavy and light minerals
- Analysis
- Conclusions
- Future work

GEOLOGIC BACKGROUND

The Brushy Canyon Fm., Delaware Basin, west Texas and south New Mexico



(http://www.beg.utexas.edu/techrvw/presentations/posters/wtgs-dutton/index.htm)

- The Brushy Canyon:

500 meters of sandstones and siltstones onlap the older carbonate slope deposits

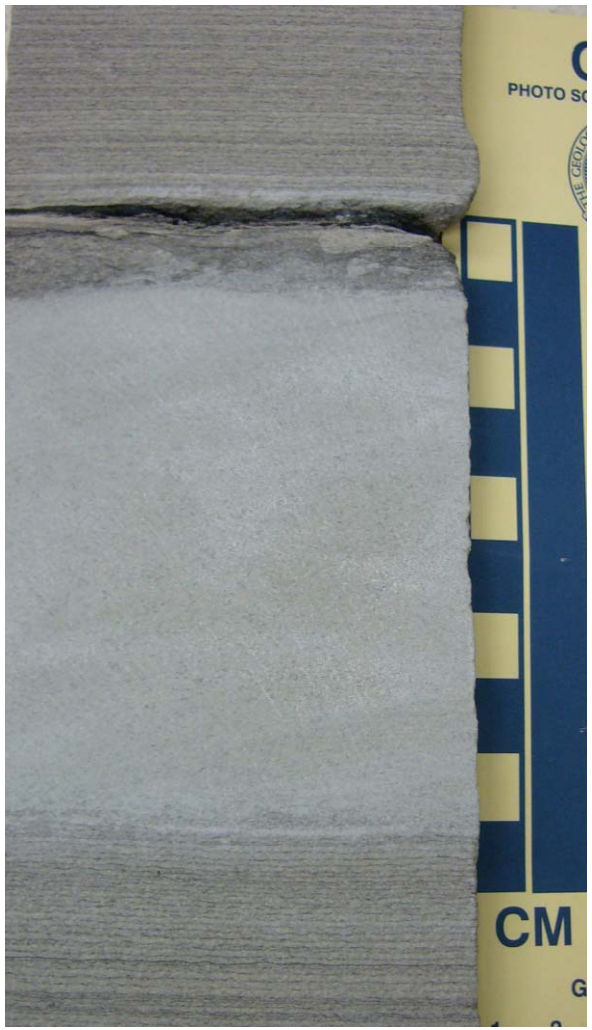
- Lowstand fan systems tracts:

laterally extensive sand-prone basin, sand-filled channels incised into siltstone on the slope

GEOLOGIC BACKGROUND

The Brushy Canyon Fm., Guadalupe Mtn. Nat'l Park

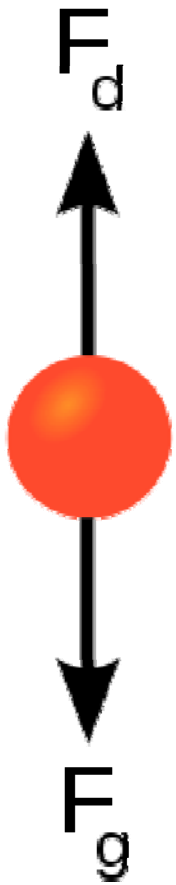
1 meter



Bass Enterprizes Unit 46 Core

SETTLING VELOCITY

Infinitely diluted suspension



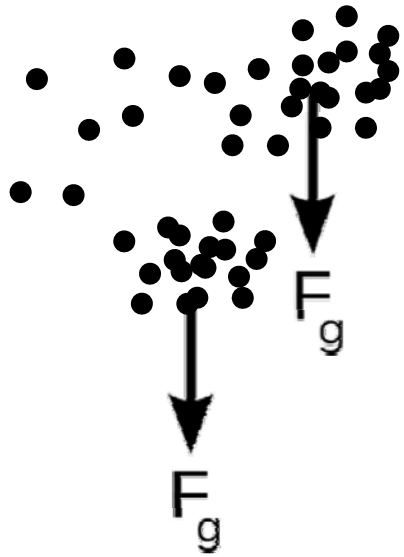
Stokes settling velocity:

$$u = \frac{d^2(\rho_s - \rho)g}{18\,\mu}$$

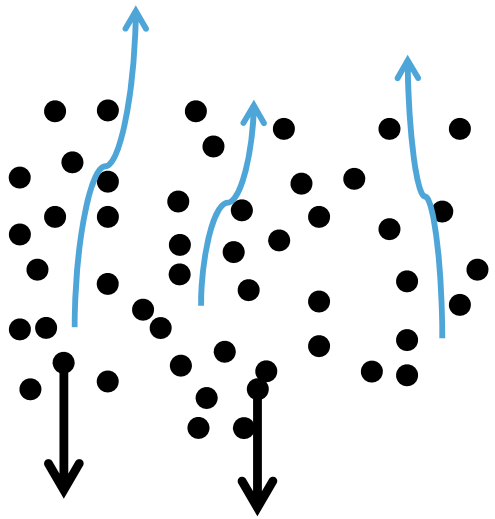
Balancing viscous drag force to effective weight of particle

SETTLING VELOCITY

Concentrated suspension



Group Settling



Hindered Settling

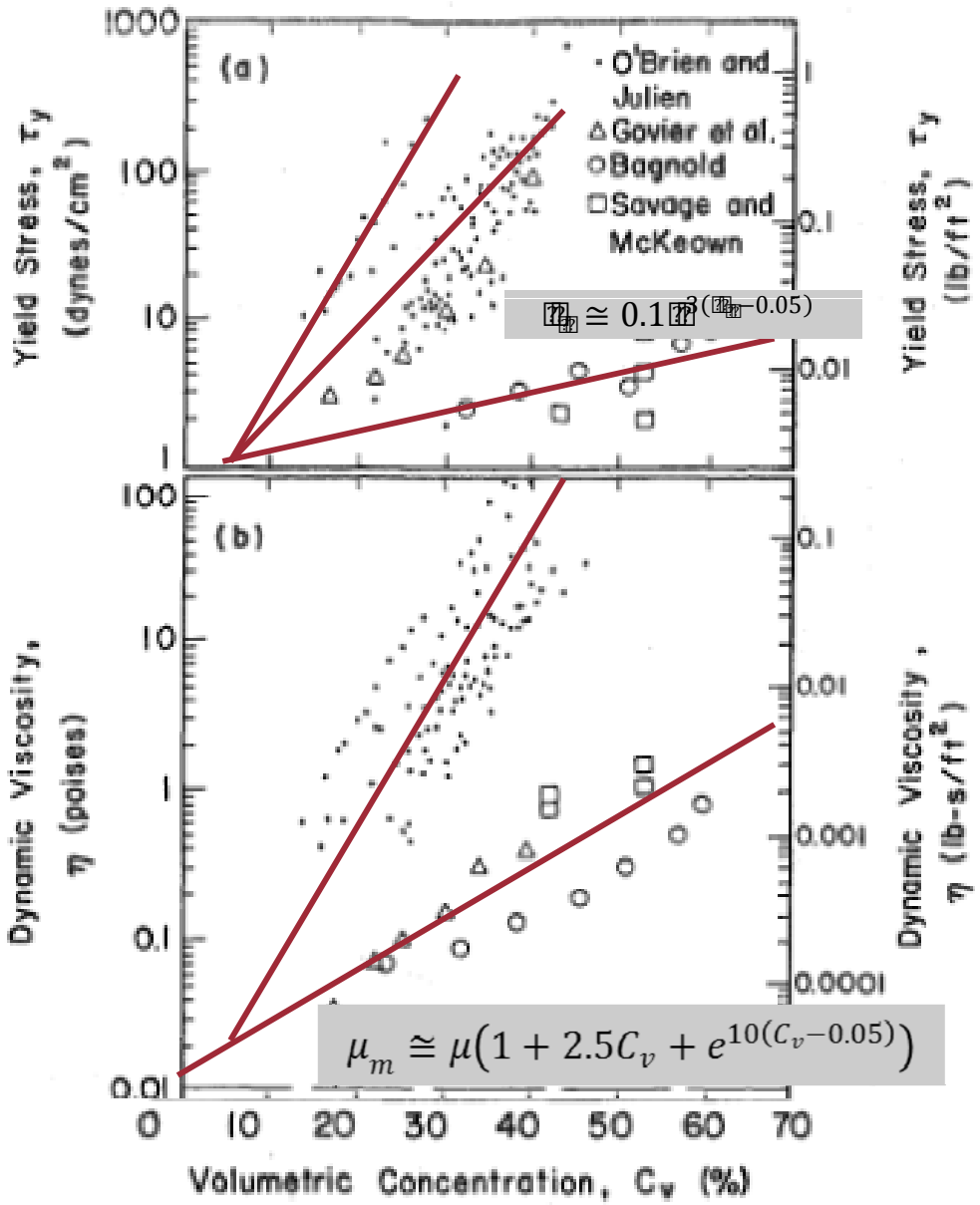
SETTLING VELOCITY

- Terminal velocity at Cv from 5%-40%
  - Richardson and Zaki' model

$$u_1 = u(1 - c)^n$$

  - u is Stokes' settling velocity
  - u_1 is terminal velocity corrected by sediment concentration c
  - $n\ (zircon) = 4.6$
  - $n\ (K - feldspar) = 4.3$

SETTLING VELOCITY



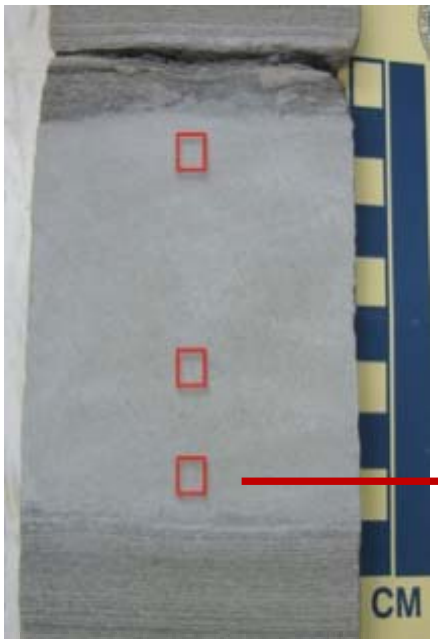
(modified after Julien and Lan, 1991)

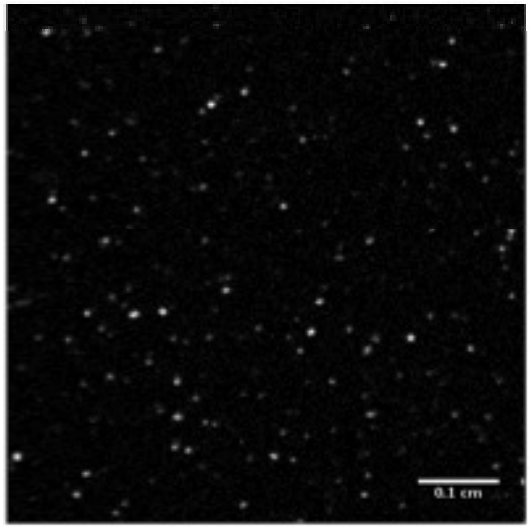
Hyperconcentrated suspension: Fluid properties are effected by suspended particles

- Yield strength
- Dynamic viscosity
- Mixture density

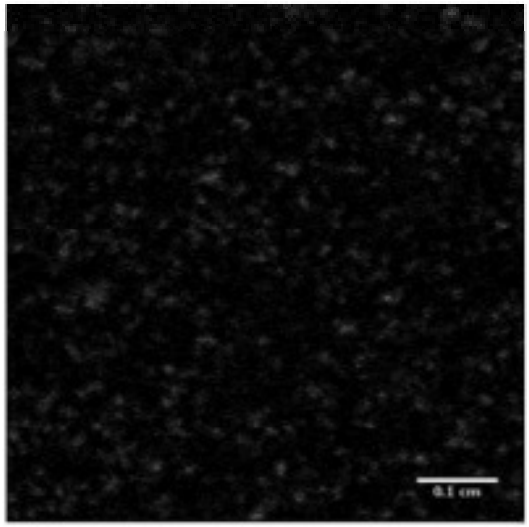
Settling velocity for suspended load developed by Julien (1998)

METHODS





Zr-riched minerals (heavy)

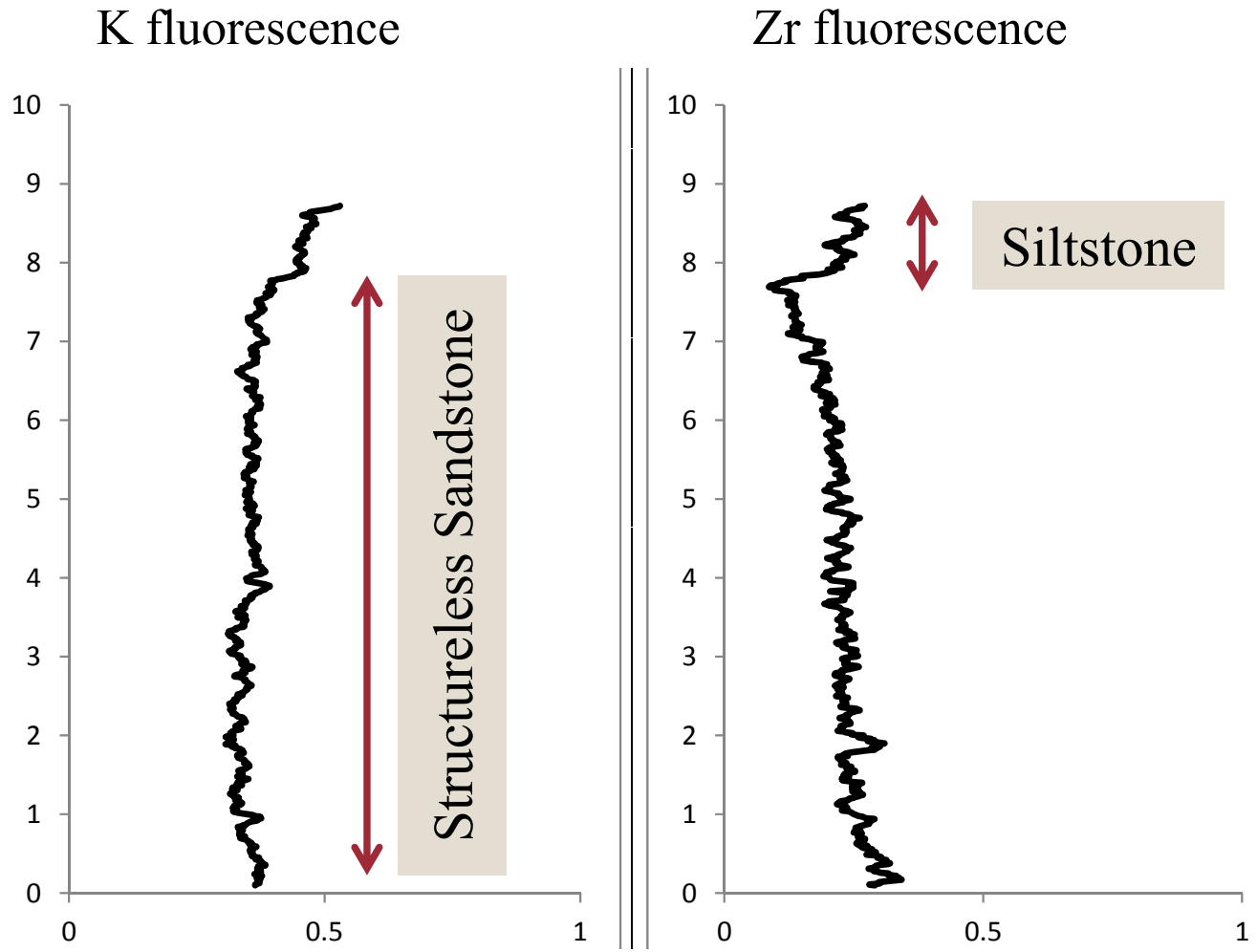


K-riched minerals (light)

- Semiquantitative element maps obtained by the XRF
- Spatial abundances and grain size distributions of light and heavy minerals

RESULTS

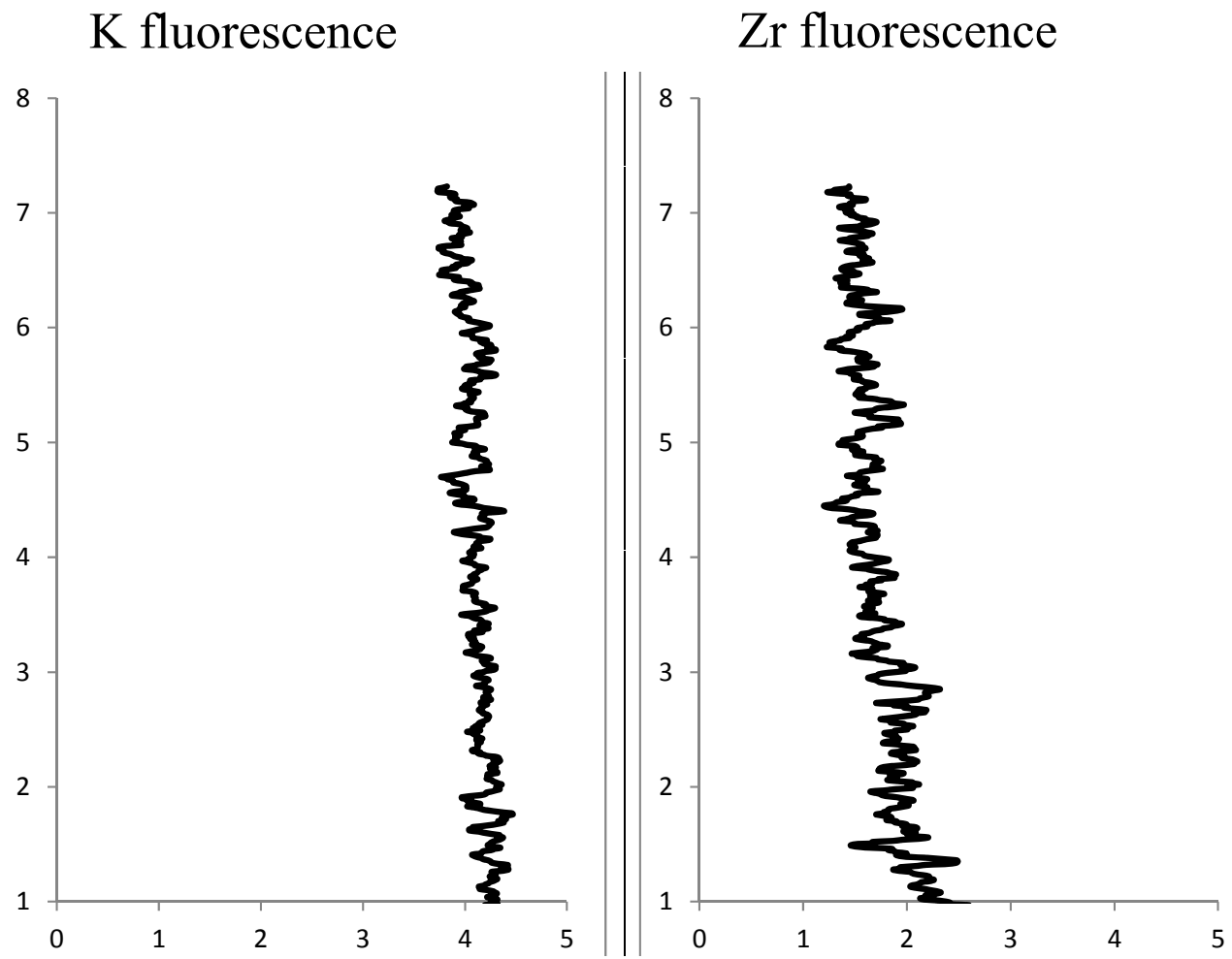
Abundances of heavy and light minerals



Bass Enterprizes Unit 46 at 6100 ft

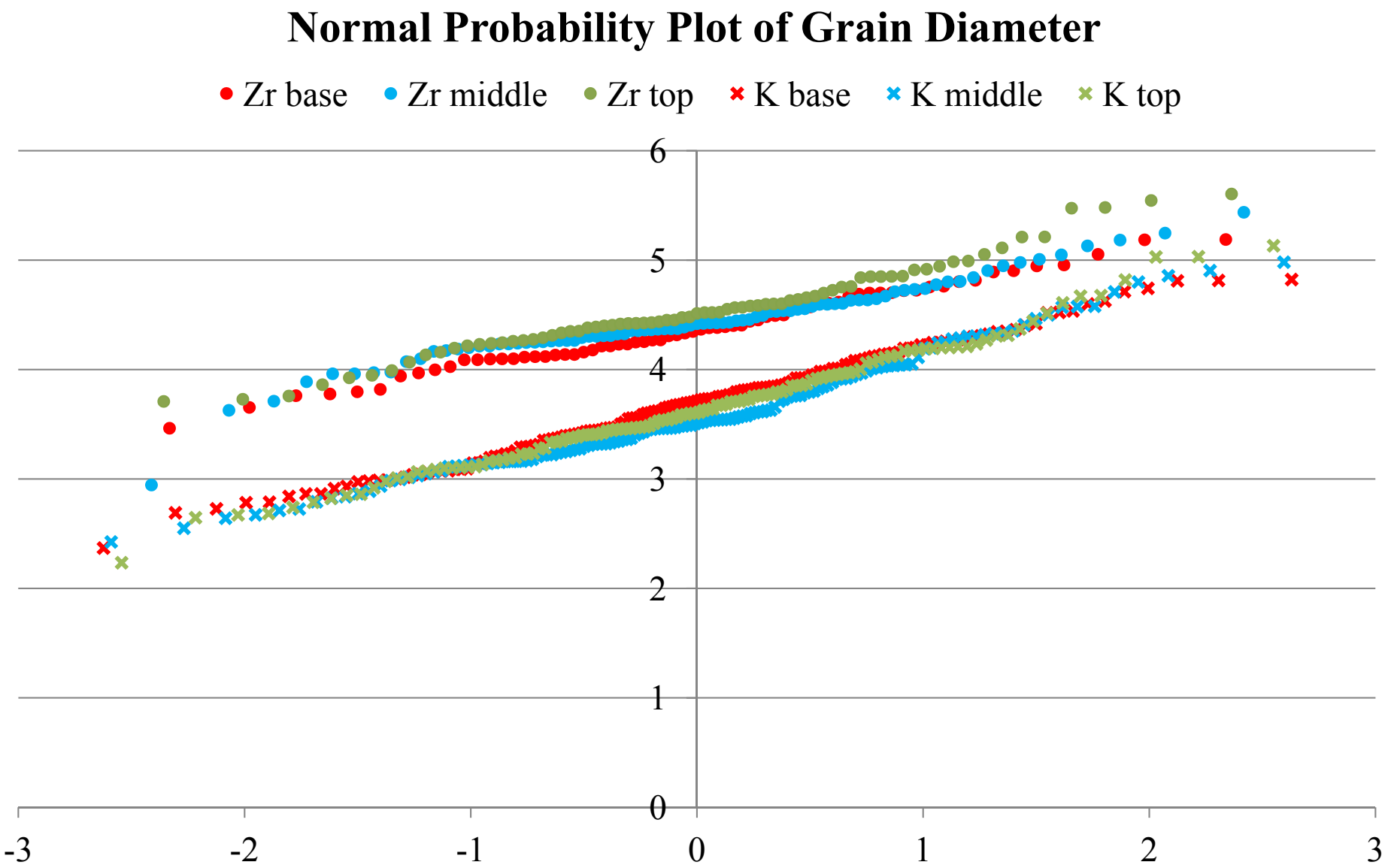
RESULTS

Abundances of heavy and light minerals



Bass Enterprizes Unit 46 at 6111.5 ft

RESULTS

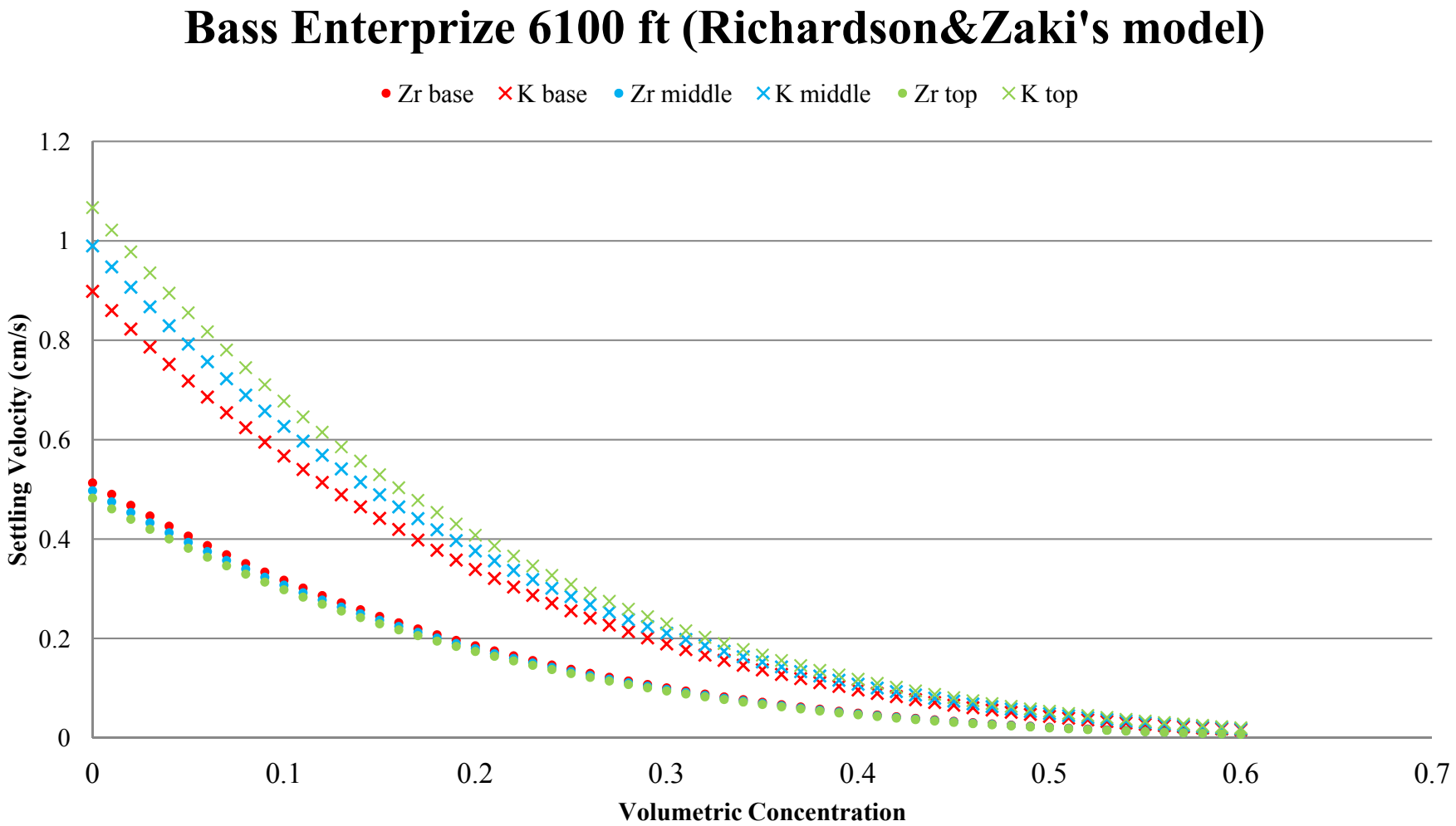

Normal Probability Plot of Grain Diameter
Zr base
Zr middle
Zr top
K base
K middle
K top
6
5
4
3
2
1
0
-3
-2
-1
0
1
2
3

RESULTS

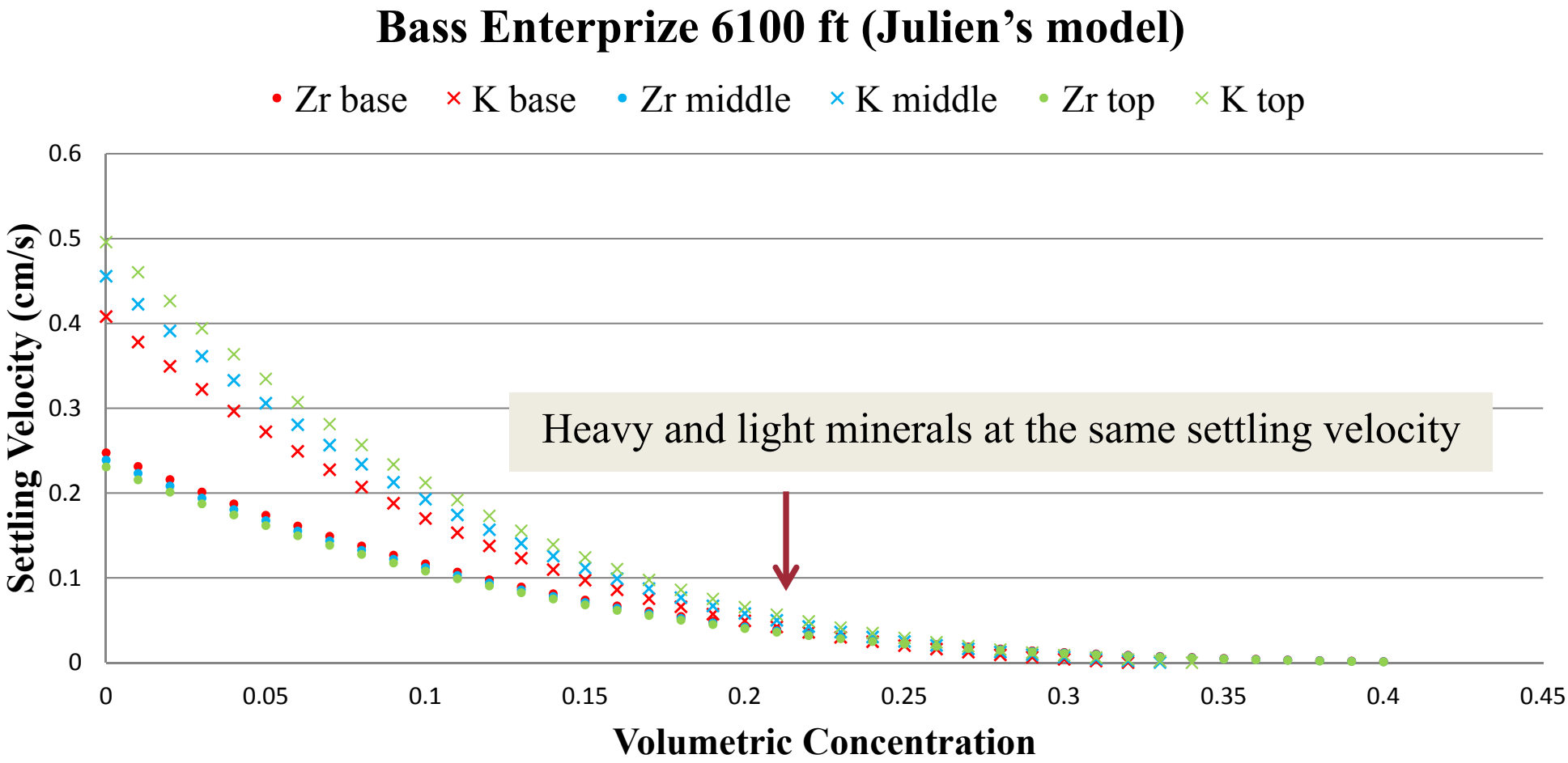
Bass Enterprize 6100 ft	Height (mm) from the base	Number of grains	Avg. grain diameter (phi)	Zr/K
Zr 0	0	237	4.308±0.031	Base: 0.736±0.063
Zr 20	20	204	4.330±0.039	Mid: 0.652±0.059
Zr 60	60	142	4.352±0.030	Top: 0.497±0.051
K 0	0	322	3.276±0.042	
K 20	20	313	3.206±0.049	
K 60	60	286	3.152±0.044	

- No statistically significant size grading (t-test on means)
- Zircon grain abundance decreases upsection relative to K-feldspar
- Stokes terminal velocity of zircons are less than those of K-feldspars (calculated at infinite dilution)

ANALYSIS


Bass Enterprize 6100 ft (Richardson&Zaki's model)
Zr base
K base
Zr middle
K middle
Zr top
K top
Settling Velocity (cm/s)
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Volumetric Concentration

ANALYSIS


Bass Enterprize 6100 ft (Julien's model)
Zr base
K base
Zr middle
K middle
Zr top
K top
Settling Velocity (cm/s)
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Volumetric Concentration
Heavy and light minerals at the same settling velocity

CONCLUSIONS

- Zircons behaved like hydraulically coarse grains during deposition of massive sandstones
- At volumetric concentrations of 20%-30%, observed zircons and K-feldspars have similar settling velocities (Julien & Lan model)
- No existing models explicitly predict differential velocities during group settling of bimodal mixtures (different in both density and size)

FUTURE WORK

- Settling velocity experiments and modeling of hydraulically equivalent heavy and light particles