

Mike Gardner PhD

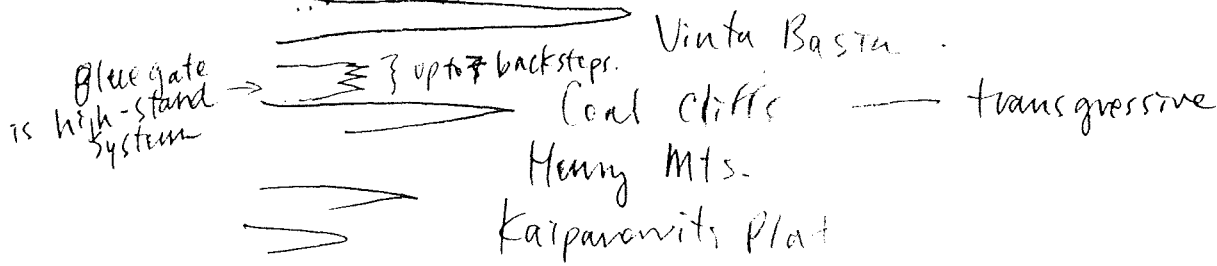
- 3 PHASES:
- ① regional - major depositional systems
 - ② hierarchical pattern of progradational stacks
 - ③ each progradational stack - 5th order cycle
- Vail 3rd order
4th cycle

"forward stepping" - seaward
backward - landward

landward vs seaward pinch outs

low-stand systems
high-stand systems

scaled thickness to time with biostrat data
along strike variation:



all Utah transgressive sequences are coal-bearing.

So actually sequence boundary in Funuk. Shale

offshore shelf marine clausen Washburn of Mancos → lowstand until ① + ② lower sandstones of Ferron

then highstand Bluegate

subsidence vs eustatic sea level curves

lower Ferron
clawson →

low-stand

upper Ferron → transgressive high-stand

basin always subsiding during Ferron deposition.
So actually still stand during deposition.
base-line always rising.
(coal deposition)

so coals deposited during both transgression + regression.

Model:

Events

lower forward stepping with seaward deposition 1-2

(shoreface more complex) → more stored sand

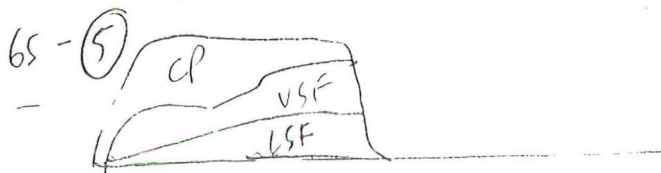
upper back stepping - most deposition landward 4-7

prograding events ↓ more sand non-marine. (fluvial more complex)

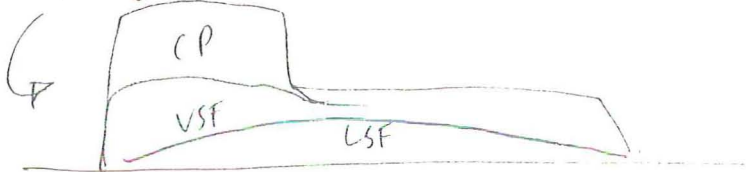
Study:

volume ratio of marine non-marine sands:

UNIT 4: vertical stepping

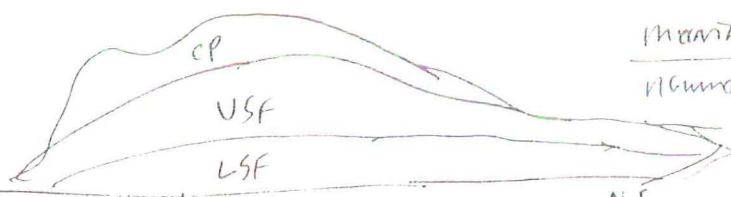


$$\frac{\text{marine}}{\text{non-marine}} = \frac{1}{1} \text{ back step}$$



$$\frac{\text{marine}}{\text{non-marine}} = \frac{2}{1} \text{ vertical}$$

65-4



$$\frac{\text{marine}}{\text{non-marine}} = \frac{3}{1} \text{ forward step}$$

65-3

Part 2 of study:

flooding surface

can one trace marine transgression from shoreface
back into non-marine.

bentonites
c-coal - } time-line.

parasequence: $\frac{1}{2}$ coal + bentonite lower
(couplet) $\frac{1}{2}$ transgressive lag intensely bioturbated upper

$\frac{1}{2}$ mile

UNIT 4: → ① then shoreface

more landward ② then

upward: bentonite, coal shale, channel ss (crevasse)

base-level
rising

15 fam-
around

then prograde system
around.

soft-
sediment
deformation

③ new bentonite
into fluvial channel of alluvial plain
(thick)

forward step - multilateral "marine space" bypass fluvial [compressed]
low aggradation.

backward step - multistage channel belt - high aggradation.
expanded space

↓ immediate
channel fill

expanded space

long term fill
style of fluvial in forward-stepping
isolated channels

incision in forward stepping, not enough space low aggradation.

lateral^{-thick} coals - forward stepping.

vertically-thick coals - back step

transgressive
flooding
surface

Forward step

with transgression

multilateral channel

seaward stepping

3x more sand

tidal worked
low-energy platform

sand waves parallel to flow

Backward - have reworking with
multistage channels → landward stepping
(low sedimentation)

higher energy
- more sand
cleaner

more ripples?

symmetrical ripples - lower shore
multidirectional cross-strat + hummocky X-strat, bioturbated
hummocky strat, swaley beddings

④ is ~~actually~~ twice as big as ③ and ⑤

So may actually be 2 stacked shorefaces,
vertical stacking, so no transgression between.

Dry Wash standing on Dakota SS

Photo (9) lower Clawsen - giant biotridal concentrations
 upper gray Washboard
 top - Number (2) upper shoreface - coastal plain

(10) dark layer is condensed section above number (1)
 no #10 here
 * seaward pinch out to south of Dry Wash.

(11) bottom of slope
 2 benthonites
 #3 to south caps far cliff Woolgrai Zone (Ammonite)

5 miles from seaward to landward pinch out of #5

#3 here is tidal deposit - 8° dip, imbricate beds - irregular pools.
 but paleocurrents all directions
 (top of coal is flooding surface below #3)

In Wash SS lower shoreface #5
 #4 intense convolutions (earthquakes)

(12) off-shore shale

mud-filled scours



#3 tidal
 ① coarse upward lens-traction transport
 ② ephimorpha
 ③ imbricate lens

erosional surface

lower shoreface ① symmetrical ripples

③ bioturbated tops at x-st. at ② hummocky x-st. at

① *Ophiura* fossil lag at base

bleached lag mouthbar distributary channel

thin shoreface #2 SS

① soft silt det early
 ② carb. shale below

#3 upper shore-face near in transgression, tidal traction deposits

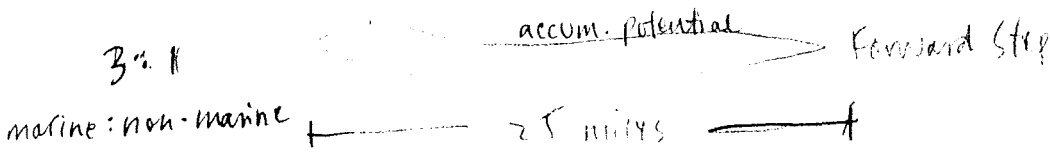
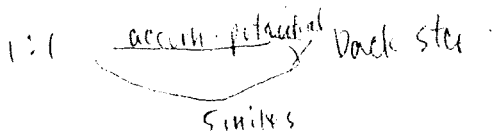
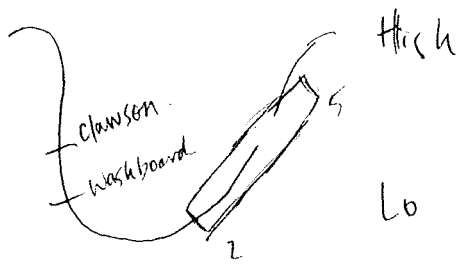
#2 thick here because forward stepping

#4 vertical stepped

flooding, overtop
 ③ unidirectional dip lateral accretion (point bar)

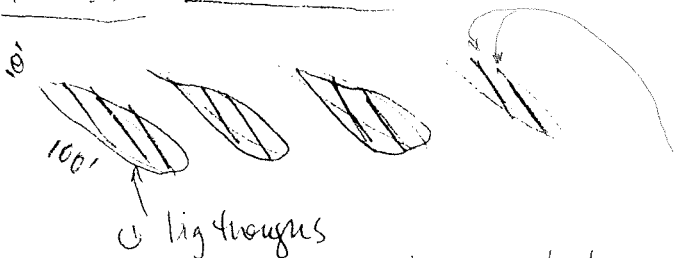
Pywash cont.

Overall
Seal level
of
FERRON



tidal reworking
more important
when flooded
because longer + larger
deposit to be
reworked.
tidal creeks become
very sinuous.

Tidal SS Cliniforms



- ① light troughs
- ② carbonaceous rip-ups at base
- ③ thicken downdip

- ④ reactivation surfaces
is burrowed
coarse grained

at cattle road
road curve

{ pinch out to west into shale
and #4 thicken to west, seaward pinch out here.
#5 seaward pinch out here

carb. shale between #2 #3

① high tundra - clay ② noted SS ③ rip ups at top
gastropod - grass stems

"A" coal above #2

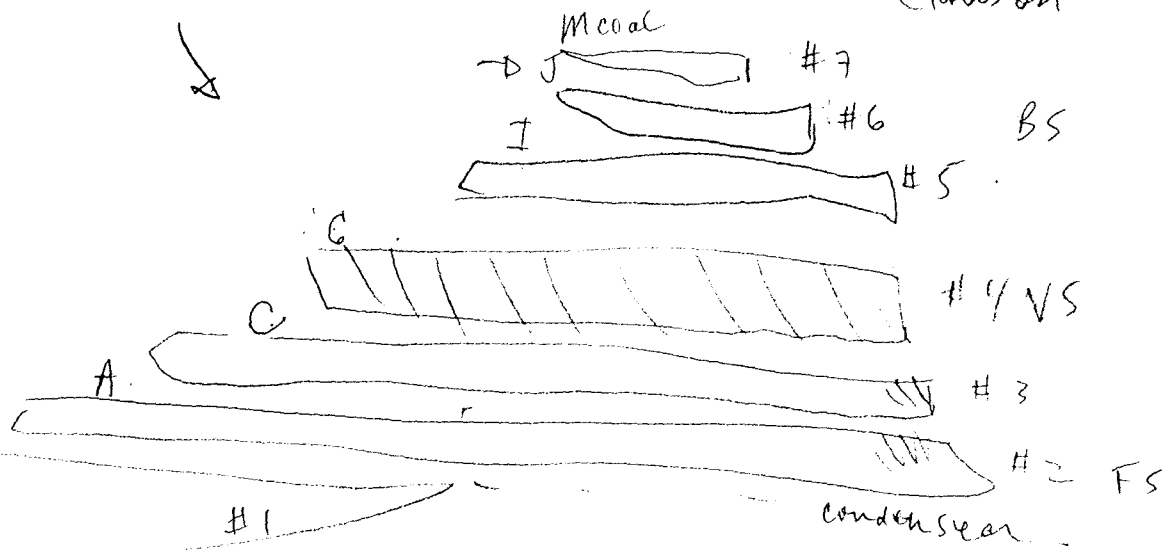
"C" coal above #3

photo ③ point bar - lat. accretion to left, #2

Last Chance lga

45 miles

Clawson



flooding surface sands -

well-cemented
hummocky x-strat above

Muddy Creek:

Photo (14)

Channel cutting into parallel bedding which overlies trough x-bedding. Intensely bioturbated.

Upper shoreface all

#6 beach profile
more sand tied up
in fluvial so
lots of reworking

this surface
a higher order
boundary surface - progradational event

actually clinoform
and repeated



muddy creek

photo (16) #6 sand pinches out to south

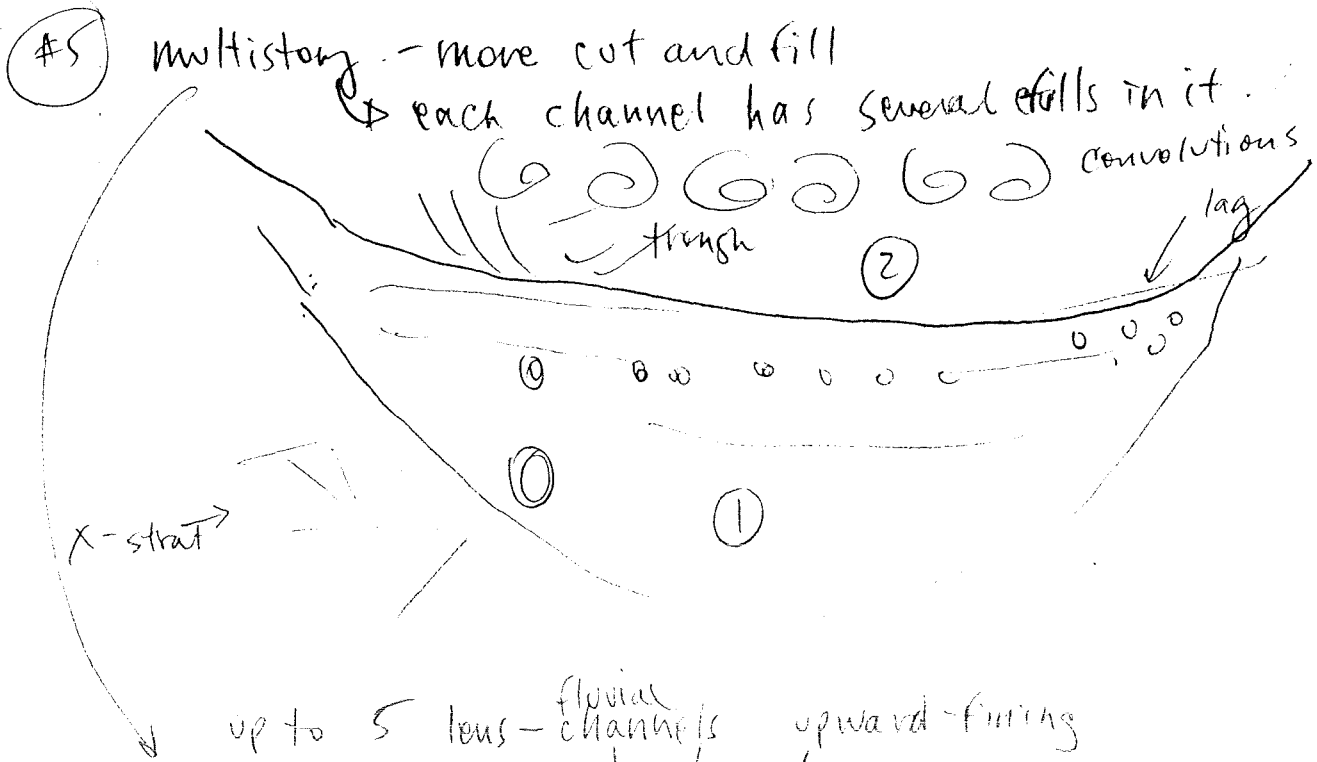
Sequence boundaries are 4th order. } parasequence boundaries
(each sand cycle is a 4th order.)

Whole Ferron is a 3rd order system (one depositional system)

photo (17) tree root into top of #6
↘ along flooding surface

photo (18) dramatic thinning of #6 near landward pinch-out into coal

(19) ripple laminations — #5
with iron concretions.



(#5) multistory - more cut and fill

↘ each channel has several fills in it.

up to 5 lens-fluvial upward-fining
more common landward
backstepping fluvial

(20) at least one channel in #5 pinching out #6 on top
cuts into lower shoreline parallel bed.

Petroglyphs

Lower Miller Canyon -

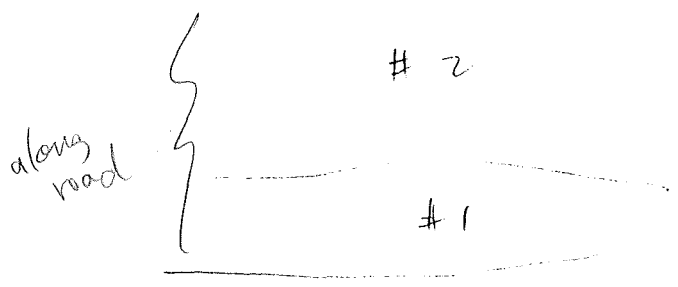
#1, #2 very close, landward of #3, #5, #6
 #1 - seaward pinch-out, no imbricate structure
 IJ coal
 #5 fluvial

C coal - carbonaceous shale

#4 - shorfice, brownish.

AC coal } bentonites no longer have #3 shorfice to separate (pinched out 1 mile north)
 traction troughs, asym. ripple marks } good bidirectional

bay fill



Mouth of Miller Canyon on left - red burnt zone } example of preferentially compacted SS drapes over coal

#2 ball and pillow - lower shorfice
 reworked sands during storms

here b + p between #1 and #2

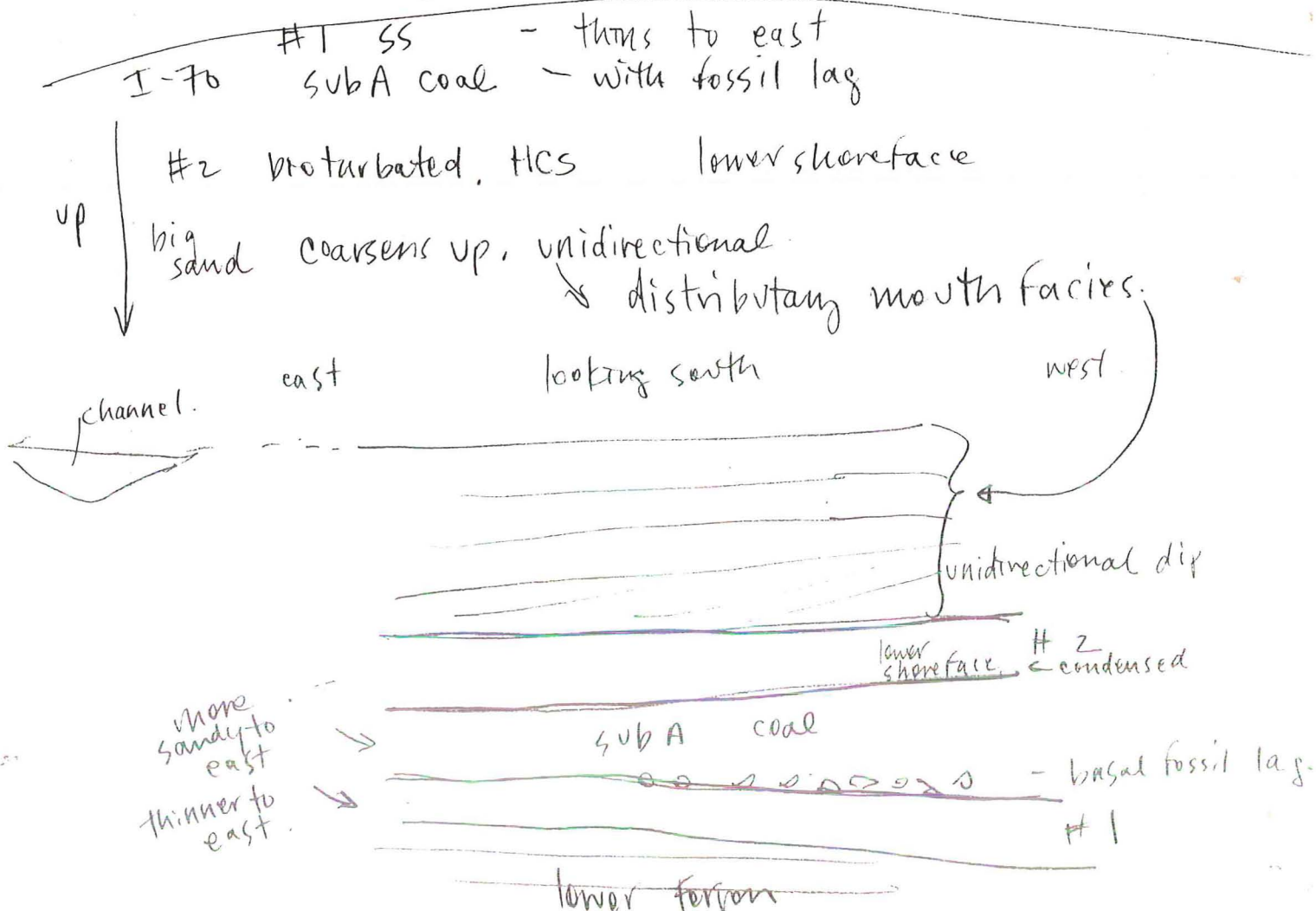
still in Miller cyn:
to right growth faults -
TN #2

to left - dark bed above 2 light beds - bentonite
in Tunupa is Woolgaaie bed - bentonite
(thicker here (ammonites)).

#4 landward pinch-out here ↗ above all big distributary channels.

to right - up cyn thickens very quickly in vertical stack, all upper shoreface
could be a doubled unit

So from here to I-70, only shoreface (main) units left are ① and ②.



I-70

the subA is an interdistributary back bay coal

sand waves - big troughs in #1

top is definitely mouth bars

bottom sand #1 is old, abandoned delta lobe

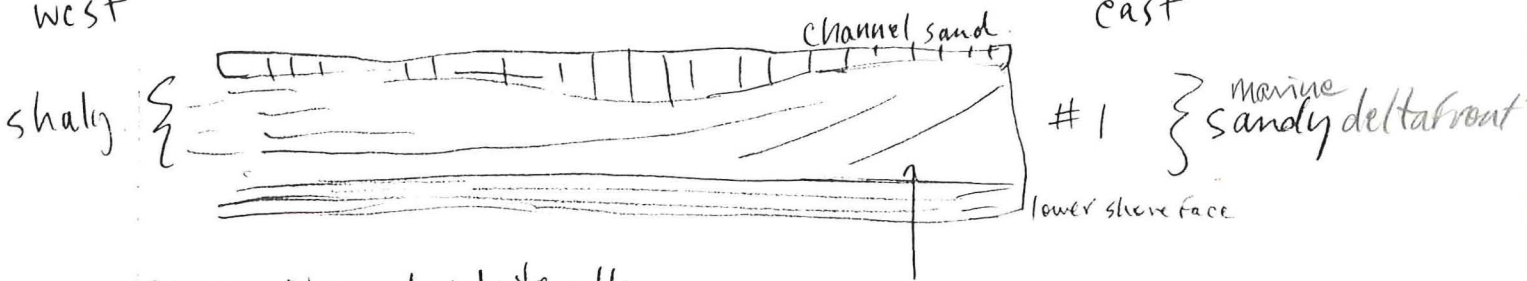
fossils - restricted fauna small size

Photo (1)

looking south

west

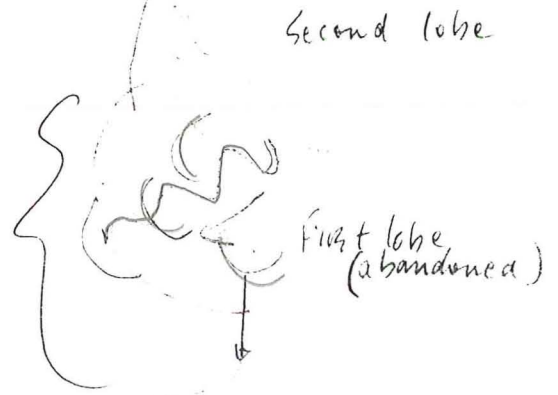
east



same unit grades laterally from sand to shale → is evidence for edge of deltaic lobe.

in forward step - multilateral longhams isolated more deltaic
channel developed on delta front deposits

abandoned lobe develops isolated channels



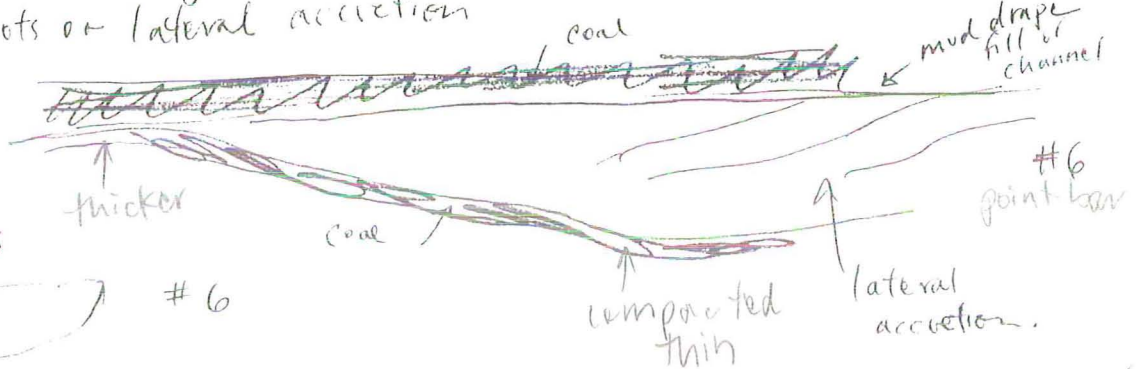
up I-70

multistage channels

more fluvial

lots of lateral accretion

Photo (2) (3)



Meandering abandonment mechanisms:



shoot bar - slow abandonment.
More SS -

or



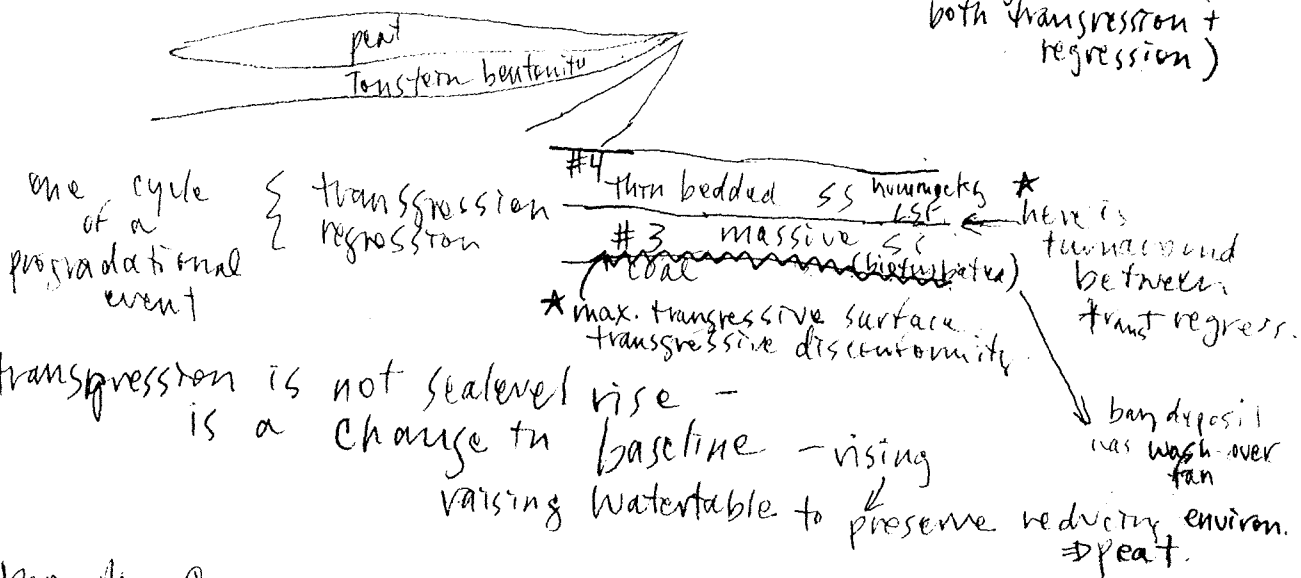
neck bar - fast abandonment.
more clay
total avulsion

Day Two - Miller Cyn.

#3 shoreface pinched out 1 mile north
 ↳ coastal plain - c coal instead. (replace of #3 ss)
 bentonites - "Tonstein" - ash in coal swamp
 Rye 1980 -
 Peat Swamp expands during progradation.

(can get coals with both transgression + regression)

Photo (14)

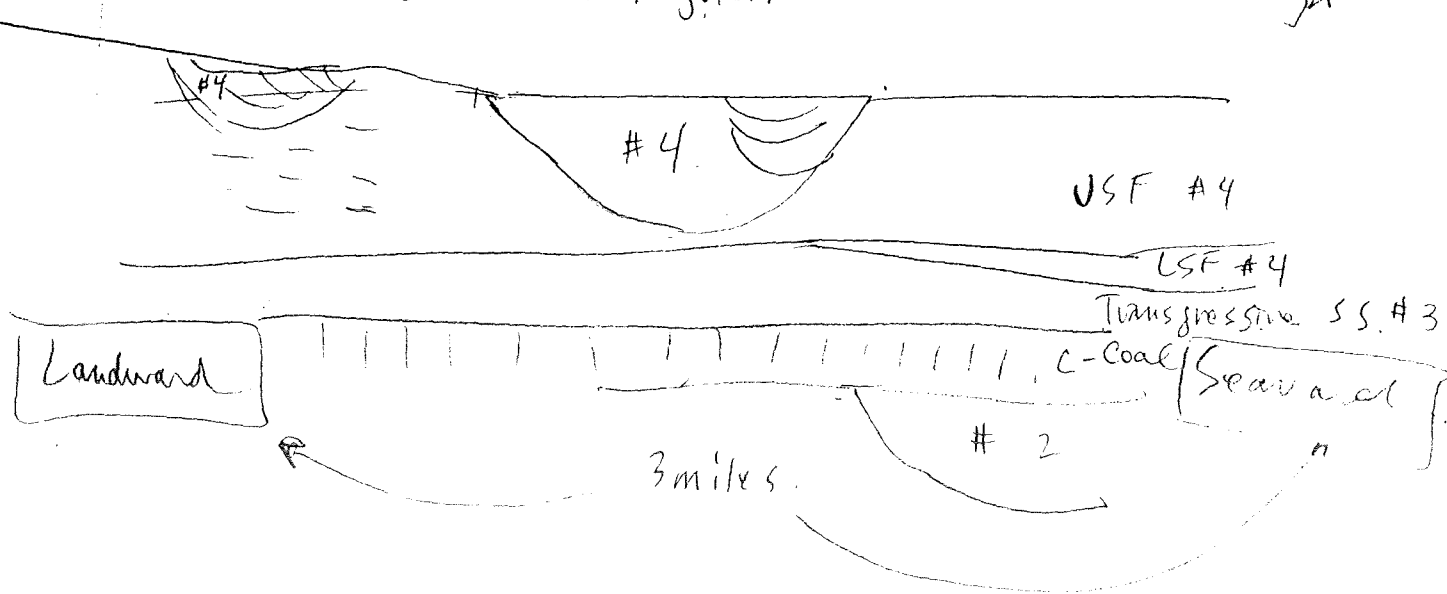


transgression is not sealevel rise -
 is a change in baseline - rising
 raising watertable to preserve reducing environ.
 ⇒ peat.

Cowboy Mine Cyn

Bear gulch

Miller Cyn



← here #3 big channel / scours out c-coal = 8 ft thick
 ↳ btm - extremely bioturbated
 we will track this from marine to non-marine

Cowboy Mine

regressive - feed shore face

transgressive surfaces are timelines - in marine - is surface above shore face; in non-marine, is a ss over coal

ex: So at Dry Wash - basal lag below tidal deposits. #3 is same as surface in Miller Cyn - where bay deposits cut into c-coal. [same transgressive event].

Cowboy Mine -

now 6' coal seam below upper shore of #4 ^{coarse grained through x-beds.}

up into beach

so progradation of #3 assoc. w/ thicker "c" coal (creates more space by thickening shore face sedimentation)
3 bentonites

transgressive #3 - only 1 foot thick above coal

above #4 beach - flat bedding, multistage channel belt

above - coastal plain - crevasse-splay, lateral accretion point bars.

photo (5) #4 upper shore face
(6) people

"I" coal on top some buried

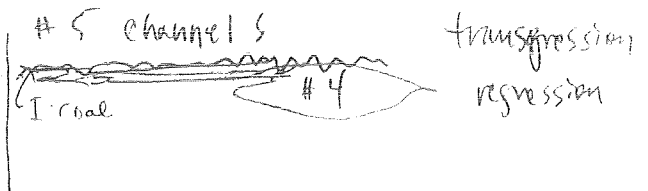
(7) trough x-beds with vertical fractures

Cowboy Mine Cyn

#4 pinched out - landward
I-coal

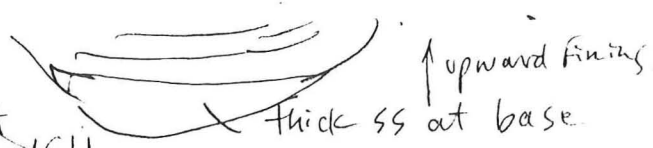
#5 - type point bar - beautiful lateral accretion.

parasequence so timing wise I coal and #5 go together in non-marine (in marine setting, coal is associated with ...)



Cowboy
Cyn. → about
mine
photo (8)

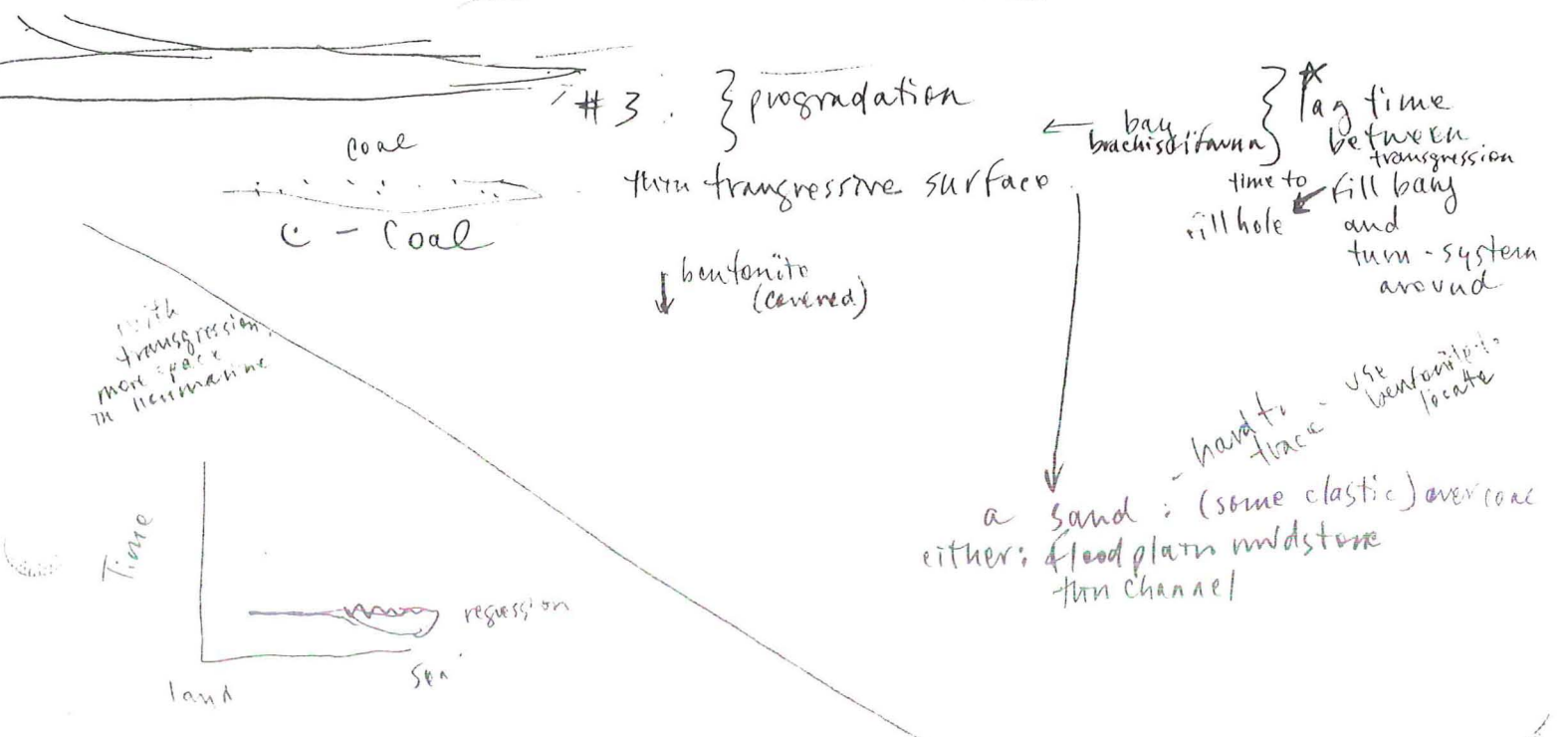
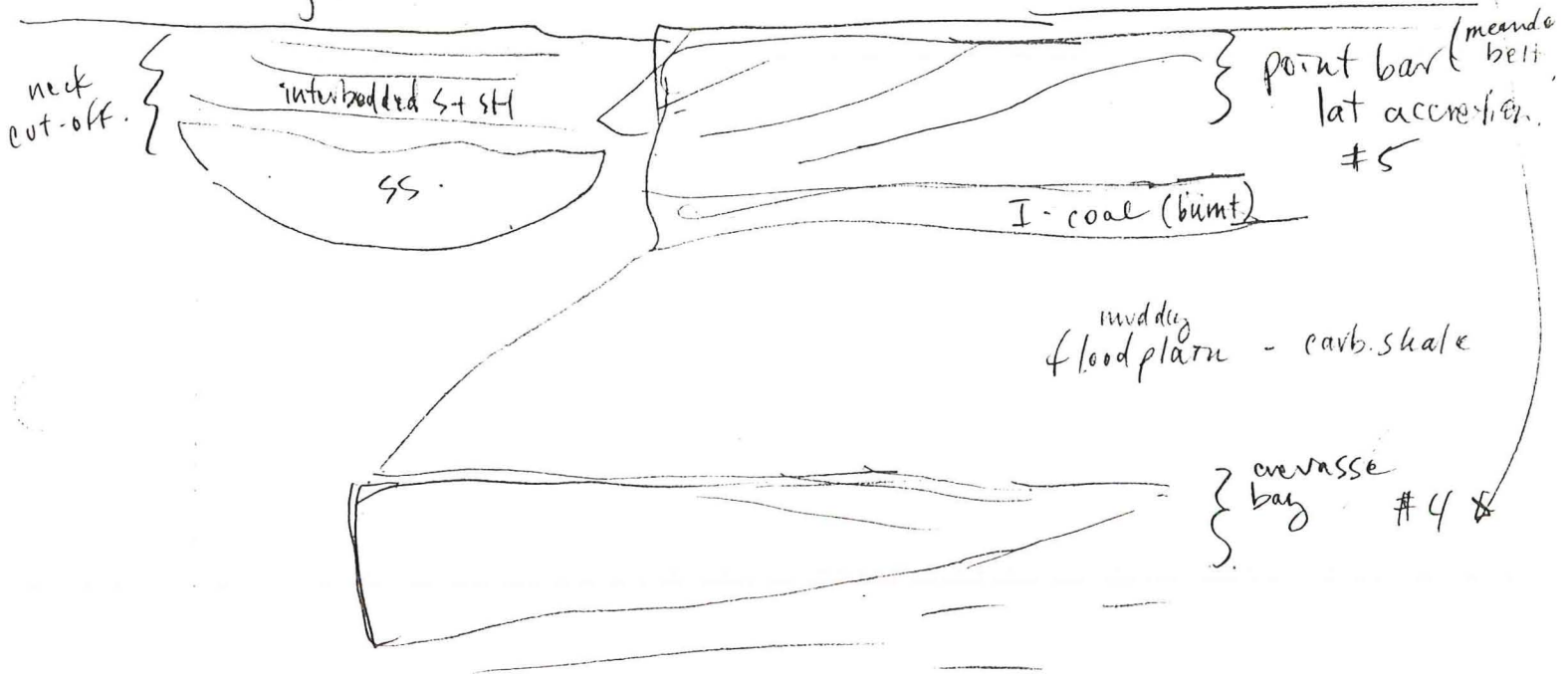
neck bar abandonment
cut-off
rapid abandonment - with mudfill



types of fluvial channels -

- (1) point bar - lat. accretion
- (2) crevasse bay (bay filled with crevasse splays) #4
- (3) distributary - downcut

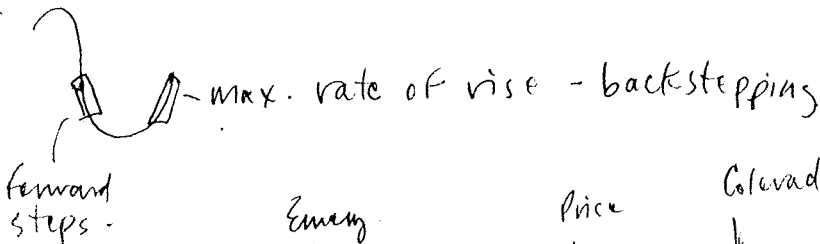
is a process, not genetic



still Cambrian Cgm

Eustasy. Sealevel

High
Low



forward steps -

With Subsidence and transgression →

Emerg ammonitic 'woolgrate'

Price

Colorado

restricted open

(Anco's work)

↓ discontinuity condensed section

exxon's "low-stand systems track" -

but opposite to passive margins -

space is backstepped, with passive platform - space in marine with transgression

transgressive surface sand now in brackish-water

nummulinid bivalves & rooted mudstone as sandstone clasts

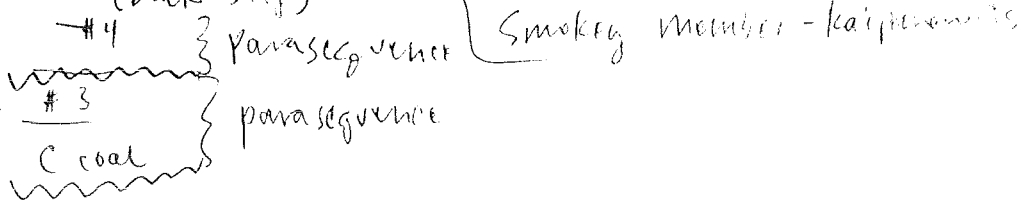
above → gastropods in #3 bay (4, 11) splay channel clasts

these are 250,000 yr events =

1.5 my event { forward step - Tepeats Cgm - Henry Alts.
(low-stand) systems Lower Frontier - Vinta Basin
Ferron

transgressive system - upper Ferron - all coal-bearing (back step)

Photo 9 lower



10

#3, #4, #5

11

multistage channel belt - but also with compaction over burnt "I"

Emery Mine → Consolidated Coase

out of "I" assoc. with #5

possibly I + J assoc with 5+6 ??
20' thick

photo (2) + (13)

at mine. strike view
dips to north

2 dip views here

along top here - some Opimorpha-

transgressive surface on

#4 - white in back
- wing of longhorn

channel belt
Correlations - from Miller Cyn
to I-70.
type multistage unit.
(backstepped)

possibly an
amalgamation of
5+6 = 80' of sand

possibly #5?
(but right under
Blue Gate)

Willows Springs Amphitheater

Photo (14) } #2, #3, #4 top. I+J, #5 very top
 (15) }
 people shots

(20) - to south, #2 - main cliff
 ↳ Lower shoreface, quick transition into
 distributary bar mouth
 or channel?

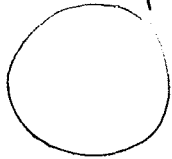
Willow Springs

subA coal

black stuff at btm - little ridge Woolaire zone
 from here to #2 is 150' thicker than at Dry Wash.

(21) #2 pinch-out

Mike: mouth bar plan

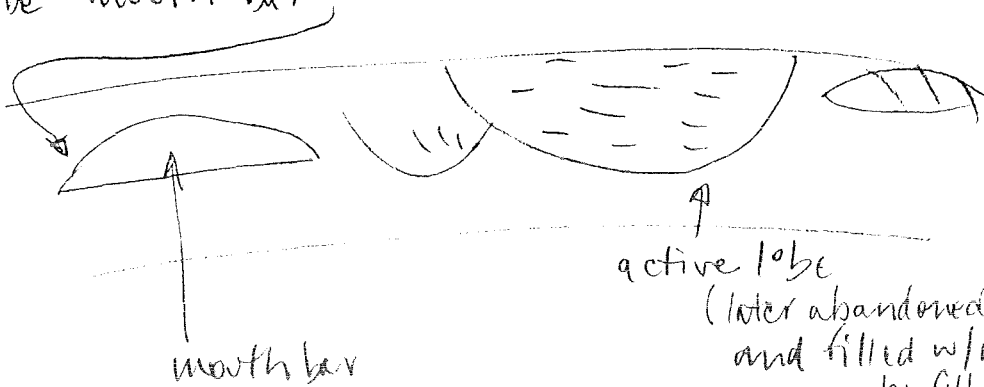


cross-section



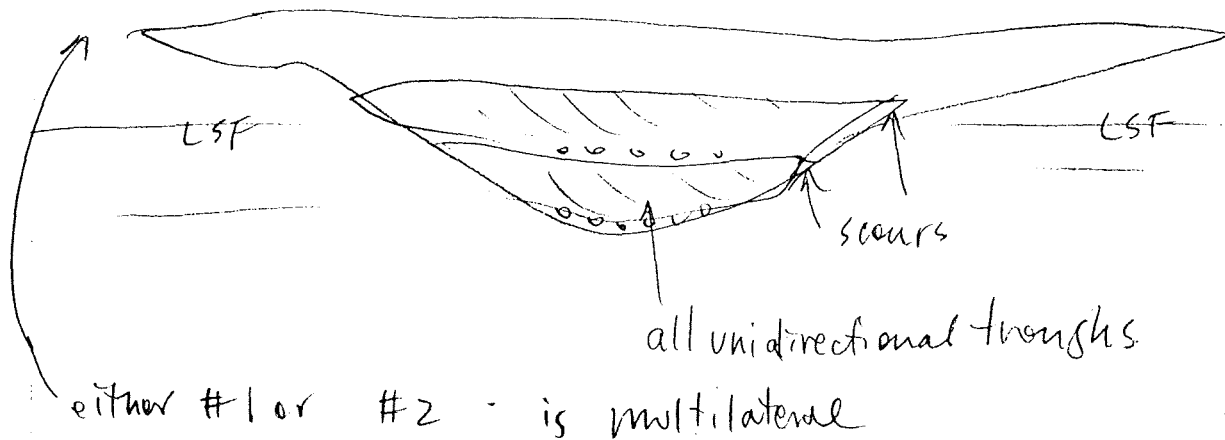
so at amphitheater and here, top channel may
 be mouth bar

in
 theory



active lobe
 (later abandoned
 and filled w/mud)
 bay fill

Willow Springs
 Longhorn:



a longhorn in multistory:



stacked up
 channels fill
 longhorn -

(23) + (24) two sides of longhorn #2 big channel
 cuts into #1, Forward stepping longhorn
 & between all these (4)
 channels -
 ripple-laminated SS

Further south
 (last chance lgn) ↓

lower shoreface pinches out