THE RAP

GL04723

① GREAT UTILITY OF STRAT-SCAT

A — STRATIGRAPHIC UNITS & FACIES

B — SEDIMENTARY STRUCTURES

C — HELP DETERMINE SEDIMENT-TRANSPORT DIRECTIONS

② FLUVIO-DELTAIC SYSTEMS ** ESP. GOOD APPLICATION (Paul)

A — GAS-RESERVOIR ANALOG

ⓐ e.g. WILCOX @ LAKE CREEK

SLIDE 1 Ferron otc. @ Dry Wash ⇒ ③ TEST OF STRAT-SCAT for FLUVIODELTAIC-ENV. CHARACTERIZ. FERRON SS (K) OF CENTRAL UTAH

A — KNOWN ANALOG

B — WELL-EXPOSED

SLIDE 2 HXS @ Dry Wash ⇒ ⓐ MEAS. OF SED. FEATURES IN THREE DIMENSIONS

- HXS

④ FIRST PHASE — DETAILED OUTCROP STUDY

A — REPRESENTATIVE SITES (Major dep. environments)

SLIDE 3a Miller Canyon otc. ⇒ ⓐ Miller Canyon (fluvial-dominated)

- Point-bar sequences, transverse & longitudinal barform, stacked channels.

ⓑ Dry Wash (marine-dom.)

SLIDE 4 Dry Wash otc. ⇒
- Delta-front sandstone sequences
  - * distal-bar, mouth-bar
  - * some thin intervening delta-plain deposits

SLIDE 5 Muddy Creek otc. ⇒ ⓒ Muddy Creek (marine & fluvial mix)

- drill sites — high water table
- optimum for drilling phase

⑤ AT EACH SITE, APPROACH:

A — MEASUREMENT OF DETAILED STRAT. SECTIONS

B — SUPPLEMENTAL MEASUREMENT OF SELECTED REPRESENTATIVE SEDIMENTARY STRUCTURES & BEDFORMS

C. INFO. GATH. @ EACH MEASURED SECTION

ⓐ Lithology ⓑ Grain size & size trends

ⓒ Mineralogy ⓓ Sedimentary structures & facies

ⓔ Bed forms and thicknesses.

D. RATIONALE for SECTION MEASUREMENT

ⓐ simulate a borehole course

ⓑ Obtain & process (STRAT-SCAT) simulated dipmeter data.

ALSO measured attitudes of all planar & curvi-planar features which the borehole intersected

⑥ OUTCROP STUDY — EXAMPLE OF APPROACH (MC-7 @ MUDDY CREEK)

SLIDE; 6 MC-7 Strat. section →

A — STRAT-SECTION MC-7

ⓐ generalized

ⓑ thick section of delta-plain & distributary-channel deposits sandwiched between No. 4 & No. 5 delta-front sandstones

EXPLAIN COLORS

ⓒ section meas. from bottom up

- converted to equivalent depth to simulate an actual borehole record.

SLIDE 7 MC-7 Arrow Plot →

B — MC-7 simulated arrow OR TADPOLE PLOT

ⓐ Great deal of information available

- regional dip (green) • some apparent red, blue, yellow dip patterns.

ⓑ Much of plot ambiguous

ⓒ Data reveal much more about individual sedimentary bodies when analyzed using STRAT-SCAT

SLIDE 8 MC-7 L* PLOT →

C — EXAMPLE — MC-7 L*-PLOT VS. STRATIGRAPHY

ⓐ dip magnitude component in stratigraphic L* direction

- scatter of dip data points defines a pseudostratigraphy which otc. studies show correlates well w/ actual stratigraphy

SLIDE 9
Tripp isopach of net sand thickn. ⇒

ⓑ Stratigraphic L* direction?
- By analogy with structural SCAT ⇒ dir. of least change in stratigraphic dip

ⓒ For all of our sections, the L* direction has been defined, for preliminary SCAT analysis of otc. data, as a <u>regional</u> trend or direction
- due E-W, // to axis of major deltaic lobe revealed by Tripp's net-sand isopach map.

ⓓ T* direction, that of maximum stratigraphic dip in a regional sense, by definition due N-S

ⓔ Whatever the local significance of the regional L & T directions, plotting local dip components *relative* to these 2 directions:
- Nicely establishes a dipmeter pseudostratigraphy which, based on our outcrop data, closely coincides with actual stratigraphy intersected by our sections.

SLIDE 10
MC-7 T*-plot vs. stratigraphy ⇒

ⓕ EXAMPLE ⇒ T*-plot vs. strat. for MC-7
- T-plot subdivided into smaller units based on position of dip data & scatter of that dip data relative to T-direction
  - * scatter patterns of the data reflect energy of deposition

ⓖ Once this T-plot pseudostratigraphy has been defined, individual units further analyzed by other STRAT-SCAT methods to yield additional information about strata intersected (or in this case, measured).

// NOTE 5 PSEUDOSTRATIGRAPHIC UNITS ON T* PLOTS.

Ⓓ FACIES ANALYSIS OF HIGH-ENERGY DEPOSITS, MC-7

ⓐ High degree of scatter suggests high-energy deposition
- implies some sort of high-∡ XS

SLIDE 11
DVA for upper 3 XS units

ⓑ D-V-A plots for upper 3 high-energy units section MC-7.

ⓒ 10.4–16.7 FT: (DVA)
- broad azimuthal scatter, moderate dips
- no real diagnostic pattern here
- meandering channels? multiple

ⓓ 27.3–33.0 FT: (DVA)
- blue—upper part of channel
  - ★ 90° azimuthal spread
  - ★ concentration of points at low dip ∡'s & high dip angles — little in between.
  - ★ could reflect XS more planar-tabular than TXS
  - ★ could be too few data points for full characterization
- red—distinctive "half horseshoe pattern
  - ★ probable significance for determining principal sed. structure & sediment-transport direction

(e) 37.7–43.9 FT (DVA)

- Know from OTC studies — fluvial channel dominated by TXS
- DVA pattern for entire unit broadly duplicates the ideal DVA pattern for TXS (unidirectional) (Andy)
  - ⋆ broader azimuthal spread (~140° vs. 90°)
    - ⇒ troughs not all aligned // to current
    - ⇒ shifting current

SLIDE 12
Bengtson's ideal TXS DVA

(f) can see the similarity of these patterns by looking at ideal DVA for TXS

(g) Tangent plot for ideal TXS (corresponding)

(h) current directions revealed by these plots would be midway between "horns"

- DUE E ✓

SLIDE 13
Tan plot MC-7 TXS channel

(i) Tan plot of our channel reveals a decided similarity with ideal tan plot for TXS

- Again, aggregate bulk curvature of sandstone body mimics the bulk curvature of individual trough.

SLIDE 14
DVA lower 2 channels MC-7

(j) RETURN TO LOWER TWO CHANNEL SS SEQUENCES PICKED OUT BY ANALYSIS OF THE T-PLOT.

(k) 48.8–55.9 FT & 65.7–77.9 FT.

- Similar "half horseshoe" patterns
- all TXS — must reflect an incomplete DVA "horseshoe" as expected for individual or aggregate TX beds.
  - ⋆ reason unclear
    - ⇒ position relative to channel axis, so that somehow one side of aligned troughs preferentially penetrated.

⇒ possibly an inadequate # of data pts.

* whatever the reason for the curious asymmetry of these DVA patterns, almost certainly are partial pattern characteristic of aggregate TXS
  ⇒ sediment transport direction
  ∴ must be ~ N10°W

SLIDE 15
ML-1 & 2
DVA

② DIP DATA for lateral accretion sets at the edges of fluvial channels dominated by TXS could enhance this asymmetrical, partial-horseshoe DVA pattern.

- data for 2 sections through a fluvial channel sequence at Miller Canyon both define the characteristic partial horseshoe
- red pattern, at W side of channel reflects not only TXS but also mod-steeply dipping lat. accr. planes dipping in toward channel axis.
  * strong asymmetry to the horseshoe pattern on the W
- yellow pattern, toward center or perhaps more toward eastern edge of channel, only a few 100 feet away fills in the missing eastern edge of the channel DVA
- together the two "limbs" of the horseshoe enclose a mean sediment-transport direction about due North.

SLIDE 16
photo of DMB – Dry Wash

Ⓔ DISTRIBUTARY–MOUTH–BAR ANALYSIS, Dry Wash

ⓐ Excellent example of DMB here
- coarsening upward
- prom. convoluted upper portion
- pt. of Ryer's No. 2

SLIDE 17
strat, T & L plots DW-6

ⓑ Position relative 135' strat. section DW-6
- same location as previous photo.
- section mostly No.s 2, 3 & 4 DF ss
- here, sec. mostly distal-bar deposits
- possible tidally deposited ss. body between Nos. 3 & 4

ⓒ #2 DMB shows up extremely well on the pseudostratigraphic sections defined by dip-data scatter characteristics on T & L plots
- scatter in part to to TXS
- in part due to convolute stratif.

SLIDE 18
DVA DMB DW-6

ⓓ DVA for the TXS #2 DMB @ Dry Wash
- significantly different than anything observed for TXS fluvial channel/distributary channel sandstones
  - Anisotropic scatter
  - wide azimuthal spread
  - scattered outlying points representing convolute stratification.

SLIDE 19
DVA DMB, DW-1, DW-2

ⓔ Anisotropic DVA repeated whenever this mouth bar is measured at Dry Wash

ⓕ One explanation for anisotropism shown by #2 DMB DVA

- interfering influences of several prevailing currents
  * from Distributary Channel
  * wave & longshore currents
- this multiple-current interference would be likely to occur only near the point where the distributary channel enters the marine environment.
    * this type of SCAT analysis, then, would seem to have potential for helping to determine relative position within an upper delta-front sandstone body
- At other positions within such a TXS marine sandstone body, the DVA plot could look much different
  * signature would reflect to what extent the trough X-beds in the deposit were aligned in response to a prevailing current direction.

SLIDE 20
DVA, DMB, DW-1

(8) (E.G.) the DVA for this DMB TXS sandstone at Dry Wash resembles the signature for many TXS channel sandstones — perhaps with a slightly greater azimuthal spread.

SLIDE 21
DW-6
strat,
T* & L*
(REPEAT OF SLIDE 17)

→ (F) DW-6 SECTION AT DRY WASH GIVES US A CHANCE TO EXAMINE, USING STRAT-SCAT, ANOTHER COMMON DELTA-FRONT SS. FACIES IN THE FERRON— THE DISTAL BAR

(a) Makes up virtually the entire No. 3 & No. 4 ss's.

(b) lower No. 3 intbd. f.g. ss., siltstone & mudstone principal sed. struc. → planar lamination, ripple lamination, ripple X-lamination, some convolute bedding, and minor hummocky X-stratification.

- low-energy, low-moderate scatter on the downhole T* & L* plots.

(c) Upper No. 3, all of No. 4, dominated by hummocky X-stratified fine-grained ss.

- mod. energy, mod. scatter on T & L plots

SLIDE 22
DW-6
DISTAL-BAR
DVA

→ (d) DVA plots for these 3 distal-bar sequences reflect depositional energies.

- lower plot — outer distal-bar #3
  - ★ essentially same as for homoclinally-dipping strata, essentially what we're dealing with
  - ★ non-diagnostic

- upper two plots — inner distal-bar #3 & #4
  - ★ almost all dip data here represent HXS
  - ★ both plots show patterns reminiscent of the horseshoe or boomerang DVA patterns typical of unidirectional TXS, but lower ∡'s
  - ★ very much contrary to the DVA pattern predicted for ideal HXS sequence

SLIDE 23
Andy's theoretical HXS – DVA

ⓔ HXS consists of alternating swales & hummocks with ideally a full 360° of bulk curvature

(Andy)

- predicted DVA pattern spans that full 360°, with dip maxima defining nodes at regular intervals

SLIDE 24
DVA for all HXS at Muddy Creek

- predicted pattern closely matches the DVA pattern for all hummocky XS measured at all Muddy Creek sections.

SLIDE 25
DVA for HXS ½ EXPOSED SWALE

- also matches reasonably well the actual DVA signature of a partially (½ exposed) swale at Muddy Creek

ⓕ Theoretical HXS DVA, however, does not match the actual DVA signatures of HXS intervals measured at Dry Wash

(REPEAT)
SLIDE 26
.DVA DW-6 distal bar

- Reasons?
  - * influence of regional dip — correcting would leave you with a much broader azimuthal spread at low angles
    - ⇨ by no means a full 360° spread
    - ⇨ still leave you with a residual, though weaker "horseshoe" pattern
  - * hummocks and swales measured may be large enough, so that [redacted] certain dip azimuths are preferentially intersected by the section.

(7) CONCLUSION

A — OTC STUDIES HAVE SHOWN THAT STRAT-SCAT ANALYSIS OF DIP DATA CAN BE USED IN MANY THOUGH NOT ALL, SITUATIONS, TO:

(a) help identify sedimentary facies
(b) deduce depositional environment
(c) determine sediment transport directions

B — T* & L* DIP-COMPONENT PLOTS, as INITIAL STEP IN THE STRAT-SCAT ANALYSIS, CAN BE USED EFFECTIVELY TO IDENTIFY INDIVIDUAL STRATIGRAPHIC UNITS.

C — ONCE IDENTIFIED IN THIS FASHION, THESE UNITS CAN BE FURTHER CHARACTERIZED USING ADDITIONAL STRAT-SCAT TECHNIQUES.

SLIDE 27
DVA's for selected channel sandstones.

D AS A SUMMARY EXAMPLE OF THIS APPROACH, THIS ILLUSTRATION SHOWS SOME OF THE CHARACTERISTIC DVA SIGNATURES OF CHANNEL SANDSTONES IN THE FERRON FLUVIO-DELTAIC SETTING

(a) 3 of THESE DVA PATTERNS ARE PARTIAL TO COMPLETE "HORSESHOE" CONFIGURATIONS.

- PRINCIPAL REASON: a body made up of unidirectionally oriented trough X-beds will reflect the bulk curvature of individual troughs
- that effect will be augmented in some cases, as we observed for Miller Canyon, by the attitudes of lateral accretion planes & beds dipping inward toward a channel axis.

- Prevailing sediment-transport directions in the simplest case will be equidistant between the two "limbs" of the horseshoe.
    - * indicated by red arrows
    - * broader the horseshoe, the less certainly current directions can be determined.

ⓑ Pattern at lower right, found to characterize some thinner channel sandstones, shown to reiterate that this approach, while it works a great deal of the time, isn't infallible

- really not much information extractable from a pattern like this

- All other available information about a given site & its regional setting should be employed for best characterization of a particular subsurface sedimentary body.

E — WHAT REMAINS TO BE DETERMINED IN THIS UNDERTAKING IS: JUST WHAT FEATURES A DIPMETER WILL RECORD IN THE FERRON RELATIVE TO THE FULL SUITE OF FEATURES MEASURABLE IN OUTCROP

ⓐ can these actual dip data be used to reveal the same information about specific facies in the Ferron that [redacted] are available from dip data obtained from outcrop.

ⓑ Answering these questions is the aim of the proposed drilling phase of our project, which Dennis Nielson will address as the [redacted] workshop's concluding presentation.