ACCOMMODATION CHANGE DURING BYPASS ACROSS A LATE-STAGE FAN IN THE SHALLOW AUGER BASIN

CHARLES W. BOHN IV
The Pennsylvania State University, University Park, Pennsylvania 16802, U.S.A.
Present address: Shell Exploration and Production Company, 200 N. Dairy Ashford, Houston, Texas 77079, U.S.A.
e-mail: charles.bohn@shell.com
PETER B. FLEMINGS
University of Texas at Austin, 1 University Station C1100, Austin, Texas 78712-0254, U.S.A.
e-mail: pflemings@sg.utexas.edu
AND
RUDY L. SLINGERLAND
The Pennsylvania State University, 513A Deike Building, University Park, Pennsylvania 16802, U.S.A.
e-mail: sling@geosc.psu.edu

ABSTRACT: Apron 1 in the Shallow Auger Fan System records the transition from ponded deposition in the lobe complex to bypass at the top of the channel complex. The lobe complex, at the base of Apron 1, exhibits characteristics typical of ponded apron deposits: it onlaps the basin margin, exhibits a concentric isopach pattern, has a lobe geometry in amplitude extraction, and is composed of continuous seismic reflections that have uniform thickness. The transition from ponded deposition to bypass is recorded with increasing gradients along the four channels in the channel complex. Healed-slope accommodation is filled as these channels aggrade at the sediment entry point. In the proximal reaches, the channels have thick levee deposits and minimal incision. Down-dip, the levee deposit thickness decreases and incision increases. Each channel aggrades to a single gradient; once this gradient is achieved, the channel avulses to an area of greater accommodation. As healed-slope accommodation fills, channel gradients in the proximal reaches decrease and sinuosity increases. In the distal reaches of the channel, greater incision depths may compartmentalize the underlying ponded deposits.

KEY WORDS: Shallow Auger Fan, slope accommodation, healed-slope accommodation, submarine-valley morphology

INTRODUCTION

The stratigraphic architecture of turbidite deposits in withdrawal mini-basins follows a repeatable succession (Fig. 1): initially, sediments are deposited as low-gradient sheet deposits; subsequently these deposits are overlain by sloping channelized deposits. This characteristic architecture has been described as a "ponded phase", which is overlain by a "slope healing phase" (Beaubouef and Friedmann, 2000; Booth et al., 2003; Prather et al., 1998). Analysis of this commonly observed architecture is important for a range of reasons. First, ponded deposits vs. healed-slope deposits have very different stratigraphic architectures. A better understanding of the geometry, the lithology, and the evolution of these deposits is important for optimizing petroleum production. Perhaps more fundamentally, a process-based understanding of the controls behind ponded vs. healed-slope deposition will help us to better understand deep marine sedimentation.

Sediments deposited in ponded accommodation aggrade to a horizontal surface coincident with the lowest elevation of the basin margin (Beaubouef and Friedmann, 2000; Prather, 2003; Prather et al., 1998) (Fig. 1). After this accommodation is filled, incoming flows begin to bypass the basin and proceed downslope (Clair and Tomasso, 2002). During the healing phase, sediments aggrade to a baselevel defined by the basin entry and basin exit points (Beaubouef and Friedmann, 2000; Prather, 2003; Prather et al., 1998).

The ponded phase is characterized by flat-lying or gently sloping deposits of alternating sand and shale that result from containment of the flow within the basin (Beaubouef et al., 2003a; Beaubouef and Friedmann, 2000; Beaubouef et al., 2003b; Toniolo et al., 2006a; Toniolo et al., 2006b; Van Wagoner et al., 2003). Beaubouef and Friedmann (2000) proposed a conceptual and quantitative model wherein sheet sands are deposited when the deposition rate of turbidity flows exceeds the erosion rate at all locations. These deposits have a concentric isopach map pattern that is thick in the center and thins at the margins. Ponded turbidite deposits are commonly interpreted to be formed when a long-lived turbidity current enters a basin. Under these conditions, a horizontal settling interface is maintained at a constant height by the incoming flow; this creates a deposit of uniform thickness (Hoyal et al., 2003; Toniolo et al., 2006a; Toniolo et al., 2006b; Van Wagoner et al., 2003). Imran et al. (1998) proposed a conceptual and quantitative model wherein sheet sands are deposited when the deposition rate of turbidity flows exceeds the erosion rate at all locations.

In the slope healing phase, apron deposition at the sediment entry point builds a basinward-tapering wedge (Beaubouef et al., 2003a). These aprons are convex up and exhibit an elongate isopach map pattern where the isopach thick shifts updip to the basin entry point (Mitchum, 1985; Nelson, 1984; Nilsen, 1990; Richards and Bowman, 1998; Shanmugam and Moiola, 1985). Seismic reflections range from chaotic in proximal and medial regions of the apron to downlapping, continuous sheetlike reflections in distal portions (Beaubouef et al., 2003a; Beaubouef et al.,...
Fig. 1.—Schematic dip section and accommodation terminology. Conceptual model relating depositional gradients of a typical sequence in an idealized withdrawal mini-basin to accommodation and baselevel. Deposits in “ponded” accommodation are flat-lying or low gradient, while gradients progressively increase through deposition in the “healed-slope” accommodation. Terminology for accommodation is modified after Prather et al. (1998), and the baselevel positions are modified after Beaubouef and Friedmann (2000), Booth et al. (2000), Prather et al. (1998), and Sinclair and Tomasso (2002).

Fig. 2 (above and on facing page).—A) Location of the Auger Basin in the Gulf of Mexico. Seismic structure map of the seafloor overlaid on a sidelite bathymetric image of the Andros, Auger, and Tampa basins. The Auger Basin lies 345 km southwest of New Orleans, Louisiana (inset). Lines of section A–A’ (Fig. 3) and B–B’ (Fig. 4) are indicated with dashed lines. Black arrows indicate the source locations for Aprons 1, 2, and 3 in the Shallow Auger Fan System, and the red arrow indicates the basin exit point. Seismic image courtesy of CGGVeritas, Houston, Texas. B) Detail of the Shallow Auger Fan System. Color bar is thickness between the top and base of the Shallow Auger Fan System in meters (pink and light blue lines in Figure 3). The outlined areas correspond to Channels A–D (Figs. 8, 9, 11) and the location of Aprons 1, 2, and 3 that constitute the Shallow Auger Fan System. Line of section C–C’ (Fig. 5) is indicated with a heavy black line. Seismic image courtesy of CGGVeritas, Houston, Texas.
way, we document the filling of healed-slope accommodation by gradient change through the growth of the slope apron. In this valley systems to document their morphologic evolution and slope apron. We perform detailed analysis of these submarine valley systems (Channels A–D). The morphology of these valley systems records the growth of the channel-complex (Fig. 3). The channel complex is composed of four successive ponded facies at the base, the lobe complex, which is overlain by a slope facies termed the channel complex (Winker and Booth, 2000) (Figs. 2A, B). Apron 2 is sourced from the southwest and is composed of a ponded apron at the base, the lobe complex, which is subsequently incised by four submarine valley systems (Channels A, B, C, and D; Figs. 2B, 3). Apron 2 is sourced from the southwest and is composed of a ponded apron at the base, the lobe complex, which is subsequently incised by four submarine valley systems (Channels A, B, C, and D; Figs. 2B, 3). Apron 2 is sourced from the southwest and is composed of a ponded apron at the base, the lobe complex, which is subsequently incised by four submarine valley systems (Channels A, B, C, and D; Figs. 2B, 3).

**Seismic Data**

The seismic data used in this study cover an area of 1200 km² and have a bin spacing of 25 m. Using an average sediment velocity of 1915 m/s obtained from the Macaroni M4 well (Fig. 2B) and a peak frequency of 50 Hz for the shallow Auger data, the approximate vertical resolution is 10 m. The data are approximately zero phase (Fig. 4).

**Well Data**

The Shallow Auger Fan System is penetrated by four wells in Macaroni Field (M1, M3, M3ST1, and M4) and three wells in Oregano Field (OR1, OR2, and OR3) (Fig. 2B). We used checkshot data from the Macaroni M4 well to tie the wells to the seismic data (Fig. 2B). We depth-converted time seismic events using a single average sediment velocity of 1915 m/s that was calculated from the Macaroni and Oregano wells.
APRON 1

Apron 1 covers 250 km² of the southern portion of Auger Basin (Fig. 2B). Its sediment was sourced from the west, across the basin-bounding salt ridge (Fig. 2A, B). The deposits are thickest in the west, onlap the basin margin in the south and east, and thin and downlap to the north (Figs. 2B, 3, 4). A series of stacked lobes (lobe complex) are preserved at the base of Apron 1 (Figs. 4, 5, 6).

There are no observed channels at this level, but there is considerable postdepositional erosion of the lobe complex by Channels A–C in the channel complex (Figs. 5, 9).

Lobe Complex

The lobe complex is imaged by two negative seismic reflections in the north that increase to a maximum of four reflections.
Fig. 4.—Dip seismic line B–B’. The location of dip line B–B’ is given in Figure 2A. The section line is oriented along the depositional axis of the lobe imaged in Figure 6. Reflectors within the Lobe Complex are of uniform thickness and continuous across the section; they onlap the basin in the west and east. The channel complex is thickest in the west and thins to the east. Seismic image courtesy of CGGVeritas, Houston, Texas.
in the south (Fig. 5). The reflections are continuous and of uniform thickness and amplitude (Fig. 4). The concentric isopach pattern of the lobe complex is slightly elongated toward the sediment entry point in the northwest (Fig. 6). The thickest deposits are in the southeast along the basin margin (Figs. 5, 6). Peak negative amplitudes taken at the top of the lobe complex form a distributary pattern in the north (Fig. 6). The lowest amplitudes (cool colors) are interpreted as slumping associated with the overlying channels (e.g., Fig. 5); the reds and greens in the northern portion of Figure 6 record a single depositional lobe within the lobe complex.

The Macaroni and Oregano wells penetrate the lobe complex along depositional strike (Figs. 5, 6). The Macaroni M1 well penetrates the thickest portion of the lobe complex and contains three thick sandy intervals (Fig. 5). The lower two sand intervals are sharp-based and shale upward, while the upper interval exhibits a gradational base (Fig. 5). To the north, the thickness and number of sandy intervals decreases; this is accompanied by a
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decrease in the number of seismic reflections in the lobe complex (Fig. 5). The lower sand content in the Oregano wells relative to the Macaroni M1 and M3 wells is interpreted to record deposition in a more distal position (Figs. 5, 6).

Channel Complex

The top of the channel complex is convex-up along strike and thickest in the west and along the channels (Figs. 5, 7). Individual reflections downlap onto the lobe complex and thin as they onlap the basin margin in the west and east (Fig. 4). Channels A, B, C, and D enter the basin from the west and exit in the south (Figs. 2B, 8). Channels A–C occur at three different stratigraphic levels in the basin and exit the basin at the same height at the downdip sill (Figs. 3, 9). Channel A and Channel B enter the basin at the same position; Channel A is completely truncated by Channel B (Fig. 8). Channel C enters the basin from a source 5.3 km to the north and exits the basin east of Channel B (Figs. 2B, 8). Channel D enters and exits the basin at the same points as Channels A and B, but at a higher position on structure (Fig. 9). Channel D incises into the upper deposits of Apron 1 and Apron 3, suggesting that it postdates the deposition of Apron 3 (Figs. 3, 5, 9).

The channels described in this study are composed of multiple, stacked, channel–levee pairs similar to the channel–levee complexes described by Deptuck et al. (2003) and Barton (this volume). Individual channel forms cannot be traced with confidence in Apron 1. We use the term channel to describe a set of channel forms, recognized by basal high-amplitude reflections (HARs of Deptuck et al., 2003). Channels were mapped based on their relative stratigraphic position, sediment source, and, when present, basal high-amplitude reflections (Fig. 9). The channels are characterized by high-angle, high-amplitude reflections (Figs. 5, 9). We interpret these features as rotational slides that developed during prolonged sediment evacuation through the channels. Sawyer et al. (2007) presented a similar interpretation for features below channels in the Mars–Ursa Basin.

We separate the channel complex into two facies. We define the channel facies as the deposits in the interpreted channel margins and the levee facies as all of the deposits outside the channel margins. The seismic characteristics of the channel facies vary for each channel (Figs. 5, 9). Amplitude within a single channel generally decreases with height above the channel base and distance from the sediment entry point (Figs. 5, 9). Individual channel forms in Channel A stack vertically, while the channel forms in Channels B and C shift laterally within the channel margins and are dominated by reincision surfaces at their bases (Fig. 9). Channel D is smaller than the underlying channels and is composed of a single channel form along most of its length (Figs. 5, 9). Channel A incises the upper 20 m of the

Fig. 6.—Amplitude extraction from the top of the lobe complex. Amplitude extraction from a 25 ms window above and below the top of the lobe complex (yellow line Figures 3, 4, 5, and 9). The contours are isopach thickness of the lobe complex (contour interval is 10 m). The location of Channels A–D are shown in light gray. The highest amplitudes correspond to the high-amplitude reflections at the base of the channels (Figs. 5, 9). The arrow points to the distributary amplitude pattern corresponding to the thick sand within the lobe complex at the Macaroni M3 well (Fig. 5).
Fig. 7.—Channel-complex isopach. Color and contours are isopach thickness in meters of the channel complex, calculated as the difference between the seismically defined thickness of Apron 1 and the thickness of the lobe complex (Fig. 4). The contour interval is 20 m. The thalweg locations for Channels A–D are indicated with heavy black lines. The channel complex is thickest along the depositional axis of the channels and along the western basin margin.

Fig. 8.—Structure map of Channels A–D. Structure map of the channels that cross Apron 1; the colors are meters below sea level converted from two-way travel time using a constant sediment velocity of 1915 m/s. Channels A–C occur within the channel complex at the top of Apron 1; Channel D crosses the top of the channel complex and Apron 3 (Fig. 9). The position of cross section D–D' (Fig. 9) is indicated with a heavy black line. The location of the lobe complex at the base of Apron 1 (Fig. 6) and Apron 3 are shown in light gray (Fig. 2B).
lobe complex, while Channels B and C erode into the levee facies associated with the underlying channels (Figs. 5, 9). Where the channels are proximal to each other, the Levee Facies partially fills the antecedent topography of underlying channels (Fig. 9).

There is variability in the seismic reflections of the levee facies as a function of position (Fig. 10). In cross section, amplitude and continuity in the levee facies decreases away from the channel margins (Figs. 5, 9). The slope of the levees decreases away from the channels and the reflections downlap (Figs. 5, 9).
The nature of the seismic reflections in the study area suggests that the lithology of the channel and levee facies exhibit a high degree of spatial variability.

Well penetrations through the channel facies and the levee facies generally have a lower sand content, and the individual beds are thinner than in the lobe complex (Fig. 5). The Maaroni M1 well is the only penetration through the channel facies (Figs. 5, 8). It penetrates the top of Channel B 11 km from its entry point into the basin and is composed of two thin, sand-poor intervals (Fig. 5). The levee facies is composed of intercalated sand and shale; sand content is greater near the channel margins (Fig. 5).

The top of Apron 1 is draped by a continuous, 6-meter-thick shale interval in all penetrating wells that corresponds to the continuous strong positive reflection at the top of Apron 1 (D seismic facies of Prather et al., 1998) (dark blue line in Figs. 5, 9). We interpret the draping shale as a condensed interval that marks the shift in the locus of deposition to the north and increasing deposition in Apron 2; Channel D occurs above this interval (Figs. 2B, 4, 8).

**Channel Morphology**

We examined the morphology of the submarine valley systems along their length to better understand how healed-slope accommodation is filled in Auger Basin. Measurements were taken from a series of cross sections that lie perpendicular to the channel margins at approximately 350 m intervals along each of the identified channels (Figs. 8, 10). Measurements of thickness are taken with respect to a datum at the base of the levee facies (dashed line, Fig. 10 inset). The position of the datum coincides with the relative decrease in outer-levee strike (Fig. 13A). The projection distance for Channel C is significantly greater (as much as 4 km) than for Channel A. The projection distance for Channel C downdip remained a topographic low until it was filled by the overbank deposits of Channel C (Fig. 9). Conversely, Channel C downdip remained a topographic low until it was filled by the onlapping deposits of Apron 3 (Fig. 9).

**Channels B and C.**

The morphology of Channels B and C is similar (Fig. 10). They have a higher sinuosity and a lower meander amplitude, wavelength, and radius of curvature than Channel A (Figs. 10, 12; Appendix A). The depth of the channel base below the datum increases down the length of each channel (Fig. 11). For the first 5.5 km of Channel B, the channel base is an average of 5 m below the datum and depth below the datum increases from this point to the end of the channel. The base of Channel C is below the datum horizon down the entire length of the channel, and incision rapidly increases from a distance of 16 km to the basin exit point (Figs. 11, 12). Both channels incise into the lobe complex at their distal ends. The increased incision corresponds to a decrease in levee deposit thickness (Fig. 12). Thalweg and bankfull width and sinuosity also decrease down the length of the channels as incision increases (Fig. 12).

In the proximal regions of Channels B and C, the channel filled from the base of the channel to the levee crests (Fig. 11). Levee deposits are thickest in this region (Fig. 11). In contrast, in the distal channel reaches where the levee deposits are thinner, the top of the channel fill lies below the levee crests (Figs. 9, 11). In the downdip region, the topographic low at Channel B was filled by the overbank deposits of Channel C (Fig. 9). Conversely, Channel C downdip remained a topographic low until it was filled by the onlapping deposits of Apron 3 (Fig. 9).

**Channel D.**

Channel D is smaller than Channels A–D and varies less along the length of the channel than the underlying channels (Figs. 10, 11, 12). While there is a slight decrease in the channel width and thickness of the levee deposit, the depth of the channel below the datum and the sinuosity are nearly constant (Fig. 12). Unlike Channels B and C, the channel fill is below the levee crest for the entire length of the channel (Fig. 11).

**DISCUSSION**

Active channels adjust to an equilibrium profile that is the baselevel surface. Channels either deposit or erode to attain this equilibrium state (Pirmez et al., 2000). Channels A–C in the channel complex are interpreted to record the evolution of channels to an equilibrium profile, and Channel D is interpreted to record a channel that is at the equilibrium profile. Below, we describe the morphologic evolution of channel systems to their equilibrium profile. To gain insight into the growth of the channel complex slope apron and the effects on the morphology of Channels A–D, we first define the surface on which the channel complex was deposited. The top of the lobe complex is ideal since it was deposited during the ponded phase and should be approximately horizontal (Fig. 1).

**Paleotopography of the Channel Complex**

To compare the topography, we projected the topography of each channel onto a single cross section (Fig. 13). In this way we compare the channel characteristics at the same position along depositional strike (Fig. 13A). The projection distance for Channels A, B, and D were small (order 1.5 km). The projection distance for Channel C is significantly greater (as much as 4 km) (Fig. 13A).

To account for postdepositional subsidence in the basin, we assume that the top of the lobe complex is a paleo-horizontal...
surface (Fig. 1) and we assume no subsidence during deposition of the channel complex (sediment supply >> subsidence). We then flatten the top of the channel fill and the base of each of the overlying channels with respect to this surface to recover the paleotopography of each channel (Figs. 13B, C, 14). When these surfaces are flattened in this manner, the variation in topography is striking: the channel-top gradients remain constant while there is an increase in the channel-base gradients of Channels A–D (Fig. 14A, B). This is perhaps most clear when comparing Channel A and Channel C (Fig. 14A, B).

For each flattened channel, we calculate the average gradients for the projected data (valley gradient) and for the unprojected data (thalweg gradient) (Fig. 15A). To examine changes down the channels, we also calculate the gradients over a 4 km window for the projected data at the tops and bases of the flattened channel surfaces (Fig. 15B). In the calculation of gradient, we exclude the first 5 km and the last 1.5 km of the channel data, where erosion and slumping of the lobe complex leads to irregularities in the flattened channel profiles (Fig. 14).

The average valley gradients are calculated along the red lines in Figure 14A and B. The valley gradients increase from 0.08° at the base of Channel A to 0.26° at the base of Channel C as deposition shifts progressively to the north (Figs. 8, 15A). The valley gradients at the top of the fill in Channels A–C are all

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**Fig. 10.**—Definition of measured channel parameters. A schematic representation of the measurements taken along Channels A–D. The results are presented in Figures 11 and 12. These data are used in the analysis of the channels. The colors and depth conversion technique for the plan-view maps of Channels A–D are the same as in Figure 8. The channels were sampled at approximately 350 m intervals along their length. At each sample point, channel width and depth (circles), and levee deposit thickness (triangles) were extracted. Meander wavelength, amplitude, and radius of curvature are taken from the channel thalweg (heavy black line) and were recorded at the nearest channel sample point. Seismic image courtesy of CGGVeritas, Houston, Texas.
Fig. 11.—Structural profiles along Channels A, C, and D. The profiles are generated from depth-converted two-way-time data extracted from seismically defined horizons at the sample points given in Figure 10. The data were depth converted using a constant sediment velocity of 1915 m/s. Channels B and C are similar; Channel A is truncated by Channel B but is unique because there is an apparent decrease in incision down the channel. Channel D was deposited after the deposition of Apron 3 and shows little change down the length of the channel (Fig. 8). The cross sections of Channel C are at the same vertical exaggeration as the profile and represent the trend of increased incision and decreased levee height downdip that also occurs in Channel B. Seismic image courtesy of CGGVeritas, Houston, Texas.
Fig. 12.—Morphologic trends along Channels A, C, and D extracted from the profiles in Figure 11 at the sample locations indicated in Figure 10. The gradient at the base of Channel D reflects the topography that developed during the deposition of Channels A–C and Apron 3 (Figs. 5, 7, 8). The valley gradient is 0.48°, and the thalweg gradient is slightly lower than the valley gradient at the top of the underlying channels (Fig. 15A). The gradient at top of Channel D is similar to the channel-top gradients of Channels A–C (Fig. 15A).

Depositional Characteristics of the Channel Complex

The healed-slope accommodation in southern Auger Basin is filled by the channel complex. Channel A occurs at the transition between the ponded deposits of the lobe complex and the slope deposits of the channel complex (Fig. 9). Erosion of the proximal and distal portions of Channel A, however, obscures the exact nature of this transition (Fig. 8). The morphology of the preserved reach in Channel A is similar to the morphology of the reach between 8 km and 12 km in Channel C (Figs. 8, 10 12). This suggests that the preserved reach is not representative of the overall morphology of the channel. We interpret that prior to removal of the proximal and distal reaches by Channel B, the morphology of Channel A resembled that of Channels B and C.

The incremental growth of the fan and the transition from ponded deposition to bypass is recorded by the increasing valley gradients in Channels A–D (Fig. 15A). This is the result of preferential sedimentation at the basin entry point and erosion at the exit point (Fig. 16). As sediment accumulates at the entry point to the basin, there is a decrease in the proximal reach gradients at the bases of Channels A–C and a straightening of the longitudinal profiles (Figs. 15B, 16).

While there is an increase in the channel-base gradient through the growth of the channel complex, the gradients at the top of the channel fill remain relatively constant (Figs. 14, 15A, 17). The tops of Channels A–C are approximately parallel as presented in the healed-slope accommodation of Fig. 1 (Fig. 14A). The fact that each channel builds to the same grade suggests that the combination of sediment input and the available accommodation fixes the gradient in the healed-slope accommodation in Auger Basin (Figs. 15A, 17). Once this grade is established for a given channel, it seeks a new path through the basin. This results in increasing channel-base gradients in successive channels as the fan grows and fills the accommodation (Fig. 17).

In the proximal reaches, Channels B and C are aggradational and fill to the levee crests (Fig. 16). They are characterized by broad, thick levee deposits and minimal incision (Figs. 11, 16). This is accompanied by increased sinuosity and channel width, which act in tandem to promote overbank deposition and the areal extent of deposition by the channel belt (Figs. 12, 16). Downstream
incision and flow confinement result in a decrease in the concentration of the flow available for levee construction (Figs. 16, 17). As a result, the distal levee deposits are thin (Fig. 16).

Channels A–C record aggradation and build to grade, whereas Channel D represents true bypass. Channel D was deposited following a hiatus during which deposition shifted from the southern source to the north (Fig. 2B). Between the deposition of Channel C and Channel D, the remaining slope accommodation at the basin exit point in Auger Basin was filled by Apron 3 (Fig. 2B) (Winker and Booth, 2000). This explains the relative decrease in the gradients in the distal reach of Channel D and the return to a more convex-up longitudinal profile (Figs. 11, 15B). At this point the system has equilibrated to carry its load across the basin, and flows entering Auger Basin from the northwest are transferred downdip to Tampa Basin.

CONCLUSIONS

Apron 1 in the Shallow Auger Fan System consists of two distinct architectural styles. The lobe complex was deposited in the ponded phase and exhibits characteristics that conform to previous models and observations of low-relief ponded aprons (e.g., Prather et al., 1998). This is followed by deposition of the channel complex in the healing phase, culminating in bypass through Channel D. The healed-slope accommodation fills in the proximal zone through the aggradation of Channels A–C.
This is recorded by thick levees and low incision depths. Each channel builds until it achieves an along-channel gradient set by a combination of the sediment input and the available accommodation. After this gradient is reached, the channel moves to the north, where there is more accommodation. In addition to controlling channel morphology, the manner in which the healed-slope accommodation fills impacts sand distribution and connectivity.

Through the development of the channel complex, gradients decrease in the proximal reaches of Channels A–C, resulting in increased sinuosity and channel width. This geometry coupled with the break in slope results in preferential deposition at the sediment entry point. Updip, the channels fill to the crest of the thickened levee deposits. This may indicate a higher sand content than observed in the Macaroni M1 well, where the channels remain underfilled. The development of rotational slides or...
downcutting caused by increased channel incision downdip may compartmentalize the ponded deposits of the lobe complex.

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Fig. 15.—Average and instantaneous channel gradients for Channels A–D. A) Gradients for Channels A–D calculated for the flattened channel profiles over the “representative reach” defined in Figure 14. The thalweg gradients (hachured area) are calculated using the difference in elevation between the first and last point in the representative reach over the total distance down the channel thalweg. The valley gradients are calculated using the projected distance defined in Figure 13A. B) Gradients of the flattened channel profiles calculated as the elevation difference between sample points over the projected “distance down fan” described in 13A. The gradients are averaged over 4 km. The representative reach is indicated by the light gray area.
Fig. 16.—Conceptual model for growth of the channel complex. Conceptual model for the growth of the channel complex modified from Figure 1 to reflect the decreasing proximal gradients observed through Channels A–C (black lines in the light brown area). The data suggest that the bases of the early channels are more convex-up than later channels (Fig. 13B). The morphology of Channels B and C offer a mechanism for the growth of the fan; incision is minimal and levee height and channel width are maximum at the sediment entry point (Figs. 11, 12). Incision increases downdp, accompanied by a decrease in levee height and channel width (Fig. 12).

Fig. 17.—Process summary for observed channel morphology and fan growth. Channel profiles are idealized from Figure 11. The along-channel trends are described in the text and in Figure 16. Through the evolution of the channel-complex fan there is an increase in the overall channel-base gradients. The channel-top gradient remains constant and may reflect the balance between sediment input and available accommodation (see discussion in text).

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