

# Application of 3D seismic visualization techniques for seismic stratigraphy, seismic geomorphology and depositional systems analysis: examples from fluvial to deep-marine depositional environments

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**Abstract:** In recent years, 3D seismic has become an essential tool for the interpretation of subsurface stratigraphy and depositional systems. Seismic stratigraphy in conjunction with seismic geomorphology, calibrated by borehole data, has elevated the degree to which seismic data can facilitate geological interpretation. 3D seismic data has enabled interpreters to visualize details of complex depositional systems, which can be incorporated into borehole planning for exploration as well as development needs to improve risk management significantly. Common techniques for geological visualization include (1) imaging stratigraphic horizons, (2) time slicing and flattened time slicing, (3) interval attribute analysis, (4) voxbody interpretation and mapping, (5) 3D perspective rendering and (6) opacity rendering.

One of the key benefits of modern 3D seismic interpretation is that stratigraphic horizons can be interpreted and horizon attributes (such as reflection amplitude, dip magnitude, dip azimuth, and curvature) can then be imaged directly in 2D or 3D space. Techniques such as variable illumination can enhance geomorphological interpretations, and, when integrated with stratigraphic analyses, can yield insights regarding distribution of source, seal, and reservoir facies. Stratigraphic intervals bracketing sections of geological interest can be evaluated for amplitude and frequency content and can contribute to geological interpretations. Time slices and flattened time slices (also referred to as horizon slices) can bring to light map patterns and geological features that other techniques might overlook. Voxel picking can further bring out features of geological interest. This method involves auto-picking of connected voxels of similar seismic character, a technique that can illuminate discrete depositional elements in three dimensions. Similarly, opacity rendering, which makes opaque only those voxels that lie within a certain range of seismic values, can further bring out features of stratigraphic interest. Examples of fluvial, shallow marine, and deep marine depositional environments are shown. A variety of visualization techniques are applied to these examples in an effort to illustrate the variety of interpretation techniques available to the geoscientist. These examples will highlight the integration of seismic stratigraphic and seismic geomorphological analyses essential for maximum benefit to be derived from geological analyses of 3D seismic data.

**Keywords:** seismic stratigraphy, seismic geomorphology, 3D seismic visualization

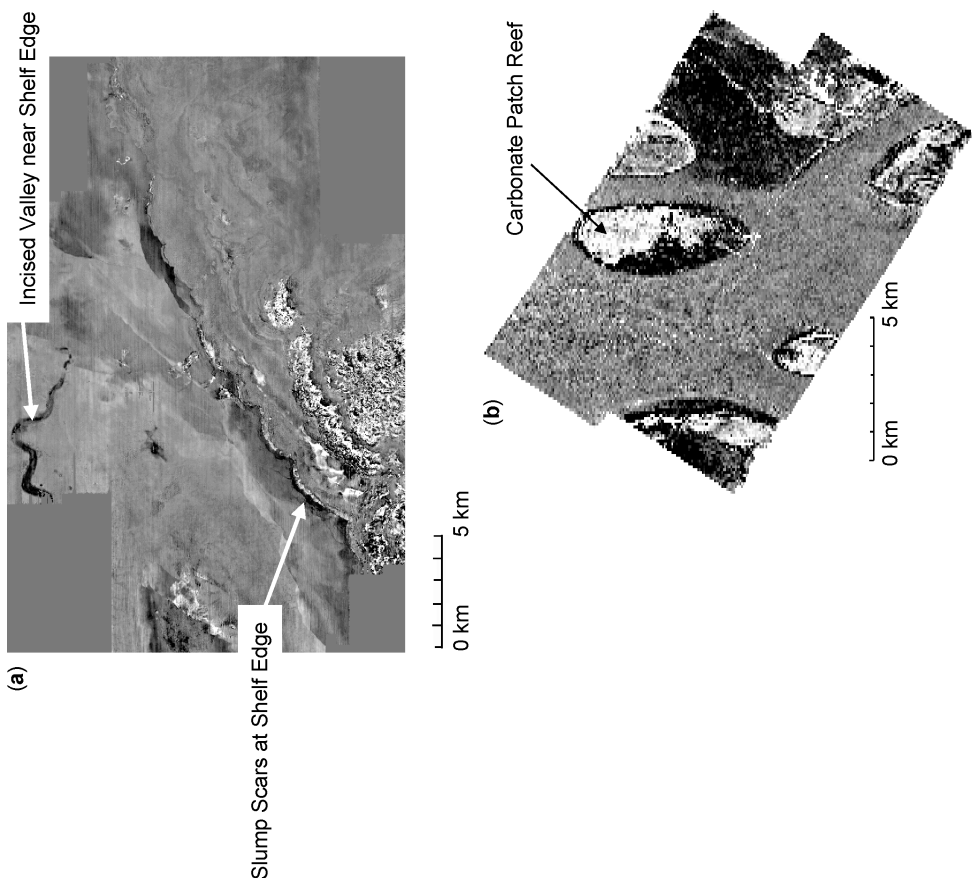
Seismic data have long been used for lithological prediction. Initially, predictions of lithology were based on analyses of 2D seismic reflection profiles and the technique was referred to as seismic stratigraphy (Vail *et al.* 1977). The approach that was used involved the identification of reflection terminations indicative of stratigraphic discontinuities, the description of reflection geometries between discontinuity surfaces, and mapping of the amplitude, continuity, and frequency of reflections, all on seismic reflection profiles (Fig. 1a). Integration of these observations into seismic facies maps (Fig. 1b) provided the basis for interpretation of depositional environment and lithology.

With the development of 3D seismic acquisition techniques, the opportunity to image geological features in map view has opened up new approaches to geological prediction (e.g. Weimer & Davis 1996). Various seismic reflection attributes such as amplitude, dip magnitude and azimuth, time/depth structure and curvature, to name a few, can yield direct images of depositionally and structurally significant features. In addition, analysis of seismic attributes over multi-cycle seismic intervals can lend further insights to such features. The study of depositional systems using 3D seismic derived plan-view images has been referred to as seismic geomorphology (Posamentier 2000). This represents a significant step change in how seismic interpreters use 3D seismic data for the analysis of depositional systems. Previously, using 2D seismic, depositional environments and

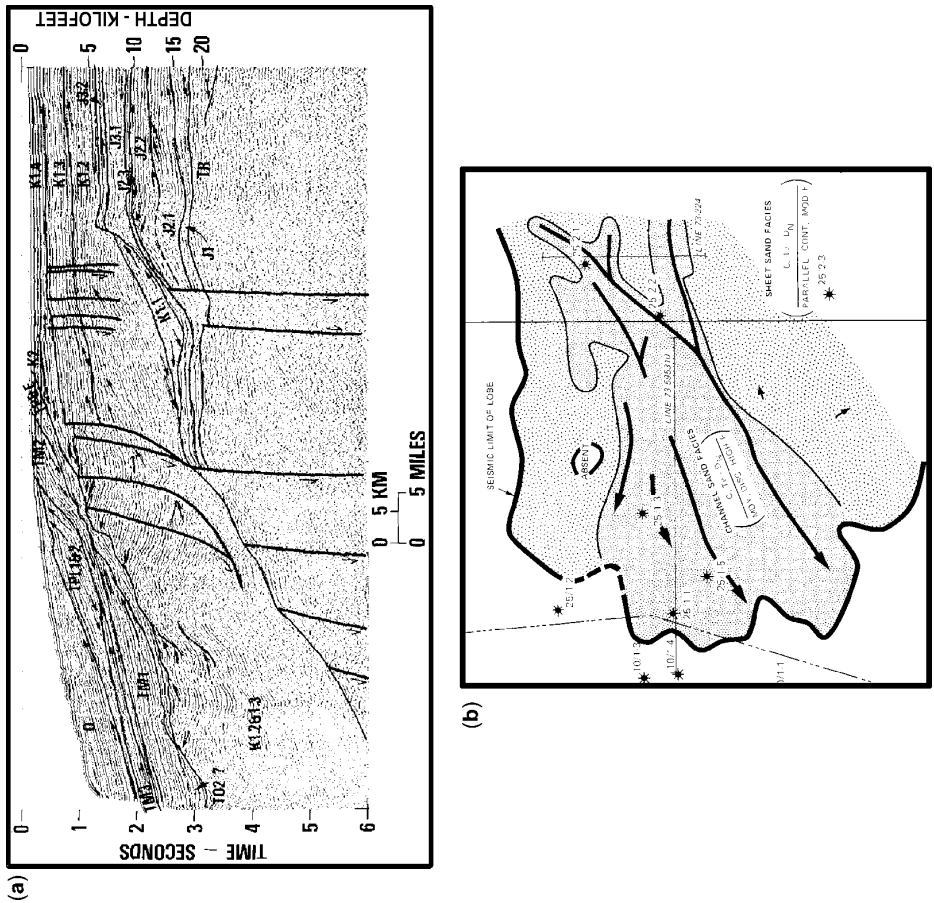
lithologies were inferred on the basis of cross-section derived seismic reflection geometries and associated map patterns derived from time-consuming seismic facies mapping (Fig. 1b). With the advent of seismic geomorphology, discrete, detailed depositional subenvironments and depositional elements could be interpreted directly from map view images such as time slices or horizon slices (e.g. Fig. 2) leading to much more accurate understanding of lithological distribution patterns and enhanced prediction of the distribution of reservoir, source and seal facies.

## Techniques

Numerous volume-based data manipulation techniques exist for the extraction of stratigraphic information from 3D seismic data. These techniques range from analyses of discrete horizons to analyses of discrete sub-volumes. In each instance, 3D visualization techniques can play a significant role in assisting with interpretation. With the advent of high-speed, affordable hardware and software, many techniques and avenues of inquiry that in the past might have been unrealistic to pursue have now become mainstream tools in the interpreter's toolkit. This evolution of interpretation techniques, which has afforded interpreters the opportunity to ask more of their data, has necessitated an additional required skill set on the part of the interpreter: the ability to recognize and interpret landforms seen in map view, and



**Fig. 2.** (a) Seismic horizon slice illustrating outer shelf and upper slope geomorphology of offshore Indonesia. Features of interest imaged here include: (1) a small incised valley that terminates just inboard of the shelf edge, and (2) a series of slump scars at the shelf edge, with associated slump debris downslope. This image was produced by flattening on an overlying seismic horizon and then extracting the reflection amplitude information 36 ms below that horizon; (b) Miocene carbonate patch reefs offshore northwest Java, Indonesia. This image was produced by flattening on a horizon below the reefs and slicing at a level 120 ms above, and subsequently extracting the reflection amplitude at that level.



**Fig. 1.** (a) Seismic reflection profile from offshore Morocco illustrating the application of classical seismic stratigraphic interpretation (from Vail *et al.* 1977); (b) Seismic facies map of the Eocene Frigg submarine fan offshore Norway, based on interpretation of 2D seismic reflection profiles (from McGovney & Radovitch 1985).

to infer their stratigraphic significance. The disciplines of seismic stratigraphy and seismic geomorphology go hand in hand in the geological interpretation of 3D seismic data. Features observed in plan view should be corroborated by cross-section view images. Hence the integration of stratigraphy (i.e. section view) with geomorphology (i.e. plan view).

### *Time slices and horizon slices*

Time slices and horizon slices are excellent for initial reconnaissance through a 3D volume. Time slices represent horizontal slices through the seismic volume. From a stratigraphic perspective, these yield the most meaningful images in data sets where the strata are close to horizontally bedded (Fig. 3a and b). In data sets where time slices are not parallel to seismic reflections, hints of depositional features of interest nonetheless may be observed on time slices, but may be more fully revealed using other techniques. With variably dipping seismic reflections, slicing parallel to reflections commonly yields the best insights (Fig. 3c). These images are referred to as horizon slices or flattened/datumed time slices. Using either of these techniques, reflection amplitude map patterns can indicate the presence of discrete depositional elements such as channels or reefs. When slices reveal the presence of features of interest in map view, it is essential to examine the feature in cross section to confirm that what has been observed is

stratigraphic rather than structural in origin, and that the feature is not a seismic data acquisition or processing artefact (see discussion below).

### *Horizon attributes*

Once features of interest are identified using time slices or other reconnaissance techniques, specific reflections associated with these features are interpreted. The interpreted horizons can be examined using a variety of attributes. These attributes can include structure, amplitude, dip azimuth, dip magnitude, curvature and roughness (Fig. 4). Each attribute can reveal different characteristics of the feature of interest, with each characteristic aiding in the interpretation of the geological feature and ultimately the prediction of lithologies in the associated section. Simply lighting a surface from various directions can also aid in interpretation and afford significantly different insights (Fig. 5).

### *Interval attributes*

In some instances, seismic interval attribute extractions rather than horizon attributes are the tool of choice. This is especially true where features are subtle and discrete seismic reflections are difficult to interpret and map. This approach involves the seismic analysis of stratigraphic intervals or seismic 'slabs' that bracket features of interest; attribute analyses include characterization of amplitude, frequency, and seismic waveforms (Fig. 6).

### *Voxbody detection*

Features of interest also can be imaged by detecting, mapping, and visualizing voxels in 3D views. In this approach, voxels (i.e. three-dimensional pixels) are highlighted according to amplitude (or some other seismic attribute) range and then tracked in three dimensions (Fig. 7). The seismic attribute range can be selected to correspond to a specific lithology, the presence of hydrocarbons, or simply a specific seismic reflection. Identification of depositional elements, fluid contacts, and interpretation of seismic reflections can be facilitated through this approach.

### *Opacity rendering*

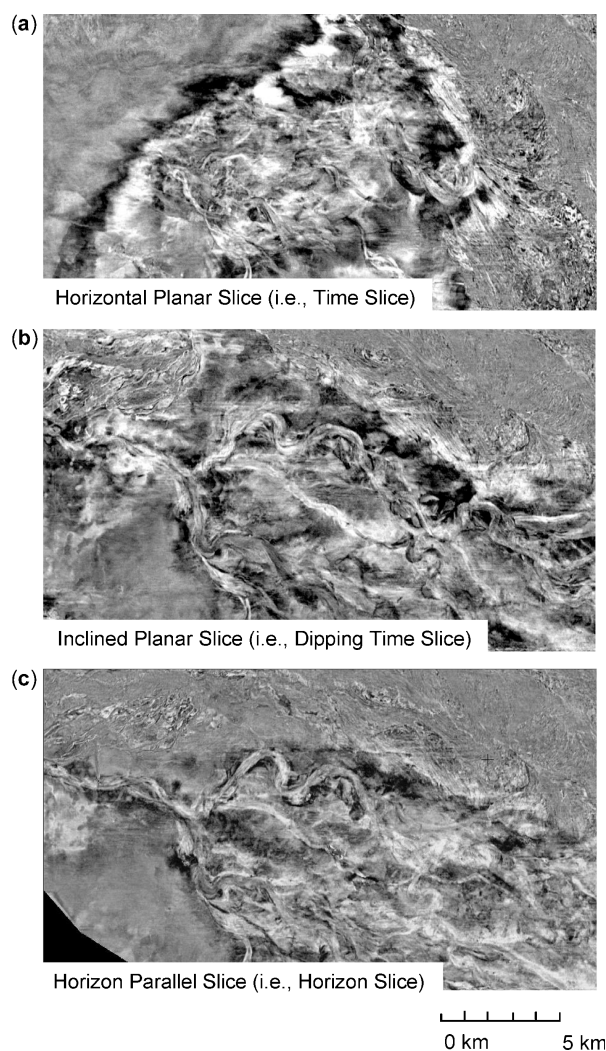
3D seismic volumes can be rendered transparent or partially transparent according to the interpreter's display criteria. In this way, the interpreter can 'see through' the seismic volume and concentrate on features of interest that can be imaged within a certain amplitude range, which the interpreter has rendered opaque (Fig. 8). The interpreter can quickly target features of interest for follow-up analyses. This technique can benefit from volume 'sculpting', which can isolate parts of the 3D seismic volume for closer inspection. This is especially useful where high amplitude reflections just above or below target zones can be 'sculpted' out leaving behind only those sections where opacity rendering is meant to highlight subtle stratigraphic detail.

### *3D perspective rendering*

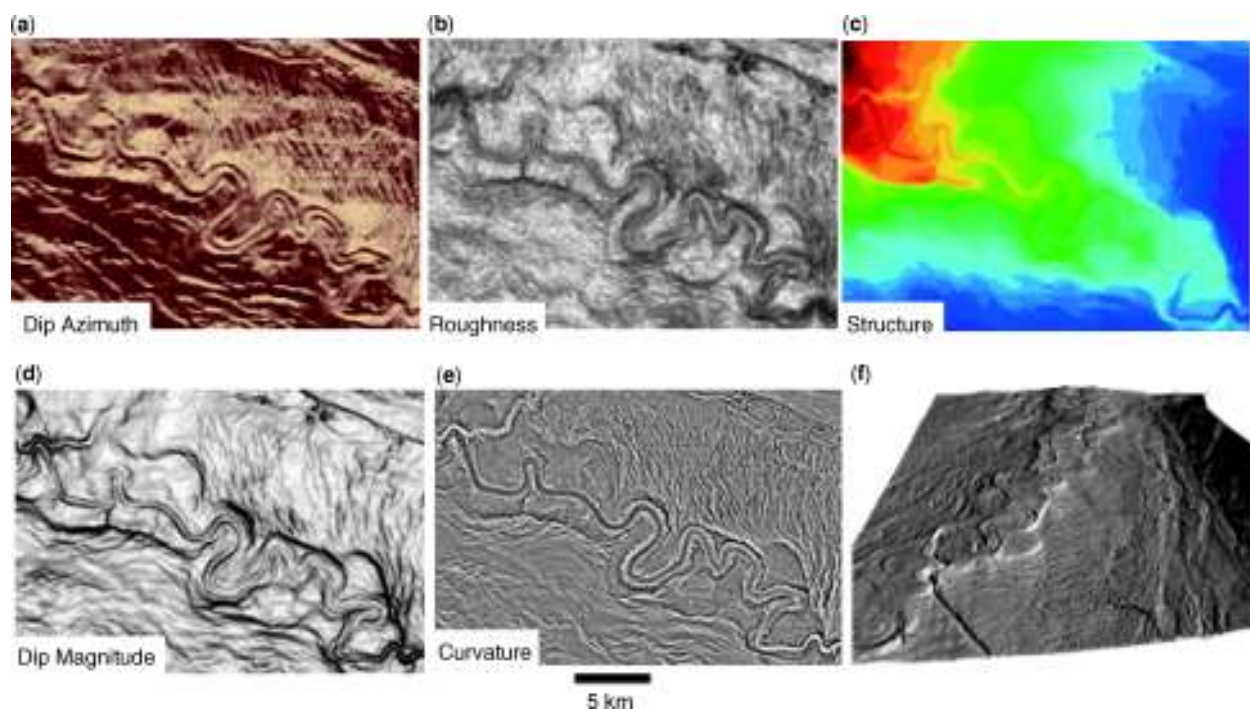
Interpretation of depositional elements can be facilitated by viewing horizons in perspective view. Such views are especially useful in illustrating spatial relationships between different elements, which can assist in interpretations and communication of ideas (Fig. 9a). Perspective views are also useful in those instances where depositional settings are characterized by erosional or depositional relief (Fig. 9b).

## **Discussion**

Features imaged in map view can be analyzed using basic principles of geomorphology and stratigraphy. Map representations



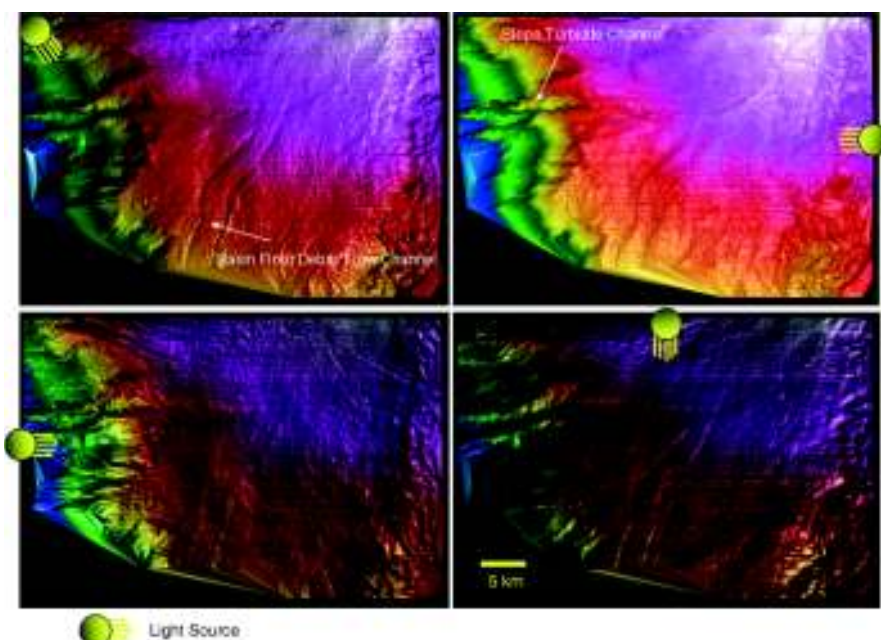
**Fig. 3.** Three views of a Pleistocene leveed channel and associated frontal splay/lobe on the ultra-deep basin floor of the Gulf of Mexico: (a) horizontal time slice; (b) a planar surface, dipping slightly (approximately at a one degree dip); and (c) horizon parallel slice.



**Fig. 4.** Multiple visualizations of a Pleistocene channel-levee complex on the ultra-deep basin floor of the Gulf of Mexico. The visualizations include (a) dip azimuth; (b) roughness; (c) structure; (d) dip magnitude; (e) curvature; and (f) perspective. Dip azimuth maps are maps that assign value to a surface area as a function of the direction that surface faces. Roughness maps describe the degree of irregularity or 'bumpiness' of surface areas. Structure maps illustrate the time (or depth) map for a given horizon. Dip magnitude maps display the angle of inclination of surface areas. Curvature maps illustrate the deviation from a planar surface characterizing small surface areas. Perspective views portray seismic horizons in three-dimensional space.

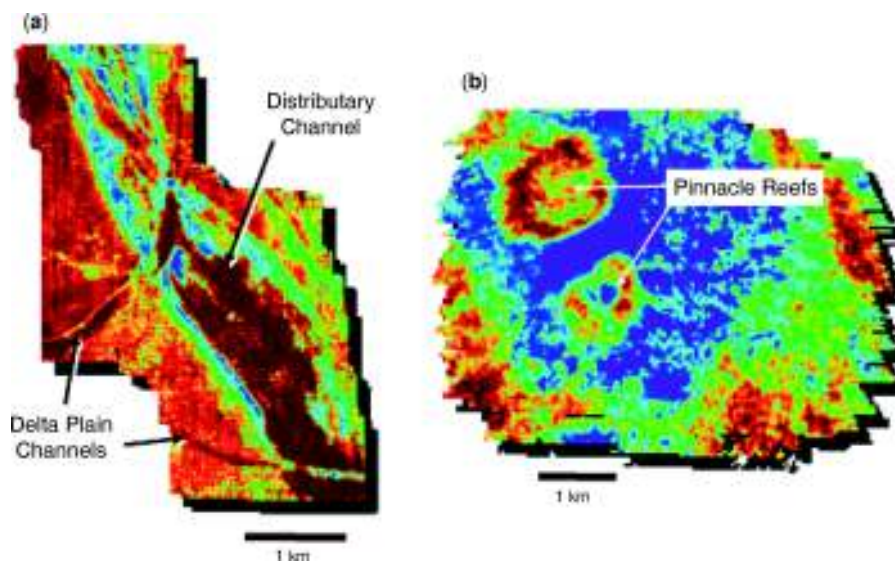
of depositional elements comprise a view of the landscape or seabed as it existed in the distant past, with one minor caveat. That is, what is seismically imaged actually represents that part of the landscape or seabed that has been preserved subsequent to post-depositional erosion. For example, fluvial channels are dynamic in nature and, because of repeated reactivation and potential erosion, present-day landscapes are subject to later modification. Landscapes observed on seismic data represent the end product of these dynamic processes.

The integration of seismic geomorphology and seismic stratigraphy is a critical part of the workflow designed to extract geological information from seismic data. Once features of interest are identified in map view, it is essential to examine these features in cross section to obtain stratigraphic confirmation of depositional origin if possible. 3D seismic data make possible any orientation of cross section desired. These cross sections can be used to evaluate stratigraphic architecture and confirm geological interpretations based initially on recognition of depositional elements in plan

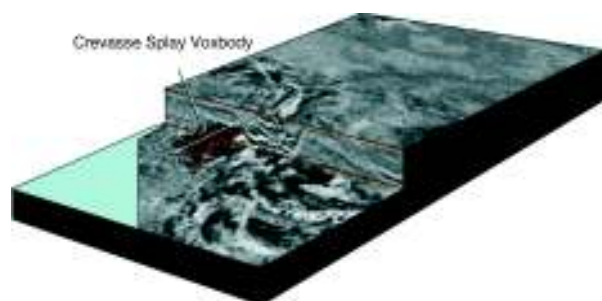


**Fig. 5.** A seascape in the deep water of the Gulf of Mexico with lighting from four different directions. Note that different lighting angles highlight different geomorphic details, in particular with respect to the slope and basin floor channels.

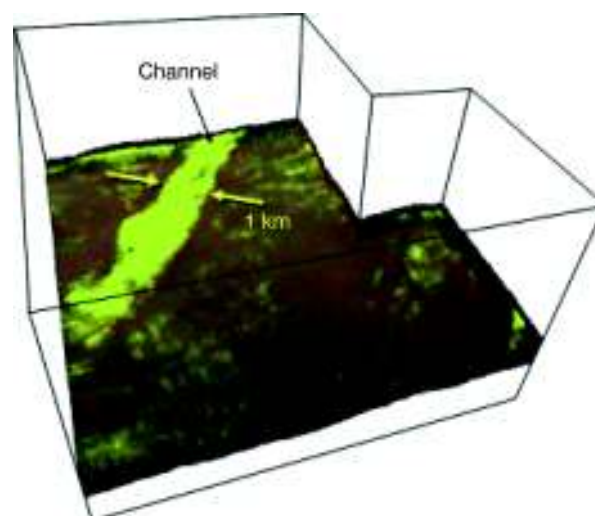




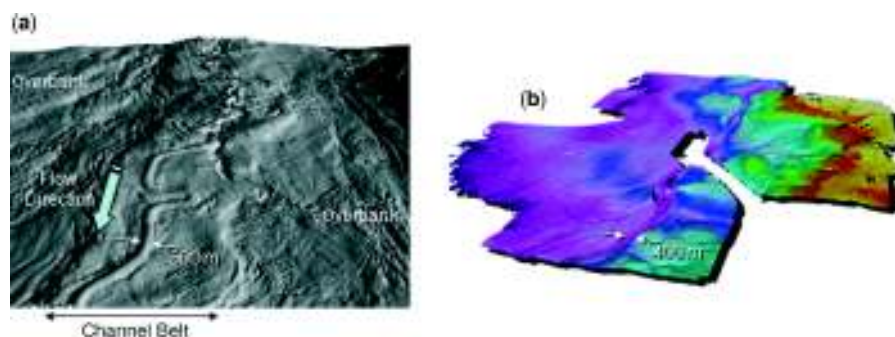
**Fig. 6.** Two examples of interval attribute images from the western Canada sedimentary basin. (a) Interval attribute of a Cretaceous distributary channel; the attribute illustrates the amplitude strength of a 40 ms interval; (b) Interval attribute of two pinnacle Devonian reefs; the attribute illustrates the peak amplitude within a 60 ms interval that brackets the reefs.



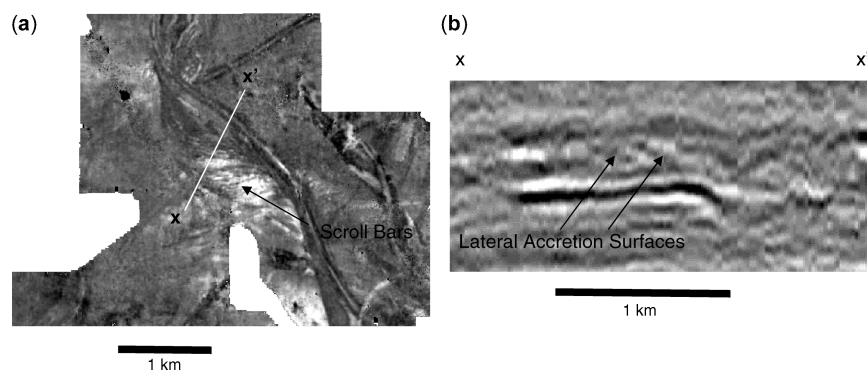
**Fig. 7.** Voxbody interpretation of a deep-water Pleistocene channel crevasse splay on the basin floor of the Gulf of Mexico. The splay is approximately 4 km wide. This image was produced by 'seeding' a voxel of a specific amplitude and then allowing the autopicker to find all adjacent voxels of similar or higher amplitude.



**Fig. 8.** Opacity rendering of a shelf channel, western Canada sedimentary basin. The channel is approximately one kilometre wide. Two prominent horizons bracketing the channel were selected for horizon sculpting, a process by which all voxels above the upper horizon and all voxels below the lower horizon are rendered transparent. Subsequently, the interval between the two horizons is rendered partially transparent whereby only the extreme amplitudes are left opaque.



**Fig. 9.** (a) Time structure perspective view of a Pleistocene channel-levee complex on the basin floor of the Gulf of Mexico illustrating several depositional elements including channel, channel belt, and overbank/levee. The channel belt is approximately 3.5 km wide; (b) Time structure perspective view of the base Cretaceous unconformity separating Cretaceous fluvial to estuarine deposits from underlying Mississippian carbonates in the western Canada sedimentary basin. The channel in the foreground is approximately 400 m wide.



**Fig. 10.** (a) Time slice through an Upper Cretaceous fluvial channel in the western Canada sedimentary basin. Flow direction is inferred from lower right to upper left. The arcuate forms are interpreted as point bar deposits; (b) Seismic reflection profile across fluvial channel shown in A. Note the lateral accretion surfaces leading to an interpretation of point bar deposits consistent with the interpretation of the plan view image in A.

view. For example, as illustrated in Figure 10a, a meandering fluvial channel observed in plan view is characterized by a succession of meander loops and possible scroll bars. This same feature viewed in cross section (Fig. 10b) is characterized by lateral accretion sets suggesting the presence of point bar deposits, an interpretation that is consistent with the interpretation of a meandering fluvial channel derived from plan view images. In this way, the stratigraphy and geomorphology constitute 'converging lines of evidence' that yield a more robust geological interpretation than is possible with either approach alone. Further confirmation of this interpretation comes from borehole information, where well logs exhibit a fining-upward trend, typical of point bar deposits.

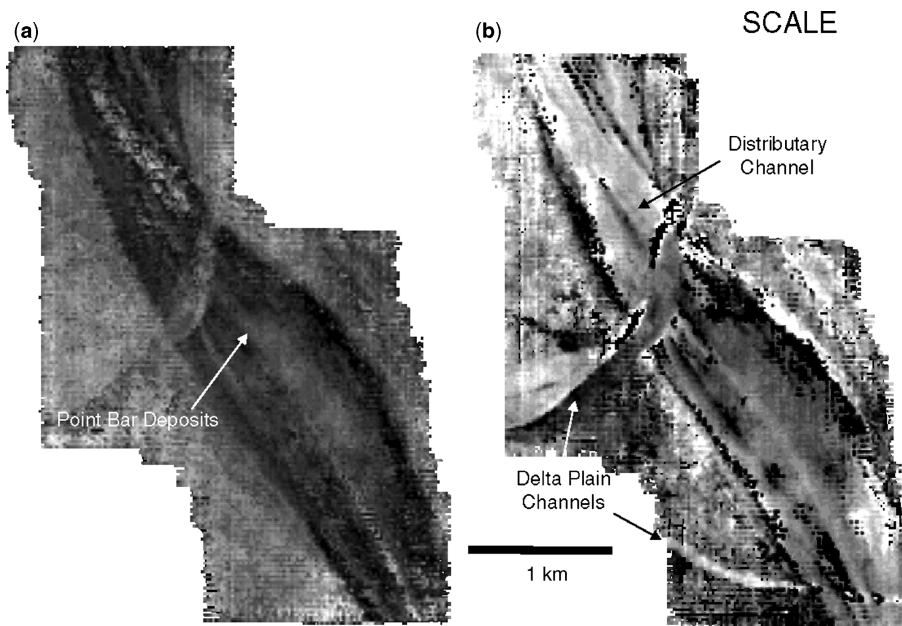
Another reason for integrating plan view and section images is to confirm that the origin of a given map pattern is in fact stratigraphic rather than a data processing or acquisition artefact, a structural feature, a map of fluid distribution, or an artefact of an unusual slice through the data. For example, horizon slices that cut across seismic reflections at a low angle can result in a map pattern similar to that of a high-sinuosity meandering channel. Viewing such features in cross section immediately confirms that this pattern is not indicative of a

specific depositional element but rather is an artefact of the analysis technique. Similarly, cross sections can quickly reveal a structural explanation for features that might initially be interpreted as stratigraphic in nature.

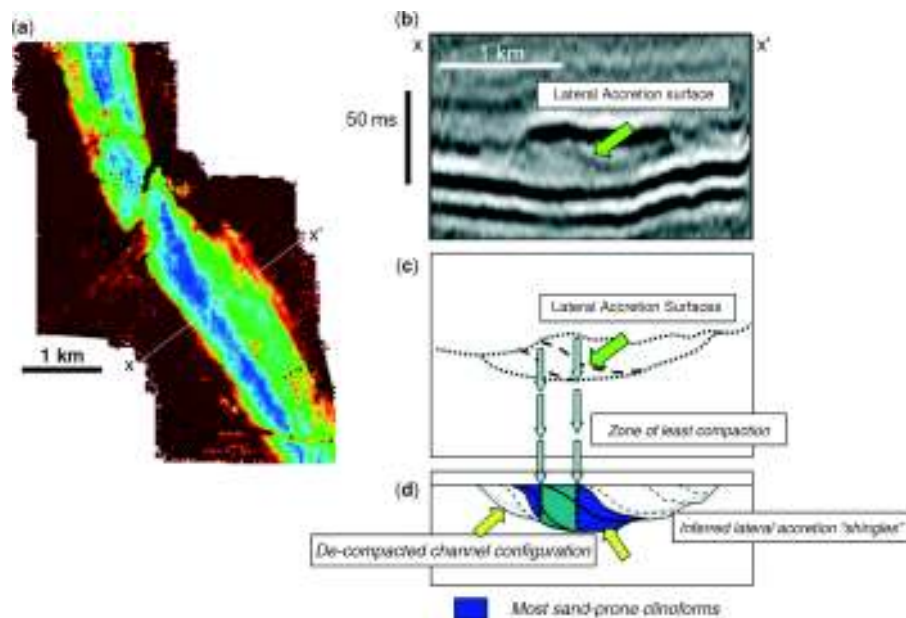
### Depositional elements: examples

Seismic geomorphological analyses require specific skill sets. It is critical for interpreters to be able to recognize geologically significant map patterns. They must be able to distinguish seismic noise from seismically imaged depositional elements. In order to do that, the interpreter must be familiar with the geomorphology of as broad a range of depositional elements as possible. Of course, the interpreter must also be familiar with various expressions of seismic noise (whether due to data acquisition or data processing issues).

A Cretaceous-aged, kilometre-wide channel crosscut by two lesser channels is imaged in a variety of plan and section views (Figs 11 and 12). Figure 11a is a horizon slice or flattened time slice, whereby a reflection 32 ms above was interpreted and used as a reference horizon for the purpose of slicing through the 3D seismic volume. Figure 11b is a reflection amplitude extraction of



**Fig. 11.** Seismic images of a distributary channel crosscut by later, smaller delta plain channels, western Canada basin (compare with Fig. 6A). (a) Horizon slice or flattened time slice and subsequent amplitude extraction across distributary channel. Note the lineaments within the channel, interpreted as point bar or side bar deposits. A smaller crosscutting channel can be observed in the central part of the image; (b) Reflection amplitude map of reflections immediately below the level associated with the channel (the NRG attribute of Paradigm Geophysical's Stratimagic application). Note that this image brings to light another crosscutting channel in the lower part of the image.

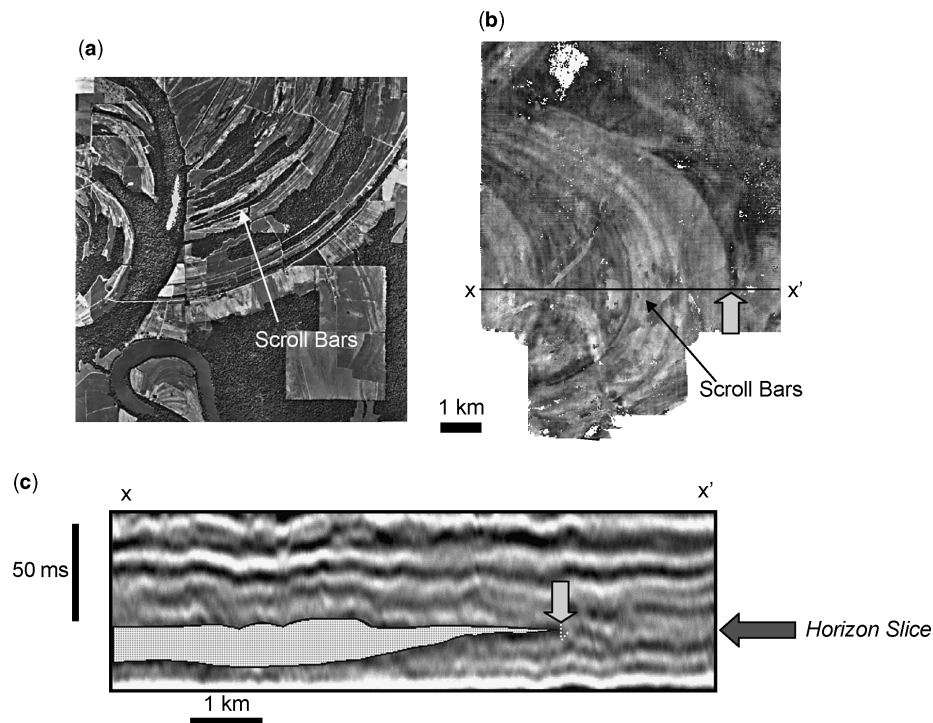


**Fig. 12.** (a) Time thickness map of the distributary channel shown in Figure 11; blue colours represent thicks and red colours represent thins; (b) Transverse seismic profile across distributary channel shown in A. Note the lateral accretion surfaces suggesting point bar accretion from left to right; (c) Line drawing of distributary channel stratigraphy based on seismic reflection geometry. Note the bump along the upper bounding surface, likely corresponding to a differential compaction effect; (d) Channel stratigraphic architecture reconstructed by decompacting the channel fill. Note that the shingles (i.e. point bar deposits) that contribute to the differential compactional bump are the most sand prone.

reflections immediately below the reflection associated with the channel. Each images the channels in a different way, with different details brought out by the two display styles. Both show linear features within the large channel, which can be interpreted as possible point bar deposits. Both show a crosscutting and therefore younger channel in the middle of the illustration. However Figure 11b shows another smaller channel crosscutting the larger channel towards the bottom of the illustration, not

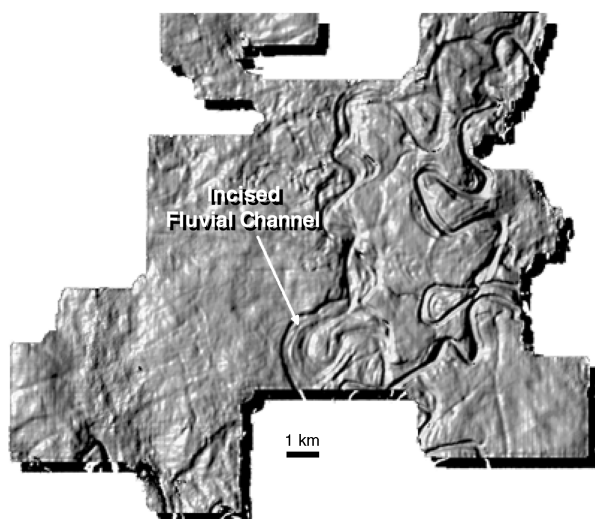
apparent in Figure 11a. This underlines the fact that multiple ways of imaging the same feature can commonly bear fruit insofar as subtle features might not be imaged on every form of display.

The integration of seismic geomorphology and seismic stratigraphy is illustrated in Figure 12. Inclined reflections within the interpreted channel fill can be observed on the reflection profile oriented normal to the long axis of the large channel (Fig. 12b).



**Fig. 13.** (a) Meander loops and scroll bars on the modern Mississippi River flood plain; (b) Cretaceous-age meander loops and scroll bars on a seismic horizon slice (western Canada sedimentary basin); (c) Seismic reflection profile transverse to meander loop shown in (b); Note position of the horizon slice shown in (b). This profile shows no obvious stratigraphic expression suggesting the presence of point bar deposits.



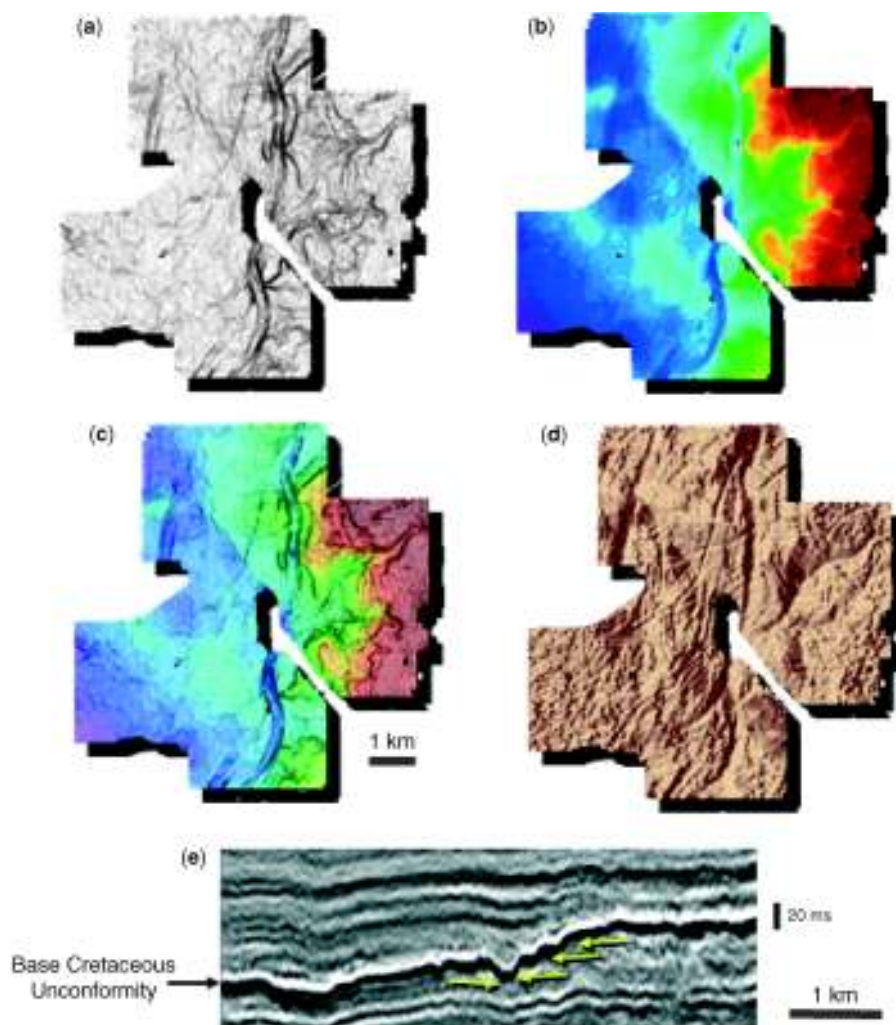


**Fig. 14.** Dip azimuth map of the base Cretaceous unconformity in the western Canada sedimentary basin. Note the high-sinuosity fluvial channels entrenched in Mississippian-aged carbonates.

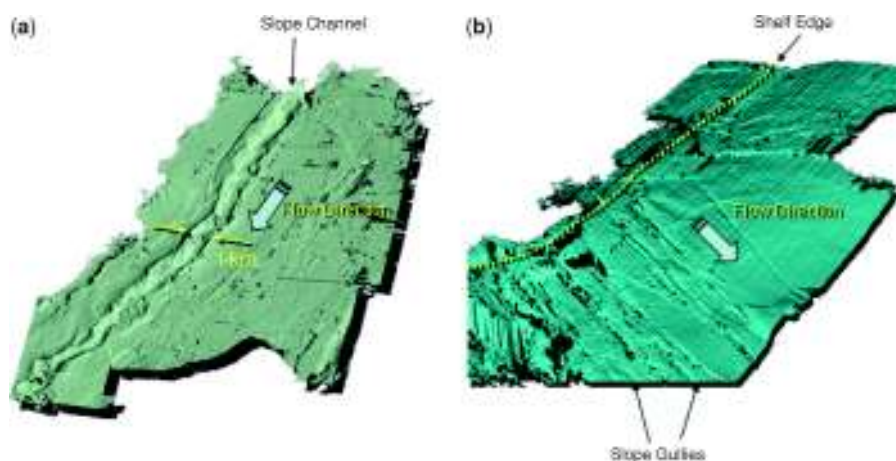
These reflections can be interpreted to represent lateral accretion surfaces associated with point bar deposition within the channel (Fig. 12c and d). The time thickness map indicates the presence of a thicker channel fill on the southwestern side of the channel (Fig. 12a and b). The seismic profile reveals that the thicker part of the channel does not correspond to a deeper channel thalweg, but rather is associated with a 'bump' across part of the channel. This 'bump' is interpreted to be associated with a fill that is less compactable than the other part of the channel fill (Fig. 12c). This less compactable section would suggest the presence of lateral accretion sets that are sand-rich, sand being less compactable than silt or shale (Fig. 12d).

Fluvial systems characterized by high-sinuosity channel belts are illustrated in Figure 13. The concentric arcs imaged in map view (Fig. 13b) represent sections through point bar deposits and may represent scroll bars. Figure 13a illustrates an analogous modern feature from the Mississippi floodplain for comparison. Examination of the reflection profile shown in Figure 13 illustrates a stratigraphic representation of such deposits; interpretation of the correct depositional element would probably not have been possible if only the reflection profile were available.

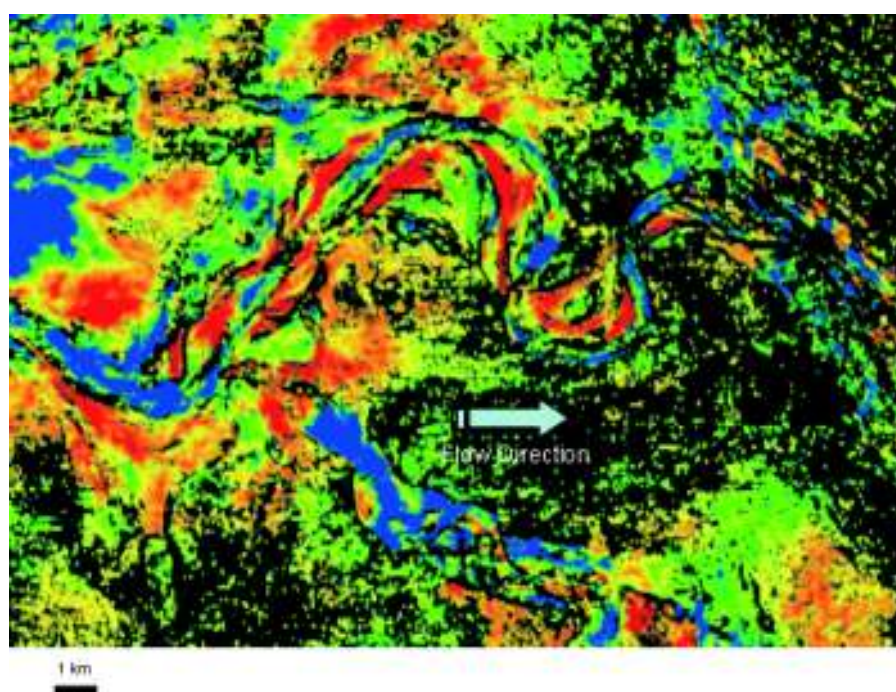
Fluvial systems overlying a major unconformity surface are illustrated in Figs 9b and 14. In this instance, Cretaceous fluvial channel fill deposits directly overlie Mississippian-aged



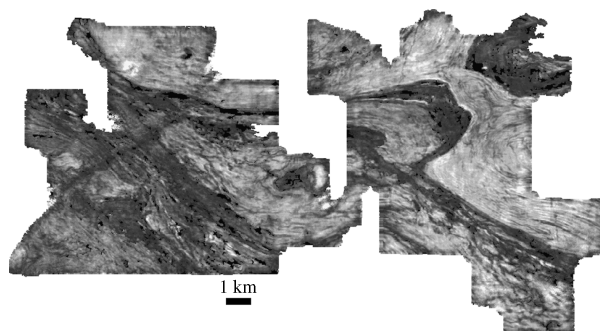
**Fig. 15.** Four map views and one section view of the base Cretaceous unconformity, western Canada sedimentary basin. (a) Dip magnitude map illustrating incised Cretaceous-aged drainage pattern; (b) Time structure map of the same surface highlighting the dendritic drainage of an ancient highland area on the right side of the image (compare with perspective view of Fig. 9b); (c) Co-rendered image of dip magnitude and time structure bringing together benefits of both (a) and (b); (d) Dip azimuth map of the same surface bringing to light more obscure lineaments that correspond to smaller channels; (e) Seismic reflection profile across the study area illustrating the stratigraphic view of the same surface shown in (a–d). Note the reflection terminations that define the unconformity. Note also the onlapping fill section above the unconformity.



**Fig. 16.** Perspective views of a Late Pleistocene upper slope environment. (a) Turbidity flow slope channel on the upper slope. This channel is approximately 1.8 km wide and is flanked by levees on both sides; (b) Small slope gullies approximately 200–300 m wide located at the uppermost slope. These features are associated with the presence of a shelf edge delta that was active during Pleistocene sea-level lowstand.



**Fig. 17.** Co-rendered seismic coherence and amplitude for a deep-water turbidite channel-levee complex. The coherence attributes emphasizes reflection discontinuities and therefore enhances channel edges, whereas the amplitude attribute is an indication of lithology distribution and helps define potential sand and mud. Note the multiple channel threads that characterize this system. These channel threads are indicative of meander loop evolution suggesting flow from left to right.

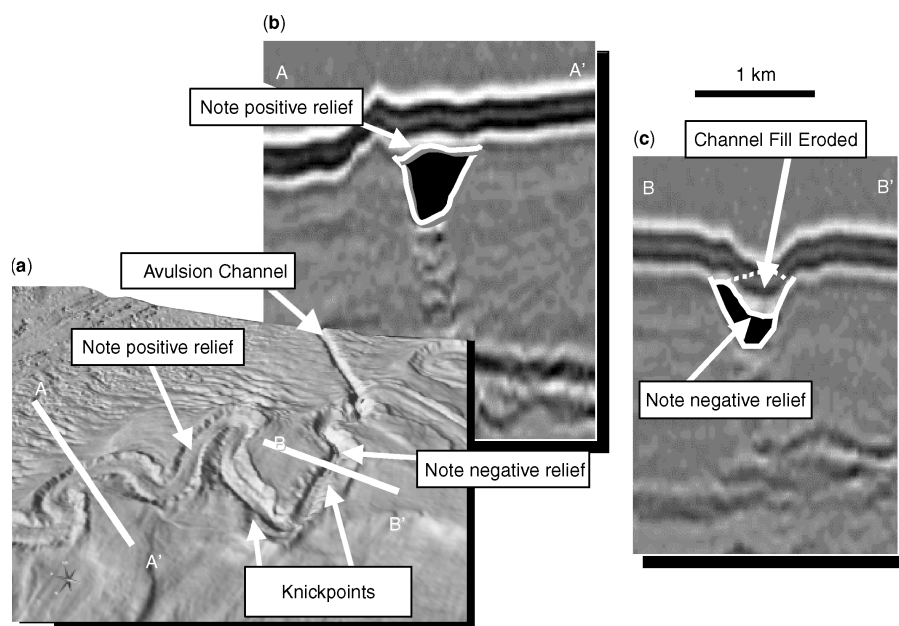


**Fig. 18.** Seismic amplitude extraction of basement reflection, western Canada sedimentary basin. Basement lithology here likely is metamorphic.

carbonates. Figure 15 illustrates several horizon attributes as well as a seismic profile showing the stratigraphic discontinuity between the Cretaceous and Mississippian deposits. Note the apparent dendritic drainage pattern off the highland area at the right side of Figures 9b and 15. Each image portrays the depositional elements somewhat differently. In comparing Figures 9b and 15b, note that the perspective view (Fig. 9b) allows for enhanced understanding of the landscape elements. Figures 9a and 16 illustrate additional examples of how perspective views enhance the understanding of the distribution of depositional elements.

Co-rendering of different attributes, whereby two or more attribute maps are overlain and imaged simultaneously, can also serve to enhance geological features (Figs 15c and 17). Images that provide complementary information can synergistically combine to bring together the best of each individual image. The image of a deep-marine leveed channel shown in Figure 17 combines the edge





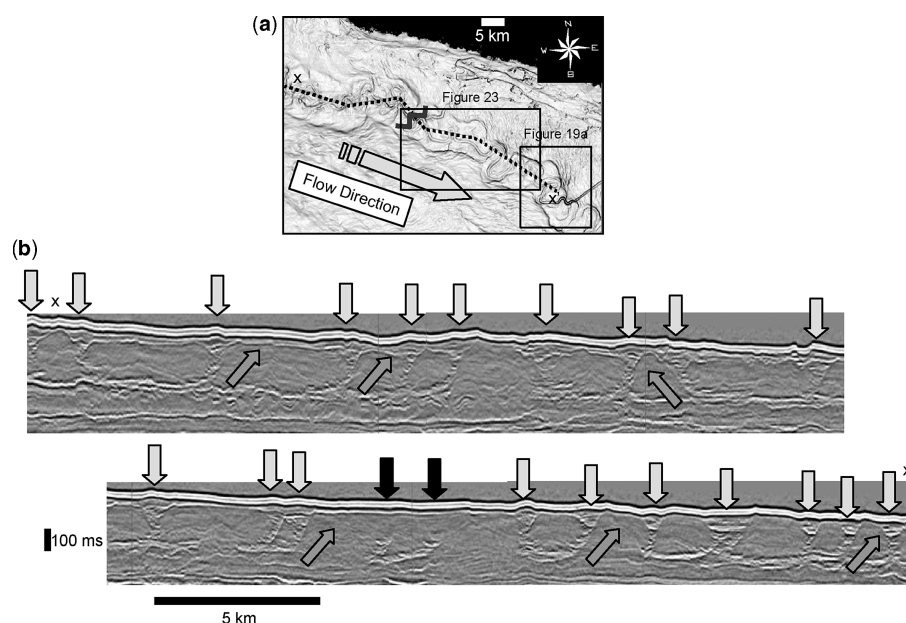
**Fig. 19.** (a) Perspective view of Late Pleistocene sea floor in the eastern Gulf of Mexico, characterized by a high-sinuosity leveed channel (see Fig. 20 for location) and an associated avulsion channel. In the main channel, updrift of the avulsion channel, associated knickpoints representing the upstream end of channel incision associated with the avulsion event can be observed. Note that the channel upstream of the knickpoint; (b) is characterized by a convex-up profile suggesting that the channel is sand filled there, and downstream of the knickpoint (c) is characterized by a concave-up profile suggesting that the channel is mud filled there.

detection capabilities of a 'coherence' map with the lithology indications inherent in a seismic amplitude map to portray clearly both the margins of the channel as well as the inferred type of fill in the channel.

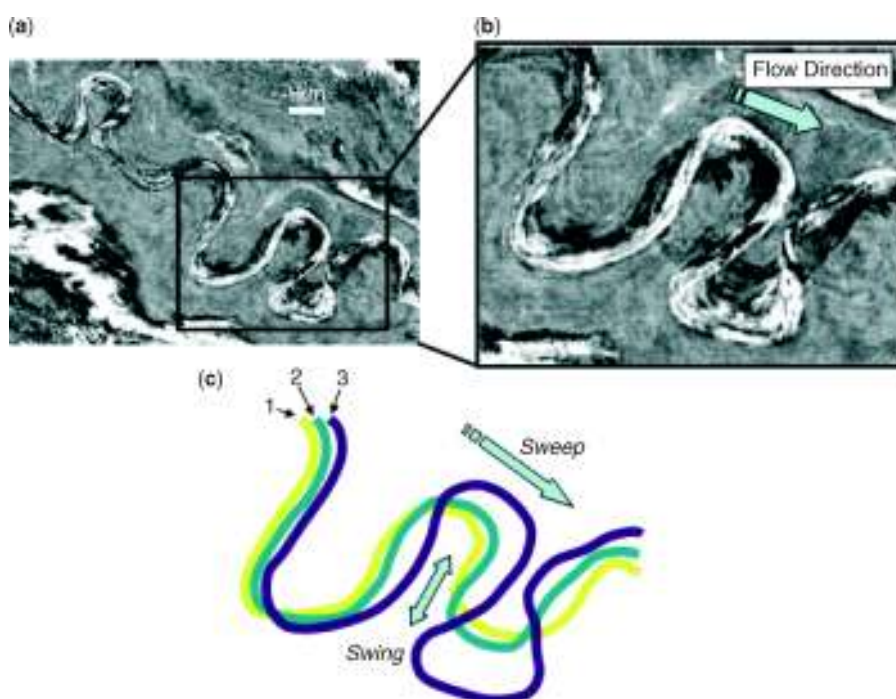
In certain instances, where basement reflections are well defined, subcrop seismic expression can provide significant insight with regard to basement lithologies. Figure 18 illustrates subcrop seismic amplitude expression and styles of deformation (i.e. the folded banding in the subcrop) indicative of a metamorphic basement terrain.

The application of the 3D-based seismic geomorphology approach has been particularly important for improved

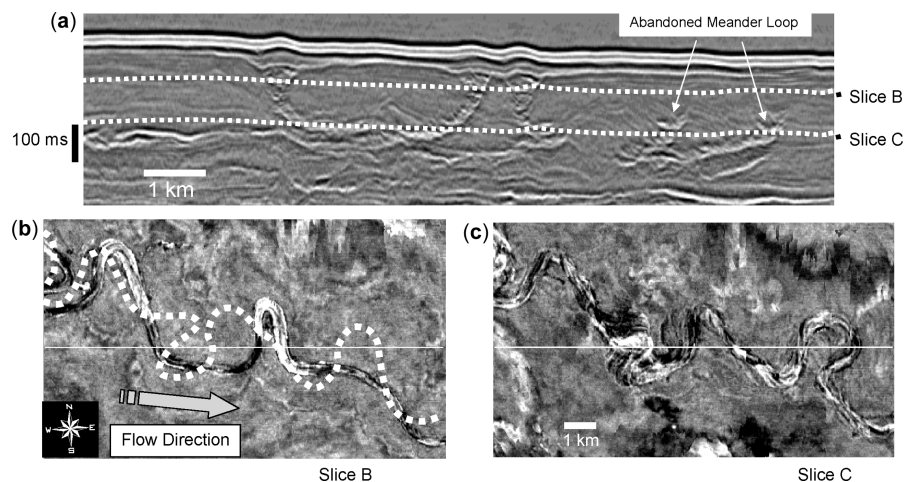
understanding of sedimentary processes in deep-water depositional environments. These settings are difficult to study first hand because of their remoteness and inaccessibility. 3D seismic data affords section and plan view images that have significantly enhanced our understanding of spatial and temporal distribution as well as lithology of deep-water depositional elements. Figure 19 illustrates a high sinuosity Pleistocene channel deposited in the eastern Gulf of Mexico in water depths greater than 2500 m. This channel, described by Posamentier & Kolla (2003), appears to be sand filled in part, as indicated by the positive relief of the channel fill, and mud filled in part, where the channel fill is characterized by a concave-up upper surface (Fig. 19). This



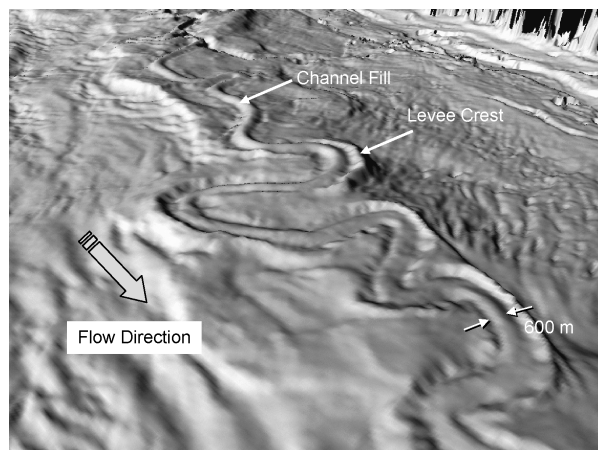
**Fig. 20.** (a) Dip magnitude map of a Late Pleistocene high sinuosity leveed channel, eastern Gulf of Mexico; (b) Axial transect through leveed channel shown in (a). Light grey arrows indicate locations where transect crosses the channel; dark grey arrows indicate the direction of migration of the channel through time as the system aggraded. In most instances they indicate a down-system meander loop migration.



**Fig. 21.** (a) Time slice of a Late Pleistocene high sinuosity leveed channel, eastern Gulf of Mexico; (b) Detail of this channel indicates a progressive shift of the channel through time as shown in the line drawing interpretation showing meander loop evolution (c). Both meander expansion (i.e. swing) and down-system migration (i.e. sweep) through time can be observed.



**Fig. 22.** (a) Seismic reflection transect through same channel shown in Figure 20. Note abandoned meander loop; (b) Seismic horizon slice taken near top of meandering channel section illustrating position of channel axis at level B shown in (a). The dashed line in (b) represents the channel position at the lower level C as shown in the seismic horizon slice C.



**Fig. 23.** Perspective view of the late Pleistocene channel shown in Figure 20. The channel is approximately 600m wide. Note the raised profile of the channel indicating the presence of sand there. Note also the enhanced height of the levees along each outer channel bend.

channel was probably characterized by channel avulsion in its late stage of development, resulting in an upstream-migrating knickpoint. Cross-section views show how this channel evolved through time and space (Fig. 20). Figure 21 illustrates progressive down-system meander loop migration in map view, whereas Figure 22 illustrates map views of this channel at different times in its evolution. Note also the greater height of the levees on each outer meander loop (Fig. 23), a characteristic consistent with partially channelized sediment gravity flow deposits.

## Conclusions

The study of depositional systems in time and space has benefited greatly from analyses of 3D seismic data. Through a combination of plan views and section views, discrete depositional elements can be identified and visualized, and ultimately interpreted with regard to paleogeography, temporal evolution and lithology. This approach constitutes an integration of seismic geomorphology

(i.e. plan views) and seismic stratigraphy (i.e. section views). Interpretation of 3D seismic volumes can involve a variety of analytical techniques ranging from mapping, visualizing and characterizing attributes of seismic horizons, to performing amplitude extractions from seismic slices, to characterizing seismic attributes of seismic intervals. Knowledge of map view expression of a range of depositional elements as well as a sound understanding of stratigraphic architecture is essential for this approach. From an exploration perspective, the identification of depositional elements facilitates lithology prediction because most depositional elements have a somewhat predictable distribution of rock types.

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