Sequential Geometric Models of Detachment Folds: Alaminos Canyon Area, Gulf of Mexico

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EXTENDED ABSTRACT

Based on published seismic lines, the Alaminos Canyon in the Western Gulf of Mexico contains a N-S trending wave train of detachment folds that are tilted basinward (eastward). The folds are periodic and change geometry from normal folds in their cores to a box-shaped geometry outward. In the folded pre-growth layers, the limb dips increase up section, which is indicative of detachment folding. The age of the oldest growth sediments decreases updip to the west, with the oldest folds at the toe or downdip end (to the east) as would be predicted for internal shortening within a gravity slide. New sequential geometric models of box-shaped detachment folds are used to model the folding. Natural detachment folds consist of pre-growth layers that can undergo massive thickness changes above a detachment horizon above an undeformed basement. The geometric models produce box folds that have inclined axial surfaces with opposed dips that intersect both upsection and downsection to form anticlines and synclines with only one axial surface in the core of the folds (Figs. 1K-O) as observed on the seismic data. In these new geometric models, box-shaped folds grow more slowly in amplitude than those with a single anticlinal axis. After initial layer-parallel shortening, all of the models undergo a line length elongation (stretching) which occurs first at the highest levels in the anticline and migrates downward with increasing shortening. This initial shortening followed by elongation is shown by the requisite strains in Figure 1. In most natural detachment folds, the synclines do not actually move down in an absolute sense but are left behind as the anticlines move up in an absolute sense. Figure 2 shows geometric models for a wave train in detachment folds for the case of vertical axial surfaces. In the natural detachment folds the deformable layer below is thick enough that the synclines may actually move down. The sequential geometric models reveal that shortening and thickening of the deformable layer forms a wedge-shaped zone that produces a tilted wave train similar to the natural detachment folds (not shown in Figure 2).

REFERENCES CITED

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Groshong, R. H., Jr., and J.-L. Epard, 1994, The role of strain in area-constant detachment folding: Journal of Structural Geology, v. 16, p. 613-618.

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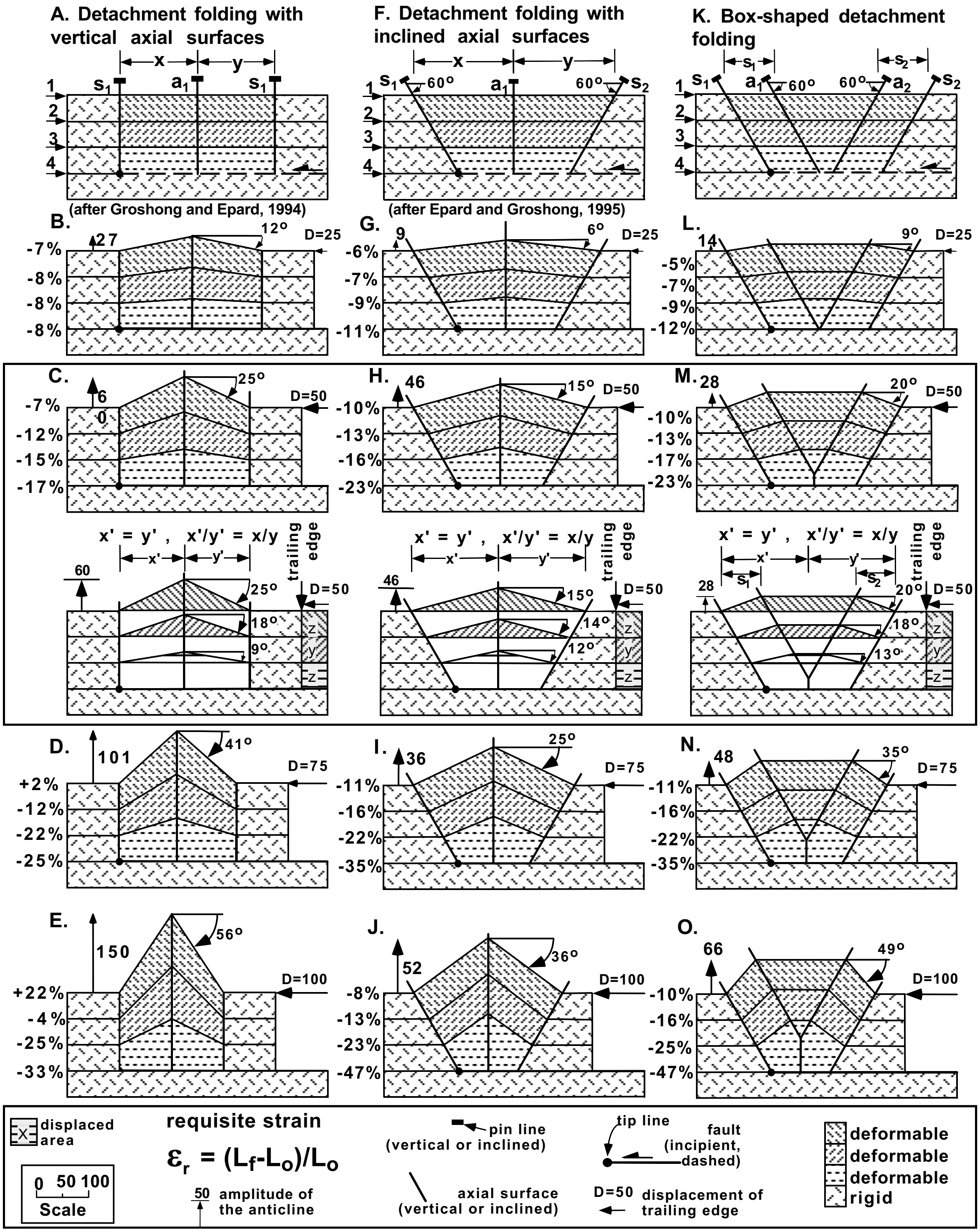
A. Detachment folding with vertical axial surfaces
F. Detachment folding with inclined axial surfaces
K. Box-shaped detachment folding
x
y
s_1
a_1
s_2
a_2
60°
1
2
3
4
(after Groshong and Epard, 1994)
(after Epard and Groshong, 1995)
B.
G.
L.
27
12°
D=25
9
6°
14
9°
-7%
-8%
-8%
-8%
-6%
-7%
-9%
-11%
-5%
-7%
-9%
-12%
C.
H.
M.
60
25°
D=50
46
15°
28
20°
-7%
-12%
-15%
-17%
-10%
-13%
-16%
-23%
-10%
-13%
-17%
-23%
x' = y' , x'/y' = x/y
trailing edge
x'
y'
18°
9°
14°
12°
18°
13°
z
y
D.
I.
N.
101
41°
D=75
36
25°
48
35°
+2%
-12%
-22%
-25%
-11%
-16%
-22%
-35%
-11%
-16%
-22%
-35%
E.
J.
O.
150
56°
D=100
52
36°
66
49°
+22%
-4%
-25%
-33%
-8%
-13%
-23%
-47%
-10%
-16%
-25%
-47%
x displaced area
0 50 100
Scale
requisite strain
$\varepsilon_r = (L_f - L_o)/L_o$
50 amplitude of the anticline
pin line (vertical or inclined)
axial surface (vertical or inclined)
tip line
fault (incipient, dashed)
D=50 displacement of trailing edge
deformable
deformable
deformable
rigid

(FACING PAGE) **Figure 1. Two existing geometric models for detachment folding with vertical axial surfaces (Fig. 1A, modified after Groshong and Epard, 1994) and for detachment folding with inclined axial surfaces (Fig. 1F, modified after Epard and Groshong, 1995). One new geometric model for the development of box-shaped detachment folds with inclined axial surfaces (Fig. 1K) is introduced here. Both of the existing models have three axial surfaces consisting of two synclinal axial surfaces (s_1, s_2) with an intervening anticlinal axial surface (a_1) all of which are fixed in space in the rocks. The new geometric model has two synclinal axial surfaces (s_1, s_2) with two intervening anticlinal axial surfaces (a_1, a_2), which produces a box-shaped anticline. The two synclinal axial surfaces are also pin lines, and the folds have planar limbs (for simplicity), and the resulting folds have a kink-like geometry. During deformation, the spacing of the axial surfaces is equal, such that x=y and x'=y' and the ratio of the spacing of the axial surfaces remains constant, such that x/y = x'/y'. A wide range of other ratios of the spacing of the axial surfaces is both possible and geologically reasonable. With horizontal displacement (D) above the detachment, the anticline grows in amplitude. These different axial surface geometries result in distinctly different fold shapes, limb dips and line length/thickness changes (the change in line length is called the requisite strain) in the layers (shortening strain is negative). Figures 1C, H and M contain an additional copy of the figure that shows that limb dip and amplitude increases upsection for each of the three different models at the same shortening, D = 50 units). These additional figures also illustrate why the limb dips increase upsection. At stratigraphic level 3, the area with the horizontal lines shows how much area has been added to fold to push the top of the layer up. This material came from the displaced area below the top of layer 3 at the right end of the hanging-wall block (labeled z). Layer 2 has a steeper dip than layer 3 because more displaced area (y and z) has been added to the fold at this stratigraphic level.**

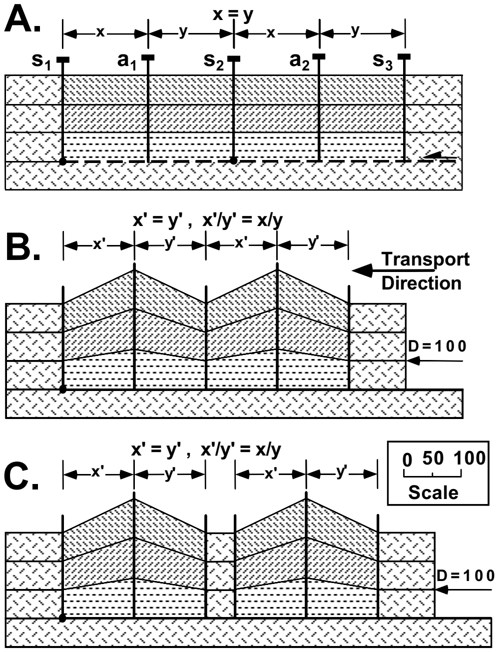

Figure 2. Wave trains of detachment folds. This illustrates wave trains of geometric models of symmetric detachment folds with vertical axial surfaces (A). The fold trains could also include both symmetrical and asymmetrical folds or all asymmetrical folds (not shown). In these geometric models (B), true synclines cannot form since the rock in the hanging-wall block cannot move down in an absolute sense due to the rigid rock below the detachment. Anticlines grow while the troughs of the synclines remain at or near their original stratigraphic level. Flat-bottomed synclines can develop due to the presence of undeformed areas of differing widths between the anticlines (C). See Figure 1 for a detailed legend.