The Compass: Earth Science Journal of Sigma Gamma Epsilon

Volume 84 | Issue 4 Article 3

1-31-2013

Plains-type Folds: Their Origin and Development

Dan Merriam
University of Kansas, dmerriam@kgs.ku.edu

Follow this and additional works at: https://digitalcommons.csbsju.edu/compass

Part of the Earth Sciences Commons

Recommended Citation
Merriam, Dan (2012) "Plains-type Folds: Their Origin and Development," *The Compass: Earth Science Journal of Sigma Gamma Epsilon*: Vol. 84: Iss. 4, Article 3.
Available at: https://digitalcommons.csbsju.edu/compass/vol84/iss4/3

This Article is brought to you for free and open access by DigitalCommons@CSB/SJU. It has been accepted for inclusion in The Compass: Earth Science Journal of Sigma Gamma Epsilon by an authorized editor of DigitalCommons@CSB/SJU. For more information, please contact digitalcommons@csbsju.edu.

PLAINS-TYPE FOLDS: THEIR ORIGIN AND DEVELOPMENT

Daniel F. Merriam
Kansas Geological Survey
and the University of Kansas
1930 Constant Avenue
Lawrence, KS 66047 USA
dmerriam@kgs.ku.edu

ABSTRACT

Small in areal extent, plains-type folds in Paleozoic sediments of the Midcontinent of the United States form by as the result of draping sediments over highs in underlying Precambrian crystalline basement rocks. Fracture systems in underlying Precambrian rocks may propagate upward through overlying sedimentary rocks. Movement on the basement structures occur when there is an adjustment in the basement, which results in an adjustment of the overlying units and a draping over the tilted fault blocks. The incidence of earthquakes, which result from this adjustment, are recorded in the overlying sediment as convolute features known as seismites.

KEY WORDS: geologic structures, plains-type folding, Kansas geology, seismites.

INTRODUCTION

Plains-type folds occur in the Midcontinent of the United States. Plains-type folds are important not only for understanding their origin and development as a geologic structure, but they may contain deposits of petroleum. A general definition of these features is:

> …an anticlinal or dome-like structure of the continental platform which has no typical outline and for which there is no corresponding synclinal structure.

Plains-type folds are local, subtle anticlines formed in the thin sedimentary package overlying a shallow, crystalline basement on the craton (Merriam, 2005). The sedimentary package differentially compacts over tilted, rigid basement fault blocks forming the plains-type folds. The history on the description of these anticlines and their importance was given by Merriam (1963).

Although these features were first observed and described in Paleozoic sediments, they persist through the Paleozoic stratigraphic section and are recognizable in younger Cretaceous rocks (Merriam and Förster, 2000).

Gardner (1917) was perhaps the first to champion vertical uplift in explaining plains-type folding of the Midcontinent, and Blackwelder (1920) concluded the features were formed by the differential settlement of sediments. In his classic paper, Fath (1920) explained the features and their formation.

Plains-Type Folds

Essentially plains-type folds are anticlines formed in the sedimentary sequence which are small in areal extent, increase in amplitude with depth, may not have a corresponding depression (syncline), and usually are asymmetric and associated with normal faulting. They formed, in this instance, by the draping of sediments over highs on the buried Precambrian crystalline basement rocks. Much can be learned about the fold's development by noting the direction of them geographically (Merriam and Davis, 2008).

Plains-type folds can be described by plotting the amount of closure on different stratigraphic units plotted in a time frame. The assumptions are:

1. Lithologic units are spread over the area in equal thickness;
2. The changes in thickness are due to differential compaction over a rigid feature; and
3. Compaction of different lithologies is different in (greatest to least): shale, sandstone, limestone.

The change occurs at a point in the stratigraphic section where a major variation in structure development of the area took place. There are several ways in which this change can be displayed, but the most effective is by plotting the amount of structural closure vs. the stratigraphic time scale (Fig. 1).

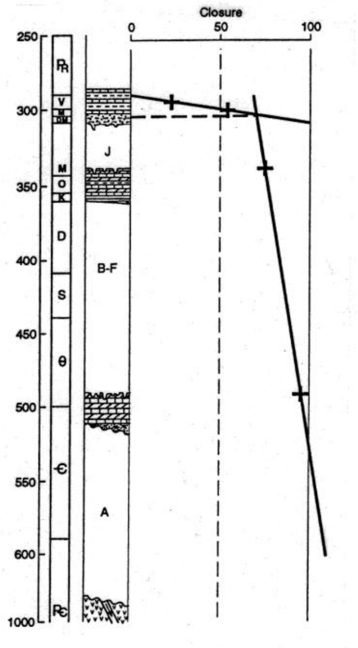

Figure 1. Diagram representing the change in structural movement in time for the Slick-Carson anticline in Cowley County, Kansas. Gaps in the stratigraphic record are noted by blanks. Note the significant change in closure in the Pennsylvanian strata. From Merriam and Förster, 1996; Merriam, 2010.

Another method to help with the interpretation is the structural gradient, which, in some respects, is similar to thermal gradients. High gradients indicate gradual changes with time or low structural development, whereas low gradients indicate high structural development.

Structural Gradient

A gradient is defined as 'a grade or incline' in the dictionary. The *Geologic Glossary* defines gradient as 'a degree of inclination, or rate of ascent or decent.' A structural gradient is defined herein as *the change in slope of the amount of closure with depth.*

The concept can be applied to areas with plains-type folds where the structural development is not intense and the folding is gentle. The Midcontinent of the United States is an ideal example of an area where the folds in the sedimentary cover over Precambrian crystalline basement rock are gentle (Merriam and Forster, 1994). Computation, use, and interpretation of a structural gradient are similar to computation, use, and interpretation of geothermal gradients.

The method essentially is determining the amount of structural closure on anticlines on several horizons, measuring the distance between them and computing the gradient (Fig. 2).

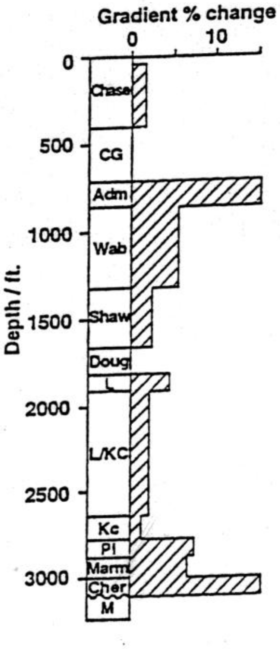

Figure 2. Structural interval gradient plot for the Slick-Carson anticline. High % change in thickness shows time of structural adjustment and maximum sediment compaction. From Merriam and Förster, (1996).

The gradient is expressed in change per 100 ft.

$$\text{Gradient} = \frac{\text{Amount of Closure}}{\text{Distance Between Surfaces}} \times 100$$

The values then are plotted on a map for contouring to determine areas with a similar gradient. This then can be interpreted in relation to the geology and other conditions (Fig. 3).

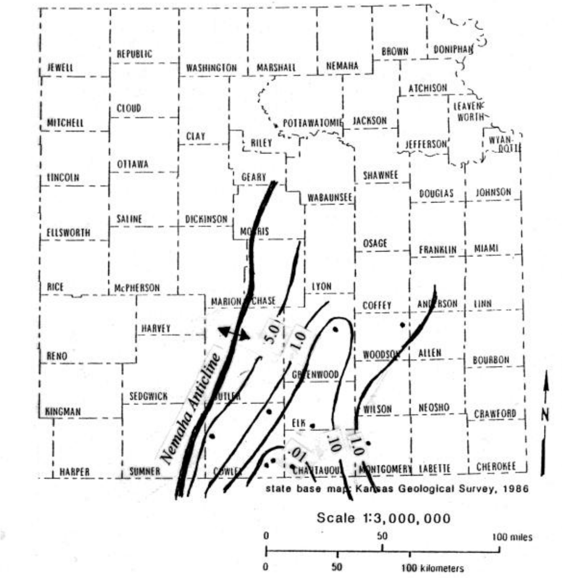

Figure 3. Map showing structural gradient. Note the increase in gradient towards the Nemaha anticline, a very active major structural feature. This anticline is still active today, as noted by earthquakes recorded within historic time. From Merriam and Förster, (1996).

Direction of Features

It is important to understand the relation of the fracture system (faulting) in the Precambrian crystalline basement rocks and the overlying sediments, if they are connected structurally. A study by Merriam and Davis (2008) concluded, from available data, that fracture systems were related to some extent and the fracture pattern in the Precambrian was propagated upward through the overlying sedimentary rock sequence (Fig. 4). Many of these features such as lineaments, topographic features, and drainage patterns, are expressions of the fracture pattern.

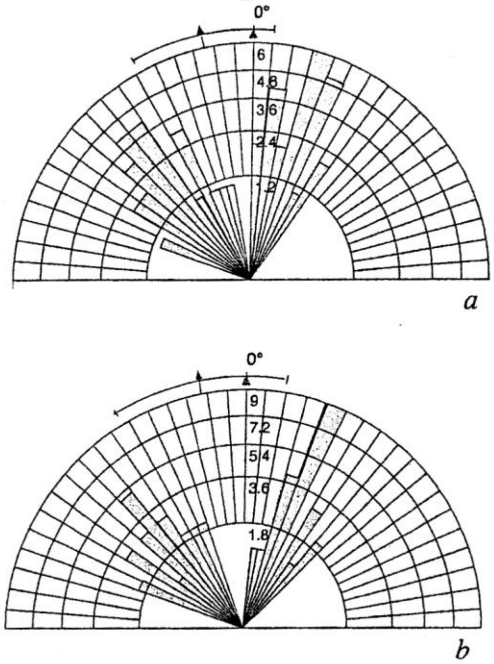

Figure 4. (A) Rose diagram of 45 faults in the Precambrian of Kansas mapped by Cole (1962). Mean direction is 347.9°. (B) Rose diagram of 44 faults mapped in Kansas by Merriam (1963). Mean direction is 354.4°. Distributions are not significantly different (U^2 = 0.1175). From Merriam and Davis (2008).

Movement on the basement structures occur when there is an adjustment in the basement, which results in an adjustment of the overlying units and a draping over the tilted fault blocks. The incidence of earthquakes, which result from this adjustment, are recorded in the overlying sediment as convolute features known as seismites. Seimites can be mapped stratigraphically and geographically to determine the areal extent of the quake and it's magnitude within limits (Merriam and Förster, 2000, 2002). The seismites are readily recognizable once they have been identified (Fig. 5).

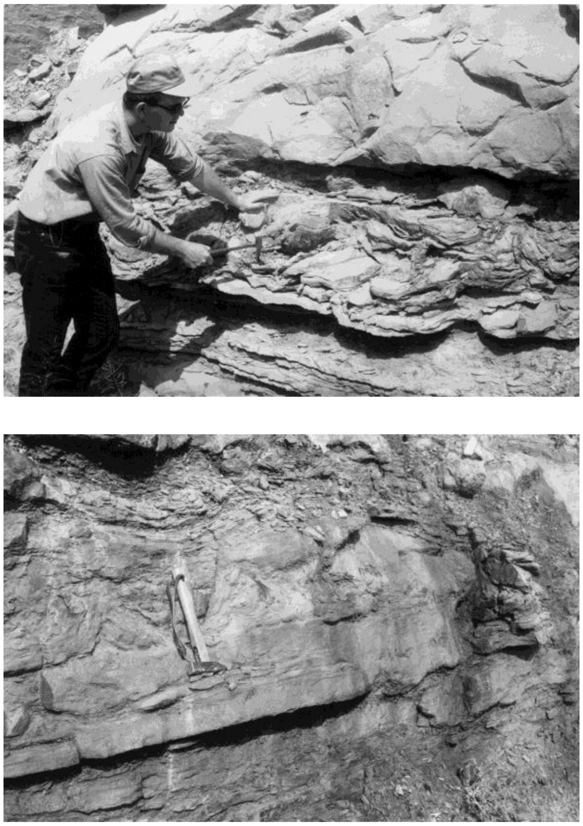

Figure 5. Photographs of seismites (soft sediment deformation) exposed at the surface in eastern Kansas, indicating incremental movement of Precambian basement fault blocks. Seismite in sandstone in Douglas Group (Upper Pennsylvanian in southeastern Kansas (upper photo); seismite in sandstone just below the Lecompton Limestone exposed adjacent to the the Kansas Turnpike at mile 40.1 (lower).

Summary

Although much is known about plains-type folding their occurrence, and origin, much is left to be learned. They are interesting structures and presumably occur in most cratonic areas and not just in the U.S. Midcontinent. With more and complete data, the study of plains-type folds can add much to their history by noting their structural closure, direction, development, and relation to other features and time of formation. Much is left to be done until the full story is known.

REFERENCES CITES

Blackwelder, E., 1920. The origin of the central Kansas oil domes. *American Association of Petroleum Geologists, Bulletin*, v. 4(1), p. 89-94.

Cole, V.B., 1962. Configuration of tope of Precambrian basement rocks in Kansas. *Kansas Geological Survey, Oil and Gas Investigations 26,* Map Sheet 1.

Fath, A.E., 1920. The origin of the faults, anticlines, and buried 'granite ridge' of the northern part of the Midcontinent oil and gas field. *U.S. Geological Survey Professional Paper 128-C,* p. 75-84.

Gardner, J.H., 1917. The vertical component in local folding. *Southwestern Association of Petroleum Geologists, Bulletin*, v. 1, p. 107-110.

Merriam, D.F., 1963. The geologic history of Kansas. *Kansas Geological Survey Bulletin 162*, 317p.

Merriam, D.F., 2005. Origin and development of plains-type folds in the Midcontintent (United States) during the late Paleozoic. *American Association of Petroleum Geologists, Bulletin*, v. 89(1), p. 101-118.

Merriam, D.F., 2010. Slick-Carson oil field, Cowley County, Kansas, *in*, Merriam, D.F. (ed), *New Plays and Ways,* Kansas Geological Society, Wichita, p. 147-152.

Merriam, D.F. and Davis, J.C., 2008. Statistical analysis of physiographic and structural directional data in the U.S. Midcontinent (Kansas), *in*, Bonham-Carter, G.F. and Cheng, Q. (eds.), *Progress in Geomathematics*, Springer-Verlag, Berlin, p. 481-498.

Merriam, D.F. and Förster, A., 2000. The origin and development of plains-type folds during the Cretaceous in central and western Kansas: *The Compass: Earth Science Journal of Sigma Gamma Epsilon*, v. 75 (2/3), p. 45-56.

Merriam, D.F. and Förster, A., 2002. Stratigraphic and sedimentological evidence for late Paleozoic earthquakes and recurrent structural movement in the U.S. midcontinent, *in*, Ettensohn, F.R., Rast, N., and Brett, C.E. (eds.) *Ancient Seismites, Geological Society of America Special Paper 359*, p. 99-108.