Geoscience Canada

"On Orogeny and Epeirogeny in the Study of Phanerozoic and Archean Rocks": The Concept of Epeirogeny is Re-emphasized

Gerald M. Friedman

Volume 15, Number 3, September 1988

URI: https://id.erudit.org/iderudit/geocan15_3car01

See table of contents

Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)
1911-4850 (digital)

Explore this journal

Cite this document

Friedman, G. M. (1988). "On Orogeny and Epeirogeny in the Study of Phanerozoic and Archean Rocks":: The Concept of Epeirogeny is Re-emphasized. *Geoscience Canada*, *15*(3), 230–231.

Comment on "On Orogeny and Epeirogeny in the Study of Phanerozoic and Archean Rocks"

The Concept of Epeirogeny Is Re-emphasized

Gerald M. Friedman
Department of Geology
Brooklyn College of the City University of New York
Brooklyn, New York 11210

and

Northeastern Science Foundation
affiliated with Brooklyn College-CUNY
Rensselaer Center of Applied Geology
15 Third Street
Box 746
Troy, New York 12180-0746

Contrary to recent discussions (Hermes and Borradaile, 1987; Thurston and Easton, 1987; Miall, 1987) the concept of epeirogeny is today more important than when Gilbert (1890) first introduced this term. In the past, epeirogeny was commonly explained in terms of glacial rebound. More recent interest in episodes of crustal epeirogeny relates to vertical movements of the crust in continental platform regimes and intracatonic basins at sites like the Appalachian Basin (Friedman and Sanders, 1982, 1983; Johnson, 1986; Friedman, 1987a, b), Arbuckle Montains (Harrison *et al., in prep.*; Glash and Friedman, 1988), Michigan Basin (Fisher and Barratt, 1985), Ozark Dome (Friedman, 1987a), Adirondacks (Isachsen, 1985), Nashville Dome (Stearns and Reesman, 1986), Athabasca Basin of Saskatchewan (Pagel, 1975; Hoeve, 1984; Fred Langford, *pers. comm.*, 1987), Orcadan Basin of Scotland (Das *et al., in prep.*), basins in Africa (Openshaw *et al.*, 1978; Fred Langford, *pers. comm.*, 1987), and elsewhere.

Various techniques of study of strata exposed at the surface in underformed areas of continental platform regimes and intracratonic basins (fluid-homogenization temperatures, $\delta^{18}O$, vitrinite reflectance, diagenetic minerals, fission-track analyses, argon-loss, conodont-alteration data, and mathematical geodynamic models) imply that these strata have been heated to temperatures that suggest a great depth of burial, much greater than previously thought, and subsequent uplift. Unexpectedly, large amounts of uplift and erosion, ranging from 4.3 to 7.0 km, for example, for the northern Appalachian Basin, have re-exposed these formerly deeply buried rocks. Therefore, the lithosphere, in its isostatic unroofing of thick sequences of sedimentary strata, has undergone much larger vertical motions than geologists had estimated. It has been claimed that vertical movements of the crust are not important and that lateral motion of plates is the driving mechanism that activates tectonic changes. Yet the data imply deep uplift and erosion of former covering strata. Such former great depth of burial of undeformed strata, which are now exposed at the surface, reflect large-scale vertical movements of the crust and uplift of the lithosphere. These drastic changes represent unroofing with widespread implications for paleogeography of a kind unrecognized at present (Friedman, 1987b). As an example for the Appalachian Basin, surface-exposed Silurian strata are interpreted to have reached maximum burial depth of 5.0 km; Devonian strata in the Catskill Mountains had former burial depth of about 6.5 km; Lower Ordovician carbonate sequences were buried to more than 7.0 km; Middle Ordovician strata had paleodepth of approximately 5.0 km. (Brockerhoff and Friedman, 1987; Friedman, 1987a, b; Friedman and Sanders, 1982; Gurney and Friedman, 1987; Urschel and Friedman, 1984). Beaumont *et al.* (*in prep.*), using a mathematical geodynamic model computed for sedimentary basins in North America in undisturbed areas, removal by erosion of in excess of 15 km of strata. Whitney and Davin (1987) hypothesized that a thick wedge of Taconic rocks overrode Lower Ordovician carbonates. If so, this wedge was removed by erosion. Crough (1981) interpreted that southeastern Canada and New England have been elevated at least 4 km relative to the central Appalachian region and have subsequently been eroded.

When I wrote the chapter on sedimentary tectonics ("Sedimentary Strata and Tectonic Movements") of my co-authored textbook *Principles of Sedimentology* (Friedman and Sanders, 1978) unnamed structural geologists, serving as reviewers, asserted that all tectonic movements relate to laterally driven plates and heretic views expressing vertical movements should be abandoned. Now I recognize how blind these reviewers were. The usage of concepts of plate tectonics reminds me of the bible "Search And Thou Shalt Find". Epeirogenic movements in continental platform regimes and intracratonic margins can be explained by reference to plate margin processes. However, whether or not these vertical movements ultimately are genetically related to plate margins is certainly not known, and indeed is less relevant than to recognize the distinction between tectonic deformation at plate margins resulting in deformed strata and the vertical motion of undeformed strata in continental platform regimes and intracratonic basins. The recognition of these two kinds, deformation in mobile belt areas at plate margins and the yoyo motion of undeformed strata on stable platforms, are both tectonic features. Recently the importance of vertical movements has been re-emphasized in platform and intracratonic settings (Friedman and Sanders, 1982; Johnsson, 1986; Friedman, 1987a). Thus, epeirogeny has retained its importance.

For the Appalachian Basin, three ages of vertical uplift for undeformed strata may be proposed: (1) Late Pennsylvanian to Permian coinciding with the Allegheny orogeny based on (a) recrystallization of authigenic feldspars and their Ar-age spectra in Cambro-Ordovician carbonates (Hearn and Sutter, 1985), (b) fission-track data on fluorite in Silurian carbonates (V. Harder and G.M. Friedman, unpublished data), (c) paleomagnetic ages (Levine, 1986), (d) illitization (Elliot and Aronson, 1987), (e) mathematic geodynamic model (Beaumont, Quinlan, and Hamilton, *in prep.*) and, (f) an absence of Pennsylvanian strata beneath Mesozoic basins of the eastern United States; (2) a Cretaceous age has been proposed based on (a) structural-geochemical approach (Tillman and Barnes, 1983) and (b) apatite fission-track analyses (Duddy *et al.*, 1987); and a Tertiary age based on structural and tectonic studies (Isachsen, 1985). These three inferred ages suggest that the Appalachian Basin may have undergone several episodes of uplift with its original strata remaining undeformed.

Authigenic feldspar in Cambro-Ordovician carbonates of the kind inferred as Late Pennsylvanian to Permian occurs along the proto-Atlantic shelf from New York to Newfoundland, Scotland, and Greenland paralleling the Taconic belt suggesting active crustal epeirogeny at this time along this entire belt. Whether this event may ultimately be explained by plate tectonics or not is a secondary matter. Epeirogeny, as a concept expressing the vertical motion of undeformed strata, is very much alive. From an economic point of view, rocks that are now exposed at the surface or occur at shallow depth may have lain within the window of maturity for hydrocarbon source rocks before the removal of thick sequences of strata, although the present depth of burial may be too shallow.

References

Beaumont, C., Quinlan, G.M. and Hamilton, J., *in prep.*, The Alleghanian orogeny and its relationship to the evolution of the eastern interior, North America.

Brokerhoff, F.G. and Friedman, G.M., 1987, Paleo-depth of burial of Middle Ordovician Chazy Group carbonates in New York State and Vermont: Northeastern Geology, v. 9, p. 51-58.

Crough, S.T., 1981, Mesozoic hotspot epeirogeny in eastern North America: Geology, v. 9, p. 2-6.

Das, N., Bluck, B.J. and Mackenzie, A.B., *in prep.*, Uranium geochemistry and the apatite fission tract age of Orcadian rocks from northeast Scotland: Scottish Journal of Geology.

Duddy, I.R., Gleadow, A.J.W., Green, P.F., Hegarty, K.A., Marshallsea, S.A., Tingate, P.R. and Lovering, J.F., 1987, Quantitative estimates of thermal history and maturation using AFTA (apatite fission track analysis) in extensional and foreland basins-Selected case studies: American Association of Petroleum Geologists, Bulletin, v. 71, p. 550-551.

Elliot, W.C. and Aronson, J.L., 1987, Alleghanian episode of K-bentonite illitization in the southern Appalchian basin: Geology, v. 15, p. 735-739.

Fisher, J.H. and Barratt, M.W., 1985, Exploration in Ordovician of Central Michigan: American Association of Petroleum Geologists, Bulletin, v. 12, p. 2065-2076.

Friedman, G.M., 1987a, Deep-burial diagenesis: its implications for vertical movements of the crust, uplift of the lithosphere and isostatic unroofing-A review: Sedimentary Geology, v. 50, p. 67-94.

Friedman, G.M., 1987b, Vertical movements of the crust: Case histories from the northern Appalchian Basin: Geology, v. 15, p. 1130-1133.

Friedman, G.M. and Sanders, J.E., 1978, Principles of Sedimentology: John Wiley & Sons, New York, 792 p.

Friedman, G.M., and Sanders, J.E., 1982, Time-temperature-burial significance of Devonian anthracite implies former great (6.5 km) depth of burial of Catskill Mountains, New York: Geology, v. 10, p. 93-96.

Friedman, G.M. and Sanders, J.E., 1983, Reply To Comment on "Time-temperature-burial significance of Devonian anthracite implies former great (6.5 km) depth of burial of Catskill Mountains, New York": Geology, v. 11, p. 123-124.

Gilbert, G.K., 1890, Lake Bonneville: United States Geological Survey, Monograph, v. 1, 438 p.

Glash, S. and Friedman, G.M., 1988, Paleodepth of burial of surface-exposed Paleozoic carbonates in Arbuckle Mountains, Oklahoma: American Association of Petroleum Geologists, Bulletin, v. 72, p. 962-963.

Gurney, G.G. and Friedman, G.M., 1987, Burial history of the Devonian Cherry Valley carbonate sequence, Cherry Valley, New York: Northeastern Geology, v. 9, p. 1-11.

Harrison, T.M., Burke, K. and Heizler, M.T., *in prep.*, Aspects of the thermal evolution of the Anadarko Basin, Oklahoma.

Hearn, P.P.J., Jr. and Sutter, J.F., 1985, Authigenic potassium feldspar in Cambrian carbonates: evidence of Alleghenian brine migration: Science, v. 228, p. 1529-1531.

Hermes, J.J. and Borradaile, G.J., 1987, Reply on "On orogeny and epeirogeny in the study of Phanerozoic and Archean rocks": Geoscience Canada, v. 14, p. 125.

Hoeve, J., 1984, Host rock alteration and its application as an ore guide at the Midwest Lake uranium deposit, northern Saskatchewan: Canadian Institute of Mining and Metallurgy, Bulletin, v. 77, no. 868, p. 63-72.

Isachsen, Y.W., 1985, Structural and tectonic studies in New York State: United States Nuclear Regulatory Commission, Washington, D.C., NUREG/CR-3178 RA, 74 p.

Johnsson, M.J., 1986, Distribution of maximum burial temperatures across the northern Appalachian Basin and implications of Carboniferous sedimentation patterns: Geology, v. 14, p. 384-387.

Levine, J.R., 1986, Deep burial of coal-bearing strata, Anthracite region, Pennsylvania: Sedimentation or tectonics: Geology, v. 14, p. 577-580.

Miall, A.D., 1987, Epeirogeny: is it really orogeny or theology?: Geoscience Canada, v. 14, p. 126-129.

Openshaw, R., *et al.*, 1978, Phases fluides contemporaines de la diagenese des gres, des mouvements tectonique et du functionment des reacteurs, nucleaires d'Oklo (Gabon), *in* Les reactures de fission naturels: International Atomic Energy Agency, Vienna, p. 267-295.

Pagel, M., 1975, Determination des conditions physico-chemiques de la silicification diagenetique des gres Athabasca (Canada) au moyen des inclusions fluides: C. R. Acad. Sc. Paris, Ser. D, p. 2301-2304.

Stearns, R.G., and Reesman, A.L., 1986, Cambrian to Holocene structural and burial history of Nashville Dome: American Association of Petroleum Geologists, Bulletin, v. 70, p. 143-154.

Tillman, J.E. and Barnes, H.C., 1983, Deciphering facturing and fluid migration histories in the northern Appalachian Basin: American Association of Petroleum Geologists, Bulletin, v. 67, p. 692-705.

Thurston, P.C. and Easton, R.M., 1987, Comment on "On orogeny and epeirogeny in the study of Phanerozoic and Archean rocks": Geoscience Canada, v. 14, p. 122-129.

Urschel, S.F. and Friedman, G.M., 1984, Paleodepth of burial of Lower Ordovician Beekmantown Group carbonates in New York State: Compass, v. 61, p. 205-215.

Whitney, P.R. and Davin, M.T., 1987, Taconic deformation and metasomatism in Proterozoic rocks of the easternmost Adirondacks: Geology, v. 15, p. 500-503.

Accepted 3 March 1988.