BULLETIN OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
VOL. 31, NO. 7 (JULY, 1947), PP. 1289-1293, 1 FIG.

GEOLOGICAL NOTES

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GEOSYNCLINAL NOMENCLATURE AND THE CRATON[1]

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INTRODUCTION

Geosynclines are the largest stratigraphic units, comprising rocks of relatively great thickness and extent laid in sinking areas in the earth's surface. Classification is based on the rocks, rather than on the form of the original surface of deposition, or on subsequent tectonic or vulcanic history. Some have referred to oceanographic "troughs" and structural synclinoria as geosynclines. Though the etymology of the word, earth down-fold, does not exclude them, the original definition[3] gives rocks as representatives, considers geosynclines to be potential sites of orogeny though including unfolded examples, and definitely excludes synclinoria.

CRATON

North America had a comparatively stable interior in the early Paleozoic, bordered by more mobile geosynclinal belts. A consolidated, rather immobile area such as this central shield is a *craton*[4] (krā'-tŏn)[5], the adjoining geosynclines are *orthogeosynclines*[6] (that is, straight), geosynclines lying between cratons, whether higher continental or lower oceanic cratons. The monoclinal flexure or hinge delimiting the North American early Paleozoic craton trended on present geography from Labrador toward Quebec City, thence through northeastern New York, south-central Pennsylvania, northwestern Virginia, and eastern Tennessee, to central Alabama; the medial Ordovician position is the Adirondack line (Fig. 1).[7] That on the west, along the Wasatch line,[8] extended from western Mackenzie through western Alberta, Montana, and Wyoming to central Utah, southeastern

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[3] J. D. Dana, "On Some Results of the Earth's Contraction from Cooling Including a Discussion of the Origin of Mountains and the Nature of the Earth's Interior," *Amer. Jour. Sci.*, 3d Ser., Vol. 5 (1873), p. 430.

[4] Hans Stille, "Wege und Ergebnisse der geologisch-tektonischen Forschung," *25 Jahre Kaiser Wilhelm Gesellsch. Förd. Wissensch.*, Bd. 2 (1936), pp. 84–85.

[5] Pluton and allochthon have similarly pronounced endings.

[6] Hans Stille, *op. cit.* (1936).

[7] Marshall Kay, "Development of the Northern Allegheny Synclinorium and Adjoining Regions," *Bull. Geol. Soc. America*, Vol. 53 (1942), p. 1748.

[8] Hans Stille, *Einführung in den Bau Amerikas*, Borntraeger, Berlin, 1940 (1941), p. 83.

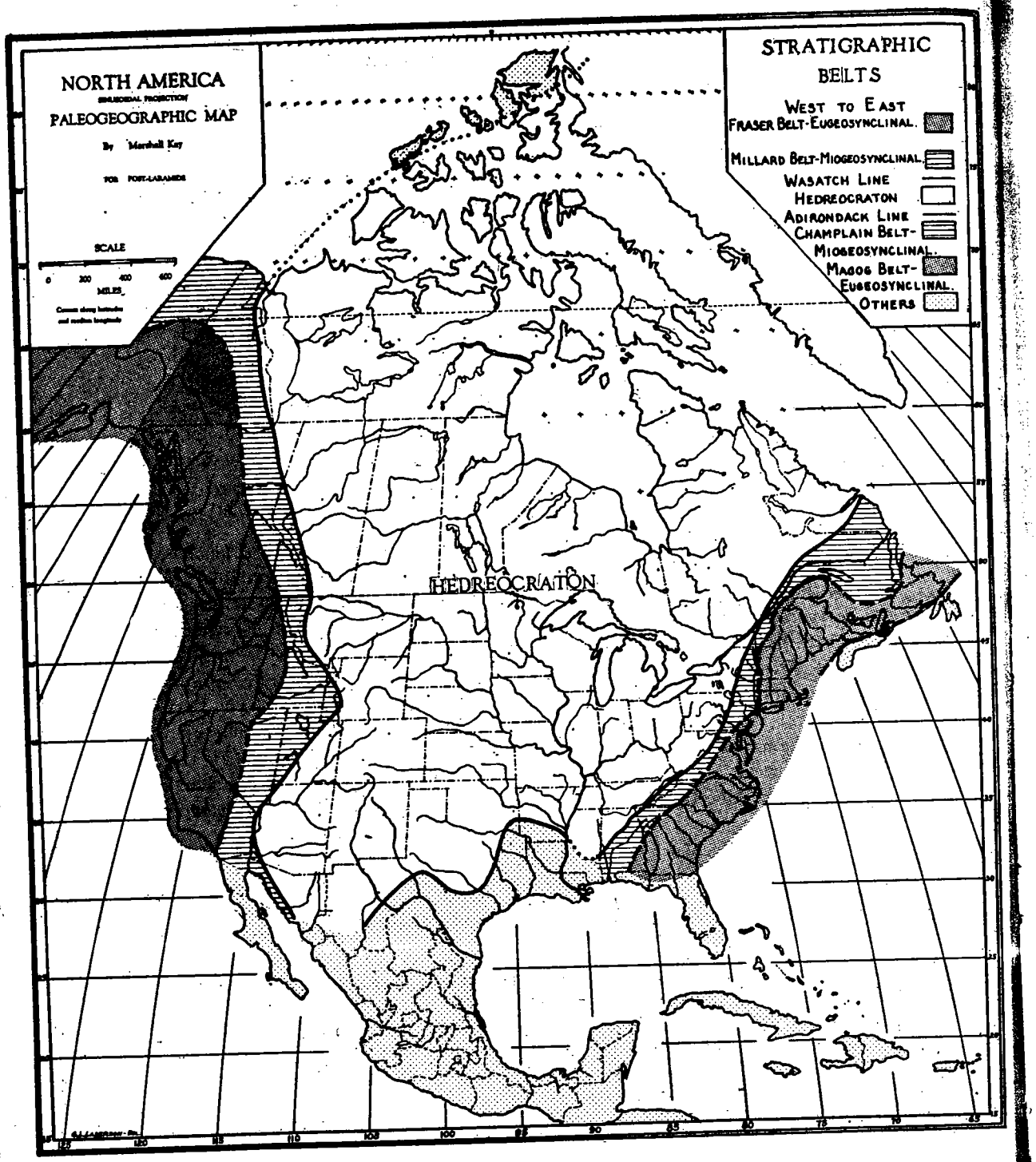
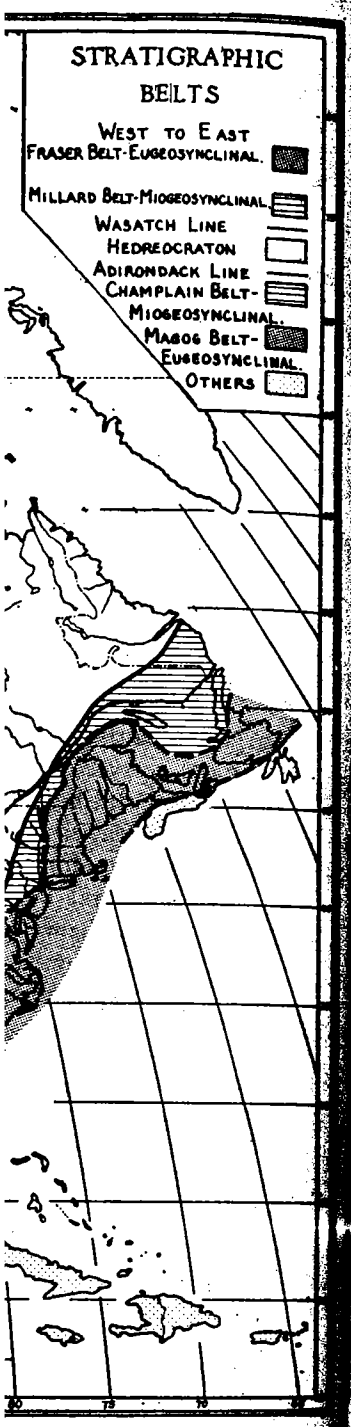

NORTH AMERICA
PALEOGEOGRAPHIC MAP
By Marshall Kay
SCALE
MILES
STRATIGRAPHIC
BELTS
WEST TO EAST
FRASER BELT-EUGEOSYNCLINAL
MILLARD BELT-MIOGEOSYNCLINAL
WASATCH LINE
HEDREOCRATON
ADIRONDACK LINE
CHAMPLAIN BELT-
MIOGEOSYNCLINAL
MAGOG BELT-
EUGEOSYNCLINAL
OTHERS
HEDREOCRATON

FIG. 1



Nevada, and western Sonora. A craton is transitory, expanding as orogenies add rocks of former orthogeosynclines, contracting as new orthogeosynclines reduce its area.

North America is perhaps peculiar in that the early Paleozoic craton has had persisting influence on continental development, and has close correlation with present structure. Although the eastern side lost the initial bordering geosyncline by the middle Paleozoic, the western flexure endured into late Mesozoic. The area of this early Paleozoic North American craton is designated as an *hedreocraton* (steadfast),[9] one having long continuing influence.

ORTHOGEOSYNCLINES

The classification of geosynclines is based on their form, the character and derivation of their rocks, and in the principal classes, on their position relative to a craton. The linear orthogeosynclines between cratons are of two types, *miogeosynclines* (less) and *eugeosynclines* (truly).[10] Those nearer the craton, the miogeosynclines, were rather regularly sinking as deposition progressed and lack appreciable volcanic material; North American early Paleozoic miogeosynclines derived their initial detritus from erosion of the hedreocraton. The more distant eugeosynclinal belts had rapidly sinking linear geosynclines with locally thick and abundant volcanic rocks, as well as sediment eroded from rising narrow intervening lands, like island arcs. The early Paleozoic rocks in the eastern eugeosynclinal belt of North America extend from central Newfoundland through New Brunswick, Maine, New Hampshire, and central Massachusetts to the Atlantic Piedmont; possibly eastern Newfoundland and Nova Scotia lie in an opposite miogeosynclinal belt. Devonian orogeny with accompanying intrusion closed the eugeosynclinal history. Paleozoic and early Mesozoic rocks in the western eugeosynclinal belt extend westward to the Pacific from central Alaska, Yukon and British Columbia, western Idaho and central Nevada, occupying all but southeastern California; eugeosynclinal development ended with the late Jurassic Nevadian orogeny.

The present areas of the early Paleozoic eastern miogeosynclinal and eugeosynclinal rocks have been called the Champlain and Magog belts.[11] It is proposed that the corresponding western belts of miogeosynclinal and eugeosynclinal rocks be called the Millard and Fraser belts, after Millard County, Utah and Fraser River, British Columbia. The Millard belt had exceptionally broad and long

[9] Pre-Paleozoic cratons had quite different disposition; thus the pre-Algoman rocks north of Lake Superior and east to western Quebec formed in an orthogeosynclinal belt (F. J. Pettijohn, "Archean Sedimentation," *Bull. Geol. Soc. America*, Vol. 54 (1943), p. 968); and the late pre-Cambrian Beltian sediments of the west (N. E. A. Hinds, "Uncompahgran and Beltian Deposits in Western North America," *Carnegie Inst. Washington Pub. 463* (1936), pp. 53–136) formed in a great geosyncline extending far into the hedreocraton.

[10] Hans Stille, *op. cit.* (1941), p. 15.

[11] Marshall Kay, "Stratigraphy of the Trenton Group," *Bull. Geol. Soc. America*, Vol. 48 (1937), p. 290.

continuing miogeosynclinal development in Paleozoic and earlier Mesozoic, submarine volcanic rocks being almost absent; it is not now a miogeosyncline, and the rocks were so distorted by post-miogeosynclinal orogenies as to require restoration to their original relative geographic positions on palinspastic base maps[12] to give true paleogeography. The eastern margin has major Laramian[13] thrusts, and plutons are present in limited areas. The Fraser belt contains rocks of Paleozoic and earlier Mesozoic eugeosynclines and intervening narrow lands; the rocks in the belt are of types characteristic of eugeosynclines interruptedly in place and time. It contains the principal late Jurassic Nevadian plutons, and its eastern margin is a zone of major thrusts.

GEOSYNCLINES WITHIN CRATONS

Three types of geosynclines lie outside the orthogeosynclines and within the cratons. A geosyncline invading the margin of a craton, having detritus gained principally from orogenic highlands in the adjacent belts of orthogeosynclinal rocks, was called by the writer a deltageosyncline.[14] The term was ill chosen and confusing, for it has been supposed to include deposits in various stream deltas. Therefore, it is proposed that *exogeosyncline* (outside) replace the term deltageosyncline, in reference to the principal source of detritus being outside the craton; the Upper Ordovician, earlier Silurian, and later Devonian of Pennsylvania and adjacent states are typical; stratigraphic units commonly diverge until they closely approach the source. The second type, the *autogeosyncline*[15] has in the typical Upper Silurian and Devonian of lower Michigan, non-detrital carbonates and salines, and detritus from low near-by land and from orogenic mountains in a distant orthogeosynclinal belt; stratigraphic units generally converge gradually from the center or axis of the deposit. Autogeosynclines may trend toward orthogeosynclinal belts, but seem essentially independent of them; the structure of the base changed from a plane to a basin or trough as the geosyncline developed. An exogeosyncline tends to diminish gradually and regularly within the craton or to pass into autogeosynclinal patterns, as in the earlier Upper Cretaceous of the western hedreocraton, whereas a miogeosyncline tends to meet the craton in a distinct flexure. American Paleozoic and Mesozoic exogeosynclines enter the margin of the hedreocraton. A third type, the *zeugogeosyncline*[16] (yoked), has detritus from near-by uplifts within the craton, as in the late Paleozoic of northwestern Colorado.

[12] Marshall Kay, "Paleogeographic and Palinspastic Maps," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 29 (1945), pp. 426–50.

[13] Structures formed in the Laramian orogeny are Laramides: *ibid.*, pp. 447–49.

[14] Marshall Kay, "Development of the Northern Allegheny Synclinorium and Adjoining Regions," *Bull. Geol. Soc. America*, Vol. 53 (1942), p. 1643.

[15] Marshall Kay, *ibid.*

[16] Marshall Kay, "North American Geosynclines—Their Classification" (abstract), *Bull. Geol. Soc. America*, Vol. 56 (1945), p. 1172.

OTHER GEOSYNCLINES

There are other geosynclinal types whose definition does not depend on their relations to the hedreocraton. A *taphrogeosyncline*[17] (trench) is bounded by high-angle faults, as in the late Triassic geosynclines of the Atlantic Coast. An *epieugeosyncline*[18] (above) has elongate, relatively non-volcanic deposits derived from adjoining rising swells in areas of former eugeosynclines, as in the Carboniferous of Nova Scotia, and the Tertiary of California. The *idiogeosyncline*[19] (distinct), based on the Tertiary of central Sumatra and Java, has not been defined on a comparable basis, but suggests a late-cycle miogeosyncline. A *paraliageosyncline*[20] (coastal) is one such as the Tertiary of the northern Gulf of Mexico coast, a linear geosyncline along the present continental margin, having flexures on the foreland similar to those delimiting miogeosynclines.

GEOSYNCLINAL DURATION

Geosynclines have temporal as well as geographic limits. Deformation in a single cycle commonly but not invariably progresses from orogenies in the eugeosynclinal belts to those in the miogeosynclinal belts, with development of exogeosynclines on the cratonal border, and consolidation in an enlarged craton. Subsequent cycles may have quite different positions and trends. Thus, there are belts of pre-Cambrian eugeosynclinal rocks that trend across the early Paleozoic cratons of North America and Fennoscandia. Moreover, eugeosynclines can overlie miogeosynclines, and there are instances of eugeosynclines that closely approach a craton. Though many geosynclines have the characters of a single class others are compound in their attributes. The late Upper Cretaceous of the western part of the North American hedreocraton is principally exogeosynclinal, but has independently sinking autogeosynclinal areas, and others of zeugeosynclinal nature adjoining rising swells in the earlier exogeosynclinal belt.

[17] Marshall Kay, "Geosynclines in Continental Development," *Science*, Vol. 99 (1943), p. 462.

[18] Marshall Kay, *op. cit.* (1945), p. 1172.

[19] J. M. B. Umbgrove, "Verschillende typen van tertiaire geosynclinalen in den Indischen Archipel," *Leidsche Meded.*, Vol. 6 (1933), pp. 33–43.

[20] Marshall Kay, *op. cit.* (1945), p. 1172.