PHANEROZOIC STRUCTURAL DEVELOPMENT IN THE AREA OF THE FOREST CITY BASIN, SOUTHWESTERN IOWA (A BRIEF OVERVIEW)

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PHANEROZOIC STRUCTURAL DEVELOPMENT IN THE AREA OF THE FOREST CITY BASIN, SOUTHWESTERN IOWA (A BRIEF OVERVIEW)

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This report is a brief summary of a series of papers presented at the North-Central Geological Society of America meeting in Ames, Iowa, 1981 (Bunker, et al., 1981; Bunker, 1981a,b). It is an update of information from the files of the Iowa Geological Survey that has accumulated since the original work summarizing the regional structural development of the Forest City Basin area (Lee, 1939, 1943, 1946, 1948, 1956; Anderson and Wells, 1968).

The present day structural configuration of southwestern Iowa is the result of several periods of discordant structural movements. These movements have warped the originally flat lying formations in different directions and at different times during the Phanerozoic. Anderson (p. 40) summarizes the interpreted structural development of the Late Precambrian Keweenawan rift system, which passes through Iowa.

In order to best describe the structural history of the area through the Phanerozoic, a series of isopach and paleogeologic maps have been generated to help define the sequence of events that led to the eventual development of the Forest City Basin. These maps are an update of those originally developed by Lee (1943, 1946), which were generated upon well defined lithostratigraphic intervals of widespread occurrence. Sloss (1963) characterized the sedimentary record from very late Precambrian to the present as being comprised of a series of six sedimentary rock sequences which are bounded above and below by major interregional unconformities. These cratonic sequences are illustrated in fig. IV-1, and it was primarily within this stratigraphic framework that Lee (1946) attempted to summarize the structural development of the Forest City Basin area.

The structural deformation that took place during the Upper Cambrian through the Lower Ordovician (Sauk Sequence) is reflected by changes in the thickness of the interval from the top of the Precambrian to the top of the Prairie du Chien Group of Lower Ordovician age. Because the lowermost sediments of this interval (Mt. Simon Sandstone) filled in many of the irregularities on the deeply dissected Precambrian erosional surface, and also because of difficulties in defining the contact between the Mt. Simon Sandstone and the underlying Precambrian "red clastics," the isopach map has been constructed from the top of the Mt. Simon to the top of the Prairie du Chien Group (fig. IV-2).

The north-south axis of thickening through central Iowa is readily apparent on fig. IV-2 and has been termed the Hollandale Embayment (Austin, 1969, 1970; Sims and Morey, 1972, p. 13). Precambrian topographic highs along

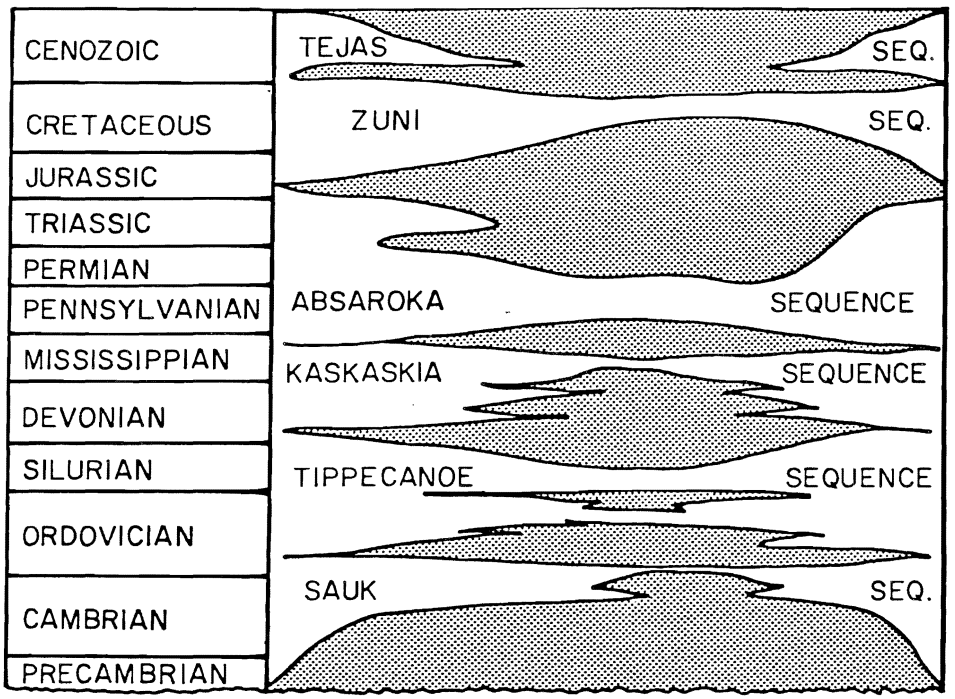

Figure IV-1. Time-stratigraphic relationships of the cratonic sequences on the North American continent. Shaded areas represent the major unconformities recorded in the rock record across the continent. The more complete depositional sequences are preserved at the continental margins (modified from Sloss, 1963, p. 110).

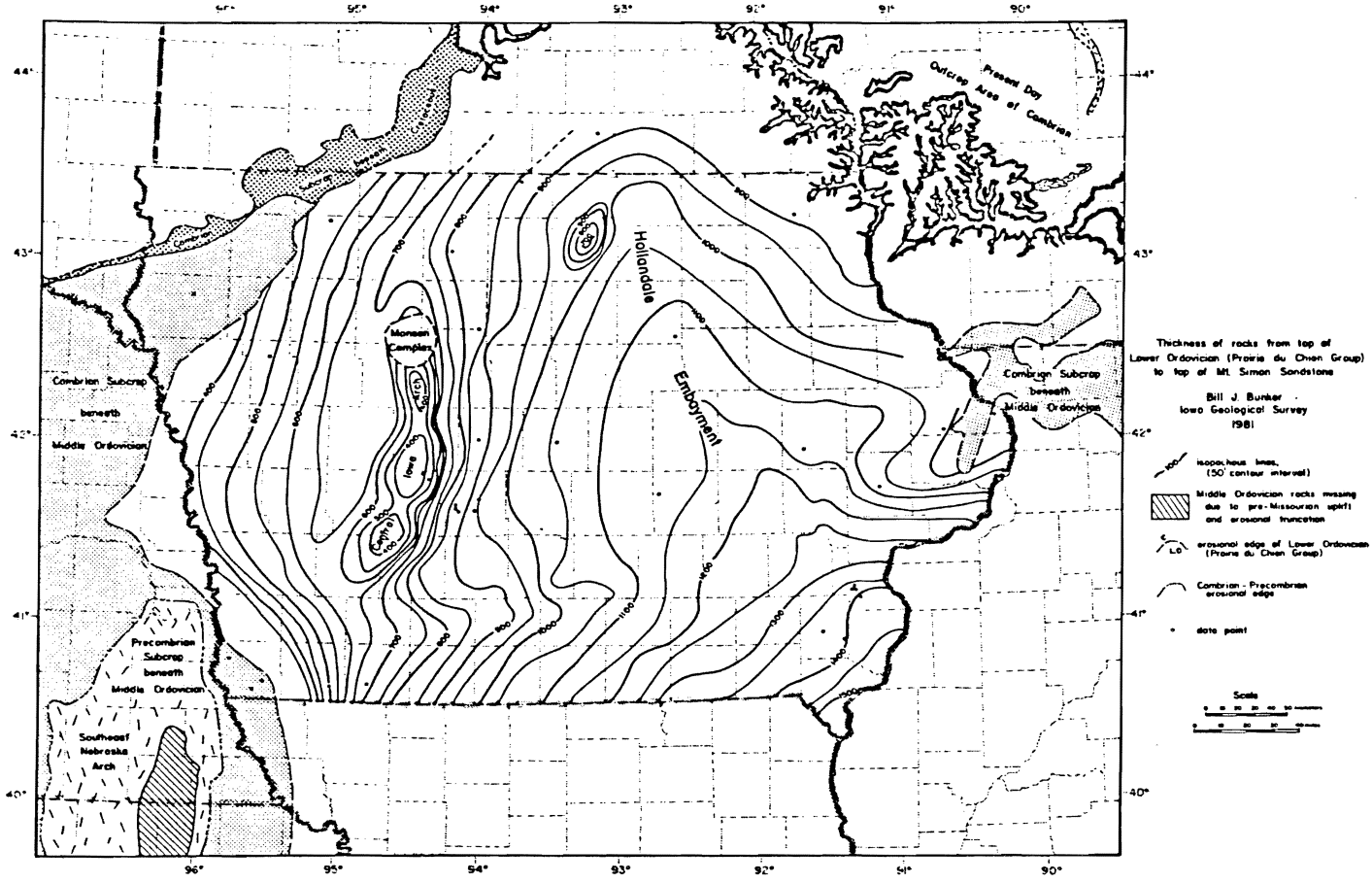

Figure IV-2. Isopach and paleogeologic map of the upper Sauk Sequence (modified from Burchett and Carlson, 1966; Carlson, 1970; Willman and Buschbach, 1975, p. 59; Bunker, 1981b).

the axis of the Midcontinent Geophysical Anomaly (MGA) were progressively buried during deposition of the Sauk Sequence. One topographic high, the Central Iowa Arch (Bunker, 1981b, p. 6), is delineated by a long north-south axis of thinning in central Iowa, and played an important role in the later structural development of the Forest City Basin. Sauk Sequence rocks were erosionally truncated on and around the trend of the Southeast Nebraska Arch (fig. IV-2) prior to the deposition of the Middle Ordovician St. Peter Sandstone, indicating post-Sauk-pre-Tippecanoe uplift of the arch. The St. Peter Sandstone regionally overstepped the truncated Sauk rocks and lies directly upon Precambrian crystalline rocks along the crest of the arch in southeastern Nebraska as illustrated in fig. IV-3.

After a prolonged period of erosion at the end of Sauk deposition and the initial transgression of Middle Ordovician (St. Peter) seas into the region, the previously noted Southeast Nebraska Arch began a long period of differential subsidence during Tippecanoe (Middle Ordovician-Silurian) deposition. This resulted in the development of the North Kansas Basin (Rich, 1933), which subsided at least 1,000 feet (300 meters) relative to the surrounding area prior to Kaskaskia deposition (fig. IV-4).

Maximum development of the North Kansas Basin occurred during the Silurian. At least 500 feet of Silurian rocks were structurally preserved in the basin center prior to the Kaskaskia transgression. The Central Iowa Arch is also still evident on this map (fig. IV-4), as well as a northerly trending low in extreme western Iowa paralleling a possible northern extension of the Humboldt Fault Zone, which developed primarily during the Middle Pennsylvanian. The previously defined Hollandale Embayment and its extensions southward into the ancestral Illinois Basin area were cut off by the rising Northeast Missouri Arch, resulting in the structural development of the East-Central Iowa Basin (Bunker, 1981b, p. 6) whose structural history during Tippecanoe deposition was similar to that in the North Kansas Basin area.

A reconstruction of the pre-Devonian paleogeology of Iowa and the adjoining states (fig. IV-5) reveals that an erosion surface beveling Tippecanoe, Sauk, and Precambrian rocks developed prior to Kaskaskia deposition. Uplift of the Northeast Missouri Arch and erosional beveling across the crest of the arch is illustrated at the bottom of the map by the regional truncation of Tippecanoe rocks down to the St. Peter Sandstone. The Central Iowa Arch is indicated by the thin sliver of Middle Ordovician rocks subcropping in central Iowa. The general positions of the North Kansas and East-Central Iowa Basins are delineated by the distribution and outline of Silurian rocks illustrated on the map. Regional beveling along the Transcontinental Arch can be recognized by the occurrence of Upper Devonian rocks on the Precambrian crystalline surface in northwestern Iowa (fig. IV-5; Ludvigson and Bunker, 1979, p. 4; Bunker, 1981b, p. 11).

An examination of the lithostratigraphy and biostratigraphy of rocks that comprise the Kaskaskia (Middle Devonain-Mississippian) Sequence reveals that complex structural and depositional patterns characterize

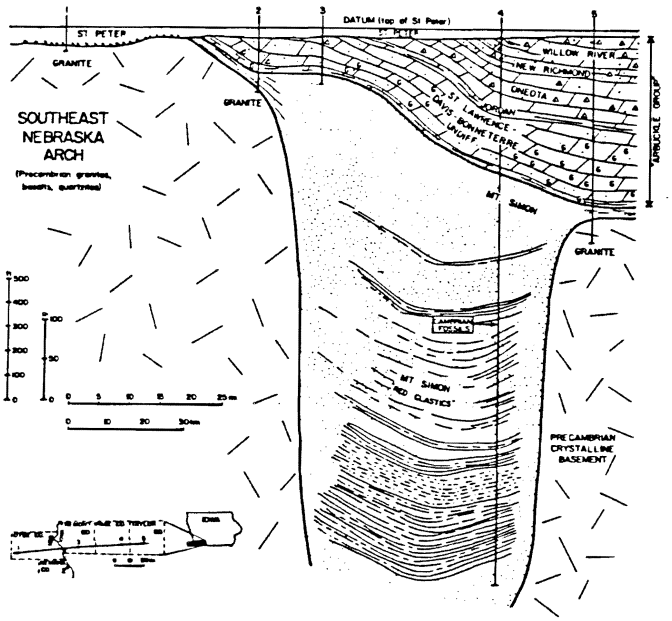

Figure IV-3. Stratigraphic cross-section across southwestern Iowa. Top of St. Peter Sandstone (Middle Ordovician) is used as the stratigraphic datum. Cross-section is used courtesy of Brian Witzke, Iowa Geological Survey.

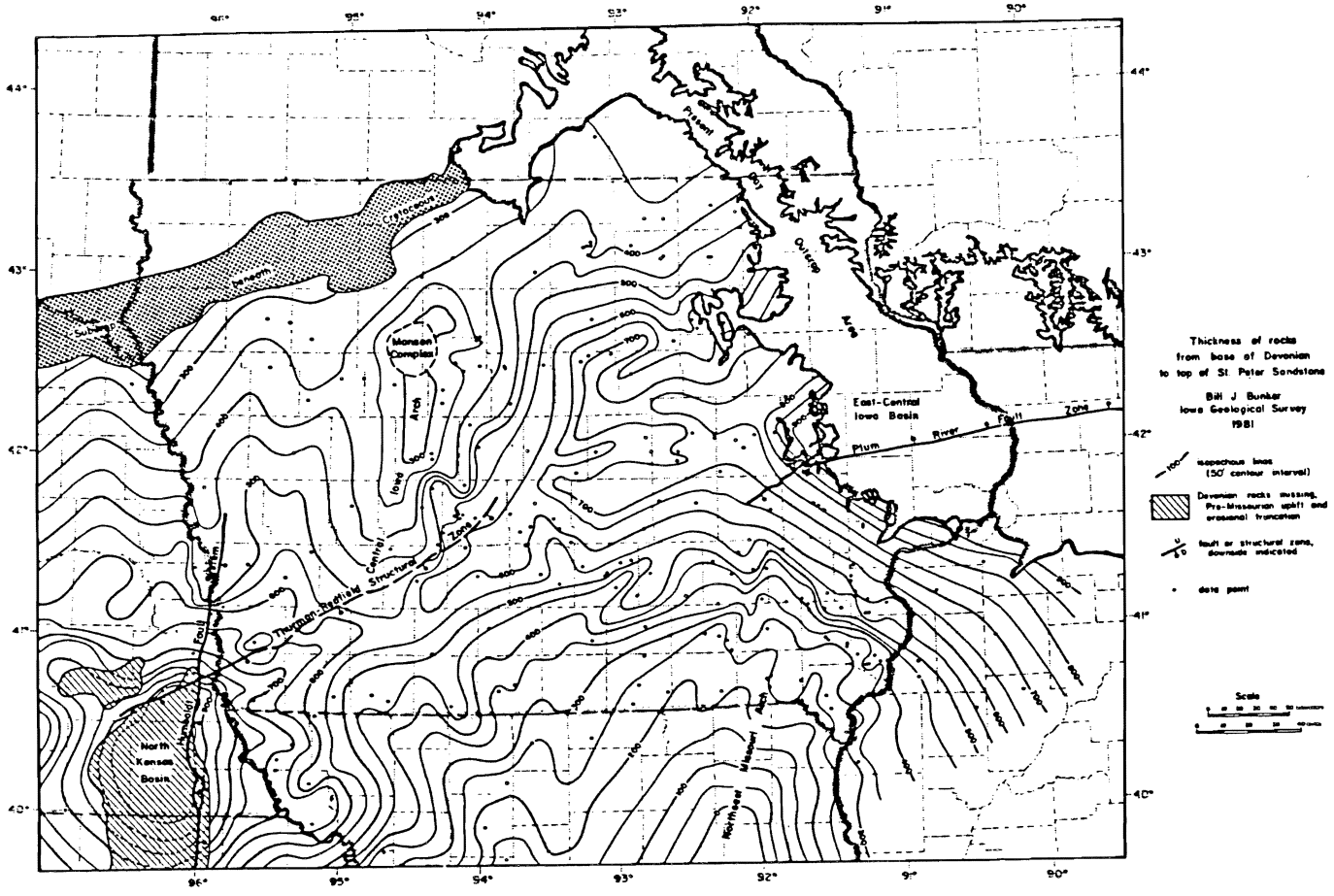

Figure IV-4. Isopach map of the Tippecanoe Sequence in Iowa and adjoining states. The fault or structural zones have been added to this map and to the following series of maps to show their general positions relative to the structural development in the region. They do not necessarily imply faulting at any particular point in time, although there are linear trends apparent with their noted positions, inferring possible structural development during specific periods of geologic time.

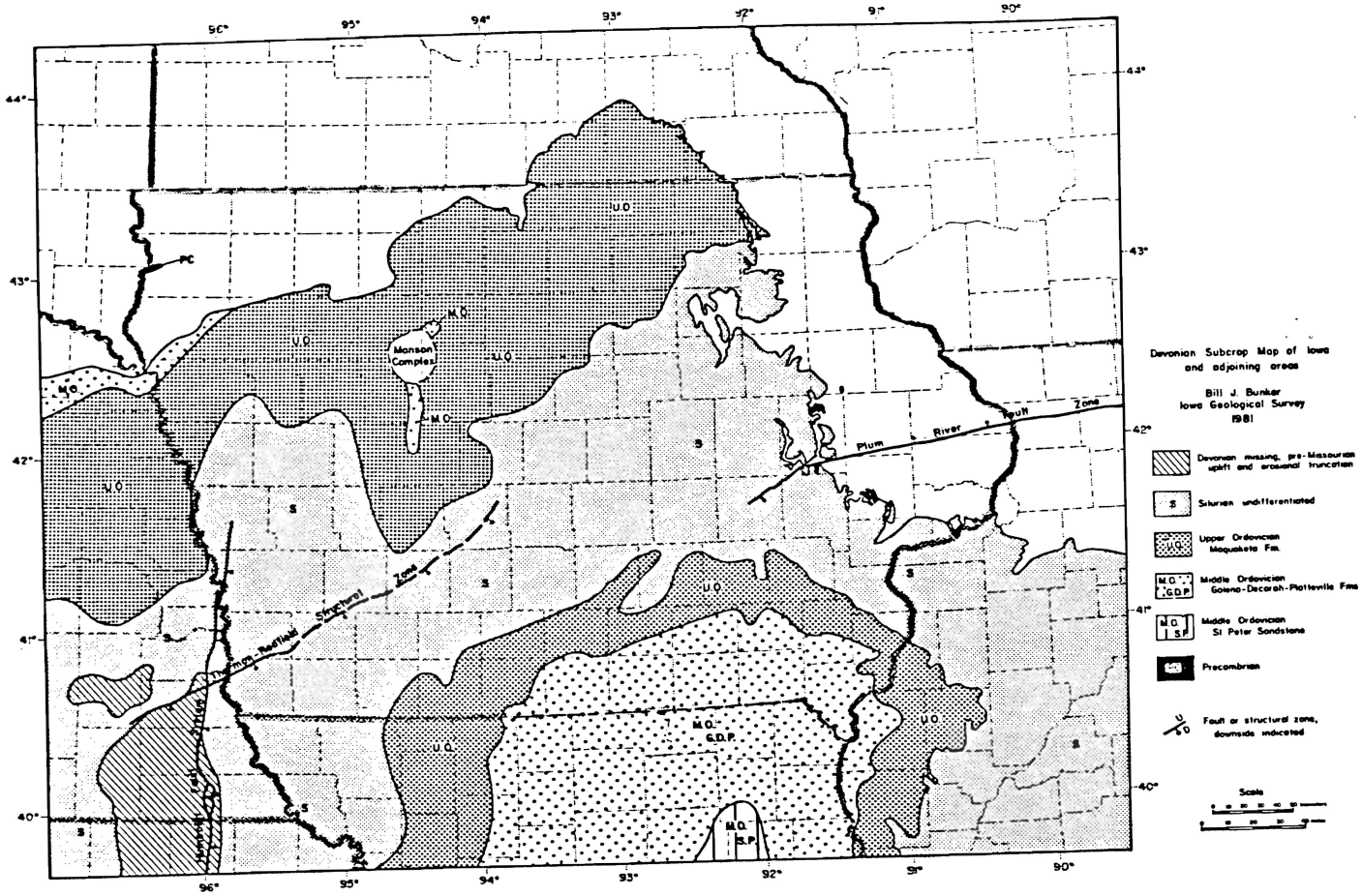

Figure IV-5. Paleogeologic map of the pre-Devonian surface in Iowa and adjoining states (modified from Carlson, 1963; Merriam, 1963; Burchett and Carlson, 1966; Collinson, 1967; Sims, 1970; Collinson and Atherton, 1975; Bunker, 1981b).

this interval. The Lincoln Fold System (McQueen, et al., 1941, 1961) is a series of northwest-southeast trending folds that developed across the area of the former northerly trending Northeast Missouri Arch (fig. IV-6) and strongly influenced Kaskaskia deposition. A north-south oriented structural depression also developed between the northwesterly oriented Lincoln Fold System of northeastern Missouri and an area of renewed uplift along the trend of the previously defined Southeast Nebraska Arch. Maximum structural thickening occurred in an area straddling the Thurman-Redfield Structural Zone of southwestern Iowa and occupies the same general position as the northerly trending structural low delineated on the Tippecanoe isopach map (fig. IV-4).

Prior to and contemporaneous with the advance of Pennsylvanian seas into the area, faulting along the Humboldt Fault Zone gave rise to the Nemaha Uplift, in part a reactivation of the older Southeast Nebraska Arch, and bisected the region formerly occupied by the North Kansas Basin. Up to 1050 feet (320 meters) of pre-Missourian (Middle Pennsylvanian) rocks accumulated in a depressed area just to the east of the Humboldt Fault Zone (fig. IV-7) during this period of renewed structural activity. This structurally depressed area constitutes the Forest City Basin as defined by Lee (1943, 1946). The center of the basin is located in northeastern Kansas with its axis oriented north-south. The previously noted low in extreme western Iowa became the northern extension of the Forest City Basin during the Middle Pennsylvanian, and the Central Iowa Arch formed its northeastern boundary. During the Late Pennsylvanian, differential basinal subsidence in the area progressively decreased, and more stabilized conditions prevailed, although relatively minor movements persisted along the Humboldt Fault Zone.

Structure contour (fig. IV-8) mapping on the base of the Hertha Limestone (Upper Pennsylvanian), a regionally significant stratigraphic datum, shows post-Hertha deformation in the area of the Forest City Basin. The structural center of the basin is located in northeastern Kansas and is oriented in a north-south direction extending into southeastern Nebraska. The northern extension of the basin into western Iowa is still evident and the Nemaha Uplift is also well defined.

A recent hydrogeologic investigation of the Cretaceous System in northwestern Iowa has revealed the presence of a northerly trending structural fold extending along the axis of the Nemaha Uplift. Fig. IV-9 is a structure contour map drawn on top of the Greenhorn Limestone (Upper Cretaceous) which illustrates this northerly trending fold. Additional structural mapping on sub-Greenhorn Cretaceous stratigraphic units (Munter, et al., in prep.) continues to delineate this northerly trending fold in northwestern Iowa and shows the area to be more structurally complex than illustrated in fig. IV-9. Post-Zuni ("Laramide") deformation in the Forest City Basin area, as shown on the structure contour map (fig. IV-9), indicates at least 800 feet of uplift relative to the surrounding region. Erosional beveling of the uplifted Cretaceous section has removed all rocks deposited subsequent to the lowermost member of the Dakota Formation (Nishnabotna Member) in the Forest City Basin area. Erosional remnants of the Nishnabotna Member can be found in the southwest Iowa outcrop area today.

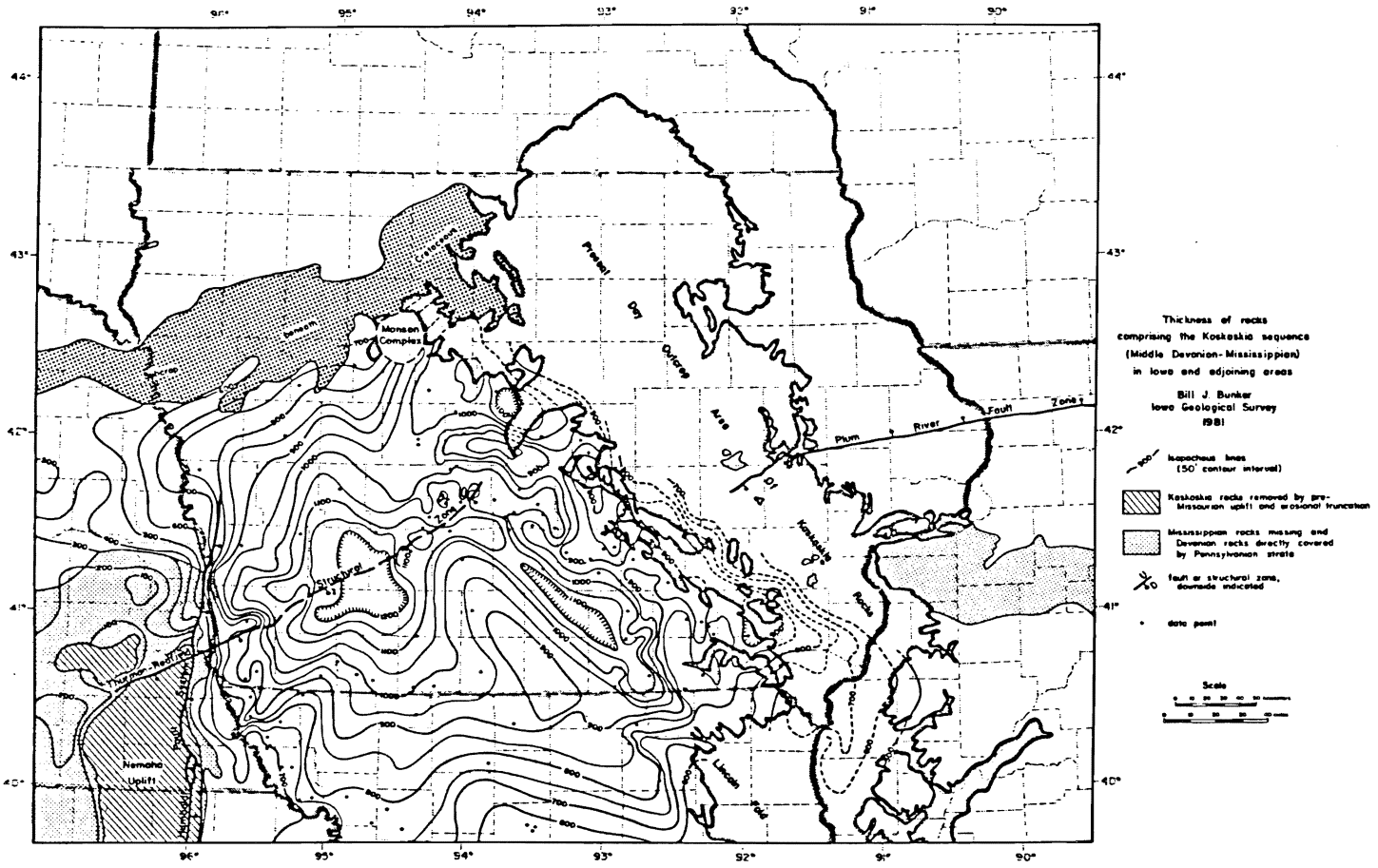

Figure IV-6. Isopach map of the Kaskaskia Sequence (modified from Calrson, 1963; Burchett and Carlson, 1966; Willman et al., 1967; Carlson, 1970).

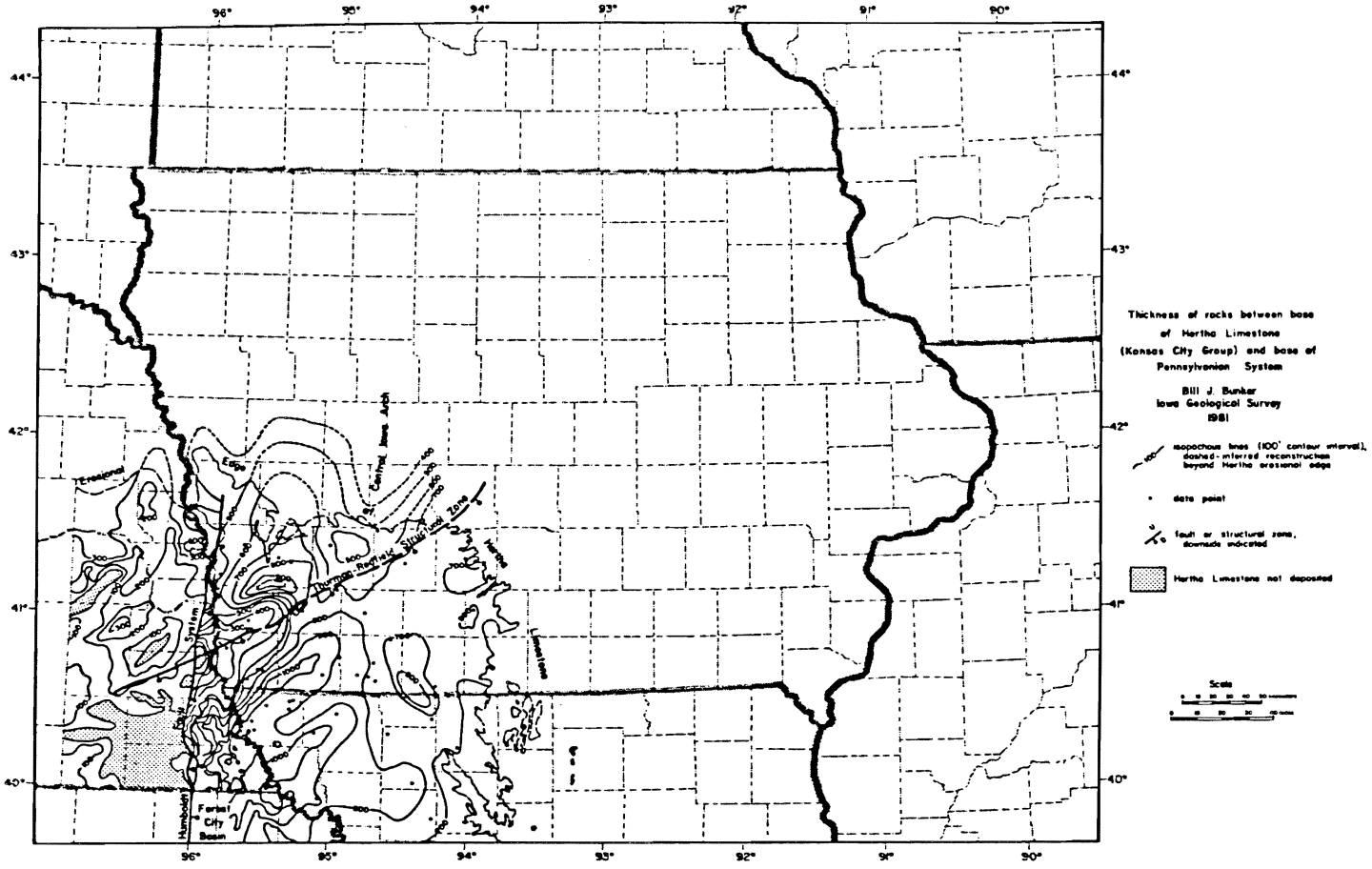

Figure IV-7. Isopach map of rocks from the base of the Pennsylvanian System to the base of the Hertha Limestone (modified from McQueen and Greene, 1938; Lee, 1946; Burchett and Carlson, 1966).

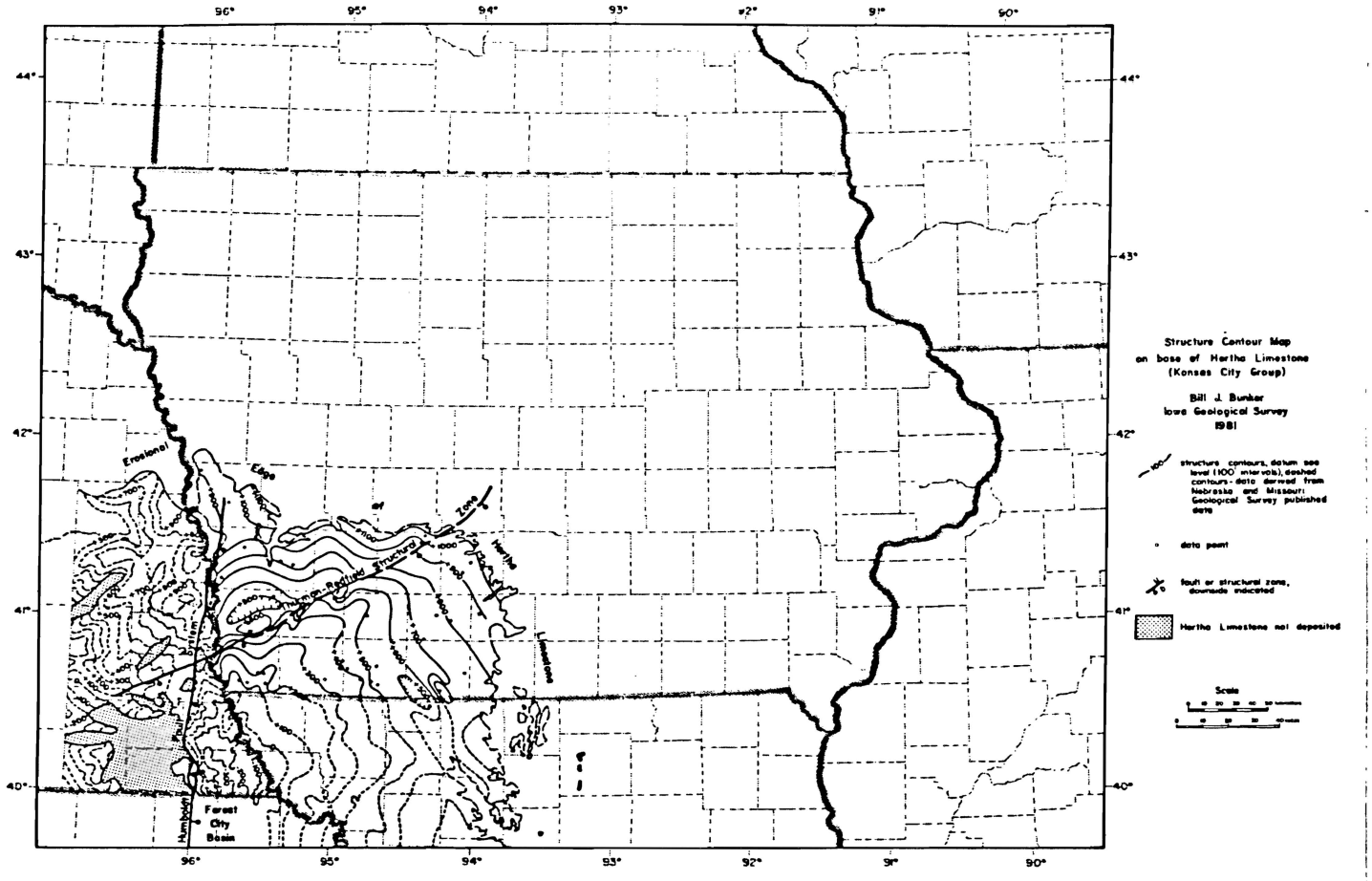

Figure IV-8. Structure contour map on the base of the Hertha Limestone (modified from McQueen and Greene, 1938; Burchett and Carlson, 1966).

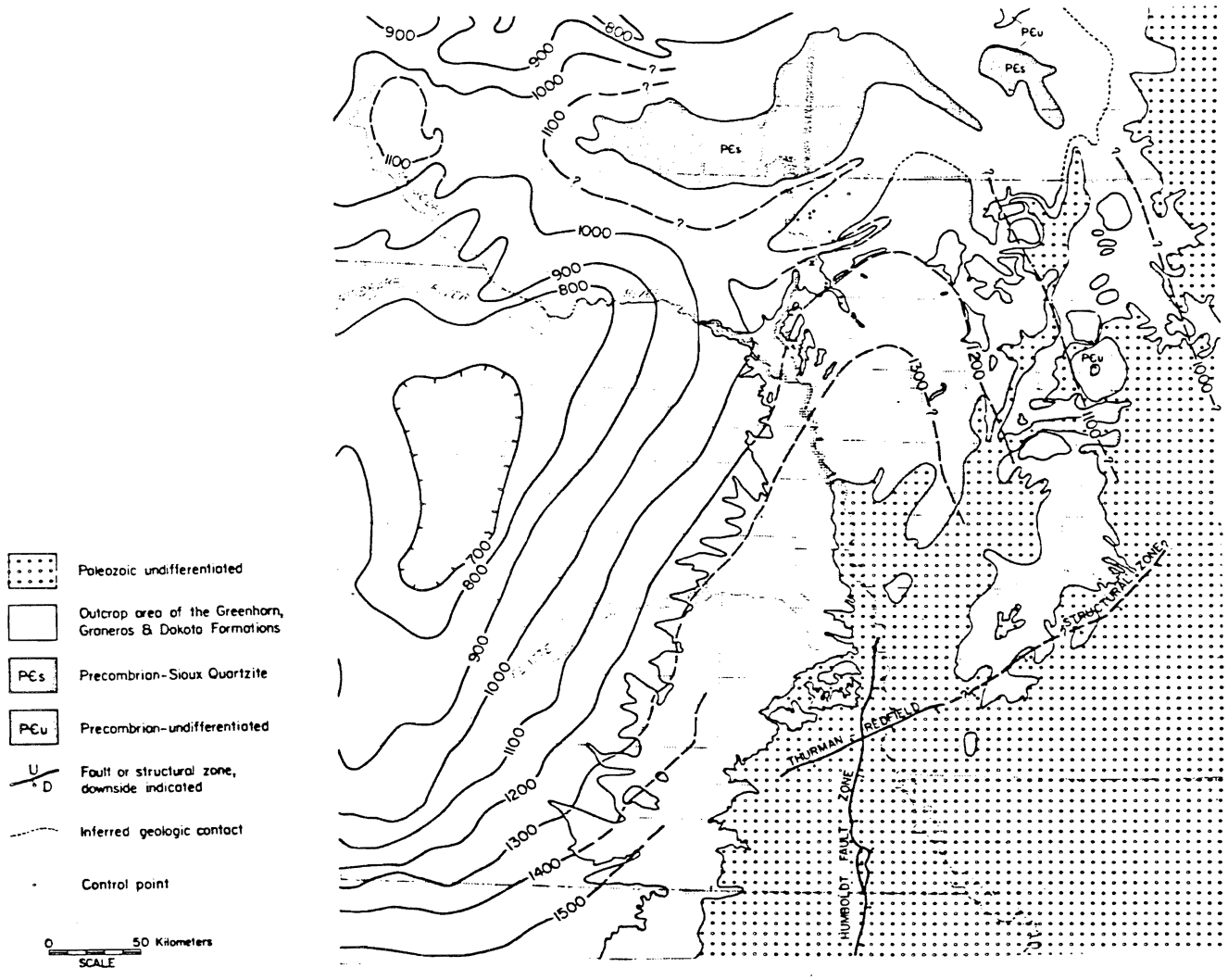

Figure IV-9. Structure contour map on top of the Greenhorn Limestone (Upper Cretaceous) (modified from Bunker, 1981b, p. 16).

"Laramide" (Late Cretaceous-Early Tertiary) orogenic features are reminiscent of older Late Paleozoic uplifts (e.g. the Ancestral Rockies and the Black Hills-Central Kansas Uplift). Regional truncation and burial of Cretaceous rocks by Tejas sediments (Tertiary) along the Colorado Front Range has been well established. An examination of the geologic map of eastern Nebraska and western Iowa (fig. IV-10) shows regional truncation of Late Cretaceous age rocks and Tertiary overstepping in an eastward direction towards the crest of the reactivated post-Greenhorn "Nemaha Uplift." Vertebrate fossils of late Tertiary age have been identified from several Pleistocene sand and gravel localities in western and southwestern Iowa (H. Semken, University of Iowa, pers. comm.). The excellent preservation of these fossils indicates that they have not traveled far from their original site of burial. Their presence suggests that at one time Tertiary sediments probably extended well into western Iowa and potential outliers could possibly still exist in the western Iowa subsurface.

Structure contouring on top of the Galena Group (fig. IV-11), a widespread Lower Paleozoic stratigraphic datum delineates many of the previously mentioned structural features. The shaded areas on the map denote regions where Middle and/or Upper Devonian rocks are physically resting directly on the Galena Group or older rocks, the result of pre-Middle Devonian uplift and erosion in the midcontinent. The structural center of the Forest City Basin, as shown on the base of the Hertha structure map (fig. IV-8), was located in northeastern Kansas. Inferences from the Galena structure map illustrate the same general structural relationship. The northern extensions of the Forest City Basin into southwestern and western Iowa, the Central Iowa Arch, and the Lincoln Fold System of northeastern Missouri-southeastern Iowa are all still evident on this map.

Fig. IV-12 depicts the present day structural configuration of the Precambrian surface in Iowa and parts of adjoining states. It was constructed within the constraints of the previously discussed structure and isopach maps and a limited number of control points that penetrate to the Precambrian surface. The map represented here is not a crystalline surface map but includes the Late Precambrian Keweenawan clastic interval. Many of the structural features noted on the earlier maps are still identifiable. The Northeast Missouri Arch is represented as a broad Precambrian high across northern Missouri and southern Iowa that has been cross-folded by a series of northwest-southeast trending folds, the most evident of which is the Lincoln Fold System of northeastern Missouri. The Central Iowa Arch is delineated by the deflection of the structure contour lines in central Iowa, and the position of the Forest City Basin from western Iowa into northeastern Kansas is apparent.

The structural development in the central midcontinent region, and in particular the area of the Forest City Basin, has been the result of several periods of geometrically discordant structural movements acting in different senses and times in the geologic past. It is apparent that the Precambrian basement has played an active role in the structural development of the Forest City Basin area, as well as many of the other

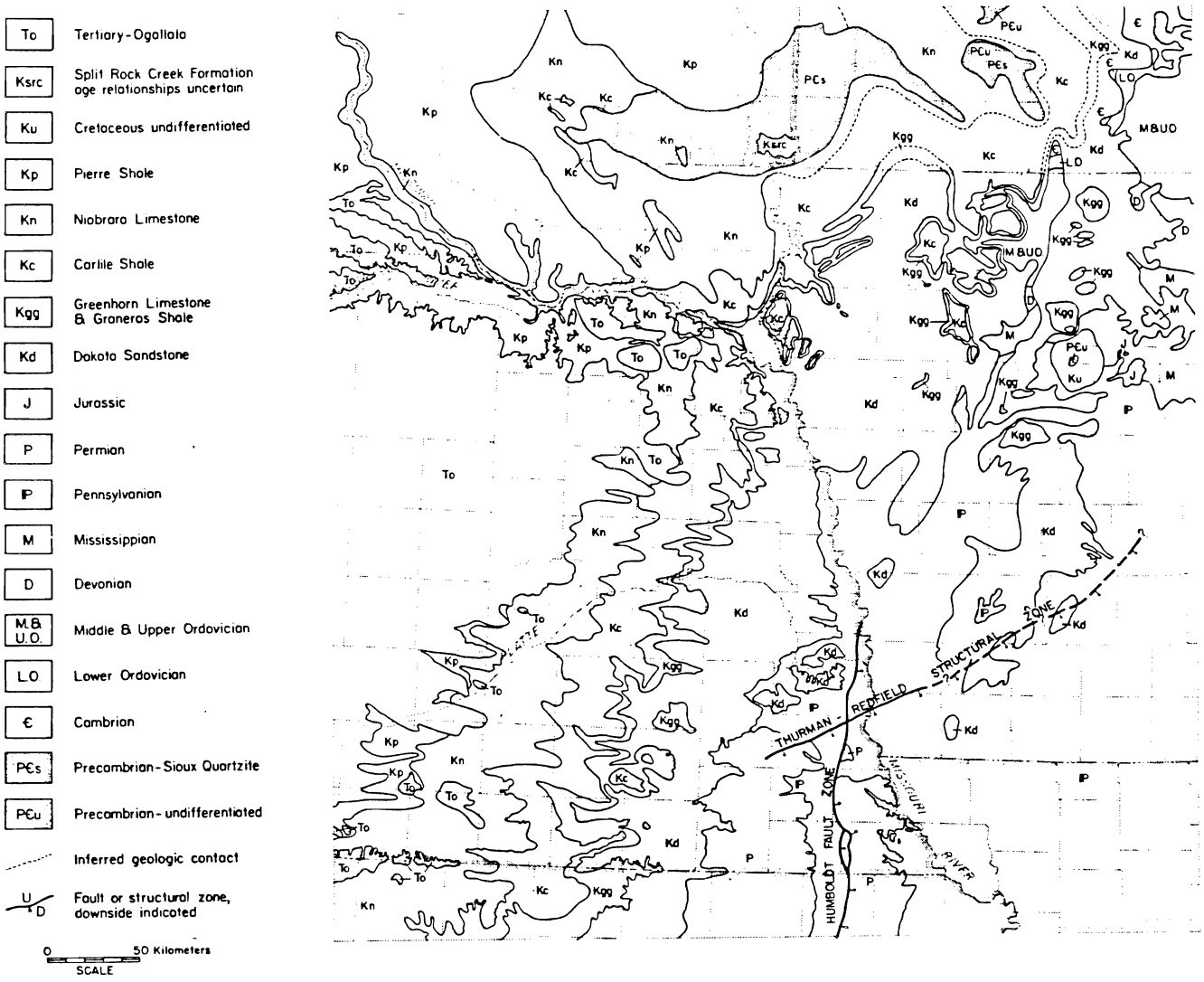

Figure IV-10. Generalized geologic map of the central midcontinent (modified from Bunker, 1981, p. 17).

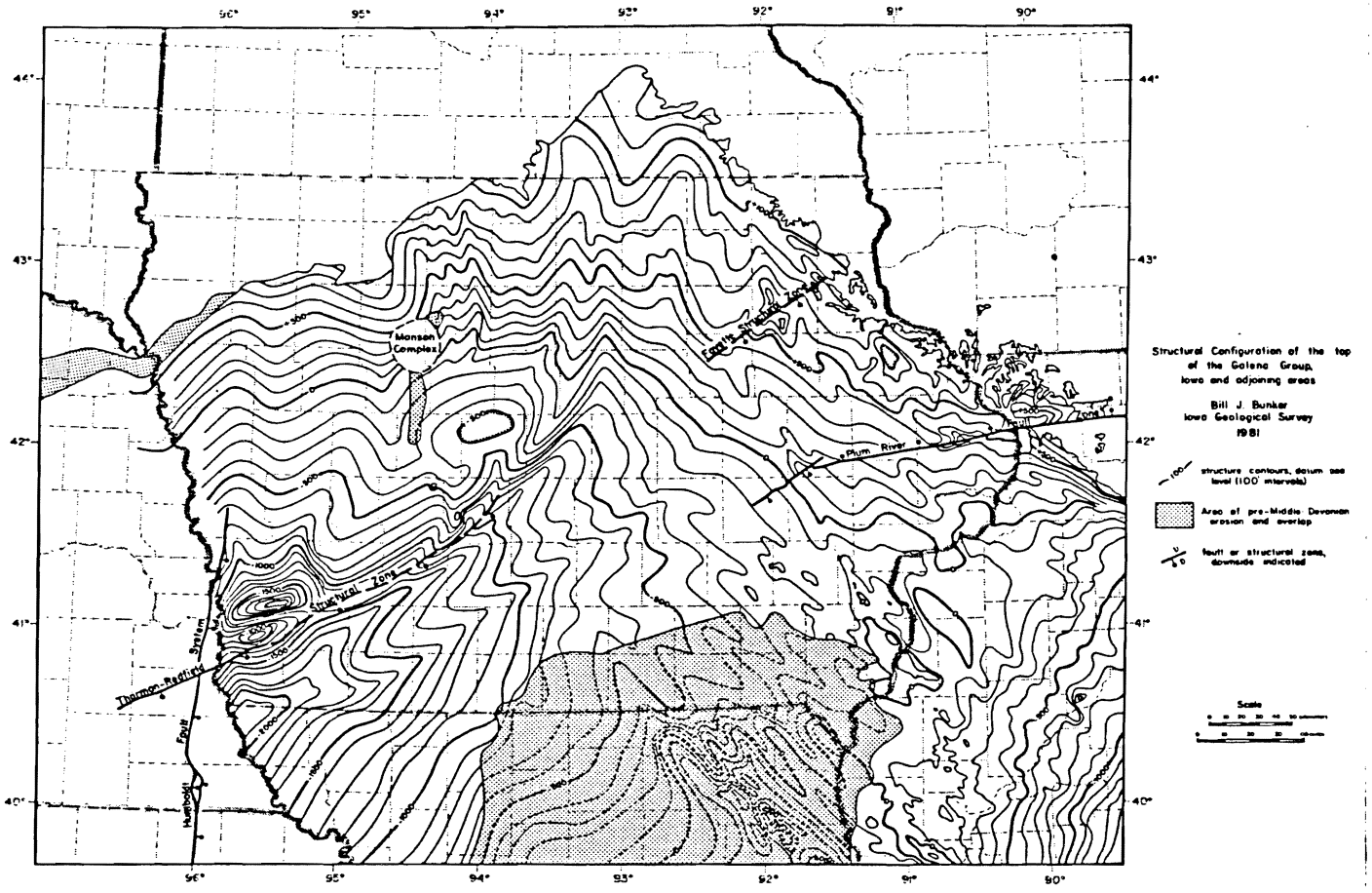

Figure IV-11. Structure contour map on top of the Galena Group (Middle Ordovician) of Iowa and parts of adjoining states (modified from McQueen et al., 1961; Bristol and Buschbach, 1973).

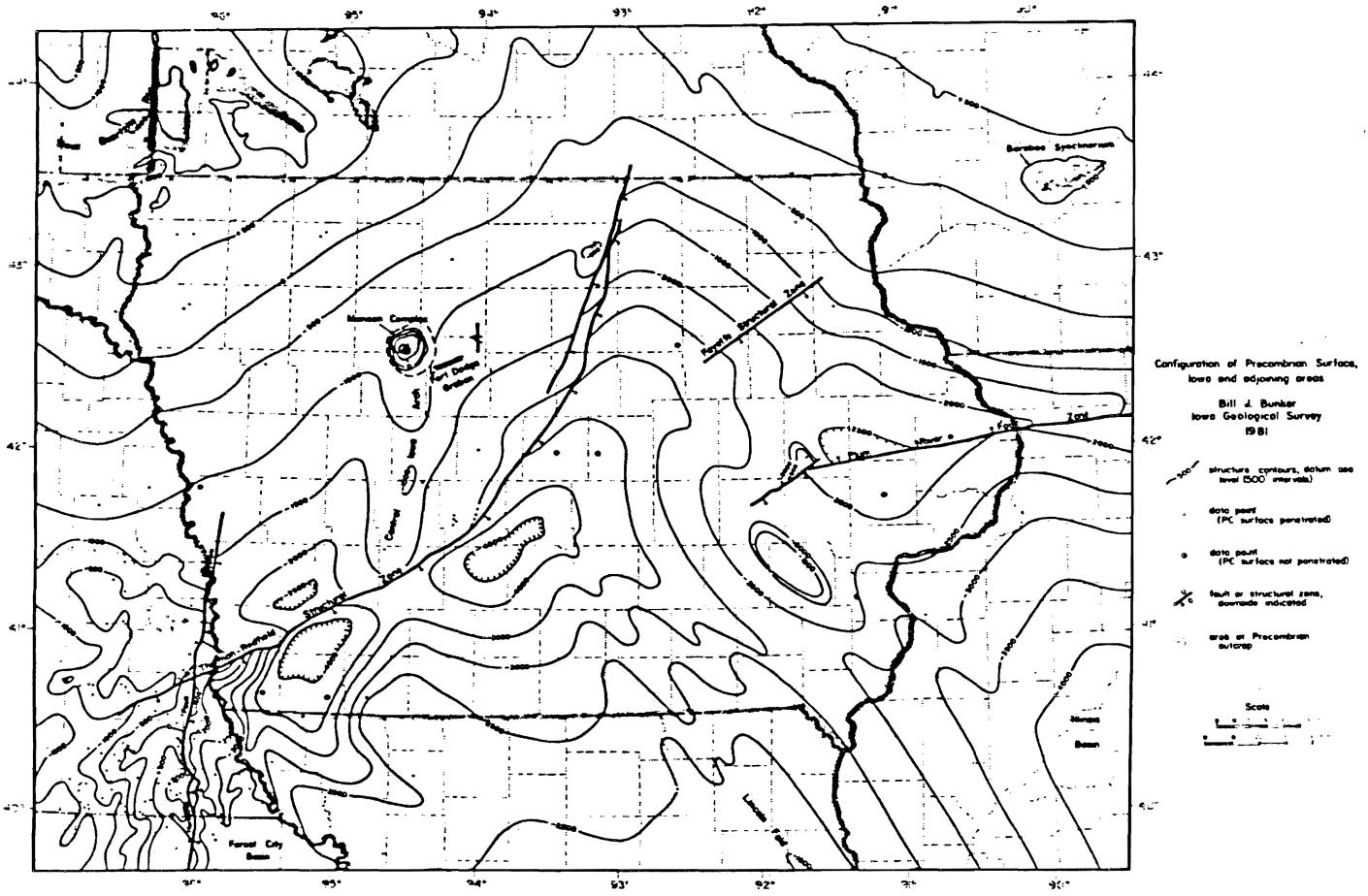

Figure IV-12. Structural configuration of the Precambrian surface in Iowa and adjoining states (modified from Thwaites, 1957; Bradbury and Atherton, 1965; Burchett and Carlson, 1966; Sims and Morey, 1972, p. 461; Kisvarsanyi, 1975; Derrick Iles, South Dakota Geological Survey, pers. comm., 1980; Bunker, 1981c).

structural features discussed. Ongoing biostratigraphic and lithostratigraphic investigations of the Phanerozoic and Precambrian rocks by the Iowa Geological Survey are already modifying and refining the structural history presented in this brief overview.

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