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Stratigraphy and Conodont Biostratigraphy of the Uppermost Carboniferous and Lower Permian from the North American Midcontinent

Darwin R. Boardman II
Oklahoma State University
Stillwater, Oklahoma 74078–3031

Bruce R. Wardlaw
U.S. Geological Survey
Reston, Virginia 20192–0002

Merlynd K. Nestell
University of Texas at Arlington
Arlington, Texas 76019–0408

PART A—General Sequence Stratigraphy and Conodont Biostratigraphy (including new species) of the Uppermost Carboniferous (upper Gzhelian) to Lower Permian (lower Artinskian) from the North American Midcontinent

Bruce R. Wardlaw, Darwin R. Boardman II, and Merlynd K. Nestell

PART B—Conodont Distribution, Systematics, Biostratigraphy, and Sequence Stratigraphy of the Uppermost Carboniferous and Lower Permian (uppermost Wabaunsee, Admire, Council Grove, and lower Chase Groups) from the North American Midcontinent

Darwin R. Boardman II, Merlynd K. Nestell, and Bruce R. Wardlaw

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Authors' Preface

This study was initiated in 1991, and originally was planned to be a summary of the sequence stratigraphy and naming of the new conodont species document that would be printed; the sometimes more detailed discourse about stratigraphic philosophy and observation to accompany the more detailed discussion and illustration of the conodont biostratigraphy was to be a digital supporting document. The research greatly evolved in scope in order to adequately deal with taxonomic, stratigraphic, and sequence stratigraphic issues.

Part A is largely a summary of the most essential elements of the conodont taxonomy, biostratigraphy, and sequence stratigraphy and is a printed document. Part B contains detailed conodont biostratigraphy, including an in-depth analysis of the problems of stratigraphic misplacement of species, clarification of types, and more complete discussion of the sequence stratigraphic concepts and is included on a cd-rom in the back envelope of this volume. Some redundancy exists between Part A and Part B, but we felt the basic concepts are better served in this format.

—Darwin R. Boardman II
Bruce R. Wardlaw
Merlynd K. Nestell

This entire Bulletin also is available on the Kansas Geological Survey web site at http://www.kgs.ku.edu/Publications/Bulletins/255/index.html.

Appendix I—Translation of Russian and German Species Descriptions

In this section, we present translations by Nestell from the Russian and German of 18 late Carboniferous and Early Permian species of *Streptognathodus*. These translations should aid those interested in understanding the species concepts presented by the original authors and original plates can be consulted by those interested parties. We would like to thank Nataliya Bocharova and Jurgen Schieber for helping us over a few sticky translation phrases. The species translations are listed alphabetically and include *S. alekseevi, S. alius, S. artinskiensis, S. asselicus, S. barskovi, S. conjunctus, S. constrictus, S. cristellaris, S. fusus, S. insignitus, S. invaginatus, S. latus, S. longissimus, S. nodulinearis, S. postfusus, S. ruzhencevi, S. tulkassensis,* and *S. zethus*.

1. *Streptognathodus alekseevi* Barskov, Isakova, and Shchastlivceva, 1981

Streptognathodus alekseevi sp. nov.
Plate I, fig. 11–14.
?*Streptognathodus* sp. A: von Bitter, 1972, pl. 1, fig. 2a–c.
Streptognathodus elegantulus: [2, Plate 2, fig. 18]

Specific name: In honor of A. S. Alekseev (MGU)

Holotype: MGU No. 197/16; Hole No. 7, Kaznevo, bed 6, Gzhelian Stage, Russavkinsky horizon.

Diagnosis: Platform with deep and wide axial groove of 'U'-shaped profile, which occupies median position. Axial carina extends not more than one-half of length of platform. Nodes of axial carina and transverse ribs of parapet do not pass through axial groove, bottom of axial groove smooth. Accessory lobes absent.

Description: Platformed conodonts, right and left. Platform elongate, weakly asymmetric (concave in plan with convexity in outer side) or almost symmetric. Posterior end of platform rounded (Plate I, fig. 11) or pointed (Plate I, fig. 13, 14). Forms with rounded end usually have more symmetric profiles of platform. Accessory lobes absent, but more gerontic forms can have nodes on outer side of platform. Axial groove very well developed, deep and wide, 'U'-shaped in transverse section. Axial carina located in its anterior part, extending as combined or isolated denticles at distance of not more than one-half of length of platform, often considerably less than one-third of length. Remaining part of axial groove has plane smooth bottom. Neither nodes of axial carina or transverse ribs of parapets pass through it. Lateral parapets bear short transverse ribs, interrupted on lateral sides of axial groove. Free blade with respect to form of denticles and nature of anterior end usual for representative specimens of genus. Its length little exceeds length of platform. Basal cavity and lower side of platform also do not have specific features.

Comparison: With regard to profiles of the platform, presence of a deep and wide groove [this species] is closest to *S. elegantulus*. It differs from it in the fact that the axial carina does not pass to the posterior end of the platform and the axial groove in the axial posterior part has a smooth bottom, devoid both of nodes of the axial carina and also of the transverse ribs.

Remarks: In the new species are distinguished forms, which were originally considered [2] as a part of *S. elegantulus*. However, in accord with the first definition (*S. elegantulus* Stauffer and Plummer, 1932) and subsequent identifications [4, 11] of the latter species, its diagnostic feature is the fact that the axial carina extends as a series of isolated nodes along the bottom of the axial groove up to the end of the platform. However, clearly observed is the tendency to fusion of nodes of the axial carina in the posterior end of the platform with the transverse ribs of the outer parapet. As a result of this, the pointing of the posterior end of the platform becomes asymmetric. Apparently, this tendency to fission of the nodes of the median carina with the outer parapet extends from the posterior end of the platform forward, and results in the formation of the species *S. elongatus* from *S. elegantulus*. *S. elongatus* has clearly asymmetric parapets and axial groove of 'V'-shaped section shifted to the inner edge of the platform. Some forms, which can be considered as transitional, are depicted in Plate I (fig. 16). As was indicated above, among numerous specimens of *S. alekseevi* are present forms distinguished by the nature of the point of the posterior end of the platform. In many specimens from various localities, one cannot clearly separate forms with a rounded end and forms with a pointed end; however, either one, or the other, or an intermediate morphological type is present in each specific sample.

Distribution: Gzhelian Stage of the Carboniferous–Asselian Stage of the Permian; Russian Platform, Urals, Donbass; Upper Pennsylvanian–Lower Permian of the United States.

Material: More than 400 specimens from the Russavkinsky, Amerevsky, and Noginsky horizons of the Gzhelian Stage of the Moscovian Syneclise; about 45 specimens from boundary sediments of the Carboniferous and Permian sections near Nikol'skoe Village (see Plate 1–1).

2. *Streptognathodus alius* Akhmetshina, 1990

Streptognathodus alius Akhmetshina, sp. nov.
Plate 1, fig. 9, 10
Streptognathodus barskovi: Chernykh and Reshetkova, 1987; plate VII, fig. 1.

Specific name: From the Latin *alius*—other, another.

Holotype: AO KazNIGRI, No. 12/1, left Pa element; Aktyubinsk area, subsalt elevation Zhanazhol, well 12, depth 2,827–2,837 m; Lower Permian, Asselian Stage, subzone *Daixina bosbytauensis*.

Description: Platform Pa element broad, symmetric, massive, posterior end rounded, smooth axial carina short, occupying less than one-third of length of platform. Anterior parts of parapets separate from median carina by shallow short furrows (adcarinal grooves). Median groove shallow, narrow extended to posterior end of platform. Surface of platform ornamented by 14–16 low and wide transverse ribs, discontinuous at median groove. Accessory lobes absent, sometimes one to two nodes present on inner side of platform close to end of axial carina. In side view platform straight, raised in anterior third, free blade short. Basal cavity deep, asymmetric most widened in middle part, somewhat pointed at posterior end.

Comparison: The described species in structure of the Pa elements is most similar to *S. barskovi* Kozur. H. Kozur (*in* Kozur and Mostler, 1976) in the diagnosis of *S. barskovi* did not comment on the presence of long anterior branches of the parapet. However, the holotype of *S. barskovi* differs from *S. alius* by strongly developed anterior branches of the parapet, whereas the compared species are identical in the remaining features, the present species differs from *S. elongatus* by a wider platform, and from *S. conjunctus* by the absence of continuous transverse ribs in the anterior part of the platform.

Distribution: USSR, eastern part of the Siscaspian depression, western slope of the middle Urals, lower part of the Asselian Stage of the Lower Permian, Gzhelian Stage, zone of *Daixina sokensis*.

Material: Thirty-six specimens from cuts of 11 deep holes of the area of the Shanatan and Sinel'ni Kovskii Sis Caspian depressions.

3. *Streptognathodus artinskiensis* Kozur and Movshovitsch, 1979

Gnathodus [Streptognathodus] artinskiensis Kozur and Movschovitsch, sp. nov.
Plate IV, fig. 14.

Specific name: From the locality in Artinskian deposits.

Holotype: Specimen number Ko/Mov.1977/1–7; TSNIGR Museum, Leningrad (St. Petersburg): Plate 4, fig. 14. Orenburg district, Saraktash region, exposures at the water divide of the Usalyka and Assel' rivers, Aktasta horizon (base).

Material: Three specimens.

Diagnosis: Platform very long and narrow, in posterior half similar to that of *Idiognathodus* and in anterior half to that of *Gnathodus*. Accessory nodes on one side of platform.

Description: Platform long and narrow. Edge of platform bears in anterior half closely spaced nodes of small marginal denticles, which, to rear, change to transverse ribs with increasing length. Almost in middle of platform, slightly closer to posterior end, transverse marginal ribs fuse into one single rib extending across platform. Simultaneously, initially deep axial groove of platform flattens out so that platform is very slightly depressed in posterior half. Accessory nodes on one side of platform.

Median carina extends from anterior end to middle of platform. In the described material, free blade not preserved or partly preserved. It has low broad denticles in posterior part.

Comparison: The specimen illustrated by Rhodes, called *Streptognathodus elongatus* Gunnell (Rhodes, 1963, Plate 47, fig. 29) has transient transverse ribs, only somewhat further back than those of *Gnathodus artinskiensis* sp. nov., i.e., that specimen is identical to the described species.

Gnathdous artinskiensis sp. nov. is easily distinguished from all other species of the genus by its very long platform and is clearly transitional in nature between *Gnathodus* and *Idiognathodus*.

Distribution: Lower Artinskian deposits of the sub-Ural (base of the Aktasta horizon) and upper strata of the Tensleep Sandstone in Wyoming (USA).

4. *Streptognathodus asselicus* Isakova, 1986

Streptognathodus asselicus Isakova, sp. nov.
[This form is not present in our material from Kansas]
Plate XXXI, fig. 20–25.

Specific name: From the name of the Asselian Stage.

Holotype: N 4632/194 GIN AN SSSR; Little Syuren River; Asselian Stage, zone of *Schwagerina moelleri–Pseudofusulina fecunda*.

Diagnosis: Conodonts narrowly lanceolate shaped. Platform laterally curved. Longitudinal groove occupies axial position or displaced to interior side. Accessory lobes weakly delineated.

Description: Platform lanceolate, significantly widened in anterior third of half of length, then sharply constricted and extended to posterior end. Outer side of platform slightly convex; inner side in anterior third convex in length, after sharp constriction of platform—almost straight. Posterior end of platform bluntly rounded. Longitudinal groove deep, occupies axial position, sometimes displaced to interior side. Entire axial carina extends to length of widest part of platform. Lateral parapets situated in widened anterior third of platform pustulate, 'V'-shaped in place of sharp constriction of platform (at level of end of axial carina). Surface of platform ornamented by 10–11 transverse ribs interrupted by longitudinal groove. At displaced position of groove, outer edge of platform above inner. On inner side of platform at place of its curve, there are one to two nodes. Side of platform raised at widened anterior half, then is sloped to posterior end. Basal cavity, deep and wide, asymmetric, widest at anterior part.

Variability is expressed in degree of expansion of anterior part of platform, in degree of displacement of longitudinal groove from medial position.

Comparison: From the closest species *S. wabaunsensis* Gunnell, it differs by the form of the platforms, and weakly expressed lobe.

Distribution: Asselian Stage of the Southern Urals.

Locality and material: Southern Urals, at the Syuren River, Akma River, Uskalyk River. Twenty-five specimens.

5. *Streptognathodus barskovi* Kozur, 1976

Gnathodus [*Streptognathodus*] *barskovi* Kozur n. sp.
Plate 3, fig. 2, 4, 6.

Derivation of the name: In the honor of Dr. I. S. Barskov, Moscow.

Holotype: The illustrated specimen, Plate 3, fig. 6.

Type location: Outcrop on the Tabantal River, southern CisUral, compare to Ruzhensev, 1952.

Type stratum: Upper Asselian.

Diagnosis: Carina short, it stops considerably prior to middle [of platform] and consists in its posterior part of smooth rib. Towards direction of free blade, small denticles occur which on free blade become longer and broader towards anterior. Frontmost denticle again shorter. Platform broad and only weakly depressed. It possesses very long narrow ribs partly fused in middle.

Occurrence: Upper Asselian of the CisUral area (outcrop on the Tabantal River and the Ajdaralasi outcrop, bed 12 according to Ruzhensev, 1952, upper Tensleep Sandstone of Wyoming (Sakmarian).

Relationship: *G. simplex* (Gunnell 1933) possesses a considerably more slender and deeper depressed platform. *G. wabaunsensis* (Gunnell 1933) corresponds in platform development, but has accessory nodes.

6. *Streptognathodus conjunctus* Barskov, Isakova, and Shchastlivceva, 1981

Streptognathodus conjunctus Barskov, Isakova, and Shchastlivceva, sp. nov.
Plate II, fig. 1–5.

Specific name: From the Latin *conjunctus*—jointed, articulated.

Holotype: MGU No. 197/116; southern Urals, section at Nikol'skoe Village, level 31; upper Carboniferous.

Diagnosis: Platform with asymmetrically located axial groove of 'V'-shaped cross section. Axial carina takes up less than one-third of length of platform and ends usually with large node, which joins with transverse ribs of one or both parapets, and in this way forms continuous transverse rib over whole platform. Posterior part of axial groove flattens out, and in this part has one to three transverse ribs which pass through groove uninterrupted. Accessory lobes absent.

Description: Platformed conodonts, right and left. Platform elongated, somewhat asymmetric and concave in plan, with convexity in outer side. Posterior end of platform usually pointed. Accessory lobes absent. Axial groove located asymmetrically and has 'V'-shaped cross section. At posterior end of axial carina, which takes up one-third of length of platform, last denticle joins with nearest to it by continuous transverse rib, partitioning axial groove. This continuous transverse rib usually wide and thicker than remaining ribs of parapets. At posterior end of platform axial groove flattens, and through it pass one to three uninterrupted transverse ribs. Lateral parapets bear sculpture in form of 15–20 transverse ribs, interrupted on most of platform by axial groove. Free blade little longer than platform. Nature of dentition and anterior border of blade as usual for representatives of genus. Basal cavity and lower side of platform does not have special peculiarities for species.

Comparison: In profiles of the platform and the nature of the ornamentation [this species] is nearest of all to *S. elongatus*, but differs from it with respect to the less elongated platform, shorter median groove, the presence of continuous or a partially discontinuous transverse rib in the anterior part of the platform, which is connected with the denticle of the axial carina and limits its extension.

Distribution: Upper part (Noginsky horizon) of the Gzhelian Stage of the Carboniferous—Asselian Stage of the Permian; southern Urals.

Material: Ten specimens from the section at Nikol'skoe Village (levels 31, 41, 42, see Plate II); six specimens from the middle zone of the Asselian stage of the section on the Assel' River.

7. *Streptognathodus constrictus* Reshetkova and Chernykh, 1986

Streptognathodus constrictus Reshetkova and Chernykh, sp. nov.

Specific Name: *constrictus* (Latin) —constricted, squeezed.

Holotype: MIGG, no. ZSP/2; Bashkirian ASSR, Salavat region, left bank of the Yuryuzan River, below mouth of Ust–Kanda Creek; Lower Permian, Asselian Stage, zone of *Schwagerina moelleri–Pseudofusulina fecunda*.

Description (fig. 1, I–r): Conodonts, right and left. Platform elongate, with well-developed furrows in anterior part, weakly asymmetric, with distinct constriction in middle part, posterior end pointed. Accessory lobes, as a rule, absent. Isolated nodes may be present on interior side of constriction. Axial carina occupies more than half of length of platform, axial groove arranged symmetrically, has 'V'-shaped cross section, and flattens out toward posterior end. Lateral parapets bear transverse ridges (from 8 to 12), of which last two to three ridges intersect axial furrow, and are not interrupted. Outer parapet rises somewhat above inner at posterior end of platform. Parapets on anterior half have distinctive symmetric flaps outside and join smoothly with free blade; their interior depressed portions, directly abutting free blade, smooth; marginal parts, continuation of parapets, have more or less even ribbing. Free blade little shorter than platform, and evenly denticulate, but its first three denticles located somewhat separately from others.

In side view, upper margin of platform has smooth arcuate outlines. Lower side of platform as usual for this genus.

Comparison: The existence of constrictions of the platform, the presence of deep flaps, and the symmetric position of the axial furrow, readily distinguish this species from the similar species *S. simplex*.

Distribution: Middle zone of the Lower Permian Asselian Stage; western slope of the South Urals.

Material: Fifteen well-preserved specimens and numerous fragments from two localities.

8. *Streptognathodus cristellaris* Chernykh and Reshetkova, 1987

Streptognathodus cristellaris Chernykh and Reshetkova, sp. nov.
[This form is not present in our material from Kansas]
Plate 1, fig. 9–11.

Holotype: No. 165; Bashkirian ASSR, Salavatsk Region, right bank of the Yuruzan River, below the mouth of Kazarba Creek; Lower Permian, Asselian Stage, zone of *Schwagerina fusiformis–S. vulgaris*.

Diagnosis: Elongate conodonts with symmetrically located median groove. Posterior end sharp. Outer parapet somewhat raised above interior in middle part of platform. Ribbing as usual for conodonts of the *S. elongatus* lineage. Anterior branches of parapets steeply depressed downwards and separate from free blade by smooth troughs. Accessory lobes consist of a few tongues situated relative to long ribs, distorting the regularity in arrangement of ribs on parapets. Median groove straight, smooth, passing to posterior end of platform. Axial carina almost smooth, making up about one-third of length of platform.

Discussion: The structure of the accessory lobes is most variable. A continuous series of forms from *S. wabaunsensis* to the described species can be constructed according to the peculiarity of construction of the accessory lobes. In *S. wabaunsensis* the accessory lobe consists of irregularly situated nodes, a few isolated. In the early stages of transition of *S.*

wabaunsensis to *S. cristellaris*, short ribs appear in the accessory nodes by the fusion of the nodes; the isolativeness of the node is preserved (Plate 1, fig. 9). At the terminal stage the reconstructed ribs of the nodes are merged with the ribs of the parapet. In such specimens the previous isolativeness of the node is emphasized by the preserved narrowing of the platform immediately in front of [behind] the termination of the axial carina.

Comparison: The present species is distinct from *S. wabaunsensis* by the structure of the accessory nodes; from *S. fusus*, by the presence of accessory nodes.

Distribution: Asselian Stage of the Lower Permian, zone of *S. cristellaris*; western slope of the southern Urals.

9. *Streptognathodus fusus* Chernykh and Reshetkova, 1987

Streptognathodus fusus Chernykh and Reshetkova, sp. nov.
Plate 1, fig. 12–14.

Specific name: From the Latin *fusus*—spindle.

Holotype: No 146; Bashkirian ACCR, Salavat Region, left bank of the Yuryuzan River below the mouth of Yet'Kanda; Lower Permian, Asselian Stage, zone of *Schwagerina moelleri–Pseudofusulina fecunda* (*S. constrictus*).

Diagnosis: Platform elongate, noticeably constricted at level of end of middle carina, with asymmetrically arranged axial groove. Axial carina occupies less than half of length of platform. Anterior part of platform asymmetrically constructed; more developed inner parapet isolated from free blade [fixed blade] by deep scoop-shaped trough, narrow outer parapet by slit-shaped trough. Regular ribbing of parapets broken in area of narrowing of platform.

Description: Platform elongate. Anterior and posterior parts of platform separated by clear narrowing, located at level of end of axial carina. Profile of posterior part of platform in plan spindle-shaped. Axial groove straight, narrow, distinct, located weakly asymmetrically so that outer parapet is little bit wider than inner. Parapets wide, flattened, bearing clearly delineated regularly arranged ribs. Parapets of anterior part of platform have unequal construction and are by different ways attached to free blade. Outer parapet almost closely joins free blade, being isolated from it by narrow slit-shaped trough; has regular ribbing. Wider inner parapet attached to free blade, forms scoop-shaped trough (sinus). Ribbing of inner parapet at level of end of axial carina dislocated in one way or another; one or two ribs either shortened or displaced, or represented by nodes, etc. Axial carina straight, low, narrow, takes up less than half of length of platform. Free blade shorter than platform. Lower side of the conodont as usual for given genus.

Variability: Examples are encountered with the platform relatively wider in comparison with the typical forms.

Comparison: The presence of an elongate platform with a clearly delineated constriction, well-developed sinusoidal structures, the presence of ribs along the entire length of the parapets—all make these characters closely compare the described conodont with *S. constrictus*. The latter, in distinction with the one described here has a relatively narrow platform and a symmetric construction of the parapets.

Material: Fifteen complete specimens and numerous fragments of conodonts from two localities.

Distribution: Middle zone (*S. constrictus*) of the Asselian Stage of the Lower Permian; western slopes of the southern Urals.

10. *Streptognathodus insignitus* Akmetshina, 1990

Streptognathodus insignitus Akhmetshina, sp. nov.
Plate 1, fig. 12, 13

Specific name: From the Latin *insignitus*—noticeable.

Holotype: AOKazNIGRI, no. 12/1, left Pa-element; Aktyubinsk area, subsalt elevation Zhanazhol, well 7–12, depth 2,854–2,864 m; upper Carboniferous, Gzhelian, zone of *Daixina sokensis*.

Description: Platform Pa element asymmetric, elongated with acutely rounded posterior end. In anterior part of platform rounded, massive, constricted at posterior end. Anterior parts of parapets separate from median carina by long furrows. Axial carina short, takes up one-third of length of platform, composed of slightly projected nodes. Median groove narrow, deep, extended to posterior end of platform, displaced on interior side. Surface of platform ornamented by 11–15 short, transverse corrugated ridges broken by median groove. Accessory lobes absent, one to two nodes on interior side of platform. Basal cavity deep, widest in anterior third, pointed at posterior end.

Comparison: The present species differs from the closest species *S. simplex* by the roundness of the anterior part of the platform.

Distribution: Upper Carboniferous, Gzhelian Stage–Lower Permian, Asselian Stage; USSR, east part of the SisCaspian depression and the western slope of the Middle Urals.

Material: Sixty-seven specimens from cuts of 19 deep holes of the SisCaspian depression.

11. *Streptognathodus invaginatus* Reshetkova and Chernykh, 1986

Streptognathodus invaginatus Reshetkova and Chernykh, sp. nov.

Specific name: From the Latin *invaginatio* ("invagination").

Holotype: MIGG, no. ZSP/3; Bashkirian ASSR, Krasnousol'sk region, right bank of Usolka River; Lower Permian, Asselian Stage, zone of *Schwagerina fusiformis–S. vulgaris*.

Description (fig. 1, s–v): Conodonts right and left. Platform relatively wide, its posterior half with oviform outlines, more rounded on inner side. Outer margin arcuate. Inner side of platform has distinctive peculiarity in outline immediately in front of inner lobe, margin of platform bends sharply inward, forming a distinct pointed sinus. As a result, an additional inner lobe (separated from the posterior half of platform by distinct bend) is clearly separated, consisting of two to five closely spaced nodes or a few short ridges, from axial carina by narrow parapet; outer lobe absent or consisting of single indistinct isolated node. Axial carina occupies approximately half of length of platform. Axial furrow initially deep and narrow, rapidly flattens out toward posterior margin; its accompanying parapets high, convex, and strongly contiguous at first, then gradually flatten out to become planar at posterior end of platform. Parapets have transverse ridges. On flattened surface of platform, ridges intersect axial furrow, and are not interrupted. Last two ridges may merge into broad marginal ridge. Anterior branches of parapets which extend

along the axial carina narrow, and bear wide short ridges. Basal cavity wide, asymmetric.

Comparison: In the general structure of the platform, this species resembles *S. wabaunsensis*, but differs from it in the wider rounded platform with an almost symmetrically located axial furrow, and the presence of a distinct sinus on the inner lateral side; in addition, in *S. invaginatus*, in contrast to typical *S. wabaunsensis*, the end of the platform is rounded and the terminal ridges are not interrupted by the axial carina.

Material: Fifteen specimens from one locality.

12. *Streptognathodus latus* Chernykh and Reshetkova, 1987

Streptognathodus latus Chernykh and Reshetkova, sp. nov.
[This form is not present in our material from Kansas]
Plate II, fig. 1, 3.

Specific name: From the Latin *latus*—wide.

Holotype: No. 169; Bashkirian ACCR, Krasnousl'sk Region, right bank of the Dal'nii Tyul'kas River, in 1 km east of the city of Krasnousol'sk; Lower Permian, Asselian Stage, zone of *S. constrictus*.

Diagnosis: Platform symmetric, wide in middle part, gradually constricted to ends. Median groove narrow, distinct at beginning, flattened out to posterior end. Parapets flattened, covered by transverse ribs, some of them dichotomized.

Description: In plan platform has inflated spindle-shaped profile, ration of maximal wideness to maximal length 1:2, largest width of platform in middle part. Posterior end of platform acute. Surface of platform flat, covered by transverse ribs, part of which can be dichotomized from outer edge or truncated. Middle groove divides platform into two equal parts; initially—relatively deep and clearly delineated, then progressively flattened out and almost disappears at posterior end so that last ribs intersect platform not brokenly. Principal peculiarity of sculpture of platform is absence of regularity of arrangement of ribs. Anterior branches of parapets extend along short median carina, devoid of ribs.

Comparison: The wide, symmetric platform with a slightly pointed posterior end compares the described form with *S. barskovi*, but the irregular ribbing and complete plan surface for *S. latus* permit the distinguishment of these forms.

Remarks: Simultaneously with the described (species) are met forms with a 'V'-shaped transverse cross section of the upper surface in the preservation of the dichotomy and irregular ribbing (Plate II, fig. 2).

Material: Five fragments of platforms from one locality.

Distribution: Zone of *S. constrictus* of the Asselian Stage of the Lower Permian; western slope of the southern Urals.

13. *Streptognathodus longissimus* Chernykh and Reshetkova, 1987

Streptognathodus longissimus Chernykh and Reshetkova, sp. nov. Plate II, fig. 4–7.

Specific name: From the Latin *longissimus*—very long.

Holotype: No. 173; Bashkirian ACCR, Salavat Region, left bank of the Yuryuzan river 0.5 km below the mouth of Ust'Kanda Creek; Lower Permian, Asselian Stage, zone *S. constrictus*.

Diagnosis: Strongly elongated platform, usually symmetric, with weak constriction in middle part. Anterior part of platform makes up about one-third of length, has well-developed furrows. Posterior part of platform bears uniform, clearly delineated ribs.

Description: Conodonts of large sizes. Platform narrow, strongly elongated in longitudinal axis, symmetric or almost symmetric, with very weak constriction in middle part. Posterior end rounded or somewhat pointed. Axial groove 'V'-shaped, sometimes somewhat displaced to interior side, deepest and widest in middle, to posterior end constricted and flattened out. Lateral parapets, steeply raised near end of median carina, progressively turn out, becoming almost horizontal to posterior. Anterior branches of parapets almost without ribbing, extend along free blade [fixed blade], forming shallow troughs. Parapets along median groove bear clear, usually regularly distributed ribs. Median carina low, very short, straight, smooth. Free blade equal to length of platform, uniformly denticulate. In side view platform in posterior part noticeably concave. Lower side of conodont usual for given genus. Flanges of basal cavity broad, in shape from above far expressed beyond platform, sometimes broken.

Comparison: Small forms resemble *S. simplex*, but have a shorter median carina. Of *S. simplex*, in distinction from the described species, two or three of the last ribs intersect the middle groove. Mature forms of *S. longissimus* always are considerably larger.

Material: Five complete specimens and numerous fragments of platforms from one locality.

Distribution: Zone of *S. constrictus* of the Asselian Stage, Lower Permian; western slope of the southern Urals.

14. *Streptognathodus nodulinearis* Reshetkova and Chernykh, 1986

Streptognathodus nodulinearis Reshetkova and Chernykh, sp. nov.

Specific name: From the Latin *nodus* (a "node") and *linearis* ("linear").

Holotype: MIGG, no ZSP/4; Bashkirian ASSR, Krasnousol'sk region, right bank of the Usolka River; Lower Permian, Asselian Stage, zone of *Schwagerina fusiformis–S. vulgaris*.

Description (fig. 1, w–zz): Conodonts right and left. Platform moderately elongate, almost symmetric, insignificantly curved in plan. Posterior end pointed. Anterior parts of parapets narrow, separated from median carina by shallow spurs. Most characteristic feature of construction of platform is presence on its inner side of accessory lobe consisting of linear series of three to six small even-sized distinct nodes, parallel to axial groove; last node located almost at level of end of median carina or has been shifted somewhat closer to posterior margin. Axial groove straight and deep, with smooth floor, gradually contracts toward posterior end, sometimes being intersected by last transverse rib. Lateral parapets have transverse ribs and usually are obliquely arranged with respect to axial groove. Axial carina extends to one-third of length of platform, often ending in distinctly separate node. Free blade, along with median carina, is a little longer than platform.

Comparison: The constant presence of a linear row of nodes in the accessory lobe distinguishes *S. nodulinearis* from all other known species of the genus.

Material: Twenty well-preserved specimens from one locality.

15. *Streptognathodus postfusus* Chernykh and Reshetkova, 1987

Streptognathodus postfusus Chernykh and Reshetkova, sp. nov. Plate II, fig. 11–13.

Holotype: No. 181; Bashkirian ASSR, Krasnousol'sk Region, right bank of the Usolka River; Lower Permian, Asselian Stage, zone of *S. postfusus*.

Diagnosis: Platform high, from above flattened, elongated, constricted at level of end of median carina, with almost symmetrically located axial groove. Axial carina takes up less than one-fourth of length of platform.

Description: Platform elongated, high. Short anterior and large posterior parts of platform divided by distinct constriction, located at level of end of median carina. Profile of posterior part of platform fusiform in plan. Axial groove straight, narrow, situated almost symmetrically. Parapets on both sides of it wide, flattened, bear clearly expressed ribs, some of which cross axial groove. Some ribs arranged in pairs or dichotomously branched at inner edge of platform. Short parapets of anterior part of platform almost symmetrical and bear weakly expressed ribs. Junction of parapets with free blade steeply drops downwards. Trough almost not defined. Axial carina short, straight, takes up less than one-fourth of length of platform. Free blade bears seven to nine denticles and is approximately equal length of platform. Lower side of conodont as usual for given genus.

Comparison: From the very similar *S. fusus*, the described forms are distinguished by the general symmetric construction of the platform, less deep weakly developed axial groove and, in particular, by the type of attachment of the anterior branches of the parapet to the free blade; on *S. fusus* the line of junction sloping in side view, long, parapets are separated from the free blade by deep scoop-shaped troughs, but on *S. postfusus* the troughs are practically absent.

Material: Ten complete specimens and numerous fragments of platforms.

Distribution: Upper zone of the Asselian Stage of the Lower Permian; western slope of the southern Urals.

16. *Streptognathodus ruzhencevi* Kozur, 1976

Gnathodus [*Streptognathodus*] *ruzhencevi* Kozur n. sp. Plate 3, fig. 12.

Derivation of the name: In the honor of Dr. V. E. Ruzhencev, Moscow.

Holotype: The illustrated specimen, Plate 3, fig. 12.

Type locality: Outcrop on the right bank of the Ural River, northwest of Ilinskaya.

Stratum typicum: Middle Gzhelian (upper Carboniferous).

Diagnosis: Platform in plan view long, narrow, with pointed posterior. Trough moderately deep. Transverse ribs shallow quickly towards middle of trough, so that impression is given of marginal teething, or in other words, of a knotted platform. Free blade long and bears six to nine high, fused denticles flattened on side and gradually smaller from anterior to posterior. Anteriormost denticle smaller than second denticle, remaining denticles become gradually shorter. Carina extends until posterior of platform or stops shortly before end of platform. Its denticles either fuse into rib or rise only slightly above rib. With adult forms occasionally carina in posterior portion resolved into low denticles (transitional forms to *Gnathodus elegantulus*, type B). Large deep basal pit changes under free blade into basal furrow.

Occurrences: Kasimovian to Upper Gzhelian of the CisUral and the Russian Platform, Conemaugh Group of Ohio, Shawnee Group (Virgilian) of Kansas.

Relationships: The taxonomy of *Gnathodus* (previously *Streptognathodus*) species of the middle and, especially of the upper Carboniferous, is handled quite differently from author to author. This negatively affects their stratigraphic utilization, even though there are clear phylogenetic sequences that can be drawn upon for detailed subdivision, as has been emphatically pointed out by Merrill (1974). Those forms described here as *Gnathodus ruzhencevi* were previously described, in part, as "*Streptognathodus*" *elegantulus* (for example, by von Bitter, 1972, Plate 1, fig. 1a; Merrill, 1974, Plate 2, fig. 5), in part combined with "*Streptognathodus*" *oppletus* (Barskov and Alekseev, 1975). If one considers *Gnathodus oppletus* like Ellison (1941) or like von Bitter (1972, in the text on p. 54, 55, it was probably erroneously designated as "*Streptognathodus gracilis* Stauffer and Plummer", but on Plate 2, fig. 5a–c was correctly assigned to "*Streptognathodus*" *oppletus*), then *Gnathodus ruzhencevi* can be differentiated very easily from *G. oppletus*. With the latter species the carina ends prior to or at the middle of the platform, and in the posterior half of the platform, the transverse ribs are either continuous or interrupted very close to the middle. The closest relationship exists to *Gnathodus simplex* (Gunnell 1933). Between *G. ruzhencevi* and *G. simplex* are transitional changes in the stratigraphic sequence whereby *G. ruzhencevi* occurs first alone, then both species including transitional forms can be found together (Upper Gzhelian), and finally only *G. simplex* occurs in the Asselian. The transition is realized by a stepwise reduction in carinal length with simultaneous elongation of the transverse ribs. Only those forms are assigned to *G. ruzhencevi* in which the carina or at least the separate denticles in the extension of the carina reach to or close to the posterior end [of the platform]. The conodonts of the *G. elegantulus–G. ruzhencevi–G. simplex* group are by far the most abundant *Gnathodus* species of the Upper Gzhelian and Asselian. Their last representatives are found in the Sakmarian. Unfortunately, the taxonomy of the group is very confused. In most instances, all three species are assigned to *Streptognathodus elegantulus* Stauffer and Plummer (1932). This goes back to the broad definition of *Gnathodus elegantulus* by Stauffer and Plummer (1932). Connected to the holotype of this species are those forms in which the carina ends at or prior to the middle [of the platform] and in which there is a fairly broad, flat, and smooth area in the middle of the trough. The transverse ribs are correspondingly short. The stratigraphically highest occurrence of those forms to which "*Streptognathodus*" *elegantulus* of Barskov and Alekseev (1975) was justly restricted was documented in the lower *Triticites jigulensis* Zone of the CisUrals area. Stauffer and Plummer (1932), however, also included with

Streptognathodus elegantulus forms with a slender long platform and a deeply depressed trough, and carina of variable lengths. Such forms, particularly very narrow ones with a deep trough, were in reference to Ellison (1941), frequently described as *S. elongatus* (Gunnell 1933). However, this is not justified because *G. elongatus* has accessory nodes on the platform according to the definition and the holotype. Such forms, on the other hand, are mostly describable as *Streptognathodus gracilis* (Stauffer and Plummer 1932), which actually looks quite similar, but has a shorter platform with fewer marginal ribs or nodes, and a slightly to moderately depressed trough. Forms with a slender deeply depressed platform without accessory nodes were described by Gunnell (1933) as *Streptognathodus simplex*. The holotype of this species comes from the Americus Limestone Member (Wolfcampian) of Kansas. Likewise the holotype of *G. elongatus* (Gunnell 1933) and of *G. wabaunsensis* (Gunnell 1933), whose synonyms are *Streptognathodus walteri* Gunnell 1933, *S. flangulatus* Gunnell 1933, *S. farmeri* Gunnell 1933, and *S. acuminatus* Gunnell 1933, came from the Americus Limestone Member. *G. simplex*, *G. elongatus*, *G. wabaunsensis*, and the new species *G. barskovi* are closely related. *G. simplex* has a narrow deeply depressed platform and no accessory nodes. *G. elongatus* shows the same type of platform development, but it has accessory nodes. *G. barskovi* is characterized by a broad slightly depressed platform without accessory nodes. *G. wabaunsensis* shows the same platform [as *G. barskovi*], but it has accessory nodes.

17. *Streptognathodus tulkassensis* Chernykh and Reshetkova, 1987

Streptognathodus tulkassensis Chernykh and Reshetkova, sp. nov. **[This form is not present in our material from Kansas]** Plate II, fig. 8–10.

Specific name: From the Dal'nii Tyul'kas River.

Holotype: No. 176; Bashkirian ASSR, Krasnousol'sk Region, right bank of the Dal'nii Tyul'kas River, is 1 km east of the city of Krasnousol'sk; Lower Permian, Asselian Stage, zone of *S. wabaunsensis*.

Diagnosis: Platform massive, blade-shaped in plan, with symmetric axial groove; posterior end of platform slightly pointed. At level of end of short median carina, parapets arranged almost vertically, being separated by narrow deep gap.

Description: Platform massive, somewhat elongated. At level of end of median carina, parapets of platform steeply raised and strongly converge, divided by narrow deep gap; toward posterior end of conodont, height of parapets quickly diminishes, parapets themselves become wider, and upper surface of the platform becomes flatter. Axial groove at first narrow, slit-shaped, then quickly flattening out, placed symmetrically and at posterior edge intersected by last rib. Parapets bear regular, clearly delineated transverse ribs. Short narrow anterior branches of parapets devoid of ribbing and steeply lowered down on both sides from free blade [fixed blade]. At level of end of median carina on inner parapet and on lateral side of platform are located two or three transverse large folds or transverse nodose carinae. Axial carina short, smooth, not subdivided by nodes. In available specimens free blade broken. Lower part of platform as usual for given genus.

Comparison: The strongly contiguous and initially steeply raised platform parapets, ornamented by coarse folds, and also the general massive composition of the platform permit the described forms to be differentiated for other Asselian streptognathoids.

Material: Ten specimens of satisfactory preservation and numerous platform fragments from three localities.

Distribution: Zone of *S. cristellaris* of the Asselian Stage of the Lower Permian; western slope of the southern Urals.

18. *Streptognathodus zethus* Chernykh and Reshetkova, 1987

Streptognathodus zethus Chernykh and Reshetkova, sp. nov.

Specific name: From the Latin *Zethus* after the name of a mythological personage.

Holotype: No. 43; Bashkirian ACCR, Krasnousol'sk Region, right bank of the Usolka River; upper Carboniferous, Kasimovian Stage.

Diagnosis: Platform lanceolate, pointed at posterior end, with asymmetrically located median groove. Median carina, as a rule, takes up one-third of length of platform. Accessory lobes, unequal in size, on both sides of platform.

Description: Platform elongated, pointed to posterior end, widest at level of median carina. Exterior side of platform weakly convex, interior–straight. Median groove straight, initially wider and deeper, progressively flattening out to posterior end of platform, noticeably displaced to interior side. Median carina smooth, straight, takes up not less than one-third of length of platform. Exterior parapet wider and somewhat elevated over interior, bears rounded, wedge-shaped in plan transverse ribs (9–10). Narrower parapet covered by short, somewhat elongate ribs (8–9). On both sides of platform are nodose accessory lobes. The exterior lobe obliquely positioned relative to median carina, consists of linearly oriented nodes (4–5). Interior lobe insignificantly expressed at edge of platform, displaced relative to exterior and its posterior end dropped scarcely below end of median carina.

Comparison: By the presence of two accessory lobes, the described form is similar to *S. excelsus*, but differs from it by the asymmetric position of the median groove and the general asymmetric platform in plan. From *S. eccentricus* it differs by the presence of the median furrow (but not a groove), by the concave upper surface of the platform and shorter, thick ribs.

Variability: Younger (Gzhelian) forms have a longer median carina, which can reach one-half of the length of the platform.

Remarks: R. I. Kozitskaya [2] described a very similar form from the upper Carboniferous of the Donets basin (Plate XXIX, fig. 7–9), referring it to *S. excelsus*. However, judging from the illustrations, these conodonts cannot be identified as *S. excelsus*; apparently, they belong to the described species.

Distribution: Upper Carboniferous; Donbass and western slope of the southern Urals.

Material: Fifteen specimens well preserved from two localities.

Appendix II— Locality Register, Section Locations, and Detailed Measured Sections and Sample Locations

Locality 1—Roadcut on unimproved road, type locality for Janesville Shale, SW SE sec. 23, T. 23 S., R. 10 E., Thrall 7.5-min quadrangle, Greenwood County, Kansas.
[Brownville Limestone Member through Americus Limestone Member, figs. 53, 54]

Locality 2—Roadcut on unimproved road north of Foraker, SW sec. 16, T. 29 N., R. 8 E., Foraker North 7.5-min quadrangle, type locality Foraker Formation, Osage County, Oklahoma (type locality for Foraker Limestone).
[Pony Creek Shale Member through Red Eagle Limestone, figs. 55, 56]

Locality 3—Roadcut on Kansas Highway K–38, SW SW sec. 22, T. 32 S., R. 8 E., Dexter NE 7.5-min quadrangle, Chautauqua County, Kansas.
[Brownville Limestone Member through West Branch Shale Member, figs 57, 58]

Locality 4—Roadcut on Kansas Highway K–38, south line of SE sec. 21, T. 32 S., R. 8 E., Dexter NE 7.5-min quadrangle, Cowley County, Kansas.
[West Branch Shale Member through Red Eagle Limestone, figs. 57, 59, 60]

Locality 5—Roadcut on north side of Interstate Highway I–70 southwest of Paxico, SW SE sec. 27, T. 11 S., R. 11 E., McFarland 7.5-min quadrangle, Wabaunsee County, Kansas.
[Foraker Limestone, figs. 61, 62]

Locality 6—Spillway cut for Tuttle Creek Dam, NE sec. 19, SE sec. 18, T. 9 S., R. 8 E., Tuttle Creek Dam 7.5-min quadrangle, Pottawatomie County, Kansas.
[Foraker Limestone through Beattie Limestone, figs. 63–67]

Locality 7—Roadcut on Kansas Highway K–38, NW NE sec. 30, T. 32 S., R. 8 E., Dexter NE 7.5-min quadrangle, Cowley County, Kansas.
[Red Eagle Limestone through Neva Limestone Member, figs. 68, 69]

Locality 8—Roadcut on north side of Kansas Highway K–18 (Fort Riley Boulevard) west of Manhattan, SW sec. 23, T. 10 S., R. 7 E., Manhattan 7.5-min quadrangle, Riley County, Kansas (co-type locality for Grenola Limestone).
[Grenola Limestone through Cottonwood Limestone Member, figs. 70, 71]

Locality 9—Railroad cuts, stream cutbank, and hillside exposures SE SW SW sec. 4, T. 31 S., R. 8 E., Grand Summit and Cambridge 7.5-min quadrangles, Cowley County, Kansas (type locality for Grenola Limestone).
[Red Eagle Limestone through Eiss Limestone Member, figs. 72–75]

Locality 10—Streambank cut immediately east of Cowley County Road 7 near Hooser, Kansas, NW NW sec. 36, T. 33 S., R. 7 E., Cowley County, Kansas.
[Cottonwood Limestone Member through Crouse Limestone, figs. 76–78]

Locality 11—Roadcut on both west and east sides of Anderson Road in Manhattan, Kansas, W/2 sec. 10, T. 10 S., R. 7 E., Keats 7.5-min quadrangle, Riley County, Kansas.
[Eskridge Shale through Middleburg Limestone Member, figs. 79–81]

Locality 12—Roadcut on east side of Scenic Drive in Manhattan, Kansas, NW sec. 22, NE sec. 21, T. 10 S., R. 7 E., Keats 7.5-min quadrangle, Riley County, Kansas.
[Stearns Shale through Schroyer Limestone Member, figs. 79, 82–85]

Locality 13—Roadcut on both sides of Kansas Highway K–38, NW sec. 30 (long section), T. 32 S., R. 8 E., Dexter NE 7.5-min quadrangle, Cowley County, Kansas.
[Middleburg Limestone Member through Threemile Limestone Member, figs. 68, 86–87]

Locality 14—Roadcut on Kansas Highway K–38, C/NL, NW sec. 30, T. 32 S., R. 7 E., Cowley County, Kansas.
[Speiser Shale through Schroyer Limestone Member, figs. 88, 89]

Locality 15—Railroad cut, 1.7 mi (2.7 km) east of Burden, Kansas, NE sec. 36, T. 31 S., R. 6 E., Cambridge 7.5-min quadrangle, Cowley County, Kansas.
[Kinney Limestone Member through Blue Springs Shale Member, figs. 90, 91]

Locality 16—Roadcut on Highway US–77 south of Junction City, Kansas, SE sec. 3, NW sec. 10, T. 13 S., R. 5.E., Wreford 7.5-min quadrangle, Geary County, Kansas.
[Kinney Limestone Member through Oketo Shale Member, figs. 92, 93]

Locality 17—Roadcut on Kansas Highway K–38, NW NW NW sec. 30, T. 32 S., R. 7 E., Cowley County, Kansas.
[Blue Springs Shale Member through Florence Limestone Member, figs. 88, 94]

Locality 18—Roadcut on Highway US–77 south of Junction City, Kansas, NE sec. 34, T. 12 S., R. 5 E., Wreford 7.5-min quadrangle, Geary County, Kansas.
[Florence Limestone Member through Fort Riley Limestone Member, figs. 92, 95]

Locality 19—Roadcut on Highway US–54, NL, NW sec. 9, T. 26 S., R. 8 E., Rosalia 7.5-min quadrangle, Butler County, Kansas.
[Speiser Shale through Kinney Limestone Member, figs. 96, 97]

Locality 20—Roadcut on Highway US–50, NW sec. 17, T. 17 S., R. 8 E., Strong City 7.5-min quadrangle, Chase County, Kansas.
[Upper Eiss Limestone Member, figs. 98, 99]

Locality 21—Roadcut on east side of Kansas Highway K–177 on northwest side of Strong City, 200 m south of its intersection with Highway US–50, S/2, NW sec. 17, T. 17 S., R. 8 E., Strong City 7.5-min quadrangle, Chase County, Kansas.
[Florena Shale Member through Eiss Limestone Member, figs. 98, 100]

Locality 22—Roadcut at intersection of Highway US–60 and Oklahoma Highway OK–18, due southeast of Burbank,

Oklahoma, C/WL, sec. 32, T. 26 N., R. 6 E., Burbank 7.5-min quadrangle, Osage County, Oklahoma.
[Salem Point Shale Member through Neva Limestone Member, figs. 101, 102]

Locality 23—Roadcut on Highway US–77 northeast of Junction City, Kansas, E/L N/2 sec. 28, E/L, NW sec. 34, T. 11 S., R. 4 E., Junction City 7.5-min quadrangle, Geary County, Kansas.
[Florence Limestone Member through Towanda Limestone Member, figs. 103, 104]

Auxiliary Localities

Locality A1—Roadcut on unimproved road south of Highway US–166, NE NE long sec. 30, T. 32 S., R. 8 E., Dexter NE 7.5-min quadrangle, Cowley County, Kansas.
[Five Point Limestone Member through Americus Limestone Member, figs. 68, 105]

Locality A2—Lakeside exposure on Adams Lake on Acker Creek, center of sec. 16, T. 29 N., R. 8 E., Foraker North 7.5-min quadrangle, type locality Foraker Formation, Osage County, Oklahoma (type locality for Foraker Limestone).
[Brownville Limestone Member through Falls City Limestone, figs. 55, 106]

Locality A3—Streambank cut just south of Bennet, Nebraska, east of center line, NW SW NE sec. 10, T. 8 N., R. 8 E., Bennett 7.5-min quadrangle, Lancaster County, Nebraska (type locality for Bennett Shale).
[Red Eagle Limestone, figs. 107, 108]

Locality A4—Quarries on the east side of Burbank, SE and NE sec. 25, T. 26 N., R. 5 E., Burbank 7.5-min quadrangle, Osage County, Oklahoma (principal reference section for the Red Eagle Limestone).
[Foraker Limestone through Neva Limestone Member, figs. 101, 109, 110]

Locality A5—Roadcut on north side of I–70, CNL of SW sec. 28, T. 11 S., R 10 E., Alma 7.5-min quadrangle, Wabaunsee County, Kansas.
[Threemile Limestone Member, figs. 111, 112]

Locality A6—Roadcut on north side of I–70, CNL of SW sec. 29, T. 11 S., R. 10 E., Alma 7.5-min quadrangle, Wabaunsee County, Kansas.
[Crouse Limestone through Funston Limestone, figs. 111, 113]

Locality A7—Roadcut on north side of I–70, NE SE sec. 30, T. 11 S., R. 10 E., Alma 7.5-min quadrangle, Wabaunsee County, Kansas.
[Stearns Shale through Crouse Limestone, figs. 111, 114]

Locality A8—Roadcut on I–70, SW sec. 27, T. 11 S., R. 12 E., Maple Hill 7.5-min quadrangle, Wabaunsee County, Kansas.
[Foraker Limestone, figs. 115, 116]

Locality A9—Roadcut on I–70, NL NW sec. 31, T. 11 S., R. 12 E., Maple Hill 7.5-min quadrangle, Wabaunsee County, Kansas.
[Foraker Limestone, figs. 115, 117]

Locality A10—Roadcut on Highway US–166, NW long sec. 7, T. 34 S., R. 8 E., Dexter 7.5-min quadrangle, Cowley County, Kansas.
[Foraker Limestone, figs. 118, 119]

Locality A11—Roadcut south of Highway US–166, SL W/2 long sec. 7, T. 34 S., R. 8 E., Dexter 7.5-min quadrangle, Cowley County, Kansas.
[West Branch Shale Member through Americus Limestone Member, figs. 118, 120]

Locality A12—Roadcut, NL NE NW sec. 27, T. 8 S., R. 10 E., Louisville 7.5-min quadrangle, Pottawatomie County, Kansas.
[Brownville Limestone Member through Falls City Limestone, figs. 121, 122]

Locality A13—Roadcut, NL NW NW NW sec. 9, T. 8 S., R. 10 E., Westmoreland NE 7.5-min quadrangle, Pottawatomie County, Kansas.
[Houchen Creek limestone bed through Foraker Limestone, figs. 123, 124]

Locality A14—Roadcut, NL NW NW sec. 10, T. 8 S., R. 10 E., Westmoreland NE 7.5-min quadrangle, Pottawatomie County, Kansas.
[Foraker Limestone, figs. 123, 125]

Locality A15—Roadcut, NL NW sec. 11, T. 8 S., R. 10 E., Westmoreland NE 7.5-min quadrangle, Pottawatomie County, Kansas.
[Brownville Limestone Member through Five Point Limestone Member, figs. 123, 126]

Locality A16—Streambank cut, NW NW NW sec. 8, T. 9 S., R. 9 E., Flush 7.5-min quadrangle, Pottawatomie County, Kansas.
[West Branch Shale Member through Five Point Limestone Member, figs. 127, 128]

Locality A17—Roadcut NL NE sec. 7, T. 9 S., R. 9 E., Flush 7.5-min quadrangle, Pottawatomie County, Kansas.
[Houchen Creek limestone bed, figs. 127, 129]

Locality A18—Roadcut on Cowley County Road 5, adjoining sec. 3 and 4, T. 31 S., R. 6 E., Atlanta 7.5-min quadrangle, Cowley County, Kansas.
[Kinney Limestone Member, figs. 130, 131]

Locality A19—Roadcut section line road separating sec. 2 and 3, C/WL NW sec. 2, C/EL NE sec. 3, T. 12 S., R. 12 E., Keene 7.5-min quadrangle, Wabaunsee County, Kansas.
[West Branch Shale Member through Five Point Limestone Member, figs. 132, 133]

Locality A20—Roadcut on I–70, C/SL SW sec. 26, T. 11 S., R. 12 E., Maple Hill 7.5-min quadrangle, Wabaunsee County, Kansas.
[Brownville Limestone Member through Aspinwall Limestone Member, figs. 134, 135]

Locality A21—Roadcut, NW SW sec. 15, T. 1 N., R. 13 E., Humboldt SW 7.5-min quadrangle, Richardson County, Nebraska.
[Foraker Limestone, figs. 136, 137]

Locality A22—Roadcut, SW SW sec. 14, and the SE SE sec. 15, T. 1 N., R. 13 E., Humboldt 7.5-min quadrangle, Richardson County, Nebraska.
[Grenola Limestone, figs. 136, 138]

Locality A22—Roadcut, SW SW sec. 14, and the SE SE sec. 15, T. 1 N., R. 13 E., Humboldt 7.5-min quadrangle, Richardson County, Nebraska.
[Grenola Limestone, figs. 136, 138]

Locality A23—Roadcuts on north side of road from Elmdale to Cottonwood Falls, SE SW NW sec. 26, T. 19 S., R. 7 E., Elmdale 7.5-min quadrangle, Chase County, Kansas (type locality for Neva Limestone Member).
[Johnson Shale through Cottonwood Limestone Member, figs. 139–142]

Locality A24—Spillway exposure for Shidler Lake (formerly called Phillips Lake) and adjacent roadcut on Oklahoma Highway OK–18, N/2 sec. 10, T. 26 N., R. 6 E., Osage County, Oklahoma.
[Hamlin Shale Member through Foraker Limestone, figs. 143, 144]

Locality A25—Streambank cut, C/EL SE NE sec. 8, T. 8 S., R. 10 E., Louisville 7.5-min quadrangle, Pottawatomie County, Kansas.
[West Branch Shale Member through Five Point Limestone Member, figs. 145, 146]

Locality A26—Hillside exposure, NW SE sec. 33, T. 7 S., R. 11 E., Onaga 7.5-min quadrangle, Pottawatomie County, Kansas.
[Aspinwall Limestone Member through Houchen Creek limestone bed, figs. 147, 148]

Locality A27—Roadcut on north side of westbound lane of Highway US–166, NE sec. 11, T. 34 S., R. 7 E., Dexter SW 7.5-min quadrangle, Cowley County, Kansas.
[Crouse Limestone, figs. 149, 150]

Locality A28—Roadcut on eastbound lane of Highway US–166, NW sec. 11, T. 34 S., R. 7 E., Dexter SW 7.5-min quadrangle, Cowley County, Kansas.
[Blue Rapids Shale through Funston Limestone, figs. 149, 151]

Locality A29—Roadcut on eastbound lane of Highway US–166, C/NW sec. 8, T. 34 S., R. 7 E., Dexter SW 7.5-min quadrangle, Cowley County, Kansas.
[Speiser Shale through Schroyer Limestone Member, figs. 152, 153]

Locality A30—Roadcut on Highway US–166, C/N2 sec. 12, T. 34 S., R. 6 E., Dexter SW 7.5-min quadrangle, Cowley County, Kansas.
[Funston Limestone through Threemile Limestone Member, figs. 152, 154]

Locality A31—Roadcut on south side of road from Elmdale to Cottonwood Falls, 1.8 mi (2.9 km) west of its intersection with highway US–177, NE sec. 30, T. 19 S., R. 8 E., Cottonwood Falls 7.5-min quadrangle, Chase County.
[Eiss Limestone Member through Crouse Limestone, figs. 155, 156]

Locality A32—Roadcut on west side of Highway US–177 at a point 2.9 mi (4.6 km) north of its intersection with Highway US–50, C/EL sec. 31 (long section), T. 18 S., R. 8 E., Strong City 7.5-min quadrangle, Chase County, Kansas.
[Eiss Limestone Member through Middleburg Limestone Member, figs. 157, 158]

Locality A33—Roadcut on east side of Highway US–177 at a point 5.3–5.5 mi north of its intersection with Highway US–50, NW sec. 20, T. 18 S., R. 8 E., Strong City 7.5-min quadrangle, Chase County, Kansas.
[Blue Rapids Shale through Funston Limestone, figs. 159, 160]

Locality A34—Roadcut on eastbound land of Highway US–166, C sec. 22, T. 34 S., R. 5 E., Maple City 7.5-min quadrangle, Cowley County, Kansas.
[Barneston Limestone, figs. 161, 162]

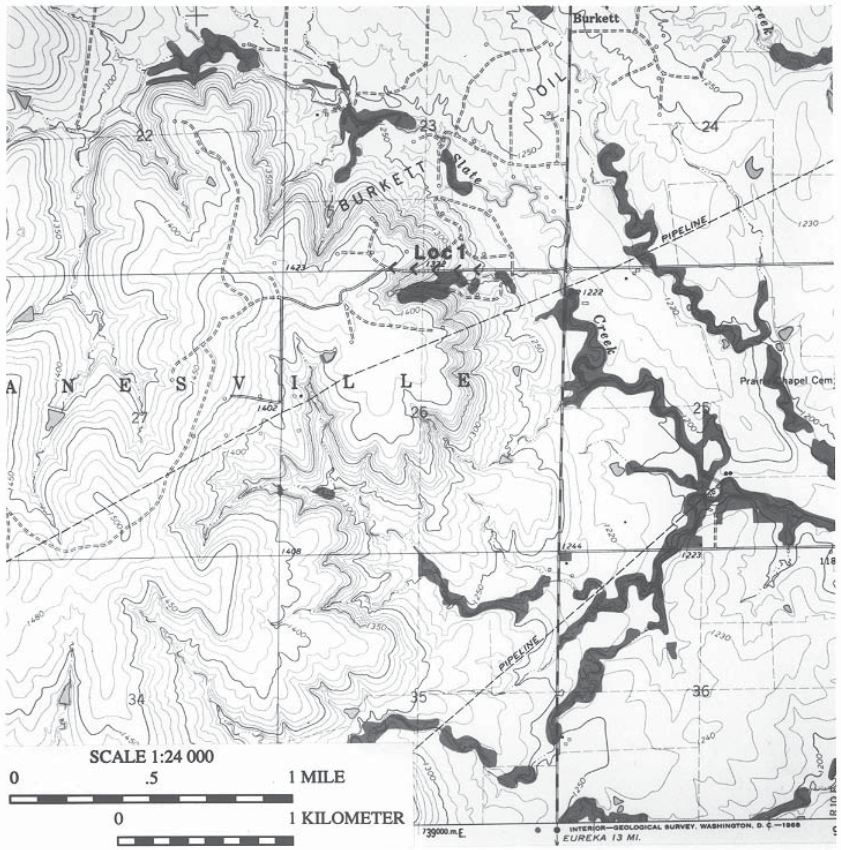

FIGURE 53—Map showing location of Locality 1.

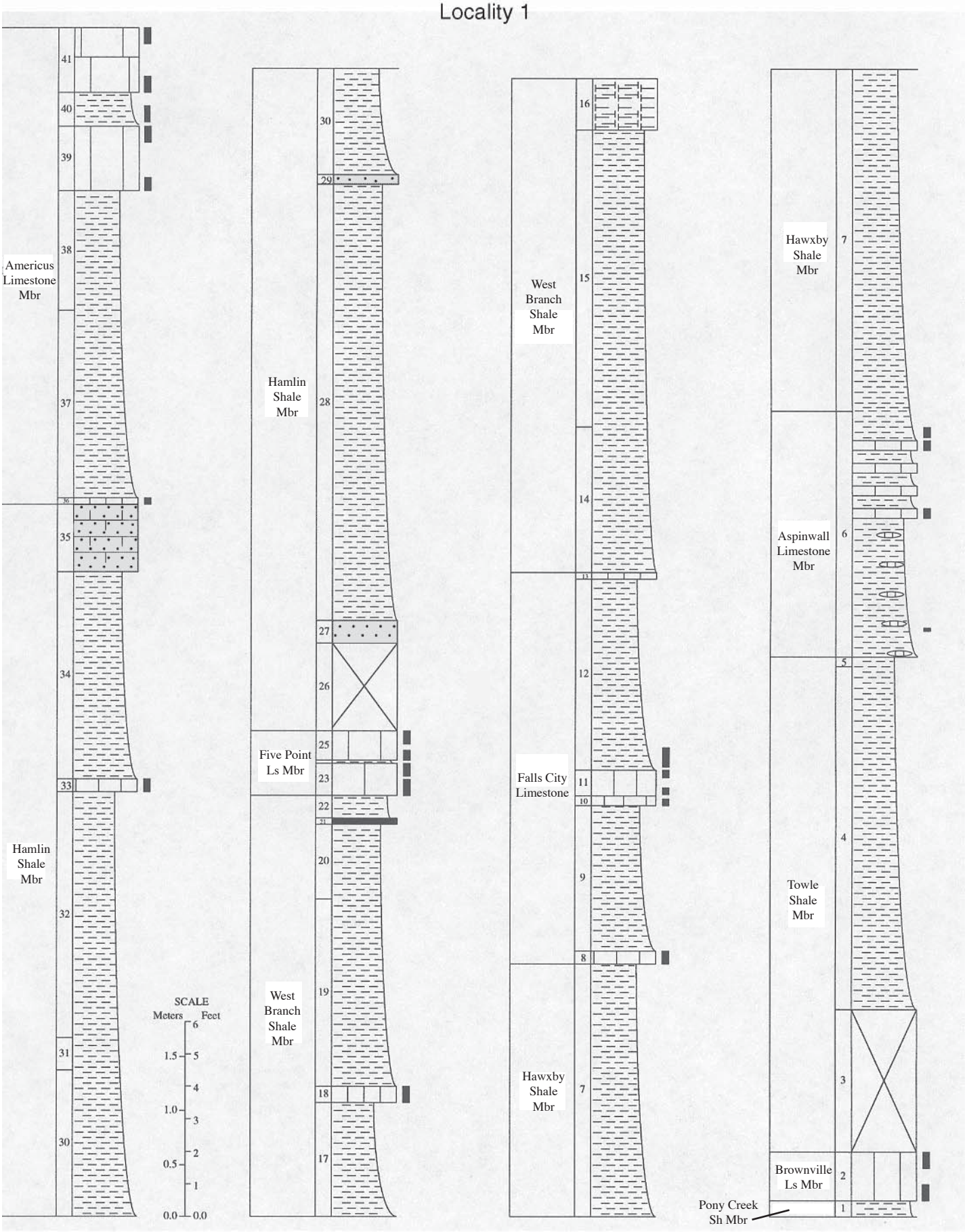

FIGURE 54—Measured section Locality 1–Type Janesville, uppermost Pony Creek Shale Member to Americus Limestone Member.

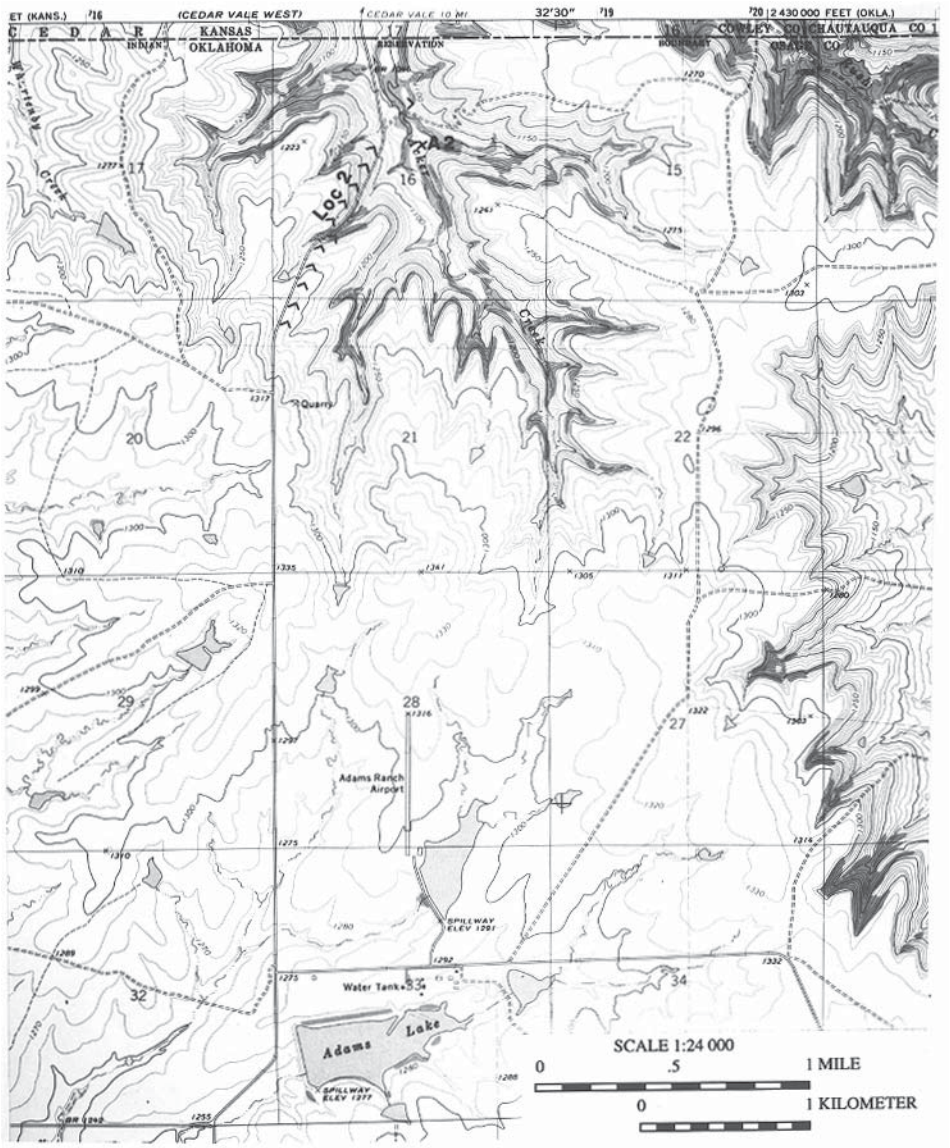

FIGURE 55—Map showing locations of Localities 2 and A2.

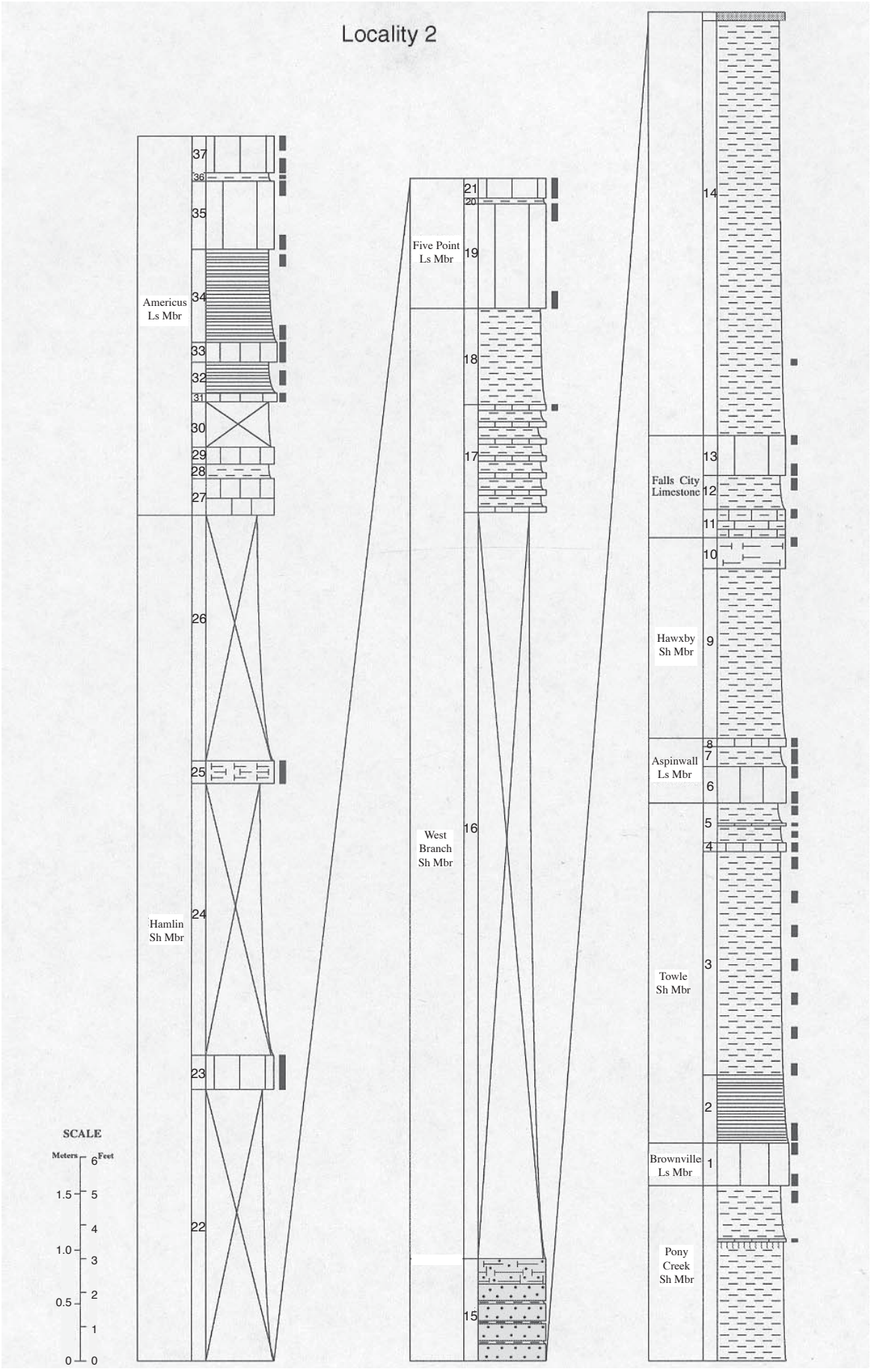

FIGURE 56—Measured section Locality 2–Type Foraker, upper Pony Creek Shale Member through Americus Limestone Member, samples and sample interval indicated by bars beside column.

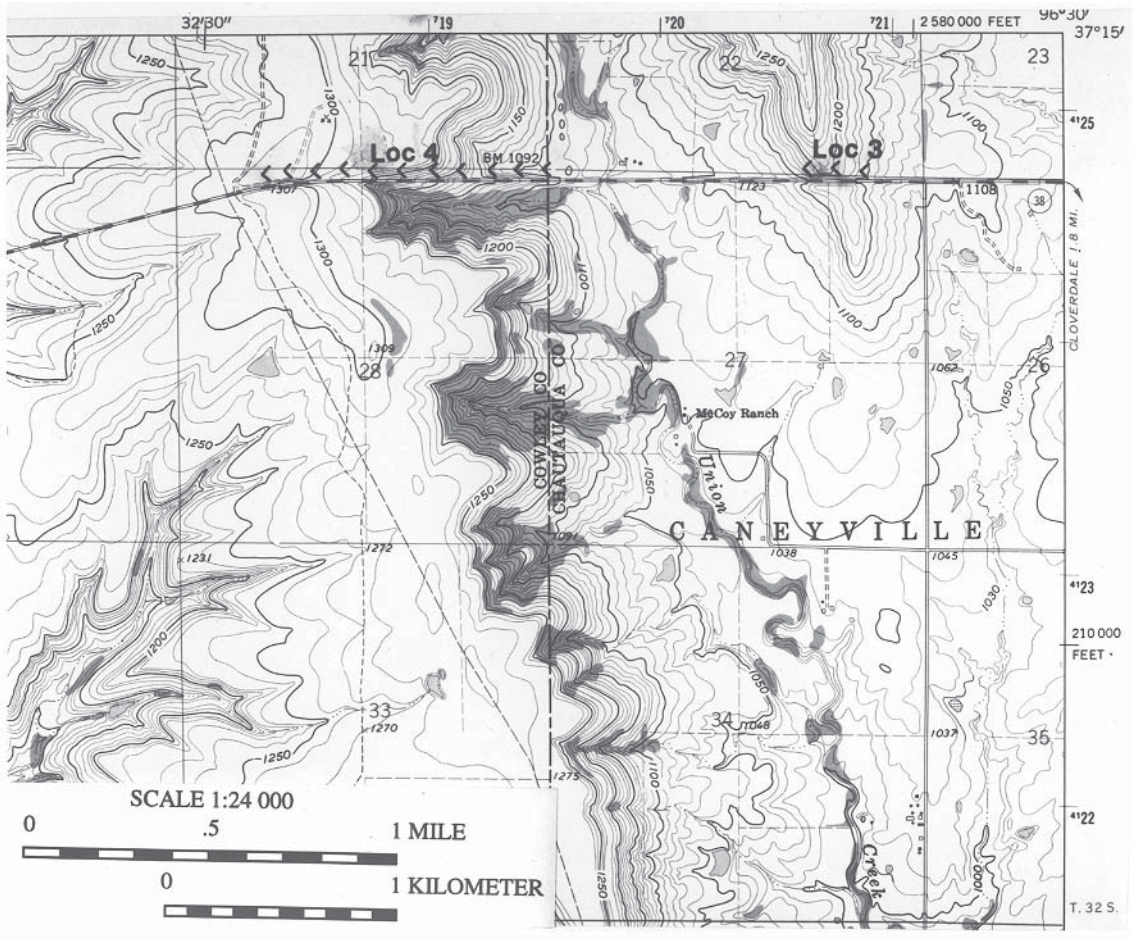

FIGURE 57—Map showing location of Localities 3 and 4.

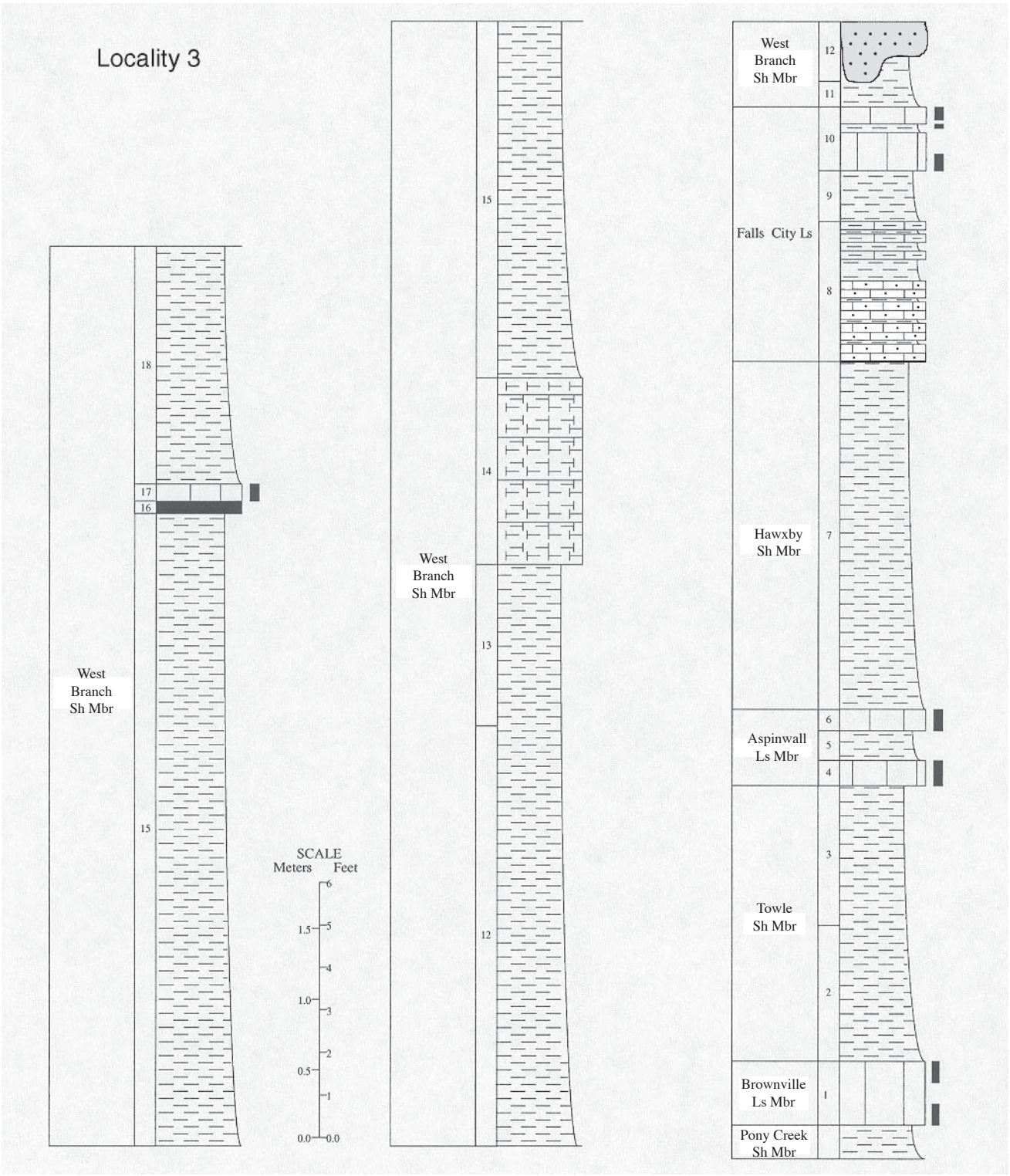

FIGURE 58—Measured section Locality 3–uppermost Pony Creek Shale Member through West Branch Shale Member, samples and sample interval indicated by bars beside column.

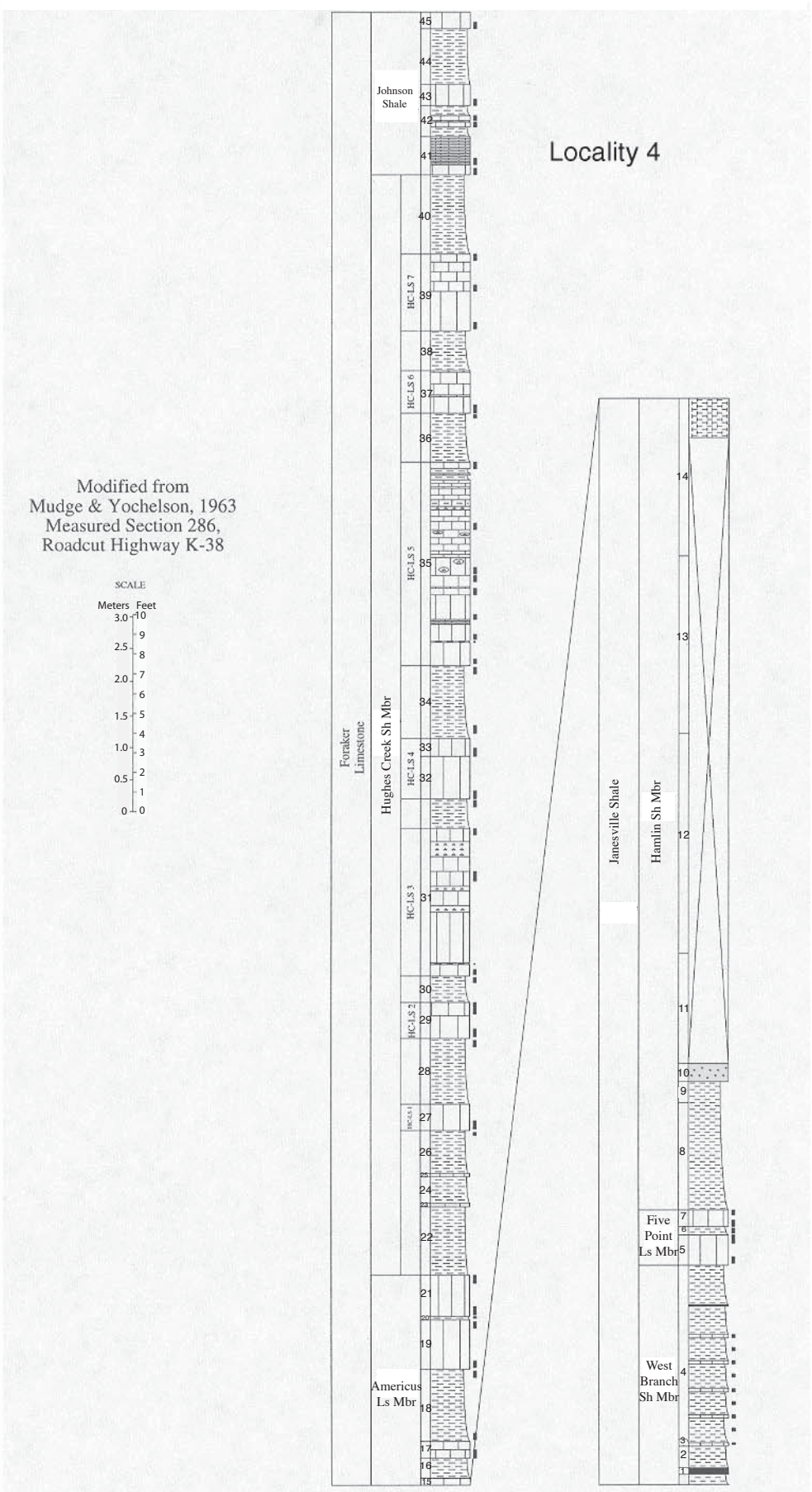

FIGURE 59—Measured section Locality 4–West Branch Shale Member through Long Creek Limestone Member (modified from Mudge and Yochelson, 1963, section 286), samples and sample interval indicated by bars beside column.

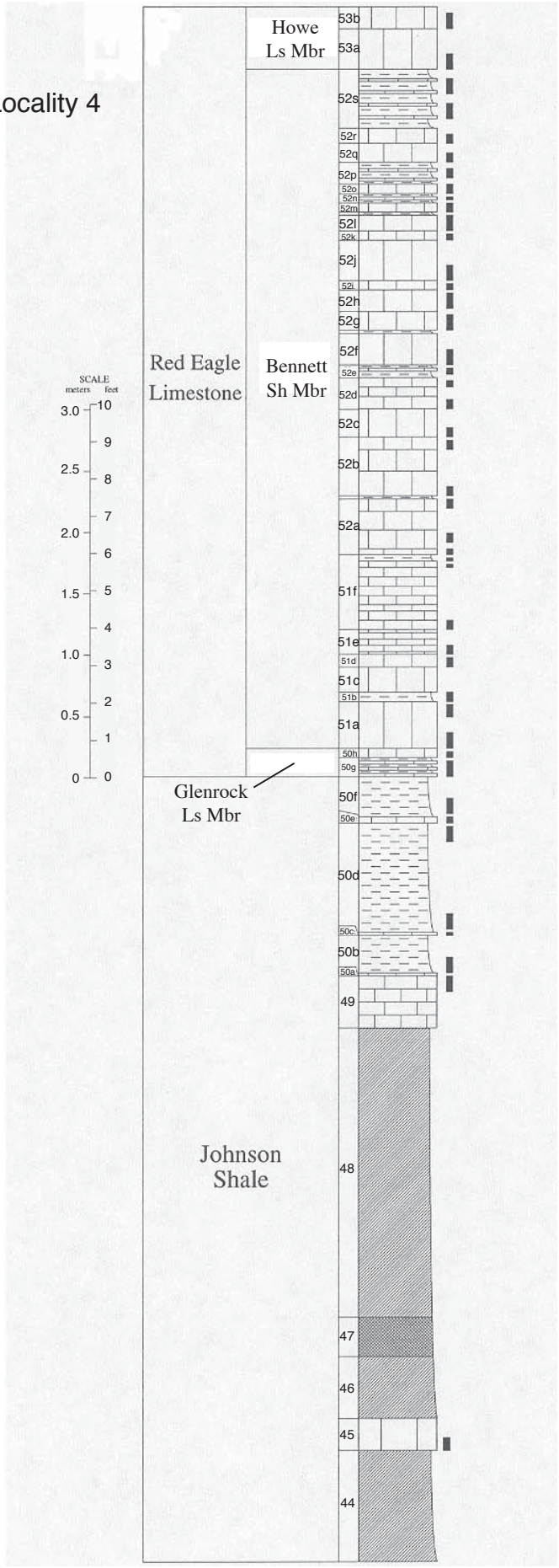

FIGURE 60—Measured section Locality 4–Johnson Shale through Howe Limestone Member, samples and sample interval indicated by bars beside column.

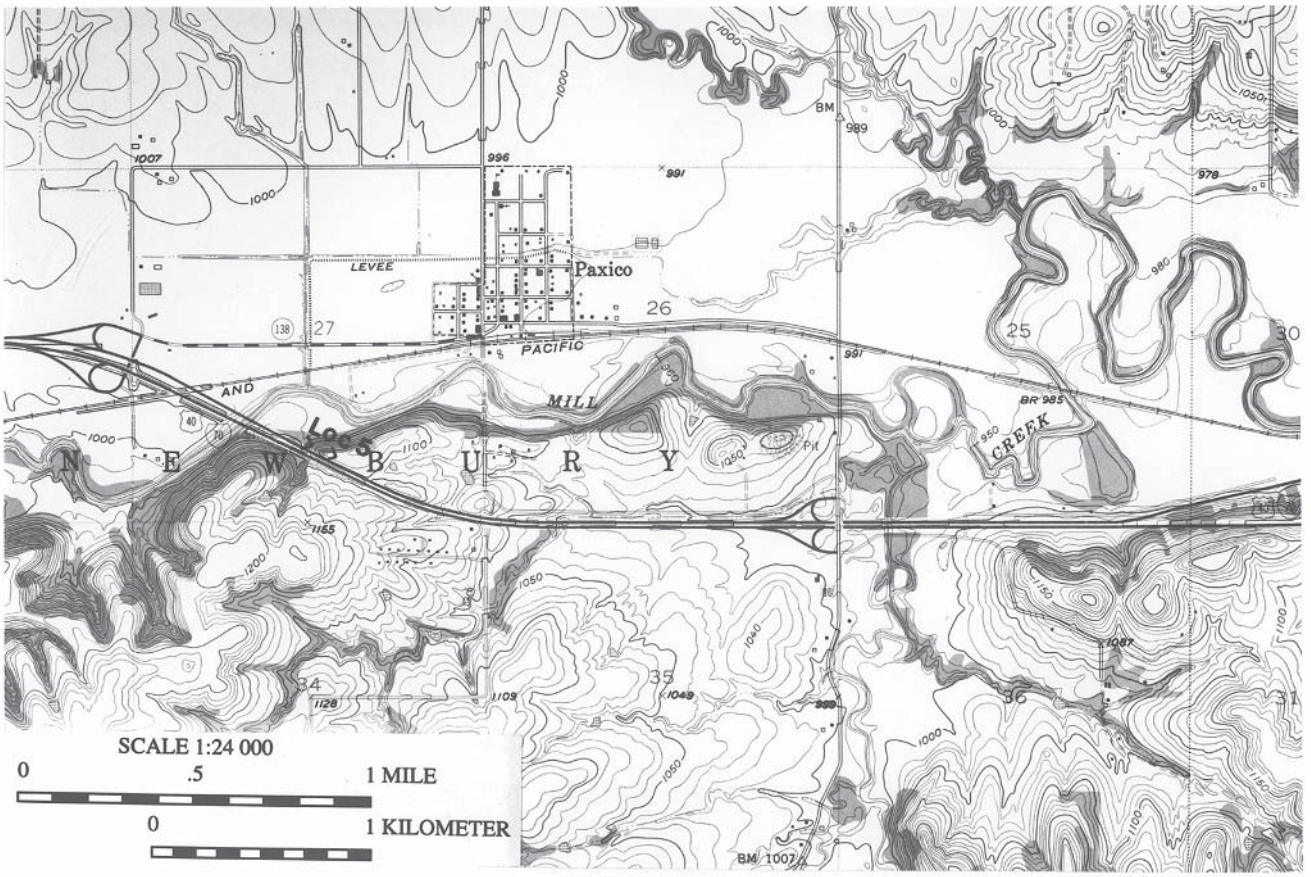

FIGURE 61—Map showing location of Locality 5, Paxico.

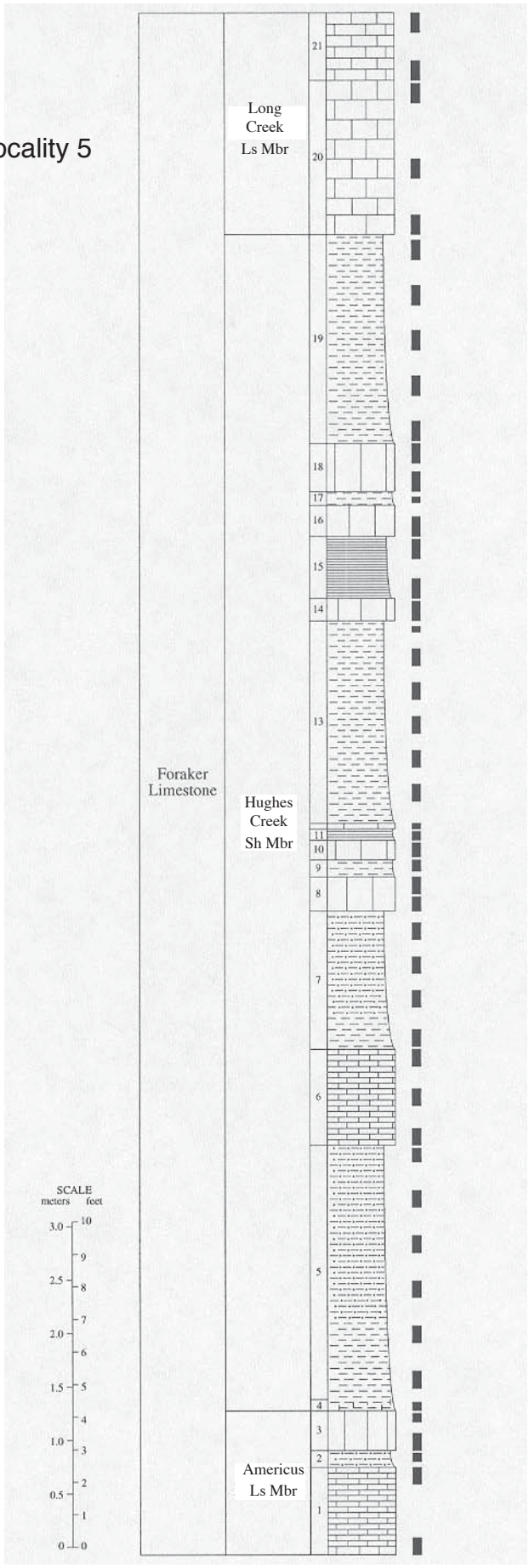

FIGURE 62—Measured section Locality 5–Americus Limestone Member through Long Creek Limestone Member (Foraker Limestone), samples and sample interval indicated by bars beside column.

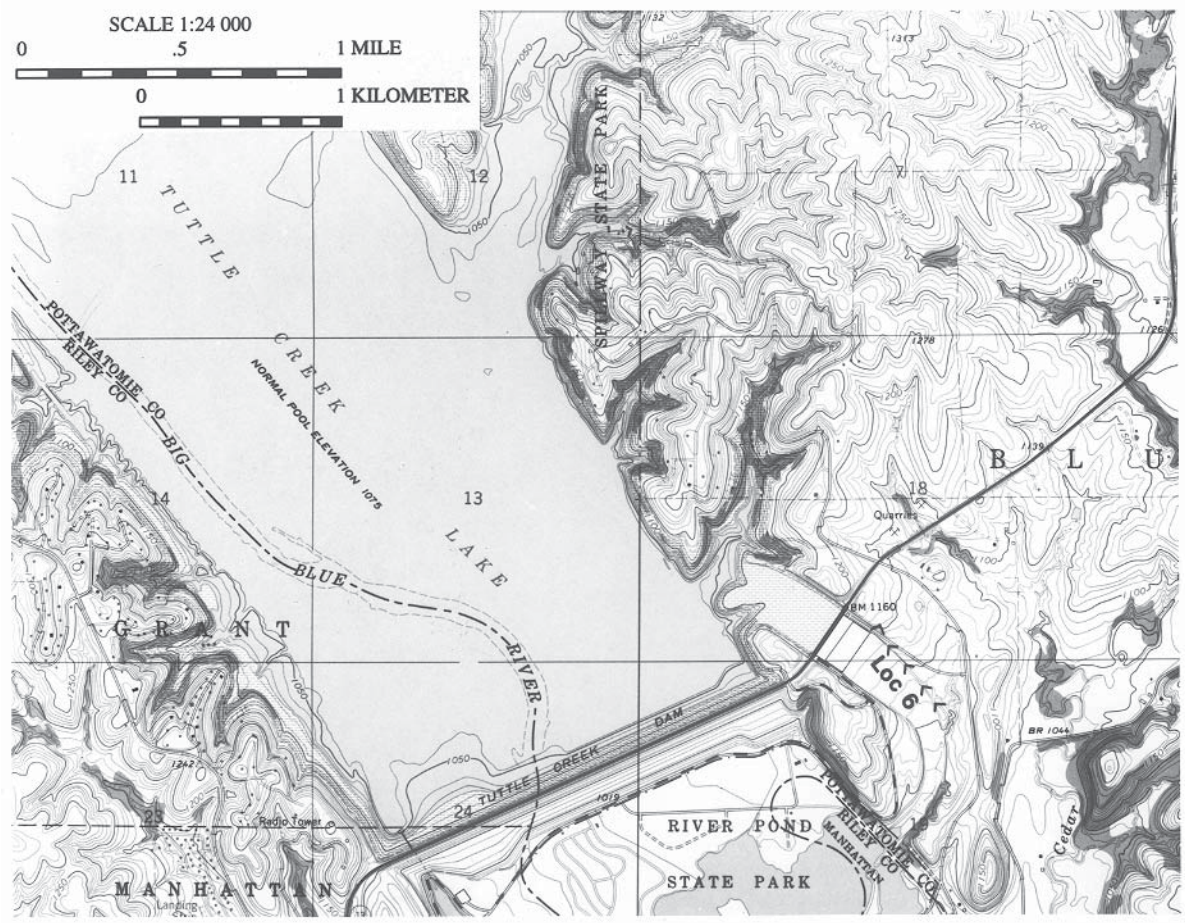

FIGURE 63— Map showing location of Locality 6, Tuttle Creek.

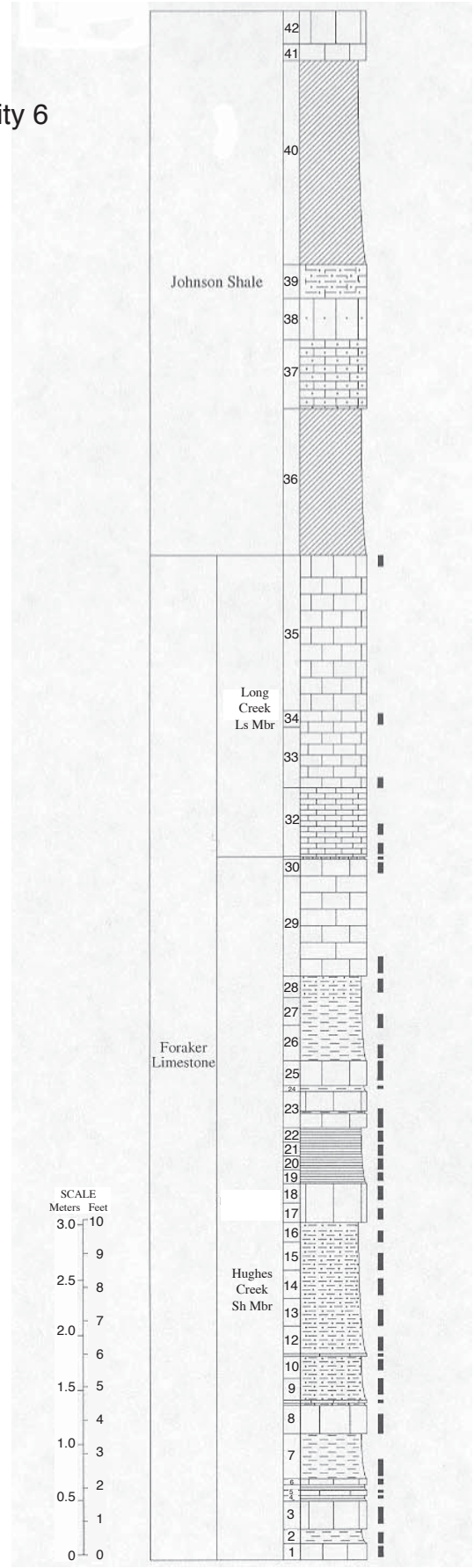

FIGURE 64—Measured section Locality 6–Hughes Creek Shale Member through Johnson Shale, samples and sample interval indicated by bars beside column.

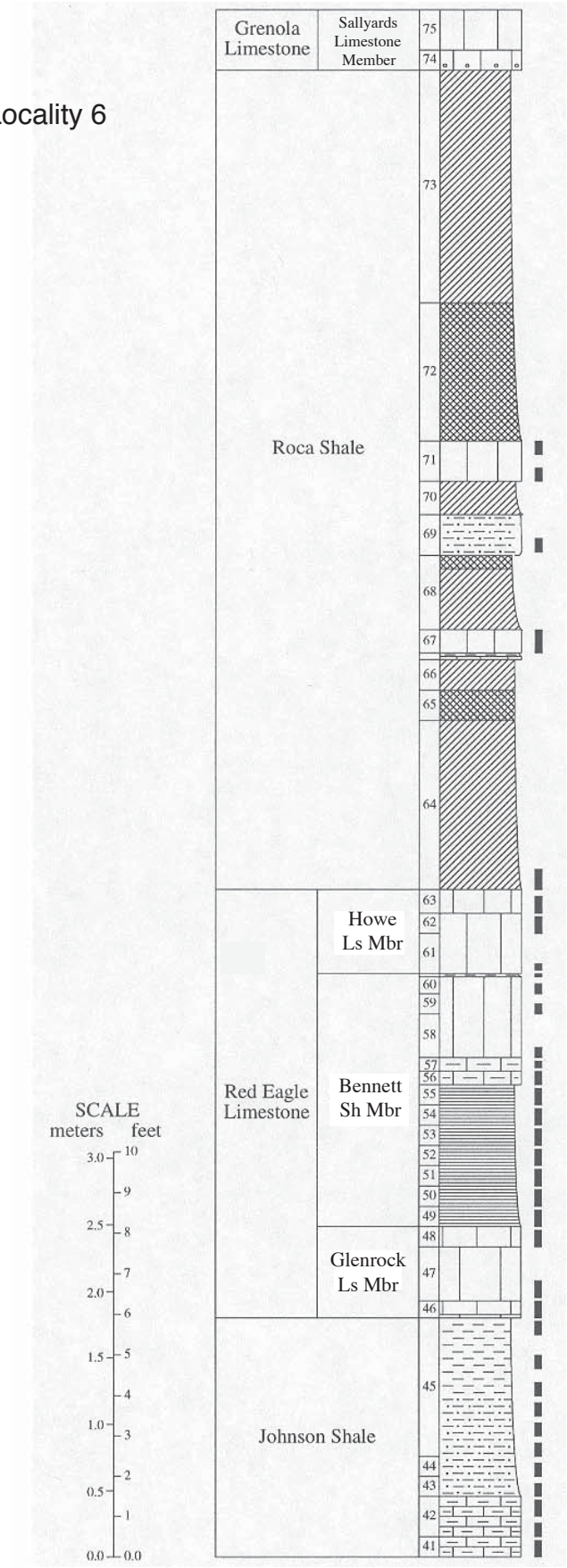

FIGURE 65—Measured section Locality 6–Johnson Shale through Sallyards Limestone Member, samples and sample interval indicated by bars beside column.

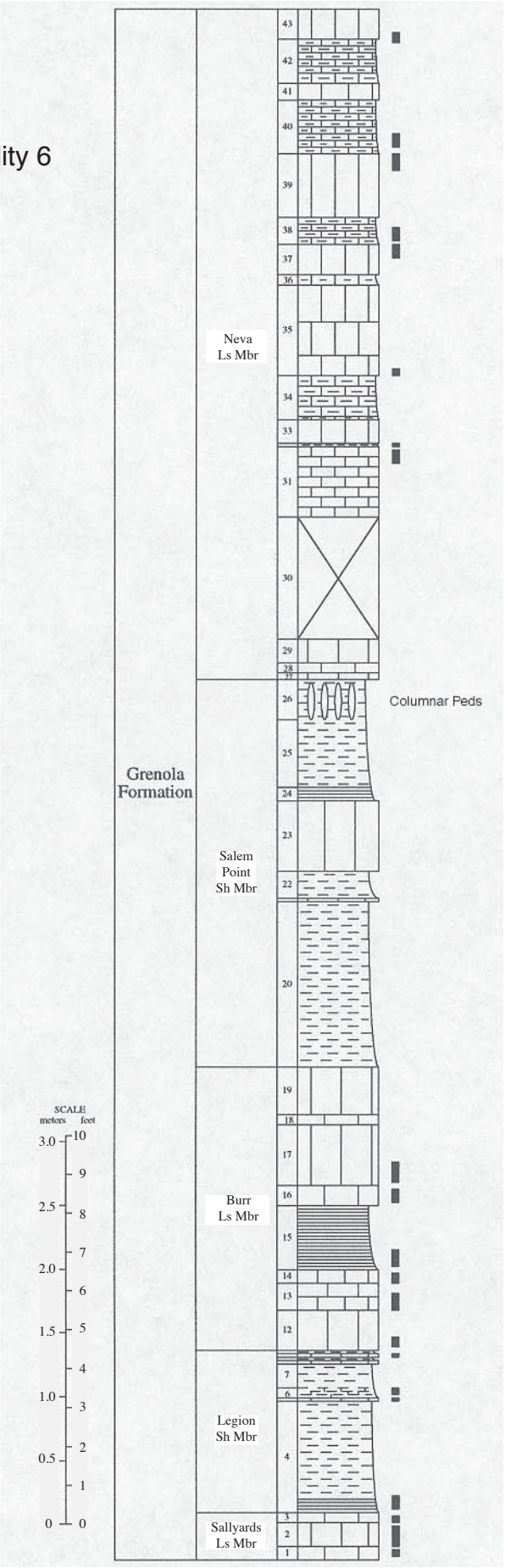

FIGURE 66—Measured section Locality 6–Sallyards Limestone Member through Neva Limestone Member, samples and sample interval indicated by bars beside column.

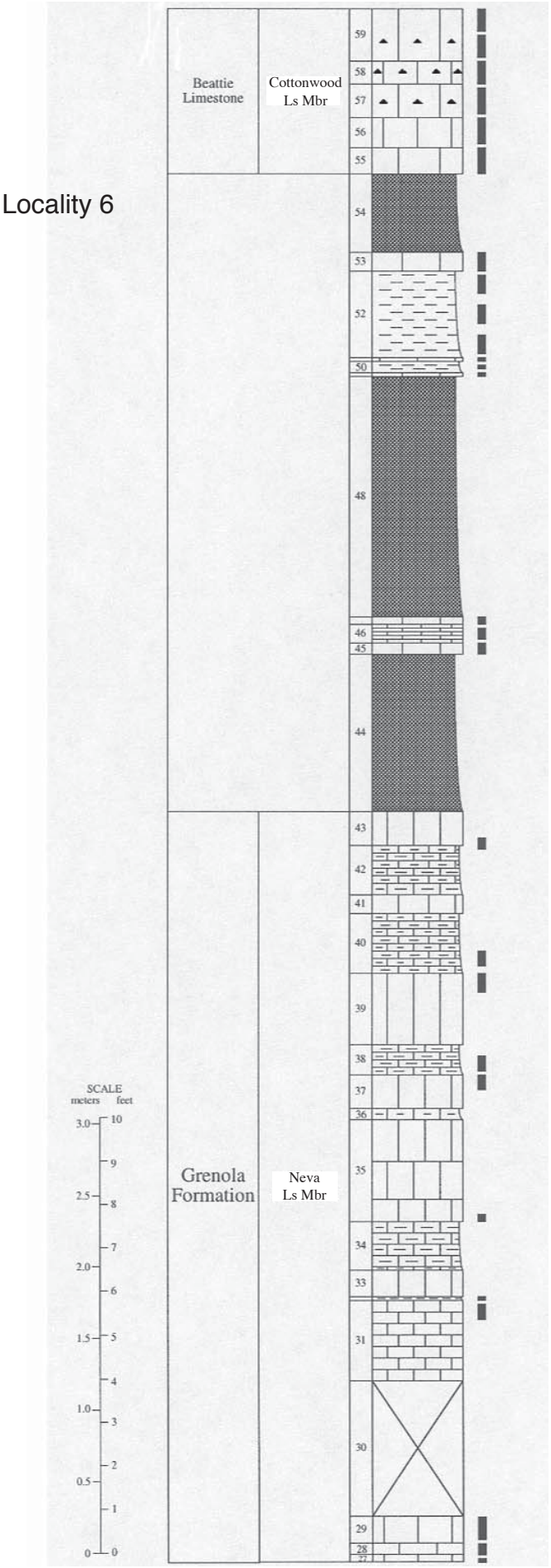

FIGURE 67—Measured section Locality 6–Neva Limestone Member, Eskridge Shale, and Cottonwood Limestone Member, samples and sample interval indicated by bars beside column.

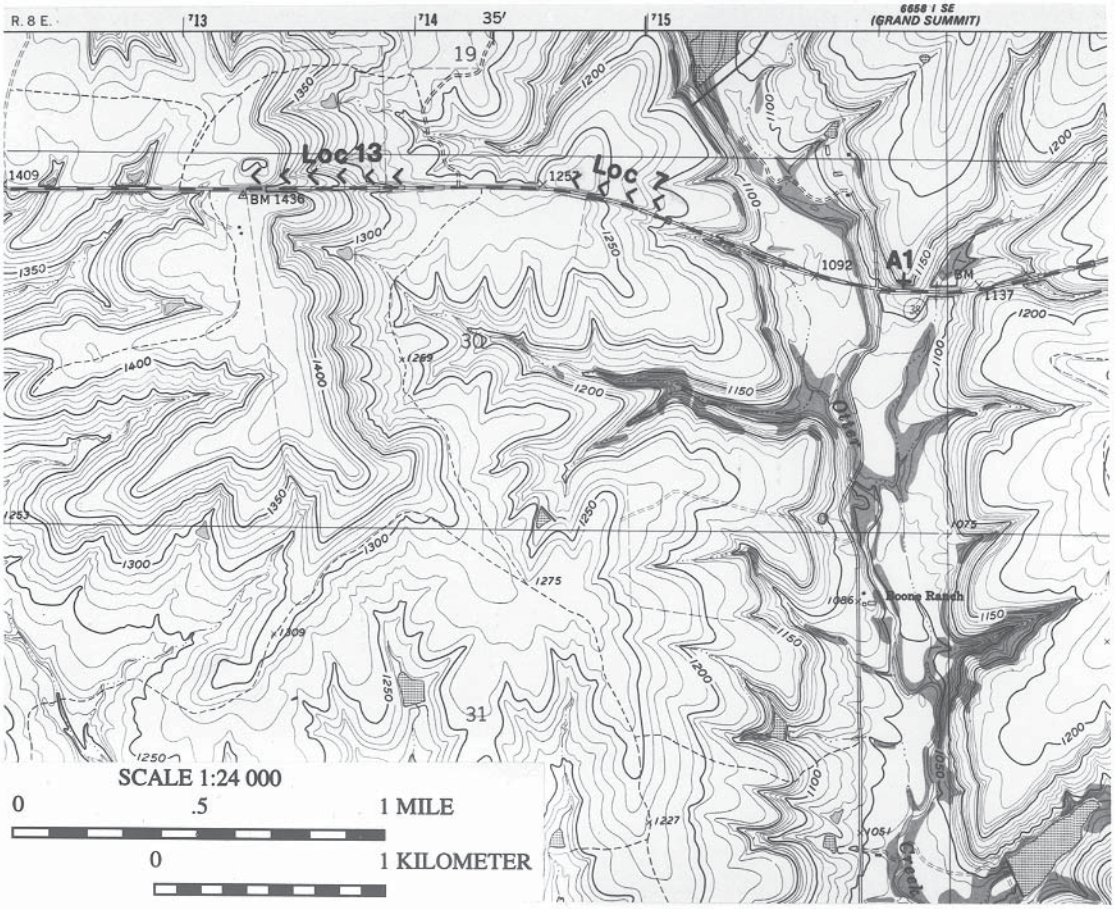

FIGURE 68—Map showing location of Localities 7, 13, and A1, Kansas K–38.

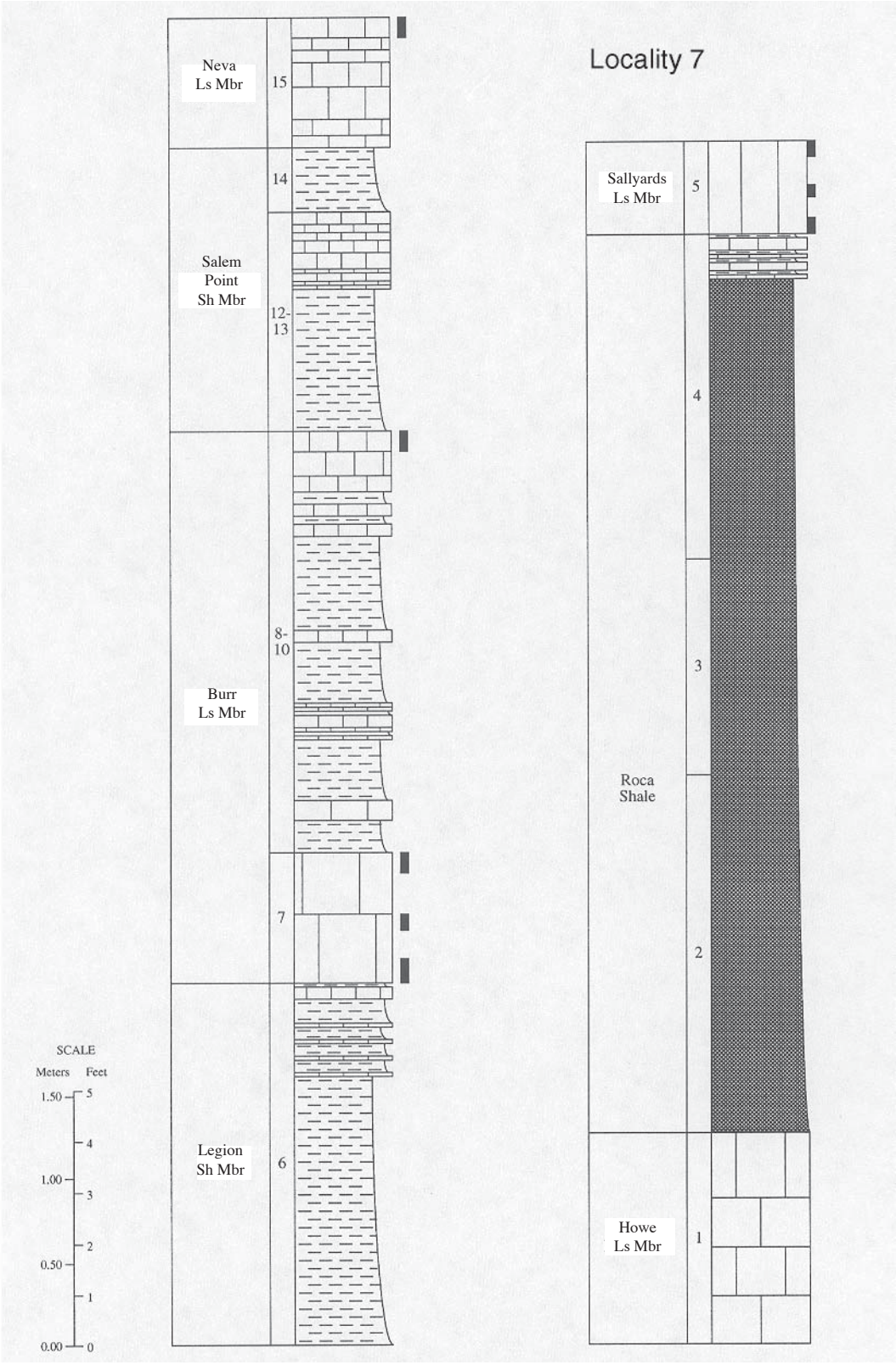

FIGURE 69—Measured section Locality 7–Howe Limestone Member through Neva Limestone Member, samples and sample interval indicated by bars beside column.

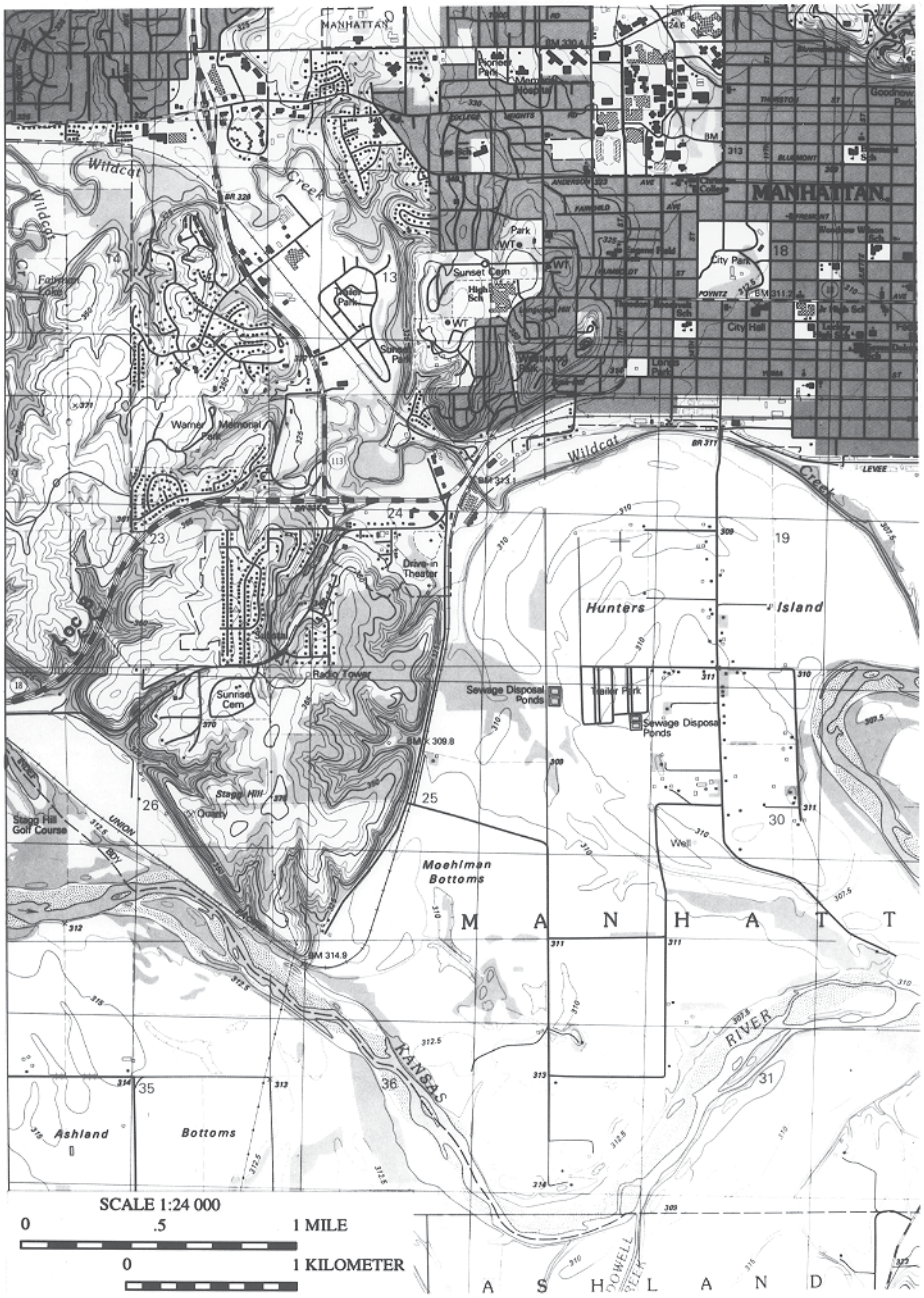

FIGURE 70—Map showing location of Locality 8, Manhattan.

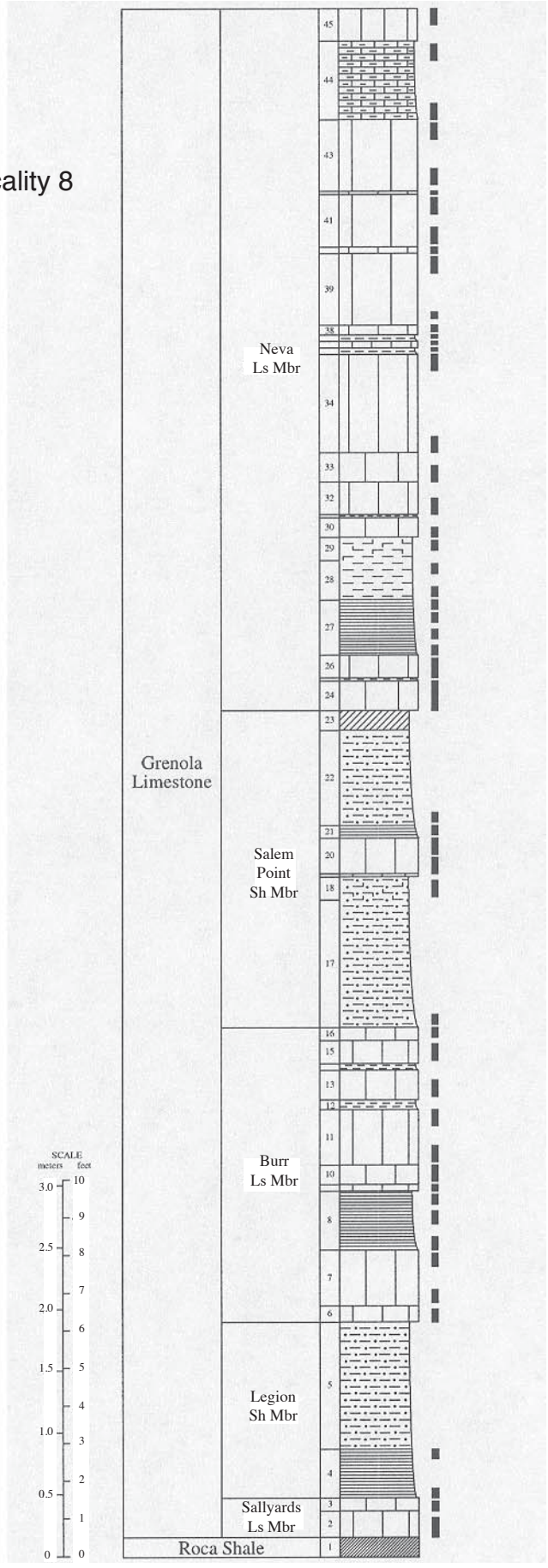

FIGURE 71—Measured section Locality 8–upper Roca Shale through Neva Limestone Member, samples and sample interval indicated by bars beside column.

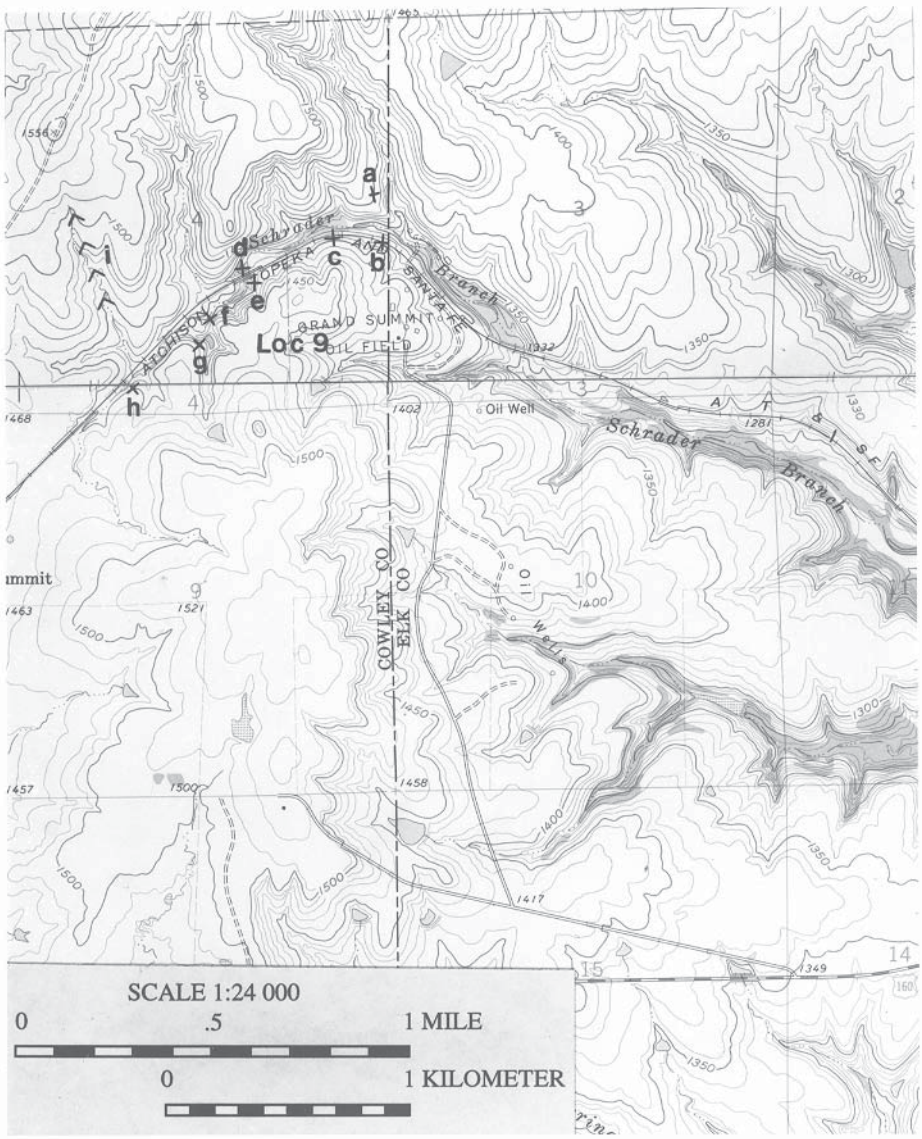

FIGURE 72—Map showing location of Locality 9, a series of short sections, a–i used for a composite.

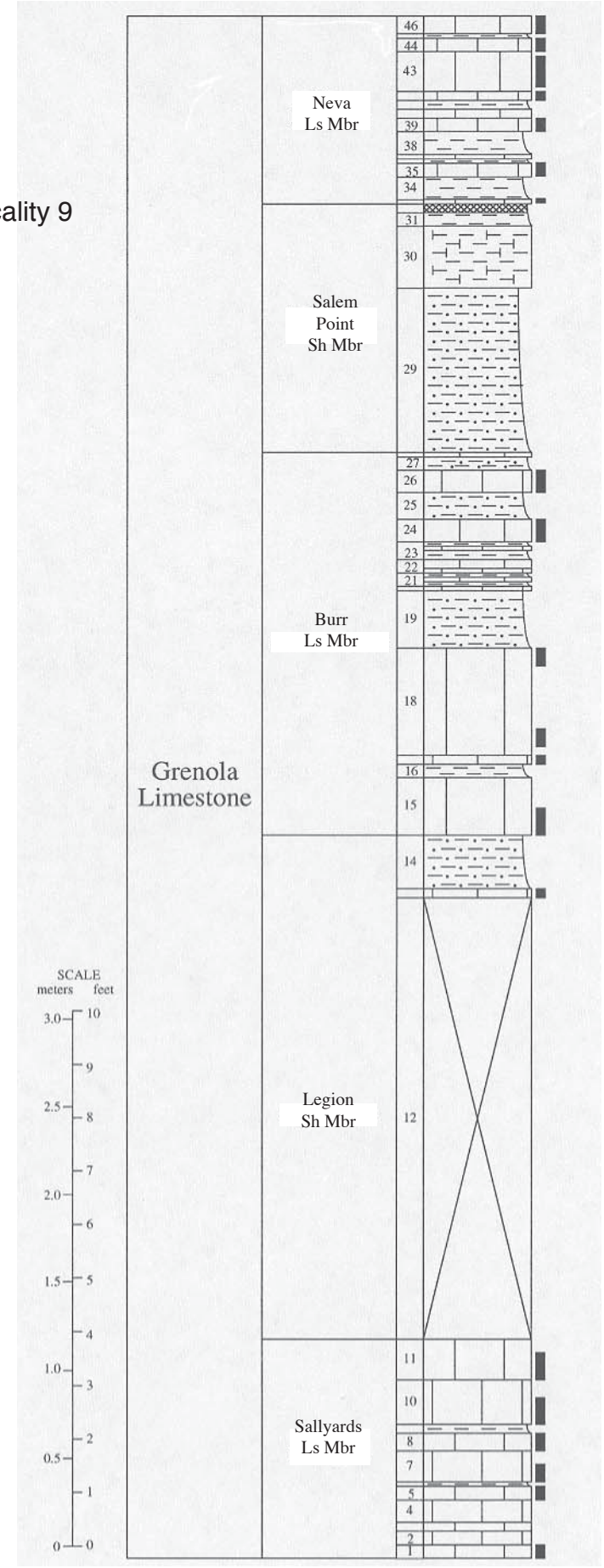

FIGURE 73—Composite section Locality 9–Sallyards Limestone Member through Neva Limestone Member, samples and sample interval indicated by bars beside column.

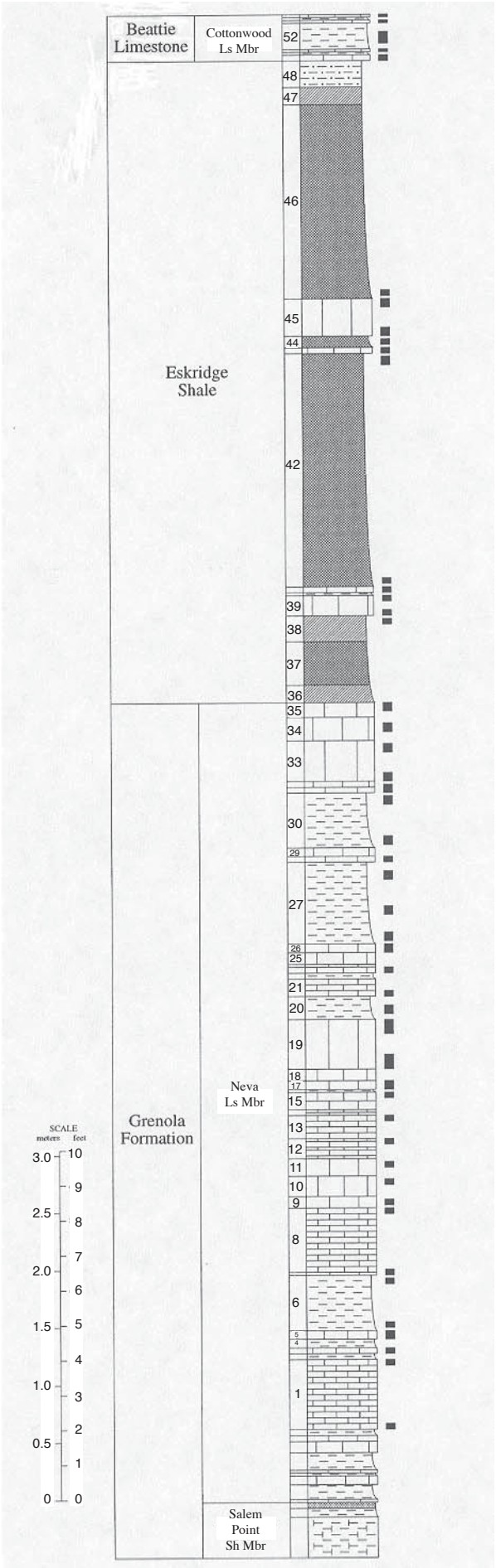

FIGURE 74—Composite section Locality 9–upper Salem Point Shale Member through lower Cottonwood Limestone Member, samples and sample interval indicated by bars beside column.

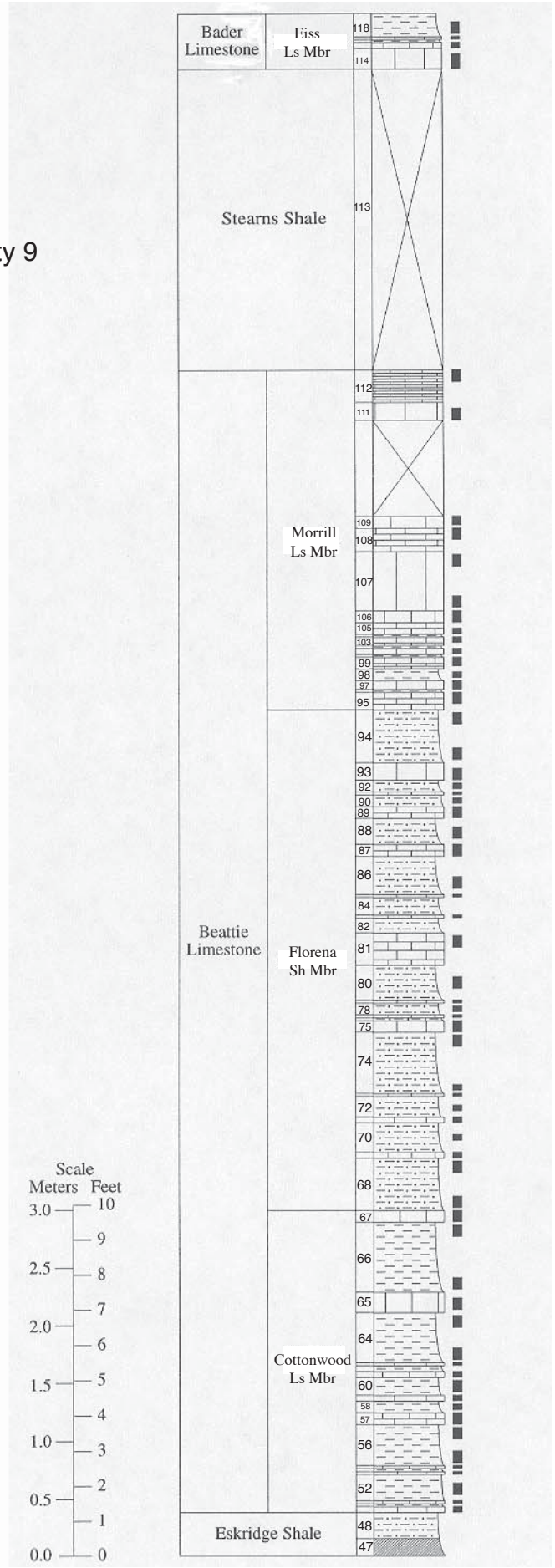

FIGURE 75—Composite section Locality 9–Cottonwood Limestone Member through Eiss Limestone Member, samples and sample interval indicated by bars beside column.

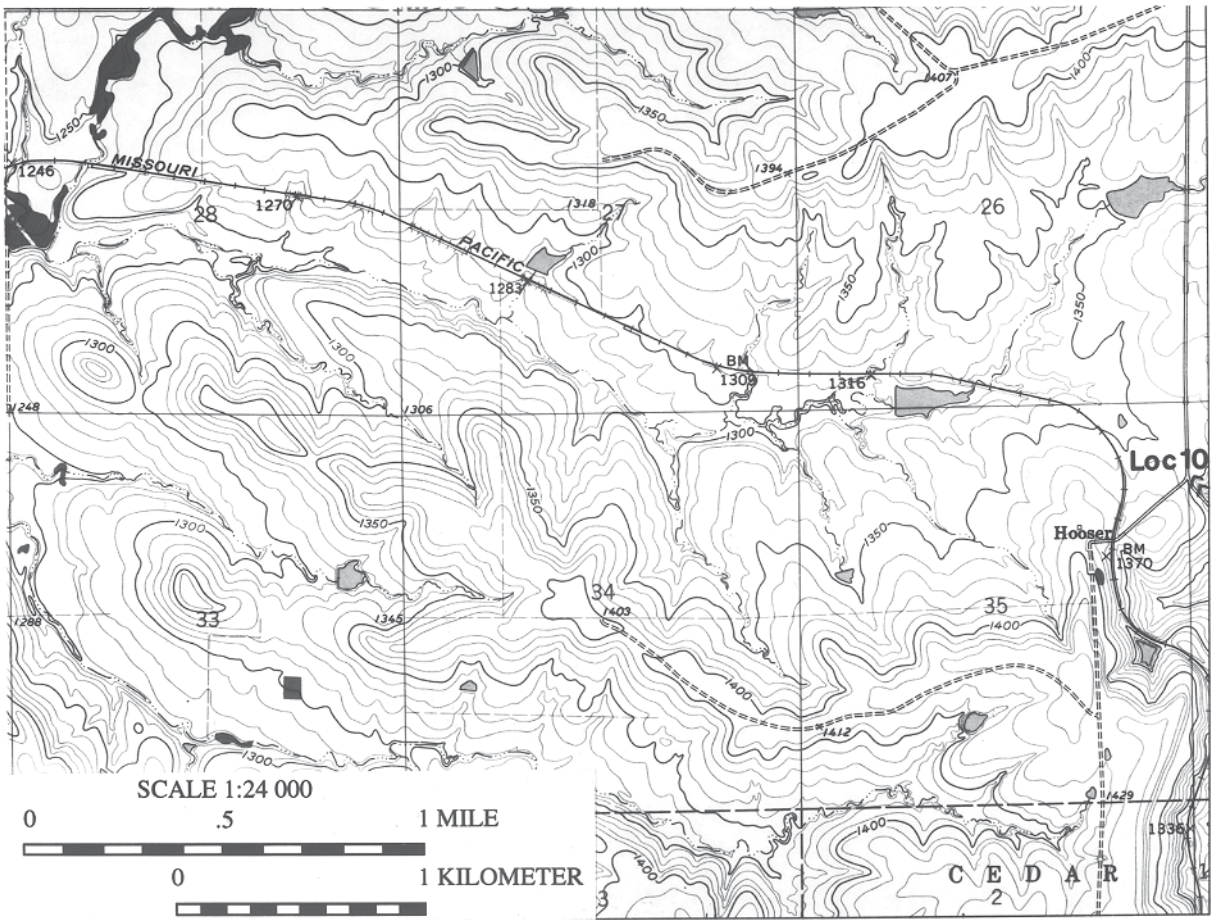

FIGURE 76—Map showing location of Locality 10.

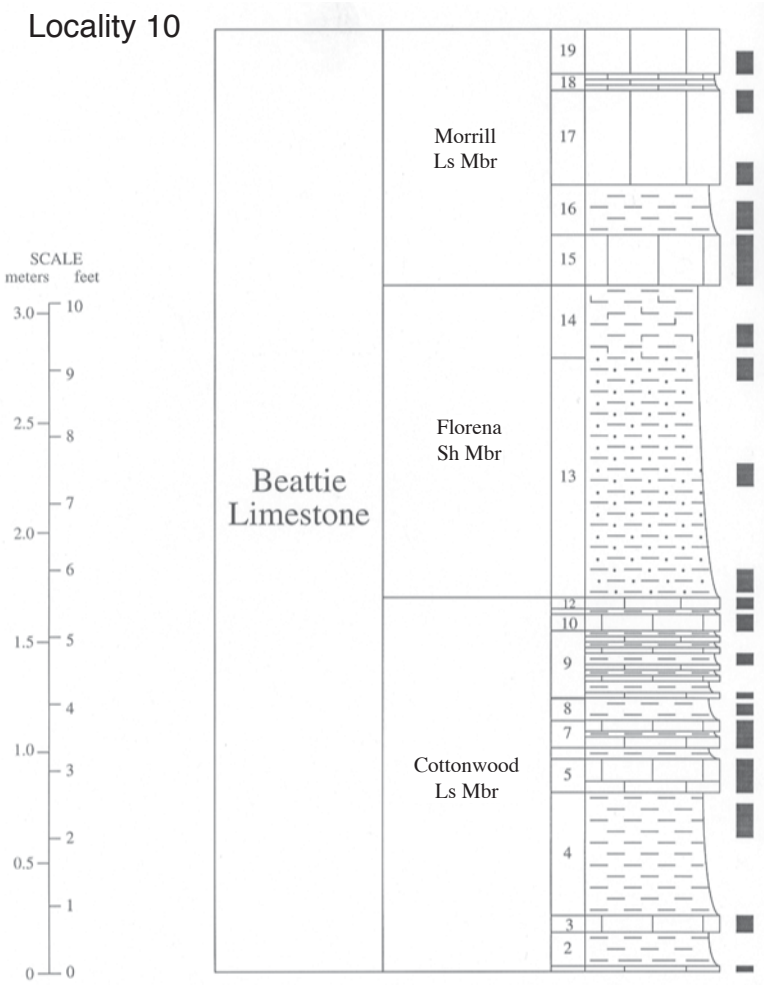

FIGURE 77—Measured section Locality 10–type Hooser, Cottonwood Limestone Member through Morrill Limestone Member, samples and sample interval indicated by bars beside column.

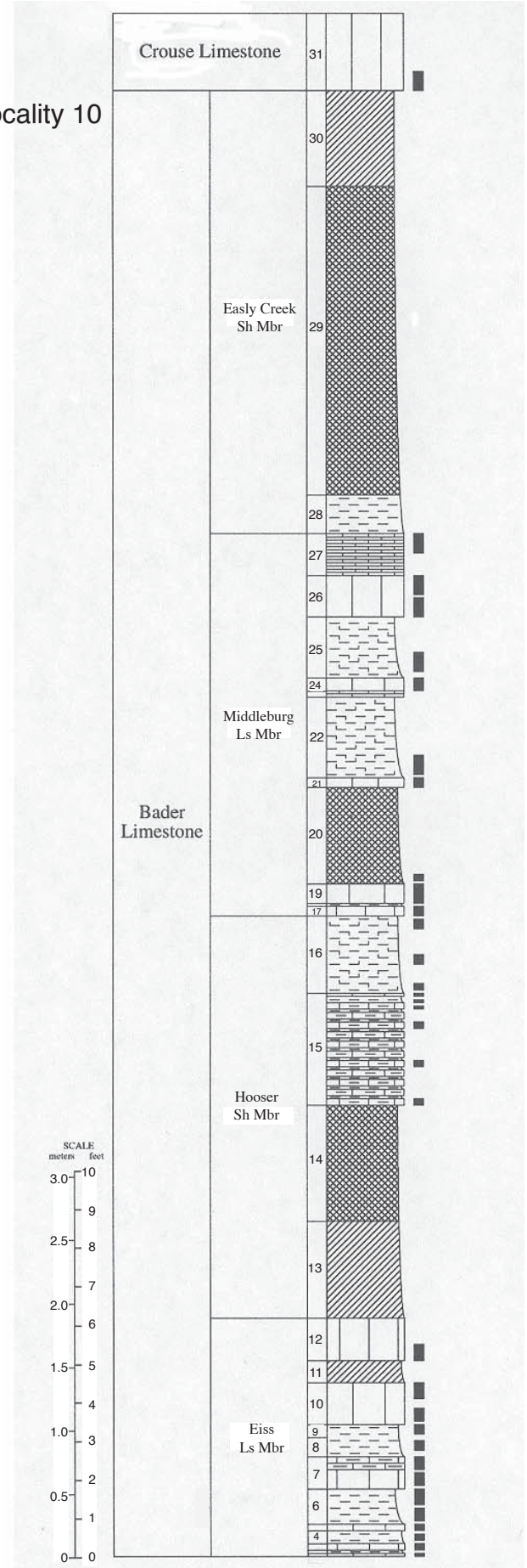

FIGURE 78 (right)—Measured section Locality 10–type Hooser, Eiss Limestone Member through Crouse Limestone, samples and sample interval indicated by bars beside column.

FIGURE 79—Map showing location of Localities 11 (Anderson Road) and 12 (Scenic Drive).

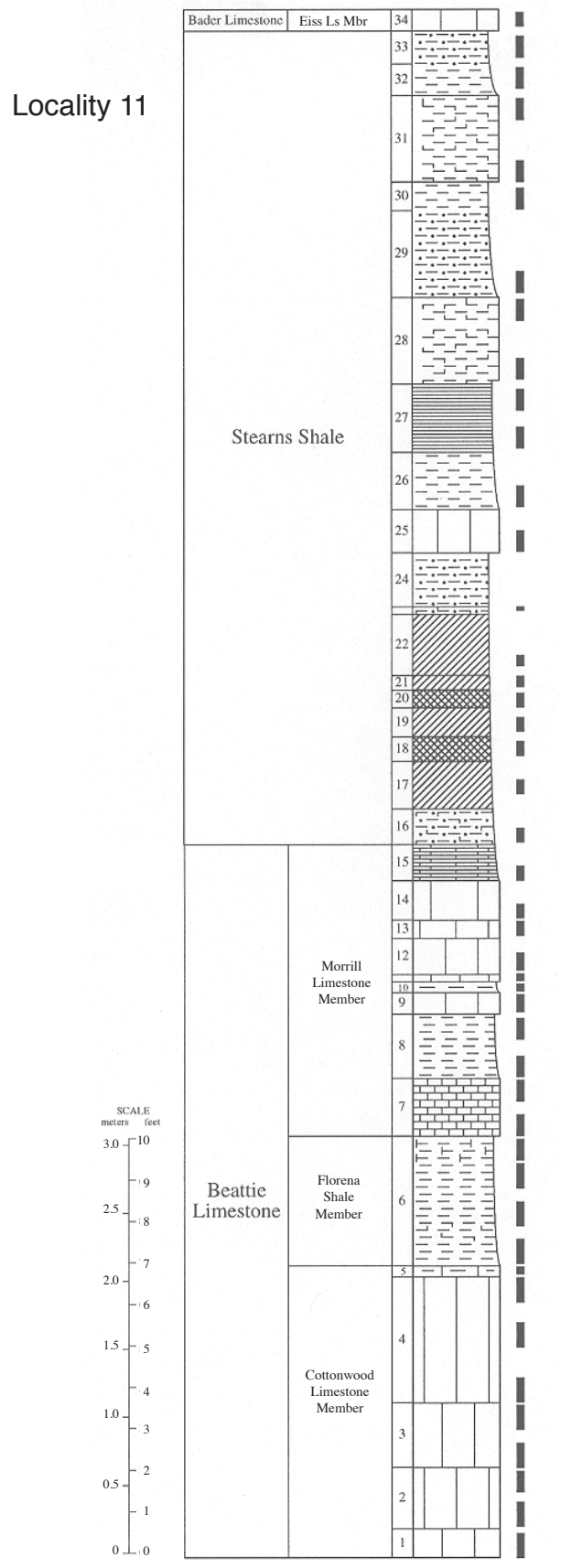

FIGURE 80—Measured section Locality 11–Cottonwood Limestone Member through lower Eiss Limestone Member, samples and sample interval indicated by bars beside column.

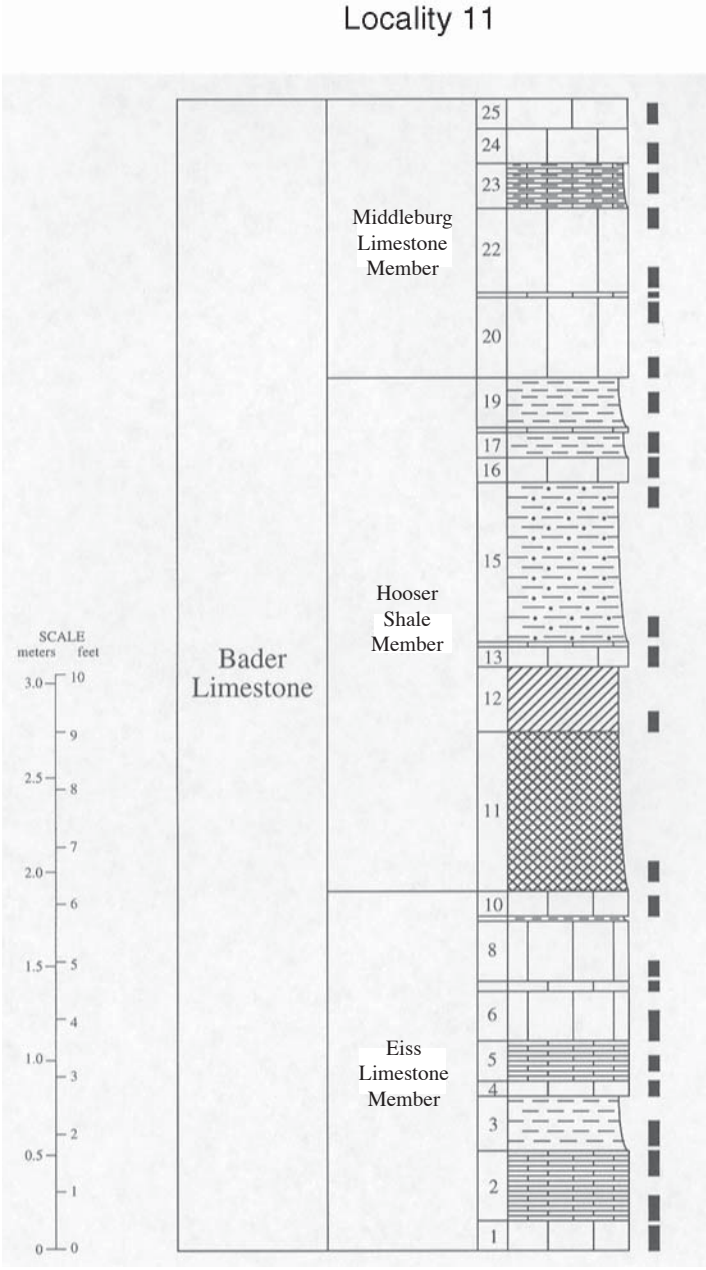

FIGURE 81—Measured section Locality 11–Eiss Limestone Member through Middleburg Limestone Member, samples and sample interval indicated by bars beside column.

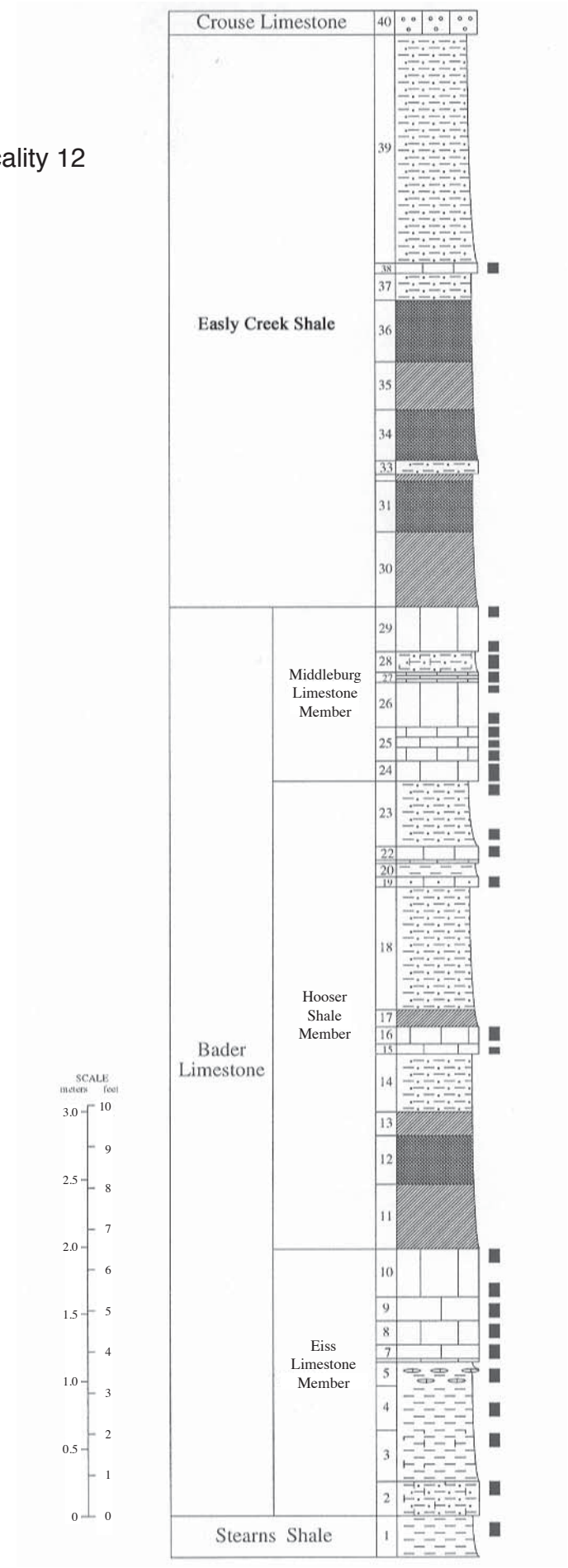

FIGURE 82—Measured section Locality 12–upper Stearns Shale through lower Crouse Limestone, samples and sample interval indicated by bars beside column.

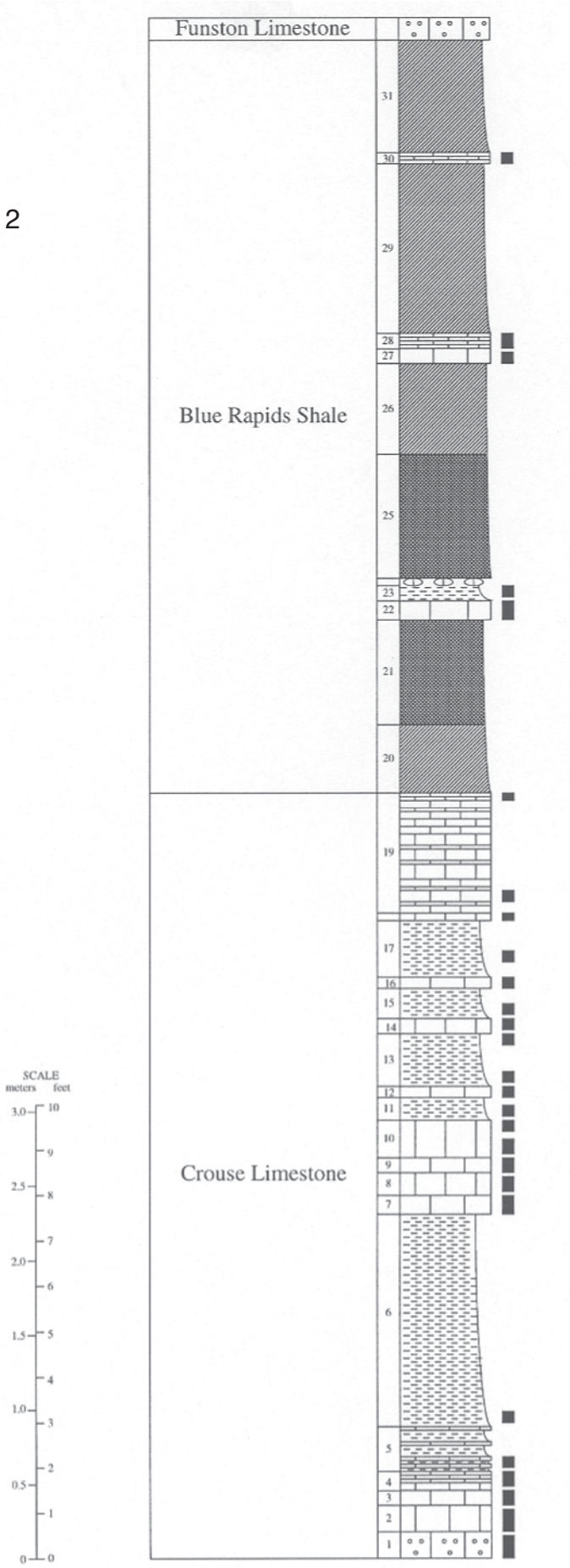

FIGURE 83—Measured section Locality 12–Crouse Limestone through lower Funston Limestone, samples and sample interval indicated by bars beside column.

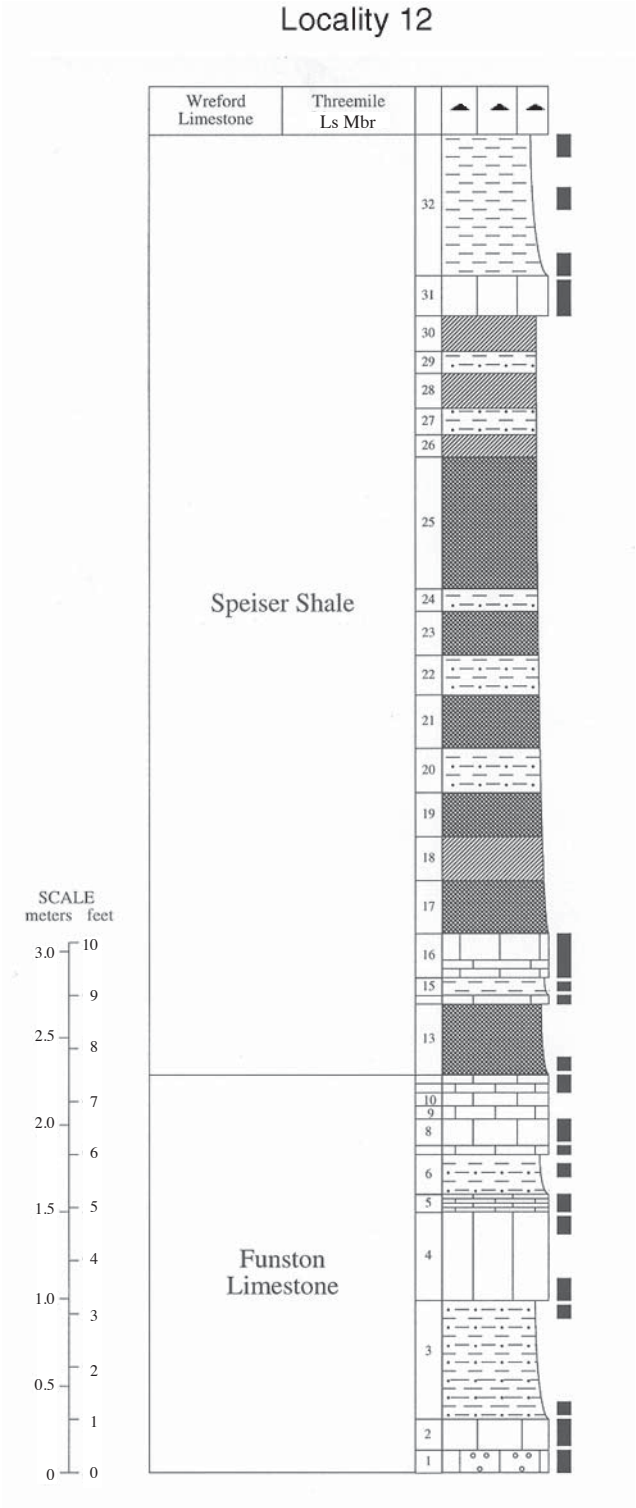

FIGURE 84—Measured section Locality 12–Funston Limestone through lower Threemile Limestone Member, samples and sample interval indicated by bars beside column.

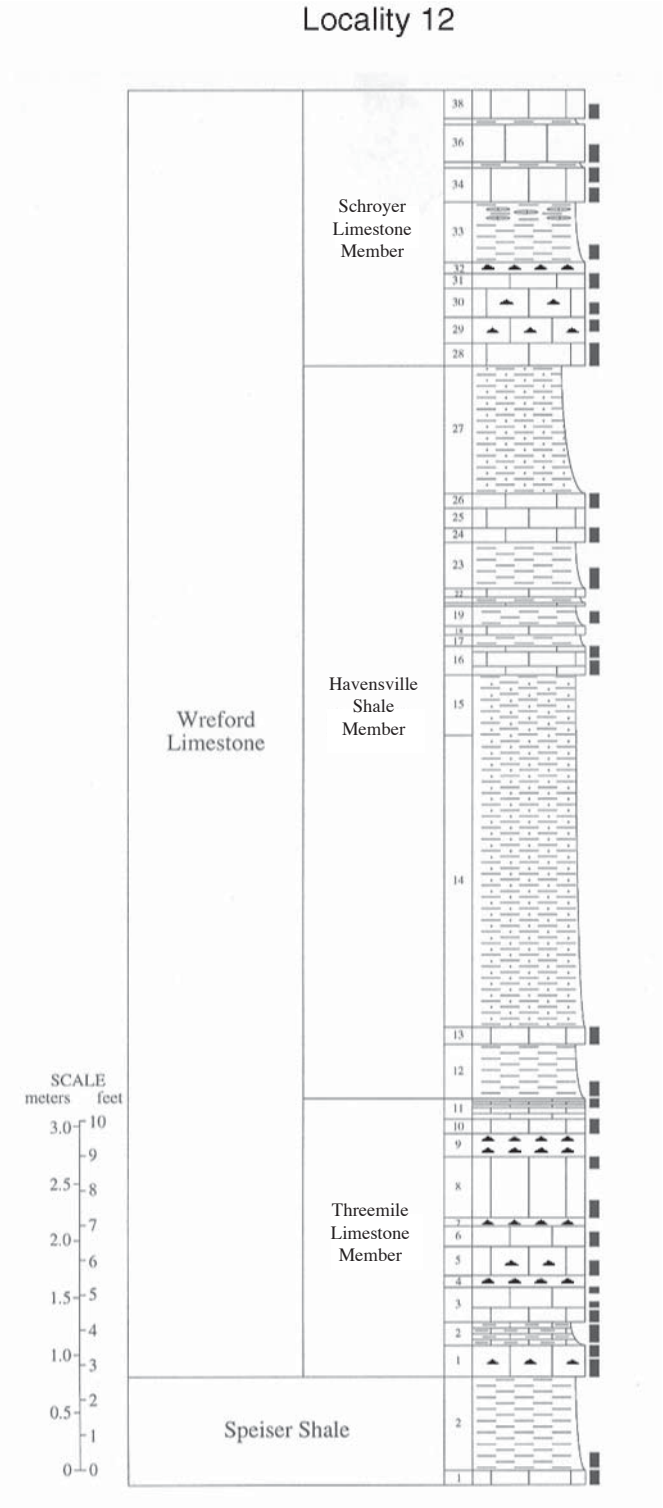

FIGURE 85—Measured section Locality 12–upper Speiser Shale through Schroyer Limestone Member, samples and sample interval indicated by bars beside column.

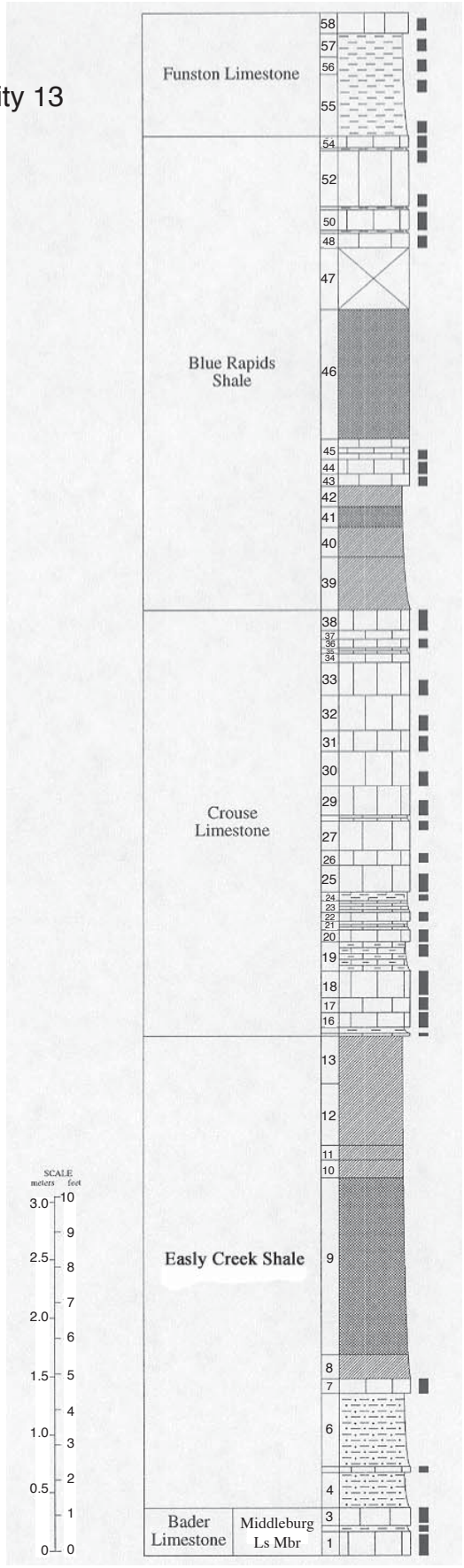

FIGURE 86— Measured section Locality 13–upper Middleburg Limestone Member through lower Funston Limestone, samples and sample interval indicated by bars beside column.

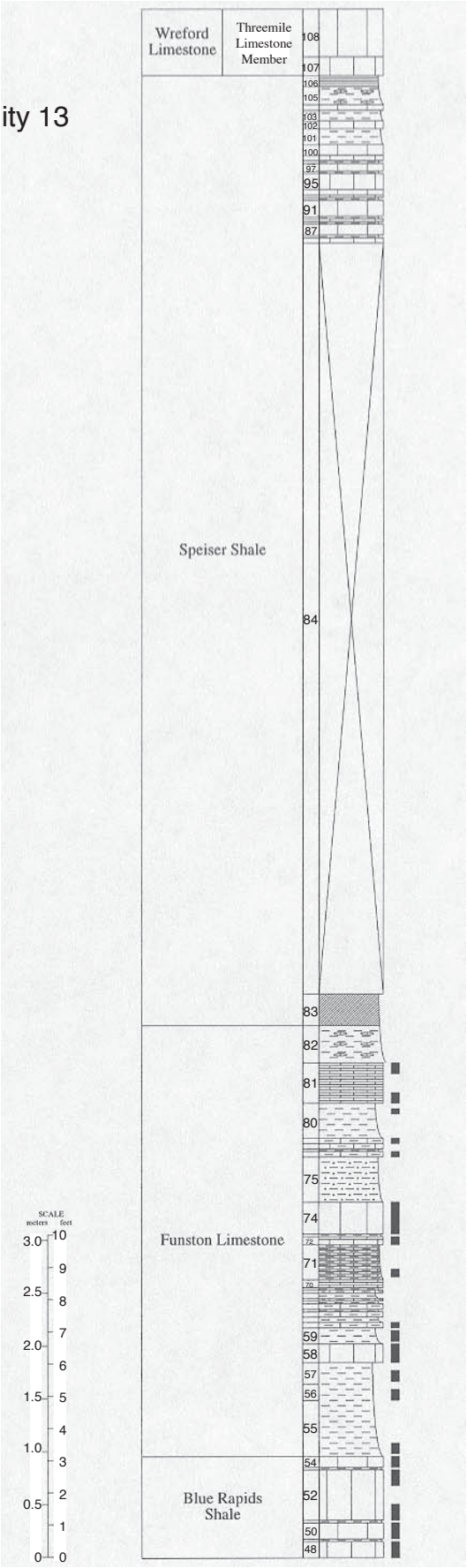

FIGURE 87— Measured section Locality 13–upper Blue Rapids Shale through lower Threemile Limestone Member, samples and sample interval indicated by bars beside column.

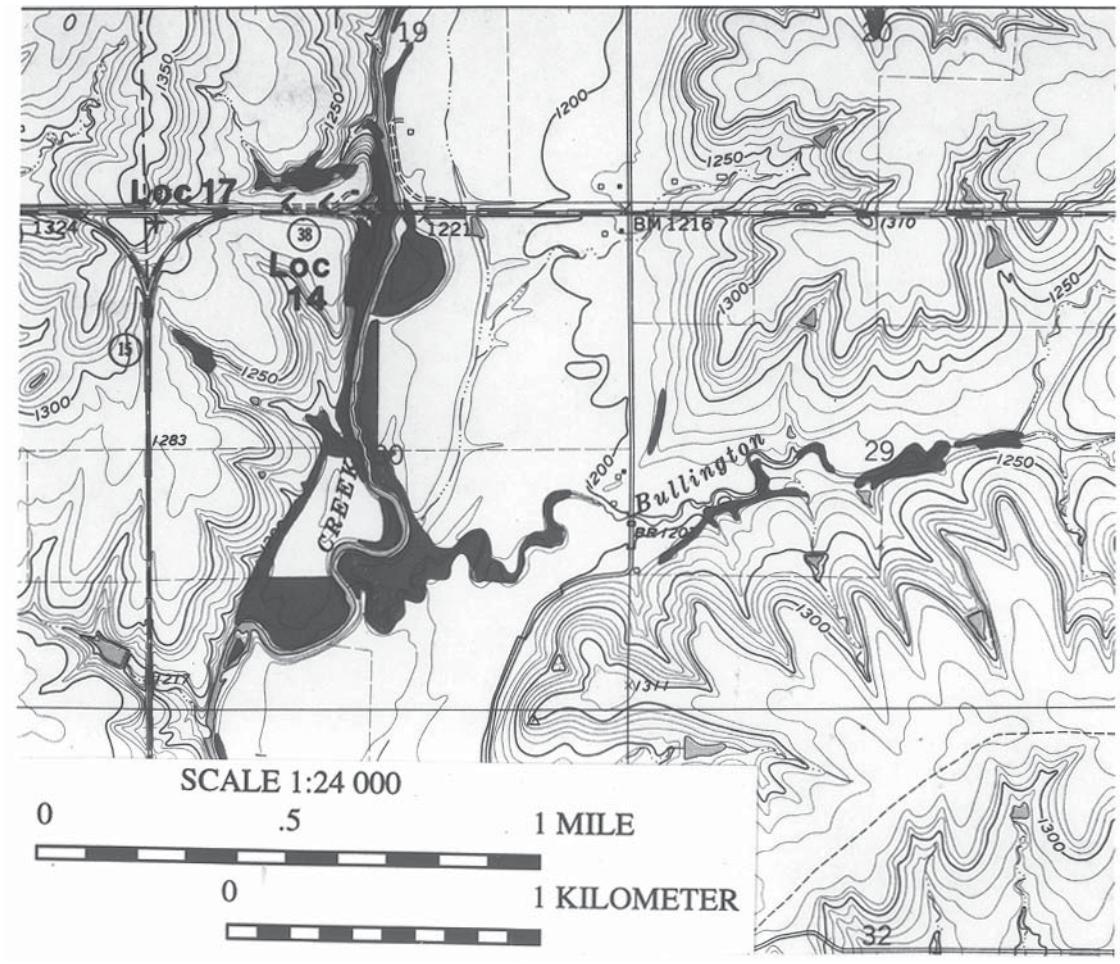

FIGURE 88—Map showing location of Localities 14 and 17.

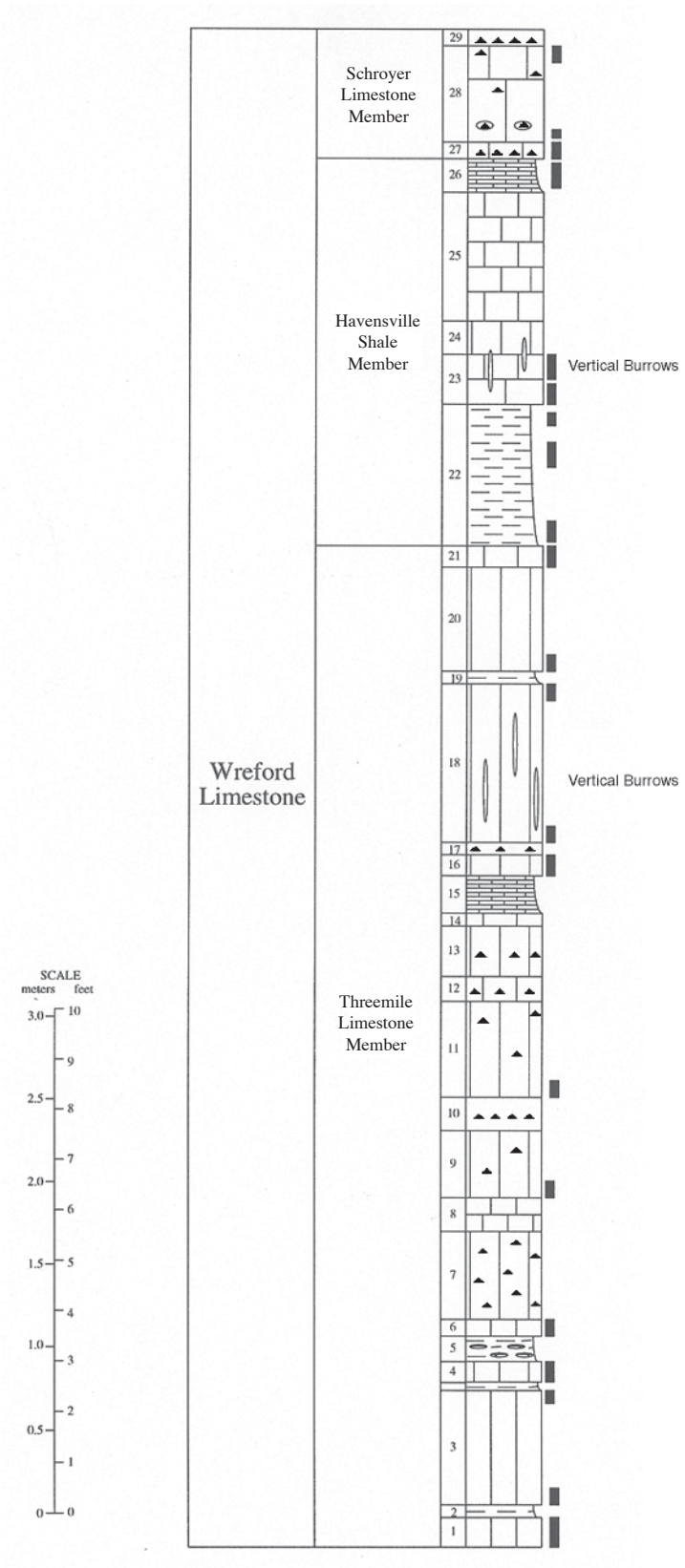

FIGURE 89—Measured section Locality 14–Threemile Limestone Member through Schroyer Limestone Member (Wreford Limestone), samples and sample interval indicated by bars beside column.

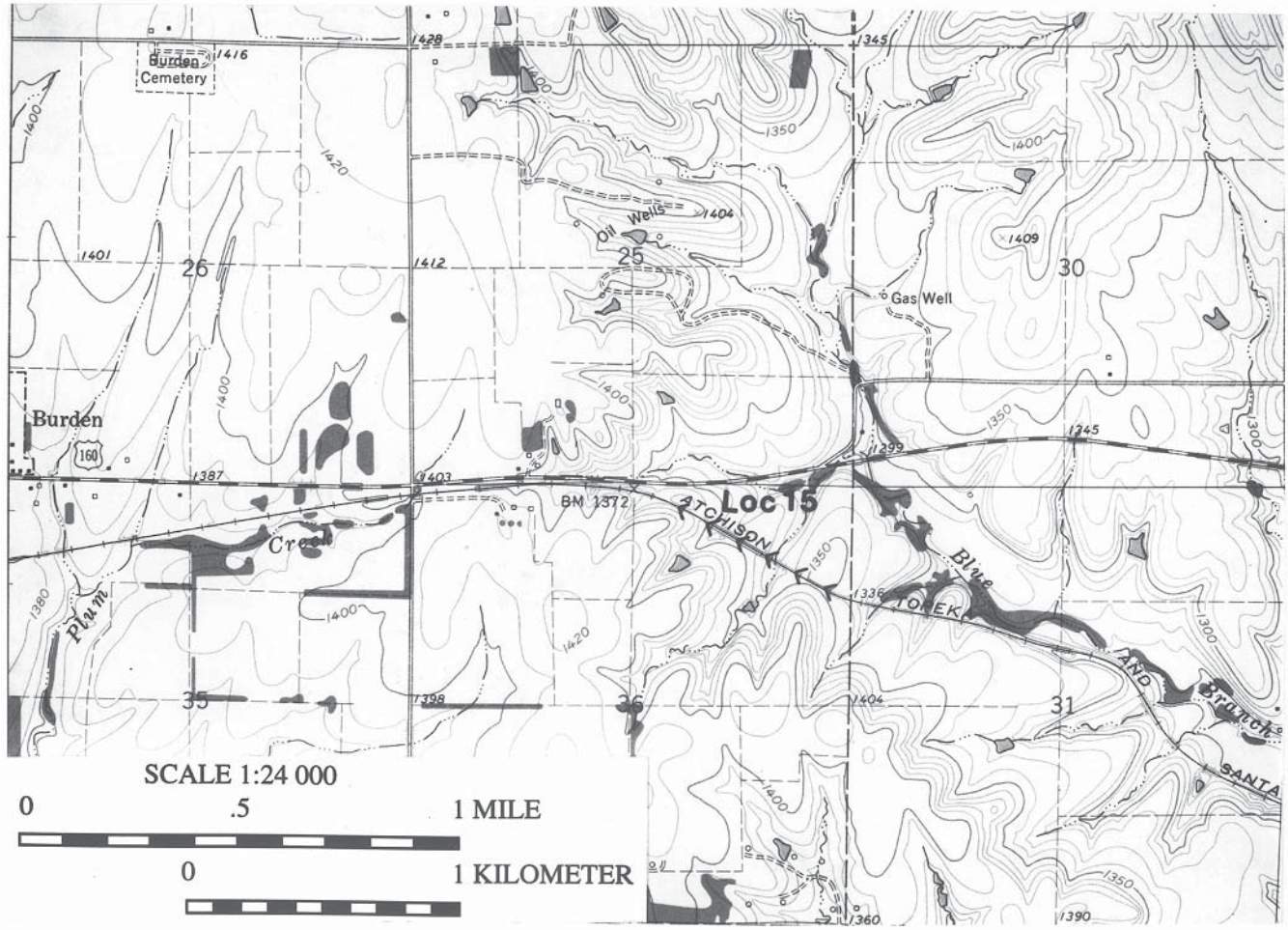

FIGURE 90—Map showing location of Locality15.

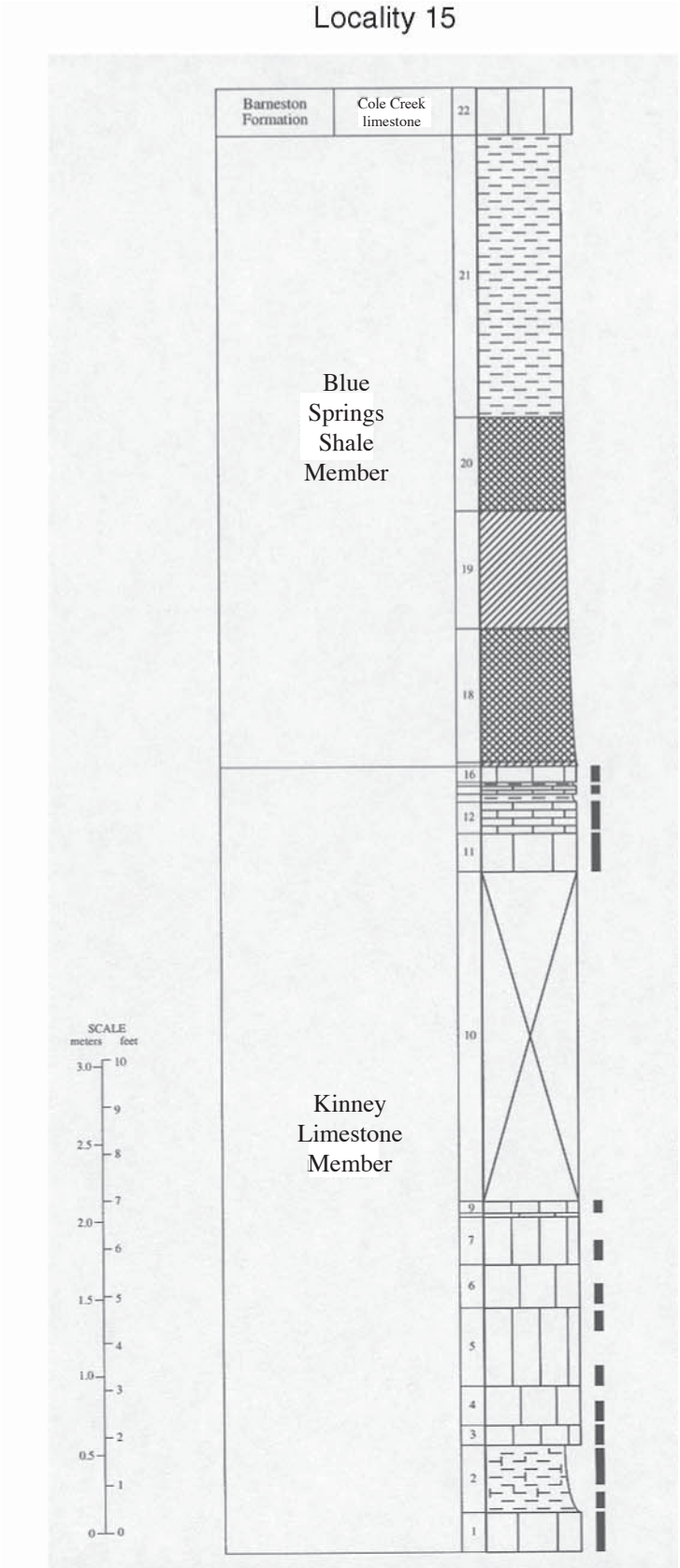

FIGURE 91—Measured section Locality 15–Kinney Limestone Member through lower Cole Creek limestone, samples and sample interval indicated by bars beside column.

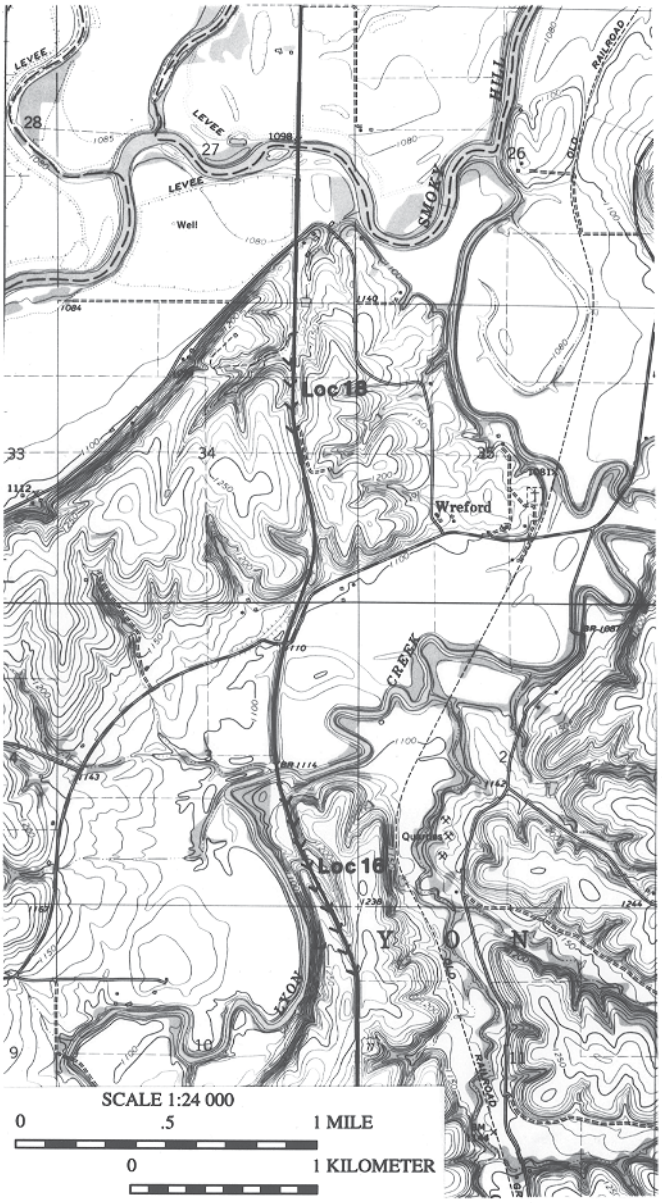

FIGURE 92—Map showing location of Localities 16 and 18, US–77.

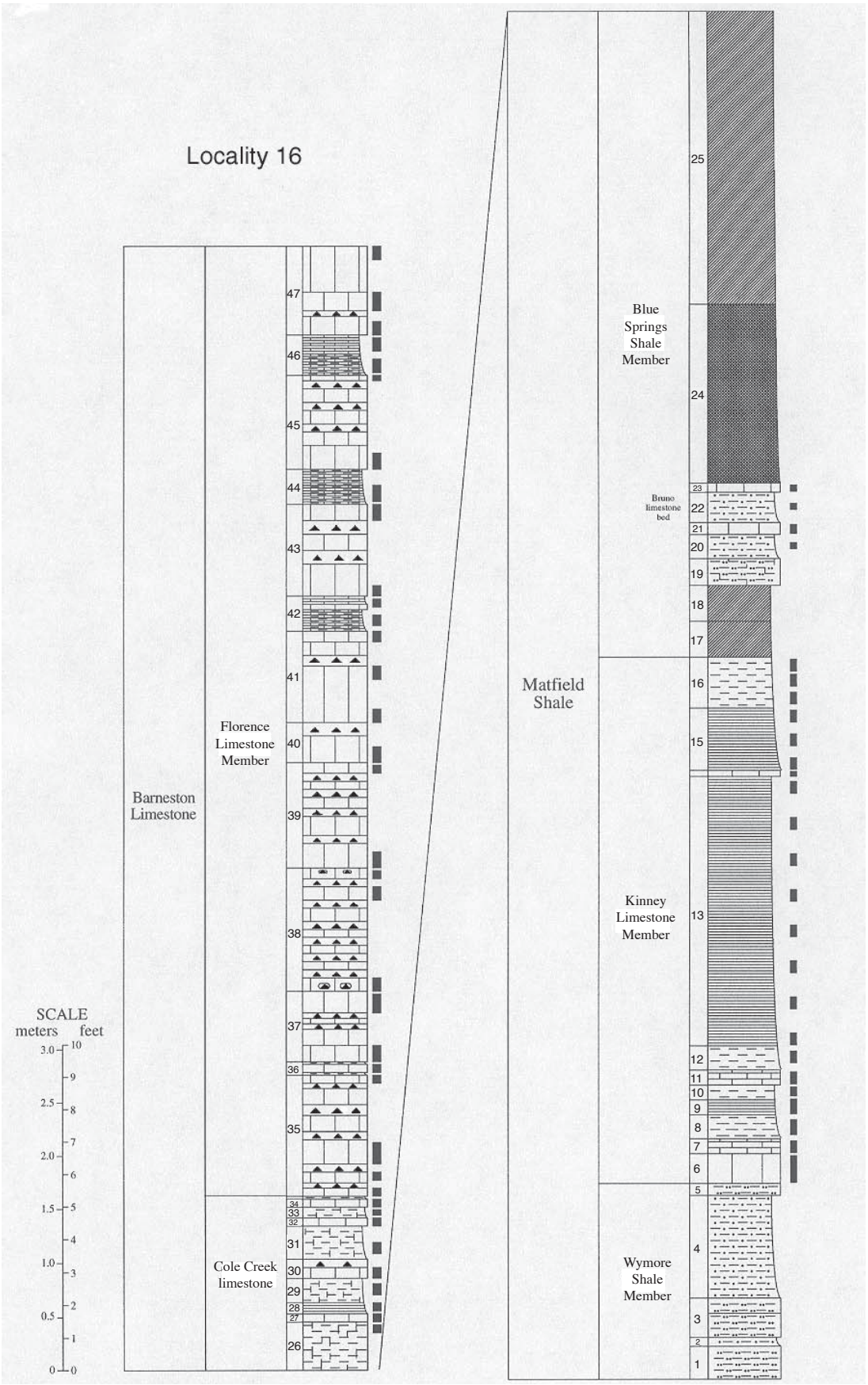

FIGURE 93—Measured section Locality 16–upper Wymore Shale Member through Florence Limestone Member, samples and sample interval indicated by bars beside column.

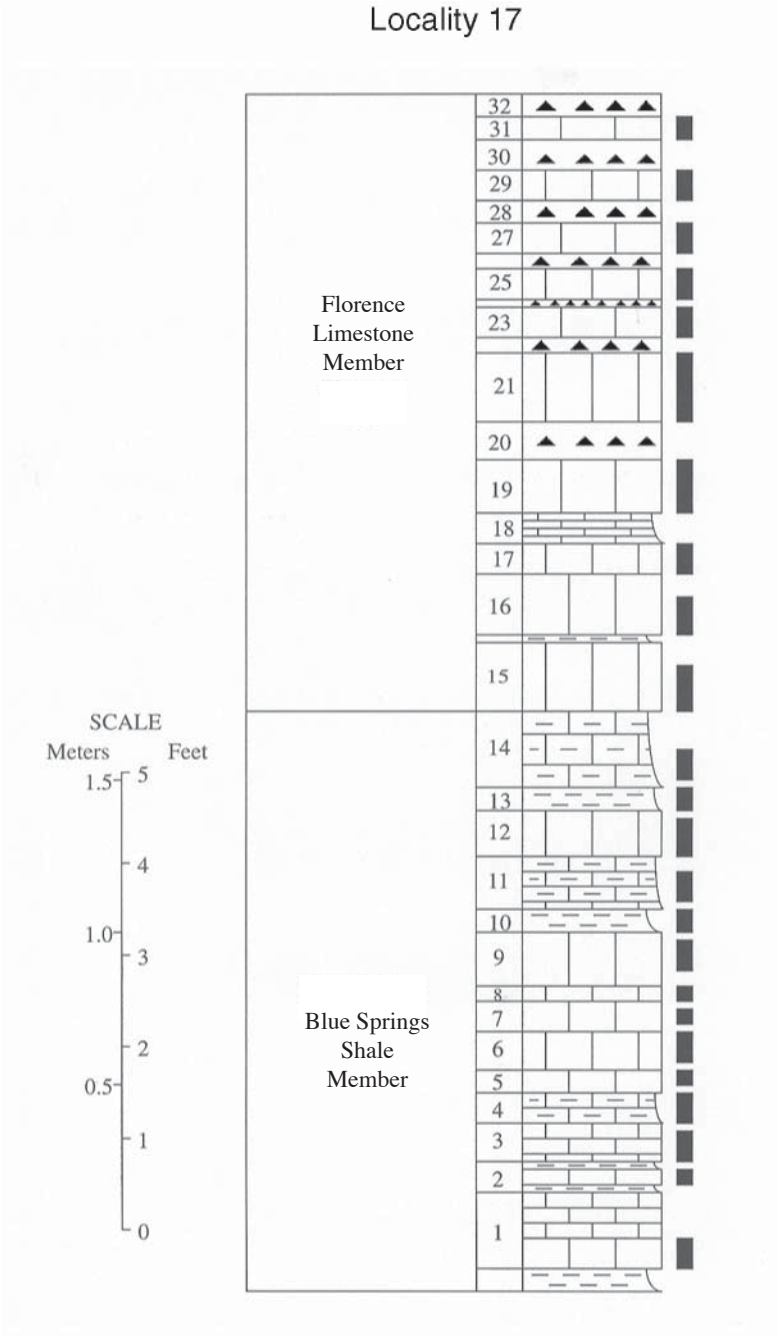

FIGURE 94—Measured section Locality 17–Blue Springs Shale and Florence Limestone Member, samples and sample interval indicated by bars beside column.

Locality 18

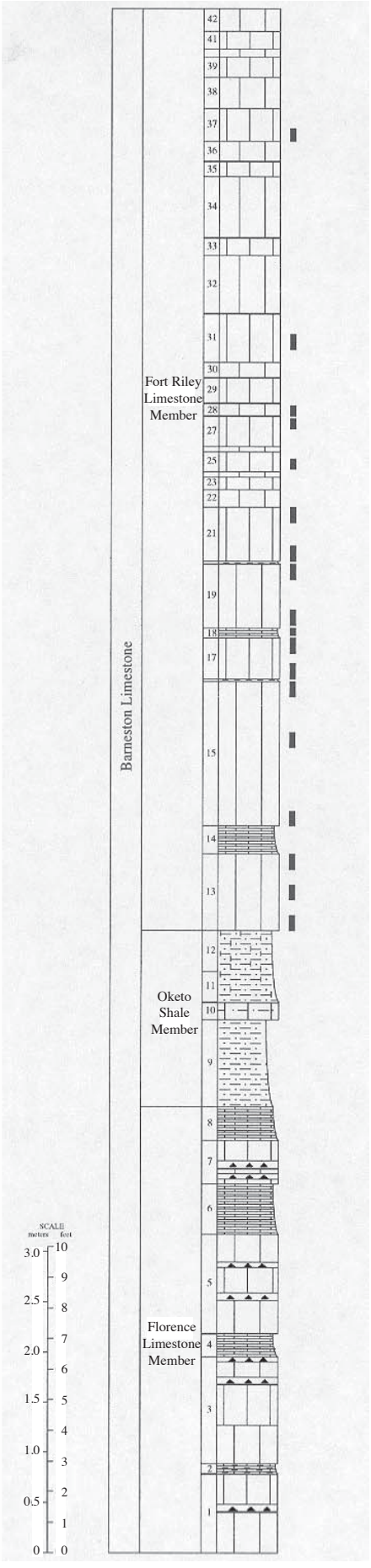

FIGURE 95—Measured section Locality 18–Florence Limestone Member through Fort Riley Limestone Member, samples and sample interval indicated by bars beside column.

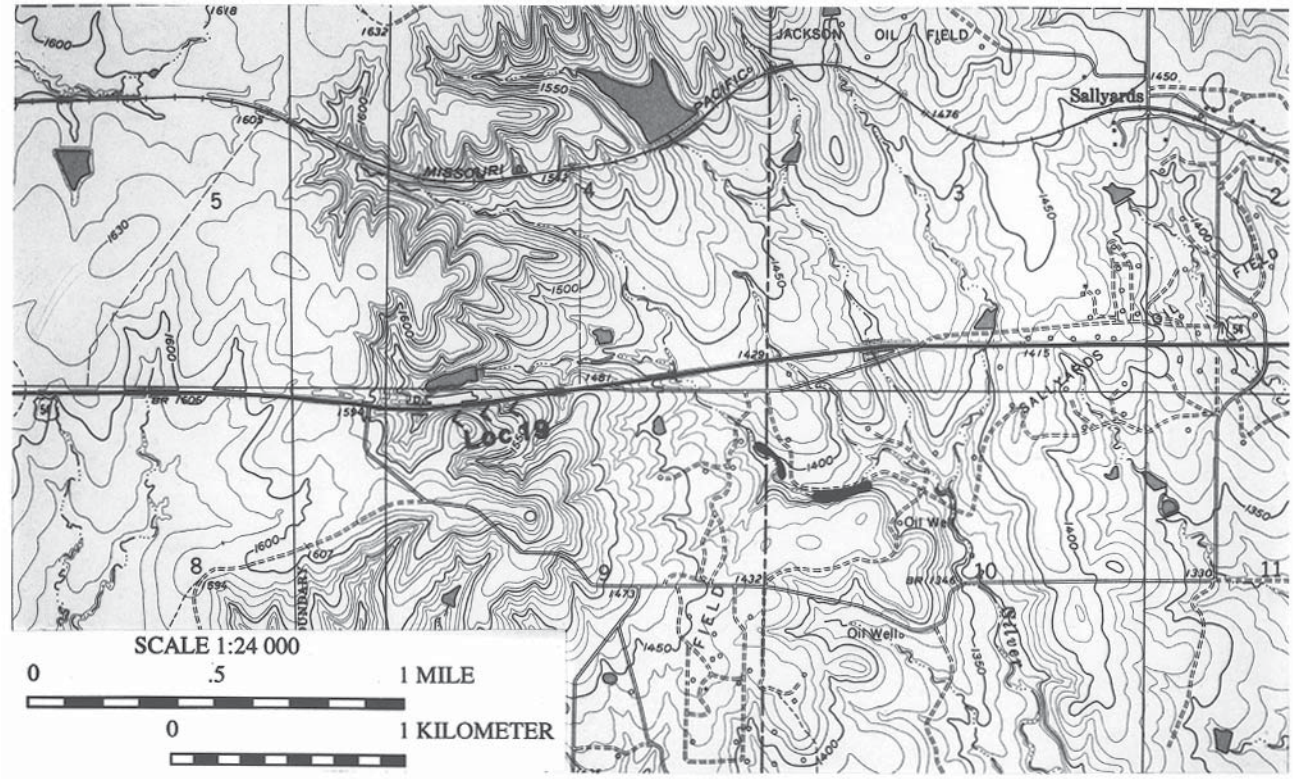

FIGURE 96—Map showing location of Locality19.

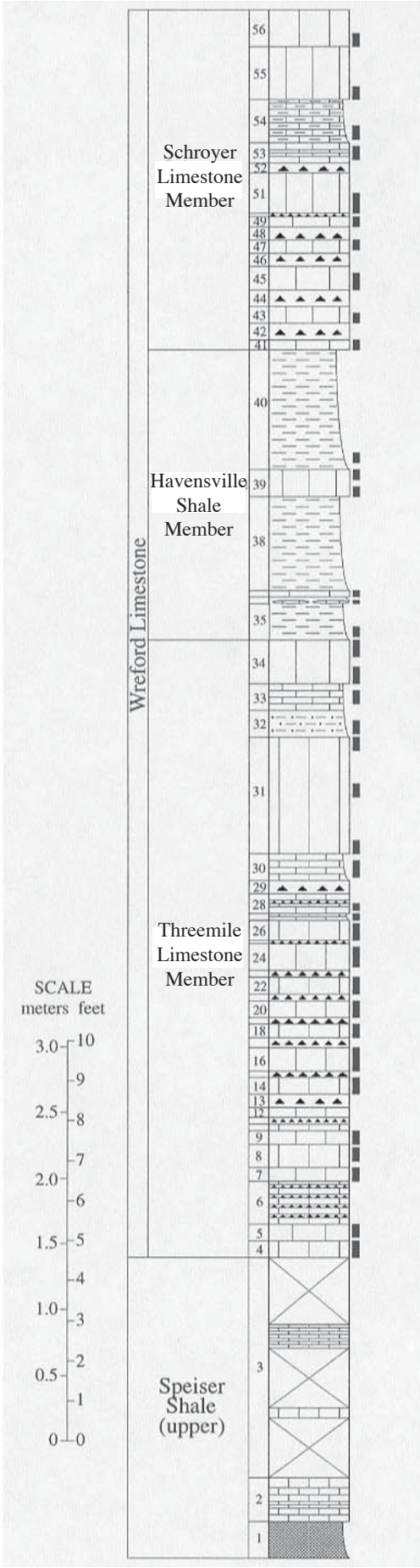

FIGURE 97—Measured section Locality 19–upper Speiser Shale through Schroyer Limestone Member, samples and sample interval indicated by bars beside column.

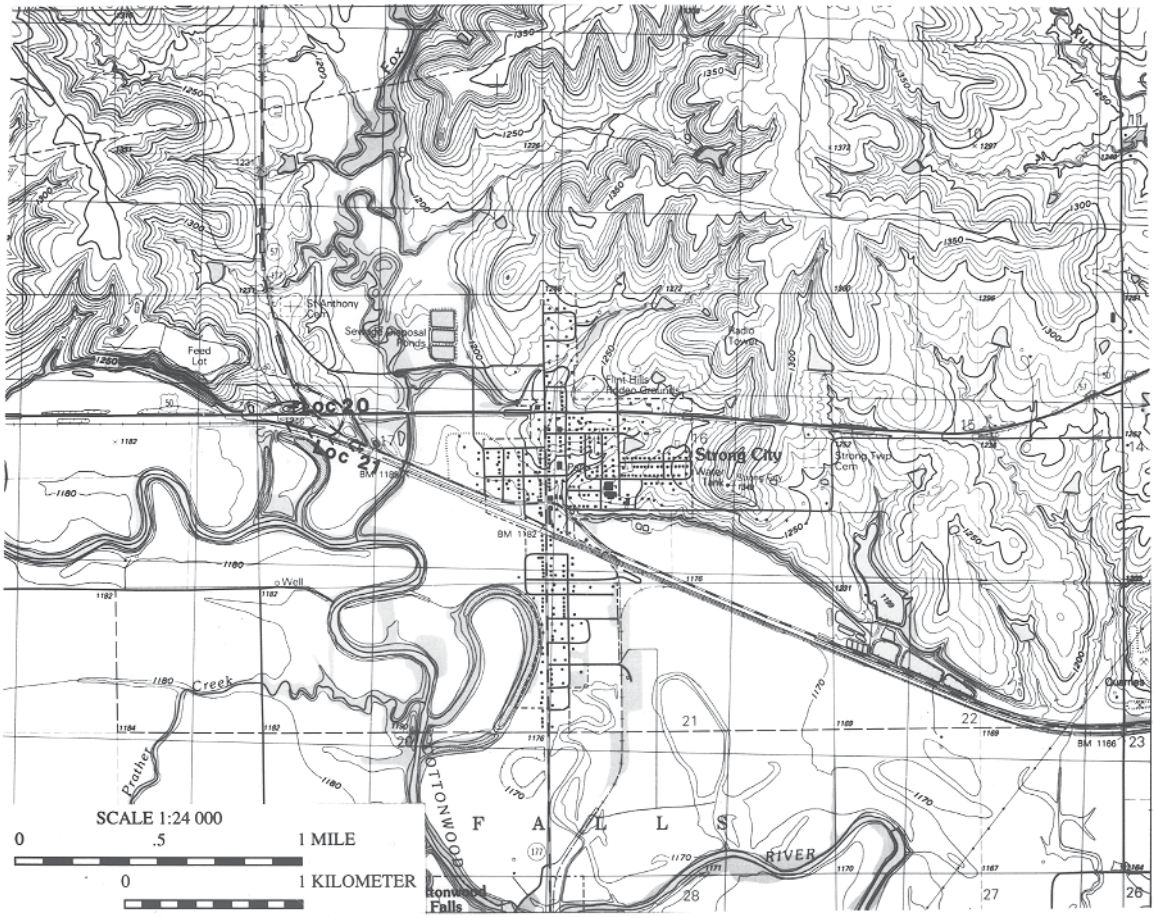

FIGURE 98—Map showing location of Localities 20 and 21.

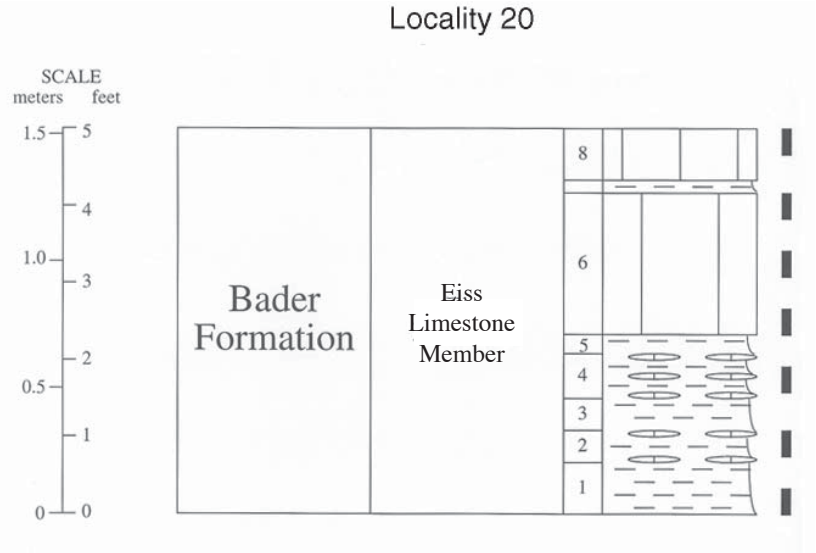

FIGURE 99—Measured section Locality 20–upper Eiss Limestone Member, samples and sample interval indicated by bars beside column.

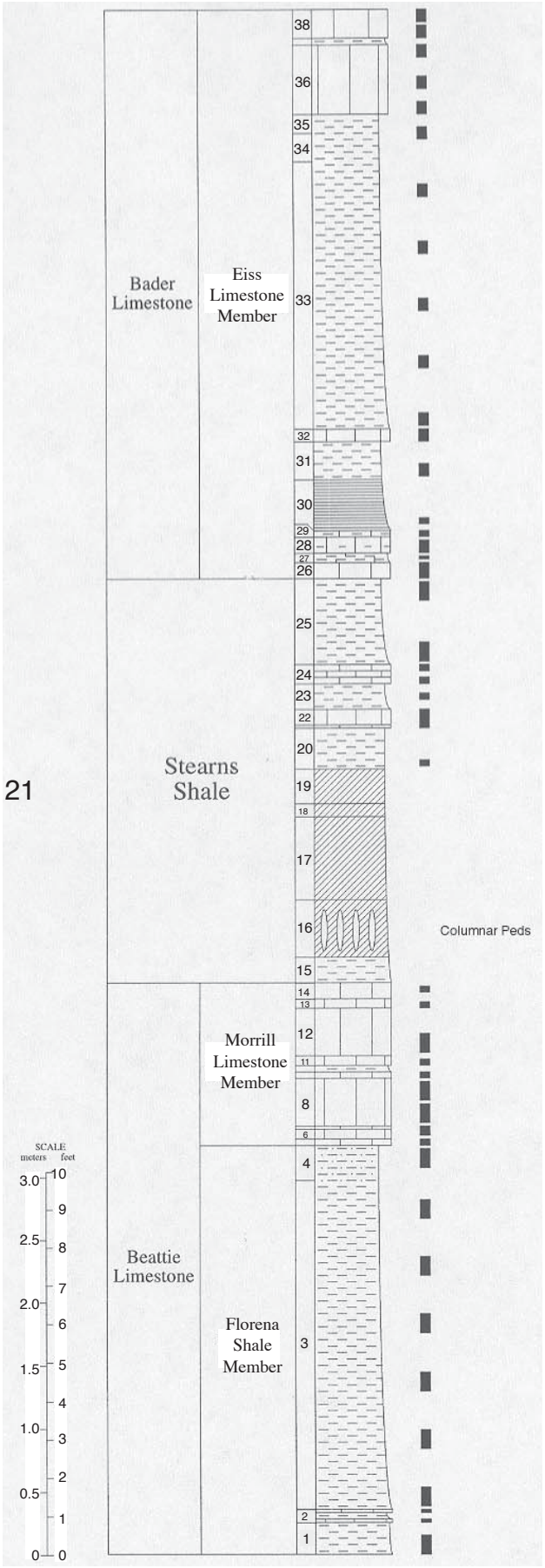

FIGURE 100 (right)—Measured section Locality 21–Florena Shale Member through Eiss Limestone Member, samples and sample interval indicated by bars beside column.

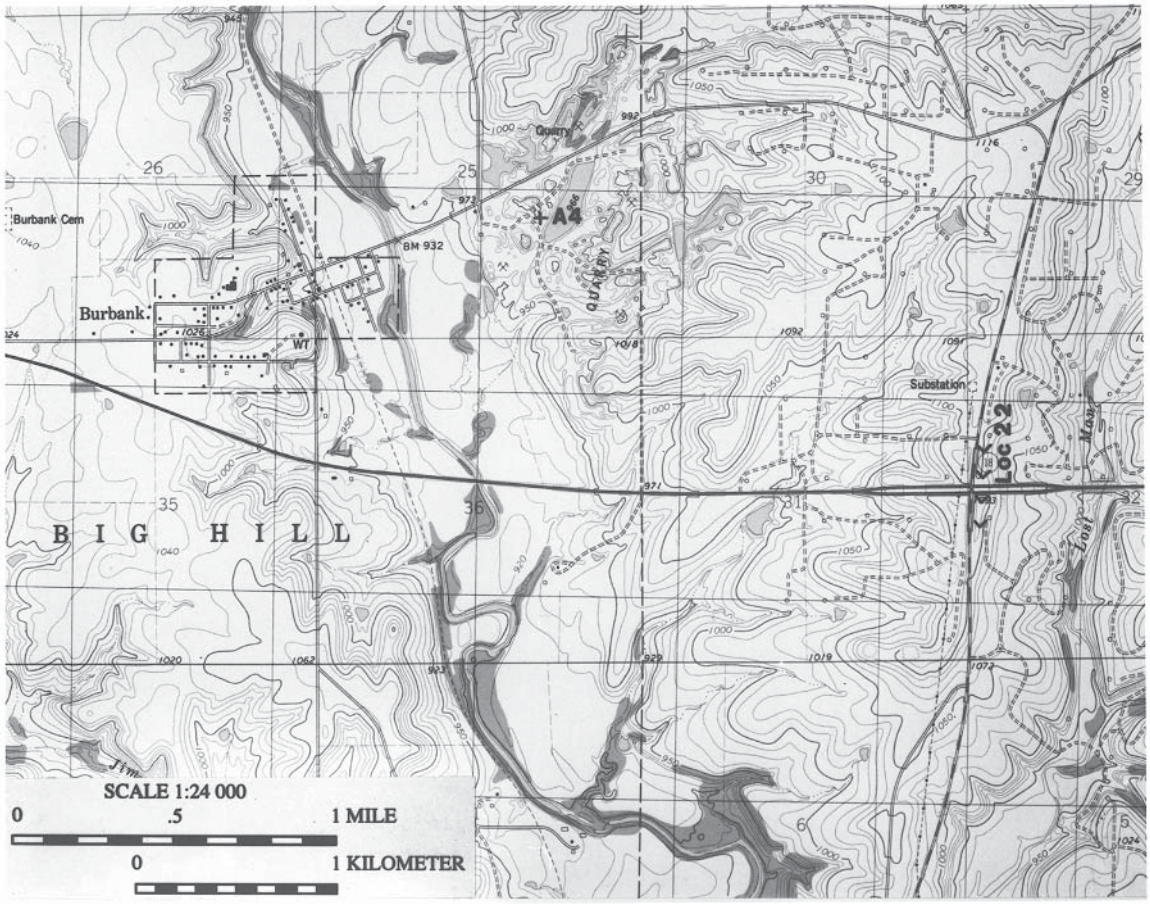

FIGURE 101—Map showing location of Localities 22 and A4.

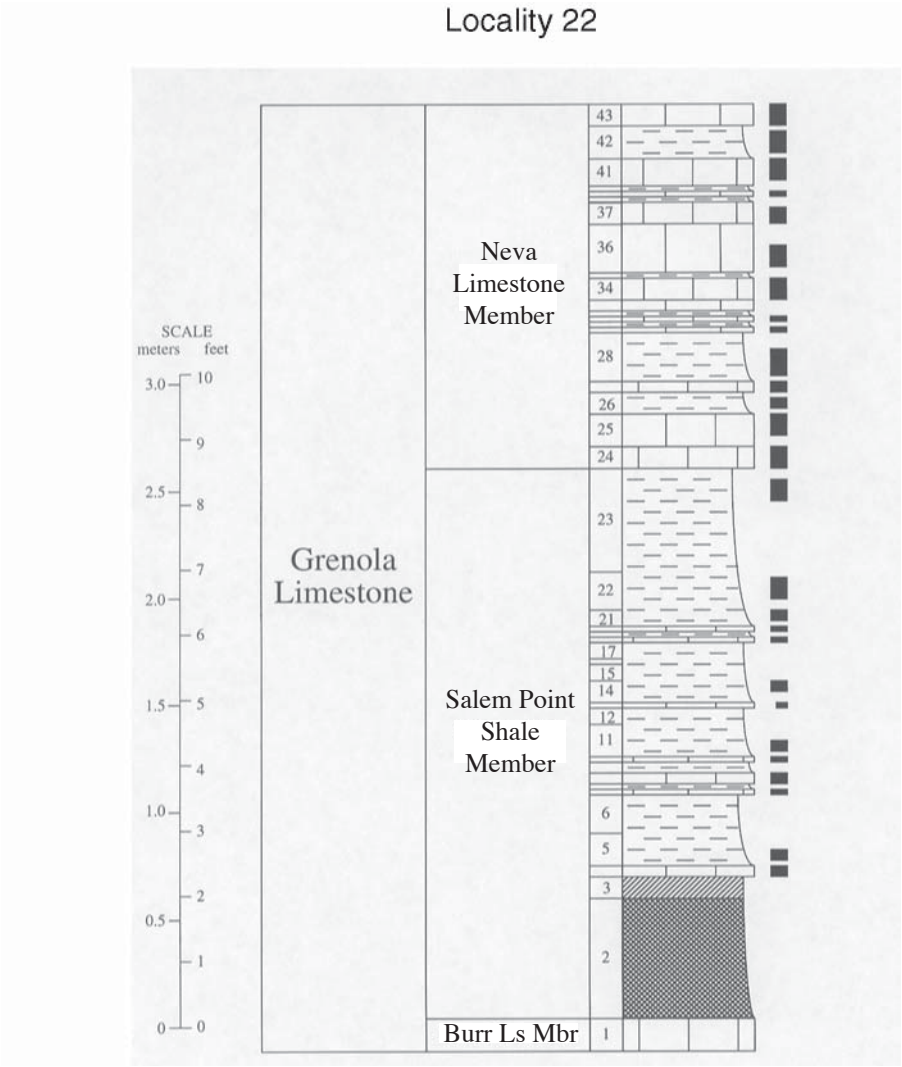

FIGURE 102—Measured section Locality 22–upper Burr Limestone Member through Neva Limestone Member, samples and sample interval indicated by bars beside column.

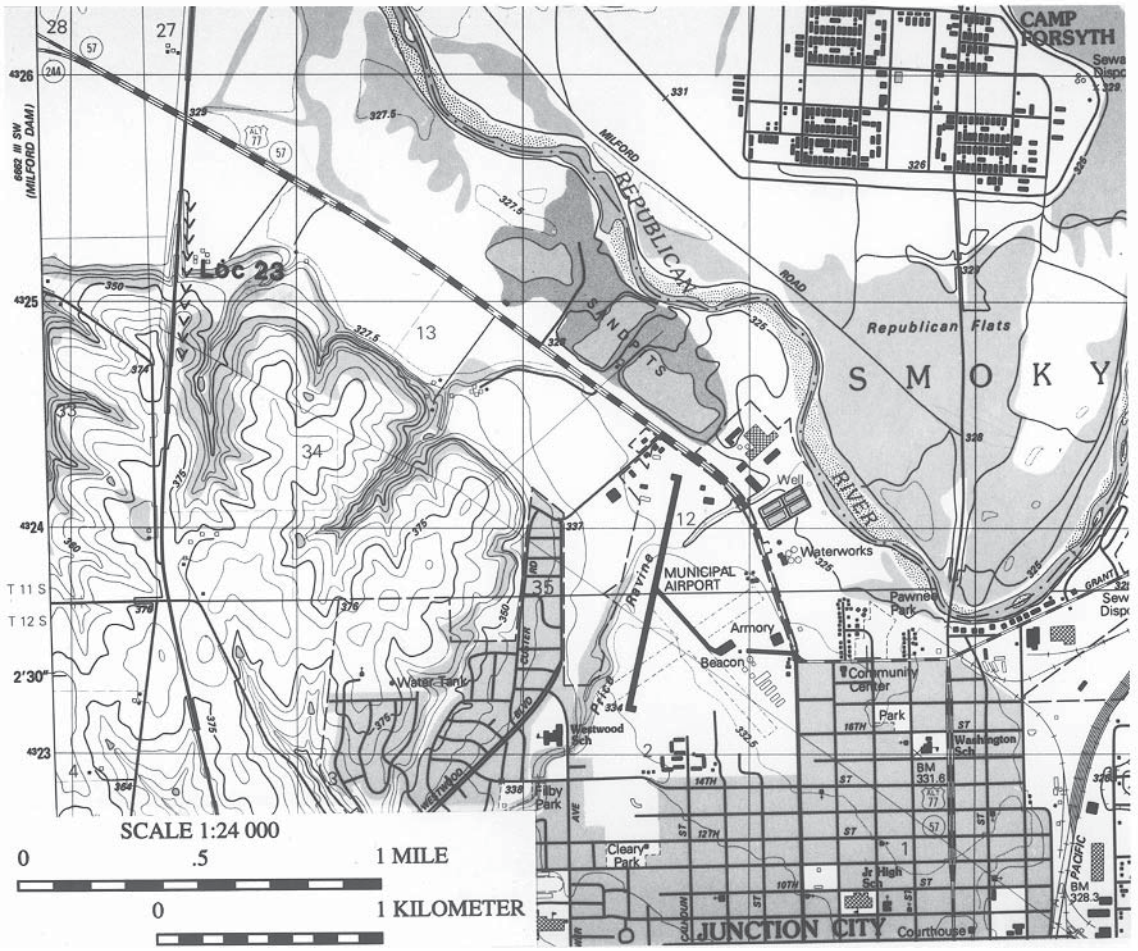

FIGURE 103—Map showing location of Locality 23.

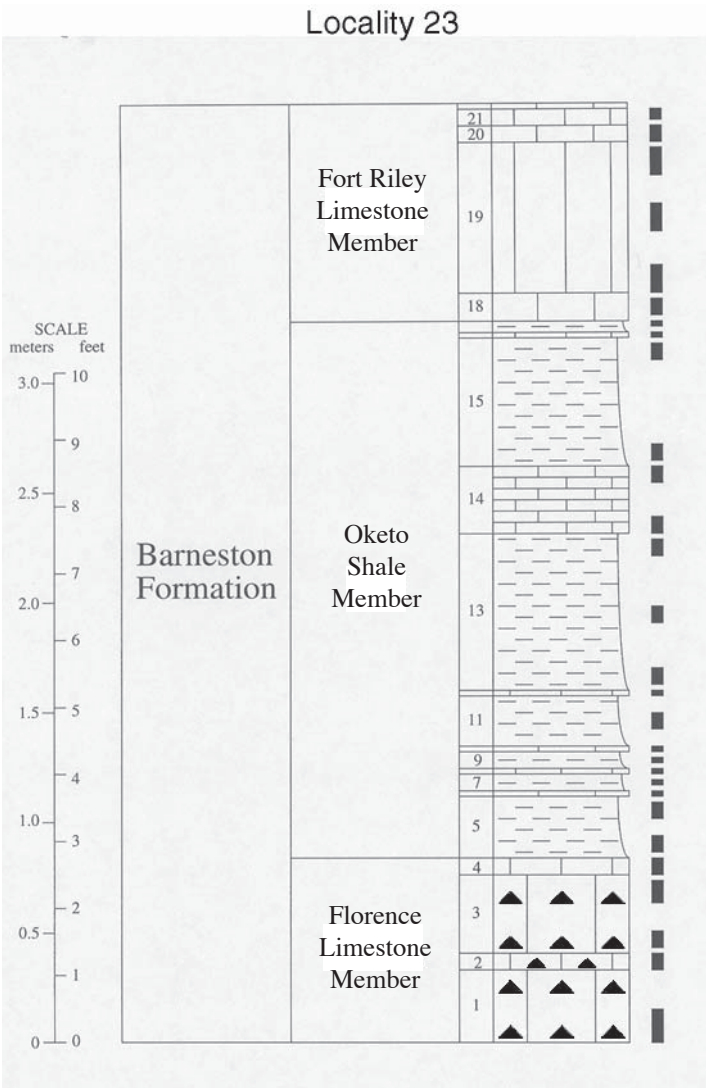

FIGURE 104—Measured section Locality 23–Florence Limestone Member through Fort Riley Limestone Member, samples and sample interval indicated by bars beside column.

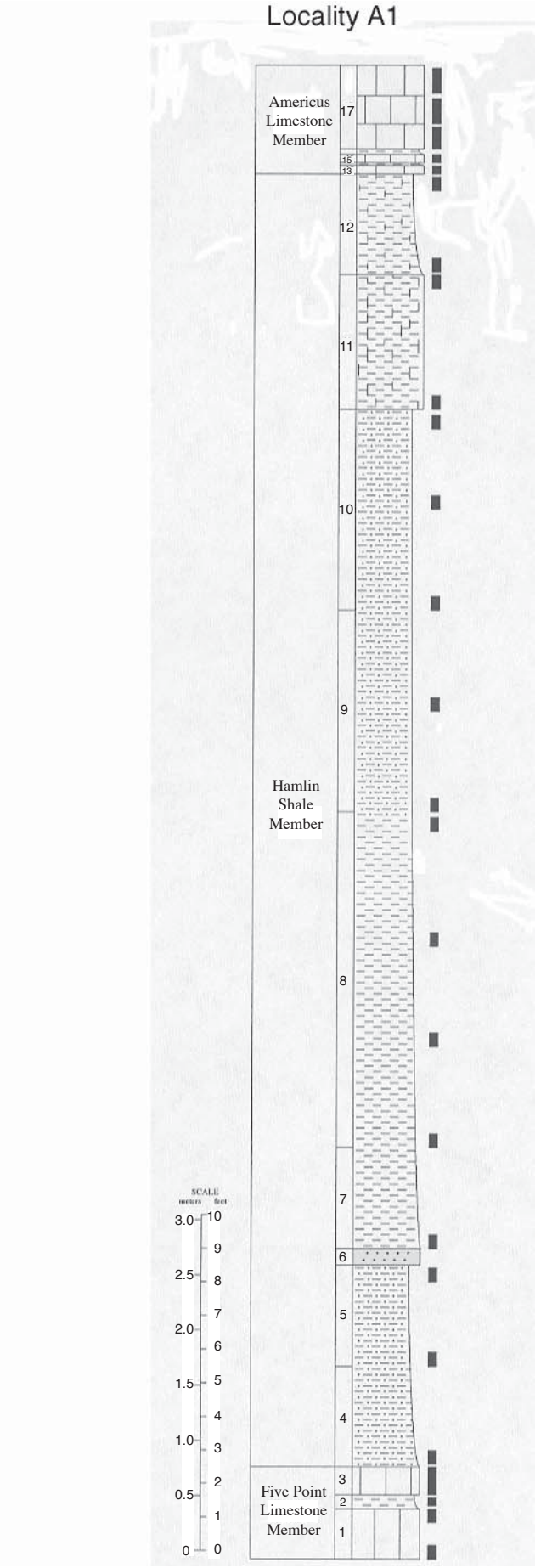

FIGURE 105—Measured section Locality A1, K–38– Five Point Limestone Member through Americus Limestone Member, samples and sample interval indicated by bars beside column.

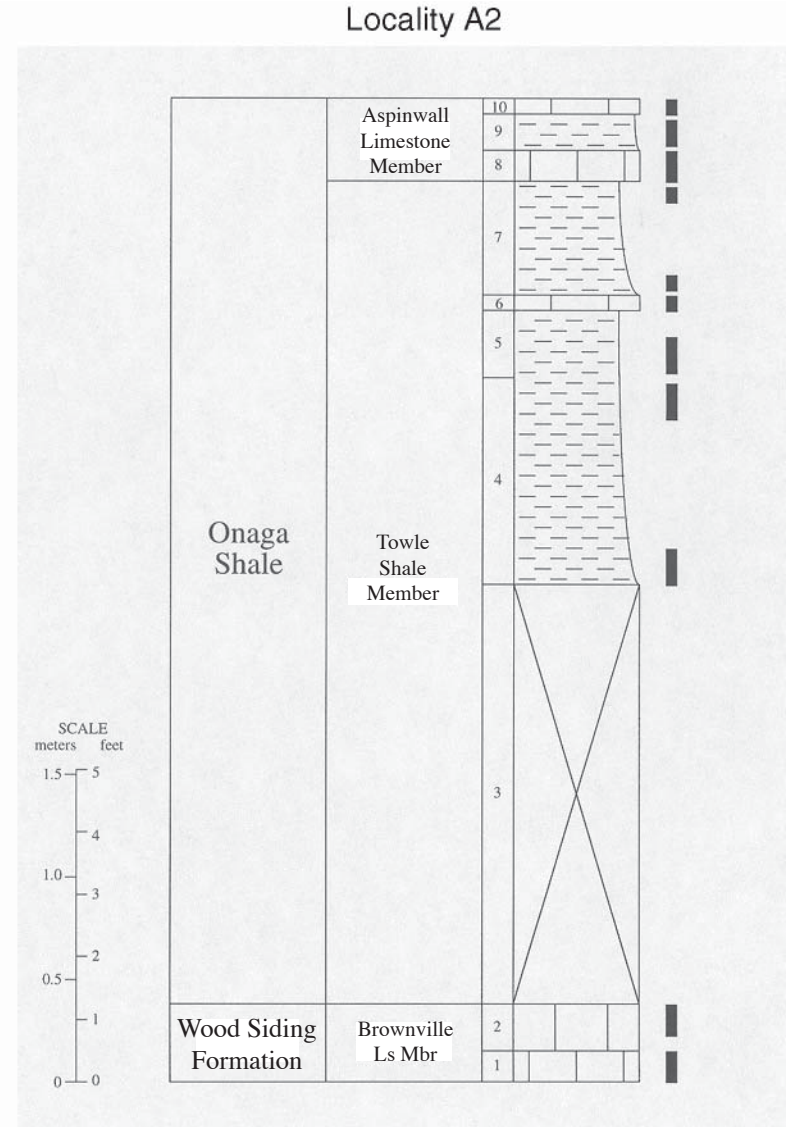

FIGURE 106—Measured section A2, Adams Lake–Brownville Limestone Member through Aspinwall Limestone Member, samples and sample interval indicated by bars beside column.

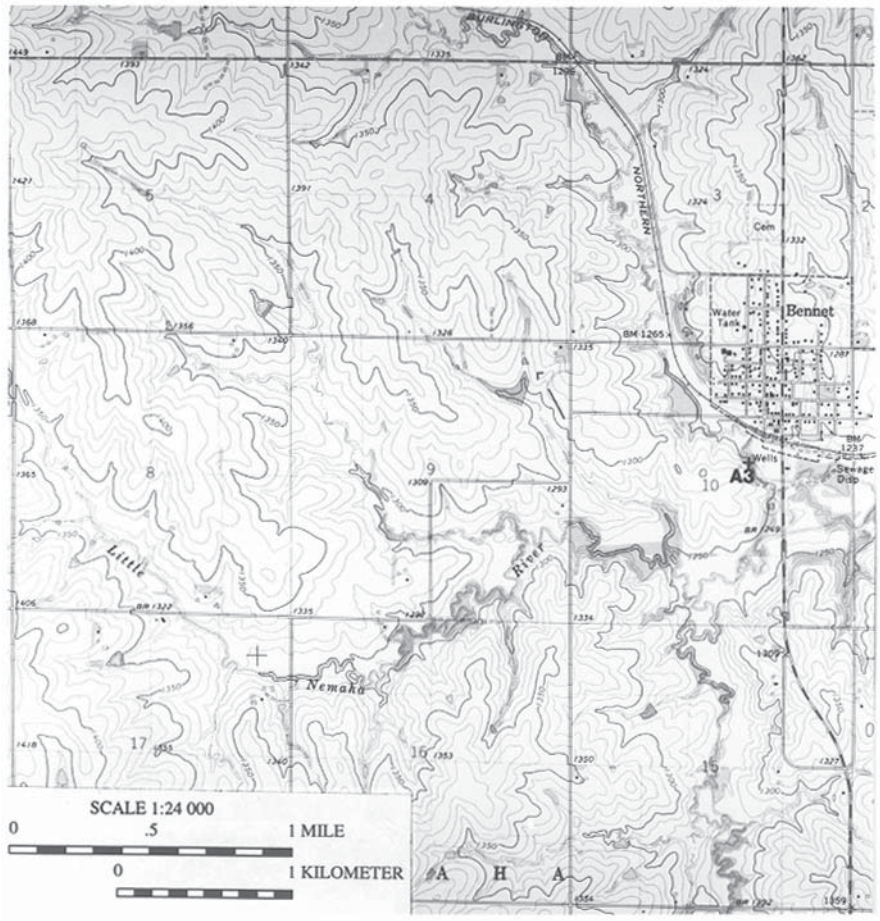

FIGURE 107—Map showing location of Locality A3, type Bennett Shale Member.

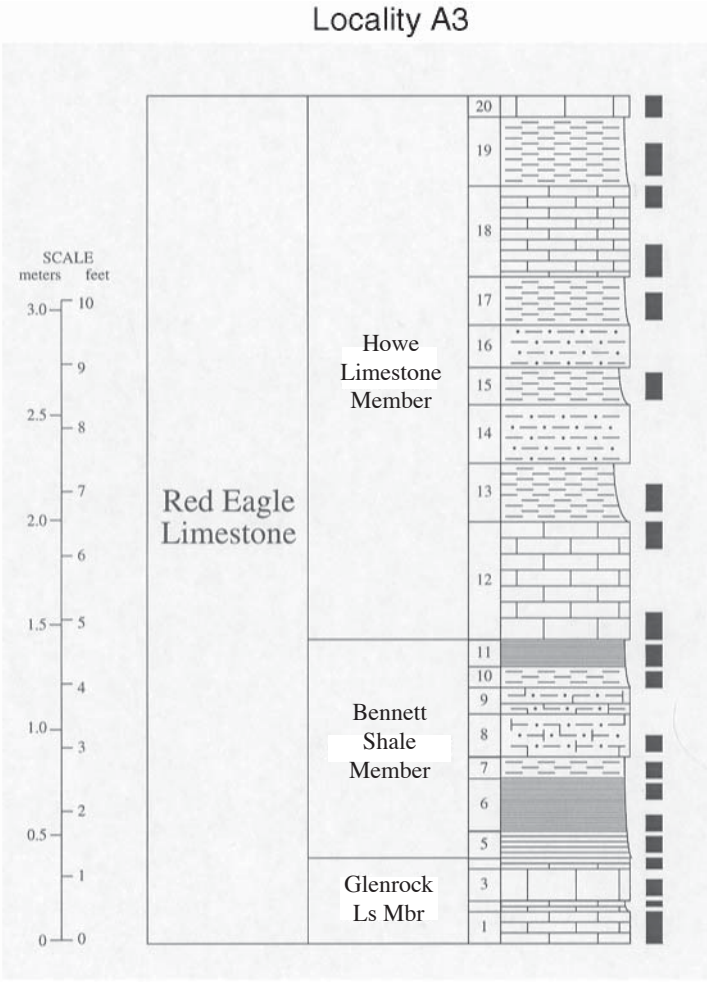

FIGURE 108—Measured section Locality A3–Glenrock Limestone Member through Howe Limestone Member (Red Eagle Limestone), samples and sample interval indicated by bars beside column.

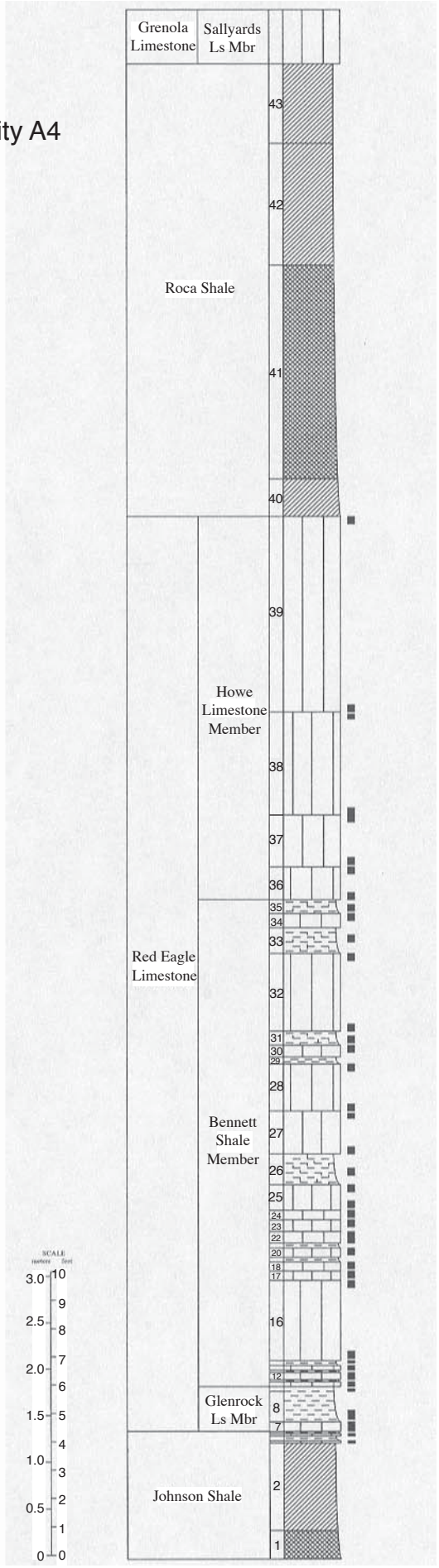

FIGURE 109 (right)—Measured section Locality A4, Burbank quarry–upper Johnson Shale through Sallyards Limestone Member, samples and sample interval indicated by bars beside column.

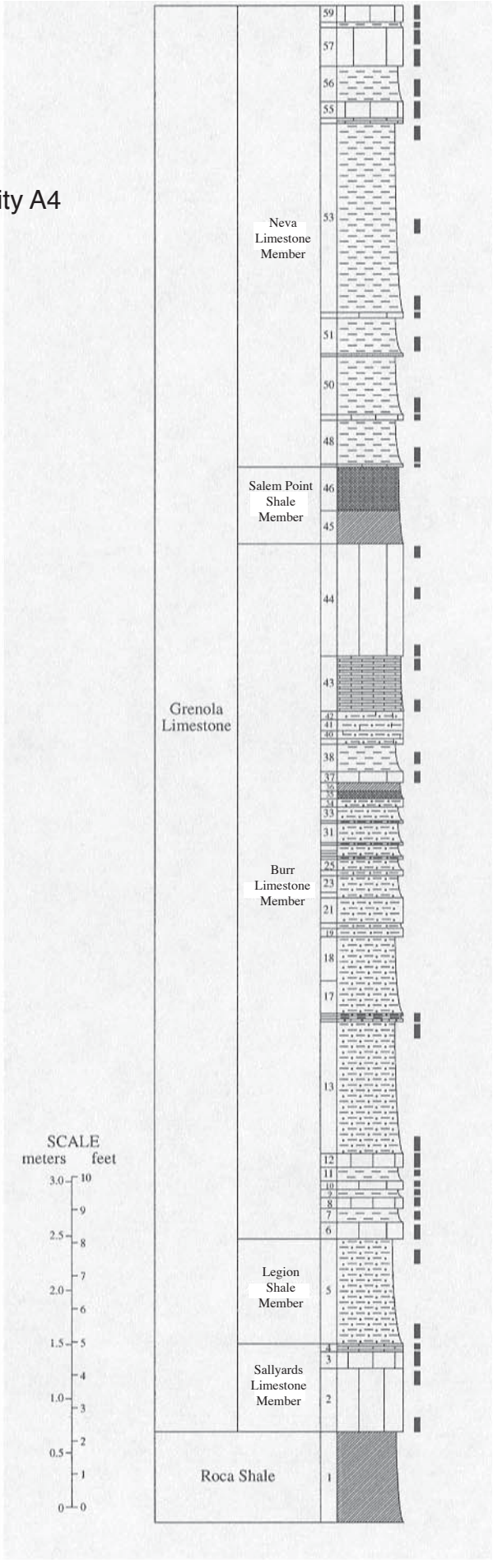

FIGURE 110—Measured section Locality A4, Burbank quarry–upper Roca Shale through Neva Limestone Member, samples and sample interval indicated by bars beside column.

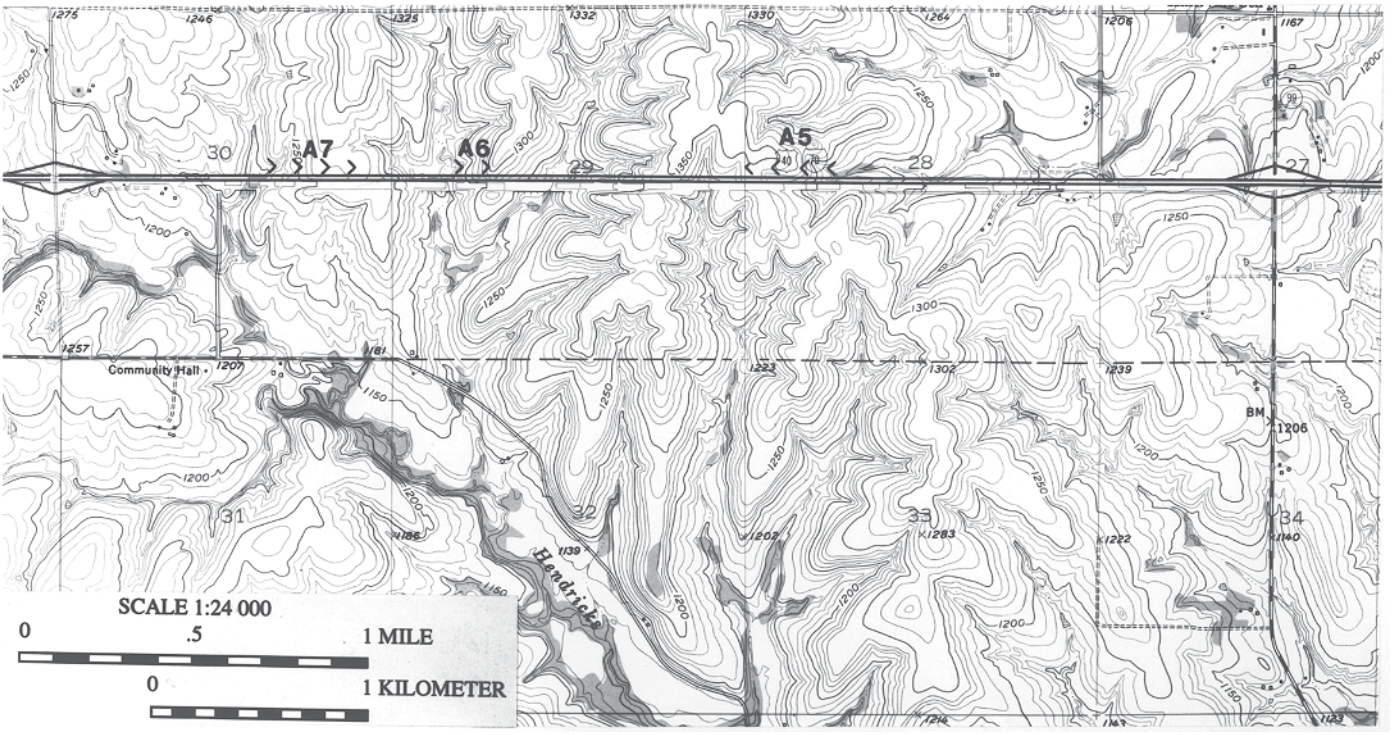

FIGURE 111—Map showing location of Localities A5, A6, and A7, I–70.

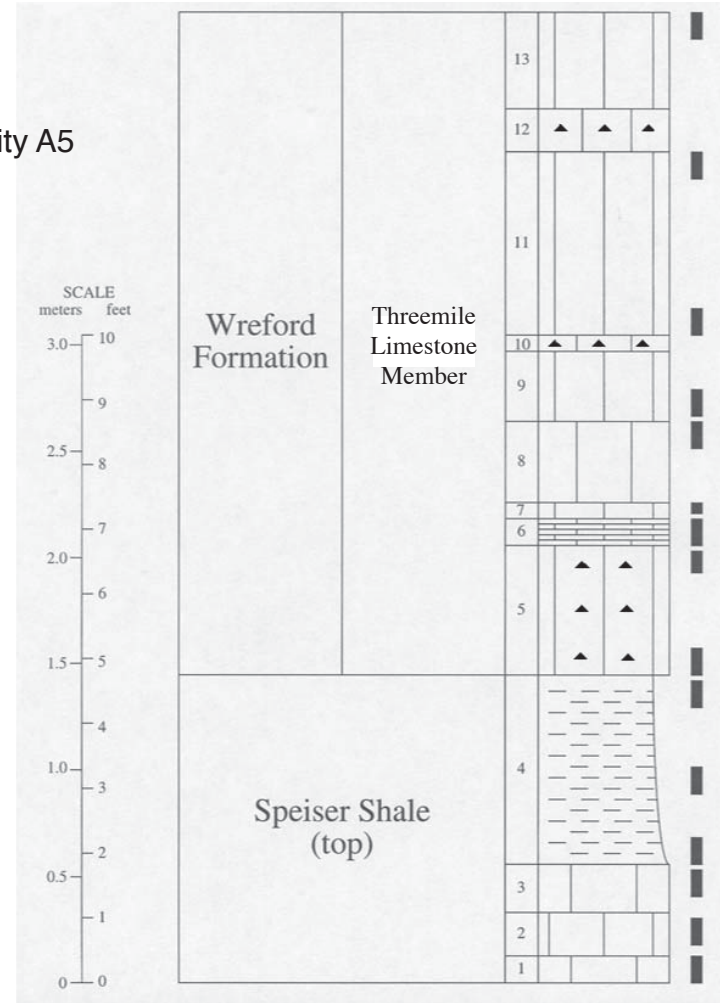

FIGURE 112 (right)—Measured section Locality A5–upper Speiser Shale and Threemile Limestone Member, samples and sample interval indicated by bars beside column.

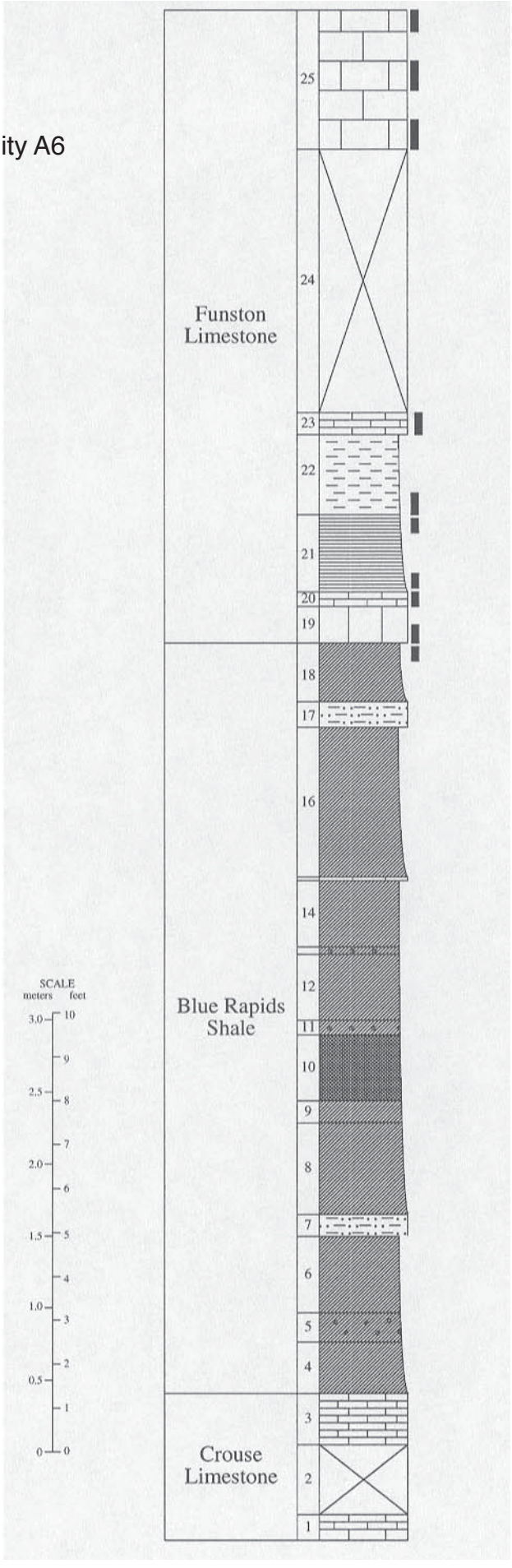

FIGURE 113—Measured section Locality A6–Crouse Limestone through Funston Limestone, samples and sample interval indicated by bars beside column.

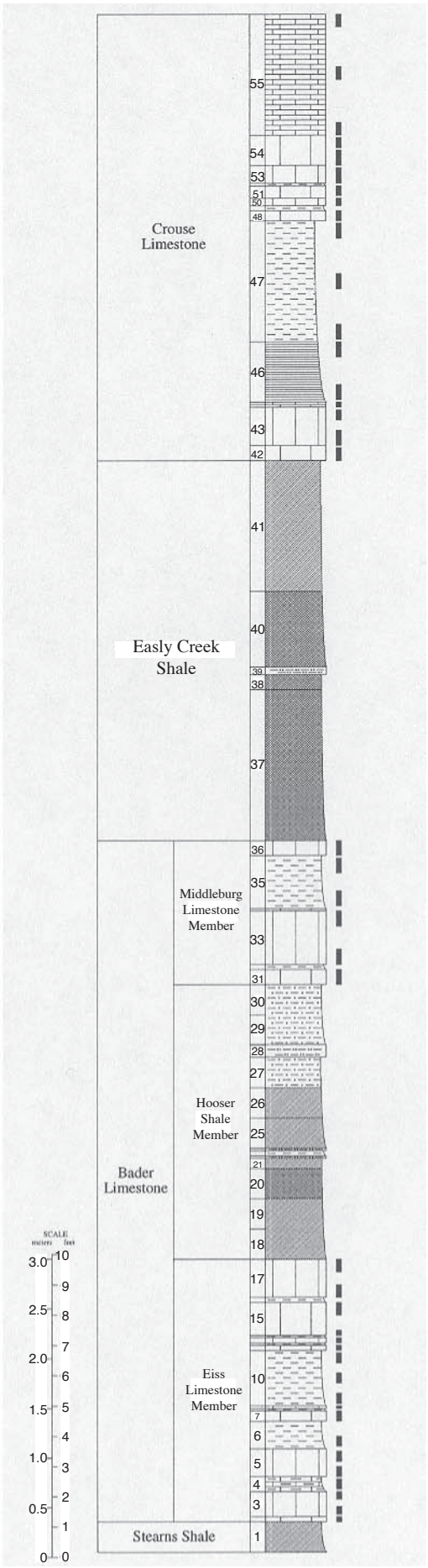

FIGURE 114—Measured section Locality A7–upper Stearns Shale through Crouse Limestone, samples and sample interval indicated by bars beside column.

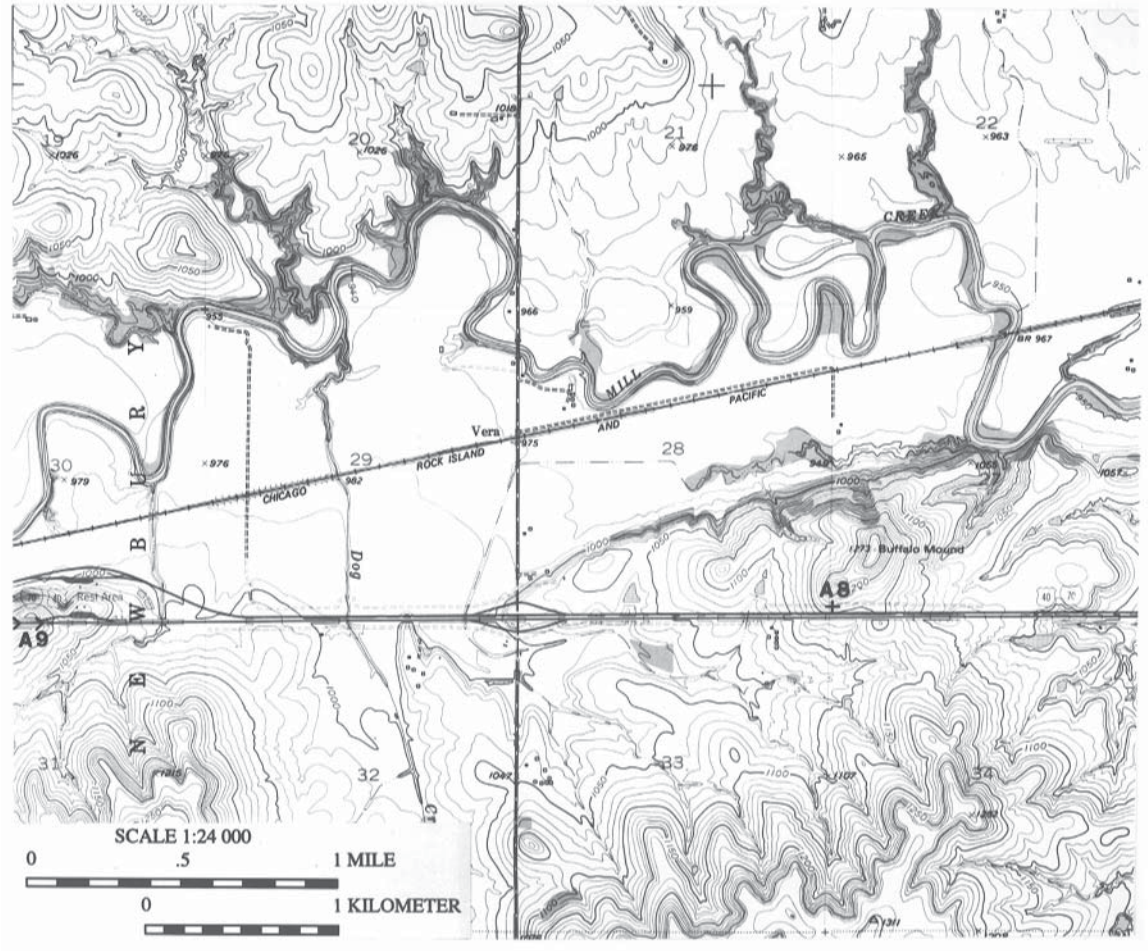

FIGURE 115—Map showing location of Localities A8 and A9, I–70.

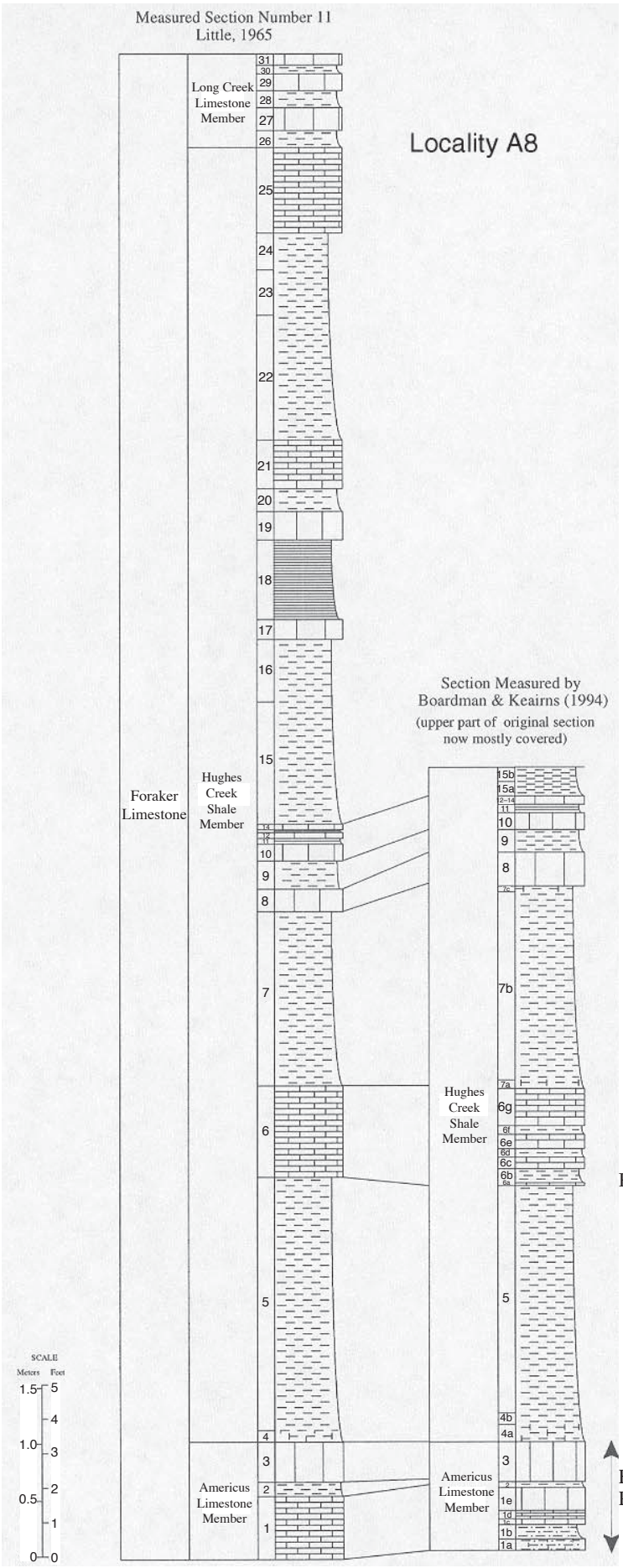

FIGURE 116—Measured section Locality A8–Americus Limestone Member through Long Creek Limestone Member showing section of Little (1965, section 11) and Keairns and Boardman (1994) and what was collected by Perlmutter (1975) as Falls City Limestone, but was Americus Limestone Member.

Locality A9

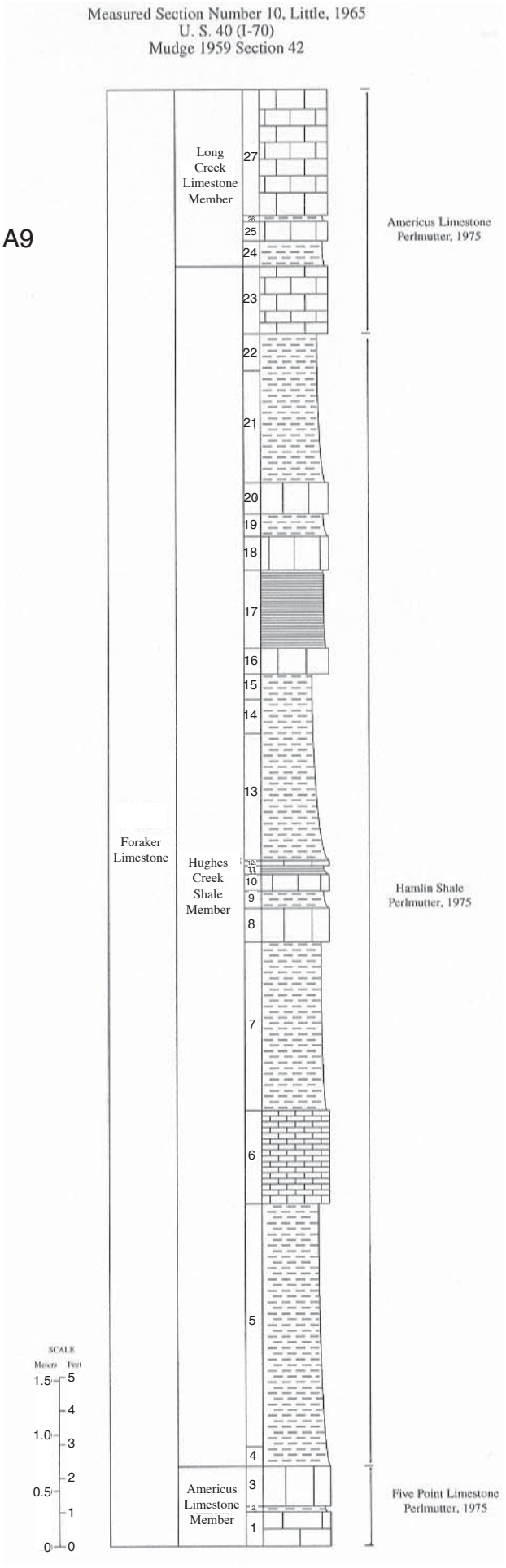

FIGURE 117—Measured section Locality A9–Americus Limestone Member through Long Creek Limestone Member (same section as Mudge and Burton, 1959, section 42, and Little, 1965, number 10) with mistaken unit identifications of Perlmutter (1975).

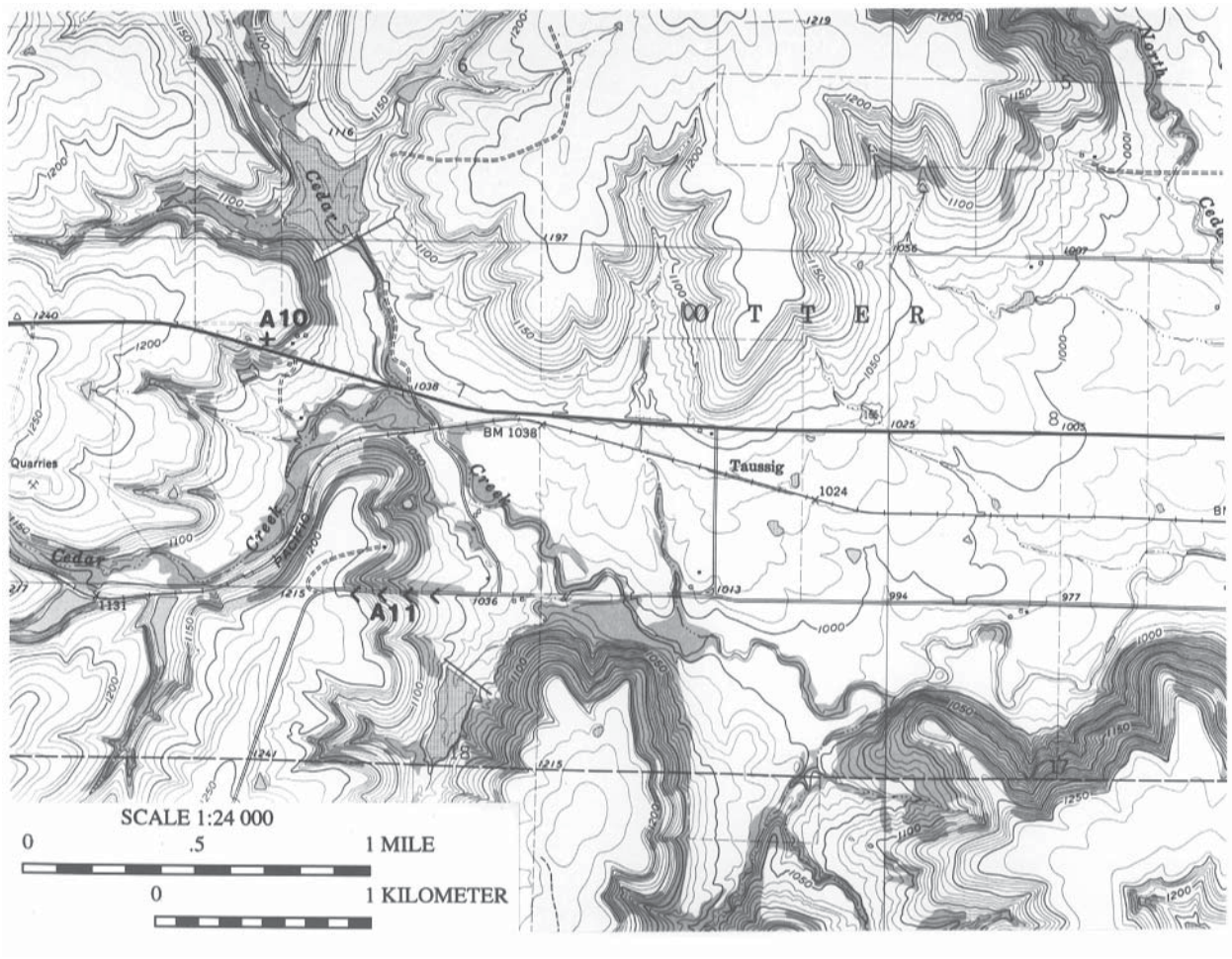

FIGURE 118—Map showing location of Localities A10 and A11, US–166 and US–166S.

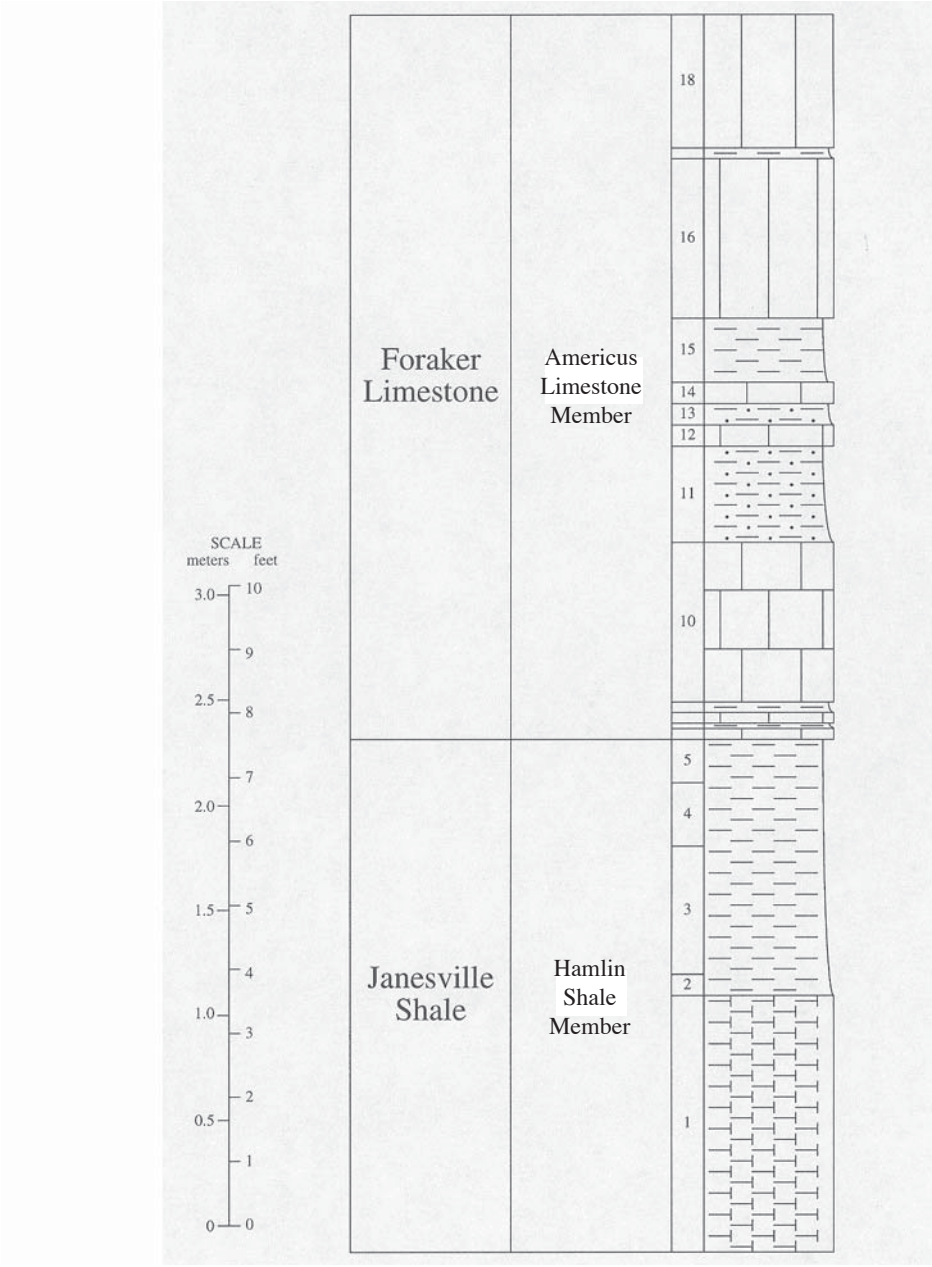

FIGURE 119—Measured section Locality A10–Hamlin Shale Member and Americus Limestone Member.

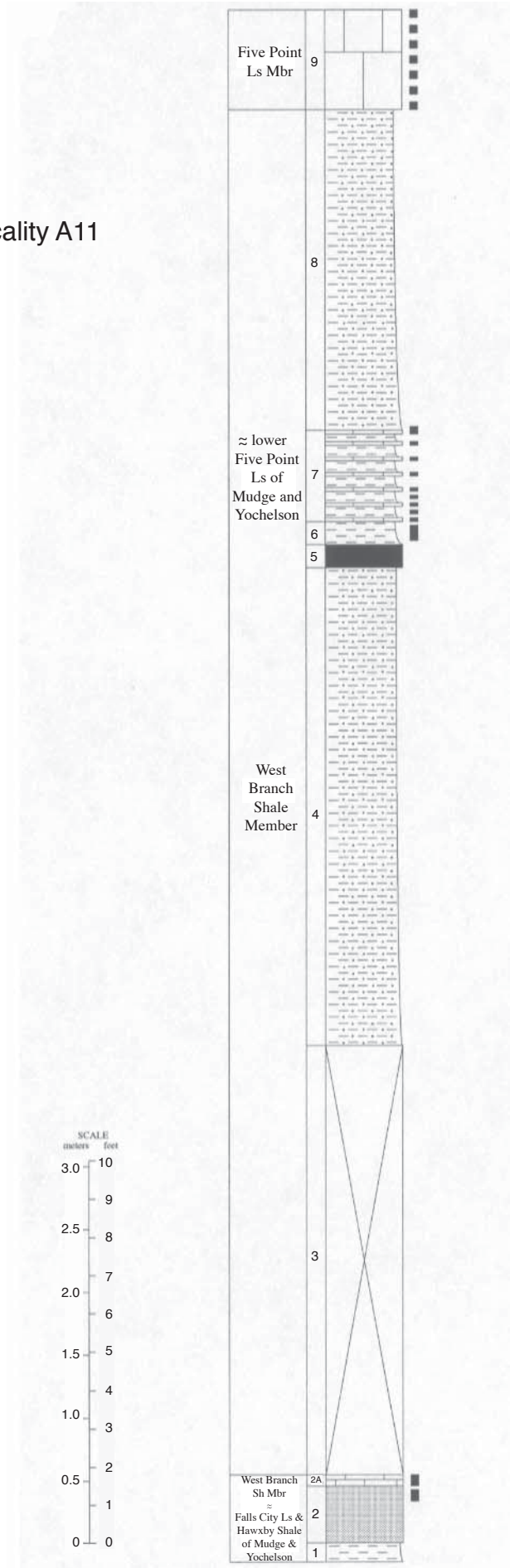

FIGURE 120—Measured section Locality A11–West Branch Shale Member and Five Point Limestone Member, showing unit identifications of Mudge and Yochelson (1963), samples and sample interval indicated by bars beside column.

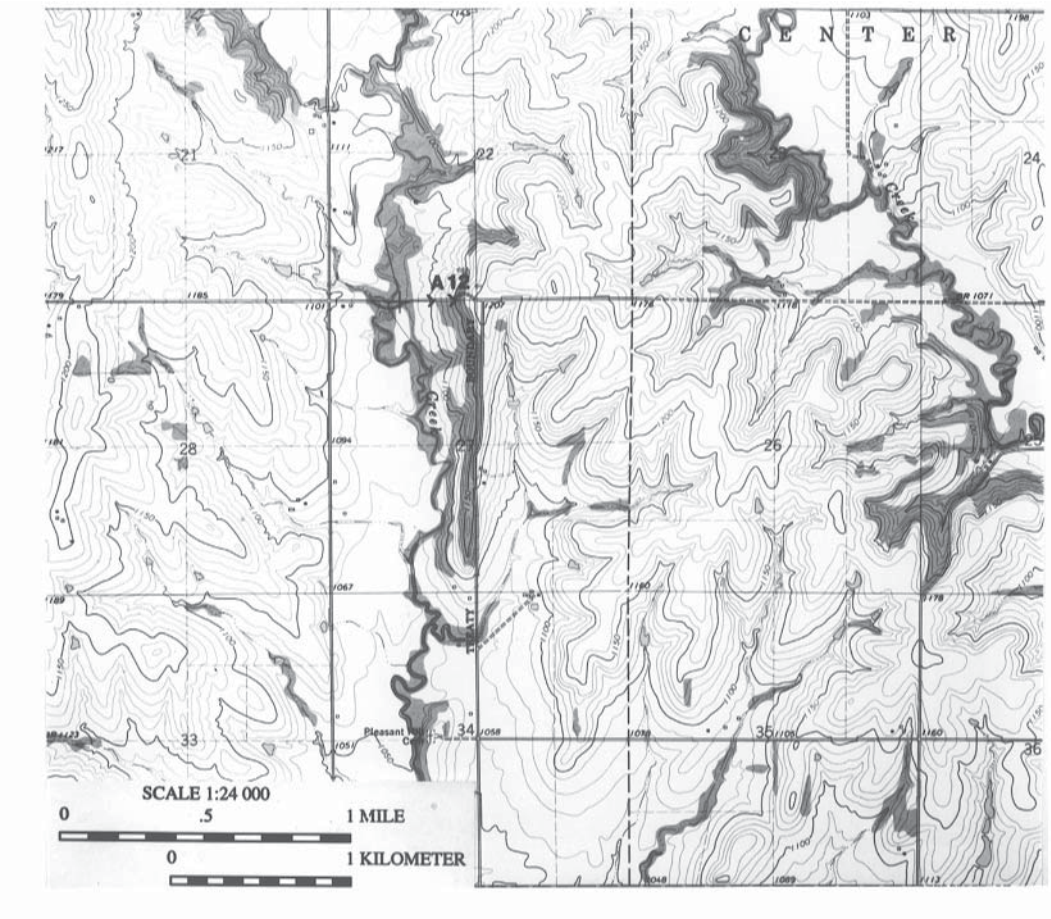

FIGURE 121—Map showing location of Locality A12.

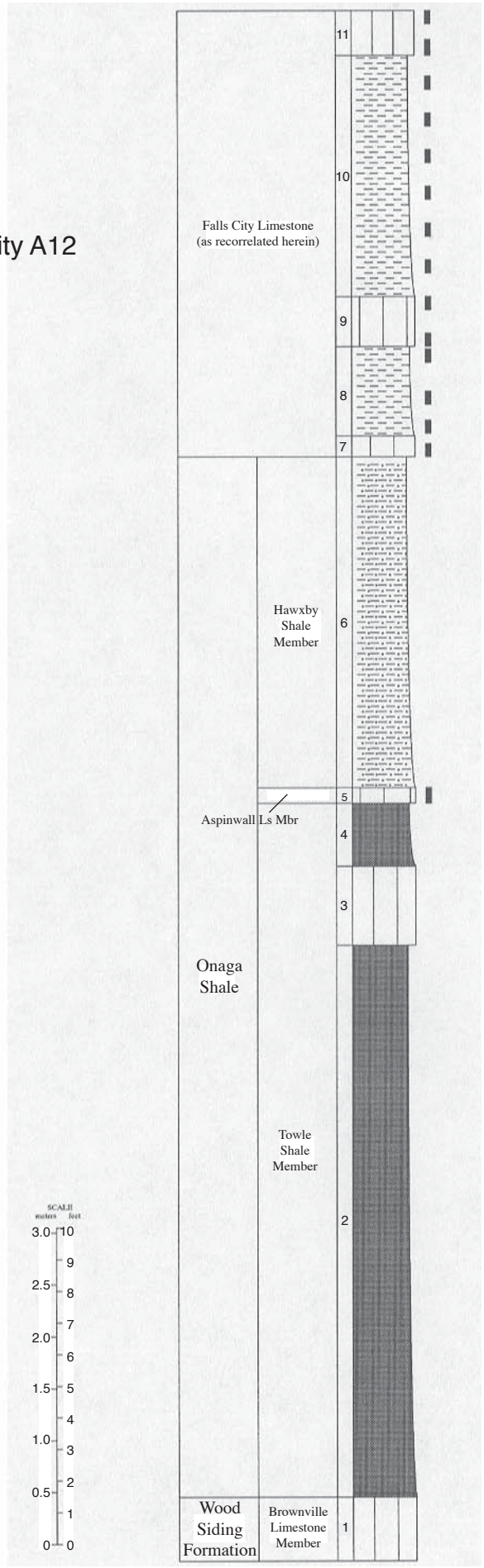

FIGURE 122—Measured section A12–Brownville Limestone Member through Falls City Limestone, samples and sample interval indicated by bars beside column.

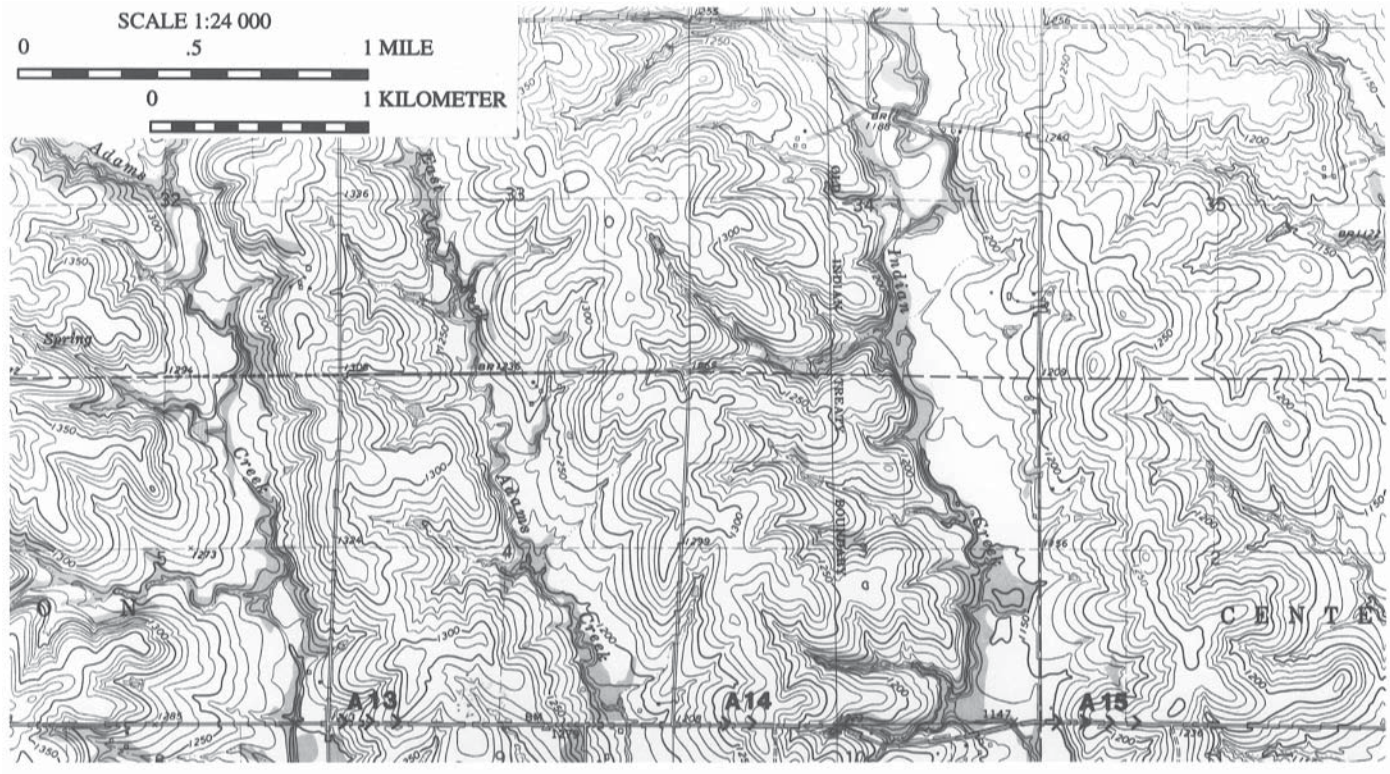

FIGURE 123—Map showing location of Localities A13, A14, and A15, Onaga.

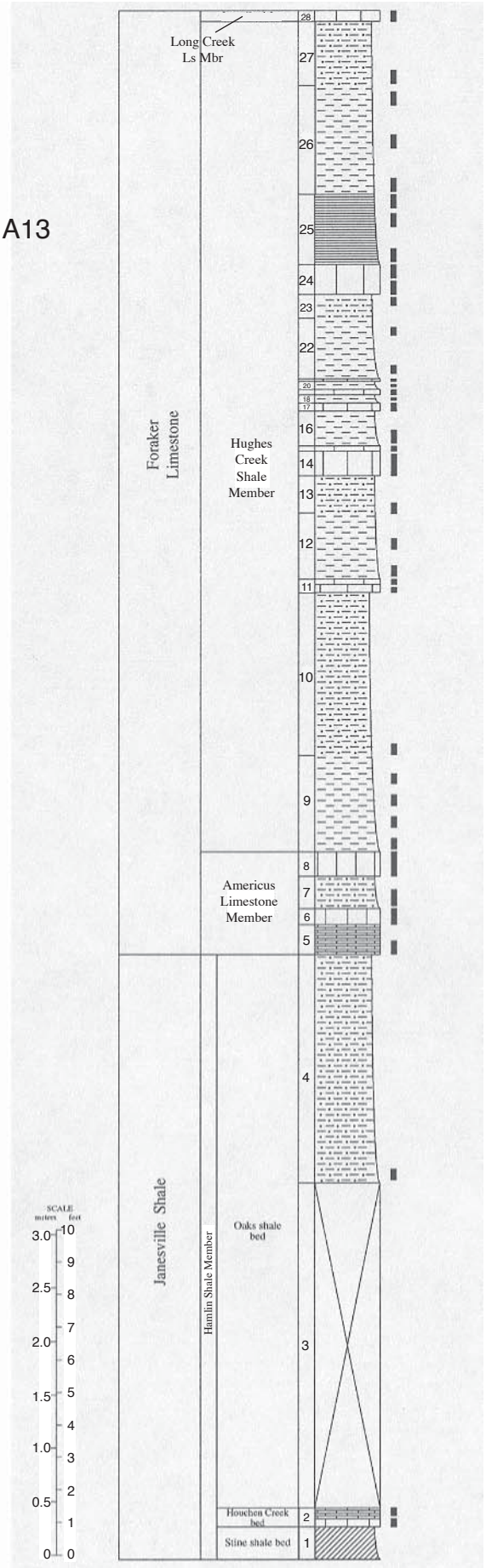

FIGURE 124—Measured section Locality A13–Stine shale bed through Long Creek Limestone Member, samples and sample interval indicated by bars beside column.

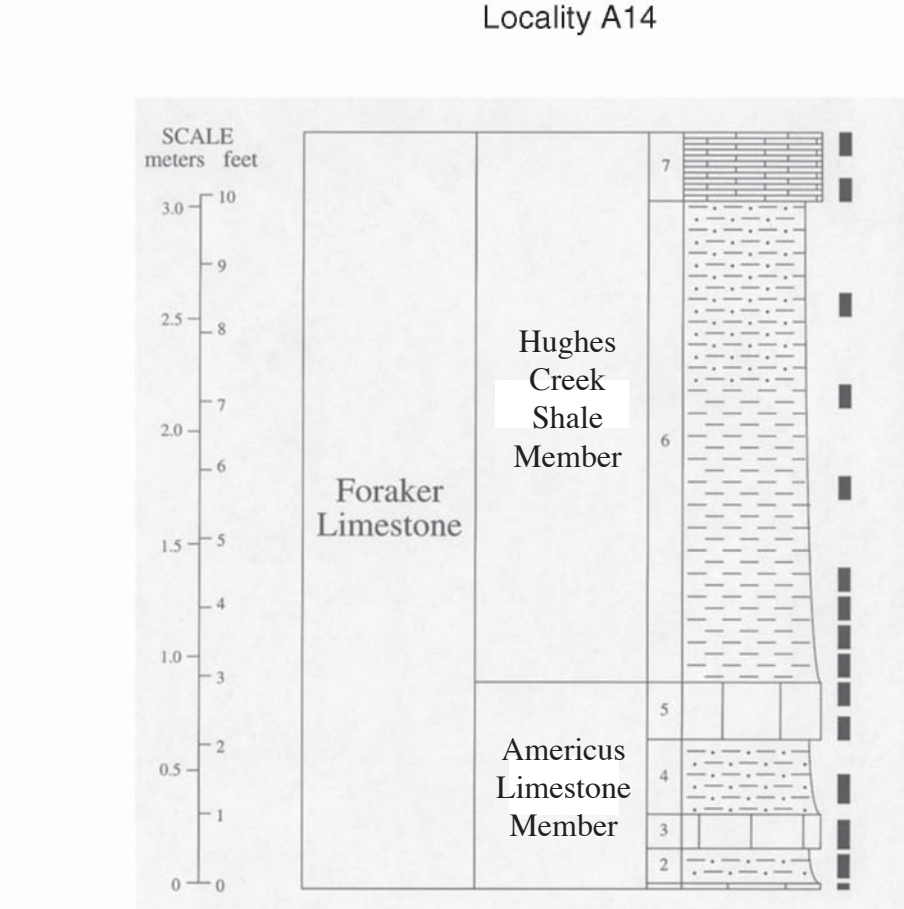

FIGURE 125—Measured section Locality A14–Americus Limestone Member and Hughes Creek Shale Member, samples and sample interval indicated by bars beside column.

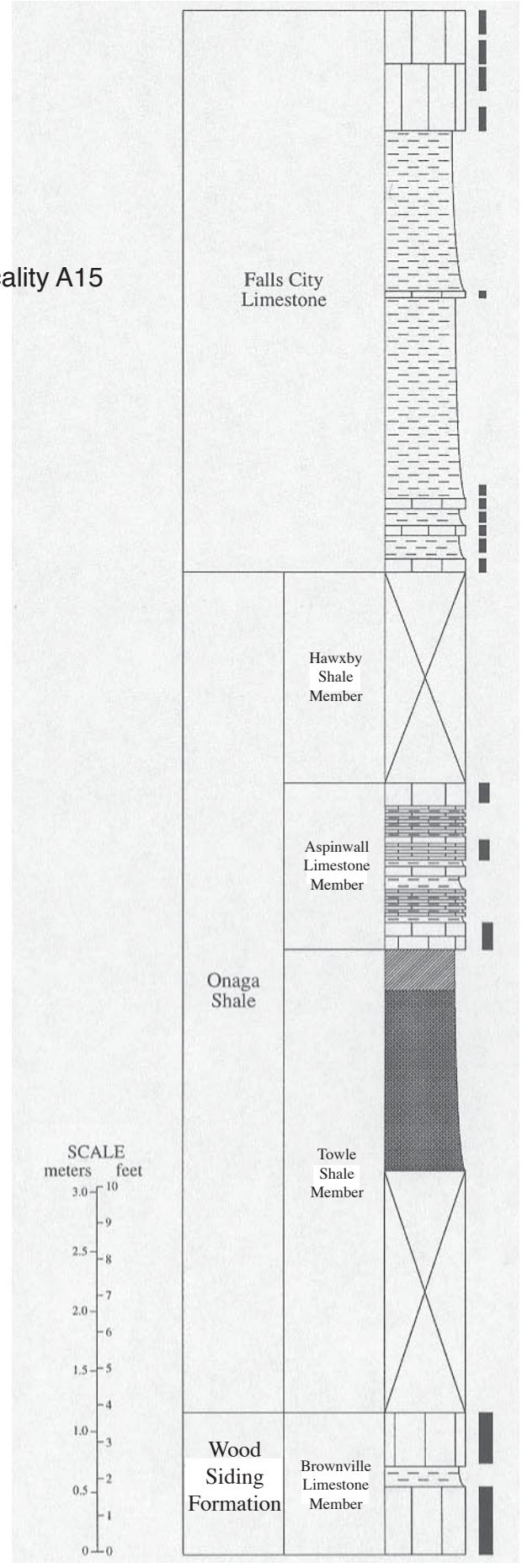

FIGURE 126—Measured section Locality A15–Brownville Limestone Member through Falls City Limestone, type Onaga Shale, samples and sample interval indicated by bars beside column.

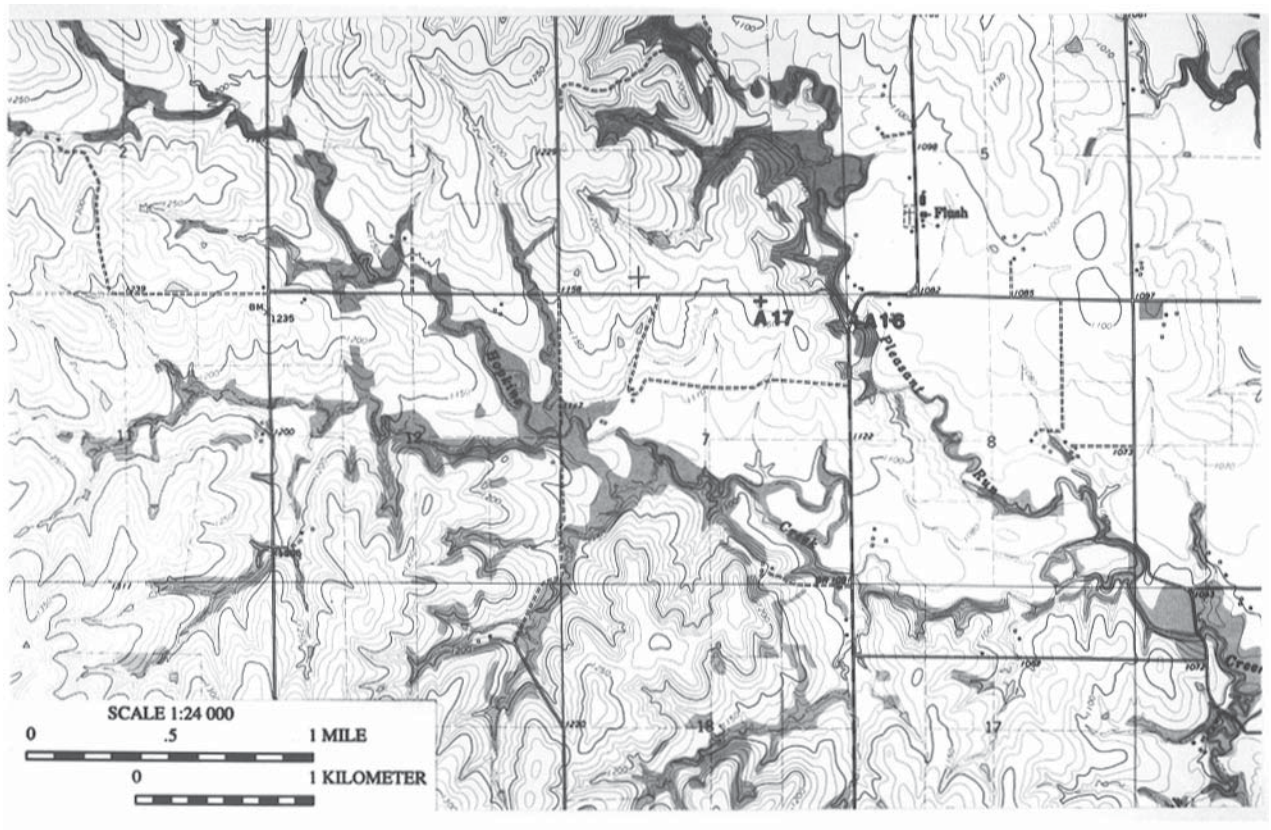

FIGURE 127—Map showing location of Localities A16 and A17, Flush.

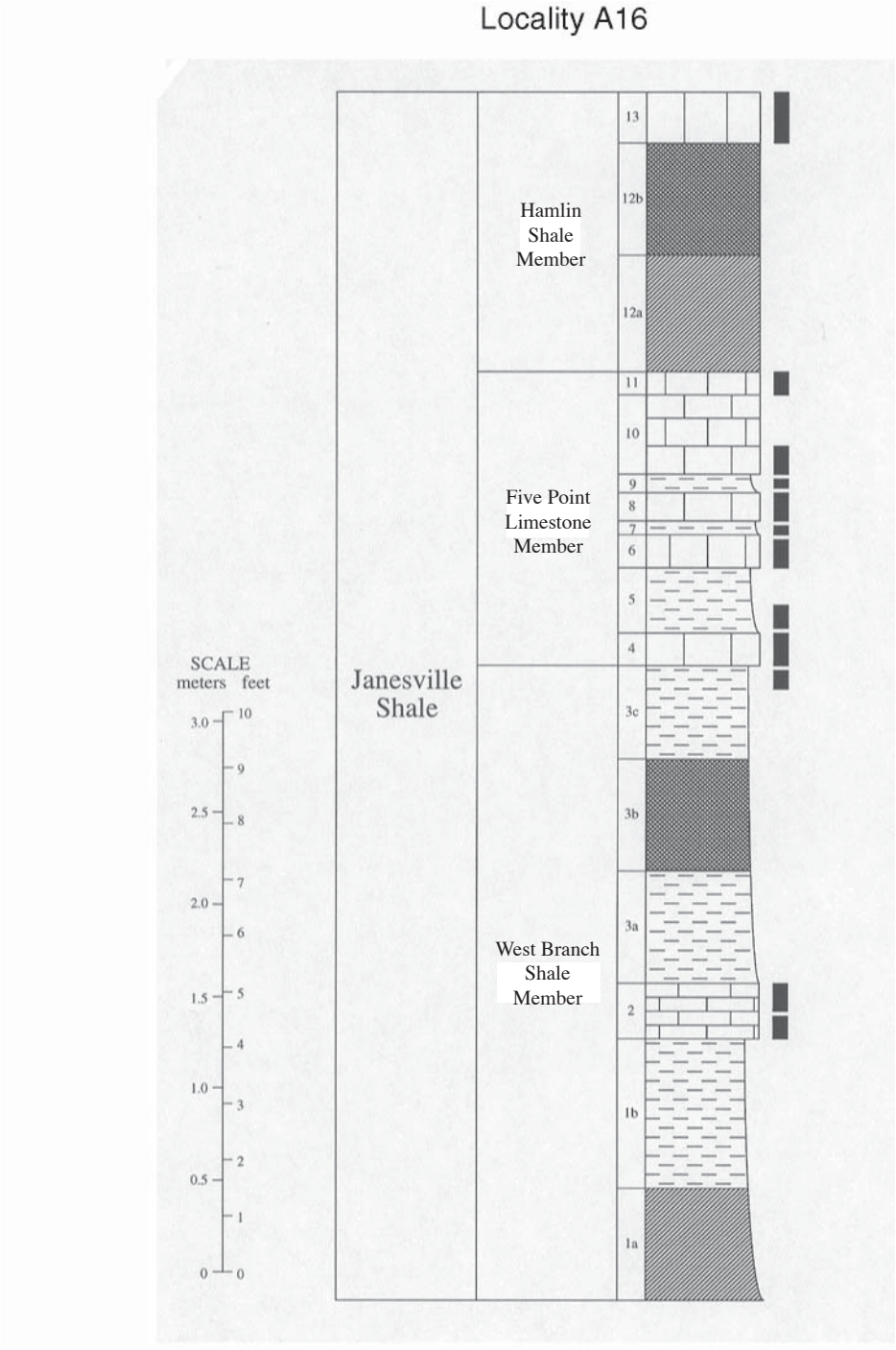

FIGURE 128—Measured section Locality A16–West Branch Shale Member through Hamlin Shale Member, samples and sample interval indicated by bars beside column.

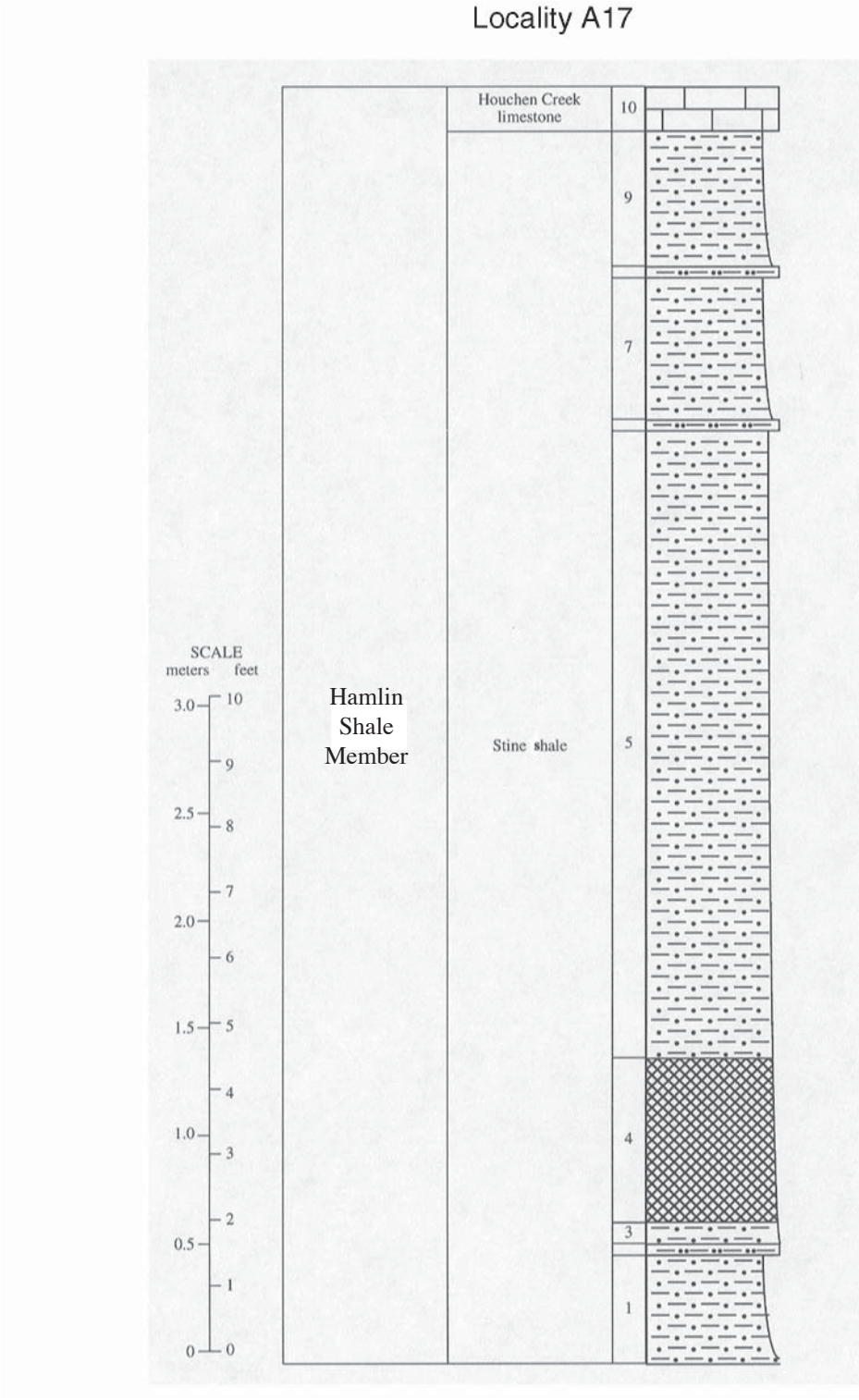

FIGURE 129—Measured section Locality A17–Stine shale bed and Houchen Creek limestone bed of the Hamlin Shale Member.

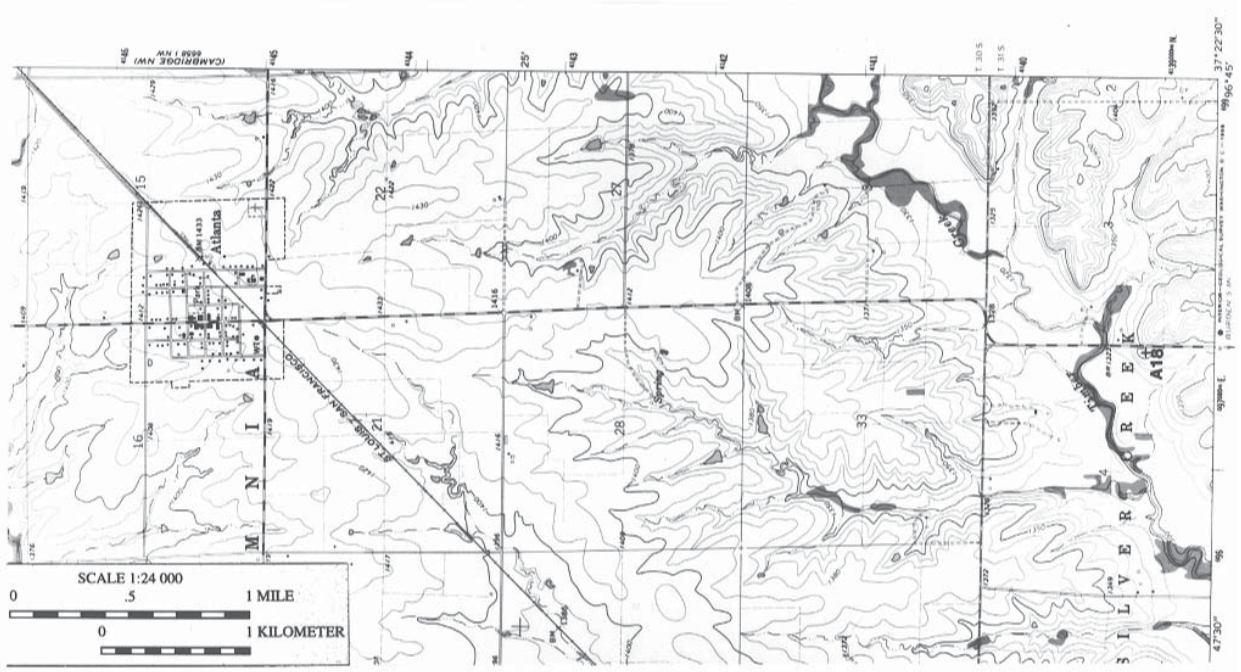

FIGURE 130—Map showing location of Locality A18, Atlanta.

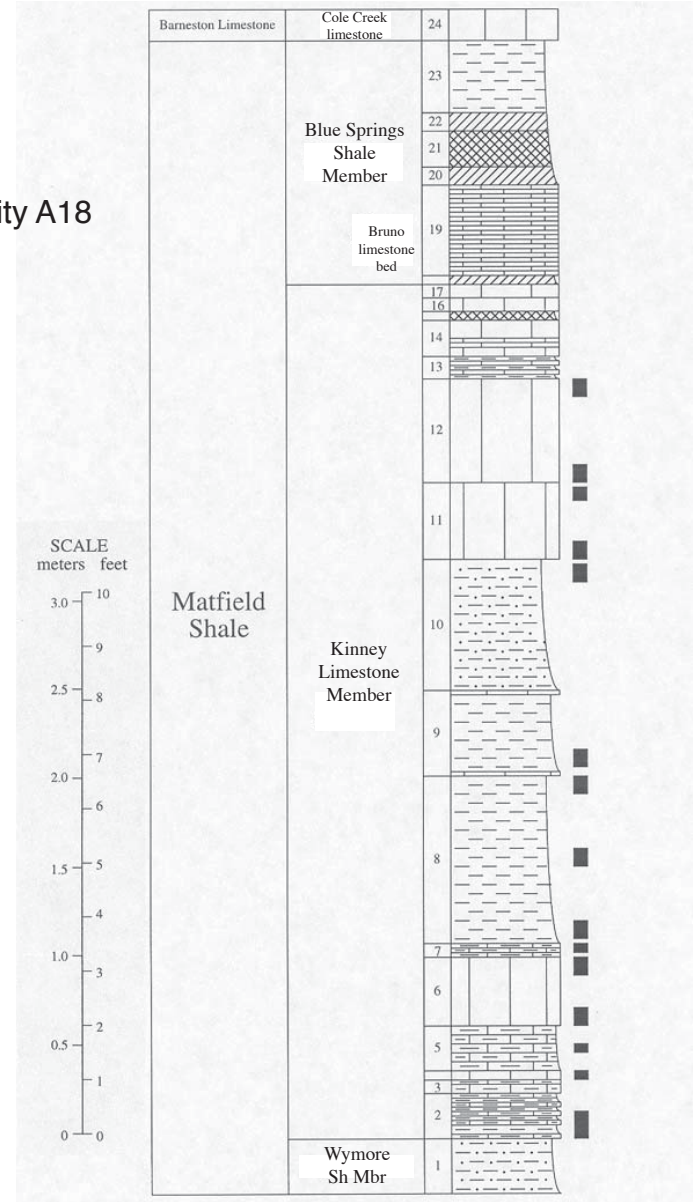

FIGURE 131 (right)—Measured section Locality A18–upper Wymore Shale Member through lower Cole Creek limestone, samples and sample interval indicated by bars beside column.

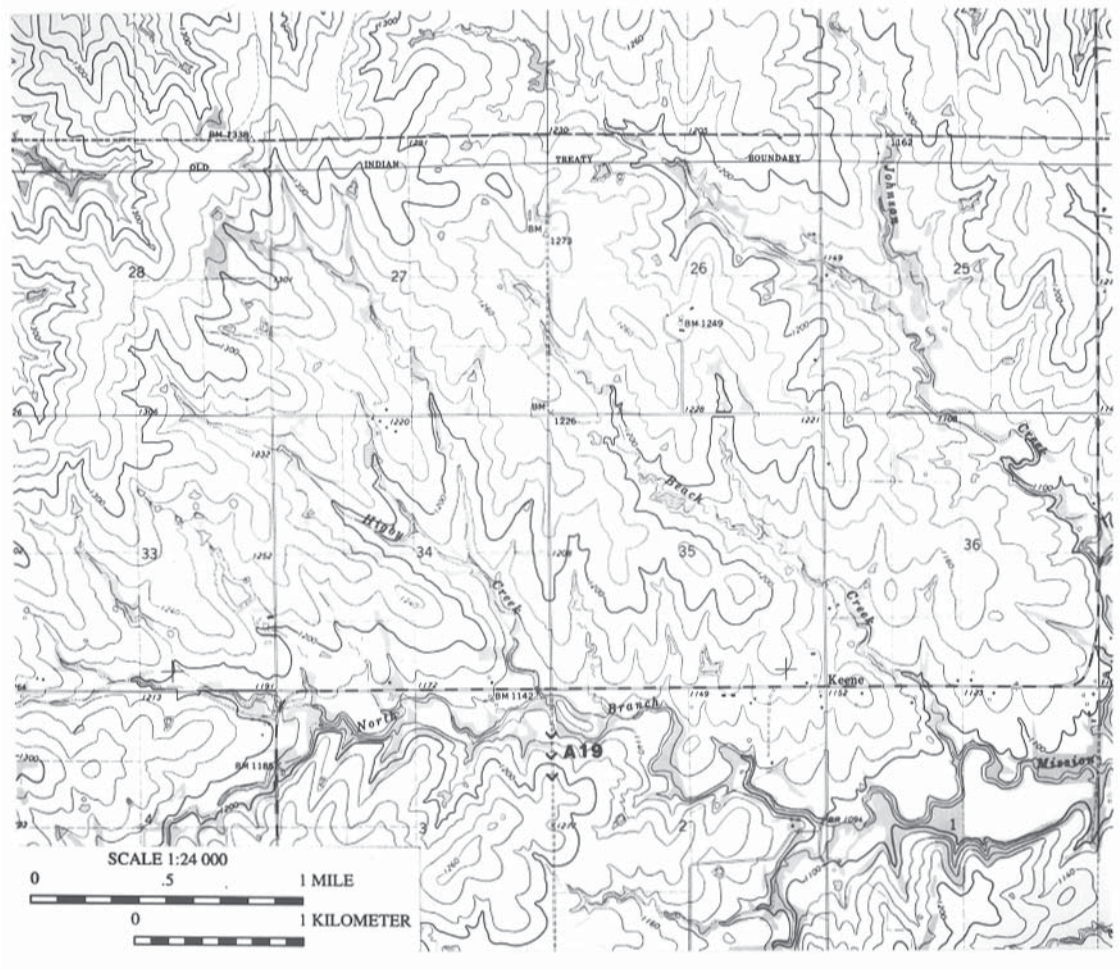

FIGURE 132—Map showing location of Locality A19, Keene.

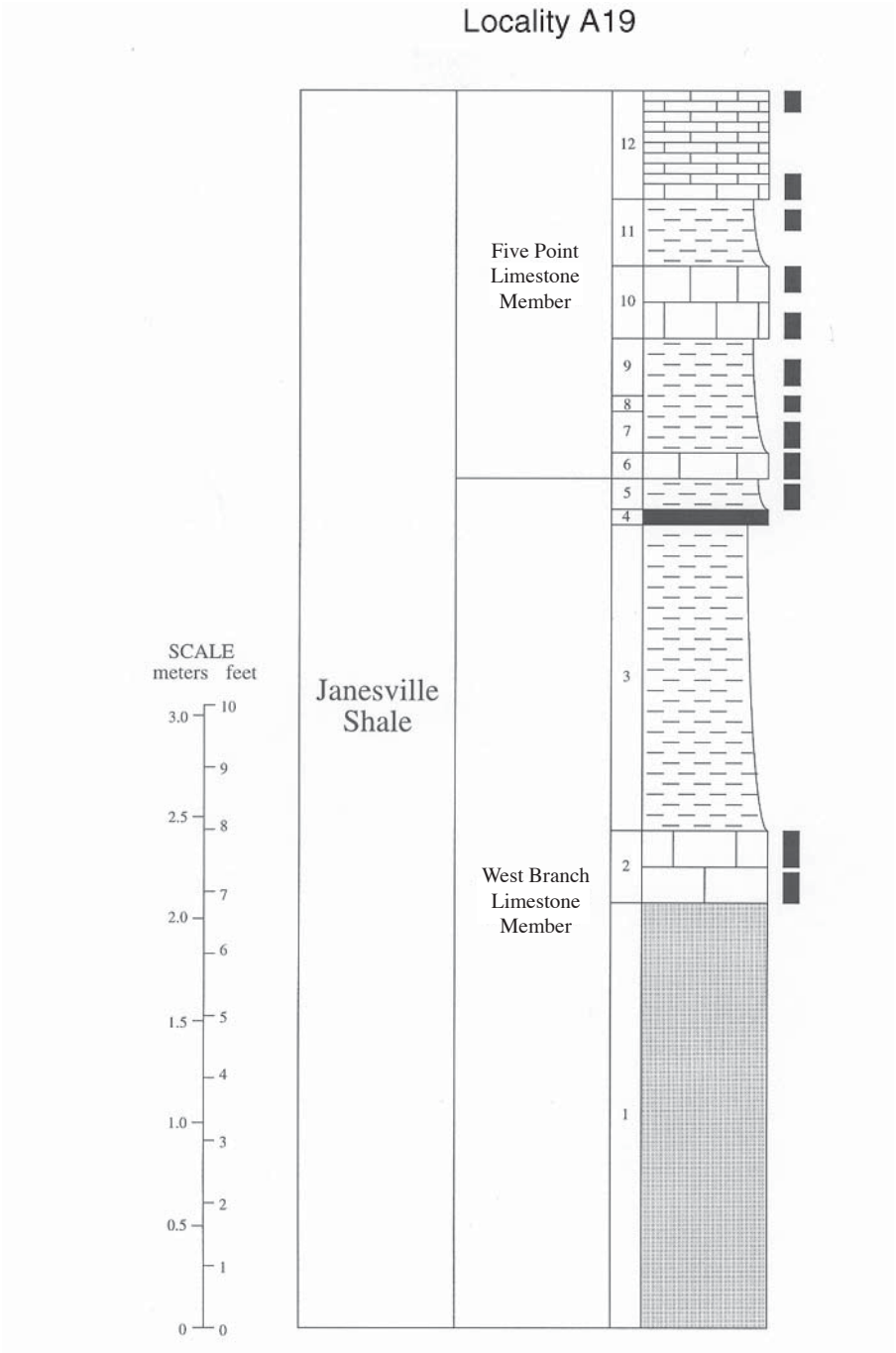

FIGURE 133—Measured section Locality A19–West Branch Shale Member and Five Point Limestone Member, samples and sample interval indicated by bars beside column.

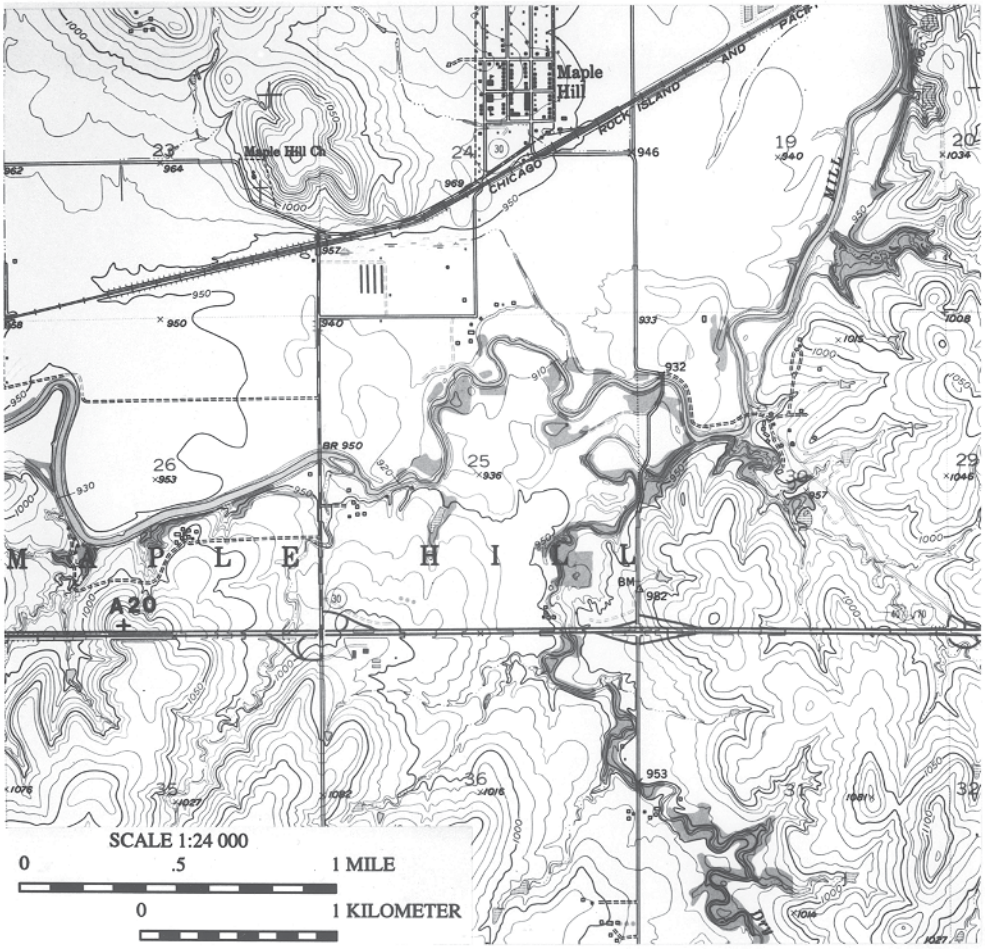

FIGURE 134—Map showing location of Locality A20, I–70.

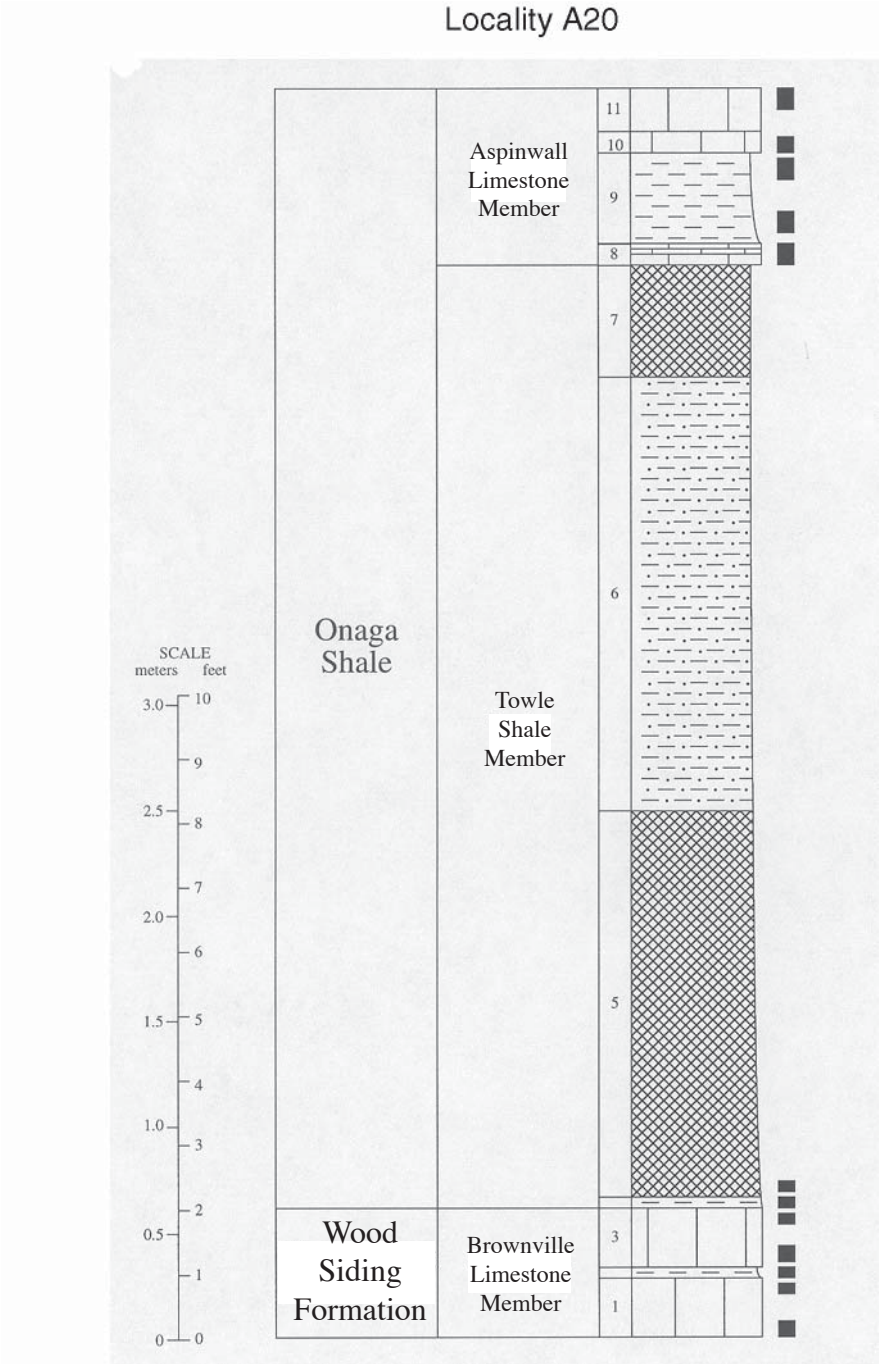

FIGURE 135—Measured section Locality A20–Brownville Limestone Member through Aspinwall Limestone Member, samples and sample interval indicated by bars beside column.

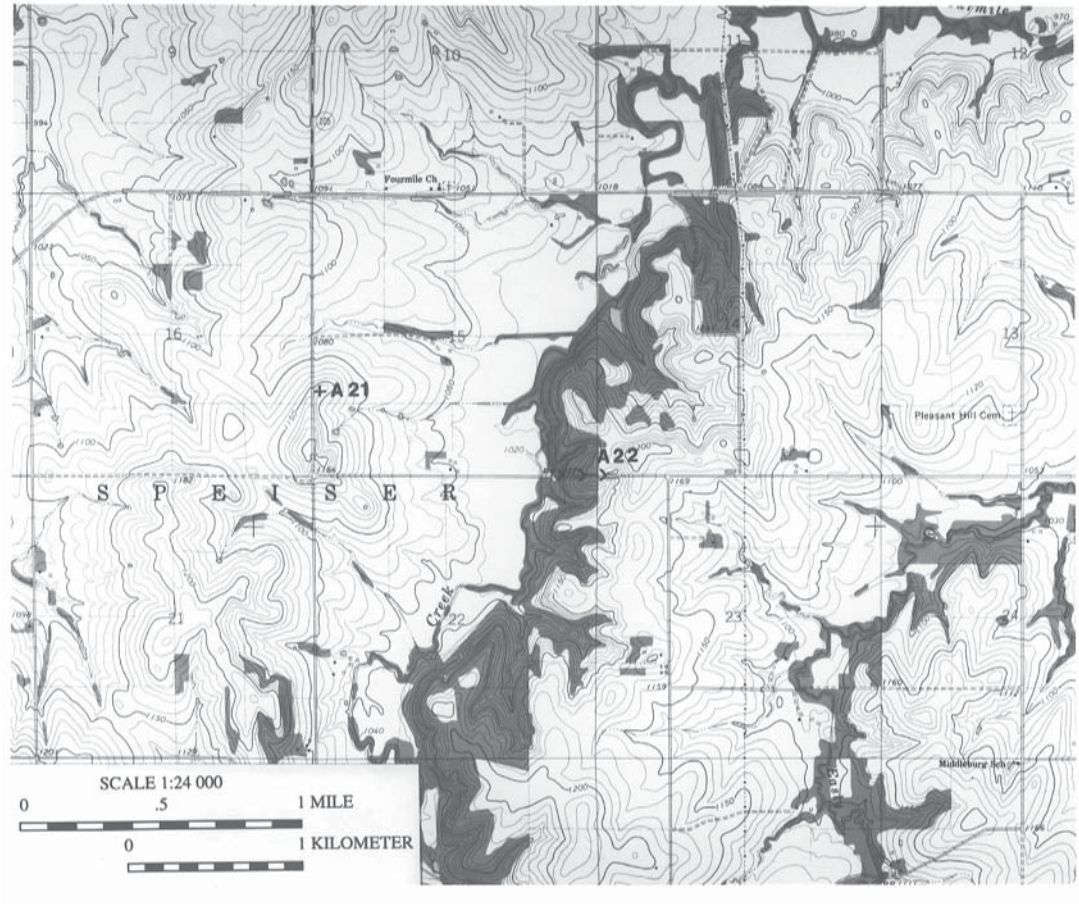

FIGURE 136—Map showing location of Localities A21 and A22.

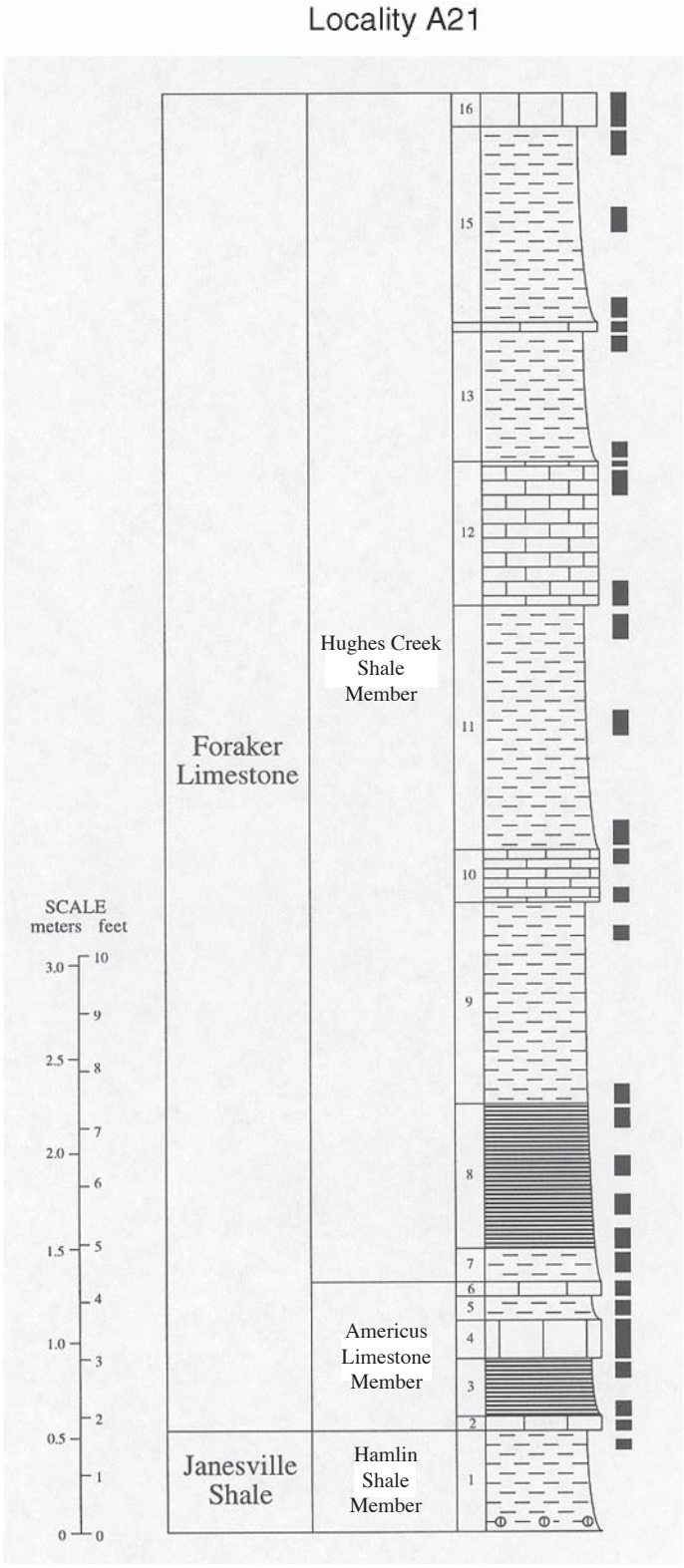

FIGURE 137—Measured section A21–upper Hamlin Shale Member through Hughes Creek Shale Member, samples and sample interval indicated by bars beside column.

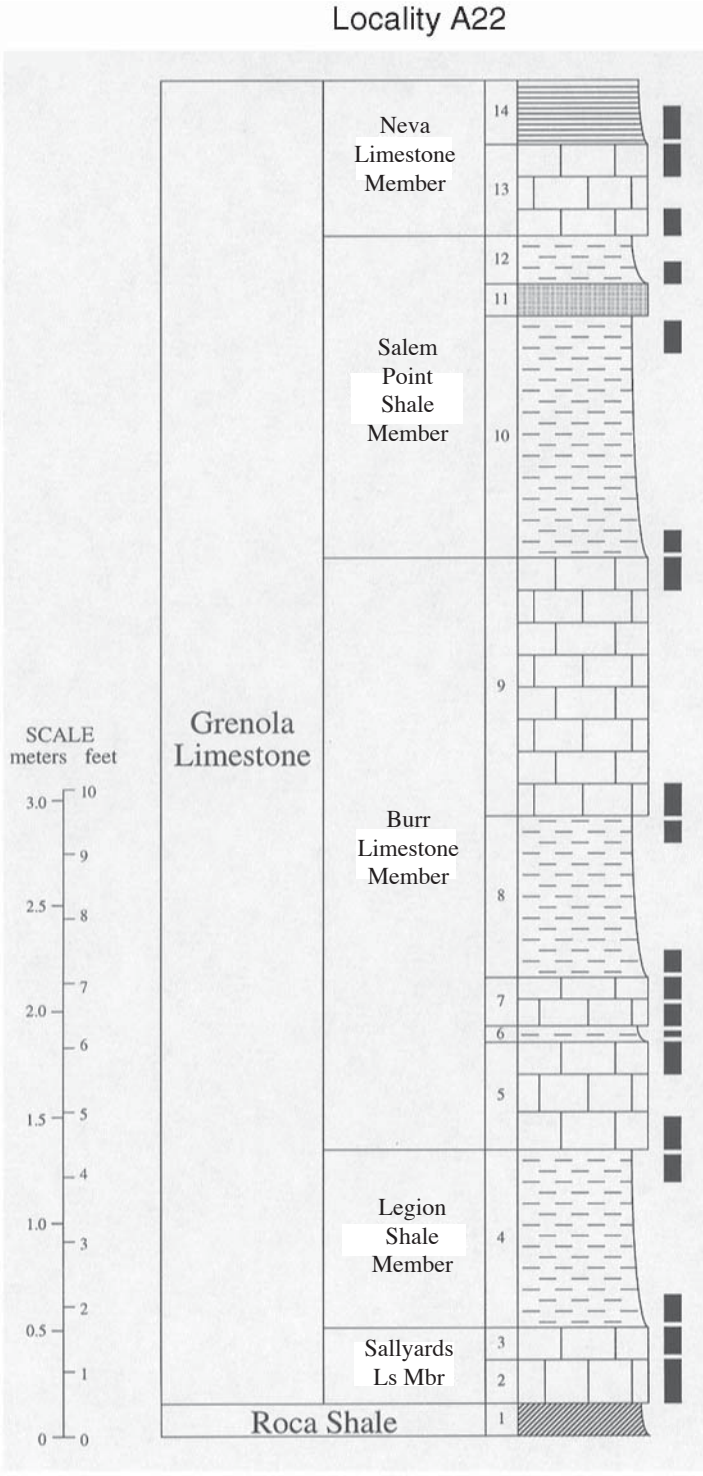

FIGURE 138—Measured section A22–upper Roca Shale through Neva Limestone Member, samples and sample interval indicated by bars beside column.

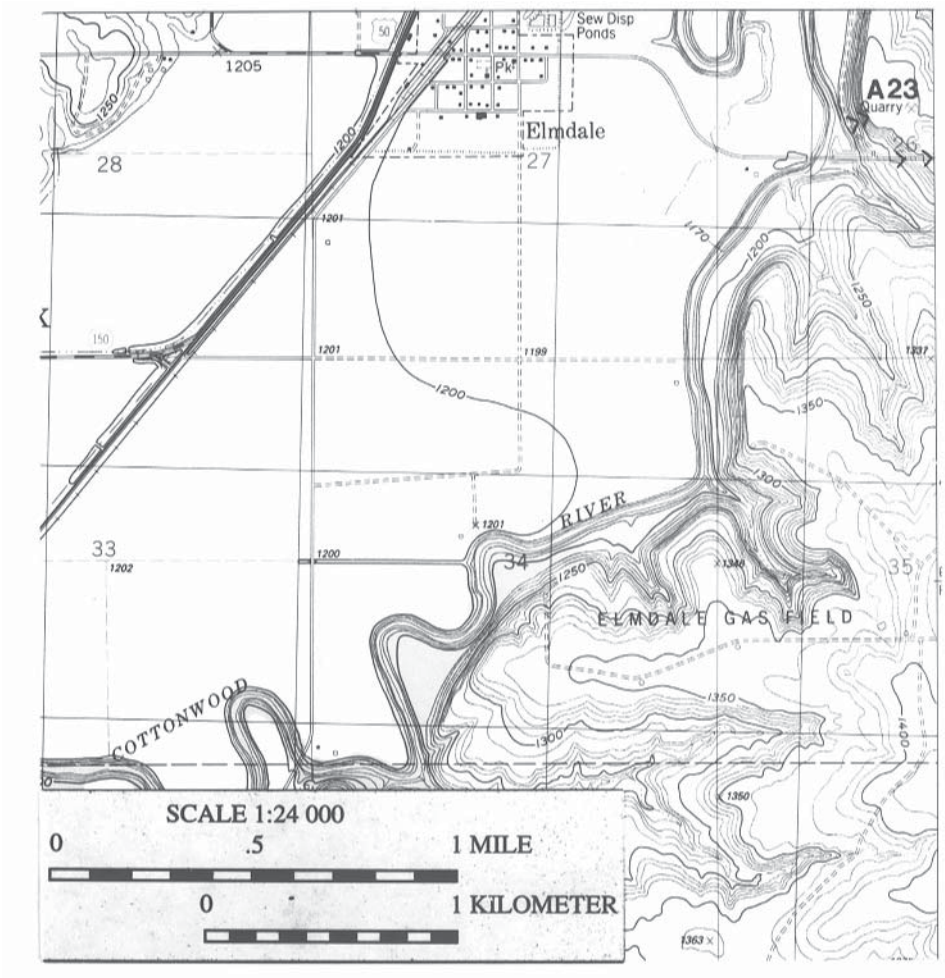

FIGURE 139—Map showing location of Locality A23, type Neva.

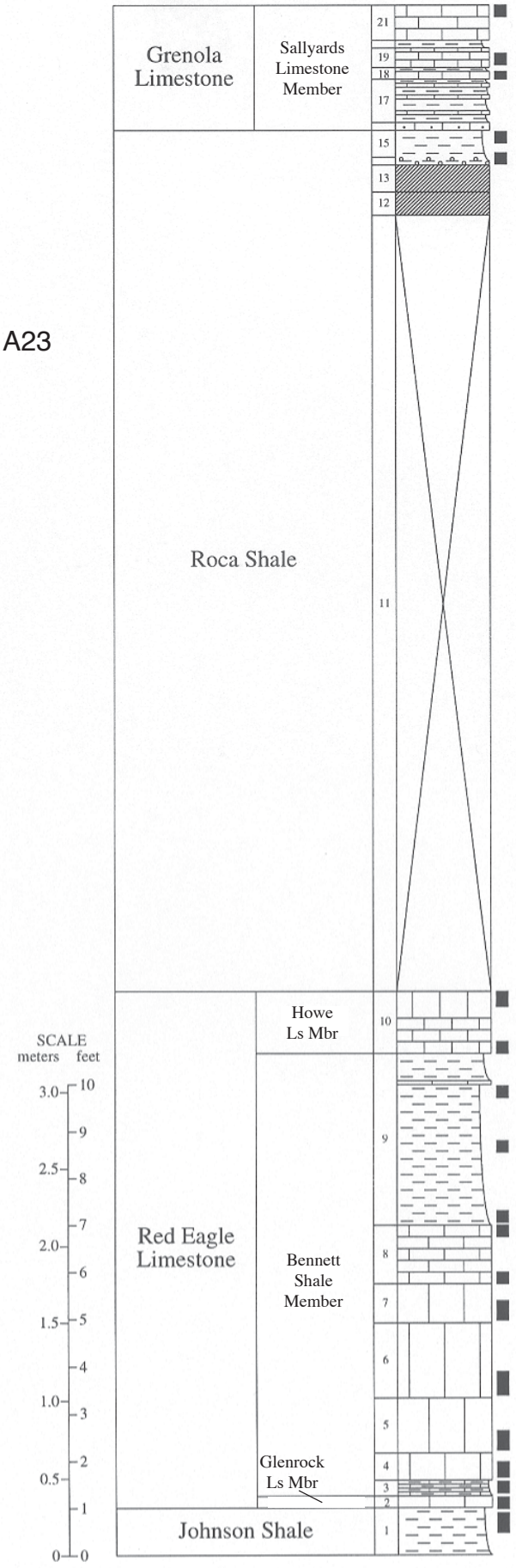

FIGURE 140—Measured section A23–upper Johnson Shale through Sallyards Limestone Member, samples and sample interval indicated by bars beside column.

Locality A23

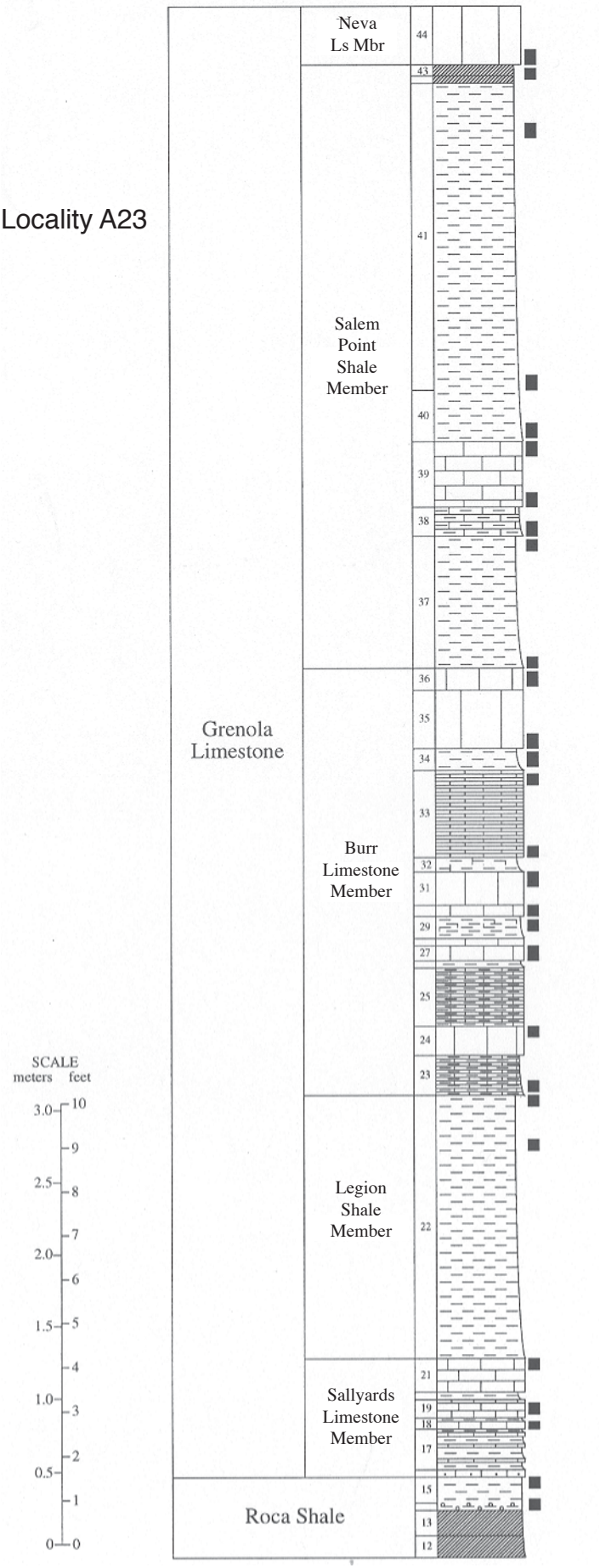

FIGURE 141—Measured section A23–upper Roca Shale through lower Neva Limestone Member, samples and sample interval indicated by bars beside column.

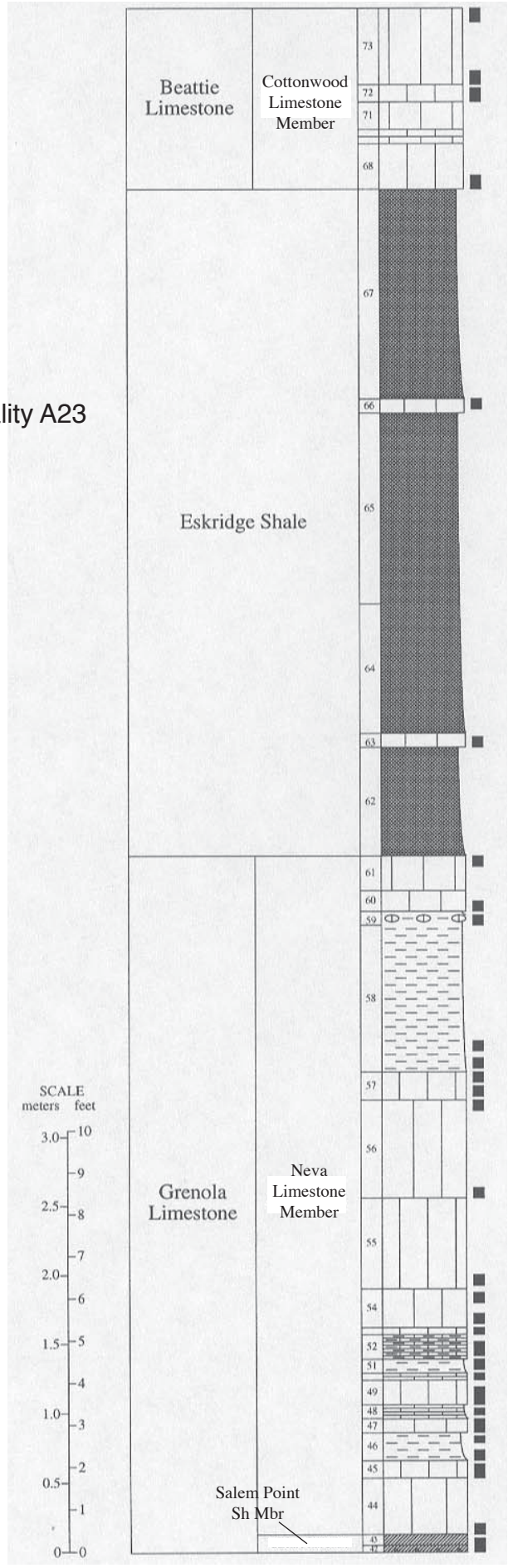

FIGURE 142—Measured section A23–upper Salem Point Shale Member through Cottonwood Limestone Member, samples and sample interval indicated by bars beside column.

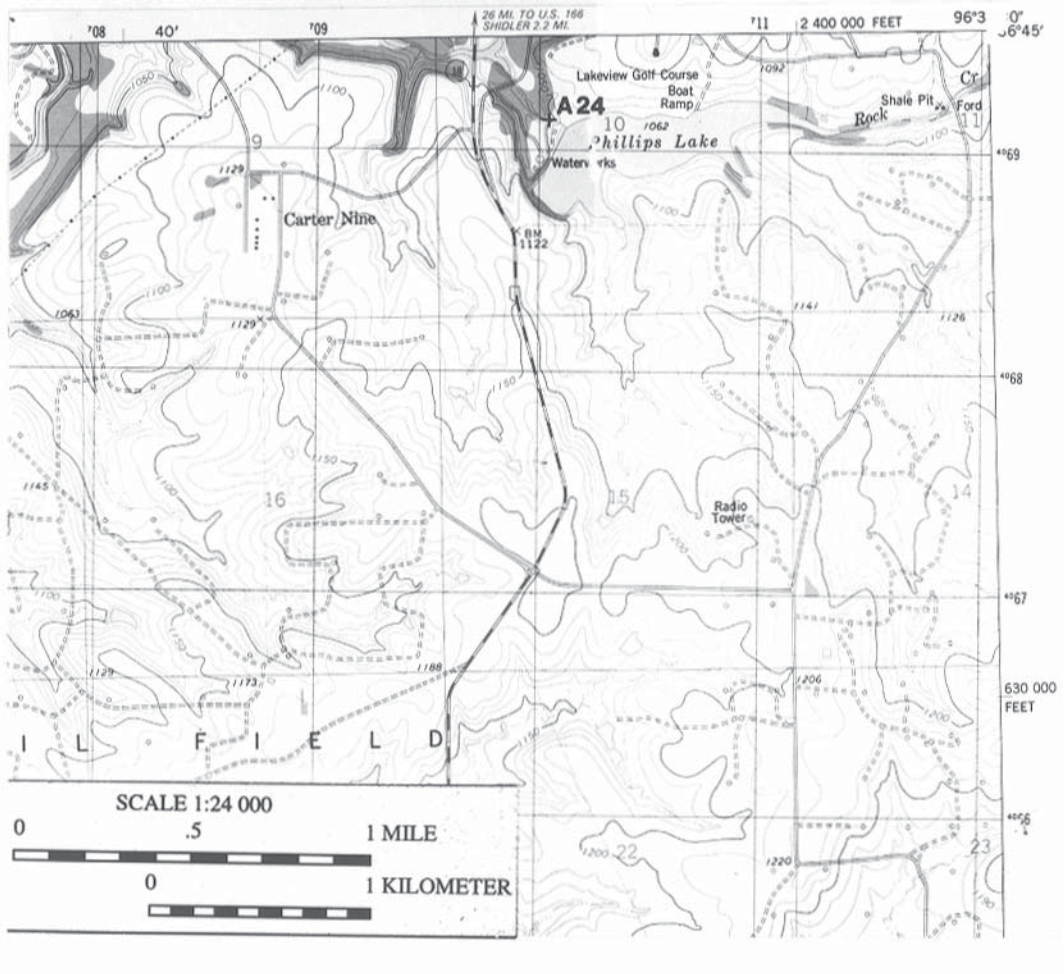

FIGURE 143—Map showing location of Locality A24, Shidler Spillway.

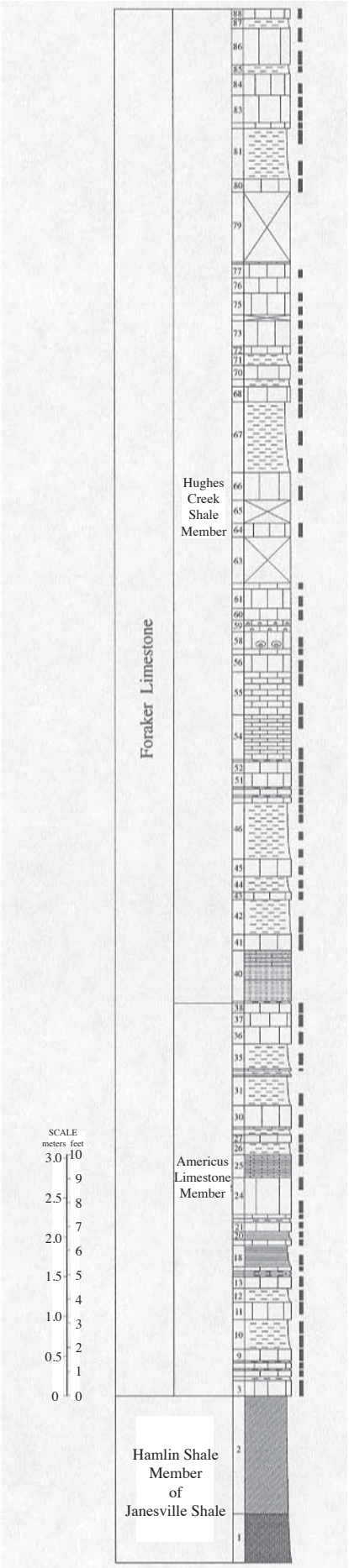

FIGURE 144—Measured section A24–upper Hamlin Shale Member through Hughes Creek Shale Member., samples and sample interval indicated by bars beside column

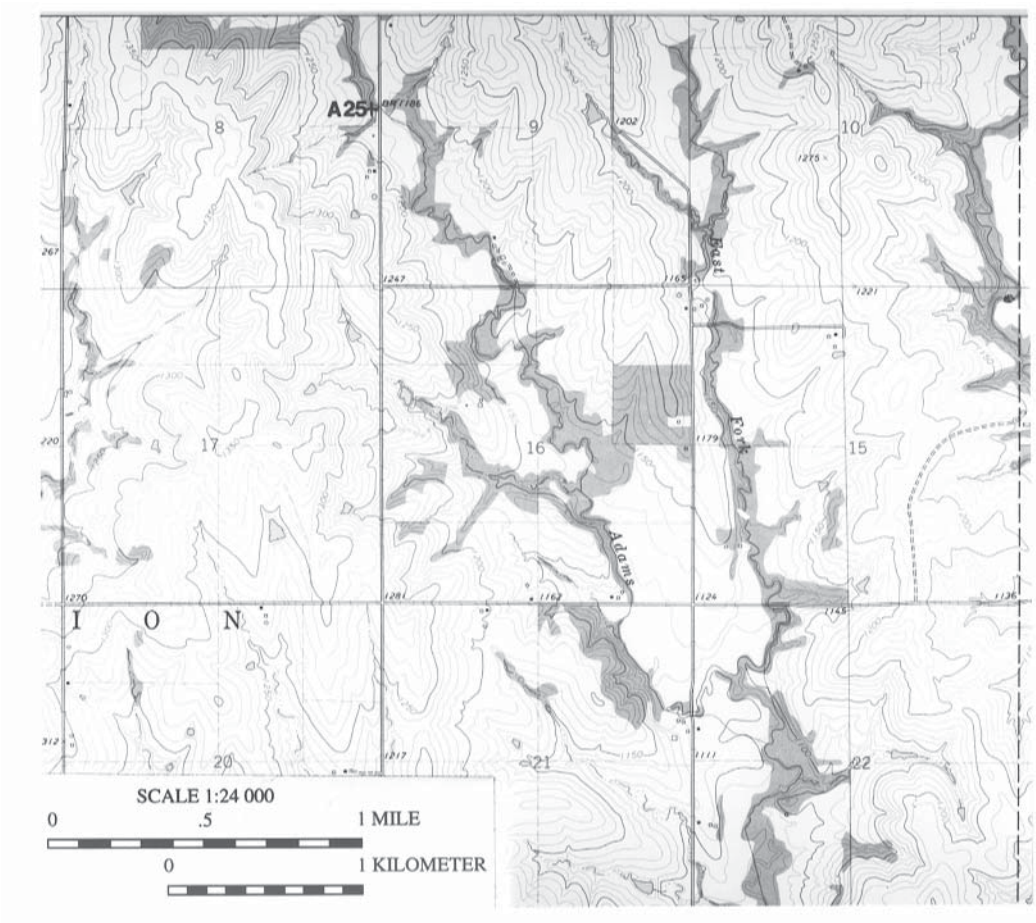

FIGURE 145—Map showing location of Locality A25, Onaga SW.

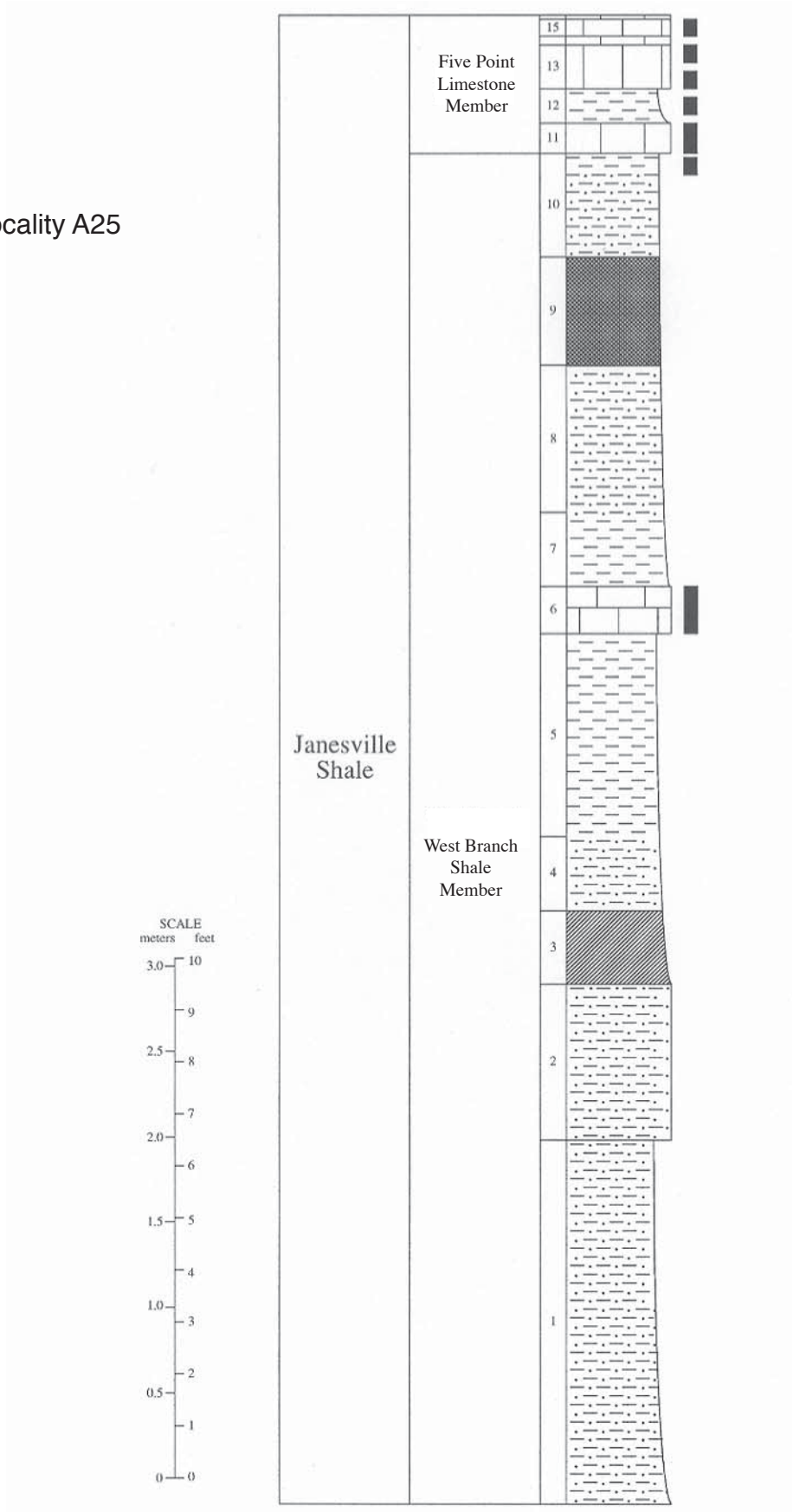

FIGURE 146—Measured section A25–West Branch Shale Member and Five Point Limestone Member, samples and sample interval indicated by bars beside column.

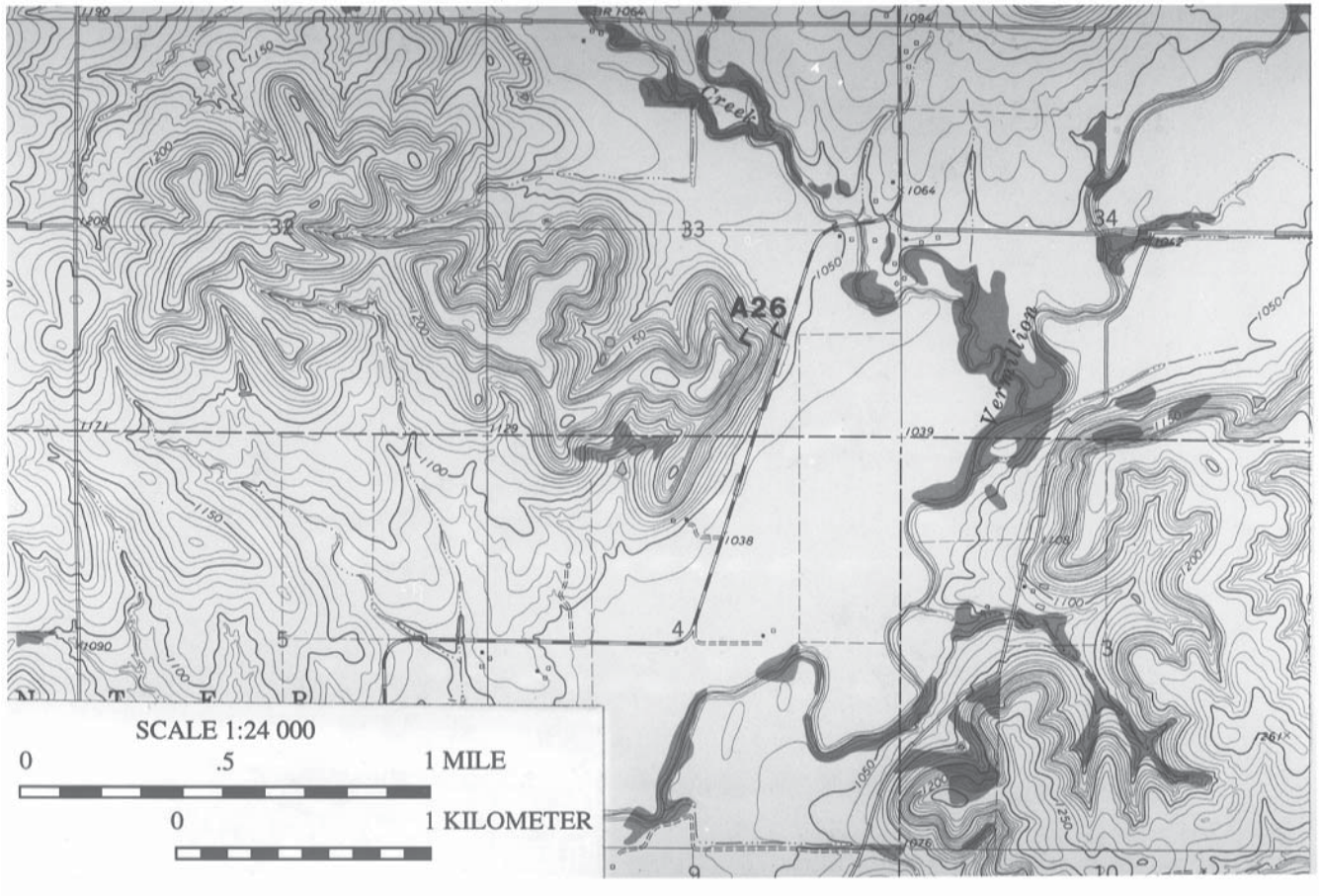

FIGURE 147—Map showing location of Locality A26, Laclede.

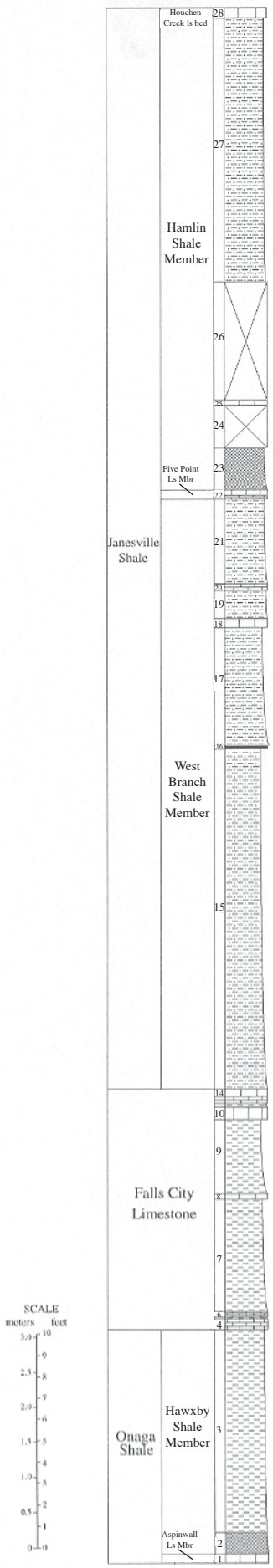

FIGURE 148—Measured section A26–upper Aspinwall Limestone Member through Houchen Creek limestone bed, Hamlin Shale Member.

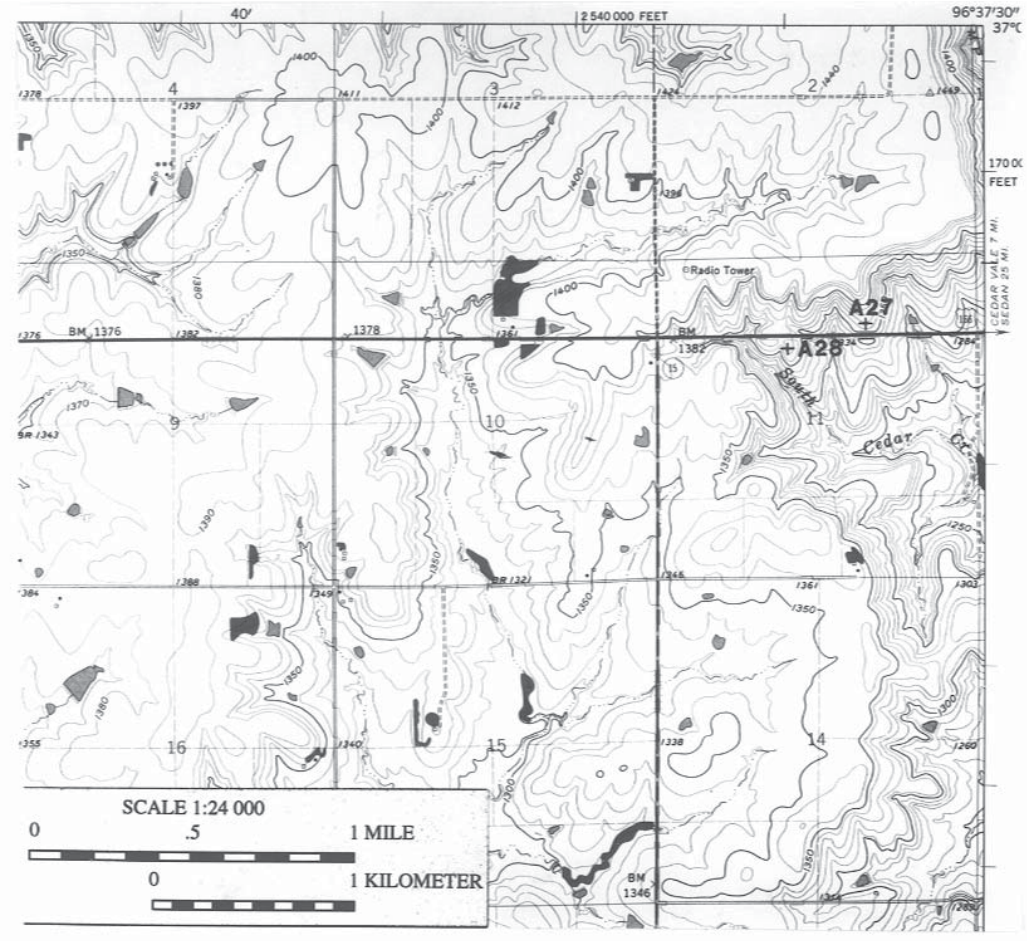

FIGURE 149—Map showing location of Localities A27 and A28, US–166.

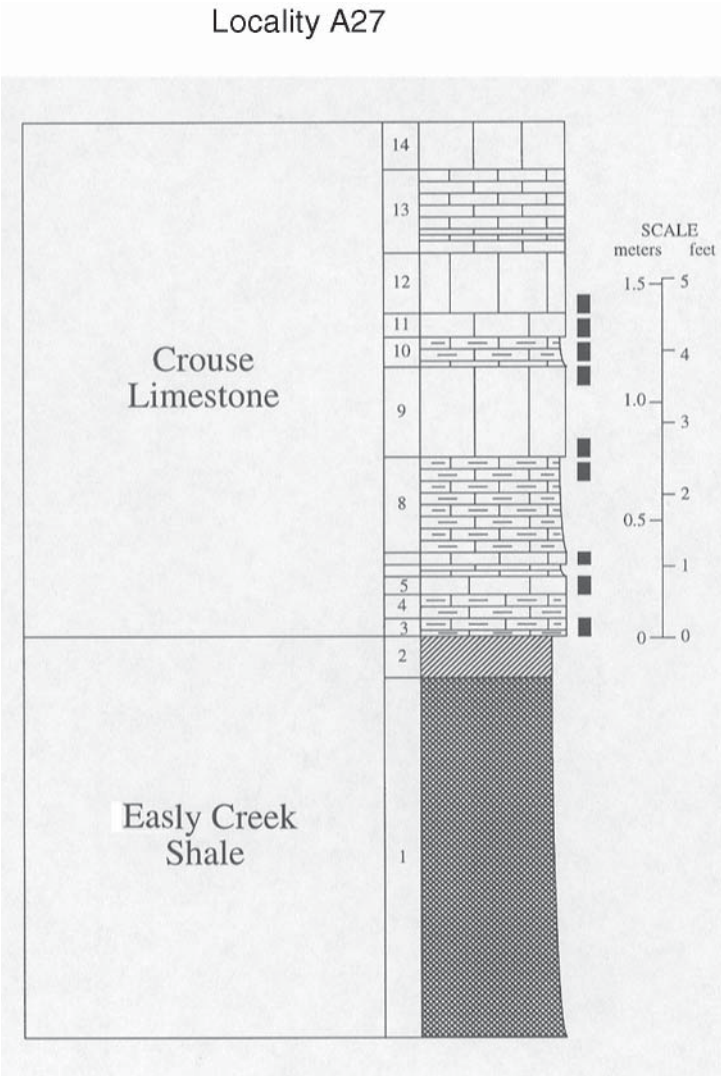

FIGURE 150—Measured section A27–Easly Creek Shale and Crouse Limestone, samples and sample interval indicated by bars beside column.

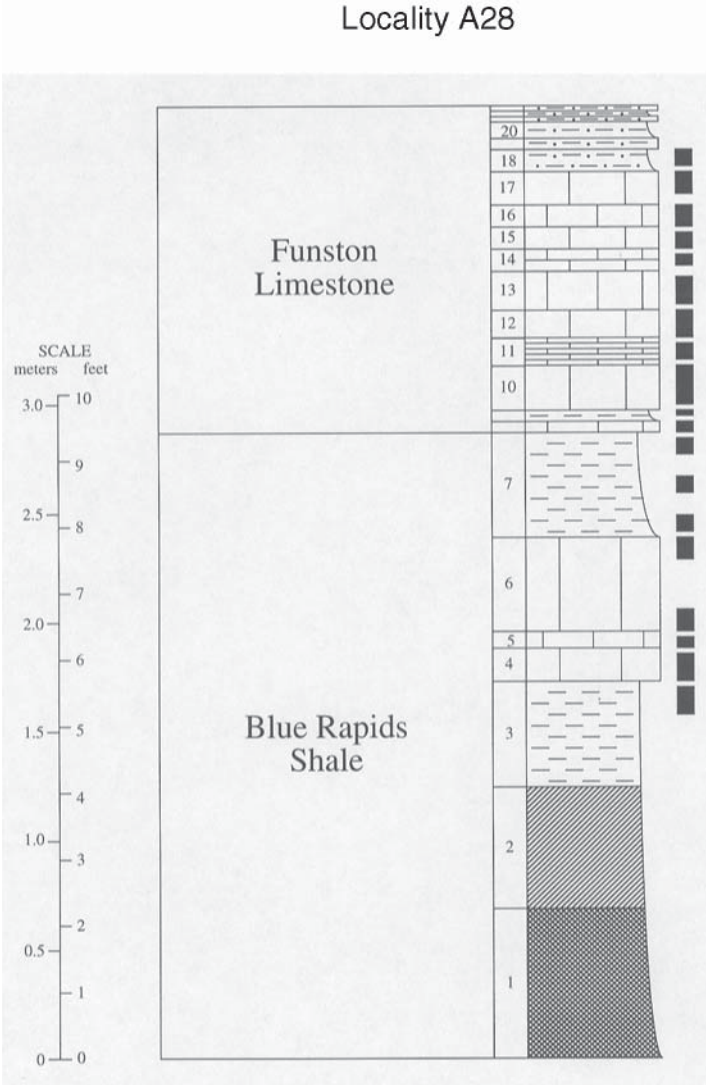

FIGURE 151—Measured section A28–Blue Rapids Shale and Funston Limestone, samples and sample interval indicated by bars beside column.

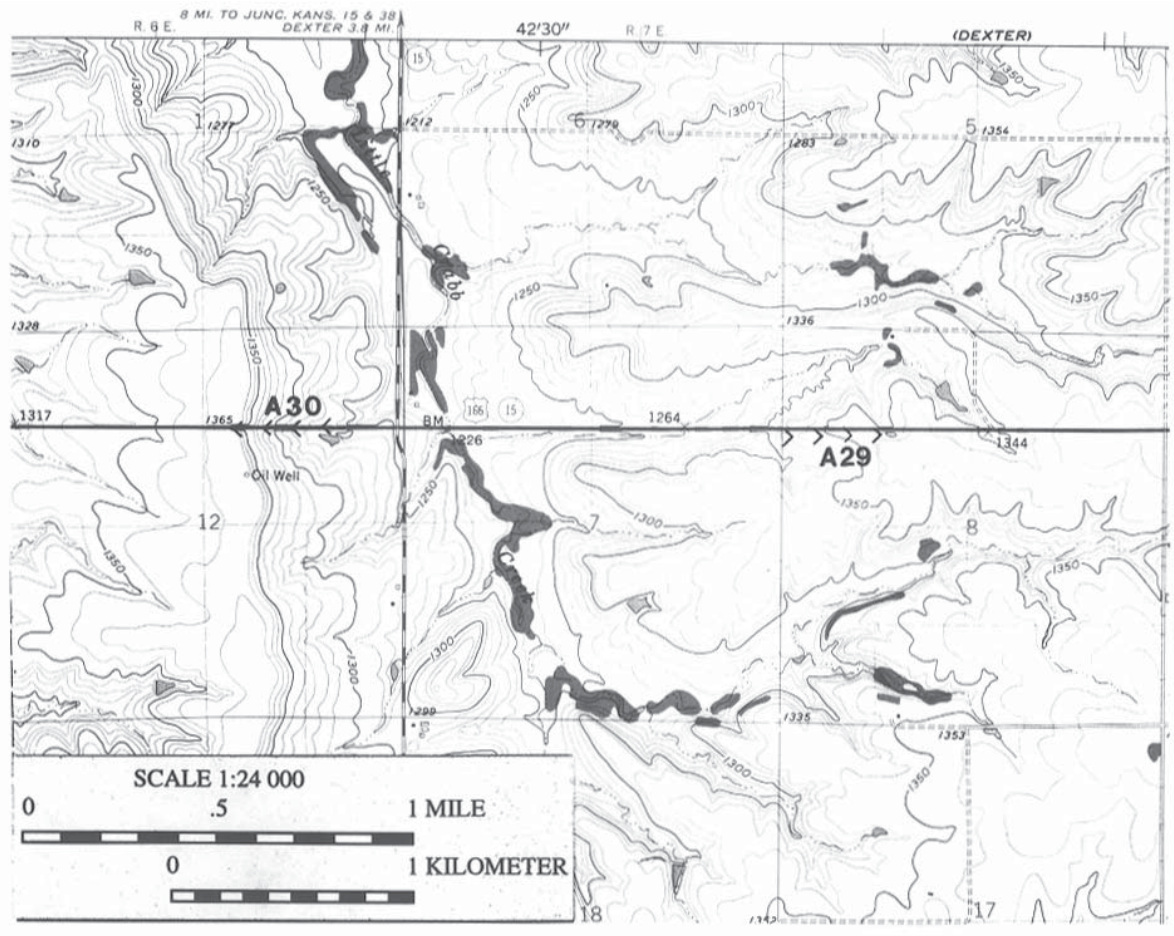

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FIGURE 152—Map showing location of Locality A29 and A30, US–166.

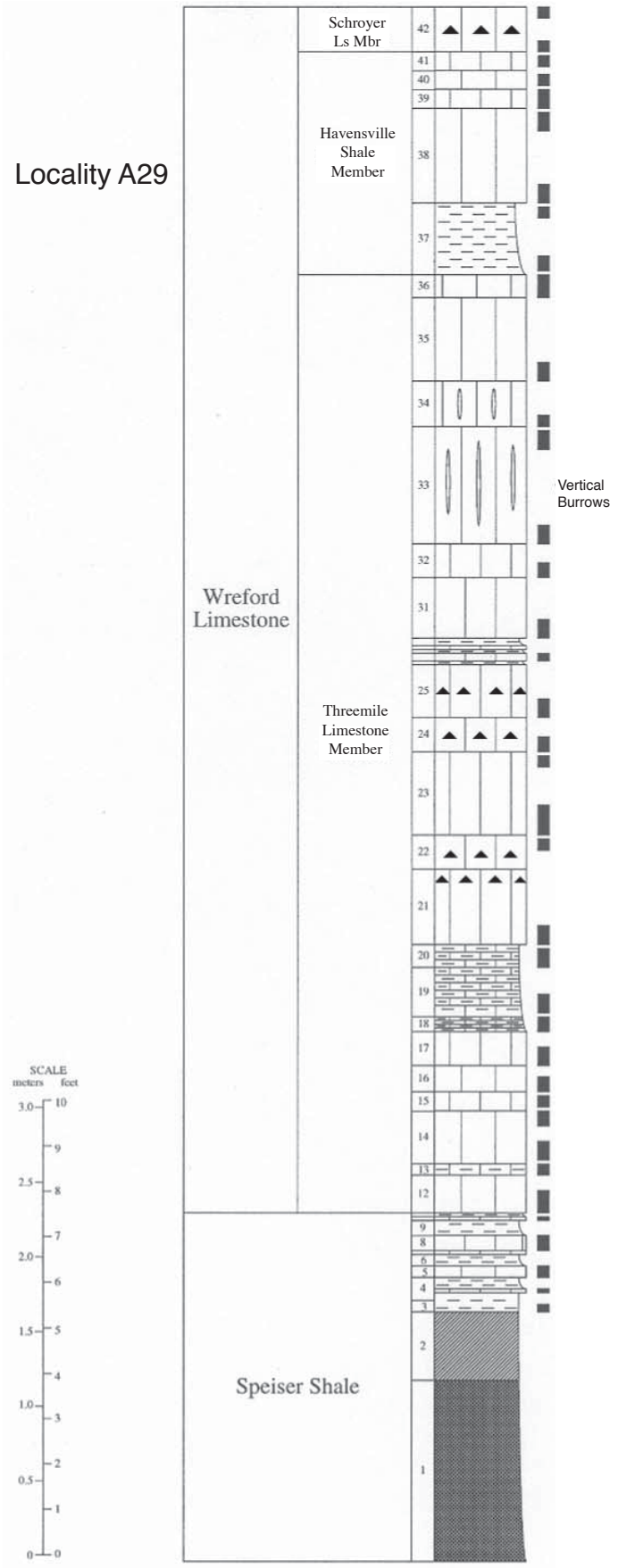

FIGURE 153—Measured section A29–Speiser Shale through Schroyer Limestone Member, samples and sample interval indicated by bars beside column.

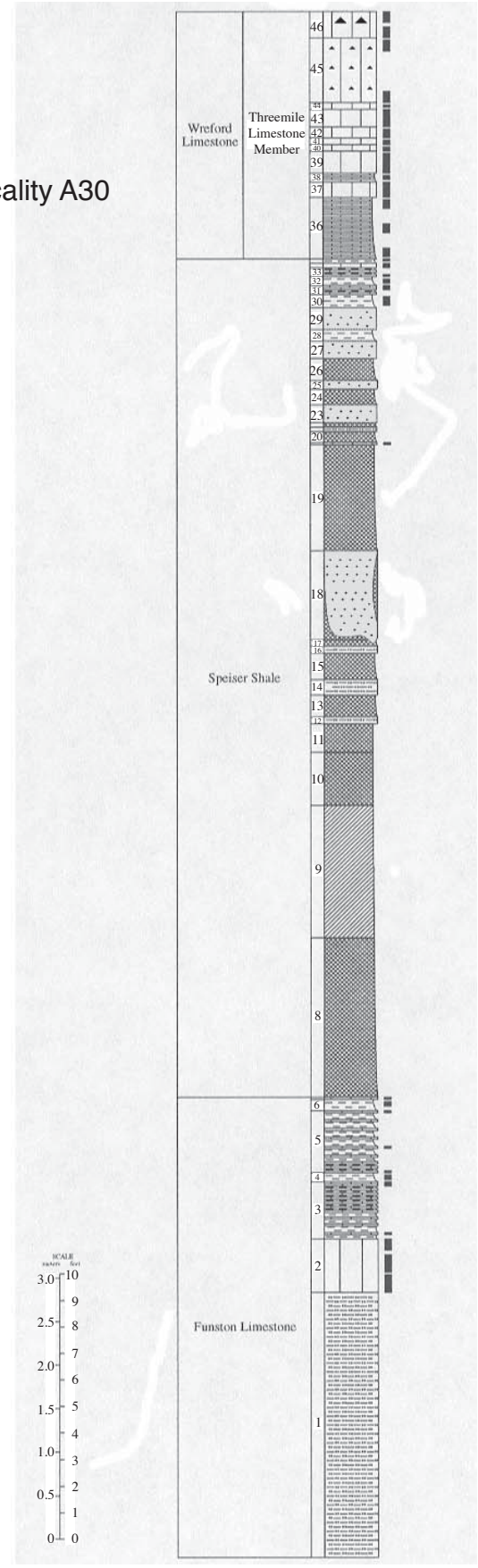

FIGURE 154—Measured section A30–upper Funston Limestone through Threemile Limestone Member, samples and sample interval indicated by bars beside column.

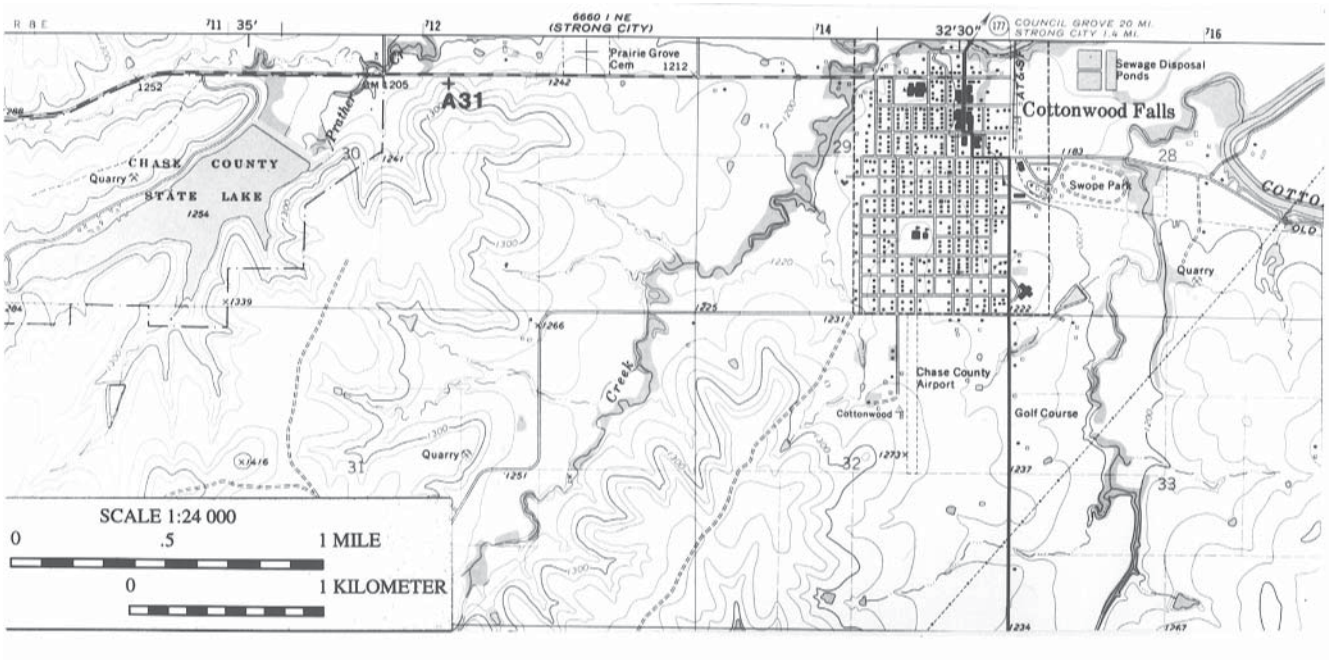

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FIGURE 155—Map showing location of Locality A31, Cottonwood Falls West.

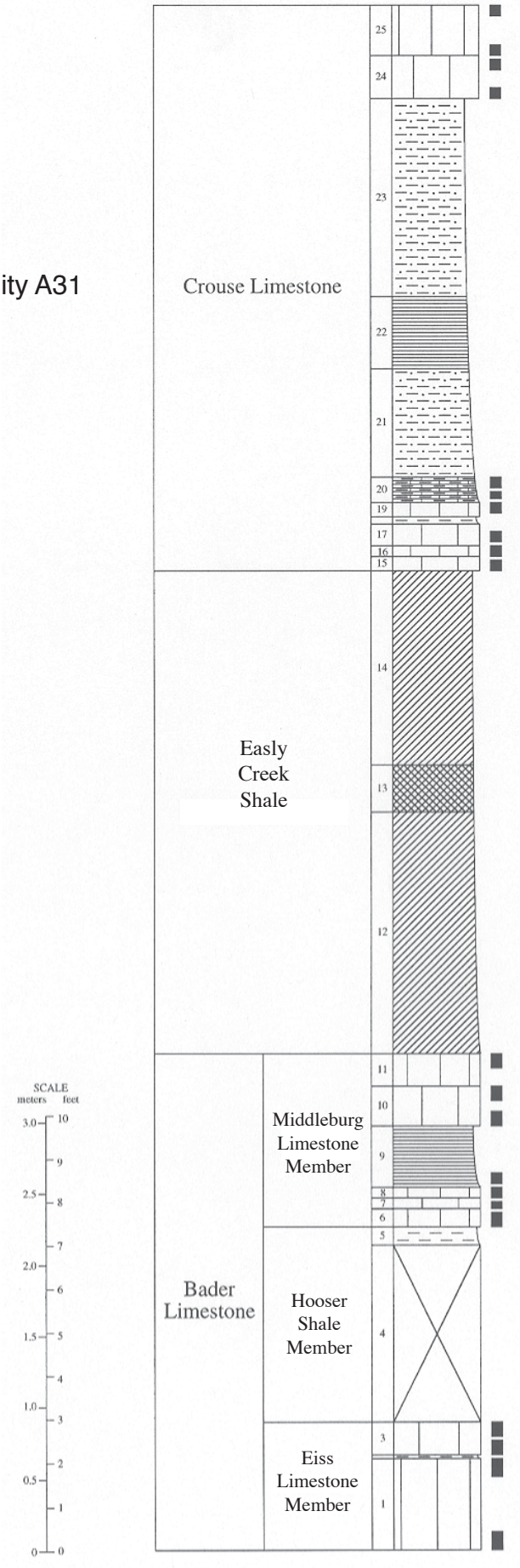

FIGURE 156—Measured section A31–Eiss Limestone Member through Crouse Limestone, samples and sample interval indicated by bars beside column.

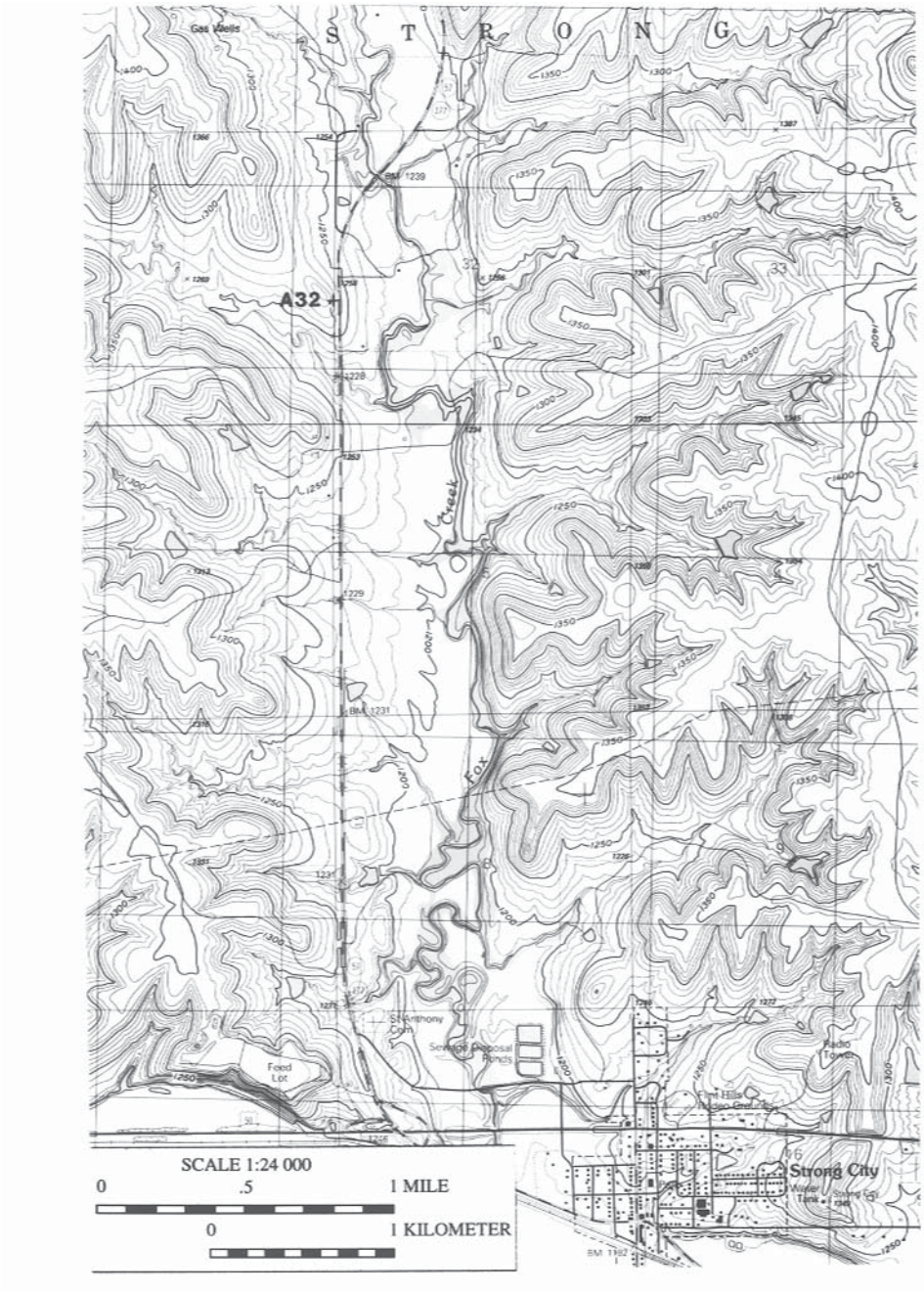

FIGURE 157—Map showing location of Locality A32, Strong City N.

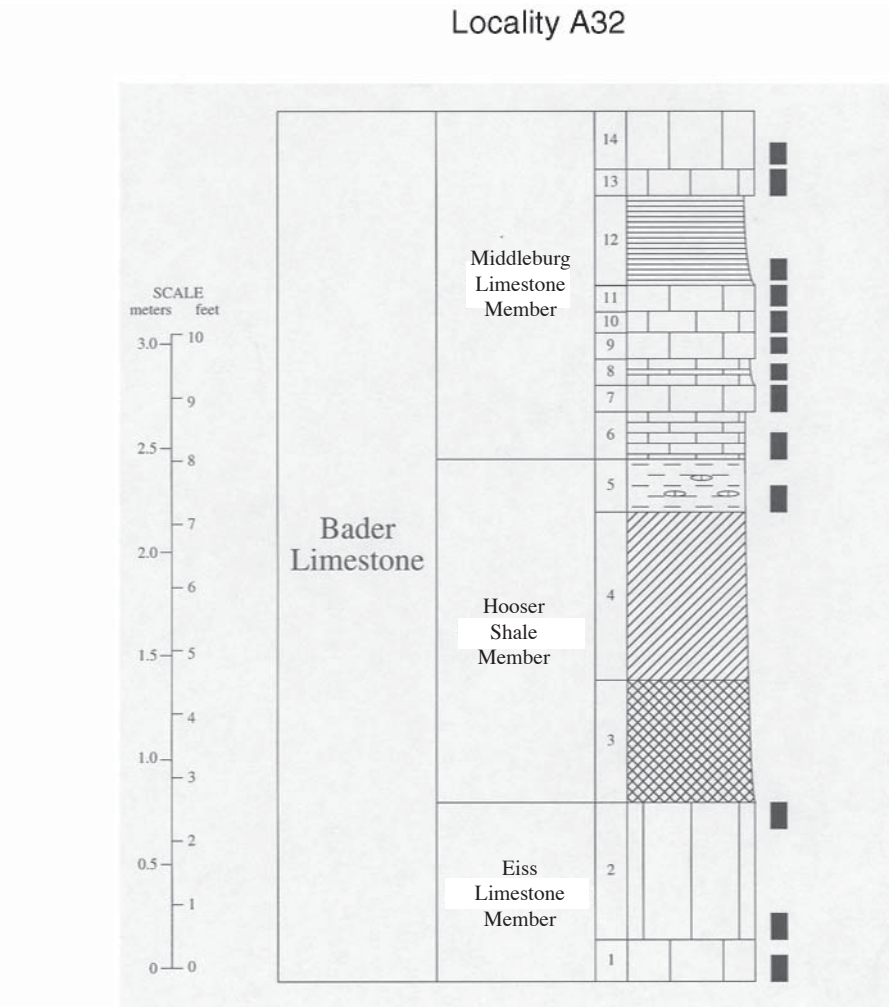

FIGURE 158—Measured section A32–Eiss Limestone Member through Middleburg Limestone Member, samples and sample interval indicated by bars beside column.

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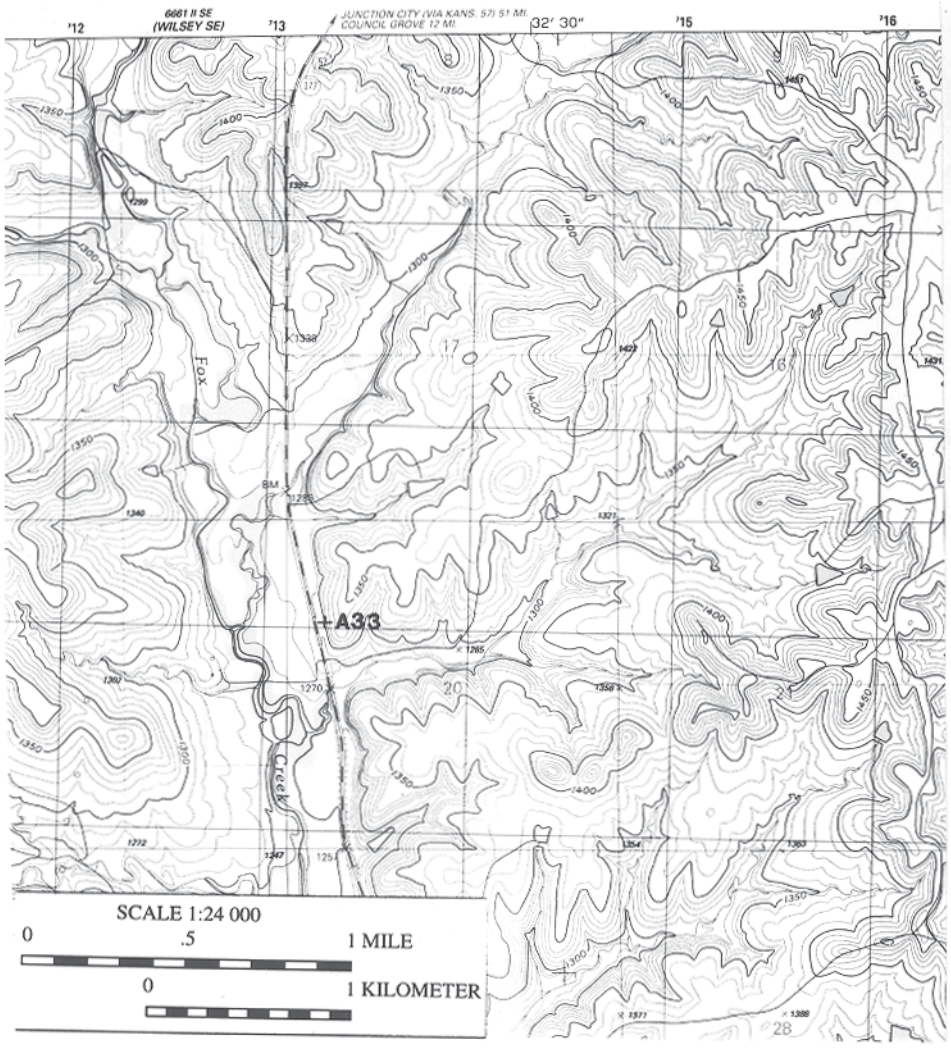

FIGURE 159—Map showing location of Locality A33, Strong City N.

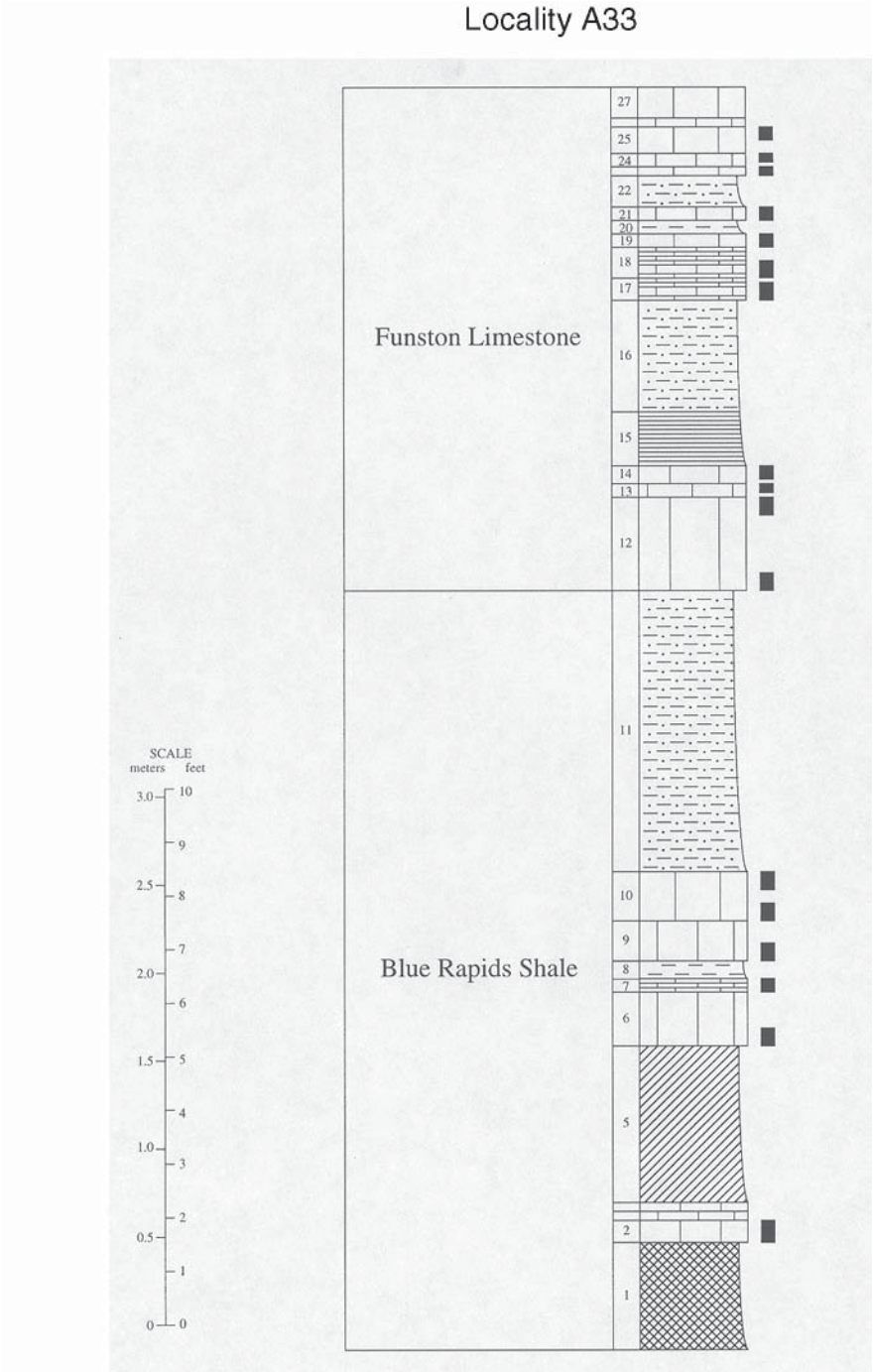

FIGURE 160—Measured section A33–Blue Rapids Shale and Funston Limestone, samples and sample interval indicated by bars beside column.

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FIGURE 161—Map showing location of Locality A34, US–166.

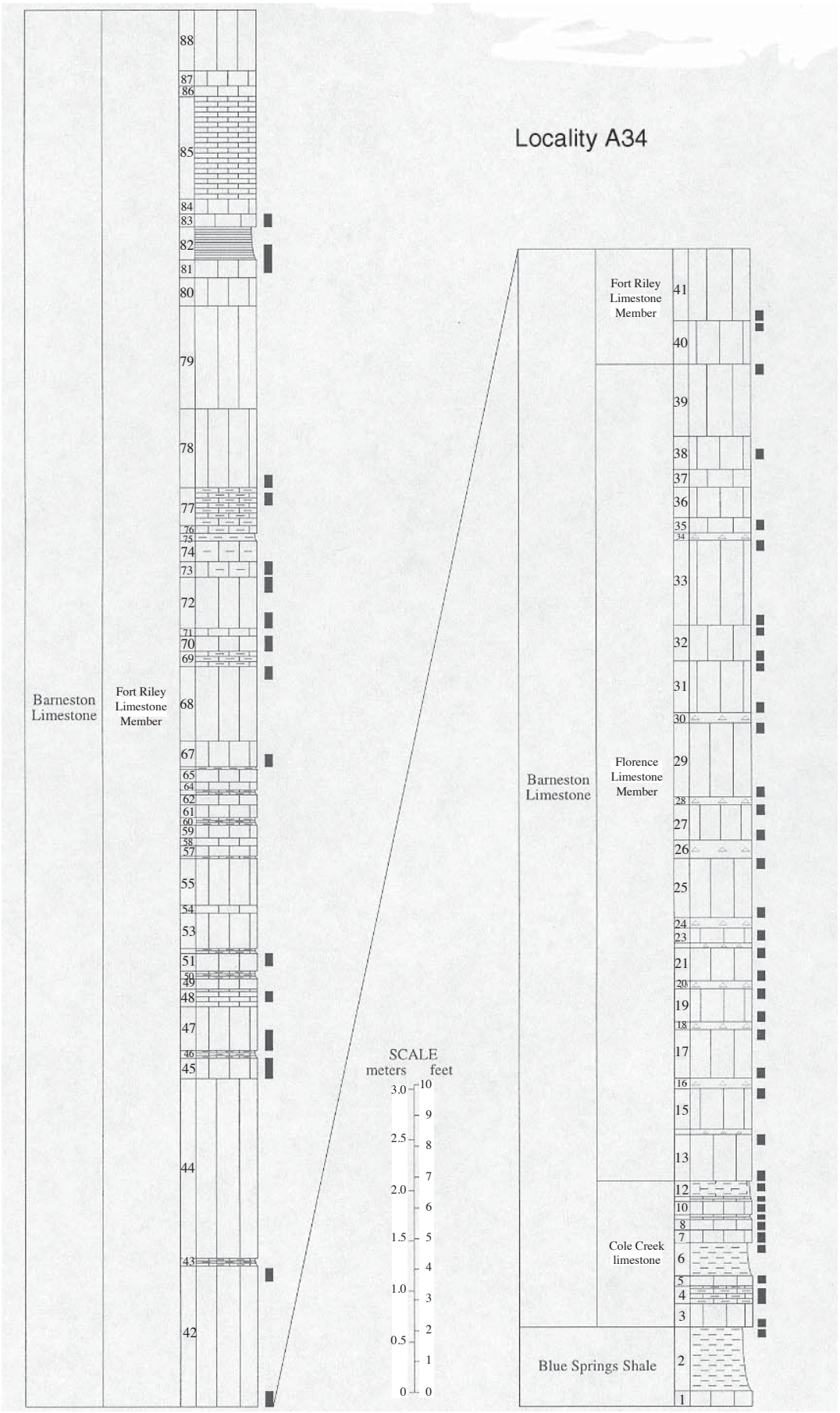

FIGURE 162—Measured section A34–upper Blue Springs Shale through Fort Riley Limestone Member, samples and sample interval indicated by bars beside column.