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Geology Beneath the Primary Management Systems Evaluation Area (MSEA) Site Southwest of Shelton, Buffalo County, Nebraska

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**Geology Beneath the Primary Management Systems
Evaluation Area (MSEA) Site Southwest of Shelton, Buffalo
County, Nebraska**

R.F. Diffendal, Jr. and Frank A. Smith

**Geological Survey Report of Investigations
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**Conservation and Survey Division
Institute of Agriculture and Natural Resources
University of Nebraska-Lincoln**

University of Nebraska-Lincoln

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February 1996

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Introduction

In 1990, as part of a national presidential initiative on water quality, researchers from the University of Nebraska-Lincoln (UNL) Institute of Agriculture and Natural Resources (IANR) received a multi-year grant from the U.S. Department of Agriculture, Cooperative State Research Service, to study management of irrigated corn and soybeans to minimize groundwater contamination. D.G. Watts, R.F. Spalding and J.S. Schepers, of the IANR led a study at one of the Management Systems Evaluation Areas (MSEA). This area was made up of two sites, a primary site on a terrace of the Platte River near Shelton and a secondary site nearer the river. R.F. Diffendal, Jr., research geologist with the UNL Conservation and Survey Division (CSD) was responsible for collecting samples from and geophysically logging a series of boreholes drilled by Bob Pollack, of Pollack Well Drilling, Grand Island, Nebraska, at the primary site and for using these data to characterize the site geology. Diffendal was assisted in the sampling

and logging by hydrogeologist Frank A. Smith and technician Kenneth A. Hueske, both of CSD. Raw geophysical data from the boreholes was converted to a standard format by Jerry F. Ayers, CSD research hydrogeologist. Samples and logs from the boreholes and from others drilled and logged later by other researchers were studied, analyzed, and interpreted as part of this investigation.

Acknowledgments

We thank Dr. Roy F. Spalding for inviting us to participate in his project and Dr. Jerry Ayers of the Conservation and Survey Division for help in processing geophysical log data. S. Summerside and Dr. Mark Kuzila offered helpful suggestions for improvement of the manuscript. This research was funded in part by the Conservation and Survey Division, University of Nebraska-Lincoln, and by part of grant funds from the U.S. Department of Agriculture, Cooperative State Research Service. Charles Flowerday edited the manuscript.

Robert Diffendal, Jr. is a research geologist and professor, and Frank Smith is a research hydrogeologist and associate professor emeritus, both with the Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

Geologic Framework of the Site

Previous Work

Perhaps the first geological study of southeastern Nebraska (including the area of the current MSEA site), directed principally to answering general questions about groundwater supply, was conducted during the summer and fall of 1896 by N.H. Darton and two field assistants (Darton, 1898). Darton (1898) noted that windmill irrigation was already being used on some small acreages and that average annual rainfall was not sufficient to get a full crop. Darton's geologic map and map of the depths to water-bearing formations are useful even today for comparison with current observations.

Since 1896, basic geologic data from local test drillings near Shelton and regional test drillings, including sites near Shelton, have been used in a number of important reports. By 1929, population centers, industries, and irrigated acreages in the central Platte River Valley had become important enough that G.E. Condra, CSD director, assigned A.L. Lugn to a detailed study of the geology of the Platte River valley between Chapman and Gothenburg, Nebraska. L.K. Wenzel of the U.S. Geological Survey worked on the hydrologic aspects of the area for that study. Test drillings were done in 1931-1933 and a report published subsequently (Lugn and Wenzel, 1938). Further test drillings were done in 1939, 1946, 1947, 1948, and 1954 in Buffalo County as parts of an effort to better understand the Nebraska geologic and hydrologic framework (Anonymous, 1953, 1954). Data from the drillings were used in the preparation of a report on the county's geology and

groundwater supplies (Schreurs, 1956). Further field and laboratory work, supplemented by the results presented in earlier reports, were used to prepare a geologic map of the Grand Island 1° x 2° quadrangle, including thicknesses of Quaternary deposits (Dreeszen and others, 1973) in the vicinity of Shelton. Additional test drilling was done in 1975 in southeastern Buffalo and southwestern Hall counties to collect data for use in later reports on groundwater contamination (Gormly and Spalding, 1979) and chemistry (Spalding and Exner, 1980). The data from test drilling were used by the U.S. Geological Survey in three hydrologic atlases (Gutentag and Weeks, 1980; Luckey and others, 1981; Weeks and Gutentag, 1981) and a report (Weeks and others, 1988) on the High Plains aquifer.

Location of Study Site and Test Holes

The study site is located on a fill terrace north of the Platte River in southeastern Buffalo County, Nebraska. Thirteen test holes were drilled and geophysically logged in sections 14 and 15, T. 9 N., R. 13 W. (fig. 1). Sediment samples were collected during the drilling of each of the holes.

Fifteen cores, four to depths of 22 ft, the remainder to 19 ft, were partially recovered at other places on the site. Five of the more complete cores were studied as part of the geological characterization of the site (fig. 1). Descriptive logs of six of the 1947 test holes, 15 of the 1975 test holes and one test hole drilled in 1991 (fig. 1, hole labeled Og3), as well as the records of sediments encountered during drilling of irrigation wells in the area, were also used in the study.

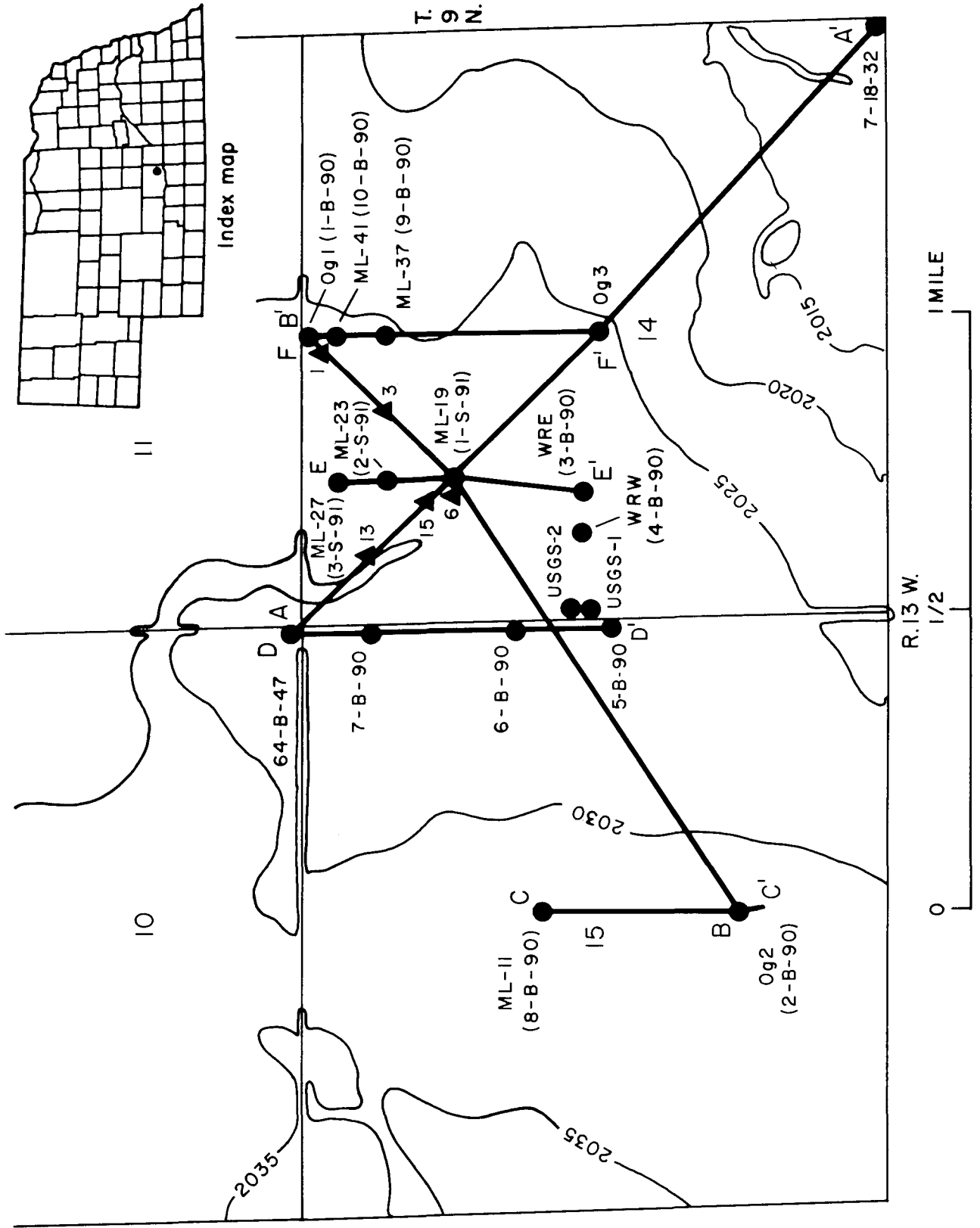


Fig. 1. Topographic map of area including MSEA site (after U.S. Geological Survey Denman, Gibbon North, Gibbon South and Shelton 7.5' quadrangles) showing test holes and cross sections in figure 3. Circles show geophysical logs; triangles show geophysical logs. Contour: 5 ft.

Site Geology

Darton's geologic map of part of southeastern Nebraska shows that the Platte Valley at Shelton is about 12 miles wide and trends generally northeastward. The bluffs on the north side of the valley are underlain by wind-deposited silts (loess), the valley floor by alluvium. A belt of sand dunes forms the south valley side. To the south of these dunes, the land is underlain directly by more loess (Darton, 1898, pl. III). The north valley side is shown as between 150 and 200 ft high on this map, a range that compares favorably with the more recent topographic maps of the area, which are drawn at a larger scale and with smaller contour intervals (1:24,000, compared to 1:633,600 [approximately], and 10/20 ft, compared to 50 ft, respectively); on the later maps, the height is between 170 and 190 ft.

Darton (1898, pl. XVIII A) shows a generalized cross section of the area with the loess on the uplands underlain by "Neocene" deposits (what is later called part of the Ogallala Group) and with the alluvium confined to the area beneath the valley floor and also resting there on "Neocene" deposits.

Two relatively recent cross sections through the Shelton area are useful in helping to interpret the geology of the site. Schreur's (1956, pl. 1, section E-E') northwest-southeast cross section gives the reader a good general picture of the stratigraphy beneath the area (fig. 2a), but some of the formation names he applied have proven to be incorrect and are modified here (fig. 2b). Spalding and Exner (1980, fig. 1) show three north-south cross sections, two of which bracket the site and give an additional overview of the site geology.

As noted previously, the MSEA site is on part of an alluvial fill terrace of the Platte River, the first terrace above the present floodplain of the river. Going north from the Platte River, this terrace is marked by an increase of 5-10 ft in the altitude of the land surface and a perceptible increase in slope on the terrace riser. No higher terrace fills were identified between the Platte River and the Wood River in the study area.

Quaternary (Holocene, Qs) Silt

The sediments directly below the land surface at the study site are mainly composed of silts (Qs) combined with varying proportions of clays and sands that soil scientists classify as various types of loams (Buller and others, 1974). Their thickness ranges from almost 0 ft to a maximum of about 10 ft. These loamy silts are developed on a combination of river overbank flood deposits and wind deposits and have been largely homogenized by burrowing organisms. Despite farming of the upper parts of the loams, soil horizons are still apparent in cores taken from parts of the site, but primary sedimentary stratification is lacking. Fragments of gastropod shells from samples from test hole ML 23 indicate a moist environment during the earliest deposition of the silt. The silts were deposited on an erosion surface developed on the underlying sediments principally by stream erosion.

Quaternary (Holocene, Qal₂) Alluvium

Sand and gravel deposits laid down by the Platte River at an earlier time in history underlie the surficial silts (fig. 3; see pocket on inside back cover). Geophysical logs (resistivity and natural gamma), cuttings collected during test drilling, and cores, all studied in combination, show that these deposits have lateral and vertical changes that are typical of braided rivers like the Platte that carry large quantities of sand and gravel and that have highly variable flows. Iron oxide (Fe₂O₃) stains covering grains support the idea that some of the sediments were exposed to the atmosphere during deposition. The sands and gravels (Qal₂) vary in thickness across the study site (figs. 3 and 4) because the top of these deposits has been irregularly eroded and because the deposits rest on an irregular fluvial (river) erosion surface (fig. 5). Thicknesses range from about 45 to about 57 ft. Two areas underlain by the thinnest sands and gravels trend generally parallel to the course of the Platte River. The base of Qal₂ (fig. 5) is generally highest in the southern part of the site, but there

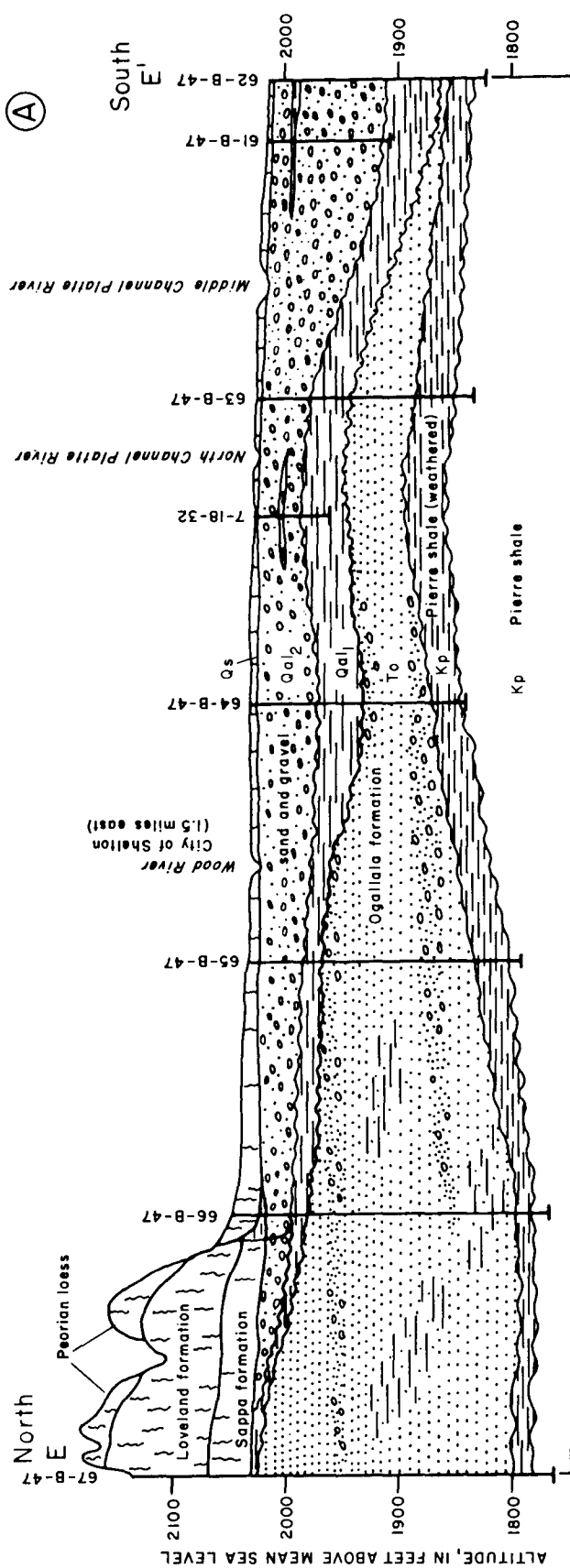
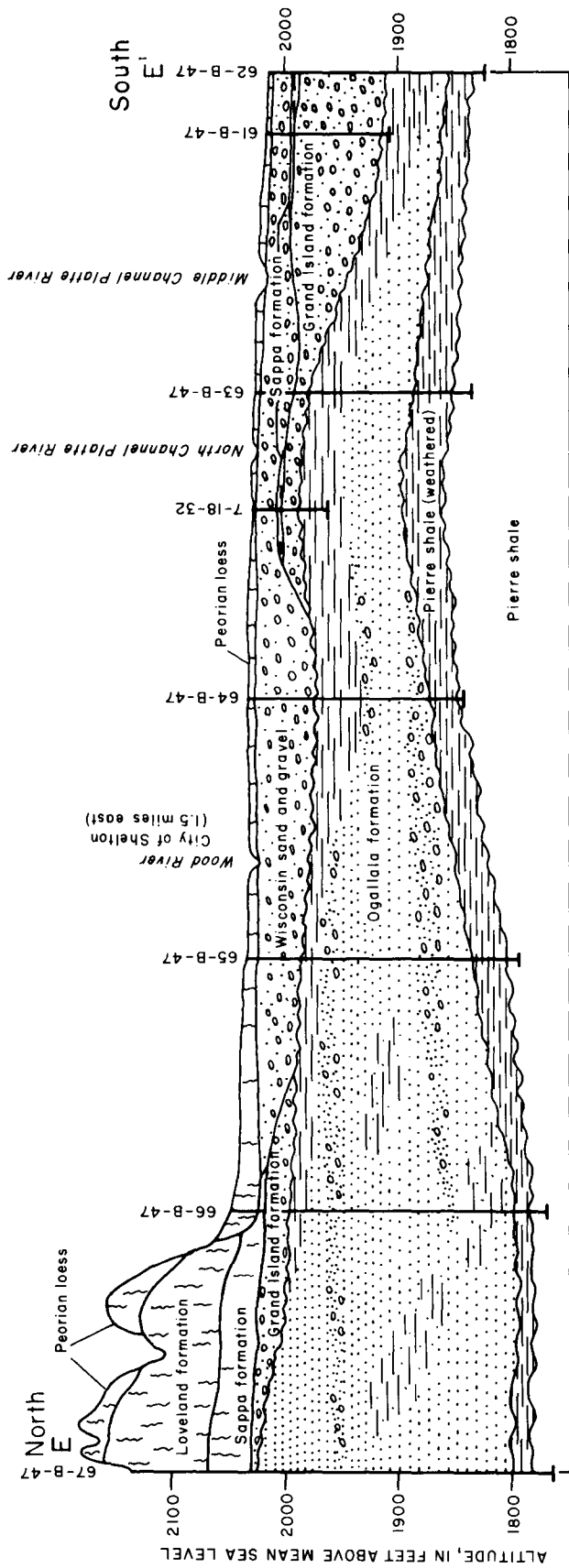


Fig. 2. a) Northwest-southeast cross section across southeastern Buffalo County, Nebraska, crossing area of present MSE_A site, by Schreurs (1956, pl. 1, E-E'); b) Modification of figure 2a with current changes in stratigraphic terminology and interpretations. Qs - Quaternary (Holocene) silt; Qal₁ - Quaternary (Holocene) alluvium; Qal₂ - Quaternary (Holocene) alluvium; To - Tertiary (Miocene) Ogallala Group; Kp - Cretaceous Pierre Shale.

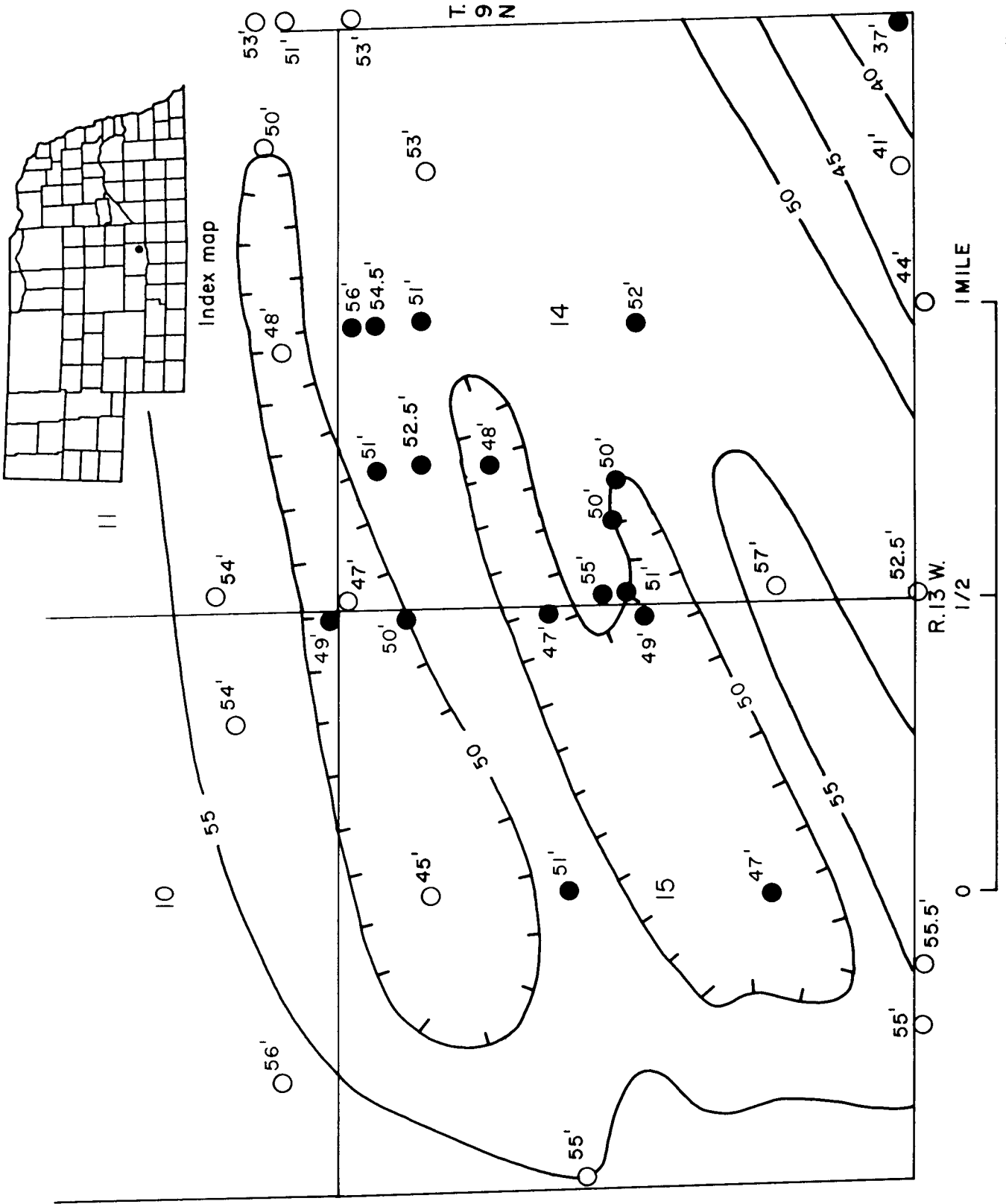


Fig. 4. Thickness of Qal₂ at study site. Contour: 5 ft. Hachured contours show thinning. Closed circles--test holes; open circles--irrigation wells.

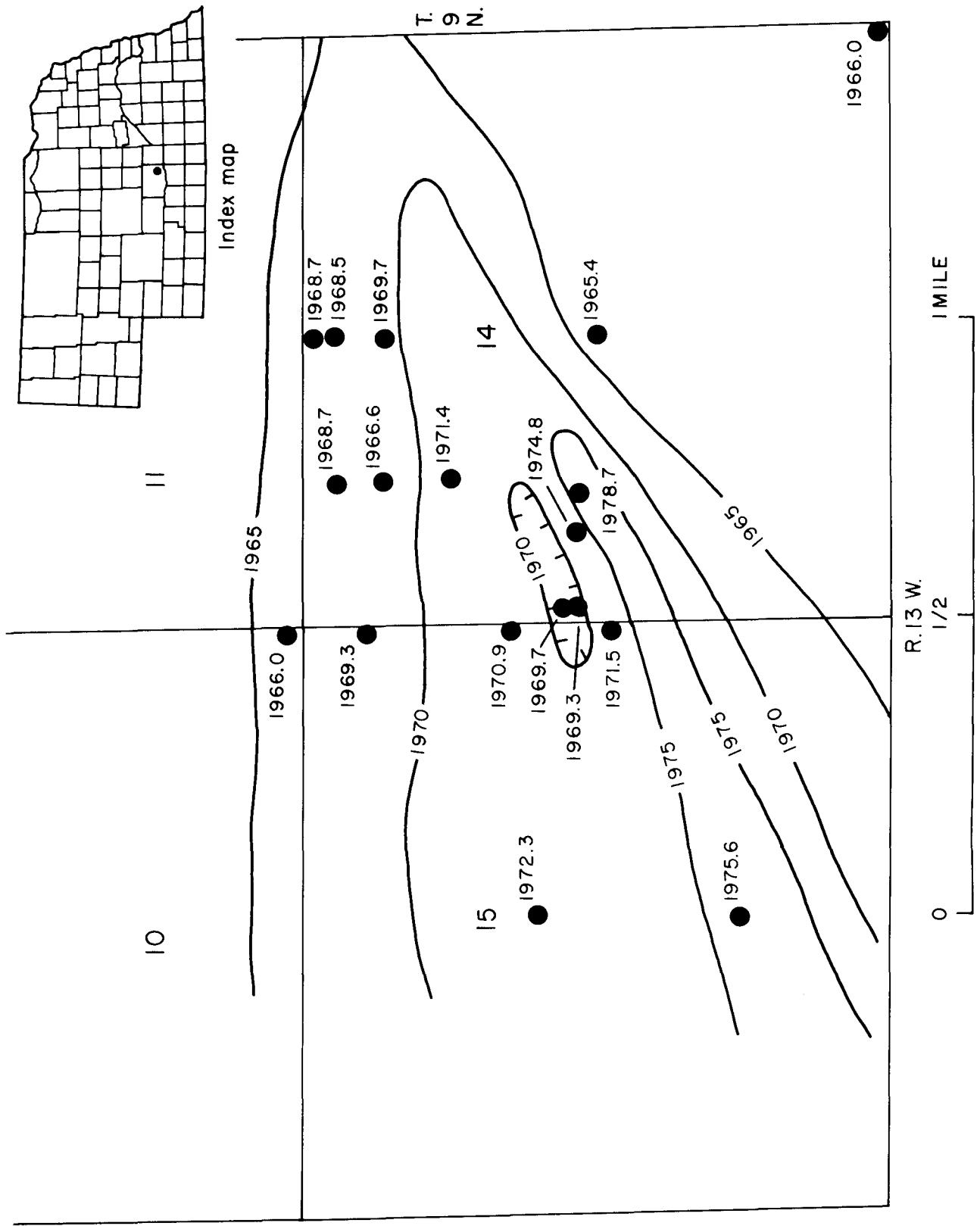


Fig. 5. Configuration of base of Q_{al_1} . Contour: 5 ft. Hachured contours show closed depressions.

also appears to be a small lower area there noted by a hachured contour (fig. 5) too. The base slopes from this high area northward toward the Wood River, southeastward toward the Platte River and northeastward, generally parallel to the slope of the Platte Valley.

Finer grained silts and clays occur interbedded with sands and gravels in braided river deposits. These fines were deposited on floodplains adjacent to channels during fluvial alluviation, when eolian deposition occurred on floodplains or sand-bar surfaces during subaerial exposure in periods of low flow, or when tributaries such as the Wood River, which drain areas underlain by finer grained deposits, carry greater loads of these silts and clays to their trunk stream during high runoff events generally restricted to drainage basins of these tributaries. Silts and clays occur in the sand and gravel sequence beneath parts of the study area (figs. 2 and 3), but no single bed is continuous throughout the MSEA site (fig. 3). Of the thirteen test wells that were drilled for this study, five had no silt and clay layer interbedded in Qal₂ sands and gravels, six had one layer, one had two layers, and one had three layers. One or more silt layers were also encountered in some holes during drilling of additional wells used for the groundwater studies at the MSEA site, but none was present in all wells (M. Burbach, personal communication, 1992).

Quaternary (Holocene?, Qal₁) Alluvium

Unconformably below Qal₂ are beds of brown silts resembling loams, and sands and gravels that were placed by Schreurs (1956) in the Ogallala "Formation" (known to us as a group; fig. 2a). These beds, which were completely penetrated in three of the test wells drilled for the MSEA study (wells Og

1, Og 2, and Og 3) and in test hole 64-B-47 drilled as part of the Schreurs' study, are probably Quaternary in age, rather than Tertiary. We have designated them as older Quaternary alluvium, Qal₁ (figs. 2b and 3). These beds rest unconformably upon the Ogallala Group, as it is now designated, and fill two shallow valleys, one generally south of the MSEA site and another north of the MSEA site (figs. 2 and 6). Qal₁ thickness ranges from about 30 to about 64 ft at the MSEA site.

Tertiary (Miocene, To) Ogallala Group

The Ogallala Group (To) unconformably underlies Qal₁ and can be separated easily from it lithologically because the former has olive colors, is generally sandier, and contains siliceous root tubules not present in the latter. Geophysical logs of the Ogallala show greater departures from their shale lines indicating coarser grained deposits than generally encountered through Qal₁ (fig. 3). We have only a general idea of the thickness of the Ogallala at the MSEA site because only one test hole drilled just off the site in 1947 (64-B-47) penetrates the entire unit. The Ogallala in that hole is approximately 43 ft thick, but thins considerably to the southeast and thickens to more than 200 ft northwest (fig. 2) of the site.

Cretaceous (Kp) Pierre Shale

The Ogallala Group rests unconformably on the Pierre Shale of Late Cretaceous age beneath the study area (fig. 2) (Dreeszen and others, 1973). The Pierre is essentially impermeable and forms the base of the regional aquifer system in the study area.

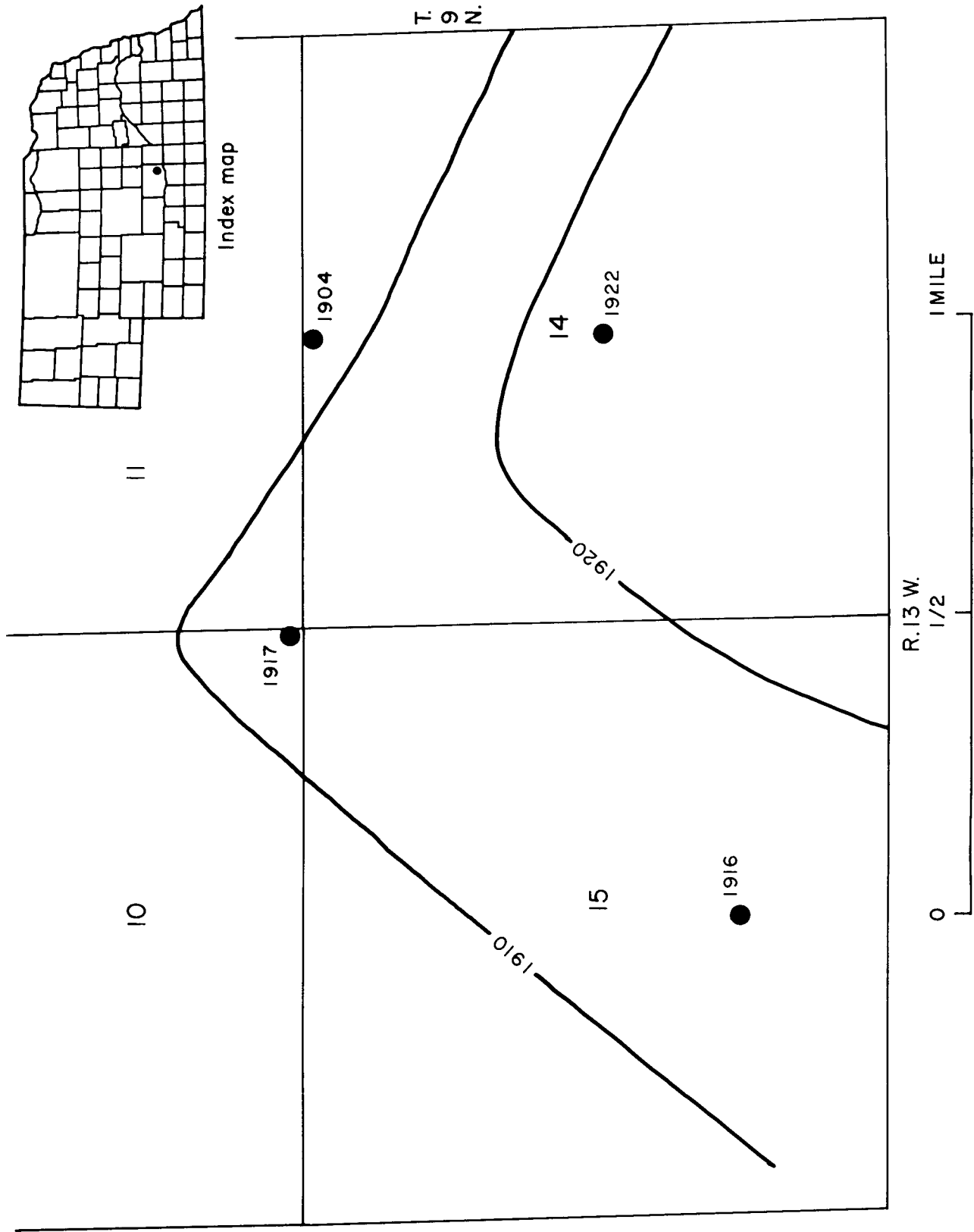


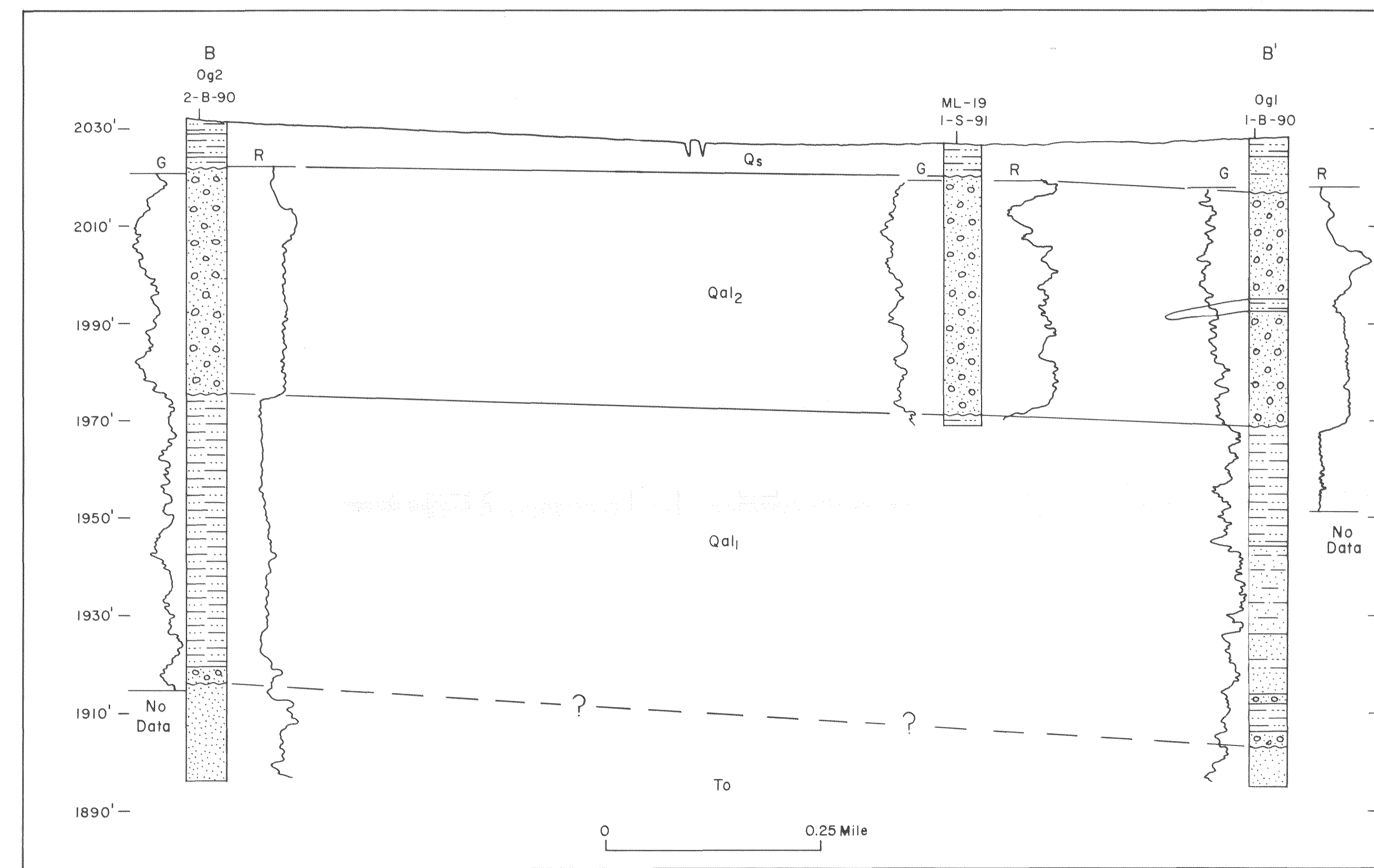
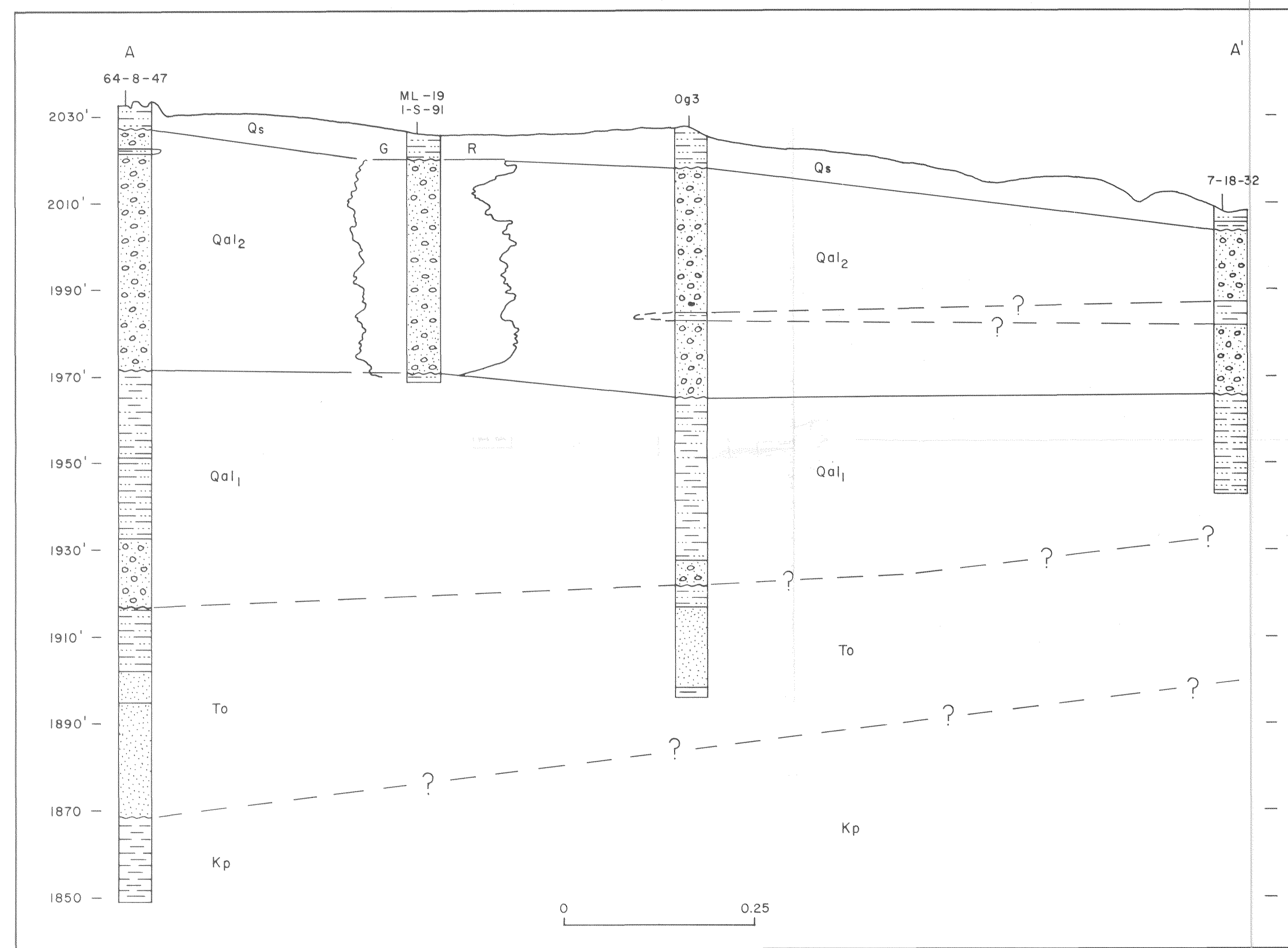
Fig. 6. Configuration of base of Qal₁ at study site. Contour: 10 ft.

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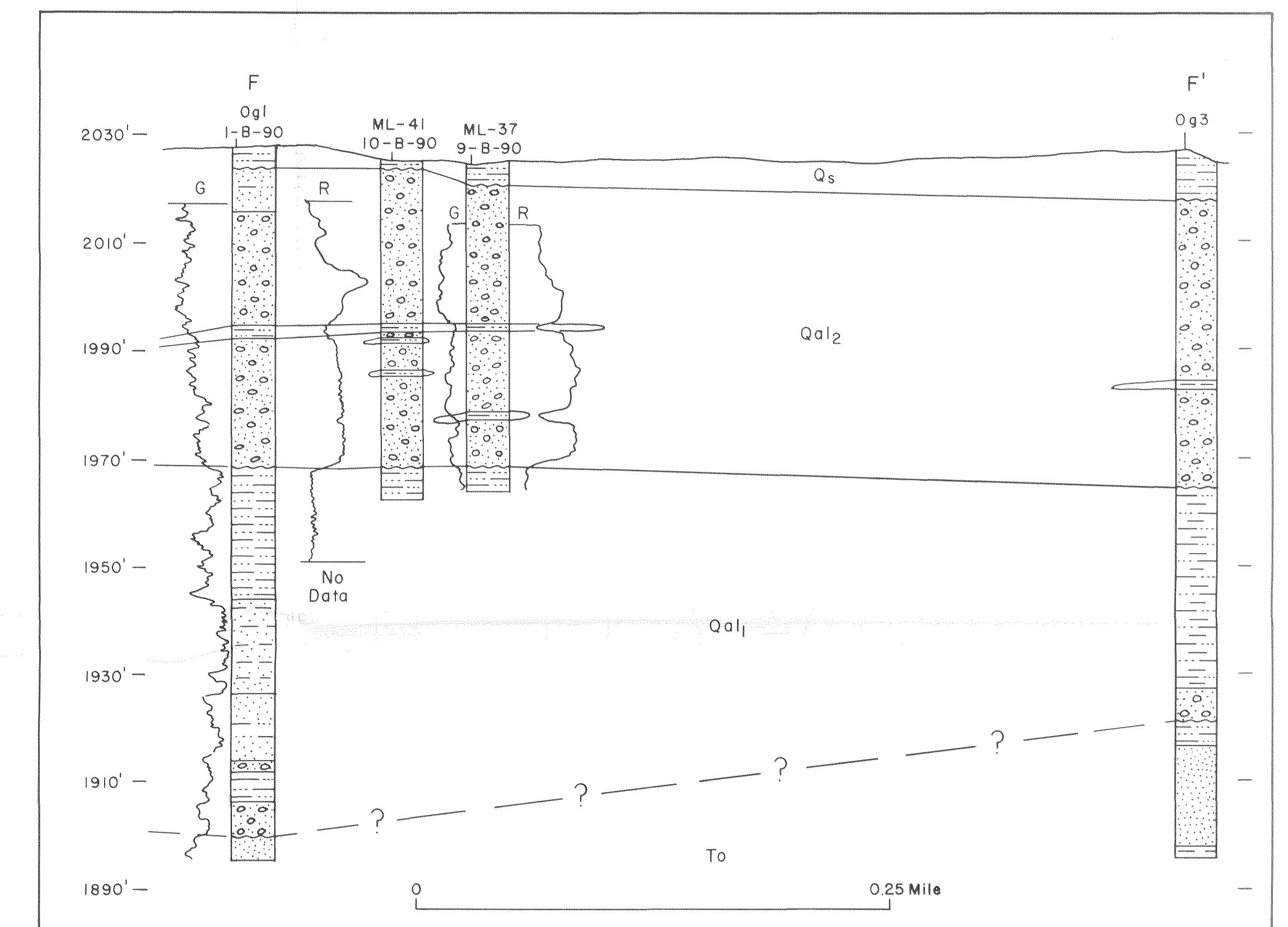
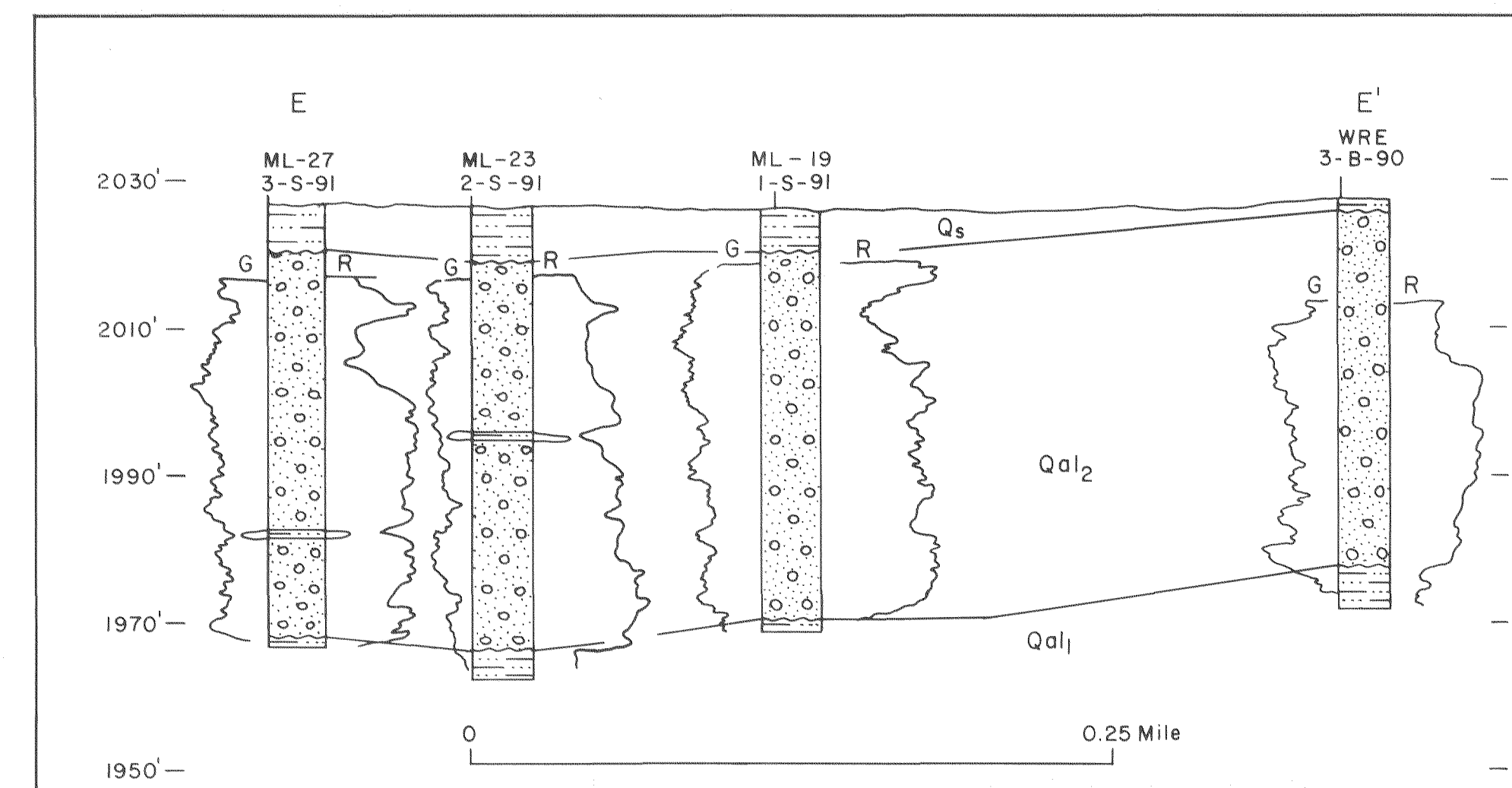
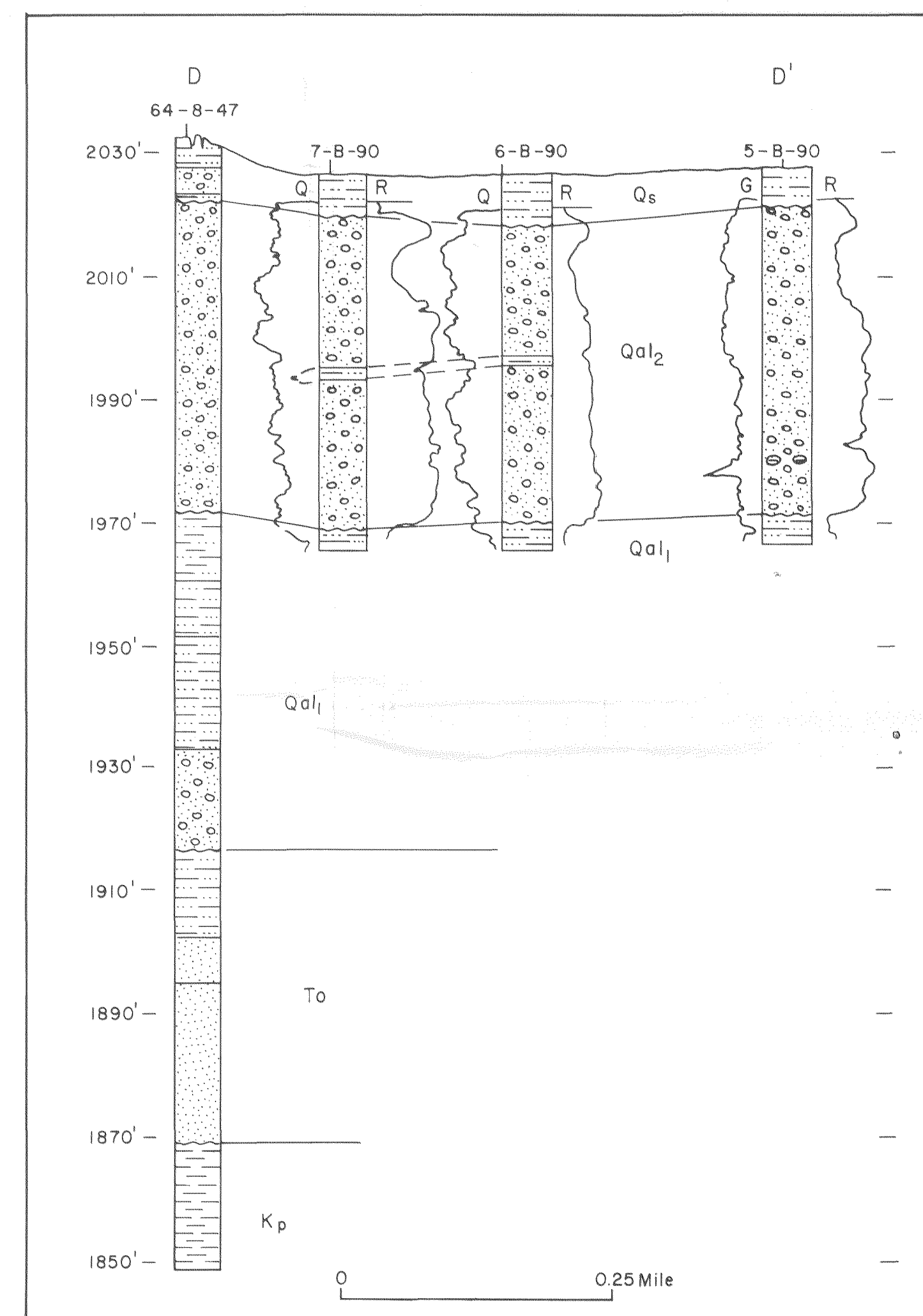
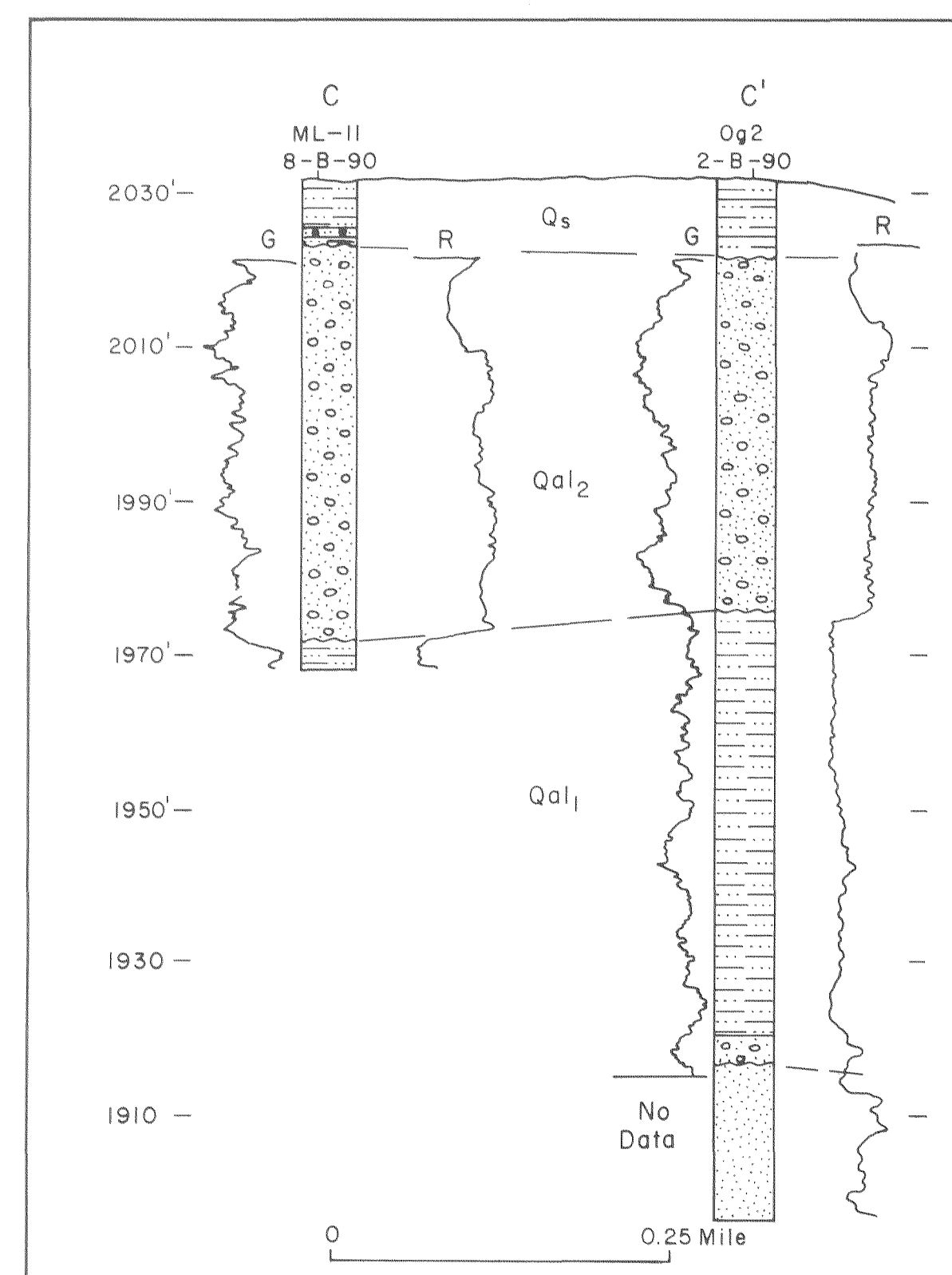
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- LITHOLOGIC SYMBOLS**
- Sand and Gravel
 - Sand, Sandstone
 - Silt, Siltstone
 - Silty Clay, Clayey Silt
 - Clay, Shale
 - Mud Lump
 - Unconformity
- CONTACTS**
- Probable
 - Inferred
 - Possible



- GEOLOGIC COLUMN**
- Qs - Quaternary (Holocene) Silt
 - Qal₂ - Quaternary (Holocene) Alluvium
 - Qal₁ - Quaternary (Holocene?) Alluvium
 - To - Miocene Ogallala Group
 - Kp - Cretaceous Pierre Shale

Fig. 3. Geologic cross sections across the MSEA site.

Illustration from Diffendal and Smith (1996), *Geology Beneath the Primary Management Systems Evaluation Area (MSEA) Site Southwest of Shelton, Buffalo County, Nebraska*, Conservation and Survey Division, University of Nebraska-Lincoln.