

A COCORP SEISMIC REFLECTION PROFILE IN NORTHEASTERN KANSAS

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REGIONAL BACKGROUND

Seismic reflection profiling in northeastern Kansas by COCORP was initiated to investigate several prominent features of the midcontinent, including the Midcontinent Geophysical Anomaly (MGA), which has been associated with a buried extension of the Keweenawan rift, and the Nemaha Uplift, part of a crystalline basement block uplifted in Pennsylvanian time (Figure 1). The MGA is characterized by gravity and aeromagnetic highs extending from the Lake Superior region to near the Kansas-Oklahoma border (Figure 1, 2, 3; see Yarger, 1981). Surface exposures in the north, as well as samples drilled along the trend of the anomalies, indicate that mafic volcanic rock and associated clastic sediments were deposited in a narrow trough formed by continental rifting of Keweenawan age (1.1 b.y. ago; see also King and Zietz, 1971; Chase and Gilmer, 1973).

The Nemaha Uplift is a north-south trending feature extending from Omaha, Nebraska to northern Oklahoma (Figure 1). In northeastern Kansas the Nemaha separates the Forest City basin from the Salina basin to the west (Steeple, in press). The origin of the Nemaha Uplift and associated Humboldt border fault (Figure 4) is enigmatic, but their lateral proximity and subparallelism to the MGA suggests that they may represent reactivated rift structures (Yarger, 1981).

KANSAS LINE 1

For display purposes, the main east-west profile, line 1, is divided approximately in half. The eastern profile crosses the Nemaha Uplift, the Humboldt Fault, and the Big Springs Magnetic Anomaly (Figure 3, stippled area), while the western profile traverses the MGA (Figure 2). The sections are displayed with approximately 1.3 times horizontal exaggeration and are unmigrated. Approximate time-depth conversions are achieved by multiplying two-way traveltime by a factor of 3 km/sec (1.8 mi/sec).

The upper 0.5 to 0.6 secs (1 to 2 km; 0.6 to 1.2 mi) of the eastern part of line 1 are characterized by a strong, relatively undeformed and continuous sequence of reflectors which correspond to the Phanerozoic sediments of the Forest City and Salina basins (Brown et al, in press). Minor offsets and diffractions suggestive of faulting are common in the sediments. In some cases, weak reflections, perhaps from fault planes, can be traced from the sediments into basement. These generally have an east dip on line 1. Crossline control indicates a component of dip to the south.

The line crosses the Humboldt Fault zone in the vicinity of stations 900-910. Drilling and shallow seismic reflection studies indicate that the fault zone is composed of a number of steeply dipping normal and reverse faults. In this seismic section the lower sediments of the Forest City basin are truncated by the fault while upper Paleozoic sediments are upwarped over the Nemaha. The uplifted basement surface of the Nemaha dips to the west where the sediments of the Salina basin eventually overlap the basement rocks.

The Humboldt Fault cannot be unequivocally traced into the basement. A weak, southeast-dipping (apparent, unmigrated dip of 25 to 30°) reflection extending from beneath the sedimen-

tary section to at least 2 secs (approximately 6 km; 3.7 mi) on the seismic section is the most likely candidate for the deeper extension of this fault. If so, the Humboldt would seem to be a normal rather than reverse fault since the sedimentary units are offset down to the east. Other weak reflections, possibly corresponding to other faults, also dip to the east and southeast on the section.

The Big Springs Magnetic Anomaly (stations 300-400; Figure 3) appears to be associated, at least spatially, with two southeasterly dipping reflections seen at approximately 1.5 secs (4 to 4.5 km; 2.5 to 2.8 mi) beneath Station 150. Drilling on this anomaly to the south encountered a 1.3 b.y. old granite with high magnetite content (Bickford et al, 1981).

One of the most striking aspects of the seismic section are the numerous strong, dipping and arcuate reflections at depth. Crosscutting relationships are common among the unmigrated reflections. Information from the cross lines confirms a complex three-dimensional subsurface geometry. In general, the mid- to lower-crustal reflection complexes appear to become shallower to the west and north, rising to within 3 secs of the surface at VP 1150 on line 1. Whether this is due to regional upwarping associated with the Keweenaw rifting to the west or some other factor event is not known. None of the deep reflectors have yet been drilled, and hence cannot be positively identified. Igneous, tectonic, and relict sedimentary layering have all been considered as possible explanations (Brown et al, in press).

Perhaps the most prominent structure on line 1 is located below stations 1500-2000, corresponding to the central part of the gravity high which defines the MGA (Figure 2). The data show a sequence, which may include some multiples, of high amplitude west-dipping layered reflections between 1 and 3 secs (3 to 9 km; 1.8 to 5.6 mi). The sequence exhibits gradual increase in dip with increasing depth, characteristic of deposition within a subsiding basin. The correlation of the layered reflections with the location of the MGA strongly suggests that the reflections are associated with Keweenaw rift structures, probably a thick pile of interbedded basalts and sediments analogous with the middle Keweenaw sequence exposed in the Lake Superior region (Halls, 1966). Brown et al (in press) proposed the same interpretation for a remarkably similar reflection sequence mapped by COCORP surveys across a branch of the Keweenaw rift system beneath the Michigan basin.

The layered sequence is truncated on the west by an apparent low angle reflection which may delineate a fault plane. This reflection also truncates the strong reflection at 2 to 3 secs which runs from station 1900-2100. The truncating fault may represent an intrarift normal fault, but a reverse fault, such as the Keweenaw fault in the Lake Superior Region, resulting from post-rift compression cannot be ruled out.

To the east of the main basin, several smaller, shallower basins are identified. Under station 1500 a possible fault offsetting what is interpreted as basement can be observed between 1 and 2 secs. This fault is yet another east-dipping structure which seems to control movement in the basement blocks.

The rift appears to have developed by asymmetric subsidence of a basin formed by rotation of crustal blocks along east to southeast dipping normal faults. Subsidence was accompanied by deposition and westward onlapping of sediments and basalts into the basin.

The middle and lower crust around the rift fill is again characterized by numerous dipping arcuate events. However, under the central part of the rift, deep events appear to be fewer in number and exhibit less continuity, possibly a result of fracturing and igneous intrusion associated with rifting. The lack of reflectors may also be an artifact of reduced seismic penetration through the thick basin wedge.

Although no obvious Moho reflections are found in the section, several reflections from below the expected Moho arrival time of 12 to 13 secs (Steeple, 1976; Stewart, 1968) are observed beneath station 1200. A crossline confirms that these very deep reflections are not sideswipe.

These data have only recently been obtained and are not fully processed or interpreted as yet. Some reflectors may not be identifiable with these data but future extensions of the survey may allow us to trace these reflections to subcrop where they can be identified by drilling. The complexity and heterogeneity in the middle to lower crust of the midcontinent is demonstrated perhaps more clearly here than in any other seismic study of the crust. The structure contrasts sharply with that of simple layered models for the crust and represents an important step in unravelling the evolution of the continental craton.

ACKNOWLEDGMENTS

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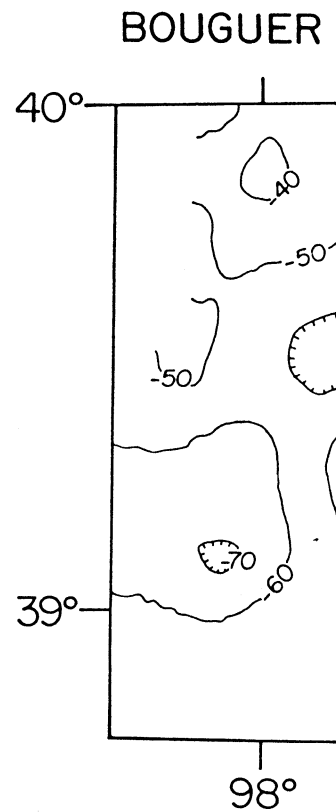
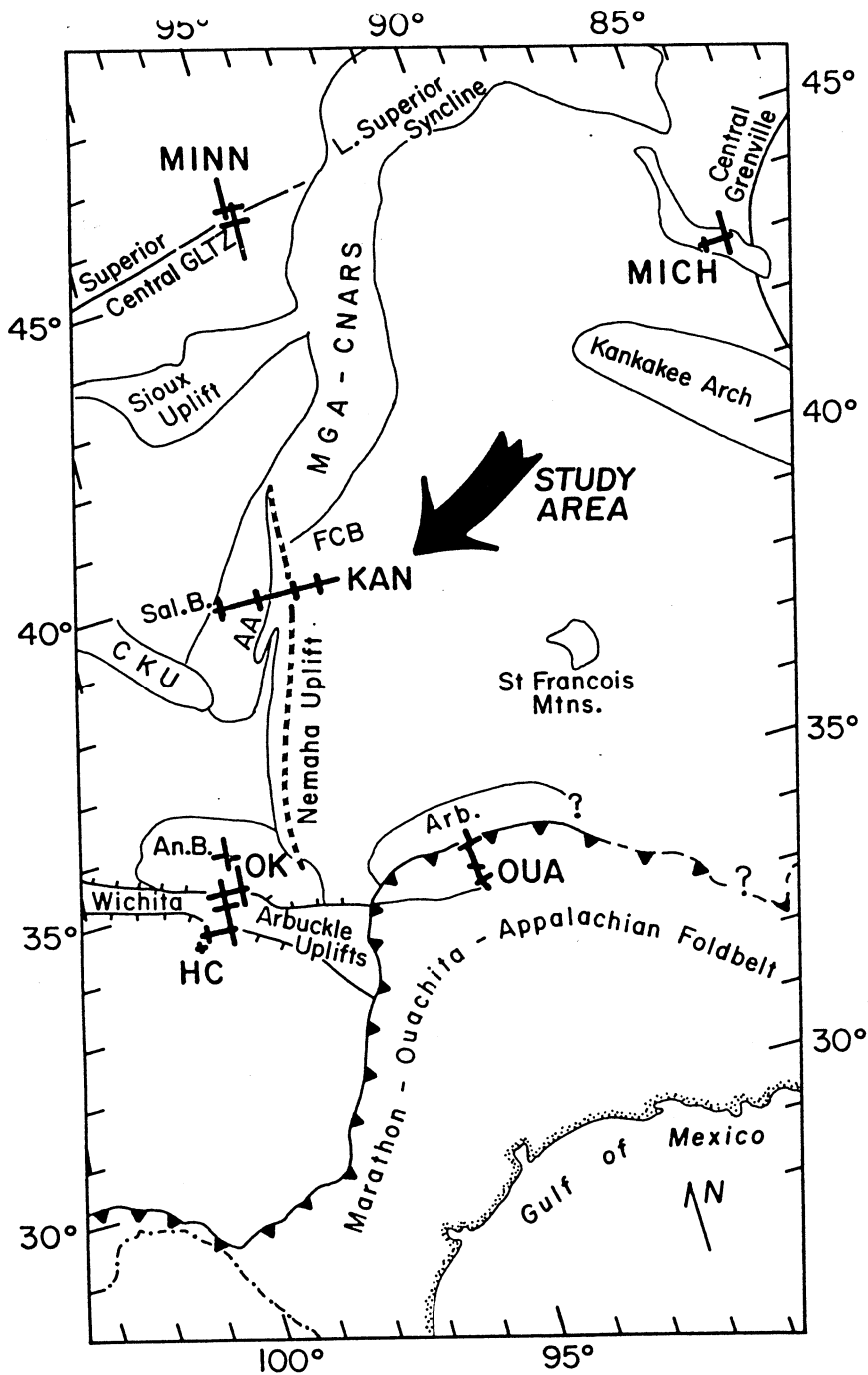


Figure 2: Bouguer g
interval is 10 mgal.

Figure 1: COCORP profiles (solid lines) in the midcontinent. Humboldt fault, dotted line; MGA, Midcontinent Geophysical Anomaly; CNARS, Central North American Rift System; CKU, Central Kansas Uplift; AA, Abilene Anticline; FCB, Forest City basin; Sal. B., Salina Basin; An. B., Anadarko basin; Arb., Arkoma basin; HC, COCORP Ouachita survey; MINN, COCORP Minnesota survey; MICH, COCORP Michigan survey. From Brown et al (1982).

BOUGUER GRAVITY

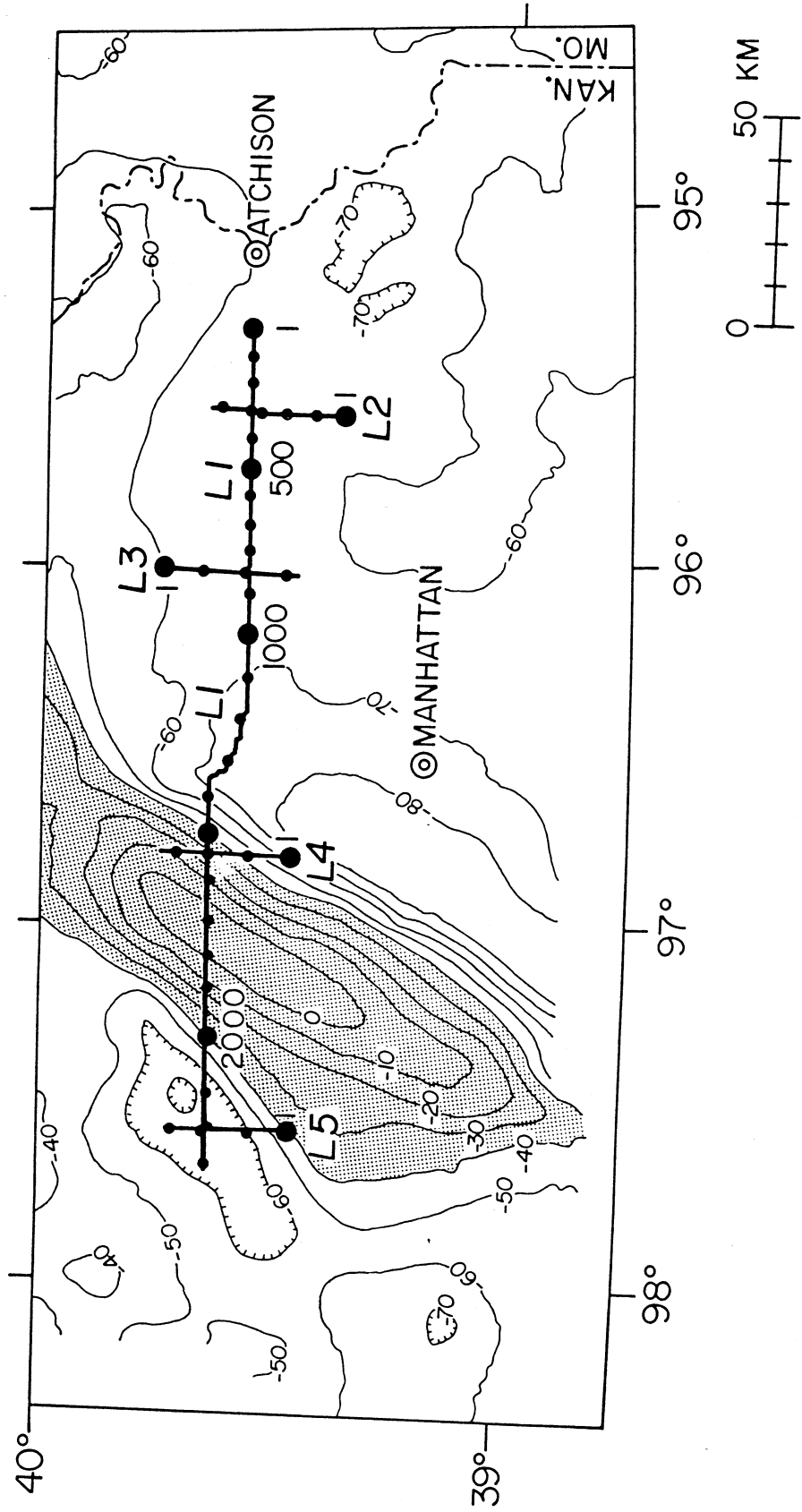


Figure 2: Bouguer gravity map of northeastern Kansas. Gravity high at MGA indicated by stippled pattern. Contour interval is 10 mgal. From Brown et al (in press).

AEROMAGNETIC

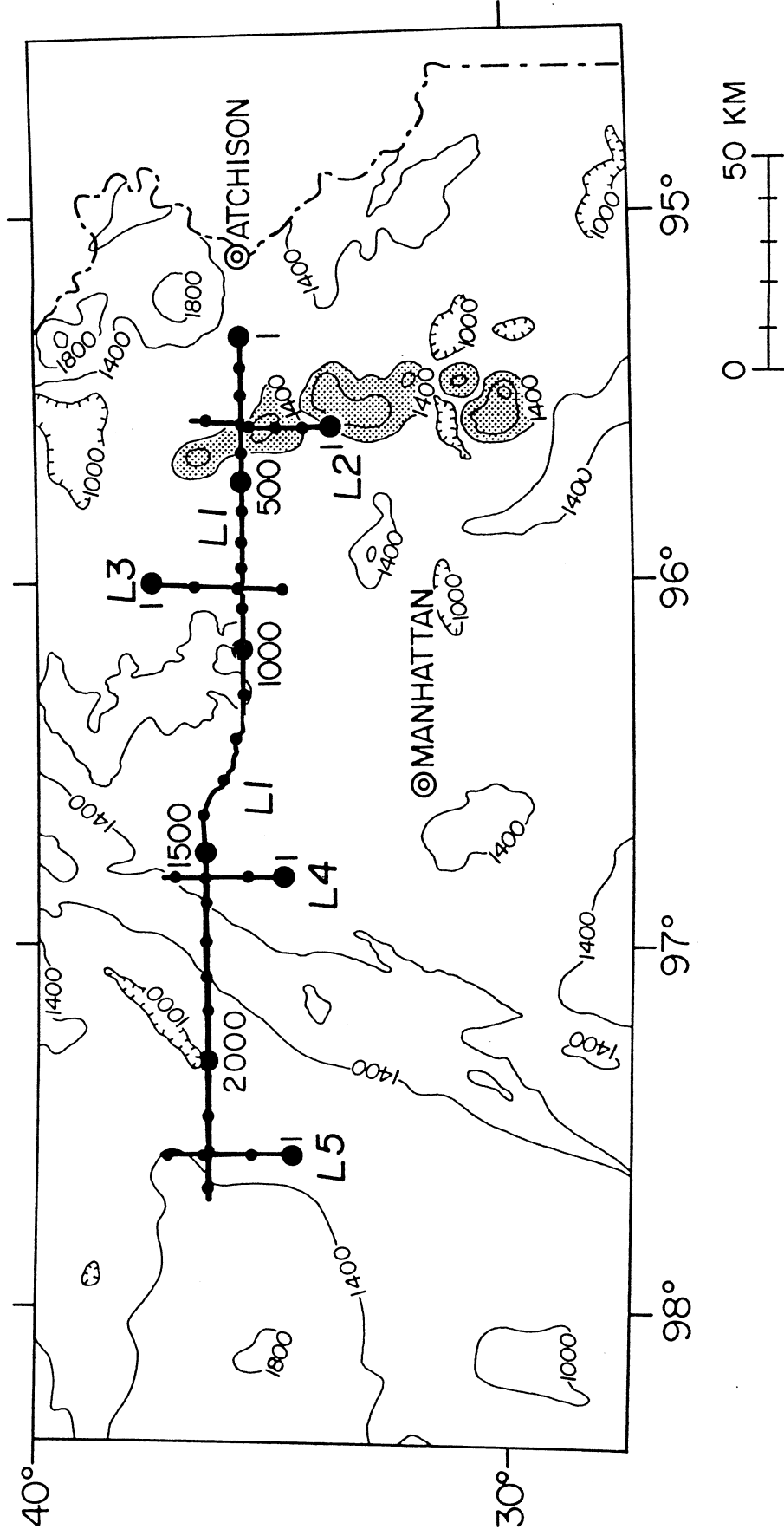


Figure 3: Aeromagnetic map of northern Kansas. Big Springs Magnetic Anomaly indicated by stippled pattern. Contour interval is 400 gammas. From Brown et al (in press).

PRECAMBRIAN BASEMENT TOPOGRAPHY

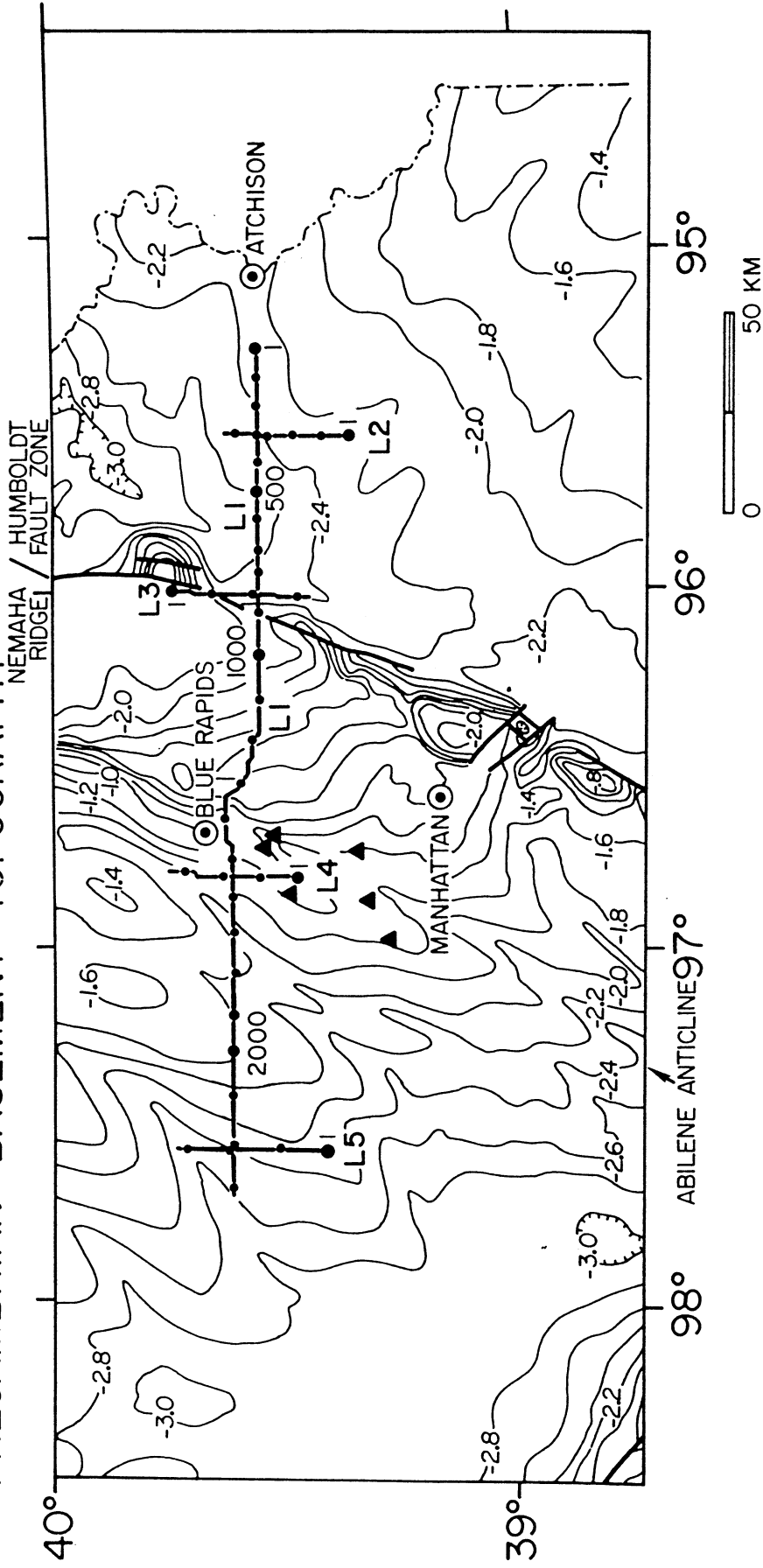
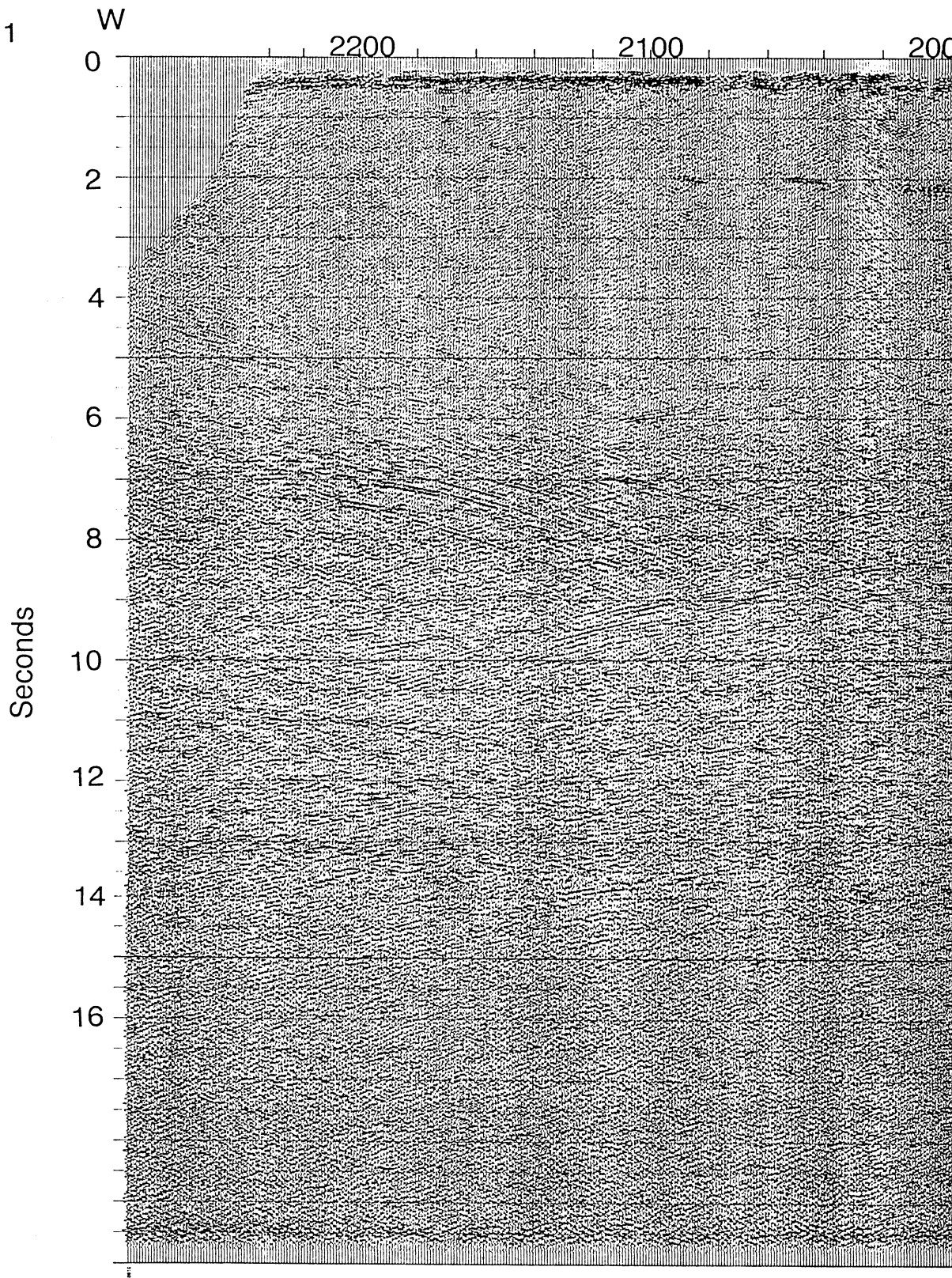


Figure 4: Precambrian basement topography map of northeastern Kansas. Contour interval is 200 ft (61 m). From Brown et al (in press).

KANSAS LINE 1
(Western Half)



(Fig. 5)

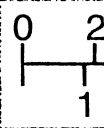
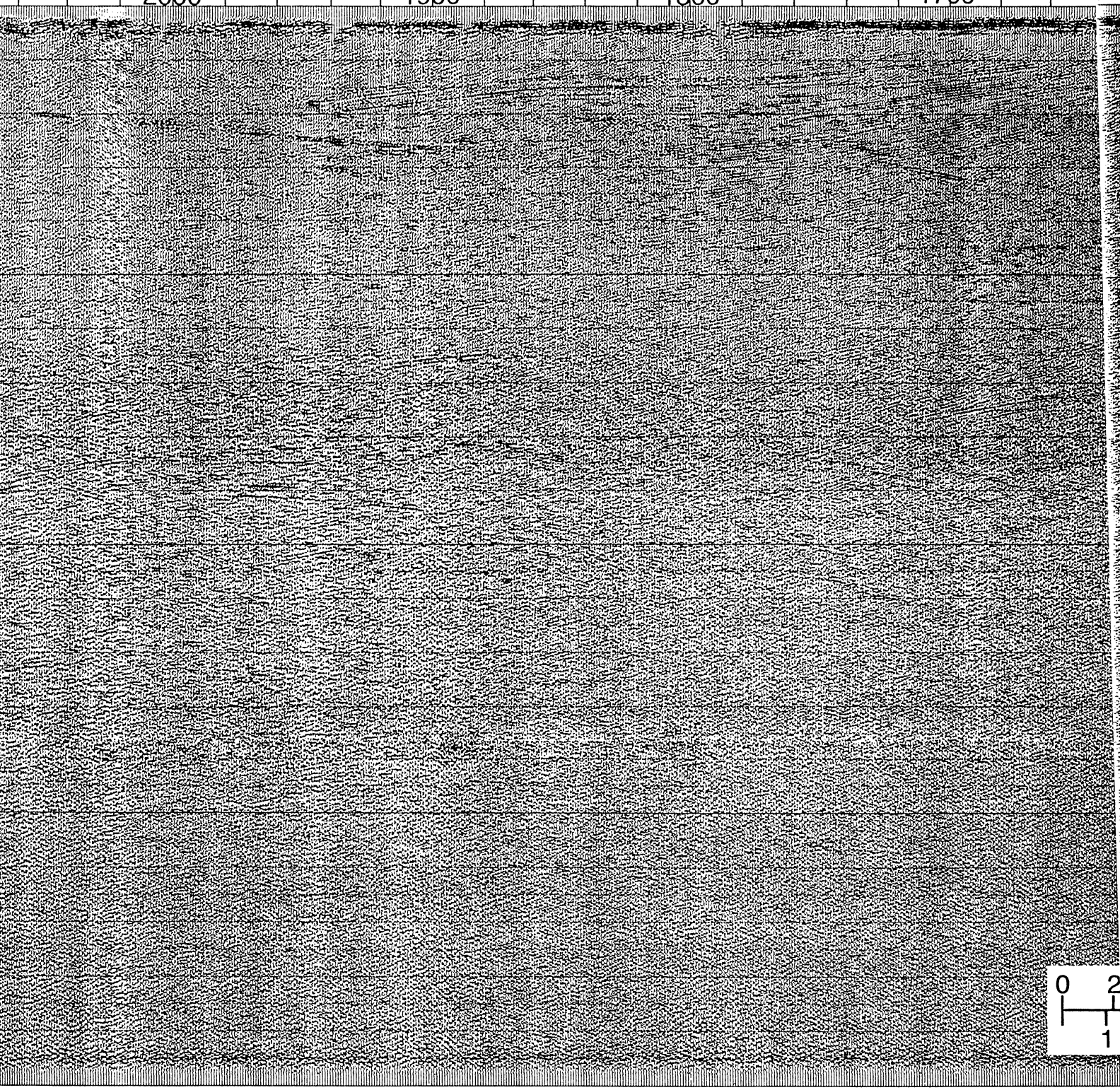
MID CONTINENT GEOPHYSICAL ANOMALY

2000

1900

1800

1700



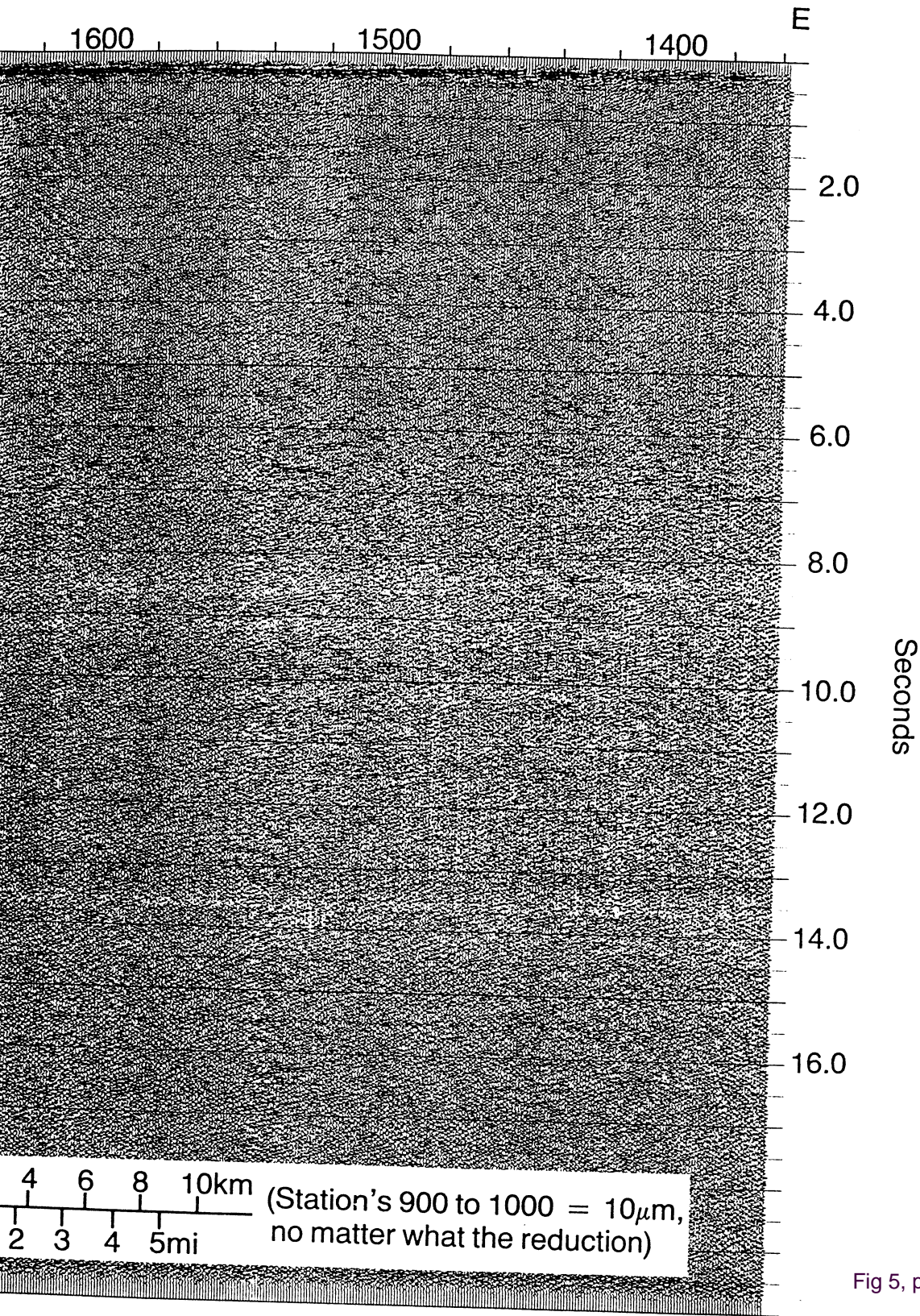
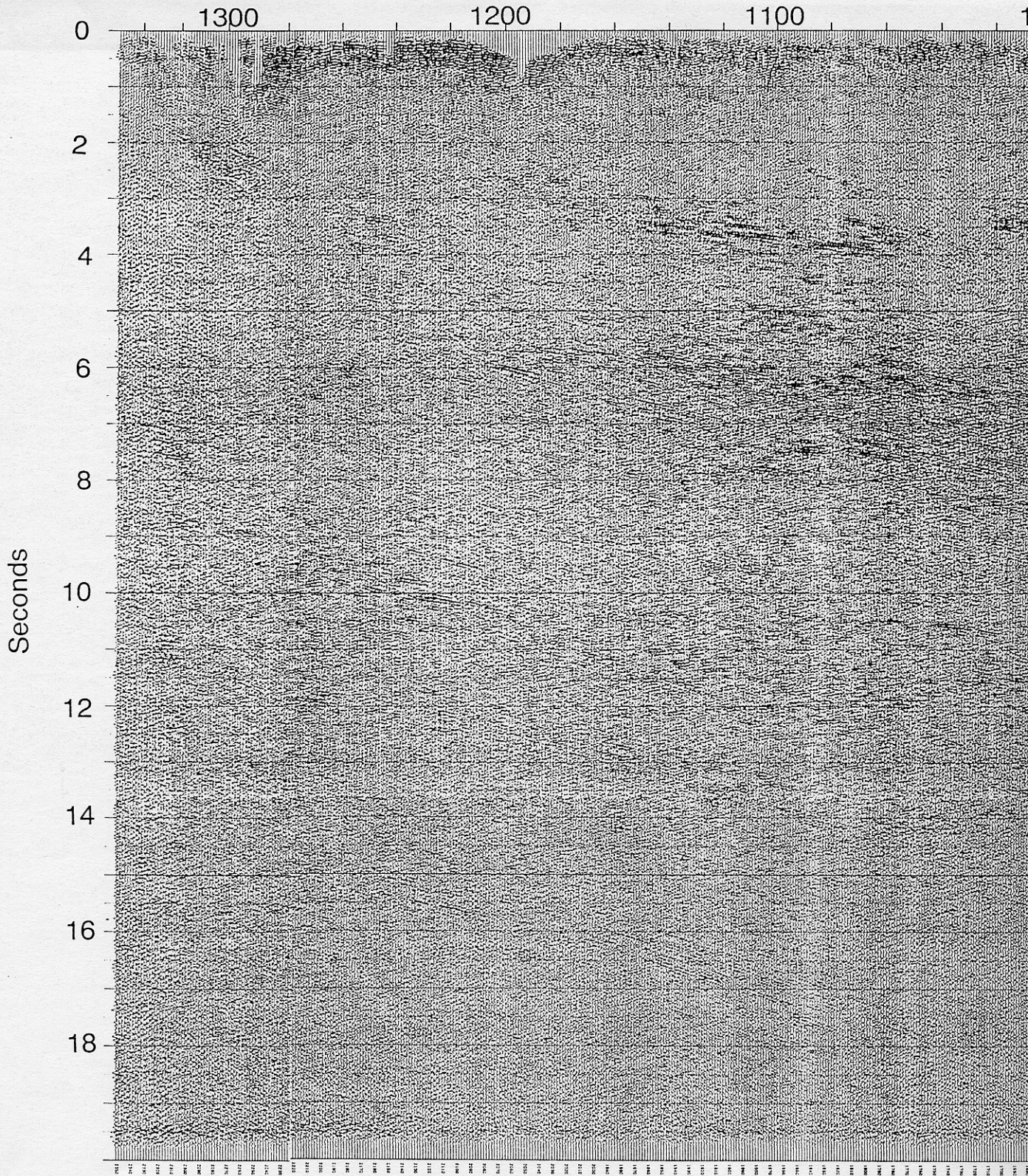
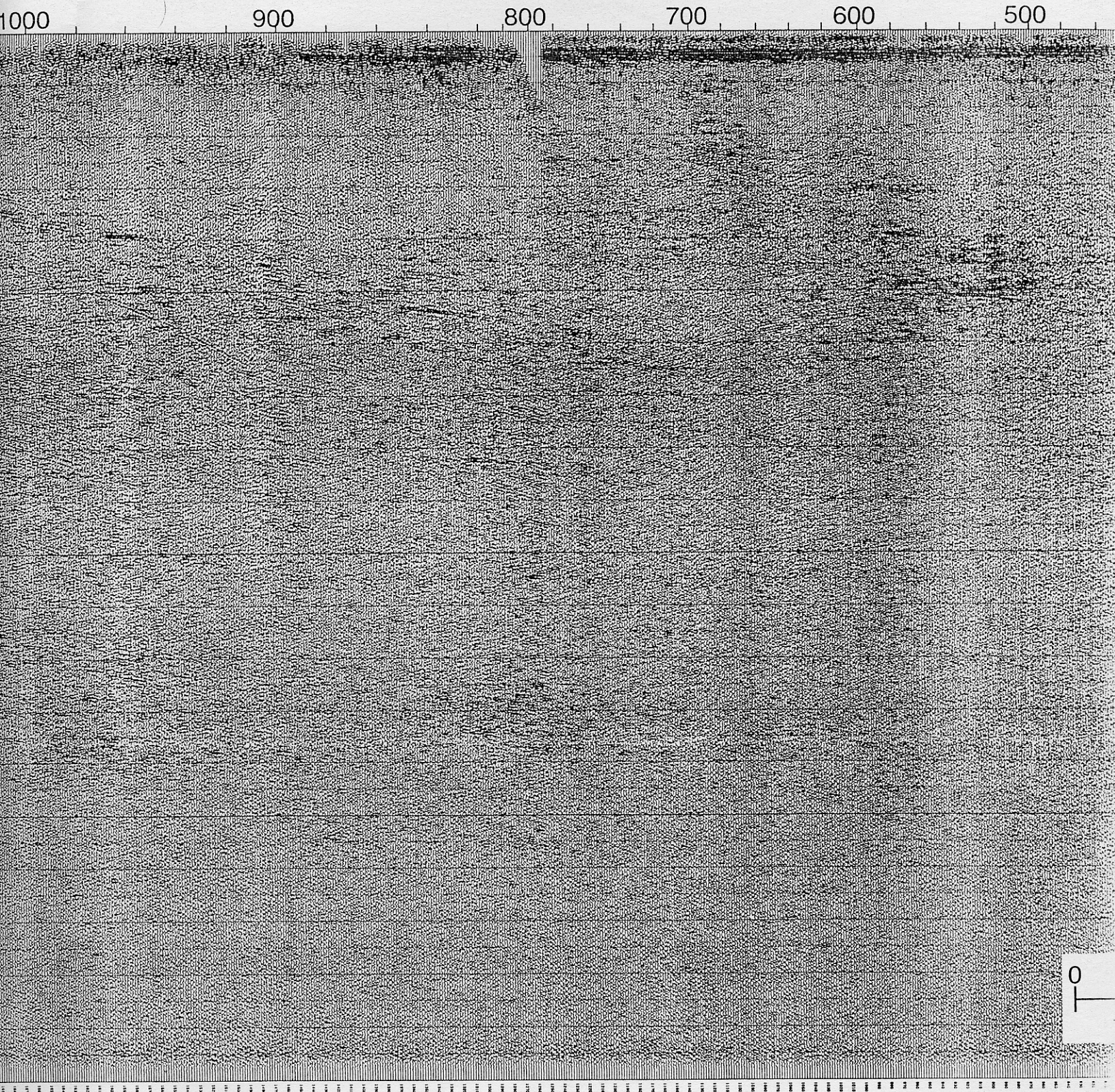


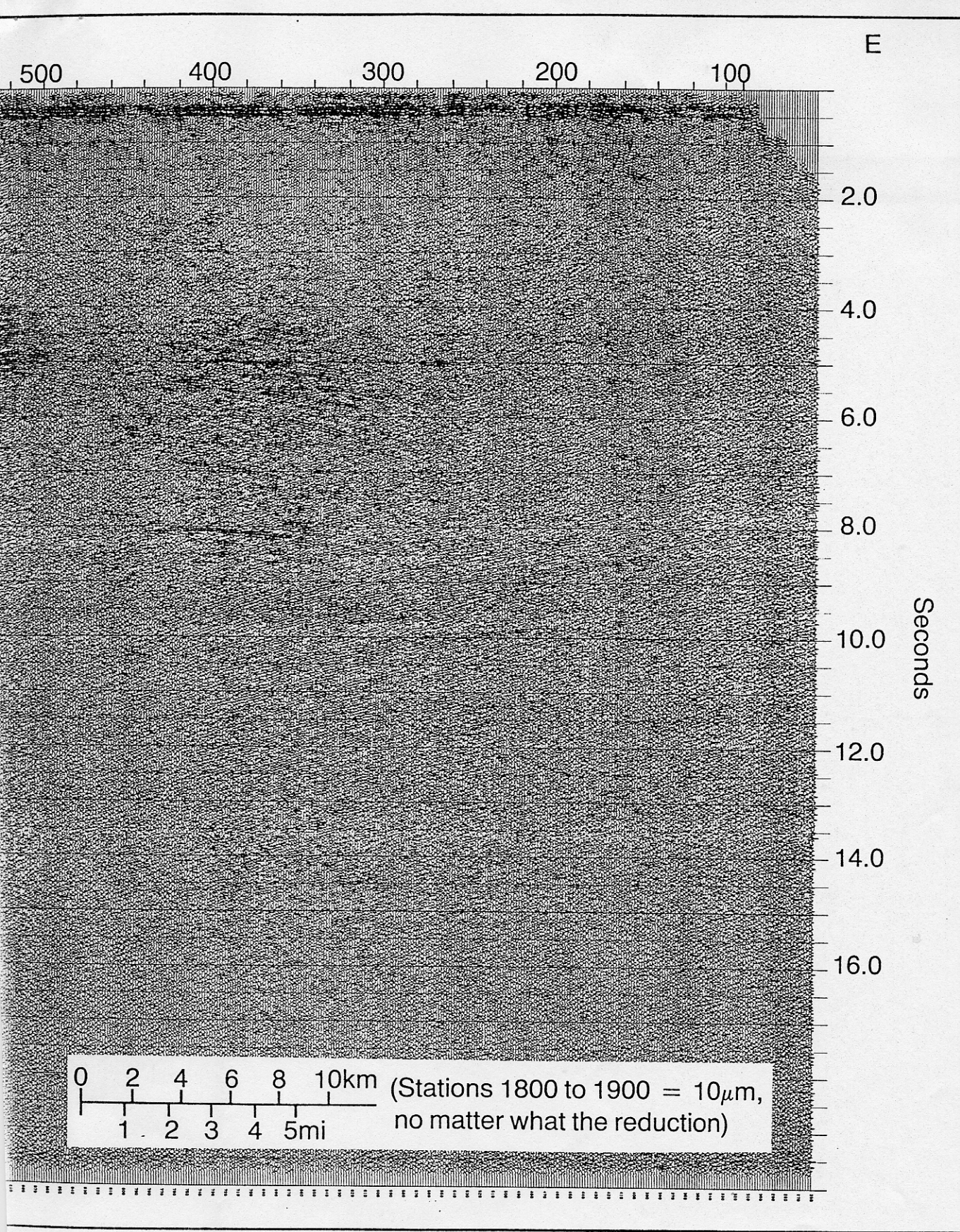
Fig 5, p. 3 of 6

W KANSAS LINE 1 (Eastern Half)



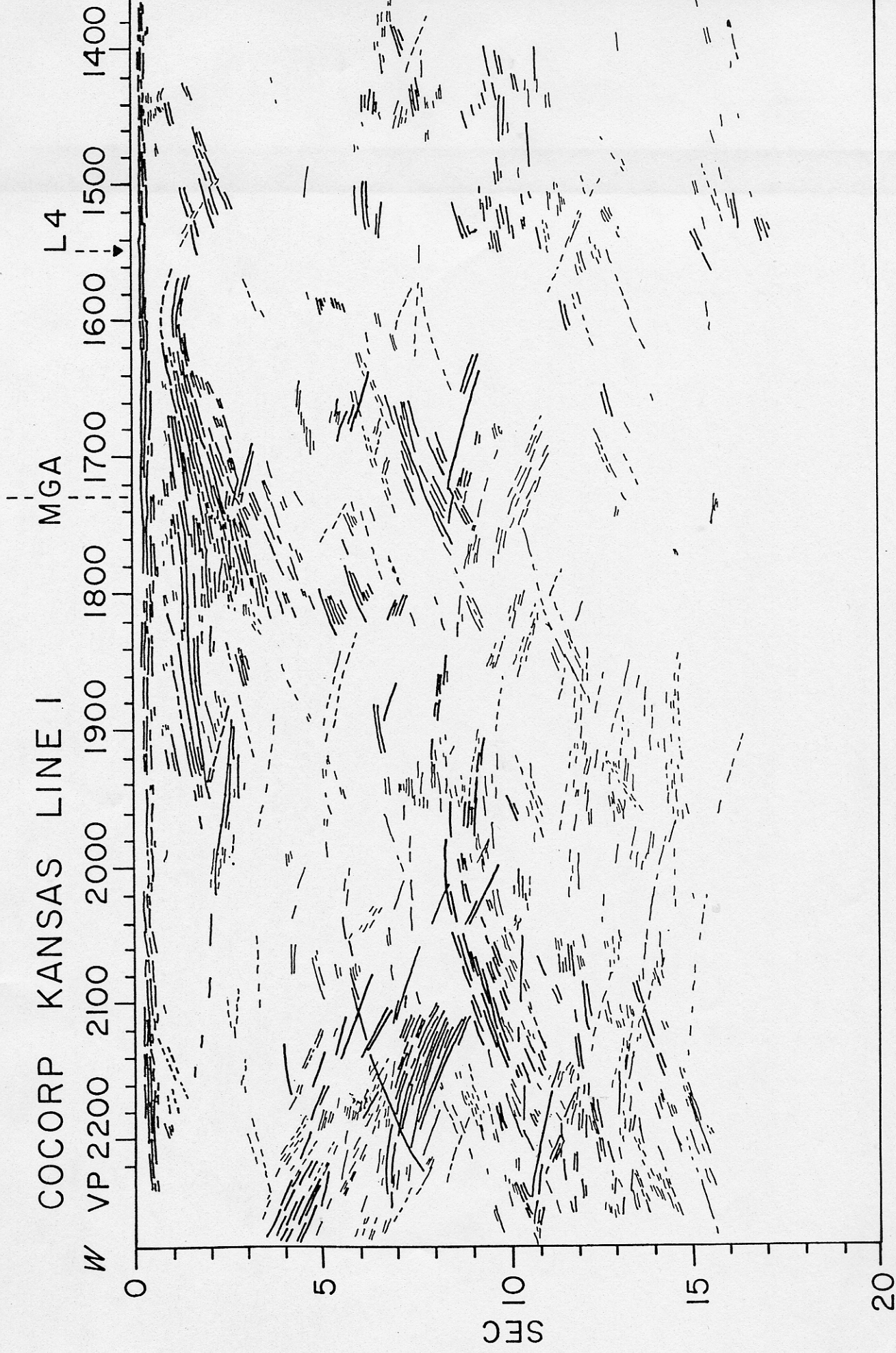
NEMAHA UPLIFT HUMBOLDT FAULT



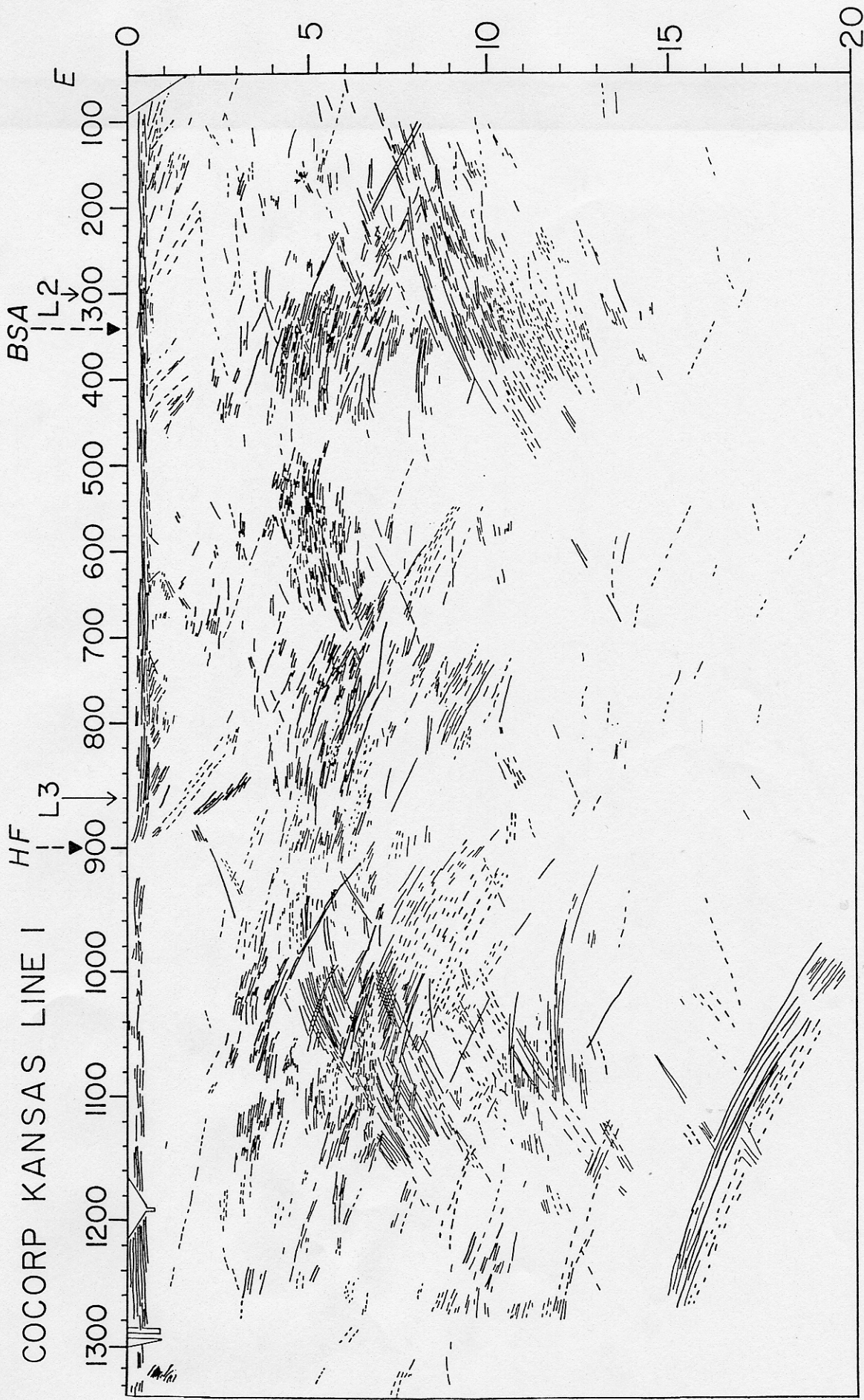


E

LINE DRAWING, KANSAS LINE 1



(west half)



TIME

(east half)

(for horizontal scale, no matter what the reduction, station 1800 to 1900 = 10 μ m)