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50-482

April 24, 1982

Mr. J. J. Ray
Advisory Committee on Reactor Safeguards
U. S. Nuclear Regulatory Commission
H Street
Washington, D. C. 20555

Subject: Wolf Creek site visit and review, April 21, 1982 - Seismic and Geologic Considerations

Dear Mr. Ray:

As I understand it, the only open question concerning geology and seismology of the Wolf Creek plant and site concerns the calculation of site-specific spectra and seismic risk for seismic Category I structures outside the standard plant portion of the facility. In my opinion the high degree of conservatism built into the assumed seismic risk, together with the wide margin of uncertainty in relating spectra to seismic loading of structures suggests the current design for peak horizontal acceleration for SSE of 0.12, as carried out by the applicant, is adequate.

In support of the above opinion I cite the following points:

1. The seismic risk at the plant site is extremely low.

   a. Presentation by Frank Wilson of the Kansas Geological Survey, who emphasized the absence of surface, subsurface or geophysical evidence for faulting near the plant site, and the absence of seismic activity in the 19 counties of southeastern Kansas, including Coffey County. Dr. Wilson noted that the distribution of microearthquakes observed on the state network closely approximates historical earthquakes, and that neither has been recorded from southeastern Kansas.

   b. Note also that the controlling earthquakes, the 1867 listed as intensity VIII, and the 1906, intensity VII, together with 8 other felt earthquakes (10 of 25 total in the state) are arranged in an east-west belt in northeastern Kansas, and that a concentration of microearthquakes

occurs in the same area. This reinforces the opinion expressed in my letter of 11/26/79 to Mr. Harold Etherington that the controlling faults trend easterly rather than north-south, the trend of ancient bounding faults of the Nemaha uplift. The current regional maximum compressive stress is oriented east-west (Zoback and Zoback, Jour. Geophys. Research, Nov. 1980, p. 6148), hence, reactivation of easterly trending normal faults would be predicted. There is no indication that such faults exist in the Coffey County region.

c. The above letter also notes that the 1867 earthquake should probably be listed as intensity VII as in earlier catalogues, rather than elevated to intensity VII-VIII, as in NUREG/ CR-0294.

2. Gross assumptions and highly imprecise calculations of seismic spectra are involved, especially when based, as here, on intensities deduced from a limited number of newspaper reports. Dr. Trifunac emphasized this point during the review in Elmira.

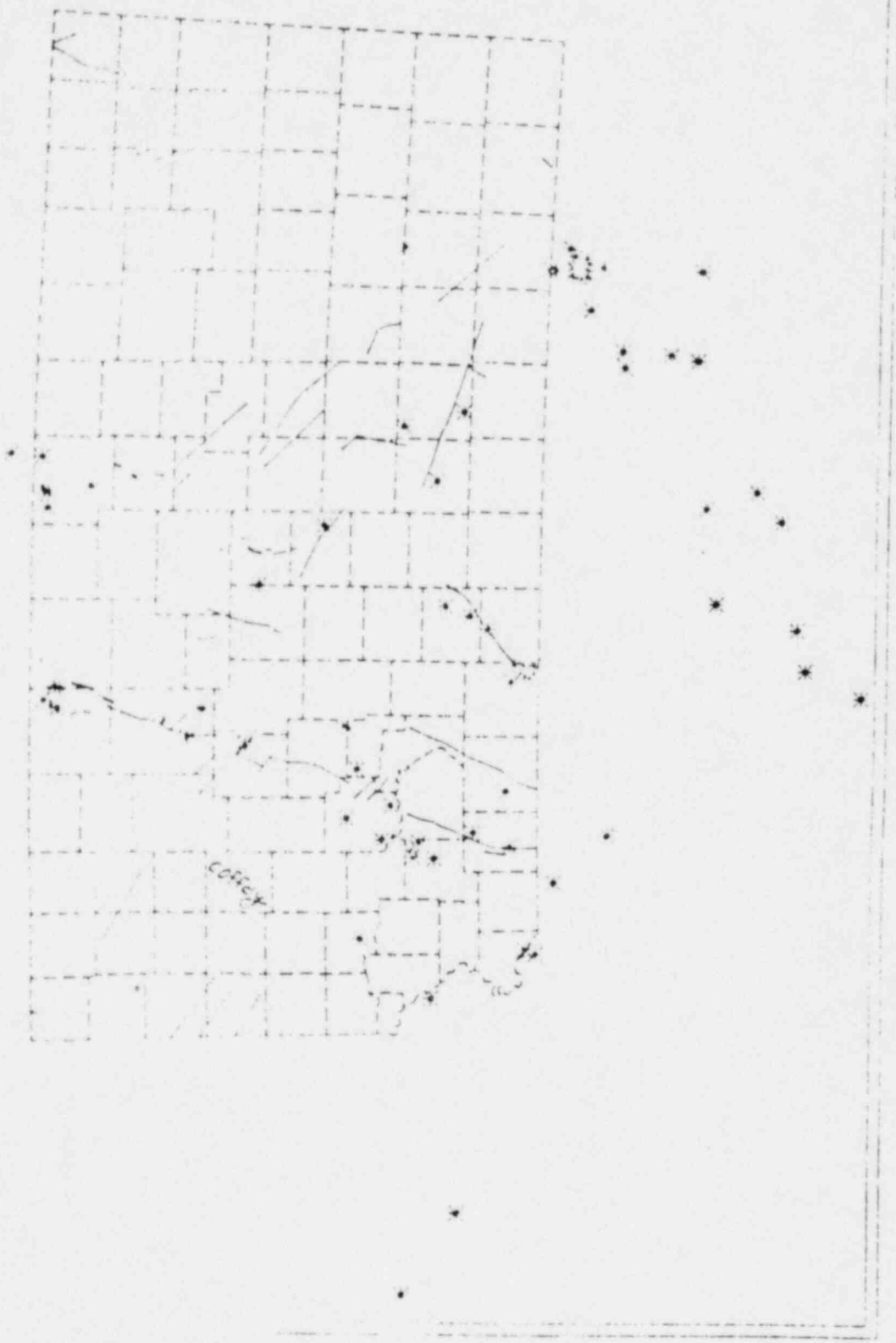
Respectfully submitted

John C. Maxwell
Consultant

c.c. Dr. Kerr

FRANK WILSON 4/21/82

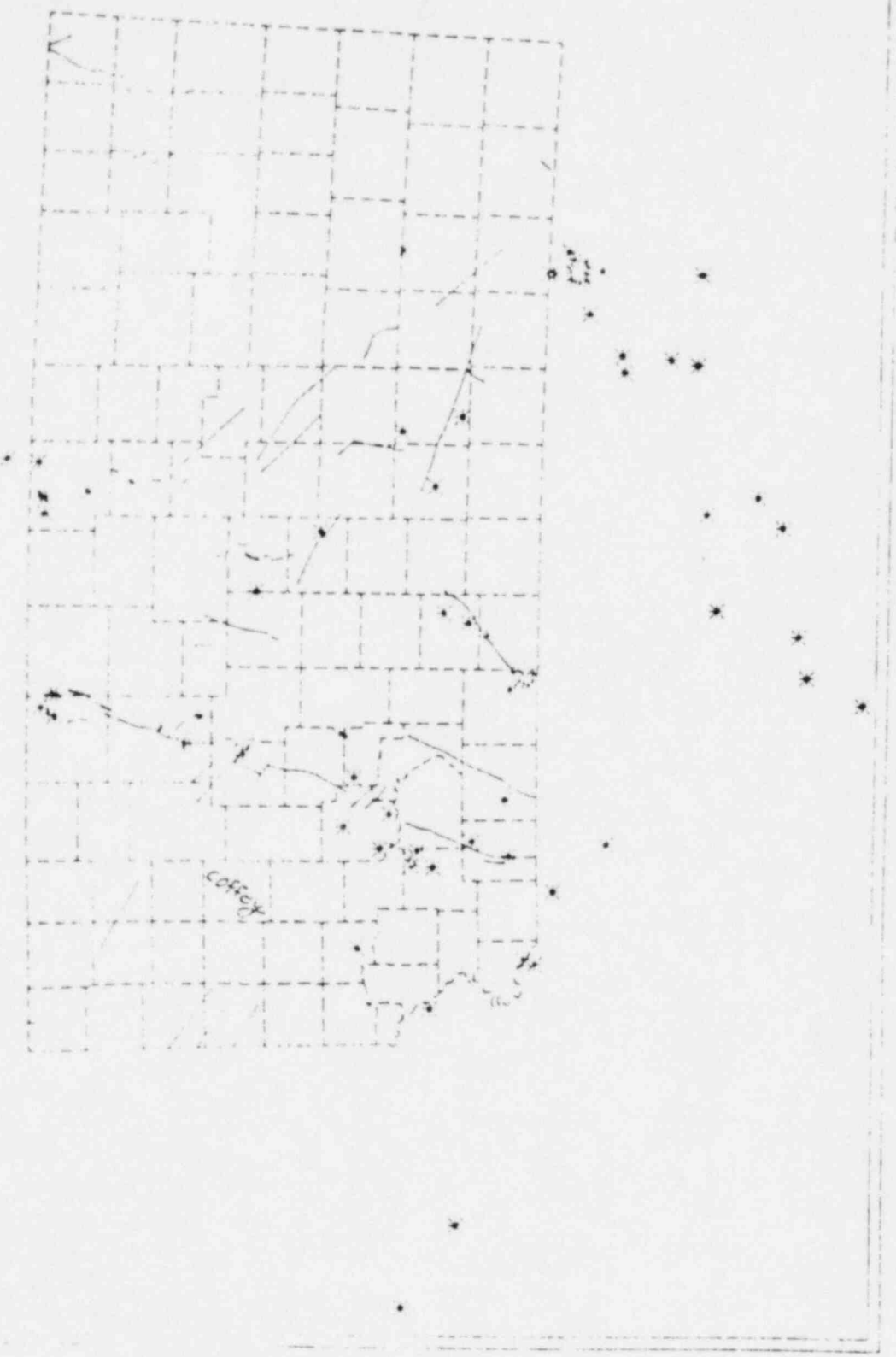
GIMMAP/KGS February, 1982 Lambert Conformal



Microearthquakes (•) And Faults (/) In Kansas

FRANK WILSON 4/21/82

GIMMAP/KGS February, 1982 Lambert Conformal



Microearthquakes (•) And Faults (/) In Kansas

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November 26, 1979

Mr. Harold Etherington
Advisory Committee on Reactor Safeguards
Nuclear Regulatory Commission
Mail Stop H 1016
Washington, D. C. 20555

Dear Mr. Etherington:

Subject: Additional comments on my letter of October 1, 1979 referring to the Wolf Creek Project

At the time of writing my letter of October 1, 1979 I did not have available to me NUREG/CR-0294, containing information on damage reports relating to the 1867 Manhattan, Kansas earthquake. I have now had the chance to examine this material. It appears that the authors have thoroughly researched the available newspaper sources and have produced a reasonable isoseismal map for this earthquake (figure 3, page 17 in the NUREG/CR-0294). On the basis of this study the location of the 1867 epicenter was shifted about 20 miles southeastward to the vicinity of the subcrop of the north-south trending Humboldt fault, bordering the buried Nemeha uplift on the east side. It was further suggested that the intensity of the earthquake was in the range of VII-VIII rather than VII as previously listed.

The isoseismal lines shown in figure 3 are reasonably well established for the eastern half of the figure, but the shape and extent of the western half is unknown. Note also the highly elongated intensity VII zone, which could extend westward or southwestward for an unknown distance. From reading the accompanying damage reports, it seems to me that the choice of a location for the epicenter within this 150-mile long zone of intensity VII is quite arbitrary. For example, at the western end of the zone, location 28, it was noted that: "train on Pacific Railroad violently rocked by shock, locomotive was stopped and train men abandoned cab for fear the boiler was about to blow up," and to the east, at location 13, Leavenworth, Kansas, "man shaken off load of hay; two contiguous buildings lifted up, separated two inches, settled back; nearly everything toppled over in private homes; several chimneys overthrown." At the site chosen for the epicenter near Wamego (number 30 on figure 3) the damage to buildings appeared to

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be comparable to that observed throughout this long zone. The apparent reason for locating the epicenter here, other than its nearness to the trace of the Humboldt fault, was an observation that "on the farm of John Cotton . . . . during the earthquake the earth opened and water was thrown out of the opening in considerable quantities. At another place not far distant from the above, the earth opened and fire and smoke issued out. So one of our papers states". To this phenomenon the writers assign a questioned intensity VIII. If this were a bonafide major occurrence of sand boils in unconsolidated sediments, then an assignment of intensity VIII would probably be justified. However, in view of the very similar degree of damage throughout the isoseismal VII zone, and the lack of evidence of greater damage in the Wamego area it would seem to me more probable that the observed phenomena were related to escape of marsh gas and accompanying water. I see no compelling reason for raising the intensity in this area to VIII.

If the 1867 earthquake resulted from movement on the Humboldt fault, it would indeed be logical to assume similar motion could occur along the general extension of that fault southward, about 75 kilometers west of the Wolf Creek site. Figure 3 of NUREG/CR-0666 shows that this fault is discontinuous and the continuity and displacement diminishes in a southerly direction. Furthermore, the locations of the three earthquakes for which isoseismals were prepared (1867, 1875, and 1906) lie on an east-west trend approximating the VII isoseismal zone of the 1867 earthquake. The center trace of the isoseismal zone and epicenters of the 1867, 1875 and 1906 earthquakes are plotted on figure 4, NUREG/CR-0666 (photostat attached). The possibility that the 1867 and 1906 earthquakes are related to the basic intrusive rocks of the Keweenawan mafic igneous belt, as initially postulated by the applicant is quite apparent. To me it seems more likely, however, that these and other earthquakes shown on figure 2, NUREG/CR-0294 occurred along an easterly trending fault or zone of faults approximately paralleling the VII isoseismal zone of the 1867 earthquake. Multiple shocks accompanying that earthquake, plus one aftershock some 25 hours later, also seem to have been distributed along this zone.

A map summarizing all known earthquakes for eastern North America, intensity I through XII for the period 1534-1971 has been published by Lynn Sykes (Reviews of Geophysics and Space Physics, November, 1978, page 648). Two observations of particular interest for the Wolf Creek area are: (1) that the 20 or so counties in the southeast corner of Kansas, and the adjacent areas in Missouri and Oklahoma, have been free of observed seismic activity, and (2) that the most obvious

seismic zones trend east-west to east-southeast, reflecting the Ouachita-Wichita structures and the Manhattan and other earthquake trends in Kansas and adjacent states. There is no obvious seismic reflection of the north-south trending Nemaha structure. It seems unlikely, therefore, that large earthquakes of the Manhattan, Kansas type will occur southward along southerly extending faults corresponding to the Humboldt fault of northern Kansas and southern Nebraska. For this reason and because I find the evidence for an intensity VIII assignment for the 1867 earthquake to be unconvincing, I believe the assigned SSE value of 0.12g is still reasonable for the Wolf Creek site.

In his letter of June 29, 1979 to the NRC Commissioners Mr. William H. Ward, attorney for MACEA brought up another point, also touched in my October 1, 1979 letter, namely that the regional structural setting of the Wolf Creek Project is similar to that of Tyrone, for which the SER recommended an SSE of 0.2g horizontal acceleration. Both the Wolf Creek and Tyrone sites are in the Central Stable Region tectonic province. Both are also in regions which are seismically quiet. No historical earthquakes have been reported within 100 miles of the Tyrone site and only 10 earthquakes of intensity IV or greater have been reported within 200 miles of that site. The SER (page 2-16) says, "in our review of the vibratory ground motion potential for the Tyrone site, we took the position that an intensity MM VII-VIII event could occur at the site based on the criteria defined in appendix A to 10 CFR part 100. In our evaluation the resulting acceleration value due to this intensity would be 0.2g". Using the same line of reasoning it is apparently true that an intensity of 0.2g would now be similarly applied to the Wolf Creek site by the staff. This appears to be a matter of accepted policy, not specifically required by the tectonic setting of the Wolf Creek site.

Respectfully submitted:

John C. Maxwell

John C. Maxwell
Consultant

ISOSEISMAL MAP OF THE APRIL 24, 1867 EARTHQUAKE IN KANSAS

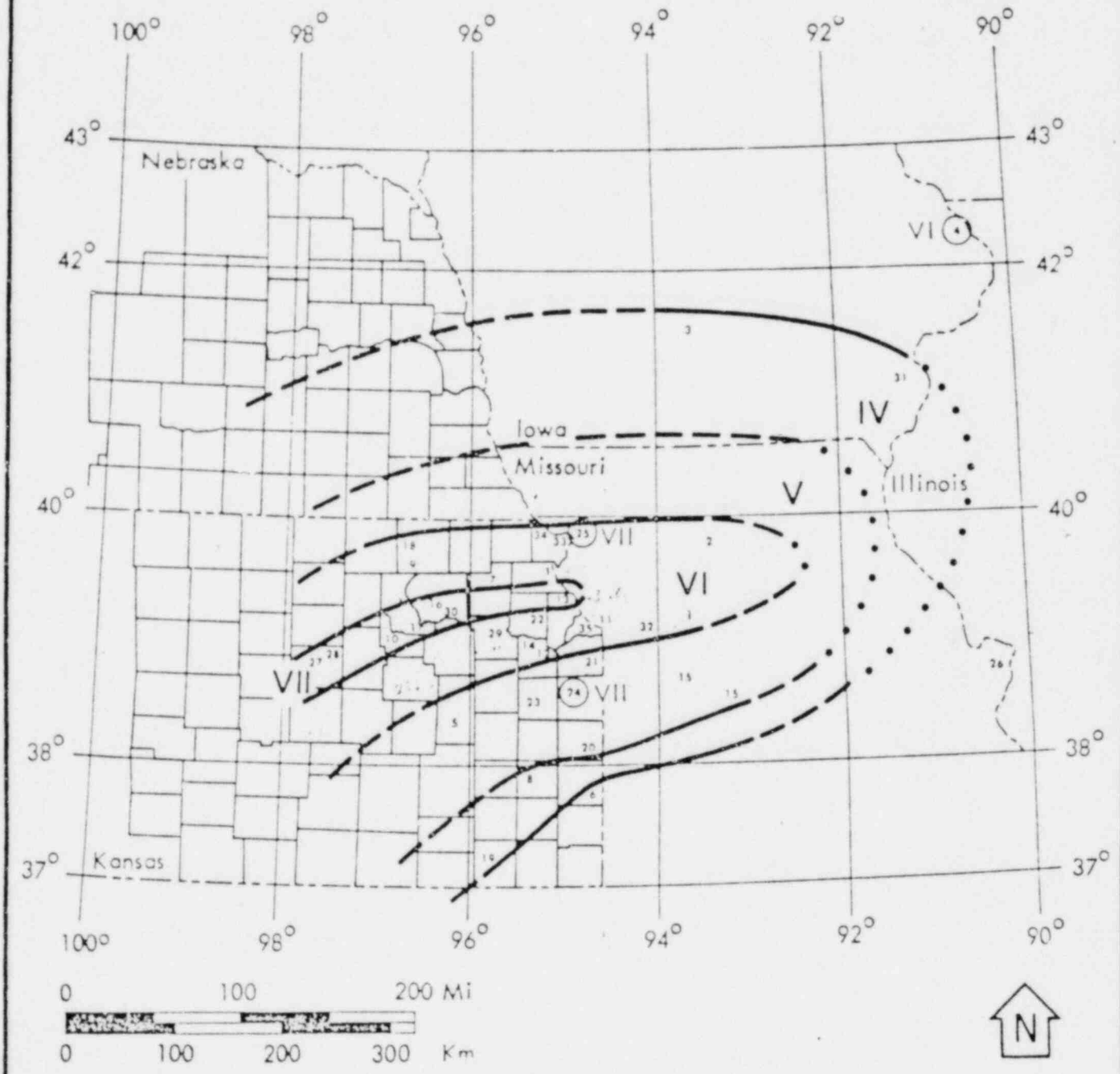
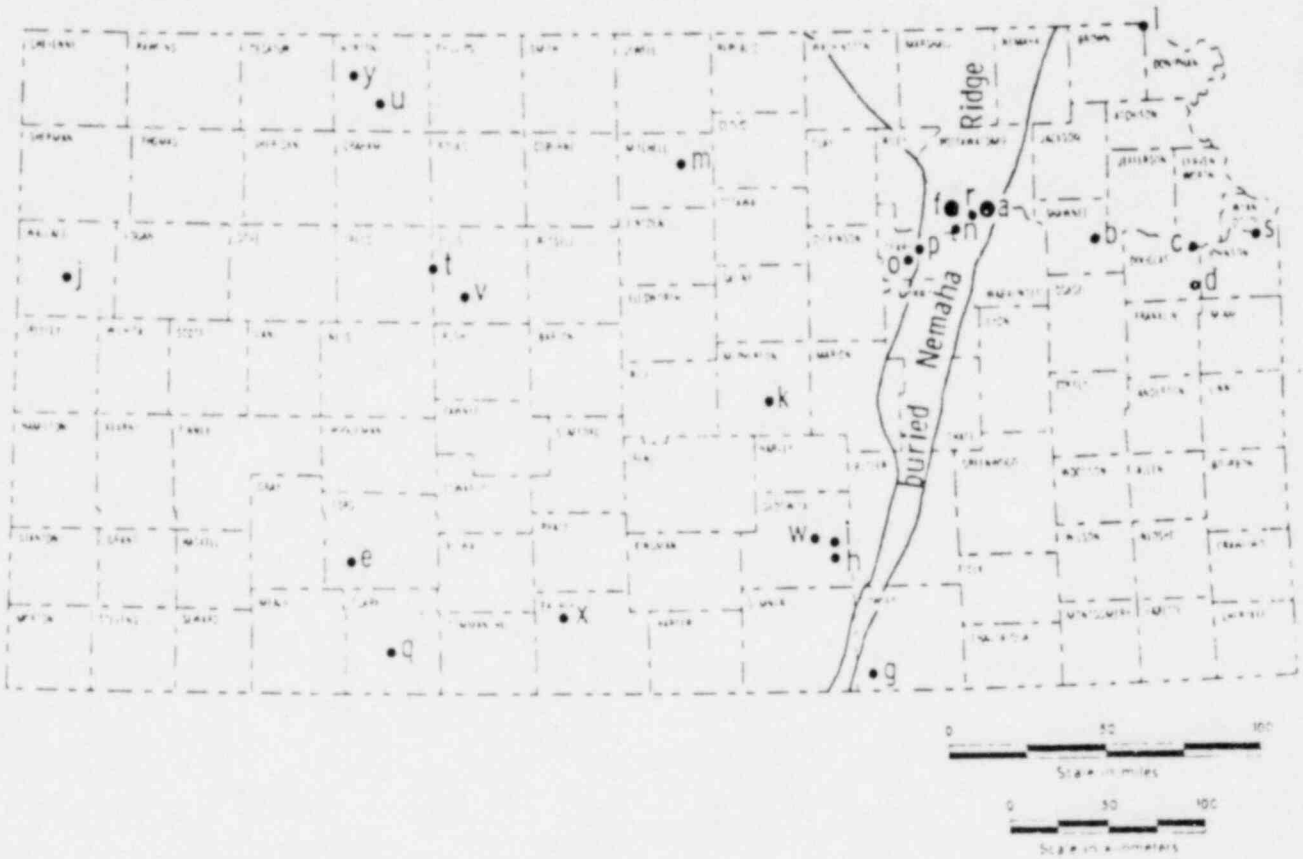


Fig. 3

EARTHQUAKES IN KANSAS



Explanation

a	1867	VIII	f	1906	VII	k	1927	V	p	1929	V	u	1933	V
b	1875	V	g	1907	IV	l	1927	VI	q	1929	V	v	1942	IV
c	1881	III	h	1919	IV	m	1928	IV	r	1929	V	w	1948	IV
d	1903	II	i	1919	IV	n	1929	V	s	1931	VI	x	1956	VI
e	1904	IV	j	1926	?	o	1929	V	t	1932	VI	y	1961	V

FIGURE 2. LOCATIONS AND DATES OF EARTHQUAKES IN KANSAS, 1867-1977 (DUBOIS AND WILSON, 1978).

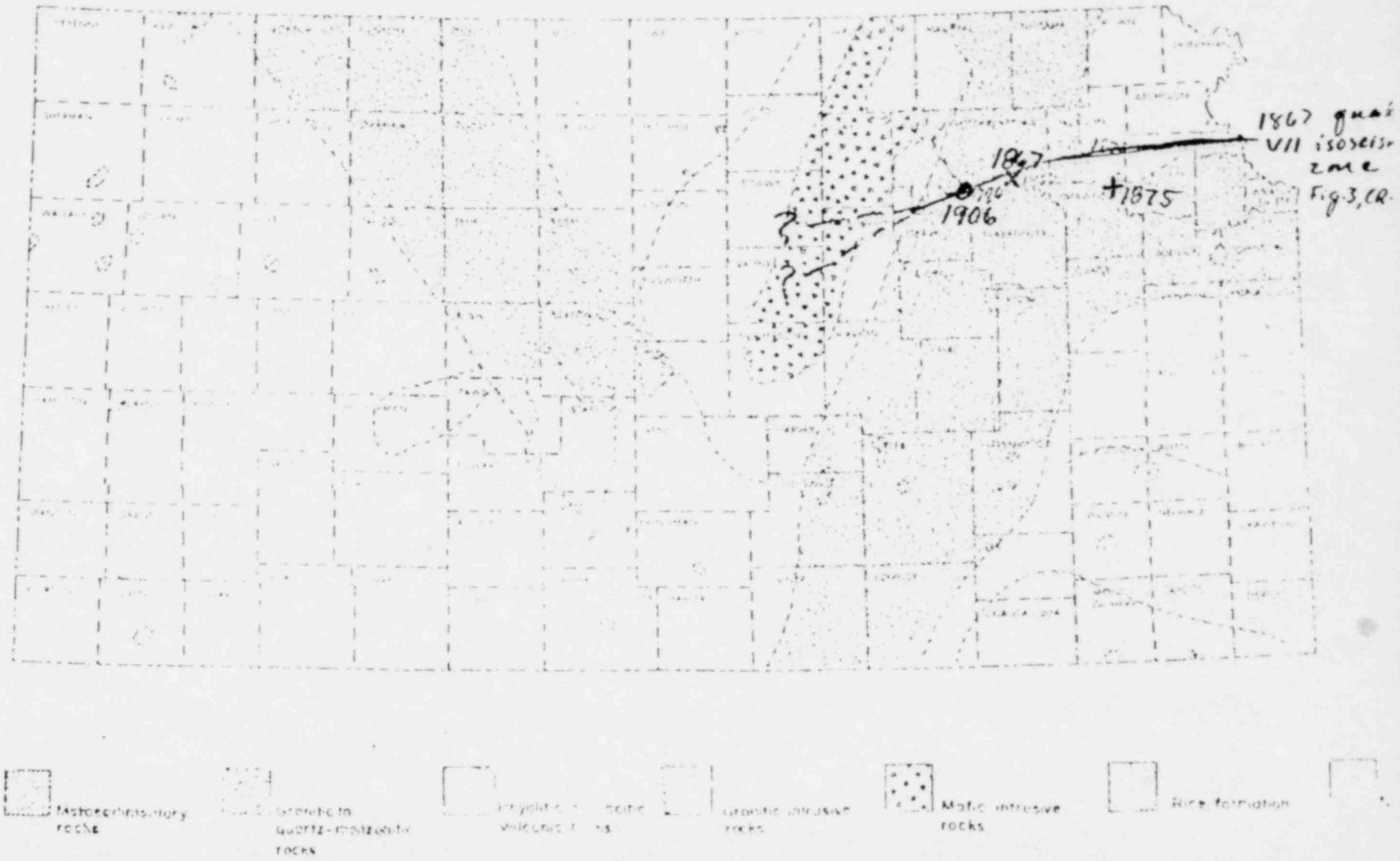


FIGURE 4. GEOLOGIC MAP OF PRECAMBRIAN BASEMENT ROCKS IN KANSAS (AFTER BICKFORD AND OTHERS, IN PRESS).

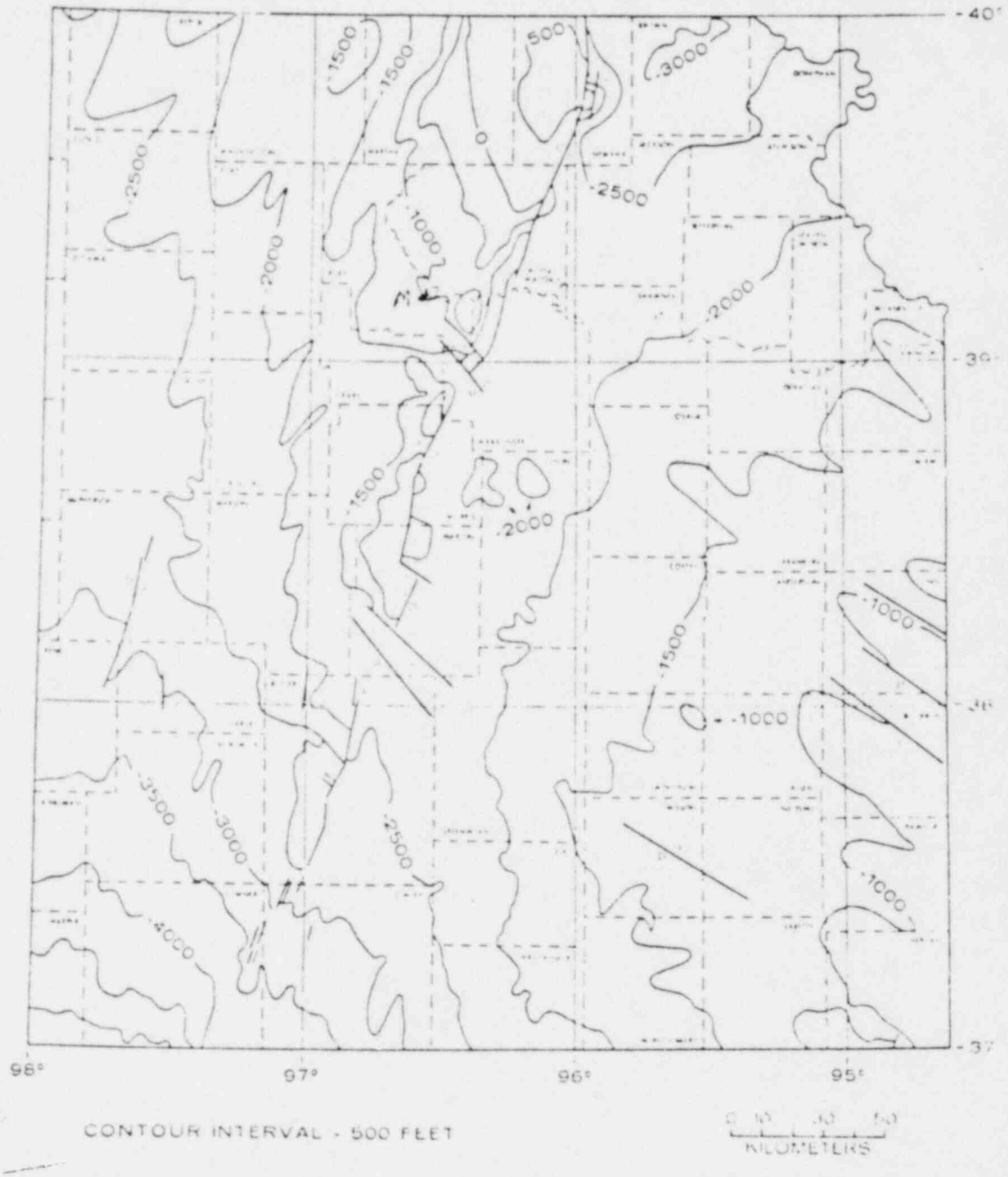


FIGURE 3. GENERALIZED CONTOUR MAP OF THE TOP OF PRECAMBRIAN BASEMENT ROCKS IN KANSAS (AFTER COLE, 1977).

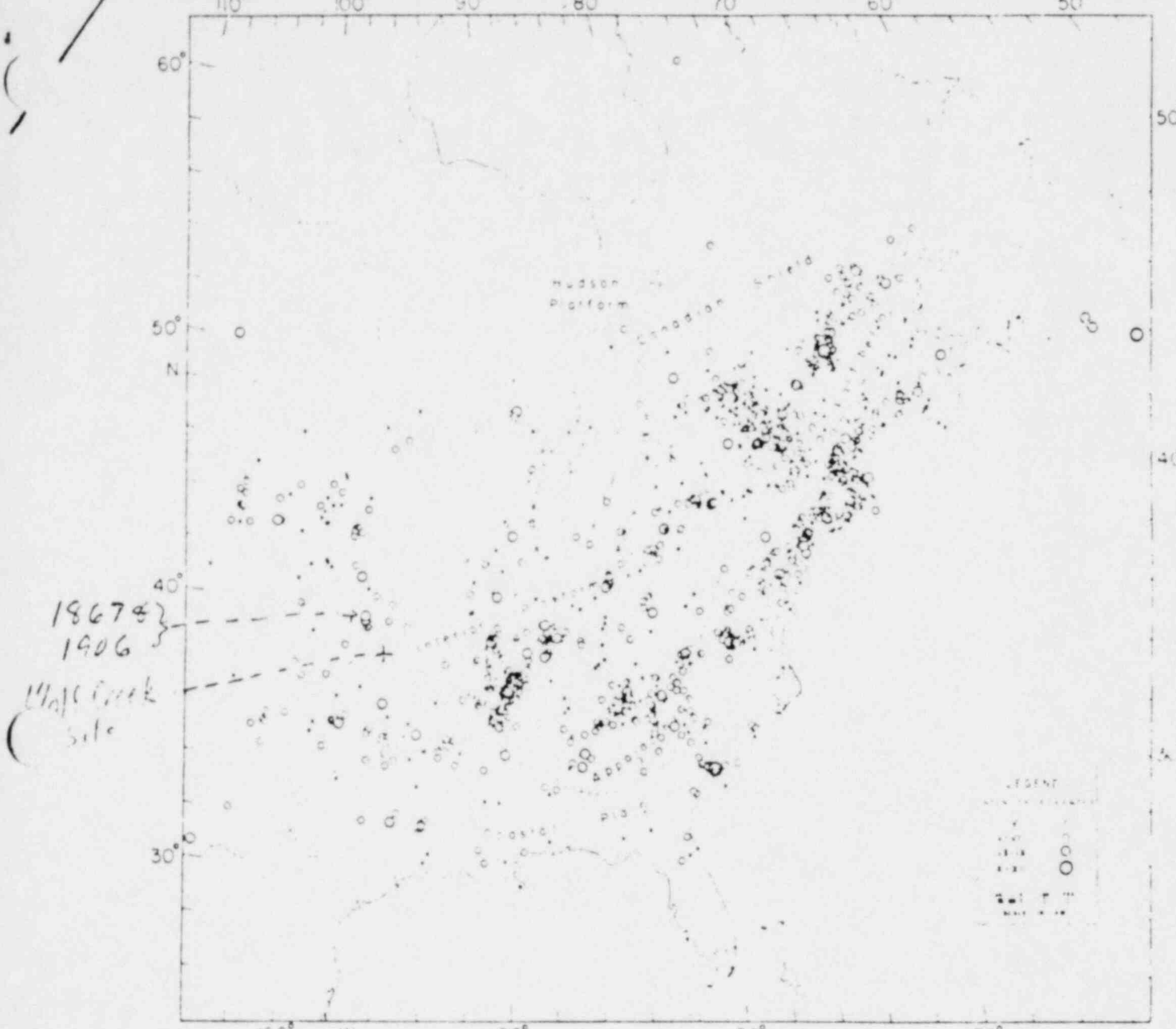


Fig. 14. Distribution of reported earthquakes in eastern North America [illegible] from historic and instrumental data [after Tark and Hover, 1976]. Note activity along the Appalachian trend [illegible] northwest trending zone in New England and southern Quebec and the northwesterly trend in South Carolina.

the existing evidence from instrumental locations argues for a region of low activity in Vermont. Thus new and historic data indicate that the Boston-Ottawa seismic zone is composed of two distinct zones of high activity, one extending from offshore Massachusetts into central New Hampshire and another extending northwest from northern New York State to Kirkland Lake, Ontario. As will be discussed later, however, alkalic rocks postdating the opening of the western Atlantic extend across the gap in seismic activity in Vermont and western New Hampshire.

Younger Igneous Rocks in New England and Southern Quebec

Although major tectonism and magmatism are commonly thought to have ended in most of the eastern United States in the Triassic, igneous rocks with ages postdating the initial separation of North America from Africa are found in the White Mountain magma series of New England, in the Monteregian Hills of southern Quebec, and along the New England seamount chain (Figure 18). The White Mountain magma series extends NNW across New Hampshire and ranges in age from about 200 m.y. (the initial stage of rifting of North America from Africa) to about 100 m.y. [*Foland and Faul*, 1977]. A small percentage of the radiometric ages are between 220 and 235 m.y. The Monteregian Hills, a group of alkalic mafic and ultramafic rocks in southern Quebec, trend WNW from north of New Hampshire to Montreal. Carbonatites and diatremes are found in the western part of the Monteregian province [*Gold*, 1967]. The $^{87}Sr/^{86}Sr$ ratio of 0.704 obtained by *Fairbairn et al.* [1963] for rocks of the Monteregian province