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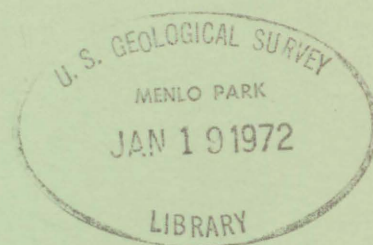
ENVIRONMENTAL GEOCHEMISTRY

Geochemical Survey of Missouri,
Plans and progress for first six-month period
(July - December, 1969)

Branch of Regional Geochemistry
U.S. Geological Survey
Denver, Colorado

1972

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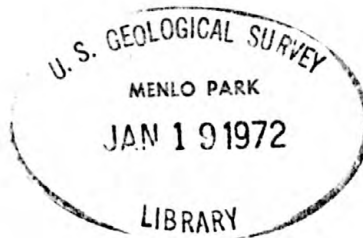
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Preface

This compilation briefly describes the objectives and purpose of a reconnaissance geochemical survey of Missouri, the results of the survey for the first 6 months, and the expenditures in funds and personnel for the present fiscal year and, as anticipated, for the fiscal year beginning on July 1, 1970. It is prepared primarily for the information of the Environmental Health Center of the University of Missouri in the interest of continuing communication at both the administrative and scientific levels.

The study was begun in July, 1969, and will continue for an indefinite period. It is expected, however, that the basic reconnaissance surveys of the bedrock geology, the soils, and the vegetation can be completed by 1973, or earlier, depending on continuation of the availability of funds and personnel. Investigation of geochemical anomalies identified in the reconnaissance survey, and of anomalous areas recognized in epidemiological studies, is also expected, but its extent cannot be estimated at this time. Much depends on the number and character of the geochemical and epidemiological anomalies that are identified and chosen for special investigation.

We regard the environmental geochemistry studies in Missouri as a pilot venture into a field of geology that is certain to increase in interest and activity among geologists and medical scientists, and feel fortunate to work in cooperation with personnel of the University of Missouri, Environmental Health Surveillance Project. The systematic and comprehensive approach being taken in their epidemiological studies of an area that is large enough to be geologically diverse, offers an opportunity for parallel studies in environmental geochemistry that has not been previously available.

A. T. Miesch, Chief
Branch of Regional Geochemistry
U.S. Geological Survey

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OBJECTIVES AND PLANS

The Geochemical Survey of Missouri has been undertaken at the request of, and in cooperation with, the Environmental Health Surveillance Project of the Environmental Health Center of the University of Missouri. The Surveillance Project is headed by Carl J. Marienfeld, M.D., and is staffed by representatives from a broad range of disciplines, including various fields of medicine (pediatrics, surgery, community health, epidemiology, pharmacology), veterinary medicine, entomology, horticulture, agriculture, chemistry (analytical and nuclear), geology, civil engineering, hydrology, ecology, statistics, and computer science.

The Surveillance Project is presently concentrating their efforts on the establishment of a computer-based data system to provide automatic construction of maps showing the occurrences of congenital malformations in people, pigs, and rabbits throughout the State. The basic components of the system are operational and further developments will pertain to methods of data collection and various ways of summarizing and displaying data on maps.

The purpose of the geochemical survey is to describe the chemical character of the environment. Results will be used by the Surveillance Project to search for correlations between environmental geochemistry and congenital malformation occurrences. The survey is regarded as a pilot study that will serve to guide future work of this kind. We hope to learn how a geochemical survey of an area as large as Missouri can be made most efficiently, and how it should be done in order to provide the medical profession with the information they need.

A significant part of the survey, therefore, is focused on development of efficient methods of sampling and sampling design in geochemistry, and on the collection and synthesis of geochemical data in a rigorous, scientifically defensible, manner.

The survey presently consists of three phases, directed at the geochemistry of rocks, soils, and vegetation throughout the State. It is expected that a fourth phase, on the geochemistry of ground water, will be initiated soon. Preliminary sampling programs are underway in all 3 of the existing phases to determine efficient and proper frameworks within which final sampling programs can be conducted. In general, the problem consists of determining at what level in a hierarchical classification the framework should be established--for example, do plant species of the same genera differ in composition so much that they should be sampled separately, or are they properly grouped for compositional studies--or can plants be grouped at some higher level of the hierarchical classification? Similarly, can soils be grouped at the Family, Subgroup, Great Group, or some higher level, or are soil Series

(the lowest hierarchical level) so different compositionally that each must be sampled separately? Answers to these questions will be of general interest in field geochemistry--not only environmental studies.

All samples will be analyzed spectrographically for 54 elements. These analyses will be supplemented by determinations for silicon, aluminum, iron, potassium, phosphorous, calcium, iodine, sodium, magnesium, mineral carbon, organic carbon, fluorine, mercury, selenium, arsenic, cadmium, and zinc. All analyses will be done by the same laboratory methods to insure compatibility of data throughout the program.

It is expected that close liaison will continue with the Surveillance Project so that, concurrent with the Statewide survey, specific investigations of problem areas can be made. It has been mutually agreed that areas found to be geochemically anomalous in any way will be investigated epidemiologically by the Surveillance Project, and that areas identified to have unusual health or disease characteristics will be investigated geochemically. Neither the epidemiological studies nor the geochemical survey are quite far enough along to pursue this approach as yet.

Outlines of the 3 existing phases of the geochemical survey of Missouri follow:

I. Geochemical survey of geologic units

- A. Objectives: To derive an estimate of the chemical characteristics and regional geochemical variability of major rock units in the State for its bearing on the geochemistry of ground water, soils, and vegetation.
- B. Justification: This objective is based on the premise that the geochemical character of an environment is related ultimately to that of the solid crust of the earth, as the underlying crust is the ultimate source of all naturally-occurring inorganic constituents in an area as well as of many industrial contaminants.
- C. Methods: Geologic units will be sampled within 2 or 3 stratigraphic sections pieced together across the State. Special studies will be made of Precambrian rocks and host rocks for mineral deposits in the southern part of the State and of loess deposits north of the Missouri River. A preliminary sampling survey will be made to determine an efficient method of grouping stratigraphic units within rock types and the required volume of sampling within each group.
- D. Present status: Approximately 4 man-months were spent in the Summer of 1969 becoming familiar with major stratigraphic units, and various stratigraphic problems, relying on the cooperative guidance of geologists of the Missouri Division of Geological Survey and Water Resources. The best exposures of the geologic

column are in roadcuts along major highways. Preliminary sampling and laboratory analysis has shown that contamination of the rock exposures by automobile exhaust is insignificant and that if normal precautions are taken to chip away exposed surfaces, virtually uncontaminated rock samples may be taken from highway roadcuts. Samples of soil and grass collected along some highways showed drastically high contents of lead and other elements.

II. Geochemical survey of soils

- A. Objectives: To derive an estimate of the chemical characteristics of soils and their regional variability as related especially to geologic parent and other geologic factors.
- B. Justification: The chemistry of soils is regarded as a factor of possible major importance by epidemiologists because of soil-atmosphere interactions and the relationships between soil chemistry and the trace element content of agricultural produce. The chemistry of soils is also a factor in the degree to which the soils will support bacterial growth and reproduction.
- C. Methods: Results of an initial reconnaissance program will indicate whether soil types can be grouped for sampling at the Series, Subgroup, or Suborder level of the hierarchical scheme of soil classification (Seventh Approximation, U.S. Dept. of Agriculture). This initial sampling will be followed by a final sampling program designed to provide the optimum information on soil composition variability throughout the State, in view of both field and laboratory costs. Special sampling will be done to investigate specific problems and to study the geochemical and biochemical processes involved in the rock-soil-plant system.

In addition, the University of Missouri Extension Division has agreed to submit 10 soil samples from each of the 114 counties in the State. These will be samples that farmers will have submitted to county agents for fertilizer recommendations. The samples from each county will be selected from geographically separated farms. They will be analyzed spectrographically to provide data for soil chemistry maps.

- D. Present status: The initial sampling program (220 samples) has been completed. Exceedingly fine cooperation and guidance in field work was obtained from soil scientists of the U.S. Department of Agriculture.

Preliminary analyses of the samples were made in the field using a mobile spectrographic laboratory. The data are presently being analyzed.

III. Geochemical survey of vegetation

- A. Objectives: To derive an estimate of the chemical characteristics of selected cultivated and native plant species and plant communities, and of the variability in these characteristics with various aspects of their environments. Important among these environmental aspects are soil type, geology, climate, seasons, and associated vegetation.
- B. Justification: The response of vegetation to its chemical and physical environment is of basic interest in this study. Moreover, the chemical characteristics of forage vegetation and agricultural produce will be of prime interest in the interpretation of epidemiological patterns. In addition, the presence of elements in vegetation serves to indicate the presence and availability of the elements in soils and their parent materials.
- C. Methods: The initial work is exploratory to become familiar with the plant species present, their distribution over the State, and their chemical characteristics. An effort will be made to determine the level (species, genera, etc.) at which plants can be grouped for chemical characterization. Preliminary sampling programs will be conducted to estimate local and regional variability in the chemical characteristics of selected representative plant groups, and to devise an efficient Statewide sampling plan.
- D. Present status: One summer of exploratory work has been completed which included sampling of mosses and selected tree species along highways to assess the degree of contamination from automobile exhaust and the response of various species to this source of pollution. A Statewide sampling program was completed to derive estimates of the local and regional variability of elements in certain species of trees and in the soils in which they grow. The samples are presently being prepared for laboratory analysis. Results will be used to design an appropriate and efficient sampling plan for execution next summer.

PROGRESS REPORT (July to December, 1969)

The principal effort during the first 6 months of the project has been in gaining a familiarity with the rocks, soils, and vegetation of the State. Some preliminary sampling programs designed to estimate the chemical variability in soils and selected vegetation were executed and examinations were made of contamination in rocks, soils, and vegetation along highways. All of the samples collected have been submitted to our laboratories for analysis, but only partial results have been received to date. The observations noted below are based principally on the results of about 500 preliminary analyses made at the site of the Environmental Health Center in Columbia, in field laboratories that included a truck-mounted spectrograph.

Geochemical survey of geologic units
by J. J. Connor, J. D. Sims, and R. J. Ebens

Geologic investigations during the first six months of the project involved studies in reconnaissance stratigraphy and roadside contamination of rocks.

Reconnaissance stratigraphy studies.--The reconnaissance stratigraphic study of the geologic rock column was based on both field and library research. Geologists of the Missouri Division of Geological Survey and Water Resources assisted by lending the benefit of their knowledge of the geology of the State and guided us to significant outcrop areas. The study was undertaken to determine the variety of rock types present in Missouri, their importance in terms of geographic extent and their availability for sampling in outcrop. This study indicates that the rocks may be viewed as consisting of four major groups, each more or less distinct in its geographic distribution. These groups are shown on the accompanying map (fig. 1). The explanation of the major rock groups follows.

- Group 1. The Precambrian granites and rhyolites of the St. Francois Mountains. These rocks are rich in aluminosilicate minerals, but their limited extent and resistance to weathering restrict their influence on the State's geochemical environment.
- Group 2. The Lower and Middle Paleozoic limestones and dolomites of southern and northeastern Missouri. These rocks are rich in calcium carbonate and throughout most of southern Missouri (map unit 2.b.) are rich in magnesium as well. They readily weather to a red clay residuum (see group 4).
- Group 3. The Upper Paleozoic shales and limestones of western and northwestern Missouri. These rocks are rich in aluminosilicate minerals (shale) and calcium (limestone). The presence of local coal beds and the abundant shale content probably makes these rocks, on the average, the richest of the four groups in trace elements.
- Group 4. Tertiary and Quaternary argillaceous rocks throughout the State. These rocks are poorly consolidated and include extensive deposits of glacial material throughout the northern half of the State (map unit 4.b.), large areas of red clay residuum in southern Missouri (map unit 4.c.), and thick alluvial deposits along the major river systems. Although these rocks are in part weathering products, they nevertheless serve as the "parent" to most of the soil in Missouri. Large parts of the area of rock groups 2 and 3 are covered by these rocks.

Sampling designs for each rock group are still under study. In terms of areal extent, sampling two rock types in each of group 2 (limestone and dolomite), group 3 (shale and limestone), and group 4 (glacial material and red clay residuum) should result in chemical information on perhaps 90 percent of the rocks exposed at the surface in Missouri.

Explanation

Figure 1.--Major rock groups of Missouri.

Major rock group	Geologic age	Rock type	Dominant metals
4.a.	Quaternary	River alluvium	Si, Al
b.	Quaternary	Glacial deposits	Si, Al
c.	Cenozoic (?)	Red clay residuum	Si, Al
3.	Upper Paleozoic	Shale, limestone	Si, Al, Ca
2.a.	Middle Paleozoic	Limestone	Ca
b.	Lower Paleozoic	Dolomite	Ca, Mg
1.	Precambrian	Granite	Si, Al

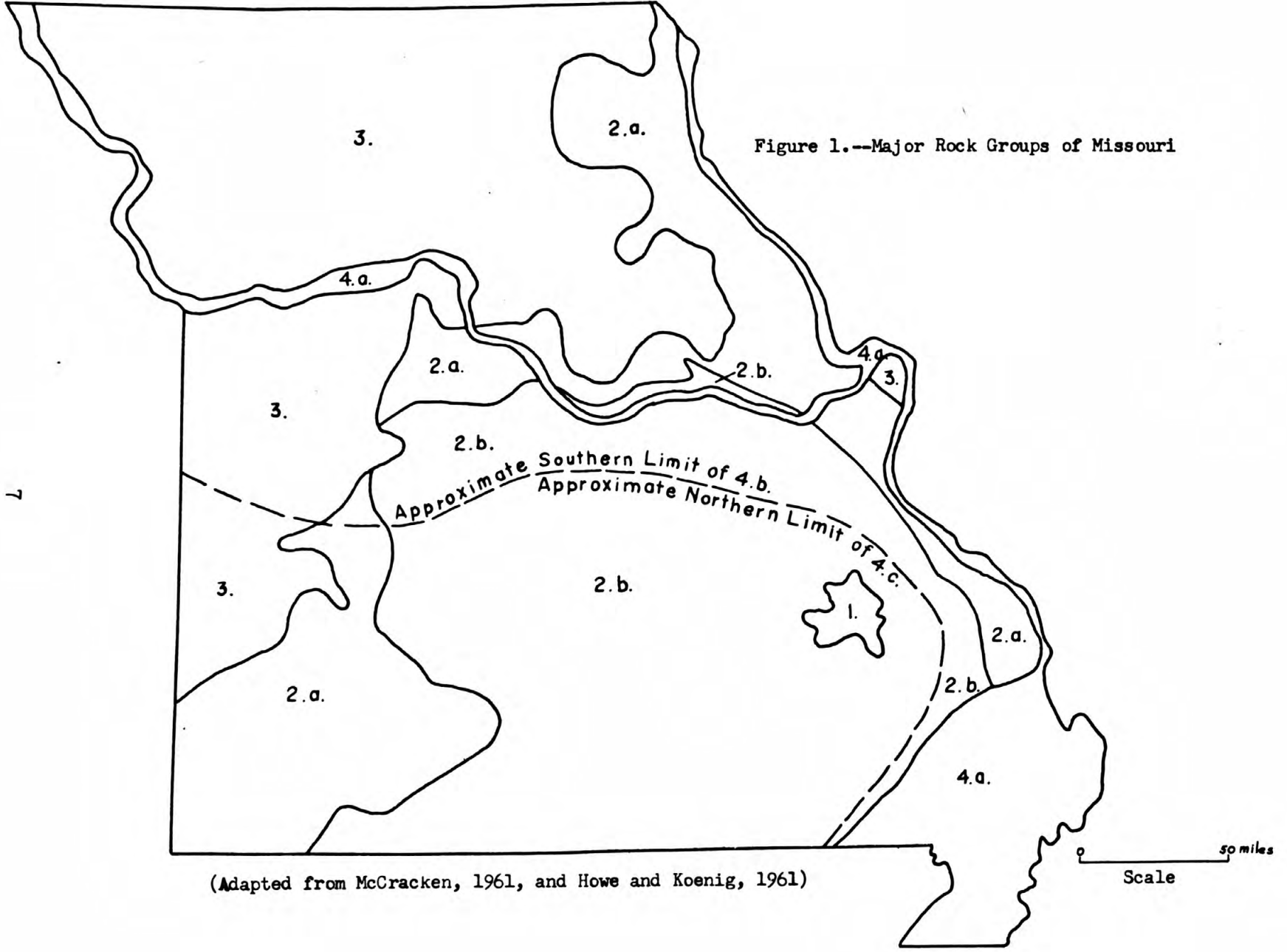


Figure 1.--Major Rock Groups of Missouri

(Adapted from McCracken, 1961, and Howe and Koenig, 1961)

Scale 50 miles

Roadside contamination of rocks.--Reports of lead contamination of roadside plants and soils by vehicular traffic (see Cannon and Bowles, 1962; Rühling and Tyler, 1968) raise the question of whether similar contamination of roadside rock exposures occurs.

Possible metal contamination of rocks in roadside exposures was investigated in two areas; on U.S. Route 50 in southeast Kansas City, Missouri, and on U.S. Route 66 in Pacific, Missouri (near St. Louis). At each locality 15 samples each of rock, soil, and grass were collected along the highway and 15 companion samples were collected in nearby quarries that were not along the highway. The following table compares mean lead (Pb) contents.

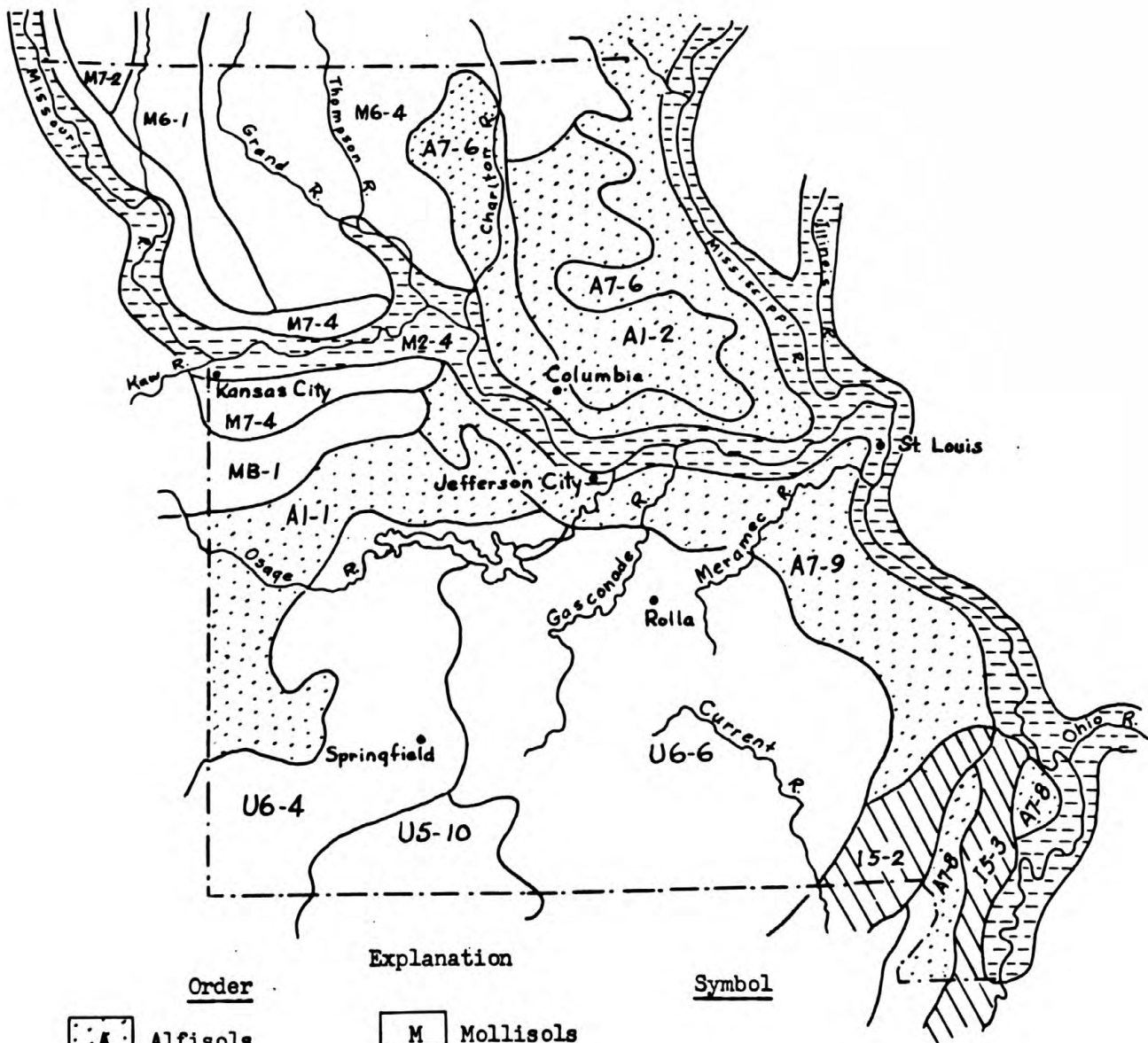
Material	Location	Geometric mean, Pb (ppm)	
		On road	Off road
Limestone -----	Kansas City, Missouri	< 10	< 10
Shale -----	do.	10	24
Soil -----	do.	10	14
Grass (ash) -----	do.	170	54
Sandstone -----	Pacific, Missouri	< 10	< 10
Soil -----	do.	10	< 10
Grass (ash) -----	do.	170	39

If judged on the assumption that lead content is the key index to "roadside effects," the most marked effects were found in grasses. Effects in soil are much less obvious, if indeed they exist at all, and no effects were observed in limestone, shale, or sandstone. This result is of immediate and important consequence in that much of the bedrock sampling of the four rock groups, especially the rocks in map unit 3, must be undertaken in highway exposures.

Geochemical survey of soils
by R. R. Tidball

Soil classification.--There appears to be a great diversity in the soils of Missouri (fig. 2), especially when viewed in terms of the taxonomic criteria of the prevailing soil classification system (Soil Survey Staff, 1960, 1967, 1968). About 275 soil Series have been designated to date, with only part of the State having been mapped. It would be expedient to organize this complex array of soils according to the existing classification categories, but this is feasible only if geochemical criteria also result in the same taxonomic grouping as that which applies to existing diagnostic properties.

The soil classification system contains six taxonomic levels (Order, Suborder, Great Group, Subgroup, Family, and Series, in descending order). A sampling experiment based on a nested analysis of variance design









<u>Order</u>	<u>Explanation</u>	<u>Symbol</u>
		<p style="margin-left: 20px;">Order</p> <p style="margin-left: 40px;">Suborder</p> <p style="margin-left: 60px;">A 7 - 6</p> <p style="margin-left: 80px;">Great Group</p>
		
		
<p>Alfisols</p>	<p>M Mollisols dry</p>	
<p>Inceptisols</p>	<p>U Ultisols</p>	
<p>Mollisols wet</p>		

Figure 2.--Principal kinds of soils in Missouri: Orders, Suborders, and Great Groups. (Adapted from Soil Conservation Service, 1969)

(Bennett and Franklin, 1954, p. 358-368) was used to estimate the kind and magnitude of chemical variability associated with three of these taxonomic levels (Suborder, Subgroup, and Series); other levels could not be tested, owing to inadequate representation in Missouri. Information derived from the sampling experiment is necessary to plan an efficient sampling program. The cooperation of Soil Conservation Service personnel, particularly Mr. H. E. Grogger, State Soil Scientist, has been crucial to the success of this initial project, and is gratefully acknowledged.

Geochemical variation.--Results of spectrographic analysis for 18 minor elements in 188 specimens of soil taken from the plow zone (0-6 inches depth), from widely separate areas throughout the State (fig. 3), indicate that about half of the elements do not vary significantly among Suborders. None of the elements vary among Subgroups. Two-thirds of the elements vary significantly at the Series level. Moreover, significant variation is found between separate geographic occurrences of the same Series.

The more prevalent concentration of significant variation at lower taxonomic levels rather than higher levels suggests that taxonomic grouping based on geochemical criteria fails to correspond sufficiently to the grouping based on conventional criteria. Consequently, a sampling plan based on the soil classification system that might otherwise characterize more all-inclusive taxonomic categories at the higher levels which have more regional importance (fig. 2) must, instead, characterize lower levels which have only local importance. The large number of localities that might be involved requires an extensive and therefore costly sampling plan to provide reliable estimates of concentration for numerous elements. An alternate unifying principle is, therefore, being sought by means of which a more efficient sampling plan of regional scope can be devised.

Geochemical survey of vegetation
by Hansford T. Shacklette, James A. Erdman, and John R. Keith

Studies of Missouri vegetation during the summer and fall of 1969 consisted of investigations that were necessary to establish a comprehensive sampling plan for the principal study that will begin in 1970. Field work was completed for two objectives--the evaluation of road contamination effects on element content of vegetation, and the sampling of the six vegetation types of the State to determine variation in element abundance within and between types. The analytical work necessary to complete the evaluation of field collections has not been entirely completed.

Roadside contamination of vegetation.--Cedar trees (*Juniperus virginiana* L.) were selected for sampling in investigating contamination of vegetation that grows along roads. These trees are common on roadsides throughout Missouri and are evergreen; they have, therefore, the potential for leaf absorption of road contaminants throughout the year. Cedars have dense and finely-divided foliage, and may be effective "filters" of the air that passes through their branches.

Mosses also were sampled along roads; they, too, are evergreen and have finely-divided vegetative parts. They are known to concentrate

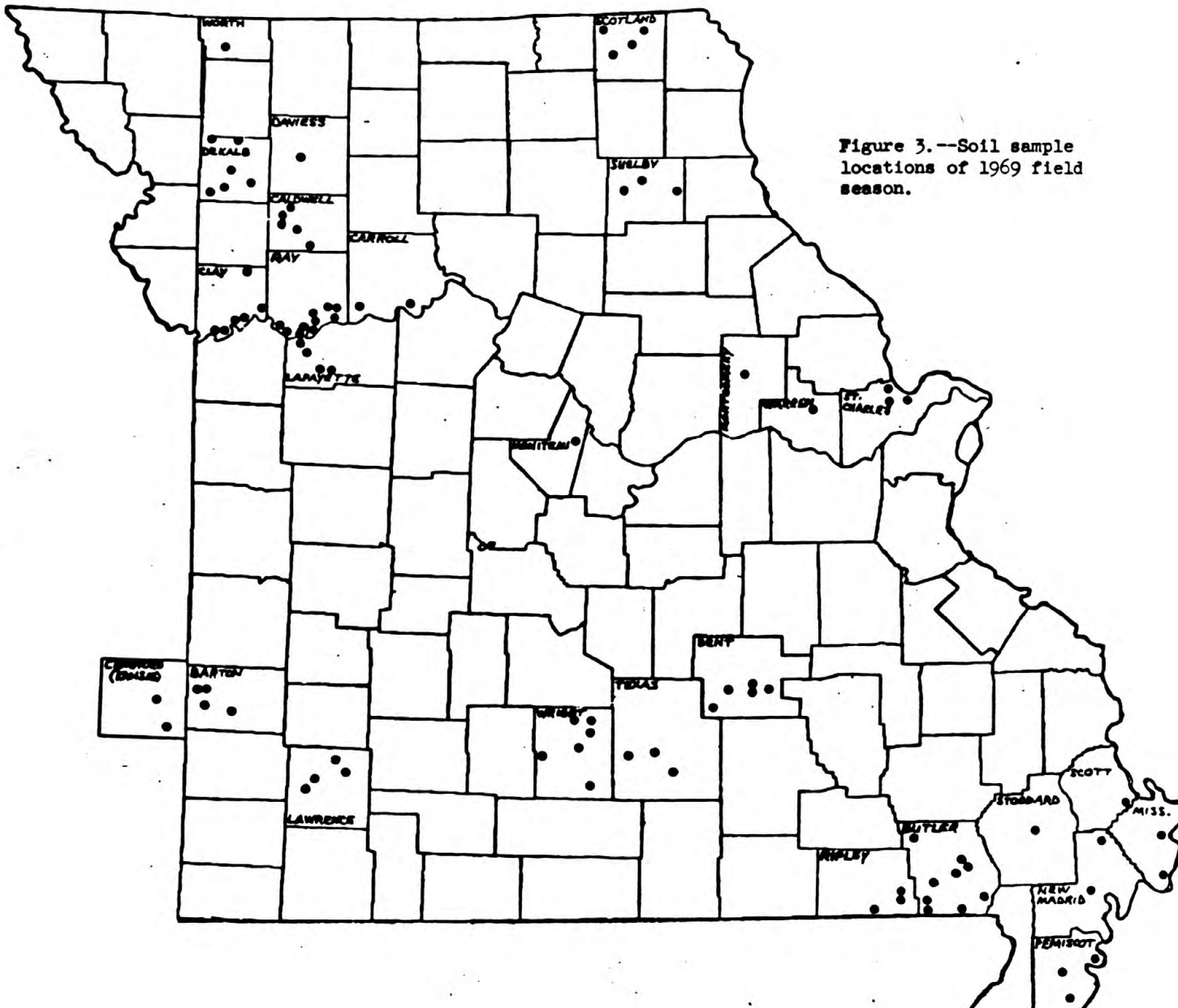


Figure 3.--Soil sample locations of 1969 field season.

heavy metals in their tissues (Shacklette, 1965, Rühling and Tyler, 1968), and recently have been used in Sweden to detect fallout of heavy metals from industrial air pollution (Rühling, 1969). Roadside grasses were sampled for effects of road contamination by J. J. Connor, J. D. Sims, and R. J. Ebens at sites of rock contamination studies, and the results are presented elsewhere in this report.

Samples of cedar and mosses were collected in corresponding pairs at sample sites--one from as near the road pavement as possible, the other at sites 300-600 feet from the pavement. The exact distances of the sample sites from the road were determined by the locations of cedars and mosses that were suitable for sampling. The distribution of the sampling localities in Missouri is shown in figure 4. The cedars selected for sampling commonly were small trees 6-12 feet in height, and the mosses were all densely-growing kinds that form mats on the ground surface. Soil also was sampled at each plant sample site, but analyses of soil and moss samples are incomplete at present.

The concentration of lead in vegetation was selected as the principal measure of highway contamination because reports in the literature (Cannon and Bowles, 1962; Chow and Johnstone, 1965) indicate that lead is a common effluent from vehicle engines that contaminates roadside plants. The concentrations of 29 other elements also were measured in the cedar and soils samples; studies of data from these measurements indicate that zinc and chromium may also be considered as roadside contaminants at certain places in Missouri. Roadside contaminants and air pollutants, as measured by soil and plant analyses, were reported in Sweden by Rühling and Tyler (1968, 1969) to be lead, zinc, copper, and chromium, and in Scotland by Purvis and Mackenzie (1969) to be copper, boron, lead, and zinc.

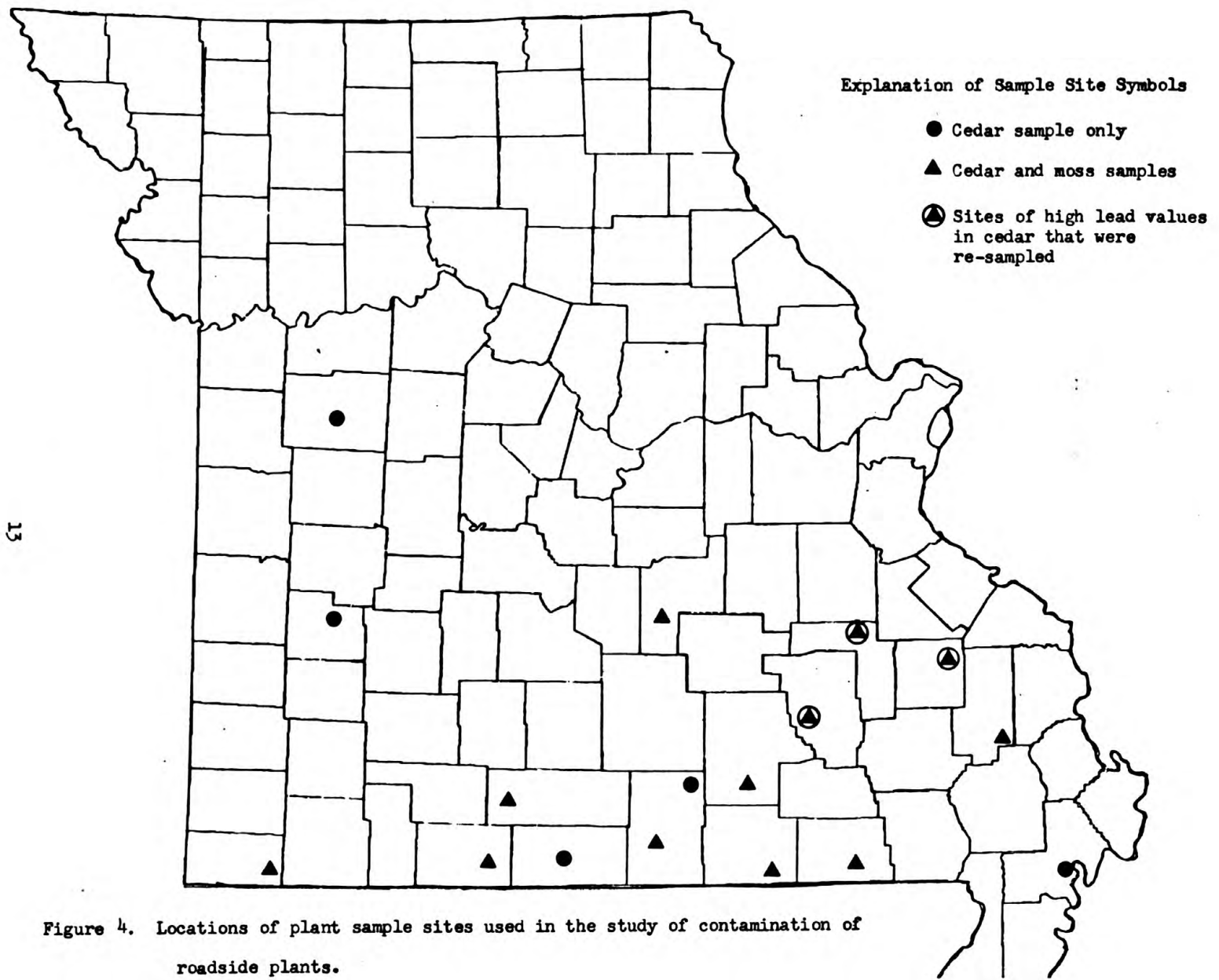
Of the original 17 cedar sites that were sampled, only 15 were used in making an analysis of variance, inasmuch as one site lacked an off-road companion sample and another site indicated a unique contamination load that may have come from ore that was transported by the site. Only three elements--lead, chromium, and boron--differed significantly in amounts between on-road and off-road cedar samples, as is shown in the following table.

Element	Geometric mean (ppm)	
	On road	Off road
Lead -----	210	100**
Chromium -----	75	51*
Boron -----	220	260*

** Difference significant at 0.01 probability level.

* Difference significant at 0.05 probability level.

It should be noted that boron values were higher in off-road than in roadside samples; based on these data, therefore, boron cannot be considered a road contaminant in Missouri.



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Figure 4. Locations of plant sample sites used in the study of contamination of roadside plants.

No obvious effects attributable to road-related contamination could be detected in the soil samples that were from the cedar sample sites.

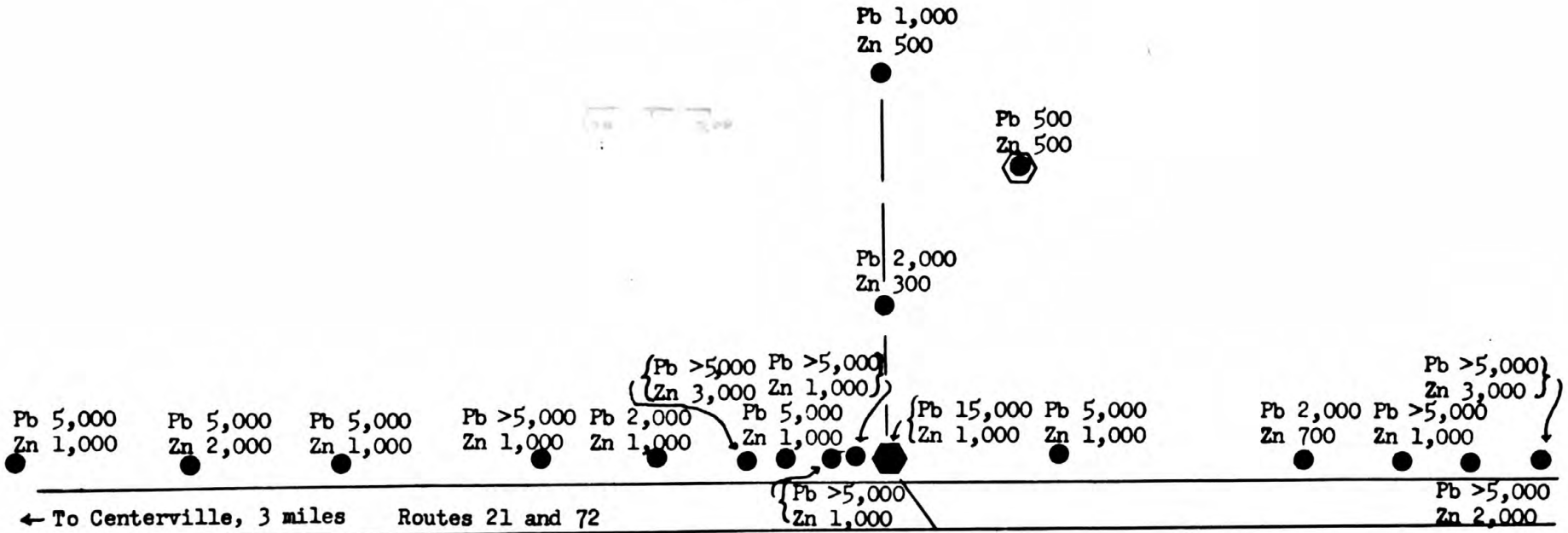
The July field studies revealed that cedar trees at three sample sites (fig. 4) had very high lead contents. These sites were investigated by additional sampling in October. The individual trees that were sampled in July were located and resampled; additional samples were collected of other cedar trees at each site along traverses both parallel and perpendicular to the road. This resampling program is presented in figures 5-7, and a discussion of each site follows.

Centerville site. Stems and leaves of the original sample tree on the roadside were analyzed in the mobile spectrographic laboratory and were found to contain 15,000-20,000 ppm (1.5-2 percent) lead in the ash, whereas the tree located about 300 feet from the road contained only 500 ppm lead. The locations of the additional trees that were sampled in October and the lead and zinc content of the tree samples are given in figure 5.

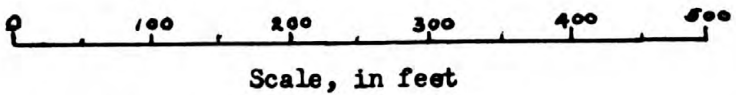
The very large amounts of lead and zinc present in the roadside trees, contrasted with the small amounts in trees away from the road, strongly suggest that the high values resulted from road contamination. The upper limit of analysis for lead by the method used for the resampling program was 5,000 ppm; the full extent of the contamination, therefore, is not known for some samples. These high lead values suggest, moreover, that lead contamination from sources additional to vehicular exhaust emissions must have occurred. Geologic investigations offer no evidence that the bedrock at the site contains anomalous amounts of the two metals. A possible source of this roadside contamination is the lead ore (?) that is being transported by trucks on this road. The ore containers are not covered; dust from this ore may be the cause of the highly anomalous lead and zinc contents of cedar along this road.

Bellevue site. This site is in a cedar glade underlain by a shallow soil covered dolomite that cropped out at many places (fig. 6). The cedar tree that was originally sampled contained 1,000 ppm lead and 500 ppm zinc in its ash. Resampling at this site indicated lead contamination along the road that could have originated from vehicular emissions. Trees at off-road sites contained small amounts of lead. Zinc is not identified as a road contaminant at this site.




Fredericktown site. This site is bounded by an open pasture to the north and an oak-hickory woods to the south (fig. 7). Resampling along the road from the original high-lead cedar indicated that lead contamination had occurred. The lead in cedars at sites off the road was in the background range. Zinc values generally are somewhat elevated in trees along the road. Analyses at this site suggest that vehicular emissions alone may be responsible for the contamination of roadside cedar trees.



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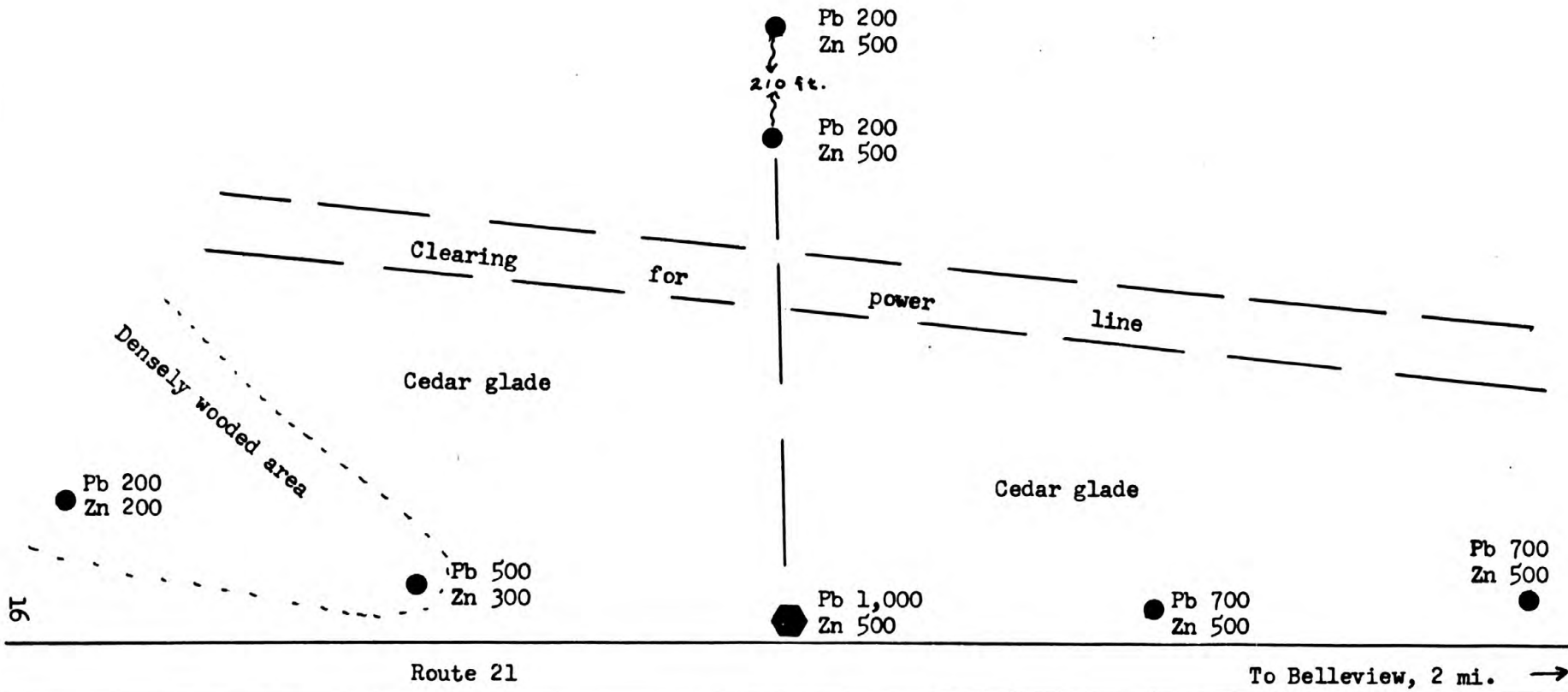
Explanation of Sample Site Symbols

-  Original roadside site
-  Original off-road site
-  Re-sampling sites

Pb 1,500
Zn 300


Pb 300
Zn 300


Figure 5. SITE NEAR CENTERVILLE, REYNOLDS COUNTY, MISSOURI

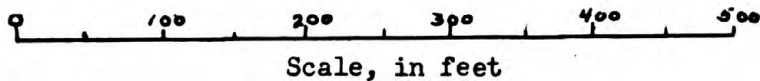


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Explanation of sample site symbols

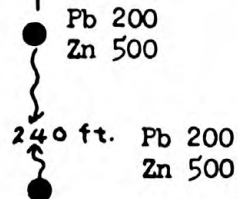
 Original roadside site

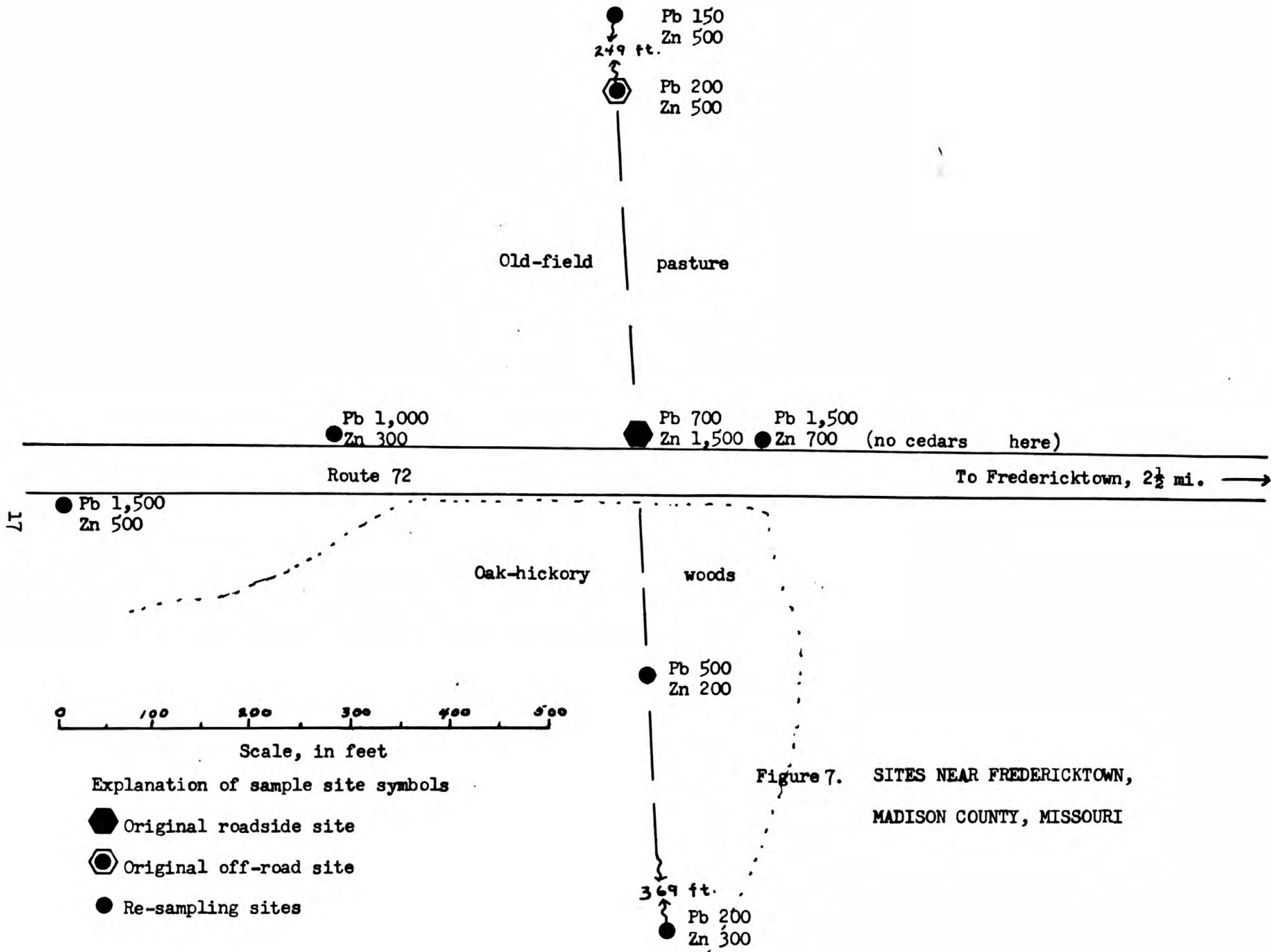
 Re-sampling sites



Cedar glade

Figure 6. SITE NEAR BELLEVUE, IRON COUNTY, MISSOURI





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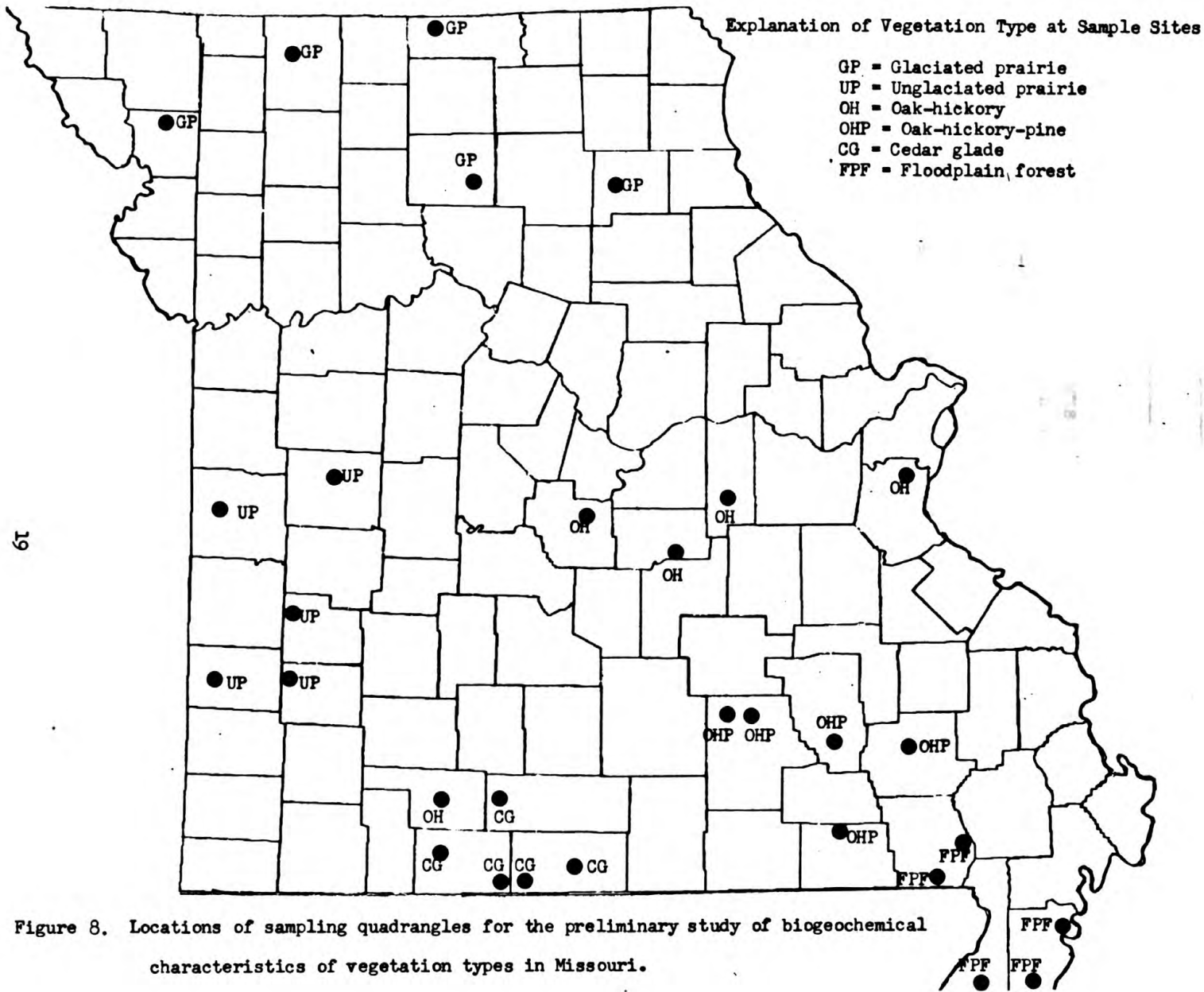
Figure 7. SITES NEAR FREDERICKTOWN, MADISON COUNTY, MISSOURI

Summary of roadside contamination.

1. The lead content of cedar trees appears to be responsive to factors of contamination that are associated with nearness to roads.
2. The difference in lead content of roadside and off-road cedars is highly significant, and the difference in chromium is significant.
3. No other elements were present in significantly higher amounts in roadside than in off-road samples of cedar. At a few sites, however, zinc appeared to be a roadside contaminant.
4. Differences in amounts of elements in soils from roadside and off-road sites were not significant.
5. One site of highly anomalous amounts of lead and zinc in cedars apparently has been contaminated by means other than vehicular emissions; dust from open containers of ore that has been transported on this road may be the source of the two metals in these roadside cedars.
6. These findings indicate that vegetation near roads cannot be used in studies of the geochemical properties of natural plant communities.

Geochemical characteristics of vegetation types.--The potential natural vegetation types of Missouri were included in the map by Kuchler (1964), and these types were used in the present study as a basis for classifying the vegetation for biogeochemical investigations. We modified Kuchler's classification somewhat because his "Cross timbers" type was no longer identifiable as mapped in the very small area of southwestern Missouri. Also, we divided his "Mosaic of bluestem prairie and oak-hickory forest" into "Glaciated prairie" and "Unglaciated prairie." Kuchler's use of the term "potential natural vegetation" allowed him to ignore cultivated land in his classification scheme because he considered only the former natural vegetation of areas, or vegetation that presumably would return if cultivation ceased. The present study, however, must deal with both natural and cultivated vegetation that now exists in the State.

The areal extents of the six vegetation types that we recognize were outlined on a quadrangle index map of Missouri; five quadrangles from those included in the area of each of the six vegetation types were randomly selected for sampling (fig. 8). Each of the 30 randomly-selected quadrangles was subdivided into 100 parts, and two of these parts were randomly selected as the actual sample sites for the quadrangle. Following this method of site selection, soils and plants were sampled at 60 sites. The plants sampled were trees and shrubs, and included white oak, post oak, overcup oak, cedar, and two species of sumac. Analyses of these samples, when completed, will be used in determining the sampling program to be initiated in 1970.



PROJECT BUDGET, FISCAL YEARS 1970 AND 1971

Title	1970		1971	
	Percent of time on Missouri project	Salary expenses	Percent of time on Missouri project	Salary expenses
Supervisory Geologist ---	25	\$ 5,700	25	\$ 6,000
Soil Scientist -----	100	12,500	100	13,000
Botanist -----	75	14,100	75	14,500
Botanist -----	100	10,900	100	12,000
Botanist -----	100	9,300	100	10,000
Geologist -----	25	4,100	50	8,500
Geologist -----	10	1,400	100	14,500
Geologist -----	25	2,800	100	14,000
Herbarium Assistant -----	20	<u>1,200</u>	20	<u>1,300</u>
Total salaries -----		\$ 62,000		\$ 93,800
Travel and equipment -----		12,000		12,000
Estimated laboratory expenses ---		50,000		100,000
Computer time and programming ---		500		5,000
		<u>\$ 62,500</u>		<u>\$117,000</u>
Subtotal		124,500		210,800
Administrative support (30%) ----		<u>53,400</u>		<u>90,300</u>
Total -----		<u>\$177,900</u>		<u>\$301,100</u>

PERSONNEL
(exclusive of support personnel)

Name and title: Alfred T. Miesch, Chief, Branch of Regional Geochemistry,
U.S. Geological Survey

Date and place of birth: May 10, 1927 - Hammond, Indiana

Education:

St. Joseph's College (Indiana)	-	Geology	BS	1950
Indiana University	-	Geology	MA	1954
Northwestern University	-	Geology	PhD	1961

Honors and awards:

Shell Oil Company Fellowship, Northwestern University, 1958-1959

Research interests:

Environmental geology and geochemistry
Sampling designs in geologic problems
Statistical methods in geochemistry
Geochemical processes at low temperatures and pressures

Experience:

Geologic technician, New Mex. Bureau of Mines and Mineral Resources,
1951-1952

Geologist, U.S. Geological Survey, 1953 - present

Bibliography: See attached list.

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- Connor, J. J., and Miesch, A. T., 1964, Analysis of geochemical prospecting data from the Rocky Range, Beaver County, Utah: U.S. Geol. Survey Prof. Paper 475-D, p. 79-83.
- _____, 1964, Application of trend analysis to geochemical prospecting data from Beaver County, Utah: Trans. of symposium on "Computers in the mineral industries"; Stanford Univ., June, 1963, p. 110-125.
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- Wayman, C. H., and Miesch, A. T., 1965, Accuracy and precision of laboratory and field methods for the determination of detergents in water: Water Res. Research, v. 1, no. 4, p. 471-476.
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- Miesch, A. T., 1967, Theory of error in geochemical data: U.S. Geol. Survey Prof. Paper 574-A, 17 p.
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- Shacklette, H. T., Sauer, H. I., and Miesch, A. T., 1970, Geochemical environments and cardiovascular mortality rates in Georgia: U.S. Geol. Survey Prof. Paper 574-C.

Name and title: Jon J. Connor, Geologist, Branch of Regional
Geochemistry, U.S. Geological Survey

Date and place of birth: December 12, 1932 - Columbus, Ohio

Education:

Ohio State University - Geology - BS 1955
University of Colorado - Geology & mineralogy - PhD 1963

Honors and awards: National Science Foundation summer fellowship,
1960 and 1961

Research interest:

Geochemistry of sedimentary rocks
Statistical methods in field geochemistry
Mineralogy and petrology

Experience:

Geologist, Buckeye Mineral Corporation, 1955 (summer)
Geologist, U.S. Geological Survey, 1955-1958
Geologist, American Metals Climax Co., 1959 (summer)
Geologist, U.S. Geological Survey, 1962 - present

Bibliography: See attached list.

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- Connor, J. J., 1969, A geochemical discriminant for sandstones of Mississippian and Pennsylvanian age in Kentucky: Colorado School Mines Quart., v. 64, no. 3, p. 17-34.



Name and title: John D. Sims, Geologist, Branch of Central
Environmental Geology, U.S. Geological Survey

Date and place of birth: December 7, 1939 - Decatur, Illinois

Education:

University of Illinois - Geol. Chem. Math. - BS - 1963
University of Cincinnati - Strat. Sed. Petro. - MS - 1964
Northwestern University - Sed. Petro. Strat. - PhD - 1967

Honors and awards:

NASA Traineeship - University of Cincinnati - 1964
NATO Extramural Fellowship - University of Cincinnati, 1964
Fenneman Fellowship - University of Cincinnati, 1964
NSF Summer Fellowship - University of Cincinnati, 1964
Research Fellowship - Northwestern University, 1966

Research interests:

Sedimentary petrology and geochemistry
Stratigraphy

Experience:

Geologist, Illinois Geological Survey, 1960 - 1963

Geologist, U.S. Geological Survey, 1967 - present

Bibliography: See attached list.

Sims, J. D., 1968, Stratigraphy and Paleocurrents of the Livingston Group, Northern Crazy Mountains, Montana: Geol. Soc. America, Rocky Mtn. Sec., 21st Ann. Mtg., p. 74, and Special Paper 121, p. 636.

_____, 1968, Thermodynamic Model for Zeolitic Diagenesis in the Livingston Group, Northern Crazy Mountains, Montana: Geol. Soc. America, Rocky Mtn. Sec., 21st Ann. Mtg., p. 74-75, and Special Paper 121, p. 636-637.

Name and title: Richard J. Ebens, Geologist, Branch of Regional
Geochemistry, U.S. Geological Survey

Date and place of birth: January 13, 1939 - Berwyn, Illinois

Education:

Beloit College - Math., Geology - BS - 1961
University of Wyoming - Geology, Statistics MA - 1964
University of Wyoming - Geology, Statistics - PhD- 1966

Honors and awards:

Teaching fellow in Geology, University, of Wyoming, 1964 - 1965.

Research interests:

Sedimentology and sedimentary geochemistry
Statistical methods in geology

Experience:

Geologist, Wyoming Geological Survey, 1965

Assistant Professor of Geology, Emory University, Atlanta,
1966 - present

Geologist, U.S. Geological Survey, 1967 - present

Bibliography: See attached list

Ebens, R. J., 1965, Tower sandstone lenses at Green River, Wyoming: Contributions to Geology, Univ. of Wyoming, v. 4, p. 75-79.

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Ebens, R. J., and Smithson, S. B., 1965, Petrology of rocks from a 3.05-km. deep Precambrian borehole, Wind River Mountains, Wyoming: Geol. Soc. America Ann. Mtg., Kansas City.

_____, 1966, Petrography of Precambrian rocks from a 3.05-km. deep borehole, Wind River Mountains, Wyoming: Contributions to Geology, Univ. of Wyoming, v. 5, p. 31-38.

Smithson, S. B., and Ebens, R. J., 1967, Geophysical data and petrography of Precambrian rocks from a 3.05-km. borehole, Wind River Mountains, Wyoming: Am. Geophys. Union. Ann. Mtg., Washington, D.C.

Name and title: Ronald R. Tidball, Soil Scientist, Branch of Regional
Geochemistry, U.S. Geological Survey

Date and place of birth: July 13, 1930 - Greeley, Colorado

Education:

Colo. State University	- Forestry	BS	1952
University of Washington	- Forest Soils	MF	1957
University of California (Berkeley)	- Soil Science	PhD	1965

Honors and awards:

State Scholarship, Colorado State University, 1948 - 1950
Bloedel Fellowship (forestry), University of Washington, 1955 - 1956
Research Assistantship, University of Washington, 1956 - 1957
Research Assistantship, University of California, 1957 - 1964
Agricultural Fellowship, University of California - 1959

Research interests:

Influence of soil on plant distribution and animal health
Statistical applications in pedology
Geochemical processes in soil development
Soil geography

Experience:

Forestry technician, Weyerhaeuser Co., Tacoma, Wash., 1955, 1957.
Forestry research assistant, University of Washington, 1956-1957
Soils research assistant, University of California, 1957-1964
Soil scientist, U.S. Geological Survey, 1965 - present.

Bibliography: See attached list.

Tidball, R. R., and Connor, J.J., Distribution of elements in a black shale parent and its derivative soil, western Kentucky (abs.): Abstracts with Programs for 1970, Geol.Soc. America Southeastern Sectional Meeting, April 1970, Lexington, Kentucky (in press).

Reports in preparation

Tidball, R. R., Regional variation of some selected soils and trees in Kentucky.

Tidball, R. R., Geochemical variation in Missouri soils (Paper prepared for Conference on Trace Substances in Environmental Health, June, 1970, Columbia, Missouri).

Cannon, H. L., and Tidball, R. R., Some changes in metal content of a peat bog, 20 years after draining.

Miesch, A. T., Connor, J. J., and Tidball, R. R., Reconnaissance geochemical surveys: U.S. Geol. Survey Prof. Paper.

Name and title: Hansford T. Shacklette, Botanist, Branch of Regional Geochemistry, U.S. Geological Survey

Date and place of birth: September 1, 1914 - Henderson, Kentucky

Education:

University of Kentucky - Horticulture, Entomology - BS (Agr.) 1935
" " - Botany MS 1937
University of Michigan - Botany PhD 1963

Honors and awards:

U.S. Department of Interior Special Act or Service Award, April 29, 1966
Bronze Star Decoration, WW II, Europe, January 1945
Four Campaign Stars, WW II, Europe, July 1944-April 1945

Research interests:

Biogeochemistry, plant ecology, taxonomy of bryophytes

Experience:

Instructor in botany, University of Kentucky, 6/37 to 6/41.
Officer, Medical Dept., U.S. Army, WW II, Europe, 9/41 to 4/45.
Teaching Fellow, Dept. of Botany, Univ. of Michigan, 9/48 to 6/49.
Self-employed, farming, livestock and grain, 7/49 to 4/51.
Officer, Medical Dept., U.S. Army, Korean War, 5/51 to 10/52.
Self-employed, farming and greenhouse, 11/52 to 8/55.
Instructor in botany, Colgate University, 9/55 to 6/56.
Asst. Professor of botany, Hanover College, 1/57 to 6/57.
Asst. Professor of botany and Asst. Dean of Men, Georgetown College, 9/57 to 6/61.
Botanist, U.S. Geological Survey, 6/61 to present.

Bibliography: See attached list.

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- Shacklette, H. T., 1951, the control of poison ivy on military posts: *Monthly Health Bulletin, Second U.S. Army*, v. 6, no. 11, 1-7.
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- _____, 1964, Flower variation of Epilobium angustifolium L. growing over uranium deposits: The Canadian Field-Naturalist, v. 78, no. 1, p. 32-42.
- _____, 1965, A leafy liverwort hydrosere on Yakobi Island, Alaska: Ecology, v. 46, no. 3, p. 377-378.
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Shacklette, H. T., Erdman, J. A., and Keith, J. R., Annotated list of vascular plants, in Shacklette, H. T., and others, Vegetation of Amchitka Island, Aleutian Islands, Alaska: U.S. Geol. Survey Prof. paper 648 (in press).

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Shacklette, H. T., Sauer, H. I., and Miesch, A. T., Geochemical environments and cardiovascular mortality rates in Georgia: U.S. Geol. Survey Prof. Paper 574-C (in press).

Shacklette, H. T., Hamilton, J. C., Boerngen, J. G., and Bowles, J. M., Elemental composition of surficial materials in the conterminous United States: U.S. Geol. Survey Prof. Paper (in press).

Shacklette, H. T., Lakin, H. W., Hubert, A. E., and Curtin, G. C., Absorption of gold by plants: U.S. Geol. Survey Bull. (in press).

Name and title: James A. Erdman, Botanist, Branch of Regional
Geochemistry, U.S. Geological Survey

Date and place of birth: December 20, 1935 - Milwaukee, Wisconsin

Education: North Central College - Zoology, Botany - BA - 1958
University of Colorado - Botany, Zoology - MA - 1962
" " - Botany - PhD - 1969

Honors and awards:

Beta Beta Beta Biological Honorary Society (undergraduate)
Phi Sigma Biological Honorary Society (graduate)
Graduate Scholarship in Biology, 1961-1962
Superior Performance Award, Wetherill Mesa Archeological Project,
NPS, 1963.
National Defense Graduate Fellowship in Physiological Ecology,
1964-1965.

Research interests:

Plant ecology, particularly fire effects on vegetation, sampling
techniques; archeoecology; biogeochemistry.

Experience:

Plant ecologist, Wetherill Mesa Archeological Project, National Park
Service, Mesa Verde National Park, Colorado, 1959-1964.

Instructor, Fort Lewis College, Durango, Colorado, 1966-1967.

Botanist, U.S. Geological Survey, Denver, Colorado, 1967-present.

Bibliography: See attached list.

- Erdman, J. A., 1961, Plant ecological studies on Wetherill Mesa (Wetherill Mesa Archeological Project Symposium): Abstract in Program of 128th Annual Meeting, American Association for the Advancement of Science, December, 1961, Denver.
- Erdman, J. A., Tucker, J. M., and Weber, W. A., 1962, Quercus ajoensis in Colorado: Southwestern Naturalist, v. 7, p. 269-270.
- Welsh, S. L., and Erdman, J. A., 1964, Annotated checklist of the plants of Mesa Verde, Colorado: Brigham Young Univ. Science Bull. Biol., v. 4, no. 2, 32 p.
- Erdman, J. A., 1964, Climatic differences of the Mesa Verde, and their effects on the vegetation: Abstract in Ecological Society of America Program, 15th Annual Meeting, American Institute of Biological Sciences, August, Boulder.
- Douglas, C. L., and Erdman, J. A., 1967, Development of terminal buds in pinyon pine and Douglas-fir trees: The Pearce-Sellards Series No. 8, Texas Memorial Museum, Austin, 19 p.
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Name and title: John R. Keith, Botanist, Branch of Regional Geochemistry,
U.S. Geological Survey

Date and place of birth: March 7, 1940 - St. Louis, Missouri

Education:

Georgetown College - Biology, English BA 1962
University of Michigan - Botany, Geology
University of Kentucky - Botany, Geology MS 1967

Honors and awards:

Beta Beta Beta Biological Honorary Society (undergraduate)
Sigma Tau Delta, National English Literature Honorary Fraternity
(undergraduate)
Sigma Xi, National Science Honorary Fraternity (graduate)
NSF Summer Fellowship, Paleobotany, University of Michigan, 1962
Research Assistantship in Palynology, University of Michigan, 1962-1963
Teaching Fellowship, Botany, University of Kentucky, 1965

Research interests:

Plant geography, element contents of plants

Experience:

Instructor, Alma College, 1963-1964
Instructor, Georgetown College, 1964-1966
Botanist, U.S. Geological Survey, 1966 - present

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Name and title: Frederick N. Ward, Chemist, Branch of Exploration Research, U.S. Geological Survey

Date and place of birth: December 1, 1915 - Elba, Alabama

Education:

Huntington College - Chemistry
George Washington University - Chemistry - BS 1943
University of Maryland - Chemistry

Honors and awards:

Superior Performance Award for Federal Service - 1968

Research interests:

Trace methods of analytical chemistry
Application of analytical chemistry to problems in environmental geochemistry and mineral exploration
Analytical techniques in the study of organic materials

Experience:

Junior and assistant chemist, U.S. Dept. Agric., 1942-1948

Chemist, U.S. Geological Survey, 1948 - present

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Current Field Studies in Environmental Geochemistry
Branch of Regional Geochemistry
U.S. Geological Survey

I. Studies in direct cooperation with medical groups:

- a. Geochemical survey of Missouri. This survey is being made on behalf of the Environmental Health Center of the University of Missouri, and is intended to estimate the abundance and distribution of elements in rocks, soils, vegetation, and water throughout the State. The data will be used in support of epidemiological studies of the Environmental Health Center, and to further our understanding of geochemical processes at the earth's surface. The project is staffed by 3 geologists, 3 botanists, 1 soil scientist, and support personnel. It is expected that a ground water hydrologist-geochemist will be added.
- b. Comparison of geochemical environments in central and southern Georgia. This study has been conducted in cooperation with personnel of the U.S. Public Health Service in Columbia, Missouri. Its objective has been to describe the geochemical environments in two areas having extremely different cardiovascular mortality rates. Results will be published early in 1970.
- c. Geochemical investigations of selected counties of the U.S. with extreme cardiovascular death rates. This study is in the initial phases and is being done in collaboration with the U.S. Public Health Service. An attempt will be made to find "geochemical consistencies" among areas having high rates of death due to heart disease, or among areas having low rates. Examinations will be made of rocks, soils, plants, and water.
- d. Descriptions of geochemical environments in Washington Co., Md., and San Juan Co., N. Mex. A geochemical study of rock-soil-plant-water relationships in SE Washington Co., Md., was supported in the early stages by the Cancer Institute to clarify the effect of geochemistry on the environmental setting of a high-cancer area. For comparison a similar project was established in San Juan Co., N. Mex., a low cancer area, in cooperation with an environmental Public Health unit. The geochemistry-health relationships that can be drawn from these data and from epidemiological information collected simultaneously by these Public Health units may provide information of value in the study of cancer.

- e. Smelter contamination in the Helena Valley, Montana. This study was undertaken at the request of the National Air Pollution Control Administration of the U.S. Public Health Service. The work involved techniques of sampling and laboratory analysis of general use in geochemical exploration. A report is being prepared for USPHS.

II. Regional geochemical investigations of selected areas (independent of medical groups):

- a. Selected soils and vegetation of the U.S. The entire conterminous U.S. has been covered by nearly 1000 more or less evenly distributed sampling sites. Samples of soil and selected plant species were collected at each site and analyzed for 30 chemical elements. The results, contained in a report presently in the process of publication, will be of interest in epidemiology as well as agronomy and geochemical exploration.
- b. Geochemical survey of Kentucky. This study pertains mainly to the Paleozoic rock units of the State and is being done in conjunction with the Statewide mapping program. It includes, however, study of compositional variation in a selected soil type as well as in oak and hickory trees growing on this soil type, for the purpose of assessing the geochemical relations in the rock-soil-plant system.

III. Regional geochemical investigations of selected rock units, and rock and soil types (independent of medical groups):

- a. Pierre Shale of the Great Plains Region. Objectives are to describe mineralogical and chemical variations within the unit and to interpret these in terms of stratigraphic and faunal relationships to obtain a better understanding of the total geologic and geochemical history of the formation.
- b. Cambrian and Lower Ordovician Rocks of the Cratonic Area of the Western U.S. Objectives are to describe the regional components of geochemical variation in the basal Cambrian sandstone, Cambrian shales and siltstones, and Cambro-Ordovician carbonates, and to examine these for the bearing they may have on the formation of these units. The compositional variations of the basal Cambrian sandstone, a medium to coarse grained unit derived largely from crystalline rocks, will also be examined for pertinence to problems in exploration for heavy metals.

- c. Fountain Formation of north-central Colorado. A preliminary sampling survey was made of this unit to determine an efficient final sampling plan. Results indicated that at least five samples should be taken per stratigraphic section, and that sections should be spaced 15 to 35 miles apart. Subsequent work has shown the Fountain to consist of coalescing alluvial fans having an average breadth of about 25 miles. The recommended spacing between sections, therefore, would tend to place a section in each fan.
- d. Chattanooga, New Albany, and Ohio Shales of Kentucky. Regional geochemical surveys of these black shale units are being made in behalf of the Heavy Metals program, and are designed to follow up previously reported concentrations of metals in rocks of this type.
- e. Granitic rocks of the Basin and Range Province. This study involves a regional geochemical survey of granitic plutons scattered throughout the Basin and Range Province. The principal objective is to evaluate the effects of tectonic environment, including the nature of the country rock, on both large and small scale compositional variations.
- f. Cretaceous rocks of the Atlantic and Gulf Coastal Plain. The Cretaceous rocks of the Atlantic and Gulf Coastal Plain include continental, transitional, and marine sequences, and provide an opportunity to search for geochemical indicators of these environments. The rocks were derived from crystalline rocks known to be gold-bearing locally and therefore could be of interest in the Heavy Metals program. Also, because the Coastal Plain as a whole has somewhat unique characteristics in terms of geographic pathology, and because the Cretaceous underlies most of the large urban areas, the study is of special importance in environmental geochemistry.
- g. Soils on glacial lacustrine deposits of the north-central and northeastern U.S. This soil unit occurs in widely separated localities throughout the glaciated region of the north-central and northeastern U.S., and comprises preferred farm land. The principal objectives of the regional geochemical study will be to detect, describe, and interpret causes for any regional compositional variations that may be present, and to begin the establishment of a norm for minor element concentrations in agricultural soils in support of environmental geochemical studies. Detailed sampling will also be done to investigate the behavior of minor elements in the development of soil profiles.

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