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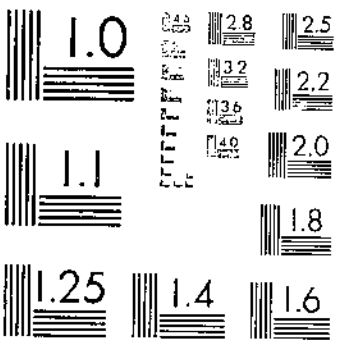
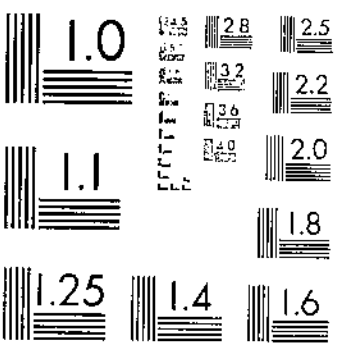


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

TECHNICAL BULLETIN No. 530 December 1936

SELENIUM OCCURRENCE IN CERTAIN SOILS IN THE UNITED STATES WITH A DISCUSSION OF RELATED TOPICS

SECOND REPORT

BY

HORACE G. BYERS

Principal Chemist
Soil Chemistry and Physics Research Division
Bureau of Chemistry and Soils

UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

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ACKNOWLEDGMENT

It is obvious that the writer could not have assembled personally all the materials reported upon in this bulletin. As a matter of fact, a large number of persons were responsible to varying degrees. J. T. Miller of the Soil Survey Division collected most of the samples and made most of the field observations. Valuable contributions were made by T. D. Rice of the Soil Survey Division; H. J. Wichman of the United States Food and Drug Administration, through field representatives of that Administration; C. S. Howard of the Quality of Water Division, United States Geological Survey; and C. S. Scofield of the Division of Western Irrigation Agriculture, Bureau of Plant Industry. Much assistance was also given by the scientists of various State institutions, in particular by O. A. Beath of the University of Wyoming. K. T. Williams and H. W. Lakin of the Soil chemistry and Physics Research Division did the greater part of the analytical work, and contributed many helpful suggestions. They were aided by H. Fleisher and W. M. Noble. A part of the work was done by R. W. Harkness and L. H. Greathouse. C. S. Slater did the analytical work on arsenic. During the whole progress of the work W. O. Robinson gave counsel and criticism. Figures 1, 2, and 3 were prepared by T. M. Shaw. The photographs were furnished by J. T. Miller. S. F. Blake of the Bureau of Plant Industry identified many of the plants. The common names of the plants have been checked by F. V. Coville of the Bureau of Plant Industry.

Technical Bulletin No. 530 December 1936

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

SELENIUM OCCURRENCE IN CERTAIN SOILS IN THE UNITED STATES, WITH A DISCUSSION OF RELATED TOPICS. SECOND REPORT

By HORACE G. BYERS

Principal chemist, Soil Chemistry and Physics Research Division, Bureau of Chemistry and Soils

CONTENTS

INTRODUCTION

Technical Bulletin 482 (*2*) [1] presents a résumé of the work done in the Bureau of Chemistry and Soils on the occurrence of selenium in certain soils of the United States up to and including the surveys made during the growing season of 1934. The present bulletin presents a similar account of the results obtained during 1935. It concerns itself chiefly with five major problems: The distribution of selenium in an area surrounding the Black Hills in South Dakota, Nebraska, Montana, and Wyoming; the sources of selenium in and about the junction of the Gunnison and Colorado Rivers in western Colorado; the extent of the occurrence of selenium in western Kansas; the demonstration of the existence of seleniferous areas in Montana; and the effect of rainfall and of irrigation upon the selenium content of soils and vegetation.

Incident to these main purposes, a number of other problems have been considered. Some of the results were thought of sufficient interest to warrant brief publication (*11*, *17*, *18*, *19*). It will be observed that none of these topics deals directly with the very important questions relative to toxic limits in respect to animals or plants, or to public health. Some of the results have an indirect bearing on these questions, however, and attention is called to these as they arise.

[1] Italic numbers in parentheses refer to Literature Cited, p. 77.

74490°—36——1

This survey of seleniferous areas was not designed to determine definite limits of lands adversely affected by the selenium content of the soil. Indeed, the variable selenium content of the soil and the extremely variable content of the vegetation indicate that such limits may not be accurately defined. Nor was the investigation undertaken for the purpose of designating areas unfit for general agriculture and fit only for restricted or special uses. It is true, however, that the data may serve very useful ends whenever problems involving land adaptation to use arise in these areas. The work was designed to present as accurate and as complete a picture of the selenium situation in these areas as may be given within the limits of our resources. To attain this purpose it has been necessary to present a great number of individual determinations upon definitely located samples. These demonstrate the impossibility of arriving at valid conclusions by means of averages. The individual determinations point to certain limited areas as more likely to be unfit for specific uses than are others within the larger areas. Such indications may serve useful ends in projects involving specific or restricted use of land

METHODS OF EXAMINATION

The samples reported upon were collected for the greater part by John T. Miller, a smaller portion by the writer, and some were sent in by various individuals as mentioned when analyses are given. Usually soil samples representative of the first 6 inches were taken. Occasionally profiles were taken to a depth of 4 feet, and also occasionally shale samples were obtained partly as a means of indication of the probable immediate source of selenium in the soil samples. Where possible, the samples of vegetation were taken immediately upon or adjacent to the soil samples. Frequently it was necessary to go several feet from the soil sample in order to obtain a sample of vegetation of sufficient size. Occasionally it was not possible to obtain any vegetation representative of an area. In general, the samples were taken where the presence of selenium was, for one reason or another, suspected. Usually the basis of suspicion was the kind of soil parent material, although at times reports of particular forms of animal disease or the presence of a particular plant occasioned selection. Since it has been shown that particular plant species are especially prone to selenium absorption, these were ordinarily taken if present. In some areas cultivated crops could not be used as samples, since there were none.

The analytical methods used were essentially those previously employed (*14*), except that during the progress of the work it was demonstrated that the organic matter could be more accurately and more rapidly prepared for analysis by the wet combustion method described by Williams and Lakin (*17*), and thereafter this method was used. The methods employed are very satisfactory, as is shown by Rader and Hill (*12*) and by repeated rechecking. Except where otherwise stated, the results for soils are accurate to ± 0.5 part per million and for vegetation to approximately $\pm$ 1 part per million except when the quantities exceed 50 parts per million. In the very high concentrations there is a probable variation from accuracy of 5 to 10 parts per million.

NAMES AND TERMS EMPLOYED

Names of shales in the tables of analytical data were taken from the maps and geological descriptions of the United States Geological Survey or from various State publications, when such were available for the areas examined. Since for the most part maps are not minutely detailed, and in some areas work was done at or near the junction of two or more formations, it is not always wholly certain that the shale source is accurately identified. It is believed, however, that such uncertainties are few and not significant. In figure 1 are given the generalized geologic relations for the areas examined. The

AGE			MONTANA	NEBRASKA EASTERN WYOMING SOUTH DAKOTA	EASTERN COLORADO KANSAS	WESTERN COLORADO
QUARTERNARY			GLACIAL DRIFT		LOESS	
TERTIARY				WHITE RIVER	OGALLALA	
CRETACEOUS	UPPER CRETACEOUS	MONTANA GROUP	BEARPAW	FOX HILLS		MESAVERDE
			JUDITH RIVER	PIERRE A	BEECHER ISLAND	
			CLAGGETT	PIERRE B	UNDIFFERENTIATED	
			EAGLE	PIERRE C	SALT GRASS	
			TELEGRAPH CREEK	PIERRE D	LAKE CREEK	
				PIERRE E	WESKAN	
				PIERRE F	SHARON SPRINGS	MANCOS
		COLORADO GROUP	COLORADO	NIOBRARA	SMOKY HILL FORT HAYS	
				CARLILE	BLUE HILL FAIRPORT	
				GREENHORN	PFEIFER JETMORE HARTLAND LINCOLN	
				GRANEROS	GRANEROS	
			???	DAKOTA FUSON LAKOTA	DAKOTA	DAKOTA
	LOWER		KOOTENAI			
CRETACEOUS ?			MORRISON	MORRISON		

FIGURE 1.—The generalized geologic relations for the areas examined.

sections were prepared from United States Geological Survey Bulletins 510, 796 (B), and 822 (A), and State Geological Survey of Kansas Bulletins 16 and 18. The Pierre subdivisions are based upon unpublished data submitted by J. E. Upp. Since, in different areas, the formations are of widely varying thickness, exact correlations are not possible.

The names of the soils examined were taken in part from the soil surveys when such were available. The reconnaissance surveys of South Dakota, Montana, and Kansas are not sufficiently detailed to furnish distinctions required in some areas. In such cases, and in general where it seemed best, the soil samples were named from the shale formations which are their presumable parent material, hence such names as Niobrara clay loam and Carlile clay loam. In many cases the source of a soil is uncertain both by reason of mixing of material and because the underlying shale is not the soil source but

rather that it comes from residual material of the strata above it. Also, in some cases, it seems certain that soils have been seriously modified by the presence of recent wind-blown material or by the removal of surface soil.

Identification of the samples of vegetation was difficult. Very valuable assistance in this matter was rendered by S. F. Blake, Bureau of Plant Industry, who identified many specimens. He must however, not be held responsible for any errors, since many samples were taken at stages of growth which rendered exact identification impossible. For this, and for other reasons, the common names of the plants are used where such names are current. In some instances common names appear nonexistent. The botanical systematic names and the corresponding common names are listed in the following tabulation. Common names in quotation marks are used locally, although in other parts of the country the same name is used for a different plant. The ordinary crops and the common native plants are not included in this list.

Botanical name	*Common name*
Allium mutabile	"Wild garlic."
Aplopappus spinulosus	Ironplant.
Asclepias pumila	Plains milkweed.
A. syriaca	Common milkweed.
Aster fendleri	"Blue aster."
A. multiflorus	Wreath aster.
Astragalus bisulcatus	Two-groove poisonvetch.
A. drummondii	Drummond milkvetch.
A. mollissimus	Woolly loco.
A. pectinatus	Narrowleaf milkvetch.
A. missouriensis	
A. racemosus	
A. richardsonii	Milkvetch.
A. succulentus	Groundplum.
Avena fatua	Wild oats.
Boutelona curtipendula	Side-oats grama.
Conringia orientalis	Hares-ear-mustard.
Delphinium sp	Larkspur.
Distichlis stricta	Desert saltgrass.
Eriogonum cernuum	"Umbrella-plant."
Eurotia lanata	Winterfat.
Glycyrrhiza lepidota	Wild licorice.
Grindelia squarrosa	Gumweed.
Gutierrezia sarothrae	Broom snakeweed.
Helianthus maximiliani	Maximilian sunflower.
H. tuberosus	Jerusalem-artichoke.
Ipomoea leptophylla	Bush morning-glory.
Kuhnia glutinosa	False boneset.
Lacinaria punctata	Dotted gayfeather.
Lepidium virginicum	American peppergrass.
Hoffmanseggia jamesii	
Lupinus aduncus	Lupine.
L. argenteus	Do.
L. pusillus	Do.
Mentzelia decapetala	"Stickleaf."
M. nuda	"Sandlily."
Oxytropis lambertii	Crazyweed.
Pentstemon alpinus	Mountain pentstemon.
Phleum pratense	Timothy.
Polanisia trachysperma	Clammyweed.
Physalis sp	Groundcherry.
Psoralea tenuiflora or *P. digitata*	Scurf-pea.
Rhus glabra	Smooth sumac.
Sarcobatus vermiculatus	Greasewood.
Salvia pitcheri	Great azure sage.

Botanical name	*Common name*
Senecio riddellii	Groundsel.
S. purshianus	Do.
Silphium laciniatum	Compassplant.
Sphaeralcea coccinea	Scarlet globemallow.
Solidago missouriensis or *S. mollis*	Goldenrod.
Stanleya pinnata and *S. bipinnata*	Stanleya.
Stenosiphon linifolius	"Skeletonweed."
Termopsis rhombifolia	Goldenpea.
Trifolium stoloniferum	Clover.
Verbascum thapsus	Mullein.
Vernonia baldwini	Baldwin ironweed.
Vicia sparsifolia	Stiffleaf vetch.
Viorna scottii	Viorna.
Xylorhiza parryi	Parry aster.
Zygadenus gramineus	Deathcamas.

SELENIUM IN SOILS ADJACENT TO THE BLACK HILLS

The Black Hills are the eroded residue of an extrusion of rocks of the igneous type through the sedimentary deposits of the Cretaceous

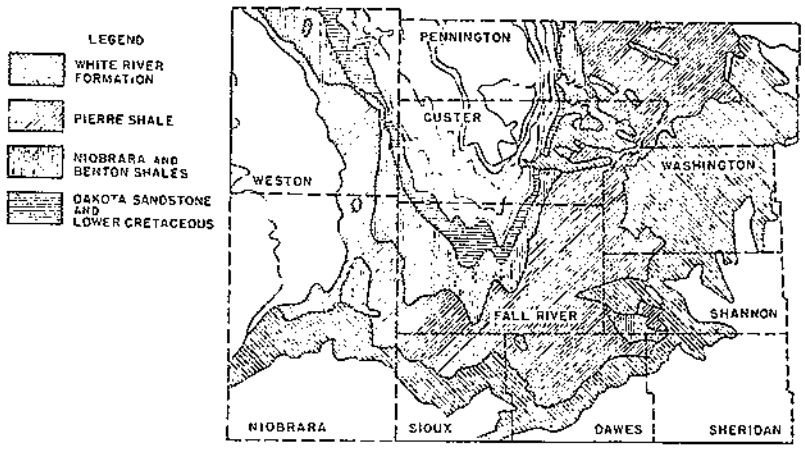

FIGURE 2.—A portion of the geologic relations adjacent to the southern portion of the Black Hills.

and later geological periods. The eroded sedimentary formations, therefore, present roughly annular areas about the hills. As one leaves the hills the exposures are in the inverse order of the formation deposition. Outside the area of uplift the cretaceous shales may be covered more or less completely by deposits of a later type or may be exposed over wide areas. Figure 2 is a sketch taken from the geologic map of the United States (*16*) to illustrate the general relationship. The areas of particular interest are those showing exposures of Pierre shales and Niobrara and Benton shales. Since it has been demonstrated that some of the cretaceous shales, particularly the Pierre and Niobrara formations, are high in selenium (*2*) and that where they give rise to soils both soils and vegetation may contain measurable quantities of selenium and that the plants may be toxic to animals, it was thought desirable to explore the general area of Niobrara and Pierre exposures shown in figure 2. It was not the purpose to gain detailed information concerning local variations but to determine the general distribution of the selenium and the degree of toxic-

ity. The samples examined, their location, character, and content, are given in tabular form. Table 1 contains data concerning the areas south and southwest of the Black Hills in Nebraska, South Dakota, and Wyoming, arranged by counties. Table 2 contains data relative to areas northwest, north, and east of the Black Hills, arranged in a similar manner.

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*

SHERIDAN COUNTY, NEBR.

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B15216	1	Sec. 30, T. 35 N., R. 46 W.	Niobrara stony clay loam, 0–6 inches.	3.5	
B15217	1a	do	Parry aster (100 feet from soil sample, on colluvial soil).		20
B15217A	1a	do	Groundplum		15
B15218	2	Sec. 32, T. 35 N., R. 46 W.	Pierre clay, 0–6 inches	.7	
B15219	2a	do	Drummond milkvetch		15
B15220	3	Sec. 10, T. 34 N., R. 46 W.	Dawes clay loam, 0–6 inches	.2	
B15221	3a	do	Sweetclover		12
B15222	4	Sec. 35, T. 35 N., R. 46 W.	Pierre clay loam, 0–6 inches	1	
B15223			Pierre clay loam, 6–12 inches	.6	
B15224			Pierre clay loam, 24–36 inches	2	
B15225			Pierre clay loam, 36–48 inches	2	
B15226	4a	do	Drummond milkvetch		20
B15227	5	Sec. 34, T. 35 N., R. 46 W.	Niobrara clay loam, 0–6 inches	1.5	
B15228	5a	do	*Astragalus missouriensis*		10
B15229	6	NE. corner sec. 28, T. 35 N., R. 46 W.	Niobrara clay loam, 0–6 inches	2	
B15230	6a	do	Wheatgrass		30
B15231	7	W¼ corner sec. 23, T. 35 N., R. 46 W.	Niobrara clay loam, 0–6 inches	3.5	
B15232	7a	do	Yucca		8
B15233	8	SW. corner sec. 28, T. 35 N., R. 46 W.	Niobrara clay loam, 0–12 inches	8	
B15234	8a	do	*Oxytropis lambertii*		12
B15235	8b	do	Stanleya		1,080
B15237	10	E½ corner sec. 23, T. 35 N., R. 46 W.	Niobrara clay loam, 0–6 inches	6.0	
B15238	10a	do	*A. racemosus*		1,270
B15236	9	Sec. 24, T. 35 N., R. 47 W.	Pierre clay (?), 0–6 inches	.2	
B15237	9a	do	Drummond milkvetch		10

DAWES COUNTY, NEBR.

B14500	1	SW. corner sec. 29, T. 35 N., R. 47 W.	Shale outcrop, 0–20 inches	14	
B14503	2	do	Shale outcrop, 0–6 inches (50 feet above no. 1, in slope)	.8	
B14505	3	do	Chalky material in fissures of shale	2.5	
B14501	1a	do	Broom snakeweed, dead		0
B14502	1c	do	*A. racemosus*		450
B14502A	1c	do	*A. missouriensis*		5
B14501	2a	do	Groundsel		4
B14506	4	8 rods east of NW. corner sec. 32, T. 35 N., R. 47 W.	Niobrara clay loam, 0–6 inches	2	
B14507	4a	do	Winterfat		10
B14508	4b	do	*Townsendia exscapa*		170
B14669	102	70 rods east of NW. corner sec. 32, T. 35 N., R. 47 W.	Bentonite in Pierre shale, 100 feet above Niobrara chalk	10	
B14670	103	do	Pierre shale, 3 feet above bentonite	10	
B14671	104	do	Selenite crystals in Pierre shale	.4	
B14670A	103a	do	*A. racemosus*		1,230
B14672	105	40 rods east of NW. corner sec. 34, T. 35 N., R. 47 W.	Graneros shale	.6	
B14673	106	Center of SW¼ sec. 28, T. 35 N., R. 47 W.	Carlile shale	.5	
B14674	107	do	"Pierre" clay from Carlile shale	.2	
B14675	107a	do	Unidentified vegetation		1

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

DAWES COUNTY, NEBR.—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B14676	108	Center sec. 29, T. 35 N., R. 47 W	Pierre clay, 0–6 inches, from Pierre shale	4	
B14677	108a	do	Parry aster		200
B14509	5	Sec. 29, T. 35 N., R. 47 W	Pierre clay, 0–6 inches	.8	
B14510	6	80 rods south of NW. corner sec. 21, T. 35 N., R. 47 W.	Niobrara clay, 0–6 inches	7	
B14512	7	80 rods east of NW. corner sec. 21, T. 35 N., R. 47 W.	do	5	
B14513	7a	do	Sagebrush		2
B14513A	7b	do	*A. racemosus*		5,500
B14513B	7c	do	*A. missouriensis*		25
B14625	71	SW. corner sec. 32, T. 35 N., R. 48 W.	Pierre clay, 0–6 inches	2	
B14626	72	SW. corner sec. 29, T. 35 N., R. 48 W.	do	1	
B14627	72a	do	Gumweed, dead		2
B14629	73	SE. corner sec. 19, T. 35 N., R. 48 W.	Pierre clay, 0–6 inches	.7	
B14630	74	NE. corner sec. 19, T. 35 N., R. 48 W.	do	1	
B14622	12	SW. corner sec. 30, T. 35 N., R. 49 W.	do	.6	
B14523	13	SE. corner sec. 31, T. 35 N., R. 49 W.	do	.5	
B14521	13a	do	Russian-thistle, dead		1
B14630	75	NE. corner sec. 22, T. 35 N., R. 49 W.	Pierre clay, 0–6 inches	1.5	
B14631	76	NW. corner sec. 26, T. 35 N., R. 49 W.	do	.7	
B14632	77	330 feet north of E. line sec. 27, T. 35 N., R. 49 W.	do	1	
B14633	78	W. corner sec. 27, T. 35 N., R. 49 W.	do	.7	
B14634	79	E. corner sec. 34, T. 35 N., R. 49 W.	do	2	
B14661	101	100 feet east of SW. corner sec. 23, T. 35 N., R. 49 W.	Pierre clay, 0–8 inches	.5	
B14662			Pierre clay, 8–12 inches	.5	
B14663			Pierre clay, 12–20 inches	.8	
B14664			Pierre clay, 17–21 inches (nodular masses)	1	
B14665			Pierre clay, 20–30 inches	.5	
B14666			Pierre clay, 30–36 inches	.4	
B14514	8	NW. corner sec. 21, T. 35 N., R. 50 W.	Pierre clay loam, 0–6 inches	.6	
B14515	8a	do	Gumweed, dead		1
B14516	9	NE. corner sec. 31, T. 35 N., R. 50 W.	Pierre clay, 0–6 inches	.7	
B14517	9a	do	Sagebrush		0
B14517A	9b	do	*A. racemosus*		800
B14517B	9c	do	Wheatgrass		20
B14518	10	E. corner sec. 22, T. 35 N., R. 50 W.	Pierre clay, 0–6 inches	.7	
B14519	11	NW. corner sec. 25, T. 35 N., R. 50 W.	do	.7	
B14520	11b	do	Crazyweed		20
B14652	92	SE. corner sec. 32, T. 35 N., R. 50 W.	Pierre clay, 0–6 inches	.5	
B14653	93	SE. corner sec. 20, T. 35 N., R. 50 W.	do	.7	
B14651	91	SW. corner sec. 31, T. 35 N., R. 50 W.	do	.7	
B14559	31	SW. corner sec. 36, T. 35 N., R. 51 W.	do	.5	
B14560	31a	do	Russian-thistle, dead		0
B14503	33	SW. corner sec. 24	Pierre clay, 0–6 inches	.8	
B14561	33a	do	Russian-thistle, dead		0
B14505	34	NE. corner sec. 23, T. 35 N., R. 51 W.	Pierre clay, 0–6 inches	.8	
B14567	35	SW. corner sec. 24, T. 35 N., R. 51 W.	do	1	
B14569	36	NW. corner sec. 27, T. 35 N., R. 51 W.	do	.8	
B14571	37	NE. corner sec. 21, T. 35 N., R. 51 W.	do	.5	
B14573	38	NW. corner sec. 23, T. 35 N., R. 51 W.	do	.7	
B14575	39	NE. corner sec. 31, T. 35 N., R. 51 W.	do	.8	
B14577	40	NE. corner sec. 36, T. 35 N., R. 52 W.	do	.6	
B14579	41	SW. corner sec. 25, T. 35 N., R. 52 W.	do	.7	
B14580	41a	do	Gumweed, dead		5
B14581	42	NW. corner sec. 26, T. 35 N., R. 52 W.	Pierre clay, 0–6 inches	.6	
B14582	42a	do	Gumweed, dead		3
B14583	43	NW. corner sec. 24, T. 35 N., R. 52 W.	Pierre clay, 0–6 inches	.7	
B14525	11	NE. corner sec. 5, T. 34 N., R. 49 W.	do	.5	
B14526	11a	do	Wheatgrass, dead		

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

DAWES COUNTY, NEBR.—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or silnle	Vegetation
				P. p. m.	*P. p. m.*
B14527	15	SE¼ sec. 4, T. 34 N., R. 49 W.	Pierre clay, 0–6 inches	0.3	
B14528	15a	do	Gumweed, dead		6
B14529	16	NW¼ sec. 14, T. 34 N., R. 49 W.	Pierre clay, 0–6 inches	.7	
B14530	16a	do	Wheatgrass, dead		0
B14530A	16b	do	Crazyweed		35
B14530B	16c	do	*A. racemosus*		109
B14530C	16d	do	*A. missouriensis*		25
B14658	98	NE¼ sec. 16, T. 34 N., R. 49 W.	Clay shale, 10–25 feet	4	
B14659	99	SE¼ sec. 20, T. 34 N., R. 49 W.	Pierre clay, 0–6 inches	1	
B14660	100	SW corner sec. 2, T. 34 N., R. 49 W.	Pierre clay, 0–6 inches	.5	
B14531	17	SE¼ sec. 4, T. 34 N., R. 49 W.	Pierre clay, 0–6 inches	1	
B14532	17a	do	*A. racemosus*		510
B14646	87	SE corner sec. 33, T. 34 N., R. 50 W.	Pierre clay, 0–6 inches	.7	
B14647	88	S¼ corner sec. 26, T. 34 N., R. 50 W.	do	1.5	
B14648	89	80 rods south of center sec. 26, T. 34 N., R. 50 W.	do	.7	
B14649	90	NE corner sec. 17, T. 34 N., R. 50 W	do	.7	
B14650	90a	do	Russian-thistle, dead		3
B14651	91	SE corner sec. 5, T. 34 N., R. 50 W	Pierre clay, 0–6 inches	.7	
B14635	80	NW corner sec. 2, T. 34 N., R. 50 W	do	1	
B14655	95	NW corner sec. 1, T. 34 N., R. 50 W	do	.7	
B14656	96	NW corner sec. 13, T. 34 N., R. 50 W	Pierre clay, 0–6 inches (partly Brule clay).	.4	
B14657	97	NE¼ sec. 21, T. 34 N., R. 50 W	do	.1	
B14547	25	SE corner sec. 35, T. 34 N., R. 51 W	Pierre clay, 0–6 inches	1.5	
B14548	25a	do	Russian-thistle, dead		1
B14549	26	NE corner sec. 35, T. 34 N., R. 51 W.	Pierre clay, 0–6 inches	.8	
B14550	26a	do	Russian-thistle, dead		0
B14551	27	NE corner sec. 26, T. 34 N., R. 51 W.	Pierre clay, 0–6 inches	.7	
B14552	27a	do	Russian-thistle, dead		.3
B14553	28	NW corner sec. 24, T. 34 N., R. 51 W.	Pierre clay, 0–6 inches	.6	
B14555	29	SW corner sec. 12, T. 34 N., R. 51 W.	do	.6	
B14557	30	SE corner sec. 2, T. 34 N., R. 51 W.	do	1	
B14585	44	SW corner sec. 23, T. 34 N., R. 51 W.	do	.5	
B14586	45	SE corner sec. 20, T. 34 N., R. 51 W	Pierre clay loam, 0–6 inches	.4	
B14585	46	NE corner sec. 29, T. 34 N., R. 51 W	Pierre clay, 0–6 inches	.5	
B14583	50	NW corner sec. 10, T. 34 N., R. 51 W	do	.3	
B14595	51	SE corner sec. 12, T. 34 N., R. 57 W	do	.5	
B14591	48	S½ sec. 21, T. 34 N., R. 52 W.	do	.5	
B14596	52	SE corner sec. 2, T. 34 N., R. 52 W	Pierre clay loam, 0–6 inches	.2	
B14597	53	NW corner sec. 1, T. 34 N., R. 52 W	Pierre clay, 0–6 inches	.4	
B14668	59	NW corner sec. 4, T. 34 N., R. 52 W	Pierre clay loam, 0–6 inches	.7	
B14610	61	SW corner sec. 8, T. 34 N., R. 52 W.	Pierre clay, 0–6 inches (over Brule formation).	.4	
B14611	61	do	Brule clay, 4–5 feet	.2	
B14613	62	SW corner sec. 20, T. 34 N., R. 52 W.	Pierre clay, 0–6 inches	.4	
B14533	18	S¾ corner sec. 18, T. 33 N., R. 49 W	do	.5	
B14534	18a	do	Wreath aster, dead		7
B14534A	18b	do	Broom snakeweed		7
B14534B	18c	do	Wreath aster, young		180
B14637	81	NE corner sec. 8, T. 33 N., R. 49 W.	Pierre clay, 0–6 inches	1	
B14638	81	do	Vlorna		4
B14639	82	E¼ corner sec. 7, T. 33 N., R. 49 W.	Pierre clay, 0–6 inches	3	
B14640	82a	do	Vlorna		2
B14641	83	SW corner sec. 6, T. 33 N., R. 49 W.	Pierre clay, 0–6 inches	2	
B14642	84	NE corner sec. 12, T. 33 N., R. 50 W.	do	1	
B14643	84a	do	Vlorna		2
B14644	85	NW corner sec. 11, T. 33 N., R. 50 W	Pierre clay, 0–6 inches	1	
B14645	86	SE corner sec. 4, T. 33 N., R. 50 W.	do	1	
B14637	20	N¼ corner sec. 30, T. 33 N., R. 50 W.	Ormond silty clay loam, 0–6 inches (irrigated).	.7	
B14538	20a	do	Alfalfa		200
B14539	21	SW corner sec. 18, T. 33 N., R. 50 W	Pierre clay, 0–6 inches	.7	
B14540	21a	do	Wheatgrass, dead		1
B14540A	21b	do	Wheatgrass, green		12
B14540	21c	do	Wild onion		35
B14826	110	SW corner sec. 7, T. 33 N., R. 50 W.	Pierre clay, 0–6 inches (above irrigation ditch).	.5	
B14827	110a	do	Wheatgrass		10
B14828	111	do	Pierre clay, 0–6 inches (above irrigation ditch).	.5	
B14829	111a	do	Alfalfa		25
B14830	111b	do	Wheatgrass		25
B14535	19	SW corner sec. 36, T. 33 N., R. 51 W.	Pierre clay, 0–6 inches	.7	
B14536	19a	do	Russian-thistle, dead		3

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

DAWES COUNTY, NEBR.—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B14641	22	SE corner sec. 12, T. 33 N., R. 51 W.	Pierre clay, 0–6 inches	0.7	
B14643	23	SE corner sec. 1, T. 33 N., R. 51 W.	do	.7	
B14645	24	NE corner sec. 35, T. 33 N., R. 51 W.	do	1.5	
B14614	63	E½ corner sec. 2, T. 33 N., R. 52 W.	do	1	
B14615	63a	do	Russian-thistle, dead		1
B14616	64	NE corner sec. 11, T. 33 N., R. 52 W.	Pierre clay, 0–6 inches	.7	
B14617	64	do	Thin bedded shale	1.5	
B14618	65	NW corner sec. 13, T. 33 N., R. 52 W.	Pierre clay, 0–6 inches	.4	
B14619	66	SW corner sec. 13, T. 33 N., R. 52 W.	Pierre shale, 25–40 feet	1.5	
B14620	67	E½ corner sec. 26, T. 33 N., R. 52 W.	Epping silty clay, 0–6 inches	.2	
B14621	67	do	Brule formation, 6–8 feet	.2	
B14624	70	NE corner sec. 5, T. 32 N., R. 52 W.	Epping clay, 0–6 inches (Brule formation)	.2	
B14624A	70a	do	Wheatgrass, dead		2

SIOUX COUNTY, NEBR.

B14698	5	SE corner sec. 35, T. 35 N., R. 53 W.	Pierre clay, 0–6 inches	0.5	
B14699	6	SE corner sec. 26, T. 35 N., R. 53 W.	do	.6	
B14700	7	SW corner sec. 23, T. 35 N., R. 53 W.	do	1	
B14701	8	NE corner sec. 34, T. 35 N., R. 53 W.	do	.4	
B14702	9	E½ corner sec. 28, T. 35 N., R. 53 W.	do	.6	
B14703	10	NW corner sec. 28, T. 35 N., R. 53 W.	do	.5	
B14704	11	NW corner sec. 29, T. 35 N., R. 53 W.	do	.5	
B14705	12	NW corner sec. 30, T. 35 N., R. 53 W.	do	1	
B14705A	12a	do	*A. racemosus*		920
B14708	74	SE corner sec. 33, T. 35 N., R. 53 W.	Pierre clay, 0–6 inches	1	
B15277			do	1.6	
B15277A	95	SE corner sec. 31, T. 35 N., R. 53 W.	Pierre clay, 0–1 inch	2	
B15277B			Organic debris, 0–1 inch		4
B15275	95a	do	Two-groove locoweed		570
B14770	65	SE corner sec. 33, T. 33 N., R. 55 W.	Pierre clay, 0–6 inches	1	
B14771	66	E½ corner sec. 34, T. 34 N., R. 55 W.	do	1.5	
B14772	67	SE corner sec. 35, T. 35 N., R. 55 W.	do	.5	
B14773	68	NW corner sec. 36, T. 35 N., R. 55 W.	do	1	
B14774	69	NE corner sec. 36, T. 35 N., R. 55 W.	do	1	
B14722	26	SE corner sec. 35, T. 35 N., R. 56 W.	do	.7	
B14723	27	SE corner sec. 27, T. 35 N., R. 56 W.	do	.5	
B14724	28	W½ corner sec. 25, T. 35 N., R. 56 W.	do	.8	
B14725	29	NW corner sec. 21, T. 35 N., R. 56 W.	do	.6	
B14725A	29a	do	*A. racemosus*		570
B14726	30	NW corner sec. 35, T. 35 N., R. 56 W.	Pierre clay, 0–6 inches	1.5	
B14727	31	SE corner sec. 22, T. 35 N., R. 56 W.	do	1	
B14728	32	N½ corner sec. 22, T. 35 N., R. 56 W.	do	1	
B14729	32a	do	Sagebrush		2
B14730	33	SE corner sec. 28, T. 35 N., R. 56 W.	Pierre clay, 0–6 inches	.5	
B14731	34	NE corner sec. 33, T. 35 N., R. 56 W.	do	1	
B14751	54	SE corner sec. 33, T. 35 N., R. 56 W.	do	.6	
B14752	55	SE corner sec. 34, T. 35 N., R. 56 W.	do	1	
B14753			do	.7	
B14754			Pierre clay, 6–12 inches	.5	
B14755	56	NW corner sec. 29, T. 35 N., R. 56 W.	Pierre clay, 12–18 inches	.5	
B14756			Pierre clay, 18–26 inches	.8	
B14757			Pierre clay, 26–36 inches	1	
B14758			Pierre clay, 36–48 inches	.7	
B14759	57	NW corner sec. 20, T. 35 N., R. 56 W.	Pierre clay loam, 0–6 inches	2	
B14760	57a	do	Sweetclover		3

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

SIOUX COUNTY, NEBR.—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or similar	Vegetation
				P. p. m.	*P. p. m.*
B14761	58	SW¼ sec. 30, T. 35 N., R. 56 W.	Pierre clay, 0–6 inches	0.8	
B14762	58a	do	*Astragalus* (spl.)		2,250
B14735	38	W½ corner sec. 31, T. 35 N., R. 50 W.	Pierre clay, 0–6 inches	.8	
B14740	43	Center sec. 33, T. 35 N., R. 57 W.	do	.6	
B14741	44	NE corner sec. 28, T. 35 N., R. 57 W.	do	1	
B14742	45	sec. 22, T. 35 N., R. 57 W.	do	2	
B14742A	45a	do	*A. racemosus*		110
B14742B	45b	do	Unidentified vegetation		20
B14743	46	NW corner sec. 21, T. 35 N., R. 57 W.	Pierre clay, 0–6 inches	1	
B14692	1	SW corner sec. 23, T. 34 N., R. 53 W.	do	.2	
B14693	1a	SW corner sec. 23	Sagebrush		1
B14694	2	N¼ corner sec. 24, T. 34 N., R. 53 W.	Pierre clay, 0–6 inches	.7	
B14695	2a	do	Sagebrush		4
B14696	3	Near SW corner sec. 12, T. 34 N., R. 53 W.	Pierre clay, 0–6 inches	.4	
B14697	4	SW corner sec. 1, T. 34 N., R. 53 W.	do	.7	
B14786	72	SW corner sec. 16, T. 34 N., R. 53 W.	do	1.5	
B14787	73	E¼ corner sec. 5, T. 34 N., R. 53 W.	do	1	
B15276	95a	do	Drummond milkvetch		15
B14789	75	SW corner sec. 6, T. 34 N., R. 53 W.	Pierre clay, 0–6 inches	.8	
B15275	94a	Center sec. 21, T. 34 N., R. 53 W.	Crazyweed		12
B14792	77	W¼ corner sec. 17, T. 34 N., R. 53 W.	Pierre clay, 0–6 inches	1	
B14790	76	NW corner sec. 12, T. 34 N., R. 54 W.	do	1.5	
B14791	76a	do	Broom snakeweed, dead		9
B14793	78	E¼ corner sec. 23, T. 34 N., R. 54 W.	Pierre clay, 0–6 inches	1	
B14794	79	NE¼ sec. 22, T. 34 N., R. 54 W.	do	.6	
B14795	80	N¼ corner sec. 21, T. 34 N., R. 54 W.	do	1	
B14796	80a	do	Broom snakeweed		7
B14797	80b	do	*A. racemosus*		460
B14798	81	S¼ corner sec. 17, T. 34 N., R. 54 W.	Pierre clay, 0–6 inches	.7	
B14713	18	NW corner sec. 17, T. 34 N., R. 54 W.	Pierre clay, 0–6 inches (Brule formation).	.4	
B14715	19	NW corner sec. 13, T. 34 N., R. 55 W.	Pierre clay, 0–6 inches	.7	
B14715A	19a	do	Crazyweed		350
B14716	20	E¼ corner sec. 10, T. 34 N., R. 55 W.	Pierre clay, 0–6 inches	.7	
B14717	21	SW corner sec. 5, T. 34 N., R. 55 W.	do	.7	
B14718	22	SE corner sec. 5, T. 34 N., R. 55 W.	do	.5	
B14718A	22a	do	*A. racemosus*		160
B14719	23	SE corner sec. 6, T. 34 N., R. 55 W.	Pierre clay, 0–6 inches	1	
B14709	82	SW corner sec. 13, T. 34 N., R. 55 W.	do	.6	
B14800	82a	do	Broom snakeweed		3
B14801	83	SE corner sec. 15, T. 34 N., R. 55 W.	Pierre clay, 0–6 inches	.6	
B14802	84	NE corner sec. 22, T. 34 N., R. 55 W.	do	.7	
B14803	84a	do	Gumweed, dead		0
B14804	86	E¼ corner sec. 28, T. 34 N., R. 55 W.	Pierre clay, 0–6 inches	.7	
B14805	85a	do	Russian-thistle, dead		4
B14807	87	SW corner sec. 18, T. 34 N., R. 55 W.	Pierre clay, 0–6 inches	.6	
B14808	88	SE corner sec. 18, T. 34 N., R. 55 W.	do	1.5	
B14720	24	SE corner sec. 1, T. 34 N., R. 56 W.	do	1	
B14721	25	NE corner sec. 11, T. 34 N., R. 56 W.	do	1	
B14732	35	NE corner sec. 5, T. 34 N., R. 56 W.	do	.7	
B14733	36	NE corner sec. 6, T. 34 N., R. 56 W.	do	.6	
B14733A	36	do	*A. racemosus*		70
B14747	60	S½ corner sec. 7, T. 34 N., R. 56 W.	Pierre clay, 0–6 inches	.8	

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

SIOUX COUNTY, NEBR.—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B14748	51	Near S¼ corner sec. 7, T. 31 N., R. 56 W.	Pierre clay, 0–6 inches (on slope of butte).	0.5	.....
B14750	53	SE corner sec. 5, T. 31 N., R. 56 W.	Pierre clay, 0–6 inches	1.5	.....
B14808	89	E½ corner sec. 13, T. 31 N., R. 56 W.	do	.4	.....
B14810	90	E½ corner sec. 14, T. 31 N., R. 58 W.	do	.7	.....
B14811	90a	do	Gumweed, dead	.....	1
B14812	91	Center sec. 23, T. 31 N., R. 56 W	Pierre clay, 0–6 inches	.7	.....
B14813	91a	do	*A. racemosus*	.....	670
B14814	92	E½ corner sec. 27, T. 34 N., R. 56 E.	Pierre clay, 0–6 inches	1	.....
B14734	37	NE corner sec. 1, T. 31 N., R. 57 W	do	.5	.....
B14736	39	NE corner sec. 2, T. 31 N., R. 57 W	do	.4	.....
B14737	40	W½ corner sec. 2, T. 31 N., R. 57 W	do	.3	.....
B14738	41	E½ corner sec. 1, T. 31 N., R. 57 W	do	1	.....
B14739	42	Center sec. 1, T. 31 N., R. 57 W	do	.3	.....
B14744	47	NW corner sec. 10, T. 31 N., R. 57 W.	Pierre clay, 0–6 inches (Brule formation).	.2	.....
B14745	48	N½ corner sec. 15, T. 31 N., R. 57 W.	do	.3	.....
B14746	49	S½ corner sec. 12, T. 31 N., R. 57 W	Pierre clay, 0–6 inches	.6	.....
B14749	52	SE corner sec. 1, T. 31 N., R. 57 W	do	.5	.....
B14806	86	E½ corner sec. 1, T. 33 N., R. 55 W	do	.7	.....
B14807	86a	do	*A. racemosus*	.....	1,280

SHANNON COUNTY, S. DAK.

B15241	2	Center sec. 8, T. 35 N., R. 45 W	Pierre clay loam, 0–6	0.3	.....
B15242	2a	do	Wheatgrass	.....	10
B15243	3	NW corner sec. 1, T. 35 N., R. 46 W	Niobrara clay, 0–6 inches	.3	.....
B15244	3a	do	Wreath aster	.....	10
B15247	5	SW¼ sec. 2, T. 35 N., R. 47 W	Niobrara clay, 0–6 inches	1.5	.....
B15248	5a	do	*A. racemosus*	.....	450
B15249	6	SW corner sec. 18, T. 36 N., R. 46 W	Niobrara clay loam, 0–6 inches	1	.....
B15250	6a	do	Wheatgrass	.....	10
B15251	7	SE¼ sec. 10, T. 36 N., R. 46 W	Niobrara clay loam, 0–6 inches	2	.....
B15252	7a	do	Deathcamas	.....	8
B15245	4	SE¼ sec. 24, T. 36 N., R. 47 W	Niobrara clay loam, 0–6 inches (poison lick).	20	.....
B15246	4a	do	Broom snakeweed	.....	35
B15300	8	Center sec. 30, T. 36 N., R. 46 W	Pierre clay loam, 0–6 inches	1	.....
B15301	8a	do	*A. racemosus*	.....	2,170
B15318	17	SW corner sec. 28, T. 36 N., R. 47 W	Niobrara stony clay loam, 0–6 inches.	14	.....
B15319	17a	do	Broom snakeweed	.....	30
B15320	18	SE corner sec. 29, T. 36 N., R. 47 W	Niobrara clay loam, 0–6 inches	3	.....
B15321	18a	do	Deathcamas	.....	7
B15322	19	N½ corner sec. 30, T. 36 N., R. 47 W.	Niobrara clay loam, 0–6 inches	6	.....
B15323	19a	N½ corner sec. 30, T. 36 N., R. 47 W.	*A. racemosus*	.....	1,700
B15215		Sec. 34, T. 36 N., R. 47 W	Water (from poison spring)	.07	.....
B15302	9	3 miles northwest of Oglala, State Route 18.	Pierre clay loam 0–6 inches	.3	.....
B15303	9a	do	Wreath aster	.....	10
B15304	10	9 miles northwest of Oglala, State Route 18.	Pierre clay loam, 0–6 inches	.5	.....
B15305	10a	do	Wheatgrass	.....	15
B15306	11	9½ miles northwest of Oglala, State Route 18	Pierre clay loam, 0–6 inches	3	.....
B15307	11a	do	Narrow leaf milkvetch	.....	3,110
B15308	12	13 miles northwest of Oglala, State Route 18	Pierre clay loam, 0–6 inches	.5	.....
B15309	12a	do	Wheatgrass	.....	12
B15310	13	15 miles northwest of Oglala, State Route 18	Pierre clay, 0–6 inches	1.5	.....
B15311	13a	do	*A. racemosus*	.....	120
B15312	14	16 miles northwest of Oglala, State Route 18.	Pierre clay loam, 0–6 inches	2	.....
B15313	14a	do	*A. racemosus*	.....	230
B15314	15	17 miles northwest of Oglala, State Route 18	Pierre clay loam, 0–6 inches	.5	.....
B15315	15a	do	*A. racemosus*	.....	35

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

SHANNON COUNTY, S. DAK.—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B15316	16	100 feet east of Fall River County line, State Route 18.	Pierre clay, 0–6 inches	0.6	
B15317	16a	do	*A. racemosus*		50
B15158	3	Sec. 20, T. 10 S., R. 9 E.	Pierre clay, 0–6 inches	1	
B15158A	3a	do	*A. racemosus*		910
B15159	4	do	Pierre clay, 0–6 inches	.8	
B15204	10	Sec. 9, T. 9 S., R. 9 E.	Pierre clay loam, 0–6 inches	.6	
B15205	10a	do	*A. racemosus*		270
B15160	5	Sec. 5, T. 10 S., R. 8 E.	Ferruginous clay (partly White River).	1.5	
B15161	5a	do	Sagebrush		8
B15162	6	do	Very fine sand, 0–6 inches (clay subsoil).	.1	
B15163	6a	do	Sagebrush		25
B15262	18	Sec. 11, T. 9 S., R. 8 E.	Pierre clay loam, 0–6 inches	.3	
B15263	18a	do	*A. missouriensis*		10
B15263A	18b	do	Wheatgrass		15
B15263B	18c	do	*Vicia sparsifolia*		15
B15260	17	Sec. 6, T. 9 S., R. 8 E.	Pierre clay, 0–6 inches	1	
B15261	17a	do	*A. racemosus*		30
B15171	12	Sec. 12, T. 12 S., R. 7 E.	Pierre clay loam, 0–6 inches	.5	
B15170	11	Sec. 25, T. 11 S., R. 7 E.	do	1.5	
B15166	10	Sec. 13, T. 11 S., R. 7 E.	do	1.5	
B15169	10a	do	Sweetclover		12
B15166	9	Sec. 1, T. 11 S., R. 7 E.	Pierre clay, 0–6 inches	.5	
B15165	8	Sec. 25, T. 10 S., R. 7 E.	do	1	
B15165A	8a	do	Sweetclover		25
B15164	7	Sec. 13, T. 10 S., R. 7 E.	Pierre clay, 0–6 inches	1.5	
B15164A	7a	do	Sweetclover		25
B15252	13	Sec. 15, T. 10 S., R. 7 E.	Pierre clay loam, 0–6 inches	1	
B15253	13a	do	Wheatgrass		6
B15254	14	Sec. 1, T. 10 S., R. 6 E.	Pierre clay loam, 0–6 inches	1	
B15255	14a	do	*A. racemosus*		280
B15256	15	Sec. 32, T. 9 S., R. 6 E.	Brown clay loam	1	
B15257	15a	do	*A. racemosus*		320
B15257A	15b	do	Wreath aster		210
B15258	16	Sec. 33, T. 9 S., R. 6 E.	Pierre clay, 0–6 inches	1	
B15259	16a	do	*A. racemosus*		30
B15330	20a	Sec. 34, T. 9 S., R. 6 E.	Two-groove poisonvetch		360
B15157	2	Sec. 4, T. 8 S., R. 6 E.	Graneros shale, 40–50 feet	.7	
B15155	1	Sec. 33, T. 7 S., R. 6 E.	Graneros shale, 25–35 feet	1.5	
B15156	1a	do	Great azure sage (on shale)		8
B15331	21	Sec. 15, T. 12 S., R. 4 E.	Pierre clay, 0–6 inches	1	
B15332	21a	do	Two-groove poisonvetch		100
B15333	22	Sec. 8, T. 12 S., R. 4 E.	Pierre clay loam, 0–6 inches	3	
B15334	22a	do	Two-groove poisonvetch		1,400
B15335	23	Sec. 12, T. 12 S., R. 4 E.	Pierre clay, 0–6 inches	4	
B15336	23a	do	Two-groove poisonvetch		1,960

FALL RIVER COUNTY, S. DAK., FALL COLLECTION

B17726	1	Center sec. 27, T. 7 S., R. 5 E.	Spearfish loam, 0–6 inches	0.2	
B17727	1a	do	Broom snakeweed		1
B17728	2	SW¼ corner sec. 19, T. 9 S., R. 5 E.	Greenhorn shaly clay loam, 0–6 inches.	1.5	
B17729	2a	do	Two-groove poisonvetch		2
B17730	3	500 feet south of northeast corner sec. 29, T. 9 S., R. 5 E.	Niobrara shaly clay loam, 0–6 inches.	1.5	
B17734	3a	do	Broom snakeweed		1
B17732	4	SW corner sec. 10, T. 10 S., R. 5 E.	Niobrara stony clay loam, 0–6 inches.	1	
B17733	4a	do	*A. racemosus*		1
B17734	5	400 feet south of northeast corner sec. 1, T. 11 S., R. 3 E.	Niobrara clay loam, 0–6 inches	1.5	
B17735	5a	do	Gumweed, dead		5
B17736	6	SE corner sec. 1, T. 11 S., R. 3 E.	Niobrara clay loam, 0–6 inches	10	
B17737	6a	do	Wheatgrass, dead		2
B17738	7	80 rods southeast of east ¼ corner sec. 7, T. 11 S., R. 4 E.	Niobrara clay loam, 0–6 inches	12	
B17739	7a	do	Broom snakeweed		45

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

FALL RIVER COUNTY, S. DAK., FALL COLLECTION—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B17740	8	500 feet south of west ¼ corner sec. 8, T. 11 S., R. 4 E.	Niobrara clay loam, 0–6 inches	10	
B17741	8a	do	Sagebrush		80
B17742	9	500 feet south of northeast corner sec. 7, T. 11 S., R. 4 E.	Niobrara clay loam, 0–6 inches (with efflorescent salts).	40	
B17743	9a	do	Wreath aster		260
B17744	9b	do	Two-groove poisonvetch		160
B17745	10	NE¼ of NE¼ sec. 35, T. 10 S., R. 3 E.	Niobrara clay loam	8	
B17746	10a	do	Broom snakeweed		4
B17747	11	SE corner sec. 15, T. 10 S., R. 3 E.	Niobrara clay loam, 0–6 inches	10	
B17748	11a	do	Wheatgrass, dead		5
B17749	12	200 feet west of northeast corner sec. 18, T. 10 S., R. 3 E.	Niobrara clay loam, 0–6 inches	8	
B17750	12a	do	Alfalfa		4
B17751	13	W½ corner sec. 12, T. 9 S., R. 2 E	Cranero clay loam, 0–6 inches	1	
B17752	13a	do	Broom snakeweed		1
B17753	14	80 rods north of southeast corner sec. 14, T. 9 S., R. 2 E.	Greenhorn clay loam, 0–1 inch	14	
B17754	14	do	Greenhorn clay loam, 1–6 inches	4	
B17755	14a	do	Two-groove poisonvetch (tops)		60
B17756	14b	do	Two-groove poisonvetch (roots)		270
B17757	15	NW corner sec. 24, T. 9 S., R. 2 E.	Greenhorn clay loam, 0–6 inches	.7	
B17758	15a	do	Broom snakeweed		1
B17759	16	200 feet west of NE corner sec. 25, T. 9 S., R. 2 E.	Greenhorn clay	.5	
B17760	16a	do	Broom snakeweed		7
B17761	17	1,080 feet southwest of NE corner sec. 36, T. 9 S., R. 2 E.	Carlile clay loam, 0–6 inches	.3	
B17762	17a	do	Broom snakeweed		1
B17763	18	N¼ corner sec. 1, T. 10 S., R. 2 E.	Carlile clay loam, 0–6 inches	.8	
B17764	18a	do	Broom snakeweed		1
B17765	19	Center sec. 13, T. 10 S., R. 2 E	Niobrara clay loam, 0–6 inches	6	
B17766	19a	do	Alfalfa		3
B17767	20	Center sec. 24, T. 10 S., R. 2 E.	Niobrara clay, 0–6 inches (colluvial).	22	
B17768	20a	do	Wheatgrass		5
B17769	21	East ¼ corner sec. 14, T. 10 S., R. 2 E.	Niobrara clay loam, 0–6 inches	6	
B17770	21	do	Niobrara chalk, 6–8 feet	14	
B17771	21a	do	Two-groove poisonvetch		5
B17772	22	N¼ corner sec. 14, T. 10 S., R. 2 E	Efflorescent deposit	1	
B17773	22a	do	Algae and efflorescent material		2
B17774	23	700 feet south of NE corner sec. 15, T. 10 S., R. 2 E.	Niobrara clay loam, 0–6 inches		
B17775	23a	do	Wreath aster		6
B17776	24	NW corner sec. 28, T. 10 S., R. 2 E	Niobrara clay loam, 0–6 inches	5	
B17777	24a	do	Gumweed, dead		15
B17778	25	500 feet north of E¼ corner sec. 10, T. 10 S., R. 2 E.	Niobrara clay loam, 0–6 inches		
B17779	25a	do	Wreath aster, dead		30
B17780	26	500 feet south of NE corner sec. 20, T. 10 S., R. 2 E.	Niobrara clay loam, 0–6 inches	6	
B17781	26a	do	Wreath aster, dead		4
B17782	27	E¼ corner sec. 18, T. 10 S., R. 2 E	Niobrara clay loam, 0–6 inches	6	
B17783	27a	do	Two-groove poisonvetch		280
B17784	28	S½ corner sec. 18, T. 10 S., R. 2 E.	Niobrara clay loam, 0–6 inches	4	
B17785	28a	do	Two-groove poisonvetch		6
B17786	28b	do	Corn		1
B17787	29	NE corner sec. 26, T. 10 S., R. 1 E.	Niobrara clay loam, 0–6 inches	1	
B17788	29a	do	Two-groove poisonvetch		160
B17789	30	SW corner sec. 22, T. 10 S., R. 1 E	Niobrara clay loam, 0–6 inches	3.5	
B17790	30a	do	Gumweed, dead		180
B17791	31	N¼ corner sec. 8, T. 10 S., R. 1 E.	Niobrara clay loam, 0–6 inches	8	
B17792	31a	do	Gumweed		330
B17793	32	500 feet south of center sec. 28, T. 9 S., R. 1 E.	Niobrara clay loam, 0–6 inches	10	
B17794	32a	do	Two-groove poisonvetch		230
B17795	33	500 feet east of NW corner sec. 27, T. 9 S., R. 1 E.	Niobrara clay loam	4	
B17796	33a	do	Wreath aster		7
B17797	34	NW corner sec. 27, T. 10 S., R. 4 E	Greenhorn clay loam, 0–6 inches	2	
B17798	34a	do	Two-groove poisonvetch		6
B17799	35	E½ corner sec. 28, T. 10 S., R. 4 E	Seepage efflorescence	3	

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

NIOBRARA COUNTY, WYO.

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B15340	2	1.6 miles south of Wes on County line, on U. S. 85.	Niobrara clay loam, 0–6 inches	0.2	.....
B15341	2a	do	Crazyweed	.....	7
B15342	3	4 miles south of Weston County line, on U. S. 85.	Pierre clay loam, 0–6 inches	.3	.....
B15343	3a	do	Lupine	.....	25
B15344	4	6 miles south of Weston County line, on U. S. 85.	Clay alluvium, 0–6 inches	1	.....
B15345	4a	do	Two-grooved poisonvetch	.....	15
B15346	5	1 mile north of junction of U. S. 18 and 85.	Pierre clay, 0–6 inches	2	.....
B15347	5a	do	*A. racemosus*	.....	500
B15179	1	Junction of U. S. 85 and 18	Yellow silt loam, 0–6 inches	.2	.....
B15180	1a	do	*Astragalus* sp.	.....	17
B15181	1b	do	do	.....	5
B15182	1c	do	do	.....	25
B15348	6	300 feet east of junction of U. S. 85 and 18.	Niobrara clay loam, 0–6 inches	.8	.....
B15349	6a	do	Stanley t	.....	370
B15350	7	150 feet west of South Dakota line on U. S. 18.	Niobrara clay, 0–6 inche	3	.....
B15351	7a	do	Two-grooved poisonvetch	.....	210
B15352	8	2.2 miles south of junction of U. S. 85 and 18.	Pierre shale, 0–6 inches	16	.....
B15353	8a	do	Goldenpea	.....	30
B15354	9	4 miles south of junction of U. S. 85 and 18.	Pierre clay loam, 0–6 inches	.5	.....
B15355	9a	do	Wheatgrass	.....	15
B15356	10	6.5 miles south of junction of U. S. 18 and 85.	Pierre clay, 0–6 inches and vegetation	14	.....
B15358	11	8 miles south of junction of U. S. 18 and 85.	Pierre clay loam, 0–6 inches	12	.....
B15359	11a	do	Stanley t	.....	430
B15360	12	9 miles south of Red Bird, on U. S. 85.	Pierre clay loam, 0–6 inches	.2	.....

WESTON COUNTY, WYO.

B15392	17	2 miles north of Thornton, on U. S. 20.	Niobrara clay loam, 0–6 inches	0.3	.....
B15393	17a	do	Two-grooved poisonvetch	.....	.....
B6317	C26S	31 miles southeast of Upton	Graneros shale	1	.....
B15388	15	6 miles southwest of Osage	Pierre shaly clay loam, 0–6 inches	1	.....
B15389	15a	do	Furry asker	.....	12
B6318	E27a	12 miles northwest of New Castle	Two-grooved poisonvetch	.....	110
B6319	E28	6 miles southwest of New Castle	Pierre clay, 0–6 inches	.7	.....
B15185			do	1	.....
B15186	1	Sec. 16, T. 41 N., R. 62 W.	Pierre clay, 12–24 inches	.7	.....
B15187			Pierre clay, 24–36 inches	1.5	.....
B15188			Shale, 36–48 inches	4	.....
B15189	1a	do	Vetch *sparsifolia*	.....	4
B15190	1b	do	Unidentified vegetation	.....	10
B15191	1c	do	Wheatgrass	.....	6
B15192	2	Sec. 9, T. 41 N., R. 63 W.	Soil on Fox Hill formation, 0–6 inches	1	.....
B15194	4	Sec. 36, T. 45 N., R. 62 W.	Brown clay loam, 0–10 inches	.2	.....
B15193	3a	do	*A. racemosus* tops	.....	650
B15191A	3b	do	*A. racemosus* roots	.....	20
B15361	12a	9 miles south of Red Bird, on U. S. 85.	Two-grooved poisonvetch	.....	80
B15362	13	11 miles south of Red Bird, on U. S. 85.	Pierre clay loam, 0–6 inches	.....	.....
B15363	13a	do	Two-grooved poisonvetch	.....	60
B15364	14	3.4 miles west of U. S. 85, on Lance Creek Road.	Pierre clay loam, 0–6 inches	.5	.....
B15365	14a	do	Broom snakeweed	.....	15
B15366	15	6 miles west of U. S. 85, on Lance Creek Road.	Pierre clay loam, 0–6 inches	.4	.....
B15367	15a	do	Two-grooved poisonvetch	.....	450
B15194A	4a	Sec. 36, T. 45 N., R. 62 W.	*A. missouriensis*	.....	7
B15368	5	3.5 miles south of New Castle, on U. S. 85.	Pierre clay loam, 0–6 inches	.3	.....
B15369	5a	do	Crazyweed	.....	8

TABLE 1.—*Selenium content of soils and vegetation in Nebraska, South Dakota, and Wyoming, south and southwest of the Black Hills*—Continued

WESTON COUNTY, WYO.—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B15370	6	5.8 miles south of New Castle, on U. S. 85	Pierre clay loam, 0–6 inches	2	
B15371	6a	do	Two-grooved poisonvetch		50
B15372	7	7 miles south of New Castle, on U. S. 85	Pierre clay loam 0–6 inches	1	
B15373	7a	do	Two-grooved poisonvetch		40
B15374	8	10.5 miles south of New Castle, on U. S. 85	Pierre clay loam, 0–6 inches	.3	
B15375	8a	do	Crazyweed		6
B15376	9	15 miles south of New Castle, on U. S. 85	Niobrara clay loam, 0–6 inches	.4	
B15377	9a	do	*A. missouriensis*		20
B15378	10	17.5 miles south of New Castle, on U. S. 85	Niobrara clay loam, 0–6 inches	.8	
B15379	10a	do	Mountain penstemon		7
B15380	12	2.75 miles west of U. S. 85, on Morrisey Trail	Pierre clay loam, 0–6 inches	1.5	
B15381	12a	do	Parry aster		25
B15382	13	6.5 miles west of U. S. 85, on Morrisey Trail	Pierre clay loam, 0–6 inches	1.5	
B15383	13a	do	Parry aster		110
B15384	14	8.25 miles west of U. S. 85, on Morrisey Trail	Pierre clay loam, 0–6 inches	.4	
B15385	14a	do	Wheatgrass		25

TABLE 2.—*Selenium content of miscellaneous samples of soil and vegetation adjacent to the Black Hills on the northwest, north, and east*

CROOK COUNTY, WYO.

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P. p. m.	*P. p. m.*
B15394	1	0.5 mile north of county line, on U. S. 216	Pierre clay loam, 0–6 inches	6	
B15395	1a	do	Two-grooved poisonvetch		6,530
B15396	1b	do	Parry aster		460
B15397	2	2.7 miles north of county line, on U. S. 216	Pierre clay loam, 0–6 inches	.5	
B15398	2a	do	Two-grooved poisonvetch		20
B6308	E19	9 miles southeast of Alzada	Pierre clay, 0–6 inches	.6	
B6308A	E19a	do	Mixed grasses		0

CARTER COUNTY, MONT.

B15722	1a	36 miles southeast of Broadus	Two-grooved poisonvetch		460
B15723	1b	do	Stanleya		800
B6292	E5	4 miles west of Ridge	Pierre clay, 0–6 inches	0.4	
B6292A	E5a	do	Mixed grasses		0
B6293	E6	12 miles east of Ridge	Pierre clay, 0–6 inches	.8	
B6294	E6a	do	Sagebrush		1.7
B6294A	E7a	7 miles north of E6	Two-grooved poisonvetch		510
B6297	E9	7 miles northeast of Alzada	Pierre clay, 0–6 inches	1	
B6298	E9a	do	Two-grooved poisonvetch		200
B6299	E10a	13 miles northeast of Alzada	do		980
B6300	E11	13.5 miles northeast of Alzada	Alluvial soil, 0–6 inches	1	
B6301	E11a	do	Two-grooved poisonvetch		515

TABLE 2.—*Selenium content of miscellaneous samples of soil and vegetation adjacent to the Black Hills on the northwest, north, and east*—Continued

BUTTE COUNTY, S. DAK.[1]

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B11534	1	SW corner sec. 15, T. 10 N., R. 4 E.	Pierre clay, 0-6 inches	0.7	
B11535	1a	do	Corn (ears)		0
B11474	2	NW corner sec. 29, T. 10 N., R. 4 E.	Orman clay, 0-6 inches	1.5	
B11475	2a	do	*Astragalus* (sp?)		15
B10382A	3	NW corner sec 27, T. 9 N., R. 6 E.	Pierre clay, 0-6 inches	1.5	
B10382	3a	do	Russian-thistle		40
B10374	2	NE corner sec. 18, T. 9 N., R. 6 E.	Pierre clay, 0-6 inches	1	
B10374	2a	do	Wreath aster		80
B12331	1	NE corner sec. 35, T. 9 N., R. 5 E.	Pierre clay loam, 0-6 inches	1.5	
B11540	1a	do	*Astragalus* (sp?)		235
B10335	7	NW corner sec. 36, T. 9 N., R. 4 E.	Orman clay, 0-9 inches	1.5	
B10333	5	do	Wild lettuce		30
B10334	6	do	Alfalfa		2
B11536		NW corner sec. 17, T. 8 N., R. 5 E.	Niobrara chalk (unweathered)	10	
B11536A		do	Niobrara chalk (weathered)	24	
MEADE COUNTY, S. DAK.					
B11523	2	NW corner sec. 1, T. 7 N., R. 5 E.	Pierre clay, 0-6 inches (irrigated)	10	
B11524	2a	do	Russian-thistle		3
B10835	3	NW corner sec. 6, T. 7 N., R. 6 E.	Pierre clay, 0-6 inches (irrigated)	1.6	
B10836	3a	do	Sweetclover		1
B11519	1	NE corner sec. 1, T. 7 N., R. 7 E.	Pierre clay, 0-6 inches (irrigated)	1	
B11520	1a	do	Rabbitweed		20
B11772	1	NE corner sec. 8, T. 7 N., R. 7 E.	Pierre clay loam, 0-6 inches (not irrigated)	.3	
B11773	1a	do	Gumweed		40
B6865	F18	Sec. 11, T. 3 N., R. 9 E.	Gumbo soil, 0-6 inches	.7	
B6866	F18a	do	Alfalfa		1
B6888	F31	8 miles north of Viewfield	Gumbo soil, 0-6 inches	2.5	
B6889	F31a	do	Unidentified plant		6
B6895	F35	4 miles northeast of Underwood	Gumbo soil, 0-6 inches	1.5	
B6896	F35a	do	Wheatgrass		3
PENNINGTON COUNTY, S. DAK.					
B13519	66	Sec. 26, T. 2 N., R. 9 E.	Pierre soil, 0-6 inches	1	
B13519A	66a	do	Mixed grasses		1
B13567	106	Sec. 10, T. 1 N., R. 8 E.	Pierre soil, 0-6 inches	1	
B13570	106a	do	Alfalfa		4
B13575	9	Sec. 17, T. 1 N., R. 9 E.	Pierre soil, 0-6 inches	20	
B13475	9a	do	Mixed grasses		2
B13074	57	Sec. 33, T. 1 N., R. 9 E.	Pierre soil, 0-6 inches	1.6	
B13511	57a	do	*Astragalus* (sp?)		420
B13633	50	Sec. 6, T. 1 S., R. 9 E.	Pierre soil, 0-6 inches	2	
B13533	50a	do	*Astragalus* (sp?)		250
B13637	54	do	Pierre soil, 0-6 inches	1.5	
B13537	54a	do	*Astragalus* (sp?)		930
B15206	1a	3 miles east of Rapid City	*A. racemosus*		920
B15207	1b	do	Dandelions growing under *Astragalus*		25
B15271	3b	½ miles east of Rapid City	Dandelions		170
B15272	3c	do	Alfalfa		25
B15274	5a	5½ miles southeast of Rapid City	Young wheat		25
CUSTER COUNTY, S. DAK.					
B13643	79	Sec. 26, T. 2 S., R. 8 E.	Pierre soil, 0-6 inches	0.5	
B13645	79a	do	Mixed grasses		0
B13641	77	Sec. 35, T. 2 S., R. 8 E.	Pierre soil, 0-6 inches	4	
B13643	77a	do	Buffalo grass		1
B13661	102	Sec. 1, T. 3 S., R. 8 E.	Pierre soil, 0-6 inches	14	
B13662	99	Sec. 18, T. 3 S., R. 8 E.	do	1.5	
B13505	99a	do	Alfalfa		60
B14833	2	Sec. 18, T. 6 S., R. 7 E.	Dark-gray alluvium, 0-6 inches	2	
B14834	2a	do	Young wheatgrass		6
B3069	6 4	Sec. 23, T. 3 S., R. 8 E.	Pierre shales	8	
B3078	7 8	do	Niobrara chalk	20	

[1] Representative samples from several hundred analyses.

The soil survey of Sheridan County, Nebr. (*8*), shows a small area of soils derived from Pierre and Niobrara shales in the extreme northwestern corner of the county. The soil map shows that the area is partially covered by Rosebud soils and by rough undifferentiated land. In such areas the surface soils are much mixed, and it is not to be expected that sharp differentiation between seleniferous areas and nonseleniferous areas will be found.

In figure 2 there is indicated a small dome where Niobrara shales are exposed, and in this area the soils and vegetation are strongly impregnated with selenium (nos. B15233 and B15237, table 1). This district is indicated by the analyses to be a potentially serious source of animal disturbance by the selenium content of the vegetation. It is also locally recognized as toxic.

The area in Dawes County, Nebr., represented by the samples in the second section of table 1, is indicated by the soil map (*1*) to consist largely of Pierre soils derived from Pierre and Niobrara shales. Included in this area, however, are small spots consisting of soils derived wholly or in part from Carlile shale, Brule clay, and other members of the White River formations which are either lacking or low in selenium. It is doubtful whether more than very limited areas consist wholly of soil derived from seleniferous sources.

In the northeastern section there is a definite outcropping of Niobrara shales with consequent high selenium content of both soils and vegetation (field nos. 6, 7, and 7b). The samples in this county were for the most part collected so early in the spring that either no vegetation or only that which was dead and leached could be obtained. These samples contained little or no selenium. Later in the bulletin it will be shown that dead vegetation very rapidly loses its selenium content (p. 18). A little later in the season (late May) a few samples of green vegetation (mostly species of *Astragalus*) were obtained. These showed that the normal content of selenium for the various species corresponds roughly to the selenium content of the soils. The species *A. missouriensis* was low in selenium as compared with either *A. racemosus* or *A. bisulcatus*. Certain other species of *Astragalus* usually show little tendency toward absorption of selenium.

Over the greater portion of the Dawes County area the selenium content of the soil is below 1 part per million and in many places below 0.5 part per million. Soils as low as 0.5 part per million will render toxic only plants having exceptional power of selenium absorption. It is reasonably certain that the ordinary forage plants are usually not highly seleniferous. Such, however, is not always the case. Wheatgrass and alfalfa samples were found which were toxic, one of the latter notably so (B14538). One pair of samples on an irrigated area (B14829 and B14830) are to be particularly noted. These samples were collected by the writer and were definitely under irrigation conditions. No information is at hand with reference to the length of time irrigation has been used or to the character of the irrigation water.

The area represented by the samples collected from Sioux County corresponds to the area covered by Pierre soils in the soil survey report of that county (*15*). In this area intermixture of White River formation materials is frequently evident, and considerable portions of the soil may be regarded as derived chiefly from these sources.

Among the soil samples examined many have a selenium content of more than 0.5 part per million and are consequently regarded as capable of producing injurious vegetation. That toxic vegetation is produced is indicated by the samples examined, even though they are relatively few in number.

One group of samples is of particular interest. B15277 (table 1) represents a soil to the depth of 6 inches in which a sample of two-groove poisonvetch was growing. The soil had a selenium content of 1.5 parts per million and the poisonvetch of 570 parts per million. The first inch of the soil contained but 2 parts per million, and the organic debris upon it, representing the semidecayed vegetation of the previous season, contained but 4 parts per million. This relation has shown itself to be general. Numerous examples show that the selenium of air-dried vegetation is readily leached and returned to the soil when the plants are macerated in water or are dead and partially decayed.

The samples from Shannon and Fall River Counties in South Dakota represent the areas shown in figure 2 as outcrops of Pierre and Niobrara shales. No detailed soil map has been made of these areas. The reconnaissance survey of western South Dakota (5) shows the same areas as dominantly of the Pierre type. The greater portion of the samples were collected in late May, and hence vegetation was readily obtainable. In November additional samples were secured in order to present a better picture of the area of Niobrara-derived soils north and west of Ardmore. The outcrop of Niobrara shales in southwestern Shannon County presents a small area of particularly toxic soils. In this area are a number of springs which are reputedly poisonous and presumed to owe their toxicity to arsenic. This is more fully discussed on page 69.

It would appear that the whole area indicated in figure 2 as representing outcrops of Pierre and Niobrara shales in Shannon and Fall River Counties has soils seleniferous in character and produces toxic vegetation. It seems clear, however, that much of this area is not seriously affected, and as a result of variation in soil character and the selective powers of various types of vegetation by no means is all the vegetation injurious. It must be kept in mind that this investigation had for its purpose the location of seleniferous areas and not the determination of the limits of intensely toxic as contrasted with less toxic areas.

Continuing the investigation of the areas corresponding to the outcrops of Pierre and Niobrara shales, a number of samples were secured in Niobrara and Weston Counties in Wyoming. Because of the relative narrowness of the strips and the presence of overlying material derived from other formations, the samples were for the most part collected from spots adjacent to or upon the exposures along the line of United States Highway 85 between New Castle and Hat Creek. The same general relations were found as in South Dakota and Nebraska. The soil content ranged from fractional to 16 parts per million. The samples of vegetation, selected for the most part from plants known to be good absorbents of selenium, ranged from four to several hundred parts per million. It is safe to assert that vegetation ranging from nontoxic to extremely toxic is produced over the whole area. It is also clear that the variation is wide, depending upon the character of the vegetation and the soil.

Examination of the geologic map of the United States (*16*) shows that the belt of Pierre and Niobrara soils continues about the northern section of the Black Hills and includes parts of Crook County, Wyo.; Carter County, Mont.; Butte, Meade, Pennington, and Custer Counties, and a small portion of Washington County, S. Dak. No attempt has been made to connect these areas through a continuous series of samples. In Technical Bulletin 482 (*2*) are given a series of samples from Carter County, Mont., and from Butte, Meade, and Pennington Counties, S. Dak.

In table 2 are given the results of analyzing some miscellaneous samples from the region in question. These samples, taken in 1934, are only a small fraction of the total samples examined.

Study of the data in table 2 reveals that the same general conditions obtain in the soil areas north and east of the Black Hills as south and west of them. Wherever the soils are derived in major part from Pierre and Niobrara shales toxic vegetation may be produced. The degree of toxicity varies widely with variation in soils and in types of vegetation. By no means is all the vegetation toxic. It seems reasonably well established that normal forage and cereal crops are among the forms of vegetation not frequently found virulently toxic.

SELENIUM IN COLORADO SOILS

As a result of the reconnaissance survey of T. D. Rice, reported in Technical Bulletin 482 (*2*), selenium was shown to occur in various parts of Colorado. These observations warranted a closer inspection of several areas, the largest of which appeared to be in Mesa, Montrose, and Delta Counties. Interest in this area is acute since it includes two large irrigation projects and remarkable quantities of selenium have been found in the drainage water of the irrigation areas and in the Uncompahgre, Gunnison, and Colorado Rivers below the points of reception of these drainage waters (*17*). For the purpose of making an inspection, John T. Miller and the writer visited the area in the latter part of May 1935 and collected a considerable number of representative samples of soils and vegetation as well as of drainage and other waters. The results of the examination of these are given in table 3.

TABLE 3. *Selenium content of soils and vegetation from Colorado*

MESA COUNTY

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P.p.m.	*P.p.m.*
B15075			Billings clay loam, 0-12 inches (not irrigated).	2	
B15076	1	Sec. 10, T. 9 S., R. 103 W.	Billings clay loam, 12-24 inches	3	
B15077			Billings clay loam, 24-36 inches	5	
B15078			Billings clay loam, 36-48 inches	8	
B15078A	1a	do	*Astragalus* (sp?)		8
B15078B	1b	do	Unidentified plant		6
B15078C	1c	do	American peppergrass		5
B15078D	1d	do	Wild oats		1
B15079			Billings clay loam, 0-12 inches (irrigated).	2	
B15080	2	Sec. 15, T. 9 S., R. 103 W.	Billings clay loam, 12-24 inches	1.5	
B15081			Billings clay loam, 24-36 inches	3	
B15082			Billings clay loam, 36-48 inches	5	

TABLE 3.—*Selenium content of soils and vegetation from Colorado*—Continued

MESA COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P.p.m.	*P.p.m.*
B15085	2a	Sec. 15, T. 9 S., R. 103 W.	Alfalfa	-------	40
B15083A	2b	do	Red clover	-------	8
B15083B	2c	do	Young wheat	-------	18
B15084	3	Sec. 6, T. 2 N., R. 3 W.	Shale in drainage ditch	4	-------
B15085	4	Sec. 15, T. 9 S., R. 103 W.	Alkali seepage crust	52	-------
B15086	5a	4 miles west of Mack	*Astragalus* (sp?)	-------	40
B15087A	6a	1 mile north of Mack	Sego-lily	-------	25
B15087	6b	do	*Astragalus missouriensis*	-------	6
B15088	6c	do	Prairie daisy	-------	25
B15090	7	Sec. 34, T. 2 N., R. 3 W.	Alkali seepage soil, 0-8 inches	8	-------
B15091	7a	do	Common milkweed	-------	25
B15105	16	Sec. 8, T. 2 N., R. 2 W.	Billings clay loam, 0-12 inches	.5	-------
B15106	17	do	Billings silt loam, 0-12 inches (not irrigated).	.5	-------
B15107			Billings silt loam, 12-24 inches (not irrigated).	.6	-------
B15108			Billings silt loam, 24-36 inches (not irrigated).	.7	-------
B15109			Billings silt loam, 36-48 inches (not irrigated).	.5	-------
B15109A	17a	do	*Astragalus* (sp?)	-------	30
B15110	18	Sec. 17, T. 2 N., R. 2 W.	Billings silt loam, 0-12 inches (irrigated).	1	-------
B15111			Billings silt loam, 12-24 inches (irrigated).	1	-------
B15112	18	do	Billings silt loam, 24-36 inches (irrigated).	.5	-------
B15113			Billings silt loam, 36-48 inches (irrigated).	.5	-------
B15114	18a	do	Alfalfa	-------	8
B15115	19	do	Alkali seepage	6	-------
B15117	20	Sec. 28, T. 2 N., R. 2 W.	Billings clay loam, 0-12 inches	1	-------
B15118	21	East line of Fruita	Alkali crust, 0-12 inches	.4	-------
B15119	22	1 mile south of Fruita	Laurel silt loam, 0-12 inches (alkali crust).	.6	-------
B15120	23	2½ miles southwest	Gunnison shale	5	-------
B15120A	23a	do	*Astragalus* (sp?)	-------	440
B15121	24	*2 miles south of Fruita*	*Clay from Gunnison shale*	2	-------
B15122	25	Dinosaur bed south of Fruita	Fragment of dinosaur (fossil)	.2	-------
B15092			Mesa clay, 0-12 inches (not irrigated).	4	-------
B15093	8	Sec. 20, T. 1 S., R. 1 E.	Mesa clay, 12-24 inches (not irrigated).	10	-------
B15094			Mesa clay, 24-36 inches (not irrigated).	4	-------
B15095	8a	do	*Astragalus* (sp?)	-------	12
B15096	9	Sec. 32, T. 1 S., R. 1 E.	Mesa clay, 0-12 inches (irrigated)	.5	-------
B15097			Mesa clay, 12-24 inches (irrigated)	.5	-------
B15098			Mesa clay, 24-36 inches (irrigated)	.6	-------
B15099	9a	do	Alfalfa	-------	10
B15100	10	Sec. 29, T. 1 S., R. 1 E.	Salt crust soil, 0-8 inches	2.5	-------
B15101	15	5 miles southeast of Grand Junction, on U. S. 50	Mesa clay loam, 0-12 inches	1	-------
B15101A	15a	do	Alfalfa	-------	12
B15100A	13a	½ mile north of Whitewater	Plains milkweed	-------	15
B15101	12	¼ mile north of Whitewater	Billings clay loam, 0-6 inches	2	-------
B15102	13	1¼ miles east of Whitewater	Billings clay loam, 0-6 inches	3	-------
B15103	14	3 miles north of Whitewater	Mancos shale	3	-------
B15123	26	Sec. 36, T. 1 S., R. 1 W.	Chipeta sandy clay, 0-12 inches	5	-------
B15124	27	Sec. 1, T. 1 S., R. 1 W.	Mesa clay loam, 0-12 inches (not irrigated).	.7	-------
B15125			Mesa clay loam, 12-24 inches (not irrigated).	3	-------
B15126			Mesa clay loam, 24-36 inches (not irrigated).	3.5	-------
B15128	28	do	Mesa clay loam, 0-12 inches (irrigated).	.5	-------
B15129			Mesa clay loam, 12-24 inches (irrigated).	.6	-------
B15130			Mesa clay loam, 24-36 inches (irrigated).	1.5	-------
B15130A	28a	do	Alfalfa	-------	15
B15131	29	Sec. 12, T. 1 S., R. 1 W.	Mesa clay loam, 0-6 inches	.6	-------

TABLE 3.—*Selenium content of soils and vegetation from Colorado*—Continued

MESA COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P.p.m.	*P.p.m.*
B15132	30	Sec. 9, T. 11 S., R. 98 W.	Mesa fine sandy loam, 0–12 inches (irrigated).	0.3	
B15133			Mesa fine sandy loam, 12–24 inches (irrigated).	.5	
B15134			Mesa fine sandy loam, 24–36 inches (irrigated).	.5	
B15135			Mesa fine sandy loam, 36–48 inches (irrigated).	.7	
B15136	30a	....do....	Young Canadian field peas		12
B15137	31	Sec. 9, T. 11 S., R. 98 W., 475 feet from tile drain)	Mesa fine sandy loam, 0–12 inches (irrigated).	.5	
B15138			Mesa fine sandy loam, 12–24 inches (irrigated).	.3	
B15139			Mesa fine sandy loam, 24–36 inches (irrigated).	.4	
B15140			Mesa fine sandy loam, 36–48 inches (irrigated).	.7	
B15141	31a	....do....	Young Canadian field peas		10
B15143	32	Sec. 9, T. 11 S., R. 98 W..	Mesa fine sandy loam, 0–12 inches	.3	
B15144			Mesa fine sandy loam, 12–14 inches	.3	
B15145			Mesa fine sandy loam, 24–36 inches	.5	
B15146			Mesa fine sandy loam, 36–48 inches	.5	
B15147	33a	Sec. 5, T. 11 S., R. 98 W..	Common milkweed		6
B15148	34a	....do....	Timothy		7
B15150	35	2½ miles southeast of Palisade	Shale, 35 feet	.4	
B15151	36	2¾ miles southeast of Palisade	Shale, 100 feet	1	

DELTA COUNTY

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P.p.m.	*P.p.m.*
B15050	1	Sec. 20, T. 15 S., R. 95 W..	Mesa clay, 0–12 inches (irrigated)	1	
B15051			Mesa clay, 12–24 inches (irrigated)	1	
B15052			Mesa clay, 24–36 inches (irrigated)	.2	
B15052A			Alfalfa		10
B15053	2	....do....	Alkali seepage soil, 0–6 inches	1	
B15054	4	N ½ sec. 26, T. 15 S., R. 95 W..	Chipeta clay, 0–12 inches (formerly irrigated).	3	
B15055			Chipeta clay, 12–24 inches (formerly irrigated).	3.5	
B15056			Chipeta clay, 24–30 inches (formerly irrigated).	2.5	
B15057			Chipeta clay, 30–36 inches (formerly irrigated).	2	
B15058	4a	....do....	Desert daisy		50
B15060	5	Sec. 19, T. 15 S., R. 95 W.	Billings clay, 0–12 inches	4	
B15061			Billings clay, 12–24 inches	4	
B15062			Billings clay, 24–36 inches	4	
B15063			Billings clay, 36–48 inches	2.5	
B15064	5a	....do....	Alfalfa		15
B15065	6	8 miles north of Delta, on U. S. 50.	Mancos shale, 50 feet	2	
B15066			Bentonite, 250 feet	.8	
B15067			Concretions, 300 feet	.5	
B15068			Limestone, 400 feet	2	

MONTROSE COUNTY

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P.p.m.	*P.p.m.*
B15023	9	Sec. 9, T. 48 N., R. 9 W.	Billings clay, 0–12 inches (irrigated).	0.4	
B15024			Billings clay, 12–24 inches (irrigated).	.3	
B15025			Billings clay, 24–36 inches (irrigated)	.5	
B15026			Billings clay, 36–38 inches (irrigated)	.6	
B15023A	9a	....do....	Alfalfa		3
B15023B	9b	....do....	Unidentified vegetation		8
B15002	1a	Sec. 26, T. 49 N., R. 9 W.	Young wheat		5
B15002A	1b	....do....	Dandelions		8
B15003	2	Sec. 27, T. 49 N., R. 8 W.	Billings clay, 0–6 inches (not irrigated).	3.6	
B15004	2a	....do....	Greasewood		7
B15005	3	....do....	Billings clay loam, 0–8 inches (irrigated).	1	
B15006			Billings clay loam, 8–18 inches (irrigated).	1	
B15007			Billings clay loam, 18–24 inches	1	
B15008			Billings clay loam, 24–36 inches	1	
B15009			Billings clay loam, 36–48 inches	.7	

TABLE 3.—*Selenium content of soils and vegetation from Colorado*—Continued

MONTROSE COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soil or shale	Vegetation
				P.p.m.	*P.p.m.*
B15011	4	Sec. 27, T. 49 N., R. 8 W. (100 feet west of no. 3).	Billings clay loam, 0–10 inches (not irrigated).	1.5	
B15012			Billings clay loam, 10–20 inches (not irrigated).	2	
B15013			Billings clay loam, 20–28 inches (not irrigated).	2	
B15014			Billings clay loam, 28–38 inches (not irrigated).	3	
B15015			Billings clay loam, 38–48 inches (not irrigated).	2	
B15016	4a	----do----------	American peppergrass..		20
B15018	5	---do----------	Salt crust, 0–1 inch	2	
B15019	6a	About SW corner sec. 30, T. 49 N., R. 8 W.	Alfalfa----------		2
B15021	7a	About SE corner sec. 25, T. 49 N., R. 9 W.	Alfalfa----------		10
B15022	8	do----	Gypsiferous shale---	3.5	
B15027	10	Sec. 17, T. 47 N., R. 8 W.----	Billings clay loam, 0–8 inches (irrigated).	2	
B15028			Billings clay loam, 8–18 inches (irrigated).	1.5	
B15029			Billings clay loam, 18–36 inches (irrigated).	1	
B15029A	10a	do--	Dandelions.		15
B15030	11	Sec. 17, T. 47 N., R. 8 W. (100 yards south of no. 10).	Billings clay loam, 0–8 inches (not irrigated).	1.5	
B15031			Billings clay loam, 8–18 inches (not irrigated).	2	
B15032			Billings clay loam, 18–36 inches (not irrigated).	1.5	
B15033	11a	---do----------	*Astragalus* (sp?).		330

The samples reported upon in table 3 were collected on or near the Grand Valley and Uncompahgre irrigation projects. They do not present a comprehensive survey of the area, but do present a representative selection which offers a fair picture of the conditions in a portion of the area shown in the Geological Survey map of the United States as an outcrop of Colorado and Mesaverde formations (*16*) (fig. 1). In these formations are included a variety of shales, among them the Pierre system. The shale in the immediate area with which this investigation is concerned appears to be Mancos shale for the most part. A considerable number of samples of shale, presumably Mancos, have been examined, and show a selenium content ranging from 12 parts per million downwards. No samples of definitely identified Mesaverde material have been examined. The exposure of these soil sources continues westward nearly to the Utah-Nevada line and southward toward Arizona. It is presumed, therefore, that similarly seleniferous soil areas may be found wherever these shales are the soil parent material. The data of table 3 seem to point to a lower selenium content of the soils influenced by the Mesaverde material, but the study is not sufficiently detailed to determine whether the result is owing to a smaller initial impregnation or to removal by water from the more porous soil derived from this shale.

That drainage removes the selenium from the soils is evident from the data in table 4. The samples represented in this table were collected through cooperation with W. D. Collins and C. S. Howard of the Quality of Water Division, United States Geological Survey

(*17*). They present a general picture of the selenium relations shown by the drainage water derived from seleniferous soils.

TABLE 4.—*Selenium content of irrigation and drainage waters or ditch deposits*

Laboratory no.	Field no.	Location	Material	Selenium content
				P. p. m.
B14417	1	Colorado River, near Cameo	Water	0
B14423	8	Gunnison River, near Cimarron	do	0
B15107	3	Uncompahgre River, 5 miles south of Ouray	do	0
B15106	2	Uncompahgre River, 13 miles south of Montrose	do	0
B15108	4	Bear Creek, 3 miles south of Ouray	do	0
B15200	6	Cow Creek	do	.002
B15201	7	Uncompahgre River at Colona (December 1934)	Water	.002
B15202	7	Uncompahgre River at Colona (May 1935)	do	.003
B14425	10	Uncompahgre River, ¾ mile northwest of Delta	do	.220
B14414	20	do	Sand and clay bar	9
B14427	12	Gunnison River, ½ mile north of Delta	Water	.007
B14416	22	Drainage ditch, ½ mile north of Delta	Ditch deposit	1.5
B14421	6	Drainage ditch, near Montrose	Water	.700
B14426	11	Drainage ditch, 2 miles east of Montrose	do	.320
B14415	21	Drainage ditch, 2 miles east of Delta	Ditch deposit	28
B14424	9	Main lateral ditch, 1 mile south of Chipeta	Water	1.050
B14412	18	do	Salt crust	100
B14413	19	do	Ooze in ditch	4
B14420	4	Gunnison River, near Redlands	Water	.080
B14420A	5	Colorado River, near Grand Junction	do	.030
B15203	9	Surface drainage, 1 mile north of Mack	do	.007
B14418	2	Drain, 4 miles north of Mack (December 1934)	do	1.980
B15202	8	Drain, 4 miles north of Mack (May 1935)	do	2.680
B14419	3	Main drain, 1½ miles east of Loma	do	.630
B14422	28	do	Salt crust	16
B15204	10	Surface drainage, near Loma	Water	.003
B14439	25	6.5 miles east of Fruita	Salt crust	260
B17825		San Juan River, at Bluff, Utah	Water	.006
	31	Dolores River, near Cisco	do	(?)
	32	Green River, at Green River	do	(?)
	33	Colorado River, near Topock	do	.003

[1] Compare B15072 and B15085, table 3.

[2] Trace.

The data of table 4 demonstrate very clearly that the three streams which furnish water to the irrigation districts under investigation contain no selenium in excess of 1 part per billion before they receive the drainage from irrigation. The tributary of the Uncompahgre, Cow Creek, which shows the first trace of selenium, 2 parts per billion, receives the drainage of about 1,200 acres of irrigated land, according to information received from C. B. Carpenter of the Denver & Rio Grande Railway. Every sample of drainage water examined within the area contained selenium, and the quantities ranged from 3 parts per billion up to 2.68 parts per million. The river content increases with increase of drainage area. Despite the dilution produced by nonseleniferous streams, for example, the Green and Dolores, the Colorado still has a readily determinable selenium content at Topock, Ariz. Thus, the Uncompahgre near its confluence with the Gunnison has a selenium content of 220 parts per billion, and the Gunnison near its junction with the Colorado, 80 parts per billion. The quantities so contributed added to that collected by the Colorado itself give it a content at Grand Junction of 30 parts per billion.

These observations are of extreme importance, especially when coupled with the evidence that selenium in green vegetation becomes water-soluble during plant decay. They show that not only is the fate of selenium in soil-forming processes dependent upon eluviation, but also that irrigation, with under drainage, is a potent influence in decreasing the injurious effects produced by selenium upon crop production.

In Technical Bulletin 482 (*2*) attention was called to the striking freedom from selenium of normal crop vegetation in the Belle Fourche area in South Dakota. This effect was ascribed in part to lowering of the selenium content of the soils through drainage and, perhaps in still larger part, to the presence of large quantities of sulphates in the irrigation water. An analagous situation exists in the areas under discussion. The Uncompahgre irrigation supply has 416 parts of sulphate per million; that from the Gunnison, 22; and that from the Colorado, 270. The corresponding concentrations at the mouths of the Uncompahgre and Gunnison are 1,061 and 861 parts per million, while the Colorado at Grand Junction has 565. It is evident, then, that not only is the protective effect against selenium absorption by plants, demonstrated by Hurd-Karrer (*9*), to be expected from the sulphate content of irrigation water, but that it is increased by solution from the irrigated soils themselves. Indeed, in the drainage ditch near Montrose (B14421, table 4) the sulphate content of the water rises to 4,000 parts per million and the sulphate-selenium ratio is approximately 5,700.

The presence of sulphates does not wholly inhibit the absorption of selenium (*10*). This is also shown by the data given in table 4. (See also p. 52.)

Despite the presence of selenium in all the samples collected by the writer, whether on irrigated or on unirrigated soils, the quantities found are not serious unless they represent a general average of food and forage crops over the whole district. In order to determine this point H. J. Wichmann, of the Food and Drug Administration, enlisted the services of field agents of that organization to secure a large number of samples of the commercial crops grown in these areas. They were collected, for the most part, by A. D. Cromartie. They included 33 samples of apples, 14 samples of alfalfa, 18 samples of corn, and 11 assorted samples of beans, beet tops, carrot tops, and oat hay. These were examined for selenium. One sample of corn leaves from the area near Mack in the Grand Valley area contained 18 parts per million of selenium. The assorted samples, including the corn and alfalfa, showed a selenium content ranging from 3 parts per million to the merest trace. No sample of apples, either in pulp or skin, showed any trace of selenium, at least in excess of 0.1 part per million. The apple seeds had a maximum content of 0.5 part per million, but in most cases even the seeds showed scarcely detectable traces. The apparent reasons for the higher selenium content in the vegetation collected by the writer are that the collections were made before active irrigation had begun and the plant samples were young and selected from locations specially favorable for selenium absorption. It seems clear that no serious selenium danger exists in these irrigated areas. There is a certain menace from forage poisoning in the nonirrigated areas.

SELENIUM IN KANSAS SOILS

The geological maps of Kansas show outcropping formations in a series of increasing age, extending from the western portion of the State eastward. These exposures include the Cretaceous shales, known elsewhere to contain selenium. These shales are not exposed uniformly, but a generalized sketch (fig. 3) shows a succession of

exposures in a line running through the north-central portion of the State. The exposures present a series of "spear heads", very clearly shown in figure 4.

In Technical Bulletin 482 (*2*) there was reported a series of shale and vegetation samples of notably high selenium content from Gove, Logan, and Wallace Counties. It seemed important therefore to determine the nature and extent of this seleniferous area. For this purpose, John T. Miller, in the late summer and fall of 1935, undertook the collection of a series of samples and observations. It soon became apparent that the geological maps offered an excellent guide to seleniferous soils. It later became clear that the flora also could

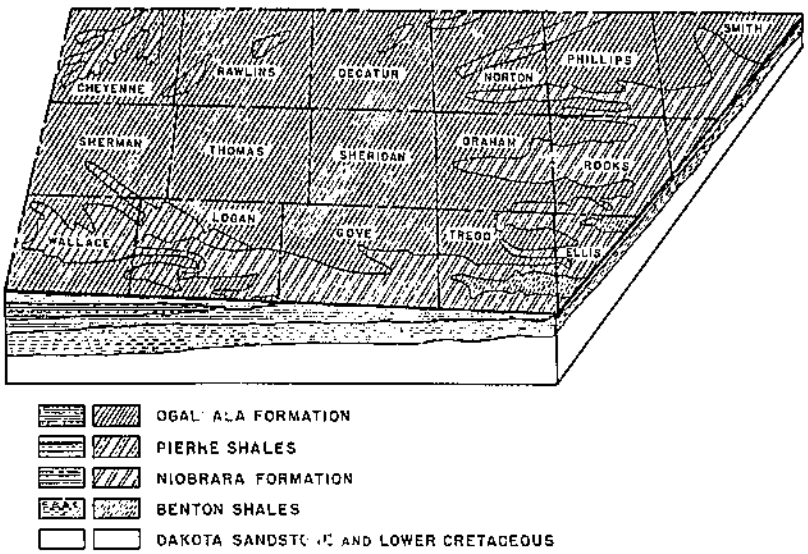

FIGURE 3.—Generalized sketch showing the relation of geologic formations to soil formation. In this sketch a mantle of loess overlying a considerable part of the area is disregarded.

be used as indicators of seleniferous areas. A number of difficulties were encountered. Among these, as ought to be expected from the echelon character of the shale exposure, is that at or near the junction of the different shales it is impossible to determine to what extent a given shale contributes to the residual soil, and since the successive shales also overlap on the north and south sides of areas, this condition added to the difficulty of accurate differentiation.

Difficulty also arose from the fact, previously shown (*2*), that different portions of individual shales vary in selenium content. It is also known that different species of plants show wide range in selective absorption and that absorption is notably influenced by soil components other than selenium (*9*, *10*), notably sulphur. Another influence modifying the selenium content of the soil, and therefore of the vegetation, is the shifting of soil by the wind. This is particularly important in the areas immediately over rough outcrops of seleniferous shales.

The ultimate method of survey was to make a transverse sampling of the geological outcrops to determine the width of the area pre-

sumably capable of producing toxic vegetation. The samples were taken so that at least one transect was made for each series of townships. Where little or no selenium was expected to be found, the number of samples taken was smaller than where it was definitely known to be present. As in other areas, the vegetation selected was

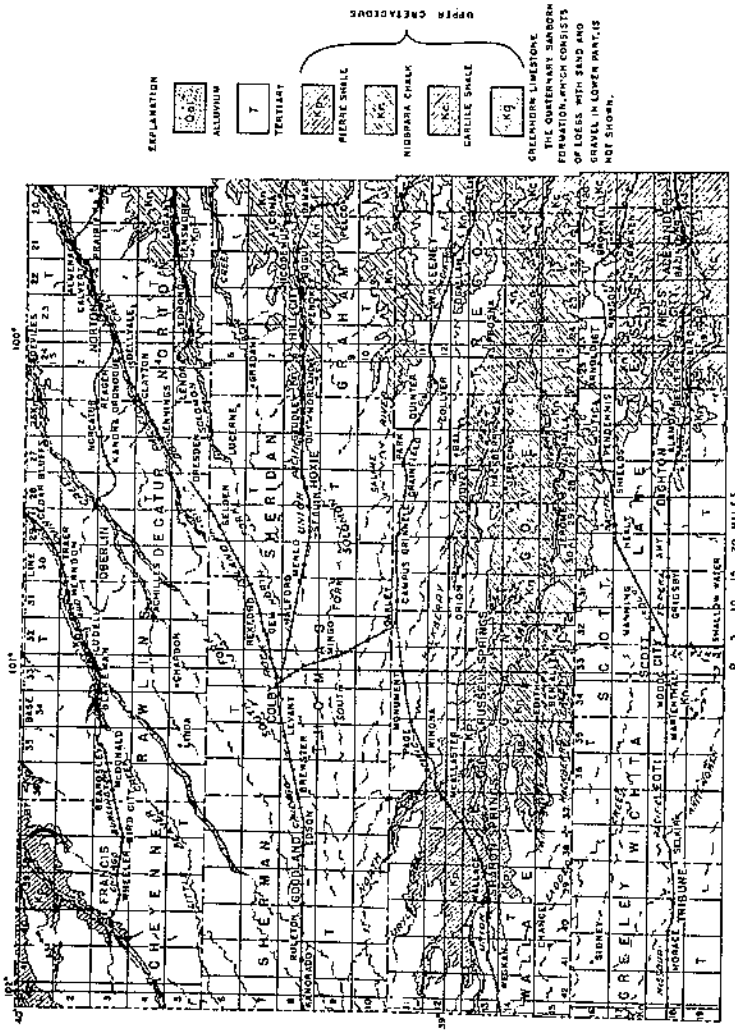

FIGURE 4. Geologic map of northwestern Kansas. (Published by University of Kansas, State Geological Survey.)

largely of plant species known to be good absorbers of selenium, but generally representative vegetation was also included. Also, normally the soil sample taken was representative of the first 6 inches in depth. Included also were a number of profiles and a large number of shale samples. The location of the samples and their selenium content are given in table 5. The data are arranged by counties and as a rule in a west-east sequence. Where this sequence is not followed, the relative positions are readily observed by recalling the fact that

the township numbers increase from north to south and the range numbers from east to west.

TABLE 5.—*Selenium content of soils and vegetation from Kansas*

WALLACE COUNTY

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16196	1	2.8 miles south of Smoky Hill River, south of Wallace.	Pierre clay, 0–6 inches	6	
B16197	1a	do	Wreath aster		310
B16198	2	1.5 miles south of Smoky Hill River, south of Wallace.	Colby clay loam, 0–6 inches (on loess).	.3	
B16199	2a	do	Corn (leaves)		4
B16200	3	SE corner sec. 28, T. 13 S., R. 41 W.	Pierre clay, 0–6 inches, from Weskan shale.	.5	
B16201	3a	do	Corn (leaves)		3
B16202	4	200 feet south of NW corner sec. 2, T. 12 S., R. 42 W.	Pierre clay loam, 0–6 inches	2	
B16203			Shal loam, 6–12 inches	1	
B16204			Weathered shale, 12–24 inches	1.5	
B16205			Weathered shale, yellow streaks, 24–30 inches.	1	
B16206			Clay shale, 36–108 inches	2.5	
B16207	4a	do	Two-groove poisonvetch		660
B16208	5	200 feet south of W¼ corner sec. 19, T. 12 S., R. 41 W.	Pierre light clay loam, 0–6 inches	.3	
B16209	5a	do	Narrowleaf milkvetch		170
B16210	6a	200 feet south of E¼ corner sec. 36, T. 12 S., R. 41 W.	Cane		1
B16214	7	N¼ corner sec. 27, T. 13 S., R. 39 W.	Pierre clay loam, 0–6 inches	2	
B16215	7a	do	Two-groove poisonvetch		210
B16216	8	SW corner sec. 7, T. 13 S., R. 3 W.	Soil over shale, 0–6 inches (possibly from loess).	.3	
B16217	8a	do	Wreath aster		1
B16218	9	200 feet north of SW corner sec. 28, T. 12 S., R. 38 W.	Pierre clay loam (Lake Creek formation in Pierre).	.6	
B16219	9a	do	Corn (leaves)		2
B16220	10	300 feet south of NW corner sec. 18, T. 12 S., R. 38 W.	Pierre loam, 0–6 inches	1	
B16221			Lake Creek shale, 2–8 feet (Pierre)	1.5	
B16222	10a	do	Sunflower		1
B16223	11	500 feet south of N¼ sec. 35, T. 13 S., R. 40 W.	Light clay loam, 0–6 inches	.5	
B16224	11a	do	Sunflower		1
B16235	12	NE corner sec. 23, T. 12 S., R. 38 W.	"Weskan" clay loam, 0–6 inches	1	
B16236			Weskan shale, 4–6 feet	5	
B16237	12a	do	Russian-thistle		160
B16326	13	W¼ corner sec. 11, T. 13 S., R. 42 W.	Pierre clay loam, 0–6 inches	.7	
B16327	13a	do	Scurf-pea		3
B16328	14	SE corner sec. 3, T. 12 S., R. 42 W.	Pierre clay loam, 0–6 inches	1	
B16329	14a	do	Sunflower		5
B16330	15	NW corner sec. 35, T. 13 S., R. 42 W.	"Elkader" clay loam	.5	
B16331	15a	do	Narrowleaf milkvetch		160
B16332	16	NW corner sec. 36, T. 11 S., R. 42 W.	Grayish clay shale, 0–6 inches	.3	
B16333	16a	do	Scurf-pea		2
B16334	17	NW corner sec. 31, T. 11 S., R. 42 W.	Pierre clay loam, 0–6 inches	.5	
B16335	17a	do	Narrowleaf milkvetch		660
B16336	18	80 rods east of northwest corner sec. 6, T. 12 S., R. 41 W.	Pierre clay loam, 0–6 inches	2	
B16337	18a	do	Russian-thistle		3
B16338	19	NE corner sec. 6, T. 12 S., R. 41 W.	Pierre clay loam, 0–6 inches	.7	
B16339	19a	do	Russian-thistle		2
B16340	20	SE corner sec. 32, T. 12 S., R. 41 W.	Colby silt loam, 0–6 inches	.5	
B16341	20a	do	Russian-thistle		2
B16342	21	SW corner sec. 34, T. 11 S., R. 41 W.	Colby silt loam, 0–6 inches	.5	
B16343	21a	do	Sunflower		2
B16344	22	W¼ corner sec. 2, T. 12 S., R. 41 W.	Pierre clay loam, 0–6 inches	.7	
B16345	22a	do	Russian-thistle		1

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

WALLACE COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16346	23	NW corner sec. 12, T. 12 S., R. 41 W.	Dark layer in alluvium, 18-24 inches	0.7	.....
B16347	23a	do	Sunflower	.....	4
B16348	24	NW corner sec. 14, T. 12 S., R. 41 W.	Pierre clay loam, 0-6 inches	.6	.....
B16349	24a	do	Corn (leaves)	.....	6
B16350	25	NW corner sec. 26, T. 12 S., R. 41 W.	Colby clay loam, 0-6 inches	.8	.....
B16351	25a	do	Cane (heads)	.....	6
B16352	26	SW corner sec. 26, T. 12 S., R. 41 W.	Alluvial clay loam, 0-6 inches	1	.....
B16353	26a	do	Cane (heads)	.....	7
B16354	27	SE corner sec. 27, T. 12 S., R. 41 W.	Pierre clay loam, 0-6 inches	.5	.....
B16355	27a	do	Narrowleaf milkvetch	.....	750
B16356	28	SW corner sec. 36, T. 12 S., R. 41 W.	Colby clay loam, 0-6 inches	.7	.....
B16357	28a	do	Corn (leaves)	.....	2
B16358	29	NE corner sec. 6, T. 13 S., R. 40 W.	Alluvial clay loam, 0-6 inches	.7	.....
B16359	29a	do	Sunflower	.....	2
B16360	30	NE corner sec. 12, T. 13 S., R. 41 W.	Colby clay loam, 0-6 inches	1	.....
B16361	30a	do	Cane (heads)	.....	8
B16362	30b	do	Narrowleaf milkvetch	.....	510
B16363	31	W½ corner sec. 8, T. 13 S., R. 40 W.	Colby clay loam, 0-6 inches	1.5	.....
B16364	31a	do	Sunflower	.....	1
B16365	32	SW corner sec. 20, T. 13 S., R. 40 W.	Colby clay loam, 0-6 inches	.7	.....
B16366	32a	do	Sunflower	.....	8
B16367	33	NW corner sec. 28, T. 13 S., R. 40 W.	Colby clay loam, 0-6 inches	1.5	.....
B16368	33a	do	Narrowleaf milkvetch	.....	170
B16369	34	N½ corner sec. 3, T. 14 S., R. 40 W.	Colby clay loam, 0-6 inches	.7	.....
B16370	34a	do	Sunflower	.....	2
B16371	35	Center sec. 34, T. 13 S., R. 40 W.	Pierre clay loam, 0-6 inches	2	.....
B16372	35a	do	Russian-thistle	.....	5
B16373	35b	do	Two-groove poisonvetch	.....	190
B16374	36	SW corner sec. 27, T. 13 S., R. 40 W.	Colby clay loam, 0-6 inches	.8	.....
B16375	36a	do	Wreath aster	.....	2
B16376	37	S½ corner sec. 22	Colby silt loam, 0-6 inches	.6	.....
B16377	37a	do	Corn (leaves)	.....	8
B16378	37b	do	Wreath aster	.....	3
B16379	38	S½ sec. 15, T. 13 S., R. 40 W.	Colby clay loam, 0-6 inches	.5	.....
B16380	38a	do	Cane (heads)	.....	4
B16381	39	S½ corner sec. 3, T. 13 S., R. 40 W.	Colby silt loam, 0-6 inches	.6	.....
B16382	39a	do	Sunflower	.....	5
B16383	40	NW corner sec. 2, T. 13 S., R. 40 W.	Colby clay loam, 0-6 inches	.5	.....
B16384	40a	do	Narrowleaf milkvetch	.....	50
B16385	40b	do	Broom snakeweed	.....	8
B16386	41	SW corner sec. 26, T. 12 S., R. 40 W.	Colby clay loam, 0-6 inches	1	.....
B16387	41a	do	Narrowleaf milkvetch	.....	60
B16388	42	NE corner sec. 31, T. 11 S., R. 39 W.	Pierre clay loam, 0-6 inches	1.5	.....
B16389	42a	do	Broom snakeweed	.....	20
B16390	42b	do	Two-groove poisonvetch	.....	45
B16391	43	NE corner sec. 32, T. 11 S., R. 39 W.	Pierre shaly clay loam, 0-6 inches	1.5	.....
B16392	43a	do	Russian-thistle	.....	1
B16393	44	NW corner sec. 34, T. 11 S., R. 39 W.	Pierre clay loam, 0-6 inches	1.5	.....
B16394	44a	do	Wreath aster	.....	41
B16395	45	N½ corner sec. 36, T. 11 S., R. 39 W.	Alluvial silt loam, 0-6 inches	2	.....
B16396	45a	do	Corn (leaves)	.....	5
B16397	45b	do	Wild licorice	.....	1
B16398	46	SW corner sec. 31, T. 11 S., R. 39 W.	Colby silt loam, 0-6 inches	.7	.....
B16399	46a	do	Corn (leaves)	.....	6

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

WALLACE COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in— Soils or shales	Selenium in— Vegetation
				P. p. m.	*P. p. m.*
B16400	47	W½ corner sec. 7, T. 12 S., R. 38 W.	Pierre clay loam, 0–6 inches	2	
B16401	47a	do	Russian-thistle		5
B16402	48	SE corner sec. 24, T. 12 S., R. 39 W.	Colby silt loam, 0–6 inches	1	
B16403	48a	do	Cane (heads)		5
B16404	49	SW corner sec. 31, T. 12 S., R. 38 W.	Pierre shaly clay loam, 0–6 inches	.7	
B16405	49a	do	Scurf-pea		1
B16406	50	E½ corner sec. 25	Alluvial loam, 0–6 inches (Smoky Hill River bottom)	1	
B16407	50a	do	Corn (leaves)		2
B16408	51	SE corner sec. 28, T. 13 S., R. 38 W.	Niobrara clay loam, 0–6 inches	5	
B16409	51a	do	Wreath aster		210
B16410	51b	do	Two-grooved poisonvetch		50
B16411	51c	do	"Stickleaf"		7
B16412	52	N¼ corner sec. 36	Niobrara clay loam, 0–6 inches	3	
B16413	52a	do	Russian-thistle		3
B16414	53	NE corner sec. 35, T. 13 S., R. 38 W.	Niobrara clay loam, 0–6 inches	8	
B16415	53a	do	"Stickleaf"		1
B16416	54	NE corner sec. 34, T. 13 S., R. 38 W.	Niobrara clay loam	2	
B16417	54a	do	Narrowleaf milkvetch		560
B16418	55	NE corner sec. 33, T. 13 S., R. 38 W.	Niobrara clay loam, 0–6 inches (partly topsoil)	1	
B16419	55a	do	Narrowleaf milkvetch		640
B16420	56	NE corner sec. 32, T. 13 S., R. 38 W.	Terrace clay loam, 0–6 inches	1.5	
B16421	56a	do	Sunflower		2
B16422	57	NW corner sec. 4, T. 14 S., R. 38 W.	Colby silt loam (over Niobrara)	1.5	
B16423	57a	do	Russian-thistle		7
B16424	58	SW corner sec. 34, T. 13 S., R. 38 W.	Niobrara clay loam, 0–6 inches (partly loessial)	1	
B16425	58a	do	Russian-thistle		1
B16426	59	NW corner sec. 2, T. 14 S., R. 38 W.	Niobrara clay loam, 0–6 inches	2	
B16427	59a	do	Narrowleaf milkvetch		840
B16428	60	NE corner sec. 2, T. 14 S., R. 38 W.	Niobrara clay loam, 0–6 inches	3.5	
B16429	60a	do	Russian-thistle		2
B16430	61	SW corner sec. 23, T. 13 S., R. 38 W.	Terrace silty clay loam, 0–6 inches	.5	
B16431	61a	do	Russian-thistle		2
B16432	62	NE corner sec. 22, T. 13 S., R. 38 W.	Colby clay loam, 0–6 inches	.5	
B16433	62a	do	"Stickleaf"		2
B16434	63	NE corner sec. 13, T. 13 S., R. 38 W.	Colby clay loam, 0–6 inches	.5	
B16435	63a	do	Russian-thistle		1
B16436	64	SW corner sec. 2, T. 13 S., R. 38 W.	Colby silt loam, 0–6 inches	.5	
B16437	64a	do	Russian-thistle		3
B16438	65	NW corner sec. 35, T. 12 S., R. 38 W.	Colby clay loam, 0–6 inches (basin phase)	.3	
B16439	65a	NW corner sec. 35	Unidentified vegetation		2
B16384	1	NE corner sec. 30, T. 12 S., R. 40 W.	Water from large pool in Pierre shale, after 2½-inch rain.	0	

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B16175	1	Center sec. 13, T. 12 S., R. 37 W.	Pierre clay, 0–12 inches	8	
B16176			Sharon Springs shale, lowest member of Pierre.	10	
B16177			Shale, 30 feet below surface	22	
B16178	1a	do	Broom snakeweed		180
B16179	2	80 rods north of SE corner sec. 24, T. 13 S., R. 37 W.	Niobrara clay loam, 0–6 inches	2.5	
B16180			Niobrara clay loam, 6–12 inches	2.5	
B16181			Niobrara clay loam, 12–18 inches	2.5	
B16182			Niobrara clay loam, 18–24 inches	5	
B16183			Niobrara clay loam, 24 inches +	20	
B16184			Smoky Hill chalk, 8 feet	16	

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16185	2a	80 rods north of SE corner sec. 24, T. 13 S., R. 37 W.	Russian-thistle	.....	4
B16186	3	80 rods north of center sec. 6, T. 15 S., R. 36 W.	Niobrara stony loam, 0–6 inches	4	.....
B16187	3a	80 rods north of center sec. 6, T. 15 S., R. 36 W. 1200 feet east of no. 3.	Two-groove poisonvetch	.....	550
B16188	3b	80 rods north of center sec. 6, T. 15 S., R. 36 W.	Stanleya	.....	210
B16189	3c	do	Narrowleaf milkvetch	.....	1,750
B16190	3d	do	Unidentified plant (in basin near sample)	.....	18
B16191	4	80 rods south of NE corner sec. 1, T. 15 S., R. 37 W.	Smoky Hill chalk (Niobrara)	8	.....
B16192	5	W ½ corner sec. 1, T. 15 S., R. 37 W	Pierre stony loam, 0–6 inches	2	.....
B16193	5a	do	Sunflower	.....	7
B16194	6	NW corner sec. 2, T. 15 S., R. 37 W.	Niobrara clay loam, 0–6 inches	8	.....
B16195	6a	do	Narrowleaf milkvetch	.....	1,330
B16238	7	SE corner sec. 21, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	2	.....
B16239	7a	do	Corn (leaves)	.....	3
B16240	8	Sec. 21, T. 13 S., R. 36 W.	Elkader light clay loam, 0–6 inches	3	.....
B16241	8a	do	Cane	.....	4
B16242	9	NW corner sec. 19, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2	.....
B16243			Brown clay loam, 6–12 inches	2.5	.....
B16244			Brown clay loam, 12–30 inches	2.5	.....
B16245			Yellow chalk, 30+ inches	6	.....
B16246	9a	do	*Astragalus bisulcatus* (?)	.....	2
B16247	10	E ½ corner sec. 25, T. 13 S., R 32 W.	Colby light-gray loam, 0–12 inches	2	.....
B16248			Colby heavy subsoil, 12–21 inches	.5	.....
B16249			Colby heavy subsoil, 21–36 inches	.3	.....
B16250	10a	do	Cane (leaves)	.....	4
B16251	11	80 rods south of NE corner sec. 26, T. 13 S., R. 32 W.	Colby silt loam, 0–6 inches	.6	.....
B16252	11a	do	Cane (leaves)	.....	2
B16253	12	500 feet north of SW corner sec. 10, T. 14 S., R. 32 W	Colby silt loam, 0–12 inches	1.5	.....
B16254			Colby silt loam, 12–21 inches	.6	.....
B16255			Colby silt loam (brown, 21–36 inches	.4	.....
B16256	12a	do	Russian-thistle	.....	3
B16257	12b	do	Narrowleaf milkvetch	.....	1,690
B16258	13	N ¼ corner sec. 11, T. 15 N., R. 32 W.	Niobrara clay loam, 0–6 inches	3	.....
B16259	13a	do	Two-groove poisonvetch	.....	690
B16260	14	600 feet south of E ¼ corner sec. 24, T. 14 S., R. 32 W.	Niobrara clay loam, 0–6 inches	2	.....
B16261	14a	do	Russian-thistle	.....	5
B16262	15	500 feet west of SE corner sec. 30, T. 14 S., R. 32 W.	Elkader clay loam, 0–6 inches	3	.....
B16263	15a	do	Narrowleaf milkvetch	.....	640
B16264	16	W ¼ corner sec. 12	Niobrara clay loam, 0–6 inches	5	.....
B16265	16a	do	Russian-thistle	.....	10
B16266	17	500 rods west of SE ¼ sec. 4, T. 14 S., R. 32 W.	Niobrara clay loam, 0–6 inches	2.5	.....
B16267	17a	do	Two-groove poisonvetch	.....	460
B16268	18	N ½ corner sec. 16, T. 15 S., R. 32 W.	Elkader clay loam, 0–6 inches	3	.....
B16269	18a	do	Sunflower	.....	12
B16270	19	SW corner sec. 28, T. 15 S., R. 32 W.	Colby clay loam, 0–6 inches	2	.....
B16271	19a	do	Cane (leaves)	.....	4
B16272	20	300 feet east of SW corner sec. 15, T. 15 S., R. 32 W.	Colby silt loam	3	.....
B16273	20a	do	Wreath aster	.....	40
B16274	21	500 feet south of NE corner sec. 21, T. 15 S., R. 32 W.	Pierre clay loam, 0–6 inches (mixed phase)	3	.....
B16275	21a	do	Narrowleaf milkvetch	.....	420
B16276	22	NW corner sec. 23, T. 15 S., R. 32 W.	Colby silt loam, 0–6 inches	.6	.....
B16277	22a	do	Cane (leaves)	.....	3
B16278	23	80 rods south of N ¼ sec. 10, T. 15 S., R. 32 W.	Niobrara clay loam, 0–6 inches	4	.....
B16279	23a	do	Stanleya	.....	1,070
B16280	24	80 rods east of SW corner sec. 34	Clay loam alluvium, 0–6 inches	3	.....
B16281	24a	do	Sunflower	.....	3

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16282	25	E¼ corner sec. 31, T. 14 S., R. 32 W.	Clay loam alluvium, 0-6 inches	2.5	
B16283	25a	do	Sunflower		3
B16284	26	SW corner sec. 26, T. 14 S.	Niobrara clay loam, 0-6 inches	3	
B16285	26a	do	Narrowleaf milkvetch		1,050
B16286	27	500 feet south of NW corner sec. 28, T. 13 S., R. 32 W.	Pierre clay loam, 0-6 inches (mixed phase).	1.5	
B16287	27a	do	Russian-thistle		3
B16288	28	500 feet north of E¼ corner sec. 34, T. 13 S., R. 32 W.	Niobrara clay loam, 0-6 inches (steep phase).	.7	
B16289	28a	do	Two-groove poisonvetch		100
B16290	29	NE corner sec. 3, T. 14 S., R. 32 W.	Niobrara clay loam, 0-6 inches (steep phase)	1.5	
B16291	29a	do	Scurf-pea		3
B16292	30	SW corner sec. 2, T. 14 S., R. 32 W.	Colby clay loam, 0-6 inches (underlain by Niobrara).	.7	
B16293	30a	do	Sunflower		4
B16294	31	E¼ corner sec. 15, T. 14 S., R. 32 W.	Niobrara clay loam, 0-6 inches	3	
B16295	31a	do	Scurf-pea		4
B16296	32	SW corner sec. 23, T. 14 S., R. 32 W.	Niobrara clay loam, 0-6 inches	1	
B16297	32a	do	Russian-thistle		5
B16298	33	900 feet southeast of N¼ corner sec. 12, T. 15 S., R. 32 W.	Niobrara clay loam, 0-6 inches	2.5	
B16299	33a	do	Narrowleaf milkvetch		820
B16300	33b	do	Seeds of *Astragalus*		5
B16301	34	NW corner sec. 32, T. 15 S., R. 34 W.	Elkader clay loam, 0-6 inches	.5	
B16302	34a	do	Sunflower		4
B16303	35	1 40 mile north of NW corner sec. 29, T. 15 S., R. 31 W.	Colby clay loam, 0-6 inches (Niobrara shale below 6-8 feet).	.5	
B16304	35a	do	Wreath aster		3
B16305	36	S¼ corner sec. 11, T. 15 S., R. 32 W.	Niobrara clay loam, 0-6 inches (steep phase).	1.5	
B16306	36a	do	Wreath aster		4
B16307	37	SE corner sec. 1, T. 15 S., R. 33 W.	Silt loam alluvium, 0-6 inches (high bottom phase).	2.5	
B16308	37a	do	Russian-thistle		10
B16309	38	660 feet north of SW¼ sec. 7, T. 15 S., R. 36 W.	Niobrara clay loam, 0-6 inches	.7	
B16310	38a	do	Narrowleaf milkvetch		30
B16311	39	NE corner sec. 12, T. 15 S., R. 37 W.	Colby clay loam, 0-6 inches (over Niobrara).	.6	
B16312	39a	do	Cane thistle		7
B16313	40	NE corner sec. 35, T. 14 S., R. 37 W.	Colby clay loam, 0-6 inches (over Niobrara).	.7	
B16314	41	500 feet south of NW corner sec. 35, T. 14 S., R. 37 W.	Niobrara clay loam, 0-6 inches	2	
B16315	41a	do	Russian-thistle		1
B16316	42	W¼ corner sec. 34, T. 14 S., R. 37 W.	Niobrara clay loam, 0-6 inches	5	
B16317	42a	do	Stanleya		470
B16318	42b	do	Two-groove poisonvetch		460
B16319	43	500 feet west of SE corner sec. 14, T. 14 S., R. 38 W.	Niobrara clay loam, 0-6 inches	3	
B16320	43a	do	Wreath aster		1
B16321	43b	do	Wild licorice		2
B16322	44	500 feet west of NE corner sec. 25, T. 14 S., R. 37 W.	Pierre clay loam, 0-6 inches	2	
B16323	44a	do	Sunflower		2
B16324	45	80 rods north of SW corner sec. 30, T. 14 S., R. 36 W.	Niobrara clay loam, 0-6 inches	3.5	
B16325	45a	do	"Stickleaf"		3
B16450	46	NE corner sec. 25, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches	2.5	
B16451	46a	do	Two-groove poisonvetch		35
B16452	47	400 feet south of E¼ sec. 36, T. 13 S., R. 37 W.	Alluvium clay loam, 0-6 inches	1.5	
B16453	47a	do	Sunflower		5
B16454	48	SE corner sec. 36, T. 13 S., R. 36 W.	Niobrara clay loam, 0-6 inches	1	
B16455	48a	do	Broom snakeweed		70

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16456	49	1,000 feet west of $S\frac{1}{4}$ sec. 1, T. 14 S., R. 37 W.	Pierre shaly clay loam, 0-6 inches (Sharon Springs member).	1	
B16457	49a	do	Wreath aster		90
B16458	50	NE corner sec. 11, T. 14 S., R. 37 W.	Pierre clay loam, 0-6 inches	3	
B16459	50a	do	Wreath aster		160
B16460	51	300 feet northeast of SW corner sec. 2, T. 14 S., R. 37 W.	Pierre shaly clay loam, 0-6 inches	3	
B16461	51a	do	Russian-thistle		10
B16462	52	600 feet east of SW corner sec. 35, T. 13 S., R. 37 W.	Niobrara shaly clay loam, 0-6 inches	8	
B16463	52a	do	Stanleya		550
B16464	53	NW corner sec. 3, T. 14 S., R. 37 W.	Colby clay loam, 0-6 inches (heavy subsoil phase).	.7	
B16465	53a	do	Narrowleaf milkvetch		110
B16466	54	NW corner sec. 10, T. 14 S., R. 37 W.	Colby silt loam, 0-6 inches (heavy subsoil phase).	.8	
B16467	54a	do	Corn (leaves)		8
B16468	55	$NW\frac{1}{4}$ sec. 8, T. 14 S., R. 37 W.	Pierre shaly clay loam, 0-6 inches (steep phase).	3	
B16469	55a	do	Russian-thistle		6
B16470	56	80 rods east of $N\frac{1}{4}$ sec. 6, T. 14 S., R. 37 W.	Pierre shaly clay loam, 0-6 inches	1.5	
B16471	56a	do	Stickweed		1
B16472	56b	do	Clammyweed		5
B16473	57	NW corner sec. 5, T. 14 S., R. 37 W.	Pierre shaly clay loam, 0-6 inches (steep phase).	5	
B16474	57a	do	Stanleya		170
B16475	58	1,600 feet north of SE corner sec. 31, T. 13 S., R. 37 W.	Colby silt loam (heavy subsoil phase)	1.5	
B16476	58a	do	Narrowleaf milkvetch		310
B16477	59	NW corner sec. 33, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches	2	
B16478	59a	do	Broom snakeweed		7
B16479	60	300 feet west of NE corner sec. 35, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches	3	
B16480	60a	do	Two-groove poisonvetch		150
B16481	61	NW corner sec. 35, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches	1.5	
B16482	61a	do	Cane (heads)		3
B16483	61b	do	Narrowleaf milkvetch		1,340
B16484	62	NW corner sec. 36, T. 13 S., R. 37 W.	Colby silt loam, 0-6 inches (over Niobrara)	.7	
B16485	62a	do	Cane		4
B16486	63	700 feet west of NE corner sec. 26, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches	1.5	
B16487	63a	do	Narrowleaf milkvetch		800
B16488	63b	do	Bush morning-glory		5
B16489	64	NE corner sec. 27, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches	.7	
B16490	64a	do	Sunflower		1
B16491	65	700 feet west of NE corner sec 28, T. 13 S., R. 37 W	Niobrara clay loam, 0-6 inches	.7	
B16492	65a	do	Cane (leaves)		1
B16493	66	1,000 feet west of NE corner sec. 20, T. 13 S., R. 37 W	Alluvial clay loam	.3	
B16494	66a	do	Cane (heads)		2
B16495	66b	do	"Sandlily"		2
B16496	67	80 rods west of $S\frac{1}{4}$ corner sec. 20, T. 13 S., R. 37 W	Wind-blown loam, 0-6 inches	.5	
B16497	67a	80 rods west of $S\frac{1}{4}$ corner sec. 20, T. 13 S., R. 37 W	Bush morning-glory		2
B16498	68	300 feet west of $N\frac{1}{4}$ corner sec. 30, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches (partly loessial).	.5	
B16499	68a	do	Russian-thistle		5
B16500	69	NW corner sec. 19, T. 13 S., R. 37 W	Colby clay loam, 0-6 inches (heavy subsoil).	.5	
B16501	69a	do	Russian-thistle		.1
B16502	70	200 feet north of $W\frac{1}{4}$ corner sec. 20, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches (smooth phase).	.4	
B16503	70a	do	Russian-thistle		1
B16504	71	80 rods east of SE corner sec 16, T. 13 S., R. 37 W.	Niobrara clay loam, 0-6 inches	1	
B16505	71a	do	Russian-thistle		6

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16506	72	1,650 feet east of NW corner sec. 22, T. 13 S., R. 37 W.	Niobrara clay loam, 0–6 inches (partly loessial).	0.5	.....
B16507	72a	do	Russian-thistle	.....	15
B16508	73	80 rods southeast of NW corner sec. 23, T. 13 S., R. 37 W.	Niobrara stony clay loam, 0–6 inches (steep phase).	6	.....
B16509	73a	do	Two-groove poisonvetch	.....	260
B16510	73b	do	Wild licorice	.....	5
B16511	74	1,000 feet west of NW¼ sec. 24, T. 13 S., R. 37 W.	Niobrara clay loam, 0–6 inches (smooth phase).	.6	.....
B16512	74a	do	Russian-thistle	.....	3
B16513	75	NW corner sec. 19, T. 13 S., R. 36 W.	Alluvial clay, 0–6 inches	.3	.....
B16514	75a	do	Corn (leaves)	.3	2
B16515	76	300 feet south of NE corner sec. 30, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	2	.....
B16516	76a	do	Narrow-leaf milkvetch	.....	130
B16517	77	NW corner sec. 32, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	5	.....
B16518	77a	do	Corn (leaves)	.....	4
B16519	77b	do	Narrow-leaf milkvetch	.....	580
B16520	78	500 feet north of SE corner sec. 32, T. 13 S., R. 36 W.	Niobrara shaly clay loam, 0–6 inches	6	.....
B16521	78a	do	Stanleya	.....	430
B16522	78b	do	Wreath aster	.....	230
B16523	79	500 feet north of SW corner sec. 32, T. 13 S., R. 36 W.	Pierre shale fat contact with Ogallala.	6	.....
B16524	80	700 feet south of NE corner sec. 20, T. 13 S., R. 36 W.	Elkader loam, 0–6 inches	.2	.....
B16525	80a	do	Cane (heads)	.....	6
B16526	81	NW corner sec. 27, T. 13 S., R. 36 W.	Niobrara stony clay loam, 0–6 inches	1.5	.....
B16527	81a	do	Stickweed	.....	1
B16528	81b	do	Broom snakeweed	.....	3
B16529	82	200 feet west of NE corner sec. 27, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	2	.....
B16530	82a	do	"Sandhly"	.....	2
B16531	83	NE corner sec. 34, T. 13 S., R. 36 W.	Colby silt loam 0–6 inches	1	.....
B16532	83a	do	Corn (leaves)	.....	7
B16533	84	700 feet north of SW corner sec. 25, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	.8	.....
B16534	84a	do	Russian-thistle	.....	1
B16535	85	NW corner sec. 11, T. 14 S., R. 36 W.	Pierre shaly clay loam, 0–6 inches	10	.....
B16536	85a	do	Russian-thistle	.....	7
B16537	86	NE corner sec. 4, T. 14 S., R. 36 W.	Colby silt loam, 0–6 inches	1	.....
B16538	86a	do	Cane (heads)	.....	2
B16539	87	600 feet south of NW corner sec. 31, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	3	.....
B16540	87a	do	Narrow-leaf milkvetch	.....	2,580
B16541	88	Near NW corner sec. 9, T. 14 S., R. 36 W.	Pierre clay loam, 0–6 inches (colluvial phase).	34	.....
B16542	88a	do	Stanleya	.....	920
B16543	88b	do	Two-groove poisonvetch	.....	860
B16544	89	Near SW corner sec. 4, T. 14 S., R. 36 W.	Niobrara stony loam, 0–6 inches	4	.....
B16545	89a	do	Unidentified plant	.....	7
B16546	89b	do	Stanleya	.....	280
B16547	90	1,300 feet north of S¼ corner sec. 33, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	4	.....
B16548	90a	do	Two-groove poisonvetch	.....	2,680
B16549	91	300 feet east of NE corner sec. 22, T. 13 S., R. 36 W.	Colby silt loam, 0–6 inches	.5	.....
B16550	91a	do	"Sandhly"	.....	2
B16551	92	NE corner sec. 26, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches (smooth phase).	3	.....
B16552	92a	do	Broom snakeweed	.....	10
B16553	93	Near SW corner sec. 25, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	3.5	.....
B16554	93a	do	Narrow-leaf milkvetch	.....	910
B16555	93b	do	Ironplant	.....	180

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B116556	94	1,600 feet east of SW. corner sec. 30, T. 13 S., R. 35 W.	Niobrara stony clay loam, 0-6 inches	5	.....
B116557	94a	do	Stickweed	.....	3
B116558	94b	do	Sideoats grama (in soil sample)	.....	2
B116559	94c	do	Wreath aster (in soil sample)	.....	40
B116560	95	700 feet southwest of NE. corner sec. 1, T. 13 S., R. 36 W.	Colby silt loam, 0-6 inches (heavy subsoil phase)	2	.....
B116561	95a	do	Wreath aster	.....	80
B116562	96	SW. corner sec. 7, T. 14 S., R. 36 W.	Colby silt loam, 0-6 inches (heavy subsoil phase)	.5	.....
B116563	96a	do	Cane (heads)	.....	2
B116564	97a	SE. corner sec. 10, T. 14 S., R. 36 W.	Niobrara clay loam, 0-6 inches	.8	.....
B116565	97a	do	Two-groove poisonvetch	.....	30
B116566	98	SW. corner sec. 29, T. 11 S., R. 36 W.	Colby silt loam, 0-6 inches (heavy subsoil phase)	.7	.....
B116567	98a	do	Russian-thistle	.....	10
B116568	99	300 feet south of E¼ corner sec. 6, T. 15 S., R. 36 W.	Niobrara stony clay loam, 0-6 inches	2	.....
B116569	99a	do	Stickweed	.....	2
B116570	99b	do	Sideoats grama	.....	4
B116571	99b	do	Little bluestem	.....	4
B116572	100	SE. corner sec. 6, T. 15 S., R. 36 W.	Niobrara clay loam (colluvial phase)	.8	.....
B116573	100a	do	Wreath aster	.....	130
B116574	100b	do	Sideoats grama	.....	2
B116575	100c	do	Stanleya	.....	450
B116576	101	600 feet northeast of SW. corner sec. 8, T. 15 S., R. 36 W.	Niobrara clay loam, 0-6 inches (steep phase)	3	.....
B116577	101a	do	Two-groove poisonvetch	.....	230
B116578	102	80 rods west of NE. corner sec. 7, T. 15 S., R. 36 W.	Niobrara clay loam, 0-6 inches (colluvial phase)	3	.....
B116579	102a	do	Stanleya	.....	170
B116580	103	NE. corner sec. 8, T. 15 S., R. 36 W.	Niobrara clay loam, 0-6 inches (bench phase)	1.5	.....
B116581	103a	do	Narrowleaf milkvetch	.....	1,360
B116582	104	500 feet north of S¼ corner sec. 5, T. 15 S., R. 36 W.	Alluvial clay loam, 0-6 inches	2	.....
B116583	104a	do	Wreath aster	.....	150
B116584	105	NE. corner sec. 5, T. 15 S., R. 36 W.	Colby silt loam, 0-6 inches (heavy subsoil phase)	1.5	.....
B116585	105a	do	Narrowleaf milkvetch	.....	1,110
B116586	106	200 feet south of NW. corner sec. 10, T. 15 S., R. 36 W.	Niobrara clay loam, 0-6 inches	1	.....
B116587	106a	do	Broom snakeweed	.....	4
B116588	106b	do	Unidentified plant	.....	3
B116589	107	NE. corner sec. 16, T. 15 S., R. 36 W.	Niobrara stony clay loam (steep phase)	1.5	.....
B116590	107a	do	Two-groove poisonvetch	.....	80
B116591	108	Near NE. corner sec. 10, T. 15 S., R. 36 W.	Niobrara clay loam	.8	.....
B116592	108a	do	Russian-thistle	.....	2
B116593	109	W¼ corner sec. 27, T. 11 S., R. 36 W.	Colby silt loam, 0-6 inches (heavy subsoil phase)	.5	.....
B116594	109a	do	Corn (leaves)	.....	5
B116595	110	700 feet south of E¼ corner sec. 29, T. 14 S., R. 36 W.	Niobrara clay loam, 0-6 inches	.5	.....
B116596	110a	do	Russian-thistle	.....	1
B116597	111	200 feet east of N¼ corner sec. 32, T. 14 S., R. 36 W.	Niobrara clay loam, 0-6 inches	.5	.....
B116598	111a	do	Narrowleaf milkvetch	.....	130
B116599	112	1,000 feet west of NE. corner sec. 33, T. 14 S., R. 36 W.	Niobrara clay loam, 0-6 inches	.2	.....
B116600	112a	do	Narrowleaf milkvetch	.....	150
B116601	113	100 feet south of NE. corner sec. 22, T. 14 S., R. 36 W.	Niobrara clay loam, 0-6 inches	.5	.....
B116602	113a	do	Russian-thistle	.....	6
B116603	114	Near SW. corner sec. 18, T. 14 S., R. 36 W.	Niobrara stony loam, 0-6 inches	.5	.....
B116604	114a	do	Stickweed	.....	6
B116605	115	SW. corner sec. 25, T. 14 S., R. 36 W.	Colby clay loam, 0-6 inches (heavy subsoil phase)	.6	.....
B116606	115a	do	Sunflower	.....	4

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16607	116	500 feet south of NW corner	Niobrara clay loam, 0–6 inches (colluvial phase)	4	
B16608	116a	do	Broom snakeweed		116
B16609	117	80 rods east of SW corner sec. 1, T. 15 S., R. 36 W	Niobrara clay loam, 0–6 inches (colluvial phase)	2	
B16610	117a	do	Corn cleaves		10
B16611	118	700 feet east of center sec. 11, T. 15 S., R. 36 W.	Niobrara stony loam, 0–6 inches (steep phase)	.8	
B16612	118a	do	Sunflower		1
B16613	119	SE corner sec. 1, T. 15 S., R. 36 W	Niobrara clay loam, 0–6 inches (smooth phase)	1	
B16614	119a	do	Two-grooved poisonvetch		160
B16615	119b	do	Unidentified vegetation		8
B16616	120	80 rods south of NW corner sec. 6, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	8	
B16617	120a	do	Stickweed		4
B16618	121	SE corner sec. 31, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	3.5	
B16619	121a	do	Stanleya		10
B16620	122	500 feet south of NW corner sec. 19, T. 14 S., R. 35 W	Niobrara clay loam, 0–6 inches	1	
B16621	122a	do	Scurf-pea		6
B16622	123	300 feet south of N¼ corner sec. 30, T. 14 S., R. 35 W	Niobrara clay loam, 0–6 inches	1	
B16623	123a	do	Scurf-pea		5
B16624	124	80 rods east of NW corner sec. 7, T. 14 S., R. 35 W.	Pierre shaly clay loam, 0–6 inches	1.5	
B16625	124a	do	Wreath aster		20
B16626	125	80 rods southeast of NW corner sec. 6, T. 14 S., R. 35 W	Niobrara clay loam, 0–6 inches	30	
B16627	125a	do	Stanleya		410
B16628	126	150 feet south of NE corner sec. 30, T. 13 S., R. 35 W	Niobrara clay loam, 0–6 inches	22	
B16629	126a	do	Narrowleaf milkvetch		500
B16630	126b	do	Desert saltgrass		5
B16631	127a	80 rods south of NE corner sec. 30, T. 13 S., R. 35 W	"Umbrella-plant" on Niobrara outcrop		6
B16632	128	80 rods north of W¼ corner sec. 28, T. 13 S., R. 35 W	Niobrara clay loam, 0–6 inches	8	
B16633	128a	do	Scurf-pea		2
B16634	129	300 feet north of SE corner sec. 27, T. 13 S., R. 35 W	Pierre shaly clay loam, 0–6 inches	5	
B16635	129a	do	Broom snakeweed		12
B16635	129b	do	Russian-thistle		4
B16689	5	200 feet north of SE corner sec. 29, T. 13 S., R. 35 W	Niobrara clay loam, 0–6 inches	140	
B16690	5a	do	Broom snakeweed		1
B16691	5b	do	Russian-thistle		1
B16692	5c	do	Narrowleaf milkvetch		500
B16636	130	Center sec. 32, T. 13 S., R. 35 W	Niobrara clay loam, 0–6 inches	1.5	
B16637	130a	do	Narrowleaf milkvetch		1,070
B16638	130b	do	Milkweed (pods)		8
B16639	131	SW corner sec. 28, T. 13 S., R. 35 W	Colby clay loam, 12–24 inches	.8	
B16640	131a	do	Corn cleaves		12
B16641	132	NE corner sec. 6, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B16642	132a	do	Russian-thistle		7
B16643	133	100 feet north of W¼ corner sec. 5, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches (colluvial phase	10	
B16644	133a	do	Goldenrod		3
B16645	134	80 rods north and 80 rods east of SW corner sec. 4, T. 14 S., R. 35 W	Niobrara clay loam, 0–6 inches	3	
B16646	134a	do	Two-grooved poisonvetch		340
B16647	135	80 rods north of SE corner sec. 20, T. 14 S., R. 35 W	Niobrara clay loam, 0–6 inches	.5	
B16648	135a	do	Sunflower		2
B16649	136	SE corner sec. 32, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	10	
B16650	136a	do	Gumweed		130
B16651	137	900 feet south of NE corner sec. 8, T. 15 S., R. 35 W	Niobrara clay loam, 0–6 inches	2	
B16652	137a	do	Ironplant		170

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in— Soils or subsoils	Selenium in— Vegetation
				P. p. m.	*P. p. m.*
B116653	138	80 rods north of SE corner sec. 33, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B116654	138a	do	Narrowleaf milkvetch		900
B116655	139	500 feet south of NE corner sec. 9, T. 14 S., R. 35 W.	Niobrara gravelly clay loam	6	
B116656	139a	do	Two-groove poisonvetch		230
B116657	140	500 feet south of SW corner sec. 10, T. 14 S., R. 35 W.	Niobrara gravelly clay loam, 0–6 inches	4	
B116658	140a	do	Two-groove poisonvetch		350
B116659	141	100 feet west of SE corner sec. 3, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B116660	141a	do	Two-groove poisonvetch		25
B116661	142	E¼ corner sec. 3, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B116662	142a	do	Wreath aster		140
B116663	143	NE corner sec. 15, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B116664	143a	do	Broom snakeweed		610
B116665	144	SW corner sec. 22, T. 14 S., R. 35 W.	Dark-gray loam, 12–24 inches	.8	
B116666	144a	do	Sunflower		3
B116667	145	700 feet west of SE corner sec. 33, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches (colluvial phase)	.6	
B116668	145a	do	Two-groove poisonvetch		110
B116669	146	SE corner sec. 4, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B116670	146a	do	Scurf-pea		1
B116671	147	200 feet west of SE corner sec. 3, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	.5	
B116672	147a	do	Scurf-pea		2
B116673	148	700 feet east of SE corner sec. 11, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	.5	
B116674	148a	do	"Stickleaf"		1
B116675	149	700 feet northeast of SE corner sec. 10, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2	
B116676	149a	do	Wild licorice		2
B116677	150	100 feet northwest of SE corner sec. 7, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches (colluvial phase)	1.5	
B116678	150a	do	Stanleya		30
B116679	150b	do	Scarlet globemallow		200
B116680	151	80 rods north of SW corner sec. 5, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2	
B116681	151a	do	Broom snakeweed		30
B116682	152	700 feet south of NW corner sec. 18, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2.5	
B116683	152a	do	Stanleya		180
B116686	2a	Near N¼ corner sec. 2a, T. 13 S., R. 38 W.	Alfalfa (on river terrace)		1
B116693	6	80 rods east of NW corner sec. 20, T. 13 S., R. 36 W.	Niobrara clay loam, 0–6 inches	16	
B116691	6a	do	Two-groove poisonvetch (tops)		90
B116691A	6b	do	Two-groove poisonvetch (roots)		40
B116695	6c	do	Stanleya		200
B116696	6d	do	"Stickleaf"		2
B116696A		SE¼ sec. 21, T. 13 S., R. 35 W	Smoky Hill Blue chalk	22	
B116725	153	300 feet south of NE corner sec. 28, T. 15 S., R. 35 W	Niobrara clay loam, 0–6 inches	.7	
B116726	153a	do	Prairie pink		3
B116727	153b	do	Side-oats grama		2
B116728	153c	do	Little bluestem		1
B116729	154	600 feet south of NE corner sec. 33, T. 15 S., R. 35 W	Terrace clay loam, 0–6 inches	.5	
B116730	154a	do	Sunflower		4
B116731	155	50 rods west of NE corner sec. 34, T. 15 S., R. 35 W.	Niobrara shaly loam, 0–6 inches	.7	
B116732	155a	do	Scurf-pea		3
B116733	156	E¼ corner sec. 35, T. 15 S., R. 35 W	Niobrara clay loam, 0–6 inches	1	
B116734	156a	do	Two-groove poisonvetch		30
B116735	157	S¼ corner sec. 35, T. 14 S., R. 35 W	Niobrara clay loam, 0–6 inches	2	
B116736	157a	do	Narrowleaf milkvetch		680
B116737	158	NW corner sec. 2, T. 15 S., R. 35 W	Alluvial clay loam, 0–6 inches	1.5	
B116738	158a	do	Corn ears		1

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16739	159	500 feet southeast of NW corner sec. 35, T. 15 S., R. 35 W.	Niobrara clay loam, 0–6 inches	0.7	
B16740	159a	do	Narrowleaf milkvetch		40
B16741	160	500 feet south of W¼ corner sec. 24, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	.5	
B16742	160a	do	Wreath aster		1
B16743	161	NE corner sec. 11, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	.7	
B16744	161a	do	Broom snakeweed		3
B16745	162	500 feet south of NW corner sec. 1, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	3	
B16746	162a	do	"Stickleaf"		2
B16747	163	do	Iron concretions in no. 162	48	
B16748	164	SW corner sec. 25, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B16749	164a	do	Broom snakeweed		400
B16750	165	80 rods east of NW corner sec. 35, T. 13 S., R. 35 W.	Niobrara stony loam	2	
B16751	165a	do	Two-groove poisonvetch		110
B16752	166	80 rods east of SW corner sec. 27, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B16753	166a	do	Russian-thistle		6
B16754	166b	do	Narrowleaf milkvetch		220
B16755	167	1,000 feet west of NE corner sec 34, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2	
B16756	167a	do	Scurf-pea		1
B16757	168	300 feet east of W¼ corner sec. 23, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1.5	
B16758	168a	do	Two-groove poisonvetch		110
B16759	169	Near NW corner sec. 22, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	14	
B16760	169a	do	Two-groove poisonvetch		50
B16761	170	500 feet east of NW corner sec. 20, T. 13 S., R. 35 W.	Niobrara stony loam, 0–6 inches	2	
B16762	170a	do	Wreath aster		220
B16763	171	1,000 feet east of NW corner sec. 22, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	12	
B16764	171a	do	Two-groove poisonvetch		8
B16765	172	400 feet west of SE corner sec. 23, T. 13 S., R. 35 W.	Alluvial clay loam	2	
B16766	172a	do	Corn (in the milk)		1
B16767	173	500 feet west of SE corner sec. 14, T. 13 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2.5	
B16768	173a	do	Stanleya		230
B16769	174	700 feet west of NE corner sec. 25, T. 13 S., R. 35 W.	Niobrara stony clay loam, 0–6 inches	10	
B16770	174a	do	Two-groove poisonvetch		170
B16771	175	1,400 feet east of SW corner sec. 26, T. 13 S., R. 34 W.	Niobrara loam, 0–6 inches (colluvial phase)	24	
B16772	175a	do	Two-groove poisonvetch		180
B16773	176	SE¼ sec. 29, T. 13 S., R. 34 W	Niobrara clay loam, 0–6 inches	1.5	
B16774	176a	do	"Stickleaf"		2
B16775	176b	do	"Blue aster"		3
B16776	177	700 feet west of NE corner sec 36, T. 13 S., R. 35 W	Niobrara clay loam, 0–6 inches	32	
B16777	177a	do	Broom snakeweed		10
B16778	178	80 rods south of NW corner sec. 32, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2.5	
B16779	178a	do	"Stickleaf"		2
B16780	179	200 feet west of NE corner sec. 5, T. 14 S., R. 34 W.	Niobrara clay loam, 0–6 inches	32	
B16781	179a	do	Stanleya		110
B16782	180	500 feet south of NE corner sec 12, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	1	
B16783	180a	do	Scurf-pea		1
B16784	181	SW¼ corner sec. 7, T. 14 S., R. 34 W.	Niobrara clay loam, 0–6 inches	14	
B16785	181a	do	Two-groove poisonvetch		450
B16786	182	500 feet east of SW corner sec 19, T. 14 S., R. 34 W	Niobrara clay loam, 0–6 inches	1	
B16787	182a	do	Russian-thistle		2
B16788	183	80 rods east of SW corner sec 21, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2	
B16789	183a	do	Goldenrod		6

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16790	184	SE corner sec. 25, T. 14 S., R. 35 W.	Niobrara clay loam, 0–6 inches	2	
B16791	184a	....do	Two-groove poisonvetch		100
B16792	185	500 feet west of SE corner sec. 36, T. 14 S., R. 35 W.	Niobrara clay loam	2.5	
B16793	185a	....do	"Stickleaf"		1
B16794	186	E¼ corner sec. 7, T. 15 S., R. 34 W.	Niobrara stony clay loam, 0–6 inches.	2	
B16795	186a	....do	Scurf-pea		1
B16796	187	500 feet east of NW corner sec. 7, T. 15 S., R. 34 W.	Niobrara clay loam	2.5	
B16797	187a	....do	Narrowleaf milkvetch		2,660
B16798	188	700 feet east of NW corner sec. 18, T. 15 S., R. 34 W.	Niobrara clay loam, 0–6 inches	1.5	
B16799	188a	....do	Russian-thistle		5
B16800	189	100 feet west of SE corner sec. 17, T. 13 S., R. 34 W.	Niobrara clay loam, 0–6 inches	2	
B16801	189a	....do	Narrowleaf milkvetch		360
B16802	190	700 feet west of SE corner sec. 16, T. 34 S., R. 34 W.	Niobrara clay loam, 0–6 inches	12	
B16803	190a	....do	Narrowleaf milkvetch		60
B16804	191	SE corner sec. 21, T. 13 S., R. 34 W.	Niobrara clay loam, 0–6 inches	.5	
B16805	191a	....do	Russian-thistle		2
B16806	192	700 feet north and 200 feet west of SE corner sec. 28, T. 13 S., R. 34 W.	Niobrara clay loam, 0–6 inches	1	
B16807	192a	....do	Narrowleaf milkvetch		130
B16808	193	300 feet south of W¼ corner sec. 20, T. 13 S., R. 34 W.	Niobrara clay loam, 0–6 inches	3	
B16809	193a	....do	Narrowleaf milkvetch		800
B16810	194	1,000 feet south of NE corner sec. 27, T. 13 S., R. 34 W.	Niobrara stony clay loam, 0–6 inches.	1	
B16811	194a	....do	"Stickleaf"		1
B16812	195	100 feet north of SE corner sec. 34, T. 14 S., R. 34 W.	Colby silt loam, 0–6 inches	1	
B16813	195a	....do	Narrowleaf milkvetch		30
B16814	196	500 feet west of NE corner sec. 10, T. 15 S., R. 34 W.	Niobrara stony clay loam, 0–6 inches.	22	
B16815	196a	....do	Two-groove poisonvetch (tops)		660
B16815A	196b	....do	Two-groove poisonvetch (roots)		210
B16816	197	E¼ corner sec. 15, T. 15 S., R. 34 W.	Niobrara stony clay loam, 0–6 inches.	6	
B16817	197a	....do	Broom snakeweed		2
B16818	198	300 feet east of SW corner sec. 23, T. 15 S., R. 34 W.	Niobrara shaly clay loam, 0–6 inches	2.5	
B16819	198a	....do	Two-groove poisonvetch		15
B16820	199	NE¼ corner sec. 34, T. 15 S., R. 34 W.	Niobrara clay loam, 0–6 inches	14	
B16821	199a	....do	Stanleya		220
B16822	200	200 feet south of NW corner sec. 20, T. 13 S., R. 33 W.	Niobrara clay loam, 0–6 inches	2	
B16823	200a	....do	Cane (leaves)		5
B16823A	200b	....do	Broom snakeweed		5
B16824	201	700 feet south of NW corner sec. 29, T. 13 S., R. 33 W.	Niobrara clay loam, 0–6 inches	40	
B16825	201a	....do	Stanleya		420
B16826	202	1,000 feet south of NW corner sec. 32, T. 13 S., R. 33 W.	Niobrara clay loam, 0–6 inches	2	
B16827	202a	....do	Narrowleaf milkvetch		530
B16828	203	200 feet west of E¼ corner sec. 6, T. 14 S., R. 33 W.	Niobrara clay loam, 0–6 inches	6	
B16829	203a	....do	Broom snakeweed		180
B16830	204	NE corner sec. 18, T. 14 S., R. 33 W.	Niobrara clay loam, 0–6 inches	2	
B16831	204a	....do	Narrowleaf milkvetch		280
B16832	205	NE corner sec. 19, T. 14 S., R. 33 W.	Niobrara clay loam, 0–6 inches	6	
B16833	205a	....do	Broom snakeweed		40
B16834	206	NE corner sec. 30, T. 14 S., R. 33 W.	Colby clay loam, 0–6 inches	1.5	
B16835	206a	....do	Russian-thistle		6
B16836	207	700 feet south of W¼ corner sec. 32, T. 14 S., R. 33 W.	Niobrara clay loam, 0–6 inches	6	
B16837	207a	....do	Stanleya		140

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16838	208	NE¼ corner sec. 7, T. 15 S., R. 33 W.	Niobrara clay loam, 0–6 inches	4	
B16839	208a	....do....	Two-grooved poisonvetch		160
B16840	209	80 rods east of NW corner sec. 18, T. 15 S., R. 33 W.	Niobrara clay loam, 0–6 inches	12	
B16841	209a	....do....	Two-grooved poisonvetch		250
B16842	210	SW corner sec. 19, T. 15 S., R. 33 W.	Colby silt loam, 0–6 inches	.5	
B16843	210a	....do....	Corn (leaves)		2
B16844	211	200 feet east of SW corner sec. 30, T. 15 S., R. 33 W.	Niobrara clay loam, 0–6 inches	.3	
B16845	211a	....do....	"Sandlily"		2
B16846	212	500 feet south of NW corner sec. 23, T. 14 S., R. 34 W.	Colby silt loam, 0–6 inches	.5	
B16847	212a	....do....	Narrowleaf milkvetch		120
B16848	213	500 feet north of SE corner sec. 10, T. 14 S., R. 34 W.	Niobrara clay loam, 0–6 inches	2	
B16849	213a	....do....	Broom snakeweed		1
B16850	213b	....do....	Russian-thistle		4
B16851	214	700 feet south of NE corner sec. 3, T. 14 S., R. 34 W.	Niobrara clay loam, 0–6 inches	3	
B16852	214a	....do....	Broom snakeweed		5
B16853	215	E½ corner sec. 34, T. 13 S., R. 31 W.	Niobrara shaly clay loam, 0–6 inches	3	
B16854	215a	....do....	Two-grooved poisonvetch		330
B16855	216	700 feet south of E¼ corner sec. 30, T. 13 S., R. 32 W.	Niobrara clay loam, 0–6 inches	5	
B16856	216a	....do....	Two-grooved poisonvetch		260
B16857	217	200 feet west of SE corner sec. 11, T. 14 S., R. 33 W.	Niobrara gravelly loam, 0–6 inches	2	
B16858	217a	....do....	"Sandlily"		5
B16859	218	NW corner sec. 24, T. 14 S., R. 33 W.	Colby silt loam, 0–6 inches	.5	
B16860	218a	....do....	Ironplant		7
B16861	219	NE corner sec. 26, T. 14 S., R. 33 W.	Colby silt loam, 0–6 inches	.5	
B16862	219a	....do....	Corn (leaves)		6
B16863	220	SW¼ corner sec. 25, T. 14 S., R. 33 W.	Niobrara clay loam, 0–6 inches	2.5	
B16864	220a	....do....	Two-grooved poisonvetch		250
B16865	221	80 rods north of SE corner sec. 2, T. 15 S., R. 33 W.	Niobrara clay loam, 0–6 inches	2	
B16866	221a	....do....	Narrowleaf milkvetch		120
B16867	221b	....do....	Corn (leaves)		1
B16868	222	500 feet west of SE corner sec. 11, T. 15 S., R. 33 W.	Niobrara shaly clay loam, 0–6 inches	82	
B16869	222a	....do....	Two-grooved poisonvetch (tops)		1,500
B16869A	222b	....do....	Two-grooved poisonvetch (roots)		470
B16870	223	500 feet west of SE corner sec. 11, T. 15 S., R. 33 W. (10 feet from 222).	Niobrara shaly clay loam, 0–6 inches	16	
B16871	224	N¼ corner sec. 25, T. 13 S., R. 35 W.	Clay alluvium, 0–6 inches	1.5	
B16872	225	S½ corner sec. 30, T. 13 S., R. 35 W.	Orange Niobrara shale	1.5	
B16873	226	E½ corner sec. 1, T. 13 S., R. 36 W.	Colby clay loam, 0–6 inches	.4	
B16874	226a	....do....	Sunflower		1
B16875	227	500 feet south of E¼ corner sec. 31, T. 13 S., R. 33 W.	Niobrara clay loam, 0–12 inches	6	
B16876			Niobrara clay loam, 12–24 inches	1	
B16877			Niobrara clay loam, 24–36 inches	.8	
B16878			Niobrara clay loam, 36–48 inches	1	
B16879			Niobrara clay loam, 48–60 inches	.8	
B16880			Niobrara clay loam, 60–72 inches	.8	
B16881	227a	....do....	Narrowleaf milkvetch		140
B16882	228	600 feet east of N¼ corner sec. 29, T. 14 S., R. 33 W.	Niobrara clay loam, 0–12 inches	1	
B16883			Niobrara clay loam, 12–24 inches	.7	
B16884			Niobrara clay loam, 24–36 inches	.5	
B16885			Niobrara clay loam, 36–48 inches	.5	
B16886			Niobrara clay loam, 48–60 inches	.5	
B16887			Niobrara clay loam, 60–72 inches	.6	
B16888			Niobrara clay loam, 72–81 inches	.7	
B16889	228a	....do....	Narrowleaf milkvetch		110

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

LOGAN COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16890	229	NE corner sec. 15, T. 13 S., R. 35 W.	Niobrara shaly clay loam, 0–6 inches	16	----
B16891	229a	....do....	Stanleya	----	230
B16892	230	80 rods north of SW corner sec. 1, T. 14 S., R. 35 W.	Orange layer of Niobrara chalk	18	----

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B16897	1	S¼ corner sec. 28, T. 14 S., R. 31 W.	Orange Niobrara chalk	18	----
B16898	1a	....do....	Two-groove poisonvetch (tops)	----	570
		....do....	Two-groove poisonvetch (roots)	----	170
B16899	1b	....do....	Rabbitbrush (tops)	----	1
B16700	1b	....do....	Rabbitbrush (roots)	----	4
			"Blue aster" (tops)	----	90
B16701	1c	....do....	"Blue aster" (roots)	----	60
B16702	2	300 feet south of NW corner sec. 12, T. 13 S., R. 27 W.	Niobrara clay loam, 0–6 inches	14	----
B16703	2a	....do....	Side-oats grama	----	5
B16704	2b	....do....	Two-groove poisonvetch (tops)	----	470
			Two-groove poisonvetch (roots)	----	230
B16705	2c	....do....	Russian-thistle	----	110
B16706	2d	....do....	Groundsel	----	6
B16707	2e	....do....	Wreath aster	----	170
B16708	2f	....do....	Dotted gayfeather	----	12
B16708A	2g	....do....	Sunflower	----	10
B16709	2h	....do....	Ragweed	----	59
B16710	2i	....do....	Great azure sage	----	5
B16901	1	1,000 feet south of NW corner sec. 12, T. 14 S., R. 31 W.	Niobrara clay loam, 0–6 inches	5	----
B16902	1a	....do....	False boneset	----	1
B16903	2	300 feet east of S¼ corner sec. 14, T. 14 S., R. 31 W.	Niobrara clay loam, 0–6 inches	1.5	----
B16904	2a	....do....	Ironplant	----	25
B16905	3	1,000 feet west of N¼ corner sec. 22, T. 14 S., R. 31 W.	Niobrara clay loam, 0–6 inches	2	----
B16906	3a	....do....	Broom snakeweed	----	100
B16907	4	600 feet south of N¼ corner sec. 28, T. 14 S., R. 31 W.	Niobrara clay loam, 0–6 inches	5	----
B16908	4a	....do....	"Sticklef"	----	1
B16909	5	500 feet south of W¼ corner sec. 34, T. 14 S., R. 31 W.	Niobrara clay loam, 0–6 inches	14	----
B16910	5a	....do....	"Blue aster"	----	270
B16911	6	80 rods south of NW corner sec. 3, T. 15 S., R. 31 W.	Colby silt loam, 0–6 inches	16	----
B16912	6a	....do....	Dotted gayfeather	----	3
B16913	7	SW corner sec. 10, T. 15 S., R. 31 W.	Niobrara clay loam, 0–6 inches	10	----
B16914	7a	....do....	Stanleya	----	600
B16915	8	200 feet south of NW corner sec. 24, T. 15 S., R. 30 W.	Niobrara shaly clay loam, 0–6 inches	16	----
B16916	8a	....do....	Two-groove poisonvetch (tops)	----	220
			Two-groove poisonvetch (roots)	----	190
B16917	8b	....do....	Russian-thistle	----	7
B16918	9	700 feet southwest of W¼ corner sec. 12, T. 15 S., R. 30 W.	Niobrara clay loam, 0–6 inches	8	----
B16920	10	W¼ corner sec. 1, T. 15 S., R. 30 W.	....do....	2.5	----
B16921	10a	....do....	Ironplant	----	70
B16922	11	100 feet east of W¼ corner sec. 36, T. 14 S., R. 30 W.	Niobrara clay loam, 0–6 inches	2.5	----
B16923	11a	....do....	Two-groove poisonvetch	----	20
B16924	11b	....do....	Side-oats grama	----	2
B16925	12	W½ corner sec. 24, T. 14 S., R. 30 W.	Colby silt loam, 0–6 inches	2.5	----
B16926	12a	....do....	Sunflower	----	4
B16927	13	800 feet north of W¼ corner sec. 13, T. 14 S., R. 30 W.	Niobrara clay loam, 0–6 inches	1	----
B16928	13a	....do....	Two-groove poisonvetch	----	20
B16929	14	80 rods north of SW corner sec. 1, T. 14 S., R. 30 W.	Niobrara clay loam, 0–6 inches	2	----
B16930	14a	....do....	Russian-thistle	----	1

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

GOVE COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16931	15	500 feet south of NW corner sec. 36, T. 13 S., R. 30 W.	Niobrara clay loam, 0–6 inches	0.3	.....
B16932	15a	....do.....			2
B16933	16	80 rods south of NE corner sec. 11, T. 13 S., R. 30 W.	Niobrara stony clay loam, 0–6 inches	1	.....
B16934	16a	....do.....	"Stickleaf".....	.....	3
B16935	16b	....do.....	Cane (leaves).....	.....	1
B16936	17	W¼ corner sec. 35, T. 12 S., R. 30 W.	Niobrara clay loam, 0–6 inches.....	1	.....
B16937	17a	....do.....	Broom snakeweed.....	.....	1
B16938	18	300 feet south of NW corner sec. 30, T. 12 S., R. 28 W.	Colby silt loam, 0–6 inches.....	.3	.....
B16939	18a	....do.....	Cane (leaves).....	.....	2
B16940	19	500 feet north of SE corner sec. 25, T. 12 S., R. 29 W.	Niobrara clay loam, 0–6 inches	.5	.....
B16941	19a	....do.....	Narrowleaf milkvetch.....	.....	110
B16942	20	NW corner sec. 12, T. 13 S., R. 29 W.	Niobrara clay loam, 0–6 inches.....	.3	.....
B16943	20a	....do.....	Cane (leaves).....	.....	4
B16944	21	500 feet south of NW corner sec. 13, T. 13 S., R. 29 W.	Niobrara clay loam, 0–6 inches	.2	.....
B16945	21a	....do.....	Dotted gayfeather.....	.....	1
B16946	22	700 feet north of SE corner sec. 20, T. 13 S., R. 29 W.	Niobrara clay loam, 0–6 inches	.3	.....
B16947	22a	....do.....	Two-groove poisonvetch.....	.....	3
B16948	23	400 feet north of E¼ corner sec. 11, T. 14 S., R. 29 W.	Niobrara clay loam, 0–6 inches.....	.2	.....
B16949	23a	....do.....	Russian-thistle.....	.....	1
B16950	24	80 rods south of NW corner sec. 36, T. 14 S., R. 29 W.	Niobrara clay loam, 8–12 inches.....	.5	.....
B16951	24a	....do.....	Cane (heads).....	.....	1
B16952	25	NE corner sec. 2, T. 13 S., R. 29 W.	Niobrara clay loam, 0–6 inches	1	.....
B16953	25a	....do.....	Narrowleaf milkvetch.....	.....	660
B16954	25b	....do.....	Russian-thistle.....	.....	5
B16955	26	1,000 feet south of W¼ corner sec. 12, T. 15 S., R. 29 W.	Niobrara sandy clay loam, 0–6 inches	12	.....
B16956	26a	....do.....	Broom snakeweed (tops).....	.....	80
			Broom snakeweed (roots).....	.....	70
B16957	27	700 feet north of SE corner sec. 14, T. 15 S., R. 29 W.	Recent alluvium, 0–6 inches	3	.....
B16958	27a	....do.....	Sunflower.....	.....	3
B16959	28	SE corner sec. 26, T. 15 S., R. 29 W.	Colby clay loam, 0–6 inches	.5	.....
B16960	28a	....do.....	Corn (tassels).....	.....	1
B16961	29	80 rods north of SE corner sec. 36, T. 12 S., R. 28 W.	Niobrara stony clay loam, 0–6 inches.	1.5	.....
B16962	29a	....do.....	Russian-thistle.....	.....	4
B16963	30	NE corner sec. 12, T. 13 S., R. 28 W.	Alluvial silt loam, 0–6 inches	.2	.....
B16964	30a	....do.....	Cane (leaves).....	.....	2
B16965	31	NE corner sec. 13, T. 13 S., R. 28 W.	Colby silt loam, 0–6 inches (soil under plant).	1	.....
B16966	31a	....do.....	Groundcherry.....	.....	4
B16967	31b	....do.....	Green corn.....	.....	1
B16968	32	80 rods north of SE corner sec. 24, T. 13 S., R. 28 W.	Niobrara clay loam, 0–6 inches	1.5	.....
B16969	32a	....do.....	Stanleya.....	.....	370
B16970	33	500 feet south of NE corner sec. 24, T. 14 S., R. 28 W.	Niobrara clay loam, 0–6 inches	.5	.....
B16971	33a	....do.....	Russian-thistle.....	.....	3
B16972	34	SE corner sec. 25, T. 14 S., R. 28 W.	Niobrara clay loam, 0–6 inches (soil under plant).	1	.....
B16973	34a	....do.....	Wreath aster.....	.....	5
B16974			Niobrara clay loam, 0–6 inches	2	.....
B16975			Niobrara clay loam, 6–12 inches	1.5	.....
B16976	35	900 rods north of SW corner sec. 7, T. 15 S., R. 27 W.	Niobrara clay loam, 12–18 inches	1.5	.....
B16977			Niobrara clay loam, 18–24 inches	3	.....
B16978			Niobrara clay loam, 24–60+ inches	1	.....
B16979	35a	....do.....	Broom snakeweed.....	.....	1
B16980	36	Sec. 13, T. 15 S., R. 28 W.....	Niobrara clay loam, 0–6 inches.	2	.....
B16981	36a	....do.....	Maximilian sunflower.....	.....	5
B16982	36b	....do.....	Stanleya.....	.....	150
B16983	36c	....do.....	Two-groove poisonvetch.....	.....	270
B16984	37	SE corner sec. 13, T. 15 S., R. 28 W.	Alluvial silty clay, 0–6 inches (recent overflow).	3	.....
B16985	37a	....do.....	Cane (tops).....	.....	5

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

GOVE COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B16986	38	$E\frac{1}{4}$ corner sec. 36.	Niobrara clay loam, 0–6 inches (colluvial phase).	0.5	
B16987	38a	do	Broom snakeweed (in soil sample)		2
B16988	39	400 feet west of $E\frac{1}{4}$ corner sec. 27, T. 15 S., R. 27 W.	Niobrara clay loam, 0–6 inches	1.5	
B16989	39a	do	Two-groove poisonvetch		5
B16990	40	SW corner sec. 23, T. 15 S., R. 27 W.	Niobrara clay loam, 0–6 inches (colluvial phase).	3	
B16991	40a	do	Two-groove poisonvetch		18
B16992	41	$N\frac{1}{4}$ corner sec. 21, T. 15 S., R. 27 W.	Niobrara clay loam, 0–6 inches (under plant).	8	
B16993	41a	do	Broom snakeweed		2
B16994	42	80 rods north of SE corner sec. 2, T. 15 S., R. 27 W.	Niobrara clay loam, 0–6 inches (under plant).	2	
B16995	42a	do	Ironplant		100
B16996	43	NE corner sec. 2, T. 15 S., R. 27 W.	Niobrara clay loam, 0–6 inches (under plant).	2.5	
B16997	43a	do	Broom snakeweed		140
B16998	44	600 feet south of NW corner sec. 35, T. 14 S., R. 27 W.	Niobrara clay loam, 0–6 inches	8	
B16999	44a	do	Stanleya		130
B17000	45	$W\frac{1}{4}$ corner sec. 1, T. 14 S., R. 27 W.	Niobrara clay loam, 0–6 inches (under plant).	.4	
B17001	45a	do	Russian-thistle		2
B17002	46	80 rods south of NE corner sec. 14, T. 13 S., R. 27 W.	Niobrara clay loam, 0–6 inches	3	
B17003	46a	do	Groundsel		3
B17004	47	1,600 feet south of NW corner sec. 12, T. 13 S., R. 27 W.	Niobrara clay loam, 0–6 inches	8	
B17005	47a	do	Broom snakeweed		120
B17006	48	500 feet north of SW corner sec. 24, T. 12 S., R. 26 W.	Niobrara clay loam, 0–6 inches	.4	
B17007	48a	do	Broom snakeweed		1
B17008	49	SE corner sec. 14, T. 13 S., R. 26 W.	Colby silt loam, 0–6 inches	7	
B17009	49a	do	Green corn		4
B17010	49b	do	Groundcherry		2
B17011	50	80 rods west of $E\frac{1}{4}$ corner sec. 36, T. 13 S., R. 26 W.	Niobrara clay loam, 0–6 inches (under plant).	2.5	
B17012	50a	do	Wreath aster		25
B17013	51	NE corner sec. 1, T. 14 S., R. 26 W.	Clay loam (terrace phase)	4	
B17014	51a	do	Two-groove poisonvetch		110
B17015	52	80 rods east of NW corner sec. 12, T. 14 S., R. 26 W.	Niobrara clay loam, 0–6 inches (under plant).	16	
B17016	52a	do	Broom snakeweed		430
B17017	53	$E\frac{1}{4}$ corner sec. 23, T. 14 S., R. 26 W.	Niobrara shaly clay loam, 0–6 inches	10	
B17018	53a	do	Broom snakeweed		15
B17019	53b	do	Russian-thistle		4
B17020	54	200 feet northwest of $E\frac{1}{4}$ corner sec. 35, T. 14 S., R. 26 W.	Niobrara clay loam, 0–6 inches (under plant).	1	
B17021	54a	do	*Tetraneuris hastigiata*		1
B17022	55	1,000 feet south of NE corner sec. 2, T. 15 S., R. 26 W.	Colluvial wash, 0–6 inches	2.5	
B17023	55a	do	Groundcherry		3
B17024	56	$W\frac{1}{4}$ corner sec. 12, T. 15 S., R. 26 W.	Alluvial clay loam, 0–6 inches	2	
B17025	56a	do	Great azure sage		1
B17026	56b	do	Two-groove poisonvetch		18
B17027	57	80 rods south of NW corner sec. 13, T. 15 S., R. 26 W.	Niobrara shaly clay, 0–6 inches (under plant).	8	
B17028	57a	do	Russian-thistle		20
B17029	58	300 feet south of NW corner sec. 21, T. 15 S., R. 26 W.	Niobrara clay loam, 0–6 inches (under plant).	1	
B17030	58a	do	Dotted gayfeather		2
B17031	59	700 feet north of SE corner sec. 23, T. 15 S., R. 26 W.	Niobrara clay loam, 0–6 inches (under plant).	.5	
B17032	59a	do	Wreath aster		8
B17033	60	80 rods north of SW corner sec. 25, T. 15 S., R. 26 W.	Niobrara clay loam, 0–6 inches (under plant).	1	
B17034	60a	do	"Blue aster"		12
B17033A	61	SW corner sec. 7, T. 11 S., R. 28 W.	Colby silt loam, 0–6 inches	.4	
B17034A	61a	do	Wreath aster		2

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

SCOTT COUNTY

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B17046	1	W¼ corner sec. 10, T. 16 S., R. 31 W.	Niobrara clay loam (colluvial phase)	28	.....
B17047	1a	....do.....	Broom snakeweed	.....	370

LANE COUNTY

B17035	1	NW corner sec. 12, T. 16 S., R. 29 W.	Niobrara clay loam, 0-6 inches (colluvial phase).	2	.....
B17036	1a	....do.....	Stanleya	.....	120
B17037	2	....do.....	Ferruginous concretions	54	.....
B17038	3	80 rods south of NE corner sec. 1, T. 16 S., R. 27 W.	Niobrara clay loam, 0-6 inches	2	.....
B17039	3a	....do.....	Narrowleaf milkvetch	.....	260
B17040	4	80 rods south of NW corner sec. 18, T. 16 S., R. 27 W.	Niobrara clay loam, 0-6 inches	1	.....
B17041	4a	....do.....	Narrowleaf milkvetch	.....	70
B17042	5	80 rods south of NE corner sec. 24, T. 16 S., R. 28 W.	Niobrara clay loam, 0-6 inches	.2	.....
B17043	5a	....do.....	Scurf-pea	.....	1
B17044	6	Center sec. 12, T. 16 S., R. 27 W.	Niobrara clay loam, 0-6 inches	8	.....
B17045	6a	....do.....	Narrowleaf milkvetch	.....	120
B17683	1	E½ corner sec. 1, T. 19 S., R. 27 W.	Niobrara clay loam, 0-6 inches	4	.....
B17684	1a	....do.....	Two-groove poisonvetch	.....	15
B17685	2	3 miles west and ½ mile north of southeast corner of county.	Greensburg clay loam, 0-6 inches	.3	.....
B17686	2a	....do.....	Broom snakeweed	.....	1

TREGO COUNTY

B16715	.....	East of Trego Center	Fort Hays limestone	0.5	.....
B16719	.....	....do.....	Two-groove poisonvetch	.....	2
B17107	1	SE corner sec. 20, T. 15 S., R. 25 W.	Colby silt loam, 0-6 inches	.3	.....
B17108	1a	....do.....	Cane (heads)	.....	1
B17109	2	80 rods south of NE corner sec. 23, T. 15 S., R. 25 W.	Niobrara clay loam, 0-6 inches	1	.....
B17110	2a	....do.....	"Blue aster"	.....	140
B17111	3	600 feet south of NE corner sec. 14, T. 15 S., R. 25 W.	Niobrara clay loam, 0-6 inches	1	.....
B17112	3a	....do.....	Sunflower	.....	4
B17113	4	700 feet north of W¼ corner sec. 12, T. 15 S., R. 25 W.	Niobrara clay loam, 0-6 inches (colluvial phase).	1	.....
B17114	4a	....do.....	Wreath aster	.....	10
B17115	5	SW corner sec. 29, T. 14 S., R. 25 W.	Greensburg stony loam, 0-6 inches	1.5	.....
B17116	5a	....do.....	Wreath aster	.....	2
B17117	6	1,000 feet south of NE corner sec. 26, T. 14 S., R. 25 W.	Greensburg stony clay loam, 0-6 inches.	.7	.....
B17118	6a	....do.....	Broom snakeweed	.....	6
B17119	7	W¼ corner sec. 21, T. 14 S., R. 25 W.	Niobrara clay loam, 0-6 inches	2	.....
B17120	7a	....do.....	Broom snakeweed	.....	15
B17121	8	E½ corner sec. 14, T. 14 S., R. 25 W.	Niobrara clay loam, 0-6 inches	2	.....
B17122	8a	....do.....	Two-groove poisonvetch	.....	90
B17123	9	80 rods north of SE corner sec. 14, T. 14 S., R. 24 W.	Colby silt loam, 0-6 inches	.3	.....
B17124	9a	....do.....	Cane (heads)	.....	1
B17125	9b	....do.....	Groundcherry	.....	1
B17126	10	W½ corner sec. 11, T. 15 S., R. 24 W.	Greensburg clay loam, 0-6 inches	.7	.....
B17127	10a	....do.....	Goldenrod	.....	1
B17128	11	80 rods north of SE corner sec. 10, T. 15 S., R. 24 W.	Fort Hays limestone	.3	.....
B17129	12	300 feet north of SE corner sec. 22, T. 15 S., R. 24 W.	Greensburg stony clay loam, 0-6 inches	.3	.....
B17130	12a	....do.....	Wreath aster	.....	3

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

TREGO COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B17131	13	SE corner sec. 27, T. 15 S., R. 24 W.	Greensburg stony clay loam, 0–6 inches	1.5	
B17132	13a	do	Broom snakeweed		3
B17133	14	80 rods south of NE corner sec. 34, T. 15 S., R. 24 W.	Niobrara clay loam, 0–6 inches	2	
B17134			Niobrara clay loam, 6–14 inches	3	
B17135			Niobrara clay loam, 14–24 inches	5	
B17136			Niobrara clay loam, 24–36 inches	2	
B17137			Niobrara clay loam, 36–60 inches	8	
B17138	14a	do	Stanleya		1,160
B17139	14b	do	Two-grooved poisonvetch		520
B17140	15	W½ corner sec. 12, T. 15 S., R. 23 W.	Greensburg stony loam, 0–6 inches	.5	
B17141	15a	do	Broom snakeweed		1
B17142	16	E½ corner sec. 1, T. 15 S., R. 23 W.	Greensburg clay loam, 0–6 inches	.3	
B17143	16a	do	Broom snakeweed		1
B17144	17	E½ corner sec. 25, T. 14 S., R. 23 W.	Greensburg clay loam, 0–6 inches	.5	
B17145	17a	do	Broom snakeweed		1
B17146	18	NW corner sec. 26, T. 14 S., R. 23 W.	Greensburg clay loam, 0–6 inches	.7	
B17147	18a	do	Russian-thistle		0
B17148	19	1,000 feet east of SW corner sec. 11, T. 14 S., R. 23 W.	Niobrara clay loam, 0–6 inches	2.5	
B17149	19a	do	Narrowleaf milkvetch		140
B17150	20	500 feet north of SW corner sec. 1, T. 14 S., R. 23 W.	Niobrara clay loam, 0–6 inches	1.5	
B17151	20a	do	Two-grooved poisonvetch		70
B17152	21	200 feet east of SW corner sec. 36, T. 13 S., R. 23 W.	Niobrara clay loam, 0–6 inches	1.5	
B17153	21a	do	Two-grooved poisonvetch		4
B17154	22	500 feet north of southeast corner	Greensburg clay loam, 0–12 inches	.7	
B17155			Greensburg clay loam, 12–24 inches	1	
B17156			Greensburg clay loam, 24–36 inches	3	
B17157			Greensburg clay loam, 36–60 inches	6	
B17158	22a	do	Wreath aster		20
B17159	22b	do	Blue grama		0
B17160	23	NW corner sec. 23, T. 14 S., R. 22 W.	Greensburg stony loam, 0–6 inches	.4	
B17161	23a	do	Broom snakeweed		1
B17162	24	1,000 feet south of NE corner sec. 27, T. 14 S., R. 22 W.	Greensburg stony loam, 0–6 inches	.4	
B17163	24a	do	Broom snakeweed		2
B17164	25	80 rods south of NE corner sec. 26, T. 14 S., R. 22 W.	Black clay loam, 0–6 inches (over Carlile)	.5	
B17165	25a	do	Cane cholla		1
B17166	26	500 feet north of E¼ corner sec. 2, T. 17 S., R. 22 W.	Upper Carlile shale, below Fort Hays limestone	.7	
B17167	27	80 rods south of NE corner sec. 11, T. 15 S., R. 22 W.	Greensburg stony clay loam, 0–6 inches	.3	
B17168	27a	do	Maximilian sunflower		1
B17169	28	80 rods south of NE corner sec. 23, T. 15 S., R. 22 W.	Niobrara clay loam, 0–6 inches	.5	
B17170	28a	do	Gumweed		12
B17171	29	SE corner sec. 22, T. 15 S., R. 21 W.	Clay loam from Ogallala formation, 0–6 inches	3	
B17172	29a	do	Broom snakeweed		1
B17173	30	NE corner sec. 22, T. 15 S., R. 21 W.	Greensburg stony loam, 0–6 inches	2	
B17174	30a	do	Goldenrod		0
B17175	31	80 rods south of NE corner sec. 8, T. 15 S., R. 21 W.	Greensburg stony loam, 0–6 inches	2	
B17176	31a	do	Broom snakeweed		1
B17177	32	80 rods south of NE corner sec. 8, T. 15 S., R. 21 W.	Upper Carlile shale	.5	
B17178	33	E½ corner sec. 32, T. 14 S., R. 21 W.	Recent alluvial silty loam, 0–6 inches	1.5	
B17179	33a	do	Greensburg stony loam, 0–6 inches	.3	
B17180	34	W½ corner sec. 21, T. 14 S., R. 21 W.	do	.3	
B17181	34a	do	Broom snakeweed		0
B17182	35	SE corner sec. 9, T. 14 S., R. 21 W.	Greensburg clay loam, 0–6 inches	.3	
B17183	35a	do	Wreath aster		1

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

TREGO COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B17184	36	SW. corner sec. 3, T. 14 S., R. 21 W.	Greensburg clay loam, 0–6 inches	0.5	
B17185	36a	do	Groundsel		1
B17186	37	700 feet north of SE. corner sec. 16, T. 13 S., R. 21 W.	Greensburg clay loam, 0–6 inches	3	
B17187	37a	do	Wreath aster		1
B17188	38	N½ corner sec. 13, T. 11 S., R. 25 W.	Niobrara shaly clay loam, 0–6 inches	20	
B17189	38a	do	Gumweed		100
B17190	38b	do	Smooth sumac		5
B17191	39	80 rods south of NW. corner sec. 18, T. 11 S., R. 23 W.	Niobrara clay loam, 0–6 inches	8	
B17192	39a	do	Broom snakeweed		2
B17193	40	700 feet south of NE. corner sec. 25, T. 11 S., R. 24 W.	Niobrara clay loam, 0–6 inches	1.5	
B17194	40a	do	Wreath aster		10
B17195	40b	do	Goldenrod		1
B17196	41	E½ corner sec. 28, T. 11 S., R. 23 W.	Greensburg clay loam, 24–36 inches (subsoil).	1.5	
B17197	41a	do	Narrowleaf milkvetch		100
B17198	41b	do	Great azure sage		1
B17199	42	80 rods east of NW. corner sec. 15, T. 11 S., R. 21 W.	Niobrara clay loam, 0–6 inches	8	
B17200	42a	do	Two-grove poisonvetch		140
B17201	43	NW. corner sec. 15, T. 11 S., R. 21 W.	Niobrara shaly loam, 0–6 inches	6	
B17202	43a	do	Two-grove poisonvetch		180
B17203	43b	do	"Blue aster"		130
B17204	44	80 rods south of NE. corner sec. 9, T. 11 S., R. 21 W.	Efflorescence on soil	4	
B17205	44a	do	Groundcherry		3

GRAHAM COUNTY

B17320	1	NE. corner sec. 25, T. 10 S., R. 25 W.	Niobrara clay loam, 0–6 inches	4	
B17321	1a	do	"Blue aster"		1
B17322	2	NE. corner sec. 25, T. 10 S., R. 22 W.	Greensburg clay loam, 0–6 inches	7	
B17323	2a	do	Wreath aster		18
B17324	3	500 feet south of NW. corner sec. 23, T. 10 S., R. 22 W.	Niobrara clay loam, 0–6 inches	8	
B17325	3a	do	Two-grove poisonvetch		10
B17326	3b	do	Russian-thistle		0
B17327	4	NE. corner sec. 34, T. 10 S., R. 21 W.	Niobrara clay loam, 0–6 inches	7	
B17328	4a	do	Wreath aster		1
B17329	4b	do	Maximilian sunflower		4
B17330	5	300 feet northwest of S¼ corner sec. 11, T. 8 S., R. 25 W.	Niobrara clay loam, 0–6 inches	8	
B17331	5a	do	Two-grove poisonvetch		100
B17332	5b	do	Wreath aster		25
B17333	6	N½ corner sec. 17, T. 8 S., R. 24 W.	Niobrara clay loam, 0–6 inches	8	
B17334	6a	do	Two-grove poisonvetch		30
B17335	7	900 feet west of N¼ corner sec. 15, T. 8 S., R. 24 W.	Niobrara clay loam, 0–6 inches	2	
B17336	7a	do	Two-grove poisonvetch		60
B17337	7b	do	Corn (ears and husks)		7
B17338	8	500 feet north of W¼ corner sec. 23, T. 8 S., R. 24 W.	Niobrara clay loam, 18–24 inches	12	
B17339	8a	do	Two-grove poisonvetch		60
B17340	9	300 feet south of N¼ corner sec. 13, T. 9 S., R. 23 W.	Niobrara shaly clay loam, 0–6 inches	2	
B17341	9a	do	"Blue aster"		100
B17342	9b	do	Two-grove poisonvetch		20
B17343	10	300 feet north of SE. corner sec. 4, T. 8 S., R. 22 W.	Niobrara clay loam, 0–6 inches	1	
B17344	10a	do	Two-grove poisonvetch		5
B17345	11	300 feet south of W¼ corner sec. 27, T. 7 S., R. 22 W.	Niobrara clay loam, 0–6 inches	1.5	
B17346	11a	do	Two-grove poisonvetch		12

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

GRAHAM COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B17347	12	80 rods north of SE corner sec. 21, T. 7 S., R. 22 W	Niobrara clay loam, 0–6 inches	1	----
B17348	12a	do	"Blue aster"		120
B17349	12b	do	Two-groove poisonvetch		220
B17350	13	80 rods west of SE corner sec. 5, T. 8 S., R. 21 W	Niobrara clay loam, 0–6 inches	1.5	----
B17351	13a	do	Broom snakeweed		4
B17352	14	SE corner sec. 3, T. 9 S., R. 22 W	Niobrara clay loam, 0–6 inches	20	----
B17353	14a	do	Two-groove poisonvetch		840
B17354	14b	do	Wreath aster		390

ROOKS COUNTY

B17355	1	500 feet east of $W\frac{1}{4}$ corner sec. 4, T. 6 S., R. 20 W.	Niobrara clay loam, 0–6 inches	2.5	
B17356	1a	do	Wreath aster		160
B17357	1b	do	Two-groove poisonvetch (tops)		200
B17358	2	500 feet south of NE corner sec. 5, T. 6 S., R. 20 W.	Niobrara clay loam, 0–6 inches	.3	----
B17359	2a	do	Wreath aster		2
B17360	3	80 rods north of SW corner sec. 17, T. 7 S., R. 20 W.	Niobrara clay loam, 0–6 inches	3	----
B17361	3a	do	Two-groove poisonvetch		12
B17362	3b	do	Maximilian sunflower		3
B17363	4	500 feet north of $E\frac{1}{4}$ corner sec. 17, T. 7 S., R. 20 W	Niobrara clay loam, 0–6 inches	.4	----
B17364	4a	do	Wreath aster		25
B17365	5	$E\frac{1}{4}$ corner sec. 7, T. 8 S., R. 20 W.	Greensburg clay loam, 0–6 inches	.7	----
B17366	5a	do	Gumweed		2
B17367	6	300 feet east of SE corner sec. 29, T. 8 S., R. 20 W	Smoky Hill shale, 5–7 feet	8	----
B17368	6a	do	Two-groove poisonvetch		15
B17369	7	800 feet southeast of NW corner sec. 32, T. 8 S., R. 20 W.	Niobrara clay loam, 0–6 inches	1.5	----
B17370	7a	do	Two-groove poisonvetch		180
B17371	7b	do	Gumweed		2
B17372	7c	do	Russian-thistle		4
B17373	8	500 feet north of SW corner sec. 9, T. 9 S., R. 20 W	Niobrara clay loam, 0–6 inches	2	----
B17374	8a	do	Two-groove poisonvetch		90
B17375	9	80 rods north of SE corner sec. 5, T. 10 S., R. 20 W.	Niobrara clay loam, 0–6 inches	4	----
B17376	9a	do	Wreath aster		120
B17377	10	80 rods east of SW corner sec. 33, T. 10 S., R. 20 W	Niobrara clay loam, 0–6 inches	6	----
B17378	10a	do	Two-groove poisonvetch		8
B17379	10b	do	Stanleya		230
B17380	11	600 feet south of NW corner sec. 27, T. 10 S., R. 19 W	Niobrara stony clay loam, 0–6 inches	.4	----
B17381	11a	do	Broom snakeweed		8
B17382	12	SW corner sec. 22, T. 9 S., R. 19 W.	Niobrara clay loam, 0–6 inches	1	----
B17383	12a	do	Unidentified plant		6
B17384	13	500 feet north of $E\frac{1}{4}$ corner sec. 16, T. 9 S., R. 19 W	Niobrara clay loam, 0–6 inches	1	----
B17385	13a	do	"Blue aster"		13
B17386			Niobrara clay loam, 0–6 inches	8	
B17387			Niobrara clay loam, 6–12 inches	1	
B17388	14	1,000 feet north of SW corner sec. 10, T. 9 S., R. 19 W	Niobrara clay loam, 12–21 inches	1	
B17389			Niobrara clay loam, 21–36 inches	8	
B17390			Niobrara clay loam, 36+ inches	5	
B17391	14a	do	Wreath aster		12
B17392	14b	do	Corn (ears and husks)		1
B17393	15	80 rods south of NW corner sec. 4, T. 8 S., R. 19 W	Niobrara stony clay loam, 0–6 inches	.5	----
B17394	15a	do	Russian-thistle		6
B17395	16	do	Niobrara clay loam, 0–6 inches	5	----
B17396	16a	do	Two-groove poisonvetch		8
B17397	17	80 rods south of NE corner sec 9, T. 8 S., R. 19 W	Greensburg stony clay loam, 0–6 inches	4	----
B17398	17a	do	Broom snakeweed		4

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

ROOKS COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B17399	18	200 feet south of NW corner sec. 27, T. 7 S., R. 19 W.	Niobrara stony clay loam, 0–6 inches	8	
B17400	18a	do	Broom snakeweed		1
B17401	19	500 feet south of NW corner sec. 15, T. 7 S., R. 19 W.	Niobrara stony clay loam, 0–6 inches	1	
B17402	19a	do	"Blue aster"		25
B17403	20	80 rods north of SW corner sec. 27, T. 6 S., R. 19 W.	Niobrara clay loam, 0–6 inches	.7	
B17404	20a	do	Wreath aster		10
B17405	21	W½ corner sec. 10, T. 6 S., R. 19 W.	Niobrara stony clay loam, 0– inches	5	
B17406	21a	do	Two-groove poisonvetch		130
B17407	22	NE corner sec. 2, T. 6 S., R. 18 W.	Niobrara clay loam, 0–6 inches	.5	
B17408	22a	do	Wreath aster		1
B17409	23	80 rods south of NE corner sec. 23, T. 6 S., R. 18 W.	Greensburg stony clay loam, 0–6 inches	4	
B17410	23a	do	Maximilian sunflower		1
B17411	24	600 feet south of E¼ corner sec. 35, T. 7 S., R. 18 W.	Greensburg stony clay loam, 0–6 inches	.3	
B17412	24a	do	Broom snakeweed		1
B17413	25	N¼ corner sec. 23, T. 8 S., R. 18 W.	Niobrara stony clay loam, 0–6 inches	.5	
B17414	25a	do	Two-groove poisonvetch		20
B17415	26	300 feet north of S¼ corner sec. 26, T. 8 S., R. 18 W.	Greensburg stony clay loam, 0–6 inches	.7	
B17416	26a	do	Great-azure sage		0
B17417	26b	do	Cane tops		1
B17418	27	S¼ corner sec. 35, T. 8 S., R. 18 W.	Niobrara clay loam, 0–6 inches	.4	
B17419	27a	do	Russian-thistle		2
B17420	27b	do	Two-groove poisonvetch		80
B17421	28	Center sec. 11, T. 9 S., R. 18 W.	Niobrara clay loam, 0–6 inches	.8	
B17422	28a	do	Grannidcherry		4
B17423	29	300 feet south of center sec. 26, T. 10 S., R. 18 W.	Niobrara clay loam, 0–6 inches	.7	
B17424	29a	do	Wreath aster		10
B17425	30	300 feet south of N¼ corner sec. 35, T. 10 S., R. 18 W.	Niobrara clay loam, 0–6 inches	.3	
B17426	30a	do	Wreath aster		2
B17427	31	S½ corner sec. 35, T. 10 S., R. 17 W.	Niobrara stony clay loam, 0–6 inches	.5	
B17428	31a	do	Broom snakeweed		1
B17429	32	80 rods west of NE corner sec. 2, T. 10 S., R. 17 W.	Niobrara clay loam, 0–6 inches	.5	
B17430	32a	do	Broom snakeweed		1
B17431	33	SW corner sec. 13, T. 10 S., R. 17 W.	Niobrara clay loam	.5	
B17432	33a	do	Wreath aster		10
B17433	33b	do	Cane tops		2
B17434	34	60 rods south of NW corner sec. 34, T. 10 S., R. 17 W.	Fort Hays limestone	6	
B17434A	34a	do	Concretions in no. 34	300	
B17435	35	1,000 feet south of NE corner sec. 35, T. 9 S., R. 17 W.	Niobrara clay loam, 0–6 inches	.5	
B17436	35a	do	Broom snakeweed		0
B17437	36	80 rods south of NE corner sec. 15, T. 8 S., R. 17 W.	Niobrara clay loam, 0–6 inches	.7	
B17438	36a	do	Wreath aster		0
B17439	37	SE corner sec. 36, T. 6 S., R. 17 W.	Greensburg clay loam, 0–6 inches	.3	
B17440	37a	do	Goldenrod		1
B17441	38	500 feet north of E¼ corner sec. 25, T. 6 S., R. 17 W.	Niobrara clay loam, 0–6 inches	.5	
B17442	38a	do	Wreath aster		1
B17443	39	900 feet south of NE corner sec. 1, T. 6 S., R. 17 W.	Niobrara clay loam, 0–6 inches	1	
B17444	39a	do	"Blue aster"		20
B17445	40	80 rods south of NW corner sec. 34, T. 6 S., R. 17 W.	Niobrara clay loam, 0–6 inches	.5	
B17446	40a	do	Broom snakeweed		0
B17447	41	80 rods north of SW corner sec. 3, T. 7 S., R. 16 W.	Niobrara stony loam, 0–6 inches	.5	
B17448	41a	do	"Blue aster"		0

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

ROOKS COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in—	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B17449	42	80 rods south of NW corner sec. 24, T. 7 S., R. 16 W.	Greensburg clay loam, 0–6 inches	0.2	.....
B17450	42a	do	Wreath aster	.....	0
B17451	42b	do	Side-oats grama	.....	1
B17452	43	NW corner sec. 25, T. 9 S., R. 16 W.	Niobrara stony clay loam, 0–6 inches	.5	.....
B17453	43a	do	Cane (tops)	.....	0
B17454	44	W¼ corner sec. 24, T. 8 S., R. 16 W.	Niobrara clay loam, 0–6 inches	1	.....
B17455	44a	do	"Blue aster"	.....	2
B17456	45	NW corner sec. 25, T. 9 S., R. 16 W.	Greensburg stony loam, 0–6 inches	.8	.....
B17457	45a	do	Wreath aster	.....	1
B17458	46b	do	Side-oats grama	.....	0
B17459	46	80 rods south of NE corner sec. 1, T. 10 S., R. 16 W.	Greensburg stony loam, 0–6 inches	.2	.....
B17460	46a	do	"Blue aster"	.....	1
B17461	47	1,000 feet south of N¼ corner sec. 26, T. 10 S., R. 16 W.	Niobrara clay loam, 0–6 inches	.5	.....
B17462	47a	do	"Blue aster"	.....	0

NORTON COUNTY

B17546	1	500 feet south of E¼ corner sec. 10, T. 4 S., R. 21 W.	Niobrara clay loam, 0–6 inches	5	.....
B17547	1a	do	Broom snakeweed	.....	1
B17548	2	500 feet south of E¼ corner sec. 22, T. 4 S., R. 21 W.	Niobrara clay loam, 0–6 inches	.5	.....
B17549	2a	do	Wreath aster	.....	2
B17550	3	200 feet north of SE corner sec. 24, T. 4 S., R. 21 W.	Niobrara shaly loam, 0–6 inches	3	.....
B17551	3a	do	Wreath aster	.....	25

PHILLIPS COUNTY

B17570	1	500 feet west of NE corner sec. 3, T. 4 S., R. 20 W.	Niobrara clay loam, 0–6 inches	0.4	.....
B17571	1a	do	Broom snakeweed	.....	1
B17572	2	150 feet south of NW corner sec. 12, T. 4 S., R. 19 W.	Niobrara clay loam, 0–6 inches	.8	.....
B17573	2a	do	Wreath aster	.....	3
B17574	3	NE corner sec. 11, T. 5 S., R. 19 W.	Niobrara clay loam, 0–6 inches	2	.....
B17575	3a	do	"Blue aster"	.....	10
B17576	3b	do	Two-groove poisonvetch	.....	50
B17577	4	NE corner sec. 14, T. 5 S., R. 19 W.	Niobrara shaly clay loam, 0–6 inches; rubrufunge toward plants	4	.....
B17578	4	do	Niobrara shaly clay loam, 0–6 inches; 50 feet from B17577, under plants	4	.....
B17579	4a	do	Two-groove poisonvetch	.....	400
B17580	5	500 feet north of SE corner sec. 11, T. 5 S., R. 19 W.	Niobrara clay loam, 0–6 inches	5	.....
B17581	5a	do	Maximilian sunflower	.....	2
B17582	6	700 feet north of SE corner sec. 11, T. 5 S., R. 18 W.	Niobrara clay loam, 0–6 inches	1.5	.....
B17583	6a	do	Broom snakeweed	2	.....
B17584	7	SE corner sec. 2, T. 5 S., R. 18 W.	Niobrara clay loam, 0–6 inches	1	.....
B17585	7a	do	Wreath aster	.....	2
B17586	8	SE corner sec. 36, T. 4 S., R. 18 W.	Niobrara clay loam, 0–6 inches	2	.....
B17587	8a	do	Two-groove poisonvetch	.....	60
B17588	9	80 rods north of SW corner sec. 31, T. 4 S., R. 17 W.	Greensburg stony clay loam, 0–6 inches	.8	.....
B17589	9a	do	Wreath aster	.....	0
B17590	10	SE corner sec. 11, T. 5 S., R. 17 W.	Niobrara clay loam, 0–6 inches	.8	.....
B17591	10a	do	"Blue aster"	.....	1

TABLE 5.—*Selenium content of soils and vegetation from Kansas*—Continued

PHILLIPS COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B17592	11	NW corner sec. 15, T. 5 S., R. 17 W.	Niobrara clay loam, 0–6 inches (colluvial phase).	0.5	
B17593	11a	do	Baldwin ironweed		1
B17593A	11b	do	Wreath aster		2
B17594	12	800 feet north of SW corner sec. 15, T. 5 S., R. 17 W.	Niobrara clay loam, 0–6 inches	1	
B17595	12a	do	Ragweed		3
B17596	13	80 rods south of NE corner sec. 28, T. 5 S., R. 17 W.	Niobrara clay loam, 0–6 inches	.4	
B17597	13a	do	Wreath aster		4
B17598	14	80 rods south of NW corner sec. 15, T. 5 S., R. 16 W.	Niobrara clay loam, 0–6 inches	1	
B17599	14a	do	Gumweed		3
B17600	14b	do	Cane		1
B17601	14c	do	"Blue aster"		0
B17602	14d	do	Skeletonweed		1
B17603	14e	do	Groundcherry		1
B17604	15	500 feet south of E¼ corner sec. 1, T. 5 S., R. 16 W.	Colby silt loam, 0–6 inches	.3	
B17605	15a	do	Groundcherry		2
B17606	15b	do	Cane		1
B17607	16	80 rods south of NW corner sec. 15, T. 5 S., R. 16 W.	Niobrara clay loam, 0–6 inches	6	
B17608	16a	do	Two grooved poisonvetch		70

In Wallace County the geological maps and examination of the soil indicate an area of about 275 square miles of Pierre shales, which are presumably parent material for soil. Because of intermixture with material derived from Ogallala deposits, and more particularly with material of loessial origin, the greater portion of this area is not sufficiently seleniferous to produce toxic vegetation. Even where a reasonably large quantity of selenium is present (1 part per million or more), the normal forage plants and crops are not highly seleniferous. In the eastern portion of the county a "spear head" of Niobrara chalk outcrops. The outcrop is of the Smoky Hill division of the Niobrara, which appears to be highly seleniferous. It is estimated that the total area giving rise to toxic soil does not exceed 10 square miles and lies for the most part in T. 13 S., R. 38 W. Examination of the tabular data will reveal the existence of many soil samples marked Colby clay loam, Niobrara clay loam partly loessial, terrace clay loam, and alluvial silt loam. As a rule the selenium content of these is low by reason of the admixture of wind-blown material or through leaching by drainage waters. Altogether it appears that the total area of toxic soils, including soils from both Pierre and Niobrara, does not exceed 50 square miles, and much of this area produces highly toxic vegetation only in the notably efficient absorbers of selenium, such as various species of *Astragalus*, *Stanleya*, and *Aster*. In 1935 this area produced but small quantities of food or forage crops.

Logan County presents quite a different picture. An irregular exposure of Niobrara shale extends from the western border in T. 13 S., R. 37 W., across the county. It is bordered on the north by a broad strip of Pierre shale, which narrows toward the east, and on the south by a narrower strip of the same parent material, which in the eastern half of the county is deeply covered by loessial material. Altogether

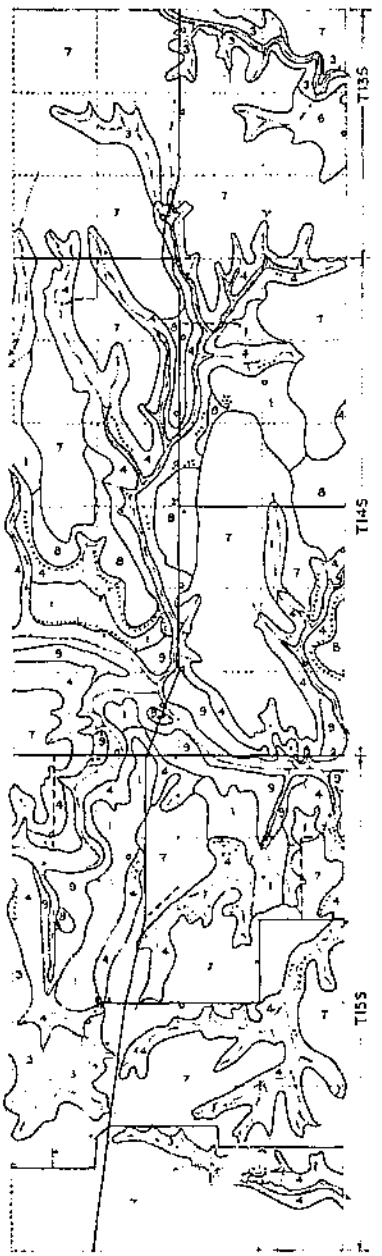

FIGURE 5.—A semidetailed soil map of portions of T. 13 S., T. 14 S., T. 15 S., R. 32 W., in Logan County, Kans.: 4, Niobrara clay loam; 4, Niobrara clay loam, steep phase; 7, Colby silt loam (loess); 8, Colby silt loam (loess over Niobrara); 6, Colby silt loam (over Pierre); 3, Pierre clay loam; 9, Elkader silt loam (terrace soil, mixed origin); 11, alluvium; ×, rock outcrops; 0, and number, sample location.

the two areas comprise more than 500 square miles, or more than half the county. The largest area of wholly nontoxic soil is in the northern and northeastern portions with a smaller area in the southwestern portion of the county. Altogether about 500 samples of shale, soil, and vegetation from this county were examined. The area subject to selenium contamination lies on both sides of the Smoky Hill River and includes the breaks of that stream. Parts of it are extremely rough and unfit for agricultural purposes. The greater portion is not farmed and is covered by only a sparse vegetation consisting for the most part of nonforage or inferior forage plants. In many places the soil is shallow and steep. Over the whole area outcrops of Pierre or Niobrara shale are frequent. Interspersed between low ridges are smooth areas consisting in part, and in some places almost wholly, of soil derived from loess and therefore low in selenium content. A fair idea of the general character of the area may be gained from figure 5, which presents a semidetailed soil map of parts of Townships 13, 14, and 15, in R. 32 W. which lie on either side of the river. It will be observed that only a small portion of the area in question is wholly derived from the Niobrara shale. Indeed, it would seem fair to estimate on the basis of the data in the tables and on field observations that but 10 percent of the Pierre area and about 40 percent of the Niobrara area actually produce toxic vegetation. Even with these limitations it appears that approximately 140 square miles are seriously affected.

Within this area the evidence of unsatisfactory conditions finds a variety of means of expression. Not only is the vegetation more meager than in adjacent areas not affected, but the population is less dense, and the houses and barns, if any, are of the poorer sort.

One effect which may at least in part be ascribed to the presence of selenium is that in the most highly seleniferous portion of the county it appears that the ratio of population for unit area which is on rehabilitation or relief is to that of the most prosperous area in the same county as 24 is to 1. In another county similar comparison of a seleniferous area with a nonseleniferous area gives a ratio of 9 to 1. It is not fair to ascribe this difference of indicated prosperity wholly to selenium, since the selenized areas are rougher, more difficult to farm, consist of shallower soils, and are more largely devoted to stock raising. It is, however, an indication of the general effect of selenium. Figure 6 is an example of a home in a seleniferous area.

FIGURE 6.—A home in the seleniferous area.

A number of items in table 5 deserve special consideration. It may be noted that the profile B16179–B16184 (p. 29) shows a rather high

FIGURE 7.—Two-grooved pulsumvetch, narrowleaf milkvetch, and "sandlily", at spot corresponding to sample B16253.

selenium content throughout its depth and this is highest where the shale is reached. This is not true of profiles represented by B16247–B16249 and B16253–B16255 (p. 30). In the latter profiles the parent material is loess, and the explanation of the relatively high selenium in the surface portion which seems warranted is that seleniferous dust has been transferred from adjacent seleniferous areas.

Samples B16693–B16696 (p. 36) show the relative selenium content of the soil and of three samples of vegetation at the spot shown in figure 7. The three samples of vegetation are growing upon essentially the same spot, yet there is a wide difference in selenium content. The tops of the two-groove poisonvetch have a higher selenium content than the roots. In all cases where such comparison has been made the result is the same if leaves are included with the tops. If the data in table 1 be compared with corresponding data in table 5 it will be seen that in general selenium concentration in the vegetation is lower for corresponding soil content in the Kansas area. This is not to be ascribed entirely to the higher sulphate content of the soil solution (p. 24).

In examining the data of table 5 it will be noted that the selenium content of ordinary crops and forage vegetation is usually low. This

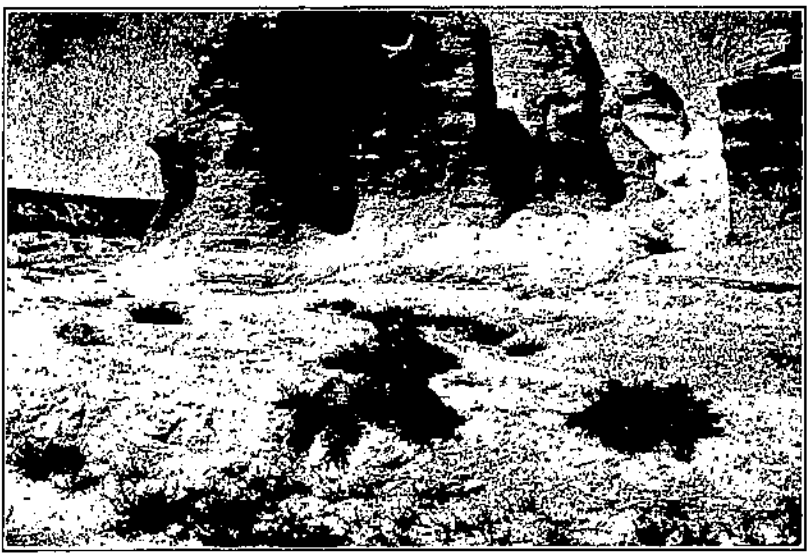

FIGURE 8.—The source of sample B16868.

is in part owing to the fact that such samples could be obtained only in the better portions of the area, that is, in places where soil was wholly or partly of loessial origin.

Special attention may also be drawn to sample B16868 (p. 39), which has the highest selenium content of any soil sample so far examined, and to sample B16870, which was taken but 10 feet from the other and has only one-fifth the selenium content. As is to be expected such soil is essentially barren of ordinary vegetation (fig. 8). B16868 was taken from around the roots of the two-groove poisonvetch shown in the figure. The analyses of tops and roots were made separately (B16869 and B16869A, p. 39).

In Gove County the geologic map (*16*) shows an outcrop of Niobrara formation extending across the county and covering the whole southern half of it. The outcrop extends into the northeast corner of Scott County and along the northern edge of Lane County. Altogether the exposure covers approximately 650 square miles. The exposure appears to be wholly of the Smoky Hill, or upper portion

of the Niobrara. No Pierre shales appear to outcrop. As was the case in Wallace and Logan Counties, by no means is all the soil over this area derived from the chalk. In places over fairly considerable areas the Niobrara formation is covered deeply with loess and loessial-derived soil, and except directly on the outcrops, considerable dilution with loessial material appears to exist. Also, as the data on Gove County show, the selenium content of the vegetation, even of the very good absorbers, decreases toward the eastern portion of the area. It would appear doubtful whether more than 10 to 20 percent of this area produces severely poisonous vegetation. To what extent this effect is due to the portion of the shale serving as soil parent material

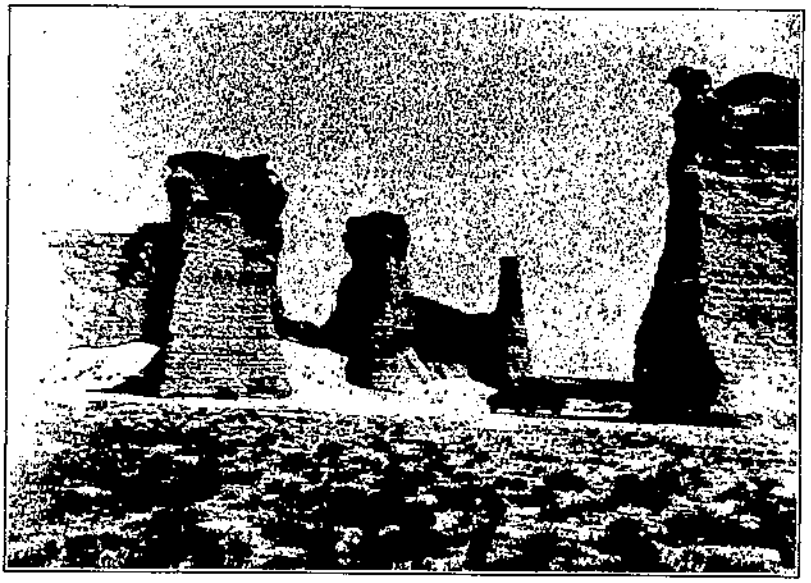

FIGURE 9.—The pyramids in Gove County, showing the general character of vegetation on soil developed from the Smoky Hill division of the Niobrara formation.

to the loessial material present, to the presence of sulphates, or to other causes is not yet clear.

Near the western border of the county is found an extremely rough area of outcrop of Niobrara shales. Figure 9 illustrates the general scenic character of the locality. This area is very seleniferous, as indicated by the data given for B16697 to B16701. The samples of vegetation, which are low in selenium content as compared with the samples of soil, illustrate the wide variation in absorption capacity as well as the general relation between roots and tops of the same plant.

Of particular interest is the series of samples B16702–B16710, which consists of one sample of soil and nine samples of vegetation. All the vegetation samples were taken immediately adjacent to or upon the spot where the soil sample was obtained. While all the vegetation is toxic, there is a wide range in content from 5 parts per million for the side-oats grama and great azure sage to 470 parts per million for the tops of the two-groove poisonvetch. The spot in question is shown in figure 10. In the foreground is a typically selenized horse. A series of 20 samples taken from shale outcrops

a few miles to the east of this point but not located by township and range were sent by J. E. Upp. These ranged in selenium content from 17 to 600 parts per million. They are not included in the tables.

A single sample of soil and one of vegetation were obtained in Scott County. They proved to be highly seleniferous (table 5).

The small number of samples from the northern border of Lane County proved to be highly seleniferous when taken upon exposures of the Smoky Hill member of the Niobrara chalk. One, B17042 (table 5), which was close to the border of the outcrop, was low. One sample, taken over Smoky Hill chalk in the southern part of the county, was low in selenium; another, in the extreme southeast corner over an outcrop of Fort Hays chalk (lower Niobrara), was essentially free from selenium.

In Trego County the band of soil overlying the Smoky Hill division of the Niobrara formation narrows somewhat, and the area is further

FIGURE 10.—A selenized horse and a typical Niobrara outcrop.

diminished by the intrusion of a "spearhead" of shale-derived soil over the Carlile shale. There is also a "spearhead" of Niobrara partially exposed along the border between Trego and Graham Counties (fig. 4). A large portion of this area represents an exposure of the lower section of the Niobrara, the Fort Hays limestone. This formation, unlike the Smoky Hill formation, is nearly white and low in selenium content. The Greensburg soil developed upon the Fort Hays is apparently always low in selenium except where largely diluted with material from a more toxic source. Altogether the shale exposure of the two portions of the Niobrara amounts to about 450 square miles. At the most, not over 25 square miles may be expected to produce toxic vegetation. This observation is in accord not only with the analytical data on the vegetation in table 5 (p. 45), but also with the fact that during the field work no cases of selenized animals were observed. Nevertheless, many of the samples of soil and both the profiles taken in the county reveal quantities of selenium which in other areas are quite capable of producing toxic vegetation, even in the plants not particularly susceptible to selenium absorption. The explanation of this low toxicity is found in the discussion of the data

on the sulphur-selenium ratio (p. 52). Despite the presence of quantities of selenium in the asters and milkvetches, which range between 40 and 1,160 parts per million in 12 out of a total of 49 samples of vegetation, it is not believed that any serious selenium situation exists in this county. Nevertheless, isolated cases of toxic effects undoubtedly occur.

All the samples from Trego County examined are included in table 5. It was not deemed necessary to tabulate the samples from Ellis County lying just east of it. Sixty-four samples were examined, 27 of which were of soil parent material. These samples in all cases save six appeared to be derived from Fort Hays chalk or Carlile shale, or a mixture of these. In no case did these samples show more than 0.5 part per million of selenium, and in no case did the vegetation exceed 4 parts per million. Among the six soil samples which showed 1 part per million of selenium four were from T. 11 S., R. 20 W.; one from T. 12 S., R. 20 W.; and one from T. 11 S., R. 19 W. The vegetation corresponding to these samples in three cases was two-groove poisonvetch, and the selenium content was 10, 70, and 100 parts per million, respectively. One sample of broom snakeweed contained 6 parts per million. It is to be noted that although search was made for other samples of *Astragalus*, none was found. Asters, broom snakeweed, and Russian-thistle were abundant, yet in most of them selenium was not present in excess of 1 part per million. It would seem that the conclusion is warranted that no serious injury results in Ellis County from the presence of selenium in the soil. It remains possible or even probable, however, that some toxic spots may exist.

Russell County lies to the east of Ellis County, and no soils are derived from the Niobrara formation. It does offer soils derived from the Carlile and the various subdivisions of the Greenhorn limestone, including the thin layer of the Post Rock section of the Pfeifer shale. These have so low a content of selenium that no toxic soils are to be expected. None was found, though seven samples were examined.

In the tier of counties north of Wallace, Logan, Gove, Trego, and Ellis, no outcrop of Pierre or Niobrara shales furnishes significant quantities of soil parent material until Sheridan County is reached. The small area of possibly toxic soil in Sheridan County was not examined. North of Trego County, in Graham County, the geologic map (*16*) shows an area of exposure of the Smoky Hill division of the Niobrara of approximately 200 square miles, and also an exposure of about 90 square miles of Fort Hays limestone. The data in table 5 (p. 45), collected from Graham County, show many soil samples which contain sufficient selenium to render the vegetation toxic. All the samples of vegetation except one are of nonforage crops. On the basis of field examination and of the analytical results it is estimated that not more than 20 square miles are seriously affected.

Rooks County, east of Graham County and north of Ellis County, has a large area of Niobrara exposure, of which approximately two-thirds is of the Smoky Hill division. In this county a total of 52 soil samples and 57 samples of vegetation were examined. A study of the data in table 5 shows that in the western portion of the county many samples of soil and vegetation are of toxic character. In the eastern portion of the county, ranges 16, 17, and 18, few or no toxic conditions appear. This is true even in cases where the soil appears,

from field inspection, to be primarily of Smoky Hill origin. It would appear that not to exceed 50 square miles are likely to produce toxic plants, and even over the greater portion of this the normal forage crops are not highly toxic.

Osborne County, north of Russell County, reveals outcropping of Niobrara shale much farther east than in the lower tier of counties. The total area so exposed is about 250 square miles, but the soils derived from it are so diluted with materials from nontoxic formations that not more than 35 square miles are potentially toxic. Even in this area, partly at least because the soils are derived from the lower portion of the Smoky Hill division and intermixed with materials from the Fort Hays division, the degree of toxicity of both soils and vegetation is low. Out of 82 samples of soils and vegetation examined in this county, only 1 sample of gumweed was toxic. Even the samples of wreath aster or "blue aster" did not contain selenium in excess of 3 parts per million, and but one surface soil sample had as high as 1 part per million. The detailed data are not included in the tables. It seems probable, therefore, that in Osborne County only stray samples of highly seleniferous vegetation will be found and these will be of plants growing on eroded areas where Niobrara shale of high selenium content is exposed. It may be noted that no samples of the milkvetches were found in this county.

East of Osborne County no seleniferous area is to be expected and therefore no examination was made.

In the northernmost series of counties in Kansas no seleniferous area exists until Norton County is reached. The geologic map shows an outcrop of Pierre shales in the northwestern portion of Cheyenne County. A field inspection of this area shows the soils to be almost wholly derived from loess and Ogallala materials. Pierre shale is exposed only in deep cuts. No toxic area of serious extent is to be expected. This last statement may also be made concerning Rawlins and Decatur Counties, though doubtless toxic spots and samples of seleniferous vegetation may occur.

In Norton County, in the southeastern portion, an outcrop of Niobrara shales occurs. No adequately careful examination of this was made. It seems probable that an area of about 10 square miles is sufficiently toxic to produce injurious vegetation.

The southeastern section of Phillips County has a considerable area shown by the geologic maps to be underlain by Niobrara shales. Of this the greater portion is so low in selenium, by reason of intermixture with nontoxic soils, that vegetation of nontoxic types is to be expected. Where the major portion of the soil is from material derived from the Smoky Hill formation, toxic plants are found. A detailed examination was not made, but the samples reported on page 49 of table 5 indicate the character of material found. It is estimated that not more than 20 square miles are seriously affected.

Smith County is shown by the geologic maps to have an exposure of a large area of Niobrara shales, and as nearly as may be estimated it is about equally divided between the Smoky Hill and Fort Hays formations. In this county, out of a total of 39 samples, only 1 sample of soil was found that contained more than 1 part per million and 1 sample of vegetation, wreath aster, that contained more than 3 parts per million of selenium. One is forced, therefore, to the conclusion

that only in spots where the Smoky Hill area actually is exposed upon the surface is toxic vegetation to be expected.

In Jewell County there is also an extensive area of soils underlain by the Niobrara formation, but the Smoky Hill division of that formation forms so small a fraction of the residual soil material, or the leaching has been so extensive, that the selenium content is uniformly low. Of a total of 32 samples of soil and vegetation, only 1 sample of soil and 1 of vegetation showed toxic quantities of selenium.

Since, as reported in Technical Bulletin 482 (*2*), a single sample of vegetation, supposedly obtained in Clark County, Kans., contained a toxic quantity of selenium, 910 parts per million, it seemed desirable to determine whether the Permian-derived soils in that county contained selenium. Out of a total of 18 samples, none had a toxic quantity. Incident to the journey required to collect the samples from Clark County there were collected and examined 50 samples of soil and vegetation from areas underlain by the Niobrara formation in Ness, Hodgeman, and Finney Counties. Of these but one, a soil sample from sec. 15, T. 17 S., R. 26 W., in Ness County, showed a selenium content in excess of 1 part per million, and the sample of two-groove poisonvetch at the same spot had but 2 parts per million. Despite the low selenium content observed in these cases it is believed that toxic samples may be found in suitable locations in the three counties last named. It cannot be said, however, that any serious situation exits in these areas.

It was not possible during this field season to make any investigation of the area of exposed shale in Hamilton County to determine the extent of the affected soil area or the degree of toxicity. Since this area represents an extension of cretaceous shales found over a large area in southeastern Colorado, it may form a part of subsequent investigation.

A review of the total data from Kansas indicates that in the neighborhood of 400 square miles of soils are more or less seriously affected by the presence of selenium. It is not to be inferred from this statement that this large area is either useless or that its use for agricultural purposes is a threat to the general public interest. The presence of selenium is a natural condition, like rainfall, temperature, and drainage, to which the agriculture of the district must intelligently adapt itself.

SELENIUM IN MONTANA SOILS

The reconnaissance soil map of the northern plains (*7*) of Montana shows considerable areas of Pierre clay, presumably derived from shales similar in character to the Pierre shales in South Dakota and in Carter County in the southeastern portion of the State. These last have been shown to contain varying quantities of selenium (*2*). It seemed desirable, therefore, to make a general examination of other areas in order to determine whether detailed examinations were necessary. For this purpose J. T. Miller collected a series of samples during June and July 1935. Some of the results obtained from examination of these samples, and their locations, are given in table 6. A still larger number of results are not detailed in the table since significant quantities of selenium were not found.

TABLE 6.—*Selenium content of soils and vegetation from Montana*

VALLEY COUNTY

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B15419	1	1 mile north of Frazer	Pierre clay loam, 0-6 inches	0.5	--
B15420	1a	do	Broom snakeweed	--	15
B15421	2	9½ miles northwest of Glasgow	Tampico clay, alluvial (irrigated)	5	--
B15422	2a	do	Two-grooved poisonvetch	--	25
B15423	3	10 miles south of Glasgow	Scobey clay loam, 0-6 inches	.5	--
B15424	3a	do	Young wheat	--	7
B15425	4	10 miles northwest of Lismas	Lismas clay, 0-6 inches	1	--
B15426	4a	do	Two-grooved poisonvetch	--	35
B15427	5	15 miles west of Lismas	Ormun clay loam, 0-6 inches	.7	--
B15428	5a	do	Two-grooved poisonvetch	--	810
B15429	6	11.5 miles west of Lismas	Lismas clay loam, 0-6 inches	1	--
B15430	6a	do	Wheatgrass	--	12
B15431	7	14.5 miles west of Lismas	Pierre clay, 0-6 inches	1	--
B11632	7a	do	Broom snakeweed	--	7
B15433	7b	do	Two-grooved poisonvetch	--	140
B15434	8	16.5 miles west of Lismas	Lismas clay loam, 0-6 inches	.6	--
B15435	8a	do	Stiffleaf vetch	--	15
B11636	9	18.5 miles west of Lismas	Pierre clay, 0-6 inches	1.5	--
B15437	9a	do	Two-grooved poisonvetch	--	90
B15438	10	0.9 mile south of Glasgow	Ormun clay, 0-6 inches (irrigated)	.6	--
B15439	10a	do	Young wheat	--	7
B17440	11	1.9 miles southeast of Glasgow	Ormun clay, 0-6 inches (not irrigated)	.5	--
B15441	11a	do	Wheatgrass	--	5
B15442	12	5 miles southeast of Glasgow	Ormun clay, 0-6 inches	.5	--
B15443	12a	do	Wheatgrass	--	5
B15444	13	10 miles southeast of Glasgow	Ormun clay (irrigated)	.4	--
B15445	13a	do	Young wheat	--	80
B15446	14a	2.5 miles west of Glasgow	Two-grooved poisonvetch	--	1,520
B15447	15	2 miles northeast of Nashua	Bearpaw shale	2	--
B15448	16	6 miles northwest of Hinsdale	Pierre clay loam	.4	--
B15449	16a	do	Two-grooved poisonvetch	--	320
B15450	17a	6 miles southeast of Saco	Young wheat	--	2

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B15451	1	12 miles north of Malta	Pierre clay loam, 0-6 inches	2.5	--
B15452	1a	do	Wreath aster	--	12
B15453	2	600 feet north of SE¼ corner sec. 12, T. 34 N., R. 30 E.	Ormun clay, 0-6 inches	.4	--
B15454	2a	do	Sunflower	--	30
B15455	3a	Cottonwood Creek Bridge, on State Highway 4.	Two-grooved poisonvetch	--	210
B15456	4	3½ miles northwest of Cottonwood Creek bridge.	Calcareous sandstone	.1	--
B15457	4a	do	Crazyweed	--	9
B15458	5a	3.8 miles northwest of Cottonwood Creek bridge	Two-grooved poisonvetch	--	60
B15459	6	4 miles northwest of Cottonwood Creek bridge	Judith shale	1.5	--
B15460	7a	5 miles northwest of Cottonwood Creek bridge.	Drummond milkvetch	--	9
B15462	8	W½ corner sec. 16, T. 34 N., R. 28 E.	Scobey loam, 0-6 inches	.5	--
B15463	8a	do	Narrowleaf milkvetch	--	260
B15464	9	SE corner sec. 14, T. 35 N., R. 28 E.	Pierre clay, 0-6 inches	1	--
B15465	9a	do	Goldenpea	--	20
B15466	10	80 rods northwest of Cottonwood Creek bridge.	Claggett shale	2	--
B15468	11	SE¼ sec. 25, T. 33 N., R. 31 E.	Ormun clay, 0-6 inches	.5	--
B15469	11a	do	Scarlet globemallow	--	340
B15470	12	Tatanail	Ormun clay, 0-6 inches	1	--
B15471	12a	do	Scarlet globemallow	--	7
B15472	13	80 rods north of mouth of White Creek	Ormun clay, 0-6 inches	.1	--
B15473	13a	do	Sunflower	--	25
B15474	14	1½ miles east of Stinking Creek	Ormun clay, 0-6 inches	2	--
B15475	14a	do	Two-grooved poisonvetch	--	880
B15476	15	3 miles north of Frenchmans Creek	Ormun clay, 0-6 inches	1.5	--
B15477	15a	do	Sunflower	--	15

TABLE 6.—*Selenium content of soils and vegetation from Montana*—Continued

PHILLIPS COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B155478	16	10.7 miles upstream from mouth of Frenchmans Creek	Orman clay, 0–6 inches	1	
B155479	16a	do	Sunflower		7
B155480	16b	do	Two-groove poisonvetch		660
B155481	17	½ mile north of bridge over Milk River on Saco Road.	Orman clay, 0–6 inches	3	
B155482	17a	do	Hares-ear-mustard		5
B155484	18a	9 miles east of Malta on U. S. 2	Two-groove poisonvetch		45
B155485	19	21 miles east of Malta on U. S. 2	Beaverton clay, 0–6 inches	3	
B155486	19a	do	Sunflower		4
B155487	20	1 1 miles east of Saco	Lismas clay, 0–6 inches	.5	
B155488	20a	do	Two-groove poisonvetch		7
B155489	21	15.5 miles south of Saco	Pierre clay, 0–6 inches (on Judith shale	.2	
B155490	21a	do	Two-groove poisonvetch		45
B155491	22	NW corner sec. 36, T. 29 N., R. 33 E.	Lismas clay loam, 0–6 inches	4	
B155492	22a	do	Two-groove poisonvetch		9
B155493	23a	T. 27 N., R. 33 E.	do		150
B155494	24	8.1 miles south of Bowdoin	Pierre clay, 0–6 inches	1	
B155495	24a	do	Sunflower		3
B155496	25	4.5 miles south of Malta, on State Highway 39	Scobey clay loam, 0–6 inches	.2	
B155497	25a	do	Young rye		9
B155498	26	21.5 miles south of Malta, on State Highway 39	Orman clay, 0–6 inches	.5	
B155499	26a	do	Scarlet globemallow		3
B155500	27	31.9 miles south of Malta, on State Highway 39.	Orman clay, 0–6 inches	5	
B155501	27a	do	Foxtail		2
B155502	27b	do	Two-groove poisonvetch		7
B155503	28	6½ miles north of Leedy	Bearpaw shale	2	
B155504	28a	do	Goldenpea		9
B155505	29	3 miles north of Leedy	Bearpaw shale	2	
B155506	29a	do	Goldenpea		50
B155507	30	1.3 miles north of Leedy	Orman clay, 0–6 inches	1.5	
B155508	30a	do	Sunflower		7
B155509	31	6 miles west of Leedy	Claggett shale	8	
B155510	32	11.7 miles west of Leedy	Lismas clay loam, 0–6 inches	3	
B155511	32a	do	Sunflower		8
B155512	33	1b miles north of Legg	Orman clay, 0–6 inches	5	
B155513	33a	do	Sunflower		7
B155514	34	W½ corner sec. 13, T. 30 N., R. 28 E.	Harlem silty clay, 0–6 inches (not irrigated).	1	
B155515	34a	do	Wheatgrass		2
B155516	35	E½ corner sec. 13, T. 30 N., R. 28 E.	Harlem silty clay loam, 0–6 inches (irrigated).	1	
B155517	35a	do	Alfalfa		6
B155518	36	NE corner sec. 20, T. 30 N., R. 29 E.	Bowdoin clay, 0–6 inches (irrigated)	3	
B155519	36a	do	Slender wheatgrass		5
B155520	37	NW corner sec. 21, T. 30 N., R. 29 E.	Bowdoin clay, 0–6 inches (not irrigated).	5	
B155521	37a	do	Sunflower		12
B155522	38	7.6 miles southwest of Malta	Scobey clay loam, 0–6 inches	4	
B155523	38a	do	Broom snakeweed		3
B155524	39a	16.2 miles southwest of Malta	Two-groove poisonvetch		220
B155525	40	22.7 miles southwest of Malta	Orman clay, 0–6 inches	2	
B155526	40a	do	Two-groove poisonvetch		280
B155527	41	4.5 miles west of Phillips	Scobey loam, 0–6 inches	4	
B155528	41a	do	Young wheat		5
B155529	42	5 miles west of Phillips	Scobey loam, 0–6 inches	1	
B155530	42a	do	Young wheat		3
B155531	43	5 miles west and 2 1 miles north of Phillips	Bearpaw shale	1	
B155532	43a	do	Slender wheatgrass		6
B155533	44	5 miles west and ¼ mile north of Phillips	Bearpaw shale	1.5	
B155534	44a	do	Goldenpea		3
B155535	45	6.3 miles south of Brookside	Bearpaw shale	2	
B155536	46	11.1 miles south of Brookside	Lismas clay, 0–6 inches	3	
B155537	47a	3 miles north of Zortman	Two-groove poisonvetch (on Scobey loam).		8
B155538	48a	10.9 miles north of Dodson	Young wheat (on Scobey loam)		10
B155539	49a	16 miles north of Dodson	Two-groove poisonvetch		310

TABLE 6.—*Selenium content of soils and vegetation from Montana*—Continued

PHILLIPS COUNTY—Continued

Laboratory no.	Field no.	Location	Material	Selenium in	
				Soils or shales	Vegetation
				P. p. m.	*P. p. m.*
B155540	50	24 miles north of Dodson	Bearpaw shale	0.8	..
B155541	50a	do	Goldenpea		4
B155542	51	20.5 miles north of Dodson	Lisuns clay, 0–6 inches (on Bearpaw shale)	2	..
B155543	51a	do	Goldenpea		6
B155544	52a	36.8 miles north of Dodson	Young wheat (on Scobey loam)		8
B155545	53a	6.1 miles southeast of Phillips	Young wheat (on Scobey loam)		3
B155546	54a	2.5 miles southeast of Midale	Young oats (on Scobey loam)		6
B155547	55	2 miles south of Midale	Scobey loam, 0–6 inches	.7	..
B155548	55a	do	Young wheat		9
B155549	56	¼ mile west of Midale	Orman clay loam, 0–6 inches	.7	..
B155550	56a	do	Alfalfa		15
B155551	56b	do	Broom snakeweed		9
B155552	57a	Midale	Two-groove poisonvetch (on alluvial soil)		400
B155553	58	¼ mile southeast of Midale	Scobey loam, 0–6 inches	1	..
B155554	58a	do	Young oats		8
B155555	59	1 mile east of Midale	Scobey loam, 0–6 inches	.4	..
B155556	59a	do	Two-groove poisonvetch		12
B155556A	60	6 miles west of Dodson	Harlem clay, 0–6 inches	.5	..
B155556B	60a	do	Sunflower		10

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B156669	1	4½ miles east of Dunkirk	Joplin clay loam, 0–6 inches	0.4	..
B156670	1a	do	Two-groove poisonvetch		250
B156671	1b	do	Wreath aster		1
B156672	2	3½ miles east of Dunkirk	Joplin light clay loam, 0–6 inches	.6	..
B156673	2a	do	Two-groove poisonvetch		200
B156675	3a	13 miles west of Shelby	Narrowleaf milkvetch		730
B156676	4	At Etheridge	Joplin light clay loam, 0–6 inches	.4	..
B156677	4a	do	Narrowleaf milkvetch		110
B156678	5	11.1 miles east of Etheridge	Colorado shale	1.5	..
B156681	6	do	Fossil in Colorado shale	2	..
B156682	7	1.8 miles north of Shelby	Colorado shale	2	..

The data in table 6 show the existence of a seleniferous area in Valley and Phillips Counties. The detail is not sufficient to show how extensive the total area involved may be nor how intensive or uniform it is. They do indicate the need of special and detailed study, particularly because in some instances the selenium content of the plants examined was high as compared with the quantity in the soil. The area in Phillips County is particularly important because of its relationship to irrigation already in operation or projected in the Milk River Valley. The water supplies of the district and the effect of leaching upon the drainage waters have not yet been examined, although steps have been taken to secure the information required. A single sample of two-groove poisonvetch collected 14 miles west of Poplar, in Roosevelt County, showed a selenium content of 450 parts per million. This sample probably represents an extension of an area of seleniferous soils into Roosevelt County similar in type to those in Valley and Phillips Counties. Its extent is not known.

A single sample of narrowleaf milkvetch collected 13 miles south of Wolf Point in McCone County showed a selenium content of 1,350 parts per million. It is not believed, on geological grounds, that this indicates a general distribution in McCone County, but, on the

same basis, an area in the northwestern portion of this county and areas in the northern portions of Garfield, Petroleum, and Fergus Counties adjacent to the Missouri River deserve close investigation. A single sample in Prairie County (B15416) showed the highly toxic quantity of 620 parts per million in narrowleaf milkvetch, although but 0.4 part per million was found in the surface soil. This has no special significance except for the fact that it was growing on soil presumably derived in part from the Fort Union formation. It is possible that localized material derived from seleniferous shales may be included in glacial drift.

The data of table 6 indicate a seleniferous area in Toole County in the vicinity of Dunkirk, Shelby, and Ethridge. This area deserves detailed examination since it may extend into parts of Glacier County and into Pondera and Teton Counties. All five samples of vegetation taken in Glacier County contained selenium, but only one contained a serious quantity. Three samples taken in Teton County contained selenium, but not in excessive quantities.

A large number of samples in other Montana areas have been examined, but in none was there sufficient selenium to make urgent a further examination. Unfortunately, the necessity for work in the South Dakota area prevented any study of certain areas in Big Horn, Treasure, and Rosebud Counties, where geological data would indicate the presence of selenium if the exposed strata are the source of the soil parent materials. The point previously made will bear repetition. An underlying seleniferous shale indicates only the possible presence of selenium in soil and vegetation. Even when such formations are the source of the soil, the quantity of selenium and the concomitant conditions may render the condition essentially harmless. The study of these areas is therefore a protective measure

EFFECT OF RAINFALL UPON THE SELENIUM CONTENT OF SOILS AND VEGETATION

In Technical Bulletin 482 (*2, p. 45*), attention is called to the fact that the whole period during which the selenium content of soils and vegetation had been studied had been one of excessive dryness. Consequently, no data were available upon which to base an estimate of what is to be expected in wet seasons. An attempt was made to get some basis of expectation from the testimony of persons living in seleniferous areas and familiar with alkali disease. There was no agreement. Some were positive that alkali disease is worse in dry years. Others were equally positive that this is not the case. An apparent plurality was uncertain. For a time the growing season of 1935 seemed an especially favorable opportunity for the study of this problem, since more rain fell in April 1935 at Pierre, S. Dak., than in the entire growing season of 1934. Unfortunately for this purpose, this high rainfall did not persist throughout the season. Nevertheless, it seemed desirable to collect a new series of samples in 1935 corresponding as closely as possible in character and location to those collected in 1934. The rainfall at Pierre from September 1, 1933, to September 1, 1934, was, as reported by the Weather Bureau, 7.74 inches. From September 1, 1934, to September 1, 1935, it was 14.12 inches. The mean annual rainfall for 45 years is reported as 16.7 inches. Four areas were sampled. Two of these are in the northern

part of Lyman County; two are in Gregory County. The samples taken were located as closely as possible to the spots sampled the year previously. In table 7 only those samples are reported which are believed to present corresponding conditions. The samples from Gregory County, and particularly from Randall Creek, may not represent a difference in rainfall so marked as those from Lyman County.

TABLE 7.—*Selenium content of soils and vegetation obtained in 1934 and in 1935*

SEC. 3, T. 108 N., R. 79 W., LYMAN COUNTY, S. DAK.

Laboratory no.	Field no.	Material	Selenium in soil or shale		Selenium in vegetation	
			1934	1935	1934	1935
			P. p. m.	*P. p. m.*	*P. p. m.*	*P. p. m.*
B15877	1	Alluvium, 0–6 inches	1	3		
B15878	1a	Wheatgrass			5	2
B15879	2	Wind-blown clay loam, 0–6 inches	2	1		
B15880	2a	Wheatgrass			2	1
B15882	3	Wind-blown clay loam, 0–6 inches	2	2		
B15883	3a	Wheatgrass			4	1
B15885	4	Wind-blown clay loam, 0–6 inches	2.5	5		
B15886	4a	Wheatgrass			10	6
B15888	5	Boyd clay, 0–6 inches	2.7	4		
B15889	5a	Needlegrass, Wheat (heads)			1	1
B15891	6	Boyd clay, 0–6 inches	1	5		
B15892	6a	Needlegrass			1	2
B15894	7	Boyd clay, 0–6 inches	3	5		
B15897	7c	Wheat (heads)			20	18
B15898	8	Boyd clay, 0–6 inches	5	5		
B15899	8a	Needlegrass			7	4
B15901	9	Boyd clay, 0–6 inches	7	2		
B15902	9a	Dropseed			1	3
B15905	20	Boyd clay, 0–6 inches	1	4		
B15906	20a	Wheat (heads)			6	4
B15907	21	Boyd clay, 0–6 inches	4	2		
B15908	21a	Needlegrass			10	7
B15910	22	Boyd clay, 0–6 inches	1	1		
B15911	22a	Wheat (heads)			30	4
B15913	23	Boyd clay, 0–6 inches	3			
B15914	23a	Wheat (heads)			30	12
B15915	34	Boyd clay, 0–6 inches	4	6		
B15916	34a	Wheat (heads)			1	2
B15917	35	Boyd clay, 0–6 inches	12	4		
B15918	35a	Wheat (heads)			10	30
B15920	36	Boyd clay, 0–6 inches	1	5		
B15921	36a	Wheat (heads)			1	25
B15922	37	Boyd clay, 0–6 inches	2.5	4		
B15923	37a	Wheat (heads)			4	2
B15924	49	Boyd clay, 0–6 inches	1	4		
B15925	49a	Wheat (heads)			1	2
B15926	50	Boyd clay, 0–6 inches	2	1		
B15927	50a	Needlegrass			3	3
B15928	50b	Wheat (heads)			5	7
B15929	51	Boyd clay, 0–6 inches	3	4		
B15930	51a	Wheat (heads)			4	5
B15931	52	Boyd clay, 0–6 inches	3	2.5		
B15932	52a	Wheat (heads)			10	6
B15933	53	Boyd clay, 0–6 inches	2	4.2		
B15934	53a	Wheat (heads)			8	12
B15935	54	Boyd clay, 0–6 inches	2.5	2.5		
B15936	54a	Needlegrass, Wheat (heads)			2	3
B15937	55	Boyd clay, 0–6 inches	3	1.7		
B15938	55a	Wheat (heads)			6	3
B15939	56	Boyd clay, 0–6 inches	1	2.5		
B15940	56a	Wheat (heads)			4.1	15

SEC. 4, T. 108 N., R. 79 W., LYMAN COUNTY, S. DAK.

B15725	1	Boyd clay, 0–6 inches	1.7	1.7		
B15726	1a	Wheatgrass			3	3
B15727	1b	Wheat (heads)			10	8
B15728	2	Boyd clay, 0–6 inches	1.5	1.5		
B15729	2a	Wheat (heads)			1	2
B15730	2b	Needlegrass			1.1	1

TABLE 7.—*Selenium content of soils and vegetation obtained in 1934 and in 1935*—Continued

SEC. 4, T. 103 N., R. 70 W., LYMAN COUNTY, S. DAK.—Continued

Laboratory no.	Field no.	Material	Selenium in soil or shale		Selenium in vegetation	
			1934	1935	1934	1935
			P. p. m.	*P. p. m.*	*P. p. m.*	*P. p. m.*
B15731	4	Boyd clay, 0–6 inches	1.5	2.5	--	--
B15732	4a	Wheat (heads)			7	7
B15733	5	Alluvium clay, 0–6 inches	2.5	2.5	--	--
B15734	5a	Needlegrass			5	8
B15735	6	Boyd clay, 0–6 inches	1	1	--	--
B15736	6a	Wheatgrass			4	3
B15737	6	Boyd clay, 0–6 inches	1.5	1.5	--	--
B15738	6a	Needlegrass			5	2
B15739	7	Boyd clay, 0–6 inches	2	2		
B15740	7a	Wreath aster			120	40
B15741	8	Boyd clay, 0–6 inches	2	3	--	--
B15742	8	Needlegrass			2	3
B15743	9	Boyd clay, 0–6 inches	1	3	--	--
B15744	9a	Wheatgrass			15	20
B15745	10	Boyd clay, 0–6 inches	3	4	--	--
B15746	10a	Needlegrass			6	7
B15747	11	Boyd clay, 0–6 inches	1.5	1.5	--	--
B15748	11a	Wheatgrass			1	1
B15749	12	Boyd clay, 0–6 inches	1.5	1.5	--	--
B15750	12a	Wheat (stubble)			1	2
B15752	13	Boyd clay, 0–6 inches	1	2	--	--
B15754	13a	Wheat (stubble)			1	1
B15755	14	Boyd clay, 0–6 inches	1.5	2	--	--
B15756	14a	Wheat (heads)			2	1
B15757	15	Boyd clay, 0–6 inches	2.5	4	--	--
B15758	15a	Wheat (heads)			45	25
B15759	16	Boyd clay, 0–6 inches	1	1.5	--	--
B15760	16a	Wheat (heads)			2	4
B15761	17	Boyd clay, 0–6 inches	3	2.5	--	--
B15762	17a	Wheat (heads)			10	5
B15763	18	Boyd clay, 0–6 inches	2.5	2	--	--
B15764	18a	Young corn (Barley (heads)			2	8
B15765	19	Boyd clay, 0–6 inches	1.5	2.5	--	--
B15766	19a	Groundcherry (Barley (heads)			15	5
B15767	20	Boyd clay, 0–6 inches	2	3	--	--
B15768	20a	Young cornstalks (Barley (heads)			8	2
B15769	21	Boyd clay, 0–6 inches	2	2	--	--
B15770	21a	Mixed grasses (Wheatgrass)			2	3
B15771	22	Boyd clay, 0–6 inches	3	4	--	--
B15772	22a	Needlegrass			15	8
B15774	23	Boyd clay, 0–6 inches	2	3	--	--
B15775	23a	Barley (heads)			12	9
B15776	24	Boyd clay, 0–6 inches	3	2.5	--	--
B15777	24a	Barley (heads)			12	4
B15778	25	Boyd clay, 0–6 inches	2.5	2.5	--	--
B15779	25a	Barley (heads)			10	2
B15780	26	Boyd clay, 0–6 inches	2	2	--	--
B15781	26a	Cornstalks (Oats			3	9
B15782	27	Boyd clay, 0–6 inches	2	2.5	--	--
B15783	27a	Wheatgrass			4	4
B15784	28	Boyd clay, 0–6 inches	3	1	--	--
B15785	28a	Wheatgrass			3	8
B15786	29	Boyd clay, 0–6 inches	2.5	2.5	--	--
B15787	29a	Small grain (stubble (Barley (heads			30	8
B15790	30	Boyd clay, 0–6 inches	5	8	--	--
B15791	30a	Wheatgrass			30	17
B15792	31	Boyd clay, 0–6 inches	6	6	--	--
B15793	31a	(Barley (heads) (Oats (heads)			80	50
B15795	32	Boyd clay, 0–6 inches	5	5	--	--
B15796	32A	Needlegrass			10	10
B15797	33	Boyd clay, 0–6 inches	4	5	--	--
B15798	33a	Needlegrass			3	10
B15799	34	Boyd clay, 0–6 inches	2.5	2.5	--	--
B15800	34a	Needlegrass			3	1
B15801	35	Boyd clay, 0–6 inches	4	2.5	--	--
B15802	35a	Needlegrass			1	8

TABLE 7.—*Selenium content of soils and vegetation obtained in 1934 and in 1935*—Continued

SEC. 4, T. 108 N., R. 79 W., LYMAN COUNTY, S. DAK.—Continued

Laboratory no.	Field no.	Material	Selenium in soil or shale		Selenium in vegetation	
			1934	1935	1934	1935
			P. p. m.	*P. p. m.*	*P. p. m.*	*P. p. m.*
B15803	36	Boyd clay, 0–6 inches	8	6		
B15804	36a	Needlegrass			18	3
B15805	37	Boyd clay, 0–6 inches	3.5	5		
B15807	37b	Wheat (grain)			40	
		Wheat (heads)				60
B15808	38	Alluvium, 0–6 inches	20	8		
B15809	38a	Wheatgrass			12	5
B15810	38b	Wheat (heads)			40	10
B15811	39	Boyd clay, 0–6 inches	3	6		
B15812	39a	Wheat (heads)			.5	2
B15813	39b	Needlegrass			1	5
B15814	39c	Wreath aster (?)			5	5
B15815	40	Boyd clay, 0–6 inches	4	6		
B15816	40a	Wheatgrass			3	2
		Oats (heads)				
B15818	41	Boyd clay, 0–6 inches	4	7		
B15819	41a	Wheatgrass			9	10
B15820	42	Boyd clay, 0–6 inches	3	2.5		
B15821	42a	Rye (heads)			20	15
B15822	43	Boyd clay, 0–6 inches	3.5	5		
B15823	43a	Rye (stubble)			20	7
B15825	44	Alluvium, 0–6 inches	3	5		
B15826	44a	Cordgrass			15	5
B15827	45	Boyd clay, 0–6 inches	3.5	4		
B15828	45a	Barley (heads)			3	3
B15829	45b	Wheatgrass			1	2
B15831	46	Boyd clay, 0–6 inches	4	3.5		
B15832	46a	Needlegrass			1	6
B15833	46b	Wreath aster			5	120
B15834	47	Boyd clay, 0–6 inches	3	4		
B15835	47a	Needlegrass			2	6
B15836	48	Boyd clay, 0–6 inches	3	4		
B15837	48a	Needlegrass			1	4
B15838	49	Boyd clay, 0–6 inches	5	6		
B15839	49a	Needlegrass			1	4
B15812	50	Boyd clay, 0–6 inches	2.5	3		
B15813	50a	Needlegrass			8	10
B15844	50b	Wreath aster			12	60
B15845	51	Boyd clay, 0–6 inches	2.5	3		
B15846	51a	Needlegrass			1	5
B15847	52	Boyd clay, 0–6 inches	3	3		
B15848	52a	Needlegrass			40	5
B15849	53	Boyd clay, 0–6 inches	6	8		
B15850	53b	Needlegrass			2	5
		Wheatgrass			7	3
B15853	54	Boyd clay, 0–6 inches	4	5		
B15854	54a	Wheatgrass				8
B15855	54b	Rye (heads)			10	
B15856	55	Boyd clay, 0–6 inches	2	2.5		
B15857	55a	Needlegrass			11	
		Wheat (heads)				8
B15858	56	Boyd clay, 0–6 inches	2.5	2		
B15859	56a	Sunflower			25	10
B15911	1	Boyd silty clay loam, 0–6 inches	13	4		
B15912	1a	Wheatgrass			10	10
B15913	2	Boyd clay loam, 0–6 inches	4	5		
B15914	2a	Side-oats grama			1	2
B15915	3	Alluvial clay, 0–6 inches	2	7		
B15916	3a	Wreath aster			60	210
B15917	4	Boyd clay, 0–6 inches	12	2.5		
B15919	6	Boyd clay loam, 0–6 inches	2	8		
B15950	6a	Little bluestem			0	1
B15951	7	Boyd clay loam, 0–6 inches	2.5	1		
B15952	7a	Little bluestem			0	
		Wheatgrass				1
B15953	8	Boyd clay loam, 0–6 inches	2.5	1.5		
B15954	8a	Little bluestem			1	
		Side-oats grama				1
B15955	9	Boyd clay loam, 0–6 inches	4.5	3.5		
B15956	9a	Side-oats grama				2
		Western wheatgrass			20	
B15957	10	Boyd clay loam, 0–6 inches	1.5	3		
B15958	10a	Little bluestem and side-oats grama			.5	1

TABLE 7.—*Selenium content of soils and vegetation obtained in 1934 and in 1935*—Continued

SEC. 4, T. 108 N., R. 70 W., LYMAN COUNTY, S. DAK.—Continued

Laboratory no.	Field no.	Material	Selenium in soil or silule		Selenium in vegetation	
			1934	1935	1934	1935
			P. p. m.	*P. p. m.*	*P. p. m.*	*P. p. m.*
B15959	11	Boyd clay, 0–6 inches	3	3		
B15960	11a	Side-oats grama and little bluestem			1	7
B15961	12	Boyd clay loam, 0–6 inches	2	2.5		
B15962	12a	Sunflower (heads) Unidentified plant				6
B15963	24	Boyd sandy clay loam, 0–6 inches	2	4	2	
B15964	24a	Russian-thistle Unidentified weed			50	10
B15965	25	Boyd sandy clay loam, 0–6 inches	2	6		
B15966	25a	Wreath aster Unidentified weed			100	7
B15967	26	Boyd sandy clay loam, 0–6 inches	2	3.5		
B15968	26a	Side-oats grama Little bluestem			.5	1
B15969	27	Boyd clay loam, 0–6 inches	2	8		
B15970	27a	Mixed grasses			.5	1
B15971	28	Boyd sandy clay loam, 0–6 inches	2	3		
B15972	28a	Side-oats grama Little bluestem			.5	1
B15973	29	Boyd clay loam	7	4		
B15974	29a	Little bluestem			1	1
B15975	30	Boyd clay loam	1.5	8		
B15976	30a	Little bluestem			0	1
B15977	31	Boyd sandy clay loam, 0–6 inches	2.5	3		
B15978	31a	Little bluestem			.5	2
B15979	32	Boyd sandy clay loam, 0–6 inches	2	5		
B15980	32a	Little bluestem			1	2
B15981	33	Boyd sandy clay loam, 0–6 inches	2.5	6		
B15982	33a	Little bluestem			1	1
B15983	34	Boyd sandy clay loam, 0–6 inches	2	8		
B15984	34a	Little bluestem			.5	0
B15985	46	Wind-blown soil, 0–6 inches	5	8		
B15986	47	Boyd sandy clay loam, 0–6 inches	4	6		
B15988	47a	Young wheatgrass			7	12
B15989	48	Boyd clay, 0–6 inches	3	6		
B15990	48a	Wheatgrass			35	8
B15991	49	Boyd clay, 0–6 inches	5	3		
B15992	49a	Little bluestem			1	1
B15993	50	Boyd clay loam, 0–6 inches	5	3		
B15994	50a	Side-oats grama Little bluestem			0	1
B15995	51	Boyd clay, 0–6 inches	2.5	3		
B15996	51a	Little bluestem			0	1
B15997	52	Boyd sandy clay loam, 0–6 inches	4	1.5		
B15998	52a	Buffalo grass Side-oats grama			12	2
B15999	53	Boyd clay loam, 0–6 inches	6	4		
B16000	53a	Little bluestem			.5	5
B16001	54	Boyd clay, 0–6 inches	12	2		
B16002	54a	Little bluestem			2	2
B16003	55	Boyd clay, 0–6 inches	4	2.5		
B16004	55a	Little bluestem			1	1
B16005	56	Boyd clay, 0–6 inches	9	4		
B16006A	56a	Western wheatgrass			40	5
B16007	68	Wind-blown clay, 0–6 inches	6	8		
B16008	68a	No vegetation Sunflower				0
B16009	69	Boyd sandy clay loam, 0–6 inches	3	3.5		
B16010	69a	*Hoffmanseggia jamesii* *Astragalus* *Kuhnia*			4	2
B16011	69b	Western wheatgrass			1	5
B16012	70	Boyd sandy loam, 0–6 inches	5	3		
B16013	70a	Wheatgrass and side oats grama			15	4
B16014	70b	Sunflower Unidentified weed			60	20
B16015	71	Boyd clay, 0–6 inches	5	1		
B16016	71a	Western wheatgrass			7	12
B16017	72	Boyd clay, 0–6 inches	8	4		
B16018	72a	Mixed grasses Little bluestem			70	10
B16019	73	Boyd clay loam, 0–6 inches	3	3.5		
B16021	74	Boyd clay loam, 0–6 inches	5.5	4		
B16022	74a	Western wheatgrass			30	15

TABLE 7.—*Selenium content of soils and vegetation obtained in 1934 and in 1935*—Continued

SEC. 4, T. 108 N., R. 79 W., LYMAN COUNTY, S. DAK.—Continued

Laboratory no.	Field no.	Material	Selenium in soil or shale		Selenium in vegetation	
			1934	1935	1934	1935
			P. p. m.	*P. p. m.*	*P. p. m.*	*P. p. m.*
B16023	75	Boyd clay loam, 0–6 inches	5	2.5		
B16024	75a	Mixed grasses			2	7
B16025	76	Boyd clay loam, 0–6 inches	6	4		
B16026	76a	Wheatgrass			8	10
B16027	77	Boyd clay loam, 0–6 inches	8	5		
B16028	77a	Side-oats grama and little bluestem			1	1
B16029	78	Boyd clay loam, 0–6 inches	3	6		
B16030	78a	Black grama			25	15
B16031	90	Boyd clay, 0–6 inches	0.5	4		
B16032	90a	Side-oats grama			1	3
B16033	91	Boyd clay loam, 0–6 inches	6	3.5		
B16034	91a	Little bluestem			0	1
B16035	92	Boyd clay loam, 0–6 inches	2.5	1		
B16036	92a	Little bluestem			1	0
B16037	93	Boyd clay loam, 0–6 inches	3.5	4		
B16038	93a	Little bluestem			1	1
B16039	93b	*Hoffmanseggia jamesii*			1	2
B16040	94	Boyd clay loam, 0–6 inches	5	3		
B16041	94a	Little bluestem			2	2
B16042	95	Boyd clay loam, 0–6 inches	3	3		
B16043	95a	Little bluestem			1	2
B16044	96	Boyd clay loam, 0–6 inches	3.5	1.5		
B16045	96a	Little bluestem			1	3
B16046	97	Boyd clay loam, 0–6 inches	2	8		
B16047	97a	Little bluestem			1	2
B16048	98	Boyd clay loam, 0–6 inches	3.5	3		
B16049	98a	Little bluestem			.5	4
B16050	99	Boyd clay loam, 0–6 inches	3	4		
B16051	99a	Corn cleaves Russian-thistle			20	20
B16054	100	Boyd clay loam, 0–6 inches	2.5	2.5		
B16054	100a	Young Russian-thistle Tumbleweed Russian-thistle			7	10
B16056	112	Boyd clay loam, 0–6 inches	6	6		
B16057	112a	Little bluestem Side-oats grama			1	8
B16058	113	Boyd clay loam, 0–6 inches	8	6		
B16059	113a	Big bluestem			1	2
B16060	114	Boyd clay loam, 0–6 inches	2	1		
B16061	114a	Little bluestem Side-oats grama			1	1
B16062	115	Boyd clay loam, 0–6 inches	3	2.5		
B16063	115a	Side-oats grama			1	4
B16064	116	Boyd clay loam, 0–6 inches	5	3		
B16065	116a	Little bluestem			.5	3
B16066	117	Boyd clay loam, 0–6 inches	9	8		
B16067	117a	Big bluestem			1	3
B16068	118	Boyd clay loam, 0–6 inches	3	5		
B16069	118a	Big bluestem			1	1
B16070	119	Boyd clay, 0–6 inches	11	6		
B16071	119a	Little bluestem			1	2
B16072	120	Boyd clay loam, 0–6 inches	8	3.5		
B16073	120a	Little bluestem			1	1
B16074	121	Boyd clay loam, 0–6 inches	3	2		
B16075	121a	Prairie rose Groundcherry			25	10
B16076	121b	Western wheatgrass			35	7
B16076	122	Boyd clay loam, 0–6 inches	4	3.5		
B16077	122a	Young Russian-thistle			35	45
		RANDALL CREEK VALLEY, GREGORY COUNTY, S. DAK.				
B16085	1	Terrace silt loam, 0–6 inches	2.5	2		
B16086	1a	Russian-thistle			15	50
B16087	2	Terrace silt loam, 0–6 inches	2.5	2		
B16088	2a	Russian-thistle			20	18
B16089	3	Alluvium clay loam, 0–6 inches	2	3		
B16090	4a	Corn cleaves Russian-thistle			4	18
B16091	4	Terrace silt loam, 0–6 inches	2	1		

TABLE 7.—*Selenium content of soils and vegetation obtained in 1934 and in 1935*—Continued

RANDALL CREEK VALLEY, GREGORY COUNTY, S. DAK.—Continued

Laboratory no.	Field no.	Material	Selenium in soil or shale		Selenium in vegetation	
			1934	1935	1934	1935
			P. p. m.	*P. p. m.*	*P. p. m.*	*P. p. m.*
B16092	4a	Corn (leaves)				
		Young barley			2	
B16093	5	Terrace silt loam, 0–6 inches	2	2		
B16094	5a	Corn (leaves)				17
		Young barley			2	
B16096	6	Alluvial clay loam, 0–6 inches	1.5	1.5		
B16096	6a	Young barley			5	
		Russian-thistle				8
B16097	7	Terrace silt loam, 0–6 inches	1.5	1		
B16098	7a	Wreath aster			15	25
B16099	8	Terrace silt loam, 0–6 inches	1.5	2		
B16101	9	do	2	1.5		
B16102	9a	Western wheatgrass			5	
		Corn (leaves)				6
B16103	10	Terrace silt loam, 0–6 inches	1	1.5		
B16104	10a	Young wheat			6	
		Rye (heads)				6
B16105	11	Terrace silt loam, 0–6 inches	2	1.5		
B16106	11a	Young wheat			4	
		Rye (heads)				7
B16107	12	Terrace silt loam, 0–6 inches	1	1		
B16108	12a	Young wheat			2	
		Rye (heads)				6
B16109	13	Terrace silt loam, 0–6 inches	1	1		
B16110	13a	Young wheat			8	
		Rye (heads)				7
B16111	14	Terrace silt loam, 0–6 inches	.7	1		
B16112	14a	Lambsquarters			8	12
B16113	15	Missouri River bottom soil, 0–6 inches	1.5	2		
B16114	15a	Lambsquarters			2	6
B16115	16	Missouri River bottom soil, 0–6 inches	2.5	2.5		
B16117	17	Terrace silt loam, 0–6 inches	3	2		
B16118	17a	Lambsquarters			15	20
B16119	18	Terrace silt loam, 0–6 inches	.7	.7		
B16120	18a	Sunflower			7	15
B16121	19	Terrace silt loam, 0–6 inches	.7	.7		
B16122	19a	Lambsquarters			9	
		Corn (leaves)				15
B16123	20	Terrace silt loam, 0–6 inches	.5	.6		
B16125	21	do	.5	.5		
B16126	21a	Oats				10
		Young barley			1	
B16127	22	Terrace silt loam, 0–6 inches	.7	1.5		
B16128	22a	Wheatgrass			50	5
B16129	23	Terrace silt loam, 0–6 inches	.7	.7		
B16130	23a	Black grama			4	7
B16131	24	Terrace silt loam, 0–6 inches	.4	.5		
B16132	24a	Black grama			0	2
B16133	25	Terrace silt loam, 0–6 inches	.3	.7		
B16134	25a	Black grama			0	1
B16135	26	Terrace silt loam	.5	.8		
B16136	26a	Russian-thistle				5
		Wheatgrass			50	
B16137	27	Terrace silt loam, 0–6 inches	1	6		
B16138	27a	Russian-thistle			50	2

Study of the data in table 7 shows a surprising constancy in the results obtained in the examination of the soils. In a few instances there are sharp differences, yet in the greater number of cases the results are more nearly identical than should be expected from duplicate analyses of the same sample. In cases where marked divergences were found, the analyses were repeated to make sure that the differences were real. It will be observed that the most marked variations are found in sec. 21, T. 100 N., R. 72 W. This section is in one of the worst of the wind-eroded areas in South Dakota,

and marked erosion and accumulations of eroded material were noted by F. A. Hayes, who collected the samples in 1934, and by J. T. Miller, who collected them in 1935. In certain places the surface soil was completely removed, thus exposing the subsoil. In other places the soil of 1934 was deeply covered by wind-blown material in 1935. Despite these variations in material, which occur to some extent in all the locations, the mean values, shown in table 8, are essentially the same for the soils. This result was to have been expected since, as previously noted (*2*), the Fort Randall area was shown to be toxic in 1856, and was still toxic in 1934. If limited rainfall seriously modifies the total selenium content of soils, this area should have been rendered nontoxic. In this table are also shown the mean values for the selenium content of the vegetation.

TABLE 8.—*The mean selenium content of samples of soil and vegetation obtained in South Dakota in 1934 and in 1935*

Area	Samples	Selenium in soil		Selenium in vegetation	
		1934	1935	1934	1935
	Number	*P. p. m.*	*P. p. m.*	*P. p. m.*	*P. p. m.*
Sec. 3, T. 108 N., R. 79 W. (Lyman County)	25	3.6	3.5		
	20			8.2	6.7
Sec. 4, T. 108 N., R. 79 W. (Lyman County)	50	3.1	3.3		
	65			12.3	10.8
Sec. 21, T. 10 N., R. 72 W. (Gregory County)	66	4.3	4.1		
	67			10.6	8.2
Fort Randall (Gregory County)	27	1.3	1.6	10	11.5

It will be observed that the variations of the mean selenium content of the vegetation, while considerable, are not uniform. In three of the locations the mean content appears somewhat higher in 1934, but in the Fort Randall area it is slightly higher in 1935. Too great importance may readily be attached to these mean values. In arriving at the mean values certain obviously noncomparable results were omitted. Included in the collection of 1935 was one sample of wreath aster containing 1,220 parts per million. It is not included in table 7 because no corresponding sample was collected in 1934. Two pairs of samples were also omitted. In one case a sample of sunflower had but 1 part per million of selenium in 1934, while the corresponding sample for 1935 contained 210 parts per million. A sample of wreath aster in 1934 showed a content of 1,300 parts per million, and its 1935 analog, presumably collected at the same spot, had but 380 parts per million. Such sporadic variations of single plants are of sufficiently frequent occurrence to justify exclusion of these samples. Their presence does, however, lessen the validity of the apparently justified inference that selenium absorption by plants is somewhat decreased by increased rainfall. When, however, these observations are combined with the fact that in seasons of abundant rainfall animals are afforded a greater liberty of choice in food selection, due to its greater abundance, it is not difficult to believe that toxic effects from moderately toxic vegetation are likely to be less marked in seasons of high rainfall.

Another fact brought out by the comparisons shown in table 8 is the total absence of any constant relation between the quantity of

selenium in the surface soil and that in the corresponding vegetation. This is, of course, in part due to the fact that the vegetation types are not represented to the same extent in the different areas. If, however, all the plants were of the same species and taken at the same stage of growth, it is unlikely that any constant relation would be found, for reasons discussed on page 71 et. seq. It is also to be observed that the relatively low mean selenium content of the vegetation of these areas is due to the relatively large number of samples of vegetation of low absorptive capacity.

SPECIAL ITEMS

"POISONOUS" SPRINGS

In various portions of the seleniferous areas the writer has observed, or has been informed of, springs or other water supplies from which animals are debarred by fences. Usually this is because of the assumption that alkali disease or similar troubles are due to the water. In Technical Bulletin 482 (*2*) it was shown that in the area where water samples were examined, no selenium content sufficient to produce poisoning could be demonstrated. During the winter of 1934–35 the writer learned of what appeared to be an authentic case of water poisoning in the neighborhood of Buffalo Gap, S. Dak. This case was investigated, and the results have been published (*11*).

In this case it seems to have been demonstrated that neither selenium nor arsenic was present in the water in sufficient quantity to produce the results noted. On the other hand, the vegetation adjacent to the temporary spring was shown to have ample quantities of selenium to produce toxic effects when eaten, particularly so when supplemented by the solvent effect of ample water supply. In no case has selenium been found in ordinary water supplies in sufficient quantities to produce severe poisoning. In the drainage water from irrigation areas, in the water from a new drain in the Belle Fourche area in South Dakota (*2*), and in drainage water from both the Grand Valley and Uncompahgre districts in Colorado (p. 23), quantities of selenium were found which would probably produce serious poisoning if present in a normal water supply. In all these cases, however, the water is essentially nonpotable.

Water from a shallow well near Fallon, Nev., furnished by C. S. Scofield, was found to contain 0.56 part per million of selenium, while water from a deep artesian well not far distant contained no selenium. On the basis of present evidence it is believed that potable waters toxic by reason of their selenium content are not likely to be found.

RELATION OF SELENIUM IN THE SOIL TO THAT IN THE PLANT

Both in Technical Bulletin 482 (*2*) and in this report (p. 52) attention has been called to the wide differences in selenium absorption shown by different plant species. The data in the previous tables show striking differences in selenium absorption for a given species. A few examples may be cited. *Astragalus racemosus* shows a range of ratios of selenium in the plant to that in the surface soil from 2,800 (B14761, p. 10) to 30 (B15258, p. 12). Narrowleaf milkvetch shows a range of ratios from 1,550 (B15416, not in tables) to 5 (B16802, p. 38). Two-groove poisonvetch shows a variation for 1 part per million

in the soil to that in the plant between the limits of 1,100 (B15394, p. 15) and 4 (B17742, p. 13). Stanleya shows a range of ratios between 580 (B17133, p. 44) and 3 (B16618, p. 35). Wreath aster shows a range of ratios between 610 (B15904, not in tables) and 2 (B17584, p. 48).

An attempt was made to determine whether the soluble sulphate content of the soils is an adequate explanation of these remarkable relations. For this purpose extracts of the soil samples were made as previously described (*2*), and the sulphur-selenium ratio was determined. It is to be recalled that this ratio of the water-soluble sulphate, computed as sulphur, to the total selenium found in the soil, is a purely empirical relation and by no means represents the relative concentration of these elements in the soil solution at any given time. Further, there is every reason to believe that the relations shown by the upper 6 inches of the soil do not hold for lower levels. It is probable, however, that such a comparison does reveal any general relation which exists. Indeed, as a result of the examination of 60 samples of soils showing the range of selenium absorption discussed in the previous paragraph, it was shown that the sulphur-selenium ratios for the surface samples range between the extreme limits of 1 (B16628, p. 35) and 424 (B16636, p. 35). In general, where the soluble sulphates are high, i. e., the sulphur-selenium ratio is high, the selenium content of comparable samples is low, and, conversely, when the sulphur-selenium ratio is low, the plant content is high. However, the relation is not consistent. Thus, in the case just cited, the sample of narrowleaf milkvetch from B16628 was by no means the sample highest in selenium in comparison with the soil content, nor was the sample of the same species from B16636 the lowest. On the contrary, the latter sample contained 1,070 parts per million of selenium derived from surface soil containing but 1.5 parts per million.

Since, from the examples just cited and from abundant supplementary data, it is clear that the surface soil content is no reliable guide to probable plant content for a given plant species, even when sulphur-selenium ratios are considered, an attempt was made to determine whether the influence of the lower portions of the soil profile could be determined. It is clear, from data already presented herein as well as previously (*2*), that no consistent variation of selenium content with depth is found. It is possible that were a sufficient number of profile examinations made, a general trend would be found. A single example of the relations found may be cited. In Logan County, Kans., a profile (B16875 to B16880, p. 39) showed a selenium content of 6 parts per million at the surface, ranging downward to 0.8 part per million at a depth of 72 inches. The sulphur-selenium ratio ranges from 44 at the surface to 805 at 72 inches. The narrowleaf milkvetch growing on this soil had a selenium content of but 140 parts per million, or a ratio of surface soil to plant of 1 to 23. In a profile in Trego County (B17133 to B17137, p. 44), the selenium content of the soil ranged from 2 parts per million at the surface to 8 parts per million at a depth of 60 inches. The sulphur-selenium ratio ranges from 12 at the surface to 134 at the lower level. A sample of stanleya on this soil had a selenium content of 1,160 parts per million, or a ratio of selenium content of the surface soil to that of the plant of 1 to 580. Since under fairly comparable conditions

stanleya is less absorbent than narrowleaf milkvetch, the influence of the sulphur in inhibiting absorption is apparent.

In other cases a dissimilar relation is found. A profile in Wallace County, Kans., (B16202 to B16206, p. 27) had a selenium content of 2 parts per million at the surface, ranging to 2.5 parts per million at a depth of 108 inches. The sulphur-selenium ratio ranges from 480 at the surface to 3,000 at 36 inches, and in the lowest layers is 526. The two-groove poisonvetch growing on this soil had a selenium content of 690 parts per million, or a ratio of selenium in the soil to that in the plant of 1:345. In a profile in Logan County (B16882 to B16888, p. 39), the selenium content of the soil ranged from 1 at the surface to 0.7 at a depth of 84 inches. The sulphur-selenium ratio ranges from 32 to a maximum of 1,780 at 72 inches, becoming 563 in the lowest layer. The two-groove poisonvetch on this soil had but 110 parts per million of selenium. It is evident that even the very high sulphur-selenium ratio of the Wallace County sample has not inhibited selenium absorption to a marked degree. It seems clear, therefore, that factors other than quantity of selenium and variation of sulphur-selenium ratios affect the absorption by a given plant species.

THE SELENIUM CONTENT OF SOIL EXTRACTS

Since in general the selenium absorbed by plants appears to be decreased by irrigation and perhaps by increased rainfall, it may be inferred that the selenium content of the soil solution may bear no direct relation to the quantity in the soil, even when the soils appear to be of very similar composition. A study was made therefore of the relative quantities of selenium which are extracted by water. The procedure followed was to shake overnight 60 g of air-dry soil with 600 cubic centimeters of distilled water. The water was removed by suction through a Pasteur-Chamberland filter. Five hundred cubic centimeters of this extract was evaporated to dryness after addition of 5 cubic centimeters of 30-percent hydrogen peroxide and sufficient sodium hydroxide to render the solution distinctly alkaline. The selenium in the residue was determined in the usual manner, and the results were expressed in parts per million of the air-dry soil.

In all, about 100 samples were so examined. The quantities of selenium dissolved ranged from undetectable quantities to a maximum of 38 parts per million. In about 80 percent of the cases the quantities dissolved were not expressible as more than traces though there was a probable accuracy of 0.1 part per million. In a few instances, where the quantity found ranged from 0.2 to 0.7 part per million, there seemed to be no relation between these variations and the variations of plant content, obscured as these were by variations of soluble sulphates.

In the case where the maximum water solubility of selenium is found (B6488, Technical Bulletin 482, (*2, p. 43*), the quantity of selenium extracted by water was 93 percent of the total quantity present. Nevertheless, the quantity found in adjacent vegetation was very low. This result may be satisfactorily accounted for by the fact that the sulphur-selenium ratio of the salt crust is 716. Also, the next highest water-soluble sample (B17742, p. 13), which contained 40 parts per million of selenium, behaved differently. Even though 70 percent of the total selenium was soluble, and the sulphur-

selenium ratio (100) was not exceptionally high, the two-groove poisonvetch grown at this point contained but 160 parts per million. A possible explanation of this peculiar result may be that the surface salt crust (from seepage) was so dry and the soluble salts so high (17,000 parts per million) that the deep-rooted poisonvetch fed actually upon soil very much poorer in selenium than the salt crust examined.

In another sample (B16868, p. 39), the water-soluble selenium was 14 parts per million, representing 17 percent of the total amount present. The two-groove poisonvetch growing out of this soil sample contained 1,590 parts per million of selenium, despite the presence of much sulphate in the soil solution. The sulphur-selenium ratio is only 14, but this value is to be considered in the light of the very high soil content of 82 parts per million of selenium. This is the highest selenium content yet found in any soil.

It would seem from all the available data, as well as on a priori grounds, that selenium occurs in the soils and shales in several different forms. What these are in specific cases has not been definitely determined, though the investigation is under way. It appears very certain that but little selenium is associated with the soil organic matter after it has become humified. That in the soils of high water-soluble selenium a considerable portion is present as calcium selenate, or possibly selenite, is also clear. There remains to be explored the extent to which elementary selenium, selenides, and basic selenium salts of iron may be present.

Attention should also be called, at this point, to the probability that plants vary in their selenium concentration at different stages of growth, and that roots, stems, leaves, and fruit are not equally toxic even in the same plant. Therefore, in view of all the data assembled, it seems impossible at present to determine whether a given area is seriously affected by selenium in any other way than by a field study of the area and analytical investigation of both soil and vegetation.

During the period of systematic examinations reported herein, a number of samples from various sources were examined for purposes not directly concerned with the main purposes of the investigation. As a result of these random tests, some data of general import were obtained.

MISCELLANEOUS DATA

No special investigations in Wyoming are included in the present research. However, there were collected on the Duell ranch a sample of two-groove poisonvetch and of the soil in which it was growing. The soil sample was divided into three parts: Organic semidecayed debris from the previous year's vegetation; the 1½-inch top layer of soil, and the layer from 1½ to 8 inches. A separate examination was made of the roots and tops of the two-groove poisonvetch. The results (in parts per million): Two-groove poisonvetch, 1,180; roots, 130; organic debris, 280; wheatgrass among the debris, 35; 0 to 1.5-inch portion of soil, 28; 1.5- to 8-inch portion of soil, 5.0. These results are in general accord with those obtained elsewhere when roots and tops were examined.

A Morrison shale sample from near Laramie, Wyo., was examined for selenium. There were three subsamples: One, of the limestone phase, showed but a trace of selenium; another, the characteristic clay phase, had 0.1 part per million; and the third, the reddish phase, also had but 0.1 part per million. A sample of *Astragalus pectinatus*, the

narrowleaf milkvetch, growing in soil presumably derived from Morrison shale, contained 1,350 parts per million of selenium. It is impossible to determine whether this most unexpectedly high selenium content of the milkvetch is due to spottiness in the Morrison shale or to the residual soil from overlying shales. It does emphasize the importance of numerous samples as a basis for evidence concerning a given area.

Two other samples from Wyoming gave most unexpected results. A sample of *Astragalus pectinatus* growing on soil derived from the Chugwater shale and sent in by T. D. Rice had a selenium content of 420 parts per million. A sample of Parry aster at the same location had but 7 parts per million, while the soil itself showed but 0.4 part per million. Similarly, a sample of an unidentified species of *Astragalus* collected by the writer and growing on soil derived from the Spearfish formation in Custer County, S. Dak., showed a selenium content of 40 parts per million. A sample of *A. bisulcatus* (two-groove poisonvetch) collected from the White River formation by J. T. Miller contained 800 parts per million of selenium. So far as known at present, none of these formations produce, as a rule, soils which contain selenium in sufficient quantity to produce toxic vegetation. The sporadic occurrence of highly seleniferous plants in unexpected localities is doubtless occasioned by particularly favorable local conditions. Such cases add to the many perplexing problems with which the subject fairly bristles.

O. A. Beath, of the University of Wyoming, sent a sample of seeds of *Astragalus pectinatus* and one of *A. crassicarpus*. The former contained 3,490 parts per million of selenium, the latter 1 part per million. The seeds of both species germinate, but if any difference exists it is in favor of the highly seleniferous seed.

No systematic investigations have been made in North Dakota, but a few samples have been examined. A profile furnished by the Soil Survey Division from McKenzie County and one from Billings County, both of Patent clay loam, showed selenium in quantities ranging from 0.2 to 1.0 part per million. No vegetation samples accompanied the profiles. A profile of Rogers silty clay from La Moure County showed a selenium content of 1.0 part per million in the surface layer, and in the lower portions 0.4, 0.4, and 0.3 part per million. The mixed grasses showed but a trace of selenium. Six samples of forage from the Bureau of Animal Industry experiment station at Mandan, N. Dak., were submitted by J. R. Dawson. Less than 1 part per million was demonstrated in these samples. It has not yet been shown that any seriously seleniferous soils exist in North Dakota, though a sample of the B horizon of Solonchak soil from near Bismarck was shown to contain 2 parts per million.

A few samples of soil and vegetation were obtained from Canada, north of Malta, Mont., and four samples of plants were furnished by J. S. Fulton from the University of Saskatchewan. The selenium content of the soil was low, but in the vegetation samples it ranged from 1 part per million in a sample of gumweed to a maximum of 4,410 parts per million in a sample of two-groove poisonvetch taken from a point 3 miles north of Val Marie. Undoubtedly a seleniferous area exists in the locality, but not even a guess is hazarded concerning its extent or intensity. The existence of a seleniferous area is also indicated by the relatively high selenium content of a sample of wheat obtained from the elevators at Regina (*13*).

No detailed examinations were made in New Mexico, but a series of four samples, furnished by the Bureau of Biological Survey, which contained very high percentages of selenite crystals ($CaSO_4.2H_2O$) showed only a trace of selenium. This is in accord with the general results, which indicate that recrystallization of calcium sulphate lowers the selenium content. A series of seven samples of irrigated farm products from near Farmington, N. Mex., showed essentially no selenium content. There are reasons, however, based on geological relations, why certain areas in New Mexico may be seleniferous to some degree.

No attempt has been made to extend to any marked degree the investigation of Texas soils. A number of samples of soils developed upon Austin chalk in Maverick County have been examined, and also a group of samples of the Austin formation from Maverick and Uvalde Counties. So far, no sample has been found containing in excess of 1 part per million of selenium. One sample of Maverick clay, 0 to 12 inches, and one of Pryor clay, 30— inches, contained 1 part per million. The Austin chalk samples showed a selenium content not to exceed 1 part per million.

Several samples of Houston black clay have also been examined and one of Wilson clay. These were developed from cretaceous material, but showed no marked selenium content.

A very considerable number of humid soils from a wide variety of sources in the United States have been examined. Only one sample, a Cecil clay subsoil from North Carolina, had as much as 1 part per million of selenium. Two samples of low-grade tobacco, grown on Cecil subsoil, had 1 part per million of selenium. While in two or three instances selenium was not detected, it is believed that it may be found in all soils when the search is sufficiently thorough. If any soils contain no selenium it is believed they will be found among the sandy soils in highly leached areas.

A few samples of soils from Puerto Rico and Cuba have been examined for selenium, and in no case has the selenium content exceeded 1 part per million except in a sample of muck from Hoyo Colorado, in Cuba. This sample contained 32 percent of organic matter and 20 parts per million of selenium. This instance of selenium accumulation in a swamp area is of particular importance, since it seems to present an opportunity for tracing the course of accumulations from parent rock to soils and vegetation.

In this connection it may be mentioned that through the kindness of T. G. Thompson, of the oceanographic laboratories of the University of Washington, an opportunity was afforded of examining a series of samples of sea-bottom deposits from Bering Sea and the Arctic Ocean (*18*). The results show the presence of selenium in quantities ranging between 0.03 and 0.7 part per million.

A number of samples of soils and vegetation from areas subject to smelter fumes were examined. These include areas near Butte and Anaconda, Mont., Kennet, Calif., and Copper Hill, Tenn. In all cases selenium was found, and in general a decrease in quantity as the distance from the smelter increased. This matter deserves fuller investigation.

GENERAL DISCUSSION

The comments made on the tabular data submitted in the foregoing pages are considered reasonably adequate for detailed study of the

material reported. A few general considerations remain for discussion.

The most important question with reference to the presence of selenium in the soil is What should be done about it? It is obvious from the data presented in this and previous reports that selenium is of general distribution in essentially all soils. In most soils its quantity is insufficient to produce actively toxic vegetation. But even in such areas unpublished data seem to indicate that it may have a serious effect on crop yields in general and particularly for certain crops. Also, it seems clear that in areas otherwise satisfactory, occasional plants may have a selenium content sufficiently concentrated to produce serious physiological disturbance in animals consuming them in sufficient quantity. In the more highly seleniferous areas a situation seems to exist that makes very difficult the use of any blanket method of dealing with the problem. The selenium content of the soils grades imperceptibly from quantities producing no toxic vegetation to quantities which make some varieties of plants lethal to animals and most if not all of them injurious. Moreover, it is impossible to set an arbitrary lower limit for toxic soils because the toxicity in vegetation varies with the content of materials other than selenium, notably of sulphates, and with the form of selenium present (*10*). Further, by reason of the intermixture of soil-producing formations in the development of the soil or by wind and water erosion, the soils are variable to a degree.

It seems wholly impractical to look forward to a sharp delimitation of toxic from nontoxic areas. Even were such a definition possible, it seems clear that the areas of soil more or less seriously affected are so great that no attempt to withdraw such areas from all agricultural use could be successful even were it desirable. If we add to this extensive demonstrated total acreage that which, from geologic or other grounds, may be expected to be found affected, it seems evident that complete withdrawal of these lands is not practical.

It seems to be evident from the data so far collected that irrigation provides a means of lowering the selenium content of soils, if it be of proper type, and under certain conditions decreases the absorption of selenium by plants even before any sensible removal has occurred. It is not certainly known whether this effect is shown by "sweet" water. Irrigation, therefore, offers a remedial measure where it can be applied. The fraction of the more highly seleniferous area which is possible of irrigation is but minute. The greater portion of this soil must be used in other ways. The history of the areas most affected seems to indicate that despite the losses incurred, due to toxic vegetation, stock raising can be and has been carried on profitably. Also, the history of the greater portion of the areas in which the presence of selenium has been demonstrated indicates that general farming operations are carried on under severe handicaps from causes other than the presence of selenium. When highly seleniferous soils decrease yields of crops and growth of animals, and prevent their full utilization for food or power, it would appear that successful competition in the open market becomes doubtful. The simplest possible solution of the disposition of these lands would therefore seem to be their gradual reversion to range.

It must, however, be pointed out that selenium is not the only cause of forage trouble on range or farm. While it seems clear that

selenium in forage is the sole, or in some cases perhaps the major, cause of certain animal losses, it is by no means the cause of all such losses. Without intending to dispute the solution of the problem of stock losses from rayless goldenrod, arrived at by Couch (*6*), it seems wholly probable to the writer that loco disease is also produced by organic compounds secreted by certain plants. Special attention is directed to the presence of selenium in crazyweed (*Oxytropis lambertii*) shown in tables 1 and 2. The constituent of this plant which is responsible for the development of locoism, or one of its forms, in animals has been found by Couch (*5*) to be a nitrogenous organic substance. Since selenium was present in many of the samples of crazyweed examined, it was of considerable interest to determine whether this toxic substance is also seleniferous. A sample of the toxin that had produced locoism in cats, submitted by Couch, was examined and found to be wholly free from selenium. It thus appears that plants toxic from selenium may also be toxic for other reasons, and, therefore, in seleniferous areas be doubly dangerous. The problems of forage poisoning are by no means to be wholly solved as a result of finding selenium in certain soils.

The remedial measure suggested by the work of Hurd-Karrer (*10*), the addition of sulphur or of sulphates to the soils, while perhaps effective and certainly ameliorating, is not practical in soils of low value. The cost seems prohibitive, and the data indicate that in certain areas the quantity of sulphates already present is very great. At any rate, where the sulphates are abundant the natural vegetation is scanty, and the plant associations consist largely of nonforage plants. The writer has devoted much thought to this problem and at present is of the opinion that nothing should be done affecting the lands directly except to ascertain the areas affected, the degree of toxicity, and the plant species most dangerous to animal life. The users of the land may then more intelligently adapt their procedures to the circumstances. In some cases it would seem that much loss could be avoided by such simple procedures as eradication of plants of the highly absorbent type, or by avoiding close pasturage of seleniferous areas when eradication is ill-advised or impossible. This last procedure evidently permits the animals to protect themselves.

Nevertheless, it is undesirable to lose sight of possible human injury as a result of marketing foods of toxic quality. A recent publication by Munsell [2] has demonstrated that the previous estimate (*2*) of four parts of selenium per million as a tolerance limit in foodstuffs for lower animals is not far from the mark, although it seems probable that three parts per million is a safer figure. It would appear that a satisfactory solution of the human side of the problem would be found were the matter to be brought under the control of the United States Food and Drug Administration, which at present has no jurisdiction. Under this control foodstuffs containing quantities of selenium beyond any established tolerance limit would be diverted to nonfood utilization.

Whatever be the ultimate disposition of the problem of utilization of seleniferous lands, the desirability of definitely locating all seleniferous areas becomes increasingly important. From available data it

[2] MUNSELL, H. E., DEVANEY, O. M., and KENNEDY, M. H. TOXICITY OF FOOD CONTAINING SELENIUM AS SHOWN BY ITS EFFECT ON THE RAT. U. S. Dept. Agri. Tech. Bull. 534, 26 pp., illus. 1936.

is clear that wherever cretaceous shales are a source of soil material, selenium is a soil component, but whether in serious quantity can only be ascertained by examination. That in some areas certain of these formations are essentially free from selenium is equally clear. Whether they are always so remains to be determined. The fact that these shales are by no means confined to the United States makes the problem one of world-wide importance.

No satisfactory evidence is as yet available with reference to the possible beneficent effects of selenium, in very small amounts, upon either plant or animal metabolism. Investigation along this line should be pursued.

Evidence is available showing that the soils of seleniferous areas contain other trace elements to varying degrees. What bearing the mutual reactions of these may have on plant growth and composition is a problem of the first magnitude.

SUMMARY

The existence of large areas of land containing sufficient selenium to produce toxic vegetation has been demonstrated in the area surrounding the Black Hills, in western Colorado, in portions of the valleys of the Uncompahgre, Gunnison, and Colorado Rivers, in a portion of western Kansas, and in certain portions of Montana.

The data show that in these seleniferous areas not all the vegetation is toxic and that the degree of toxicity varies within wide limits for given plants, even for soils of similar selenium content, and also for different plants upon the same soil.

Additional evidence shows that irrigation, with underdrainage, tends to diminish the selenium content of the soil, and, if the irrigation water contains sulphates, diminishes the selenium content of the vegetation.

Data are presented that indicate a close relationship between the selenium content of soil and of the soil parent material. The parent material so far demonstrated as producing toxic soils appears to be limited to the lower portion of the Pierre and the upper portion of the Niobrara formations and the corresponding Cretaceous formations named otherwise. It is not asserted that toxic conditions are limited to these formations.

The analytical data, as well as field observations, show no close relationship between the quantity of selenium in the soil and that absorbed by individual members of the same plant species. The results of examination indicate that the variations found are owing only in part to sulphate variations in the soil solution and point to the influence of other soil components as well as to the existence of the selenium in different forms.

LITERATURE CITED

(1) Byers, H. G., Davis, L. V., Snyder, J. M., Hays, F. A., and Kokjer, T. E.
1919. soil survey of dawes county, nebraska. U. S. Dept. Agr., Bur. Soils, Field Oper. 1915, Rept. 17: 1963-1999, illus.

(2) Byers, H. G.
1935. selenium occurrence in certain soils in the united states, with a discussion of related topics. U. S. Dept. Agr. Tech. Bull. 482, 48 pp., illus.

(3) COFFEY, G. N., and party.
1912. RECONNOISSANCE SOIL SURVEY OF WESTERN SOUTH DAKOTA. U. S. Dept. Agr., Bur. Soils, Field Oper. 1909, Rept. 11: 1401-1476, illus.

(4) ——— RICE, T. D., and party.
1912. RECONNOISSANCE SOIL SURVEY OF WESTERN KANSAS. U. S. Dept. Agr., Bur. Soils, Field Oper. 1910, Rept. 12: 1345-1412, illus.

(5) COVICH, J. F.
1929. A CONTRIBUTION TO THE STUDY OF LOCOISM. Jour. Pharmacol. and Expt. Ther. 36: 55-83, illus.

(6) ——— ———
1930. THE TOXIC CONSTITUENT OF RAYLESS GOLDENROD. Jour. Agr. Research 40: 649-658, illus.

(7) GIESEKER, L. F., MORRIS, E. R., STRAHORN, A. T., and MANIFOLD, C. B.
1933. SOIL SURVEY (RECONNAISSANCE) OF THE NORTHERN PLAINS OF MONTANA. U. S. Dept. Agr., Bur. Chem. and Soils, Ser. 1929, Rept. 21, 74 pp., illus.

(8) HAYES, F. A., WOLFANGER, L. A., BEDELL, H. L., BRITTON, L., TAYLOR, S. C. H., and DECPSCH, F. M.
1924. SOIL SURVEY OF SHERIDAN COUNTY, NEBRASKA. U. S. Dept. Agr., Bur. Soils, Field Oper. 1918, Rept. 20: 1411-1496, illus.

(9) HURD-KARRER, A. M.
1934. SELENIUM INJURY TO WHEAT PLANTS AND ITS INHIBITION BY SULPHUR. Jour. Agr. Research 49: 343-357, illus.

(10) ——— ———
1935. FACTORS AFFECTING THE ABSORPTION OF SELENIUM FROM SOILS BY PLANTS. Jour. Agr. Research 50: 413-427, illus.

(11) MILLER, J. T., and BYERS, H. G.
1935. A SELENIUM SPRING. Indus. and Engin. Chem., News Ed. 13: 456, illus.

(12) RADER, L. F., JR., and HILL, W. L.
1936. OCCURRENCE OF SELENIUM IN NATURAL PHOSPHATES, SUPERPHOSPHATES, AND PHOSPHORIC ACID. Jour. Agr. Research 51: 1071-1083.

(13) ROBINSON, W. O.
1936. SELENIUM CONTENT OF WHEAT FROM VARIOUS PARTS OF THE WORLD. Indus. and Engin. Chem., Indus. Ed. 28: 736-738, illus.

(14) ——— ——— DUDLEY, H. C., WILLIAMS, K. T., and BYERS, H. G.
1934. DETERMINATION OF SELENIUM AND ARSENIC BY DISTILLATION IN PYRITES, SHALES, SOILS, AND AGRICULTURAL PRODUCTS. Indus. and Engin. Chem., Analyt. Ed. 6: 274-276, illus.

(15) ROCKIE, W. A., DEARDORFF, C. E., BRITTON, L. H., and PAINE, L. S.
1925. SOIL SURVEY OF SIOUX COUNTY, NEBRASKA. U. S. Dept. Agr., Bur. Soils, Field Oper. 1919, Rept. 21: 1757-1799, illus.

(16) UNITED STATES GEOLOGICAL SURVEY.
1933. GEOLOGIC MAP OF THE UNITED STATES, 1932. Prepared by G. W. Stose and O. A. Ljungstedt.

(17) WILLIAMS, K. T., and BYERS, H. G.
1935. OCCURRENCE OF SELENIUM IN THE COLORADO RIVER AND SOME OF ITS TRIBUTARIES. Indus. and Engin. Chem., Analyt. Ed. 7: 131-132.

(18) ——— and BYERS, H. G.
1935. SELENIUM IN DEEP SEA DEPOSITS. Indus. and Engin. Chem., News Ed. 13: 353.

(19) ——— and LAKIN, H. W.
1935. DETERMINATION OF SELENIUM IN ORGANIC MATTER. Indus. and Engin. Chem., Analyt. Ed. 7: 409-410.

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