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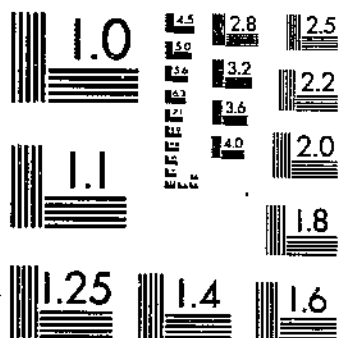
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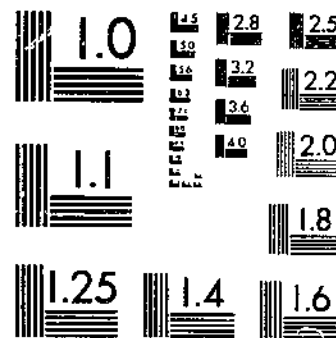
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SELENIUM OCCURRENCE IN CERTAIN SOILS IN THE UNITED STATES WITH
WILLIAMS, K. T. LAKIN, HENRY BYERS, H. G. W. 100F-1

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UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

SELENIUM OCCURRENCE IN CERTAIN
SOILS IN THE UNITED STATES, WITH
A DISCUSSION OF RELATED TOPICS;
FOURTH REPORT¹

By K. T. WILLIAMS, *associate chemist*, H. W. LAKIN, *assistant chemist*, and
HORACE G. BYERS, *principal chemist*, *Division of Soil Chemistry and Physics*,
Bureau of Plant Industry

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INTRODUCTION

Summaries of the results of the selenium studies carried out in the Division of Soil Chemistry and Research up to and including the calendar year 1936 have been presented in previous bulletins (3, 4, 6).² In this series of bulletins the greater portion of the work reported was devoted to the survey of areas in which the soils are affected by selenium to such an extent as to produce vegetation toxic to animals. The present report presents results of studies subsequent to 1936, including the results of a survey made in Montana. In addition to the regular survey data, information is given on the use of indicator plants in survey work and a comparison is made of the ability of two of them to absorb selenium. An account of a reconnaissance survey made in Mexico, with special emphasis on the area in which “soliman” disease occurs, is given. Data on “nontoxic” seleniferous soil, improved methods of analysis, a brief review of current literature, and miscellaneous data are also included.

¹ Submitted for publication March 2, 1939.

² Italic numbers in parentheses refer to Literature Cited, p. 56.

REVIEW OF RECENT LITERATURE

The many ramifications of the selenium problem have attracted the attention of workers in different branches of science. In the three previous reports (3, 4, 6) the progress on this problem has been reported by including references to the current literature. Such references, when pertinent to the topic under discussion, have been given in this bulletin. However, in order to keep the report of progress on the problem up to date, this brief review is also included. The recent literature is striking evidence of the wide attention that has been attracted to the various economic and health aspects of the selenium problem. The divergence of effort in various fields solves many phases of the problem and at the same time opens many more phases of it for consideration.

Knight and Beath (23) found that "alkali disease" in the early stages, usually recognized by hoof deformities and loss of hair, can be cured by administering daily drenchings of calcium lactate and placing the animal on a selenium-free diet. About one-third of an ounce of calcium lactate in a quart of water is a dose for a 600- to 800-pound animal. In an attack of "blind staggers" or acute selenium poisoning, the animal normally does not show any particular abnormality previous to the time it breaks down. The acute attack is usually characterized by a partial or complete collapse accompanied by driveling, impaired vision, and loss of appetite. Beath found that temporary relief may be obtained in the less severe cases by drenching with copious quantities of warm water and injecting small quantities of strychnine hypodermically. One-tenth to one-fifteenth of a grain of strychnine is about the right dose for an animal weighing 600 to 800 pounds, and should be administered two or three times at intervals of from 2 to 3 hours. After a day or two, additional help can be given by drenching with a tonic containing iron and quinine sulfate or nux vomica. At no time during the initial illness is it advisable to administer laxatives.

Hurd-Karrer (21) reported that wide differences in the absorption of selenium from sodium selenate by 13 different crop plants grown in Keyport clay loam, untreated with respect to sulfur, were directly correlated with corresponding differences in their sulfur-absorbing capacities. She concludes that the parallelism suggests that the sulfur requirement of the plant determines its tendency to absorb selenium.

In another set of experiments (20) Hurd-Karrer found that the comparative toxicity of selenates and selenites depends on the concentration of available sulfate. Her experiments showed that toxicity of the selenates decreased progressively with increasing sulfate sulfur, while that of the selenites was greater with high concentrations of sulfate than at intermediate ones, with the result that at sulfur concentrations below about 30 p. p. m., selenate selenium was more toxic than selenite, while at the high sulfur concentrations the selenite selenium was the more toxic.

With 3 p. p. m. of selenium in the culture solution, the snow-white selenium chlorosis occurred at all sulfur levels up to about 36 p. p. m. in the case of selenate selenium, but 6 p. p. m. of sulfur completely inhibited it in the case of selenites.

A series of pot experiments reported by Gile, Lakin, and Byers (16) brings out several interesting facts concerning the effect of sodium selenate on the growth of millet (*Setaria italica*) in sand and soil. It was found that the application of 4.4 mg. of selenium in a pot containing 5 kg. of quartz sand (0.88 p. p. m.) under favorable conditions of fertilization reduced the growth of millet by one-half. Under comparable conditions of fertilization and moisture most soils require one and one-half times the amount of selenium to reduce the growth of millet one-half. This value would be roughly $1\frac{1}{2}$ p. p. m. Variations in phosphate above that necessary for normal growth had no effect on selenium injury. Increase in sulfate application decreased the effect of the selenium. This confirms the work of Hurd-Karrer (18). From the similarity of the results obtained on 13 soils, in which the silica-sesquioxide ratios ranged from 1.07 to 3.41 in the colloid, it was concluded that soil colloids have very little effect on the availability of sodium selenate. Quite different results are being obtained with sodium selenite. It is believed that selenites are more abundant in soil than selenates (46).

Franke and Painter (11) have demonstrated by a series of field experiments that the addition of sulfur or gypsum to a naturally seleniferous soil did not inhibit the absorption of selenium by wheat and corn. They give evidence to show that plants absorb less selenium when grown during extremely dry seasons than when grown during seasons of normal rainfall. Sulfur absorption is not reduced during dry seasons, so they concluded that there is little relation between the absorption of selenium and sulfur by plants. They were unable to electro dialyze a detectable amount of selenium from a sample of Pierre soil. When sodium selenite was added to the soil not all of it could be removed by electro dialysis. When the experiment was repeated using sodium selenate much more of it could be electro dialyzed.

The data from four summers of field observations together with the analyses of thousands of samples of vegetation led Miller and Byers (29) to conclude that certain plants can use large amounts of selenium without injury. Further, it seemed probable that selenium was of some importance in their physiological processes. Recently Trelease and Trelease (39) reported experiments on the growth of *Astragalus racemosus*, an indicator plant, in artificial media. One set of plants was supplied with the usual mineral nutrients and the other sets had in addition various concentrations of sodium selenite. Though receiving a considerable quantity of selenium from the seed, the plants that were given no additional selenium made slow growth in comparison with those which obtained selenium from the culture solution. Marked stunting of the plants deprived of selenium became evident within a few weeks after their transference to the mineral solution.

Byers, Miller, Williams, and Lakin (6) reported larvae in the roots of an *Astragalus racemosus* plant containing 190 p. p. m. The larvae contained 7.5 p. p. m. Another sample of the same larvae had a selenium content of 10 p. p. m., and the roots they were infesting contained 420 p. p. m. Flies (possibly though not certainly *Pseudoteaphritis*) living on *Astragalus pectinatus* that contained 1,800 p. p. m. of selenium were caught and found to contain 10 p. p. m. of selenium. Trelease and Trelease (40) report similar results on bruchid larvae.

These larvae contained 36 p. p. m., while infested seeds contained 1,360 p. p. m.

In Hoskins' preliminary report (17) on the absorption of selenium by grapes and by citrus fruits, with special reference to orchards and vineyards sprayed with Selocide (30-percent solution of a material with the empirical formula $(\text{KNH}_4\text{S})_2\text{Se}$), the following conclusions are given: The average selenium content of the untreated soils examined was 0.25 p. p. m. The highest selenium content found in the sprayed soils was 0.91 p. p. m. The average selenium content of citrus fruits from sprayed orchards was 0.21 p. p. m. in the skin and 0.06 p. p. m. in the pulp. In the unsprayed orchard the average selenium content of the skin was 0.10 p. p. m. and of the pulp was 0.05 p. p. m. The grapes ranged from 0.14 to 0.64 p. p. m. in the sprayed vineyards and one sample from an unsprayed vineyard contained 0.11 p. p. m.

Elementary selenium is readily made available for *Astragalus*, as shown by the work of Beath, Eppson, and Gilbert (1). A nonseleniferous soil was mixed with 25 p. p. m. of elementary selenium and sown with seeds of *A. bisulcatus* and *A. pectinatus*. In 3 months the seedlings were seleniferous. A composite sample gave 1,150 p. p. m. of selenium. In another set of experiments, it was found that sulfur and soluble sulfate do not inhibit the absorption of organic selenium, derived from native range plants, by type cereals and other farm crops. They also report that native range plants do not show chlorosis even when the selenium content reaches 15,000 p. p. m. Experiments show a considerable loss of selenium when certain plants are air dried, running as high as 66 percent.

Beath, Gilbert, and Eppson (2) report further studies on the selenium content of the Permian and Triassic formations and soils derived from them. Soils formed from some members of these formations produce seleniferous vegetation of high toxicity.

Poley and Moxon (33) report that the hatchability of fertile eggs was not appreciably reduced by a laying ration containing 2.5 p. p. m. of selenium, was slightly reduced by 5 p. p. m., and was decreased to zero by 10 p. p. m. The selenium content of the diet was varied by incorporating various amounts of toxic grains.

Moxon and Poley (32) report that if chickens are on rations containing 2.5 p. p. m. of selenium or less, the eggs and meat will contain less than 4 p. p. m. With a level of 10 p. p. m. of selenium in the ration the selenium content of edible meat and eggs from most fowls is well above 4 p. p. m.

Franke and Painter (12) found a pronounced restriction of food consumption by albino rats in every diet containing more than 10 p. p. m. of selenium as it occurs in cereals. In various seleniferous diets the gain per gram of diet consumed was less than for control diets. Concentrations of less than 5 p. p. m. of selenium in diets prevented normal growth. All but one of 35 diets containing more than 9 p. p. m. of selenium caused death in young animals. It is probable that only naturally occurring selenium will regularly cause deaths at this level. They concluded that if the results obtained by feeding rats can be applied to larger animals, it is evident that farmers have suffered great losses by feeding seleniferous feeds with surprisingly low selenium contents, these losses not being due alone to death but to decreased rate and extent of growth.

Albino rats were fed salts of arsenic, molybdenum, tellurium, vanadium, and selenium at levels of 25 and 50 p. p. m. of the elements in their diet. Toxicity of the elements was determined by their effect upon the growth, food consumption, mortality, and hematopoietic system of the animals by Franke and Moxon (10). The order of increasing toxicity was as follows: Arsenic (Na_3HASO_3), molybdenum ($(\text{NH}_4)_6\text{Mo}_7\text{O}_{24}$), tellurium (Na_2TeO_4 and Na_2TeO_3), vanadium (NaVO_3), and selenium (Na_2SeO_3 and Na_2SeO_4). At the 50-p. p. m. level, arsenic and molybdenum were slightly toxic, tellurium and vanadium were moderately toxic, and selenium was very toxic. Of these elements only selenium caused a distinct disturbance of the hematopoietic system. The rats receiving tellurium in their diet exhibited loss of hair.

It is of interest to note that selenium is far more toxic than arsenic and other elements that are commonly considered the most deadly of poisons.

From experiments on rats, rabbits, and cats, Smith, Stohlman, and Lillie (34) have inferred that the symptomatology of milder forms of chronic selenium poisoning is most likely to point to gastric or hepatic dysfunction and possibly to disturbances of the hematopoietic organs.

From another set of experiments Smith, Westfall, and Stohlman (36) found in the case of cats that from 50 to 80 percent of the total intake of selenium as sodium selenite is usually excreted in the urine and from traces to 18 percent is excreted in the feces. The bulk of the stored selenium in chronic poisoning with small doses of inorganic selenium is eliminated within 2 weeks after its administration is discontinued.

A field study was made by Smith and Westfall (35), September 1936, on a selected group comprising 50 rural families in a highly seleniferous area in four counties of South Dakota and Nebraska. Their analyses of urine showed, as a rule, little variation in the urinary concentration of selenium for the several members of the same family or for the same individual at different times, thus indicating that the excretion level of selenium in man is a fairly reliable index of the availability of selenium and of the hazard to which he is exposed. They conclude that outside of a high incidence of symptoms pointing to gastric or intestinal dysfunction, and a few instances of apparent hepatic dysfunction, both probably the result of continual selenium ingestion, no other evidence of ill health was noted that could be ascribed to selenium with any degree of certainty. When locally produced, meat, eggs, milk, and vegetables constitute the most important sources of selenium to which man is exposed in the selenium-endemic region studied.

Dudley and Miller (8) found that the pathological changes resulting from the exposure of guinea pigs to small concentrations of hydrogen selenide were, primarily, an early fatty metamorphosis of the liver and a hypertrophy of the spleen which developed later. All animals exposed to 0.02 mg. per liter of hydrogen selenide for 60 minutes died within 25 days.

Experiments are reported by Ellis, Motley, Ellis, and Jones (9) to show the effect of selenium on fish. About a week after injections of sodium selenite the eyes began to protrude and the abdomen became more or less pendulous. Autopsies showed the body cavities to be more or less distended with ascites and the periorbital spaces to be filled with edematous tissue. The eyes had been extended by pres-

sure from behind. At water temperatures of 10° to 13° C., daily injections of 0.002 mg. per 50-grm. fish produced the popeye condition after 5 days.

In the discussion of the elements that occur in small quantities in sea water, Wattenberg (41) gives the concentration of selenium as 4 gamma per liter. This value is evidently taken from the work of Strock (37). The present investigators were unable to confirm this value, although samples from the Atlantic Ocean, the Pacific Ocean, and the North Sea were analyzed (6), the North Sea being the source of Strock's samples.

Moxon (31) has prepared a review of the work on the selenium problem and especially the work of the South Dakota Agricultural Experiment Station.

A short review of the work on selenium and its relation to soil, plants, and animals has been prepared by Williams (44).

METHODS OF EXAMINATION

No changes have been made in the methods of examination previously described for soil (43) and vegetation (47).

The nitric-sulfuric acid method used for vegetation was investigated by Mathews, Curl, and Osborn (26), who substituted complete digestion of the sample, in a system having a condenser and trap, for the incomplete digestion at a regulated temperature in an open beaker. With the present methods of estimation no superiority of the closed system could be demonstrated.

The nitric-sulphuric acid mixture used in the preparation of vegetation for distillation was not considered adequate for coal, hence experiments were made using 94-percent nitric acid and coal that had been ground to pass a 100-mesh sieve. When the acid was added to the coal the mixture ignited and burned with a smoky flame. When coal was dusted into the acid at room temperature the oxidation went smoothly until the mixture was heated to finish the reaction. On heating, the mixture frothed and could not be confined to a beaker of reasonable size. When coal was dusted into boiling acid, portions of the coal ignited and burned before it could be stirred beneath the surface of the acid. It was found that the reaction could be carried out successfully if certain conditions were maintained. Two grams of the coal were dusted slowly with stirring into 60 ml. of 94-percent acid at 60° C. in a 600-ml. Pyrex beaker, and after the reaction had quieted the mixture was heated to boiling on a hot plate for 5 minutes. The mixture was then removed from the hot plate and the 94-percent acid added to bring the volume to 60 ml., the temperature was adjusted to 60°, and 2 gm. more added as before. This procedure was repeated until 10 gm. had been added to the acid. The beaker was then covered and heated on the hot plate for 2 hours. The mixture was then cooled, 50 ml. of sulfuric acid added, and the nitric acid removed by heating to a temperature not higher than 120°. The last traces of nitric acid were removed by adding 50 ml. of distilled water and again evaporating below 120°.

The cooled residue was transferred to a distilling flask, the beaker was rinsed with 100 ml. of hydrobromic acid containing 1 ml. of bromine and then with 30 ml. of water, and the distillation and estimation were carried out as with soil.

During the past year cooperation with the Bureau of Animal Industry has made necessary the analysis of a few hundred samples of animal matter. That investigation has not been completed. In the analysis of animal matter for selenium, the hydrogen peroxide method of oxidation (?) requires nearly 2 days. It is subject to frothing that is difficult to control; and further, when the mixture "is evaporated to essentially complete dryness on the steam bath or hot plate" there is very likely to be a loss of selenium from the "black paste" of sulfuric acid and undecomposed organic material. Under similar conditions selenium was lost from sulfuric acid and vegetal material (47).

The nitric-sulfuric acid method was slightly modified for use on animal matter. In order for the acid mixture to maintain its strong oxidizing power the amount of sulfuric acid was increased. This addition was necessary because of the large amount of water in the animal matter. The procedure is as follows: Flesh samples are cut into small pieces and 50 gm. added to a mixture of 100 ml. of nitric acid (sp. gr. 1.42) and 100 ml. of sulfuric acid (sp. gr. 1.84) contained in a 1-liter Pyrex beaker. The mixture is digested slowly at a temperature not exceeding 120° C. until a brownish-yellow liquid is obtained and brown fumes of oxides of nitrogen cease to evolve. The cooled residue is transferred to an all-glass distilling flask (6, 43), and the beaker is rinsed with 100 ml. of hydrobromic acid containing 1 ml. of bromine and then with 30 ml. of water. The still is connected so that the adapter is below the surface of 5 ml. of bromine water in the receiving flask. A distillate of 50 ml. is collected, chilled, and the wax is removed by filtering through an asbestos pad in a Gooch crucible. The solution, having a volume of 85 ml., is reduced, and the selenium is estimated as described for soils (43).

The selenium content of 50 gm. of feces was determined in the same manner.

The selenium content of 50 ml. of urine was determined in the same manner except that when nearly all of the nitric acid had been driven off 50 ml. of water was added and the evaporation repeated to effect the complete removal of the nitric acid.

The selenium content of 100 ml. of blood was determined in a like manner except that the volume of both nitric and sulfuric acid was increased to 125 ml.

SELENIUM SURVEY IN MONTANA

GENERAL FEATURES

Samples of soil and vegetation were collected during the summer of 1934 along a transect in Carter County by T. D. Rice. The examination of the samples revealed the presence of seleniferous soils and toxic vegetation in the area. The selenium content of five samples of *Astragalus bisulcatus*, a selenium absorber or indicator plant (6, 29), ranged from 157 to 590 p. p. m. The following summer John T. Miller made a reconnaissance survey in Valley, Phillips, and Toole Counties, collecting shale, soil, and vegetation samples. Seleniferous soils and toxic vegetation were found. The selenium content of samples of *A. bisulcatus* ranged from 7 to 1,530 p. p. m.

These surveys were made in areas where the geological maps show outcropping formations of Cretaceous age (30). Formations of cor-

responding age (fig. 1) are known to produce seleniferous soil and toxic vegetation in South Dakota, Nebraska, Wyoming, Kansas, Colorado, and New Mexico. Although all of these formations contain selenium, the amount differs greatly through their depth and from one location to another. This is further complicated in Montana by the frequent occurrence of a mantle of debris from the Keewatin ice sheet, Rocky Mountain glaciers, and outwash from the mountains. The soil may be formed from the underlying formations, the mantle of debris, or from a mixture of the two.

The data from Rice and Miller's reconnaissance surveys and the rather extensive distribution of the Cretaceous sediments made a

AGE	BEARPAW MOUNTAIN MONTANA	YELLOWSTONE BIG HORN CARBON COUNTIES MONTANA	NEBRASKA EASTERN WYOMING SOUTH DAKOTA	EASTERN COLORADO KANSAS	NORTHEASTERN NEW MEXICO
TERTIARY					
TERTIARY ?	LANCE		WHITE RIVER	OGALLALA	
CRETACEOUS	MONTANA GROUP	BEARPAW	LENNEP	FOX HILLS	ABSENT
		BEARPAW			ABSENT
		JUDITH RIVER	JUDITH RIVER	BEECHER ISLAND	VERMILION SANDSTONE AND SHALE
				UNDIFFERENTIATED	TRINIDAD SANDSTONE
		CLAGGETT	CLAGGETT	PIERRE SHALES	SALT GRASS
					LAKE CREEK
		EAGLE	EAGLE		WESKAM
		TELEGRAPH CREEK		SHARON SPRINGS	PIERRE SHALES
	COLORADO GROUP	COLORADO	NIOBRARA	NIOBRARA	SMOXY HILL
					APISHAPA
				FORT HAYES	TIMPAH
		CARLILE	CARLILE	BLUE HILL	CARLILE
				FAIRPORT	
		FRONTIER	GREENHORN	WEEFER	GREENHORN
				JETHORE	
				HARTLAND	
				LINCOLN	
		HOWRY	GRANEROS	GRANEROS	GRANEROS
		ABSENT			
			DAKOTA		
CRETACEOUS ?			FUSON		
			LAKOTA		
	XOOTENAI	CLOVERLY		DAKOTA	DAKOTA
					PURGATORY
		MORRISON	MORRISON		MORRISON

FIGURE 1. Generalized geologic relations for the areas that have been examined for selenium.

wider survey desirable. Therefore the field work during the summer of 1937 was devoted to making a closer, but by no means a detailed, examination of portions of the areas underlain by these sediments.

As in previous surveys, geological maps and flora were used as guides to seleniferous soils. In general, a sample representative of the 8-inch surface layer of soil was collected along with a sample of vegetation growing in the soil. Other samples were collected to bring out special points.

The vegetation collected was largely *Astragalus pectinatus* and *A. bisulcatus*, both known to be good absorbers of selenium and, therefore, indicator plants. In addition to these, Miller and Byers (29) list *A. carolinianus*, *A. racemosus*, *Stanleya pinnata*, *S. bipinnata*, *Aplopappus fremonti*, and *Xylorhiza parryi* as indicator plants. Samples of other native plants and cultivated crops were also collected. Sam-

pling points were selected at intervals of 3 to 6 miles, although this was varied to meet any unusual situations.

DATA BY COUNTIES

The location of the samples and their selenium content are given in table 1, the data being arranged by counties. The soil-type names assigned to the soils collected in Teton and Pondera Counties were taken from reconnaissance soil survey maps (15) furnished by the Soil Survey Division of the Bureau of Chemistry and Soils.

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana¹

BIG HORN COUNTY

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	P. p. m.
B21334	1	12.7 miles north of Hardin on road down east side of Big Horn River.	Dark-gray clay, 0-8 inches.	1.5	
B21335	1a	do.	<i>Astragalus bleucatus</i> .		20
B21336	2	4.5 miles north of Hardin on road down east side of Big Horn River.	Yellowish-brown clay loam mixed with shale, 0-8 inches.	.3	
B21337	2a	do.	<i>Stanleya pinnata</i> .		2
B21338	3	4 miles east of Hardin on road to Sarpy.	Yellowish-brown clay, 0-8 inches.	1.5	
B21339	3a	do.	<i>Stanleya pinnata</i> .		2
B21340	4	2 miles southeast of Hardin on dirt road running south between U. S. Route 87 and Big Horn River.	Yellowish-brown clay loam mixed with shale, 0-8 inches.	4.0	
B21341	4a	do.	<i>Stanleya pinnata</i> .		50
B21342	5	16.5 miles northwest of Hardin on Whitman Coulee road.	Dark-gray clay mixed with rotten gray shale, 0-8 inches.	1.0	
B21343	6	9.1 miles south of Hardin on U. S. Route 87 and 0.3 mile west of highway at foot of breaks of the Little Big Horn River.	Yellowish-brown clay loam, 0-8 inches.	.5	
B21344	6a	do.	Young Russian-thistle growing in and adjacent to soil.		1
B21345	7	1.8 miles southeast of Crow Agency on new road to Busby.	Dark-gray clay, 0-8 inches.	.5	
B21346	7a	do.	Young wheat growing in and adjacent to soil.		1
B21157	R15	½ mile south of monument on Custer's battlefield, 15 miles south of Hardin.	Yellowish-brown clay loam, 0-10 inches.	2	
B21158	R15a	do.	<i>Astragalus</i> sp.		.1
B21347	8	4.3 miles southeast of Crow Agency on new road to Busby.	Gray clay, barren, 0-3 inches.	.5	
B21348	8a	do.	Sagebrush growing 25 feet from No. 8.		1
B21349	9	do.	Yellowish-gray powdery material, 3-6 inches.	.5	
B21350	10	do.	Bentonitic material mixed with gray shale, 6-18 inches.	.2	
B21351	11	do.	Dark-gray shale, 18-30 inches.	.2	
B21352	12	11.2 miles southeast of Crow Agency on new road to Busby.	Gray clay, 0-8 inches.	.5	
B21353	12a	do.	Gumweed growing in and adjacent to soil.		1
B21354	13	5.6 miles south of Crow Agency on U. S. Route 87.	Dark-gray clay, 0-8 inches.	.8	
B21355	13a	do.	Alfalfa growing in soil, not irrigated.		1
B21356	14	5.1 miles south of Hardin on U. S. Route 87.	Gray clay, not irrigated, 0-8 inches.	1	
B21357	14a	do.	<i>Astragalus bleucatus</i> , not irrigated.		260
B21358	14b	do.	Young Russian-thistle growing adjacent to soil, not irrigated.		3

¹ The selenium content is based on the air-dry weight of the samples.

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TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.
BIG HORN COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21359	15	50 yards west of No. 14	Gray clay, irrigated, 0-8 inches	P. p. m.	P. p. m.
B21360	15a	do	Young wheat growing adjacent to soil, irrigated.	1	1
B21361	15b	do	Young Russian-thistle, irrigated.		1
B21362	16	4.5 miles southeast of Garryowen on old road to Busby.	Yellowish-brown clay, 0-8 inches.	.7	
B21363	16a	do	Young Russian-thistle within 15 feet of soil.		1
B21364	17	10 miles southwest of Lodge Grass on road up Lodge Grass Creek.	Dark-gray clay, 0-8 inches	.6	
B21365	17a	do	Young wheat.		1
B21366	18	16.7 miles southwest of Lodge Grass on road up Lodge Grass Creek.	Gray clay mottled yellow, 0-8 inches.	.4	
B21367	18a	do	<i>Astragalus bisulcatus</i>		240
B21368	19	11 miles south of St. Xavier on road to Soap Creek oil field.	Yellowish-brown clay, 0-8 inches, gravelly.	.8	
B21369	19a	do	<i>Astragalus</i> sp.		1
B21370	19x	do	Straw-yellow bentonitic material, 3½-4 feet.	.1	
B21371	20	26½ miles southeast of St. Xavier on road to Lodge Grass.	Gray clay, 0-8 inches	.4	
B21372	20a	do	<i>Astragalus bisulcatus</i>		60
B21373	21	28 miles southeast of St. Xavier on road to Lodge Grass.	Gray clay, 0-8 inches	.2	
B21374	21a	do	<i>Astragalus</i> sp.		>1
B21375	22	34 miles southeast of St. Xavier on road up Good Luck Creek.	Light-brown clay, 0-8 inches	.4	
B21376	22a	do	Gumweed		<1
B21377	23	6.3 miles west of Lodge Grass on road up Good Luck Creek.	Brown clay loam, 0-8 inches	.7	
B21378	23a	do	Gumweed growing in and adjacent to soil.		<1
B21379	24	11 miles west of Lodge Grass on road up Good Luck Creek.	Yellowish-brown clay, 0-8 inches	.7	
B21380	24a	do	<i>Hedysarum cinerascens</i>		1
B21381	25	17 miles northwest of Lodge Grass on road up Good Luck Creek.	Heavy gray clay, 0-8 inches	1.5	
B21382	25a	do	Gumweed		1
B21383	26	23.8 miles northwest of Lodge Grass on road up Good Luck Creek, 4 miles south of St. Xavier.	Gray clay, 0-8 inches	.5	
B21384	26a	do	Gumweed.		<1
B21385	27	4.6 miles south of Lodge Grass on U. S. Route 87.	Gray clay, 0-2 inches; brown clay, 2-8 inches.	1	
B21386	27a	do	Young Russian-thistle growing in and adjacent to soil.		1
B21387	28	1.8 miles southwest of Wyola on road to Antler ranch.	Dark-gray clay, 0-8 inches	.2	
B21388	28a	do	Gumweed		2
B21389	29	6.7 miles southwest of Wyola on road to Antler ranch.	Mottled yellowish-brown clay, 0-6 inches.	.4	
B21390	29a	do	<i>Hedysarum cinerascens</i>		<1
B21391	29b	do	Mixed grasses growing within 1½ feet of No. 29.		<1
B21392	30	11 miles southwest of Wyola, 1 mile north of Antler ranch.	Dark-gray clay, 0-8 inches	.6	
B21393	30a	do	Gumweed.		1
B21394	31	6.5 miles northwest of Antler ranch on road over divide between Little Big Horn River and Lodge Grass Creek.	Brown clay, 0-8 inches, some gravel on surface.	.7	
B21395	31a	do	Gumweed.		3
B21396	32	14 miles southwest of Lodge Grass, then 4 miles east on road over divide between Lodge Grass Creek and Alligator Creek.	Gray clay, 0-8 inches	1.5	
B21397	32a	do	Gumweed		20

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

BIG HORN COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	P. p. m.
B21395	33	6½ miles south of Wyoia on U. S. Route 87, then 4½ miles west up Pass Creek road.	Dark-gray clay, 0-8 inches	1	
B21399	33a	do.	Gumweed		40
B21400	34	17 miles south of Hardin on road south up west side of Big Horn River.	Yellowish-brown clay, 0-8 inches.	.4	
B21401	34a	do.	Wheat, grain in milk		1
B21402	35	44 miles south of Hardin on road south up west side of Big Horn River.	Dark reddish-brown clay loam, 0-8 inches, developed on Kootenai (?)	.2	
B21403	35a	do.	<i>Hedysarum cinerascens</i> .		<1
B21404	36	12.6 miles south of Hardin on road to St. Xavier.	Dark-gray clay, 0-8 inches, not irrigated.	3.5	
B21405	36a	do.	<i>Astragalus bisulcatus</i> , not irrigated.		890
B21406	36b	do.	Alfalfa growing 5 feet from No. 36, not irrigated.		1
B21407	37	50 feet west of No. 36.	Dark-gray clay, 0-8 inches, irrigated.	.5	
B21408	37a	do.	Young wheat, irrigated.		<1
B21409	37b	do.	Alfalfa growing 3 feet from No. 37, irrigated.		<1
B21410	38	19.2 miles south of Hardin on road to St. Xavier and 1 mile east of road.	Dark-gray clay, 0-8 inches, some gravel present.	.3	
B21411	38a	do.	Young Russian-thistle.		<1
B21412	39	1.8 miles west of St. Xavier in breaks of the Big Horn River.	Dark-gray clay mixed with rotten shale, 0-8 inches.	.5	
B21413	39a	do.	Gumweed.		<1
B21414	40	15.2 miles northeast of St. Xavier on old road to Crow Agency.	Dark-gray clay, 0-8 inches.	.7	
B21415	40a	do.	Gumweed.		<1
B21416	41	20.6 miles northeast of St. Xavier on old road to Crow Agency.	Dark-gray clay, 0-8 inches.	.5	
B21417	41a	do.	Young wheat in milk.		1
B21419	R16	6 miles west of Crow Agency on new road to St. Xavier.	Dark-gray clay, 0-10 inches.	.4	
B21419	R16a	do.	<i>Stanleya pinnata</i>		70
B21418	42	6½ miles west of Crow Agency on new road to St. Xavier.	Yellow clay loam, mixed with rotten shale, 0-8 inches.	.8	
B21419	42a	do.	<i>Hedysarum cinerascens</i>		<1
B21420	43	15.9 miles southwest of Hardin on road up Two Leggin Creek.	Yellowish - brown clay, 0-8 inches.	.5	
B21421	43a	do.	Gumweed.		<1
B21422	44	19½ miles southwest of Hardin on road up Two Leggin Creek.	Dark-gray clay, underlain by gray shale, 0-8 inches.	1.5	
B21423	44a	do.	Grewwood.		<1
B21424	45	20.3 miles southwest of Hardin on road up Two Leggin Creek.	Yellowish-brown clay, 0-8 inches.	.5	
B21425	45a	do.	<i>Stanleya pinnata</i>		140
B21426	46	24.3 miles southwest of Hardin on road up Two Leggin Creek to Fly Creek.	Yellowish - brown clay, 0-8 inches.	1	
B21427	46a	do.	<i>Astragalus bisulcatus</i>		90
B21428	47	33½ miles southwest of Hardin on road up Two Leggin Creek to head of Fly Creek.	Yellowish - brown clay, 0-8 inches.	.5	
B21429	47a	do.	Gumweed.		<1
B21464	R17	2 miles west of Hardin on U. S. Route 87.	Light-gray silt loam, 0-6 inches	.8	
B21465	R17a	do.	Young wheat.		1
B21466	R18	4 miles west of Hardin on U. S. Route 87.	Light-gray clay, 12-18 inches	.6	
B21467	R18a	do.	Western wheat grass adjacent to soil.		1
B21468	R19	5.8 miles west of Hardin on U. S. Route 87.	Yellowish - brown clay, 0-6 inches.	.5	
B21469	R19a	do.	<i>Machaeranthera putrescens</i> adjacent to soil.		2
B21470	R19b	do.	Young Russian-thistle.		3
B21471	R20	7.9 miles west of Hardin on U. S. Route 87.	Yellowish - gray clay loam, 0-6 inches.	1.5	
B21472	R20a	do.	<i>Oxytropis albiflorus</i>		1
B21473	R21x	9 miles west of Hardin on U. S. Route 87.	Gray rotten shale from road cut, 10 feet below top of cut.	1.5	

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

BIG HORN COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21174	R22	10 miles west of Hardin on U. S. Route 87.	Light-gray, mottled with white, clay loam, 0-6 inches.	P. p. m. 0.8	
B21175	R22a	do	<i>Astragalus bisulcatus</i>		60
B21176	R23	11.7 miles west of Hardin on U. S. Route 87.	Yellowish-gray clay loam, 0-6 inches.	2	
B21177	R23a	do	<i>Stanleya pinnata</i>		380
B21178	R23b	do	<i>Astragalus bisulcatus</i> , about 100 feet from soil No. 23.		590
B21179	R23c	do	<i>Tragopogon dubius</i>		5
B21180	R24	12.9 miles west of Hardin on U. S. Route 87.	Gray clay loam, 0-6 inches.	1	
B21181	R24a	do	<i>Senecio integerrimus</i>		1
B21182	R25	15.6 miles west of Hardin on U. S. Route 87.	Gray clay shale at depth of 5 feet in cut beside road.	1.5	
B21183	R26	16.3 miles west of Hardin on U. S. Route 87.	Dark-gray clay loam with gypsum crystals bedded in it, 0-6 inches.	2.5	
B21184	R26a	do	<i>Stanleya pinnata</i>		15
B21185	R26b	do	Turpentine weed near <i>Stanleya</i>		4
B21186	R27	18.2 miles west of Hardin on U. S. Route 87.	Hard dark-gray shale, 10 feet below junction with yellow shale.	5	
B21187	R27y	do	Fissile gray shale, 12 feet below junction with yellow shale.	5	
B21188	R27z	do	Yellow shale streaked gray about 5 feet above No. 27y.	8	
B21189	R28x	do	Yellow shale about 5 feet above yellowish-gray shale.	3	
B21190	R29	20.2 miles west of Hardin on U. S. Route 87.	Dark-gray silt loam, 0-6 inches.	.5	
B21191	R30	22 miles west of Hardin on U. S. Route 87.	Yellow silt loam, 0-6 inches.	1	
B21192	R30a	do	<i>Astragalus bisulcatus</i>		1,180
B21193	R31	23.9 miles west of Hardin on U. S. Route 87.	Mottled gray silt loam with effervescence, 0-3 inches.	3	
B21194	R31a	do	<i>Astragalus</i> sp. growing nearby		1
B21195	R32x	24.2 miles west of Hardin on U. S. Route 87.	Limonitic layer in yellow shale, 15 feet below top of cut in roadside.	.7	
B21196	R33	26.3 miles west of Hardin on U. S. Route 87.	Gray silt loam, 0-6 inches.	.7	
B21197	R34	28.3 miles west of Hardin on U. S. Route 87.	Yellowish clay loam, 0-6 inches.	.3	
B21198	R35	28.9 miles west of Hardin on U. S. Route 87.	Yellowish-gray clay loam, 0-10 inches.	2	
B21199	R35a	do	Legume, long flower spike		1
B21200	48	1½ miles northwest of Tolosa station on old road to Billings.	Yellowish-brown clay	3.5	

YELLOWSTONE COUNTY

B21436	1	31.6 miles west of Hardin on U. S. Route 87; then 13.3 miles south on road to Beauvais Creek.	Yellowish-brown clay mixed with rotten shale, 0-6 inches.	0.7	
B21437	1a	do	Gumweed		0
B21438	2	31.6 miles west of Hardin on U. S. Route 87; then 9.2 miles south on road to Beauvais Creek.	Yellowish-brown clay, 0-8 inches.	1.5	
B21439	2a	do	<i>Stanleya pinnata</i>		290
B21200	R36	32 miles west of Hardin on U. S. Route 87.	Dark-gray silt loam, 0-6 inches.	1	
B21201	R37	33.8 miles west of Hardin on U. S. Route 87.	do	3	
B21202	R37a	do	<i>Stanleya pinnata</i>		550
B21203	R38	35.5 miles west of Hardin on U. S. Route 87.	Dark-gray clay loam, 0-6 inches.	.7	
B21204	R38a	do	Crested wheatgrass.		
B21205	R39x	37.9 miles west of Hardin on U. S. Route 87.	Ferruginous shale at base of pale-yellow sandstone.	.4	

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

YELLOWSTONE COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21206	R40	39.7 miles west of Hardin on U. S. Route 87.	Gray-brown sandy loam, 0-6 inches.	P. p. m. 0.5	
B21207	R40a	do	<i>Oxytropis albidiflora</i>		✓
B21208	R40b	do	<i>Astragalus</i> sp.		✓
B21209	R41	41.7 miles west of Hardin on U. S. Route 87.	Yellowish-brown sandy loam, 0-6 inches.	.2	
B21440	3	NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 9, T. 2 N., R. 28 E., on Huntley Experiment Station farm.	Billings clay, 0-8 inches, not irrigated.	.2	
B21441	3a	do	Alfalfa, not irrigated		0
B21442	3b	do	Gumweed growing adjacent to soil, not irrigated.		1
B21443	4	100 feet south of No. 3.	Billings clay, 0-8 inches, irrigated.	.4	
B21444	4a	do	Alfalfa, irrigated		1
B21445	4b	do	Barley growing adjacent to soil, irrigated.		0
B21446	5	0.6 mile east of Worden on U. S. Route 10.	Yellowish-brown clay, 0-8 inches.	.4	
B21447	5a	do	Young Russian-thistle growing in and adjacent to soil.		0
B21448	6	7.4 miles east of Worden on U. S. Route 10.	Gray clay, 0-8 inches.	.3	
B21449	6a	do	Gumweed		0
B21450	7	6.3 miles south of Ballentine on road to Fly Inn.	Dark-gray clay, 0-8 inches, developed on Bearpaw formation.	1	
B21451	7a	do	Gumweed		1
B21452	8	4 miles southwest of Huntley on county road from Huntley to Billings.	Yellowish-brown clay loam, 0-8 inches.	.2	
B21453	8a	do	Gumweed		0
B21454	9	7.3 miles south of Laurel on county road up west side of Doris Creek.	Gray clay, streaked with alkali	.5	
B21455	9a	do	Gumweed		1
B21456	10	1.9 miles southeast of bridge across Yellowstone River at Duck Creek.	Yellowish-brown clay loam mixed with rotten shale, 0-8 inches.	.3	
B21457	10a	do	Alfalfa		1
B21458	11	7.9 miles northeast of bridge across Yellowstone River at Duck Creek.	Yellowish-brown clay, 0-8 inches	.3	
B21459	11a	do	Wheat in milk		<1
B21460	12	14.2 miles southeast of bridge across Yellowstone River at Duck Creek.	Yellowish-brown clay loam, 0-8 inches.	.2	
B21461	12a	do	Wheat in milk		<1
B21462	13x	1½ miles north of intersection of U. S. Route 87 and U. S. Route 10 at Billings.	Gypsiferous shaly sandstone, 30-30½ feet below top of Eagle sandstone bluff.	.3	
B21323	R111	½ mile north of junction of U. S. Route 87 with U. S. Route 10, 6 miles north of Billings.	Dark-gray clay containing gypsum, 0-6 inches.	.5	
B21324	R111a	do	<i>Astragalus adsurgens</i>		2
B21463	14	1½ miles south of Shepherd on county road to Huntley.	Gray clay, 0-8 inches	.4	
B21464	14a	do	Gumweed		3
B21465	15	2.4 miles north of Shepherd on county road.	Heavy gray clay, 0-8 inches, alkali crust on surface.	.3	
B21466	15a	do	Gumweed		<1
B21467	16	4 miles west of Shepherd on county road to Acton.	Gray clay mottled with alkali, 0-8 inches.	.4	
B21468	16a	do	Young Russian-thistle		1
B21322	R110a	40 miles south of Roundup on U. S. Route 87.	<i>Machaeranthera pulcherrima</i> on Bearpaw formation.		20
B21468	17	7.7 miles west of Shepherd on county road to Acton.	Gray clay mixed with rotten shale, 0-8 inches.	.3	
B21470	17a	do	<i>Hedysarum elaeagnifolium</i>		0
B21471	18	14.3 miles west of Shepherd on county road to Acton.	Gray clay mottled yellow, 0-8 inches.	.3	
B21472	18a	do	<i>Astragalus bisulcatus</i>		15
B21473	19	3 miles northwest of Acton on road to Comanche.	Yellowish-brown clay loam, 0-8 inches.	.2	
B21474	19a	do	<i>Astragalus bisulcatus</i>		3
B21475	20	1 mile southwest of Comanche	Gray clay, 0-8 inches.	.2	
B21476	20a	do	Gumweed		1

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TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

YELLOWSTONE COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21477	21	3.3 miles west of Comanche	Light-brown clay, 0-8 inches	P. p. m. 0.2	140
B21478	21a	do.	<i>Astragalus bisulcatus</i>		
B21479	22	10.1 miles southwest of Comanche on county road running south 1 mile east of county line.	Yellowish-brown clay loam, 0-8 inches.	.7	
B21480	22a	do.	<i>Astragalus bisulcatus</i>		530
B21481	23	15.1 miles southwest of Comanche on road south to Canyon Creek.	Yellowish-brown clay loam, 0-8 inches.	.2	
B21482	23a	do.	<i>Astragalus adsurgens</i>		1
B21483	24	21.6 miles west of Billings on Canyon Creek road.	Yellowish-brown sandy loam, 0-8 inches, on shaly sandstone at rim of canyon.	.2	
B21484	24a	do.	<i>Hedysarum cinereum</i>		0
B21485	25	19.8 miles east of Billings on U. S. Route 87, in cut east of Pryor Creek near former site of Moffitt station.	Yellowish-brown clay loam, 0-12 inches, typical exposure of Telegraph Creek formation.	1.5	
B21486	25x	do.	Yellowish-brown rotten shale just above laminated sandstone layer, 4-5 feet.	.6	
B21487	25y	do.	Yellowish-brown gypsiferous sandy shale, 14-15 feet.	2	
B21488	25a	do.	<i>Stanleya pinnata</i> growing in No. 25.		190
B21489	25b	do.	<i>Stanleya pinnata</i> growing 40 feet west of No. 25 in same shale as No. 25x.		230
B21490	26	100 yards north of southwest corner sec. 17, T. 1 S., R. 26 E.	Billings clay, 0-8 inches, not irrigated.	.6	
B21491	26a	do.	Alfalfa growing in soil, not irrigated.		0
B21492	27	20 feet east of No. 26	Billings clay, 0-8 inches, irrigated.	.8	
B21493	27a	do.	Alfalfa growing in soil, irrigated.		2
B21494	28	50 feet south of northwest corner sec. 30, T. 1 S., R. 25 E.	Billings clay, 0-8 inches, not irrigated.	.3	
B21495	28a	do.	Gumweed growing in and within 10 feet of soil, not irrigated.		2
B21496	29	20 feet east of No. 28.	Billings clay, 0-8 inches, irrigated.	.2	
B21497	29a	do.	Wheat in milk, irrigated.		0
B21498	29b	do.	Gumweed growing 1½ feet from soil, irrigated.		0
B21227	R52	0.1 mile east of northwest corner sec. 23, T. 1 S., R. 25 E.	Billings clay, 0-10 inches	.5	

ROSEBUD COUNTY

B21213	R43	6 miles south of Ingomar on State Road 39.	Dark-gray clay, 0-6 inches.	0.2	
B21213	R44	2 miles east of Ingomar.	Dark-gray clay flecked with gypsum, 0-6 inches.	1.5	
B21214	R44a	do.	<i>Machaeranthera pulcherrima</i> growing in soil.		3
B21215	R45	22 miles east of Ingomar.	Dark-gray clay flecked with gypsum, 0-6 inches.	.3	
B21216	R45a	do.	Western wheatgrass adjacent to soil.		>1
B21217	R46	18 miles north of turn east of Davidell. (Turn 24 miles east of Ingomar.)	Dark-gray clay flecked with gypsum, 0-6 inches.	.4	
B21218	R47x	15 miles north of turn east of Davidell.	Dark-gray shale with red surfaces, about 10 feet below top of 20-foot exposure along creek.	.5	
B21219	R48	100 yards south of No. R47x.	Dark-gray clay with gypsum, developed on No. R47x, 0-6 inches.	.4	
B21220	R49	9 miles north of turn east of Davidell.	Dark-gray clay containing gypsum, 0-6 inches.	.4	
B21221	R49a	do.	Mixed vegetation (8 different kinds).		1

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

ROSEBUD COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21222	R50	4 miles north of turn east of Davidell.	Gray clay, spotted with reddish-yellow material. 0-6 inches.	P. p. m. 0.4	
B21223	R51	3 miles south of junction of north-south road east of Davidell.	Dark-gray clay containing gypsum. 0-6 inches.	.5	
B21224	R51a	do	<i>Stanleya pinnata</i> growing in soil.		240

TETON COUNTY

B21257	R75x	Approximately SE $\frac{1}{4}$ corner sec. 9, T. 24 N., R. 5 W.	Rotten shale above seepage.	0.2	
B21258	R76	50 yards below No. R75x.	Dark-gray clay, no shale exposed. 0-6 inches.	.2	
B21259	R76a	do	<i>Astragalus pectinatus</i> .		120
B21260	R76b	do	Western wheatgrass growing in No. R76a.		1
B21261	R77	Approximately 0.2 mile north of SE $\frac{1}{4}$ corner sec. 19, T. 24 N., R. 4 W.	Chouteau loam, 0-6 inches.	1	
B21261A	R77a	do	Wild iris.		1
B21513	1	NE $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 19, T. 24 N., R. 4 W.	Burton clay loam, deep phase. 0-8 inches.	2.5	
B21514	1a	do	<i>Astragalus bisulcatus</i> .		80
B21515	2	NW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 8, T. 24 N., R. 4 W.	Ashuelot gravelly loam. 0-8 inches.	.2	
B21516	2a	do	Gumweed.		1
B21517	3	NW $\frac{1}{4}$ corner sec. 29, T. 26 N., R. 4 W.	Ashuelot gravelly loam, swampy phase, 0-8 inches, no gravel.	.3	
B21518	3a	do	Gumweed.		1
B21519	4	NW $\frac{1}{4}$ sec. 29, T. 26 N., R. 4 W.	Cut Bank silty clay loam. 0-8 inches.	.7	
B21520	4a	do	<i>Astragalus pectinatus</i> : Immature seeds.		190
B21521	4b	do	Leaflets.		70
B21522	4c	do	Stems.		90
B21523	4d	do	Roots.		35
B21524	5	SE $\frac{1}{4}$ sec. 5, T. 26 N., R. 4 W.	Morton gravelly loam, rough phase, 0-8 inches.	1.5	
B21525	5a	do	<i>Astragalus pectinatus</i> .		120
B21526	6	NW $\frac{1}{4}$ sec. 29, T. 27 N., R. 4 W.	Fairfield loam, 0-8 inches.	.2	
B21526A	6	do	Typical gravel.	.1	
B21527	6a	do	Gumweed.		3
B21528	7	SE $\frac{1}{4}$ sec. 22, T. 27 N., R. 4 W.	Bainville loam, 0-8 inches.	.2	
B21529	7a	do	<i>Astragalus bisulcatus</i> .		10
B21530	8	NW $\frac{1}{4}$ sec. 2, T. 26 N., R. 4 W.	Chouteau loam, 0-8 inches.	.5	
B21531	8a	do	<i>Astragalus pectinatus</i> .		360
B21532	9	Southwest corner sec. 14, T. 26 N., R. 4 W.	Cut Bank silty clay loam, 0-8 inches, with alkali crust.	.5	
B21533	9a	do	<i>Astragalus pectinatus</i> .		110
B21534	10	NW $\frac{1}{4}$ sec. 30, T. 26 N., R. 3 W.	Scobey loam, 0-8 inches, boulders and gravel.	.5	
B21535	10a	do	<i>Astragalus pectinatus</i> .		930
B21536	11	SW $\frac{1}{4}$ sec. 6, T. 25 N., R. 3 W.	Burton clay loam, deep phase, 0-8 inches.	.4	
B21537	11a	do	<i>Astragalus bisulcatus</i> .		110
B21538	12	NE $\frac{1}{4}$ sec. 25, T. 25 N., R. 3 W.	Burton clay loam, deep phase, 0-8 inches, boulders and gravel.	.2	
B21539	12a	do	<i>Astragalus bisulcatus</i> .		7
B21540	13	NE $\frac{1}{4}$ sec. 10, T. 24 N., R. 4 W.	Burton clay loam, deep phase, 0-8 inches.	.5	
B21541	13a	do	<i>Astragalus bisulcatus</i> .		70
B21542	14	Northwest corner sec. 22, T. 25 N., R. 4 W.	Chouteau loam, 0-8 inches, gravelly but no boulders.	.2	
B21543	14a	do	<i>Astragalus bisulcatus</i> .		20
B21544	15	NW $\frac{1}{4}$ sec. 27, T. 25 N., R. 3 W.	Buffalo loam, 0-8 inches, in breaks of Teton River.	3	
B21545	15a	do	<i>Astragalus pectinatus</i> .		3,040
B21546	16	SW $\frac{1}{4}$ sec. 3, T. 25 N., R. 3 W.	Scobey loam, 0-8 inches, gravelly.	.2	
B21547	16a	do	<i>Astragalus pectinatus</i> .		60
B21548	17	Northwest corner sec. 7, T. 25 N., R. 2 W.	Joplin loam, 0-8 inches, in fallow field.	.2	
B21549	17a	do	<i>Astragalus pectinatus</i> .		52

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

TETON COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m. 0.5	P. p. m.
B21550	18	SW $\frac{1}{4}$ sec. 30, T. 26 N., R. 2 W.	Yellow-brown clay, 50 feet below top of cut.		
B21551	10	NW $\frac{1}{4}$ sec. 30, T. 26 N., R. 2 W.	Gypsum.	> 1	
B21552	19a	do	Iron concretion.	.7	
B21553	20	Southwest corner sec. 21, T. 26 N., R. 3 W.	Joplin silt loam, 0-8 inches, at top of breaks of Muddy Creek.	.4	
B21554	20a	do	<i>Astragalus pectinatus</i> .		690
B21555	20b	do	Scobey loam, 0-8 inches	.5	
B21556	21	SW $\frac{1}{4}$ sec. 5, T. 26 N., R. 3 W.	<i>Astragalus pectinatus</i> in wheat field.		1,560
B21557	21a	do	Wheat partly headed.		
B21558	22	Northwest corner sec. 25, T. 24 N., R. 4 W.	Morton loam, gravelly phase, 0-8 inches.	.5	4
B21559	22a	do	<i>Astragalus pectinatus</i> .		6
B21560	R78	Approximately NW corner sec. 30, T. 24 N., R. 3 W.	Scobey silty clay loam, 0-8 inches.	.4	
B21561	R78a	do	<i>Astragalus pectinatus</i> .		30
B21562	R78b	do	Scobey clay loam, 0-8 inches.	.4	
B21563	23	SW $\frac{1}{4}$ sec. 21, T. 24 N., R. 3 W.	<i>Astragalus pectinatus</i> .		460
B21564	24a	do	<i>Thermopsis annulocarpa</i> growing in <i>Astragalus pectinatus</i> .		2
B21565	R79	Approximately W $\frac{1}{4}$ corner sec. 15, T. 24 N., R. 3 W.	Scobey silty clay loam 0-8 inches	.8	
B21566	R80	do	<i>Astragalus bisulcatus</i> .		30
B21567	R81	do	Scobey silt loam, 0-6 inches	.4	
B21568	R82	do	Grayish-brown clay loam, 6-18 inches.	.5	
B21569	R82a	do	Yellowish-brown clay loam, 18-30 inches.	.5	
B21570	R83	do	Yellowish-brown clay loam, 30-42 inches.	.3	
B21571	24	Northeast corner sec. 0, T. 24 N., R. 3 W.	<i>Astragalus pectinatus</i> growing in this profile.		700
B21572	24a	do	Scobey silty clay loam, 0-8 inches.	.5	
B21573	25	Southwest corner sec. 6, T. 24 N., R. 2 W.	<i>Astragalus pectinatus</i> .		620
B21574	25a	do	Scobey silt loam, 0-8 inches, boulders on surface.	.3	
B21575	R83	Approximately S $\frac{1}{4}$ corner sec. 8, T. 24 N., R. 2 W.	Wheat in milk.		2
B21576	R84	Approximately S $\frac{1}{4}$ corner sec. 10, T. 24 N., R. 2 W.	Scobey silt loam, 0-10 inches	.5	
B21577	R84a	do	Scobey silt loam, 0-6 inches	.5	
B21578	R85	0.1 mile east of R84 in road cut.	<i>Astragalus bisulcatus</i> .		70
B21579	R85a	do	Raw clay 20 feet below surface, yellowish-brown mottled clay.	.8	
B21580	26	SW $\frac{1}{4}$ sec. 3, T. 24 N., R. 2 W.	<i>Astragalus pectinatus</i> growing in bank.		520
B21581	26a	do	Scobey loam, 0-8 inches	.7	
B21582	27	SE $\frac{1}{4}$ sec. 21, T. 25 N., R. 2 W.	<i>Astragalus pectinatus</i> .		530
B21583	27a	do	Scobey silt loam, rough phase, 0-8 inches, breaks of Teton River.	1.5	
B21584	28	SE $\frac{1}{4}$ sec. 24, T. 25 N., R. 2 W.	<i>Astragalus pectinatus</i> .		490
B21585	R86	Approximately SW corner sec. 36, T. 25 N., R. 2 W.	Scobey silt loam, 0-8 inches	3.5	
B21586	R86a	do	<i>Astragalus pectinatus</i> .		700
B21587	R86b	do	Scobey silt loam, 0-8 inches	.5	
B21588	29	Southwest corner sec. 6, T. 24 N., R. 1 W.	Young wheat on adjacent soil.		7
B21589	29a	do	<i>Astragalus pectinatus</i> 25 feet from No. R86.		5,170
B21590	30	Center sec. 24, T. 24 N., R. 2 W.	Scobey silt loam, 0-8 inches	1	
B21591	30a	do	Wheat in milk.		3
B21592	31	Southwest corner sec. 21, T. 24 N., R. 2 W.	Buffalo loam, 0-8 inches.	1	
B21593	31a	do	<i>Astragalus pectinatus</i> .		320
B21594	32	Southwest corner sec. 24, T. 24 N., R. 3 W.	Buffalo stony loam, 0-8 inches	1.5	
B21595	32a	do	<i>Astragalus pectinatus</i> .		90
B21596	33	NE $\frac{1}{4}$ sec. 12, T. 25 N., R. 2 W.	Buffalo stony loam, 0-8 inches	1.5	
B21597	33a	do	<i>Astragalus pectinatus</i> .		250
B21598	33a	do	Joplin silt loam, 0-8 inches, top of breaks of Teton River.	.7	
B21599	33a	do	<i>Astragalus bisulcatus</i> .		310

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.
TETON COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21582	34	Northeast corner sec. 9, T. 25 N., R. 2 W.	Joplin loam, 0-8 inches, gravelly	P. p. m. 0.7	
B21583	34a	do	Wheat in milk		6
B21584	35	N $\frac{1}{4}$ corner sec. 27, T. 26 N., R. 2 W.	Joplin loam, 0-8 inches.	1.5	
B21585	35a	do	<i>Astragalus pectinatus</i>		240
B21586	36	NE $\frac{1}{4}$ sec. 25, T. 26 N., R. 2 W.	Joplin loam, 0-8 inches, some boulders.	1	
B21587	36a	do	<i>Astragalus pectinatus</i>		60
B21588	37	Northeast corner sec. 26, T. 26 N., R. 1 W.	Joplin loam, 0-8 inches, some boulders.	.5	
B21589	37a	do	Wheat in milk		1
B21590	38	E $\frac{1}{4}$ corner sec. 25, T. 26 N., R. 1 W.	Joplin loam, gravelly	.7	
B21591	38a	do	Russian-thistle		5
B21592	39	Northwest corner sec. 27, T. 26 N., R. 1 E.	Joplin loam, 0-8 inches, boulders and gravel.	.5	
B21593	39a	do	Wheat in milk		
B21594	40	Northwest corner sec. 30, T. 26 N., R. 2 E.	Joplin silt loam, 0-8 inches, some boulders and gravel.	.7	
B21595	40a	do	Wheat in milk		4
B21596	41	NE $\frac{1}{4}$ sec. 28, T. 26 N., R. 2 E.	Marias clay loam, 0-8 inches, no boulders.	.5	
B21597	41a	do	<i>Astragalus pectinatus</i>		860
B21598	42	NE $\frac{1}{4}$ sec. 25, T. 26 N., R. 2 E.	Marias clay loam, 0-8 inches, gravelly with boulders.	.7	
B21599	42a	do	Young wheat		10
B21600	43	SE $\frac{1}{4}$ sec. 1, T. 25 N., R. 2 E.	Laurel loam, 0-8 inches, gravelly, some boulders.	1	
B21601	43a	do	<i>Astragalus bisulcatus</i>		1,630
B21602	44	SW $\frac{1}{4}$ sec. 6, T. 25 N., R. 2 E.	Cheyenne gravelly loam, 0-8 inches.	1	
B21603	44a	do	<i>Astragalus pectinatus</i>		1,530
B21604	45	E $\frac{1}{4}$ corner sec. 9, T. 25 N., R. 1 E.	Joplin silt loam, 0-8 inches, gravelly, boulders.	.4	
B21605	45a	do	Wheat in milk		7
B21606	46	NW $\frac{1}{4}$ sec. 7, T. 25 N., R. 1 E.	Joplin silt loam, 0-8 inches, gravelly, few boulders.	1.5	
B21607	46a	do	<i>Astragalus pectinatus</i>		380
B21608	47	NW $\frac{1}{4}$ sec. 10, T. 25 N., R. 1 E.	Joplin silt loam, 0-8 inches, gravelly.	.5	
B21609	47a	do	Guinweed		7
B21610	48	SE $\frac{1}{4}$ sec. 21, T. 24 N., R. 1 W.	Buffalo stony loam, 0-8 inches, gravelly.	.8	
B21611	48a	do	<i>Astragalus pectinatus</i>		140
B21612	49	Northeast corner sec. 9, T. 24 N., R. 1 W.	Scobey silt loam, dark phase, 0-8 inches, gravelly.	.5	
B21613	49a	do	<i>Astragalus bisulcatus</i>		200
B21614	50	Northwest corner sec. 24, T. 24 N., R. 1 W.	Scobey silt loam, dark phase, 0-8 inches.	.5	
B21615	50a	do	<i>Astragalus bisulcatus</i>		70
B21616	51	NW $\frac{1}{4}$ sec. 21, T. 24 N., R. 1 E.	Scobey silt loam, dark phase, 0-8 inches, gravelly, alkali crust.	.5	
B21617	51a	do	<i>Astragalus bisulcatus</i>		550
B21618	52	SE $\frac{1}{4}$ sec. 14, T. 24 N., R. 1 E.	Scobey silt loam, dark phase, 0-8 inches, gravelly.	.4	
B21619	52a	do	<i>Astragalus pectinatus</i>		2,320
B21620	R87	Approximately SE corner sec. 7, T. 24 N., R. 2 E.	Scobey silt loam, 0-6 inches.	.4	
B21621	R87a	do	Young wheat on adjacent soil.		7
B21622	53	SW $\frac{1}{4}$ sec. 16, T. 24 N., R. 2 E.	Scobey silt loam, dark phase, 0-8 inches, slightly gravelly.	.6	
B21623	53a	do	<i>Astragalus pectinatus</i>		900
B21624	54	SE $\frac{1}{4}$ sec. 13, T. 24 N., R. 2 E.	Scobey loam, 0-8 inches.	.8	
B21625	54a	do	<i>Astragalus pectinatus</i>		400
B21671	55	Northeast corner sec. 26, T. 25 N., R. 1 W.	Scobey silty clay loam, dark phase, 0-8 inches, gravel and boulders.	.5	
B21672	55a	do	Wheat in milk		3
B21673	56	Southeast corner sec. 19, T. 25 N., R. 1 E.	Scobey silty clay loam, dark phase, 0-8 inches, lime encrustation on gravel.	.3	
B21674	56a	do	<i>Astragalus pectinatus</i>		630

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.
TETON COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21675	57	SW $\frac{1}{4}$ sec. 34, T. 25 N., R. 1 E.	Scobey silt loam, dark phase, 0-8 inches, lime-encrusted gravel.	P. p. m. 0.7	
B21676	57a	do	<i>Astragalus pectinatus</i>		1,220
B21677	58	W $\frac{1}{4}$ corner sec. 19, T. 25 N., R. 2 E.	Lowry loam, 0-8 inches, lime-encrusted gravel.	1	
B21678	58a	do	<i>Astragalus bisulcatus</i>		150
B21679	59	NE $\frac{1}{4}$ sec. 6, T. 24 N., R. 2 E.	Scobey silt loam, dark phase, 0-8 inches, lime-encrusted gravel.	.5	
B21680	59a	do	<i>Astragalus pectinatus</i>		180
B21681	60	E $\frac{1}{4}$ corner sec. 16, T. 25 N., R. 2 E.	Scobey silty clay loam, rough phase, 0-8 inches, lime-encrusted gravel.	2	
B21682	60a	do	<i>Astragalus pectinatus</i>		240
B21683	61	N $\frac{1}{4}$ corner sec. 3, T. 24 N., R. 2 E.	Scobey silty clay loam, rough phase, 0-8 inches, no gravel.	.8	
B21684	61a	do	<i>Astragalus pectinatus</i>		530
B21685	62	NE $\frac{1}{4}$ sec. 36, T. 25 N., R. 2 E.	Scobey silt loam, dark phase, 0-8 inches, lime-encrusted gravel.	3.5	
B21686	62a	do	<i>Astragalus pectinatus</i>		1,310
B21687	63	Southeast corner sec. 36, T. 25 N., R. 1 W.	Scobey silt loam, 0-8 inches, very little gravel.	.5	
B21688	63a	do	Wheat in milk		6
B21689	64	do	Bentonitic seam in shale	.2	
B21690	64a	do	<i>Astragalus pectinatus</i> in shale		520
B21691	65	NE $\frac{1}{4}$ sec. 17, T. 23 N., R. 4 W.	Bainville loam, 0-8 inches	1.5	
B21692	65a	do	<i>Astragalus bisulcatus</i> , <i>A. pectinatus</i> also plentiful.		380
B21693	66	NW $\frac{1}{4}$ sec. 10, T. 23 N., R. 4 W.	Laurel clay loam, 0-8 inches, lime streaks, no gravel.	1	
B21694	66a	do	<i>Astragalus bisulcatus</i>		200
B21695	67	NE $\frac{1}{4}$ sec. 12, T. 23 N., R. 4 W.	Morton loam, 0-8 inches, no gravel.	1	
B21696	67a	do	<i>Astragalus pectinatus</i>		390
B21697	68	SW $\frac{1}{4}$ sec. 3, T. 23 N., R. 3 W.	Fairfield gravelly loam, 0-8 inches, lime-encrusted gravel.	4	
B21698	68a	do	<i>Astragalus pectinatus</i>		2,150
B21699	69	NE $\frac{1}{4}$ sec. 12, T. 23 N., R. 3 W.	Morton loam, 0-8 inches, lime-encrusted gravel.	1	
B21700	69a	do	<i>Astragalus pectinatus</i>		170
B21701	70	NE $\frac{1}{4}$ sec. 9, T. 23 N., R. 2 W.	Morton loam, 0-8 inches, no gravel.	1	
B21702	70a	do	<i>Astragalus pectinatus</i>		200
B21703	71	SE $\frac{1}{4}$ sec. 1, T. 23 N., R. 2 W.	Morton loam, 0-8 inches, gravel on surface.	.7	
B21704	71a	do	<i>Astragalus pectinatus</i>		340
B21705	72	NE $\frac{1}{4}$ sec. 9, T. 23 N., R. 1 W.	Morton loam, 0-8 inches	.4	
B21706	72a	do	<i>Astragalus bisulcatus</i>		230
B21707	73	SW $\frac{1}{4}$ sec. 22, T. 23 N., R. 1 W.	Laurel loam, alkali phase, 0-8 inches.	2	
B21708	73a	do	<i>Astragalus pectinatus</i>		650
B21709	74	NE $\frac{1}{4}$ sec. 25, T. 23 N., R. 2 W.	Laurel loam, alkali phase, 0-8 inches, no gravel.	.6	
B21710	74a	do	<i>Astragalus pectinatus</i>		130
B21711	75	SW $\frac{1}{4}$ sec. 22, T. 23 N., R. 2 W.	Yellowish-brown clay, 0-8 inches, no gravel.	.4	
B21712	75a	do	<i>Astragalus bisulcatus</i>		70
B21713	76	NW $\frac{1}{4}$ sec. 30, T. 23 N., R. 2 W.	Fairfield gravelly loam, 0-8 inches, lime-encrusted gravel.	.4	
B21714	76a	do	<i>Astragalus pectinatus</i>		140
B21715	76b	do	Young wheat		12
B21716	77	SW $\frac{1}{4}$ sec. 22, T. 23 N., R. 3 W.	Fairfield gravelly loam, 0-8 inches, lime-encrusted gravel.	1	
B21717	77a	do	<i>Astragalus pectinatus</i>		790
B21718	78	NE $\frac{1}{4}$ sec. 25, T. 23 N., R. 4 W.	Morton sandy loam, 0-8 inches	.4	
B21719	78a	do	<i>Astragalus pectinatus</i>		1,070
B21720	79	Northeast corner sec. 2, T. 23 N., R. 1 W.	Morton gravelly silt loam, 0-8 inches, lime-encrusted gravel.	.5	
B21721	79a	do	<i>Astragalus bisulcatus</i>		15
B21722	80	Northwest corner sec. 24, T. 23 N., R. 1 W.	Joplin loam, 0-8 inches, alkali streaked.	1.5	
B21723	80a	do	<i>Astragalus bisulcatus</i>		60
B21724	81	NE $\frac{1}{4}$ sec. 1, T. 22 N., R. 1 W.	Pierre clay loam, 0-8 inches, some shale, top of bluff.	2	

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

TETON COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21725	81a	NE $\frac{1}{4}$ sec. 1, T. 22 N., R. 1 W.	<i>Astragalus pectinatus</i>	P. p. m.	P. p. m.
B21726	82	do	Weathered gray shale, 5-5½ feet, 5 feet below No. 81.	5	1, 160
B21727	82a	do	<i>Astragalus pectinatus</i>		1, 130
B21728	83x	do	Bentonitic clay, 8-8½ feet, yellow streaked.	3	
B21729	84x	do	Gray shale, 15-15½ feet, gypsum and limestone.	1.5	
B21730	85	SE $\frac{1}{4}$ sec. 33, T. 23 N., R. 1 E.	Morton gravelly silt loam, 0-8 inches, fallow field.	2.5	
B21731	85a	do	<i>Astragalus pectinatus</i>		4, 020
B21732	86	SW $\frac{1}{4}$ sec. 31, T. 23 N., R. 2 E.	Marine clay loam, 0-8 inches.	.5	
B21733	86a	do	<i>Astragalus bisulcatus</i>		180
B21734	87	SE $\frac{1}{4}$ sec. 33, T. 23 N., R. 2 E.	Gray clay, 0-8 inches	.5	
B21735	87a	do	<i>Astragalus bisulcatus</i>		400
B21736	88	Southeast corner sec. 36, T. 23 N., R. 2 E.	Orman clay loam, 0-8 inches	.3	
B21737	88a	do	Russian-thistle.		1
B21738	89	SE $\frac{1}{4}$ sec. 14, T. 23 N., R. 2 E.	Bainville loam, 0-8 inches	.5	
B21739	89a	do	<i>Astragalus bisulcatus</i>		15
B21740	90	NW $\frac{1}{4}$ sec. 36, T. 24 N., R. 2 E.	Scobey loam, 0-8 inches	.4	
B21741	90a	do	Gumweed		5
B21742	91	NW $\frac{1}{4}$ sec. 9, T. 23 N., R. 2 E.	Bainville silty clay loam, 0-8 inches, some gravel.	.5	
B21743	91a	do	<i>Astragalus bisulcatus</i>		80
B21744	92	SW $\frac{1}{4}$ sec. 31, T. 24 N., R. 2 E.	Scobey loam, 0-8 inches, little gravel.	.4	
B21745	92a	do	<i>Astragalus bisulcatus</i>		190
B21746	93	Southwest corner sec. 33, T. 24 N., R. 1 E.	Laurel loam, alkali phase, 0-8 inches.	.3	
B21747	93a	do	Gumweed		4
B21748	94	S $\frac{1}{2}$ corner sec. 16, T. 23 N., R. 1 E.	Bainville loam, 18-26 inches, mottled yellow, from ditch.	1.5	
B21749	94a	do	<i>Astragalus bisulcatus</i>		19
B21750	95	SE $\frac{1}{4}$ sec. 13, T. 23 N., R. 1 E.	Gray rotten shale, 0-8 inches	1.5	
B21751	95a	do	<i>Astragalus bisulcatus</i>		7
B21752	96	SE $\frac{1}{4}$ sec. 13, T. 22 N., R. 1 W.	Morton gravelly silt loam, 0-8 inches, wheat field.	1	
B21753	96a	do	<i>Astragalus pectinatus</i>		880
B21754	96b	do	Young wheat.		5
B21755	97	SW $\frac{1}{4}$ sec. 2, T. 22 N., R. 1 W.	Pierre clay loam, rough phase, 0-8 inches, lime-encrusted gravel.	.5	
B21756	97a	do	<i>Astragalus pectinatus</i>		140
B21757	98	Southeast corner sec. 2, T. 22 N., R. 2 W.	Fairfield gravelly loam, 0-8 inches, not irrigated, lime-encrusted gravel.	.2	
B21758	98a	do	<i>Astragalus bisulcatus</i>		6
B21759	98b	do	Gumweed		2
B21760	99	Northeast corner sec. 1, T. 22 N., R. 2 W.	Fairfield gravelly loam, 0-8 inches, 50 feet from No. 98, irrigated.	.3	
B21761	99a	do	Alfalfa		5
B21762	99b	do	Gumweed		2
B21763	100	NW $\frac{1}{4}$ sec. 9, T. 22 N., R. 2 W.	Fairfield gravelly loam, 0-8 inches.	.3	
B21764	100a	do	<i>Astragalus pectinatus</i>		10
B21765	101	N $\frac{1}{2}$ corner sec. 0, T. 22 N., R. 3 W.	Brown clay loam, 0-8 inches, over shallow sandstone.	.5	
B21766	101a	do	<i>Astragalus pectinatus</i>		510
B21767	102	15 feet north of No. 101.	Sandstone, 0-12 inches	.2	
B21768	102a	do	Soft yellow shale, 12-24 inches	1	
B21769	103	SW $\frac{1}{4}$ sec. 13, T. 22 N., R. 3 W.	<i>Astragalus pectinatus</i>		50
B21770	103a	do	Fairfield gravelly loam, 0-8 inches, not irrigated.	.2	
B21771	103b	do	<i>Astragalus bisulcatus</i> , not irrigated.		2
B21772	104	10 feet east of No. 103.	Young Russian-thistle, not irrigated.		4
B21773	104a	do	Fairfield gravelly loam, 0-8 inches, irrigated.	.2	
B21774	104b	do	Wheat in milk, irrigated		5
B21775	105	NW $\frac{1}{4}$ sec. 26, T. 22 N., R. 1 W.	Young Russian-thistle, irrigated		3
B21776	105a	do	Fairfield gravelly loam, 0-8 inches.	.5	
B21777	105b	do	<i>Astragalus pectinatus</i>		110

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

TETON COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21777	106	NW¼ sec. 26, T. 22 N., R. 1 W.	Fairfield gravelly loam, 0-8 inches.	P. p. m. 0.5	
B21778	106a	do.	<i>Astragalus pectinatus</i> .		130
B21779	107	SW¼ sec. 29, T. 22 N., R. 2 W.	Fairfield gravelly loam, 0-8 inches.	.5	
B21780	107a	do.	<i>Astragalus pectinatus</i> .		7
B21781	108	SE¼ sec. 1, T. 22 N., R. 4 W.	Laurel clay loam, 0-8 inches, gypsum crystals in soil.	.3	
B21782	108a	do.	Greasewood.		4
B21783	109	SE¼ sec. 24, T. 22 N., R. 4 W.	Laurel clay loam, 0-8 inches.	.8	
B21784	109a	do.	<i>Astragalus pectinatus</i> .		70
B21785	110	EW corner sec. 12, T. 21 N., R. 3 W.	Morton loam, rough phase, 0-8 inches.	.7	
B21786	110a	do.	<i>Astragalus pectinatus</i> .		330
B21787	111	EW corner sec. 25, T. 21 N., R. 3 W.	Bainville loam, 0-8 inches.	.5	
B21788	111a	do.	<i>Astragalus pectinatus</i> .		630
B21789	112	SE¼ sec. 28, T. 21 N., R. 3 W.	Bainville loam, 0-8 inches.	.4	
B21790	112a	do.	<i>Astragalus pectinatus</i> .		100
B21791	113	SE¼ sec. 25, T. 21 N., R. 4 W.	Bainville loam, 0-8 inches.	.2	
B21792	113a	do.	<i>Astragalus</i> sp.		3
B21793	114	NE¼ sec. 16, T. 21 N., R. 3 W.	Morton gravelly loam, shallow phase, 0-8 inches.	1.5	
B21794	114a	do.	<i>Astragalus pectinatus</i> .		8
B21795	115	NE¼ sec. 33, T. 22 N., R. 3 W.	Pondera sandy loam, 0-8 inches.	.5	
B21796	115a	do.	<i>Astragalus pectinatus</i> .		330
B21797	R73	W corner sec. 33, T. 22 N., R. 3 W.	Bainville loam, 0-6 inches.	.5	
B21798	R73a	do.	<i>Astragalus pectinatus</i> .		260
B21799	R73b	do.	Young <i>Astragalus</i> sp., growing adjacent to No. R73.		2
B21799	R74a	Approximately EW corner sec. 17, T. 22 N., R. 3 W.	<i>Astragalus bisulcatus</i> .		800
B21797	116	NW¼ sec. 34, T. 22 N., R. 4 W.	Bainville sandy loam, 0-8 inches.	.2	
B21798	116a	do.	<i>Astragalus pectinatus</i> .		190
B21799	117	NW¼ sec. 15, T. 22 N., R. 4 W.	Bainville loam, gravelly phase, 0-8 inches.	.3	
B21800	117a	do.	<i>Astragalus pectinatus</i> .		140
B21801	118	NW¼ sec. 31, T. 22 N., R. 4 W.	Bainville loam, 0-8 inches.	.2	
B21802	118a	do.	Russian-thistle.		1
B21803	119	NW¼ sec. 34, T. 22 N., R. 5 W.	Fairfield gravelly loam, 0-8 inches.	.2	
B21804	119a	do.	<i>Astragalus</i> sp.		3
B21805	120	NE¼ sec. 36, T. 22 N., R. 6 W.	Laurel loam, 0-8 inches, abundant lime-encrusted gravel.	.2	
B21806	120a	do.	Gumweed.		3
B21807	121	Northwest corner sec. 35, T. 24 N., R. 5 W.	Bainville loam, 0-8 inches, no gravel.	.4	
B21808	121a	do.	<i>Astragalus pectinatus</i> .		8
B21809	122	NW¼ sec. 5, T. 23 N., R. 5 W.	Morton silt loam, 0-5 inches, lime-encrusted gravel.	.4	
B21810	122a	do.	<i>Astragalus pectinatus</i> .		410
B21811	123	NE¼ sec. 2, T. 23 N., R. 6 W.	Chouteau loam, 0-8 inches.	.6	
B21812	123a	do.	<i>Astragalus pectinatus</i> .		8
B21813	124	SW¼ sec. 32, T. 24 N., R. 6 W.	Reddish-brown sandy loam, 0-6 inches, probably derived from Kootenai formation.	.2	
B21816	124a	do.	<i>Astragalus pectinatus</i> .		100
B21815	125	do.	Greenish-gray clay, 12-24 inches.	.2	
B21815a	125a	do.	Red sandstone, 30 inches.	.1	
B21817	126	SW corner sec. 33, T. 24 N., R. 7 W.	Chouteau loam, 0-8 inches.	.4	
B21818	126a	do.	Gumweed.		5
B21819	127	SW corner sec. 18, T. 23 N., R. 7 W.	Laurel loam, 0-8 inches.	.2	
B21820	127a	do.	<i>Astragalus</i> sp.		6
B21821	128	SW¼ sec. 29, T. 23 N., R. 6 W.	Bainville loam, 0-8 inches.	.5	
B21822	128a	do.	<i>Astragalus pectinatus</i> .		110
B21824	128a	do.	do.		430
B21825	130	SE¼ sec. 16, T. 26 N., R. 5 W.	Laurel loam, 0-8 inches.	.5	
B21826	130a	do.	<i>Astragalus pectinatus</i> .		50

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

TETON COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21827	131	Northeast corner sec. 3, T. 28 N., R. 5 W.	Morton loam, gravelly, rough phase, 0-8 inches.	P. p. m.	P. p. m.
B21828	131a	do	<i>Astragalus pectinatus</i>		140
B21829	132a	SE $\frac{1}{4}$ sec. 27, T. 28 N., R. 5 W.	Gray sandy shale, 24-30 inches.	.2	15
B21830	132b	do	<i>Astragalus pectinatus</i> in shale.	.6	150
B21831	133	SW $\frac{1}{4}$ sec. 11, T. 28 N., R. 5 W.	Laurel loam, 0-8 inches.		
B21832	133a	do	<i>Astragalus pectinatus</i>		

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B21840	1	Southeast corner sec. 14, T. 28 N., R. 3 W.	Scobey silty clay loam, 0-8 inches.	0.4	
B21841	1a	do	<i>Astragalus bisulcatus</i>		90
B21842	2	NE $\frac{1}{4}$ sec. 20, T. 28 N., R. 2 W.	Orman clay loam, 0-8 inches.	.4	
B21843	2a	do	<i>Astragalus bisulcatus</i>		35
B21844	3	SW $\frac{1}{4}$ sec. 13, T. 28 N., R. 2 W.	Joplin loam, 0-8 inches.	.5	
B21845	3a	do	<i>Astragalus pectinatus</i>		360
B21846	4	SE $\frac{1}{4}$ sec. 17, T. 28 N., R. 1 W.	Joplin loam, 0-8 inches.	.5	
B21847	4a	do	<i>Astragalus bisulcatus</i>		450
B21848	5	SE $\frac{1}{4}$ sec. 14, T. 28 N., R. 1 W.	Joplin sandy loam, 0-8 inches, no gravel.	.5	
B21849	5a	do	<i>Astragalus bisulcatus</i>		110
B21850	6	NW $\frac{1}{4}$ sec. 21, T. 28 N., R. 1 E.	Burton clay loam, 0-8 inches.	.5	
B21851	6a	do	Gumweed.		80
B21852	7	SE $\frac{1}{4}$ corner sec. 18, T. 28 N., R. 2 E.	Orman clay loam, dark phase, 0-8 inches.	.4	
B21853	7a	do	<i>Astragalus bisulcatus</i>		480
B21854	8	SW $\frac{1}{4}$ sec. 14, T. 28 N., R. 2 E.	Orman clay loam, 0-8 inches.	1	
B21855	8a	do	<i>Astragalus pectinatus</i>		1,370
B21856	9	SE $\frac{1}{4}$ sec. 36, T. 28 N., R. 2 E.	Joplin loam, 0-8 inches.	.4	
B21857	9a	do	<i>Astragalus pectinatus</i>		1,240
B21858	10	SW $\frac{1}{4}$ sec. 34, T. 28 N., R. 2 E.	Joplin loam, 0-8 inches.	.5	
B21859	10a	do	<i>Astragalus pectinatus</i>		580
B21860	11	SW $\frac{1}{4}$ sec. 31, T. 28 N., R. 2 E.	Joplin sandy loam, 0-8 inches.	1	
B21861	11a	do	<i>Astragalus pectinatus</i>		1,420
B21862	12	SW $\frac{1}{4}$ sec. 24, T. 28 N., R. 1 E.	Joplin loam, 0-8 inches.	1	
B21863	12a	do	<i>Astragalus pectinatus</i>		900
B21864	13	SE $\frac{1}{4}$ sec. 36, T. 28 N., R. 1 W.	Laurel loam, 0-8 inches.	1	
B21865	13a	do	<i>Astragalus pectinatus</i>		240
B21866	14	NE $\frac{1}{4}$ sec. 5, T. 27 N., R. 1 W.	Scobey loam, 0-8 inches.	1	
B21867	14a	do	<i>Astragalus bisulcatus</i>		50
B21868	15	SW $\frac{1}{4}$ sec. 36, T. 28 N., R. 2 W.	Scobey loam, 0-8 inches.	1.5	
B21869	15a	do	<i>Astragalus pectinatus</i>		650
B21870	16	SW $\frac{1}{4}$ sec. 33, T. 28 N., R. 2 W.	Scobey loam, 0-8 inches.	.5	
B21871	16a	do	<i>Astragalus bisulcatus</i>		20
B21872	17	Southwest corner sec. 36, T. 28 N., R. 3 W.	Joplin loam, 0-8 inches, slightly gravelly.	.7	
B21873	17a	do	<i>Astragalus bisulcatus</i>		25
B21874	18	do	Gray mottled clay, 24-30 inches.	.5	
B21875	19	NE $\frac{1}{4}$ sec. 4, T. 28 N., R. 2 W.	Valley silty clay loam, dark phase, 0-8 inches.	.7	
B21876	19a	do	<i>Astragalus bisulcatus</i>		360
B21877	20	W $\frac{1}{4}$ corner sec. 6, T. 26 N., R. 1 W.	Burton clay loam, 0-8 inches.	.4	
B21878	20a	do	<i>Astragalus bisulcatus</i>		6
B21879	21	NW $\frac{1}{4}$ sec. 1, T. 26 N., R. 1 W.	Orman clay loam, 0-8 inches, gravel on surface.	.5	
B21880	21a	do	<i>Astragalus bisulcatus</i>		110
B21881	22	NW $\frac{1}{4}$ sec. 11, T. 26 N., R. 2 E.	Joplin silt loam, 0-8 inches, a little gravel on surface.	.5	
B21882	22a	do	<i>Astragalus bisulcatus</i>		630
B21883	23	Southeast corner sec. 13, T. 27 N., R. 2 E.	Joplin loam, 0-8 inches.	.7	
B21884	23a	do	<i>Astragalus pectinatus</i>		80
B21885	24	do	Mottled gray clay, 30-36 inches.	.5	
B21886	25	Northwest corner sec. 22, T. 27 N., R. 2 E.	Joplin silty clay loam, 0-8 inches.	.7	
B21887	25a	do	<i>Astragalus pectinatus</i>		230
B21888	26	Southeast corner sec. 18, T. 27 N., R. 1 E.	Joplin silty clay loam, 0-12 inches.	.8	
B21889	26a	do	<i>Astragalus bisulcatus</i>		230
B21890	27	SE $\frac{1}{4}$ corner sec. 13, T. 27 N., R. 1 W.	Joplin silty clay loam, 0-8 inches.	.3	
B21891	27a	do	Russian-thistle		5

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

PONDERA COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21892	28	SE $\frac{1}{4}$ sec. 13, T. 27 N., R. 2 W.	Burton clay loam, 0-8 inches	P. p. m. 0.5	P. p. m.
B21893	28a	do	<i>Astragalus bisulcatus</i>		150
B21894	29	SW $\frac{1}{4}$ corner sec. 15, T. 27 N., R. 2 W.	Burton clay loam, 0-8 inches	1	
B21895	29a	do	<i>Astragalus bisulcatus</i>		1,580
B21896	30	NW $\frac{1}{4}$ sec. 5, T. 26 N., R. 2 W.	Joplin loam, 0-8 inches, very gravelly.	1	
B21897	30a	do	<i>Astragalus pectinatus</i>		1,350
B21898	31	NW $\frac{1}{4}$ sec. 19, T. 27 N., R. 2 W.	Joplin loam, 0-8 inches	5	
B21899	31a	do	<i>Astragalus bisulcatus</i>		160
B21900	32	Southwest corner sec. 36, T. 28 N., R. 5 W.	Laurel loam, 0-8 inches	1	
B21901	32a	do	<i>Astragalus bisulcatus</i>		10
B21902	33	N $\frac{1}{4}$ corner sec. 4, T. 27 N., R. 4 W.	Scobey loam, 0-8 inches	1	
B21903	33a	do	<i>Astragalus pectinatus</i>		190
B21904	34	SW $\frac{1}{4}$ corner sec. 36, T. 28 N., R. 4 W.	Scobey silt loam, 0-8 inches, no gravel.	4	
B21905	34a	do	<i>Astragalus bisulcatus</i>		380
B21906	35	NE $\frac{1}{4}$ sec. 5, T. 27 N., R. 3 W.	Scobey silt loam, 0-8 inches, no gravel.	3	
B21907	35a	do	Gumwood		3
B21908	36	Northwest corner sec. 15, T. 27 N., R. 3 W.	Scobey loam, 0-12 inches, gravelly.	3	
B21909	36a	do	Russian-thistle		3
B21910	37	SW $\frac{1}{4}$ sec. 10, T. 27 N., R. 3 W.	Scobey loam, 0-12 inches	5	
B21911	37a	do	<i>Astragalus pectinatus</i>		390
B21912	38	NE $\frac{1}{4}$ sec. 2, T. 28 N., R. 3 W.	Pondera loam, 0-8 inches	2	
B21913	38a	do	<i>Astragalus pectinatus</i>		5
B21914	39	NE $\frac{1}{4}$ sec. 24, T. 29 N., R. 3 W.	Scobey silty clay loam, 0-8 inches	7	
B21915	39a	do	<i>Astragalus bisulcatus</i>		60
B21916	40	Northeast corner sec. 2, T. 29 N., R. 3 W.	Scobey loam, 0-8 inches, abundant gravel.	5	
B21917	40a	do	<i>Astragalus bisulcatus</i>		130
B21918	41	NE $\frac{1}{4}$ sec. 23, T. 30 N., R. 3 W.	Joplin loam, 0-8 inches	7	
B21919	41a	do	<i>Astragalus bisulcatus</i>		360
B21920	42	N $\frac{1}{4}$ corner sec. 5, T. 30 N., R. 2 W.	Joplin sandy loam, 0-8 inches.	2	
B21921	42a	do	<i>Astragalus pectinatus</i>		1,700
B21924	43	W $\frac{1}{4}$ corner sec. 28, T. 28 N., R. 5 W.	Morton loam, salt encrusted, gravelly phase 0-8 inches.	4	
B21925	43a	do	<i>Astragalus pectinatus</i>		40
B21926	44	NW $\frac{1}{4}$ sec. 24, T. 28 N., R. 4 W.	Bainville loam, 0-8 inches	1	
B21927	44a	do	<i>Astragalus pectinatus</i>		360
B21928	44b	do	Barley heads		4
B21929	45	NE $\frac{1}{4}$ sec. 20, T. 28 N., R. 3 W.	Williams loam, 0-8 inches	1	
B21930	45a	do	<i>Astragalus pectinatus</i>		270
B21931	46	NW $\frac{1}{4}$ sec. 4, T. 28 N., R. 3 W.	Laurel loam, 0-8 inches	4	
B21932	46a	do	<i>Astragalus pectinatus</i>		190
B21933	47	NW $\frac{1}{4}$ sec. 21, T. 29 N., R. 3 W.	Scobey loam, 0-8 inches	3	
B21934	47a	do	<i>Astragalus bisulcatus</i>		130
B21935	48	SW $\frac{1}{4}$ sec. 1, T. 29 N., R. 3 W.	Scobey silty clay loam, 0-8 inches	1.5	
B21936	48a	do	<i>Astragalus bisulcatus</i>		80
B21937	49	Southwest corner sec. 33, T. 30 N., R. 3 W.	Valley silty clay loam, 0-8 inches	5	
B21938	49a	do	<i>Astragalus bisulcatus</i>		25
B21939	49b	do	Bluejoint grass		2
B21970	50	NE $\frac{1}{4}$ sec. 20, T. 30 N., R. 3 W.	Joplin loam, 0-8 inches	7	
B21971	50a	do	<i>Astragalus bisulcatus</i>		70
B21972	51	N $\frac{1}{4}$ corner sec. 5, T. 30 N., R. 3 W.	Joplin loam, 0-8 inches	1	
B21973	51a	do	<i>Astragalus bisulcatus</i>		30
B21974	52	NW $\frac{1}{4}$ sec. 13, T. 30 N., R. 4 W.	Pondera fine sandy loam, 0-8 inches.	1	
B21975	52a	do	<i>Astragalus bisulcatus</i>		250
B21976	53	NW $\frac{1}{4}$ sec. 9, T. 30 N., R. 4 W.	Joplin loam, 0-8 inches	1.5	
B21977	53a	do	<i>Astragalus bisulcatus</i>		90
B21978	54	NW $\frac{1}{4}$ sec. 12, T. 30 N., R. 5 W.	Valley silty clay loam, 0-8 inches, not irrigated.	2	
B21979	54a	do	Alfalfa, not irrigated.		1
B21980	54b	do	<i>Astragalus bisulcatus</i> , 25 feet from No. 54a, not irrigated.		140
B21981	55	25 feet east of No. 54	Valley silty clay loam, 0-8 inches, irrigated.	2	
B21982	55a	do	Alfalfa, irrigated		4
B21983	56	NW $\frac{1}{4}$ sec. 25, T. 31 N., R. 5 W.	Valley clay loam, 0-8 inches	5	
B21984	56a	do	<i>Astragalus pectinatus</i>		550

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

PONDERA COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	P. p. m.
B21985	57	SW corner sec. 2, T. 31 N., R. 5 W.	Scobey loam, 0-8 inches.	8.2	
B21986	57a	do	<i>Astragalus pectinatus</i>		100
B21987	58	Northwest corner sec. 9, T. 30 N., R. 5 W.	Valley silty clay loam, 0-8 inches	4	
B21988	58a	do	Gumweed		3
B21989	59	SW 1/4 sec. 1, T. 29 N., R. 5 W.	Valley silty clay loam, 0-8 inches	1	
B21990	59a	do	<i>Astragalus bisulcatus</i>		40
B21991	60	NW 1/4 sec. 16, T. 29 N., R. 4 W.	Scobey silty clay loam, 0-8 inches	7	
B21992	60a	do	<i>Astragalus bisulcatus</i>		80
B21993	61	NW 1/4 sec. 28, T. 30 N., R. 4 W.	Scobey silty clay loam, 0-8 inches	5	
B21994	61a	do	<i>Astragalus bisulcatus</i>		200
B21995	62	NW 1/4 sec. 25, T. 30 N., R. 5 W.	Valley silty clay loam, 0-8 inches	3	
B21996	62a	do	<i>Astragalus bisulcatus</i>		660
B21997	63	NE 1/4 sec. 6, T. 29 N., R. 5 W.	Valley silty clay loam, 0-8 inches	5	
B21998	63a	do	<i>Astragalus bisulcatus</i>		200
B21999	64	Southwest corner sec. 2, T. 29 N., R. 6 W.	Ashuelot gravelly loam, 0-8 inches.	2	
B22000	64a	do	<i>Astragalus pectinatus</i>		100
B22001	65	NW 1/4 sec. 4, T. 28 N., R. 2 W.	Pondera fine sandy loam, 0-8 inches.	1	
B22002	65a	do	<i>Astragalus pectinatus</i>		280
B22003	66	NE 1/4 sec. 2, T. 28 N., R. 2 W.	Joplin sandy loam, 0-8 inches	5	
B22004	66a	do	<i>Astragalus pectinatus</i>		40
B22005	67	W 1/4 corner sec. 24, T. 29 N., R. 2 W.	Joplin sandy loam, 0-8 inches	1.5	
B22006	67a	do	<i>Astragalus pectinatus</i>		820
B22007	68	NW 1/4 sec. 22, T. 29 N., R. 1 W.	Joplin loam, 0-8 inches	8	
B22008	68a	do	<i>Astragalus pectinatus</i>		150
B22009	69	NW 1/4 sec. 3, T. 28 N., R. 1 W.	Pierre clay loam, 0-8 inches	2	
B22010	69a	do	<i>Astragalus bisulcatus</i>		250
B22011	70	NW 1/4 sec. 22, T. 29 N., R. 1 E	Joplin loam, 0-8 inches, alkali spot.	5	
B22012	70a	do	<i>Astragalus pectinatus</i>		20
B22013	71	NW 1/4 sec. 1, T. 28 N., R. 1 E	Barton clay loam, 0-8 inches	7	
B22014	71a	do	<i>Astragalus bisulcatus</i>		35
B22015	72	Northeast corner sec. 5, T. 28 N., R. 2 E.	Joplin loam, 0-8 inches	7	
B22016	72a	do	Gumweed		4
B22017	73	NE 1/4 sec. 2, T. 28 N., R. 2 E	Joplin loam, 0-8 inches	1	
B22018	73a	do	Russian-thistle		4
B22019	74	NE 1/4 sec. 2, T. 28 N., R. 2 E., 15 feet east of 73.	Mottled gray clay, 60-70 inches	3	
B22020	74a	do	<i>Astragalus bisulcatus</i>		260
B22021	75	SE 1/4 sec. 13, T. 29 N., R. 1 W.	Joplin loam, 0-8 inches	1	
B22022	75a	do	<i>Astragalus bisulcatus</i>		730
B22023	76	NE 1/4 sec. 1, T. 29 N., R. 1 W.	Joplin loam, 0-8 inches	2	
B22024	76a	do	<i>Astragalus pectinatus</i>		110
B22025	77	NE 1/4 sec. 24, T. 30 N., R. 1 W.	Mottled gray clay, 0-8 inches, in badlands.	5	
B22026	77a	do	<i>Astragalus pectinatus</i>		40
B22027	78	SW 1/4 sec. 34, T. 30 N., R. 1 W.	Joplin sandy loam, 0-8 inches	5	
B22028	78a	do	<i>Astragalus pectinatus</i>		280
B22029	79	NE 1/4 sec. 36, T. 30 N., R. 2 W.	Joplin sandy loam, 0-8 inches	5	
B22030	79a	do	<i>Astragalus pectinatus</i>		880
B22031	80	E 1/4 corner sec. 20, T. 30 N., R. 2 W.	Joplin loam, 0-8 inches	2	
B22032	80a	do	Gumweed		5
B22033	81	SE 1/4 sec. 32, T. 30 N., R. 2 W.	Joplin sandy loam, 0-8 inches	5	
B22034	81a	do	<i>Astragalus bisulcatus</i>		35
B22035	82	SE 1/4 sec. 17, T. 29 N., R. 2 W.	Pondera loam, 0-8 inches, not irrigated.	7	
B22036	82a	do	Alfalfa, not irrigated.		4
B22037	82b	do	<i>Astragalus bisulcatus</i> , not irrigated.		180
B22038	83	SE 1/4 sec. 17, T. 29 N., R. 2 W., 60 feet north of No. 82.	Pondera loam, 0-8 inches, irrigated.	2	
B22039	83a	do	Alfalfa, irrigated.		3
B22040	84	Center sec. 1, T. 28 N., R. 6 W.	Merton loam, gravelly phase, 0-8 inches.	2	
B22041	84a	do	<i>Astragalus pectinatus</i>		230
B22042	85	SW 1/4 sec. 10, T. 28 N., R. 6 W.	Merton loam, 0-8 inches	2	
B22043	85a	do	<i>Astragalus pectinatus</i>		20

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.
CHOUTEAU COUNTY

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B22044	1.	SE $\frac{1}{4}$ sec. 6, T. 26 N., R. 3 E.	Yellow-brown clay, 0-8 inches	P. p. m. 0.6	P. p. m.
B22045	1a	do	<i>Astragalus pectinatus</i>		220
B22046	2.	S $\frac{1}{4}$ corner sec. 22, T. 24 N., R. 3 E.	Yellowish-brown clay loam, 0-8 inches.	.5	
B22047	2a	do	<i>Astragalus pectinatus</i>		4306
B22048	3.	N $\frac{1}{4}$ corner sec. 30, T. 24 N., R. 3 E.	Yellow sandy loam, 0-8 inches	.7	
B22049	3a	do	<i>Astragalus pectinatus</i>		800
B22050	4.	N $\frac{1}{4}$ corner sec. 37, T. 24 N., R. 3 E.	Yellowish-brown very fine sandy loam, 0-8 inches.	.7	
B22051	4a	do	<i>Astragalus pectinatus</i>		470
B22052	5.	W $\frac{1}{4}$ corner sec. 30, T. 24 N., R. 3 E.	Yellowish-gray silt loam, 0-8 inches.	.8	
B22053	5a	do	<i>Astragalus pectinatus</i>		320
B22054	6.	Southwest corner sec. 37, T. 24 N., R. 6 E.	Yellowish-brown clay loam, 0-8 inches.	.5	
B22055	6a	do	<i>Astragalus bisulcatus</i>		100
B22056	7.	SE $\frac{1}{4}$ sec. 36, T. 24 N., R. 5 E.	Yellowish-brown clay, 0-8 inches	.8	
B22057	7a	do	<i>Astragalus pectinatus</i>		15
B22058	8.	S $\frac{1}{4}$ corner sec. 20, T. 24 N., R. 3 E.	Gray clay, 0-8 inches	.5	
B22059	8a	do	<i>Astragalus pectinatus</i>		310
B22060	9.	N $\frac{1}{4}$ corner sec. 35, T. 24 N., R. 4 E.	Brown clay loam, 0-8 inches	.5	
B22061	9a	do	Russian-thistle		1
B22062	10.	NW $\frac{1}{4}$ sec. 33, T. 24 N., R. 4 E.	Dark-gray clay, 0-6 inches	.2	
B22063	10a	do	Gumweed		4
B22064	11.	N $\frac{1}{4}$ corner sec. 35, T. 24 N., R. 3 E.	Brown clay, 0-8 inches	.6	
B22065	11a	do	<i>Astragalus pectinatus</i>		220
B22066	12.	NE $\frac{1}{4}$ sec. 21, T. 24 N., R. 3 E.	Mottled gray clay, 0-8 inches	.4	
B22067	12a	do	<i>Astragalus pectinatus</i>		360
B22068	13.	NW $\frac{1}{4}$ sec. 16, T. 23 N., R. 6 E.	Light yellowish-brown clay, 0-8 inches.	.8	
B22069	13a	do	<i>Astragalus pectinatus</i>		620
B22070	14.	NE $\frac{1}{4}$ sec. 13, T. 23 N., R. 5 E.	Yellowish-brown clay loam, 0-8 inches.	.6	
B22071	14a	do	<i>Astragalus pectinatus</i>		16
B22072	15.	NW $\frac{1}{4}$ sec. 35, T. 23 N., R. 5 E.	Light-brown clay loam, 0-8 inches.	.5	
B22073	15a	do	<i>Astragalus pectinatus</i>		140
B22074	16.	NW $\frac{1}{4}$ sec. 32, T. 23 N., R. 5 E.	Dark grayish-brown clay, 0-8 inches.	.3	
B22075	16a	do	Wheat in milk		2
B22076	17.	NE $\frac{1}{4}$ sec. 16, T. 23 N., R. 5 E.	Grayish-brown clay, 0-8 inches	.4	
B22077	17a	do	Russian-thistle		2
B22078	18.	SW $\frac{1}{4}$ sec. 7, T. 23 N., R. 5 E.	Yellowish-brown clay, 0-8 inches	.7	
B22079	18a	do	<i>Astragalus pectinatus</i>		320
B22080	19.	NE $\frac{1}{4}$ sec. 34, T. 23 N., R. 4 E.	Dark-gray clay, 0-8 inches	.4	
B22081	19a	do	<i>Astragalus pectinatus</i>		7
B22082	20x	20 feet above No. 19	Dark-gray shale	.7	
B22083	21.	60 feet north and 50 feet above No. 19.	Gray-brown clay, 0-8 inches	1.5	
B22084	22.	do	Yellow clay, 10-14 inches	1	
B22085	23.	do	Light-gray clay, 14-21 inches	1.5	
B22086	24.	NE $\frac{1}{4}$ sec. 16, T. 23 N., R. 4 E.	Brown clay, 0-8 inches	.4	
B22087	24a	do	<i>Astragalus pectinatus</i>		190
B22088	25.	NW corner sec. 18, T. 23 N., R. 4 E.	Grayish-brown clay, 0-8 inches	.3	
B22089	25a	do	Alfalfa		2
B22090	26.	SE $\frac{1}{4}$ sec. 25, T. 23 N., R. 3 E.	Dark grayish-brown clay, 0-8 inches.	.3	
B22091	26a	do	<i>Astragalus bisulcatus</i>		20
B21280	R88	Approximately N $\frac{1}{4}$ corner sec. 14, T. 23 N., R. 3 E.	Yellowish-brown clay, 0-16 inches.	.5	
B21281	R88a	do	<i>Astragalus pectinatus</i>		450
B22092	27.	S $\frac{1}{4}$ corner sec. 10, T. 23 N., R. 3 E.	Yellowish-brown clay, 0-8 inches	.3	
B22093	27a	do	Ripe wheat heads		1
B22094	28.	SW $\frac{1}{4}$ sec. 3, T. 24 N., R. 3 E.	Light gray-brown clay, 0-8 inches.	.3	
B22095	28a	do	<i>Astragalus pectinatus</i>		180
B22096	29.	SW $\frac{1}{4}$ sec. 7, T. 24 N., R. 4 E.	Yellowish-brown clay, 0-6 inches	.4	
B22097	29a	do	<i>Astragalus pectinatus</i>		430
B22098	30.	NE $\frac{1}{4}$ sec. 15, T. 24 N., R. 4 E.	Gray clay, streaked with yellow, 0-8 inches.	.5	
B22098A	30a	do	<i>Astragalus pectinatus</i>		180

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

CHOUTEAU COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B22099	31	NW¼ sec. 7, T. 24 N., R. 5 E.	Grayish-brown clay, 0-8 inches.	P. p. m. 0.4	P. p. m.
B22100	31a	do	Gumweed.	0.4	4
B22101	32	SW¼ sec. 10, T. 24 N., R. 5 E.	Grayish-brown clay, 0-8 inches.	5	1,310
B22102	32a	do	<i>Astragalus pectinatus</i> .		
B22103	33	SW¼ sec. 7, T. 24 N., R. 6 E.	Yellowish-brown clay loam, 0-8 inches.	7	
B22104	33a	do	<i>Astragalus pectinatus</i> .		140
B22105	34	NW¼ sec. 15, T. 24 N., R. 6 E.	Mottled gray clay, 0-8 inches.	7	
B22106	34a	do	<i>Astragalus pectinatus</i> .		680
B22107	35	SE¼ sec. 7, T. 24 N., R. 7 E.	Light yellowish-brown clay, 0-8 inches.	1	
B22108	35a	do	<i>Astragalus pectinatus</i> .		7
B22109	36	SE¼ sec. 31, T. 25 N., R. 8 E.	Grayish-brown silt loam, 0-8 inches.	7	
B22110	36a	do	<i>Astragalus pectinatus</i> .		10
B22111	37	NE¼ sec. 17, T. 25 N., R. 7 E.	Light yellowish-brown clay loam, 0-8 inches.	5	
B22112	37a	do	<i>Astragalus pectinatus</i> .		30
B22113	38	SE¼ sec. 12, T. 25 N., R. 5 E.	Yellowish-brown clay loam, 0-8 inches.	1.5	
B22114	38a	do	<i>Astragalus pectinatus</i> .		4
B22115	39	N¼ corner sec. 6, T. 25 N., R. 5 E.	Light grayish-brown clay, 0-8 inches.	5	
B22116	39a	do	<i>Astragalus pectinatus</i> .		1,020
B22117	40	SW¼ sec. 14, T. 25 N., R. 3 E.	Yellow clay, 0-8 inches.	5	
B22118	40a	do	<i>Astragalus bisulcatus</i> .		30
B22119	41	SW¼ sec. 14, T. 26 N., R. 3 E.	Grayish-brown clay, 0-8 inches.	5	
B22120	41a	do	<i>Astragalus bisulcatus</i> .		150
B22121	42	SE¼ sec. 27, T. 27 N., R. 3 E.	Grayish-brown clay, 0-8 inches.	3	
B22122	42a	do	<i>Astragalus pectinatus</i> .		130
B22123	43	NE¼ sec. 10, T. 27 N., R. 3 E.	Grayish-brown clay, 0-8 inches.	1	
B22124	43a	do	<i>Astragalus pectinatus</i> .		180
B22125	44	E¼ corner sec. 4, T. 27 N., R. 4 E.	Gray clay, 0-8 inches.	7	
B22126	44a	do	<i>Astragalus pectinatus</i> .		60
B22127	45	SW¼ sec. 3, T. 27 N., R. 5 E.	Yellowish-brown clay, 0-8 inches.	3	
B22128	45a	do	<i>Astragalus pectinatus</i> .		630
B22129	45b	do	Blue grama grass.		2
B22130	46	Northeast corner sec. 8, T. 26 N., R. 5 E.	Grayish-brown clay, 0-8 inches.	4	
B22131	46a	do	Russian-thistle.		2
B22132	47	SW¼ sec. 3, T. 26 N., R. 4 E.	Grayish-brown clay, 0-8 inches.	1	
B22133	47a	do	<i>Astragalus bisulcatus</i> .		410
B22134	48	SE¼ sec. 19, T. 26 N., R. 7 E.	Light-yellow sandy loam, 0-8 inches.	5	
B22135	48a	do	<i>Astragalus pectinatus</i> .		310
B22136	49	E¼ corner sec. 29, T. 26 N., R. 6 E.	Grayish-brown clay loam, 0-8 inches.	1.5	
B22137	49a	do	<i>Astragalus pectinatus</i> .		330
B22138	50	SW¼ sec. 6, T. 26 N., R. 6 E.	Mottled gray clay, 0-8 inches.	2.5	
B22139	50a	do	<i>Astragalus pectinatus</i> .		2,060
B22140	51	NE¼ sec. 34, T. 27 N., R. 6 E.	Brown clay loam, 0-8 inches.	4	
B22141	51a	do	<i>Astragalus pectinatus</i> .		35
B22142	52	S¼ corner sec. 10, T. 27 N., R. 6 E.	Yellow clay loam, 0-8 inches.	4	
B22143	52a	do	<i>Astragalus pectinatus</i> .		30
B22144	53	SE¼ sec. 23, T. 27 N., R. 7 E.	Yellowish-brown clay, 0-8 inches.	4	
B22145	53a	do	<i>Astragalus pectinatus</i> .		190
B22146	54	SW¼ sec. 34, T. 28 N., R. 7 E.	Yellowish-brown clay loam, 0-8 inches.	4	
B22147	54a	do	<i>Astragalus pectinatus</i> .		25
B22148	55	NE¼ sec. 23, T. 28 N., R. 7 E.	Grayish-brown clay, 0-8 inches.	4	
B22149	55a	do	<i>Astragalus pectinatus</i> .		530
B22150	56	NW¼ sec. 25, T. 26 N., R. 7 E.	Yellow clay loam, 0-8 inches.	5	
B22151	56a	do	<i>Astragalus pectinatus</i> .		10
B22152	57	N¼ corner sec. 11, T. 25 N., R. 8 E.	Yellowish-brown clay loam, 0-8 inches.	7	
B22153	57a	do	<i>Astragalus pectinatus</i> .		470
B22154	58	SE¼ sec. 7, T. 25 N., R. 8 E.	Grayish-brown clay loam, 0-8 inches.	1	
B22155	58a	do	<i>Astragalus pectinatus</i> .		180
B22156	59	NW¼ sec. 33, T. 24 N., R. 9 E.	Yellowish-brown clay, 0-8 inches.	1	
B22157	59a	do	<i>Astragalus pectinatus</i> .		250
B22158	60	N¼ corner sec. 6, T. 23 N., R. 10 E.	Brown clay loam, 0-8 inches.	7	
B22159	60a	do	<i>Astragalus bisulcatus</i> .		90

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

CHOUTEAU COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B22160	61	NE¼ sec. 1, T. 23 N., R. 10 E.	Grayish-brown clay loam, 0-8 inches	P. p. m. 1	P. p. m.
B22161	61a	do	<i>Astragalus pectinatus</i>		340
B22162	62	SE¼ sec. 25, T. 23 N., R. 10 E.	Grayish-brown clay loam, 0-8 inches	3	
B22163	62a	do	<i>Astragalus pectinatus</i>		330
B22164	63	NE¼ sec. 1, T. 23 N., R. 11 E.	Yellowish-brown clay loam, 0-8 inches	1	
B22165	63a	do	<i>Astragalus pectinatus</i>		130
B22166	64	SW¼ sec. 31, T. 23 N., R. 12 E.	Brown clay loam, 0-8 inches	1	
B22167	64a	do	<i>Astragalus pectinatus</i>		550
B22168	65	RM corner sec. 1, T. 21 N., R. 11 E.	Yellowish-brown clay, 0-8 inches	1	
B22169	65a	do	<i>Astragalus pectinatus</i>		15
B22170	66	N¼ corner sec. 34, T. 21 N., R. 12 E.	Gray clay, 0-8 inches	3	
B22171	66a	do	<i>Astragalus pectinatus</i>		90
B22172	67	SE¼ sec. 29, T. 21 N., R. 13 E.	Dark grayish-brown loam, 0-8 inches	.7	
B22173	67a	do	Ripe wheat heads		1
B22174	67b	do	<i>Astragalus pectinatus</i> , 10 feet east of soil		1,500
B22175	68	SW¼ sec. 20, T. 21 N., R. 14 E.	Dark-brown clay, 0-8 inches	1.5	
B22176	68a	do	<i>Astragalus pectinatus</i>		590
B22177	69	NW¼ sec. 1, T. 21 N., R. 13 E.	Grayish-brown clay, 0-8 inches	.7	
B22178	69a	do	<i>Astragalus pectinatus</i>		30
B22179	70	SW¼ sec. 31, T. 22 N., R. 13 E.	Brown clay loam, 0-8 inches	1.5	
B22180	70a	do	<i>Astragalus pectinatus</i>		600
B22181	71	NW¼ sec. 6, T. 22 N., R. 13 E.	Yellowish-brown clay loam, 0-8 inches	.7	
B22182	71a	do	<i>Astragalus bisulcatus</i>		130
B22183	72	SW¼ sec. 23, T. 23 N., R. 13 E.	Yellowish-brown sandy loam, 0-8 inches	.7	
B22184	72a	do	<i>Astragalus pectinatus</i>		190
B22185	73	NE¼ sec. 12, T. 23 N., R. 12 E.	Brown clay loam, 0-8 inches	.7	
B22186	73a	do	<i>Astragalus pectinatus</i>		30
B22187	74	1.7 miles north of Teton on State Road 29.	Grayish silt loam, 0-8 inches	1	
B22188	74a	do	<i>Astragalus bisulcatus</i>		25
B22189	75a	From 4 elevators in Big Sandy	Composite of wheat in area		<.5
B22190	76a	From 3 elevators in Fort Benton	do		1
B22191	77	0.7 mile east of Big Sandy on State Road 27.	Brown clay loam, 0-8 inches	1.5	
B22192	77a	do	<i>Astragalus pectinatus</i>		270
B22193	78	11 miles southeast of Big Sandy on State Road 27.	Yellow fine sandy loam, 0-8 inches	1	
B22194	78a	do	<i>Astragalus pectinatus</i>		5
B22195	79	16.9 miles southeast of Big Sandy on State Road 27.	Brown clay loam, 0-8 inches	.6	
B22196	79a	do	<i>Astragalus pectinatus</i>		210
B22197	80	21.4 miles southeast of Big Sandy on State Road 27.	Brown clay loam, 0-8 inches	2	
B22198	80a	do	<i>Astragalus pectinatus</i>		720
B22199	81	26.1 miles southeast of Big Sandy on State Road 27.	Brown clay loam, 0-8 inches	.5	
B22200	81a	do	<i>Astragalus pectinatus</i>		120
B22201	82	31.2 miles southeast of Big Sandy on State Road 27.	Grayish-brown silt loam, 0-8 inches	2	
B22202	82a	do	<i>Astragalus pectinatus</i>		130
B22203	83	36.5 miles southeast of Big Sandy on State Road 27.	Grayish-brown silt loam, 0-8 inches	.5	
B22204	83a	do	<i>Astragalus pectinatus</i>		30

FERGUS COUNTY

B21294	R96a	23 miles north of Lewistown on State Road 19.	<i>Astragalus bisulcatus</i>		130
B21295	R97	41 miles north of Lewistown, 4 miles east of Winifred.	Dark-gray clay, 18-24 inches, developed on Bearpaw (?)	0.4	
B21296	R97a	do	<i>Astragalus bisulcatus</i>		20
B21297	R98x	40 miles north of Lewistown, 3 miles east of Winifred.	Limonitic gray shale, 18-24 inches	.7	

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

FERGUS COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m. 0.5	P. p. m.
B21298	R09	37 miles north of Lewistown, in Winifred.	Light-brown clay loam, 0-6 inches.		
B21299	R09a	do.	<i>Astragalus pectinatus</i> .		210
B21300	R100	25 miles north of Lewistown on State Road 19.	Dark-gray clay, developed on Judith River (?), 0-6 inches.	.2	
B21301	R100a	do.	<i>Cynoglossum officinale</i> .		2
B21302	R101	21 miles north of Lewistown on State Road 19.	Dark-gray clay, 0-6 inches.	.4	
B21303	R101a	do.	<i>Astragalus</i> sp.		2
B21304	R102a	20 miles north of Lewistown on State Road 19.	<i>Astragalus bisulcatus</i> .		30
B21305	R102b	do.	<i>Astragalus</i> sp., 2 feet from No. R102a.		1
B21306	R102c	do.	<i>Astragalus pectinatus</i> , 10 feet from No. R102b.		110
B21307	R103	7 miles north of Lewistown on State Road 19.	Gray clay developed on Claggett (?), 0-6 inches.	1.5	
B21308	R103a	do.	<i>Astragalus bisulcatus</i> .		290
B21309	R104	5 miles east of Lewistown on U. S. Route 87.	Reddish-brown clay, developed on Kootenai (?), 0-6 inches.	.2	
B21310	R104a	do.	<i>Astragalus</i> sp.		1
B21311	R105a	23 miles southeast of Lewistown on U. S. Route 87.	do.		130
B21312	R105b	do.	<i>Hedysarum cinerascens</i> .		50
B21313	R106	31 miles southeast of Lewistown on U. S. Route 87.	Gray clay loam, 0-6 inches.	.8	
B21314	R106a	do.	<i>Astragalus bisulcatus</i> .		60
B21315	R107	do.	Gray clay loam, 0-6 inches.	.5	
B21316	R107a	do.	<i>Astragalus bisulcatus</i> .		280
B21317	R107b	do.	Tall woolly <i>Astragalus</i> , roots intertwined with No. R107a.		2
B22205	1	60.7 miles north of Lewistown on State Road 27.	Yellowish-brown clay loam, 0-8 inches.	1	
B22206	1a	do.	<i>Astragalus pectinatus</i> .		260
B22207	2	57.1 miles north of Lewistown on State Road 27.	Yellowish-brown clay loam, 0-8 inches.	1.5	
B22208	2a	do.	<i>Astragalus pectinatus</i> .		470
B22209	3	53.5 miles north of Lewistown on State Road 27.	Gray clay, 0-8 inches.	.5	
B22210	3a	do.	<i>Astragalus bisulcatus</i> .		4
B22211	4	49.9 miles north of Lewistown on State Road 27.	Mottled gray clay.	.5	
B22212	4a	do.	<i>Astragalus bisulcatus</i> .		4
B22213	5	45.1 miles north of Lewistown on State Road 27.	Grayish-brown clay loam, 0-8 inches.	1	
B22214	5a	do.	<i>Astragalus pectinatus</i> .		40
B22215	6	2.9 miles west of Winifred on road to Bear Spring.	Grayish-brown sandy loam, 0-8 inches.	1	
B22216	6a	do.	<i>Astragalus pectinatus</i> .		910
B22217	7	7 miles west of Winifred on road to Bear Spring.	Grayish-brown sandy loam, 0-8 inches.	.2	
B22218	7a	do.	<i>Astragalus bisulcatus</i> .		4
B22219	8	20.2 miles southwest of Winifred on road to Denton.	Yellowish-brown clay loam, 0-8 inches.	.5	
B22220	8a	do.	<i>Astragalus pectinatus</i> .		6
B22221	9	25 miles southwest of Winifred on road to Denton.	Gray clay, 0-8 inches.	1.5	
B22222	9a	do.	<i>Astragalus pectinatus</i> .		250
B22223	10	31.1 miles southwest of Winifred on road to Denton.	Grayish-brown sandy loam, 0-8 inches.	.8	
B22224	10a	do.	<i>Astragalus pectinatus</i> .		300
B22225	11	36 miles southwest of Winifred on road to Denton.	Grayish-brown sandy loam, 0-8 inches.	1	
B22226	11a	do.	<i>Astragalus pectinatus</i> .		30
B22227	12	3 miles northeast of Denton on road to Winifred.	Yellowish-brown clay loam, 0-8 inches.	1	
B22228	12a	do.	<i>Astragalus pectinatus</i> .		350
B22229	13	In Denton, between Ed's Garage and Banner Hotel.	Gray clay, 0-8 inches.	.7	
B22230	13a	do.	<i>Astragalus bisulcatus</i> .		25
B22231	14	3.5 miles east of Denton on road to Brooks.	Dark-gray clay, 0-8 inches.	.5	
B22232	14a	do.	<i>Astragalus bisulcatus</i> .		50
B22233	15	7.9 miles southeast of Denton on road to Brooks.	Dark-gray clay, 0-8 inches.	4	
B22234	15a	do.	<i>Astragalus pectinatus</i> .		520

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

FERGUS COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
D22235	16	11.1 miles southeast of Denton on road to Brooks.	Yellowish-brown clay loam, 0-8 inches.	P. p. m. 1	P. p. m.
B22236	16a	do	<i>Astragalus pectinatus</i>		190
B22237	17	18.9 miles southeast of Denton on road to Brooks.	Dark brown clay, 0-8 inches	1	
B22238	17a	do	<i>Astragalus bisulcatus</i>		15
B22239	18	22.5 miles southeast of Denton on road to Brooks.	Gray gypsiferous shale, 15-16 feet, concretions in shale.	2.5	
B22240	18a	do	<i>Astragalus bisulcatus</i>		1,070
B22241	19	20.2 miles southeast of Denton on road to Brooks.	Yellow clay, 0-8 inches.	.5	
B22242	19a	do	<i>Astragalus bisulcatus</i>		35
B22243	20a	in Brooks.	Wheat from Montana Elevator Co., containing wheat from 30 farms in Brooks area.	.5	
B22244	21	7.6 miles northeast of Hilger on road to Roy.	Grayish-brown clay, 0-8 inches.	1	
B22245	21a	do	<i>Astragalus bisulcatus</i>		15
B22246	22	13 miles northeast of Hilger on road to Roy.	Dark grayish-brown clay, 0-8 inches.	3	
B22247	22a	do	<i>Astragalus bisulcatus</i>		110
B22248	23	7.5 miles east of Roy on road to Valentine.	Dark gray clay, 20-30 inches.	.7	
B22249	24	1.7 miles north of Grassrange on road to Roy.	Dark grayish-brown clay, 0-8 inches.	.7	
B22250	24a	do	<i>Astragalus bisulcatus</i>		0
B21318	R108	22 miles south of Grassrange on U. S. Route 87.	Dark-gray shaly clay, 0-6 inches.	.5	
B21319	R108a	do	<i>Astragalus bisulcatus</i>		60
B21320	R108b	do	Gumweed adjacent to No. R108.		2

LEWIS AND CLARK COUNTY

B21238	R65a	39 miles north of Helena on U. S. Route 91, 2 miles east of Wolf Creek.	<i>Astragalus bisulcatus</i>		2
B21239	R66a	49 miles north of Helena on U. S. Route 91.	<i>Astragalus pectinatus</i>		370
B21511	1	SE 1/4 NE 1/4 sec. 10, T. 18 N., R. 5 W.	Dark-gray granular clay, 0-6 inches.	0.3	
B21512	1a	do	<i>Astragalus pectinatus</i>		12

CASCADE COUNTY

B21240	R67	10 miles west of Great Falls on U. S. Routes 91 and 89.	Mottled dark-gray clay containing gypsum, gravelly on surface.	0.6	
B21241	R67a	do	<i>Astragalus bisulcatus</i>		240
B21242	R68	18 miles west of Great Falls on U. S. Route 89.	Dark-gray clay, alkali crust in seepage, 8-12 inches.	.5	
B21243	R68a	do	Alfalfa at edge of seepage ditch.		1
B21244	R69	20.7 miles west of Great Falls on U. S. Route 89 at junction with State Road 29.	Dark-gray clay, 0-6 inches, soil thrown out of irrigation ditch.	1	
B21245	R69a	do	<i>Astragalus bisulcatus</i>		360
B21246	R69b	do	<i>Astragalus</i> sp. (?) growing beside No. R69a.		4
B21247	R69c	do	Gumweed from adjacent flat.		2
B21248	R70	Across road from R69.	Dark-gray clay, 0-6 inches.	1.5	
B21249	R70a	do	<i>Astragalus pectinatus</i>		550
B21250	R71	25 miles west of Great Falls on U. S. Route 89.	Gray gravelly clay loam, 0-4 inches.	2.5	
B21251	K71a	do	<i>Astragalus pectinatus</i>		460
B21252	R72a	33 miles west of Great Falls on U. S. Route 89.	<i>Astragalus</i> sp.		2
B21282	R89x	On edge of Great Falls, north of river at junction with State Road 29.	Decomposed gray shale, 4 feet below top of bank.	.5	
B21283	R89a	do	<i>Astragalus pectinatus</i> growing on top of bank, 25 feet from No. R89x.		220

TABLE 1.—Selenium content of soils, shales, and vegetation from Montana—Con.

CASCADE COUNTY—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B21284	R90a.	13 miles southeast of Great Falls on U. S. Route 89.	<i>Astragalus pectinatus</i>	P. p. m.	P. p. m.
B21285	R91.	15 miles southeast of Great Falls on U. S. Route 89.	Gray clay, 0-6 inches.	2.5	460
B21286	R91a.	do.	<i>Astragalus bisulcatus</i>		1,650
B21287	R92a.	21 miles southeast of Great Falls on U. S. Route 89.	do.		3
B21288	R93x.	23 miles southeast of Great Falls on U. S. Route 89.	Yellow efflorescence at base of waste dump at Belt.	.4	
B21289	R93a.	do.	Bituminous coal at base of Kootenai (?) cliff.		
B21290	R93b.	do.	Black waste in dump		
B21291	R94x.	25 miles southeast of Great Falls on U. S. Route 89.	Yellow shale, spotted with gray, in cut 75 feet below top of cliff.	3	

HILL COUNTY

B22251	1.	27 miles northeast of Big Sandy on State Road 29.	Yellow-brown sandy loam, 0-8 inches.	1	
B22252	1a.	do.	<i>Astragalus pectinatus</i>		550
B22253	2a.	In grain elevators at Havre.	Wheat composite from 3 elevators.		5
B22254	3.	Sec. 17, T. 29 N., R. 8 E.	Grayish-brown clay loam, 0-8 inches.	1	
B22255	3a.	do.	<i>Astragalus pectinatus</i>		280

JUDITH BASIN COUNTY

B21292	R95.	66 miles southeast of Great Falls on U. S. Route 89.	Dark-brown clay, 0-20 inches.	1.5	
B21293	R95a.	do.	<i>Astragalus bisulcatus</i>		110

DISCUSSION

In Big Horn, Yellowstone, and Carbon Counties, the section underlain by Cretaceous sediments (30) was examined for seleniferous soils and toxic vegetation. A large portion of the Colorado formation is covered with a mantle of gravel. The region in general does not produce seriously toxic vegetation; however, there are portions of it where dangerous vegetation grows.

The breaks on the east side of Big Horn River in the vicinity of Hardin are cut in shale, and the gravel cover comes up to the river on the west side. Indicator plants were found on the east side of the river from 9 miles north to 11 miles south of Hardin. Two samples of *Astragalus bisulcatus*, B21367 and B21405, contained respectively 260 and 880 p. p. m. of selenium.

The occurrence of indicator plants in the vicinity of Rotten Grass and Lodge Grass Creeks is indicative of toxic vegetation. A sample of *Astragalus bisulcatus*, B21367, contained 280 p. p. m. of selenium. A rancher in this locality identified this type of vetch as a poisonous plant on his ranch.

In Townships 1 and 2 N., Ranges 29, 30, 31, and the western half of Range 32 E., indicator plants were found to be plentiful. Samples B21177, B21178, B21184, B21192, B21202, B21425, B21427, B21439, B21488, and B21489 are from this area and range from 15 to 1,180 p. p. m. in selenium content.

Two samples of *Astragalus bisulcatus*, B21478 and B21480, containing respectively 140 and 530 p. p. m., were found west of Acton where the Judith River formation outcrops. A steer observed in this area showed the symptoms of selenium poisoning (18).

In addition to these areas producing toxic vegetation, there are undoubtedly others, much smaller, scattered through this section underlain by Cretaceous shales. It is believed unlikely, however, from field observations, soil and plant analyses, and geological data, that other toxic areas of any considerable size exist in this section.

It is of interest to note that the toxic areas described are shown by a geological survey (38) to occur on Telegraph Creek and upper Niobrara formations. These formations correspond in age to the lower Pierre and upper Niobrara formations in South Dakota (fig. 1) which are highly seleniferous (8).

A reconnaissance survey was made in an area, underlain by Cretaceous sediments, in central Rosebud County and northeastern Treasure County. The vegetation was very sparse and in general relatively free of selenium. Only one indicator plant was observed, *Stanleya pinnata* (B21224), which contained 240 p. p. m. of selenium.

The greater portion of Teton County covers a transitional area between the Great Plains to the east and the Lewis Range of the Rocky Mountains to the west. The mountains rise abruptly and are without a distinct foothill section. This transitional area is underlain by the Colorado and Montana formations. These formations in many places are covered with a mantle of glacial debris made up of granitic rock and fragments of shale and sandstone of local origin.

A large portion of the eastern half of the county is tillable and includes some of the most important dry and irrigated lands in the State. Thousands of acres are devoted to dry-land farming of wheat, the principal crop. The grazing land is principally west of the wheat-land and extends to the mountains.

Altogether about 300 samples of shale, soil, and vegetation from this county were examined for selenium (table 1). Seventy percent of the soil samples contained less than 1 p. p. m., which is low when compared with other seleniferous areas (3, 4, 6). The selenium content of the indicator plants is comparable with that of those from the other areas. Sixty percent of the vegetation containing over 50 p. p. m. of selenium grew on soil containing less than 1 p. p. m. *Astragalus pectinatus* and *A. bisulcatus* samples were collected over the eastern portion of the county and, in general, they contained enough selenium to be readily toxic. The highest selenium content of any plant collected in the county was 5,170 p. p. m. in a sample of *A. pectinatus*, B21277, growing in a soil containing but 0.5 p. p. m. The selenium content of a sample of *A. pectinatus*, B21731, growing in a fallow field, to be planted to wheat, was 4,020 p. p. m. and that of the soil on which it grew 2.5 p. p. m. Another sample of *A. pectinatus*, B21554, contained 1,560 p. p. m., although wheat heads growing nearby contained only 4 p. p. m. the soil, B21553, in which they grew containing 0.5 p. p. m. The wheat in the area was not completely matured at the time the survey was made, but samples of wheat heads were collected while the wheat was in the milk stage. The selenium content of these samples ranged from 1 to 7 p. p. m. with an average of slightly less than 4 p. p. m. Undoubtedly some toxic wheat is produced in Teton County; but it probably gets mixed with

enough nontoxic wheat in the local elevators to bring the selenium content below the minimum toxic concentration, since such was the case in a comparable area in Chouteau County. (See samples B22189 and B22190 in table 1.)

A profile, samples B21266 to B21268, was selected as representative of the farm land between Dutton and Choteau, where the soil is Seehey silt loam (15). In this area *Astragalus bisulcatus* and *A. pectinatus* were abundant. A sample of the latter, growing in the soil, was taken for analysis and found to contain 700 p. p. m. The selenium content of the soil from 0 to 6 inches was 0.4 p. p. m., from 6 to 30 inches 0.5 p. p. m., and from 30 to 42 inches 0.3 p. p. m.

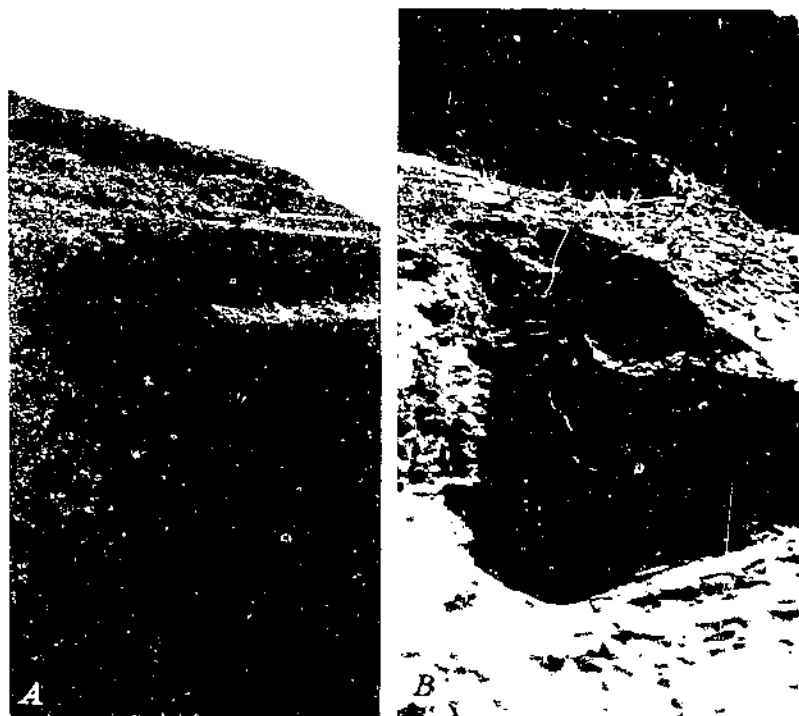


FIGURE 2. —A, Bluff of corral on which *Astragalus pectinatus* shown in B grows; B, Roots of *A. pectinatus* (B21727) in shale.

The selenium content of an *Astragalus pectinatus* plant, B21725, growing on top of the bluff shown in figure 2, A, was 1,160 p. p. m., and that of the immature soil, B21724, in which it grew, 2 p. p. m. Five feet below the top of this bluff an *A. pectinatus* plant, B21727, was found growing in slightly weathered shale. The shale was removed from the root system to a depth of 24 inches (fig. 2, B). The diameter of the taproot suggests that it penetrates the shale to a considerable depth. Fine crystals of gypsum were found in the cracks in the shale. The plant contained 1,130 p. p. m. and the shale 5 p. p. m. of selenium.

"Alkali disease," or chronic selenium poisoning, is not known to be prevalent in Teton County. Phosphate deficiency occurs in this

county, and cattle show the need of phosphate by chewing bones, sticks, stones, old leather, and similar objects. Animals in advanced stages of this disorder are lame, stiff, apparently footsore, and have a poor general appearance, including a bad coat, and some animals die. This disorder is prevented and relieved by feeding bonemeal and salt in a 50-50 mixture (42). Some of the phosphate deficiency symptoms are very similar to those of chronic selenium poisoning.

In horses and cattle chronic selenium poisoning manifests itself clinically by an alteration in the growth of the hoofs and the loss of hair. There are various graduations in these conditions, but in severe cases the coat is bad, the tail is nude and often sore at the tip, and the hoofs are malformed, a condition followed eventually by a sloughing off of the old hoofs. Frequent reports of frozen feet and tail were encountered in the county. Also, two stockmen reported symptoms of chronic selenium poisoning including malformed hoofs in their herds. They did not believe the hoof deformities were due to freezing. Many such cases in other seleniferous areas were not the result of freezing but of chronic selenium poisoning. The authors believe chronic selenium poisoning of animals in Teton County is more common than is as yet recognized, because the symptoms are confused with those of other disorders. It is not believed, however, that animal losses in this section are extensive.

The greater portion of Pondera County is also in the transitional area between the Great Plains to the east and the mountains to the west. The mountains rise abruptly without distinct foothills in the western portion of the county, the north-central portion is an undulating glacial lake basin, while in general the rest of the county is a rolling drift-covered plain.

About 175 samples of soil and vegetation were examined for selenium. More than 70 percent of the soil samples contained less than 1 p. p. m. *Astragalus bisulcatus* and *A. pectinatus* were collected from the eastern county line to 6 miles west of Valier. In the eastern portion of the county these plants were plentiful, but from Valier west they were scarce.

In general, the samples of *Astragalus* were found to contain toxic quantities of selenium. The highest selenium content of any plant collected in the county was 1,700 p. p. m. in a sample of *A. pectinatus*, B21921. A sample of gumweed, B21851, was found to contain 80 p. p. m., which is a high concentration for this plant.

Although toxic seleniferous plants of *Astragalus* were found to be plentiful over the eastern half of the county, no known cases of selenium poisoning were encountered. The discussion of chronic selenium poisoning, phosphate deficiency, and frozen feet and tails of animals, given above, is applicable to Pondera County also.

The data on samples from Teton and Pondera Counties in table 1 show that selenium is not confined to any one soil series. In fact, no series of soils can be pointed out as particularly toxic or as particularly nontoxic.

The greater portion of Chouteau County lies in the glaciated area of the Great Plains. The drift-covered plains have broad rolling relief broken in places by rough divides, and slope gently in the direction of the Missouri River. The Teton, Marias, and Missouri Rivers are deeply entrenched and bordered by rugged breaks which in many places are eroded into badlands. The Highwood Mountains rise in

the south-central portion and the Bearpaw Mountains rise in the northeastern corner of the county. The Colorado formation underlies a large portion of the county. The land is devoted primarily to grazing. *Astragalus bisulcatus* and *A. pectinatus* were collected over a great portion of the county and, in general, they contain sufficient selenium to be readily toxic. The highest selenium content found was 2,090 p. p. m. in a sample of *A. pectinatus*, B22139.

Samples B22189 and B22190 are of special interest. The former is a sample of wheat from four elevators in Big Sandy and is a composite of the wheat in the district. It contained less than 0.5 p. p. m. The latter is a sample of wheat from three elevators in Fort Benton and is a composite of the wheat in the district. It contained 1 p. p. m. Although toxic wheat may be grown in the county it seems certain that it is mixed with sufficient nontoxic wheat in local elevators to bring the selenium content below the minimum toxic concentration. The soil samples are comparable to those of Teton and Pondera Counties. More than 70 percent of the samples contained less than 1 p. p. m.

In Fergus County the survey was of a reconnaissance nature. Several transects underlain by various Cretaceous formations were made. Samples were collected from Judith southeast to Winifred, then southwest to Denton, then southeast to Brooks, then northeast through Fergus to Roy, then southeast to Grassrange. Samples were also collected from Winifred south to Lewistown, then east to Grassrange, and then southeast to the county line.

The Judith River formation outcrops from Judith to Winifred. From Winifred to Denton the Judith River, Claggett, Eagle, and Colorado formations outcrop. The latter continues on to Brooks. From Brooks to Roy the sequence is reversed. From Roy to Grassrange the Judith River and Colorado formations predominate, and the same is true from Winifred to Lewistown. From Lewistown through Grassrange to the county line the Kootenai and Colorado formations outcrop. Two samples collected east of Winifred, B21295 and B21296, and one east of Roy, B22248, were collected on the Bearpaw formation.

In all about 70 samples of shales, soil, and vegetation were examined for selenium. Sixty percent of the soil samples contained less than 1 p. p. m. *Astragalus pectinatus* and *A. bisulcatus* were not abundant and their selenium content was found to be lower than in Teton, Pondera, and Chouteau Counties. The highest selenium content of any plant collected in the county was 1,070 p. p. m. in a sample of *A. bisulcatus*, B22240. A sample of wheat, B22243, from an elevator in Brooks, representing 30 farms in the Brooks district, contained 0.5 p. p. m. of selenium. The authors do not consider the county to have a selenium problem. However, there may be small areas that are readily toxic.

In Lewis and Clark County a sample of *Astragalus pectinatus* was collected and found to contain 370 p. p. m. of selenium. A report of the symptoms of selenium poisoning was received in this district. The area producing toxic vegetation is believed to be small from field observations of flora and geology.

In Cascade County a transect was made on the Colorado formation from Great Falls west to the county line on the north side of Sun River.

The samples of *Astragalus pectinatus* and *A. bisulcatus* collected were found to contain toxic quantities of selenium. Another transect was made on the Kootenai formation (fig. 1) from Great Falls southeast to the county line. Samples of *Astragalus* were found to contain toxic quantities of selenium. This is the first report of seleniferous vegetation on this formation. Time did not permit an adequate survey of this county.

A great portion of Hill County is underlain by the Judith River formation. Two samples of *Astragalus pectinatus*, B22252 and B22255, were collected in the county. The former contained 550 p. p. m. and the latter 280 p. p. m. of selenium. A composite sample of wheat from three elevators in Havre contained 0.5 p. p. m. of selenium.

In Judith Basin County a sample of *Astragalus bisulcatus* was collected and found to contain 110 p. p. m. of selenium. Time did not permit a survey of the county.

USE OF INDICATOR PLANTS IN SURVEY WORK

It has been found that certain portions of the Cretaceous sediments are seleniferous and give rise to seleniferous soils (3, 4, 6). Therefore, in previous surveys, soil parent material has been the principal guide to seleniferous soil. This guide was lessened in value in the present survey because of the heterogeneous glacial and other debris deposited over the greater portion of the area examined.

Previous surveys led to the conclusion that certain plants are present on seleniferous soils and are wholly absent or very rare on adjacent nonseleniferous soils (29). *Astragalus pectinatus* and *A. bisulcatus* belong to this group of so-called indicator plants and were used as the principal guide in the Montana survey. This method led to the collection of samples where other factors did not point to seleniferous soils. Every soil and *Astragalus* plant so collected contained selenium. This lends considerable support to the observations of Miller and Byers (29). Three hundred samples of these plants were collected in Montana.

From the analyses of more than 1,000 samples of *Astragalus* in this laboratory it appeared that *A. pectinatus* was a better absorber of selenium than *A. bisulcatus*. The large number of these plants collected in the Montana area offered a good opportunity to compare them under similar field conditions. From the data in table 2 it is readily seen that *A. pectinatus* is a better absorber of selenium than *A. bisulcatus*. These data are taken from table 1, where this relation can be seen in a qualitative way. The average selenium content of the 189 *A. pectinatus* samples is 460 p. p. m. and the average of the 111 *A. bisulcatus* samples is 210 p. p. m.

TABLE 2.—Average, lowest, and highest selenium content of *Astragalus pectinatus* and *A. bisulcatus* growing on soils containing different amounts of selenium¹

Selenium content of surface soil, 0-6 inches (p. p. m.)	<i>Astragalus pectinatus</i>				<i>Astragalus bisulcatus</i>			
	Selenium content			Samples	Selenium content			Samples
	Average	Lowest	Highest		Average	Lowest	Highest	
	Number	P. p. m.	P. p. m.	P. p. m.	Number	P. p. m.	P. p. m.	P. p. m.
0.2-0.5	79	390	5	6,170	59	140	2	660
0.6-1.0	73	380	5	1,530	35	280	6	1,630
1.5-2.0	24	470	4	1,700	11	170	7	590
Greater than 2	13	1,500	90	4,020	6	670	80	1,650

¹ The selenium content is based on the air-dry weight of the samples.

The data in table 2 showing lowest and highest selenium content give emphasis to the lack of a constant relation between the quantity of selenium found in a given plant species and that in the surface soil (6, 44). A number of factors are thought to contribute to this lack of constancy. The most effective cause of variation in the selenium content of the plants is probably to be found in the differences in the forms of selenium present in the soil (46). Variations may be due in some instances to the differences of the sulfur-selenium ratio (18). The change in the selenium content of the soil with depth is often marked and is without any definite regularity, but the selenium content of a plant changes with the degree of maturity (6). Combinations of these factors are most likely to be in operation.

SELENIUM PROBLEM IN MEXICO

In 1934 José Figueroa, chief of the Instituto Biotechnico of the Department of Agriculture of Mexico, related to the late A. B. Clawson, of the Bureau of Animal Industry, United States Department of Agriculture, the results of the investigation by Juan Roca of a type of disease that had afflicted animals and people in the valley of the Guanajuato River, in the neighborhood of Irapuato, for upward of 200 years. Indeed, the disease was, by tradition, supposed to have appeared coincident with the metallurgical treatment, by the patio process, of ores from the mines in and about the city of Guanajuato. The disease was supposed to be due to mercurial poisoning and hence was called *soliman* disease, from the Spanish name of corrosive sublimate. According to Roca's unpublished report, the disease resulted from the consumption of vegetation grown on the flood plain of the river. This plain was subject to inundation at periodic intervals by water carrying large quantities of silt derived from the slimes of the worked ores. These slimes were deposited in vast piles in the narrow gorge of the river. In addition to the floods, material from the river was added to the soil on several large ranches through irrigation. The symptoms of the disease, as related by Dr. Figueroa, were identical with those of the "alkali disease" of the northern Great Plains, and this information, communicated to Thomas D. Rice, of the Soil Survey Division, was relayed to one of the writers. Dr. Figueroa kindly furnished the writers with a copy of the unpublished report of Juan Roca, which was written in 1931 and which contains a number of items of sufficient interest to merit record.

In addition to the long-time existence of the disease and its apparent relation to the operation of the mines and the deposition of silt, Roca reports many instances of severe losses of animals, including "several hundred horses," at the time when Irapuato was held by Porfirio Díaz, presumably in 1877. He also reports the loss of hair and teeth and a form of paralysis as symptoms of the disease among the people. The greater severity of the disease upon newcomers, both human and animal, was noted as well as the general immunity of mules. The greater injury caused by alfalfa was noted, as well as very definite correlation of the disease with vegetation. (One of the present writers can add the personal observation of cases of severe poisoning with the characteristic selenium symptoms; and the story of a cattle drover who lost an entire herd of 126 cattle which were bedded down in an alfalfa field for a single night.)

In 1935 A. Tellez-Giron, of the Instituto Biotechnico, visited the Soil Chemistry and Physics Research Division in Washington and related the extensive losses of cattle that occur in the State of Chihuahua, Mexico, when pastured near the Mexican Central Railway, particularly in the district between 40 and 100 km. north of the city of Chihuahua. These losses were attributed by him to certain species of *Astragalus* growing there. He reported also the production of toxic symptoms in and the death of guinea pigs and other experimental animals by feeding the animals extracts from these *Astragalus* plants. The animal symptoms both in the field and in the laboratory were not those of chronic selenium poisoning.

The geology of Mexico is not very definitely correlated with corresponding formations in the United States, but the work of Kellum and his associates in the State of Coahuila has demonstrated the existence in that area of shales and limestones of the Cretaceous period (22). One of these formations (Indidura, table 4) is considered by him to compare in a general way with the Eagleford of Texas (table 9) and the Niobrara (8) of the Great Plains. The Niobrara formation and those formations above and below it in geological sequence have been found to be the most important sources of seleniferous soils in the United States.

RECONNAISSANCE IN MEXICO

In the light of the above-mentioned facts, therefore, it seemed very much worth while to investigate these areas in Mexico, particularly since toxic seleniferous soil areas have been found developed upon Cretaceous shales in the Great Plains from Saskatchewan, Canada, to New Mexico. This investigation was begun in February and March 1937 through a reconnaissance examination of the areas by H. G. Byers and J. T. Miller (the latter of the Soil Survey Division). The results are detailed in table 3 and in succeeding pages.

TABLE 3.—Selenium content of soils, shales, and vegetation from Mexico¹

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
				P. p. m.	P. p. m.
B20715	1	50 miles south of Juarez on highway.	Grayish-brown clay loam, 0-8 inches.	6.4	
B20716	1a	do	<i>Astragalus</i> sp. (?) (no odor)		1.0
B20717	2	62 miles south of Juarez	Grayish-brown heavy clay loam, 0-6 inches.	.7	
B20718	2	do	Grayish-brown heavy clay loam, 6-12 inches.	.7	
B20719	2	do	Grayish-brown heavy clay loam, 12-27 inches.	.5	
B20720	2	do	Grayish-brown heavy clay loam, 27-36 inches.	.5	
B20721	2	do	Grayish-brown heavy clay loam, 36-48 inches.	.5	
B20722	3	101 miles south of Juarez	Heavy (red) clay loam, 0-8 inches.	.3	
B20723	3a	do	<i>Astragalus</i> sp. (?) Roots	.5	
			Leaves	.5	
B20724	1	51.5 miles north of Chihuahua, alkali flat.	Heavy silt loam	.3	
B20725	2	56 miles north of Chihuahua	Red gravelly sandy loam, 0-8 inches.	.1	
B20726	2A	do	<i>Oxytropis lamberti</i> (?)		1

¹ The selenium content is based on the air-dry weight of the samples.

TABLE 3.—Selenium content of soils, shales, and vegetation from Mexico—Contd.

JUAREZ AND CHIHUAHUA AREA—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B20727	3	2 miles west of highway, 56 miles north of Chihuahua.	Red gravelly sandy loam.	P. p. m. 0.2	P. p. m.
B20728	3a	do	<i>Oxytropis lambertii</i> (?)		1
B20729	4	Parrita, 56 miles north of Chihuahua.	Rancho del Doctor, east of railroad.	.1	
B20730	4a	do	<i>Astragalus</i> sp. (?)		1
B20731	5	Cusarito Cinco 45 Ranch (General Guerrero).	Gray silt loam, 0-6 inches.	.2	
B20732	5a	do	<i>Astragalus</i> sp. (?)		1
B20733	5	do	Light-gray silt loam, 0-4 inches.	.1	
B20734	5	do	Light-gray silt loam, 4-10 inches.	.2	
B20735	5	do	Light-gray silt loam, 10-18 inches.	.2	
B20736	5	do	Light-gray silt loam, 18-30 inches.	.2	
B20737	5	do	Light-gray silt loam, 30-42 inches.	.4	
B20738	5	do	Light-gray silt loam, 42+ inches.	.3	
B20739	6	do	Dark-gray silt loam, 0-8 inches.	.3	
B20740	6a	do	<i>Astragalus</i> sp. (?)		
			Roots		2
			Seeds		1
			Leaves		1
			Stems		1
B20741	7	1/4 mile west of Gallego.	Red sandy loam, 0-6 inches.	.1	
B20742	7a	do	<i>Astragalus</i> sp. (?)		2
B20743	8	3 1/4 miles west of Gallego.	Red sandy loam, 0-8 inches.	.1	
B20744	8a	do	<i>Astragalus</i> sp. (?)		1
B20745	9	6 miles west of Gallego.	Red heavy sandy loam, 0-8 inches.	.2	
B20746	9a	do	<i>Oxytropis lambertii</i>		1
B20747	10	71 miles north of Chihuahua.	Reddish-brown sandy loam, 0-8 inches.	.1	
B20748	10a	do	<i>Astragalus</i> sp. (?)		5
B20749	11	69 miles north of Chihuahua, alkali flat in Laguna Basin.	Brown clay loam, 0-8 inches.	.2	
B20750	11	do	Brown clay loam, 18-24 inches.	.2	
B20751	11a	do	<i>Astragalus</i> sp. (?)		5
B20752	12	67 miles north of Chihuahua.	Grayish-brown silt loam, 0-8 inches.	.1	
B20753	12a	do	<i>Astragalus mollissimus</i>		2
B20754	13	56 miles north of Chihuahua.	Reddish-brown silt loam, 0-8 inches.	.1	
B20755	13a	do	<i>Astragalus mollissimus</i>		2
B20756	14	Rio Tinto mine, 25 miles north of Chihuahua.	Calcite Pyrite Calcopirrite Azulite Mochalite	30	
B20757	15	1 mile west of Rio Tinto mine.	Red gritty clay loam, 0-8 inches.	.4	
B20758	15a	do	<i>Astragalus mollissimus</i>		1
B20759	16a	26 miles north of Chihuahua.	<i>Astragalus mollissimus</i> , <i>Oxytropis lambertii</i> .		5
B20760	17	31 miles north of Chihuahua.	Red clay loam, 0-8 inches.	.4	
B20761	17a	do	<i>Astragalus mollissimus</i>		1
B20762	18	37 miles north of Chihuahua.	Dark-gray silt loam, 0-8 inches.	.1	
B20763	18a	do	<i>Astragalus mollissimus</i>		1
B20764	20	Sauz.	Gray silt loam, 0-8 inches.	.1	
B20765	20a	do	<i>Astragalus mollissimus</i>		1
B20766	21	24 miles north of Chihuahua on highway.	Red gravelly silt loam, 0-8 inches.	.3	
B20767	21a	do	<i>Astragalus</i> sp. (?), tops		1
B20768	21b	do	<i>Astragalus</i> sp. (?), roots		2
B20769	23	5 miles north of Chihuahua on highway.	Dark-gray silt loam, 0-8 inches.	.2	
B20770	23	do	Red oxide at 3 feet	.1	
B20771	23	do	Calcite at 4 feet	.05	
B20772	23a	do	<i>Astragalus mollissimus</i>		1
B20773	24	At Bosque Aldama, 15 miles northeast of Chihuahua.	Brown gravelly silt loam, 0-8 inches.	.3	
B20774	24a	do	<i>Astragalus</i> sp. (?)		1
B20775	25	Near Hormigas, northeast of Chihuahua.	Grayish-brown silt loam, 0-8 inches.	.3	
B20776	25a	do	Greasewood		1
B20777	1	25 miles south of Chihuahua.	Brown clay loam, 0-8 inches.	.3	
B20778	1a	do	<i>Astragalus</i> sp. (?)		2
B20779	2	25 miles south of Las Delicias.	Dark-gray clay loam, 0-6 inches.	.2	
B20780	2a	do	<i>Astragalus bisulcatus</i> (?)		2
B20781	3	26 miles south of Jimenez.	Heavy alluvial clay, 0-8 inches.	.3	
B20782	3a	do	<i>Astragalus</i> sp. (?)		1

* Negative test.

TABLE 3.—Selenium content of soils, shales, and vegetation from Mexico—Contd.

TORREON AREA

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B20783	1	Outside gates of Dynamita	Red oxide of iron	P. p. m. 0.2	P. p. m.
B20784	1a	do	A yellow composite mallow		2
B20785	2	At Dynamita	Heamatite from mine mouth	.1	
B20786	3	1 mile north of Dynamita, at mouth of canyon.	Gritty silt loam, 8-12 inches	.2	
B20788	4	3 miles east of Dynamita	Gray silt loam, 0-8 inches	.3	
B20789	4a	do	Wild pepper		1
B20790	4b	do	Yellow sunflower, pea vines		1
B20791	4c	do	<i>Terba hedonia</i>		2
B20792	5	5 miles north of Dynamita	Clay loam, efflorescent salts: 0-8 inches	.2	
B20793	5a	do	18-24 inches	.4	
B20794	5a	do	Salt bush		3
B20795	6	24 miles north of Torreon	Clay loam, efflorescent salts: 0-1½ inch	1.5	
B20796	6a	do	0-8 inches	2	
B20797	6a	do	Mulleinlike plant		.5
B20798	6b	do	Unidentified plant		1
B20799	7	40 miles north of Torreon on Taraposa Road.	Silt loam: 0-1½ inches	.2	
B20800	7	do	3½-12 inches	.2	
B20801	7	do	12-20 inches	.2	
B20802	7	do	20-32 inches	.1	
B20803	7	do	32-60 inches	.1	
B20804	7a	do	Scattered <i>Atriplex</i>		2
B20805	7b	do	Ragweed (?)		4
B20806	8	Northeast of Tlahualilo at base of cliff.	Limestone	.1	
B20807	8	do	Gray silt loam, 0-6 inches	.4	
B20808	8a	do	Greasewood (black)		4
B20809	9	6 miles north of San Pedro	Black clay, 0-8 inches, irrigated	.2	
B20810	9a	do	Young wheat, 6 inches high		4
B20811	10	7 miles northeast of San Pedro	Dark-gray clay, 0-6 inches, not irrigated.	.2	
B20812	10a	do	Yellow nettle		2
B20813	11	9 miles north of San Pedro	Black clay loam, 0-8 inches	.1	
B20814	11a	do	Lambquarters sp. (?)		1
B20815	12	31 miles north of San Pedro, 2 miles north of Tarrque Rota.	Dark-gray Indidura shale	.4	
B20816	A12	do	Gypsum, limestone, and shale from Indidura.	2.5	
B20817	B12	150 feet from 12	Red calcite or gypsum from red layer in Indidura.	.3	
B20818	C12	do	Red highly metamorphosed shale.	.2	
B20819	D12	do	3 fossils and piece of limestone	.1	
B20820	E12	On top of small hill	Red limestone soil, 0-4 inches	1	
B20821	F12	do	Large limestone concretions	.1	
B20822	12a	do	Greasewood buds growing in Indidura colluvium.		2
B20823	13	30 miles north of San Pedro	Light-gray silt loam, 8-12 inches	.2	
B20824	13a	do	Greasewood		2
B20825	14	16 miles north of San Pedro	Dark-gray clay loam	.1	
B20826	14a	do	"Trampillo" (feed for goats)		3
B20827	14b	do	<i>Grindelia</i> (?)		8
B20828	15	15 miles east of San Pedro on road to Parras in Laguna Marvan.	0-½ inch	.2	
B20829	15	do	8-20 inches	.1	
B20830	15a	do	Greasewood		1
B20831	16	15 miles east of San Pedro	Soil among limestone: Chunk of limestone	.3	
B20832	16a	do	Pepperlike plant (<i>lepidum</i>)	.2	7
B20833	16b	do	<i>Stanleya</i> sp. (?)		2
B20834	17	8 miles north of Parras	Parras shale (?)	.2	
B20835	21	5 miles east of Parras	Parras shale with limonite and gypsum crystals	1	
B20836	22	do	Light medium-gray shale, with gypsum	.5	
B20837	23	do	Light medium-gray shale, no gypsum.	.5	
B20840	24	do	Dark-gray shale interbedded with 4 to 8-inch gypsum layers.	.4	

* 16 dead horses.

TABLE 3.—Selenium content of soils, shales, and vegetation from Mexico—Contd.

TORREON AREA—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B20841	25	5 miles east of Parras	Dark gray shale interbedded with gypsum in the seams	P. p. m. 0.2	P. p. m.
B20842	26	do	Yellowish-gray clay shale, definite formation.	.4	
B20843	27	do	Grayish-black shale	.1	
B20844	28	In Parras	Yellow limestone Indidura	.1	
B20845	29	do	Yellow shale in Indidura	.2	
B20846	30	West end of Parras	Indidura shale	1	
B20847	31	do	100 yards south of 30, Indidura shale.	.4	
B20848	32	20 miles northeast of Parras	Red silt loam, 8-12 inches; caliche below 12 inches.	.1	
B20849	32a	do	Greasewood		2

IRAPUATO AREA

B20878	11	Sirena mine, above Guanajuato.	Ore	4.0	
	11A			35.0	
	11B			2.0	
	11C			2.5	
	11D			65.0	
	11E			2.5	
	11F			2.5	
	12			2.0	
	12A			2.0	
	12C			2.0	
B20879	12D	do		2.0	
	12E			1.0	
	12F			30.0	
	12G			13.0	
	12H			2.0	
	13			4.0	
B20880	13	Slime heaps	Moist silty slime at base of dump	4.0	
B20881	14	do	Moist clayey slime at foot of dump.	5.0	
B20882	15	do	Silty slime 8 feet from bottom	5.0	
B20883	16	do	Laminated scale at top of dump	6.0	
B20884	17	do	Fresh slimes at top of dump	3.5	
B20885	18	do	Fresh scale on stream bank	4.0	
B20886	19	Guanajuato River, 0.25 mile below.	Water from stream (soluble selenium).	.2	
B20886A	19	do	Silt settled from water	5.0	
B20887	20	Marfil (abandoned town). Sonaja ranch:	Adobe wall of town	64.0	
B20861	2	4 miles south of Irapuato	Black clay, 0-8 inches	1.0	
B20866	3	80 rods south of No. 2	do	.8	
B20868	4	1.5 miles southeast of ranch house.	Dark-gray clay loam, 0-8 inches	4.0	
B20872	7	2 miles southeast of ranch house.	Recent river deposit, 0-8 inches.	3.5	
B20877	10	0.25 mile northwest of ranch house.	Dark-gray clay loam, 0-8 inches	.8	
B20896	39	1 mile south of Irapuato, sewage disposal in excavation.	Black clay, 0-10 inches	1.5	
B20897	39	do	Grayish-brown clay, 10-25 inches.	.3	
B20901	39	do	Black clay, 55-67 inches	.2	
B20903	39	do	Dark-red clay, 144-216 inches	.1	
B20904	26	Garrida ranch: 4 miles north of Irapuato	Soil and manure in corral	20.0	
B20905	27	200 yards north of ranch house	Fine sandy loam, 0-8 inches	4.0	
B20906	27	do	Fine sandy loam, 8-12 inches.	4.0	
B20910	28	250 yards north of ranch house	Sandy loam, 0-8 inches.	4.0	
B20911	29	Depression, near 27 feet	Black clay, 0-8 inches.	4.0	
B20916	31	do	Old adobe wall.	4.0	
B20917	32	Arandas ranch: 2 miles north of Irapuato	Dark-gray clay loam, 0-8 inches	4.0	
B20920	33	1 mile northeast of ranch house	Dark clay loam, 0-8 inches	1.5	
B20923	34	0.5 mile east of ranch house	Black clay, 0-8 inches	4.0	
B20925	35	Between railroad and river	Gray clay loam, 0-6 inches	6.0	
B20927	35	do	Gray clay loam, 6-12 inches	6.0	
B20929	36	1 mile north of Irapuato near roadside.	Black clay loam, 0-8 inches	1.0	
B20931	37	Jesus Velasquez ranch, 1 mile northeast of Irapuato	Dark-gray clay loam, 0-5 inches	6.0	

TABLE 3.—Selenium content of soils, shales, and vegetation from Mexico—Contd.

IRAPUATO AREA—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B20945	41	0.5 mile east of Irapuato, above flood plain.	Black clay, 0-8 inches	P. p. m. 0.4	
B20860	1	17 miles west of Queretaro	Black clay, 4-12 inches	.3	
B20946	42	1 mile east of Salamanca	Black silt loam, 0-8 inches	.4	
B20948	43	12 miles east of Queretaro	Heavy black clay, 0-8 inches	.4	
B20862	2A		Common mustard		1
B20863	2B		Cocklebur		2
B20864	2C		Immature wheat heads and leaves		1
B20865	2D		Chickpea		4
B20867	3A	Sonaja ranch	Alfalfa		3
B20869	4A		Groundcherry		8
B20871	6A		do		35
B20873	7A		Lambsquarters		2
B20874	7B		Immature wheat heads and leaves		10
B20875	8A	On bank of irrigation ditch	Milkweed		20
B20904	27A		Sweetclover		15
B20905	27B		Common mustard		5
B20911	28A		Immature wheat heads		8
B20912	28B	Garrida ranch	Lambsquarters		6
B20913	28C		Chickpea		7
B20915	30A		Milkweed		15
B20918	32A		Unidentified legume		18
B20919	32B		Johnson grass		12
B20921	33A	Arandas ranch	Milkweed		3
B20924	34A		Wild lettuce		4
B20925	34B		Johnson grass		6
B20928	35A		Common mustard		120
B20932	37A		Alfalfa		30
B20933	37B		Lambsquarters		15
B20934	38A	Jesus Velasquez ranch	Alfalfa (from manger)		18
B20934A	38B		Milk from cow eating No. 38A		6
B20935	40A		Green peas		0
B20936	40B		Radish tops		30
B20938	40C		Radish roots		15
B20939	40D		Splnach		7
B20940	40E	Irapuato market	Beans		2
B20941	40F		Cabbage		70
B20942	40G		Parsley		5
B20943	40H		Popcorn		0
B20944	40I		Unidentified (Romerillo)		2

SALTILLO AREA

B20850	1	25 miles west of Saltillo	Red shale, Morrison (?)	0.1	
B20851	1a	do	Creeping pigweed (?)		3
B20852	2	12.5 miles west of Saltillo	Red shale	.1	
B20853	3	17 miles west of Saltillo	Green shale	.1	
B20854	4	do	Red shale	.1	
B20855	5	15 miles west of Saltillo	do	.1	
B20856	6	do	Green shale	.2	
B20857	7a		Mesquite beans		1
B20858	9	3.7 miles west of Saltillo	Mesquite flowers		2
B20859	10a	22 miles west of Saltillo	Dark-gray splintery shale	.3	
			Marguey plant, on red soil		1

MEXICO CITY AND ENVIRONS

B20951	1	13.5 miles south of Texcoco	Dark-gray silt loam, 0-8 inches	0.1	
B20952	1a	do	<i>Astragalus carlei</i> (Greene)		0.5
B20953	2	14 miles south of Texcoco	Volcanic ash, about 3 to 5 feet deep	.1	
B20954	3	1/4 mile east of Los Reyes	Silt loam, 0-6 inches	.1	
B20955	3a	do	<i>Astragalus carlei</i> (Greene)		1
B20956	4a	300 feet west of No. 3	do		1
B20957	5	1/4 mile west of Los Reyes	Dark-gray silt loam, 0-6 inches, efflorescent salts	.1	
B20958	6	1 mile west of Los Reyes	Light-gray silt loam with efflorescent salts	.2	
B20959	7	do	Pale-yellow silt loam, 30-40 inches	.1	

TABLE 3.—*Selenium content of soils, shales, and vegetation from Mexico—Contd.*

MEXICO CITY AND ENVIRONS—Continued

Laboratory No.	Field No.	Location	Material	Selenium in—	
				Soil or shale	Vegetation
B20960	7a	1 mile west of Los Reyes	<i>Astragalus earlei</i> (Greene)	P. p. m.	P. p. m.
B20961	8	3 miles west of Los Reyes	Medium-gray clay, 0-6 inches	0.1	1
B20961A	8x	3 miles west of Los Reyes, ½ mile north of Road	Alkali crust	.2	
B20962	13	6 miles southeast of Los Reyes	Dark grayish-brown clay loam, 30-35 inches	.1	
B20963	13a	do	Mustardlike plant		1
B20964	14	3 miles west of Los Reyes	Fine sandy loam, 0-8 inches	.1	
B20965	14A	do	<i>Astragalus</i> sp. (?)		.5
B20966	15	5 miles west of Los Reyes	Clay from old lake basin, 0-4 inches	.1	
B20967	9	Above snow line, Toluca	Volcanic ash	.1	
B20968	10	On Nevada Toluca, near upper edge of timber line	Decomposed volcanic ash	.1	
B20969	10a	do	Black soil from volcanic ash	.2	
B20970	11	On Nevada Toluca near lower edge of timber line	<i>Lupinus mexicanus</i>		.6
B20971	12	18 miles southeast of Toluca on road to Desierto de Leon	Black decomposed volcanic ash	.1	
B20972	12a	do	Dark-gray silt loam, 0-8 inches	.1	
B20973	1	178 miles from Mexico City	Unidentified plant		5
B20974	1	do	Deep reddish-brown clay, 0-3 inches	.5	
B20975	1	do	Red heavy clay, 3-20 inches	.5	
B20976	1	do	Red heavy clay, 20-48 inches	.3	
B20977	1a	do	Red heavy clay, 48+ inches	0	
B20978	2	35 miles west of Tarmazunchale	Blossoms and leaves of a locust-like bush		1
B20979	1	Popocatepetl, on the border of the State of Mexico and Puebla	Black clay among red clay soils, 0-12 inches	1.5	
B20980	1	do	Sulfur	.6	
B20990X	x	Popocatepetl Industrial Museum, Mexico City	do	.6	
B21000	2	Citlaltépetl, State of Puebla	do	10	
B21001	3	El Chichosa, State of Chiapas	do	0	

CHIHUAHUA AREA

In the Chihuahua area the results obtained were by no means those expected, but they have a very important bearing upon the general distribution of selenium and its absorption by plants. The procedure was as follows: Samples of soil and of vegetation were taken at intervals along the highway from El Paso, Tex., to Chihuahua, Mexico, a distance of 300 miles. In those portions of this area where the incidence of cattle poisoning was reported as most marked, series of samples were taken that were presumably representative of the area lying between the mountain chains bounding the valleylike plateau on the east and west. Altogether, about 40 samples of soil were collected and 30 samples of vegetation. In addition, a few samples were collected south and southeast of Chihuahua.

The soils of the entire area are derived from mountain rubble or from wind-blown material. In certain portions of the area are enormous sand dunes totally devoid of any general vegetative cover, and some relatively small areas may be considered as alluvial soils. There are also a number of extinct or temporary lake-bottom areas. The soils in general are brown or gray desert types. A description of these and other Mexican soils is given by Miller and Brown (28). The mean rainfall is low, probably about 8 inches, and is doubtless not uniform over this great area. As a consequence, vegetation is of

the semidesert type (fig. 3) and is exceedingly scanty except where irrigation is carried on. Over the whole area various species of *Astragalus* are found. Special attention was given them because they were very similar in type to selenium-loving species in the United States and were identified by Dr. Giron as the plants shown by his experiments to be toxic. They were identified by Ivar Tidestrom as *Astragalus pervelutinus* (Rydberg), *A. wootoni* (Sheldon), and *A. carlei* (Greene). The work of Mathews and Schmidt (25) shows *A.*



FIGURE 3.—Desert vegetation in Mexico.

carlei to be toxic in Texas, and Fraps and Carlyle (14) have stated it to be toxic and free of selenium.

The general result of the examination of the 70 samples showed a maximum of 0.7 p. p. m. of selenium in the soils with quantities ranging downward to 0.1 p. p. m. In vegetation the maximum quantity found was 2 p. p. m. In view of these facts it seems improbable that any selenium poisoning can occur in this area. This conclusion is supported by the fact that Dr. Giron was unable to learn of any chronic cattle disease in the area that was characterized by loss of hoofs and hair or by any of the symptoms of mild selenium poisoning, and by the further fact that duplicate samples of those secured by the writers and found to contain very little selenium were capable of causing acute poisoning of laboratory test animals.

TORREON AREA

The great flat plains lying between Chihuahua and Torreon were not examined in detail, since no reports of disease of the "alkali disease" type were brought to the attention of the investigators. A few samples of both soil and *Astragalus* were collected, but in no case was selenium found in soils or plants in quantities to warrant special attention.

In the district about Torreon, however, not only are Cretaceous shales and limestones contributors to the soils of the great level plains areas, as has been mentioned, but these soils, like those north and south of Chihuahua, are semidesert in type. The effort was made, therefore, not only to sample the soils and the scanty vegetation but also the shales studied by Kellum and his associates (22).

Altogether 65 samples were collected and their selenium content was determined (table 3). In the soils in general the selenium content is low. Indeed, no soil was found to contain in excess of 0.5 p. p. m., except that in a shallow swale 24 miles north of Torreon a sample of heavily salt-encrusted soil, B20796, contained 2.0 p. p. m. and the efflorescent salts, B20795, on the soil, 1.5 p. p. m. The shale samples were also very low in selenium. One sample of Indidura shale near Tanque Rota and about 30 miles north of San Pedro contained 2.5 p. p. m. One sample of Parras shale 5 miles east of Parras and one of Indidura shale west end of Parras each showed a content of 1 p. p. m.

Since the selenium content of the above-mentioned samples was unexpectedly low, Dr. Kellum was asked to furnish the writers with a few identified rock samples from this area. One of these, a sample of Indidura limestone from 1 mile south of Parras, had a selenium content of 2.5 p. p. m. No other of the 12 samples exceeded 0.7 p. p. m. and 7 of them ran 0.1 p. p. m. or less (table 4).

TABLE 4.—Selenium content of geological samples from Mexico¹

Laboratory No.	Location	Material	Selenium in soil or shale
B21027	30 feet above base of Aurora limestone, east side of Puerto Astelleros, north of Sierra de Tlahualilo at south end of Sierra del Rey, Coahuila.	Aurora limestone	P. p. m. 0.1
B21028	30-60 feet below top of Aurora limestone, Sierra de Tlahualilo, Durango, Mexico, northeast of Zarogosa, just east of south end of Ashifillo near Ojo de Agua.	do	.1
B21029	On west bank of Arroyo Caracol, at east end of Casson Mesquite, Sierra de Parras, Coahuila.	Novaculite from Caracol formation	.1
B21030	In west bank of Arroyo Caracol, Sierra de Parras.	Indidura limestone from unit 4 of section.	.5
B21031	Hill just southeast of mouth of Indidura Canyon, Sierra de Santa Ana, Coahuila.	Indidura formation	.1
B21032	Casson Caracol, Sierra de Parras	Cuesta del Cura limestone	.1
B21033	In Casson de la Casita, Sierra de Parras, Coahuila.	Tuff from top of Caracol formation	.1
B21034	Ojo de Agua, west side of Sierra Tlahualilo, Durango.	Tertiary volcanic tuff and breccia	.1
B21035	Cerro Aniza, about 1 mile south of Parras, Coahuila.	Indidura limestone, member 3	.4
B21036	North of La Marita, Durango	Volcanic breccia	.2
B21037	On west bank of Arroyo Caracol at east end of Casson Mesquite, Sierra de Parras.	Indidura limestone from unit 2 of section.	.7
B21038	From Cerro Aniza, about 1 mile south of Parras.	Indidura limestone, section 3	2.5

¹ Samples furnished by Lewis B. Kellum, University of Michigan.

Nevertheless, although none of the types of vegetation found belonged to groups notably prone to selenium absorption (table 3), a sample of *Grindelia*, B20827, 16 miles north of San Pedro, had 8 p. p. m.; of *Lepidum*, B20832, 15 miles east of San Pedro, had 7 p. p. m.; a sample of young wheat, B20810, 6 miles north of San Pedro, contained 4 p. p. m. The general conclusion, from observation and the analytical

data, is that in this section no selenium problem of moment exists, although mildly toxic samples of vegetation were found. If, however, highly absorptive types of vegetation exist, or were to be introduced, they would be likely to be toxic.

IRAPUATO AREA

In the district around Irapuato a very different situation obtains (5). As previously indicated, opportunity was sought to examine this area because the animal symptoms described by Roca correspond so closely with those described by Franke, Rice, Johnson, and Schoening (18).

In making the field examination, attention was directed specifically to determining (1) whether the cause of the disease of both men and animals could be definitely assigned to selenium, (2) whether the area affected is limited to the flood plain, and (3) whether the source of the selenium is the mines or is inherent in the soil itself. No attempt was made to determine the extent of the area affected or the extent of the injuries to either men or animals. These and related questions seem to be the problem of the local authorities.

Samples were secured from the following sources: Ores presumably representative of the area, slimes from the waste dumps, water from the river below the slime heaps, soil subject to silt deposit from the river at flood levels, similar soils not subject to overflow, plants of similar types on both soil areas, feed of animals affected by the disease, and food materials consumed by the people of the area. A sample of milk was also secured from a cow that was characteristically diseased.

Table 3 gives the results of the examination of ore samples obtained from the Sirena mine and the waste dump of the mine. All of them were uncrushed rock. No attempt was made to identify the minerals represented. According to several independent sources of information, these ores are representative of the entire area in question.

The data show that the seven assorted samples of ore had a mean selenium content of 16 p. p. m. This is the type of material which, when crushed and the silver extracted (formerly by the patio process), constitutes the slimes washed into the pits near the mouth of the canyon. These enormous dumps are the real source of the stream. The unmilled mine waste is rejected material low in silver; it was examined because it is high in marcassite and other sulfides and was expected to be high in selenium. The mean content of the samples was only 7 p. p. m. The slime dumps are fed many thousand tons of fresh material daily and represent the accumulation of many years; at irregular intervals they are tremendously eroded by floods, the material carried downstream, and distributed over the flood plain of the Guanajuato both above and below the town of Irapuato. The mean selenium content of this material, as shown by the six samples, was 4.6 p. p. m.

The stream flows rapidly from the base of the dumps for some distance below the town and carries so much suspended material that the water has a milky appearance. The water is used to a considerable extent for irrigation. The analysis shows that it definitely contained selenium and that its deposited silt was markedly seleniferous. The most remarkable sample was that taken from the wall of an abandoned town about 3 miles below the slime dumps. The wall and houses were

said to have been built of adobe bricks made from the slime and organic material, probably manure. The wall is very old, and its high selenium content bears out the tradition that the soliman disease in the valley below has existed ever since these mines began to be worked, probably more than 200 years.

Table 3 gives also the results of the examination of soil samples collected in the valley. Included are soils from the flood plain of the stream that are subject to deposition of silt from the mines, and a number of samples from places that are not flooded. Included also are certain samples of soils of the same character from other areas not adjacent to Irapuato but derived from similar parent material, except alluvial deposits.

The data given in table 3 must be considered in the light of the following facts: Samples B20861 and B20866 are from an area flooded from the river only infrequently and irrigated with water from a deep well presumably not seleniferous. Samples B20868 and B20872 are from land flooded whenever the river overflows its normal banks. Both samples are more silty than B20861 and B20866. Sample B20877 was taken on a small hill presumably never flooded. It contains the normal quantity of selenium for soils not toxic and corresponds to samples B20860, B20945, B20946, and B20948. Sample B20896 is part of a profile taken from the banks of an excavation for a sewage disposal plant that is being erected. The area is subject to flooding approximately three times in 10 years, and the soil is probably an alluvial deposit. Only the recent surface contains selenium in excess of the normal traces found generally in soils.

All the samples taken on the Garrida ranch contain abnormal quantities of selenium and all are from the river flood plain. Two of them are of special interest: Sample B20904 from the corral indicates that the manure used for fertilizer is exceptionally rich in selenium, and sample B20916 from the adobe wall shows that the seleniferous condition of the ranch is of long standing. Samples B20920 and B20929 are from fields on the Arandas ranch that are infrequently flooded and not irrigated. Sample B20926 is from a field pointed out by an Indian as the spot where corn grew that was responsible for his own case of "alkali" disease. Sample B20931 is from a field on the Jesus Velasquez ranch. Alfalfa grown there was reported as the cause of the loss of 126 cattle in a night's feeding.

Obviously the source of serious quantities of selenium in the soils about Irapuato is the silty material washed down from the mines about Guamajuato.

Table 3 gives also the results of the examination of samples of vegetation collected in the district about Irapuato. Results obtained from the samples collected on nonseleniferous spots are omitted, as they were essentially free from selenium. Included are nine samples of vegetables bought at random in the Irapuato public market.

All the vegetation grown on soil known to be seleniferous contained selenium. That grown on the Sonaja ranch was definitely lower than that on the other spots examined, probably because some of the irrigation water came from a deep well presumably free from selenium. In the other samples, irrigation water came from the river, which contains dissolved selenium (table 3, sample B20886). In several areas in the United States it has been shown that irrigation tends to diminish the effects of selenium on plants (3), but not where the

irrigation water contains selenium. Sample B20928 is from the spot represented by soil B20926 of table 3 and was the only vegetation growing there when the examination was made. Sample B20934 is



FIGURE 4.—A, Selenized cow; B, hind hoofs of selenized cow shown in A.

alfalfa that was being eaten by a cow definitely suffering from selenium poisoning (fig. 4). The milk from this cow contained 0.6 p. p. m. of selenium, which is equivalent to about 6 p. p. m. of the milk solids. Incidentally, this cow, as well as two bulls also suffer-

ing from the same trouble, was a newcomer into the valley. Some of the members of the herd of about 50 cattle showed evidence of the disease to a much smaller extent.

The samples of vegetables sold in the city market are significant. Of the nine samples analyzed, all but two are definitely seleniferous, and these may not have been grown in the valley.

In the area of seleniferous soils about Irapuato the toxic agent is evidently deposited in the soils from the waste product of the mines about Guanajuato. No similar situation exists, so far as is known, in the United States.

The condition in Irapuato seems less serious than it would be if selenium-loving plants, capable of enriching the soil with available selenium, were present. In this area irrigation as practiced is not a remedial measure (3), partly because the section is semihumid and therefore does not require continuous irrigation, and partly because of the presence of selenium in the water. This point may be important in connection with the use of drainage waters from seleniferous areas for irrigation in other places.

When it is considered that more than 4 p. p. m. of selenium in dry diet are definitely injurious (4) and that the people of Irapuato live largely on their local produce, it is clear that this location is an excellent one in which to study the effect of selenium in foods upon people. Since selenium may be present in all the vegetables, milk, and meat consumed (4), the citizen of Irapuato is likely to be affected by selenium from even his prenatal days. To what extent the evident ill health of the inhabitants is due to selenium in their food is problematical but is worthy of study.³

SALTILLO AREA

In addition to the examination of the districts about Chihuahua, Torreon, and Irapuato, a number of samples were collected west of Saltillo from shales of, apparently, the Cretaceous period. No shale samples were found with a selenium content of more than 0.3 p. p. m. and no samples of vegetation with a selenium content of more than 3 p. p. m. Also, since the valley of Mexico is surrounded with volcanic peaks, it was considered worth while to collect a series of samples of soils, vegetation, and sulfur in order to determine whether in materials or in the soils derived from them any marked accumulation of selenium could be found. Four sulfur samples were obtained from the Geological Museum through the aid of Dr. Figueroa. Of these, two from the crater of Popocatepetl had 0.5 and 0.6 p. p. m. of selenium, and one from Citaltapetl 10 p. p. m., whereas one from El Chichosa gave no evidence of selenium in a 3-gm. sample. Also, two samples of volcanic ash contained only 0.1 p. p. m. of selenium. It is, therefore, to be expected that soils derived from materials of such volcanic sources would be of low selenium content. Thirteen assorted samples of soils revealed a maximum selenium content of 0.2 p. p. m. and this in only one sample. Also, no sample of vegetation was obtained (of eight examined) that had more than barely detectable traces of selenium. Even the highly ferruginous profile sample collected 178 miles north of Mexico City on the Mexico City-Laredo

³ In making the field examination here reported the Mexican Government was represented by José Figueroa. Without his local knowledge and energetic assistance the collection of materials would have been almost impossible.

Highway contained only 0.5 p. p. m. of selenium in the most seleniferous portion of the profile. These results are also included in table 3.

"NONTOXIC" SELENIFEROUS SOILS OF HAWAII AND PUERTO RICO

A lack of quantitative correlation between the selenium content of the soil and the vegetation has been evident throughout the entire investigation of seleniferous areas (3, 4, 6), and during the course of the investigations many factors influencing this correlation have been discovered. These factors may be divided roughly into the plant influences and the soil influences. This lack of correlation is certainly due in part to the variation in the forms of selenium in the soil (46) and to the distribution of the selenium throughout the soil profile, as well as to the character of the soil (6). Concurrent with these soil factors are plant factors, such as the selective absorption of selenium by some plants, its moderate absorption by others, and the very limited tolerance of selenium by a third group (29). The depth at which a plant feeds and the distribution of its root system are also items to consider as affecting the resultant absorption.

Nevertheless, when highly seleniferous soils were found in Hawaii (6), it was confidently expected that toxic vegetation would be found growing on them in spite of the apparent absence of known selenium-loving plants. However, with 16 vegetation samples that were secured, the selenium content ranged from none to a maximum of 3 p. p. m. in the air-dry weight of the tops. Ten of these plants were unidentified. The other 6 belonged to 4 different genera, including Compositae and legumes, which are frequently seleniferous when grown on selenium-bearing soils (19). These consistently low selenium values in plants from seleniferous Hawaiian soils led to a pot test in which millet, a moderate selenium absorber, was grown on a soil from the Wahiawa Erosion Experiment Station, island of Oahu, T. H. Although the soil contained 12 p. p. m. of selenium, no selenium was found in the millet. At the same time, millet grown on a mixture of quartz sand and Wabash silt loam to which had been added only 2 p. p. m. of selenium as sodium selenate, contained 1,300 p. p. m. Hawaii was the first area where the vegetation examined from highly seleniferous soils was consistently low in selenium content. An opportunity to study the vegetation of Hawaii in detail was not offered, so that the existence of a large area of "nontoxic" seleniferous soils in Hawaii is not adequately proved.

A condition similar to that in Hawaii was found in Puerto Rico when a series of soils derived from Cretaceous shales and a number of samples of vegetation growing on them were examined (24). Fortunately, an opportunity to study every kind of plant growing on a "nontoxic" seleniferous soil in Puerto Rico was made available through the aid and advice of Ray C. Roberts, of the Division of Soil Survey of this Bureau. At his suggestion, J. A. Bonnet, of the Agricultural Experiment Station of the University of Puerto Rico, collected samples of a soil profile on each slope of a small hill 1 mile north of Fajardo, and at the same time J. I. Otero, of the University of Puerto Rico, collected and classified every type of vegetation growing on the hill. An aerial photograph (fig. 5) shows the hill on which these samples were collected. The area examined covers about 40 acres. The soil is a typical Yumec silt loam and was known

to be seleniferous. The results of the examination of these samples are given in tables 5 and 6.

The Yunes silt loam resembles the Gray-Brown Podzolic soils. The surface soil is a dark-gray silt loam with a high percentage of sharp angular shale fragments. The lower horizon is a yellow heavy silt loam. In this layer iron accumulates, resulting in an iron-cemented hardpan. The soil is developed from the Fajardo shale. This gray fine-textured shale is formed from stratified volcanic ash



FIGURE 5.—The area enclosed by the broken line is the hill north of Fajardo, P. R., on which the soils and vegetation given in tables 5 and 6 were collected. (Vertical aerial photograph taken by the U. S. Navy.)

(27). The soil samples contain from 2 to 10 p. p. m. of selenium in the surface horizon and 3 to 12 p. p. m. at a depth of 12 to 24 inches. The underlying Fajardo shale ranges in selenium content from 2.5 to 8 p. p. m. The volcanic origin of this seleniferous shale is another example of observations previously made (6).

TABLE 5.—Selenium content of samples of 4 soil profiles from a small hill 1 mile north of Fajardo, P. R.

Sample No.	Location	Material	Selenium
			<i>P. p. m.</i>
B21091	West slope	Yunes silt loam, 0-12 inches	4.0
B21092	do.	Yunes silt loam, 12-24 inches	5.0
B21093	do.	Shale	4.0
B21094	East slope	Yunes silt loam, 0-12 inches	5.0
B21095	do.	Yunes silt loam, 12-24 inches	12.0
B21096	do.	Shale	2.5
B21097	North slope	Yunes silt loam, 0-12 inches	2.0
B21098	do.	Yunes silt loam, 12-24 inches	3.0
B21099	do.	Shale	8.0
B21100	South slope	Yunes silt loam, 0-12 inches	10.0
B21101	do.	Yunes silt loam, 12-24 inches	12.0
B21102	do.	Shale	4.0

TABLE 6.—Selenium content of vegetation grown on a hill 1 mile north of Pajardo, P. R.

Laboratory No.	Field No.	Description	Selenium
			P. p. m.
B21039	1	<i>Catharanthus roseus</i> (L.) Don.	<1.0
B21040	2	<i>Dolicholus reticulatus</i> (Sw.) Millsp.	<1
B21041	3	<i>Valerianoides jamaicensis</i> (L.) Kuntze	<1.0
B21042	4	<i>Adipera stahlii</i> (Urban) Britton and Rose	<1
B21043	5	<i>Abrus abrus</i> (L.) W. F. Wight	<1.0
B21044	6	Unclassified	<1.0
B21045	7	<i>Anacardium occidentale</i> L.	<1.0
B21046	8	<i>Hymenaea courbaril</i> L.	<1.0
B21047	9	<i>Borreria verticillata</i> (L.) Meyer	<1.0
B21048	10	<i>Neluma juliflora</i> (Sw.) Raf.	<1.0
B21049	11	<i>Adenopogon gossypifolium</i> (L.) Pohl	<1.0
B21050	12	<i>Serjania polyphylla</i> (L.) Radlk.	<1.0
B21051	13	Unclassified	<1.0
B21052	14	<i>Hippocratea volubilis</i> L.	<1
B21053	15	<i>Piptotis aculeata</i> (Vahl) Urban	<1.0
B21054	16	<i>Stenolaphrum secundatum</i> (Walt.) Kuntze	<1.0
B21055	17	<i>Sida acuminata</i> L.	<1.0
B21056	18	<i>Sida urens</i> L.	<1.0
B21057	19	<i>Paspalum guajana</i> L.	<1.0
B21058	20	<i>Wedelia calyculata</i> L. C. Rich.	<1
B21059	21	<i>Randia miltis</i> L.	<1
B21060	22	<i>Chaetochloa geniculata</i> (Lam.) Millsp. and Chase	<1.0
B21061	23	<i>Syntherisma sanguinalis</i> (L.) Dulac	<1.0
B21062	24	<i>Panicum maximum</i> Jacq.	<1.0
B21063	25	<i>Citharexylum frutescens</i> L.	<1.0
B21064	26	<i>Chamaecypar hypericifolia</i> (L.) Millsp.	<1.0

In this area the quantity of selenium absorbed by plants appears to depend upon the character of the soil and the form of the selenium present. Selenium may be present in the soil in three forms which become available to plants only by slow processes of hydrolytic action (6). These are as free selenium, as pyritic selenium, and as basic ferric selenite. Free selenium might well be expected in the soil where commercial selenium sprays (Seloicide) are used, but there is no evidence that it is present naturally in the soil. Pyritic selenium is certainly present in immature soils formed from parent material containing pyrites. The most likely form of essentially insoluble selenium in mature soils is basic ferric selenite. It has been demonstrated that when solutions of sodium selenite are shaken with highly ferruginous soils, the selenium is rendered essentially insoluble (46). It should be noted here that the seleniferous Hawaiian soils which did not produce toxic vegetation were highly ferruginous. In the profile of the Yunes silt loam taken on the east slope of the hill, the selenium content at a depth of 12 to 24 inches was more than twice that of the surface soil. In this lower horizon of the Yunes silt loam iron oxide accumulates to form a hardpan. The higher selenium content of this ferruginous layer suggests the association of selenium with the iron oxide. Although in the three other profiles examined the selenium content of the lower layer is higher in all of them than that of the surface soil, the difference is not sufficiently great to be significant.

These results in Puerto Rico and Hawaii serve to emphasize the previously known fact that no quantitative relationship exists between the selenium in the plant and that present in the soil. It is shown that areas exist where highly seleniferous soils do not produce toxic vegetation.

In the 26 different plants examined, representing every type of vegetation on the hill, the selenium content in every case was less than 1 p. p. m. The Yunes silt loam, then, is truly a nontoxic seleniferous soil. This lack of availability of selenium to plants in the Yunes silt loam is in strong contrast with the fact that in certain sections of the western plains of the United States and Canada toxic seleniferous vegetation has been found growing on soils containing in the 8-inch surface layer as little as 0.2 p. p. m. of selenium. On this soil, for example, in Teton County, Mont., a sample of *Astragalus pectinatus* contained 190 p. p. m. of selenium. None of the plants which are known to be high absorbers of selenium were found on the Yunes silt loam. The low selenium content of all the plants indigenous to the area would indicate that the enrichment of the surface soil with water-soluble organic selenium does not occur. Neither does the depth of the root system of individual plants enter as a factor in absorption in this area.

MISCELLANEOUS DATA

Many samples on collateral aspects of the selenium problem have been furnished us by interested workers either at the request of the writers or on their own initiative. Some of the data so obtained are presented.

Portions of a well core from the Smoky Hill member of the Niobrara formation at Eads, Colo., were furnished by C. H. Dane, of the United States Geological Survey. Samples, beginning at a depth of 44 feet, then taken at intervals of 10 feet down to 114 feet, were examined for selenium and found to range from 8 to 16 p. p. m. This is the most uniform set of consecutive samples that the writers have encountered. The detailed results are given in table 7.

This profile of sections of the Niobrara is of especial value, since it is the only shale profile so far examined in which there is no influence to be ascribed either to leaching or to weathering.

The Pierre formation in South Dakota has been subdivided into five members by Searight,¹ of the University of South Dakota, acting for the State Geological Survey. From the top down, the members are Elk Butte, Mobridge, Virgin Creek, Sully, and Gregory. Samples representative of seven outcrops of the Mobridge were furnished by Searight. The results are given in table 8. A change of selenium content with geographical location is shown, especially by sample B22584. In this area the soils are particularly toxic (3).

TABLE 7.—Selenium content of samples from a well drilled in the Smoky Hill member of the Niobrara formation at Eads, Colo.

[Location: Sec. 25, T. 17 S., R. 47 W.]

Sample No.	Depth	Selenium	Sample No.	Depth	Selenium	Sample No.	Depth	Selenium
	Feet	P. p. m.		Feet	P. p. m.		Feet	P. p. m.
B21112	44	14	B21115	74	16	B21118	104	10
B21113	53	12	B21116	84	10	B21119	113-114	8
B21114	64	14	B21117	93½	12			

¹SEARIGHT, W. V. LITHOLOGIC STRATIGRAPHY OF THE PIERRE FORMATION OF THE MISSOURI VALLEY IN SOUTH DAKOTA. S. Dak. State Geol. Survey Rept. Invest. 27. 1937.

TABLE 8.—*Selenium content of samples of the Mobridge member of the Pierre formation in South Dakota*

Laboratory No.	Field No.	Location	Selenium
B22578	1	Big Badlands, S. Dak., at Dillon Pass.	P. p. m. 1.5
B22579	2	14 miles south of Marmarth, N. Dak., on Highway 12	.2
B22580	3	Harding County, S. Dak.	.2
B22581	4	6.5 miles east of Cottonwood, S. Dak.	.8
B22582	5	7.1 miles west of Kadoka, S. Dak.	.4
B22583	6	6.3 miles west of Wall, S. Dak.	.4
B22584	7	T. 108 N., R. 78 or 79 W. (resettlement project)	12.0

Samples from the Eagle Ford formation in Texas were furnished by L. W. Stephenson, of the United States Geological Survey. The data are given in table 9. These samples contained significant quantities of selenium. The quantities are, however, much lower than those found in the Niobrara shales that occur in Nebraska, South Dakota, and Wyoming. The point of interest is that a more or less close geological correlation exists between the Eagle Ford formation in Texas, the Indidura of Mexico (table 4), and the Niobrara.

TABLE 9.—*Selenium content of samples from the Eagle Ford formation in Texas*

Laboratory No.	U. S. Geological Survey Collection No.	Location	Selenium in soil or shale
B21125	1516	3½ miles west of Dallas, at a brickyard	P. p. m. 0.8
B21126	7515	1½ miles west of the public square on road leading west from Sherman, Grayson County.	.2
B21127	7506	Waco-China Spring road, at the crossing of Bosque River, McLennan County.	.6
B21128	9698	Sowells Bluff, Red River, 14 miles north of Bonham, Fannin County.	.2
B21129	13574	Peoria road, 0.8 mile west of courthouse at Hillsboro, Hill County.	.6
B21130	13827	At base of bluff, Mill Creek, at crossing of Shannon road, 1.8 miles west of Bell's, Grayson County.	2.5
B21131	13828	Probably less than 100 feet above base of Eagle Ford clay, Martin's Spring Branch, 3.3 miles west of South Pottsboro, Grayson County.	.1
B21132	14109	Bluff on West Fork Trinity River, 1.2 miles northeast of Grand Prairie, Dallas County.	3.5
B21133	14142	Bluff on branch ¾ mile north of highway, 1½ miles north of Files Valley, Hill County.	.7

Nine samples from Cretaceous formations in northern Alaska were furnished by I. B. Mertie, Jr. One sample contained 3 p. p. m. and the others contained 0.5 p. p. m., or less, of selenium. These samples are not to be considered a cross section of Alaskan shales but are of interest in comparison with shales found elsewhere.

The investigations of C. S. Piggot, of the Geophysical Laboratory of the Carnegie Institution of Washington, of the sea-bottom cores have a general scientific interest. A series of sections of these cores were furnished the writers for examination. Their selenium content is given in table 10. They represent a series of cores taken at depths ranging from 4,200 to 15,618 feet between Halifax, Nova Scotia, and Falmouth, England (fig. 6), together with one core taken off the coast of Maryland.

The selenium content of these cores is of the same order of magnitude as the sea-bottom samples previously reported from the Bering Sea (45). To table 10 are appended two additional samples from the Bering Sea that were furnished by L. C. Covell, of the United States Coast Guard.

The investigation of sea-bottom samples has a special importance in view of the presence of selenium in certain river waters and its absence from sea water (6), and because of the bearing it may have upon the sources of selenium in the more highly seleniferous shales. It is to be noted that the quantity of selenium so far found in recent

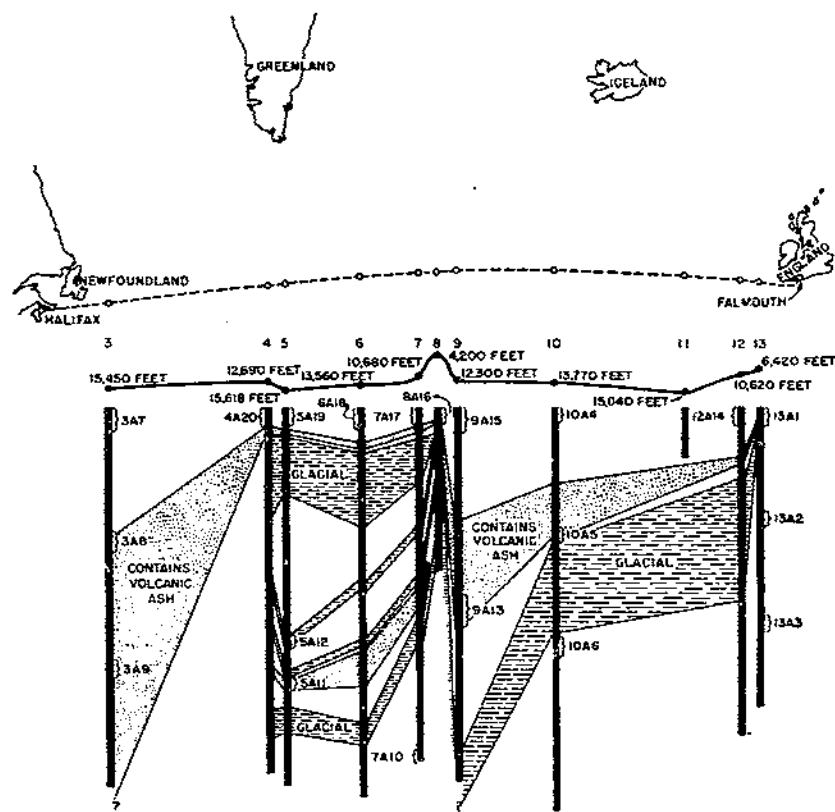


FIGURE 6.—Diagram of sea floor showing location of samples examined by C. S. Piggot.

sediments is not greatly different from that of older sedimentary formations now constituting soil parent material.

Two sets of samples of soil and parent material from New Zealand were furnished by L. A. Grange, director of scientific and industrial research, Wellington, New Zealand. In one set the soil contained 0.6 p. p. m. and the Cretaceous parent material 0.6 p. p. m. of selenium. In the other set, from Portland Road, one-half mile east of Purvera Stream, North Auckland, the soil contained 1.0 p. p. m. and the Onerahi claystone parent material 2.5 p. p. m. of selenium. Further investigation of soil, shale, and vegetation from this area would be of interest.

TABLE 10.—Selenium content of sea-floor samples from the North Atlantic Ocean and Bering Sea¹

Laboratory No.	Field No.	Location		Depth of water	Depth in core	Selenium
		Latitude	Longitude			
B20630	3A7	46°3'00" N	43°23'00" W	15,450	Chl.	P. p. m.
B20640	3A8	46°3'00" N	43°23'00" W	15,450	Top	0.15
B20641	3A9	46°3'00" N	43°23'00" W	15,450	100	.6
B22528	4A20	46°29'00" N	35°54'30" W	15,450	200	.6
B22527	5A19	46°38'00" N	36°01'00" W	12,090	Top	.1
B22530	5A12	46°38'00" N	36°01'00" W	15,618	do.	.1
B22529	5A11	46°38'00" N	36°01'00" W	15,618	155	.1
B22526	6A18	46°03'30" N	32°44'00" W	15,618	110	.1
B22525	7A17	46°22'00" N	29°31'00" W	13,560	Top	.1
B22528	7A10	46°22'00" N	29°31'00" W	10,680	do.	.1
B22524	8A16	46°36'00" N	28°54'00" W	10,680	200	.1
B22525	8A15	46°40'00" N	28°54'00" W	4,200	Top	.1
B22521	9A13	46°40'00" N	28°29'00" W	12,300	do.	.2
B20636	10A4	46°45'00" N	23°30'00" W	12,300	135	.8
B20637	10A5	46°45'00" N	23°30'00" W	13,770	Top	.8
B20638	10A6	46°45'00" N	23°30'00" W	13,770	100	.06
B22522	12A14	49°37'00" N	13°34'00" W	13,770	200	.06
B20633	13A1	49°38'00" N	13°28'00" W	10,620	Top	.1
B20634	13A2	49°38'00" N	13°28'00" W	6,420	13	.1
B20635	13A3	49°38'00" N	13°28'00" W	6,420	100	.1
B20610	1	37°26'00" N	74°28'00" W	6,420	200	.15
B20611	2	37°26'00" N	74°28'00" W	1,110	Top	.6
B20612	3	37°26'00" N	74°28'00" W	1,110	100	.1
B20267	1	37°26'00" N	74°28'00" W	1,100	200	.2
B20268	2	38°57'00" N	152°50'00" W	768	Top	.6
				540	do.	.5

¹ First 23 samples furnished by C. S. Piggot, Geophysical Laboratory of the Carnegie Institution of Washington; last 2 samples furnished by L. C. Covell, of the U. S. Coast Guard.

² 55 miles southeast of Ocean City, Md.

A set of samples from Sevier County, Utah, were furnished by H. W. Schoening, of the Bureau of Animal Industry. *Stanleya pinnata* and *Astragalus praelongus* were examined and found to contain 170 and 110 p. p. m., respectively. The Mesaverde and Mancos shales, Cretaceous sediments, outcrop in the county. The leg bone and hoof of a sick deer that had been killed were examined and found to contain selenium, although less than 0.5 p. p. m. The hoof was deformed. It is not known that selenium was responsible for the disorder of the deer.

The profiles of two soils from Keyapaha County, Nebr., were examined for selenium at the request of F. O. Youngs, of the Division of Soil Survey. A profile of Boyd clay loam contained 1.5 p. p. m. to a depth of 50 inches, except the 2- to 8-inch portion, which contained 1 p. p. m. In a profile of Boyd fine sandy loam the selenium increased from 0.2 p. p. m. in the 0- to 4-inch portion to 1 p. p. m. in the 38- to 52-inch portion. The selenium content of these soils is in agreement with data previously published (3, 4) regarding other nearby counties in Nebraska. No other samples from this county have been examined.

Samples were furnished from a garden irrigated by well water (fig. 7) by Leonard Noble, Resettlement Administration, Brookings, S. Dak. The results are given in table 11. The soil is highly seleniferous. None of the vegetables need be considered toxic. This quantity of selenium in similar soils of the section produces readily toxic vegetation (3). These plants are not good absorbers of selenium, but their very low selenium content is due in part to irrigation (3), which was carried on by use of deep well water.



FIGURE 7.—Irrigated garden in sec. 3, T. 107 N., R. 78 W., Lyman County, S. Dak.

TABLE 11.—Selenium content of vegetables from an irrigated garden on the Reed farm, sec. 3, T. 107 N., R. 78 W., Lyman County, S. Dak.

Laboratory No.	Material	Selenium in sample		Laboratory No.	Material	Selenium in sample	
		Analyzed as received but calculated on dry basis	Dried and analyzed			Analyzed as received but calculated on dry basis	Dried and analyzed
		<i>P. p. m.</i>	<i>P. p. m.</i>			<i>P. p. m.</i>	<i>P. p. m.</i>
B21942.....	Garden soil:			D21509.....	Lettuce.....	1	1.0
	0-8 inches.....		4.0	B21510.....	Spinach.....	1	2.0
B22257.....	6-18 inches.....		4.0	B21940.....	Beet tops.....	1	1.0
B21432.....	White radishes.....	3	2.0	B21941.....	Beets.....	1	1.0
B21433.....	White radish tops.....	2	2.0	B22422.....	Squash:		
					Flesh.....		.2
B21434.....	Red radishes.....	1	1.0		Seeds.....		.2
B21435.....	Red radish tops.....	1	1.0				
	Peas.....	2	1.0				
B21508.....	Pea pods.....	1	1.0				

Shortleaf pine trees were injected with various quantities of sodium selenate in an effort to find a dose that would be fatal to insects but not injurious to the tree. F. C. Craighead, of the Bureau of Entomology and Plant Quarantine, submitted samples from one tree that died. The core at 20 feet contained 3 p. p. m., twigs 70 p. p. m., and the leaves 240 p. p. m. of selenium. Similarly, in normal growth, indicator plants concentrate selenium in the leaves (6, 43).

A set of samples from McKinley County, N. Mex., were furnished by A. T. Strahorn, of the Soil Conservation Service. Four sandstone samples from a pass 10 miles northeast of Thoreau contained 0.2, 2, 12, and 46 p. p. m. The last two values are the highest yet reported for a true sandstone. It is not known whether this is a local condition or a truly seleniferous sandstone formation. Two samples of Mancos shale were found to contain 0.3 and 0.7 p. p. m. of selenium. A soil developed on Mancos shale was found to contain 0.5 p. p. m.

in the 12-inch surface layer and 1 p. p. m. in the next lower 12-inch layer. A sample of *Astragalus* sp. collected 15 miles north of Gallup, near Mexican Springs, contained 130 p. p. m. of selenium. The plant was growing on soil developed from the Mesaverde formation. This formation outcrops over a large area in McKinley and San Juan Counties.

SUMMARY

Methods for the determination of selenium in coal and in animal matter are given. Coal is treated with 94-percent nitric acid, and animal matter is treated with a mixture of equal volumes of concentrated nitric and sulfuric acids.

The results of a survey of part of Montana are reported, which establish toxic areas in Big Horn, Yellowstone, Teton, Pondera, Chouteau, Fergus, Lewis and Clark, Cascade, Hill, and Judith Basin Counties.

Indicator plants were used as guides in the survey work. *Astragalus pectinatus* was found to be a better absorber of selenium than *A. bisulcatus*.

Selenium has been established as the cause of a 200-year-old disease which occurs near Irapuato, Mexico. In addition to the examination of soils and vegetation collected over the area, vegetables from the public market were examined and found to contain from 0 to 70 p. p. m. of selenium.

Data on seleniferous soils of Hawaii and Puerto Rico that do not produce toxic vegetation are given. Soil and vegetation samples collected near Fajardo, P. R., are given as a special example.

A wide variation in the selenium content with geographical location was found in the Mobridge member of the Pierre shale.

Certain portions of the Eagle Ford formation in Texas were found to contain significant quantities of selenium.

An extension of the examination of the selenium content of sea-floor samples is reported and it is shown that the floor of the Atlantic Ocean contains selenium from Halifax, Nova Scotia, to Falmouth, England.

An area in Utah was found to produce vegetation of sufficient selenium content to be toxic.

Radishes, peas, lettuce, spinach, beets, and squash raised in an irrigated garden on highly seleniferous soil in Lyman County, S. Dak., had selenium contents below the limits normally considered toxic for rats.

A review of recent literature on topics related to the selenium problem is given.

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<i>Division of Soil Chemistry and Physics</i>	H. G. BYERS, <i>Principal Chemist, in Charge</i> .

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