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Soil Conservation Service
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ENVIRONMENTAL TECHNICAL NOTE NO. ~~5~~ 7

SUBJECT: WQP - CONSERVATION PLANNING FOR WATER QUALITY CONCERNS, TOXIC ELEMENT - SELENIUM

Purpose. To transmit the above named technical note.

Expiration date. When contents have been noted.

Filing Instructions. File in Environmental Technical Note Binder.

Explanation. Attached is paper developed by the WNTC Water Quality Staff concerning the toxic element Selenium (Se). It discusses the distribution of Se in the west; its toxicity to humans, livestock, fish and wildlife; and solutions to manage Se. This paper can be used to assist in planning alternative Resource Management Systems for farmers and ranchers.

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March 26, 1993

WATER QUALITY TECHNICAL NOTE NO. W-1
460-VI

SUBJECT: WQP - CONSERVATION PLANNING FOR WATER QUALITY CONCERNS, TOXIC ELEMENT - SELENIUM

Purpose. To transmit the above named technical note.

Effective Date. When received.

Filing Instructions. File in Technical Note binder - Water Quality Section.

Background. The WNTC mission for "quality technology for resource decisions" has prompted the Water Quality Staff to investigate and prepare a technical note on the toxic element selenium (Se). The information in the note will provide planners with one more tool for helping plan alternative Resource Management Systems for farmers and ranchers. Make it a part of your FOTG.

Planning Considerations. This paper discusses the distribution of Se in the West; it's chronic and acute toxicity; and conservation practices to control Se contamination and deficiency.

There may be a Se hazard if you are in an area where Cretaceous or Jurassic shale outcrops, annual precipitation is less than 20 inches, seleniferous vegetation such as loco weed (Astragalus) is present, there is coal, bentonite, or uranium mining, or ground water or surface water quality records indicate Se contamination.

Acute poisoning from Se first emerged as a problem with livestock grazing in the West, but now it is also known to poison fish and wildlife in ponds and wetlands, particularly where drainage from irrigation supplies much of the water and Se is bio-accumulated in the food chain.

-MORE-

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Portland, Oregon

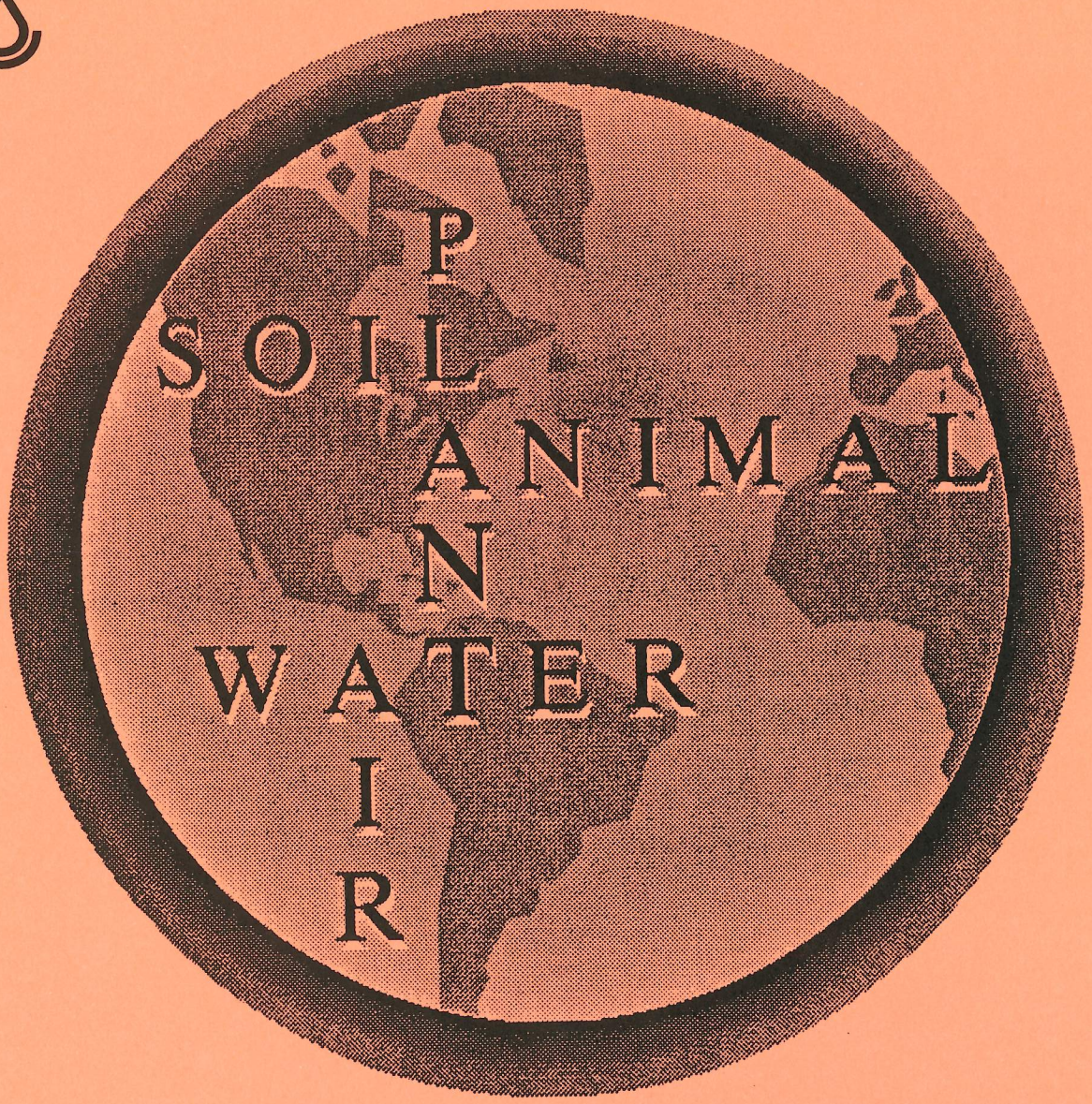
March, 1993

Technical Note

Conservation Planning for Water Quality Concerns

Toxic Element - Selenium

Water Quality Series No. W1



WNTC - Quality technology for resource decisions

CONSERVATION PLANNING FOR WATER QUALITY CONCERNS
TOXIC ELEMENT - SELENIUM

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CONSERVATION PLANNING FOR WATER QUALITY CONCERNS
TOXIC ELEMENT - SELENIUM [1/]

NO SIMPLE ANSWERS TO SELENIUM

Selenium. Do you mean that element added to horse and sheep feed for healthy growth? Then I'm all for it, or do you mean, **Selenium**, that element that may deform and kill fish, wildlife, sheep, and horses. Then I'm against it!

Think of selenium (Se) as an "essential poison"! The difference is a very fine line, but like a lot of things in life on this planet, a little is very beneficial and vital, but too much is a killer. Eating too much contaminated fish and fowl or drinking contaminated water could be hazardous to your health.

How water is managed for irrigation is critical to the concentration of Se. Seepage and deep percolation of irrigation water can pick up large amounts of Se in certain areas. When irrigation drain water is allowed to evaporate and bio-concentrate Se in wetland areas, it is acutely toxic to fish and waterfowl.

This paper discusses the distribution of Se in the West; its toxicity to humans, livestock, fish and wildlife; and solutions to manage Se.

SELENIUM DISTRIBUTION IN THE WEST

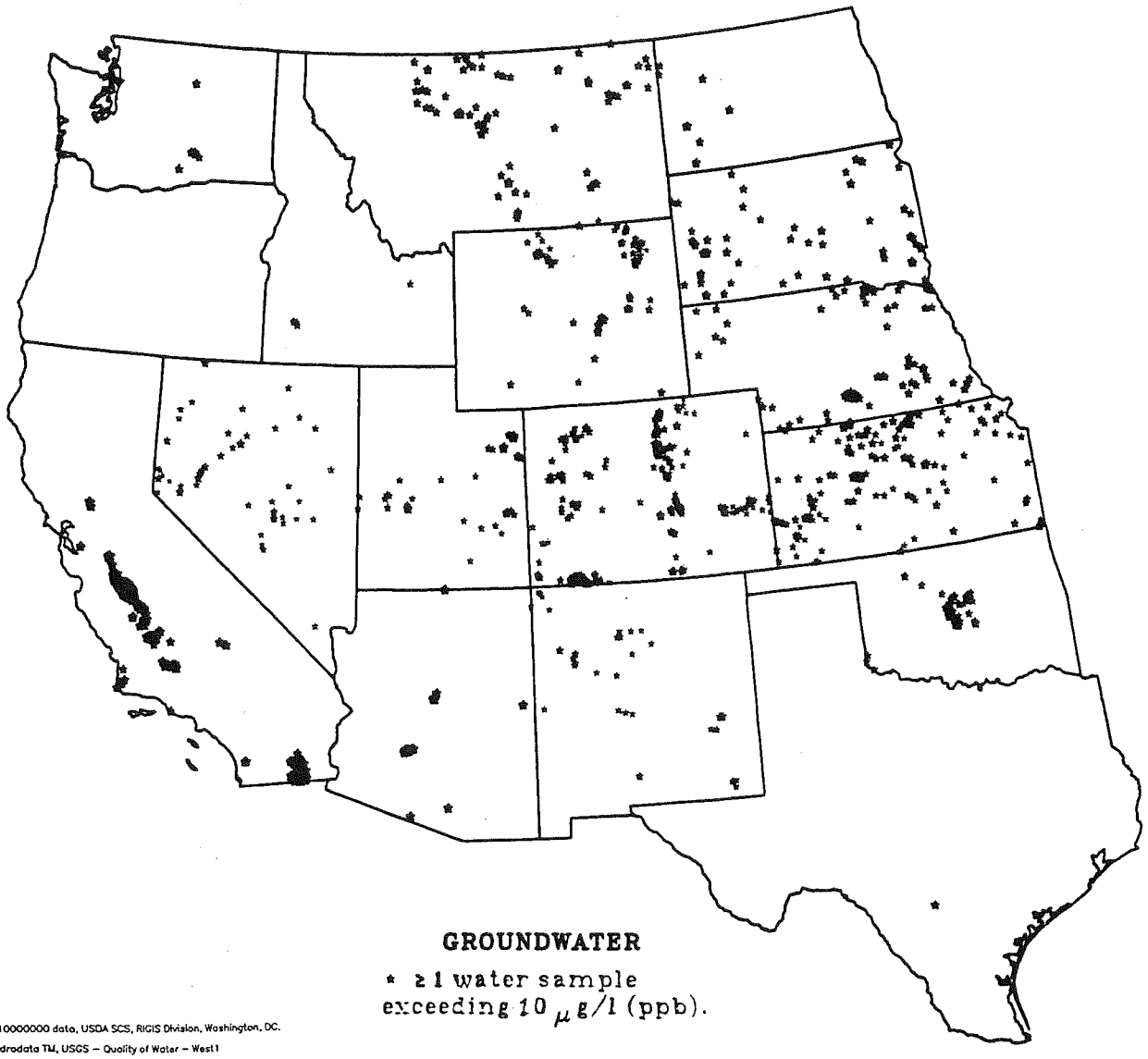
Nature provides selenium (Se) in many geologic formations throughout the world, but it is most abundant in sedimentary rocks such as shale, sandstone, limestones, and phosphorite rock and soils derived from them. It is highly mobile and biologically available in arid regions having alkaline soils typical of the Western United States. A number of plants, such as loco weed have the ability to concentrate Se extracted from the soil into a biologically available form, which, when eaten is toxic to livestock. Selenium can also be mobilized or released from the soil by a crop-fallow management system or irrigation activities. Saline seeps developed in wheat-fallow areas of the plains from Texas to Canada may have high concentrations of Se. Seepage contaminates ground water and surface runoff. Surface and ground water contain varying amounts of Se - too much can be toxic to livestock, fish, wildlife, and humans.

[1/] Prepared by John D. Hedlund, Water Quality Specialist, USDA-SCS, West National Technical Center, Portland, Oregon, January 1993.

US DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

FIGURE 1: Selected Water Quality Monitoring Stations with Elevated Selenium



GROUNDWATER

* ≥ 1 water sample exceeding 10 μg/l (ppb).

BASE MAP DATA SOURCE: 1:10000000 data, USDA SCS, RIGIS Division, Washington, DC.

SALINITY DATRA SOURCE: Hydrodata TM, USGS – Quality of Water – West 1 and 2. Earth Info, Inc., 1991.

DATA COMPILATION: USDA SCS–WNTC, Water Quality staff, Portland, OR 1992.

MAP CPMPILAION: GRASS–MAPGEN software, USDA SCS–WNTC GIS staff, Portland, OR 1993.

This map is for display purposes only.

0 50 100 150 200 250 300 350 400 450 500 STATUTE MILES

FEBRUARY, 1993

3. Identify safe and effective methods of increasing Se concentrations in plants in deficient parts of the nation.

4. Apply flexible wheat-fallow management systems in areas of saline seeps to reduce Se contamination of soil and water.

5. Reclamation and control of Se contamination of soils, surface water and ground water from uranium, coal, bentonite, and phosphate mining operations.

6. Minimizing deep percolation and seepage from irrigation, and manage drain flow containing high concentrations of Se.

Human Toxicity

Human toxicity from high levels of Se in diets derived from food grown on seleniferous soils is relatively rare. Toxic symptoms from drinking contaminated water is also relatively rare.

1. Adults in the U.S. consume approximately 160 ug Se/day. Daily recommended allowance is 50 to 200 ug Se/day (National Academy of Science, 1983). The 1992 Drinking Water Standards and Health Advisories place the **Reference Dose** (RfD) - daily exposure to the human population that is likely to be without appreciable risk of deleterious effects over a lifetime at **5 ug/kg/day** for a 70-kg adult.

2. Water. The 1977 Safe Drinking Water Act of U.S. EPA established an allowable standard for drinking water of 10 ug Se/L; The April, **1992 Drinking Water Regulations** and Health Advisories published by U.S. EPA place the Maximum Contaminant Level Goal (MCLG) and MCL **at 50 ug/L.**

3. In China no toxic symptoms were detected in individuals consuming up to 750 ug Se/day. However, individuals consuming 5000 ug Se/day or more had symptoms of hair and nail loss and skin lesions.

4. Water. A family in Durango, Colorado, including a dog, suffered hair loss, nausea, and fatigue by drinking water from a domestic well contaminated by Se. The Se concentration was 9,000 ug/L and the well was located in a shale and siltstone formation.

5. Drinking water from ponds, seeps, or creeks. A heading in the Sunday Oregonian, December 11, 1988, read, "Doctor learns of Se too late to save victim." Girard Perkins of Burns, Oregon died with every organ in his body, from his brain to his kidney, containing high Se counts, probably from drinking spring water polluted with Se.

6. If the diet does not supply sufficient Se, diseases such as Keshan (juvenile cardomystropathy) and Kaschin-Beck (chondrodystrophy in children) may occur.

palatable to livestock and have an offensive odor due to Se. The Great Plains from Texas to Canada have documentation of conditions leading to poisoning from consumption of Se-accumulator plants. Selenium concentrations in vegetation that cause acute poisoning, range between 400 and 800 mg/kg (Girling, 1984).

Protecting Domestic Livestock

Selenium deficiency in livestock diets can be overcome by adding feed supplements containing Se. Selenium fertilizer can be added to increase Se in crops grown on deficient soils. Some fertilizer materials may contribute Se for use by plants. Fertilizer made from rock phosphate may contain as much as 200 mg Se/kg. Liming acid soils was found to increase the uptake of Se by plants (Cary, 1967). Conflicting results are reported on Se solubility and changes in plant uptake due to adding lime, gypsum, sulfate, and phosphate. The contradictory effects can usually be explained by evaluating site specific information. Only two countries, New Zealand and Finland, have begun adding Se legally to fertilizers used for production of both forage and human food.

Selenium poisoning of livestock can best be controlled by proper grazing management. This would require the exclusion of livestock grazing on range where Se is concentrated in plants on seleniferous soils. Usually only during drought or when livestock are starving will they eat the normally non-palatable, acutely toxic Se-accumulator plants, such as loco weed; however, it has been found that some livestock have a greater propensity to ingest toxic plants than others. Chronic toxicity can be reduced by knowing the Se-accumulator plants and restricting grazing of them. Pest management to control or eliminate those plants which are Se-accumulators on rangeland is another possible treatment. Range seeding and alternative land uses should also be considered for these areas.

Testing water supplies for Se is another preventative measure to reduce the hazard of toxic poisoning of livestock. Alternative water sources for livestock may have to be found. If you are going to assist a farmer or rancher build a pond consider the Se hazard. Consider the factors of Se distribution: Is it located in an area of less than 20 inches annual precipitation, in an area with Cretaceous shale formations, is seleniferous vegetation present, or do ground water or surface water records indicate a Se hazard? If a Se hazard is identified, alternative sources of livestock water should be found.

Fish and Wildlife Toxicity

Toxicity varies for different forms of Se, animal species, duration of exposure, method of uptake, and other factors. In wetland areas, bio-accumulation and bio-magnification increase

TOTAL RESOURCE MANAGEMENT

A complete conservation management system which can control Se contamination as well as other problems of the soil and water, and protect the plant, animal, and air resources is called a **Resource Management System (RMS).** Table 1 displays options designed to protect soil, water, plants, and animals from Se pollution.

Table 1. Conservation practices and auxiliary actions to control selenium contamination or deficiencies

Conservation Practices and Auxiliary Actions	Soil Cond.	Water Quality Contaminants	Plants Mgt. Nutr.	Animals Mgt. Health	Air
Rural Domestic Water Supply					
Well testing		x		x	
Water treatment		x			
Use bottled water		x			
Geologic invest.	x	x			
Livestock-Se Deficiency					
Feed Se supplements			x	x	
Apply Se fertilizer	x		x	x	
Livestock-Se Poisoning					
Proper grazing use			x	x	x
Livestock exclusion			x	x	x
Pest management			x	x	
Range seeding	x		x	x	x
Alternative land use			x	x	x
Test water supplies		x		x	
Fish and Wildlife-Se Poisoning					
Cut off irrig. drain flow		x		x	
Fill in ponds	x			x	
Irrig. water mgt.		x	x	x	
Drainage mgt.		x	x	x	
Crop mgt.		x	x	x	
Cons. cropping seq.	x		x		
Alternative land use		x	x	x	

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Selenium in mining operations. Selenium is closely associated with uranium (U), bentonite, and coal mining. There is a potential for contamination of soils, surface waters, and ground waters in and adjacent to these mining operations. The highest concentrations of Se reported for soils and geological material are associated with U deposits. Concentrations as high as 4500 mg/kg have been reported in the overburden from the Powder River district in Wyoming. Selenium-concentrating vegetation was used as a botanical prospecting tool in the 1950's (Cannon). The location of uranium mining in Arizona, New Mexico, Colorado, Utah, Wyoming, and Montana is an indication of high concentrations of several trace elements and include As, Cu, Mo, Pb, and Se. A **uranium mining map** of 4600 operations is included as Figure 6 to indicate the distribution of high concentrations of Se.

Bentonite mining in Wyoming, Montana, and South Dakota are additional Se sources. Bentonite was formed from volcanic ash deposited about 75 million years ago in shallow seas. The rock formed in these Cretaceous seas was shale. The Se content of coal and carbonaceous shales may be concentrated. Increased mobility and solubility of Se can occur at coal, bentonite, and uranium mining operations.

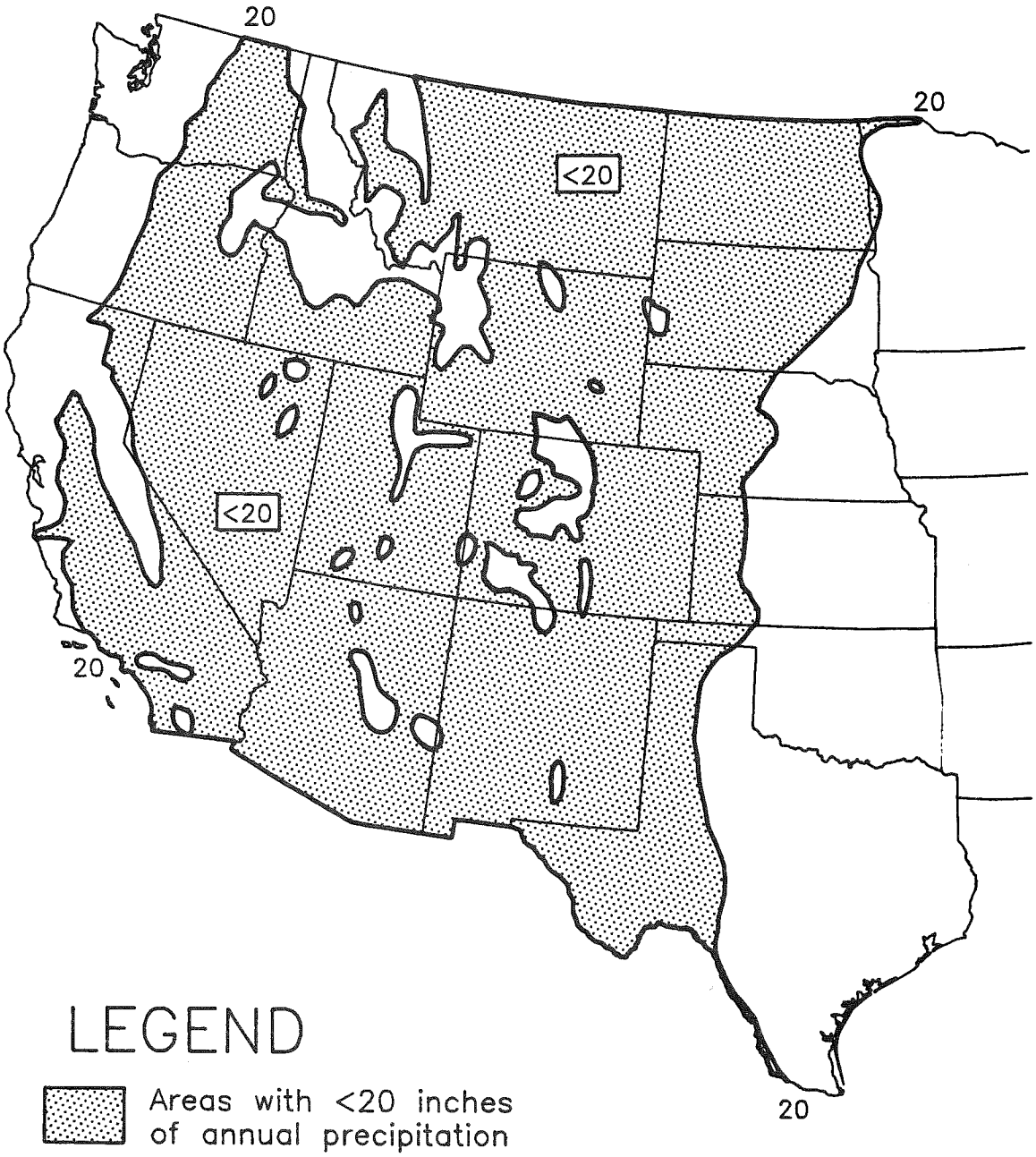

Figure 4. Areas with less than 20 inches of annual precipitation may accumulate soluble Selenium in the soil profile. (adapted from Climate Atlas of the U.S., U.S. Dept. of Commerce, Environmental Science Services Administration, Environmental Data Service, 1968.)

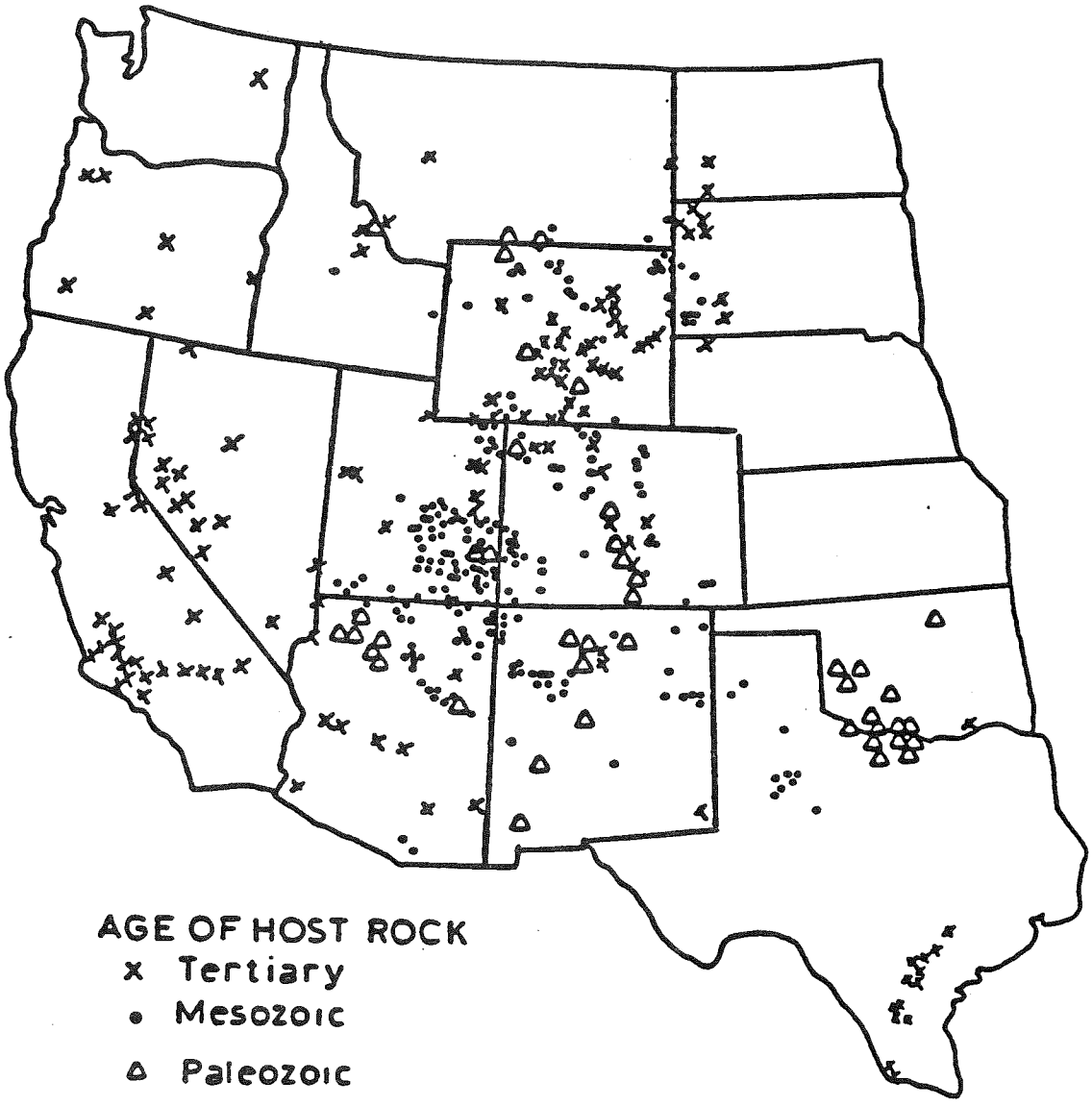

Fig. ~~6-2~~ 6. Uranium deposits in sandstones of the western USA (Finch, 1967).