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GEOGRAPHICAL ANALOG SOILS SURVEY.
VOLUME II

Lewis S. Fountain, et al

Southwest Research Institute

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13. ABSTRACT

The objective of this study was to locate land areas in the Continental United States (CONUS) that were similar in all aspects to selected land areas in other parts of the world. The purpose was to aid in the selection of land mine detection test sites analogous to strategic areas in other parts of the world.

An extensive literature search was made to collect information on world soils and climates. The survey resulted in a display kit comprising a soil map of the CONUS with transparent overlays that showed parts of the U. S. that had soils similar to the selected areas of the world.

Soils types were found in the U. S. that were analogous to those in most parts of the world if only soil depths related to land mine burial requirements were considered. Analogous climates were not always found with analogous soils. To locate true analogs of selected areas, detailed studies including sample analysis from both areas must be made.

The results of this program task were the source of information used to locate special test sites for a 12-month mine detection evaluation program and to find analog areas that represented European areas where tests were to be conducted by MERDC.

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GEOGRAPHICAL ANALOG SOILS SURVEY

by
Lewis S. Fountain
David K. Curtice

FINAL TECHNICAL REPORT VOLUME II

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Prepared for
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FOREWORD

This report is one volume of a series of reports that will make up the Final Technical Report covering work performed under U. S. Army Mobility Equipment Research and Development Center (USAMERDC) contract No. DAAK02-72-C-0638, SwRI Project 14-3440. The information in the report was compiled for the purpose of supporting land mine detector evaluation studies and was an invaluable aid in the selection of field sites in the Continental United States that would be analogous to sites in other countries of the world.

Work described in this report was performed by members of the Earth Science Applications Section of the Department of Electronic Systems Research, SwRI with the assistance of specialists from other departments. Geologist D. K. Curtice was a major contributor to the soils research task. Map and overlay production for a special display that was developed to illustrate soil analog areas in the Continental United States was done by Mr. R. C. Lynch, SwRI draftsman. Valuable advice was given by Dr. Thomas E. Owen in the development of the analog map display kit.

Acknowledgement is given to Mr. Robert A. Falls of USAMERDC whose work in 1971 on soil analogs provided the basis for this study and to William H. Johnston, the Contract Technical Monitor, for his assistance during the program. Thanks are given to the United States Air Force Environmental Technical Applications Center who assisted by supplying climatic summaries of selected worldwide locations.

SUMMARY

The objective of this study was to locate land areas in the Continental United States (CONUS) that were similar in all aspects to selected land areas in other parts of the world. The purpose was to aid in the selection of land mine detection test sites analogous to strategic areas in other parts of the world.

An extensive literature search was made to collect information on world soils and climates. The survey resulted in a display kit comprising a soil map of the CONUS with transparent overlays that showed parts of the U. S. that had soils similar to the selected areas of the world.

Soils types were found in the U. S. that were analogous to those in most parts of the world if only soil depths related to land mine burial requirements were considered. Analogous climates were not always found with analogous soils. To locate true analogs of selected areas, detailed studies including sample analysis from both areas must be made.

The results of this program task were the source of information used to locate special test sites for a 12-month mine detection evaluation program and to find analog areas that represented European areas where tests were to be conducted by MERDC.

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I. INTRODUCTION

Land mine detector effectiveness is strongly dependent upon the environment in which the detector is used. Thermal sensing types are affected by both the climate and the thermal characteristics of the soil, being dependent upon the energy exchange taking place between the earth and the atmosphere and upon a thermal imbalance in the soil. Other types are sensitive to electrical properties of the soil such as the dielectric constant and the attenuation constant. These parameters are in turn related to the soil's chemical and physical properties.

A detector should be evaluated in the exact environment in which it is destined to be used to prove its capability and dependability in a tactical situation. This is extremely important with land mine detectors because of the hazardous conditions under which they must be operated.

It is impossible to gain access to many strategic areas of interest in mine detection operations, therefore the United States Army is seeking an answer through the use of the analog test areas in the United States. Such areas should be similar to the desired areas in both soil and climatic characteristics, and they should be readily accessible as field tests sites, i. e. national forests or military reservations.

An extensive literature survey was made to gain worldwide information on climates and soil types. A total of 145 separate references including soil maps were collected and studied. Soils in other countries were compared with soils in the CONUS in every detail available from these sources. Summaries of these comparisons were then made, and a soil map display kit was designed and constructed to display the information.

The literature collected contained very good soil data on the 15 countries in the following list: (1) Afghanistan, (2) Austria, (3) Belgium, (4) Czechoslovakia, (5) England, (6) France, (7) Germany, (8) Italy, (9) Netherlands, (10) Poland, (11) Portugal, (12) Russia, (13) Scotland, (14) Spain, and (15) Turkey. Many of these countries could be divided into smaller areas. Soil analogs in the CONUS were located for a total of 42 of these areas.

The 42 areas were represented as transparent overlay maps that could be placed over a soil map of the United States to locate areas having similar soils. Another overlay transparency of the national forest system could then be placed on top of the map to locate any national forests or national grasslands in the area.

Several specific locations in the Federal Republic of Germany were selected for study. These were smaller areas; therefore, soil type and climatic averages could be more accurately determined. Analog areas in the CONUS were found for these areas, two of which were chosen as field test sites where seasonal mine detector operational data could be collected.

II. BACKGROUND DISCUSSION

A. Soil Formation

Probably no two areas in the world can be found that will have soils exactly alike if the geneses of the soils are traced back through the history of their formation. Almost universally a profile through the soil will show bedrock above which is some unconsolidated debris (regolith) which may vary in thickness from several inches to hundreds of feet. The composition of this debris will be found to vary from place to place because of its history. It may have been formed by weathering of the underlying bedrock or it may have been deposited there by the action of wind, water, and ice. Very often the top three to six feet of soil differs from the material below. This is because it is subject to atmospheric effects and the effects of plant residues originally deposited on the surface and incorporated by nature (earthworms, etc.) into surface layers and partially or totally decomposed by micro-organisms. Thus, it can be seen that top soil characteristics can be strongly dependent upon the surrounding environment during its formation as well as upon the parent material which it overlies.

It took many centuries for world soils to develop to their present form of maturity. Because of this, similar soils will be found to exist in areas where the climates are no longer alike. Also, soils in the same area only a few feet apart can be found that are notably different.

Generally, soils fall into major orders that can be classified by their physical properties and not necessarily their genesis. Such a classification is that developed by the Soil Survey Staff of the U. S. Department of Agriculture. The primary bases for identifying different classes are properties of soils as found in the field, properties that can be measured quantitatively. Even though soil types will be found to vary greatly in some cases over a small area, there is usually a slow transition from one location to another. Because of this, the major soil orders and suborders can generally be used to classify these soils over a large area.

B. Soil Classification

The Department of Agriculture classification system breaks the soil types down into the following categories: (1) order (broadest category); (2) suborder; (3) great group; (4) subgroup; (5) family; and (6) series (the most specific category). Soil types that are similar can be found in many parts of the world if only the first two or three categories are compared. The classification system is quite detailed; therefore, only the major orders will be discussed here along with a few suborders and great groups used in the text.

Ten major orders are presently used as briefly discussed below.

1. Major Orders

a. Entisols

These soils are mineral soils without natural genetic horizons. They generally consist of a deep regolith with only a plow layer horizon. A common characteristic is the lack of significant profile development.

Entisols are found under a wide range of climatic conditions. In the United States they are found in the Rocky Mountain region, southwest Texas, Florida, Alabama, Georgia, and Nebraska. Outside the United States they can be found in the Sahara Desert, Saudi Arabia, North Central Australia, Quebec, Alaska, Siberia and Tibet.

b. Vertisols

The Vertisols, found in both wet and very dry areas, have a high content of swelling clays. In the dry season they develop deep, wide cracks. They are of very fine texture, sticky and plastic when wet, and usually very hard when dry. In the older soil classification and in most of the European countries these soils have been called Grumusols.

These soils can be found in the United States in the following states: Mississippi; Alabama; southeast, southern, and east central Texas. They can also be found in India, the Sudan, and eastern Australia.

c. Inceptisols

These soils are considered to be young soils forming primarily from alteration of parent materials. The surface horizons are usually uniform with no marked accumulations of iron and aluminum oxides or clay. The physical makeup is extremely variable from area to area because of the parent materials and lack of extreme weathering.

In Europe these soils are known as Brown Forest and Sols Brun Acid, or Acid Brown soils. The soils of interest in Europe are the Acid Brown soils; however, in the United States, some Brown Forest soils, known here as Umbrepts, have been included, such as those of the Pacific Northwest.

Inceptisols can be found on all continents and in both tropical and cold climates. In the United States they extend from southern New York through central and western Pennsylvania, West Virginia, and eastern Ohio. They are found also in Washington, Oregon, Idaho, and others. Wet Inceptisols are found along the Amazon and Ganges rivers. Other suborders are found in Spain, France, Germany, North Africa, eastern China, and western Siberia.

d. Aridisols

These mineral soils have distinct horizons, are low in organic matter, generally light in color, and are never moist as long as 3 months. They are found almost always in dry climates, so have not had intensive leaching. Quite often the surface layer is high in calcium carbonate, gypsum, or other soluble salts.

In Europe, and in the old U. S. classification, the Aridisols have been called Desert, Reddish Desert, Sierozen, Reddish Brown, and Solonchak.

Aridisols include most of the soils of the arid regions of the world. They are found in parts of California, Nevada, Arizona, and New Mexico; also in the Sahara desert in Africa, the Gobi and Taklamakan deserts in China, and the Turkestan desert of Russia.

e. Mollisols

Mollisols are characterized by a surface horizon which is thick, dark, and soft. Surface horizons generally have granular or crumb structures and are not hard when dry. They are organically rich, developed in most cases under prairie vegetation.

Mollisols are dominant in the Great Plains States and are found in both moist and dry areas. They are also found in parts of Idaho, Utah, Washington and Oregon. The largest area of Mollisols outside the United States stretches from east to west across the Soviet Union. Other large areas are found in Mongolia and northern China, northern Argentina, Paraguay, and Uruguay.

f. Spodosols

Technically, a Spodosol is a light-colored soil having a spodic horizon; that is, a zone in which active amorphous materials composed of organic matter and aluminum, sometimes with iron, have precipitated. These would occur only in humid environments, most commonly in cold and temperate climates. They can occur under certain conditions where there is a dry summer period. The soils typically form in coarse-textured,

acid parent materials; thus the usual Spodosols are sandy or coarse loams and silts. In Europe, and in the old U. S. classification, these soils are classified as Podzols, Brown Podzolic, Ground Water Podzols, and often combined with the Gray-Brown Podzolics.

Spodosols are found in the Northeastern United States including much of northern Michigan and Wisconsin. They extend northeast on into Canada. Other large areas are found in Northern Europe and Siberia. Smaller areas are found in the southern part of South America and in cool mountainous areas of temperate regions.

g. Alfisols

Alfisols are usually formed in temperate to tropical regions usually having a moist or wet climate. They are usually formed under deciduous forests. They have gray to brown surface horizons and have medium to high base saturation. They appear to be strongly weathered but not as much so as Spodosols. These are the typical Gray-Brown Podzolic soils of Europe and of the older classifications.

Alfisols are found in both moist cold areas and hot dry areas. They can be found in Ohio, Indiana, Michigan, Wisconsin, Minnesota, Pennsylvania, New York, California, Texas, and New Mexico. Also, areas can be found in the Baltic States, Western Russia, Siberia, Southern Africa, Brazil, India, China, and much of both Central Europe and Australia.

h. Ultisols

Ultisols are usually moist soils and develop under warm to tropical climates. They are well weathered but not so acid as Spodosols. They are formed on old land surfaces, generally under forest vegetation. Subsurface horizons are usually red or yellow in color as evidence of free oxides of iron. Some of these soils were formerly called Reddish Brown Lateritic soils.

Moist soils in the southeastern United States are in this order. They extend from Maryland to Florida to and beyond the Mississippi Valley. They are also found in Hawaii, California, Oregon, and Washington. Outside of the United States they are found in parts of Australia, southeast Asia, southern China and also, parts of Brazil and Paraguay.

i. Oxisols

Oxisols are the most weathered soils to be found. Their most important diagnostic feature is the presence of a deep "oxic" subsurface horizon. Non-sticky type clay content is very high in

these soils that have been heavily leached. Weathering depth extends as deep as fifty feet or more. These soils have also been termed latosols and Ground Water Laterites.

Oxisols are found on old land surfaces, mostly in the tropics. No areas of this soil were found in the CONUS. The largest known areas occur in South America and Africa and are mostly still covered with native vegetation.

j. Histosols

Histosols include the organic soils (Bog soils) and some of the half-bog soils. They contain a minimum of 20 per cent organic matter if no clay is present and 30 per cent if the clay content is more than 50 per cent. In some cases the organic content is as high as 90 or 95 per cent. Less is known about these soils than the other orders, but they are usually found in marshes, bogs, and swamps. They are covered by much plant life that reoccurs in numberless generations. Decay of the many plants cause this soil to become brown or even black in color.

Small areas of these soils are found in Florida, Louisiana, California, North Carolina, Michigan, Minnesota, and Wisconsin. They can also be found in parts of Canada.

2. Suborders and Great Groups

The soil discussions in this report will, in some cases, use terms from the suborder and great group soil classifications. Those terms used are defined here.

a. Boralfs - A suborder of the Alfisol order. These soils are found in cool to cold regions having moist climates. They are medium to high in bases and have gray to brown surface horizons.

b. Borolls - A suborder of the order Mollisol. They are Mollisols found in cold climates and have horizons that are high in bases, friable, and organic-rich.

c. Ochrept - A suborder of the order Inceptisol. It is an Inceptisol soil having a very light surface color.

d. Dystrochrept - A great group division of the Ochrept suborder of the order Inceptisol. It is an Ochrept with a low base saturation.

e. Udalf - A suborder of the order Alfisol. An Alfisol soil found in humid climates.

- f. Udoll - A suborder of the Mollisol order.
A Mollisol found in humid climates.
- g. Ustalfs - A suborder of the Alfisol order.
It designates Alfisols found in dry climates that are usually hot in summer.
- h. Ustolls - A suborder of the order Mollisol
indicating Mollisols found in dry climates that are usually hot in summer.
- i. Xeralf - A suborder of the Alfisol order indicating
that the soils are found where there is an annual dry season and mild wet winter,
usually termed a "Mediterranean Climate".
- j. Xeroll - A suborder of the order Mollisol
designating those Mollisols found in areas having a "Mediterranean" climate --
hot dry summers and mild wet winters.

III. SOIL ANALOG DISCUSSION

Soils of a total of fifteen countries, some divided into smaller sections, will be discussed by country along with analog areas in the CONUS. This will be followed by a discussion of several selected areas in the Federal Republic of Germany and their analog areas.

Some soil types will be found in more than one country implying that the same area in the CONUS will be analogous to more than one foreign location. Locations of analog areas in the United States have been repeated intentionally in the discussion for each country for which they are analogs. This was done to provide a more complete discussion of a given country's soil and its CONUS analog without reference to other sections of the report.

A. Afghanistan

Aridisol soils are found in the northern, western, and southern regions of Afghanistan. They consist of various types and combinations of sands, gravels, clays, and silts on typical desert terrain.

The soils in the United States analogous to the European Aridisols are found in large areas of the Southwest and West. They occur in Texas from the Pecos River west, in much of New Mexico, northeast and southern Arizona, southeastern California, most of Nevada, and scattered areas of Utah, Colorado, and Wyoming.

B. Austria

Two major soil orders are found in Austria -- Inceptisols and Mollisols. Of the Inceptisols the suborder Ochrepts and the great group Dystrochrepts are predominant. In the Mollisol order, soils in the suborder Udoll are found.

Dystrochrept soils are found in southeastern Austria extending from the city of Klagenfurt northeastward to the Hungarian border. There is a small area of thin Dystrochrepts to the north and east of Linz near the German border.

The analogous soils of this Ochrept order in the United States are found in several areas, the largest being in the east and northeast. These soils are extensive in southern New York State, much of Pennsylvania, almost all of West Virginia, southeastern Ohio, parts of Kentucky, Indiana, and Tennessee, and in three small isolated areas in central Alabama. There are somewhat similar soils in a small area of east-central Oklahoma extending north into Kansas. Another area of Ochrepts is found in Washington and Oregon, along the coast and Puget Sound.

The Udoll soils in Austria are primarily thin Rendzinas, found in a narrow band along the northwestern border, and from Salzburg eastward to near the Hungarian border.

The Rendzinas, a classification from the old system, fall into the Rendoll suborder of Mollisols. They are thin dark-colored grassland soils developed from soft limestone and have brown or black friable surface horizons. The Rendzinas of Europe have no reasonably extensive analog in the United States, but the blacklands of north central Texas is one example. These soils have been included with the Udolls.

The analogous area in the United States for the Udolls is in the central part of the country. The largest continuous area stretches from southern Minnesota to northeastern Oklahoma. The western edge is approximately along the 97° west longitude meridian. The eastern limit is interfingered with Alfisols just west of the Mississippi River from about St. Paul, more or less southward, to the Missouri River. Here, the trend is to the southwest to east central Oklahoma.

A smaller extent of the Udoll type soils is found almost entirely in the northern two-thirds of Illinois. A very small area of these soils is found along both sides of the Red River, from near Texarkana almost to the Mississippi River.

C. Belgium

Soils of the orders Inceptisol, Spodosol, and Afisol are predominant in Belgium.

Most of the Ardennes in southeast Belgium consists of a rocky phase of Dystrachrept soils of the Ochrept suborder of Inceptisols. They extend northward to within a few miles of the Meuse River.

The analogous soils of the Ochrepts in the United States are found in several areas, the largest being in the east and northeast. These soils are extensive in southern New York State, much of Pennsylvania, almost all of West Virginia, southeastern Ohio, parts of Kentucky, Indiana, and Tennessee, and in three small isolated areas in central Alabama. There are somewhat similar soils in a small area of east-central Oklahoma extending north into Kansas. Another area of Ochrepts is found in Washington and Oregon, along the coast and Puget Sound.

Spodosol soils are found along the northern border in the area including Brugge, Gent, Antwerp, and Hasselt.

The analogous areas of these Spodosols of the colder climates in the United States are found in New England east of the Hudson River and north of Syracuse; in northern Michigan north of Grand Rapids; in northern-most Wisconsin; and in a very small area of Minnesota along the Canadian border.

Soils of the Udalf suborder of Alfisols are found across central Belgium south of Gent and Hasselt and generally north of the Meuse River. They extend from the French to the German borders.

The analogous areas of Udalfs in the United States are found in the north-central, northeast, and Mississippi Valley regions. A large area of these soils is found in most of Indiana, southern Michigan, all of Ohio except the southeast, north-central Kentucky, and upper New York State. Another area extends from Lake Michigan across the southern half of Wisconsin into east-central Minnesota. The Udalfs are found along much of the Mississippi Valley from Minnesota to Louisiana interfingering with wet to marshy alluvial and similar soils.

D. Czechoslovakia

Two major soil types are found in Czechoslovakia -- Alfisols and Spodosols.

Soils falling in the Udalf suborder of Alfisols are found in the north, northwest, and western regions and include thin mountain soils. There are also areas of Udalfs in the central and east-central regions.

The analogous areas of Udalfs in the United States are found in the north-central, northeast, and Mississippi Valley regions. A large area of these soils is found in most of Indiana, southern Michigan, all of Ohio except the southeast, north-central Kentucky, and upper New York State. Another area extends from Lake Michigan across the southern half of Wisconsin into east-central Minnesota. The Udalfs are found along much of the Mississippi Valley from Minnesota to Louisiana interfingering with wet to marshy alluvial and similar soils.

The typical Spodosols most likely would not be found in Czechoslovakia; however, those shown on incomplete soil maps are located in the west central, southern, and eastern regions, mixed with mountain soils and some Alfisols.

The analogous areas of these Spodosols of the colder climates in the United States are found in New England east of the Hudson River and north of Syracuse; in northern Michigan north of Grand Rapids; in northern-most Wisconsin; and in a very small area of Minnesota along the Canadian border.

E. England

Major soil types in England fall into the orders Alfisol and Inceptisol. The Alfisols are mostly of the Udalf suborder and the Inceptisols of the Dystrochrept great group of the Ochrept suborder.

The Udalf soils are found over most of England except the extreme west and southwest, an area between the North and South Downs, and some areas of limestone soils. There are also areas of Udalfs intermixed with Spodosols, Inceptisols, and organic soils.

The analogous areas of Udalfs in the United States are found in the north-central, northeast, and Mississippi Valley regions. A large area of these soils is found in most of Indiana, southern Michigan, all of Ohio except the southeast, north-central Kentucky, and upper New York State. Another area extends from Lake Michigan across the southern half of Wisconsin into east-central Minnesota. The Udalfs are found along much of the Mississippi Valley from Minnesota to Louisiana interfingering with wet to marshy alluvial and similar soils.

Dystrochrept soils cover all of Cornwall and Devon. There is a small area of Ochrepts southeast of London covering much of what is known as "The Weald". With the exception of some small areas of organic soils, all of Wales is covered with these soils.

The analogous soils of the Ochrepts in the United States are found in several areas, the largest being in the east and northeast. These soils are extensive in southern New York State, much of Pennsylvania, almost all of West Virginia, southeastern Ohio, parts of Kentucky, Indiana, and Tennessee, and in three small isolated areas in central Alabama. There are somewhat similar soils in a small area of east-central Oklahoma extending north into Kansas. Another area of Ochrepts is found in Washington and Oregon, along the coast and Puget Sound.

F. France

A variety of soil types are found in France. The principal types can be classified as Alfisols, Inceptisols, Mollisols, and Spodosols. Udalfs and Xeralfs are predominant in the Alfisol order, Dystrochrepts in the Inceptisol order, and Udolls in the Mollisol order.

Udalfs are found in most of north, west, and central France. They extend from the Belgium border to Normandy, and south to the Massif Central, with the exception of smaller areas of other types of soils in the vicinity of Caen, north of Poitiers, and the Berry district. The eastern extent of this area is about along the 4° east meridian. Another area of Udalfs occurs in the vicinity of Nancy and the Vosges, and along the east side of the Saone River. These soils are also found in the region east of Bordeaux, and in extreme southwest France.

The analogous areas of Udalfs in the United States are found in the north-central, northeast, and Mississippi Valley regions. A large area of these soils is found in most of Indiana, southern Michigan, all of Ohio except the southeast, north-central Kentucky, and upper New York State. Another area extends from Lake Michigan across the southern half of Wisconsin into east-central Minnesota. The Udalfs are found along much of the Mississippi Valley from Minnesota to Louisiana interfingering with wet to marshy alluvial and similar soils.

Very small areas of Xeralf soils occur in the Mediterranean coastal region of France. One area is in the vicinity of Marseille; another is to the northeast and northwest of Montpellier.

The analogous area of Xeralfs in the United States is located in California, extending from Shasta Lake in the north to Bakersfield in the south. These soils are found on the eastern and western slopes of the Sacramento and San Joaquin Valleys. Small areas of Xeralfs are found along the coast just north of Los Angeles and in the vicinity of San Diego.

The largest area of Dystrochrept soils in France is found west of the Rhône River and occupying much of the Massif Central. It extends from about the 44th parallel northward to the 47th. Another area is found in central Brittany extending from the vicinity of Brest nearly southeastward to the Loire River.

The analogous soils of the Ochrepts in the United States are found in several areas, the largest being in the east and northeast. These soils are extensive in southern New York State, much of Pennsylvania, almost all of West Virginia, southeastern Ohio, parts of Kentucky, Indiana, and Tennessee, and in three small isolated areas in central Alabama. There are somewhat similar soils in a small area of east-central Oklahoma extending north into Kansas. Another area of Ochrepts is found in Washington and Oregon, along the coast and Puget Sound.

There are a number of areas of Udolls in France, many of them rather thin upland soils. They are found in the hills and mountains west of the Rhône River extending to the Italian and Swiss border. The soils are extensive in the northeast, including most of the Lorraine and Champagne districts, and south to Dijon. There are Udolls in central Normandy, from Caen south to the Sarne River Valley. Another region is found near the coast in the area between La Rochelle and Cognac (Saintonge District). There are smaller areas of these soils in south-central France in the Quercy and Armagnac Districts and in the vicinity of Toulouse.

The analogous area in the United States for the Udolls is in the central part of the country. The largest continuous area stretches from southern Minnesota to northeastern Oklahoma. The western edge is approximately along the 97° west longitude meridian. The eastern limit is inter-fingered with Alfisols just west of the Mississippi River from about St. Paul,

more or less southward, to the Missouri River. Here, the trend is to the southwest to east central Oklahoma.

A smaller extent of the Udoll type soils is found almost entirely in the northern two-thirds of Illinois. A very small area of these soils is found along both sides of the Red River, from near Texarkana almost to the Mississippi River.

Soils in the Spodosol order are found in the southwestern coastal area known as Landes, from Bordeaux south to Bayonne, and from the coast they extend inland about 75 miles.

The analogous areas of these Spodosols of the colder climates in the United States are found in New England east of the Hudson River and north of Syracuse; in northern Michigan north of Grand Rapids; in northernmost Wisconsin; and in a very small area of Minnesota along the Canadian border.

G. Germany

Germany is covered with much the same type soils as found in France, chiefly of the Alfisol, Inceptisol, Mollisol, and Spodosol orders. The Alfisols are mostly in the Udalf suborder; the Inceptisols in the Dystrochrept group of the Ochrept suborder; the Mollisols in the Udoll suborder; and the Spodosols vary, possibly mostly of the Orthod suborder.

The Udalf soils are found in the southern part of Germany, generally, between Mannheim and Stuttgart, in the vicinity of Würzburg, and along the Alpine foreland from Lake Constance to the Danube River and south of the Danube to the point where it crosses the border into Austria.

In northern Germany these soils are found in an area from the Rhine River to the Harz Mountains between Hannover on the north and Kassel on the south. There is a small area to the southwest and northeast of Bremen and another on the eastern side of Schleswig-Holstein. A large area of Udalfs mixed with Spodosols occurs north of the Elbe River extending across East Germany to the Polish border and southward to Berlin and Frankfurt. Another area is found between Leipzig and Dresden.

The analogous areas of Udalfs in the United States are found in the north-central, northeast, and Mississippi Valley regions. A large area of these soils is found in most of Indiana, southern Michigan, all of Ohio except the southeast, north-central Kentucky, and upper New York State. Another area extends from Lake Michigan across the southern half of Wisconsin into east-central Minnesota. The Udalfs are found along much of the Mississippi Valley from Minnesota to Louisiana interfingering with wet to marshy alluvial and similar soils.

The soils in the Dystrochrept great group are found covering a large part of central Germany from France to East Germany. The southern limit is about on a line from Mannheim to Saarbrücken, and they extend north to a line from Düsseldorf to Göttingen. There is a small area of Dystrochrepts northwest and southwest of Nürnberg. They occur as thin mountain soils along the Czech border from the Thüringer Wald in East Germany to the Böhmer Wald and Danube River area. These soils are also found in the southern part of East Germany in the Ore Mountain area east to the Polish border.

The analogous soils of the Ochrepts in the United States are found in several areas, the largest being in the east and northeast. These soils are extensive in southern New York State, much of Pennsylvania, almost all of West Virginia, southeastern Ohio, parts of Kentucky, Indiana, and Tennessee, and in three small isolated areas in central Alabama. There are somewhat similar soils in a small area of east-central Oklahoma extending north into Kansas. Another area of Ochrepts is found in Washington and Oregon, along the coast and Puget Sound.

Udoll soils in Germany are found in the south-central region, primarily in the limestone plateaus and hills of the Stufenland, Schwäbische Alb and Frankische Alb. They extend from southwestern East Germany to the Danube River and southwestward to the headwaters of the Danube.

The analogous area in the United States for the Udolls is in the central part of the country. The largest continuous area stretches from southern Minnesota to northeastern Oklahoma. The western edge is approximately along the 97° west longitude meridian. The eastern limit is inter-fingered with Alfisols just west of the Mississippi River from about St. Paul, more or less southward, to the Missouri River. Here, the trend is to the southwest to east central Oklahoma.

A smaller extent of the Udoll type soils is found almost entirely in the northern two-thirds of Illinois. A very small area of these soils is found along both sides of the Red River, from near Texarkana almost to the Mississippi River.

The Spodosols are found in most of the northern parts of East and West Germany north of a line from southwest of Münster to Hannover to Braunschweig to Dessau to Dresden, and east to the Polish border. There is also an area of Spodosols in southeastern West Germany, lying generally between Nürnberg and the Czechoslovakian border, and extending southward from the Thüringer Wald to the Austrian border.

The analogous areas of these Spodosols of the colder climates in the United States are found in New England east of the Hudson River and north of Syracuse; in northern Michigan north of Grand Rapids; in northernmost Wisconsin; and in a very small area of Minnesota along the Canadian border.

H. Italy

Italy's dominant soils are those in the Alfisol, Inceptisol, Mollisol, and Vertisol orders. The Alfisols are of the Xeralf suborder; the Inceptisols in the Dystrochrept great group of the Ochrept suborder; the Mollisols in the Udoll suborder; and the Vertisol suborders vary from humid to usually dry types.

Xeralf type soils are found in the southern region and along the west coast from the southern tip of the "boot", north to Livorno. The small, separate areas of these soils are interspersed with alluvial and other types of soils and so are not extensive except in the Murge-Salento region in the southeast.

The analogous area of Xeralfs in the United States is located in California, extending from Shasta Lake in the north to Bakersfield in the south. These soils are found on the eastern and western slopes of the Sacramento and San Joaquin Valleys. Small areas of Xeralfs are found along the coast just north of Los Angeles and in the vicinity of San Diego.

Soils in the Dystrochrept great group are found in several areas of Italy, mostly as thin and rocky phases in the hills and mountains. The largest area is in the Chianti, Valdarno, and Montfeltro region. Another area lies north and south of Lagodi Bolsena. Ochrepts extend from Salerno northward to the Pescara River and northwest to near Rome. Another area is in the vicinity of Genoa.

The analogous soils of the Ochrepts in the United States are found in several areas, the largest being in the east and northeast. These soils are extensive in southern New York State, much of Pennsylvania, almost all of West Virginia, southeastern Ohio, parts of Kentucky, Indiana, and Tennessee, and in three small isolated areas in central Alabama. There are somewhat similar soils in a small area of east-central Oklahoma extending north into Kansas. Another area of Ochrepts is found in Washington and Oregon, along the coast and Puget Sound.

An area of Udoll soils is found in central Italy extending from the Camerinese region southward to the Marsica region. There are other small areas of Udolls near Cilento and in the north central region to the west of Bologna. On the southern slopes of the Dolomite Mountains there are extensive areas of Udolls, from the eastern border westward to the Swiss border, near Lugano, Switzerland.

The analogous area in the United States for the Udolls is in the central part of the country. The largest continuous area stretches from southern Minnesota to northeastern Oklahoma. The western edge is approximately along the 97° west longitude meridian. The eastern limit is interfingered with Alfisols just west of the Mississippi River

from about St. Paul, more or less southward, to the Missouri River. Here, the trend is to the southwest to east central Oklahoma.

A smaller extent of the Udoll type soils is found almost entirely in the northern two-thirds of Illinois. A very small area of these soils is found along both sides of the Red River, from near Texarkana almost to the Mississippi River.

Vertisols occur along most of the east coast of Italy, inland from the alluvial materials and on the slopes of the hills from Foggia in the south to Bologna. There are small scattered areas of Vertisols in southern Italy near Toranto and Catanzaro. In the northwest these soils are found in the Monferrato and Lunigiana Districts and also to the west and south of the Chianti District.

The analogous soils in the United States are found mostly in Texas in a narrow strip running from southwest of San Antonio north to Dallas. Also, they are found along the Rio Grande River from about Del Rio to the Falcon Reservoir and extend northeastward to near College Station.

I. Netherlands

The soils in the Netherlands are primarily of the Spodosol order. These soils are found from the southern border to the Maas River, and in the central region from Utrecht and Wageningen northward to the polders, or reclaimed land, and in an area south of Groningen.

The analogous areas of these Spodosols of the colder climates in the United States are found in New England east of the Hudson River and north of Syracuse; in northern Michigan north of Grand Rapids; in northernmost Wisconsin; and in a very small area of Minnesota along the Canadian border.

J. Poland

The principal soil type in Poland falls in the Udalf suborder of Alfisols. These soils are found over most of Poland, however, very small areas of Spodosols and Mollisols can be found. Large areas of these Udalfs are waterlogged much of the year.

The analogous areas of Udalfs in the United States are found in the north-central, northeast, and Mississippi Valley regions. A large area of these soils is found in most of Indiana, southern Michigan, all of Ohio except the southeast, north-central Kentucky, and upper New York State. Another area extends from Lake Michigan across the southern half

of Wisconsin into east-central Minnesota. The Udalfs are found along much of the Mississippi Valley from Minnesota to Louisiana interfingering with wet to marshy alluvial and similar soils.

K. Portugal

Portugal is split into two well-defined sections by the Tagus valley -- mountainous to the north and lowlands to the south. The climate is mostly temperate and moderate, the country being divided into three clearly defined climatic zones: (1) the northwestern with yearly rainfall in the range of 50 inches and with moderate winters and short summers; (2) the northeastern with long, cold, snowy winters, very hot summers, and precipitation as at the city of Breganea of greater than 50 inches per year; (3) the southern zone with rainfall in the range of 18 to 20 inches per year, moderate winters and long hot summers.

Four major soil groups will be found in Portugal: (1) Inceptisol (Ochrepts); (2) Alfisol (Xeralfs); (3) Spodosol; and (4) Entisol (Psamments).

Inceptisol-Ochrept soils are found in the entire northern half of the country. They extend from the border south to a line from Portalegre to Comora. Most of these soils in the hills and mountains are thin and dry. Along the Atlantic coast they are generally deep and moist.

These soils are typical Ochrepts, however, they fall into several of the great groups, depending mostly on climatic factors. Generally, the analogous area in the United States can be found along the Pacific coast of Oregon and Washington as far south as the Umpqua River, and 25 or so miles inland. Also, the soils are found in a narrow zone around Puget Sound. Similar soils are also to be found in much of the Appalachian region from Alabama to New York.

The areas around Coimbra and Oporta on the coast of Portugal and Bragança in the north have about equivalent annual rainfall to Ft. Lewis, Washington. Coimbra and Ft. Lewis have identical annual rainfall averages. Oporto and Bragança have heavier rainfalls. Ft. Lewis appears to be in the southern edge of Inceptisols around Puget Sound.

Alfisol-Xeralfs are found in the southeastern part of Portugal over most of the region along the border with Spain, and extending from Portalegre south to the Atlantic Ocean. Small areas of Xeralfs are located within the brown forest soils (Ochrepts) of northern Portugal, and in an area north of Lisbon in the Province of Estremadura.

The analogous soils in the United States are found in California, extending from Shasta Lake in the north to Bakersfield in the south. These soils are found on the eastern and western slopes of the Sacramento and San Joaquin Valleys. Small areas of Xeralfs are found along the coast just north of Los Angeles and in the vicinity of San Diego. McClellan AFB and

Beale AFB north of Sacramento and a part of the western edge of Sequoia National Park have Xeralf soils.

The city of Evora, Portugal, is in the general climatic range in which these soils are found. It has an annual rainfall average of 24.7 inches which compares very closely with that of McClellan AFB and Beal AFB in California. The general climate is about the same as found in the area of these two bases which are on soils analogous to the Alfisol-Xeralfs found in this part of Portugal.

Entisol-Psamment soils are found in several areas of Portugal. These are primarily in the coastal area near Comora, and to the east and west of the Tagus River valley near Santarem in the Province of Ribatejo. The soils are composed of loose, sandy sediments with some sand dunes.

The only analogous area in the United States, with a comparable climate, is found in a small area of southeastern Oregon near Crater Lake National Park. There are a number of very small local areas with the Xeropsamment (Psamment soils having an annual dry season) soils within the Sacramento and San Joaquin Valleys of California.

The area near Crater Lake National Park has an annual rainfall of 32 inches which is very close to that of Santarem, Portugal, which has an annual rainfall of about 30 inches. The area in the vicinity of Crater Lake National Park should be a very good analog of the area near Santarem in both soil and climate.

There are areas of Spodosols in the southwest region of Portugal. The Spodosols (Podzols) are found with the alluvial soils along the coast north and south of Lisbon and along the Tagus River. These Spodosols are mostly sandy or coarse loams and silts.

The nearest equivalent or analog soils in the United States are the Aquods of Florida. However, rainfall intensity is much greater in Florida, although the temperature regime of northern Florida is somewhat similar to the southwest of Portugal. Eglin AFB, Florida, is on this type of soil, but it has an average annual rainfall of 61 inches as compared to 27 inches for the area around Lisbon.

L. Soviet Union

Soils in the orders Alfisol, Aridisol, Molisol, and Spodosol predominate in Russia. The Alfisols are in the suborder Boralf; the Aridisols are in various suborders; the Mollisols are grouped into both Borolls and Ustolls; and the Spodosols fall into various suborders.

Aridisol soils are found in a large area of southern European Russia in the region around the northern part of the Caspian Sea and the Aral Sea. The western limit extends from the Caspian Sea at Makhachkala northwest to the 45th meridian and north to the 50th parallel. Here the northern limits of these Aridisols more or less follow 50° north latitude eastward. The southern limits generally follow the northern boundary of Turkmen S. S. R. to the east. No eastern limit has been given, as the Aridisols extend much farther east into Asian Russia.

The soils in the United States analogous to the European Aridisols are found in large areas of the Southwest and West. They occur in Texas from the Pecos River west, in much of New Mexico, northeast and southern Arizona, southeastern California, most of Nevada, and scattered areas of Utah, Colorado, and Wyoming.

The Boralf soils are found over a very large area in north-central European Russia. They extend eastward from the Baltic Sea and Polish border to the Ural Mountains. The southern limit begins at about the Carpathian Mountains in western Ukraine and extends in a generally northeastward direction to about the vicinity of Tula and Ryazan south of Moscow. From this point the line goes eastward to the Ural Mountains. The northern limits of the Boralfs extend from near Leningrad eastward along the 60th parallel to the Ural Mountains.

The analogous area of the Boralfs in the United States is found in the northern part of Minnesota from near the Canadian border to south of Duluth and extending into Wisconsin and Michigan along the shore of Lake Superior as far east as the Houghton area. There are scattered areas of these soils in the Rocky Mountains from northern Idaho into Wyoming. They can be found in much of west-central Colorado, extending southward from the Wyoming border into north-central New Mexico.

Boroll soils are found in an area of middle Russia extending from the borders of Czechoslovakia and Romania to the Ural Mountains. The southern boundary of the Borolls lies in a nearly northeast to east-northeast direction, beginning at the Romanian border. It passes close to Kirovograd and Kharkov in the Ukraine, and to Saratov on the Volga River, then to Kuybyshev. At this point it swings to the southeast to the Orenburg-Orsk region, and then northeast to the Ural Mountains. The northern boundary of these Boroll soils roughly parallels the southern extent to the Ural Mountains, beginning at about the area where the Czech and Polish borders meet with the Russian border.

The analogous soils occur in the United States almost entirely north of 45° latitude. They are found across the northern part of Montana, in all except a small part of North Dakota, in northeastern South Dakota, and in western Minnesota. There are small areas of Borolls scattered across Wyoming and in southwestern Montana.

Soils in the Spodosol order are found in north central European Russia from the Baltic Sea to the Ural Mountains. They lie between about 60° and 64° north latitude.

The analogous areas of these Spodosols of the colder climates in the United States are found in New England east of the Hudson River and north of Syracuse; in northern Michigan north of Grand Rapids; in northernmost Wisconsin; and in a very small area of Minnesota along the Canadian border.

The Ustoll soils are found in a strip from Romania to the Ural Mountains. The southern boundary follows the Black Sea coast to the 44th parallel, turns eastward to the 44th meridian and follows this northward to about the 50th parallel. The boundary then turns eastward along the 50° north parallel to the Ural Mountains. The northern boundary of the Ustolls lies in a nearly northeast to east-northeast direction, beginning at the Romanian border. It passes close to Kirovograd and Kharkov in the Ukraine, and to Saratov on the Volga River, then to Kuybyshev. Here it swings south-eastward to the Orenburg-Orsk region and then northeastward to the Ural Mountains.

The analogous area in the United States runs generally in a north-south direction from South Dakota to Texas. The eastern boundary roughly parallels about 97° west longitude to Central Texas, where it swings west to Del Rio on the Mexican border, and then the west boundary runs northward. This line is extremely variable but trends in a more or less north-northwesterly direction. Within the region of the Ustolls, there are large areas of soils of other types, such as the sand dunes (psamments) of Nebraska, and many areas of Alfisols in Texas. There are also soils classified as Ustolls in western Colorado, central Arizona, and scattered areas in New Mexico.

M. Scotland

The principal soil order found in Scotland is the Spodosol. These soils cover almost all of the country; however, there are small areas of highly organic soils and peats included which are not classified as Spodosols.

The analogous areas of these Spodosols of the colder climates in the United States are found in New England east of the Hudson River and north of Syracuse; in northern Michigan north of Grand Rapids; in northernmost Wisconsin; and in a very small area of Minnesota along the Canadian border.

N. Spain

Spain has four major soil orders. They are the Alfisols, the Aridisols, the Inceptisols, and the Mollisols. The Alfisols are of the subgroups Ustalfs and Xeralfs; the Aridisols are considered to be of various suborders; the Inceptisols are in the Dystrochrept great group of the Ochrept suborder; and the Mollisols are in the Udoll and Xeroll suborders.

Aridisol soils are found in several areas of Spain, the largest to the north and south of Zaragoza. They extend north to about Huesca, south to about Molina, and from the Segre River west to about Tudela. A smaller area of these soils occurs in the region between Palencia and Zamora in northwestern Spain. Another area of these soils is found on the Mediterranean coast between Cartagena and Almeria and extending inland about 75 miles.

The soils in the United States analogous to the European Aridisols are found in large areas of the Southwest and West. They occur in Texas from the Pecos River west, in much of New Mexico, northeast and southern Arizona, southeastern California, most of Nevada, and scattered areas of Utah, Colorado, and Wyoming.

Dystrochrepts are found in the northwest of Spain along the Atlantic coast as far east as Gijon. Another area extends from the northern border of Portugal northeastward along the southern slopes of the Cordillera Cantabrica to about 4° west longitude.

The analogous soils of the Ochrepts in the United States are found in several areas, the largest being in the east and northeast. These soils are extensive in southern New York State, much of Pennsylvania, almost all of West Virginia, southeastern Ohio, parts of Kentucky, Indiana, and Tennessee, and in three small isolated areas in central Alabama. There are somewhat similar soils in a small area of east-central Oklahoma extending north into Kansas. Another area of Ochrepts is found in Washington and Oregon, along the coast and Puget Sound.

An extensive area of Udolls with Rendzina soils is found along the north coast near Santander and extending eastward along the southern slopes of the Pyrenees Mountains to the Mediterranean coast.

The analogous area in the United States for the Udolls is in the central part of the country. The largest continuous area stretches from southern Minnesota to northeastern Oklahoma. The western edge is approximately along the 97° west longitude meridian. The eastern limit is interfingered with Alfisols just west of the Mississippi River from about St. Paul, more or less southward, to the Missouri River. Here, the trend is to the southwest to east central Oklahoma.

A smaller extent of the Udoll type soils is found almost entirely in the northern two-thirds of Illinois. A very small area of these soils is found along both sides of the Red River, from near Texarkana almost to the Mississippi River.

Soils of the Ustalf great group of Alfisols are found in most of eastern and southern Spain. They extend eastward from about 4° west longitude to the Mediterranean Sea. Except for several small areas of other type soils, they extend southward from south of the Ebro River to the south coast of Spain.

The analogous areas of Ustalf soils in the United States are almost entirely within Texas. They extend from east of Dallas south to Houston, then southwest to the Rio Grande Valley. The western extent of this area is from Dallas to Austin to San Antonio, and southwest to the Nueces River. A small area of these soils is found in Central Texas in the vicinity of Llano. Another small area lies at the headwater of the North Fork of the Red River on the Oklahoma border. A large area of Ustalfs is located in West Texas extending from about the 100th meridian west to the Pecos River in New Mexico, and from the Brazos River south to the Pecos River in southwest Texas.

Xeralf soils are found in a vast region of western Spain extending southward from about the 42nd parallel to the Atlantic coast in the south. They are found from Portugal eastward to Segovia and Madrid in the north and as far east as Cordoba, Linares, and Valdepenas in the south.

The analogous area of Xeralfs in the United States is located in California, extending from Shasta Lake in the north to Bakersfield in the south. These soils are found on the eastern and western slopes of the Sacramento and San Joaquin Valleys. Small areas of Xeralfs are found along the coast just north of Los Angeles and in the vicinity of San Diego.

Xeroll type soil is found in the Palencia area between Burgos and Valladolid, in the central area between Madrid and Toledo, and in smaller areas south and west of Murcia.

In the United States, the analogous soils are found primarily in California. The largest area is from San Francisco Bay northward and to the east of the Russian River to just north of Clear Lake. Other smaller areas are to the south of San Francisco along the Pacific coastal area only a few miles inland and southward to San Luis Obispo. Another area is on the coast just north of San Diego.

There are also large areas of these Xerolls in the Rocky Mountain regions of Washington, Oregon, Utah, and Colorado. However, most of these soils are intermixed with other thin mountain soils.

O. Turkey

Two principal soil types are found in Turkey. These are the Alfisols and the Mollisols. The Alfisols are of the Udalf and Ustalf great groups, and the Mollisols are of the Udoll and Ustoll great groups.

Udalfs are found as thin mountain lithosols in a number of areas of Turkey. In the west they occur primarily in an area between the 28th and 30th meridians and north and south of the Simav River. The thin soils are found in a large area of east-central Turkey centered between the 38th and 40th parallels and the 38th and 40th meridians, extending outward to the northeast in a narrow band to the Russian border, and to the northwest along the south slopes of the coastal mountains. There are other small areas of Udalfs which are also thin mountain soils in the vicinity of Hakkari in the southeast, and to the northeast of Lake Van.

The analogous areas of Udalfs in the United States are found in the north-central, northeast, and Mississippi Valley regions. A large area of these soils is found in most of Indiana, southern Michigan, all of Ohio except the southeast, north-central Kentucky, and upper New York State. Another area extends from Lake Michigan across the southern half of Wisconsin into east-central Minnesota. The Udalfs are found along much of the Mississippi Valley from Minnesota to Louisiana interfingering with wet to marshy alluvial and similar soils.

Soils of the Udoll type are found in the east-central mountains of Turkey south and west of Lake Van. The southern boundary is about 38° north latitude. Two smaller areas are located farther west, one between the 38th and 40th meridians on the 38th parallel, and the other west of Malatya. There are Udoll soils, with chestnut and alluvial soils, in the northwest region from the Black Sea southward to the Sakarya River. Another large area of these soils, with alluvial and Alfisols, is found in the Danizli-Aydin region.

The analogous area in the United States for the Udolls is in the central part of the country. The largest continuous area stretches from southern Minnesota to northeastern Oklahoma. The western edge is approximately along the 97° west longitude meridian. The eastern limit is interfingering with Alfisols just west of the Mississippi River from about St. Paul, more or less southward, to the Missouri River. Here, the trend is to the southwest to east central Oklahoma.

A smaller extent of the Udoll type soils is found almost entirely in the northern two-thirds of Illinois. A very small area of these soils is found along both sides of the Red River, from near Texarkana almost to the Mississippi River.

The Ustalf soils are found in large areas of central and southern Turkey. They extend from about the 30th meridian eastward to beyond the 36th in the Central Plateau, and from north of Ankara southward to the Mediterranean Sea. They are interfingered with Podzols in the area east of Lake Tuz, and alluvial soils are found throughout. The Ustalfs occur as Red Mediterranean soils along the south coast from west of Mugla eastward to the border with Syria.

The analogous areas of Ustalf soils in the United States are almost entirely within Texas. They extend from east of Dallas south to Houston, then southwest to the Rio Grande Valley. The western extent of this area is from Dallas to Austin to San Antonio, and southwest to the Nueces River. A small area of these soils is found in Central Texas in the vicinity of Llano. Another small area lies at the headwater of the North Fork of the Red River on the Oklahoma border. A large area of Ustalfs is located in West Texas extending from about the 100th meridian west to the Pecos River in New Mexico, and from the Brazos River south to the Pecos River in southwest Texas.

In Turkey Ustoll soils are found in a large area north of Lake Van in the eastern part of the country. The area is very mountainous, so most of these soils are thin and rocky. They extend from the Russian-Iranian border westward to the 11,000-ft. mountain peaks just east of Erzincan, a distance of about 200 miles. The north-south extent is only about 100 miles. There is a small area of chestnut soils in the Mardin region, near the Syrian border, and small scattered areas in the north and northwest.

The analogous area in the United States runs generally in a north-south direction from South Dakota to Texas. The eastern boundary roughly parallels about 97° west longitude to Central Texas, where it swings west to Del Rio on the Mexican border, and then the west boundary runs northward. This line is extremely variable but trends in a more or less north-northwesterly direction. Within the region of the Ustolls there are large areas of soils of other types, such as the sand dunes (psamments) of Nebraska, and many areas of Alfisols in Texas. There are also soils classified as Ustolls in western Colorado, central Arizona, and scattered areas in New Mexico.

P. Selected Areas in the Federal Republic of Germany

1. Flensburg

Flensburg is located in northernmost Germany, near the Danish border, and at the head of the Flensburger Förde. It is at the juncture

of the eastern moraine belt with the sand plains to the west. Flensburg itself is located on the gray-brown podzolic soils of the moraine. The equivalent in the U. S. classification are the Udalfs, the moist soils of the Alfisol order. These soils are analogous to the soils found in much of Indiana and Ohio, in large areas of Minnesota, Wisconsin, Michigan, Kentucky, New York, Tennessee, and in smaller areas of states bordering the Mississippi River. To the west of Flensburg the sandy soils are classified as Spodosols. These soils are analogous to those of northern Michigan.

Climatic conditions for Flensburg are not available, but data for Kiel will be given. Kiel is about 43 miles southeast of Flensburg. The average yearly rainfall is 27.6 inches, distributed fairly evenly throughout the year. Average January temperature is 32°F and average July temperature is 62°F. The latitude of Flensburg is about 54°48' north. The same latitude in North America is located along the southern boundary of Canada. However, climatewise the area is comparable to that of northern Michigan and Wisconsin.

2. Koblenz

At Koblenz, the Rhine valley broadens out into the Neuwied Basin and immediately narrows again at Neuwied. The Mosel River enters the Rhine at Koblenz. Most of the surrounding area is classified as acid brown forest soils with rocky and/or shallow phases; the U. S. Classification is Inceptisol-Ochrept, and further classified as probably most nearly that of the Dystrochrepts. Most general maps showing soil distributions in Europe represent central and southern Germany as having a more or less gray-brown podzolized soil. However, recent data place the Koblenz area in the acid brown forest soil type.

The soil is primarily a mixture of loess and volcanic-derived pumice. The region is one of the driest in Germany. Rainfall average is about 25.5 inches a year. Average January temperature is 34.5°F and average July temperature is 65.5°F.

Koblenz is located at about 50°21' North. The same latitude in North America falls just north of the U. S. border in southern Canada. However, according to climate and soil characteristics, the equivalent or analog area can be located along the western highlands of West Virginia, southern Indiana, eastern Ohio, and parts of Pennsylvania and New York.

The only area of the U. S. with a soil that is loessial and classified as a Dystrachrept is a small region of the Ohio River valley between Cincinnati, Ohio, and Louisville, Kentucky.

3. Meppen

Meppen is located in northwestern Germany at about 52°41' north latitude and 7°17' east longitude, on the east bank of the Ems River at the confluence of the Hase River, and about 60 miles inland from the North Sea. The general region is known as the northern lowlands, and this particular area is called Emsland. It is an area of sand and peat bogs, part of the glacial terminal moraine remnants, and generally poor, leached, infertile soils. Some of the land has been deep-plowed to mix the sand and peat. This has created an "artificial" soil type but provided thousands of acres of arable farm land.

The climate is somewhat similar to that of Michigan. The climatic data for Meppen is not available; however, the figures for Münster, Bremen, and Groningen have been combined to give an average for the region. These cities are to the south, northeast, and northwest of Meppen. The average January temperature is about 34°F and the average for July is about 63.3°F. The yearly average rainfall is about 28.6 inches, with amounts distributed very evenly throughout the year. Data indicate that about 12 days each month will be rainy.

According to the soil surveys, Meppen itself is located on alluvial river sands, but just to the east of town is the typical podzolized (spodosol) soil of northern Germany. The area is analogous to that of much of northern Michigan.

4. Munsterlagen

The Munster region is located in northeastern West Germany at about the center of the Lüneburg Heath. Munster is situated about halfway between Hamburg and Hannover at 52°59' north latitude and 10°05' east longitude. It is in the region known as the northern lowlands. The heathland itself is a remnant of a terminal moraine from the last glaciation period. It is an area predominantly sandy, with many boulders.

The climate of Munster is similar to that of Hannover, and that data will be given. Hannover has an average January temperature of 33°F and a July average of 62.5°F. The average yearly rainfall is 23.9 inches, falling fairly uniformly throughout the year, with a slight increase during the summer months.

The podzolized (Spodosol order) soils of the Munster region are generally iron-humus podzols, and may have small local areas of gley or pseudo-gley soils. Bogs and peaty depressions are not uncommon, but are not as extensive as those found to the west. The soils are extensively

leached or podzolized and normally infertile unless maintained properly. These soils are analogous to the Spodosol soils of upper Michigan in the United States.

5. Reichenhall

Bad Reichenhall is on the northern Alpine slopes in what is generally known as the Berchtesgaden Alps. It is in the extreme southeast of Germany, within a few miles of the Austrian border, and about 10 miles from Salzburg, Austria. The surrounding mountains reach elevations of over 5,000 feet. Reichenhall is located on the south side of a branch of the Salzach River at about 2,000 feet elevation. Most of the soils of the area are derived from the limestone making up the mountain ranges of the region. They are typically shallow, calcareous soils containing marl and limestone debris. These soils may or may not be developed. They are chiefly classified as mixtures of Rendolls and probably some calcareous Cryaquols, cold wet soils of the Mollisol order (Alpine meadow soils).

Climatic conditions for Reichenhall are not available, but data for Salzburg, Austria, are and will be used. The average rainfall is about 52 inches per year with seven to eight inches falling each month in the summer. No month has less than an average of 2.4 inches of rain nor less than 10 days each month without rain. The relative humidity almost never drops below 50 percent. The average January temperature is 30°F and the July average is 65°F. Temperatures quite often fall to the forties during summer and below zero in winter.

There is no particular region in the U. S. that has a similar soil history, together with the climatic conditions of the Reichenhall location. Also a factor, the parent limestone mountains of this area of the Alps are not generally found in the U. S. where cold and wet climatic conditions prevail. Although Reichenhall is located at about 47°43' north latitude, which is found along the northern border of the U. S., the altitude further affects local climatic factors.

The soils of the rendzina type are generally placed in the Mollisol group in the U. S. classification. However, a similar type derived under forests instead of grasses is the brown forest soils of Eutrochrepts, with free carbonates in the subsurface. Several small areas of Eutrochrepts can be found in the U. S., although not with the cold regime of Reichenhall. One area can be located to the southwest of Cincinnati, Ohio; one in northwest North Carolina; and another in Alabama to the west of Montgomery. The region west of Montgomery also has the equivalent rainfall of Reichenhall, an average of 52 inches a year, producing an almost continually moist soil as it is in the Alpine regions.

6. Rendsburg

Rendsburg is located in northernmost Germany, between the Kiel Canal and the Eider River, and at the juncture of the eastern moraine belt with the sand plain to the west. Rendsburg is itself located on the sandy outwash. However, depending on where the soil sampling is to be done determines whether the area will be placed in the gray brown podzolic soil classification (Udalfs) to the east of town or in the podzolized group (Spodosols) west of town.

Assuming that the area is placed in the Spodosol soil group, the analogous area in the United States will also be similar to that of the Munsterlagen (Lüneburger Heide) and the Meppen regions.

Climatic conditions for Rendsburg are not available but data for Kiel will be given. Kiel is about 20 miles east of Rendsburg. The average yearly rainfall is 27.6 inches, distributed fairly evenly throughout the year. Average January temperature is 32°F and average July temperature is 62°F.

The latitude of Rendsburg is about 54°18' north. The same latitude in North America is in Canada. However, climate-wise the area is comparable to that of northern Michigan and Wisconsin. The region on the east side of Lake Michigan and north of Grand Rapids is analogous also in the general soil types found at Rendsburg.

Q. Military Installations Located on Analog Areas of the Federal Republic of Germany

1. Flensburg, Rendsburg, Meppen, and Munsterlagen

These areas have soils and climates analogous to the northern Michigan area. The following military installations are located in this area and have analog soil types and are in the same climatic regime: (1) Calumet Air Force Station, Calumet, Michigan; (2) Empire Air Force Station, Empire, Michigan; (3) K. I. Sawyer Air Force Base, Michigan; (4) Muskegon Army Engine Plant, Muskegon, Michigan; (5) Wurtsmith Air Force Base, Oscoda, Michigan.

Soil analogs can be found at Memphis Naval Air Station, Millington, Tennessee and Sewart Air Force Base, Tennessee. These bases have milder climates but do have light snow cover during winter.

2. Koblenz

Two military bases were located that have soils representative of Koblenz and fairly good climate analogs. The largest difference is that they have greater amounts of rainfall. The installations are Fort Knox, Kentucky, and Jefferson Proving Grounds, Madison, Indiana.

3. Reichenhall

No climate analog was found in the United States for Reichenhall, but two military installations were found that are located in Alabama and have similar soils and soil moisture to that found in the Alpine regions. The bases are Maxwell Air Force Base west of Montgomery, Alabama, and Craig Air Force Base near Selma, Alabama.

IV. SOILS ANALOG DISPLAY KIT

A. Description

A special kit was designed to use as a display device to provide a quick general overview of areas in the Continental United States that had soils analogous to those found in selected areas in the rest of the world. Figure 1 is a set of photographs showing four views of the finished kit.

The display kit is packaged in a hand-finished walnut box, whose dimensions are 25-1/2 inches wide x 21-3/4 inches high x 3-1/4 inches deep in the form of a carrying case. The lid opens to display a colored soils map of the Continental United States. The lid has a felt-lined compartment in which is located the special overlays that outline the analog soil areas on the map. The outline portion is transparent and the remainder is opaque. The kit contains 42 overlay maps representing sections of 14 countries plus the National Forest System map. National forests and grasslands are suggested as possible field site areas for mine detector evaluation.

B. Instructions for Use of Display Kit

The kit should be placed on a flat area large enough for the lid to be opened and laid flat so that the lid compartment can be opened. The compartment is then opened and the area of the country desired selected from the enclosed overlay transparencies. Next, the hinged frame is raised and the selected overlay placed on the soils map. Pins located in the upper corners of the map provide proper alignment. The hinged frame is then lowered. The analog soil area in the CONUS is now displayed showing, also, any national forests or grasslands in the area. The soil map is color coded to provide a key to soils information located in a box in the lower corner of the map.



(a) Finished
Display Kit

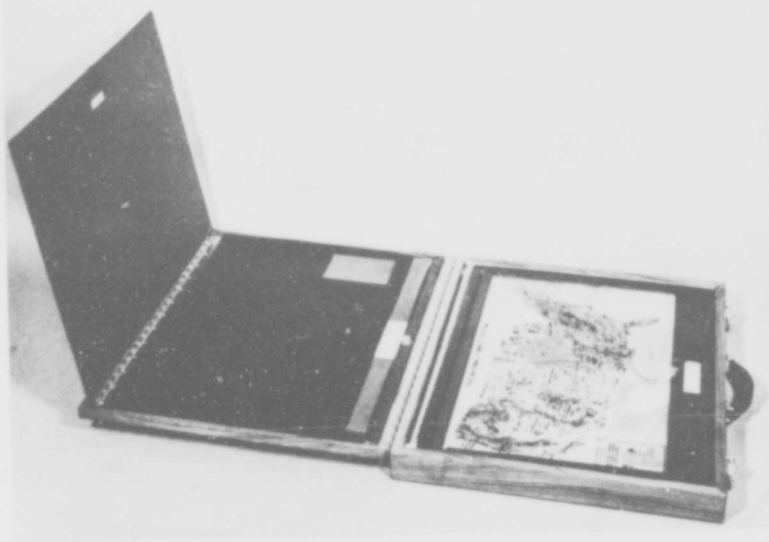


(b) Open Kit Showing
Soil Map with the
National Forest
System Map
Overlay

FIGURE 1. PHOTOGRAPHS OF SOILS ANALOG DISPLAY KIT



(c) Open Kit Showing
Soil Map with
National Forest
System Overlay
Map Raised



(d) Kit with Lid
Compartment
Open Showing
Overlay Map
Storage
Compartment

FIGURE 1. (cont.)

V. CONCLUSIONS AND RECOMMENDATIONS

This literature survey has provided very useful background information on world soils. Similar soil types can be found in many geographical areas sometimes existing in similar climates and sometimes in very different ones. The soils literature available is not complete, but it contains at least minimal information on soils and general climatic conditions in most parts of the world.

It is concluded from this study that analogs of soils in most world areas can be found in the Continental United States. In a great many cases both soil and climatic analogs can be found in the same area, especially if small specific areas can be selected. However, since soil types can vary within even a few feet in some locations, a positive analog cannot be determined in all instances from the generalities provided by the literature. An on-site inspection must be made and soil samples from the two areas should be analyzed and compared.

Three field sites in the United States on which land mine detectors can be tested were selected based on information provided by this survey. These sites were chosen as analogs of selected areas in West Germany and are located on military installations. The validity of the soil analog will be determined by an analysis of soil samples from both the German and the analog areas. Some or all of these sites will be used in another phase of this program for field tests over a 12-month period.

It is recommended that this work be expanded to provide more complete data and to improve the analog Display Kit. The following additions are recommended:

1. Extend the search for world climatic data. More areas need to be covered and in more detail.
2. Continue the search for world soil information to gain data on smaller more closely identified areas.
3. Collect information on locations of Government owned lands including all military reservations.
4. Obtain soil samples from as many locations in the world as possible. This should be a continuous operation.
5. Analyze and catalog soil properties of collected samples.
6. Construct climatic overlay transparencies that can be used with the Soils Analog Display Kit. By using both a soils analog and climatic analog overlay simultaneously, analog areas could be more quickly selected.

7. Construct an overlay map to be used with the display kit locating all military bases and other accessible Government lands in the United States.

8. There is evidence that the electrical parameters of soils are strongly related to soil physical properties such as moisture content and particle size and type. A study should be made to locate world soil analogs based on a physical classification using soils engineering/geological methods instead of agricultural classifications. There is considerable information available on surface geology and soils engineering from many areas of the world where very little information is available on agricultural properties. The two analog selection methods should then be compared to determine the one that best relates the electrical properties of the soils.

9. Data from earth resources satellites should be studied as a source to determine ground conditions and from these, soil types. Infrared and radar scans from these satellites are already being used to determine ground geology and even soil moisture based on such information as sand/clay ratios. Cloud cover information gained from these sources might also aid in the selection of climatic analogs related to infrared detection studies.

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APPENDIX

Field Offices of the Forest Service
U. S. Department of Agriculture
Washington, D. C. 20250

This Forest Service field office list is provided as a convenience. Permission to conduct tests in an analog area located in a national forest would require contacting the proper office.

Forest Service Regional Offices and addresses are listed, followed by the National Forests and their headquarters locations. Research unit and State and Private Forestry Area headquarters are also listed.

NORTHERN REGION
Federal Bldg.
Missoula, Mont. 59801

Idaho

Forest

Headquarters City

Clearwater
Coeur d'Alene
Kaniksu
Nezperce
St. Joe

Orofino
Coeur d'Alene
Sandpoint
Grangeville
St. Maries

Montana

Beaverhead
Bitterroot
Custer
Deerlodge
Flathead
Gallatin
Helena
Kootenai
Lewis and Clark
Lolo

Dillon
Hamilton
Billings
Butte
Kalispell
Bozeman
Helena
Libby
Great Falls
Missoula

Washington

Colville

Colville

SOUTHWESTERN REGION
517 Gold Ave., S. W.
Albuquerque, N. Mexico 87101

Arizona

Apache
Coconino
Coronado
Kaibab
Prescott
Sitgreaves
Tonto

Springerville
Flagstaff
Tucson
Williams
Prescott
Holbrook
Phoenix

New Mexico

Carson
Cibola
Gila
Lincoln
Santa Fe

Taos
Albuquerque
Silver City
Alamogordo
Santa Fe

CALIFORNIA REGION
630 Sansome St.
San Francisco, California 94111

California

Angeles
Cleveland
Eldorado
Inyo
Klamath
Lassen
Los Padres
Mendocino
Modoc
Plumas
San Bernardino
Sequoia
Shasta-Trinity
Sierra
Six Rivers
Stanislaus
Tahoe

Pasadena
San Diego
Placerville
Bishop
Yreka
Susanville
Santa Barbara
Willows
Alturas
Quincy
San Bernardino
Porterville
Redding
Fresno
Eureka
Sonora
Nevada City

ROCKY MOUNTAIN REGION
Federal Center, Bldg. 85
Denver, Colo. 80225

Colorado

Arapaho
Grand Mesa - Uncompahgre
Gunnison
Pike
Rio Grande
Roosevelt
Routt
San Isabel
San Juan
White River

Golden
Delta
Gunnison
Colorado Springs
Monte Vista
Fort Collins
Steamboat Springs
Pueblo
Durango
Glenwood Springs

Nebraska

Nebraska

Chadron

South Dakota

Black Hills

Custer

Wyoming

Bighorn
Medicine Bow
Shoshone

Sheridan
Laramie
Cody

INTERMOUNTAIN REGION
324 25th Street
Ogden, Utah 84401

Idaho

Boise
Caribou
Challis
Payette
Salmon
Sawtooth
Targhee

Boise
Pocatello
Challis
McCall
Salmon
Twin Falls
St. Anthony

Nevada

Humboldt
Royabe

Elko
Reno

Utah

Ashley
Cache
Dixie
Fishlake
Manti-La Sal
Uinta
Wasatch

Vernal
Logan
Cedar City
Richfield
Price
Provo
Salt Lake City

Wyoming

Bridger
Teton

Kemmerer
Jackson

PACIFIC NORTHWEST REGION
319 S. W. Pine St., P. O. Box 3623
Portland, Oregon 97208

Oregon

Deschutes
Fremont
Malheur
Mount Hood
Ochoco
Rogue River
Siskiyou
Siuslaw
Umatilla
Umpqua
Wallowa-Whitman
Willamette
Winema

Bend
Lakeview
John Day
Portland
Prineville
Medford
Grants Pass
Corvallis
Pendleton
Roseburg
Baker
Eugene
Klamath Falls

Washington

Gifford Pinchot
Mount Baker
Okanogan
Olympic
Snoqualmie
Wenatchee

Vancouver
Bellingham
Okanogan
Olympia
Seattle
Wenatchee

EASTERN REGION
633 West Wisconsin Ave.
Milwaukee, Wis. 53203

Illinois

Shawnee Harrisburg

Indiana

Hoosier Bedford

Michigan

Hiawatha Escanaba
Huron Cadillac
Manistee Cadillac
Ottawa Ironwood

Minnesota

Chippewa Cass Lake
Superior Duluth

Missouri

Clark Rolla
Mark Twain Springfield

New Hampshire

White Mountain Laconia

Ohio

Wayne Bedford, Ind.

Pennsylvania

Allegheny Warren

Vermont

Green Mountain Rutland

West Virginia

Monogahela Elkins

Wisconsin

Chequamegon
Nicolet

Park Falls
Rhineland

SOUTHERN REGION
50 Seventh St. N. E.
Atlanta, Ga. 30323

Alabama

National Forests in Alabama, 502 Washington Ave., Montgomery 36101
William B. Bankhead Talladega
Conecuh Tuskegee

Arkansas

Ouachita Hot Springs
Ozark Russellville
St. Francis Russellville

Florida

National Forests in Florida, 214 South Bronough St., Tallahassee 32302
Apalachicola Osceola
Oscala

Georgia

National Forests in Georgia, 322 Oak St. N. W., Gainesville 30501
Chattahoochee Oconee

Kentucky

Daniel Boone Winchester

Louisiana

Kisatchie Pineville

Mississippi

National Forests in Mississippi, 380 Milner Bldg., P. O. Box 1291, Jackson 39205
Bienville Holly Springs
Belta Homochitto
DeSoto Tombigbee

North Carolina

National Forests in North Carolina, P. O. Box 731, Asheville 28802
Croatan Pisgah
Nantahala Uwharrie

South Carolina

National Forests in South Carolina, 1813 Main St., Columbia 29201
Francis Marion Sumter

Tennessee

Cherokee Cleveland

Texas

National Forests in Texas, Federal Bldg., P. O. Box 969, Lufkin 75902
Angelina Sabine
Davy Crockett Sam Houston

Virginia

George Washington Harrisonburg
Jefferson Roanoke

ALASKA REGION
Federal Office Bldg.
P. O. Box 1628
Juneau, Alaska 99801

Alaska

Chugach Anchorage
North Tongass Juneau
South Tongass Ketchikan

RESEARCH HEADQUARTERS

Laboratory

Forest Products Laboratory, North Walnut St. , Madison, Wis. 53705

Institutes

Institute of Tropical Forestry, P. O. Box 577, Rio Piedras, P. R. 00928

Forest and Range Experiment Stations

Pacific Northwest -- 809 NE. Sixth Ave. , Portland, Oreg. 97212

Pacific Southwest -- 1960 Addison St. , Berkeley, Calif. 94701

Intermountain -- 507 25th St. , Ogden, Utah 84401

Rocky Mountain -- 240 West Prospect St. , Fort Collins, Colo. 80521

North Central -- Folwell Ave. , St. Paul, Minn. 55101

Northeastern -- 6816 Market St. , Upper Darby, Pa. 19082

Southern -- Federal Bldg. , 701 Loyola Ave. , New Orleans, La. 70113

Southeastern -- Post Office Bldg. , Asheville, N. C. 28802

STATE AND PRIVATE FORESTRY AREAS

State and Private Forestry offices are located in the Regional Headquarters with the exception of the following Areas:

Northeastern Area - S&PF (includes States in the Eastern Region)

6816 Market St. , Upper Darby, Pa. 19082

Southeastern Area - S&PF (includes States in the Southern Region)

50 Seventh St. NE. , Atlanta, Ga. 30323