

Cryosolic pedons from Russia and Alaska, Version 1

USER GUIDE

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Notice: This data set was first published on the [1998 CAPS CD](#).

The text for this document was taken unchanged from that CD.

1 U.S. PEDON DATA ON THE CAPS CD-ROM, IS A SAMPLE OF THE PEDON DATA CONTAINED ON A CD-ROM PRODUCED BY THE NATIONAL SOIL SURVEY CENTER - SOIL SURVEY LABORATORY, U.S. DEPARTMENT OF AGRICULTURE, LINCOLN, NEBRASKA.

The National Soil Survey Center - Soil Survey Laboratory (SSL) is pleased to make available recent pedon data from analyses for soil characterization and research within the National Cooperative Soil Survey. Less than complete characterization data are available for many pedons because only selected measurements were planned or because the planned measurements are not yet complete. This database is dynamic: data for additional pedons are added as they are sampled and analyzed, other information is updated as pedons are classified, suspect measurements are rerun and replaced, and errors are found and corrected. The data on the SSL CD-ROM (the source of the data provided for the CAPS CD-ROM Version 1.0) represents a 'snapshot' of the database.

The database includes pedons that represent the central concept of a soil series, pedons that represent the central concept of a map unit but not of a series, and pedons sampled to bracket a range of properties within a series or landscape. Thus, attribute data for some data elements may be incomplete or missing for certain portions of the United States. In instances where data are unavailable, a mask should be used to exclude the area from the analysis. For research purposes all data are retained in the database.

Users unfamiliar with a given soil or set of data may want to consult with a research soil scientist at the National Soil Survey Center. A research soil scientist can be reached by telephone at (402) 437-5006, or by writing the Soil Survey Laboratory Head, National Soil Survey Center, Natural Resources Conservation Service, Federal Building, Room 152, 100 Centennial Mall North, Lincoln, NE 68508-3866. Please do not contact the IPA or NSIDC for information the content of these pedon data.

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The Soil Survey Laboratory, National Soil Survey Center, Natural Resources Conservation Service, Lincoln, Nebraska, USA, should also be credited for any use of these data.

Analytical procedures are identified by methods codes in the column headings of the standard SSL data sheets and are described in Soil Survey Investigations Report (SSIR) No. 42. Strict quality control measures were applied in the analytical procedures but the SSL does not warrant that the data are error free nor that the measurements in all cases are within the applicability range of the laboratory methods (See SSIR No. 42 for applicability range). For example, dispersion of clay in some soils is incomplete for determining particle size distribution, determinations of clay minerals by X-ray diffraction are relative, and measurements of very high or very low quantities by any method are not very precise. Other measurements have limitations in some kinds of soils. Such data are retained in the database for research purposes. The assessment of accuracy and applicability is strictly a user responsibility.

Ellis Benham, Research Soil Scientist, developed the relational data models, processed and formatted the ASCII data, wrote the data element definitions, produced the relational databases, and recorded the CD-ROM.

Steve Baird, Computer Specialist (Programmer Analyst), unloaded the primary data and provided information on data element definitions and calculation routines.

Tom Reinsch, Soil Scientist, supplied information on erroneous values in the raw data, and provided assistance with Access and the correction of systematic errors in the ASCII data.

Rebecca Burt, Research Soil Scientist, provided information on data calculation routines and method codes.

Jim Culver, Chair, NSSC, provided management support and resources for the project.

1.2 ANALYTICAL METHODS

Detailed explanation of the methods are given in Soil Survey Investigations Report No. 42, 1992. Each method is listed by code on the data sheet and in Soil Survey Investigations Report No. 1. Method codes are listed at the end of each brief explanation.

This Appendix is broken into two parts. The first is a brief explanation of the methods used at the SSL and the code sets used on the data sheets. The second part is a discussion of considerations in the use of the laboratory data, and also a further explanation of the methodology that is the basis for criteria in Soil Taxonomy, Soil Survey Staff (1975).

General method codes for soil sampling and sample handling, and site selection and sample collection, follow the standard general methods. Sample preparation was done as described below. Air-dried samples were analyzed. Ratio of oven-dry weight to air-dry weight was measured for each sample and used to convert data to oven-dry basis for data sheets (Meth. 1A1, 1A2a, 1B1).

Conventions for reporting data: All values are on an oven-dry, <2 mm basis unless otherwise specified. The following are used (Meth. 2A1, 2A2, 2B):

tr - trace is reported if the measured value is less than half the minimum reported value

-- - dash indicates the analysis was run but the constituent was not detected

Blank - indicates the analysis was not run.

Fractions > 20 mm: Determined by sieving and weighing at the site or from volume estimates made at the site, weight percent reported (Method 3B1).

Fractions 2 to 5 mm and 5 to 20 mm: Sieved and weighed during sample preparation. Air-dried samples were crushed manually with wood and/or hard rubber rolling pin prior to sieving. Material is tested for slaking by soaking in water. Material that fails to slake is crushed to pass a 2-mm sieve for analysis if requested.

> 2 mm: Used to compute whole soil WRD and COLE. Reported as weight percent of whole soil (Method 3B1).

Particle size distribution: The < 2-mm fraction was dispersed in water with $(\text{NaPO}_3)_6$ plus Na_2CO_3 and overnight reciprocal shaking; sands are measured by sieving; clay and fine silt are measured by sedimentation, pipetting, drying, and weighing; coarse silt is calculated by difference. Pre-treatments are removal of OM (H_2O_2), removal of salts (filter candles), and oven-drying (base weight). (Method 3A1 dry and 3A2 moist samples.)

Atterberg limits: Determined on < 0.4 mm fraction. Plasticity index is the difference in water content between liquid limit and plastic limit. It is the range of water content over which a soil paste can be deformed without breaking, but it does not include flow as a liquid under operationally defined conditions. Liquid limit is the minimum water content at which the paste begins to flow as a liquid. Samples that do not deform without breaking at any water content are reported as N. P., non-plastic.

Operational definitions are in American Society of Testing Materials Method D 424 (ASTM, 1970 -- method F in SSIR-1 does not describe this method, but refers to the ASTM).

Bulk density: Plastic-coated clod is pre-wet, then desorbed to 1/3 bar, weighed in air, weighed in water, oven dried, and weighed in air and water again. Bulk densities at 1/3 bar suction and oven-dry are reported (Meth. 4A1D, 4A1h).

Water retention: Water retained at 1/10 and 1/3 bar is measured by sequential desorption of pre-wet, plastic-coated clods (Meth. 4A1, 4A1d).

Water retained at 1, 2 and 15 bar suction is measured by desorption of pre-wet < 2 mm bulk samples on a pressure membrane. A separate wetting and desorption is used for each suction (Meth. 4B2a is used with pressure adjustments for the different suctions).

Coefficient of linear extensibility (COLE): Computed from the difference in bulk density between moist clod and oven-dry clod. Cube root of the volume difference is reported and adjusted to whole soil basis by using measurements of > 2 mm (Meth. 4D).

Water retention difference (WRD): Computed from water retentions at 1/3 bar and 15 bar suction. Converted to cm of water per cm of soil by using bulk density of < 2 mm, measurements of > 2 mm, and particle density of > 2 mm (Meth. 4C1).

Organic carbon: Wet digestion with acid dichromate, automatic titration with FeSO₄. Recovery factor of 0.77 used to adjust results (Meth. 6A1c).

Total carbon: Percent total carbon determined by dry combustion using a LECO Carbon Analyzer.

Total nitrogen: Kjeldahl - acid digestion, steam distillation, automatic titration with 0.1 or 0.05 N HCl to pH 4.6 (Meth. 6B1b).

Dithionite-citrate extractable Fe, Al, Mn: Single extraction, measurement by atomic absorption (Meth. 6C2b, 6G7a, 6D2a).

Sodium pyrophosphate extractable carbon, iron, and aluminum: Single extraction, measurement of Fe and Al by atomic absorption (Meth. 6A4A, 6C8A, 6G1O). Carbon is not run at present at the NSSL.

Acid oxalate extractable Fe, Al, Si: Single extraction with pH 3.5, 0.2 molar NH₄ oxalate in dark, measurement by atomic absorption (Meth. 6G12a, 6C9a, 6Va).

KOH-Al: 0.2 g soil is shaken with 2 mls 4 N KOH for 10 minutes, brought to 20 mls and filtered. Al is determined by atomic absorption spectrophotometry (Method 6G13).

Extractable Ca, Mg, Na, K: Extracted with NH₄OAc, pH 7; equilibrated; filtered in auto-extractor; measured by atomic absorption (Meth. 5A8, 6N2e, 6O2d, 6P2b, 6Q2b).

Sum of bases: Calculated as sum of Ca, Mg, Na, and K bases described in previous section.

Extractable acidity: Equilibrated with 0.5N BaCl₂-triethanolamine, at pH 8.2, extracted by filtering; more buffer introduced drop-wise and leached through the sample for 30 minutes by auto-extractor. Acidity measured by back-titration with 0.13N HCl to pH 4.60 in auto-titrator (Meth. 6H5a).

KCl extractable Al: Extracted by unbuffered, N KCl; equilibrated and then washed with more reagent in auto-extractor (Meth. 6G9a).

Cation exchange capacity: Sum of cations (CEC-8.2) calculated by adding sum of bases and extractable acidity (Meth. 5A3a).

Cation exchange capacity: NH₄OAc, pH 7 (CEC-7) equilibrated and then washed drop-wise overnight in auto-extractor with N NH₄OAc. Excess removed with drop-wise ethanol leaching. NH₄⁺ in the soil removed by modified Kjeldahl steam distillation, auto-titrated with 0.1N HCl (Meth. 5A8, 5A8b).

Bases + Al: Effective cation exchange capacity (ECEC) derived by adding sum of bases and KCl extractable Al (Meth. 5A3b).

Al saturation: Derived using KCl extractable Al and extractable bases; computed as follows (Meth. 5G1):

$$[(\text{KCl ext. Al})/(\text{KCl ext. Al} + \text{sum of bases})] \times 100$$

Base saturation - sum: (BS-8.2) Derived from extractable bases and extractable acidity; computed as follows (Meth. 5C3).

$$[(\text{Sum of bases})/(\text{sum of bases} + \text{ext. acidity})] \times 100$$

Phosphorus retention: Percent phosphorus retained by soil after equilibration with 1000 ppm phosphorus solution for 24 hours. Equilibrated solution analyzed by colorimetric molybdo-vanadate method (Meth. 6S4). (Blakemore, et al., 1981).

KCl pH: Determined in N KCl solution mixed 1:1 with soil (Meth. 8C1f).

CaCl₂ pH: Determined in 0.01M CaCl₂ solution mixed 2:1 with soil (2:1 used instead of 1:1 for convenience) (Meth. 8C1f).

Water pH: Determined in distilled water mixed 1:1 with soil (Meth. 8C1f).

Ratio X 100 - derived using the sum of cations at pH 8.2 and measured clay:

ratio = $[(\text{CEC} - \text{sum of cats})/(\text{clay})] \times 100$

Ratios - values derived from cation exchange capacity, measured clay, and 15-bar water as follows:

First ratio = $\text{CEC} - 7/\text{clay}$,

Second ratio = $(15\text{-bar water})/(\text{clay})$.

Mineralogy, clay fraction analysis: Semi-quantitative data at survey level precision. No pre-treatments to remove Fe or organic matter.

X-ray: Oriented clays on glass slides, treated with K, heated incrementally to 300oC and 500oC; treated with Mg, with and without glycerol solvation; reported as relative peak sizes from X-ray diffraction curves.

Total analysis: Dissolution in HF in closed Teflon vessel at 110oC for 2 hours. Measurement by atomic absorption.

Sand mineralogy: Determined on dominate sand fraction, and/or on coarse silt by petrographic microscope. Dominant fractions obtained from standard PSDA.

2 CONSIDERATIONS IN THE USE OF DATA

2.1 INTRODUCTION

2.1.1 Considerations in the use of data:

Pedon characterization data, or any soil survey data, are best used when the operations for collecting the data are well understood. Our mental pictures and conceptual definitions that aid in visualizing properties and processes often differ from the information supplied by an analysis. Also, results differ by method, even though the two methods may carry the same name or the same concept. There is uncertainty in comparing one bit of data with another without knowing how both bits were gathered. This leads to operational definitions; definitions tied to a specific method.

The U.S. Soil Taxonomy, Soil Survey Staff (1975) is based almost entirely upon criteria that are defined operationally. One example is the standard particle size analysis. When Soil Taxonomy (1975) was written, the authors knew that there was no conceptual definition of clay that could be approximated in all soils by any feasible combination of laboratory analyses. Hence, instead of

defining clay, they defined operations to test the validity of a clay measurement, and they defined a default operation for those situations where the clay measurement was not valid.

The standard laboratory methods, upon which the operational definitions of Soil Taxonomy (1975 & 1992) are based, are described in the Soil Survey Investigations Report No. 42, 1992.

2.2 SYNOPSIS OF ANALYTICAL METHODS

Particle Size Distribution Analysis (PSDA) and Coarse Fragments -- reported as weight percent (coarse fragments apply as rock fragments in soil families of Soil Taxonomy).

The basic principle in these analyses is to separate natural aggregates into primary particles and to preserve fragments with as little breakage as possible. Crushing by a hand-operated rolling pin is performed carefully to minimize breakage of soft rocks.

The fractions coarser than 20 mm are derived from screening and weighing in the field or from field volume estimates. Volume estimates of the 20-75 mm and 75-250 mm and larger fractions are normally made in the field. Fractions between 2 and 20 mm are measured by sieving in the laboratory. During sample preparation, the soil is crushed so all but the coarse fragments pass through a 2-mm sieve. In the U.S. soil survey, coarse fragments are split into the 2-5 mm, 5-20 mm, and 20-75 fractions and reported as percent of the less than 75 mm material. Rock fragments larger than 75 mm are included in the column labeled > 2 mm, percent of the whole soil.

For PSDA, a sub-sample of the <2 mm sieves is treated with H₂O₂ to remove organic matter and candle filtered to remove soluble components. It is then dispersed in water with sodium hexametaphosphate plus sodium carbonate by overnight reciprocal shaking. The dispersed soil is poured onto a sieve which catches the sands and allows the silt and clay to pass through. The sand is fractionated further by dry shaking in a nest of sieves. The fine silt and clay fractions are determined by pipetting known volumes from suspensions remaining after known settling times. Fine clay (< 0.0002 mm) is measured by centrifugation and pipetting. The necessary settling and centrifugation times are based upon calculations which treat the particles as perfect spheres with consistent, designated specific gravity in a medium of constant temperature (Stokes Law). These calculations are used to determine the precise depths and times at which a pipetting will capture exactly the size fraction desired. Operationally, the clay fraction is not the array of particles smaller than 0.002 mm. It is the array that behaves, in suspension, as though it consists of perfect spheres of a designated specific gravity and a diameter of 0.002 mm. The actual dimensions may be uncertain and quite different from the conceptually perfect spheres.

Clay-sized carbonates are determined by treating the pipetted sample of clay with HCl and measuring the pressure of CO₂ in comparison with known standards.

Bulk Density -- reported in grams per centimeter cubed.

Bulk densities are determined at two or more moisture contents. In coarse and moderately coarse textured soils, they are determined at 1/10-bar moisture (moisture held against a 1/10 bar pressure difference across a semipermeable membrane), and oven dry (moisture after drying at 110oC). In soils of medium and finer texture, they are determined at 1/3 bar and oven-dryness.

Most of the bulk densities are obtained by equilibration of Saran-coated natural fabric clods at the designated pressure differentials. Clods for this purpose are selected in the field, where they are dipped in plastic that is dissolved in acetone. The dipped clods are dried by hanging them in air until the acetone evaporates. The plastic forms a thin elastic coating that allows passage of water vapor, but not liquid water. The dry plastic supports the clods for transport to the laboratory. This coating is reinforced by more additional dipping in the laboratory. It can stretch and contract, thus allowing for changes in volume as the clod wets and dries. Clod volume is determined by weighing the clods in air, then weighing them in water, and taking the difference. Bulk density is calculated by dividing the oven-dry weight of a clod by its volume (g/cm³). If the clod contains coarse fragments, it is heated in a furnace, crushed and any coarse fragments are removed and weighed. Their volume is calculated at a specific gravity of 2.65 g/cm³, unless otherwise specified. The bulk density is then corrected to a < 2-mm base.

Coefficient of Linear Extensibility (COLE) -- reported as cm/cm.

COLE is a derived value. It is based on the shrinkage of the natural soil clod between 1/3-bar moisture content (1/10 for sandier soils) and oven-dryness. Therefore, bulk densities at these moisture contents are used to calculate COLE as follows:

$$\text{COLE} = [(\text{dry bulk density}/\text{moist bulk density})^{1/3} - 1]$$

The cube root of the ratio of the two bulk densities is used to convert the volumetric shrinkage to linear shrinkage. The value obtained from the equation is corrected for coarse fragments, hence, COLE is on a whole soil base. COLE multiplied by 100 is called linear extensibility (LE) and is simply COLE in percent.

Water Retention Analyses -- reported as weight percent.

1/3-bar or 1/10 bar water

The 1/3-bar or 1/10-bar water is determined by desorbing the natural fabric clods that previously have adsorbed water at 5 m bar (10 cm) suction. The water is reported as a percent of the oven-dry < 2 mm soil.

15-bar water, 1-bar water, or 2-bar water

The 15-bar water is determined by desorption of crushed soil on a pressure membrane. Less than 2 mm soil material is placed on the membrane and saturated before desorption. The water retained is reported as a percent of the oven-dry.

Water Retention Difference (WRD) -- reported as cm/cm.

WRD, like COLE, is a derived value based on water contents at 1/3 bar (1/10 bar for sandier soils) and 15 bar. WRD is the difference between 1/3 bar (1/10 bar) and 15 bar, divided by 100, then multiplied by the 1/3-bar bulk density to put it on a volume base. If the soil contains rock fragments, the value is corrected accordingly, hence, WRD is on a whole soil base.

Organic Carbon reported as Weight Percent -- reported as weight percent.

Organic carbon is determined by a modified Walkley-Black method which is a wet combustion procedure. The sample is treated with a strong oxidizing agent (potassium dichromate) and digested in sulfuric acid. The NSSL uses a recovery factor of 0.77 as proposed by Walkley (1935) to calculate percent organic carbon. This organic carbon represents decomposed soil organic matter. It normally excludes relatively fresh plant residues, roots, charcoal, and carbon of carbonates. Measurements of total carbon include these carbon sources. Organic carbon can be multiplied by 1.72 for approximate organic matter content.

Nitrogen as Weight Percent -- reported as weight percent.

Nitrogen is determined by Kjeldahl digestion, distilling ammonium into boric acid, and titrating with HCl in an automatic titrator. The method measures both organic and inorganic forms of nitrogen. Commonly the proportion of inorganic nitrogen is greater in subsoil horizons, which explains at least part of the tendency for C:N ratio to narrow with depth in some soils.

Citrate-Dithionite Extractable Iron and Aluminum -- reported as weight percent.

The iron content is primarily from ferric oxides (hematite, magnetite) and oxyhydroxides (goethite). Aluminum substituted into these minerals is extracted simultaneously. A soil sample is treated with an excess of sodium dithionite and sodium citrate in an 8-ounce bottle and shaken overnight. A flocculant is added, the suspension is allowed to settle, and an aliquot of the supernatant is removed for analysis by atomic absorption. Dithionite reduces the ferric iron; citrate stabilizes the

iron by chelation. Iron and aluminum bound in organic matter is extracted if the citrate is a stronger chelator than the soil organic molecules. Manganese extracted by this procedure is also recorded. The iron extracted is often related to the clay distribution within a pedon, especially in argillic horizons.

Extractable Bases -- reported as meqs/100 g soil.

These are the major exchangeable bases; calcium, magnesium, sodium, and potassium. They are extracted by displacement from the cation exchange complex by another cation, ammonium (1N ammonium acetate buffered at pH 7 is the extraction solution). The term, extractable bases, is used instead of exchangeable bases because soluble salts and some bases from carbonates can be included in the extract.

Extractable Acidity -- reported as meq/100 g soil.

This is the acidity released from the soil by a barium chloride-triethanolamine solution buffered at pH 8.2. It includes all the acidity generated by replacement of the hydrogen and aluminum from permanent and pH dependent exchange sites. The procedure is very sensitive to small changes in methodology.

Extractable Aluminum -- reported as meq/100 g soil.

This measures exchangeable aluminum, which is a major constituent only in strongly acid soils (pH < 5.0). Aluminum will precipitate if the pH rises above 4.5 to 5.0 during analysis. Because the extractant KCl is an unbuffered salt, it usually affects the soil pH one unit or less. The extract is titrated with a base to the phenolphthalein end point. Titration measures exchangeable acidity as well as extractable aluminum. Many laboratories measure the aluminum by atomic absorption. In soils with pH's below 4 or 4.5 very little hydrogen would be expected on the exchange complex. However, if there is a large percentage of organic matter present there will be some hydrogen present. Care should be taken to learn which procedure was used and how data were reported.

Al Saturation -- reported as percent.

Aluminum saturation is the amount of KCl extractable Al divided by NH₄OAc extractable bases plus the KCl-Al, and is expressed in percent. A general rule of thumb is that if there is > 50% Al saturation, Al problems in the soil are likely. It may not be Al toxicity but a deficiency of Ca and Mg.

Cation Exchange Capacity (CEC) and Effective CEC (ECEC) -- reported as meq/100 g soil.

The CEC depends on the method of analysis as well as the nature of the exchange complex. Most soils have negatively charged colloids, so the CEC increases with increasing pH - the pH-dependent or variable charge.

The measured CEC depends, in part, on the pH of the extractant, which likely differs from the natural soil pH. A standard method, however, allows comparison of one soil with another even though the soil pH is not measured. NSSL reports 3 CEC values for acid soils. The effective CEC (ECEC) is calculated by adding the bases extracted by ammonium acetate plus aluminum extracted by 1N ammonium acetate and acidity extracted by 0.2M barium chloride-triethanolamine and titrated to pH 8.2. The relationship, $ECEC < CEC-7 > CEC-8.2$, holds unless the soil is dominated by positively charged colloids (e.g., iron oxides), in which case the trend is reversed. The change in CEC is the pH-dependent charge. The CEC at the soil pH can be estimated by plotting CEC vs pH of extractant, and reading the CEC at the soil pH.

Aluminum extracted by 1N KCl is negligible if the extractant pH rises toward 5.5. ECEC is then equal to extractable bases. ECEC is not reported for soils having soluble salts, although it can be calculated by subtracting the soluble components from extractable components. ECEC may also be defined as bases plus aluminum plus hydrogen. That is the more common definition for agronomic interpretations. Soil Taxonomy specifies bases plus aluminum.

CEC-8.2 is not reported if soils contain appreciable carbonates, because bases are extracted from the carbonates.

CEC measurements at other pH levels or by other cations may each yield somewhat different answers. It is important to know the operational definition (procedure, pH, and cation used) before evaluating the meaning of the measurement or before comparing data from two sources.

Base Saturation -- reported as percent of CEC.

Base saturation may be reported as a percent for two different CEC values.

Base saturation by NH₄OAc, pH 7 (BS-7) is equal to sum of NH₄OAc extractable bases divided by NH₄OAc-CEC (CEC-7) times 100. If extractable Ca is not reported because of the influence of carbonates or salts, then the base saturation is usually reported as 100%.

Base saturation percentage by sum of cations pH 8.2 (BS-8.2) is equal to the sum of NH₄OAc extractable bases divided by CEC sum of cations (CEC-8.2) times 100. This value is not reported if either extractable Ca or extractable acidity is omitted.

Differences between these two base saturations depend upon the size of the pH dependent CEC. Class definitions in Soil Taxonomy (1975) specify which is to be used.

The sum of bases is considered equal to exchangeable cations unless gypsum, salts, or carbonates are present. Normally, the bases extracted by this method exceed 100 when the more soluble constituents are present. Therefore a 100 percent base saturation is assumed. The Ca from carbonates is usually much larger than Mg. Extractable Ca is omitted if more than a trace (>0.4%) of carbonates (as CaCO₃) is present, or if calculated base saturation exceeds 110 percent, based on CEC-NH₄OAC pH7.

Other values can be obtained by using CEC derived from other methods. There are numerous methods utilized for specific purposes. Always be sure which method is used.

Calcium carbonate equivalent -- reported as weight percent.

The amount of carbonate (CO₃=) in the soil is measured by treating the sample with HCl. The evolved CO₂ is measured manometrically. The amount of carbonate is then calculated as a CaCO₃ equivalent basis no matter what form is present (Dolomite, Na₂CO₃, MgCO₃, etc.).

Calcium sulfate as gypsum -- reported as weight percent.

Calcium sulfate (gypsum) is determined by extracting gypsum in water and precipitating in acetone. Gypsum is reported on both the < 2 mm and < 20 mm base. Drying soils to oven-dryness, the standard base for reporting data, removes part of the water of hydration from the gypsum. Many measured data values must be recalculated and expressed on a gypsum containing base.

pH -- water or salts.

The pH is measured by a pH meter in a soil-water or soil-salt solution. The extent of the dilution is shown in the heading. 1:1 means one part by weight of dry soil was added for each part by weight of water. Dilution values in soil-water are usually 1:1, and are 1:2 for the dilute CaCl₂ salt solution. For convenience, the pH is first measured in water, then CaCl₂ is added to the same sample.

Dilute salt solution is a popular method for masking seasonal variations in pH. Readings in 0.01M CaCl₂ tend to be uniform regardless of time of year. Readings in 1N KCl tend also to be uniform. The former are more popular in regions lacking extremely acid soils. The latter are more popular in regions where many soils are sufficiently acid. KCl is also frequently used to extract exchangeable aluminum. The pH reading then shows the pH at which the aluminum was extracted.

The pH may also be measured in 1N NaF. This measurement is usually restricted to soils where part of the clay may have short range order (called amorphous material in Soil Taxonomy (1975)). If there is a large, poorly ordered component, this pH will be greater than 9.5. High values for the NaF pH will also be found if there are large sources of calcium, or bases including carbonates, and

in some sesquioxide-rich soils. Therefore, care must be taken in interpreting this data. One gram of soil is placed in 50 ml of 1N NaF, stirred, and the pH read after 2 minutes.

Sodium pyrophosphate extractable carbon, iron and aluminum -- reported as weight percent.

This reagent has been used widely as an extractant of organic matter. It successfully removes much of the organo-metal accumulations in spodic horizons, but is relatively ineffective in extracting many forms of inorganically bound iron and aluminum. For this reason, it is a key to the chemical identification of spodic horizons.

Water soluble cations and anions -- reported as meq/l.

Water soluble cations and anions are determined in water extracted from a saturated paste made by adding distilled water to soil until the saturation point is reached. At saturation, the soil paste glistens as it reflects light. It flows slightly when the container is tipped, and slides freely and cleanly off a spatula except for soils containing large amounts of clay.

Exchangeable Sodium Percentage (ESP) -- reported as percent of CEC-7.

Water soluble sodium is converted to meq/100g soil and subtracted from extractable sodium, divided by the CEC by ammonium acetate (CEC-7) and multiplied by 100.

An ESP of >15 percent is used in Soil Taxonomy to indicate sodium affected soils (natric horizons).

Sodium Adsorption Ratio (SAR) -- Water soluble sodium is divided by water soluble calcium and magnesium. The formula is: $SAR = Na/[(Ca+Mg)/2]^{0.5}$.

The SAR was developed as a measure of irrigating water quality, particularly when the water is used for irrigating salt or sodium affected soils. A SAR greater than or equal to 13 is used in Soil Taxonomy as a measure of sodium affected soils (Natric horizons).

Total salts -- reported as weight percent.

This is the present total water soluble salt in the soil. It is calculated from the conductivity of the saturation extract.

Electrical Conductivity -- reported as millimhos/cm.

This is the electrical conductivity (EC) of the water extracted from the saturated paste.

Phosphate Retention Index -- as the percent.

This procedure is used in the classification of Andisols. The soil is equilibrated with a solution containing 1000 ppm P in the form of phosphate. Phosphorus adsorbed by the soil is expressed as a percent of P in the equilibration solution. It shows which soils have a phosphorus fixation problem. Many soils with a high P fixation capacity have low phosphorus supplying capacity.

Acid Oxalate extractable Aluminum, Iron, and Silicon -- reported as weight percent.

This procedure is used to help identify soils in the order of Andisol. It extracts iron, aluminum, and silicon from organic matter and from amorphous mineral material. It is used in conjunction with dithionite-citrate and pyrophosphate extractions to identify the sources of iron and aluminum in the soil. Pyrophosphate extracts organic iron and aluminum. Dithionite-citrate extracts iron from iron oxides and oxyhydroxides as well as from organic matter.

Mineralogy

The mineralogy of clay, silt, and sand fractions is required in some taxa and some categories. The different techniques employed are briefly as follows:

X-ray diffraction analysis (XRD) -- reported in a 5-class system based mostly on relative peak intensities.

A Philips diffractometer with a copper tube is used. XRD is run oriented clay that is saturated with Mg⁺⁺ (room temperature and glycerated) or saturated with K⁺ (300° or 500° C).

Thermal Analysis -- reported as weight percent of clay.

Differential thermal analysis (DTA) or differential scanning calorimetry (DSC) is done on the clay fractions or on the fine earth. Endothermic reactions are calibrated to those of standard clay mineral specimens.

Petrographic analysis -- reported as weight percent of grains counted.

Minerals are identified by use of a petrographic microscope. At least 300 grains of a coarse silt very fine sand or fine sand separate are identified and counted.

2.3 OTHER USEFUL INFORMATION

Several ratios which can be developed from the data are useful in making internal checks of the data and management related interpretations.

Relationship of mineralogy and cation exchange capacity

Ratio of CEC (NH₄OAc, pH 7) to clay (CEC-7/clay) can be used to make an estimate of the clay mineralogy. For family placement CEC-7/clay relationship is as follows: Kaolinitic < 0.2, kaolinitic or mixed 0.2-0.3, mixed or illitic 0.3-0.5, mixed or montmorillonitic 0.5-0.7, and montmorillonitic > 0.7. The relationship generally holds for samples with 15-bar/clay ratios between 0.3 and 0.6. When amorphous material is present, the relationship does not hold. Poor dispersion for any reason invalidates this relationship. They do work well for areas where some detailed mineralogy data is available.

Ratios of CEC (at pH 8.2) to 15-bar water of greater than 1.5, and more exchange acidity than the sum of bases plus KCl extractable Al, implies a soil with a high pH dependent charge. This ratio along with bulk density helps distinguish subgroups that have high levels of amorphous materials such as those commonly weathered from pyroclastics, in contrast to the more crystalline mineral soils.

Relationship of 15-bar Water to Clay

This value is used to give an indication of the accuracy of the particle size determination. If the ratio is greater than 0.6, and soil-related factors do not adequately explain the situation, incomplete dispersion in particle-size analysis may be inferred. Some soil-related factors that can cause deviation from the 0.4 reference point are: (1) Low activity clays (kaolinites, chlorites, and some micas tend to lower the ratio to 0.35 or below). (2) Iron oxides, gibbsite and clay-size carbonate (these tend to decrease the ratio). (3) Organic matter (this increases the ratio because organic matter increases the 15-bar water content). (4) Amorphous mineral materials (these increase the ratio because these materials do not disperse well). (5) Clay minerals in sands and silts (these also hold water and so raise the ratio). If these are in shale, saprolite or pseudomorphs of primary minerals, it is best not to break them into smaller particles if breakage can be avoided.

Table 12 of Soil Taxonomy (1975), Key to mineralogy classes, suggests using 2.5 times 15-bar water to estimate clay if the ratio is greater than 0.6. For Oxisols, the latest edition of the Keys (1990) suggests using 3 times 15-bar water and/or measured clay by pipette method, whichever value is higher but not more than 100.

pH dependent charge

The pH dependent charge as defined by Soil Taxonomy, 1975, as the difference between the sum of bases, plus extractable acidity and sum of bases, plus 1N KCl exchangeable Al, divided by measured clay or by 15-bar water, times 2.5 under conditions defined in Soil Taxonomy, 1975.

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4 DOCUMENT INFORMATION

4.1 Publication Date

1998

4.2 Date Last Updated

2021