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IDENTIFICATION OF SOIL ASSOCIATIONS IN WESTERN SOUTH DAKOTA ON ERTS-1 IMAGERY[1]

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ABSTRACT

Soil association maps show the spatial relationships of land units having characteristic soil depths and textures, available water capacities, permeabilities, pH characteristics, plasticity indices, liquid limits, and the like, from which broad interpretations can be made such as how the soil is suited as a source for topsoil, and as a source for sand and gravel, and how corrosive the soil is for steel and concrete, and what crop and grass yields can be expected. Film color composites of bands 4, 5, and 7 viewed over a light table with magnification show the soil associations of western South Dakota that are now recognized, and, in addition, several new soil association areas have been brought to light.

INTRODUCTION

Soil maps are an integral part of an effective agricultural research and advisory program. Soil maps are used for farm and ranch planning, for crop and grass yield estimates, for land appraisal, for guidance for prospective land buyers, for land use planning, for irrigation planning, for drainage planning, for assessing potentialities for special crops, for rural zoning, and for forest management.

Soil maps are of different scales ranging usually from 1:15,840 to 1:7,000,000. The large scale maps necessary for detailed land planning show the extent of individual soils, and are made by boring holes and walking over the land so that delineations are observed over their entire extent.

Small scale soil maps, called soil association maps, are geographic associations of one or several soils and usually are at scales of 1:500,000 to 1:1,000,000. Simonson (1971) states that each soil association consists of a set of geographic bodies that are segments of the soil mantle covering the land surface. Soil associations may include like or unlike soils and they are linked together by mode of occurrence rather than degree of similarity.

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Although soil association maps of small scale are not as precise for interpretations as detailed soil maps of large scale, they nonetheless have use for broad planning purposes and for education. A recent soil association map prepared by Westin and Bannister (1971) is published at a scale of 1:500,000. The map was prepared by using detailed soil survey data along with geologic, geomorphic, topographic, climatic and biotic information as well as aerial photographs. The map units are associations of soil series. Soil profile descriptions, laboratory data and interpretation information are available for the soil series used.

It should be emphasized that the soils on soil maps are not defined in terms of profiles alone. According to the soil survey staff of the USDA (1951), each soil unit is a particular kind of landscape and it is these landscapes of soils that are classified and shown on soil association maps. Although soil profiles cannot be seen on air or satellite imagery, soil landscapes are visible. Soil landscapes exhibit a characteristic surface geometry such as relative frequency of streams, and a characteristic surface composition such as the percentage of bare soil areas. Other features used in differentiating soil landscapes include vegetation, and hydrology.

The ERTS 1 MSS imagery brings spatial and temporal advantages for the recognition of soil landscapes. These are that each frame covers about 8,400,000 acres, is available in 4 spectral bands, and the imagery is repeated every 18 days. The purpose of this study was to determine if western South Dakota soil landscapes presently shown on the Soil Association map can be recognized by viewing ERTS 1 MSS imagery and whether new or revised soil associations are recognizable.

PROCEDURE

The ERTS imagery observed for this study in western South Dakota consisted of the 4 MSS bands with wavelengths ranging from .5-1.1 um. The study was confined to 3 frames: (1) 19 August 1972 C N 42-57, W 102-37; (2) 6 September 1972 C N 44-30, W 102-06; and (3) 12 October 1972 C N 44-35; W 102-00. The four bands were observed singly and also in color composites made from bands 4 (.5-.6 um); 5 (.6-.7 um); and 7 (.8-1.1 um). The color composites were made by projecting each black and white frame through a color filter. Using this procedure the intensity of a particular hue was governed by the gray scale value shown by each feature.

The procedure used to study the soil landscapes or associations on ERTS imagery was to view, with a binocular, each of the four bands and the color composites over a light table under 3-power magnification. A mylar overlay was placed over the ERTS frame and lines were drawn upon the overlay using a 0.2 Castell 990 pen and black Pelikan drawing ink. The inking was done when the frame was under magnification. Photo interpretation techniques were used to recognize the soil association boundaries. Use was made of colors, tones, patterns, and shapes, as well as the drainages. The nature of the parent rock and its mode of deposition, and the climatic, biotic and physiographic factors of the environment all were considered. For comparison purposes the published soil association map of Westin and Bannister (1971), of scale 1:500,000 was reduced in scale to correspond to the 1:1,000,000 scale of the ERTS image.

RESULTS

The results of this study consist of four comparison maps, figures 1 through 4, on which a soil association from the published map is compared to the soil landscape recognized on the ERTS image. The lines from the ERTS map all were drawn from color composites. Although each of the four MSS bands were studied singly, the most useful images were produced by the color composites. Of the individual bands, the 5 band (.6-.7 um) gave the best contrast and clearest image. The 7 band (.8-1.1 um) appeared to be useful to show vegetation vigor. For example, in the semiarid rangeland of western South Dakota the less productive steep sides of the Cheyenne River valley showed appreciably different reflectance than the rolling to undulating interfluves having deeper soils and more grass.

The ERTS color composites for western South Dakota were clear and sharp. Images remained sharp under 3-power magnification but magnification greater than 3X or 4X resulted in hazy boundaries. No interpretation problems were encountered. Range lands were distinguishable and relative vigor of the grass was apparent by the intensity of the red hues. Dimensions of cropped fields and other features could be estimated by placing a metric scale under the magnified composite.

In addition to the vegetative features visible on the color composites, physical features also are apparent. The exact configuration of the South Dakota badlands is visible and can be traced on overlays from the composite. Within the badlands, the actively-eroding, barren wall is distinguishable from the badlands basins. This is a significant separation since the wall produces no vegetation while there is grass produced in the badlands basins although some areas are not accessible. Stream bottomlands can be seen and mapped by pattern and color. Irrigation areas and alfalfa fields present in the bottomland are red-hued and are recognizeable. Terraces in this area are separable from uplands, valley sides and bottomlands. The soil present on the terraces in this area are medium-textured in contrast to the clay soils of the uplands, and this, plus flat topography, results in their use to grow winter wheat. Steep-sided stream valleys having clay soils stand out in the September and October frames since they have less reflectance in the infrared bands and this results in a different hue. They also are obvious because of their closely-spaced parallel drains. Broad soil textures in general can be recognized on ERTS frames if some geologic information is available. The sandhills area with its lack of streams and its linear pattern speckled with red-hued subirrigated meadows is unique. The clayey soils in this area have a closely-spaced stream pattern.

In the upper Cretaceous area north of the Cheyenne River, the sandy soils derived from sandstones show up with a redder hue than the finer-textured adjacent soils from shales. This may be due to the more vigorous grass growth resulting from the fact that in this climatic area sandy soils have a better water-supplying ability than clayey soils.

Figures 1 through 4 show specific comparisons between the soil association map and the ERTS composites. Each figure is accompanied by an explanatory paragraph. It should be noted that there is general agreement between the two maps but that the use of ERTS composites would improve the accuracy of many of the soil associations presently recognized in South Dakota. Also several new associations are apparent on the ERTS imagery that were not shown on the Soil Association Map.

Figures 5 and 6 are examples of thematic and interpretation maps developed for a portion of western South Dakota. The delineations were drawn from ERTS imagery and the soil characteristic and interpretation information came from the data store of the South Dakota Cooperative Soil Survey.

Several conclusions seem apparent as a result of this study. First, in semiarid western South Dakota, landscape features are well defined. Steep valley sides, broad interfluves, contrasting textures all are present in this area and all are clearly visible on ERTS color composites. Therefore the general technique discussed in this paper should be applicable in other areas having well defined landscape features and information on the environmental factors affecting soils along with soil profile descriptions and data. Second, the 8 million acre scene that can be scanned on one frame allows for comparisons of soil associations usually over their entire extent. This is an advantage since anamolies immediately become apparent. Moreover each observed feature is in proprotion. Third, vegetation over the entire area is at the same instant of growth. Thus color differences on the composites are, at least in part, due to the different abilities of the soil associations to produce vegetation. These vegetative differences, then, reflected in the varying hues visible in the composite, help separate soil associations. This coupled with the comparisons possible with 4 spectral bands gives a wide range of images for the study of the soil landscape and its use.

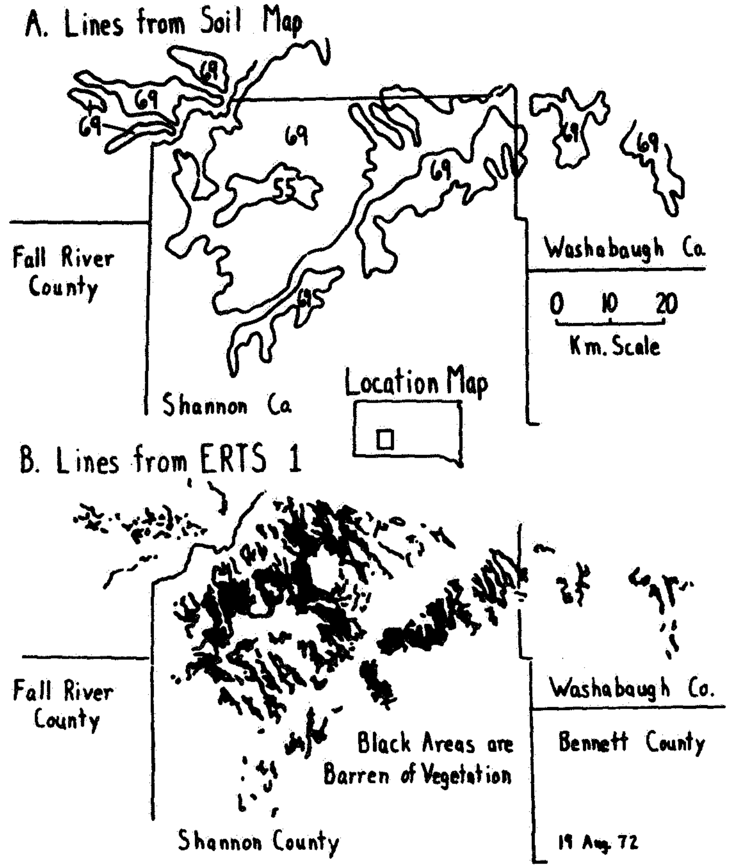
LITERATURE CITED

Soil Survey Staff. 1951. Soil Survey Manual ARS, USDA, Wash. D. C. p. 131.

Simonson, R. W. 1971. Soil Association Maps and Proposed Nomenclature. Soil Sci. Soc. Amer. Proc. 35: pp. 959-963.

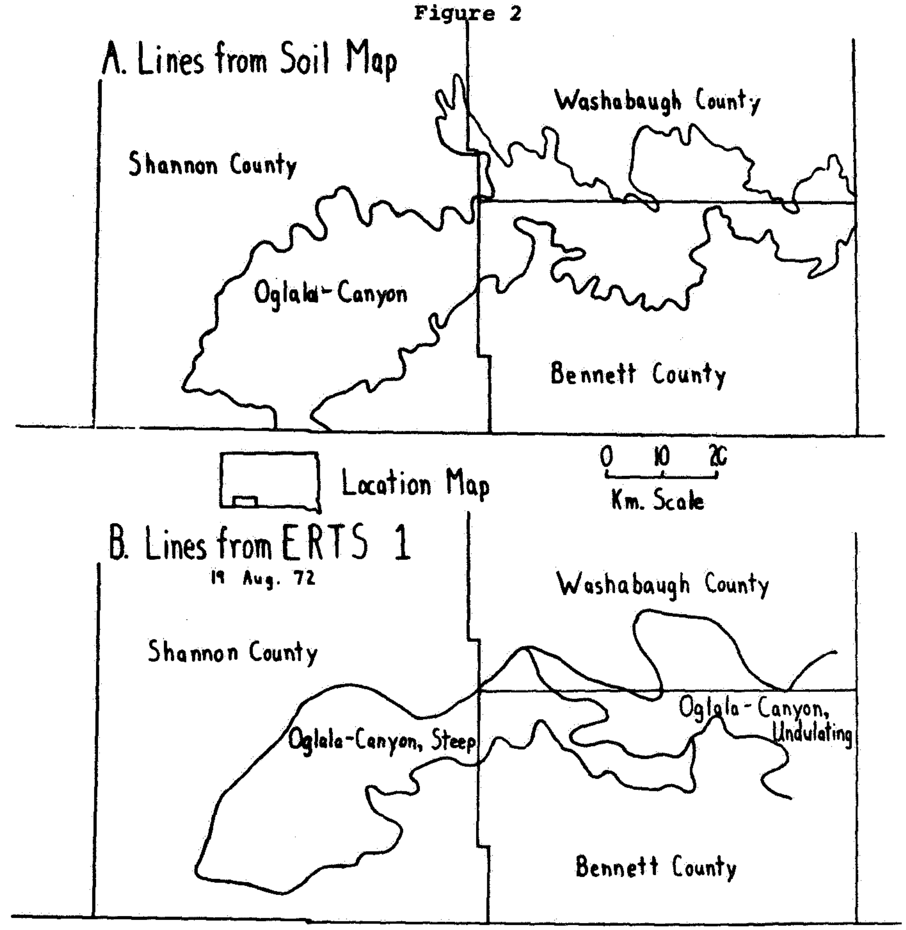
Westin, F. C. and D. L. Bannister. 1971. Soil Association of South Dakota (Map) AES Info. Series No. 3 Agr. Expt. Sta., South Dakota State University, Brookings, and USDA Soil Conservation Service, Huron, SD.

Figure 1



ON THE SOIL ASSOCIATION MAP TWO DELINEATIONS ARE SHOWN IN THIS AREA - 69 (BADLANDS) AND 55 (TUTHILL-RICHFIELD) THE 55 AREA IS A TABLELAND OF GENTLY UNDULATING SANDY LOAMS. ON THE ERTS 1 COLOR COMPOSITE THE ACTUAL BADLAND WALL OR ACTIVELY ERODING BARREN AREA SHOWS UP WHITE AND CAN BE DISTINGUISHED FROM THE ASSOCIATED AREAS WHICH HAVE VEGETATION. THIS AREA HAS BEEN MASKED OUT ON THE ERTS 1 MAP WITH BLACK INK. A COMPARISON OF THE SOIL MAP WITH THE ERTS MAP SHOWS THAT ONLY ABOUT HALF OF THE 69 AREA ON THE SOIL MAP IS IN CAPABILITY CLASS VIII - BARREN OF VEGETATION. THE REMAINING AREA HAS USEFUL VEGETATION.

Figure 2



THE PINE RIDGE AREA OF THE OLIGOCENE IS SHOWN AS ONE DELINEATION ON THE SOIL MAP (OGLALA-CANYON SOIL ASSOCIATION). THE ERTS 1 COLOR COMPOSITE SHOWS THAT THE WESTERN SECTION OF THIS SOIL ASSOCIATION IS CHARACTERIZED BY CLOSELY SPACED DRAINS, SEVERAL TO THE KILOMETER, WHICH INDICATES STEEP SLOPES. THE DRAINAGE PATTERN IN THE EASTERN PORTION CONSISTS OF WIDELY SPACED DRAINS WITH BROAD INTERFLUVES, SEVERAL KILOMETERS WIDE, INDICATING MUCH LESS RELIEF. RUNOFF, EROSION HAZARD, RANGESITE, AND STOCKING RATES WOULD BE DIFFERENT FOR THE EASTERN AND WESTERN PORTIONS OF THIS AREA.

Figure 3

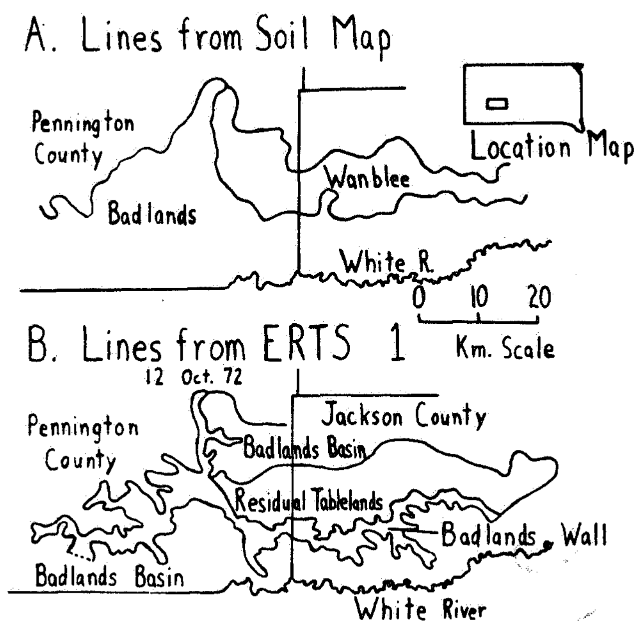
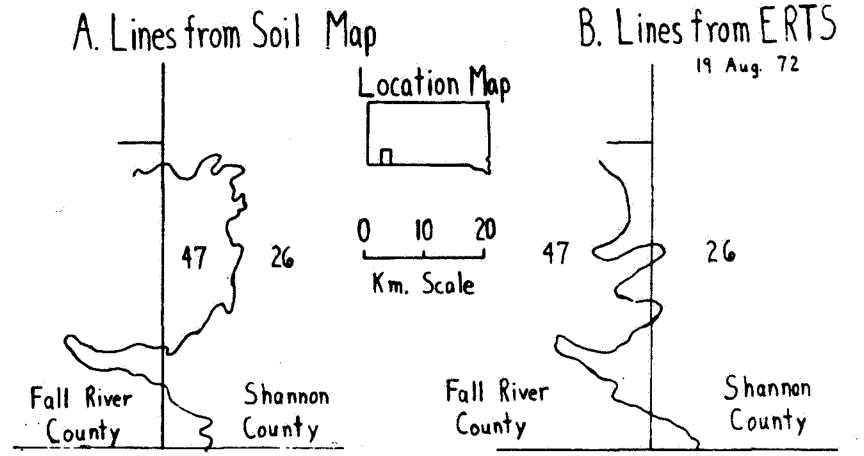


Figure 4



ON THE SOIL MAP THE BADLANDS AREA (CLASS VIII LAND) IS SEPARATED FROM THE WANBLEE SOIL ASSOCIATION (A DENSE CLAYPAN SOIL OF CLASS VI CAPABILITY). ON THE ERTS 1 COLOR COMPOSITE THREE SOIL ASSOCIATIONS ARE APPARENT: THE STEEP, ACTIVELY ERODING BARREN BADLANDS WALL, THE LOWER LYING UNDULATING IRREGULARLY DISSECTED, SLOPING, PARTLY VEGETATED BADLANDS BASINS, AND THE RESIDUAL SILTY TABLELAND. INTERPRETATIONS ARE DIFFERENT FOR EACH SOIL AREA. NO VEGETATION GROWS ON THE BADLANDS WALL WHILE THE BADLANDS BASIN HAS SOME GRASS ALTHOUGH ACCESSIBILITY IS A PROBLEM. THE RESIDUAL SILTY TABLELAND IS IN THE SILTY RANGESITE, GROWS GOOD GRASS AND IS MARGINAL CROPLAND.

THE SILTY SOILS IN ASSOCIATION NUMBER 26 (KADOKA-EPPING) ARE DERIVED FROM THE WHITE RIVER BEDS OF TERTIARY AGE. ON THE ERTS 1 COLOR COMPOSITE THIS ASSOCIATION HAS A FRECKLED APPEARANCE DUE TO THE ASSOCIATION OF THIN BARREN SOILS (EPPING) ON CONVEX KNOBS, AND DEEPER PROFILES ON PLANE AND CONCAVE POSITIONS (KADOKA). THIS PATTERN IS READILY DISTINGUISHABLE FROM THE REGULAR, UNIFORM APPEARANCE OF THE CLAY SOILS OF THE PIERRE PLAIN (SOIL ASSOCIATION NUMBER 47 PIERRE-SAMSIL). THE ERTS 1 COLOR COMPOSITE INDICATES THAT THE BOUNDARY SEPARATING THE 26 AND 47 SOIL ASSOCIATION SHOULD BE LOCATED ABOUT 15 KILOMETERS WEST OF THE BOUNDARY SHOWN ON THE SOIL MAP. THESE TWO SOILS HAVE DIFFERENT RANGESITES AND SOIL LIMITATIONS.

FIGURE 5

ESTIMATED SOIL PROPERTIES SIGNIFICANT TO ENGINEERING

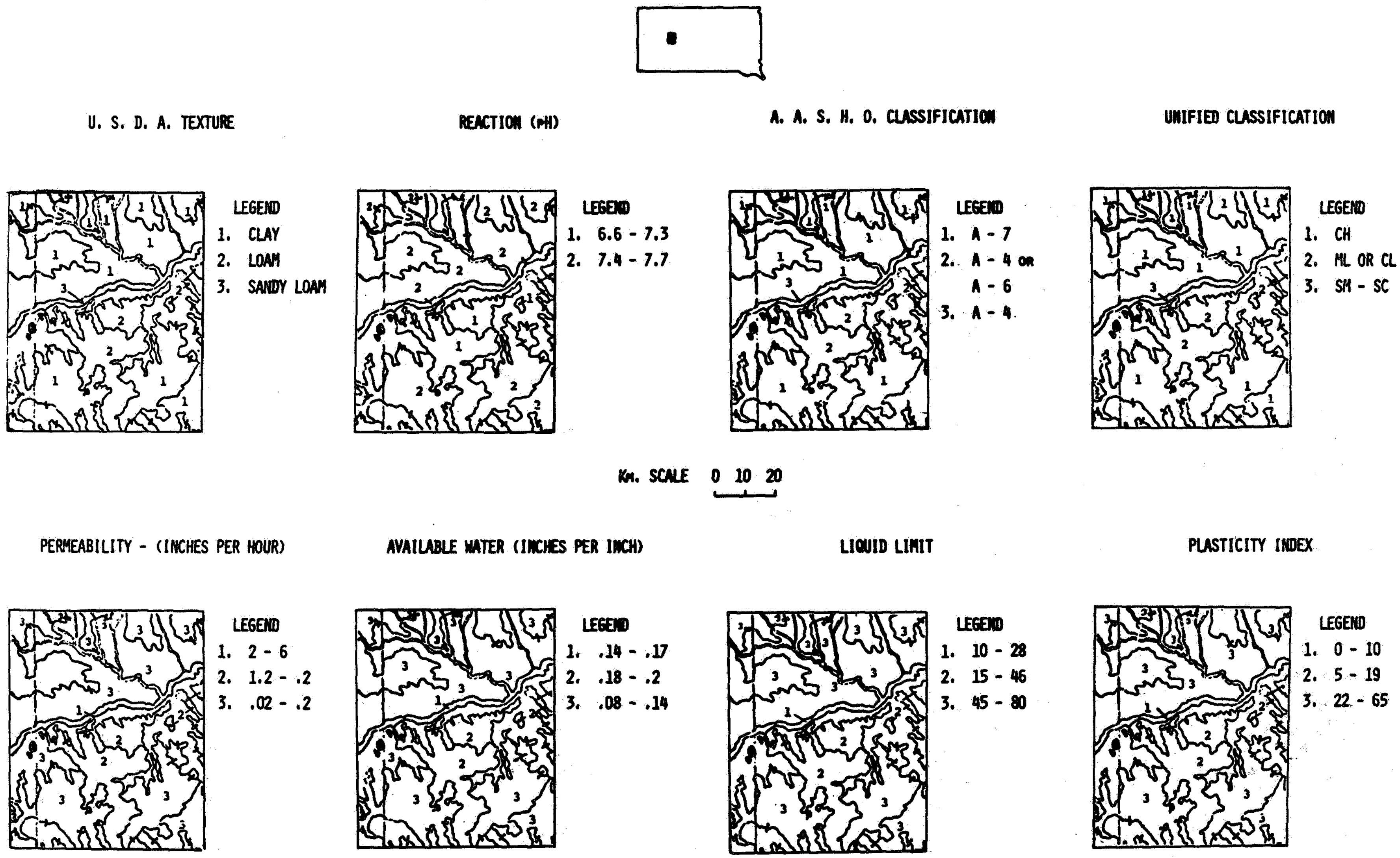


FIGURE 6

INTERPRETATION OF SOIL ASSOCIATION MAPS