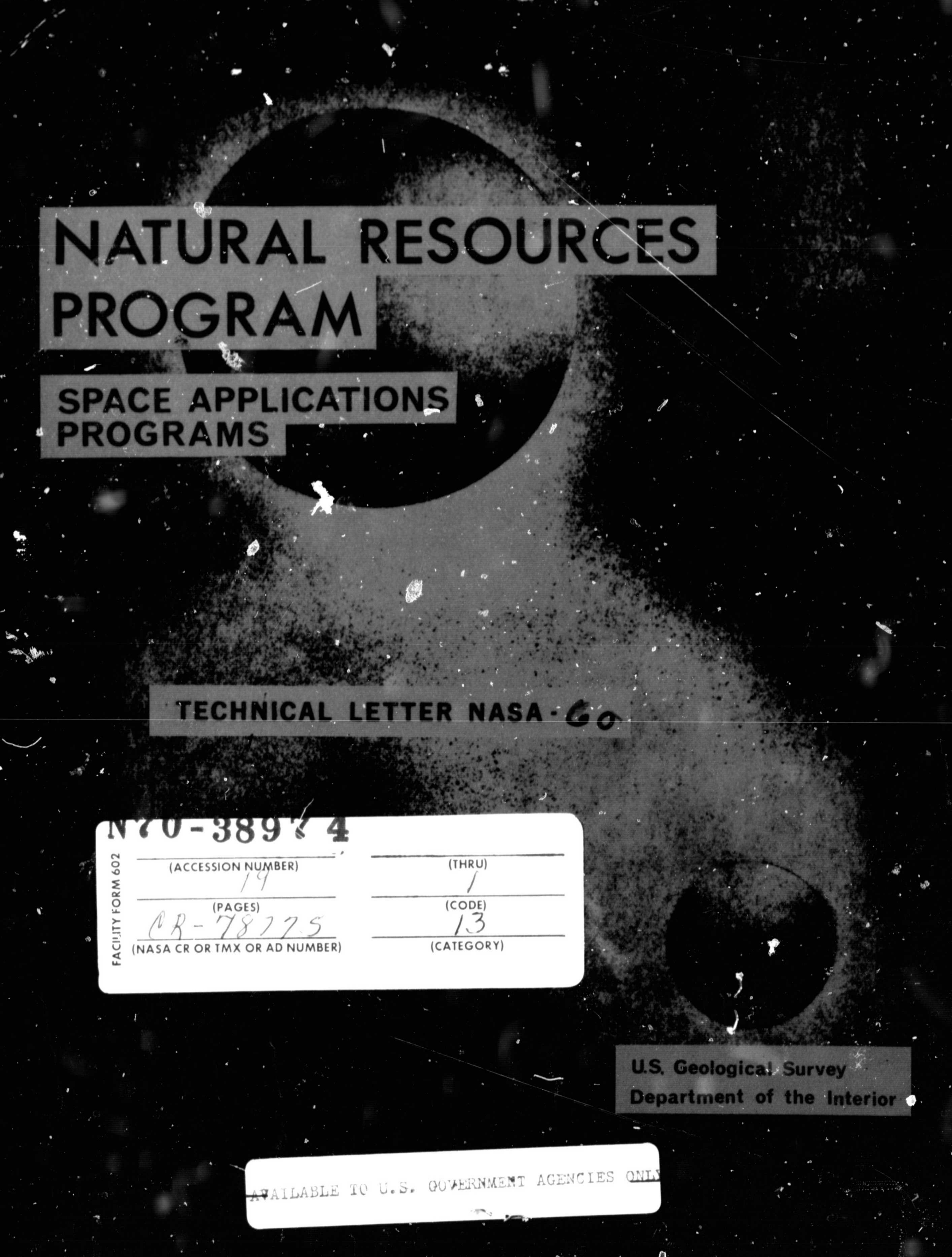

NATURAL RESOURCES PROGRAM

SPACE APPLICATIONS PROGRAMS

TECHNICAL LETTER NASA-60

U.S. Geological Survey
Department of the Interior

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Washington, D.C. 20242

Technical letter
NASA-60
October 1966

Dr. Peter C. Badgley
Chief, Natural Resources Program
Office of Space Science and Applications
Code SAR, NASA Headquarters
Washington, D. C. 20546

Dear Peter:

Transmitted herewith are 3 copies of:

TECHNICAL LETTER NASA-60

EXTENT OF RELICT SOILS

REVEALED BY GEMINI IV PHOTOGRAPHS*

by

Harald Drewes and Roger Morrison**

October 1966

Sincerely yours,

William A. Fischer
Research Coordinator
Earth Orbiter Program

*Work performed under NASA Contract No. R-09-020-011
**U.S. Geological Survey, Denver, Colorado

UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TECHNICAL LETTER NASA-60

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October 1966

These data are preliminary and should not be quoted without permission

Prepared by the Geological Survey for the National Aeronautics and Space Administration (NASA)

*Work performed under NASA Contract No. R-09-020-011
**U.S. Geological Survey, Denver, Colorado

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Extent of Relict Soils

Revealed by Gemini IV Photographs

by

Harald Drewes and Roger Morrison

SUMMARY

Synoptic observations of large areas, recorded in photographs taken from the Gemini IV mission, indicate that color photographs from orbital altitudes offer certain unique advantages for determining the extent, correlation, and development of some types of soil.

Reddish soils are the most conspicuous ones on the photographs and in general are old soils, that developed during intervals of reduced erosion and surficial deposition that were favorable for chemical weathering. Correlation of these soils would be a major factor in correlating Quaternary geologic events in separate drainage basins of the southwest with known interglacial events to the north.

Extent of Relict Soils Revealed by Gemini IV Photograhs

By Harald Drewes and Roger Morrison

Introduction

A series of overlapping color photographs from the mouth of the Colorado River across southern Arizona and New Mexico and adjacent areas of Mexico to the Edwards Plateau of western Texas were taken June 5, 1965, on the Gemini IV Mission. The photographs reveal the possibility that the extent and degree of development of red soils in many parts of the southwestern United States can be investigated effectively from orbital altitudes. The synoptic view of broad areas permitted by this method makes it possible to ascertain at a single glance the areas where such soils may be developed at the surface. At the same time it offers the possibility for widespread correlation of soil types inasmuch as establishing continuity from one basin to another by this means is not subject to the usual limitations of ground visibility or access.

The principal problems connected with the analysis of the photographs now available are that insufficient field study has been done 1) to ascertain the age of the soils represented, 2) to determine the influence of source materials and degree of development on the resulting images, 3) and to ascertain the way in which color values as expressed from orbital altitudes are related to those on the ground. Nevertheless, Figure 1, a sketch map delineating areas of intense soil development near Bisbee, Arizona, shows that soil can be studied in orbital color photographs. The photograph (Fig. 2) used in this test was obtained on the Gemini IV mission (Magazine 8, Frame 12).

Description of soils

Soils are the product of weathering of rocks and strongly reflect the environment in which they were formed and the duration of their existence in that environment. The chief environmental factors of weathering are: the parent rock from which the soil is formed, climate, topography, drainage, and vegetation. Several of these environmental factors exert overlapping influences on soil development and are not always independent. In a stable environment the older a soil is, the thicker it is and the better developed are its component zones, or soil horizons (referred to by letters A through C in descending order). The older soils may also have been exposed to partial erosion of their upper horizons, or to burial, which complicates the features seen on the ground. All together these factors and many other more subtle ones are in constant interplay to produce a complex and laterally gradational upper relatively thin layer of ground that is called soil. As a result of this complexity and because soils have been studied mainly by soil scientists, soil classifications seem to have no consideration of geologic time, of facies, or of the undesirability of mixing genetic and lithologic features. To be useful to geologists, soil classification may have to be thoroughly re-evaluated.

Soils of the southwest region adjacent to the United States-Mexican border, can be grouped into 6 major assemblages; reddish soils, brownish soils, alluvial soils, salt-affected soils, dune soils, and bare caliche soils. Several of these soil groups, especially the reddish soils, can be recognized directly from the orbital photos and the others may be inferred from vegetation and geomorphic criteria. Soil groups whose recognition is color dependent, as photographed at orbital heights, are also seen to be developed to various degrees, usually reflecting various ages of soils, but in places also suggesting the results of the interplay of several environmental soil-forming factors.

The reddish soils

Generally the reddish soils are old soils developed during a long period or periods of weathering under stable conditions. They date back to pre-Wisconsin time, i.e., at least 70,000 years. As such, they may be an important aid in widespread correlation of events during the Quaternary from one basin to another and in correlation with known interglacial periods to the north. Reddish soils, however, that are derived from red parent material, may be younger.

Reddish soils are the most conspicuous ones on the photos, and underlie the lined areas of Figure 1. They are moderately abundant along the low flanks of ranges and especially on the broad alluvial-covered surfaces between the edge of the mountains and the center of the valleys, at elevations as high as 6,000 feet. The red color is the more conspicuous on the higher, relatively smooth surfaced interfluves on which vegetation is sparse than it is along the intervening gullies where it has been largely removed by erosion. The reddish soils typically consist of an A horizon that is light reddish brown and contains little organic matter. The underlying B horizon is darker, redder, and more clayey than the A and has a prismatic or blocky structure. In the upper part of the C horizon is a zone of carbonate-rich accumulation.

Brownish Soils

Brownish soils of the southwest region are abundant at altitudes above 3,000 feet. However, they occur mainly in areas covered by brush, grass, or forests, from which their distribution may be inferred on the photos. These soils are characterized by an A horizon that is moderately dark gray to moderately dark brown, with a low to moderate organic content, a granular structure, and a midly acid reaction. The B horizon typically is more strongly colored and is more clayey than the A and it has a granular to subangular blocky structure. Carbonate accumulates in lower B and upper C horizons and the acidity generally drops to mildly or moderately alkaline.

Alluvial Soils

Alluvial soils are essentially infantile soils. They are abundant and appear in all topographic positions in which young terrace, fan, or floodplain deposits have accumulated. On the photos they are primarily recognized by their gray color, closely spaced drainage network, and denser vegetation. On the ground the A horizon is thin or absent, is generally lighter shades of gray, and contains very little organic material. The B horizon is undeveloped; therefore, these soils have either A-C or entirely C horizon profiles.

Salt-affected Soils

Salt-affected soils are more abundant in the southwest region than in most others but still are much scarcer than the first 3 soil groups. They are typically associated with closed basins, and especially with those containing playas (see Willcox Playa Fig. 2). On the photos and the ground alike they are very light colored to white, and their vegetation cover is sparce. On the ground they also are seen to contain but little organic material and they are strongly alkaline.

Dune Soils

Dune soils, like alluvial soils, are mostly infantile soils, only in the case of dune soils the mode of deposition of the parent material is eolian rather than fluvial, and consequently the sorting of the parent material and the morphology of the deposits are different. Dune soils, though still scarce in the southwestern region relative to the first 3 groups, are more abundant than in most other regions, and they are most common near beaches, either those along the sea coast or bordering the playas that contained or still contain lakes. Dune soils are recognized on the photos and on the ground by their morphology and pale yellowish gray color, and in places also by their type of vegetation cover; on the ground the sorting of the parent material is also a distinctive criterion in recognizing these soils.

Caliche Soils

Bare caliche soils are another minor soil group which are more common in the arid southwest than in most other regions. On the photos and ground alike they appear light colored to white, much like the most strongly salt-affected soils, but their morphology is that of a dissected alluvial fan rather than that of a playa. The A and B horizons are generally absent but the C horizon is strongly enriched in carbonate, which typically forms a caliche hardpan. Thin capping pale brown zones on some calcic soils may have developed after the removal of the original A and B horizons.

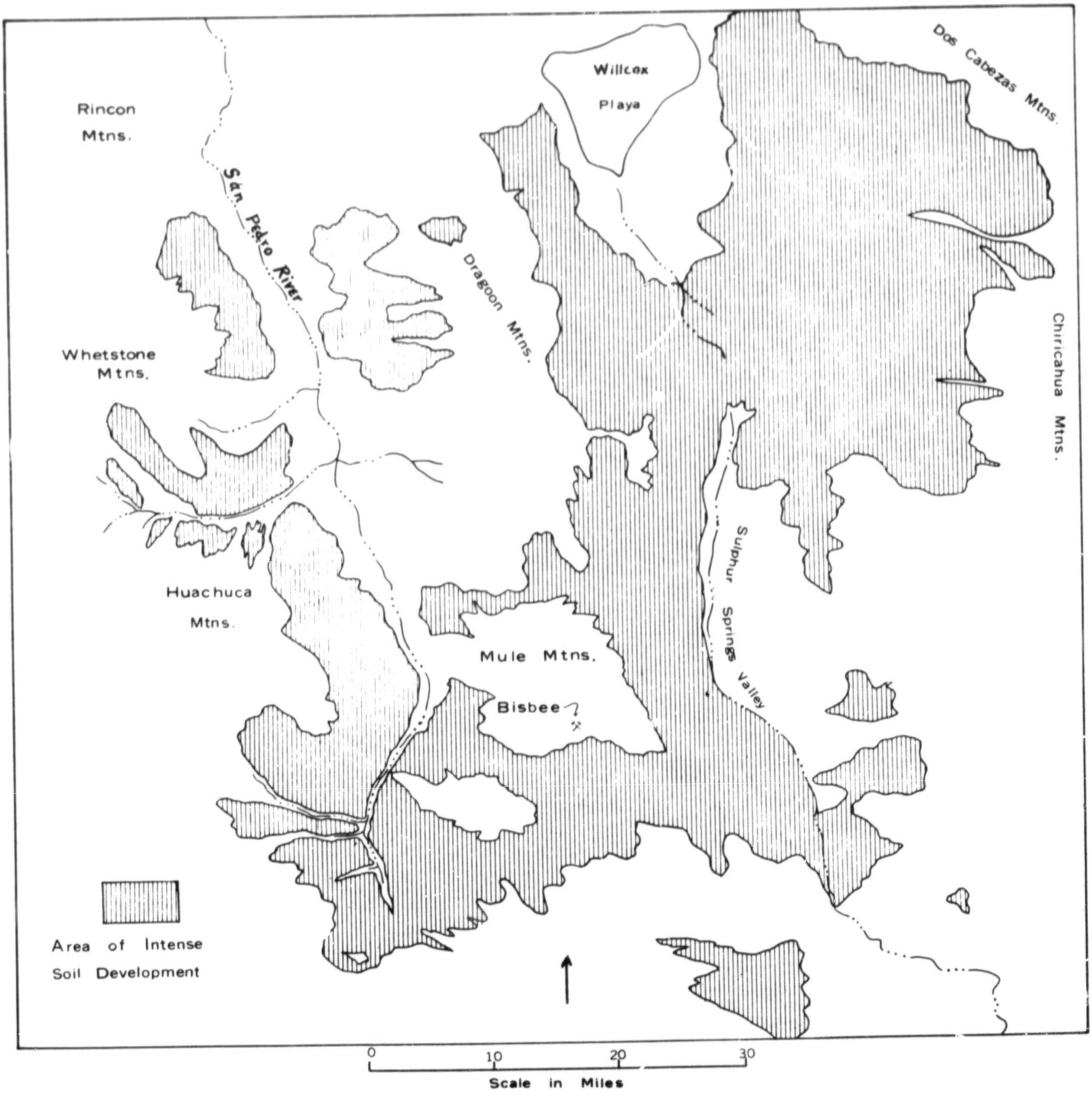
Rincon
Mtns.
San Pedro River
Willcox
Playa
Dos Cabezas Mtns.
Dragoon Mtns.
Whetstone
Mtns.
Chiricahua Mtns.
Sulphur Springs Valley
Huachuca
Mtns.
Mule Mtns.
Bisbee
Area of Intense
Soil Development
0
10
20
30
Scale in Miles

FIGURE 1.

FIGURE 2