Geography 403
Lecture 12
Soils and Geology Applications

Needs: Lect_403_12.ppt

Key Terms and Concepts
Soil Identification and Classification Techniques
Lithologic Mapping
Structural Geology and Tectonics
Economic Geology
Geothermal and Volcanic Activity

A. Soil Identification-need a fast method of classifying soils and their characteristics (a set of interrelated properties)

PP1 1. Mostly air photos used, but LANDSAT can provide general information

PP2 2. Need to develop techniques to relate processes within the soil (physical and chemical) to the reflected and emitted radiation

3. Soil color-often diagnostic of major soil classes
    a. Spectral reflectance related to soil color
    b. Red and NIR seem to be best for qualitative and quantitative descriptions of soils
    c. Influenced by mineral and chemical constituents, soil moisture, soil structure, particle size, and organic matter content
    d. Better correlations of reflectance to above properties needed for various wavelength bands available
4. Mineral content
    a. Minerals emit energy in different ranges in the TIR band (8-14 μm) and also reflect differently in the NIR
    b. Exact relationship depends on surface roughness, particle size, water film, contaminants, dust, dew, and physical discontinuities of the surface
    c. One technique is to run soils through standard mineralogical analysis, and then match sample spectrum with standard curves by computer
    d. UV reflectance has been examined in a limited way, but is restricted because of atmospheric absorption. Many soil materials react to UV, others do not.
    e. Best system would integrated UV, RED, and TIR

PP3 5. Organic matter-significant to fertility and general desirability of a soil for agriculture
    a. Dark color is generally associated with more O.M.
    b. O.M. affects color, heat capacity, water holding capability, nutrient exchange, structure, and erodability, so a rapid and easy assessment of this parameter may be one of the most useful to agriculture
    c. LANDSAT Bands 5 and 6 have the best negative correlation with soil O.M.
    d. Organic soils need to be examined more closely to determine decomposition state, which relates to reflectance
6. Particle size-affects reflectance, thermal properties, and indirectly soil moisture

a. Particle size also affects the emission of microwave energy

PP4-7 7. Soil texture-mixture of particle sizes and their variations change reflectance properties

8. Structure and roughness
   a. Structure of soil can make it appear to have different properties-fine textured soil is "clumped" and in the natural state appears to be coarse particles
   b. Will vary with tillage practices and other cultural features
   c. Roughness related to radar reflection
9. Soil emissivity-must be known to get temperatures from TIR
   a. Ability to compensate for ε problems seems to depend on bandwidth (narrow 10.4-12.6 μm 2°C error, wide 5-15 μm 6°C error)
   b. Soil moisture affects emissivity, so is a PROBLEM, but ε can be used to determine soil moisture in the TIR band

PP8 10. Soil temperature as it relates to radiometric temperature
   a. Of great importance to agricultural activities in terms of evaporation, weathering, decomposition, microbial activity, germination, and plant growth

PP9 b. Radiometric temp. will be influenced by moisture content (produce D-E areal contrast) and time of year (during high sun, top layer of soil is rapidly heated, and is less representative of soil profile conditions)
   c. TIR imagery in early fall and winter can be most productive for detecting soil conditions by taking advantage of uniform crop and soil moisture conditions over large areas

11. Additional problems with soil identification
   a. Oxygen, carbon dioxide, and water absorb certain desired bands
   b. Solar illumination varies with sun time and atmospheric conditions
   c. Structure affects reflection
   d. Solar energy is less intense away from .5 μm peak (such as in mid-IR)
12. Applications by band
   a. .52-.62 μm (green) O.M. content
   b. .7-.9 μm (NIR) iron content
   c. 1 μm several minerals
   d. 1.22-1.32 μm and 1.55-1.75 μm have a wide variety of applications
   e. 2.08-2.32 μm soil moisture
   f. LANDSAT TM satisfies many, BUT NOT ALL of these needs

B. Introduction and Lithologic Mapping

PP10 1. A large number of possibilities exist for application of remotely sensed data in Geology
   a. General mapping--understand processes and landforms
   b. Exploration for specific minerals
   c. Increase knowledge of other planet's structure and composition

PP11 2. Laboratory tests have been used to establish reflectance and emissive characteristics of various minerals and mineral associations

3. LANDSAT .5-1.1 μm (Bands 5, 6, &7) can be used to determine the presence of iron oxide, and the absence of vegetation
    a. A band ratioing technique is used
    b. Unique identification of rock materials is not possible, but considerable success can be achieved in separating rock units and delineating boundaries
4. Thematic mapper 1.6-2.2 μm bands can be used to identify hydrous (water-bearing) minerals and increase mapping discrimination

PP12 5. Use of very narrow bands in the 2.0-2.5 μm range will allow specific identification of many types of minerals
    a. Narrow band profiling instrument (10 medium and narrow bands) narrow band spectrometry for mineral identification from space
6. Mid- and Far (thermal) IR (5-40 μm) is a region where the emission of various minerals can be analyzed
    a. 8-14 μm "window" region most promising
    b. Quartz/non-silica can be discriminated and mapped
7. Stretch enhancement and computer classification of LANDSAT data very useful in geologic mapping

C. Structural Geology and Tectonics

PP13-15 1. Large areas view of regions allows placing of gross features into categories of drainage, structural control, land use, and human-induced features.

PP16-19 2. Discontinuities, faults, stress, and fracture zones can be discovered and mapped

3. Landforms themselves, and processes that formed them can be evaluated effectively from satellite

PP20-24 a. Glacially formed structures (moraines, lake bottoms)

PP25-32 b. Fluvially formed structures (rivers, estuaries, gaps)

PP33-35 c. Igneous and volcanic features

PP36-38 d. Eolian (wind produced) features-various types of dunes

4. low-azimuth sun angle can be used to accentuate linear geomorphic features into an apparent relief map (valleys, shorelines, fault lines)

D. Economic Geology--finding and assessing mineral and energy resources using LANDSAT cloud-free imagery in conjunction with air photos and knowledge of regional geologic structure

PP39 1. Mineral exploration examples
    a. Nickel deposits in Indonesia
    b. Copper deposits in Brazil identified with future areas inventoried ($100 million/year in revenues)
    c. Uranium deposits in western Australia
2. Petroleum exploration
    a. A relationship exists between surface features and the structures (usually a dome) where gas and oil can be located
    b. Visual inspection of LANDSAT images can give clues to locations of gas and oil deposits

c. RADAR can be used to enhance subtle topographic features in heavily vegetated areas, and to penetrate cloud cover-- ideal for exploration in tropical areas
d. Example--oil and gas potential in the Michigan Basin
i. LANDSAT used to map glacial features and identify linear and other features of questionable origin
ii. Identified areas were mapped and tentative analysis of structure (anticlines and synclines) was made
iii. Correlation of seismic data made with LANDSAT
iv. Gas and oil discovered in suspected locations
v. Additional payoff-details of bedrock and landform structure examined and mapped in detail during the process

3. Coal exploration--can be carried out in the same way as gas and oil exploration
a. Particularly useful in large areas of the western U.S. with vast coal reserves spread over large areas

E. Geothermal and volcanic activity

PP40 1. Thermal IR can be used to study geo-heat sources
a. Leads to better “picture” of geothermal and volcanic processes
b. Hazard warnings and development of predictive techniques possible
c. Geothermal exploration for power sources
2. 3-5.5 μm and 8-14 μm used
3. TIR surveys of dormant and inactive volcanoes indicates some may be more “active” than previously thought.

F. Hazard monitoring and other resources

PP41 1. Waste disposal-landfill, liquid, and radioactive
a. Applications of LANDSAT to find “appropriate” geologic areas
2. Location of construction materials, sand, gravel, crushed rock
a. Apply relationships to other geologic features
3. Monitoring of mining and land reclamation
4. Assessment of seismic hazards
5. Assessment of volcanic hazards
6. Inventory and assessment of glacial movement
a. Understanding of Greenland and Antarctic ice sheet dynamics
7. Assessment of "landform" features under shallow water