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SLAR Imagery and Site Selection

Side-looking aerial radar provides a synoptic display of terrain for regional site selection studies.

(Abstract on next page)

Side-looking airborne radar (slar) imagery has been studied as a terrain data gathering device for well over a decade.[4] Most of the analyses involving slar imagery have been concerned with potential applications.[3,7] Many investigators have evaluated slar imagery in terms of its potential ability to provide sub-surface information in a photographic format.[5] Often the capabilities of specific slar systems have been attributed to all slar systems. A general confusion has resulted as to what slar imagery is and what terrain information is actually contained within it.

This report is based upon the results of a research project performed at Purdue University for the U. S. Army Engineer Topographic Laboratories, Fort Belvoir, Virginia.[1] Its purpose is to present a systematic slar image interpretation procedure from which parameters necessary for regional engineering site selection can be ascertained. Although techniques and conclusions offered herein may be more generally applicable, they were derived from a study of K- and X-band slar imagery and should be considered valid only for such systems. Conditions unique to a specific wavelength are so noted.

Slar Imagery

A slar image is essentially a two-dimensional plot on photographic film of electromagnetic energy reflectivity from a terrain surface. The image consists of numerous resolution cells, each of which represents a radar cross section (σ) value for a specific portion of the terrain. The degree to which the image represents the true distribution of reflectivity from the terrain depends upon the relationship between the image tone of each resolution element, the actual radar cross section value, and the relative geometric position of each resolution element. In terms of system hardware, the relationship depends on the range of return values produced by the cathode-ray-tube (level of clipping), wavelength, and geometric distortion introduced by the system antenna or its platform. If the relative range of image-return values, wavelength, and manner of image presentation (ground or slant range display) are accounted for, the imagery can be evaluated in terms of terrain roughness and possibly complex dielectric properties of surficial features.

General Requirements for Site Selection

Those factors of terrain that usually affect the selection of a site for engineered construction include topography, geology and soils, drainage, vegetative cover, and existing cultural features. The relative regional geometric relationship between such factors is of equal if not supreme inportance for site selection studies.

Where a poorly mapped or previously unmapped area must be evaluated within a limited period of time for purposes of site selection, slar imagery can be used as the primary source of preliminary data. In any site selection situation, the slar imagery can provide a synoptic display of terrain.

Slar Image Interpretation Technique

Concept

The slar image interpretation technique reported herein was developed in a manner similar to that used for conventional airphoto interpretation.[5] Genetic or morphologic land forms are identified from characteristic patterns. Geology and soils are inferred from type of land form, whereas topography, drainage, vegetative cover, and cultural features are inferred from characteristic patterns composed of pattern elements. Figure 1 illustrates the general procedure.

PATTERN ELEMENTS

The evaluation of SLAR image patterns consists of the identification and description of variations of the elements of tone (intensity of return) and texture. The element of tone is evaluated at two levels—discrete tone and average areal tone. Individual or small groups of resolution elements with unusually high- or low-return values (high return corresponds to light tone) form discrete tonal elements which can be related to specific cultural features or natural terrain surfaces. An example of typical discrete tonal elements is illustrated in Figure 2. Average areal tones tend to indicate the general reflectivity of a regional terrain surface. Examples of typical average areal tones are illustrated in Figure 3. With few exceptions, the discrete tonal elements are significant for the delineation and identification of cultural features, radar shadow areas, and specular and cardinal reflecting surfaces. Average areal tones, on the other hand, are of significance for the interpretation of regional terrain conditions. In either case, tones are qualitatively described by the interpreter.

Table 1 lists some representative tonal ranges found to be related to general conditions of the land surface. These tonal ranges do not constitute a complete description of causal factors, but do form a basis for further study. It is evident that tone alone provides an inadequate basis for interpretation.

Image texture, formed by the distribution

ABSTRACT: *A systematic SLAR image interpretation procedure has been designed for regional engineering site selection studies. Engineering soil types (parent materials) are inferred from drainage, topographic, and land use patterns in a manner similar to the conventional airphoto interpretation procedure. Unique to SLAR imagery, however, these patterns must be evaluated with respect to pattern elements characterizing the interactions between radar energy and the land surface. The patterns are created from discrete tonal elements, average areal tones, and SLAR image textures; all of which provide information supplemental to that contained in conventional photography. Where the interpretation of engineering soil type is complemented with an analysis of regional terrain roughness, a powerful tool for preliminary site selection is achieved. Regional relationships between soil type, topography, and drainage which are often obscured on conventional photography are emphasized on small scale SLAR images. The diagnostic pattern elements and resultant patterns characteristic for a variety of engineering soil types and terrain conditions comprise an example.*

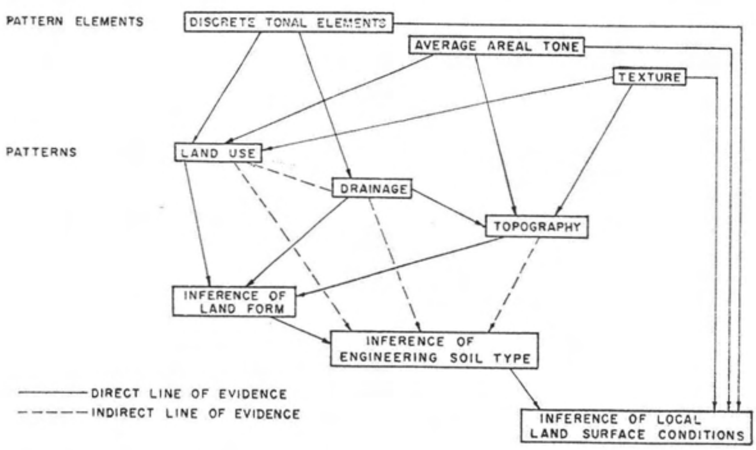

FIG. 1. Systematic interpretation flow diagram.

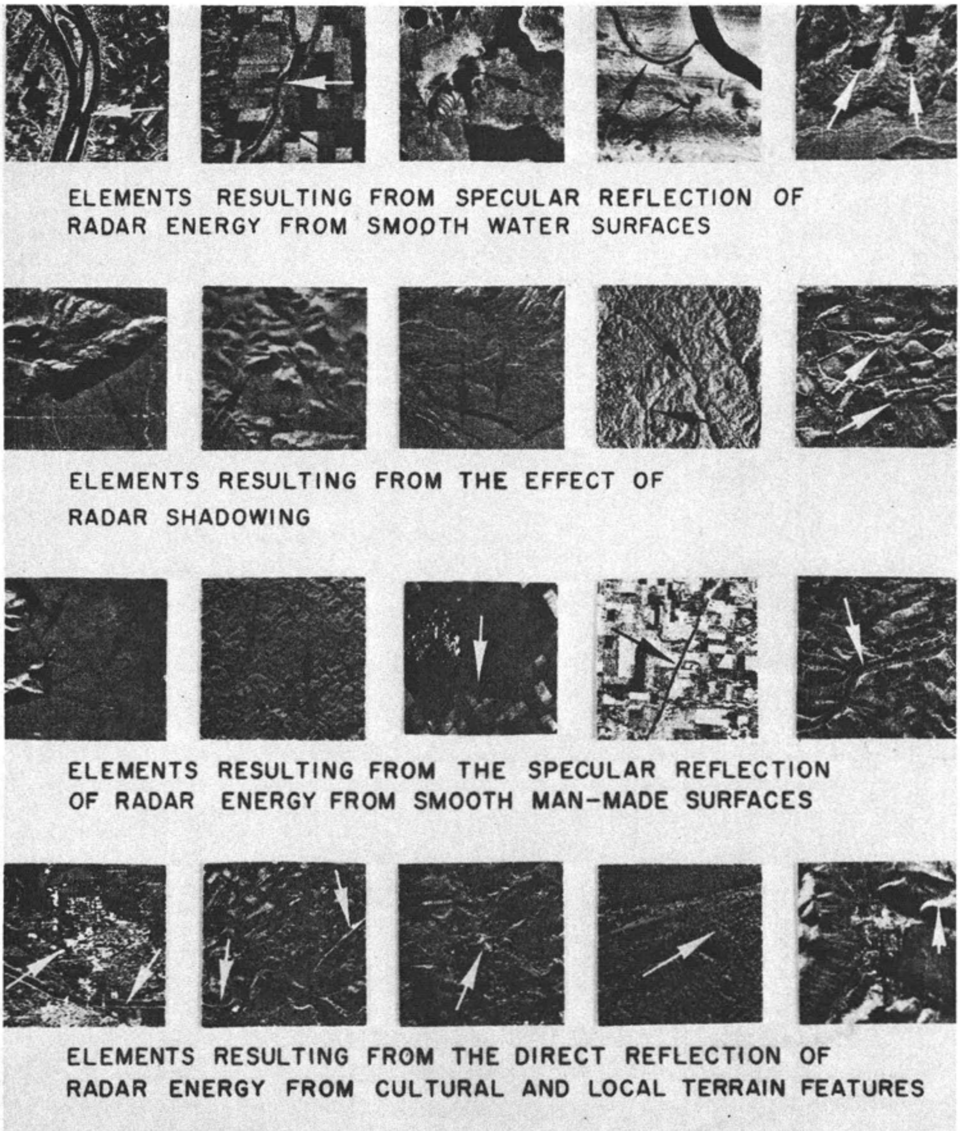

FIG. 2. Discrete tonal elements.

of resolution elements, is the second basic pattern element of a SLAR image. Whereas, the average areal tone of a portion of a SLAR image tends to indicate the capability of the corresponding terrain surface to reflect radar energy, image texture yields evidence of variability of reflection within that unit. The image texture is a measure of the micro-variability of reflecting surfaces and as such becomes an element of larger scale patterns. Pattern elements of image texture are illustrated in Figure 4. Image textures are most strongly influenced by terrain micro-roughness and vegetative cover.

SLAR IMAGE PATTERNS OF DRAINAGE

The particular design or geometric relationship formed by a group of individual streams within an area is referred to as a drainage pattern. It is generally recognized that drainage patterns can reflect the influence of such geologic factors as inequalities in rock hardness, structural controls, and the recent geologic and geomorphic history of

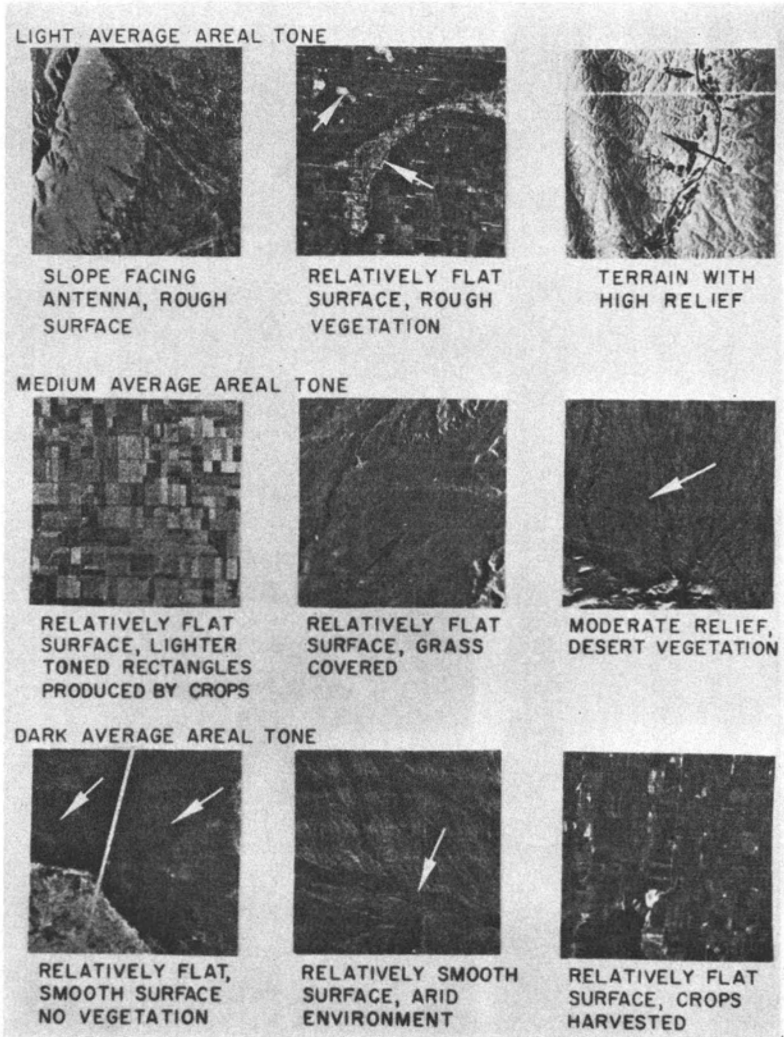

FIG. 3. Average areal tones.

an area. The term *drainage pattern* does not imply that component streams will always be filled with water. In arid regions, the drainage pattern is often only the expression of surface swales or low areas which carry water during times of rainfall.

Drainage patterns extracted from SLAR imagery are of the same order of significance as they are for conventional airphoto interpretation. However, the appearance and general level of detail of drainage patterns imaged by SLAR is different. Instead of relying upon topographic form as seen in a stereoscopic airphoto model, the SLAR image patterns of drainage must be recognized as unique associations of discrete tonal elements. Table 2 lists those conditions which usually produce discrete tonal elements which may as a group form SLAR image displays of drainage pattern.

First-order streams (gullies) are usually not interpretable from SLAR images because of scale and resolution. This situation tends to degrade the value of drainage pattern analysis for the interpretation of local terrain conditions, but detracts little from the evaluation of regional conditions. Regional drainage densities (ϵ stream lengths/area) can be measured.

Figure 5 illustrates some of the basic drainage patterns as portrayed on SLAR imagery. Such patterns, usually traced on

TABLE 1. TERRAIN FACTORS AND REPRESENTATIVE TONAL RANGES
(FACTORS ARE *Not* MUTUALLY EXCLUSIVE)

Factor	*Reflection Characteristic*	*Tonal Range*
	Topographic	
Flat Surface	Specular Reflection if Surface is Smooth, No Return	Dark Tones
Sloping Surface Facing Antenna	Relatively High Return Due to Orientation Effects	Medium to Light Tones
Sloping Surface Facing Away from Antenna	Relatively Low Return Due to Orientation Effects	Medium to Dark Tones
	Geologic	
Rough Surfaces (>1 Wavelength)	Diffuse Reflection, Medium to High Returns	Medium to Light Tones
Smooth Surfaces (<1 Wavelength)	Specular Reflection if Surface is Flat, No Return	Dark Tones Lighter Tones
	Reflection Influenced by Topographic Effects	Produced by Orientation Effects
Natural Corner Reflectors Produced in Bedrock by Weathering	Maximum Reflection of Incident Energy Back to Antenna, High Return	Very Light Tones
High Surface Moisture Content	Greater Reflection with Increasing Values of Dielectric Constant, Higher Returns with Higher Moisture Contents if Water Does not Produce a Smooth Surface	Medium to Light Tones
Low Surface Moisture Content	Lower Returns with Decreasing Values of Dielectric Constant	Medium to Dark Tones
	Vegetation	
Trees, Woods and Forests	Diffuse Reflection, High Returns	Light Tones
Brush	Higher Returns with Increasing Dielectric Constant in Humid to Subhumid Areas, Brush with Higher Moisture Content Produces Greater Degree of Reflection	Light Tones, (Medium to Dark Tones in Arid Environment)
Natural Grass, Weeds	Diffuse Reflections, Medium to Low Returns, Dry Vegetation Produces Less Reflection Than Lush, Moisture Rich Vegetation	Medium Tones in Humid to Subhumid Areas (Dark Tones in Arid Environment)
Broad Leaf Crops, Crops with Naturally High Moisture Content	Diffuse Reflection, High Returns	Light Tones
Small Leaf Crops	Diffuse Reflection, Medium Returns	Medium Tones

plastic overlay sheets during the course of an image analysis, are developed as the result of integrating all of the discrete tonal elements (Table 2) inferred to be related to the drainage system.

SLAR IMAGE PATTERNS OF TOPOGRAPHY

The capability of evaluating topography by means of viewing stereo SLAR image models is not perfected. For monoscopic SLAR images, the qualitative analysis of topography, or cross-sectional shape of terrain, depends on pattern recognition. Evaluation of topographic conditions from SLAR imagery is, of necessity, less precise in terms of estimated dimensions than is the interpretation of topography from stereoscopic airphoto models.

Discrete tonal elements, average areal tones, and image textures individually and in combination form patterns of topography. The pattern of drainage itself makes a further contribution. In general, discrete tonal elements provide evidence of high relief or

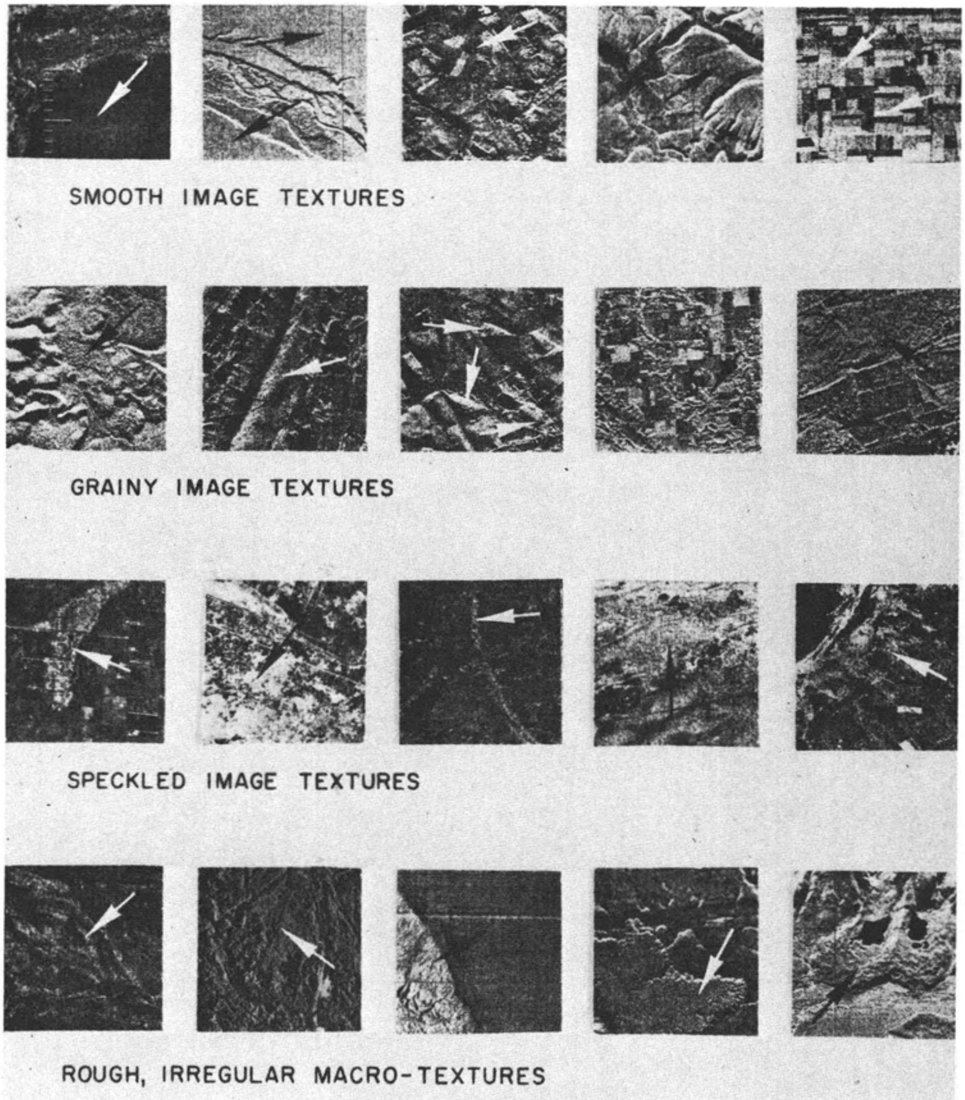

FIG. 4. SLAR image textures.

abrupt changes in topographic form, whereas, average areal tones and textures must be evaluated for the interpretation of more subtle topographic features.

Correct assessment of topographic form is vital to the interpretation of engineering soil types. The determination of genetic and morphologic land forms depends greatly on the analysis of topography. The visual effect of combinations of return elements which allow the determination of specific topographic conditions are herein defined as patterns of topography.

Conditions of high relief are portrayed on SLAR imagery in the form of radar shadows (See Figure 2). Higher topographic features generally produce shadows which are longer in the range direction. Light-toned areas produced by slopes facing the SLAR antenna are commonly found associated with the radar shadows. The overall roughness of imaged terrain affects the distribution of shadows with a greater frequency of shadow occurrence characteristic of rougher terrain.

Areas of moderate relief produce SLAR image shadows of smaller size. In such instances, patterns of drainage may be indicators of relative relief. High drainage densities are generally associated with higher relief areas. There is, however, less contrast between shadow and light toned areas on imagery obtained from moderate relief areas.

Low relief areas generally produce no radar shadow or light tones because of topographic effects. Contrasts in tone and texture are normally the result of variations in local surface roughness.

Occurrence and distribution of wooded areas sometimes offers indirect evidence of relief and topographic forms. Trees normally will be found growing in areas not suitable for agricultural activity. Agricultural field shape offers still another indirect line of evidence with regular rectangular field boundaries normally associated with relatively flat land.

Relative relief is illustrated in Figure 6. General conditions of slope and topographic form appear as a function of radar shadow, average areal tone, and image texture. The recognition of significant topographic forms by an interpreter is entirely dependent upon a knowledge of geologic and geomorphologic processes.

SLAR IMAGE PATTERNS OF LAND USE

Specific patterns of agriculture, natural vegetation, and cultural activity are considered patterns of land use. Agricultural and natural vegetative patterns are composed primarily of the elements of average areal tone and texture. Cultural patterns are usually individual or geometrically regular assemblages of discrete tonal elements. Patterns of land use are valuable for the interpretation of land form and ultimately, engineering soil type. They are critical for site selection. However, they are very sensitive to the geographic region being interpreted and attain a maximum degree of usefulness if evaluated by an experienced interpreter. Farming practices which to a large extent determine agricultural patterns are not consistent throughout the world. A knowledge of the causes of different farming practices may allow an interpreter to relate agricultural patterns to land form and engineering soil type. Similarly, natural vegetative communities vary with climate and soil. Density of cultural features and vegetative conditions can often be related to general topographic conditions where other evidence is not available.

Agricultural patterns significant for the interpretation of SLAR images consist primarily of field shapes. Rectangular fields of large size are indicative of relatively flat terrain, whereas irregular shapes interspersed with wood lots indicate rough terrain. Contour farming which produces curvilinear field boundaries is indicative of rolling terrain with moderate relief. Strip farming is indicated on SLAR imagery by narrow, banded tonal contrasts.

Cultural patterns as illustrated in Figure 2 are generally composed of discrete tonal elements. Smooth, man-made surfaces (such as highways, airfields, or urban streets) appear on SLAR imagery as dark toned lineations. Man-made corner reflectors such as the railroads, buildings, and other structures appear as very light-toned elements on SLAR imagery. Their identification requires the recognition of characteristic geometric assemblages of returns (tones).

Patterns of agricultural land use representative for portions of the United States are illustrated in Figure 7. Table 3 lists general radar characteristics of selected cultural features.

TABLE 2. DISCRETE TONAL ELEMENTS RELATED TO SLAR IMAGE DRAINAGE PATTERN

Discrete Tonal Element	*Condition Producing Element*
Thin, sinuous and/or discontinuous lineation of no return, dark tone	Specular reflection from water surface
Thin, sinuous and/or discontinuous lineation of radar shadow, dark tone	Areas absent of any return because of the blocking of radar illumination, steam entrenchment, high relief topography and dense, high riparian vegetation could produce this situation
Thin, sinuous and/or discontinuous medium to high return elements contrasting with surroundings, medium to light tones	Medium to high returns from riparian vegetation or surface formed by a stream bank facing the SLAR antenna
Thin, sinuous and/or discontinuous lineation formed as a field boundary. Contrasts between light medium and/or dark average areal tones	Irregular field boundary necessitated by an adjacent low order stream
Discontinuous lineations formed as contrasts between relatively large scale units of medium to high return and radar shadow, contrast between light tones and radar shadow	High relief topography from which radar shadows are of large areal extent, contrast with high return from slopes facing antenna is great

INTERPRETATION OF LAND FORMS

Interpretation of genetic and morphologic land forms found within an area imaged by SLAR immediately precedes the interpretation

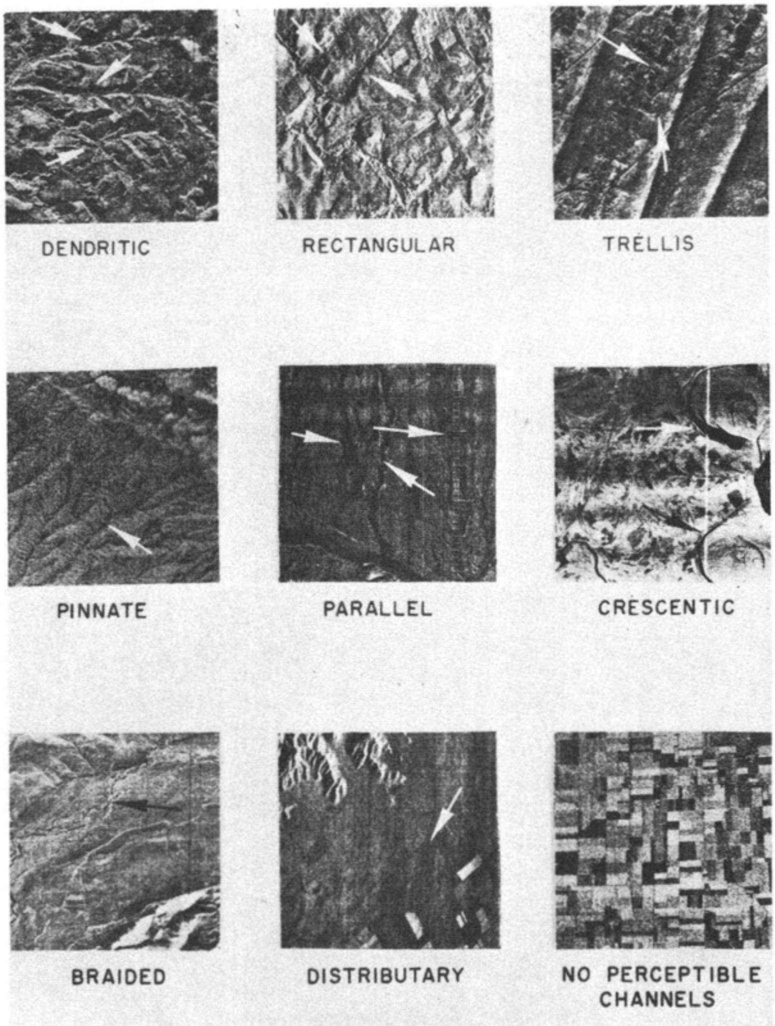

FIG. 5. Basic patterns of drainage.

of probable engineering soil types. If a genetic land form can be identified with reasonable certainty, an engineering soil type and probable land surface condition can be deduced. A specific geologic process is inherent in a genetic classification. Conversely, if only a morphologic land form can be inferred, much more dependence must be placed on the evaluation of the significance of each pattern element and the patterns of drainage, topography, and land use which they form. For example, a flood plain can be directly inferred to contain unconsolidated, relatively fine-grained alluvium, whereas a plain may contain a variety of unconsolidated or consolidated geologic materials. It is commonly through an evaluation of the regional association of several land forms that a genetic classification may be derived.

Genetic land forms usually show a characteristic well-defined and delineative shape characterized on a SLAR image by a topographic pattern. Morphologic land forms, conversely, feature such general topographic characteristics, that numerous geologic processes could have formed them.

INTERPRETATION OF LOCAL LAND SURFACE CONDITION

Local land surface condition as used in the context of this report refers to local conditions influenced by soil moisture content, soil

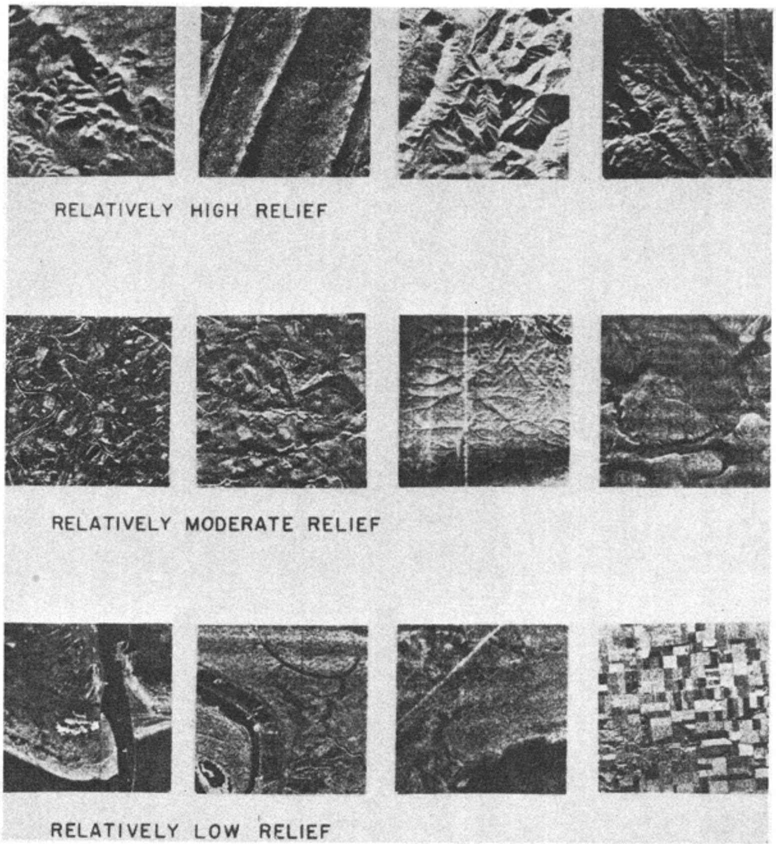

FIG. 6. Patterns of topography.

texture or particle size, or the surface roughness of bedrock. Local land surface conditions are the most difficult terrain parameters to extract from SLAR imagery. Because of the complexity of terrain reflecting surfaces, a specific land surface condition can seldom be directly inferred from the appearance of a small portion of a SLAR image. The local land surface condition must be interpreted through re-evaluation of the pattern elements of tone and texture after a regional land form has already been established. The regional association of patterns is very important in establishing a geologic setting in which specific local land surface conditions can exist.

Realizing that SLAR image displays of different local land surface condition are not mutually exclusive, an interpreter can qualitatively analyze the pattern elements of discrete tone, average areal tone, and texture in terms of a probable microwave energy-terrain surface interaction. Thus, general relationships between surface roughness and the resulting radar cross section can be utilized advantageously.

SUMMARY OF QUALITATIVE SLAR IMAGE ANALYSES

A systematic approach to the interpretation of regional engineering soil types and site selection parameters from SLAR imagery has been developed. The technique requires identification and delineation of pattern elements; evaluation of patterns formed by the pattern elements; and ultimately, inference of land form and regional engineering soil type.

Extraction of data from SLAR images can be facilitated when a definite procedure is implemented as outlined by the systematic interpretation technique. Table 4 is a data evaluation guide that was developed as a means of assuring the collection and evaluation of SLAR image data in a consistent manner.

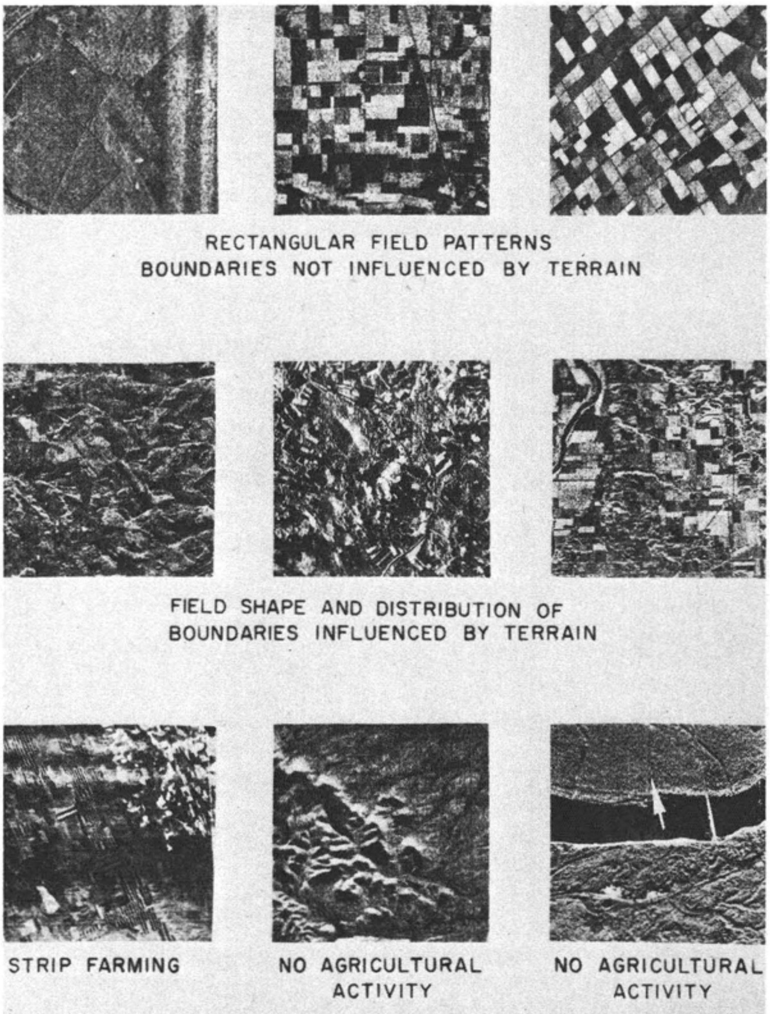

FIG. 7. Patterns of land use.

APPLICATION OF INTERPRETATION TECHNIQUE TO SITE SELECTION

The interpretation technique presented in this paper leads an interpreter toward the inference and delineation of parent material types for engineering site selection studies.

Intensity of drainage channels as well as pattern characteristics will provide indications of flood susceptibility, availability of surface water supply, and need for hydraulic structures. Patterns of topography provide for estimates of terrain roughness and relief, and such associated problems as erosion, landslides, or excessive cuts and fills. Inferences of land form and associated parent materials allow the estimation of probable foundation conditions, ground water conditions, and availability of construction materials. Local land surface conditions, including existing cultural features, can be inferred from SLAR imagery. With such preliminary information the relation of a potential engineering site to existing features can be evaluated.

Figures 8 and 9 and Tables 5 and 6 illustrate the application of the systematic SLAR image interpretation technique to unclassified K-band imagery. The table of interpreted information which is included with each image contains those parameters of terrain which must be evaluated for engineering site selections. Land form and engineering soil type are inferred from the patterns of drainage, topography, land use, and special land

TABLE 3. RADAR CHARACTERISTICS OF CULTURAL FEATURES

Cultural Feature	General Radar Image Characteristic	
	Return	*Pattern*
Urban Area	Very high	Linear and rectangular grid patterns produced by intersecting streets, clusters of high return spots from buildings
Suburban Area	Medium to High	Linear and rectangular grid produced by intersecting streets, few high return clusters
Highways-improved	Very low	Linear traces, generally smooth curves
Highways-unimproved	Very low in general but similar to return from adjacent terrain	Linear traces possibly sharp curves and poor alignment
Railroad	Very high	Linear traces very gentle curves
Power Transmission Lines	Very high	Beaded pattern resulting from reflection from individual towers
Bridge Structures	Very high	Usually individual high return spot or short linear trace
Airport runways supporting structures	Very low, high to very high	Linear traces, X-pattern, clusters of high return spots
Industrial Area	Very high	Clusters of high returns in localized area
Agricultural Area	Variable high to low	Rectangular blocks with uniform return, variation in return from block to block, contour farming produces fields which tend to parallel existing topography

TABLE 4. DATA EVALUATION GUIDE

1. Orient image with flight line at top (shadows pointing toward interpreter).
2. Delineate areas on image overlay which exhibit a generally uniform appearance.
3. Analyze each delineated area with respect to the following pattern elements:
   a) Discrete tonal elements
      1. Light tones—geometric configuration
      2. Dark tones—geometric configuration
      3. Radar shadow—size, shape, and extent
   b) Image textures
      1. Extent of smooth, grainy, or speckled image textures or rough, irregular macrotexture
4. Evaluate regional drainage
   a) Patterns (dendritic, parallel, trellis, etc.)
   b) Delineate areas exhibiting either a lack of drainage or intense surface drainage
   c) Estimate drainage density
5. Evaluate topography
   a) Estimate relative relief from size and shape of shadow and drainage density
   b) Estimate general topographic form from average areal tonal contrasts
   c) Evaluate relation of topography to vegetation and land use
6. Evaluate effect of vegetation, culture, and land use on image characteristics
   a) Identify farming practices from field shape and extent
   b) Describe vegetative types (agricultural, grass, brush or forest)
   c) Determine relative location, extent, and distribution of cultural features (cities, surface transportation networks, etc.)
7. Re-evaluate delineated areas of uniform appearance and adjust boundaries
8. Infer genetic or morphologic land forms
9. Infer engineering soil types (parent materials)
   a) Bedrock types
   b) Relative particle size or USCS classification of unconsolidated materials
10. Relate inferred parameters to requirements for specific site selection problem under consideration.

TABLE 5. EXAMPLE INTERPRETATION: ARIZONA. (SEE FIGURE 8.)

Area	*Regional Drainage*	*Regional Topography*	*Land Use*	*Special Conditions*	*Landform and Inferred Engineering Soil Type*
A	No Evidence of Surface Drainage	Very Flat (Area A_1 is Inferred to be Rough on a Micro-scale Thus Produced a Lighter Tone)	No Evidence of Any Agricultural or Natural Vegetation	Light Toned Limitations Produced by Diffuse Reflection. NE-SW Lineation Indicative of Railroad. E-W Lineation Indicative of Trail	Playa: Unconsolidated Fine Grained Sand, Silt and Clay. Area A_1 Inferred to be Dry, Cracked Surface Producing Diffuse Reflection
A-1	No evidence of Surface Drainage, Numerous Dark Toned Spots and Resultant Speckled Image Texture Inferred to be Due to Potholes, Small Lakes or Infiltration Basins	Gently Rolling with Low Relief, Surface Pitted with Basins	No Evidence of Agricultural Activity, Image Texture and Tone Indicative of Brush and Grass	Position of Area Adjacent to Playa Evidence for Inferring Eolian Origin of Deposit. Lineations Within Area Parallel to Edge of Playa	Stabilized Sand Dune Complex; Unconsolidated Eolian Material Consisting of Sand with Uniform Particle Size
C	No evidence of Surface Drainage	Curvilinear Ridge with Moderate Height	Surface Inferred to be Brush and Grass Covered	Curvilinear Feature Parallels Edge of Playa	Beach Ridge: Fluvially Deposited Sand and Fine Gravel
D	Limited Evidence of Surface Drainage, Dark Toned Areas on Image Produced by Dry Lakes and Infiltration Basins	Relatively Flat Surface	Limited Evidence of Agricultural Activity, Image Texture and Tone Indicative of Brush and Grass	Lack of Drainage Pattern Indicative of Internal Drainage	Alluvial Plain: Unconsolidated, Fine Grained Material Consisting of Fine Sand and Silt
E	Parallel, Local Distributary Patterns, Drainage Channels Accentuated on Image by Contrasting Light and Dark Toned Streaks	Gently Sloping Toward Playa, Relatively Low Relief	No Evidence of Agricultural Activity, Image Texture and Tone Indicative of Grass and Brush	Overall Dark Tone Indicative of Smooth Terrain Surface	Alluvial Apron: Unconsolidated, Fine Grained Material Consisting of Fine Gravel and Sand
F	Distributary Channels Combining to Form Parallel Channels at Outer Margin of Area Nearest Playa	Series of Fan-Shaped Sloping Units, General Slope Away from Mountain Front Toward Alluvial Apron and Playa, Moderate Relief	No Evidence of Agricultural Activity, Limited Occurrences of Brush and Grass	Light Overall Tones Produced by Slopes Facing Antenna	Alluvial Fans: Unconsolidated Material Consisting of Some Boulders, Gravel, and Coarse Sand

G	Distributary Drainage	Fan Shaped, Sloping Surface, Moderate Relief	No Evidence of Agricultural Activity, Brush and Grass Inferred to Exist on Slope	Light Overall Tone Due Primarily to Slope Facing Antenna, Surface Materials Inferred to be Dense Because of Unique Light Tone	Alluvial Fan: Cemented, Partially Consolidated Alluvial Material Consisting of Gravel and Coarse Sand
H	Dendritic Controlled in Part by Geologic Structure	Mountainous, High Relief Terrain, Linear Ridge with Sharp Crest	No Evidence of Agricultural or Natural Vegetation	Linearity of Feature and Joint Pattern Indicative of Sedimentary Origin	Bedrock Ridge: Consolidated Sedimentary or Slightly Metamorphosed Rock, Bedrock May be Calcareous If Alluvial Fan Material (Area G) Cemented
I	Dendritic	Mountainous, High Relief Regional Linear Trend	No Evidence of Agricultural or Natural Vegetation	Area Continuation of Linear Feature (Area H)	Bedrock Mountains: Consolidated Sedimentary and Metamorphic Rock
J	Dendritic	Mountainous, High Relief, Topography More Rounded Than Evidenced in Areas (h) or (i)	No Evidence of Agricultural or Natural Vegetation	No Linearity of Topographic Features	Bedrock Mountains: Metamorphic or Igneous Rock
K	Grossly Dendritic, Locally Rectangular, High Density Drainage	Hilly Topography, Moderate Relief	No Evidence of Agricultural Activity, Image Texture and Tone Indicative of Brush and Grass	Distinct, Unique Drainage Pattern Characteristic of Impermeable Material	Bedrock Hills: Consolidated-Sedimentary Rock, Possibly-Shale
L	Dendritic, Distinct Locally Pinnate Tributaries	Gross Surface Gently Sloping Toward Southwest, Moderate Relief	No Evidence of Agricultural Activity, Image Texture and Tone Indicative of Brush and Grass Cover	Locally Pinnate Drainage Pattern, Evidence of Erosion in Two Distinctly Different Types of Material	Alluvial Plain (Pediment Surface): Alluvial Gravel and Sand Veneer Over Sedimentary Bedrock
M	Distributary and Parallel Complex	Regional Slope Toward North, Low Relief	No Evidence of Agricultural Activity, Image Texture and Tone Indicative of Brush and Grass	Dark Toned Streaks Produced by Smooth Condition of Drainage Channel as Compared to Adjacent Terrain	Alluvial Apron: Unconsolidated Fine Grained Material Consisting of Sand and Silt

TABLE 6. EXAMPLE INTERPRETATION: WYOMING. (SEE FIGURE 9.)

Area	*Regional Drainage*	*Regional Topography*	*Land Use*	*Special Conditions*	*Landform and Inferred Engineering Soil Type*
A	Braided	Relative Flat, No Relief	No Evidence of Agricultural Activity, Riparian Vegetation is Indicated	Braided Stream Pattern Indicative of Excessive Stream Load	Flood Plain: Unconsolidated Alluvial Material Consisting of Gravel, Sand, and Silt
B	Grossly Dendritic, Locally Deranged, Lakes in Evidence	Rolling Somewhat Irregular Topography, Moderate to Low Relief	No Evidence of Agricultural Activity, Area Predominantly Forest Covered	Area Adjacent to Glacially Eroded U-Shaped Valleys	Ridge Moraine: Unconsolidated Till, Heterogeneous Mixture of Clay, Silt, Sand, and Gravel
C	No Evidence of Surface Drainage	Flat, Multiple Scarps Indicative of Multiple Terrace Levels	Limited Evidence of Agricultural Activity, Several Poorly Defined Rectangular Fields Which Are Probably Pastures, Natural Vegetation Inferred to Consist of Grass and Low Brush	Multiple Terrace Levels Adjacent to Moraine and Glacially Eroded Mountains	Glacial Terrace Deposits: Glacio-Fluvial Material Consisting of Stratified Sands and Gravel
D	Distributary	Gently Sloping to West, Fan Shape with Relatively Low Relief	Limited Evidence of Agricultural Activity, Natural Vegetation Inferred to Consist Primarily of Grass		Alluvial Fan: Unconsolidated Alluvial Material Consisting of Sands and Gravel
E	Grossly Dendritic with Some Parallelism of Drainage Produced by Structural Control	Mountainous Terrain with Relatively High Relief, Evidence of Linearity and Structural Control Exists	No Evidence of Agricultural Activity or Extensive Natural Vegetation, Image Texture Indicative of Limited Forest Cover	Linear Tonal Contrasts Indicative of Gross Bedrock Stratification and Regional Dip	Mountains: Resistant Bedrock Inferred to be of Sedimentary Origin
F	Dendritic	Mountainous Terrain with Relatively High Relief	No Evidence of Agricultural Activity, Image Texture Indicative of Forest Cover	Area Exhibits Rounded Form with Sharp Crests Less Prevalent Than in Area (E), Some Evidence of Linearity	Mountains: Resistant Bedrock Inferred to be of Sedimentary Origin, Bedrock Perhaps Less Resistant Than That Delineated in Area (E)
G	Grossly Dendritic with Locally Trellis Patterns	Mountainous Terrain with High Relief, Domical Form, Evidence of Gross Stratification Present Around Periphery	No Evidence of Agricultural Activity, Image Texture Indicative of Limited Forest Cover	Planimetric Shape and Topography of Feature Indicative of Breached Anticlinal or Elongated Dome Structure	Anticlinal Mountain: Bedrock Inferred to be Resistant and of Sedimentary Origin, Core of Structure Possibly Metamorphic of Igneous Rock
H	Grossly Dendritic	Mountainous Terrain with Very High Relief, U-Shaped Valleys Inferred to be the Result of Intense Glacial Erosion	No Evidence of Agricultural Activity, Limited Forest Cover at Lower Elevations	Numerous Tributary Streams Enter Major Valleys from Side Slopes, Streams Controlled by a Rectangular Joint System	Mountain: Bedrock Inferred to be Very Resistant and of Igneous Origin
I			Light Discrete Tonal Elements and Gridded Pattern Indicative of Urban Area		

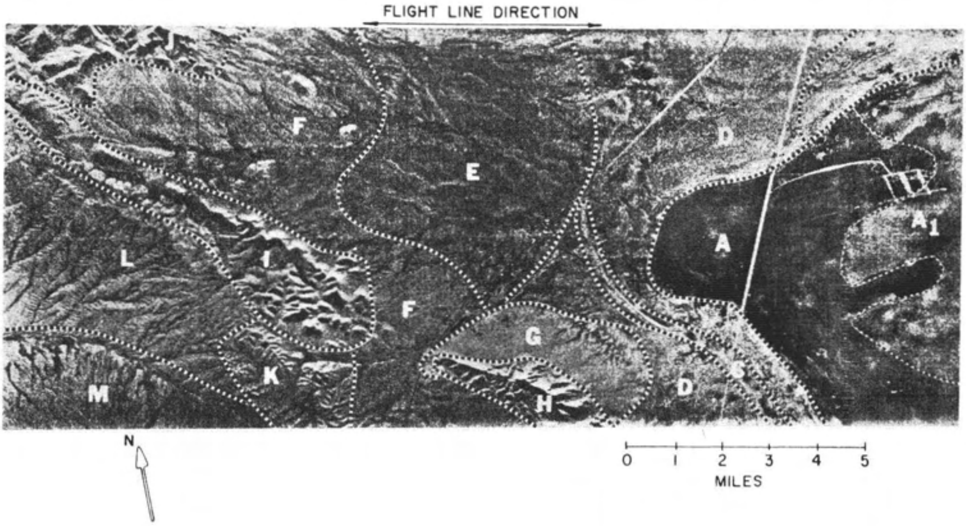

FIG. 8. Example interpretation—Arizona. See also Table 5.

surface conditions. All parameters listed in the table, however, are significant for site evaluation and selection. The relative importance of each can be determined only where the requirements of a specific site are known. Thus, the emphasis of interpretation will vary with the particular problem at hand.

SUMMARY

SLAR imagery provides a synoptic display of terrain at small scale (1/100,000 or smaller) for regional site selection studies. SLAR imagery obtained to maximize directional trends of the landscape show unique patterns. A systematic procedure of pattern analysis has been developed using a data evaluation guide, and the determination on the imagery of discrete tonal elements, average areal tone and image texture. Patterns of drainage, topography (relief), vegetation and cultural features are analyzed to classify land form types. Inferences on the geological and engineering soil conditions affecting site selection are based on the genetic and morphological land form types classified on the SLAR imagery.

The techniques discussed are applicable to the determination of corridors in remote

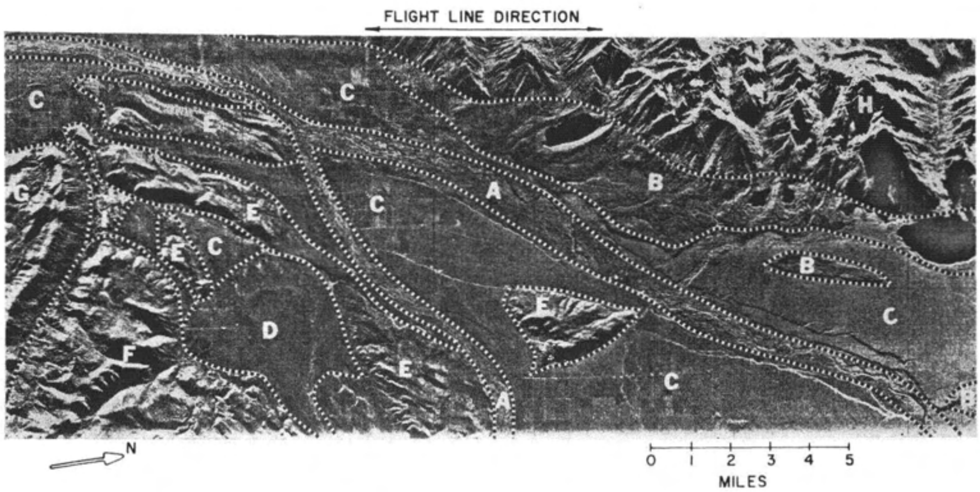

FIG. 9. Example interpretation—Wyoming. See also Table 6.

areas of the world. The specific routes or paths within corridors are analyzed by the use of large-scale aerial surveys.

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