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VEGETATIVE AND GEOLOGIC MAPPING OF THE WESTERN SEWARD PENINSULA, ALASKA, BASED ON ERTS-1 IMAGERY

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ABSTRACT

ERTS-1 scene 1009-22095 (Western Seward Peninsula, Alaska) has been studied, partly as a training exercise, to evaluate whether direct visual examination of individual and custom color-composite prints can provide new information on the vegetation and geology of this relatively well known area of Alaska.

The vegetation analysis reveals seven major vegetation types, only four of which are described on existing vegetation maps. In addition, the ERTS analysis provides greater detail than the existing maps on the areal distribution of vegetation types.

The geologic analysis demonstrates that most of the major rock units and geomorphic boundaries shown on the available geologic maps could also be identified on the ERTS data. Several major high-angle faults were observed, but the zones of thrust faults which dominate the structure of the area are much less obvious. All of the previously mapped granitic intrusive rocks in the area were identifiable on the images; however, a radial drainage pattern about 7 km in diameter, probably indicative of a buried intrusive, was recognized for the first time on the ERTS images. The known association of tin deposits with granitic rocks on the Seward Peninsula suggests that the area of this pattern be investigated further.

Background and definition of problem

Vegetation is a primary component of most landscapes and ecosystems and it is one of the most important land resources. Knowledge of the composition, structure, distribution and environmental relationships of vegetation or vegetation types is therefore a key requisite in approaching land resource problems. Similarly, geologic data indicating provinces of potential importance for the development of metallic or non-metallic mineral deposits, or fossil fuel resources, is an important element in consideration of these problems. In Alaska, data regarding vegetation is sparse and, for much of the state, geologic data, in the form of geologic maps at scale of 1:250,000 or larger, is lacking. However, there is currently major activity in land-use planning and development of resource management techniques. Important decisions must be made in the near future, in spite of the noted lack of much vital information. Among the goals of the University of Alaska ERTS-1 project is the development of image interpretation techniques to increase knowledge in these areas, and, as a corollary, to perform land resource analyses and to open lines of communication to potential data users. In particular, an immediate objective has been to assess the potential contribution which the ERTS imagery can make to rapidly providing the necessary data so that informed land-use planning decisions can be made.

It is anticipated that many potential ERTS imagery users will have no means for image analysis other than direct visual examination of photographic prints or transparencies, possibly aided by a magnifying glass. It was decided therefore that in the early stages of the present project, prior to the availability of analytical equipment, an exercise would be conducted with one of the first ERTS images to determine the extent to which interpretations could be made by direct visual examination. As a result, no enhancement techniques were employed in this study, other than the preparation of a reconstituted, simulated color-infrared photographic print prepared f- - bands 4, 5 and 7 of the ERTS-1 multi-spectral scanner (MSS). This pr. s used exclusively for the vegetation study. For the geologic analysis, the 9-1/2 x 9-1/2 NASA supplied paper prints of bands 4, 5, 6 and 7 were also employed.

Ground truth used in this study was limited to references readily available in the literature. For the vegetation study, this consisted of four small-scale vegetation maps and a few published reports (see reference list), supplemented by fire records of the U. S. Bureau of Land Management. A recent 1:250,000 scale geologic map of pa. of the area (Sainsbury, 1972) provided the ground truth for the geologic analysis.

Approach

The studies were done separately and followed the concepts of aerial photographic interpretation standard in each discipline. However, some modifications were required by the nature of the ERTS images.

For the vegetation analysis, interpretations were based on the following assumptions: (1) Most of the western Seward Peninsula is covered by vegetation and this is therefore chiefly responsible for the spectral reflectance registered on the image. (2) Different vegetation types have different spectral characteristics, and color, color intensity and textural patterns on the image therefore depict different vegetation types and their distributions. (3) Positive identification of spectral signatures according to vegetation type depends on one or more of the following forms of ground truth: aerial photography; field observations, including low overflights in light aircraft; and information in the literature, including vegetation maps. (4) The resolution of ERTS imagery permits definition of vegetation types at a level useful for the plant ecological and resource analysis questions addressed.

In the case of geologic investigations, the synoptic aspect, resolution and scale of the ERTS imagery, and the availability of multiband data, require some changes in the objectives of the study of the images from those which might be sought through the use of conventional aerial photographs. As examples, details of bedding altitude, effects of subtle changes in rock texture or composition, and the presence of minor structural features would generally not be discernable on the ERTS images. However, structural trends, drainage patterns and geological provinces of regional extent become evident. Thus, for geologic studies, the ERTS images provide information not previously obtainable except possibly from detailed study of many large-scale aerial photographs. Simultaneously, information which would have been available from the study of conventional aerial photographs cannot be extracted from the ERTS images. As a result, the present study was primarily concerned with examining the applicability of the ERTS images to small-scale reconnaissance mapping and other investigations utilizing the synoptic and multiband features of the data.

Results of vegetation studies

Seven distinct colors were recognized on the image. Four were identified through matching of their general distribution patterns with those of vegetation types on the existing maps: Bright red - shrub thicket; light gray-red - upland tundra; medium gray-red - wet tundra; gray - alpine barrens. In the bright red color two phases, violet and orange, were recognized and tentatively ascribed to differences in species composition in the shrub thicket type. Significantly more detail in the distribution of these types, particularly of small units or stands, could be seen on the image than could feasibly have been depicted on the maps at the scales used. Some of this detail is shown on the new map presented here, which was drawn at the same scale as the ERTS image (Figure 1). The three colors having no map unit equivalents were tentatively interpreted through reference to the literature and general plant ecological knowledge as follows: Pink - grassland tundra; dark gray-red - burn scars; light orange-red - senescent vegetation. The interpretation of dark gray-red as indicating areas of former vegetation fires was subsequently confirmed by records of the U.S. Bureau of Land Management.

Figure 1 is the new vegetation map of the western Seward Peninsula, drawn by tracing on an acetate overlay of the image. Besides the seven colors discussed above, five additional map units are shown. These represent mosaics of color units too small feasibly to map individually at the scale of the unenlarged ERTS image. Figure 2 is a tracing of part of an existing vegetation map (Spetzman, 1963), enlarged to the same scale, which may be compared with the new map to emphasize the increase in mappable information derived from the image. The new map required only about ten man-hours to draw and label. It is believed that considerably more detailed and accurate maps than this one will be possible using the various image enhancement and digital data processing techniques which are becoming possible with ERTS imagery.

Besides the promise this exercise shows for delineating and mapping vegetation types with ERTS imagery, promise is also shown for surveying phenological developments and vegetation fires using sequential imagery.

Knowledge of the distribution and relative areal importance of vegetation types, particularly as shown on the new map, may be applicable in the areas listed below. In each case, the broad geographic or synoptic coverage is of primary importance.

1) Hydrology. Stream patterns may be examined through the recognition of riparian vegetation types, i.e., the shrub thicket type in part, and areas of poor drainage or standing water and of excessive drainage may be recognized, at least in a general way, from the occurrence of certain vegetation types.

2) Soil science. The close relationship between soil and vegetation development could permit study of the distribution of soil types through examination of the vegetation map.

3) Plant ecology. Besides the immediate, scientific plant ecological interest of the knowledge resulting from this exercise, a basis for further study of relationships between vegetation and environmental factors is provided.

4) Meteorology. Vegetation is responsive to meteorological and climatological conditions. Therefore, study of the image and the map from this standpoint could provide an indication of conditions over broad and more or less remote areas where no weather stations are located.

5) Wildlife biology and management. Study of the distribution of vegetation types is essentially a study of the availability and distribution of habitat and food materials for wildlife. Knowledge of species preferences could enable an analysis of the distribution of animal populations and to some extent the estimation of their abundances. Insight into the nature of migration patterns may also be obtained, particularly through the study of sequential imagery and the determination of a vege tation phenology schedule.

6) Land use planning. A land use planning team could use knowledge of the presence and distribution of vegetation types (a) to help in locating areas containing representative ecosystems for preservation, (b) for identifying and delineating, for example, caribou (upland tundra), moose (shrub thicket) and waterfowl (wet tundra) ranges and determining areas to be managed primarily for sustaining populations of these animals, (c) for delineating areas suitable for certain recreational activities, including mechanized and non-mechanized forms, (d) for delineating areas with agricultural potential which might be opened to homesteading, or areas supporting substantial populations of fur bearers which should be managed to include trapping, and (e) similarly, for identifying and delineating areas for use in meeting various other human needs or desires.

<u>Results of geologic studies</u>

A total of about six-man hours were spent examining the prints of the four bands of the image. The results of the investigation were recorded on overlays for comparison with the geologic map.

The most striking result is that almost every important boundary shown on the geologic map could also be identified on the ERTS images. Particularly outstanding features are the part of the map area underlain by limestones of various ages, the metamorphic belt of the Kigluaik Mountains, several granite stocks, beach deposits and zones of thaw ponds along coastal areas. Boundaries of these units were obvious at first glance and were easily mapped over the entire image area. Further study was required to locate other, more subtly expressed boundaries. High-angle faults were easily identified on the images by their generally straight traces, but the important zones of low-angle thrust faults, which dominate the structure in some areas, were not generally recognizable. In general, however, there is no doubt that an acceptable 1:250,000 scale reconnaissance geologic map of the area could have been produced from the ERTS data with only minimal ground truth to identify rock types.

The ease with which boundaries were recognized on these images is primarily a result of the close association between rock units and vegetation patterns in the area. Many of the boundaries between vegetation types shown on Figure 1 are also geologically significant.

Two features of interest which do not appear on the geologic map were noted on the ERTS images. The first is a zone of parallel or sub-parallel lineaments which can be traced for about 60 km in an east-west direction from 65°30'N, 166°W to 65°30'N, 167°W (Figure 3). The geologic map shows small faults with this trend near the ends of the zone, but does not indicate continuity between these. It is possible that the zone was recognized during mapping and thought not to be significant, but its clarity on the ERTS images shows that it is indeed real. The second feature of interest occurs at about 65°66'N, 166°30'W. Just east of this point, a granitic stock, with associated tin deposits, is exposed in the cone of a structural dome upon which a radial drainage pattern is developed. Examination of the ERTS image shows that, at the point indicated, this drainage pattern is distorted by a second, smaller radial drainage pattern about 7 km in diameter (Figure 3). This implies the presence of a second structural dome, also probably resulting from emplacement of a smaller granitic stock which is still buried. The known association of tin deposits with granitic rocks in the area suggests that the area of the second, previously unknown, dome may have economic implications.

Conclusions

The results of this study show that reconnaissance maps of vegetative and geologic features can be produced rapidly from ERTS images, and at scales useful for resource studies, and land-use planning in Alaska.

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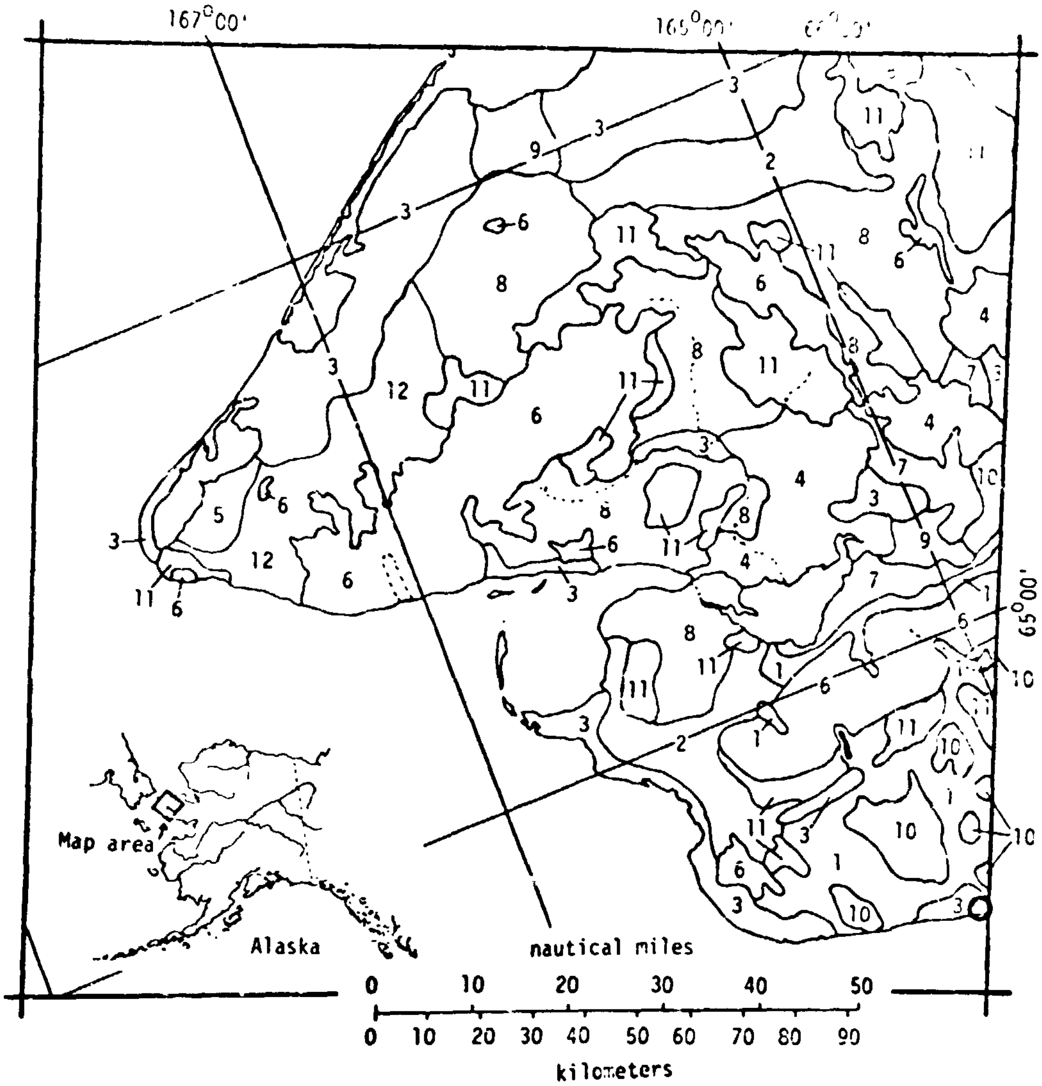

Figure 1. Vegetation map of the western Seward Peninsula, Alaska

Traced from an ERTS-1 image

1. Shrub thicket
2. Upland tundra
3. Wet tundra
4. Fire scar
5. Senescent vegetation (?)
6. Alpine barrens
7. Grassland tundra (?).
8. Shrub thicket/Upland tundra mosaic
9. Shrub thicket/Wet tundra mosaic
10. Shrub thicket/Alpine barrens mosaic
11. Shrub thicket/Upland tundra/Alpine barrens mosaic
12. Upland tundra with some senescent vegetation

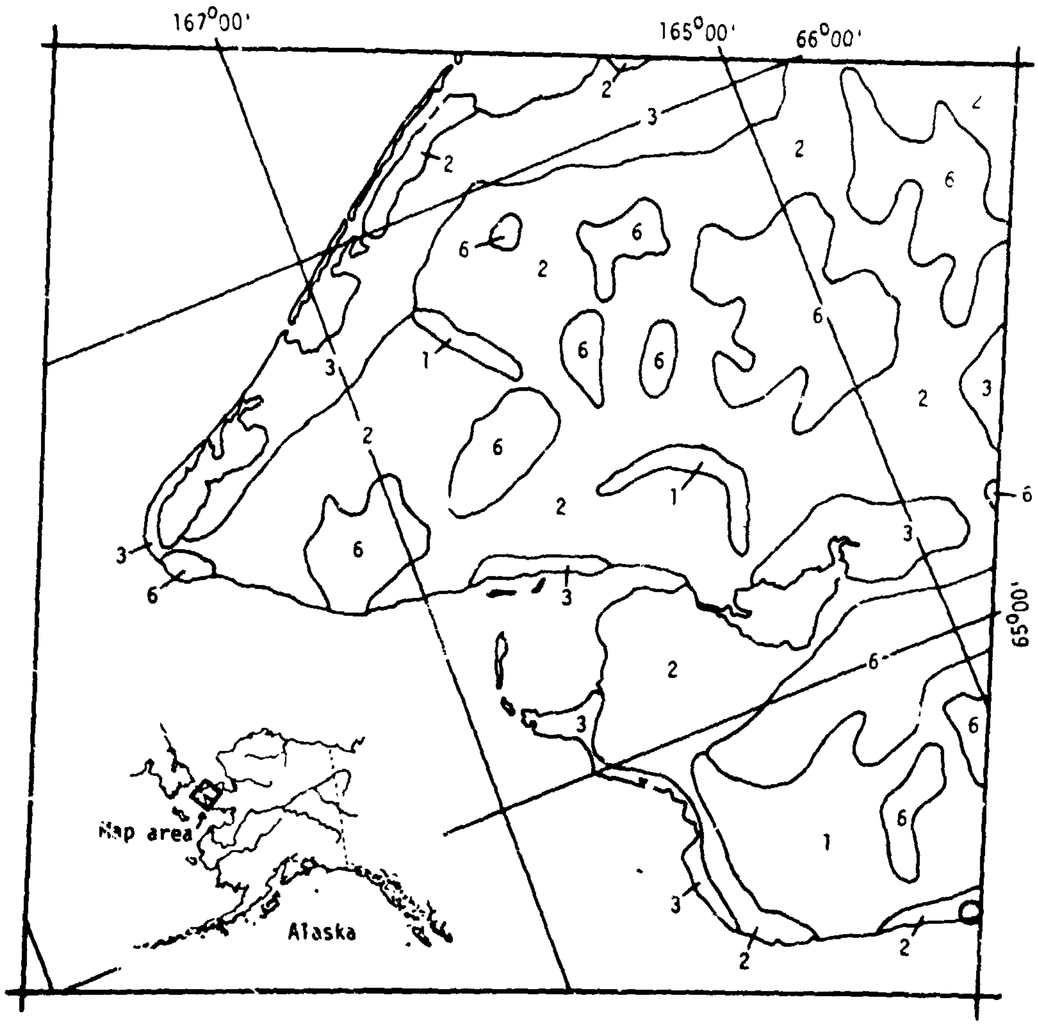

Figure 2. Vegetation map of the western Seward Peninsula traced and enlarged from Spetzman's (1963) map of Alaskan vegetation. This is provided for comparison with Figure 3. The map units designated by Spetzman and their approximate equivalents as termed in this paper are: 1. High brush - Shrub thicket; 2. Moist tundra - Upland tundra; 3. Wet tundra and coastal marsh - Wet tundra; 6. Barren and sparse dry tundra - Alpine barrens.

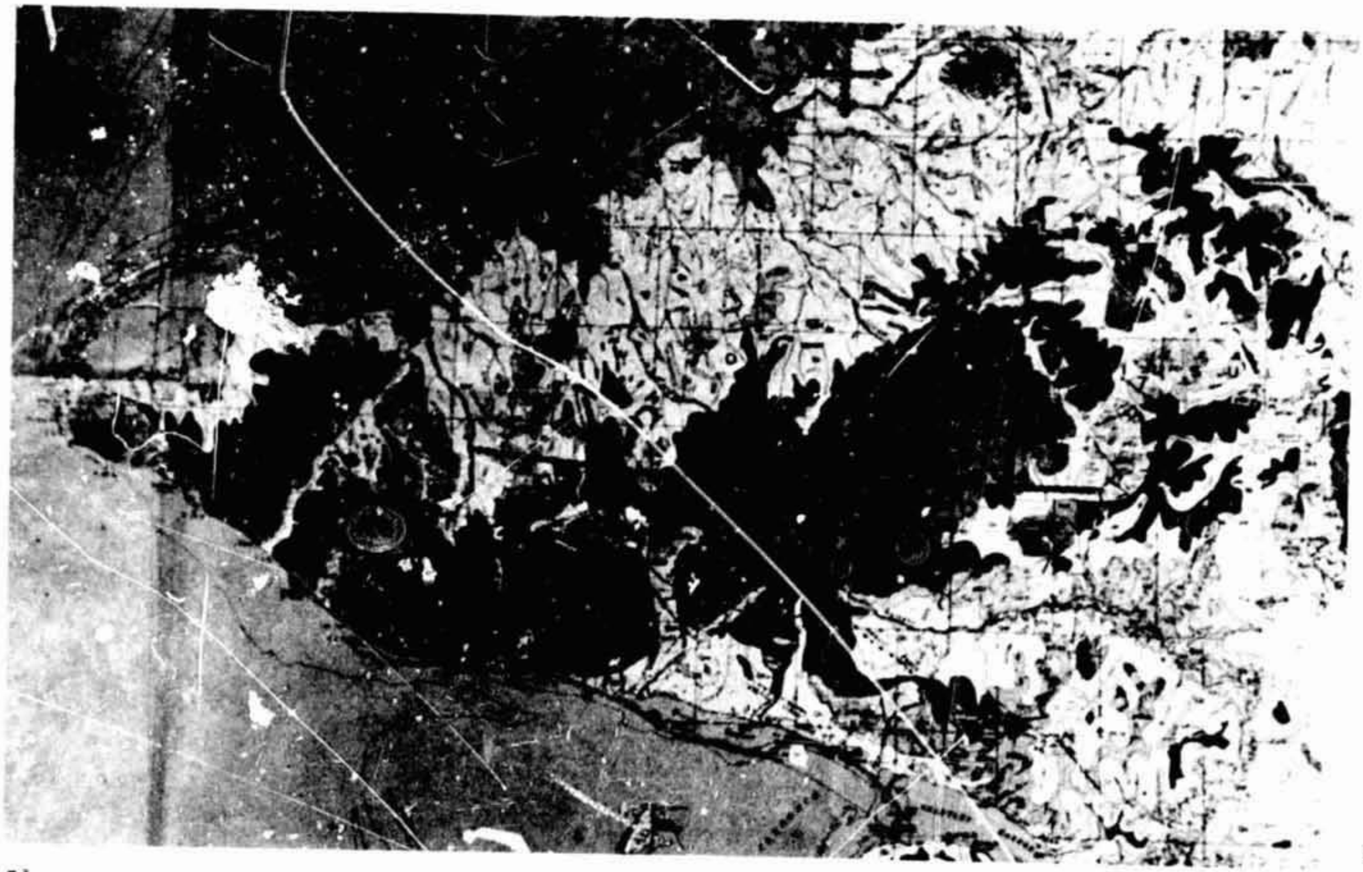

Figure 3: Geologic map of part of the Seward Peninsula (after Sainsbury, 1972). Lineament zone and site of possible buried intrusive indicated by dotted symobls (see text).