Property Analyses of Deposits and Landform in Tidal Flat using Satellite Image

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Abstract

Through the ISODATA method, the micro-landform of Julpo-Bay tidal flat was classified into mudflat, mixedflat, and sandflat using Landsat TM image. Each showed an apparent differences in its topographical characteristics and grain size composition. For example, mudflats are formed with flat faces and tidal channel of dissected gully. Its characteristics of grain size analysis that the grains have less than mean grain size 4 phi. Its sorting is bad (higher than 1 S.D.), and it showed strongly positive skewness. But sandflat is topographically flat without tidal channel. It has developed with ripple marks. According to the grain size analysis of deposits, the soil is coarse size with 90% of sand and its sorting is well(lower than 1 S.D.) Also, it showed strongly negative skewness. Mixed flat is in between mudflat and sandflat in its characteristics.

I. Introduction

The tidal flat is a sedimentary landform formed during inter tidal zone. The Julpo-Bay, study area, seems to show a geological formation of differential erosion. In a geographical terms, Byunsan Peninsula in the north of the bay, Kyungsu Mountain and Soyo Mountain in the south show signs of strong erosion as found in volcanic rock geology such as andesite of the Cretaceous period, the Mesozoic Era, thus leading to mountains with an elevation of some 400m. Meanwhile, it is thought that the central bay and the plain part linked to the east of the bay and consisting of granite of the Jurassic period subject to weathering have formed lowlands and bays owing to their vulnerability to erosion.

The bay has an average width (south - north) of 5-6Km and length (east-west) of 17km. Thus, with shallow depth, it displays wide tidal flat during the low tide. Even two-three-meter depth is found in the main tidal channel and at the entrance of the bay.

The tidal flat of Julpo - Bay is relatively wide with a size of $76km^2$, but the reclaimed size, with just $14Km^2$ (18%) covered, is very low compared with an average of 50% across South Korea. In this context that most of the tidal flat remains intact, Julpo - Bay is an idealistic research topic on the tidal flat.

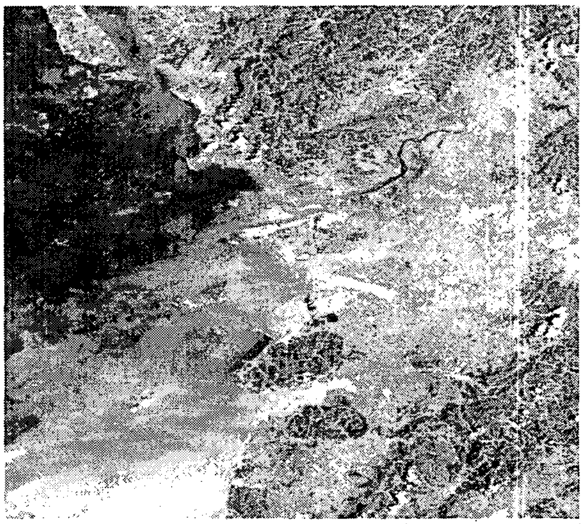

Figure 1. Landsat TM Image of the Study Area, Julpo-Bay(September 1, 1996).

This study focus on the tidal flat in Julpo – Bay(photo 1), and by means of Landsat TM images, to classify the micro-landform of tidal flat, it verifies the topography of each classified micro-landform and the characteristics of deposits through ground survey researches and laboratory analyses. The study would be able to establish the reclamation plans and utilizing lands after completion of the reclamation.

For the best images, a list of Landsat-taken pictures for the past 25 years was acquired. In the course of selecting the closest image between the low tide time of Julpo - Bay and the satellite image detection time, the photo taken on September 1, 1996 was selected.

II. Image Processing and Classification

1) Selection of Method and Procedure

For the method of classifying land cover, supervised classification is used mostly. This classification is a particularly effective method of selecting training area with precision. About, the tidal flat in Julpo – Bay, there exist no archives of pre-researches and no definite topographical boundary. However, topography and grain size composition of deposits show some changes as they move from the inner bay to its entrance. Thus, a comparison of the two bay areas shows great differences. For this reason, this study selected the method of unsupervised classification which divides a clustering of randomly abstracted pixel data into groups.

Clustering is a method of grouping spectral diversity values by their similarities. The process of clustering is divided into hierarchical clustering and non-hierarchical clustering. This study chooses the ISODATA method of non-hierarchical clustering.

2) Processing Result

Based on the map of Julpo - Bay and its surrounding area which is classified through the above-mentioned

process shown in Fig. 2. The whole area is
categorized into 10 classes. Among them, 5 are on the sea side, while the other 5 on the land side. Five sea side classes are composed of 3 classes (dark blue, light brown and dark red) for the tidal flat and 2 classes (light yellow and blue) for the sea surface.

What each class is about is subject to the following analysis of deposits and topographical research. However, given the need to avoid confusion from description, each class can be named as follows. Class I (dark blue) which occupies the innermost part of the tidal flat represents is named as "mudflat". Class II (light brown) in the center is "mixed flat" ,while Class III (dark red) located closest to the entrance of the bay means "sandflat". In the meantime, Class IV (light yellow) right next to the tidal flat is salt water which is turbided with shallow depth while Class V (blue) running farther out stands for clear saltwater with its depth farther down.

Close to Gomso lies large coverage of salt farms and breeding grounds for a yellow sea prawn. It is interesting to note that the salt farms with their beds almost exposed are classified into Class III just like sandflat and that the breeding grounds are placed Class V.

Density value and respective size are measured according to bands of Class I-III and Class IV and its result appears . The size of the tidal flat is about the same as those of the mud flat (27.4km^2) and of the mixed flat (30.2km^2). The sand flat has smaller size than the above two, occupying 18.5km^2.

It could be concluded that band 5 and 7 show at their highest discrimination power for classifying the micro-landform in the tidal flat, and, band 3 is also useful to detect the boundary between the sea and the tidal flat. In addition to, band 4 is of use for founding the boundary between the land and the tidal flat respectively.

Figure 2. Classification image of Julpo-Bay and its surrounding area by unsupervised classification of TM image(September 1,1996) 1-7 band

III. Grain Size Property of Deposits in the Classified Areas

In order to examine, from the viewpoint of characteristics of deposits, the differences of the tidal flat's three parts which were analyzed by the previously mentioned unsupervised classification, this study analyzed the surface deposits of the Julpo - Bay's tidal flat.

Soil samples were collected on two occasions between 5 and 7, September, 1997 and between 3 and 5, October, the same year and were carried out on the surface of the exposed tidal flat. Small channels of tidewater were excluded, and plate flats between the channels were chosen instead. Around 500g of samples for each was collected in same interval at a total of 42 points.

As for grain size analysis, smaller than 4phi(ϕ) were classified by gravimeter method and larger than 4phi(ϕ) by a sieve analysis.

The relationship between result of grain size analysis and of TM image classification is examined. Mean phi distribution of tidal flat deposits on satellite image classification was produced. In general, mean grain size is coarse at the entrance of the bay while, around the inner bay area, it is turning into fine grain size. However, as is the case with "Duemul", at the innermost part of a secondary small bay, though it is closer to the entrance of the bay, the mean grain size is far more fine size than outer. The boundary between Class I area (mud flat) and Class II area (mixed flat) which is classified by satellite images corresponds with isoplethic line of average mean phi of 4 phi. Thus, as for the deposits of Class I, the mean phi is more finer size than 4 phi while those of Class II, III areas are more coarse size than 4 phi. However, the boundary between area II and area III can never be established by the mean phi.

The sorting of the bay entrance part records 0.6 - 0.7 phi S.D (Standard Deviation),well sorted. However, as we go farther into the bay, the sorting turns bad, and the innermost of secondary bay gets worse, displaying over 2.0 phi S.D. In the sorting standing, the tidal flat's Class I area by classified satellite image is higher than S.D. 1 phi, while Class II and III areas are lower than of that. However, the sorting value to divide Class II and Class III area is not clear.

The deposits on the side of the entrance area and main tidal channel present negative skewness, and inner bay area and the area which is far from the main tidal channel is near the coastal line shows positive skewness. The samples from tidal flat Class I area classified with satellite image have a positive skewness tendency while those from Class II, III areas have negative skewness In general, on the part of the bay entrance and the main tidal channel, the ratio of content for the suspended load appears low whereas the ratio turns high as it comes to the inner bay area. For the inner part of secondary bay, it turns even higher. When related to the classified areas by satellite images, Class III area mostly ranges less than 10%, and, as for Class I area, it mostly ranges more than 20%. Class II area is distributed both less than 10% and more than 20%, but the main part is distributed through 10%-20% range area.

Followings are the summaries that grain size characteristics of deposits for three areas of the tidal flat. Class I area has mean phi of more than 4 phi. It consists of fine size deposits with more than 20% of finer deposits 5-phi grain size. The sorting is bad as it shows more than 1 S.D. It has a strong tendency toward positive skewness.

Class II and Class III areas are coarse size with mean phi of less than 4 phi. The sorting is well as for less than 1 S.D. It tends to present negative skewness strongly. It can be found that the ratio of content of less than 5 phi, though not exactly in correspond, shows that Class II area is distributed within 10-20% area , and that Class III mostly ranges in less than 10% area.

IV. Topographic Characteristics of Classified Areas by Satellite Image

Topographic characteristics clarified from ground survey concerning three areas of the tidal flat which has been classified by satellite images.

Class I(mud flat) area is composed of topographically flat surface and tidal channel in the form of its dissection. It looks as if it were a reduction of a plateau and a canyon. The relative height between the bottom of the tidal channel and the flat surface is about 2m and in some places, it comes to 3m. The bottom of the tidal channel is exposed with all the water ebbed when the sea level hits the lowest. The walls of the tidal channel comprise steep slopes. What makes the walls maintain steep slopes is because of strong viscosity as they contain fine size deposits such as silt and clay. The flat part between tidal channels not dissected is very flat. The surface of this flat part is partly covered with such salt herbaceous plant such as a *Suadea glauca* but, uncovered area is larger. The coverage of salt herbaceous plants is scattered on a relatively large scale and with high density at the river mouth of the Jujin River and the Sa River. However, there is almost no coverage at bays without inflow of land-oriented rivers such as Gomso Bay and bays near Sinbokri. Such distribution of salt herbaceous plants is formed possible because many nutrients such as a nitrate are provided from rivers.

Given topographical characteristics and those of deposits, Class I area is mud flat. In classifying inner-bay tidal flat, there are many cases in which salt marsh and mud flat are distinguished. However, in this study areas, no clear boundary or topographical difference has been found between areas covered by salt herbaceous plants and not covered with it. That may be why satellite images have also failed to produce clear distinction until this study.

In Class II area, there are also some tidal channels where water is ebbed, but, as in Class I area, it is not clear. The relative height between channel bed and flat top is less than 0.5 meter. Both slopes of the tidal channel are gentle, leaving no existance regarded as channel walls. One thing to notice is that on the surface, there are small protrusions. It can be assumed that they are the creation made by crabs, small octopuses and shell which made holes in tidal zone. After the processing of making holes, the soil was piled by above animals, then, rising tide acts on this contributing to the make-up of the protrusions. Class II area had much more sand than Class I area, but still considerable amount of fine size such as silt is included. Therefore, it may be regarded that Class II area is a mixed flat where there is a mixture of sand and silt.

One characteristic about Class III area is that there are no tidal channels. Most of deposits consist of sand, and, so, without viscosity, if any, the channels are soon to be collapsed. The surface is very flat with only ripple marks of about 5cm relief. The ripple marks composed gentle slopes toward the sea and steep ones toward the land, thus being asymmetrical. Thus, Class III area can be regarded as sand flat.

V. Summary

1) To classify and measure the micro-landforms of topography such as a tidal flat submerges under the sea on a regular basis, a short timeframe for exposure at the ebb time, its shape continues to change, and the boundary between landforms is not clear, satellite remote sensing was effective.
2) When the selection of training area is difficult, supervised classification can not be carried out. However, the

unsupervised classification of non-hierarchical clustering, ISODATA method, produced desirable and fruitful results.

3) Out of 7 bands from Landsat TM images, band 5 and 7 provided the highest power level for discrimination between micro-landforms of the tidal flat. Band 4 showed a clear boundary between the land and the tidal flat, and band 3 did its share by showing well a boundary between the sea surface and the tidal flat.

4) Through unsupervised classification of Landsat TM images, the tidal flat in Julpo - Bay was divided into 3 classes. Besides this classification, this study conducted a deposits grain size analysis and ground survey for topography. As a result, the innermost toward the bay could be identified as mud flat, the center, mixed flat and the farthest out to the sea, sand flat. There was a slightly coverage of *Suaeda glauca* ,salt herbaceous plants, but as there was no distinction on images between covered area and not covered area of it.

5) Mud flat deposits had an average mean phi of more than 4 phi with more than 20% of fine size of over 5 phi. Sorting was bad with more than 1 S.D., showing strong tendency of positive skewness. For mixed flat and sand flat, the coarse size deposits, the average mean phi was less than 4 phi. The sorting is good with less than 1 S.D. Strong tendency was found in favor of negative skewness. The ratio of content of fine size deposits with less than 5 phi was 10-20% for mixed flat and less than 10% for sand flat.

6) Topographically, mud flat consisted of tidal channels and flat intermediate surface. Its average relief of them is about 2 meter. Meanwhile, sand flat comprised very flat topography with well-developed ripple marks of less than 10 cm average relief. Mixed flat stood in between.

Reference

Budd,J.T.C.,and E.Jmilton, 1982,Remote sensing of salt marsh vegetation in the first four proposed Thematic Mapper, International Journal of Remote Sensing, 3(2):147-161.

Ezra,C.E., L.R.Tinney and R.D.Jackson, 1984, Effects of soil background on vegetation discrimination using Landsat data, Remote Sensing of Environment, 16:233-242.

Khan,M.A., Y.H.Fadlallah and K.G.Al-Hinai, 1992, Thematic mapping of subtidal coastal habitats in the western Arabian Gulf using Landsat TM data-Abu Ali Bay,Saudi Arabia, International Journal of Remote Sensing, 13(4):605-614.

Klemas,V., D.Bartlett,and R.Rogers,1975, Coastal zone classification from satellite imagery, P.E.R.S.,41(5):499-513.

Myung-Hee Jo, 1989, Land cover classification using Landsat TM image, Ph.D.,Thesis, Kyungpook National University, 154p.

Myung-Hee Jo and Jo Wha-Ryong, 1997, Spatial distribution of tidal flat in Korea, Journal of the Korean Association of Regional Geographers, 3(2):195-208.

Wagle,B.G.,and N.H.Hashimi,1990, Coastal geomorphology of Mahe Island, Seychelles, International Journal of Remote Sensing, 11(2):281-288.