INTRODUCTION

Contemporary development of remote sensing and its applications in the study of various aspects of environment may and in many cases have already substantially contributed to better cognizance of its structure and rules of its functioning. Remote sensing data in combination with geographical information systems create a new field of science on environment – telegeoinformation, enabling to analyse anew previous knowledge on environment, enriching it with new information provided by more and more perfect environment study oriented satellite systems. Telegeoinformation, enabling comprehensive and multilevel analysis, creates a possibility for practical and immediate use of geodata for both, scientific and practical purposes, the example of which may be using telegeoinformation in the assessment of status and forecasting crops of main cultivated plants, in monitouring and analysing rapidly changing situations connected with natural cataclysms or other occurrences requiring prompt decisions. Accessibility to satellite images, air images and other remote sensing data, both archive and performed today, allows on a wider scale for starting research on changeability and dynamics of the environment as a whole or its respective components and elements on a global, regional, and also local scale. An integrating role of telegeoinformation manifests itself here, creating a plane for linking a lot of various information and facilitating the search for dependencies between various phenomena.

One of the possibilities of using remote sensing data in geographical research is their application in the analysis of the environment structure. Going back to the past it should be stated that already in the dim and distant times, before 2.5 thousand years in China, the division of land into spatial units was performed (Chao Sung-chiao, 1984). In modern times more lively interest in the terrain structure was taken at the end of XVII and at the beginning of XVIII century. Emergence of the possibility for using air images in various types of geographical research opened new research horizons for geography. Summing up the views of the then development stage of this new field of science, which was once called photointerpretation, J. Tricart, S. Rimbert and G. Lutz wrote in 1970, that air images allow for comprehensive look upon the geographical environment, elements of which are artificially torn off from one another.

One of the deepest study using air images for the analysis of geographical environment structure, with reference to its agricultural aspects, was the study of F.J. Marschner of 1959. In this analysis spatial structures connected with the use of land in the United States were defined. For this purpose small scale air images were used where terrain complexities visible on images taken in larger scales were reduced. Separated agriculture-rural regions were illustrated with examples of photo-mosaics of air images in the scale 1:63,000. Continuation of this trend were the activities tending to analyze the regionalization of a part of the territory of Chile. Necessity to perform such a regionalization resulted from the need for starting works on the typology of rural areas. The intention was to work out a method for designating spatial units, adjusted to operating with a large number of information already accessible from thematical maps, and also open to introducing new data to be obtained in the future. It was considered, that air images provide knowledge on agricultural practices on respective types of terrain. Photo-mosaics in the scale 1:100,000 appeared to be most useful for this purpose.

D.D. Mac Phail (1971) observed then, that such images (photo-mosaics) portrayed geometrical compositions of cultivable field allotments, hydrographical network, geological structure (through rocky disclosures), dampness of land and vegetation garment. On air images these elements compose certain, spatially distinguishing themselves photo-tonal and structural units. Phototone changes depending on the form of land use, while phototexture reflects the structure of cultivable fields and settlement qualities, and strictly depends on the diversity of terrain relief. For the first time, the term „photomorphic area" was used then. MacPhail thought that, photomorphic areas are spatial units, to which information on the character of agriculture-rural areas can be referred, and that such photomorphic areas may be the object of geographical mapping. For the first time an integrational role of air image was then so explicitly proved, as a carrier of information on the one hand, and as a datum plane to which various information on the environment may be adjusted, on the other. It was stated in further considerations (Mac Phail), that photomorphic areas become a useful diagnostic tool in regional reseach. A map of such areas may be used as an initial carthographical construction for the quantitative analysis of the occurrence of the given phenomena. Photomorphic areas are the external symptom of correlation between various elements of the environment, for instance the type of land and soil use. In case of Chile it was determined that photomorphic areas reflected connections between the use of land, types of soil, relief, and other topographical features. Thus, they may constitute the basis for delimitation of landscapes or types of terrain.

Appearance of satellite images created technical possibilities for operating with small scale images. Basing on formerly mentioned complexity of small scale air images it was assumed that satellite images constitute good material for their application in the analysis of large area environment structure. However, in spite of these expectations such studies were not numerous.

Accumulation of good quality data from NOAA metheorological satellites enabled comparison of global images on which main areas of more or less uniform physiognomy are apparent. It is possible to designate large regions on them, areas in the scale of the whole globe and of continents (Olędzki, 2001).

NOAA data, obtained via the AVHRR equipment deliver images of 1,1 km resolution abilities at satellite nadir, and from 2,4 to 6,9 km off-nadir, performed in five spectral channels in visible and infrared range of electromagnetic spectrum (EM) on wave length of 0.58-0.68; 0.72-1.1; 3.55-3.93; 10.3-11.3, and 11.5-12.5 µm. Basing on such data it was possible to compose a quite detailed image of entire Europe, which spectacularly shows the regional structure of our continent. Analyzing the image of Europe in the resolution of 1946m, performed in the National Remote Sensing Center (NRSC) in Great Britain in the scale of 1:3,500,000, basing on the data from the NOAA-7 satellite, division of Europe into photomorphic areas – regions was obtained, which may correspond to provinces or sub-provinces in the physico-geographical division (Olędzki, 1998).

Further research of environment structure may be carried out on transformations of satellite images obtained from Landsat TM and Spot in the scales of 1:50,000 and 1:25,000. They allow for a very detailed study of the environment structure, at the level of forest range landscape units.

In the light of hitherto performed studies it can be stated, that photomorphic areas designated with the use of the deductive method and basing on satellite images characterize themselves with high homogeneity of environment and as such correspond to geographical regions, both in their natural and anthropogenic aspect, thereby constituting an excellent foundation for various spatial studies on the environment structure and on its monitouring.

RULES OF DIVIDING POLAND INTO GEOGRAPHICAL REGIONS

IMAGING SYSTEMS OF LANDSAT SATELLITES

Among many satellite programs more and more often appear such ones, whose appropriation is research of the environment. First satellites which may be accounted to the cathegory of "environmental" satellites were meteorological ones. They paved the way to specialized satellites appropriated for research of land and sea environment. These satellites were: ERTS-1 (Landsat-1) and Seasat. Information on satellite research of environment can be found in various studies. Among others, E.C. Barret (1974); J.J. Barrnett and C.D. Walshow (1974); H.W. Brandli (1978); M. and A. Chabreuil (1979); D.L. Armand (1980); D. Baker (1981); *Atlas zur interpretation...* (1982); A.W. Briuchanow, and others. (1982); *Atlas of geo-sciences...* (1984); P.J. Curran (1985); L.A. Barański (1987); K-H. Szekielda (1988); A. Ciołkosz and A. Kęsik (1989); R.J. Gumey, and others. (1993); T.M. Lillesand, R.M. Kiefer (2000); L. Beckel (1996) wrote on the above. The papers discuss both, technical problems connected with obtaining information, and also their use in various fields of science and economy.

One of the strategies referring to the research of the Earth was developed by the European Space Agency. This is the program called *Living Planet* (Bonet and others, 1999; Megie, Readings, 1999; Rummel, Johannessen, 1999; Hollingsworth, Ingmann, 1999; Rott, Rast, 1999; Carli, Langen, 1999; Wingham, 1999). At present, satellite data for the environment research are most often obtained from such satellites as Landsat, Spot, ERS, IRS, Ikonos, NOAA, and Meteosat. Below, mainly basing on the studies of F.F. Sabins (1986), T.M. Lillesand, and R.M. Kiefer (1994), presented is the characteristics of the imaging systems of a Landsat satellite.

First three LANDSAT satellites, subsequently orbited on 23.07.1973; 22.01.1975 and 05.03.1978, revolved polar orbits inclined to the surface of the plane of the Equator at the angle of 99°, of the shape approximate to a circle of the nominal altitude of 900 km, with the perigee of 880 km and the apogee of 940 km. The altitude of the orbit and the time of revolution around the Earth are interdependent, according to the pattern (Lillesand, Kiefer, 1994), as follows:

$$T_o = 2\pi (R_p + H')\sqrt{\frac{R_p + H'}{g_s R_p^2}}$$

where:

T_o – time of revolving the orbit measured in seconds;

R_p – radius of the planet in km (Earth – about 6380 km);

H' – Altitude of the orbit (above the planet surface);

g_s – gravitational acceleration at the surface of the planet, for the Earth being about 0,00981 km/s^2.

For Landsat 1-3 satellites this gives the time of revolution around the Earth being 103 minutes. Satellites completed about 14 orbits within twenty four hours. At the Equator subsequent orbits are about 2760 km away from one another. As the satellite board sensors imaged only a stripe of 185 km width, large gaps occurred between subsequent orbits. However, each day, a satellite moved a little bit towards the west against the first orbit of the first day. As a result of the Earth's rotation in relation to the orbit, possible was obtaining a partial overlapping of the image taken from 15th orbit upon the image of the 1st orbit of the previous day. Maximum overlapping occurs at 81° of geographical width north and south – namely about 85%, with a minimum overlapping occurring at the Equator being 14%. The orbit of such parameters causes that after 18 days a new repetition of the image from the first orbit occurs. This provided a theoretical possibility of obtaining a 20-time imaging of the same territory within one year. Satellite orbits were occasionally corrected, considering the resistance of the atmosphere. As a result of this, the centre of the image moved within the range of about 37 km.

At 103-minute period of revolving the orbit, the satelite precisely matched the pace of the Earth's revolution in the west direction. As a result of such an orbit setting, the satellite always crossed the Equator at the same time of the solar local time. Such orbits are called solarly synchronic.

LANDSAT 1-3 satellites were placed on orbits which crossed the Equator at 9:42 a.m. of the local solar time (above 52°N at about 9:25 a.m.); however, orbital perturbations caused that the time of crossing the Equator point by the orbit slightly changed. Such a time of passing above the respective points located at the orbit's projection on the Earth's surface was chosen because in the morning hours the sky is considerably clearer than in later hours of a day. Because of keeping constant orbital velocity, all other points located on the orbit were also reached in these same hours of the solar local time, on the north hemisphere before 9:42a.m., on the south hemisphere slightly after 9:42a.m. A vital result of maintaining the same time of passing above respective points resulting from the character of the solarly synchronic orbit is the fact that it secures repeatability of the Earth surface lighting conditions in these same specific seasons of the year. Repeatability of the lighting conditions is especially vital at composing mosaics of images from neighbouring orbits and comparing annual (many-year) changes of terrain cover.

Although solarly sychronic orbits secure repeatability of lighting conditions, these conditions change with the location and with the season of the year. Solar beams reach the surface of the Earth at various angles, depending on the altitude of the Sun above the horizon. This depends both on the geographical width, and on the time. For instance, solar beams in Warsaw reach the surface of the Earth at the angle of 15° in December, and at 54° in July. Along a single January orbit, the altitude of the Sun above the horizon changes from 5° at the north rim of the Scandinavian Peninsula up to 50° in Egipt. Similarly, lighting azimuth changes together with the season of the year and the geographical width. Thus the solarly synchronic orbit does not compensate the changes of the Sun altitude above the horizon, the azimuth of lighting direction nor its intensity. These factors are always variable and are connected with the changeability of atmospheric conditions between the scenes. Nonetheless, obtained images are best possible that could have been obtained, considering the aspect of lighting.

On boards of Landsat-1 and –2 satellites, identical imaging systems were placed. These were: a three channel RBV system and a four channel multispectral MSS system. RBV system consisted of three television type cameras, the purpose of which was simultaneous observation of the same area measuring 185 x 185 km. Nominal terrain resolution of these cameras was 80 m, and spectral sensitivity of each camera referred to the spectral sensitivity of single layers in the colour infrared (spectrozonal) film: 0.475-0.575 μm (green), 0.580-0.680 μm (red) and 0.690-0.830 μm (infrared region of electromagnetic spectrum). These ranges were identified as l, 2, 3 channels. This system did not contain a film, on which images could be registered. They were projected on the photosensitive surface, which was then scanned in the raster form by an internal stream of electrons to create a video signal similar to the one which appears in conventional television cameras.

Because RBV images were obtained simultaneously for the whole scene, they were carthographically more adequate than the ones obtained via the MSS scanner. They also contained a network of correction points on the surface of the image, necessary for their geometrization.

RBV equipment from Landsat - l delivered only 1960 images between 23 July and 5 August 1972. RBV from Landsat-2 acted only for technological purposes and images from this equipment were obtained only sporadically. They were used exclusively for cartographical purposes. On Landsat-3 satellite, two substantial changes were introduced in the RBV equipment. The system was already working in one wide spectrum of electromagnetic radiation (EM), from 0.505 to 0.750 μm. Spatial resolution was improved 2.6 times compared to the previous equipment. Improvement of terrain resolution up to 30 m was obtained by a double prolongation of the focal length of the camera lens, by shortening the time of exposure to eliminate the blurring of the image, and also by the removal of spectral filters compared to the previous RBV equipment. To compensate the reduction of the area covered by the image taken by the double length lens, two cameras were set in line, each of which took an image of a square of 98 km long side. Because neighbouring images had a zone of a crosswise overlapping of 13 km, in the effect a pair of images was created covering the area of 183 x 98 km. Two subsequent pairs of RBV images covered the scene obtained via the MSS scanner. Four RBV scenes matching the MSS image were marked as A, B, C, and D.

Contrary to the intentions, RBV system on Landsat 1-3 satellites became a secondary system compared to the MSS system. Two factors contributed to the origination of such a situation. Firstly, RBV operation was disturbed by numerous technical inefficiencies. Secondly, and more significantly, MSS system became the first world monitouring system, capable to deliver

multispectral data in the digital formatting. The advantages embedded in the MSS data processing by computer systems led to a wide spread of data applications within the operations of Landsat -1, -2, -3 satellites. These satellites imaged tens millions of km^2 of the Earth surface.

MSS system from Landsat 1-3 satellites scanned images of a 185 km wide path in four spectral ranges: two in a visible range: 0.5-0.6 µm (green) and 0.6-0.7 µm (red) and two infrared: 0.7-0.8 µm and 0.8-1.1 µm. These ranges were marked as 4, 5, 6, and 7 channels. On the Landsat-3 satellite, a thermal range was added to the MSS system – as 8 channel, operating within the range of 10.4-12.6 µm, however problems with the functioning of this channel caused that it ceased its operation soon after the start.

Istantaneous field of view (IFOV) of this system is a square giving the terrain resolution ability of 79 m long side. Total scanned field of view measures about 11.56°. Because this angle is so small (compared to 90-120° in air scanners), in these scanners an oscillating mirror was applied instead of the rotating one. The mirror performed one swing every 33 ms. Six neighbouring lines are scanned simultaneously within each swing of the mirror. Such a setting requires four arrangements (one for each channel) of six detectors – one for each line. When detectors do not see the Earth, they are exposed to the inside source of light and to the Sun for their calibration. An analogue signal from each detector is converted into a digital form by the board convertor. A 6-beat system is used for this purpose, giving the possibility of recording of 64 value levels, from 0 to 63. Spectral responses in 4-6 channels are distributed on 128 levels and in 7th channel they are recorded on 64 levels.

At the exit the converter tests the detectors about 100,000 times within one second, as a result of which, the nominal terrain resolution is about 56 x 79 m. It is however worth noting that the value of spectral reflection is obtained from full 79 x 79 m cell of terrain resolution.

MSS scanned each line from the west to the east with the progressive move from the north to the south, along with the move of the satellite according to the *along-track* system, pushing line by line. Each Landsat scene is framed from the continuous recording of the whole path, so that it covers the area measuring 185 x 185 km with 10% overlapping between subsequent scenes. Nominal scene contains 2340 lines of about 3240 pixsels each, which gives about 7,581,600 pixels for each channel. Taking into consideration four channels composing each image, this gives about 30 milion observations, spectral responses. Considering the fact that such an image originates within 25 seconds, the tempo of accummulating data is enormous.

Figure 1 (see p. 22), is a full scene from MSS 7th channel covering a fragment of Mazowsze, Mazury and Wielkopolska along the Vistula river valley from Puszcza Kampinoska to Tczew.

Let us observe, that the area of the image does not compose a square, it is a parallelogram. Within 25 seconds a satellite covers the road from the upper frame of the image to the bottom one, while in this time, the Earth revolving from the East to the West causes that each subsequent line of pixels is moved to the West a little bit. Marks and numbers on the margin of the image inform of geographical coordinates of the chosen points of the image. At the bottom frame, a scale of greyness is placed, consisting of 15 levels referring to a full possible range of the values of the image brightness recorded by MSS. Not all levels are visible on the image, because this scale was reduced during the reproduction.

Above the scale of greyness there is a block of information providing data on procuring the image. On figure 1, from the left side we read: the date the image was taken (02NOV73), geographical width and length of the central point of the image – in degrees and minutes (N53-05/E019-26), geographical width and length of the nadir point (N53-04/E019-28), discrepancy between the location of both points indicates a small angle of image inclination, and then a type of sensor and the channel number (MSS7) are given, the mode of data collection (D – indicates that the data were transferred directly to the Earth without being registered on the board of the satellite; R – the data were registered on the board of the satellite and transferred to the Earth later); the elevation of the Sun and the azimuth of solar lighting (SUN EL 20 AZ160), the parameter of orbits and of processing (194-6507-A-I-N-D-1L – azimuth of the satellite flight – subsequent number of orbits – revolution around the Earth – symbol of the data collection station – full scene – procedure of regular processing – indications for calculating the centre of the image – mode of sending a signal to the data collection station – strengthening the received signal); identification of the satellite (NASA ERTS); code identifying the given scene (E-1467-09114-7-0). Precise recording and markings in this information block were changed within the course of the accomplishment of the Landsat programme. MSS systems from Landsat-1, -2, -3 satellites delivered images within the period from 23.07.1972 to 31.03.1983. Apart from black and white images from single MSS channels colour images may be generated, the so called colour compositions are created from three channels: 4th channel is filtered as blue, 5th channel is filtered as green, and 7th channel is filtered in the red spectrum. Such a combination corresponds to spectrozonal films (colour infrared). Just such images were the basis for the photomorphic analysis of satellite images, and then for the environment characteristics within the distinguished geographical regions, fig. 2 (see p. 23).

FHOTOMORPHISM OF REMOTE SENSING IMAGES

In many remote sensing studies, both theoretical and practical, attention is drawn to relations binding the purport and the character of satellite images of the given terrain with the terrain reality. In some studies attention is drawn to the distinctness of the projection of respective environment elements on images and it is stated that the given element or elements of the environment substantially influence the character of the given image. Another trend in research seeking for connections and close relationships between the image and the terrain is examining the impact of the elements of environment upon phototone or colour of the image. This is the research connected with seeking regularities in shaping the so-called „spectral responses" to respective elements of the environment.

Below presented is a short survey of research and studies trying in more or less complex manner to express the relation between the image of the terrain and the terrain itself. Discussing these views seems to be of crucial importance for formulating the concept of a „photomorphic unit". It is also to prove that with this term definite geographical contents should be referred to authorizing treatment of photomorphic units as regions corresponding to geographical regions. The early stage of considerations on this issue is still connected with air images.

In a monographic study referring to remote sensing (*Manuał of Remote Sensing,* 1975) in the chapter devoted to terrain system analysis, based on photographical features of remote sensing images, it is stated that the arrangement and density of hydrographic network, size and arrangement of arable fields and settlement schemes influence the character of these images. These elements build up a determined character of the image of the given terrain.

Research within the area of Chile (Mac Phail, 1971) proved high correlation between the character of the image, its photomorphism in this case of air images, and the current use of land, soils, relief, density of population. These relations were observed both in individual cases at a local scale and across vast spaces. It is known from general rules of photointerpretation referring to indirect photointerpretation features, which was confirmed once again in Chile, that the arrangements of hydrographic network and its density reflect the lithology of the terrain through the character of its relief. (V.C. Miller, C.F. Miller, 1961; Strahier, 1971). Phototone and photostructure sometimes reflect specific relations of the features of arable vegetation, size of fields and size of farms and their ownership.

At the analysis of photomorphism, elements of a photographical image (phototone, photostructure and phototexture) are usually referred to the actual terrain features, which in return determine the character of photomorphism of the image. Table 1 (see p. 25) provides a list of views of chosen authors on the relations between photomorphism (or its features) of an image and elements of the geographical environment. Here an obvious mutual interrelation of the object and its image occurs. While reading the simplest projections of terrain objects we judge of their character. Objects of surface hydrography, geological structure and use of land belong to such most important direct objects, which in a simple way project themselves on air and satellite images. As easily identified are geomorphological features – groups of forms; or their types, for instance, mountains, undulating areas, planes. These features mainly influence the structure and texture of the image. Phototone of the image is mainly moulded by the colour of the soil and by vegetation garment.

The above mentioned features called interpretational, constitute in some measure the first stage of the analysis of the image, allowing for drawing conclusions, on the basis of the knowledge of the environment functioning, of many other elements and of their dynamics. For instance, it is possible to conclude climate conditions through the initial assessment of hydrographical network and quantity of water flowing in rivers. Vegetation garment may fulfill a similar role. The analysis of anthropogenic forms in the course of logical conclusions may also provide a lot of information on socio-economic conditions of the population living on the given area. Type and distribution of settlements may indicate inhabitants living style. Size of fields provides information on the catastral system, production ability of the given terrain and on its current productivity.

Such a chain of photomorphic analysis many a time gives more information than simple element by element reading of a photographic image. Thus spatial relating of natural and cultural features of the given environment builds up a summary, complex image of the terrain – a photomorphic unit, which may be treated as a geographical region. Homogeneity of such a region depends on participation durability of specific environment components and elements.

There are many types of photomorphism. It is not the goal of this study to discuss and analyze in detail various classifications in this respect. However, it is possible to assume that we deal with the „anthropogenic" photomorphism – urban and ruralo-agrar, and „natural" – conditioned either by a single component or element of the natural environment, or by a group of them.

The analysis of photomorphism, considering the above mentioned element relationships, is considered to be one of the most important tools of photointerpretation, especially for planning purposes.

It is deemed that photographic images, through their photomorphism give better ecological characteristics of the given terrain and in the more unambiguous manner regionalize the territories under research than methods commonly used in the course of regionalization (Grigoriew, 1975; Peplies, Keuper, 1975).

While speaking of photomorphic units as spatial ones – regions, one should be aware of the size category these units are.

They may be of great vastness – for instance in Chile the area of such units was 4000-6000 km^2 (Mac Phail, 1971). In the USA units of the area from 25 900-77 700 km^2 were most often distinguished (extreme dimensions of these units were 1813 km^2 and 376 330 km^2) *(The look of...,* 1970-1971). In the study referring to South Australia they were of 30–43 km^2 on the lowest level of classification, and 13-60 000 km^2 on the highest (Laut and others, 1977).

The size of such a unit obviously depends on the scale of the image under the analysis. Smaller scales are favourable for separating large territorial units, which in the analysis of images in larger scales come apart into units of smaller areas. For instance S. Baker and H.W. Dill (1970) while analysing a single photomorphic unit distinguished in the state of Colorado (USA), separated six smaller units within its frame by increasing the scale three times.

Apart from natural interpretation of photomorphism of photographic images in the remote sensing of the environment structure, there is also another approach, as if from the other side. Namely, this refers to characterizing landscape units, which were distinguished with the use of physical complex geography methods, in respect of their optical characteristics. J.S. Tołczelnikow (1974) was the leading representative of this trend of research.

It comes out of the quoted views that independently from still relatively small outcome of research of photomorphism of evironment images on air and satellite images, photomorphism has a specified cognitive aspect consisting in monitouring mutual relations between solar radiation and the environment, and also a practical aspect facilitating and in some cases arranging cognizance of spatial structure of the environment.

CHARACTERISTICS OF COLOUR MSS COMPOSITIONS

At the photomorphic analysis of satellite images taken of the area of Poland, the goal of which was differentiating geographical regions, colour satellite scanner images taken from the boards of Landsat -1, -2, -3 satellites were used.

To cover Poland once with images from Landsat -1, -2, -3 satellites, it is sufficient to take 29 images, figure 3 (see p. 26). Forty colour compositions of satellite images taken in 1973 and 1975-1979 were at the disposal. 24 of which originated in late spring-summer; 14 in late summer and autumn; and 2 in winter and spring months, fig. 4 (see p. 27). Thus it may be assumed that the material at the disposal was quite uniform, considering the season of the year it was obtained. Also some number of black and white images from various MSS channels taken in various times were at the disposal. This material was treated, similarly as images from soviet satellites, as complementary.

Quality of most images should be defined as good and very good. Only several of them originating from Landsat-1 satellite in 1973 and 1975 were worse by quality, having a less readable image. 19 images at the disposal were taken in cloudless weather. 11 out of remaining 21 images characterized themselves with the cloud cover, comprising less than 10% of the surface of the image and on 10 images it exceeded 50% of the surface of the image, making their interpretation more difficult.

Having 40 images at the disposal it was possible to analyse the issue of our interest on most part of our country in several time intersections.

However, no detailed studies were carried out on cartometricality of analyzed images, but the issue was examined on the example of four spectral records of the MSS image taken by the Landsat –1 satellite on 2 November 1973, covering the so called „płocka" scene. Measured were distances between terrain details, which were identifiable on images in the scale 1:250 000 and compared with the distances between the corresponding points measured on the sets of sheets of topographic maps in the scale 1:100 000. The average error in specifying the distance on the satellite image was of about 0,25%. It can be assumed that it was not bigger on colour compositions.

Both, the quality of images and their cartometric characteristics may thus be acknowledged as fully sufficient for working out the division of Poland into geographical regions.

METHODS FOR DISTINGUISHING PHOTOMORPHIC REGIONS

In the interpretation of remote sensing images there are two approaches to solve the research problems, based on two main methods of carrying out scientific research. One is an inductive approach – originating from the analysis of respective facts observed on the images and drawing conclusions referring to single components of the environment, which in further considerations are generalized. The other approach uses the method of deduction: starting from general premises it leads to detailed conclusions and different type of significative divisions. At the deductive approach, the remote sensing image is treated as a collection of facts referring to various components of the geographical environment, which can be projected on one capture. On such an image, layers of data referring to respective components of the environment overlap each other to some extent. Density of data referring to one component are emphasized by this element or a collection of elements of the same component, contributing to the fact that the remote sensing image of a specific site carries more information on this component than on others, which in a lesser degree may manifest their character on it, and often may be examined only by drawing indirect conclusions.

Considering the assumptions above, it can be stated that already at the preliminary examination of remote sensing images (both air and satellite) these images reveal differentiation of the geographical environment. Such an image is divided into areas of various sizes and of various character in respect of neighbouring areas. This is due to the fact that the image of respective fragments of the terrain is shaped according to the resultant of the importance of respective components of the geographical environment. The most important component, the leading one, projected by the largest number of interpretational features creates the appearance of such a territotial unit – its physiognomy. Such an image would once reveal the relief, the other time water relations of the given terrain, versatility of vegetation, use of land, or even socio-economic relations and the political past of the given territory (Olędzki, 1975). Each of these components of the geographical environment specially participates in creating such and not the other image of the given terrain.

Remote sensing images of the Earth surface should be treated not only as a static collection of partial images of respective components of the environment. They are a dynamic image showing relations and mutual dependencies. Ability to read these relations requires good cognizance of the overall rules governing the geographical environment.

All record of geographical information on the air photographical image or on the visualized digital satellite image is created by three elements, which at the same time are direct photointerpretation features: phototone or colour, photostructure and phototexture. All other interpretational features mentioned in various types of studies and manuals are derivatives of the record of these three features. We deal with their analysis and assessment at each examination of images recorded with the use of the photographical technique. We can assess these images in the qualitative and quantitative aspect. In the qualitative assessment we use adjectival descriptions: for phototone these are the shades of greyness from black to white, for phototexture introduced is the description of the size of a uniform element, in respect of its phototone and its shape (for instance: small-, medium-, large-, various granular, rectangular, speckled, etc.), for phototexture we specify spatial arrangement of structural elements (e.g.: parallel, striped, bar-like, dendric, circular, fan-like, etc.).

Assessment of phototone and colour

Phototone expressed with various shades of greyness strictly depends on the quantity and quality of light beams reflected by the terrain objects under examination. Objective specification of the value of phototone is reduced to measurements of „brightness" or „darkness" of the negative or a diapositive. This degree of negative blackening determines the value of the transmission of light crossing the photographical material under examination. In short, we define it as transmission *(T),* that is the amount of light crossing the given point of transparent material compared to the total amount of light falling on this point. It is possible to use here the concept of the coefficient of absorption, or „coverage" – being the reciprocal of transmission - $1/T$. Apart from the concepts of transmission and absorption describing the level of greyness of the image, also a logarithmic measure is used – „optical density" *(D).* It is assumed that „optic density" better describes changeability of greyness of the image, because of the fact, that the reaction of a human eye to light is close to a logarithmic presentation. This is why almost a linear dependence between the optical density of the image and its visual expression in the form of a phototone occurs (Lillesand, Kiefer, 1994). As it is known, optical density is described as a decimal logarithm of absorption:

$$D = \log_{10}/O_p/ = \log_{10} 1/T \ .$$

To measure optical density, various types of densitometers are used (Owen-Jones, 1977).

Many factors influence a determined level of greyness of the image. These are external factors connected with nature – the status of the object in the terrain, conditions of lighting at the moment of registration, this is why it is important to set identical conditions of lighting at any photometric measurements in the terrain (Tołczelnikow, 1974), and also internal factors connected with the registration system. In this case the character and sensitivity of the radiation collector are of most importance (Olędzki, 1992).

Colour of the image connected with the particular technique of procuring colour compositions from multispectral scanner images does not correspond to the colours occurring in reality in nature, as a result of the projection of infrared spectrum on these images (of the 800-1100 nm wave length). These are the so-called agreed colours. On Landsat images, clouds, snow and ice are presented in white colour; in dark pink – generally speaking, any live vegetation: arable fields, maedows, deciduous forests, etc; in grey and red colour up to dark red mixed and coniferous forests are presented; grey colour depicts dried vegetation; grey and blue colour depicts non arable lands with minimum vegetation cover; built-up areas are shown in blue colour, grey and blue and greenish; navy-blue reflects some communication lines and waters, black colour most often corresponds to waters.

This set of colours of basic elements of terrain cover is modified by various physical features of the environment.

At the analysis of colour compositions of Lansat satellite images of Poland, their colour was defined visually. On these images possible was distinguishing colours, as follows: white (B), blue (N), green (Z), yellow (Z), orange (P), brown (BR), pink (R), red (CZ), grey (SZ), and black (CR). In most cases shades could be distinguished for each colour. such descriptions were sufficient at this type of qualitative analysis of satellite images, on the assumed level of generalization of the colour terrain image.

Assessment of Photostructure

By the term of „photostructure" understood are elements of the image structure created by areas of identical phototone or colour. „Photostructure" specifies the shape of these elements and their size. Thus in its description there is some analogy to some aspects of rock structure observed on the surface of rocky cuts (Jaroszewski, 1966).

Photostructure can be defined in the quantitative and qualitative manner. Quantitative analysis of photostructure is based on the examination of microphotograms, presenting optical densities or values of transmissions along the chosen profiles. Size of image components can also be specified by using a magnifying glass with the metric scale, for instance Brinell's magnifying glass.

Parameters used for the assessment of microphotograms are: wave length, wave amplitude and wave concentration. T. Gacki (1977) uses the so-called „indicator of optical density modulation" to describe spatial changeability of the photographical image and its structure. Value of this indicator refers to the degree of differentiation of the landscape structure. The above mentioned parameters allow for quantitative description of photostructure by specifying the level of perpendicularly measured size of respective components of the image, and also can determine the character of this changeability in the vertical measure (wave amplitude) – stating the importance of differencies between respective components of the structure. It is difficult to determine the shape of components of the image.

At the analysis of photostructure – both in a visual way and using quantitative methods – the scale of the image should be considered as it directly conditions the size of elements perceived on it.

At the analysis of satellite images of Poland, visual assessment of shape and size of imaging elements was used. Imaging elements are understood in this case (scanner images) as certain areas of the image aggregating numerous pixels of identical phototone or colour.

Distinguished were the following types of photostructure: amorphic (A-morf), small granular (D-ziarn), medium-granular (S-ziarn), large-granular (G-ziarn), various granular (R-ziarn), small speckled (D-plam), medium speckled (Ś-plam), large speckled (W-plam), various speckled (R-plam). Patterns of the above mentioned photostructures are described in detail in the author's study (Olędzki, 1992).

Assessment of Phototexture

Specification and quantitative assessment of phototexture, that is spatial arrangement of structural elements of the image is quite a difficult task. It is connected with nondescriptiveness and difficulty to verbalize visible schemes of structural elements on the images. Only in scarce cases it is possible to perceive clear orientation and spatial arrangement of these elements.

Objective, measurable definition of phototexture, theoretically became possible the moment the analysis of images in cohesive laser light was introduced to photointerpretation. At the analysis of this type, a beam of laser ray bends while crossing the diapositive material of the analysed image. Having passed the transforming objective it is projected on the screen in the form of a difractogram, or data referring to it – specially processed – may be transferred to a computer for further analysis (Lillesand, Kieffer, 1994). Meanwhile, such possibilities exist exclusively in the best equipped laboratories of the world. In our conditions the assessment of phototexture may be still carried out only visually.

Assessment of phototexture may be carried out similarly as it is done in petrography. There the concept of texture of rocks is used for the assessment of spatial arrangement of components in rock, that is their arrangement and the degree of filling space by them (Turnau-Morawska, 1965). These observarions are often carried out while examining polished surfaces of a rocky sample. And thus, describing types of texture of rocks, distinguished are disorderly and arranged textures. Disorderly textures characterize with optional arrangement of components. Arranged textures are connected with a defined orientation and arrangement of components. Generally the assessment of this arrangement is based on geometrical criteria. Thus there may be parallel textures (fluidal, linearly parallel, flat parallel, streaky, laminating) or spherical textures (radial, spheroidal-concentric). Distinguished also are types of textures attributed to special types of rocks. For instance while describing metamorphic rocks, descriptions such as: linear, flat, lenticular (arranged textures) are used. While describing sedimentary rocks, descriptions as follows are used: streaky, layered-parallel, fractionally layered, diagonal (arranged textures). Apart from the features specifying orientation of components, while describing texture it is characterized from the point of view of filling the space by elements of rock. In this case texture is defined as: compact (dense), porous, miarolitic, vesicular, spongy (Jaroszewski, 1966).

While describing metamorphic rocks K. Maślankiewicz (1967) specifies the following types of texture: directional, granoblastic, marble (mosaic), gneiss containing various size grains, partially oriented), slate (parallel), amphibolic (parallel). M. Turnau-Morawska (1965) mentions the following types of textures: disorderly, fluidal, spongy, gneiss, lumpy, helicit, hornfels, concentric, concretional, slate, miarolitic, amygdaloidal microrythmic, oolitic, vesicular, pisolit, felt, porous, pseudoolit, ptigmatic, parallel, spheroidal, spherolitic, reticular, conical, styolite, foliated, fibrous, ribbon-like, dense, oriented.

Thus, while characterizing texture of rocks used are descriptive terms, associating the appearance of rock surface with various patterns and designs known from other fields, and in some cases a genetic meaning referring to the origin of the rock is imposed upon some texture descriptions.

It seems that the geological terminology used at describing texture of rocks is a good point to start describing phototexture of satellite images. Some analogy occurs here between the observed surface of a rocky cut and a satellite image showing the surface of the terrain.

This type of attempt to define phototexture of a satellite image for the area of województwo suwalskie was undertaken by W. Mierzwińska (1981). As a result of the analysis of satellite images of Poland taken from Landsat-1, -2 and –3 satellites, distinguished were twenty three types of phototexture. List of them together with the definition is presented in table 2 (see p. 31). Phototextures listed in it for sure do not cover the whole versatility of spatial arrangements of elements of the image of the terrain of Poland projecting spatial differentiation of the environment, nevertheless, it seems that they approximately reflect terrain reality.

FROM A PHOTOMORPHIC UNIT TO A GEOGRAPHICAL REGION

Described above in the qualitative and quantitative sense photomorphic features create on each image surface various phototone and structural configurations, limited to certain separated areas specified as spatial photomorphic units. They characterize themselves with certain features of the image, differentiating the given unit from the surface of neighbouring ones. This diversity manifests itself either in a different phototone (colour), or in a different photostructure or another phototexture, or in various combinations of these elements. Through special relations of colour or phototone, photostructure, and phototexture with components of the geographical environment, separated spatial units reflect factual – real differentiation of the environment structure. Thus, they may be acknowledged as the geographical regions.

DESIGNATING BORDERS OF GEOGRAPHICAL REGIONS

Division of the territory of Poland into geographical regions was preceded by a range of preliminary works, the goal of which was to specify the possibilities for performing such a division. In these studies, the assessment of informativity of satellite images referring to the geographical environment of Poland was also dealt with (Olędzki, 1983, 1992; Mierzwińska, 1981; Bychawski, 1982; Czyż, 1982; Kozubek, 1984; Hernik, 1998). It came out of this research that satellite images from Landsat satellite provided sufficiently much information on geographical environment, and also reflected the structure of this environment. Thus they might constitute the basis for differentiating regional units. A vital moment in this type of study is adopting a specified methodical basis for carrying out the research. The fundamental question was: to carry out such a division using the method of summing up elementary areas delimited on the images in a possibly large scale and to obtain a specified hierarchy of territorial units representing the environment structure by subsequent generalizations, or the other way round – assuming a specified n-staged division for differentiating large units at first, and then still smaller ones.

Adopted was the latter mode of the procedure – deductive division of three hierarchical stages. Such a decision was taken basing on tests, from which it came out that this method was satisfactorily adequate, and the expenditure of work and time much lesser and shorter than in the inductive approach. Adopting three hierarchical stages was dictated by the practicability of such a solution assuring the avoidance of differentiating a too large number of small units. Differentiated by way of experiment smallest units of the III stage were sufficiently homogeneous. Differentiating regions in the above defined understanding was based on features of photomorphism. All three features of image photomorphism were considered to the extent possible, focusing on separating areas differing from the neighbouring ones in this respect.

To verbally define such a type of lines separating respective regions is quite difficult. Frequency of occurrence of certain elements of the image can be some approximation, for instance lakes, whose dark, black stains are well visible on a satellite image. Dark red and grey-red patches of forests are similar elements. Occurrence of larger groupings of big area arable allotments may be another example. Occurrence of elements mentioned in two first examples is not accidental and has a special natural sense. Delimitation of such type of areas not only means designating special types of land use, but also distinguishing special natural areas. Also the arrangement and orientation of arable land allotments arer conditioned by nature.

Common occurrence of this type of forms of terrain use constituted the basis for delimiting areas on which these forms were or were not found. A reservation should be made here that a substantial simplification lies behind the definition of the line dividing the area into units of the I stage. Mentioned elements of terrain cover were often in a high degree enriched with natural elements, for instance with the changeability of ground dampness.

Further division was carried out within the precincts of units distinguished in the I stage. While distinguishing units of the II stage, attention was drawn to features, which internally differentiated a larger unit. Morphological lines, and especially clearly visible river valleys were often border contours here.

The subsequent stage was dividing regions of the II stage into still smaller areas – units of III stage. It was adopted that at separating them the criteria mentioned above but occurring in a somewhat less intensity were the basis.

This division was carried out on respective sheets of satellite images, each time covering about 36 000 km^2.

While determining the borders of regions difficulties connected with taking decisions as to appropriating the given terrain to one of the differentiated regions appeared. It was connected with high minuteness of detail of satellite images in the scale 1:250 000, which often impeded taking the decision referring to the contour of the border. This required „blurring" this minuteness of detail, which was obtained by drawing the border on semi-transparent foil, which blurring details better exposed homogeneity and internal compactness of the separated region.

Wherever it was possible, objectivization of the delimited borders was obtained by designating these borders on several images presenting the same area, and taken either from another orbit or in another season of the year. The next stage of composing the map of regions of the whole territory of Poland was photographic reduction of the interpreted foils to the scale 1:750 000. The reduced reproductions were used for drawing a map of regions on the cartometric background. For the orientation of respective foils, situational details visible both on the background map and on the interpretational foils were used. These were larger valleys, rivers and lakes. In the effect of the above mentioned graphic works the division of Poland into regions in the scale 1:750 000 was obtained. Next, the outlined map was submitted to geometrization in the GEOMEDIA programme, adjusting it to the Albers's representation, in which the satellite map of Poland was performed (Lewiński, 1994). After applying the borders upon the satellite map od Poland, corrected was the course of border lines of respective regions, removed errors originating during the analogue transfer of the purport of interpretational foils upon the above mentioned background map in the scale 1:750 000. As a result of these works, obtained was a correct image of respective regions borders in the Albers's representation. Region codes were entered upon this map. Methods of using satellite images for designating geographical regions are in detail discussed in the earlier publication of the author (Olędzki, 2003).

CHARACTERISTICS OF THE DIVISION OF POLAND INTO GEOGRAPHICAL REGIONS

As a result of the activities following the presented procedure, the territory of Poland was divided into geographical regions formulated in a three-stage hierarchy.

Fourteen macro-regions of the areas from 1432.1 km^2 to 96 637.1 km^2 were separated, with the average region area being 22 343.4 km^2. Such a big spread of areas of the separated macro-regions is connected both with the speciphics of the geographical region comprised within the borders of respective macroregions, and also with the fact that some of them straddle the border of Poland, and the areas of regions were calculated only up to the state borders. This last remark also refers to some mezoregions and microregions. Within the range of macroregions, 55 mezoregions of the area from 250.3 km^2 to 21 723.4 km^2 were separated, with the average value of – 5687.4 km^2.

In the third basic cathegory of the adopted division, distinguished were 523 microregions, of the area from 8.5 to 5169.5 km^2, with the average area being – 5981.1 km^2.

37% of regions characterize with the area of up to 300 km^2. 46% of regions have the area from 301 to 1000 km^2, and 17% are regions of the area from 1001 to 6000 km^2.

Separated regions were arranged by imposing respective codes upon them. A decimal system of numbering was adopted. For instance code 5.10.17, indicates 17th microregion located in mezoregion no. 10 and in macroregion no. 5. Additionally, at the geographical characteristics of regions, they were given descriptive names. These names, though mostly referring to physico-geographical naming do not strictly cover the areas, to which the physicogeographical names refer. Some of the adopted terminology is connected with historical names of lands and regions. Because regions cover areas different from the areas separated in different geographical and other divisions, their naming naturally may not strictly match territorial ranges covered by the names used in those divisions. Thus, adopted was certain conventionality in giving special names to regions. In cases when a substantial part of the physico-geographical region was included within the frame of the separated region – the name of physico-geographical region was adopted. Often names of geographical regions combine landscape and geomorphological or another descriptive terminology with the name of a bigger town or another geographical object (river, mountain range, forest complex, etc.). Thus, this naming should be treated as conventional. It approximately describes the physiognomy and geographical character and also the location of the separated region.

In table 3 (see p. 35), listed are codes, names and areas of the regions separated within the terrain of Poland.

CHARACTERICTICS OF GEOGRAPHICAL REGIONS OF POLAND

In this chapter presented are the characteristics of 521 geographical regions. At the analysis of the environment of these regions it was attempted to prove the relations of a colour spectrozonal satellite image – a colour MSS composition in the scale 1:250 000 with spatial differentiation of such components of the environment as geological structure, relief, underground waters, soils and use of terrain. Surveyal thematical maps in the scales from 1:200 000 to 1:500 000 served as the bases for the analysis of these relations. At the characteristics of anthropogenic activity used were data from encyclopaedic studies, among them, mainly from *Słownik geograficzno-krajoznawczy Polski [Geographical and Landscape dictionary of Poland]*, according to which numbers of ihabitants of villages mentioned in the descriptions of respective regions were given – for the years from which the satellite images originated, taking them in brackets „( )" and from *Złota encyklopedia PWN [The Golden PWN Encyclopaedia]*, from which descriptions of functions fulfilled by the mentioned villages and numbers of their inhabitants for the year 1998 were taken, presenting them in square brackets „[ ]". In some cases, the number of inhabitants was given according to the Internet data.

Digital versions of the division of Poland into geographical regions on the background of thematical maps are enclosed in the book.

1. Mosaic of colour MSS composition worked out in the convention close to natural colours, performed by Dr. Eng. Stanisław Lewiński from the Institute of Geodesy and Carthography in Warsaw. Colours of this image substantially differ from the analysed images in the scale 1:250000, however, it is more readible for readers (Lewiński ….).
2. General geographical map worked out in the Institute of Geography and Spatial Implementation of PAN [Polish Academy of Sciences] included in the Atlas of the Republic of Poland (*Mapa przegladowa* …).
3. Geological map of Poland in the scale 1:500000 (*Mapa geologiczna* …).
4. Geomorphological map of Poland in the scale 1:500000, worked out in the seventies of the XX century in the Institute of Geography and Spatial Implementation under the editorship of L.Starkel (*Przeglądowa mapa*…).
5. Digital model of the terrain of Poland SRTM (http://netgis.geo.uw.edu.pl/srtm/)
6. Map of soils of Poland in the scale 1:500000, elaborated at the turn of the sixties and seventieth of the previous century under the patronate of the Committee for the Science of Soil and Agricultural Chemistry [Komitet Gleboznawstwa i Chemii Rolnej PAN] and Institute of Cultivation, Fertilization and Science of Soil [Instytut Upraw, Nawożenia i Gleboznawstwa], issued in 1972 by Wydawnictwa Geologiczne (*Gleby Polski* …).
7. Occurance of phreatic groundwater level and its dynamics (Gutry-Korycka M …).
8. Hydrographical map of Poland in the scale 1:500 000, worked out in the Institute of Geographic and Spatial Implemetation (Galon R. …).
9. Map of land use elaborated in the seventies on the basis of Landsat-MSS satellite images, under the direction of A.Ciołkosz in the Institute of Geodesy and Carthography, and issued by PPWK in 1980 (*Polska, użytkowanie* …).

Wstęp

Opracowanie ***Regiony Geograficzne Polski*** jest kontynuacją wcześniejszych prac autora dotyczących wykorzystania zdjęć satelitarnych w badaniach środowiska geograficznego Polski. W swej warstwie teoretycznej nawiązuje ono do myśli zawartych w książkach: *Geograficzne uwarunkowania zróżnicowania obrazu satelitarnego Polski i jego podziału na jednostki fotomorficzne,* z roku 1992 oraz *Regionów Fotomorficznych Polski*, z roku 2001. W stosunku do tego ostatniego opracowania, zachowując zawarte w tym opracowaniu wprowadzenie, zostało poszerzone o charakterystykę regionów zachodniej części Polski, wyposażone w ilustracje zdjęć lotniczych i satelitarnych – wybranych regionów oraz wzbogacone o cyfrową wersję tego podziału z możliwością oglądania go na tle wybranych komponentów środowiska.

Pragnę w tym miejscu wyrazić swoje podziękowanie kolegom z Katedry Geoinformatyki i Teledetekcji, Wydziału Geografii i Studiów Regionalnych Uniwersytetu Warszawskiego, a szczególnie dr inż. Stanisławowi Lewińskiemu za pomoc i owocną współpracę w przygotowaniu wersji cyfrowej opracowania , bez wiedzy którego opracowanie to zapewne by nie powstało. Dziękuję również kolegom: dr Bogdanowi Zagajewskiemu i dr Piotrowi Pabjankowi za pomoc w przygotowaniu cyfrowych wersji map tematycznych i ich geometryzacji.

Współczesny rozwój teledetekcji i jej zastosowań w badaniach różnych aspektów środowiska może, a w wielu przypadkach już się przyczynia w istotny sposób, do lepszego poznania jego struktury i praw rządzących jego funkcjonowaniem. Dane teledetekcyjne w połączeniu z systemami informacji geograficznej tworzą nową dziedzinę wiedzy o środowisku – telegeoinformację, umożliwiającą na nowo przeanalizowanie dawnej wiedzy o środowisku, wzbogacając ją o nowe informacje dostarczane przez coraz to doskonalsze satelitarne systemy ukierunkowane na badanie środowiska. Telegeoinformacja, umożliwiając wszechstronną i wielopłaszczyznową analizę, stwarza możliwość praktycznego i szybkiego wykorzystania geodanych do celów zarówno naukowych jak i praktycznych, czego przykładem może być wykorzystanie telegeoinformacji w ocenie stanu i prognozowaniu zbiorów głównych roślin uprawnych, w monitoringu i analizie szybko zmieniających się sytuacji związanych z katastrofami przyrodniczymi czy też innych przypadkach wymagających szybkich decyzji. Dostępność obrazów satelitarnych, zdjęć lotniczych i innych danych teledetekcyjnych, zarówno archiwalnych jak i wykonywanych współcześnie, umożliwia podjęcie na szerszą skalę badań nad zmiennością i dynamiką środowiska jako całości lub też jego poszczególnych komponentów i elementów w skali globalnej, regionalnej, a także lokalnej. Przejawia się tu integrująca rola telegeoinformacji, stwarzającej płaszczyznę łączenia wielu różnych informacji i ułatwiającej poszukiwanie zależności pomiędzy różnymi zjawiskami.

Jedną z możliwości wykorzystania danych teledetekcyjnych w badaniach geograficznych jest ich zastosowanie do analizy struktury środowiska. Sięgając w przeszłość należy stwierdzić, że już w zamierzchłych czasach, przed 2,5 tysiącami lat, w Chinach wykonano podział terenu na jednostki przestrzenne (Chao Sung-chiao, 1984). W czasach nowożytnych strukturą terenu zaczęto żywiej interesować się w końcu XVII i na początku XVIII w. Pojawienie się możliwości korzystania ze zdjęć lotniczych w różnego rodzaju badaniach geograficznych otworzyło przed geografią nowe horyzonty badawcze. Sumując poglądy z wczesnego etapu rozwoju tej nowej dziedziny wiedzy, zwanej niegdyś fotointerpretacją, J. Tricart, S. Rimbert i G. Lutz w roku 1970 napisali, że zdjęcia lotnicze umożliwiają całościowe spojrzenie na środowisko geograficzne, którego elementy na mapach są sztucznie odrywane jedne od drugich.

Jednym z większych opracowań wykorzystujących zdjęcia lotnicze do analizy struktury środowiska geograficznego, w odniesieniu do aspektów rolniczych, było opracowanie F.J. Marschnera z roku 1959. W opracowaniu tym wyznaczono struktury przestrzenne związane z użytkowaniem ziemi w Stanach Zjednoczonych. Użyto do tego celu małoskalowych zdjęć lotniczych, na których zredukowane są zawiłości terenowe widoczne na zdjęciach w większych skalach. Wydzielone regiony rolniczo-wiejskie zilustrowano przykładami fotomozaik zdjęć lotniczych w skalach 1:63 000. Kontynuacją tego kierunku badań były działania zmierzające do opracowania regionalizacji fragmentu terytorium Chile. Konieczność wykonania takiej regionalizacji wynikała z potrzeby podjęcia prac nad typologią obszarów wiejskich. Chciano opracować metodę wyznaczania jednostek przestrzennych, przystosowaną do operowania dużą liczbą informacji już dostępnych z map tematycznych, jak również otwartą na wprowadzanie nowych danych uzyskiwanych w przyszłości. Uważano, że zdjęcia lotnicze dostarczają wiedzy na temat praktyk rolniczych w poszczególnych typach terenu. Najbardziej przydatnymi do tego celu okazały się fotomozaiki w skali 1:100 000.

D.D. Mac Phail (1971) zauważył wówczas, że obrazy takie (fotomozaiki) przedstawiają kompozycje geometryczne działek pól uprawnych, sieci hydrograficznej, budowy geologicznej (poprzez odsłonięcia skalne), wilgotności gruntu i szaty roślinnej. Elementy te tworzą na obrazach lotniczych określone, przestrzennie wyróżniające się jednostki fototonalno-strukturalne. Fototon zmienia się w zależności od form użytkowania terenu, fototekstura odzwierciedla zaś strukturę własności pól uprawnych, osadnictwa i jest ściśle uzależniona od zróżnicowania rzeźby terenu. Po raz pierwszy użyto wówczas określenia „obszar fotomorficzny". MacPhail uważał, że obszary fotomorficzne są jednostkami przestrzennymi, do których można odnosić informacje na temat charakteru terenów rolniczo-wiejskich i takie obszary fotomorficzne mogą być przedmiotem kartowania geograficznego. Wykazano wówczas po raz pierwszy tak dobitnie integracyjną rolę zdjęcia lotniczego – z jednej strony jako nośnika informacji, a z drugiej jako płaszczyzny, na którą mogą być wpasowywane różne informacje o środowisku. W dalszych rozważaniach stwierdzono (Mac Phail), że obszary fotomorficzne stają się użytecznym narzędziem diagnostycznym w badaniach regionalnych. Mapa takich obszarów może być używana jako wstępna konstrukcja kartograficzna do analizy ilościowej występowania danego zjawiska. Obszary fotomorficzne są zewnętrznym przejawem korelacji między różnymi elementami środowiska, na przykład typu użytkowania ziemi i gleb. W przypadku Chile stwierdzono, że obszary fotomorficzne odzwierciedlają powiązania między użytkowaniem ziemi, typami gleb, rzeźbą oraz innymi cechami topograficznymi. Mogą więc stanowić podstawę delimitacji krajobrazów lub typów terenu.

Pojawienie się obrazów satelitarnych stworzyło techniczne możliwości operowania zdjęciami małoskalowymi. Bazując na poprzednio wymienionej kompleksowości małoskalowych zdjęć lotniczych założono, że obrazy satelitarne stanowią dobry materiał do zastosowania ich w analizie struktury środowiska dużych obszarów. Wbrew jednak tym oczekiwaniom opracowań takich nie było wiele.

Nagromadzenie dobrej jakości danych z satelitów meteorologicznych NOAA umożliwiło zestawienie globalnych obrazów, na których uwidaczniają się główne obszary o mniej lub bardziej jednolitej fizjonomii. Możliwe jest wyznaczenie na nich dużych regionów – obszarów w skali całego globu ziemskiego i kontynentów (Olędzki, 2001).

Dane z NOAA pozyskane za pośrednictwem urządzenia AVHRR dostarczają obrazów o zdolności rozdzielczej (w nadirze) 1,1 km, a poza nadirem od 2,4 do 6,9 km, wykonywanych w pięciu kanałach spektralnych, w widzialnym i podczerwonym zakresie widma elektromagnetycznego (EM) w przedziałach 0,58-0,68; 0,72-1,1; 3,55-3,93; 10,3-11,3 i 11,5-12,5 µm. Na podstawie takich danych możliwe było zestawienie dość szczegółowego obrazu całej Europy, który spektakularnie ukazuje strukturę **regionalną** naszego kontynentu. Analizując obraz Europy o rozdzielczości 1946 m, wykonany w National Remote Sensing Center (NRSC) w Wielkiej Brytanii, w skali 1:3 500 000, na podstawie danych z satelity NOAA-7, uzyskano podział Europy na obszary fotomorficzne – regiony, które mogą odpowiadać prowincjom lub podprowincjom z podziału fizycznogeograficznego (Olędzki, 1998).

Dalsze badania struktury środowiska mogą być prowadzone na przetworzeniach obrazów satelitarnych z Landsata TM i Spota w skalach 1:50 000 i 1:25 000. Umożliwiają one już bardzo szczegółowe badania struktury środowiska, na poziomie jednostek krajobrazowych rangi typów uroczysk.

W świetle wykonanych opracowań można stwierdzić, że obszary fotomorficzne wyznaczane metodą dedukcyjną na podstawie obrazów satelitarnych, charakteryzując się wysoką jednorodnością środowiska i jako takie odpowiadają regionom geograficznym, zarówno w ich aspekcie przyrodniczym jak i antropogenicznym. Stanowią tym samym doskonałą podstawę do rozmaitych studiów przestrzennych nad strukturą środowiska i jego monitorowaniem.