A PRACTICAL APPLICATION OF COLOUR INFRARED (IR) IMAGE INTERPRETATION - THE CLASSIFICATION OF THE REED OF LAKE NEUSIEDL (AUSTRIA)

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1. VEGETATION AND COLOUR-IR IMAGE

Vegetation shows a significant maximum of reflectance in the near-IR and a flattening of the reflectance curve in case of vegetation damage. Thus remote sensing methods considering near-IR radiation are of optimum use for the analysis of vegetation species and damage. The Kodak colour-IR film 2443 characterizes vegetation's seasonal change or reduced vitality by variations of colour.In case of reduced vitality or aging of vegetation the colour changes from red and magenta over mauve and white to yellow and green. Many experts worked on that topic (f.e. Corten, 1966; Murtha, 1978; ...). Therefore a further discussion of vegetation colour reproduction on colour-IR film is not necessary at all.

Landsat bands 6 and 7 (0.7-0.8µm, 0.8-1.1µm) are also of good use for the documentation of vitality of vegetation.

In the discussed matter on the one hand aerial photographs (colour-IR), on the other hand Landsat-II data were available.

2. LAKE NEUSIEDL

Lake Neusiedl is a so-called "steppe-lake" characterized by shallow and salty water. Situated in the eastern part of Middle Europe, about 50 km south of Vienna, Lake Neusiedl is divided into two parts by the Austrian-Hungarian border. Extensive reed areas surround the open water. In the view of vegetation geography, Lake Neusiedl is already part of the Hungarian flora-district (Kárpáti, 1956). One can easily imagine that Lake Neusiedl is distinguished by a lot of irreplaceable features of flora, fauna and landscape. Nearly half of the Austrian part of Lake Neusiedl is covered by reed (phragmites australis). Only small areas are couvered by reedmace (typha angustifolia) or rush (schoenoplectus litoralis). Reed areas grew constantly during the last centuries except periods of complete drying up (four times during the last 250 years, for the last time from 1868 to 1870).

3. THE PRACTICAL APPLICATION

As already said the region of Lake Neusiedl is unique throughout the whole of Europe. Problems appear because of the intensive interaction of tourism, agriculture, and preservation of the environment. The number of tourists is increasing. Methods of agricultural cultivation are more and more based on too much agricultural manuring (wine-growing). The efficiency of the protection of natural landscape, flora und fauna is not sufficient any more. The reed areas are very important and sensible parts of Lake Neusiedl. The growing number of touristic installations within the reed areas (e.g. camping sites, beaches, yachting ports) and increasing oversaturation deteriorate water quality to a high extent. Reed areas work like a kind of filter accumulating certain substances. The deposition of these materials leads to effects of "over-fertilization" of the reed and to the continous increase of reed areas. Only in a few parts of Lake Neusiedl water depths prevent the growth of reed.

One may - in a sarcastic way - fear, that Lake Neusiedl will become a reed desert. Tourism managers should therefore have great interest in protecting and restoring the lake's natural beauty. A careful industrial management of reed (reed harvest followed by manufacturing) could also help to stop uncontrolled growth of reed.

The presented facts are the result of a co-operation of the Institute of Photogrammetry (Technical University of Vienna) and the Biological Research Institute Illmitz/Lake Neusiedl. The author had the possibility to analyse methodically practical applications of colour-IR image interpretation for mapping the extension of reed areas by their classification and for calculating the values of these classified areas. No corresponding informations from earlier works were available. From that point of view it was work on something like a pilote-project. Serious informations on reed classes and reed areas are not only of great importance for taking planning measures of industrial reed management without destroying the rare flora and fauna but also for serious protection of the lake's beauties. These informations should help to define areas of tourism and protect others effectively. The cartographic product to store these informations should be maps of reed in a defined scale (1:10 000).

4. IMAGE MATERIALS

4.1. LANDSAT DATA

Landsat-II data of Sept., 26th, 1975 were available. Computer processing of the data material led to an enlargement of the Landsat scene of Lake Neusiedl to a scale of about 1:186 000. Images of bands 4, 5, 6 and 7 were documented using black-and-white photographic material. The combination of bands 4 + 5 + 6 by the Optronics Photomation C 4 500 allowed the production of a simulated colour-IR image of Lake Neusiedl (defining band 4 as the blue, band 5 as the green and band 6 as the red component). This image was the keystone for a first general view of reed areas.

4.2. COLOUR-IR AERIAL PHOTOGRAPHY

The date of flight is Aug., 15th, 1979. The camera used was the WILD RC10 stereophotogrammetric camera. Scales of aerial photographs are 1:9 600 to 1:12 100. 133 aerial photographs were used for reed classification.

5. THE CLASSIFICATION OF REED AREAS

First estimations of the classification area led to approximatively 100 square-kilometers.

Without the aid of fundamental research done on a similar topic before, only studying classification methods of wetland types (Stewart et al., 1980) and the author's experiences in the classification of tree-vitality reduced by metal industry emissions (Csaplovics, 1980) were useful.

As well as other types of vegetation, reed shows a maximum of reflectance in the green and near-IR wavelengths, the near-IR max being the more significant one. Reed colour on colour-IR film varies from red to green as a function of the ratio of young to old reed plants. Reed vitality has to be defined as a function of the ratio of young to old reed. Phragmites australis is an annual plant and rests standing upright for 6-7 years, breaks down at last and forms layers of plant material.

5.1. CLASSIFICATION OF REED USING LANDSAT DATA

Based on the simulated colour-IR image (bands 4 + 5 + 6), visual interpretation and mapping of reed areas was done. It was of great importance to combine field verifications and interpretation training. Ground control in situ helped to find the ideal system of Landsat bound reed classification. The interpretation key divides reed areas into three classes of vitality. Open water areas affect the spectral signature of reed and have to be regarded (Ernst-Dottavio et al., 1981).

Landsat band 7 allows the exact definition of the reed-water-borderline. In addition band 6 shows structures of open water areas making interpretation of water-current (drifting) systems of Lake Neusiedl possible.

A general discussion of Landsat-II interpretation results localizes the largest areas of reed in the surroundings of the mouth of the Wulka brook due to the postulation of maximal inflow of nutritives at that place. Southward reed areas are characterized by the growing number of water areas penetrating reed vegetation. The efficiency of the classification of phragmites australis using Landsat data is obvious especially for general information purposes.

5.2. CLASSIFICATION USING COLOUR-IR AERIAL PHOTOGRAPHY

5.2.1. THE INTERPRETATION TRAINING

After the selection of stereopairs representative for the variability of reed growth, interpretation training with corresponding field verifications was done. In situ-verifications using the colour-IR originals allowed the development of an efficient classification key and an increase of the interpreter's reference niveau (Vink, 1970). The great extension and variability of reed produced great problems during first classification tests. In situ verifications were only possible along the reed-water and the reed-land border respectively in narrow passages passable by boat. Stereoscopic analysis of reed areas was of great importance and made the definition of a rough first classification key possible.

5.2.2. THE CLASSIFICATION KEY

Textures of colour-IR aerial photographs permit the definition of degrees of density of growth. Stereoscopic analysis of aerial photographs leads to the definition of classes of heights of growth. Colour-IR information allows the classification of vitality of reed. All of these three classification characteristics density of growth, heigth of growth and vitality are divided into subclasses.

5.2.3. THE CLASSIFICATION OF REED

Visual interpretation of reed areas was realized by using colour-IR originals. The "Stereograph" of the Institute of Photogrammetry permitted testing of classification methods and developing an economic system of interpretation techniques. From one colour-IR stereopair to the other, stereoscopic interpretation led to the mapping of classes of reed areas. The conception of the "Stereograph" allowed on-line mapping on non-deforming foil. Without interruption of the stereoscopic effect a continous association of interpretation and colour-IR stereopair contents is possible. Photographic procedures done at the Institute of Cartography (Technical University of Vienna) transformed the classification sheets of different scales to the common scale 1:10 000.

Based on fixed points mapped during the stepwise classification the completion of six maps of reed (classes) of Lake Neusiedl, scale 1:10 000, was possible. The exact classification was done after completion. Therefore it was possible to classify with the highest reference niveau. Fig. 1 shows a section of reed map No. 2.

6. CALCULATION OF REED AREAS

Aspects of practical application demanded the calculation of areas of reed classes. A reduction print of the six maps 1:10 000 to 1:50 000 was the basis for the projected calculation. Areas of the same reed class were mapped in the scale 1:50 000. Using computer procedures these maps were digitized and areas calculated. A listing of these areas resulted. The exact area of the Aufstrian part of Lake Neusiedl reed is 103.004 square kilometers.

7. DISCUSSION

7.1. REED CLASS 631 (f.e.)

Reed areas of high density and normal height of growth, characterized by a great component of young reed, can be found at points of seawards reed expansion ("pioneer areas"), at places where reed is manufactured (reed harvest or burnt down reed areas) or effects of oversaturation (in the surroundings of the Wulka) appear. These distributions can be seen in Fig. 2. Reed of class 631 covers small areas at the reed-water and reed-land border. Being pioneer areas seawards, these areas are individually cultivated landwards. The largest areas of reed class 631 are situated near the Wulka. On the one hand in this area highest rates of nutritives can be postulated, on the other hand the largest areas of reed cut for manufacturing are situated in the northwestern part of the lake. Reed areas of class 631 cover 26.35% of the total area of Austrian reed of Lake Neusiedl.

7.2. THE TOTAL REED AREAS OF LAKE NEUSIEDL

The asymmetry of areas covered by reed on the western and eastern shores of Lake Neusiedl is evident (Fig. 3).
In the western part of Lake Neusiedl land-open water-distances are 4.5 km at max (2.5 km in the average). In the eastern part average distances are about 400 to 500 meters. Towards the south the width of reed areas increases. Near the Austrian-Hungarian border maximal distances of 3.8 km are detectable. The explanation for the asymmetry can easily be found. The predominant NW-wind direction causes the destruction of young reed plants on the eastern shore during the early spring ice-floe. Thus annual growth is diminished.

Another problem is the exact definition of a reed-land border (compare with the similar problem of defining wetland boundaries, Howland, 1980). The plant association Scirpo-phragmitetum magnocaricosum TOTH 1960 (in the diction of Weisser, 1970) is characterized by a landwards increasing component of sedges and grasses (e.g. Bolboschoenus maritimus). Because of that the definition of a borderline is quite difficult. In the presented paper the reed-land-borderline ist the per definitionem breaching line of areas of straggling reed vegetation with high components of sedges and grasses and reed areas of more or less dense reed growth. This definition was also chosen for to guarantee the efficiency of area calculation for aspects of reed manufacturing.

It was necessary to find earlier works done on Lake Neusiedl reed area calculation to compare the dimensions of reed areas. Methods of area calculation of former works were hardly compatible with methods applicated in the presented paper. Available works are calculations of reed areas for the years 1901 and 1963 (Kopf, 1967), 1938 and 1958 (Riedmüller, 1965) and 1965 (Kopf, 1968). Investigations for 1938 and 1958 are based on the official Austrian map 1:50 000, investigations for 1963 were realized by having levelled along E-W profils allover the lake.

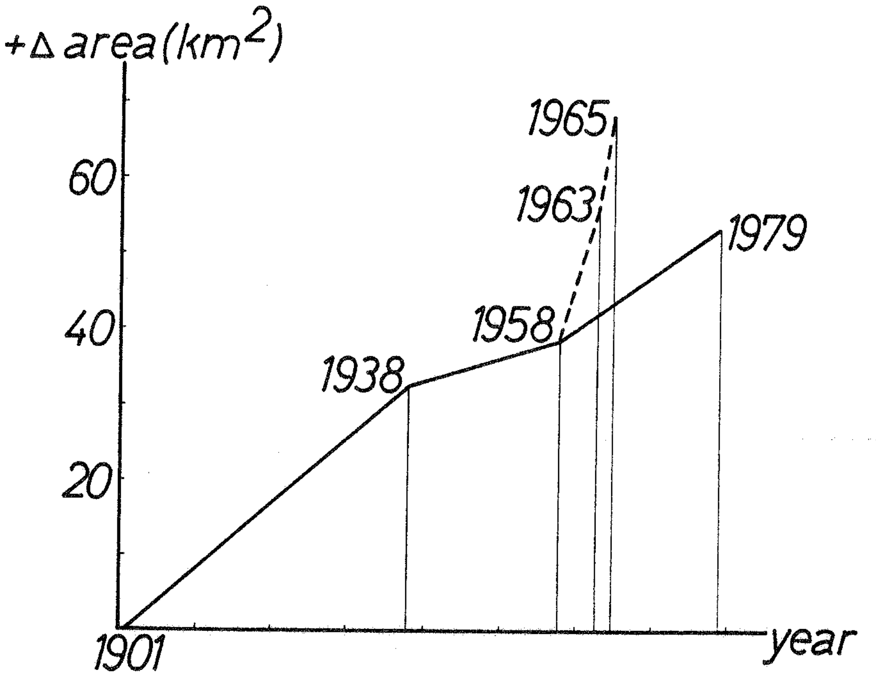

Fig. 4. Diagram of reed growth since 1901

In spite of that it was possible to produce a time series of Lake Neusiedl reed growth since 1901. Values for 1938 and 1958 fit more or less together with presented calculations, values for 1963 and 1965 seem to base on different considerations. One could postulate an approximately linear increase of reed growth.

8. COLOUR-IR AERIAL PHOTOGRAPHY VS. LANDSAT-IMAGE

Landsat-data make spectral informations from 0.4-1.1µm available. A general survey of reed areas is easily and quickly possible. A disadvantage is the lack of detailed informations on textures and structures of reed growth, especially height of growth. Primary costs of Landsat-data are low and direct access is possible. Aerial photographs are products of a lot of steps of planning. Only a few days per year can be used for realizing stereo-photogrammetric flights. Aerial colour-IR photographs show detailed information. Stereoscopic analysis permits the investigation of differences of level and thus the documentation of vegetation's height and a more efficient textural and structural analysis of vegetation species. The scale of aerial photographs can be adjusted to specific topics and allows variations of classification methods.

9. A PERPETUAL SYSTEM OF REMOTE SENSING OF LAKE NEUSIEDL

Due to the rapid changes of the environmental situation of Lake Neusiedl a perpetual system of remote sensing of the reed areas would be effective. Flights in time intervalls of 8-10 years should yield informations of reed stored by colour-IR images (scales of aerial colour-IR photographs from 1:10 000 to

1:15 000). Detailed flight planning could reduce costs and create a well-balanced ratio of precision and economic aspect of the project. During some steps of project realization simultaneous working methods of experts and technical assistants could be organized. Colour-IR aerial photography of Lake Neusiedl is a document of concrete environmental situations and basis of various investigations such as the creation of specific time series.

10. CONCLUSIO

Interpretation of colour-IR images gains increased significance. A synthesis of photogrammetry, theory and practice of image interpretation and of involved sciences realized by a team of experts is a guarantee for optimum success of project studies. The analysis of the photogrammetric-interpretational point of interest in classifying colour-IR images is the topic of the presented paper. Considering psychological and physiological aspects of visual image interpretation a theory of classification is discussed. This theory has to depend on types of images, photogrammetric components of flight, exposure and development, physical state of the atmosphere, and the spectral signatures of objects. The presented paper is a kind of a pilote study in testing the efficiency of colour-IR image interpretation in practical application: reed of Lake Neusiedl. The description of classification methods, which can be done more or less independent of large computer systems, is of great importance for users with generally limited budgets far away from university or economic centres, that is, for users trying to get informations of maximal efficiency at tolerable costs. The fusion of theory and practice realized by the definition and application of methods of classification and calculation of 103 square kilometers of reed areas situated around Lake Neusiedl may help to prove the efficiency of colour-IR remote sensing methods in solving problems of involved sciences.

The complete and detailed description of the shortly presented topic can be found in: Csaplovics, 1982. Copies are available by writing to:

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The author would be thankful for critical reviews, suggestions, and references to similar publications.

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ABSTRACT

Vegetation shows a significant maximum of reflectance in the near infrared and a flattening of the reflectance curve in the case of vegetation damage. Thus remote sensing methods considering near infrared radiation are of optimum use for the analysis of vegetation species and damage. The visual interpretation of a LANDSAT colour IR image (simulated by bands 4+5+6) of Lake Neusiedl is of great utility for separating degrees of reed vitality.

The classification of aerial colour IR photographs allows the mapping of the density of growth, the height of growth and the vitality of reed. These classes are divided into subclasses. The maps of the reed of Lake Neusiedl (scale = 1:10 000) are the product of a stereoscopic analysis using the "stereograph" of the Institute of Photogrammetry (Technical University Vienna). A calculation of areas of reed classes is realized by digitizing maps (scale = 1:150 000) of these classes (total area = 103 km^2). The efficiency of colour IR image interpretation for solving practical problems of vegetation mapping is shown.

ZUSAMMENFASSUNG

Die Remission von Vegetation besitzt ein Maximum im Bereich des nahen Infrarot. Die Remissionskurve verflacht bei zunehmendem Vitalitätsverlust. Im nahen Infrarot sensibilisierte Aufnahmematerialien sind deshalb für die Analyse von Vegetationsarten, -alter und Vitalitätszuständen von Vegetation prädestiniert.

Die visuelle Interpretation eines simulierten LANDSAT-Farbinfrarotbildes (Kanäle 4+5+6) des Neusiedler Sees liefert eine Überblickszonierung von Schilfgebieten mit unterschiedlicher Vitalität. Die Klassifikation von Farbinfrarot-Luftbildern gliedert die Information Schilf in drei Merkmale: Dichte, Höhe und Vitalität. Diese Parameter werden ihrerseits wieder in Subklassen unterteilt. Nach modellweiser stereoskopischer Analyse der Luftbilder am Stereograph des Institutes für Photogrammetrie der TU Wien entstehen Arbeitskarten im Maßstab 1:10 000, die den Schilfzonen dreiziffrige Klassifikationszahlen zuordnen. Digitalisierte Flächenauszüge 1:150 000 gestatten die Flächenbestimmung der Bestandesarten sowie die anschließende Analyse der einzelnen Flächenanteile. Die Ergebnisse der vorliegenden Projektbearbeitung (103 km^2 klassifizierte Fläche !) unterstreichen die Effizienz der Interpretation von Farbinfrarotbildern bei der Lösung praxisbezogener Probleme der Vegetationskartierung.

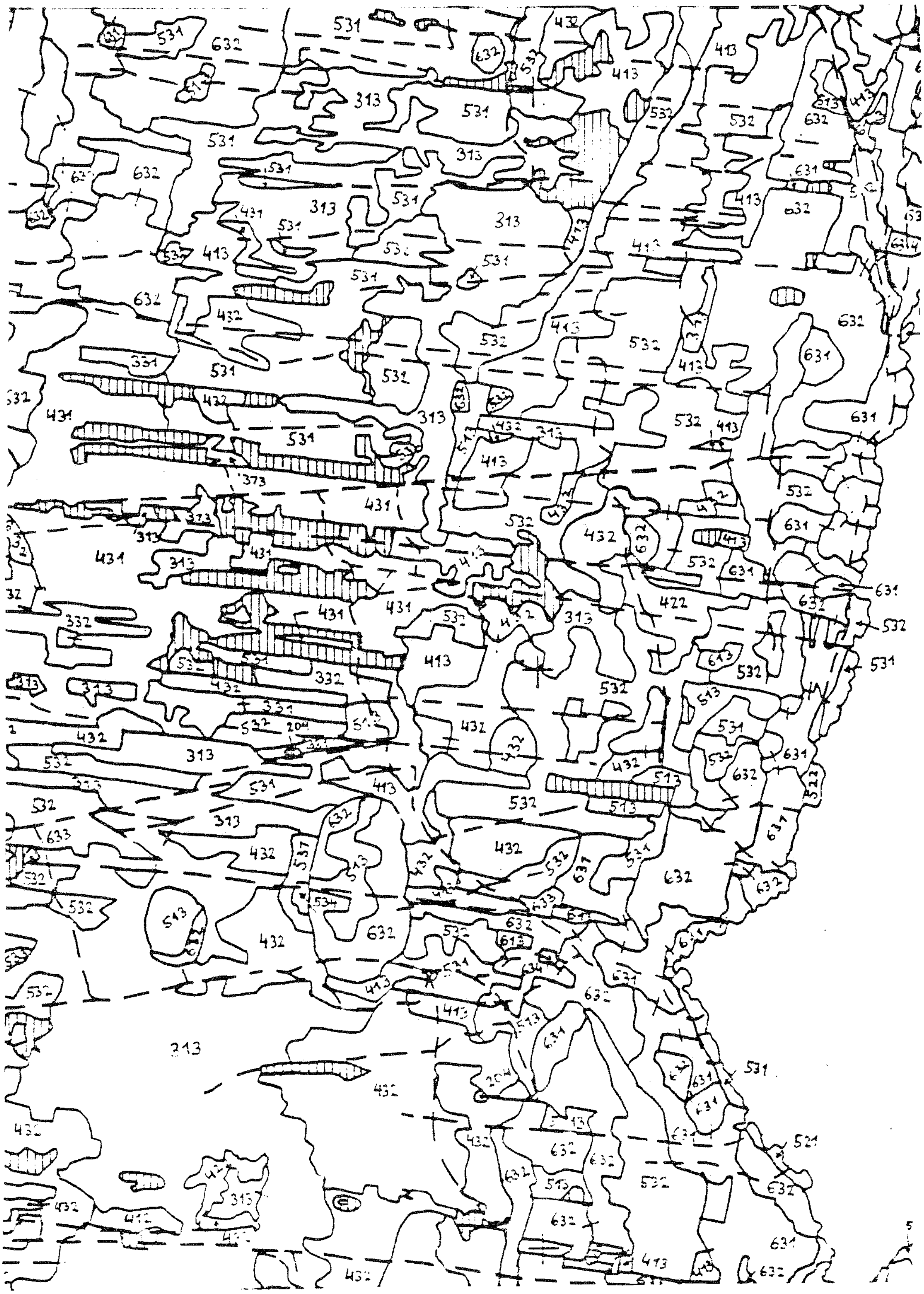

Fig. 1 Section of reed map No.2, showing reed areas south of the town of Rust. Scale = 1:10 000.

Fig. 2 Areas of reed class 631, scale 1:150 000

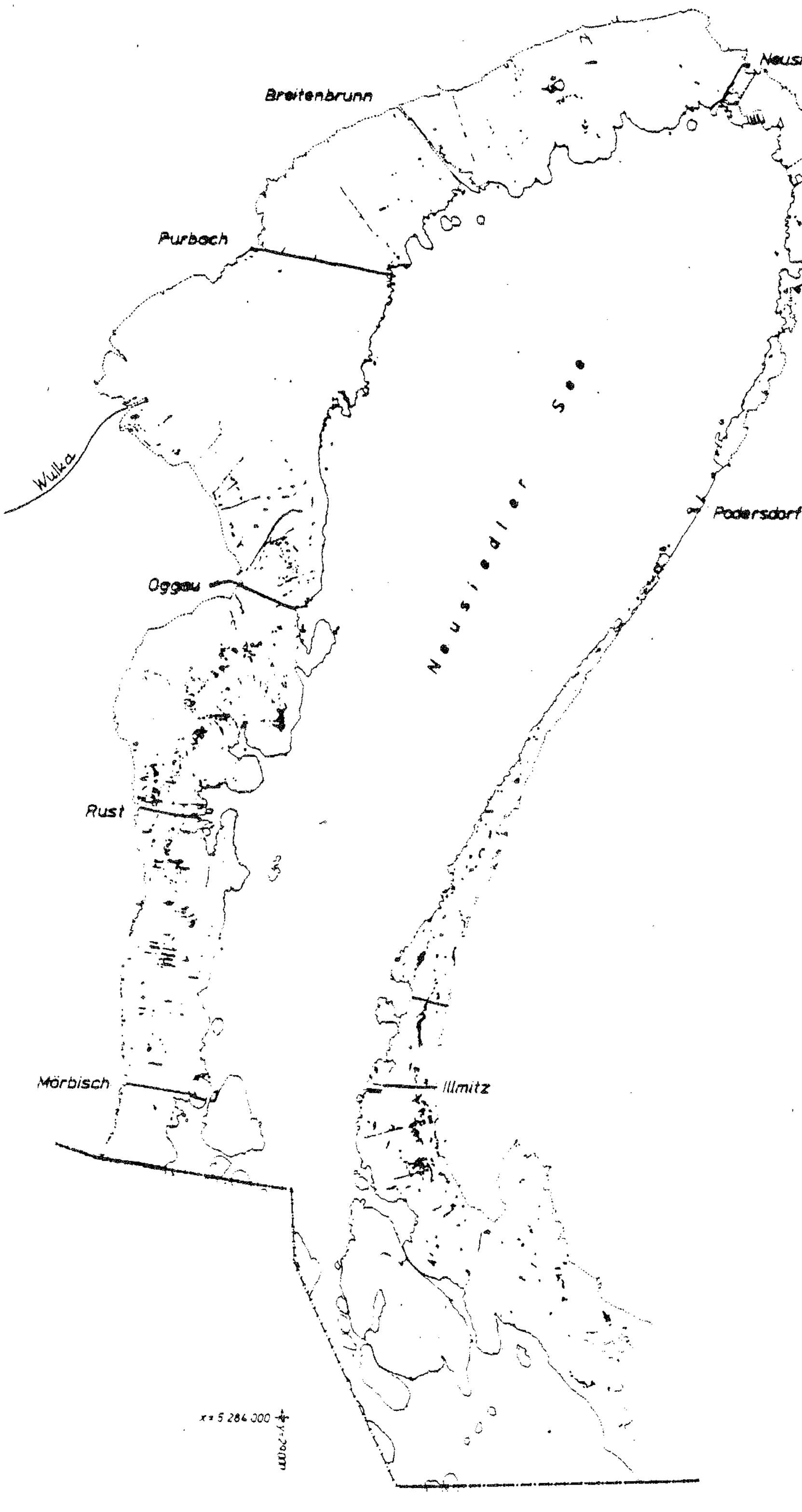

Fig. 3 Reed areas of Lake Neusiedl; black dots symbolize water areas penetrating reed vegetation. Scale 1:150 000