HIGH RESOLUTION SPACE PHOTOGRAPHY FOR LANDUSE INTERPRETATION AND THEMATIC UPDATE OF LARGE SCALE ORTHOPHOTOS

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ABSTRACT

Russian KFA- and KWR-space-photographs - besides forthcoming MOMS-02-data - fill the gap between medium resolution satellite data (Landsat TM, SPOT) and aerial photography. Comparative analysis of spatial and thematic accuracies of digital space and aerial ortho-images respectively show limits and advantages of using Russian space photography for generating and updating large scale orthophotomaps. Case studies prove, that large area coverage combined with high geometric resolution on the one hand and limited detectability of details as well as very low vertical accuracy on the other hand are the crucial points of the efficiency of Russian space photographs for the production as well as the thematic interpretation of large scale ortho-images.

RÉSUMÉ

Les photographies satellitaires prises par les caméras russes KFA et KWR sont les liens entre les images satellitaires en résolution moyenne et les photographies aériennes. L'analyse comparative de la précision spatiale et thématique des ortho-images numériques dérivés des photographies satellitaires et des photographies aériennes indique les avantages ainsi que les désavantages des capteurs russes pour la production et la révision des ortho-images à grande échelle. Etudes appliquées montrent de la haute résolution géometrique d'une part et de la detectibilité limitée des objets ainsi que de la résolution verticale limitée d'autre part étantes les paramètres d'éfficacité de l'analyse spatiale et l'intérpretation thématique des ortho-images des capteurs satellitaires KFA et KWR.

KURZFASSUNG

Weltraumphotographien der russischen KFA- und KWR-Systeme stellen das aktuelle Bindeglied zwischen Satellitenbilddaten mittlerer und Luftbildern höchster geometrischer Auflösung dar. Die vergleichende Analyse von digitalen Orthobildern, die aus KFA- und KWR-Daten bzw. Luftbildern gewonnen wurden, zeigt die entscheidenden Vor- respektive Nachteile der russischen Bilddaten für die Generierung und Nachführung großmaßstäbiger Orthobildkarten. Fallstudien zeigen, daß hohe geometrische Auflösung in der Lage einerseits, aber limitierte Erkennbarkeit von Objektdetails und geringe Höhenauflösung andererseits die entscheidenden Parameter der Nutzbarkeit russischer Weltraumbilder für Orthobildherstellung und thematische Interpretation darstellen.

1. INTRODUCTION

Geometric resolution of current operational multispectral satellite sensors is limited by ground pixel sizes of 20m x 20m (Spot XS) and 18mx18m (MOMS-02/Priroda, launch scheduled for spring 1996) respectively. Combination of panchromatic data of Spot P (10m) and/or MOMS-02/Priroda (6m) with multispectral data of Landsat TM, Spot XS and/or MOMS-02 improves geometric resolution to some extent. Nevertheless black-and-white (BW) and colour-infrared (CIR) aerial photography are of unchanged importance to satisfy the demands of topographers and ecologists on detection of details of landcover and vegetation structures (Annoni et al., 1992, Csaplovics et Senftner, 1991).

The missing link between medium to high resolution satellite imagery and very high resolution aerial photography is high resolution space photography of the Russian Kosmos and Resurs satellite missions (Krämer et Illhardt, 1990, Kramer, 1994).

Combination of space photomaps with 2mx2m ground resolution with existing topographic and thematic maps as well as with actual field work increases the efficiency of collection, analysis, management and display of multiscale spatial informations for map production and GIS application up to scales of 1:10000 (Estes, 1992, Steiner, 1992).

2. HIGH RESOLUTION SPACE PHOTOGRAPHY

Scanning of KFA-3000 diapositives with photoscanner resolution (max.7.5μm) resolves linepairs $\geq$ 80cm ($\equiv$ 1.4 • pixelsize) respectively could allow determination of high contrast objects larger than 40cm.

	Aerial Photographs	KFA-3000	KWR-1000	KFA-1000
altitude (km)	4.5	249.8	220	274.8
f (mm)	153.24	2989.46	1000	1000
scale	29400	83500	220000	275000
film size (cm^2)	23x23	30x30	18x18	30x30
coverage (km^2)	6.8x6.8	25x25	40x40	82x82
$\Delta\lambda_{film}$(nm)	350-700	550-710	500-680 (?)	570-670 670-800
res_{film}(l/mm)	100	260	260 (?)	60
distortion (mm)	≤0.005	≤0.1	≤0.1 (?)	≤0.1 (?)
$res_{ground,theor}$(m)	0.3	0.3	0.7 (?)	5
$res_{ground,real}$(m)	0.8-0.9	2.0	2.0	7-9

Table 1. Parameters of aerial and space photography used for case studies.

Considering positive effects of image motion compensation and negative influences of atmospheric scattering and absorption the theoretic accuracy of the KFA-3000 BW-Film T-J8 of 260lp/mm has to be reduced to a de facto resolution of about 70-100lp/mm, that is 80cm to 110 cm ground resolution or detectability of objects larger than 40-50cm under conditions of high contrast between adjacent features.

Russian authorities manipulate KWR-1000 and KFA-3000 data to decrease resolutions to about 2m, a threshold which is said to have been set by the Russian government (Wanninger, 1993, Capes, 1994).

Geometric resolution of KFA-1000 photographs is limited by the resolution of the two-layer film SN10 (red, n-IR) of 60lp/mm. It is therefore unlikely to detect details smaller than 7-8m. Actually KFA-3000 and KWR-1000 photographs are space-borne remote sensing data with the highest spatial resolution available and therefore important tools to document detailed patterns of landcover and landuse (figure 1).

3. TOPOGRAPHIC MAPPING

Besides spectral and radiometric resolution planimetric accuracy, elevation accuracy and detectability of objects are the three criteria of suitability of imagery for precise thematic analysis and cartographic representation (Konecny, 1995).

A transversal camera tilt of the KFA and KWR systems of about $8° \leq \omega \leq 12°$ has to be taken into consideration. As there are only few parameters known for orientation - the frame camera has no fiducial marks - it is necessary to use a lot of control points to obtain sufficient accuracy for a bundle adjustment.

Planimetric accuracy can be determined by a value of 0.2mm referring to the required map scale. Focussing on an orthophoto scale of 1:10000 requires an accuracy of 2m, which could be met by KWR-1000 and KFA-3000 photography. KFA-1000 photography could be adapted for mapping in scales of 1:50000 and smaller. In case of flat (steep) terrain, contour line intervals of 20m (50m) are required for a scale of 1:50000 and intervals of about 5m (10m) are required for a scale of 1:10000 respectively. As the point measurement accuracy in elevation should be 1/5 of the contour line interval, corresponding values are 4m (10m), respectively 1m (2m). Because of weak base-height-ratios these values cannot be provided by Russian space photography.

4. DETECTABILITY OF OBJECTS

Detectability of objects depends on contrast, shape and texture. Digitized photographs should not exceed pixel sizes of 2m, which are necessary for detecting detailed contents as defined by European mapping standards. KFA-3000 photographs meet this requirement when being digitized with 7,5μm resolution (Zeiss-PS1), whereas resolution of KWR-1000 data (digital product DD5) is limited by a de facto resolution of about 2.2m to 3.1m (≡ 1lp, 70-100lp/mm) on the one hand and limits of scanning resolution on the other (1.4 • pixelsize = 2.3m ≡ 1lp).

There is striking evidence of the efficiency of KFA-3000 and KWR-1000 photographs for updating details in topographic and thematic maps, especially concerning planimetric accuracy and detectability of objects. On the other hand height measuring accuracies and subsequently accuracies of contour lines are beyond the information value of Russian space photographs even for a scale of 1:50000.

5.CASE STUDIES

Environmental monitoring is of growing importance for the documentation of the status quo of landcover and landuse as well as of the multi-temporal dynamics of degradation and the resulting influences on the ecological quality of protected regions.

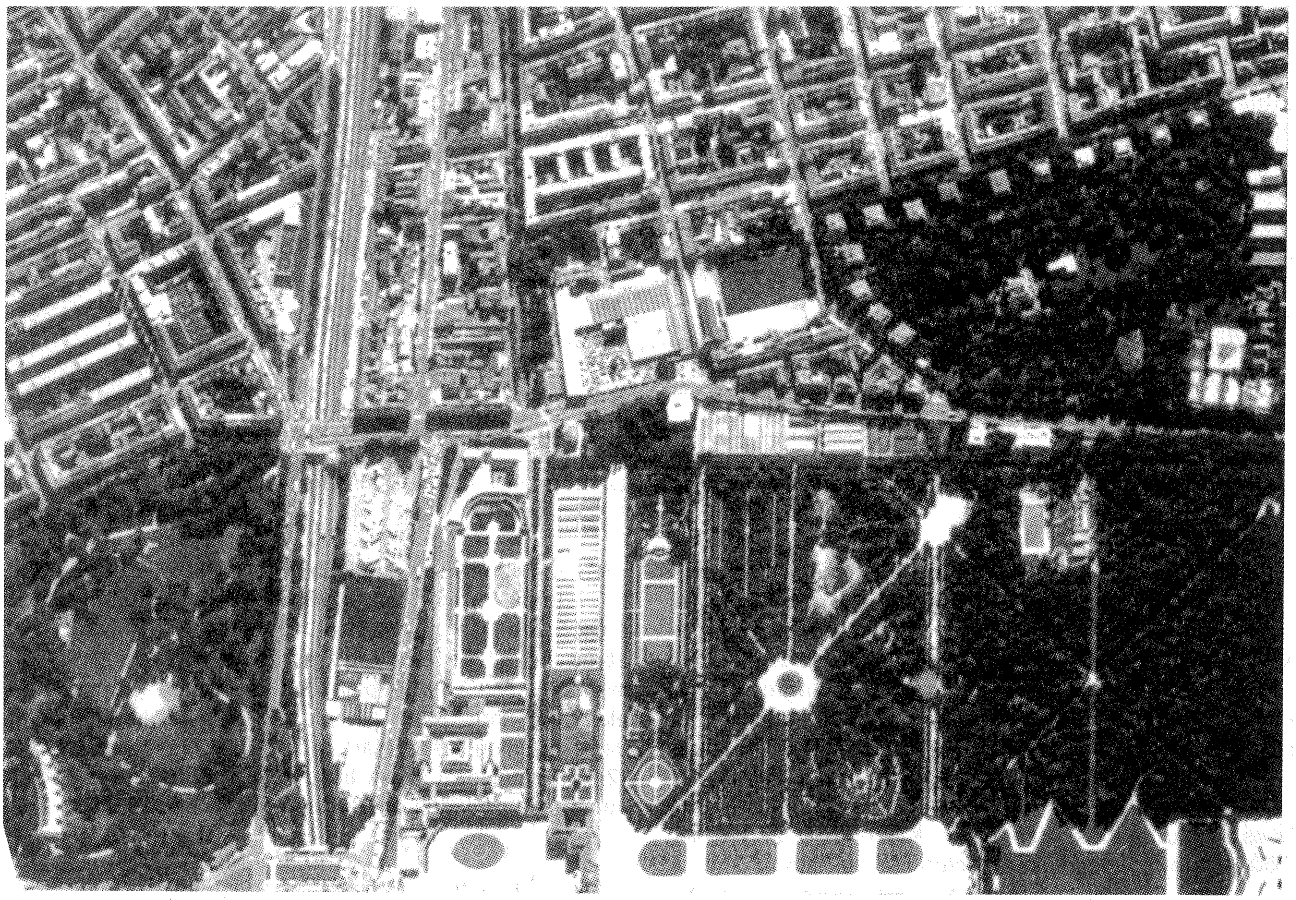

Figure 1. KFA-3000-space photography, part of Schönbrunn Palace and Gardens, Vienna, scale ≈ 1:8000.

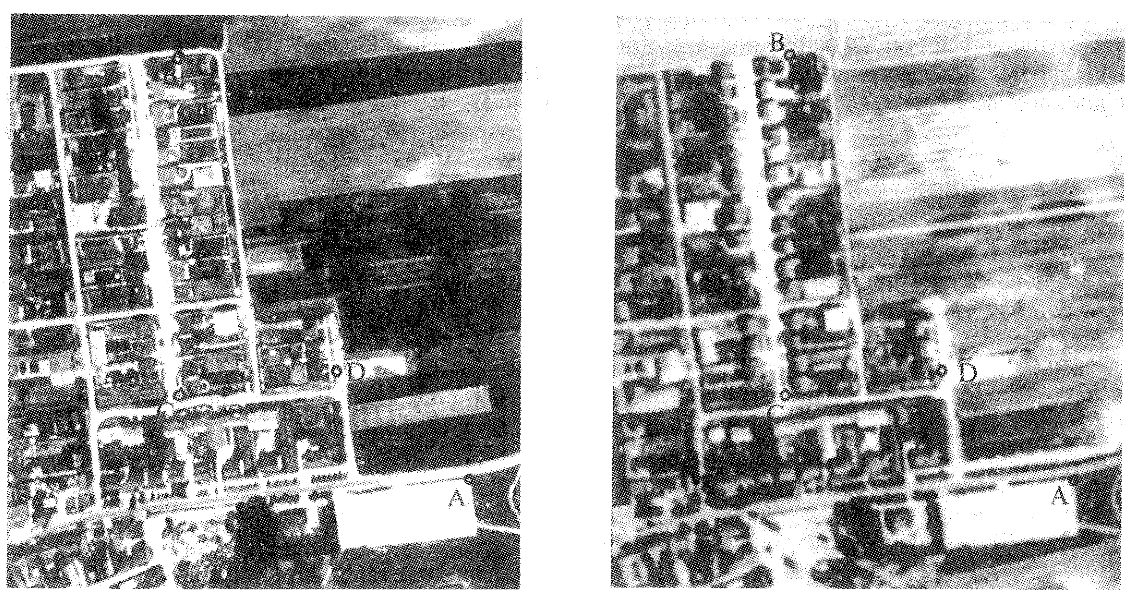

Figure 2. Ortho-images: aerial photography (left), KFA-3000 space photography (right), scale = 1:10000.

The synthesis of high-resolution remotely sensed data and geo-data is an effective way to create an integrated geographic information system (IGIS) for documentation, analysis, planning and decision finding in the frame of operational aspects of environmental management. Interpretation of KWR and KFA space photomaps for supporting large-scale topographic and thematic mapping shows positive results. A combination of digital BW-aerial ortho-imagery derived at about 10-15-year-intervals with annually available digital BW-space ortho-imagery is likely to increase the efficiency of documentation and analysis of multi-temporal dynamics of landscape transition.

6. AERIAL PHOTOGRAPHY VERSUS KFA-3000 SPACE PHOTOGRAPHY

Enlargements of details of a digital KFA-3000 space ortho-image and the corresponding digital aerial ortho-image both digitized before rectification with the Zeiss-PhotoScanner PS1 with a resolution of 15μm (pixel size 1.2m vs. 0.45m) show significant differences in geometric resolution as well as different grey values of objects due to different dates of data collection, different film sensitivities and changed landcover patterns (figure 2, Herbig, 1995).

As the BW-film used with the KFA-3000-system is sensitive in red-edge adjacent near infrared wavelenghts (710nm) vegetation and soils are brighter than in the aerial orthophoto. Detectability of geometric features such as small houses is better with aerial photography - limits are additionally set by distortion of the optics and by the artificially spoiled resolution of the KFA-3000 photographs. Selecting higher resolution with the photoscanner shows therefore not necessarily increasing detectability. Nevertheless planimetric accuracies of coordinate measurements of selected point features better than 2m meet requirements for topographic 2D-mapping at a scale of 1:10000 (Csaplovics, 1995).

7. MULTISENSOR SPACE PHOTOGRAPHY

Limits of spatial and spectral resolution of digitized KFA-1000 photography (scan resolution 30μm) for mapping in scales larger than 1:50000 are evident. On the other hand digitized KWR-1000 and KFA-3000 photographic data (pixel size 15μm) show topographic and thematic details almost comparable to the informational content of aerial photography (see figure 2). Efficiency of data interpretation is nevertheless restricted to certain photo-object groups, which are characterized by easily detectable spatial and/or spectral extures or patterns and by significant contrast differences of adjacent features.

Combination of KWR-1000 and KFA-1000 data for optimizing both geometric and spectral resolution proves, that multisensor digital space ortho-imagery can meet requirements for thematic interpretation in scales up to 1:10000. In the thematic case they even are more efficient than BW-orthophotos based on panchromatic films with limited spectral resolution.

8. CHANGE DETECTION

Multi-temporal analysis of landcover change by map-conform, land register-accurate large scale monitoring is of urgent need for updating spatial and non-spatial informations for regional planning and environmental protection. Integrated methods of data interpretation using geographical information systems and digital mapping are tools for compiling change detection maps based on multitemporal and multisensor data. High-resolution digital KFA-3000 and KWR-1000 ortho-images can be merged with digitized landcover maps derived from stereoscopic analysis of aerial photography and/or with existing field mapping of vegetation and landuse. Figure 3 is an enlarged detail of a KFA-3000-space photography of the National Park Lake Fertö (Hungary, Austria) covering the primary zone (IUCN) Lange Lacke, an important resting place for migratory birds on their way to and from their winter-ecotopes. The corresponding field map shows vegetation communities dominated by reed by chequered and halophytic vegetation types by ruled line signatures (figure 3, Herbig, 1995).

Change detection mapping based on historical aerial photography covers a period of more than 40 years.

9. CONCLUSIO

Mapping large scale patterns of landcover and landuse change requires a temporal resolution of monitoring of one to two years and can therefore benefit from high-resolution space ortho-imagery with scales up to 1:10000 based on panchromatic KWR-1000 or KFA-3000 data - eventually supplemented by n-IR spectral informations of KFA-1000 data. Costs for data acquisition are low compared to aerial survey missions - a factor of 1:3 is realistic even when calculating costs for a multisensor KFA-1000/KFA-3000 data set. Efficiency of these data is nevertheless limited by very low height measuring accuracies.

Traditional methods of map production depend on expensive aerial survey missions with update intervals of about 10 years. Digital space ortho-imagery is therefore the "missing link" to actualize topographic and thematic maps without high financial and/or organizational outlays.

10. OUTLOOK

Limits are set by problems in operational distribution of data by Russian agencies. Furthermore on the one hand MOMS-02 data will provide the user community with digital data with 3.5m and 13.5m ground resolution in panchromatic and multispectral modes respectively (de facto resolution of 6m and 15m respectively announced for the Priroda-mission 1996-1997) and along-track stereoscopy with up to 5m height measuring accuracy. On the other hand operational space-borne CCD-systems with a spatial resolution of 1m and along-track stereoscopic data acquisition even more precise than the MOMS-data have been announced by U.S.agencies for 1997. This gives, to a further extent, an impression of forthcoming challenges of mapping based on high resolution space imagery.

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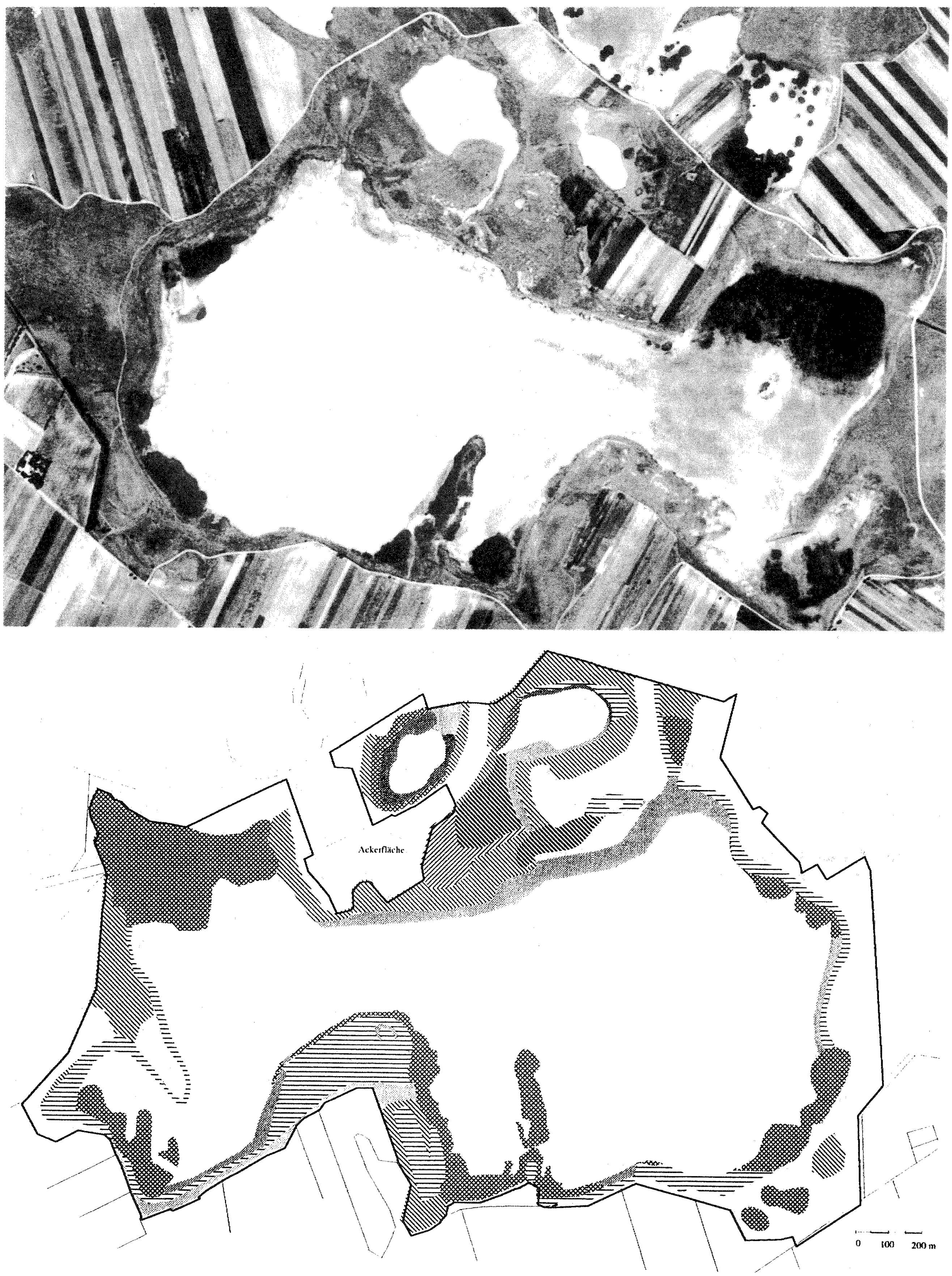

Figure 3. KFA-3000 space photography vs. vegetation map, National Park Lake Fertö, scale ≈ 1:16000.