THE "LOW ALTITUDE PHOTOGRAPHY" (LAP) - A BALLOON-BORNE MOBILE REMOTE SENSING TECHNIQUE FOR GEOSCIENTIFIC SURVEYS OF PRESENT-DAY ENVIRONMENTS AND THEIR DYNAMIC PROCESSES

Preu, Chr., Ass. Professor
Department of Physical Geography
University of Augsburg, West-Germany

Sterr, H., Ass. Professor
Department of Geography
University of Kiel, West-Germany

Wieneke, F., Professor
Department of Geography
University of Munich, West-Germany

Zumach, W.-D., Senior Student
Department of Geography
University of Augsburg, West-Germany

Comission No. V

Abstract

Since 1986 we have been using a newly designed LAP-technique as a remote sensing system for recording landscapes and monitoring environmental data. The camera platform is fixed under a 26 m/3 zeppelin-shaped balloon and consists of two parts: (1) electronic guidance system for operating the platform and the instruments; (2) camera-suspension, movable in all vertical and horizontal directions. Because both the video camera and the reflex camera cover the same area, the optimum time for making the exposure is guaranteed. The accurate altimeter and clinometer complete the camera platform. All the data and the video pictures are transmitted via an antenna to the monitor of the ground-control station and are recorded on a video recorder. The operation of the cameras and the platform is radio controlled, while the position of the balloon itself is controlled by one person with a handling line.

Our experience explicitly demonstrates that this equipment makes the LAP-technique a simple method for taking large scale photographs. This system can be used for surveys on morphological forms and structures as well as for observation of dynamic processes, whether at a point in time or over a period of time.

1. Introduction

During the last decades remote sensing has been established as a very common and useful technique in all geo-sciences. However, the scale of satellite imageries and aerial photographs is not suitable for recognizing details within smaller areas. Therefore, we took up the idea of a balloon-borne photography, first used by Felix TOURNACHON in the middle of the last century, and constructed a camera platform fixed under a small unmaned zeppelin-shaped balloon. With this technique we were able to take large scale photographs from all altitudes up to 200m in an reasonable and simple way. In addition, surveys of dynamic processes over longer periods could be carried out. This LAP-technique (PREU et al., 1987) has been successfully applied to various geographical problems.

2. Methodology

After several sets of tests and technical improvements over the last few years, we found a method of taking low altitude photographs simultaneously with their specific data. This balloon-borne mobile remote sensing technique (see Fig. 1) consists of the following three main components:
- the 26m/3 zeppelin-shaped balloon with its rigging;
- the camera platform fixed to the balloon;
- the ground-control station.

Before the balloon can be started, the video camera (1) and the reflex camera have to be mounted in such a way that both cover exactly the same area. The camera platform has to be brought into balance by moving the sliding carriage on the rail. Afterwards, the balloon navigator lets the balloon ascend by the handling line. The second person controls the altitude (transmitted by video camera (2) from the instrument panel) and observes the land surface (transmitted by video camera (1)) on the monitor of the ground-control station. When the balloon has reached the desired altitude, the camera mounting can be turned horizontally and tilted vertically by the radio-controlled motor to cover exactly the surface area you want. Subsequently, the photograph can be taken by operating the radio-controlled shutter release. Simultaneously, the monitor picture (showing the data from the instrument panel and the land surface) is recorded on the video recorder.

Using the recorded clinometer and altimeter readings, we can rectify, if necessary, distorted photographs in a simple optical way. Moreover, since all specific data are available (from the instrument panel), these photographs can be interpreted qualitatively as well as quantitatively.

Another use is the monitoring of dynamic processes, e.g. waves or water discharge on a hill slope. For this purpose it is possible to anchor the balloon, to bring the camera mounting into position, and to record the video pictures as long as necessary. Since the data from the instrument panel are simultaneously recorded, an interpretation of such video films is possible.

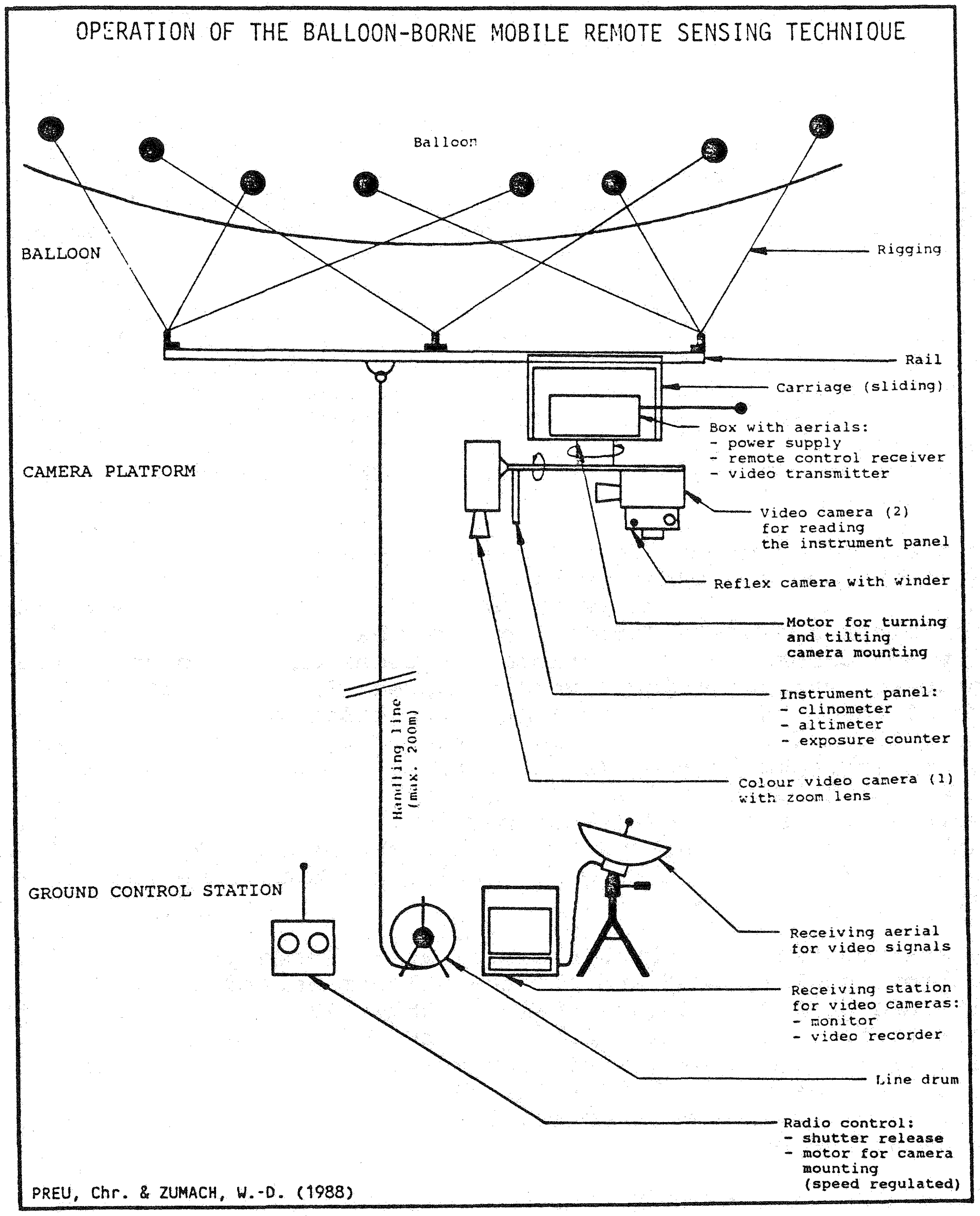

Fig. 1: Operation of the balloon-borne mobile remote sensing technique

3. Examples of application

Now we would like to present three LAP-photographs taken by this remote remote sensing technique in 1986 and 1987. These photographs demonstrate the use of this technique, in order to find a solution to various geographical problems.

3.1 A scale sequence of agrarian land use in the Alpine piedmont, S of Munich (West Germany)

During a remote sensing training course in June 1987 a group of geography students from the University of Munich took a sequence of vertical photographs from various altitudes with different films (black & white panchromatic films, colour films, and colour infrared films). The aim was to study the relation between the structured agrarian land use surfaces and their recognition as structured, textured, or non-textured patterns on the photographs. Since this relation is dependent on the scale, we hired an aircraft and took aerial photographs from altitudes between 300m and 750m to the scales of 1:1500, 1:3000, 1:6000, and 1:15000. The latter corresponds with the scale of aerial photographs taken for commercial purposes on May 30th, 1982. In addition to that, ground-based photographs whose scales were of 1:35, 1:82, and 1:250 were taken by using a ladder and an eight-meter-long pole with a reflex camera fixed on top of it.

In order to cover the gap between 1:250 and 1:1500 we used the LAP-technique on September 8th, 1987, in the same area as in June. At the same place as in June we laid out the same boards with black and white stripes to test the resolving power of film and camera lens at various altitudes above ground level. Moreover, various objects were measured (the width of the gravel road, the grass verge etc.) in order to check the altimeter and to calculate the scale of the photographs from the photographs themselves. We used a Yashica FR I reflex camera with Zeiss lenses 1:1.7 and a focal length of 50mm and tested different films (panchromatic black & white film Ilford PAN F, 50 ASA, colour film Kodak Ektachrome 100 ER, and colour infrared film Kodak Ektachrome 2236). All emulsions led to fairly good results.

We started the photographic survey at 5m above ground level (approx. scale 1:100) and let the balloon ascend to an altitude of 110m (approx. scale 1:2250). The sample photograph (see Photo 1) was taken from 72m above ground level at 16.17 MESZ on September 8th, 1987. The scale of the original photo is 1:1440; we present its enlarged print (scale approx. 1:330). The clouds were intermittent and the sun was shining (look at the shadows).

The centre of the picture shows a crossing of gravel roads with grass verges. On the triangle-shaped grass plot there are some young trees, two benches, a stone, and the test stripes (white and black) which can be exactly identified. The crossing is surrounded by fields with different land uses. On the upper left-hand corner, there is a strawberry field in which the particular plant rows are recognizable in detail. On the upper right-hand corner one can see a potatoe field with parallel running furrows. At the bottom of the photograph, the fields were already ploughed and have recently been harrowed.

Summarizing the result of this experiment we would like to

Photo 1: LAP-photograph showing agrarian land use S of Munich has been taken from 72 m above ground level at 16.17 MESZ on September 8th, 1987 (camera: Yashica FR I; focal length: 50mm; scale: 1:330).

point out that the balloon-borne remote sensing technique is well suitable for scale sequences from low altitudes. By using a standard lens (focal length 50mm) one can take a continuous sequence of large scale photographs ranging from the ground level up to 100m (scales 1:100 to 1:2000), and if necessary, even up to 200m (scale 1:4000). Moreover, photographs of a desired scale can be repeated with different emulsions within a very short interval (approx. 30-45 minutes).

3.2 Monitoring of the beach and littoral zone in a coastal sector near Kiel (West Germany)

The coastal zone between Kiel and Flensburg, part of western Kiel Bay (southwestern Baltic Sea), has been under thorough investigation in recent years. Among other studies detailed field research has been carried out by STERR (1985, 1987, 1988) between Kiel Fjord and Schlei, aiming at a better understanding of nearshore sedimentary and morphodynamics, longshore transport rates and a short-to-long term sediment balance in this semi-enclosed marine basin. In addition, a very important aspect of the current project is the question as to what extent man's presence along this coastline has had

Photo 2: LAP-photograph showing a coastal sector near Kiel has been taken from 100m above ground level at 17.15 MESZ on August 21st, 1987 (camera: Yashica FR I; focal length: 50mm; scale: 1:370).

an impact upon the natural development of the littoral zone. The monitoring and evaluation of recent manmade changes, e.g. artificial structures extending into the surf zone or the ecological pressure resulting from intensive recreational use of beaches, is essential for future management and conservation policies concerning coastal landscapes (CARTER, 1980; NORDSTROM, 1985; STERR & BOEDEKER, 1987).

Field observation during a balloon-borne camera survey on August 21st, 1987, focused on the southern shoreline of Eckernförde Bay and, in particular, on a shore segment of about 1km length near Krusendorf. This area includes a cliff to the east, an artificially protected short section in the middle and a berm-and-dune section to the west. From the series of vertical colour photographs taken during the balloon run, one example (see Photo 2) has been selected to demonstrate the main types of environmental impacts on one of these coastal sections.

The sample photograph has been taken from 100m above ground level at 17.15 MESZ by a Yashica FR I reflex camera with Zeiss lenses 1:1.7 and a focal length of 50mm. Therefore, the scale of the original photograph is approx. 1:2000; afterwards it has been enlarged to the scale approx. 1:370. As emulsion we used a Kodakchrome 64.

The picture shows a berm-and-dune area near the western edge of a camping ground where no caravan- or car- but only 'foot traffic' has invaded the front row of dunes. Part of its natural vegetation cover is thus still preserved but where it is scarce (on the right) wind erosion has caused severe blow-outs. As has been observed in other nearby dune areas, most damage was probably done to the plants by frequent walking, sunbathing and playing within the frontal primary dunes. The beach profile in this section, as the photo reveals, consists largely of a high storm-laid pebble berm below the dunes. The top of this berm reaches up to 2 m above mean water level and forms an effective natural protection of the dunes against winter storms. However, parking of boats on the berm top and hauling of the vessels up and down the beach slope has destroyed major portions of the berm here. Additional excavation of 'hauling tracks' across the beach might enable higher waves during a subsequent storm to run up to the beach top and invade the dune area. In this case the scarce grass cover which was planted recently along the dune front is likely to be eroded again.

Finally, boating and beach activities have resulted in the construction of small rock structures at the waterline and, thus, have partially removed coarse sediments (stones and pebbles) from the submarine beach slope. As this section is obviously affected by a negative sediment balance (erosion in the lee of the outlet) anyway, this may contribute to enforce the problem of shore erosion here.

The evaluation of this photograph may demonstrate the applicability and value of large-scale vertical photographs for mapping and assessing man-made impacts on a coastal ecologic system - or in other rapidly changing environments.

Among the methods applied in the Kiel Bay field studies aerial photography has proved particularly useful. Besides using small-scale stereoscopic (black & white) photographs, of which two series of the study area (1959 and 1979) were available, vertical photographs, preferably coloured slides, have been found very suitable for the purpose of comparative evaluation and mapping of littoral modifications. This coloured photograph does not only depict the adjacent backcountry, the beach and the shallow nearshore zone down to 3-4 m depth in very good resolution on a large scale; in contrast to stereoscopic photographs these pictures can also be taken more easily, at lower cost and thus far more frequently - a major advantage in surveying the rapidly changing coastal environment. Repeated viewing of a certain shore segment allows to identify specific processes operating on or below the beach and to link them to possible natural or man-made causes.

3.3 Studies on morphodynamics of a beachrock fringed coast in W Sri Lanka

Nearly one third of Sri Lanka's 1920km-long coastline is subject to varying degrees of coastal erosion. Due to these morphodynamics the beach profiles have changed drastically, settlements, public installations and hotel resorts are threatoned, and cultivated land is endangered (PREU 1987a, 1987b). Although the causes and th intensity of erosion vary from site to site, The W, SW, and S Coast are attacked by the most evident coastal retreat. Indeed, interviews with the population living close to the sea have shown that the coast erosion rates have generally ranged from 0.6m to 6.0m per annum along these coastal sectors during the last 25 years, but these subjective data are not sufficient for scientific statements on the present-day coastal morphodynamics as well as for planning and execution of protection measures. For these purposes it is extremely important to have an basis of exact data on actual erosion rates along the particular coastal sectors, in order to evaluate the importance of the terrestrial and marine-littoral factors and the manmade impact influencing these processes. Since the width of the beach is generally very small (less than 10m), the available aerial photographs led (even after enlargement) to insufficient results because of their small scales (1:40000). Therefore, we applied the balloon-borne remote sensing technique and took large scale photographs from some coastal sectors along the W and SW Coast over a period of several weeks in 1986 and 1987. We used various lenses and different kinds of films. One of these photographs (see Photo 3) is presented here and shows a coastal segment of the W Coast south of Negombo.

Photo 3 is a vertical photograph taken from 100m above ground level at 9.35 a.m.on March 22nd, 1986, and covers an area of approx. 70m to 100m. Photo 4 is the ground photograph referring to Photo 3. Since we used a Yashica T AF-D camera with a 35mm Zeiss lens (1:3.5), the original scale is approx. 1:2860. Photo 3 is a black & white print of the enlarged colour slide (Fuji 100) and is on a scale of approx. 1:785.

As Photo 3 and Figure 2 show, the covered coastal sector can be subdivided into the following five morphographic segments with different present-day morphodynamics:

1. On the upper left-hand corner a small part of the raised beach with palm trees (grey to grey-black colours) at 3-3.50m above m.s.l. can be identified.
2. The adjacent older beach ridge (grey) is covered by various kinds of grass; its edge is formed by erosional effects.
3. The wide and light stripe (various light grey colours) running parallel to it represents the present-day beach with several water level marks. This coastal segment which extends to the beachrock is covered by the latest uprushed wave in the S.
4. The present-day beach is fringed by the approx. 1.50m thick beachrock (various dark and light grey colours) and shows different parallel running small structure

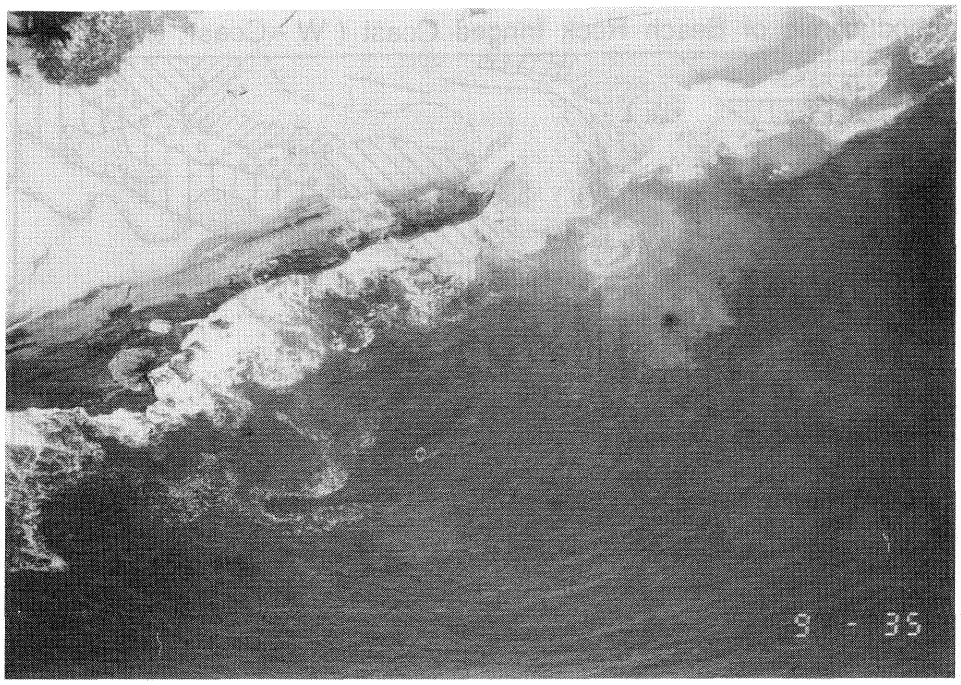

Photo 3: LAP-photography showing a coastal sector S of Negombo has been taken from 100m above ground level at 9.35 a.m. on March 22nd, 1986 (camera: Yashica T AF-D; focal length: 35mm; scale: 1:785).

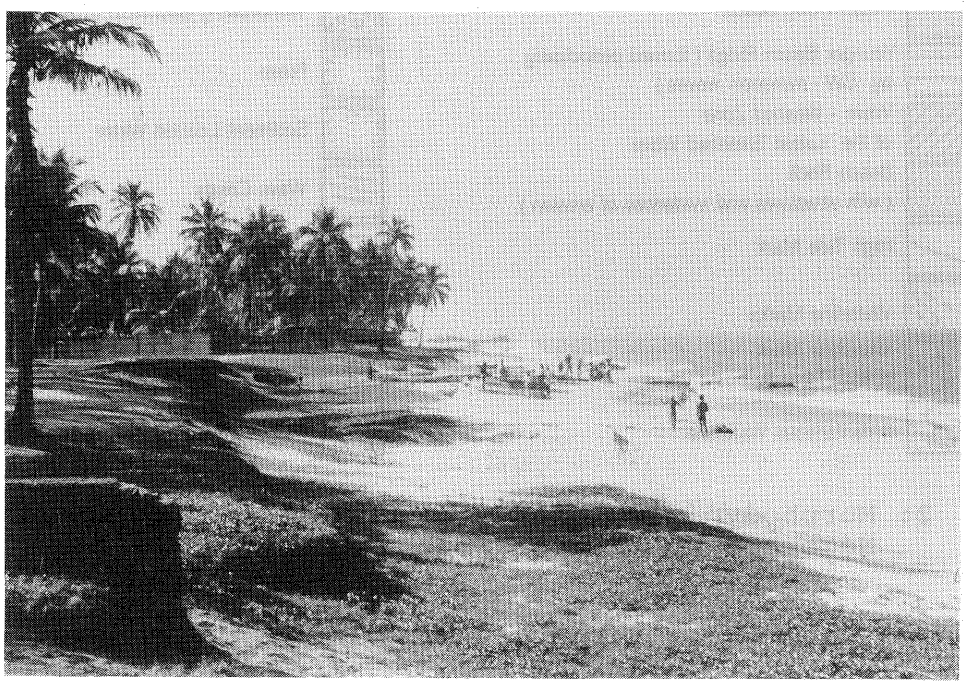

Photo 4: Ground photograph referring to Photo 3

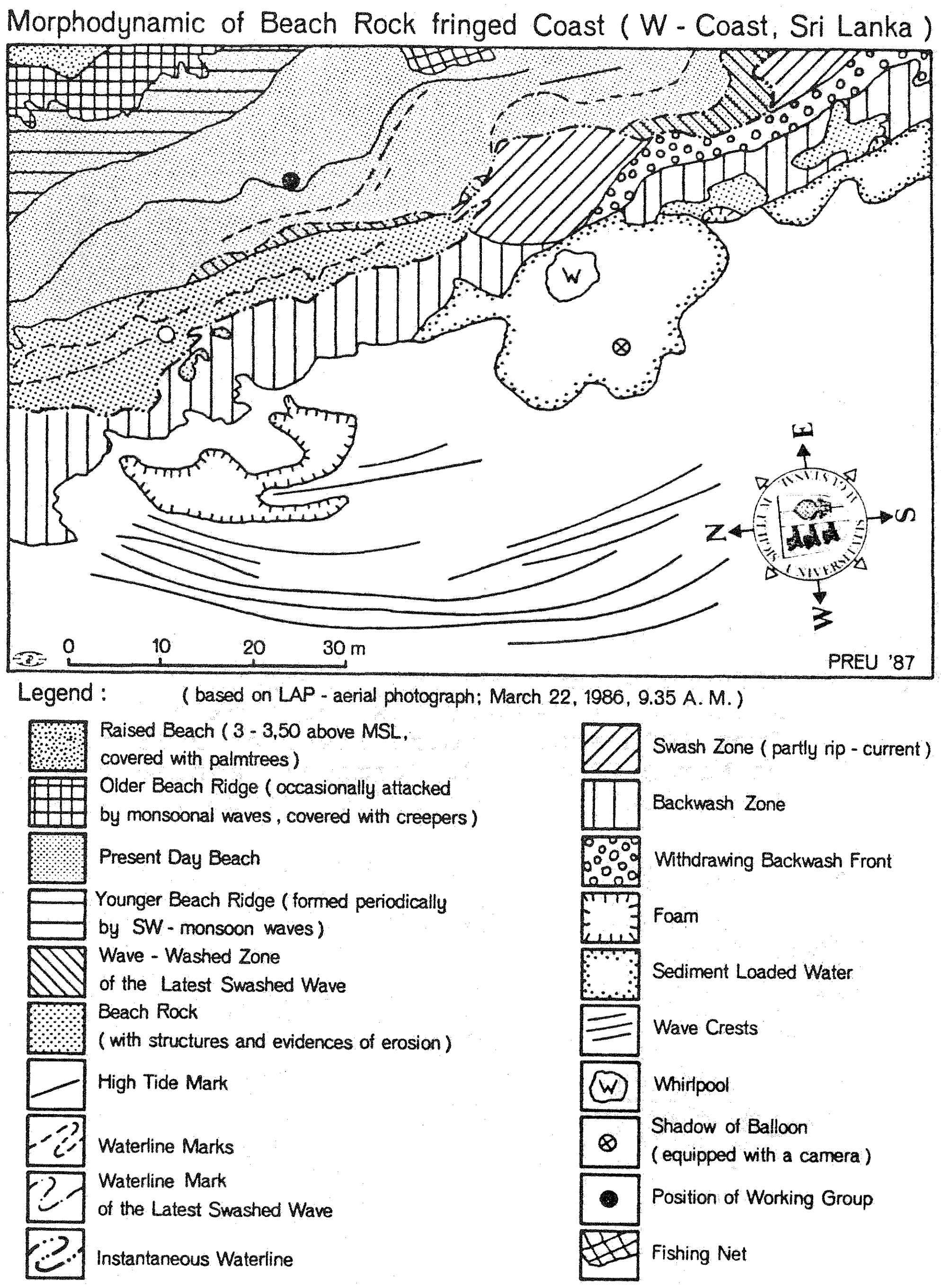

Fig. 2: Morphodynamics of the beachrock fringed coast S of Negombo, W-Coast of Sri Lanka

contours and various forms caused by erosion, abrasion and solution.
Landwards the beachrock disappears under the present-day beach, whereas seawards it forms a small cliff with some gaps in between.

5. On its lower part the photo shows the <u>nearshore and offshore area</u>. The particular wave crests prograding from WSW direction can be distinctly identified.
In the centre of the photo the sediment loaded water

including the whirlpool and the rip current stand out by light grey colours.

The forms and the structures of the present-day beach as well as the beachrock and the hydrodynamic situation described above prove the present-day morphodynamics of this coastal segment. During the SW monsoon period extraordinary high water levels and high tides come up to the raised beach and form its edge. On the contrary, the highest water level in the period of the NE monsoon is represented by the high tide mark on the present-day beach. Most of the waves reaching this coastline will be reflected and/or refracted at the part of the coast where the beachrock forms the shoreline. Consequently on one side the taking up of sediment from the beach is relatively unimportant, but on the other side the waves are not able to transport sediment to the beach. Through the gaps of the beachrock the waves can uprush onto the beach and the following rip current transports the beach sediment back to the sea. This means that the beachrock is a natural coast protection during the NE monsoon. Due to the stronger waves and often higher water levels during the SW monsoon periods the sediment can be washed off from the entire beach. These seasonally changing morphodynamics cause a negative sediment balance of the beach.

The interpretation of this photo demonstrates the importance of vertical large scale photographs for studying morphodynamics in small areas which cannot be perceived by other remote sensing techniques in detail because of their smaller scales.

4. Conclusion

In comparison to the procedure of satellite imageries and aerial photographs the balloon-borne remote sensing technique offers significant improvements and advantages: in particular easier handling and greater flexibility and precision in terms of camera positioning and focusing. It provides a great variability in camera altitude and, thus, in scale and detail of the surface photographs; thanks to the ground control mechanism it also ensures a complete coverage of the desired area of study. As shortage of time - inherent to photography from aircraft - is not an intricate problem here, repeated balloon-camera runs may serve as a surveying method that combines high monitoring frequency (e. g. hourly, daily, monthly repeats) with an optimal photo coverage.

5. Acknowledgements

The authors would like to thank Prof.Dr. H. Klug from Kiel University for his kind assistance during the photographic survey in August 1987 and all students from the Universities of Augsburg, Munich and Kiel who took part in the balloon launches. We would also like to thank Prof. Dr. K. Fischer from Augsburg University for his useful comments and

suggestions.

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