

Aerial surveys over the Patagonia Icefields

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Abstract

Three aerial surveys were carried out on December 31, 1985, and January 7, and 13, 1986. The first flight covered the snouts of glaciers terminating in Paine National Park at the southern end of the Southern Patagonia Icefield. The second mission was flown over the Soler Glacier area and the snout of Nef Glacier. Vertical aerial photographs, with sufficient forward overlaps for stereoscopic analyses, were taken using a 6×6 cm format camera at scales ranging from 1 : 22,000 to 1 : 27,000. The last flight was a circumferential flight around the Northern Patagonia Icefield, taking oblique photographs of the snouts of major outlet glaciers. Utilizing the vertical photographs, an uncontrolled mosaic of Soler Glacier and the proglacial area was prepared at a nominal scale of 1 : 16,000.

1. Introduction

Three aerial surveys were accomplished by taking; 1) oblique photographs over Paine National Park located near the southern end of the Southern Icefield, 2) vertical photographs over Soler Glacier and the snout of Nef Glacier, and 3) oblique photographs of outlet glaciers of the Northern Icefield, and the accumulation area of San Rafael Glacier (Table 1). The vertical photographs provide detailed mapping of the surface features of Soler Glacier and the proglacial

area, and facilitate comparison with similar ones taken two years ago (Aniya, 1985).

Photographing the termini of outlet glaciers facilitates comparisons with trimetrogon aerial photographs taken in 1944/45 and the vertical aerial photographs taken in 1974/75 by the United States Air Force, from which the glacial variations can be studied (Aniya and Enomoto, 1986). Photographs over San Rafael Glacier aid in locating the camps established by the San Rafael glacier boring-project team (Yamada *et al.*, 1987) on the topographic map.

Table 1. Aerial survey missions

Date	Area covered	Aircraft	Cruising speed	Flight hours	Flying height above sea level	Type of photographs
Dec. 31, 1985	Paine National Park	Piper 140 Cherokee Single engine	variable	11:45-4:55	ca. 2500 m	Oblique (35 mm)
Jan. 7, 1986	Soler and Nef Glaciers	Cessna 182 Single engine	160 km/h	11:00-14:55	3000 m	Vertical (6×6) and oblique (35 mm)
Jan. 13, 1986	Circumferential flight over the Northern Icefield and San Rafael Glacier accumulation area	Beechcraft Debonair A33 Single engine	200-220 km/h	10:46-12:05 13:20-15:43	1500 m- 1800 m	Oblique (6×6 and 35 mm)

Table 2. Photographic equipment

Camera :	Zenza Bronica SQ- Am. Lens shutter, single reflex, TTL. Equipped with moter drive. 6×6 frame (picture size 55.6 mm×55.6 mm).
Lens :	105 mm, F3.5
Filter :	UV
Film :	Kodak Ektachrome 64 Daylight Professional Film (ASA 64). EPD 220. Reversal.

A 6×6 cm format, non-cartographic camera was used for vertical photographing (Table 2). This square format facilitates easy handling when the pictures are enlarged to 23×23 cm, just like regular aerial photographs taken by photogrammetric cameras, and makes it easy to plan flight courses. This time, a lens of 105 mm focal length (equivalent to about 77 mm in the 35 mm format) was used to avoid circular trimming of the picture frame caused by the small diameter of the bay hole (ϕ 80 mm), although it decreased the B/H ratio compared with the one obtained in the previous expedition in which a 80 mm lens was used. The bay hole was located under the copilot's seat and I had to sprawl on the floor to look into the view finder while photographing.

2. Flight over Paine National Park

Paine National Park is located about 80 km northwest of Puerto Natales, the gateway to the park, and is centered around 51°10'S and 72°57'W (park administration building). The flight was intended to take photographs of glacier snouts. Unfortunately, weather was overcast and the cloud ceiling was about 2000–2500 m, which limited our flying height. Nonetheless, we managed to take photographs of the snouts of Tyndall, Pingo, Grey and Dickson Glaciers, the major outlet glaciers terminating in the park. Due to the weather conditions, *i. e.*, strong winds and low cloud ceiling, these photographs are mostly high oblique; however, they show the snout areas sufficiently to map and compare with the 1974 photographs.

3. Vertical photographs taken on Jan. 7, 1986

The primary objective of this flight was to cover the Soler Glacier area, including the neighboring Nef Glacier snout, by vertical photographs using a 6×6 cm

format camera (Table 2 and Figs. 1 & 2). Soler Glacier was covered basically in three flight courses and the proglacial area of interest, the head of the Rio Cacho Valley, was covered in another three flight courses.

The nominal flying height above sea level was about 3000 m where air was more stable than at lower altitudes, insuring better photographic conditions. Photographing was accomplished manually at F/8, shutter speed 1/500 sec., and ASA 100 although the indicated film speed was 64. From the photographic operation in the previous expedition in 1983–84, it had been learned that the automatic exposure tended to underexpose, particularly over earthy terrain, due to the effect of scattered light. In order to compensate for the atmospheric influence we were advised to adjust the ASA number as above and develop the film accordingly. As a result, the quality of photographs was generally excellent, providing detailed features of the ground scene, although one roll of film for test-developing was overexposed. From this operation, two lessons have been learned: 1) take additional rolls of film for test-developing, which can be discarded in case of over- or underdevelopment, and 2) once the test films are developed and correct developing time is known, develop the rest of the rolls in the same developer in order to obtain similar color balance. The second point is crucial for assembling a mosaic.

Altogether, seven 24-exposure rolls of film were taken to cover the Soler Glacier area, including the head of the Rio Cacho Valley, and one and a half rolls for the Nef Glacier snout area. There was no waste of film due to light leaks as on the previous expedition. Stereoscopic coverage of the area is complete and consistent with forward overlaps ranging from 60 to 75 percent and sidelaps of more than 30 percent. The scales of the photographs were computed using the topographic map "Cerro Hyades". Along the Rio Cacho where the elevation is about 250 m, scales were found to be about 1 : 27,000, whereas near the base of icefalls with the elevation of 750–850 m, the scale was

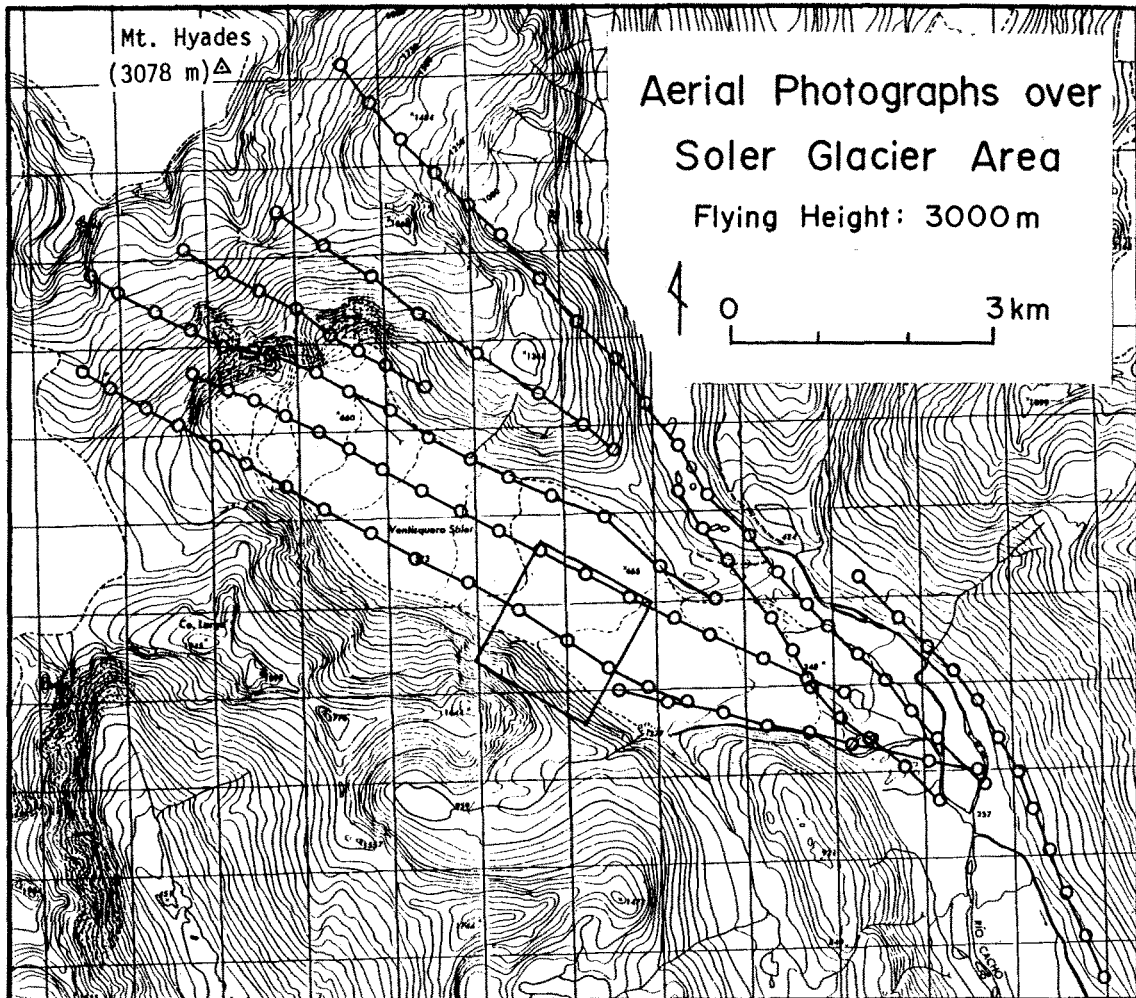


Fig. 1. Flight lines over the Soler Glacier area. A square indicates the approximate areal extent covered by a single photograph.

about 1 : 22,000. These scales agree well with those computed from the flying height of 3000 m above sea level and the focal length of the camera lens, 105 mm.

4. Circumferential flight around the Northern Icefield

The flight was counter-clockwise, starting from the northeast corner (Fig. 3), and we landed at Laguna San Rafael airfield after flying over the accumulation area of San Rafael Glacier. The flying height was about 1500-1800 m and most photographs were obliquely taken with a 35 mm camera. Over San Rafael Glacier, primarily over the right bank, the 6×6 cm

format camera was also used, with some part in oblique stereoscopic coverage. In retrospect, after working with these photographs to locate the snout positions on the maps, it was felt that the flying height should have been a little higher and the flight should have been more directly over the snout area, because with less oblique photographs, it would have been easier to locate the snout on the 1 : 50,000 topographic maps. Nonetheless, the snouts of all major outlet glaciers were adequately covered and could be located on the maps. Those glaciers whose snout was photographed include, from the northeast corner counter-clockwise, Exploradores, Grosse, unnamed, Reicher, Gualas, San Rafael, San Quintin (San Tadeo), Benito, three unnamed glaciers, Steffen, Piscis, Pared Sur and

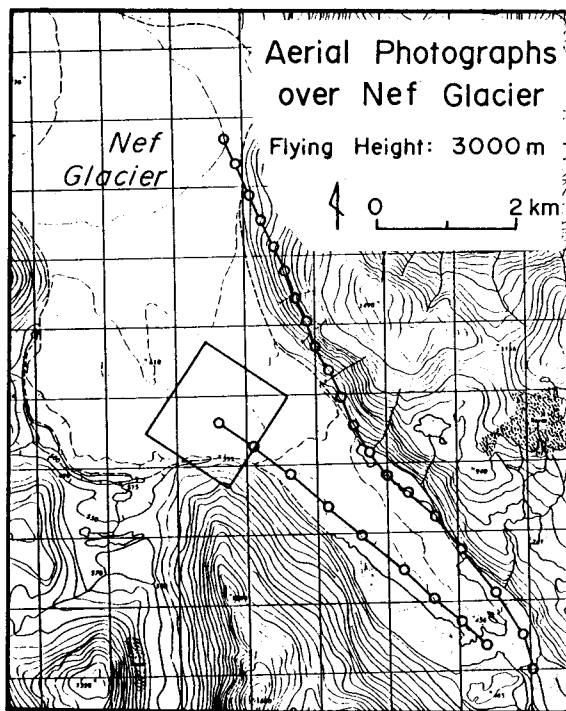


Fig. 2. Flight lines over the Nef Glacier snout. A square indicates the approximate areal extent covered by a single photograph.

Norte, Colonia, Cachet, Leones and Fiero glaciers; the names according to the topographic maps published by Instituto Geográfico Militar of Chilean government.

5. Mosaic of Soler Glacier and the head of Rio Cacho Valley

An uncontrolled mosaic of the Soler Glacier area including the proglacial terrain was prepared from 55 direct prints of the original slides. Using the 1 : 50,000 topographic map, the scale of the mosaic was determined at several cross-sections. It ranges from 1 : 16,280 in the Rio Cacho area (elevation *ca.* 250 m) to 1 : 13,900 near the icefalls (elevation *ca.* 650 m). The scale measured along the glacier length from the base of the icefalls to a proglacial pond (elevation 900–300 m) was found to be 1 : 16,125. From these measurements, the nominal scale of the mosaic was determined to be 1 : 16,000 and a graphic scale was drawn accordingly. This is slightly larger than the one made from the 1984 photographs (1 : 20,000, Aniya,

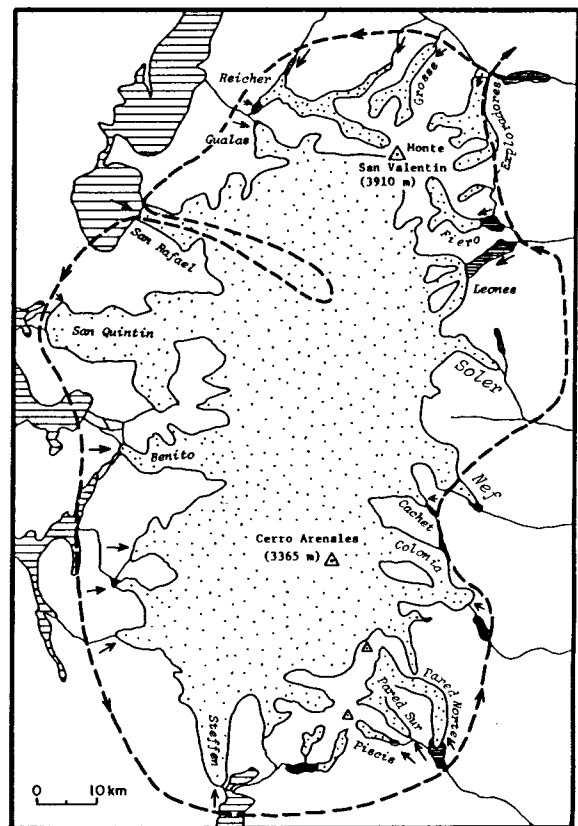


Fig. 3. Circumferential flight course over the Northern Patagonia Icefield on January 13, 1986. Small arrows indicate photographed glaciers.

1985). Since the photographs of the three flight courses covering the glacier surface were developed in different developers, their color balance is different, giving an impression of a tri-striped glacier; however the black and white reproduction of the mosaic does not show such tone imbalance. A comparison of the mosaics of 1984 and 1986 facilitates an easy assessment of changes in glacier conditions over two years.

Acknowledgments

Zenza Bronica Co., Tokyo, Japan, kindly loaned us a camera body (SQ-Am), and 80 mm and 105 mm lenses for the aerial survey and advised on film types and exposure settings. Juan Vargas of Coihaique was on board as an assistant for changing film for the 6×6 cm format camera on the Jan. 7 flight. Special thanks are due to pilot C. Robert Leon of "Don Carlos" air company based in Coihaique, who

sacrificed his vacation for the flight over Soler Glacier. Another pilot, Carlos Martinez, skillfully flew over the termini of outlet glaciers in the circumferential flight, along with Albert Chacon as navigator, who I was told was killed shortly after in an air accident near Chile Chico. Prayers.

References

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Resumen

Reconocimientos aéreos sobre los Hielos Patagónicos

Tres reconocimientos aéreos fueron efectuados durante el 31 de Diciembre de 1985, el 7 y el 13 de Enero de 1986. El primer vuelo cubrió la zona del frente de los Glaciares Tyndall, Grey y Dickson, terminando las principales líneas de vuelo en el Parque Nacional Torres de Paine, ubicado en el extremo sur del Hielo Patagónico Sur. El segundo vuelo se efectuó sobre el Glaciar Soler (Fig. 1) y el frente del Glaciar Nef (Fig. 2). Por medio de una cámara de formato 6×6 cm se tomó fotografías aéreas verticales a una escala entre 1 : 22.000 y 1 : 27.000 con suficiente cobertura estereoscópica. Durante el tercer y último vuelo se realizó un circuito alrededor de todo el Hielo Patagónico Norte (Fig. 3), tomando fotografías oblicuas del frente de los principales glaciares de desagüe. Estas fotografías, junto a aquellas tomadas por la USAF en 1944/45 y 1974/75, ayudan a llevar a cabo estudios sobre recientes variaciones glaciares. Se preparó un mosaico no controlado a una escala nominal de 1 : 16.000 del Glaciar Soler y su zona proglacial, utilizando las fotografías aéreas verticales.