

Glaciers of Europe—

**GLACIERS OF THE PYRENEES,
SPAIN AND FRANCE**

By DAVID SERRAT *and* JOSEP VENTURA

SATELLITE IMAGE ATLAS OF GLACIERS OF THE WORLD

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*The 41 glaciers in the Pyrenees, covering
a total area of 8.10 square kilometers,
have all receded since the mid-1800's
although some minor advances
took place in the late 1950's*

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GLACIERS OF EUROPE—

GLACIERS OF THE PYRENEES, SPAIN AND FRANCE

By DAVID SERRAT¹ and JOSEP VENTURA²**Abstract**

The glaciers of the Pyrenees, a range of Alpine mountains that extends along the border between Spain and France, are found in a 100-kilometer-long section in the central part of the range. According to the latest figures, compiled in 1984 for the Temporary Technical Secretariat for World Glacier Inventory (now the World Glacier Monitoring Service) and updated with 1988 aerial photographs, there are currently 41 glaciers in the Pyrenees with a total area of approximately 8.10 square kilometers. Thirteen peaks, all having elevations greater than 3,000 meters above mean sea level, support these 41 glaciers, generally on slopes that have a northern, northeastern, or eastern orientation. The current area of the Pyrenees calculated to be glacier covered is based on measurements made in the field or from vertical aerial photographs. Most published maps do not accurately differentiate between true glaciers and snowfields or snow patches. The glaciers are all small, with the largest, Glacià de Aneto, only 1.32 square kilometers. Half of the glaciers are 0.1 square kilometer or less in size. The maximum altitude of the snowline at the end of the summer melt season generally rises from west to east, with a range of 2,600 to 2,850 meters in the west and 2,750 to 3,100 meters in the east. During the Pleistocene, the Pyrenees were a local center of glaciation. During the middle 1800's, glaciers in the Pyrenees were larger and more numerous than at present. Virtually all of the glaciers have been in a state of recession since the mid-1800's. Although some glaciers reached an equilibrium in the early 1950's, a few actually exhibited minor advances beginning in the late 1950's. Cloud-free Landsat multispectral scanner images of the glacier areas are available, but the imagery has limited usefulness for glacier studies because of the small size of the Pyrenean glaciers and because the snow cover makes it difficult to distinguish the margin of glaciers. Data from sensors having greater spectral or spatial resolution should contribute greatly to glacier studies and monitoring in the Pyrenees in the near future.

Introduction

The Pyrenees are an Alpine mountain range stretching across the isthmus that lies between the Iberian Peninsula and the rest of the European continent. The mountains are oriented in an east-west direction and lie between 42° and 43° N. lat. They extend almost 400 km from 2° W. long. near the Bay of Biscay on the Atlantic Ocean side to 3° E. long. near the Mediterranean Sea and are divided into two nearly equal parts by the Greenwich meridian. The glaciers are found in a 100-km-long section in the central part of the range between about 0°30' W. and 0°50' E. lat.

The elevations of the highest mountain peaks are about 3,000 m above mean sea level, with a maximum elevation of 3,404 m on pico de Aneto (Maladeta massif). All glacierized peaks are higher than 3,000 m, although some peaks that reach this height do not have glaciers. The peaks that have glaciers are as follows (from west to east): Balaitous,

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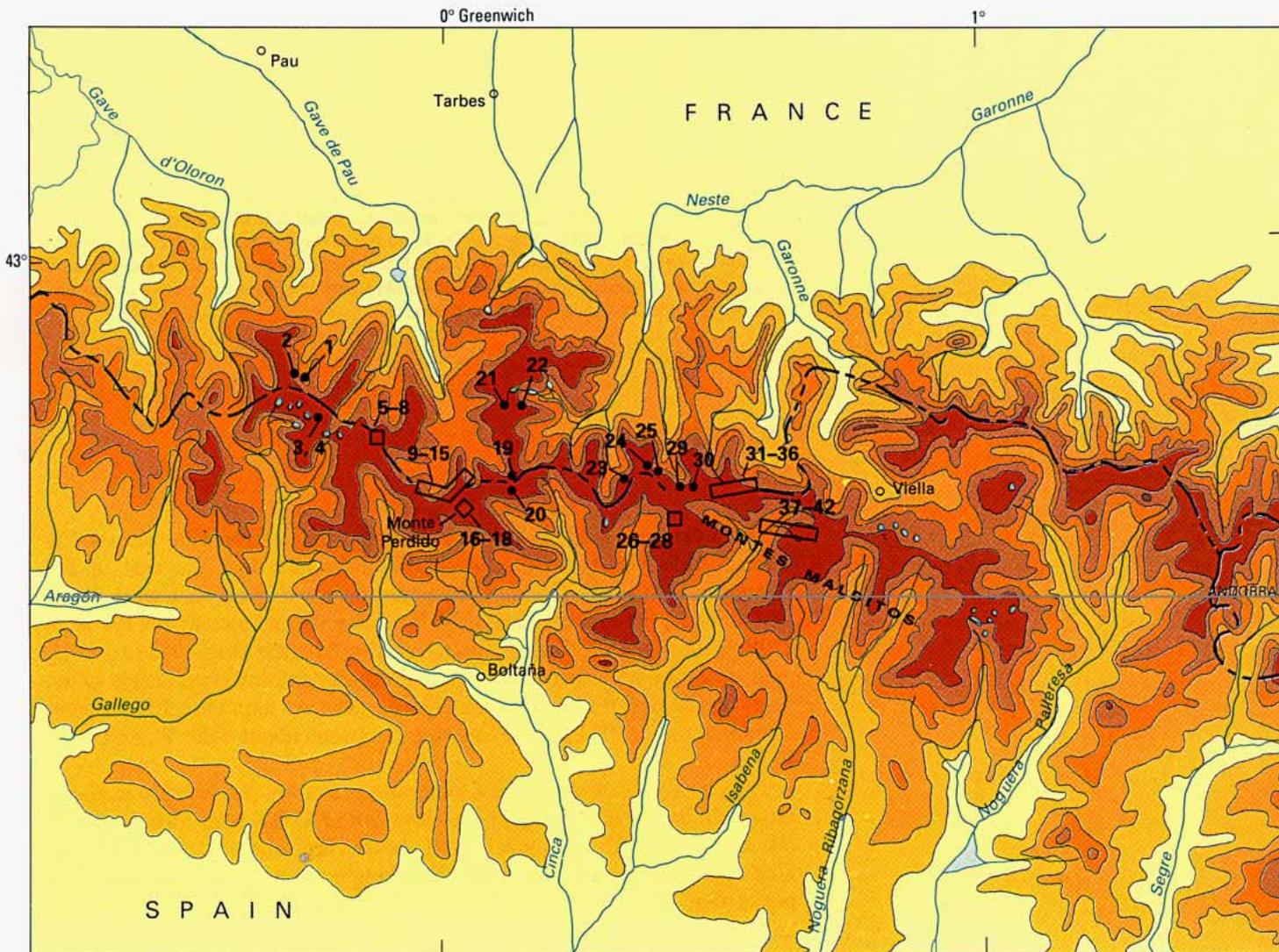
²Cartographic Institute of Catalunya, Barcelona, Spain.

Picos del Infierno, Vignemale, Gavarnie, Monte Perdido, La Múnia, Pic Long, Batoua, Gours Blancs, Posets, Espingo, Cirque de Lys, and Maladeta. The mean elevations of the glaciers range from 2,432 to 3,169 m, with an average of 2,817 m.

Distribution of Glaciers

According to the latest figures, compiled in 1984 for the Temporary Technical Secretariat for World Glacier Inventory (now part of the World Glacier Monitoring Service in Zurich, Switzerland) and updated with 1988 aerial photographs, there are currently 41 glaciers in the Pyrenees covering a total area of approximately 8.10 km². The glaciers are all small, with the largest, Glaciar de Aneto, only 1.32 km². The smallest is Glaciar de Batoua with an area of 0.03 km². Half of the glaciers are 0.1 km² or less in size. Figure 1 shows the location of the glaciers; table 1 gives statistics for each glacier. The glaciers are primarily cirque glaciers or small strip glaciers on ledges and terraces. They are remnants of

Figure 1.—Glaciers of the Pyrenees. The altitude of the area is indicated by color. The areas less than 800 m are shown in yellow. Each darker shade indicates an increase in height of 400 m. The dark brown areas at the summit of the Pyrenees range from 2,400 to 3,500 m in altitude. The numbers on the map correlate to the glaciers listed in table 7.



Base from International Map of the World 1:1,000,000
 Madrid, Sheet NK 29 & 30, 1965;
 Barcelona, Sheet NK 31, 1962

TABLE 1. --Distribution and dimensions of glaciers of the Pyrenees as of 1984

[In the following names of the Pyrenean glaciers, G. is an abbreviation for glacier, except where preceded by a single asterisk, in which case it stands for glacier. Gs. indicates glaciers. (Total number is shown in parentheses.) Accum. = accumulation; Ablat. = ablation]

Number	Name	Massif	Basin	UTM coordinates	Area (km ²)	Orientation (Accum. and ablat. areas)	Mean		Max length (m)	Elevation (meters above mean sea level)			Massif top
							Width (m)	Length (m)		Maximum	Mean	Minimum	
1...	G. de Les Néous	Balaïtous	Gave de Pau	30 TYN 222468	0.28	E	225	1,050	1,125	3,010	2,700	2,500	3,144
2...	G. de Pabat			30 TYN 220474	.10	N	340	300	450	2,850	2,740	2,610	2,996
3...	*G. del Infierno	Picos del Infierno	Gállego (Ebro)	30 TYN 246405	.06	N	200	400	500	2,960	2,820	2,720	3,061
4...	*G. del Infierno			30 TYN 243407	.09	N	300	400	500	2,940	2,800	2,700	3,061
5...	G. des Oulettes	Vignemale	Gave de Pau	30 TYN 338404	.18	N	240	500	1,010	3,152	2,490	2,340	3,298
6...	G. du Petit Vignemale			30 TYN 343403	.12	N	300	400	610	2,920	2,660	2,490	3,154
7...	G. d'Ossoue			30 TYN 342393	.70	E	380	1,500	1,880	3,195	3,050	2,630	3,298
8...	G. du Montferrat			30 TYN 347389	.06	E	180	200	450	2,970	2,780	2,680	3,219
9...	Gs. des Gabetous (3)	Gavarnie	Gave de Pau	30 TYN 414317	.26	N	640	400	800	2,935	2,650	2,380	3,144
10...	G. du Taillon			30 TYN 425315	.26	NE	320	750	940	2,900	2,710	2,570	3,144
11...	G. de la Brèche			30 TYN 438309	.123	N	410	300	400	2,860	2,660	2,580	3,006
12...	G. de la Cascade			31 TBH 548311	.056	W	105	300	380	3,030	2,780	2,680	3,248
13...	Gs. W du Marboré (2)			31 TBH 551317	.116	NW	300	270	430	2,940	2,760	2,530	3,248
14...	Gs. de Paillà (2)			31 TBH 560328	.15	N	400	300	610	2,964	2,520	2,410	3,071
15...	G. d'Azastou			31 TBH 570325	.085	N	280	240	450	2,670	2,500	2,400	3,071
16...	*G. de Monte Perdido	Monte Perdido	Cinca (Ebro)	31 TBH 572298	.48	NE	1,200	400	700	3,180	2,980	2,690	3,355
17...	*G. del Cilindro			31 TBH 565305	.05	NE	300	100	200	2,905	2,820	2,740	3,337
18...	*G. de Marboré			31 TBH 561312	.07	NE	500	100	200	2,900	2,830	2,760	3,248
19...	*G. de la Múnia	LaMúnia	Gave de Pau	31 TBH 651336	.062	NW	250	250	290	2,850	2,775	2,710	3,133
20...	*G. de Robiñera		Cinca (Ebro)	31 TBH 656321	.05	N	300	200	300	2,805	2,720	2,660	3,003
21...	G. du Lac Tourrat	Pic Long	Gave de Pau	31 TBH 629433	.07	N	260	240	300	2,960	2,860	2,740	3,192
22...	G. de Pays Baché		Garonne	31 TBH 634429	.154	E	380	450	590	3,080	2,980	2,860	3,192
23...	*G. de Batoua	Batoua	Garonne	31 TBH 816327	.03	NW	110	180	280	2,500	2,432	2,365	3,034
24...	G. de Pouchergues ³	Gourgs Blancs	Garonne	31 TBH 921303	.062	N	290	200	250	2,750	2,700	2,650	2,967
25...	G. de Gourgs Blancs			31 TBH 937311	.27	N	625	410	500	3,000	2,890	2,780	3,128
26...	*G. de Llardana	Posets	Cinca (Ebro)	31 TBH 894260	.23	NW	300	700	800	3,052	2,917	2,782	3,375
27...	*G. de la Paul		Esera (Ebro)	31 TBH 901265	.08	NE	400	200	300	3,076	3,016	2,850	3,375
28...	*G. de Posets			31 TBH 903260	.13	E	300	400	500	3,180	3,105	2,995	3,375
29...	*Gs. Sheil dera Baquó (2) ¹	Espingo	Garonne	31 TBH 948303	.39	NE	1,040	340	660	3,040	2,910	2,780	3,103
30...	*Gs. du Portillon d'Oo (3)			31 TBH 959302	.164	N	316	230	725	2,950	2,766	2,583	3,222
31...	G. W des Crabioules	Cirque de Lys	Garonne	31 TBH 977313	.088	N	300	200	350	2,860	2,755	2,650	3,116
32...	G. E des Crabioules			31 TBH 983310	.087	NE	240	250	400	2,810	2,720	2,630	3,116
33...	G. W du Maupas			31 TBH 989310	.051	N	175	170	300	3,020	2,900	2,780	3,109
34...	G. E du Maupas			31 TBH 994308	.055	NE	430	120	175	2,960	2,910	2,860	3,109
35...	G. du Boum			31 TCH 002307	.14	N	440	250	375	2,900	2,800	2,700	3,006
36...	G. des Graoues			31 TCH 010305	.09	N	375	250	375	2,840	2,740	2,640	2,942
37...	*G. de la Maladeta	Maladeta	Esera (Ebro) ²	31 TCH 066250	.60	N	900	700	900	3,240	3,100	2,780	3,308
38...	*G. de Aneto			31 TCH 075236	1.32	NE	1,600	800	1,200	3,330	3,080	2,780	3,404
39...	*G. de Coronas			31 TCH 074229	.13	W	200	600	700	3,250	3,169	2,958	3,404
40...	*G. de Barrancs			31 TCH 083230	.28	NW ⁴	400	700	900	3,290	3,110	2,900	3,404
41...	*G. de Tempestades			31 TCH 089223	.34	NE	700	400	500	3,050	2,902	2,705	3,310
42...	*G. de Salenques ³		Ribagorçana (Ebro)	31 TCH 089219	.05	E	250	250	320	3,100	2,980	2,960	3,240

¹ In French, Gs. Seil de la Baque.

² Draining to Garonne Basin by karstic conduction.

³ Additional work in 1988 led to the reclassification of Glacier de Pouchergues (#24) as a snowpatch and of a snowpatch in the Maladeta Massif as a glacier (Glacier de Salenques, #42).

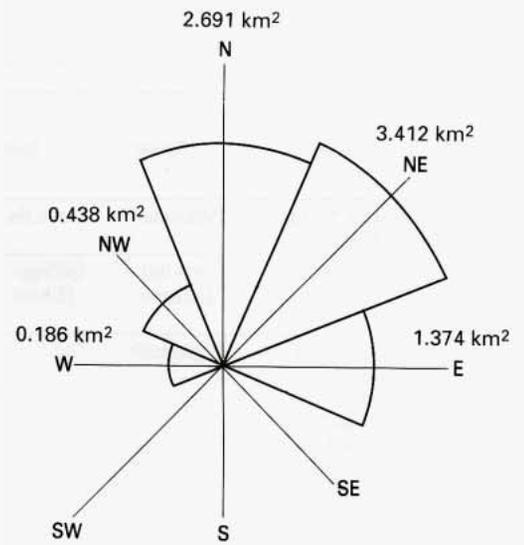
⁴ Ablation area is oriented northeast.

cirque and valley glaciers that were often connected on several levels by ice falls and avalanches. Recession has caused the larger glaciers to shrink and separate into smaller individual ice masses.

The glaciers are most often found on the northeastern, northern, and eastern slopes of the mountain range (fig. 2). The preferential north-northeast orientation is caused by the combined effects of precipitation pattern, prevailing winds, and solar radiation. Considerable precipitation

on the northern and western slopes of the Pyrenees results from the oceanic climate. The southern slopes, influenced by a Mediterranean climate, are drier (Taillefer, 1968). The prevailing winds are westerly, and solar radiation is most intense from the south. As a result, the northern and eastern slopes receive maximum deposition of snow and maximum protection from the ablativ effects of the wind and sun.

The maximum altitude of the snowline at the end of the melt season in the Pyrenees generally rises from west to east (fig. 3). Current research seems to indicate that the range of this seasonal snowline in the west is from 2,600 to 2,850 m and 2,750 to 3,100 m in the east. It is important to note that in the two instances where the seasonal snowline drops sharply, on Glacier d' Astazou and Glaciard de Batoua, the glaciers are maintained and fed by avalanche activity, an important source of nourishment for many of the glaciers in the Pyrenees. These seasonal snowline figures are not very different from those published by Höllermann (1968) of 2,900 m in the west and 3,100 m in the east, which might indicate a stablization of the glaciers since his work.



Total area = 8.101 km²

Figure 2.—The polarized distribution of the orientation of the glaciers of the Pyrenees. The distribution is weighted by area in square kilometers.

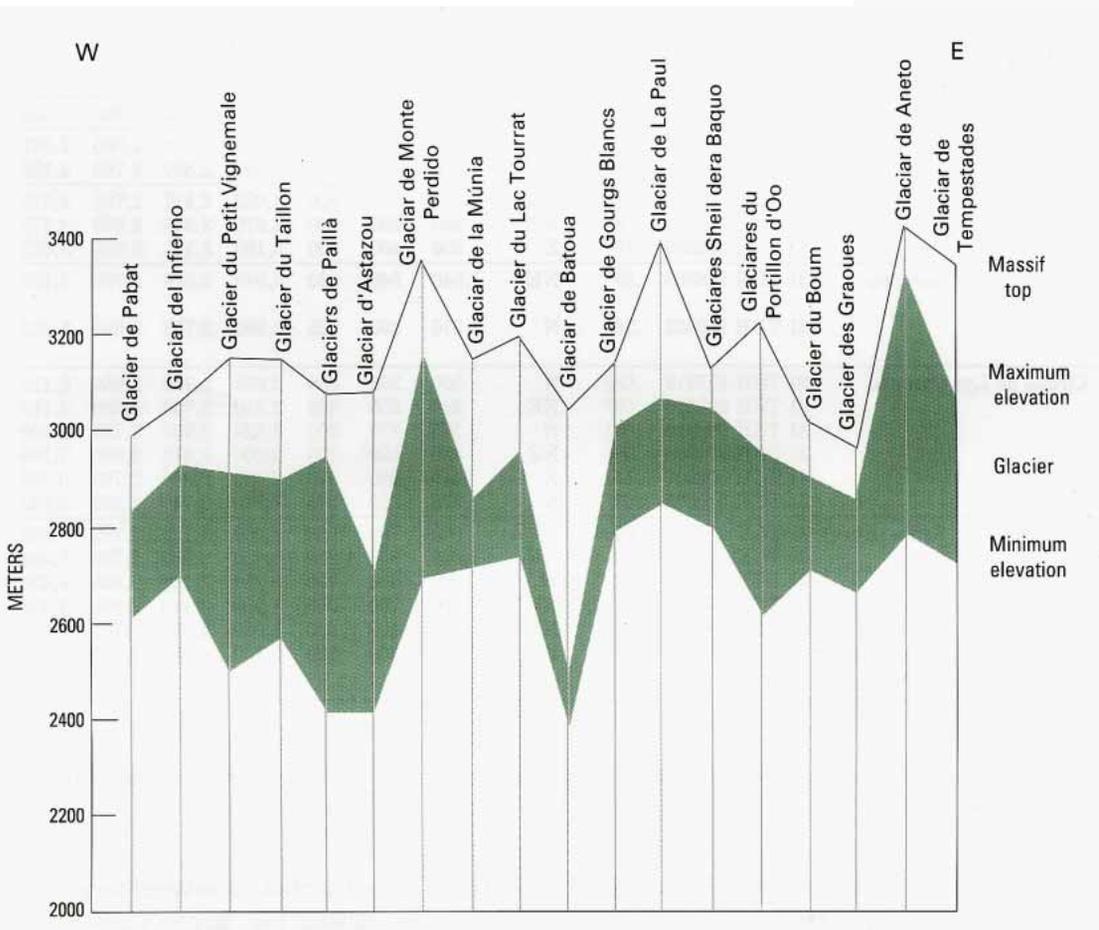


Figure 3.—Agraph of the maximum altitude of the snowline at the end of the melt season on selected peaks in the Pyrenees. This seasonal snowline generally rises from west to east. In the two instances where this seasonal snowline drops sharply, Glacier d' Astazou and Glaciard de Batoua, the glaciers are fed by avalanche activity.

Glacier Studies

In the past, glaciological work in the Pyrenees has been limited in scope. The relative remoteness of the region made travel and research difficult, and because of the small size of the glaciers there was little interest from an economic standpoint.

The first isolated observations on glaciers were made by Johann von Charpentier during his stay in the Pyrenees area from 1808 to 1812 (Charpentier, 1823). He described some of the more prominent glaciers on the peaks of Maladeta, Crabioules, Monte Perdido, Vignemale, and Néouvielle. The first scientific studies were carried out in the Maladeta massif by Collomb, Michelier, and Eugène Trutat (1875, 1894), Director of the Natural History Museum in Toulouse, France.

Work carried out by Franz Schrader from 1869 to 1883 in mapping the Pyrenees at a scale of 1:100,000 constituted the first attempt to evaluate the areal extent of its glaciers (Schrader, 1895). These earlier studies were continued by Prince Roland Bonaparte (1891) and Ludovic Gaurier (1921), who carried out periodic observations on Pyrenean glaciers during the period 1904 to 1931. Gaurier was President of the Commission de Glaciologie des Pyrénées and contributed to the journal "Etudes glaciologiques," published by the French Ministry of Agriculture until 1934. Some other interesting studies from this period were those carried out by Eydoux and Maury (1907) on the Pic Long glaciers, and by Plandé (1939).

From 1945 to 1963, French scientists directed by the engineers Chimits, Chabrol, and Sannac (Chabrol and others, 1953) studied the Ossoue, Taillon, and Sheil dera Baquo (Seil de la Baque) glaciers for hydroelectric potential. The mountaineer Raymond d'Espouy and the Geographical Institute of Toulouse have collaborated on the project since 1951. Work carried out by Barrère (1953) and Durand (1961) on glaciers of the western Pyrenean massifs (Balaitous, Vignemale, and Picos del Infierno), including two glaciers (Néouvielle, Cambalés) which no longer exist; Brunet (1955) on Sheil dera Baquo (Seil de la Baque) glaciers; Galibert (1956), Mounier (1962), and Bellan (1963) on the glaciers of the Luchonnais area (a region that encompasses the previously cited massifs); and Taillefer (1968) on the extent of Pleistocene glaciation also fell within this period.

Up to now, Spanish studies on glaciers have been limited. During the past 60 years, however, work has been carried out by Faura (1923) on Glaciar de Aneto and Glaciar de la Maladeta (where a displacement of up to 35 m per year was calculated for the Glaciar de Aneto); by Vidal-Boix (1933) and Gómez de Llarena (1936) on Glaciar de Monte Perdido; by Vedruna (1956) and, recently, by Nicolás-Martínez (1981) on the geomorphology of Tucarroya Cirque on the Monte Perdido massif.

Surveys on the distribution and extent of glaciers have been done by van Summer and Morrison (1958) and Mercer (1975) of the American Geographical Society and by Höllermann (1968). More recently, work has been carried out by Soutadé (1982) on the Luchonnais glaciers.

The most recent data included in this paper have been collected as part of the Technical Secretariat for the World Glacier Inventory project. Information was collected during successive years of fieldwork, beginning in 1979, by geologists and geographers of the Alpine Geomorphological Group of the University of Barcelona (Josepa Brú, Joan Martí, Carme Muntaner, Joan M. Vilaplana, and the authors) with the help of others interested in Alpine research (Equip de Geomorfología Alpina, 1980).

Glacier Fluctuations

During the Pleistocene, the Pyrenees were a local center of glaciation (Penck, 1884). During historic times, the glaciers reached their recent maximum during the middle of the last century. Glacier de Pays Baché reached the crest of its end moraine in 1856 (Eydoux and Maury, 1907); Glacier des Oulettes on Vignemale massif reached its moraine in 1857 (Höllermann, 1968), but all the glaciers have receded almost continuously since that time. According to Höllermann (1968), the largest glaciers had lost 40 percent of their volume since the 19th-century maximum.

According to Barrère (1953) and Taillefer (1981), recent glacier fluctuations can be grouped in different periods:

1. In the middle of the last century (“Little Ice Age”) glaciers reached their end moraines.
2. From 1850 to 1905, glaciers retreated noticeably.
3. From 1905 to 1912, glaciers advanced slightly, and new moraines were formed (Glacier des Oulettes).
4. From 1912 to about 1950, glaciers generally retreated as the climate became both warmer and drier. During this period, several glaciers vanished (Isabé and Arremoulit, for example); others were divided into small remnants (Sheil dera Baquo, or Seil de la Baque); the rest were reduced both in areal extent and volume.
5. Since 1951, an increase in precipitation has resulted in glacier stabilization. During the work carried out on Pyrenean glaciers for the World Glacier Inventory, glacier stabilization, with minor advances (Glaciar de La Paul and Glaciar de Tempestades formed push moraines), was recorded during the period from 1957 to 1979.

Up to now, data on glacier extent in the Pyrenees have been questionable and exaggerated. Confusion is mainly caused by two factors:

1. The ambiguity of early data. Many authors cite approximate data of glacier extent from the latter part of the 1800's that are very different from data for the present-day extent.
2. The small size of many glaciers makes it difficult to differentiate between glaciers and snowfields on aerial photographs unless field work has been done. The problem is complicated by the fact that many of these snowfields are remnants of old glaciers (19th century) that were in recession from 1912 to 1950. Confusion is evident when some of these snowfields exhibit end moraines that formed during the last century. French and Spanish maps, even modern ones, do not clearly differentiate between glaciers and snowfields. From the middle of the 1800's to the present time, many historic glaciers have completely vanished from several massifs (for example, Gran Bachimala, Cambalés, Punta Zarre, Bardamina, and Bessiberri). Frondellas and Brecha de Latour glaciers in the southern slopes of the Balaitous massif turned into snowfields, and Llosas and Salenques glaciers in the Maladeta massif became snowfields between 1948 and 1957.

The first data on glacier extent in the Pyrenees were provided by Franz Schrader (1895), who calculated the area at 40 km². According to Taillefer (1981), Ludovic Gaurier calculated an area of 21 km² for the French Pyrenean glaciers in 1934, and the Direction des Eaux et Forêts (French Department of Waters and Forests) calculated an extent of 8 km² for the French Pyrenean glaciers in 1950. Other compilations provided rather different data. Thorarinsson (1940) gave 40 km² as the total area of the Pyrenean glaciers. He based his total on the work of Hess (1933) who, in turn, referred to the observations by Eydoux and Maury (1907). Van Summern and Morrison's (1958) survey of glaciers produced an

estimate of 30 km² for the total area of glaciers. Mercer (1975) gave a total area of 15 km² for 70 glaciers. The figures determined for the present study are listed in table 1. Forty-one Pyrenean glaciers have a total area of about 8.10 km².

Available Data for Glacier Studies

Maps

Only a limited number of maps are available for glacier studies because often no differentiation between snow patches, snowfields, and true glaciers has been shown on the maps. The most useful are the 1:25,000-scale series of topographic maps published by the Institut Géographique National of Paris.

Aerial Photographs

Some vertical aerial photographs are available from a flight in 1957 along the southern slope of the mountains. The flight was unique because nearly optimal conditions allowed photographs of such quality that true glaciers can be distinguished from snow patches (see fig. 7). Aerial photographs acquired during a 1988 flight have been used to determine more accurately the glacerized area of the Pyrenees and reclassify two snow and ice areas on the Gours Blancs and Maladeta massifs (table 1; fig. 8).

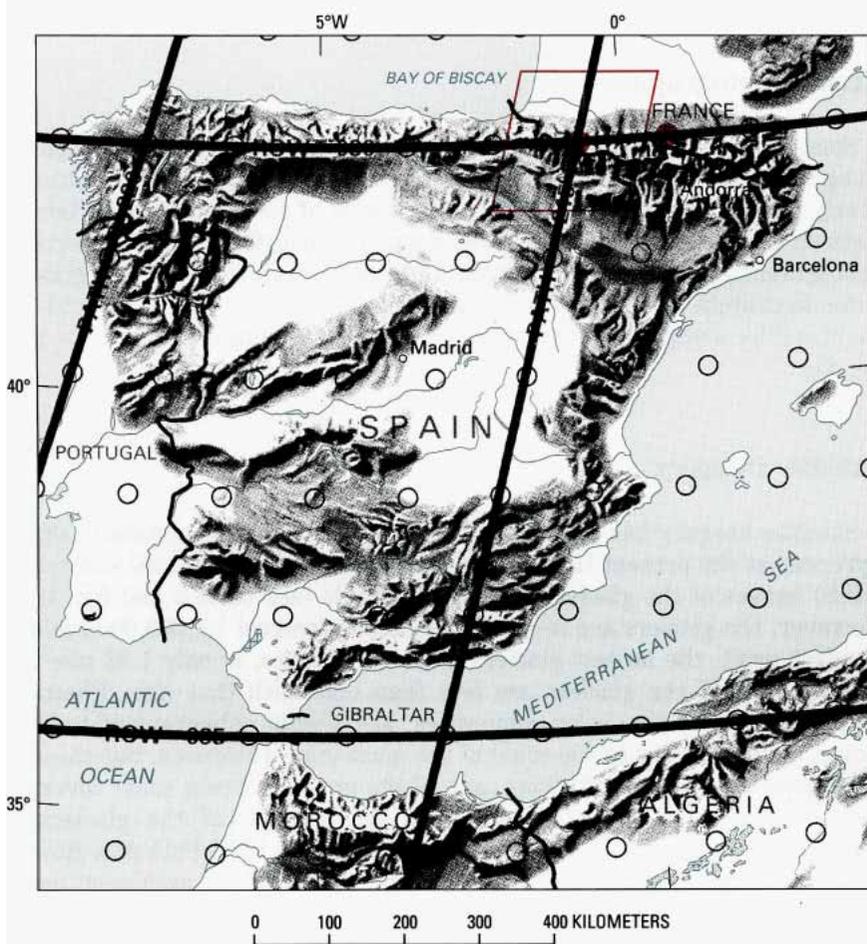
Satellite Imagery

Satellite imagery has only limited usefulness for glacier studies in the Pyrenees at the present time. Cloud-free Landsat multispectral scanner (MSS) images of the glacier areas are available (see table 2 and fig. 4). However, the glaciers are so small that, on a standard 1:1,000,000-scale Landsat print, the largest glacier, Glaciar de Aneto, is only 1.32 mm², and almost half the glaciers are less than one-tenth that size. Photographic enlargements, color composites, and digital enhancement techniques make it easier to see some of the glaciological features, but these techniques also have limitations, one of the greatest being snow cover, which makes it difficult to distinguish the margins of the glaciers. Landsat MSS image 2185-10022, acquired on 26 July 1975 (Path 214, Row 30), is virtually cloud free and is the best image in the U.S. archive at the EROS Data Center that covers all the glaciers of the Pyrenees. A section of the color composite image is shown at 1:500,000 scale in figure 5. On this image it is possible to discern Glacier d'Ossoue (#7) on the Vignemale massif and to locate the rest of the glacier massifs, but, because of the snow cover, it is difficult to delineate other individual glaciers. This problem is especially noticeable on the Maladeta massif, which is the location of the highest peak in the Pyrenees, Pico de Aneto (3,404 m) and the first and third largest glaciers in the area, Glaciar de Aneto (1.32 km²) (#38) and Glaciar de la Maladeta (0.60 km²) (#37). A sketch map of the area (fig. 6) and aerial photographs of the Maladeta massif (figs. 7,8) give details of the shape and location of the glaciers. Unfortunately, it is possible to determine only the general location of the glaciers on the Landsat image. The glacier boundaries are lost because of the limits of the spatial resolution and the snow cover.

TABLE 2.—Optimum Landsat 1, 2, and 3 images of the glaciers of the Pyrenees

[In the "Code" column, a filled-in circle indicates an excellent image]

Path-Row	Nominal scene center (lat-long)	Landsat identification number	Date	Solar elevation angle (in degrees)	Code	Cloud cover (in percent)	Remarks
21430	043°05'N. 000°42'E.	1027-10135	19 Aug 75	52	●	0	Covers all glacier areas
21430	043°05'N. 000°42'E.	2185-10022	26 Jul 75	55	●	0	Covers all glacier areas; snow cover slightly greater than above
215-30	043°05'N. 000°44'W.	1028-10193	20 Aug 72	51	●	0	Covers glaciers of Balaitous, Picos del Infierno, Vignemale, Gavarnie, Monte Perdido, La Múnia, and Pic Long



EXPLANATION OF SYMBOLS

Evaluation of image usability for glaciologic, geologic, and cartographic applications. Symbols defined as follows:

- Excellent image (0 to ≤5 percent cloud cover)
- Nominal scene center for a Landsat image outside the area of glaciers
- Approximate size of area encompassed by nominal Landsat MSS image

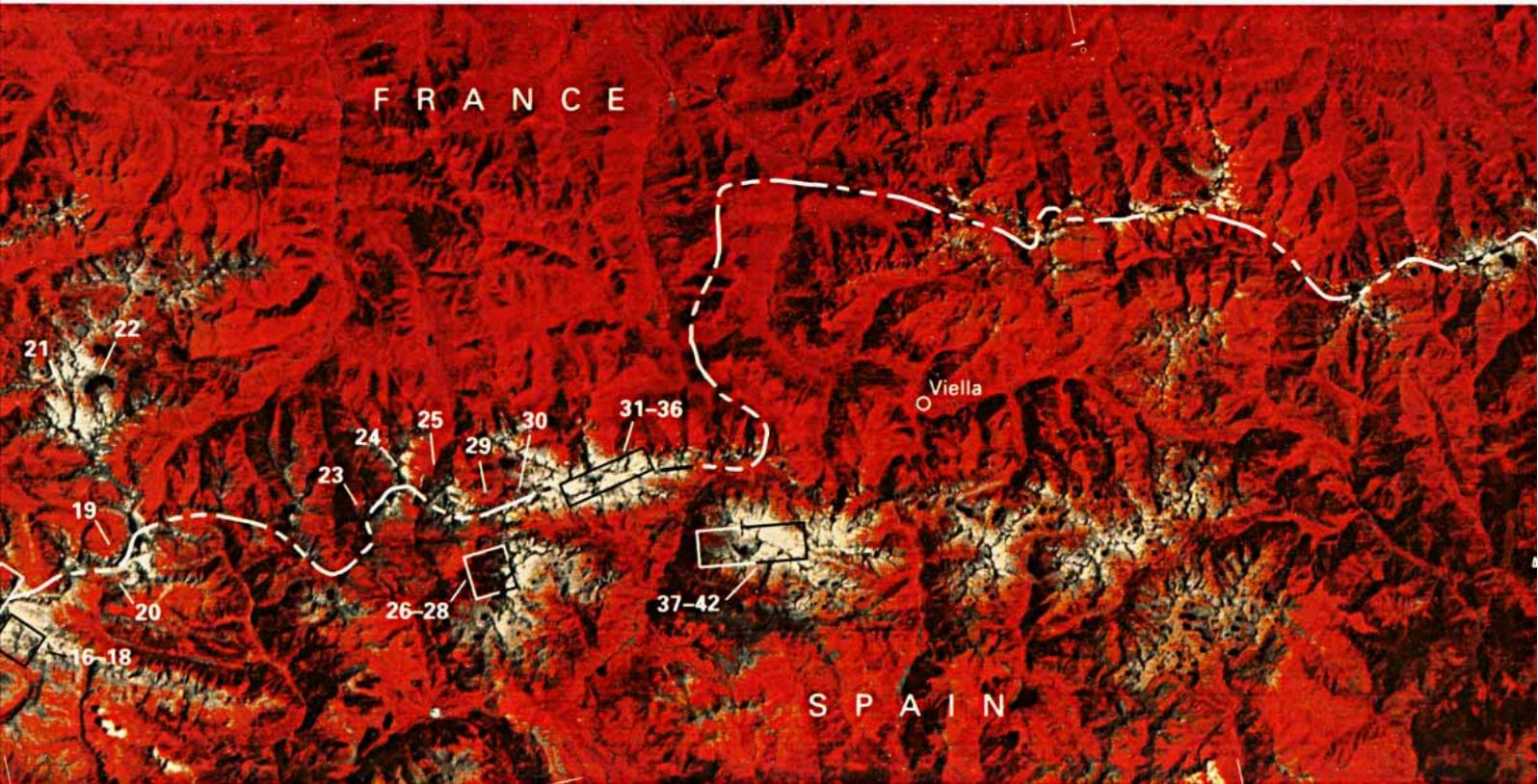
Figure 4.—Optimum Landsat 1, 2, and 3 images of the glaciers of the Pyrenees. The vertical lines represent nominal paths. The rows (horizontal lines) have been established to indicate the latitude at which the imagery has been acquired.



Landsat imagery can sometimes be used to indicate the former extent of glaciers by showing the location of abandoned moraines or by showing traces of glacial erosion such as cirques, aretes, or glaciated valleys. A good example of this can be seen on figure 5. The Valle de Ordesa extends 10km south and then west from the Gavarnie massif and has the typical appearance and shape of a valley erosionally modified by a glacier, although no glaciers can be seen today on the southern slope of the massif.

In some areas it is possible to use Landsat imagery to (1) delineate glacier distribution, (2) map glacier outlines, (3) monitor glacier fluctuations, (4) distinguish transient snowlines, and (5) even inferentially determine changes in mass balance. However, the size of the glaciers in the Pyrenees makes this difficult, given the current satellite capability. Data from sensors having greater spectral and (or) spatial resolution are now becoming available, including data from the Landsat thematic mapper, the Large Format Camera, and the French Satellite Pour l'observation de la Terre (SPOT). Such new data will be able to contribute to glacier studies and monitoring in the Pyrenees and in other mountainous regions of the world, where the spatial resolution of the Landsat MSS sensor is not adequate.

Figure 5. —Section of annotated 1:500,000-scale enlargement of Landsat 2 false-color composite image 2185-10022, Path 214, Row 30, acquired 26 July 1975. The image covers the entire glacier area of the Pyrenees. Numbers correlated to glaciers listed in table 1.



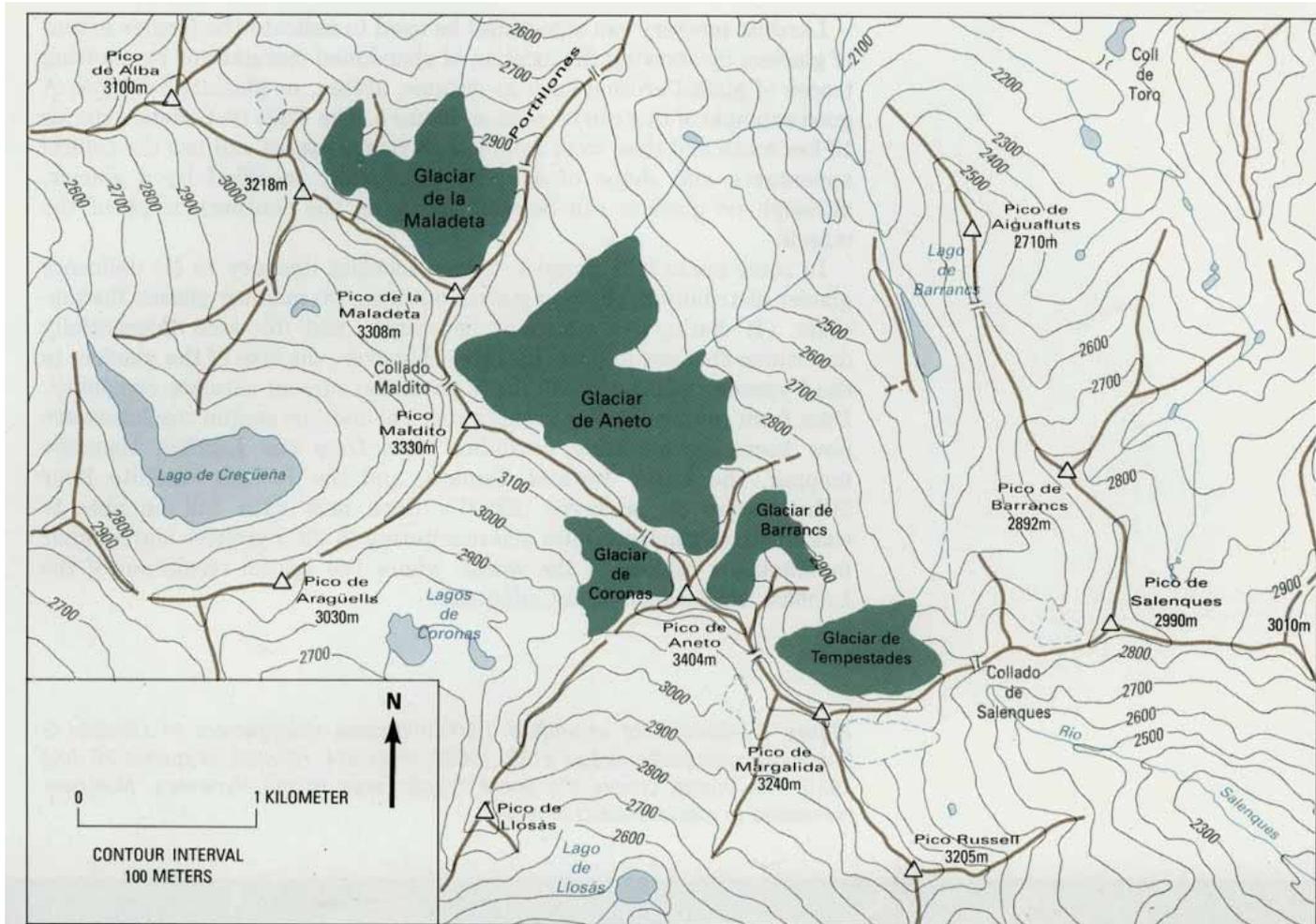


Figure 6—Maladet massif and its glaciers in 1979. Former glaciers that are now reduced to snowfields are shown by dashed blue lines (northwest of Glaciars de la Maladeta and south of Glaciars de Tempestades).

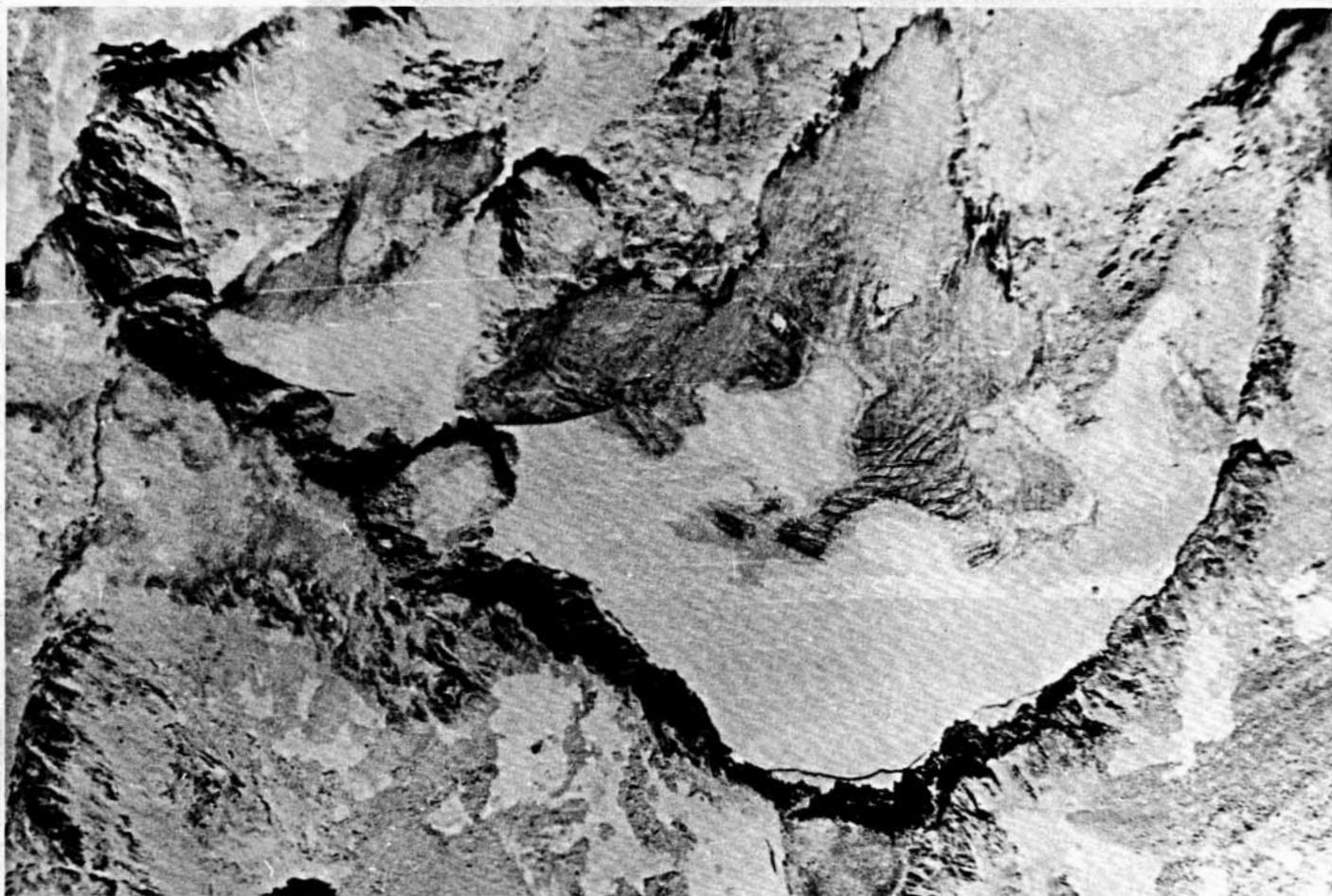


Figure 7.—Vertical aerial photograph of Glaciar de la Maladeta. Photograph taken 26 August 1957 by the U.S. Air Force.

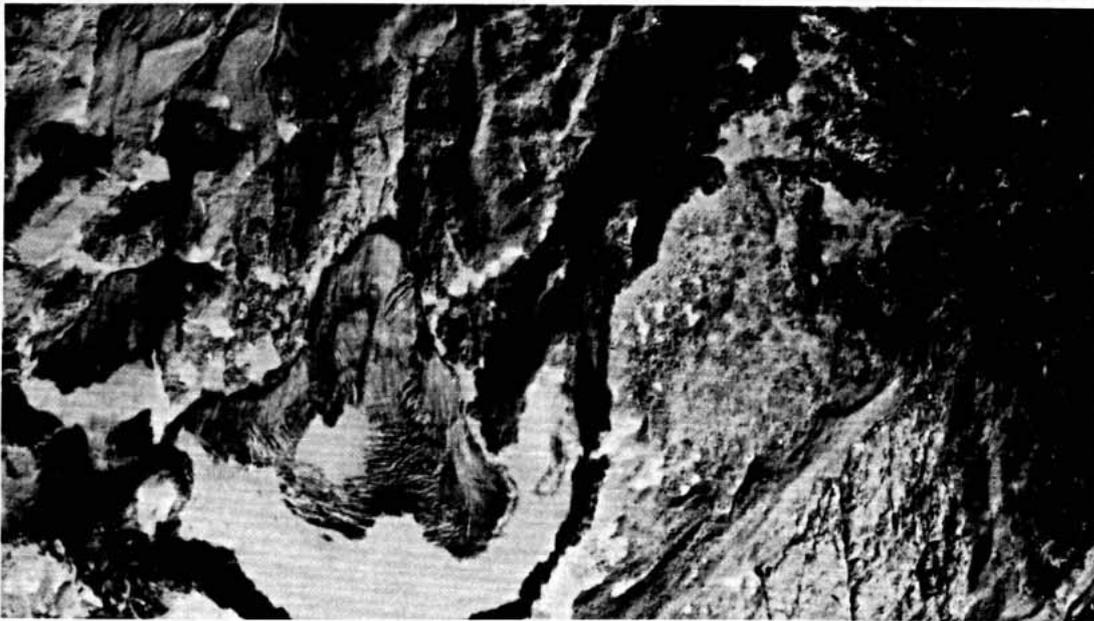
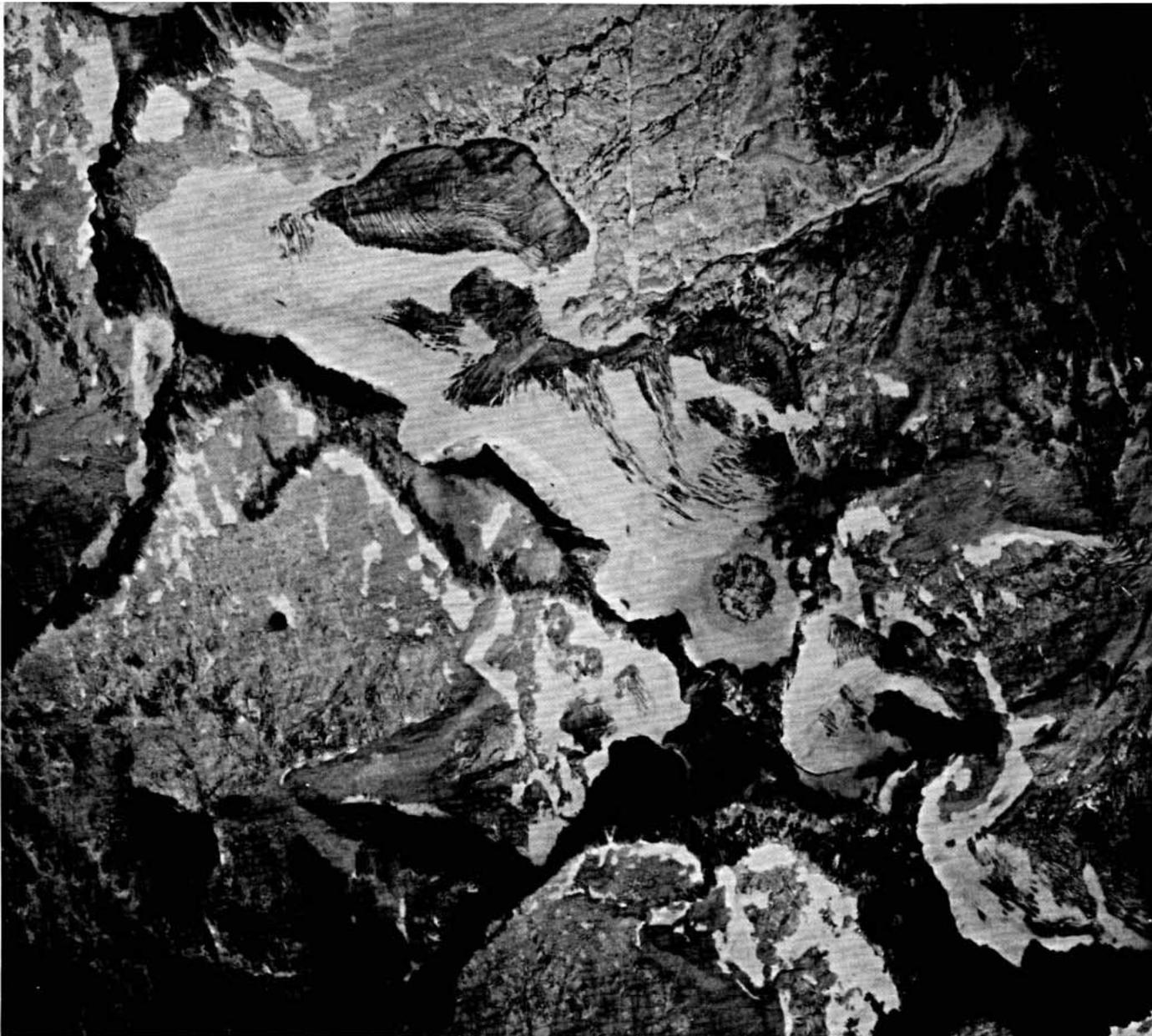


Figure 8. —Vertical aerial photographs of the Maladeta massif taken 5 September 1988 by the Institut Cartografic de Catalunya. These photographs and others taken close to the time of maximum snowmelt have been used to determine more accurately the glacierized area of the Pyrenees. Compare with figures 6 and 7. The scale is approximately 122,000.



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