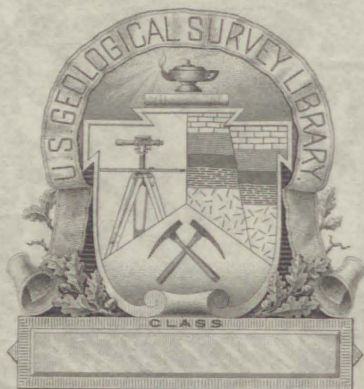


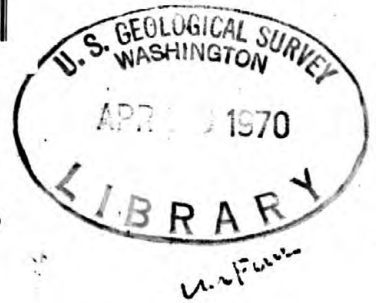
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GLACIERS OF THE CENTRAL CHILEAN ANDES
AND THEIR IMPORTANCE TO THE WATER RESOURCES

by
Austin Post
U. S. Geological Survey, Tacoma, Washington

219258

The severe drought that has been experienced in recent years in Central Chile has focused attention on the maximum utilization of fresh water resources. It has long been known that glaciers exist in the Central Andes. These have been shown in a general way on the 1:250,000 scale topographic maps published by the Instituto Geografico Militar de Chile. In 1956, Professor Louis Lliboutry published maps of the glaciers covering the high Cordillera between 32°30' and 33°30' south.

The importance of glacier melt to sustained streamflow during periods of reduced precipitation has only recently been fully realized. For example, Tangborn (Post, et al, unpublished ^{manuscript} 1/1) has computed that the relatively small glaciers covering only 3 percent of the total area in the Stehekin River basin in the North Cascades, Washington, provided 47 percent of the runoff during the months of August and September 1966, an unusually dry, warm summer.

In seeking a way to augment streamflow during periods of drought in 1969, Commandante Sergio Bravo, President of the Chilean International Hydrological Decade Committee, requested advice of the U. S. Geological Survey regarding the possibility of increasing the runoff from glaciers. As a first step, Geological Survey scientists considered it essential that new aerial photography covering the glaciers of the Central Chilean Andes be obtained so that their present size and characteristics could be analyzed. Suggestions for photographic coverage were forwarded to

1/ Post, A., Tangborn, W. V., Richardson, D., and Rosselot, F., Inventory of glaciers in the North Cascades, Washington: U. S. Geol. Survey (unpublished manuscript).

Commandante Bravo for action in March 1969 and by April 1969 most of this photography had been successfully flown by the Servicio Aerofoto Grammetico de la Fuerza Aerea de Chile. Prints from this photography were received by the U. S. Geological Survey ~~Project Office~~ in Tacoma, Washington, in May 1969 for appraisal. Most of the photography was (copy attached) plotted/using Lliboutry's 1:250,000 base maps, and sketch maps of the glaciers were prepared in other areas.

The extent and surface conditions of the glaciers were then analyzed. The extent of glacier ice in many of the river basins of Central Chile was judged to equal or to be greater than the area of glaciers in river basins in the Cascade Range of Washington State where glaciers have been found to be an important water source in summer months, even when severe drought conditions are not present.

Four glacierized Chilean Andes and two Washington North Cascades River basins are compared in table 1. From the data it would appear that the minimum percent of runoff supplied by ^{the Chilean} glaciers in late summer would be from 35 to 80 percent of the total. The analysis of Central Chilean glaciers is summarized as follows:

1. The 1969 aerial photography clearly indicates that in many of the river basins of Central Chile the glaciers contain large reserves of fresh water and provide a very important portion of the runoff during the summer months. Especially in the Maipo and Cachapoal River basins a large share, perhaps most of the runoff during serious drought conditions comes from glaciers.

Table 1.--Comparison of glacierized Chilean and Washington river basins

Central Chilean Andes				North Cascade Range, Washington			
River basin	Total area (km ²)	Glacier-ized area (km ²)	Estimated minimum percent of runoff supplied by glaciers in late summer	River basin	Total area (km ²)	Glacier-ized area (km ²)	Computed percent of runoff supplied by glaciers in August-September
Olivares	555	94 (17%)	80%	Thunder Creek	272	38.6 (14.2%)	41% in 1964 66% in 1966
Cachapoal	293	40 (13.7%)	65%	Stehekin	890	30.3 (3.4%)	21% in 1964 47% in 1966
Volcan	554	42 (7.6%)	35%	Above data from Post, et al, unpublished manuscript			
Pangal	287	22 (7.7%)	35%				

2. The 1969 aerial photography makes it possible to determine the approximate surface area and conditions of the glaciers in most of the river basins covered. Some additional late summer photographs would be required to fill in gaps in flight lines or where clouds concealed the glaciers.

3. Long-term scientific studies of the climate, mass balance, and runoff characteristics of at least one Central Chilean glacier should be made to provide information on the present and future contribution of the glaciers to the water supply in Central Chile. This information would make possible much more refined day-by-day prediction of the stream-flow under various climatic conditions.

4. Glacier modification to increase short-term runoff is clearly possible, but caution is necessary because indiscriminate "mining" of this stored water could create problems for future water supplies.

5. Glaciers provide by far the largest natural reservoirs of fresh water in Central Chile. Not only do they provide water when most needed during drought conditions, but they store water over periods of many decades, even centuries, of moist years and release this water during dry years.

However, all glaciers vary in area, volume, and runoff with climatic variables. They cannot be depended upon for long-term water supplies if ice melt exceeds the snow accumulation over a long period. The glaciers of the Central Andes have been greatly reduced in size by climatic conditions in the past 100 years, which have melted far more ice than has been replaced. As a result, recent streamflow records from glacierized basins do not accurately reflect recent precipitation

and, as the glaciers get smaller, the runoff provided by ice melt during summer months is also diminishing. Unless climatic conditions change to favor glacier growth, future artificial means of increasing the snow accumulation on the glaciers is critically important if this source of water is not to be lost. The preliminary glacier studies recommended are essential if this important source of water is to be analyzed, put to maximum use, and eventually controlled.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
Washington, D. C. 20242

In reply refer to:
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Air Mail

March 17, 1970
Date

W. F. Meier

Memorandum

To: Mark F. Meier, WRD, Tacoma, Wash.

From: Chief, Publications Unit, WRD

Subject: PUBLICATIONS - Transmittal of manuscript approved for other than Federal publication

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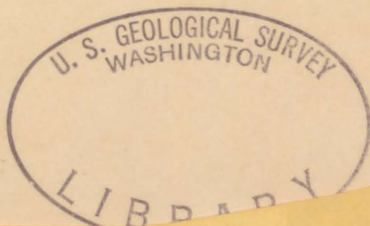
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