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ROCK GLACIER MECHANICS AND CHRONOLOGIES: MOUNT MESTAS, COLORADO

The University of Nebraska - Lincoln PH.D. 1979

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ROCK GLACIER MECHANICS AND CHRONOLOGIES:

MOUNT MESTAS, COLORADO

by

John Richard Giardino

A DISSERTATION

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Doctor of Philosophy

Major: Geography

Under the Supervision of Professor Merlin P. Lawson

Lincoln, Nebraska

October, 1979

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ROCK GLACIER MECHANICS AND CHRONOLOGIES:

MOUNT MESTAS, COLORADO

BY

JOHN RICHARD GIARDINO

APPROVED	DATE
DR. MERLIN P. LAWSON	Oct. 31, 1979
DR. JOHN F. SHRODER, JR.	Oct. 31, 1979
DR. WILLIAM J. WAYNE	Oct. 31, 1979
DR. DAVID T. LEWIS	Oct. 31, 1979
DR. BRIAN W. BLOUET	Oct. 31, 1979

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ROCK GLACIER MECHANICS AND CHRONOLOGIES:

MOUNT MESTAS, COLORADO

John Richard Giardino, Ph.D.

University of Nebraska, 1979

Advisor: Merlin P. Lawson

This dissertation studies the causes, mechanics, and rates of movement operating on the surface, within the internal structure, and along the basal contact of selected rock glaciers. In this study, two fundamental questions are explored: 1) what are the external, temporal characteristics of rock glaciers, and 2) what are the processes triggering their internal movement?

Movement of rock glaciers is an accepted fact, but the movement mechanism remains conjectural. From analysis of fabric patterns, a model has been suggested for the movement of rock glaciers in the Mount Mestas area along with a

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model for the development of ridges and furrows. By employing principles of mechanics, one can consider the water within the rock glacier matrix to behave as a fluid in a confined area. Thus, as greater force is applied to the head of the rock glacier in terms of an increase in talus mass, then a proportionally greater force is applied to the toe or lobe of the rock glacier. In addition, the confined fluid also has hydrostatic pressure that pushes against the interior side of a lobe or the toe.

Evidence for basal slippage was also found in the form of basal push lobes which were found in front of the toe of several rock glaciers. It is felt that movement along the base results from a combination of hydrostatic pressure and lubrication along the rock glacier/valley floor interface. In addition, large landslide blocks of shale were observed being incorporated <u>en</u> <u>mass</u> into the rock glacier matrix. Thus, it is likely that movement between the base of one of the large landslide blocks and the valley floor or the rock glacier matrix might occur which could also account for basal movement.

Movement along interior shear planes also is present in the rock glaciers studied at Mount Mestas. Both fabric analysis and radiocarbon dates indicate interior shearing

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occurs below the face of a lobe. This compression of the downslope flow results in the development of structures similar to folds. Many of these structures on the Mount Mestas rock glacier approach a state similar to a recumbent fold. However, stresses in many of these folds reach the point where failure occurs, and a slip plane is developed.

These slip planes can override younger materials as suggested by the radiocarbon dates.

The rock glaciers in the Mount Mestas area are thought to be Late Pinedale in age as indicated by various relative dating techniques. While not all relative dating methods were in agreement, several indicated that the lower portions of two rock glaciers could be Late Pinedale in age.

Although the rock glaciers were deposited during Late Pinedale time, their surfaces have shown numerous periods of recent down slope movement.

In conclusion, this study has shown that although the rock glaciers in the Mount Mestas area were developed under periglacial conditions, they are dynamic features that today continue to move in an attempt to adjust to variations of input and output as well as to changes in climate. Further, this study has suggested that water and fine-textured debris play important roles in the movement of rock glaciers. While this study has attempted to illustrate and

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model the movement of rock glaciers, more data are needed to determine exact rates of movement. The Mount Mestas rock glaciers are today responding to continually changing slope conditions and are displaying both random and synchronous patterns of movement.

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CHAPTER I

INTRODUCTION

Introduction

A rock glacier is a deposit of poorly sorted, angular, blocky to tabular debris held together by an ice core or a matrix of fine clastics and ice-cement. It is either moving (active) or has moved at some time in the past (inactive or fossil rock glacier).

Rock glaciers, while not occurring in large numbers, appear to be a rather common element of alpine terrain. Flowing from the bases of some rock faces down into the valleys, rock glaciers form a component of valley side slopes and are characterized by: 1) slope angles intermediate between those of the adjoining rockface above and the valley floor below, 2) a surface of coarse rock fragments, 3) either a low density or a complete absence of vegetation, and 4) concave upward slope profiles in the upper parts and strongly convex fronts.

Previous studies of rock glaciers have concentrated mainly upon the problems of age assessment and of surface microfeatures description. The internal structure,

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mechanics, and rates of movement have been largely left to speculation. With the exception of Shroder (1978), no study has attempted to analyze detailed, long-term surface movement. Potter (1972), White (1971), Wahrhaftig and Cox (1959), and Chaix (1919, 1943) have attempted only short-term (thirty years or less) surface movement studies.

The rock glacier system may be viewed as a subsystem within an alpine environment. With regard to such environments, Hewitt (1972) suggests that the study of alpine processes has a unique place in geomorphology. Among his notable observations are two: 1) the alpine environment is a high relative relief and a high energy environment, and 2) the surface of alpine landscapes, in large parts, consists of *in situ* bare rock, rock debris, snow, and ice. He cautions, however, that two complicating factors associated with alpine studies are: 1) the great variability in parameters such as climate and materials makes it difficult to generalize about alpine processes, and 2) process as well as response surfaces are not always amenable to study due to inaccessibility. Thus, the study of rock glaciers in an alpine environment must be pursued with these characteristics in mind.

Recognizing Hewitt's observations, one can appreciate the necessity for formulating a systems approach while

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investigating the many variables that are responsible for the formation of a rock glacier. By employing the systems approach, one can diagram the various morphological components and their interrelationships. These, then, can serve as the organizational basis for data collection in the field.

Statement of the Problem and Objective

This study focuses on two main methodological questions: 1) what are the external, temporal characteristics of rock glaciers, and 2) what are the processes causing their internal movement? Taken together, these research concerns should complement each other, although either could stand alone as a valid subject for study.

Most rock glacier researchers have been preoccupied with surface description and relative dating. They have ignored the question of how rock glaciers move or have relied solely on speculation in discussing it. A considerable gap exists in knowledge with regard to the relationship among surface morphology, motive mechanism, and rates of movement. The main purpose of this research is to examine these relationships as they operate on the surface, within the structure, and along the basal contact of selected rock glaciers. More specifically, this study is

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designed to investigate whether in some cases a rock glacier advance might be associated with a landslip component which, together with internal shearing and basal meltwater, would facilitate the movement of the rock glacier along its base. Further, this study is designed to show the important role rock glaciers play in alpine denudation and transport.

Literature Review and Study Justification

Rock glaciers were recognized as distinct geomorphic features more than 75 years ago. Spencer (1900) was the first to term rock glaciers as "a peculiar form of talus" while describing them in the San Juan Mountains of Colorado. A few years later Cross and Howe (1905), mapping the geology of the San Juans, referred to similar features as "rock glaciers" and "rock streams." Although most authors have attributed the term "rock glacier" to Capps (1910), a recent note (Giardino and Shroder, 1978) suggests the term first appeared in print with Cross and Howe (1905). That rock glaciers have been recognized in alpine regions throughout the world is attested by the various other terms that have been introduced: *coulees de blocs* (Chaix, 1919 and Caillius, 1947); *glaciers rocheux* (DeMartonne, 1920); *Blockglatscher* (Salomon, 1929); *Blockstrome* (Domaradzki, 1951); *colate di pietre* (Nangeroni, 1954); and *litoglaciares*

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(Catalano, 1923). The location of studied rock glaciers has a wide geographical distribution (fig. 1), with these studies being undertaken by numerous researchers (table 1).

Originally Capps (1910) described rock glaciers by their surface morphology. Many rock glaciers, however, are located adjacent to glacial deposits or in former glacial valleys, and clear glacier ice may grade into an ice-cemented matrix which led Potter (1972) to conclude that the origin of the ice was not a decisive factor in the development of surface features. Ostrem (1971) and Barsch (1971) have debated the problem of transition from rock glacier to ice-cored moraine. Shroder and Giardino (1978) have called attention to the taxonomic continuum and terminology problems that might exist between ice glacier/debris-covered glacier and ice-cored rock glaciers. The rock glaciers examined in greatest detail herein were selected because they apparently lacked an ice core and, thus, were not part of a possible continuum of ice glacier/debris-covered glacier and ice-cored rock glacier.

Over the years numerous theories have been advanced to explain rock-glacier movement. The dominant opinions (Wahrhaftig and Cox, 1959; Potter, 1972; and White, 1971) recognize two genetic types: the ice-cored and the ice-cemented. It is now generally accepted that some rock

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