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ROCK GLACIERS IN THE SAN JUAN MOUNTAINS

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Abstract—Rock glaciers are common geomorphic features in alpine areas although their formation and flow mechanics are poorly understood. The distribution of rock glaciers within a given area can also provide evidence of local climate variability or help us to understand the genesis of rock glaciers. Here, we present an updated inventory of rock glaciers in the San Juan Mountains based on the work of White (1979). Once the inventory was digitized and checked for accuracy, the distribution of rock glaciers was analyzed by cross-referencing location with rock type, elevation, and aspect. Our results indicate that rock glaciers are most common in quartzite and intrusive rocks that comprise the highest areas of the range. Additionally, we see a weak, but statistically significant, relationship between solar insolation and elevation indicating that rock glaciers were able to form at lower elevations in more shaded valleys. Lastly, for this field conference we present and discuss the rock glaciers in the area south of Ouray. The rock glaciers in this area are diverse and provide a useful representation of the rock glaciers that are seen throughout the rest of the San Juan Mountains.

ROCK GLACIER DISTIBUTION

Rock glaciers are somewhat poorly understood periglacial features that are common in most alpine areas. Rock glaciers are masses of angular rocks, ice, and debris that extend from a talus slope and flow downhill under the influence of gravity. Their origin has been widely debated (e.g., Barsh, 1992; Clark et al., 1994a) and they are often viewed as important tools for examining climate. In most areas, rock glacier inventories are still being completed (e.g., Onaca et al., in press), typically with the goal of determining the environmental factors that control rock glacier distribution. These environmental factors can then be interpreted to provide further information about how rock glaciers form.

White (1979a, b) mapped 613 rock glaciers in the San Juan Mountains interpreted from topographic maps and aerial photographs. The product was a roughly drawn map with approximate locations of each rock glacier. Other authors have worked on smaller areas within the San Juan Mountains. Brenning (2007) looked mainly at the western San Juan Mountains and used a random sampling approach to statistically determine what factors might control rock glacier formation. Other studies have looked at rock glaciers in the San Juan Mountains with a focus on morphometry and internal structure (Fitzgerald, 1994; Degenhardt et al., 2003). Not wanting to abandon White's (1979a) impressive dataset, we recently digitized and georeferenced his map to begin to create a modern database of San Juan rock glaciers. White's (1979a) map is not well projected so we georeferenced rock glaciers as clusters around individual massifs. Then, each rock glacier was re-examined using modern color remote imagery and 3-D views in Google Earth. The result is a database of 565 rock glaciers in the San Juan Mountains. For each rock glacier, we recorded the bedrock type, aspect, elevation, precipitation, latitude, longitude, solar insulation, and rock glacier type (lobate/valley wall or tongue/valley floor; see Martin and Whalley, 1987; Whalley and Martin, 1992). While this new dataset is unpublished, here we will present some of the preliminary findings and patterns.

As one would expect, the vast majority of the rock glaciers form on a northerly aspect. In fact, roughly 60% of the rock glaciers are on aspects within 45° of north and frequencies of rock glaciers decline continuously to the south. Rock type seems to play a large role in the distribution of rock glaciers as has been noted before (Johnson et al., 2007). However, while they interpreted the influence of rock type to be the result of clast size, in the San Juan Mountains it is more likely the result of elevation. Specifically, harder rock types comprise peaks at higher elevations and are more likely to host rock glaciers (Table 1). For instance, the highest density of rock glaciers formed in quartzite bedrock and the average and median elevations of those rock glaciers are second highest. The result is that quartzite and intrusive rocks have the highest occurrence of rock glaciers, gneiss and extrusive rocks have moderate density, and sedimentary rocks have the lowest density. Sedimentary rocks are particularly interesting because they make up 36% of the San Juan Mountains but contain only 16% of the rock glaciers. The average and median elevations of those sedimentary rock glaciers are the lowest, supporting the hypothesis that rock type is related to elevation (which controls rock glacier presence).

Solar insolation, which is mainly a function of aspect (but also includes topographic shading), also plays a role in the distribution of rock glaciers. There is a weak, but statistically significant, relationship between solar insolation and elevation. This indicates that in alpine valleys with strong topographic shading rock glaciers can occur at lower elevations. In contrast, rock glaciers formed at higher elevations exist in less desirable locations, specifically those alpine valleys with south facing aspects.

ROCK GLACIERS NEAR OURAY

Roughly 150 rock glaciers lie within a 20-km radius of Ouray with many more lying outside that radius (Fig. 1). The vast majority of rock glaciers (~90%) are formed in extrusive rock types that make up the mountains south and east of Ouray. In fact, nearly every north-facing cirque in the area contains at

Table 1. Table of rock glacier distribution by rock type in the San Juan Mountains with comparisons of density and elevation.

	Area (sq. km)	Bedrock Percent	Rock Glacier Occurrence	Percent of Rock Glaciers	Rock Glaciers per sq. km	Average Elevation	Median Elevation
Carbonate	128	0.5	0	0.0	0.00	0	0
Unconsolidated Sediment	2971	11.3	0	0.0	0.00	0	0
Extrusive	11320	43.1	321	56.8	0.03	3662	3689
Gneiss	552	2.1	18	3.2	0.03	3636	3628
Intrusive	1634	6.2	118	20.9	0.07	3546	3526
Quartzite	241	0.9	19	3.4	0.08	3658	3666
Sedimentary	9493	36.1	89	15.8	0.01	3504	3490
Water	57	0.2	0	0.0	0.00	0	0
SUM	**26269**	**100**	**565**	**100**			

least one rock glacier and some south-facing cirques contain rock glaciers as well. Rock glaciers receiving high insolation (i.e., south-facing) occur at higher elevations, a relationship we notice for the entire range, but which is much stronger in the Ouray area. The median elevation of rock glaciers in the Ouray area is nearly 100 m higher than the median for the entire range. This is likely a product of the high elevations of the peaks surrounding Ouray and helps explain their high occurrence in the area. In other words, nearly every alpine valley near Ouray is a good environment for a rock glacier.

Immediately west of Ouray, the Canyon Creek basin contains 27 rock glaciers with more on the opposite sides of bordering ridges. In fact, nearly every sub-basin contains at least one rock glacier including Thistledown (1), Fall (2), Imogene (8), Pierson (1), Silver (1), Governor (2), and Yankee Boy (5). The most impressive of these are the large rock glaciers in Pierson, Silver, and Yankee Boy basins. These three tongue-shaped/valley floor style rock glaciers (Martin and Whalley, 1987) flow along the valley floor indicating that they may be glaciogenic in origin (Clark et al., 1994a). While this interpretation is subject to debate (Clark et al., 1994b; Jakob, 1994), it is certainly more likely that rock glaciers that follow the valley floor are glaciogenic than the lobate style rock glaciers perched on valley walls (which are often thought of as periglacial features). Specifically, it has been hypothesized that valley floor rock glaciers form as retreating glaciers become increasingly buried in their own debris. Eventually, the till covering the surface of the glacier is able to insulate the ice underneath preserving a different glacial feature. Each of these three larger rock glaciers displays distinct flow features on the surface (Fig. 1) although the timing of flow is very difficult to assess.

Continuing to the south, the entire ridgeline connecting the Hayden Mountains to Trico Peak is dotted with rock glaciers. None are as large as those in the Canyon Creek basin but sizable rock glaciers do exist in the Savage, Middle, and Marshall Basins west of the ridge. East of the ridge, rock glaciers tend to be smaller and more lobate. A good example of this is in Mineral Basin where a small rock glacier is perched on the east face of two unnamed peaks with the same elevation (13,477 ft. on USGS quadrangle). The rock glacier is immediately south of Black Bear Pass and easily accessible from the road.

South of Ironton in the Red Mountain area, rock glaciers occur but in smaller numbers. Additionally, the rock glaciers that do occur here are small, lobate-style rock glaciers that are much less impressive. For instance, on the north flank of Red Mountain No. 3, in Champion Basin, lie three mapped rock glaciers. Each of these is very small and some may be re-categorized as protalus lobes or debris-flow deposits upon field examination.

CONCLUSIONS

Rock glaciers are spread throughout the San Juan Mountains and in quantities that produce one of the largest rock glacier inventories in the world. Rock type is one of the strongest factors controlling their distribution since rock type likely effects the distribution of high peaks. Similarly, rock glacier distribution could be thought of as tectonically or structurally controlled. Rock glaciers near Ouray range from large, valley floor (tongue-shaped) features to the southwest to small, valley-wall (lobate) to the southeast. Many of these are accessible via the old mining and forest service roads in the area.

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REFERENCES

Barsh, D., 1992, Permafrost creep and rockglaciers: Permafrost and Periglacial Processes, v. 3, p. 175–188.

Brenning, A., Grasser, M., and Friend, D. A., 2007, Statistical estimation and generalized additive modeling of rock glacier distribution in the San Juan Mountains, Colorado, United States: Journal of Geophysical Research: Earth Surface, v. 112, no. F2, p. F02S15, doi: 10.1029/2006JF000528.

Clark, D. H., Clark, M. M., and Gillespie, A. R., 1994a, Debris-covered glaciers in the Sierra Nevada, California, and their implications for snowline resonstructions: Quaternary Research, v. 41, p. 139–153.

Clark, D. H., Clark, M. M., and Gillespie, A. R., 1994b, Reply to comment by M. Jakob on Debris-covered glaciers in the Sierra Nevada, California, and their implications for snowline reconstructions: Quaternary Research, v. 42, p. 359–362.

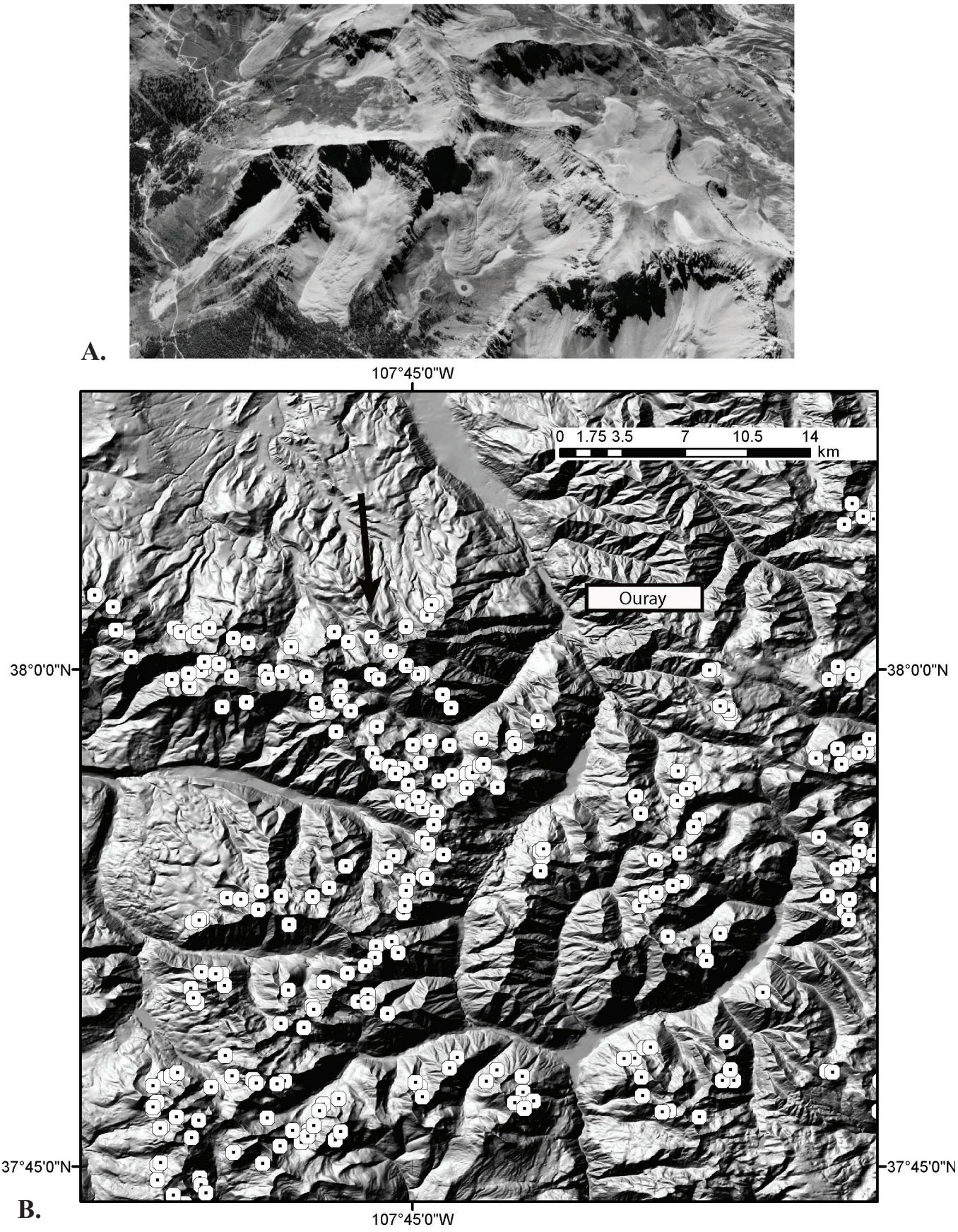

FIGURE 1. **A.** A is a shaded relief map showing the distribution of rock glaciers in the area south of Ouray. **B.** The aerial photograph shows a view of the impressive rock glaciers in Pierson, Silver, and Yankee Boy basins. The view is looking south as indicated by the arrow on the map.

Degenhardt, J. J., Giardino, J. R., and Junck, M. B., 2003, GPR survey of a lobate rock glacier in Yankee Boy Basin, Colorado, USA: Geological Society, London, Special Publications, v. 211, no. 1, p. 167–179, doi: 10.1144/GSL.SP.2001.211.01.14.

Fitzgerald, J. W., 1994, Morpho-dynamic modeling of rock glaciers: San Juan Mountains, Colorado [PhD dissertation]: College Station, Texas A&M University, 202 p.

Jakob, M., 1994, Letter to the Editor: Debris-covered glaciers in the Sierra Nevada, California and their implications for snowline reconstructions: Quaternary Research, v. 42, p. 356–358.

Johnson, B. G., Thackray, G. D., and Kirk, R. V., 2007, The effect of topography, latitude, and lithology on rock glacier distribution in the Lemhi Range, central Idaho, USA: Geomorphology, v. 91, no. 1–2, p. 38–50.

Martin, H. E., and Whalley, W. B., 1987, Rock glaciers. Part 1: Rock glacier morphology, classification, and distribution: Progress in Physical Geography, v. 11, p. 260–272.

Onaca, A., Ardelean, F., Urdea, P., and Magori, B., in press, Southern Carpathian rock glaciers: Inventory, distribution and environmental controlling factors: Geomorphology, doi: 10.1016/j.geomorph.2016.03.032.

Whalley, W. B., and Martin, H. E., 1992, Rock glaciers : II models and mechanisms: Progress in Physical Geography, v. 16, no. 2, p. 127–186.

White, P. G., 1979a, Rock glacier morphometry, San Juan Mountains, Colorado: Geological Society of America Bulletin, v. 90, no. 6 Part II, p. 924–952, doi: 10.1130/GSAB-P2-90-924.

White, P. G., 1979b, Rock glacier morphometry, San Juan Mountains, Colorado: Summary: Geological Society of America Bulletin, v. 90, no. 6, p. 515–518, doi: 10.1130/0016-7606(1979)90<515:RGMSJM>2.0.CO;2.