William C. Mahaney
Geography Department, Atkinson College, York University
4700 Keele Street, North York, Ontario M3J 1P3

Tentative Growth Curve for *Rhizocarpon geographicum s. l.* in Stroud Basin, Wind River Range, Western Wyoming

Abstract

A tentative time-size curve for *Rhizocarpon geographicum s. l.* has been developed for dating Neoglacial deposits in the Wind River Range, Wyoming. Numerous differences in the maximum diameters of *R. geographicum s.l.* on Neoglacial substrates have proved useful as relative age indicators in several Wind River cirques; however, construction of a growth curve was hampered by a lack of deposits dated by radiocarbon. Using a great-growth period similar to that derived in the Front Range, Colorado, and one radiocarbon dated substrate in Stroud Basin, Wind River Mountains, a tentative curve has been constructed. *R. geographicum s.l.* appears to grow more slowly in the Wind River Mountains than in the Front Range of Colorado, the difference amounting to ~10 mm in 3000 years.

Introduction

Neoglacial sequences are common in many valleys above 3000 m in the Wind River Range in Western Wyoming. Relative age determinations of deposits have been made using topographic position, lichen and other vegetation characteristics, weathering features on surface stones, and soil morphology (Birkeland and Shroba 1974, Miller and Birkeland 1974, Mahaney 1978, 1981, 1982, 1984, Mahaney *et al.* 1984a, 1984b). Because buried organic-rich sediments are scarce, it is only rarely possible to date these deposits using radiocarbon. Moreover, since Neoglacial deposits lie above timberline, it is impossible to use tree-ring dating methods, and the absence of tephra precludes correlation and age determination by tephrachronology. In this paper a lichen growth curve for *R. geographicum s.l.* is developed which makes it possible, for the first time, to date with some accuracy the deposits in the Neoglacial sequence. After seven field seasons in the Wind River Mountains mapping deposits in four high-altitude basins, one ^{14}C dated deposit in Stroud Basin provided the necessary time-size plot required to construct a tentative curve.

Field Area

The Wind River Range is an anticlinal uplift oriented northwest-southeast and extending from South Pass to the Gros Ventre Mountains. Erosion along the eastern and western flanks of the uplift expose numerous Phanerozoic rocks (Worl 1968). A number of high-altitude basins in this range are floored with complex sequences of glacial and periglacial deposits, some of which are of Neoglacial age. Stroud Basin (Figure 1) is representative of these glaciated basins surrounded by the summits of Gannett Peak (13804 ft., 4208 m), Mount Arrowhead (12972 ft., 3954 m) and Stroud Peak (12198 ft., 3718 m). Although relatively small now, during the Neoglacial, Stroud Glacier (Figure 1) was an important valley glacier that flowed east, then north, and finally west nearly to Peak Lake. Prior to that, during the late-Pinedale, ice flowed through Stonehammer Lake Basin to the Green River.

Climate

Climatic data are summarized in Mahaney (1978) from stations along the eastern (Dubois and Lander), and western (Pinedale) flanks of the Range. The average annual temperature, mean seasonal extremes, and absolute maximum and minimum temperatures are calculated using mean winter and summer lapse rates determined in the Colorado Rockies (Barry and Chorley 1970). This gives an average annual temperature for Stroud Basin of $-3.5°$ C which is similar to values computed for the Grand Teton Glacier at 3200 m in the Teton Range, 150 km to the northwest (Mahaney 1975). The mean annual precipitation for the alpine zone is unknown, but must be significantly higher than the average snowfall reported for intermontane basin stations. The wind is predominantly northwest most of the year, and the windiest months are from October through February.

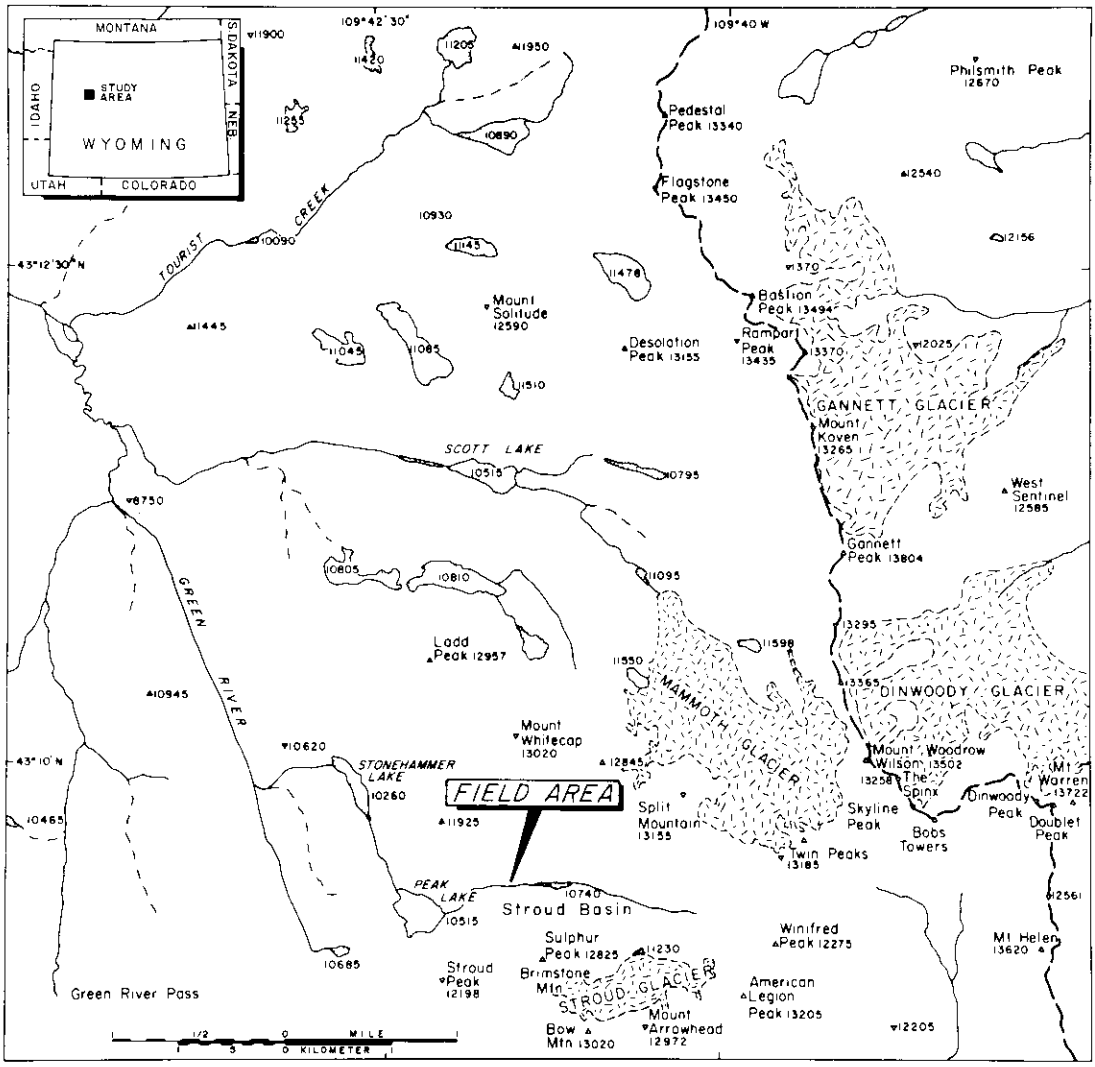

Figure 1. Stroud Basin in the central Wind River Range, Wyoming.

The alpine area is typified by short summer with cool to cold temperatures, and frequent thunderstorm activity. Winter is cold and windy with frequent cloud cover.

Precipitation regimes differ somewhat from the eastern to the western flanks of the Range (Baker 1944). On the western slope, the precipitation pattern is fairly uniform throughout the year, while on the eastern slope somewhat higher precipitation is received in May. The eastern slope is typified by a relatively higher summer rainfall than on the western slope. The Range is well-named as chinook winds descend the eastern slope toward Lander and Dubois, and are characterized by high winds. In winter months they often raise the temperature several degrees.

Vegetation

The alpine tundra, located above timberline at 3000 m, is dominated by perennial sedges, grasses, and herbaceous plants. Vegetation complexes range from kobresia meadow, dryas, and

sedge-grass, to willow-sedge stand types. The timberline zone is composed almost exclusively of whitebark pine (*Pinus albicaulis*), limber pine (*P. flexilis*), and subalpine fir (*Abies lasiocarpa*) (Reed 1976). Isolated remnants of timberline vegetation in procumbent form grow in niches sheltered from the prevailing westerly winds in the area of Peak Lake and downvalley toward Green River (Figure 1).

Methods

The principles, problems, and applications of lichenometry to geomorphological problems have been discussed by a number of workers (Beschel 1957, 1958, 1961, Benedict 1967, 1968, Curry 1969, Andrews and Webber 1964, Birkeland 1973, Birkeland and Miller 1973, Mahaney 1973, 1974, 1981, Mahaney *et al.* 1984a, 1984b, Mahaney and Spence 1984, 1985, Haines-Young 1984, 1985). The two most common assumptions employed in using lichenometry are: 1) lichen growth is indicative of elapsed time since deposition, and 2) the largest lichen thallus generally represents the oldest and fastest growing lichen on a substrate. Lichenometry may be used only for the lifespan of the lichen thallus, which is considered to be a maximum of ~3000 years for *R. geographicum s.l.* (Benedict 1967, 1968).

Deposits in Stroud and other high altitude basins were sampled with the objective of measuring the largest thalli of *R. geographicum s.l.* The measurements were made to the nearest millimeter. Only large thalli were measured and the largest of these were used to construct a tentative time-size curve. Thalli interfingering with other thalli were not measured to avoid problems with intraspecies competition. Those thalli found in depressions were not measured because snow-kill might reduce the cover and impede the development of maximum diameters (Curry 1969, Mahaney 1973, 1974).

The usual restrictions adhered to by other workers of rock type, ice crystal blasting, aspect, moisture, and substrate stability were followed in this study (Mahaney 1974, 1978). All thalli were sampled on moraine crests (Figure 2) to avoid slope wash and frost creep effects. Thalli were measured on granite and granodioritic stones to minimize differences in lithology. Futher, thalli on northwest-facing boulder surfaces were not counted to avoid ice-crystal blasting effects; however, in most instances these surfaces were either devoid of lichen cover, or they contained a population with lower maximum diameters. No significant differences between maximum diameters were observed when north and south-facing aspects of boulders were compared. In all 76 lichen thalli were measured on the moraines shown in Figure 2.

The samples used for radiocarbon dating were collected from an outwash deposit described below (Figure 2) in front of the inner Indian Basin moraine in Stroud Basin at 43° 09' 30" latitude, 109° 42' 35" longitude. These samples were collected with metal implements, air dried on aluminum foil, and stored frozen for 10 weeks before shipment to Japan for radiocarbon dating.

Results and Discussion

Indian Basin deposits in Stroud Basin are unusually well preserved and outwash deposits can be traced to moraine fronts in the area near Peak Lake (Figure 2). Just east of Peak Lake, between an outer and inner end moraine of Indian Basin age (Mahaney 1984), an outwash deposit (STR21) emplaced 2760 ± 110 yrs BP (Gak-9597) provides a maximum age for the inner Neoglacial moraine and a minimum age for the outer moraine. The organic material in this outwash consisted of a "pocket" of detrital plant material with some old roots and intact leaf material. The surface of this deposit contained an Entisol 70 cm thick with some roots extending approximately 50 cm into the Cox horizon. The pH profile in this soil showed that H+ ion activity decreased with depth suggesting little downward movement of H^+, and hence, little contamination. Ca/Mg ion determinations show only a slight increase of Ca with depth suggesting little downward movement from the surface soil solum. Moreover, at 110 cm a ^{14}C date on plant fragments of 1960 ± 150 yrs BP (Gak-11020) suggests that some geobiochemical contamination may have occurred within the soil and upper parent material. The lower parent material showed no variations in pH or Ca/Mg ratios which would suggest that no geobiochemical contamination occurred. Therefore the date of 2760 ± 100 yrs BP appears to be a reliable age determination for the emplacement of the outwash deposit.

After sampling *all* (e.g. 48 large thalli) large thalli of *R. geographicum s.l.* on the inner and

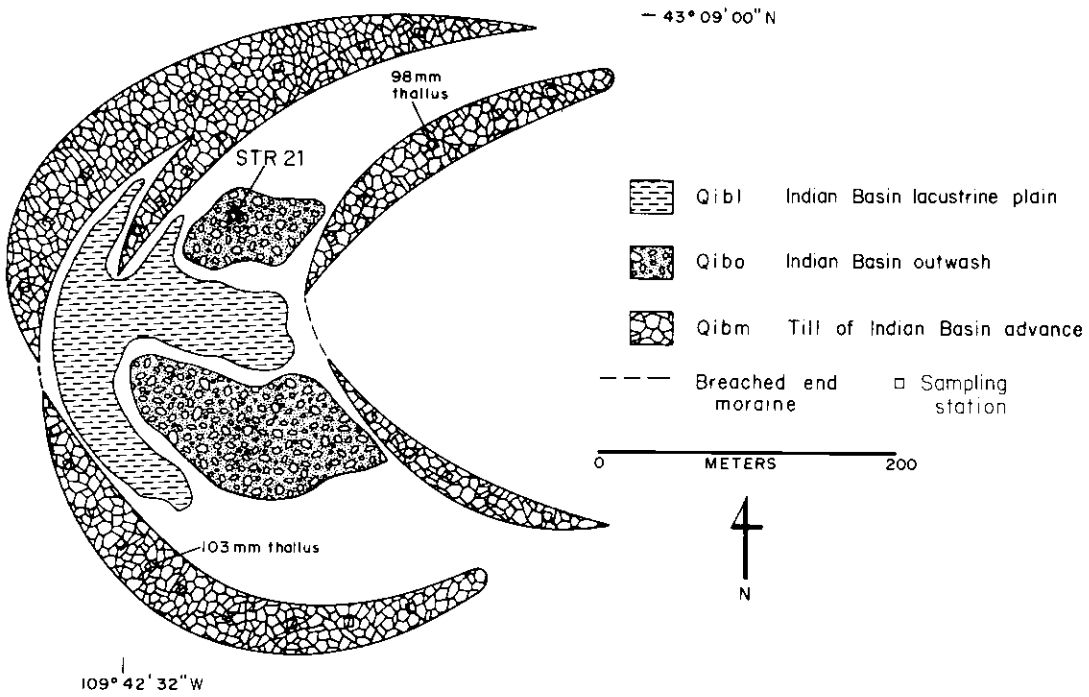

Figure 2. Indian Basin (early Neoglacial) deposits near Peak Lake, Stroud Basin, central Wind River Range, Wyoming.

outer moraine crests, the maximum diameter observed was 104 mm (Figure 3). Several other thalli gave measurements close to 100 mm, suggesting that the largest thalli was not unusually large, and that it represented the elapsed time since deposition 2760 ± 110 yrs BP. Since the cross-valley axis here is sufficiently wide (500 m), clast transport (and hence lichen transport) from the surrounding valley walls over snow banks to the moraine crest, although possible, such as in Fourth of July Cirque (Mahaney 1973), is not likely.

Having determined the maximum diameter and the age of the associated outwash deposit, it is now possible to construct a tentative growth curve for *R. geographicum s.l.* (Figure 4). The great-growth rate (defined as that occurring over the first 100 years), while not known with precision for the Wind River Range, is suspected to be similar to the Front Range in Colorado (Mahaney 1978). Assuming that the great-growth rates are similar, the differences in size after 3000 years, when compared with the Front Range, is 10 mm. The average growth per century following the great-growth period is estimated at ~3.0 mm, which is slower by 0.3 mm/century when compared with the Front Range, Colorado.

Comparing the two curves it is apparent that *R. geographicum s.l.* grows somewhat slower in the Wind River Range than in the Front Range of Colorado, apparently because it is drier there (Birkeland and Shroba 1974, Mahaney 1978, 1981). However, when making generalizations of this kind one must take into consideration that individual basins may be quite variable in the moisture available for weathering and lichen growth. Hence, further observations in the Wind River Range are needed to provide additional radiocarbon dated substrates and maximum diameters of *R. geographicum s.l.*

Conclusions

Construction of a tentative growth curve for *R. geographicum s.l.* will allow more refined dating of Neoglacial deposits in the Wind River Mountains. The initial data suggest that lichen growth (3 mm/100 yrs) is somewhat slower than in the Front Range of Colorado (3.3 mm/100 yrs),

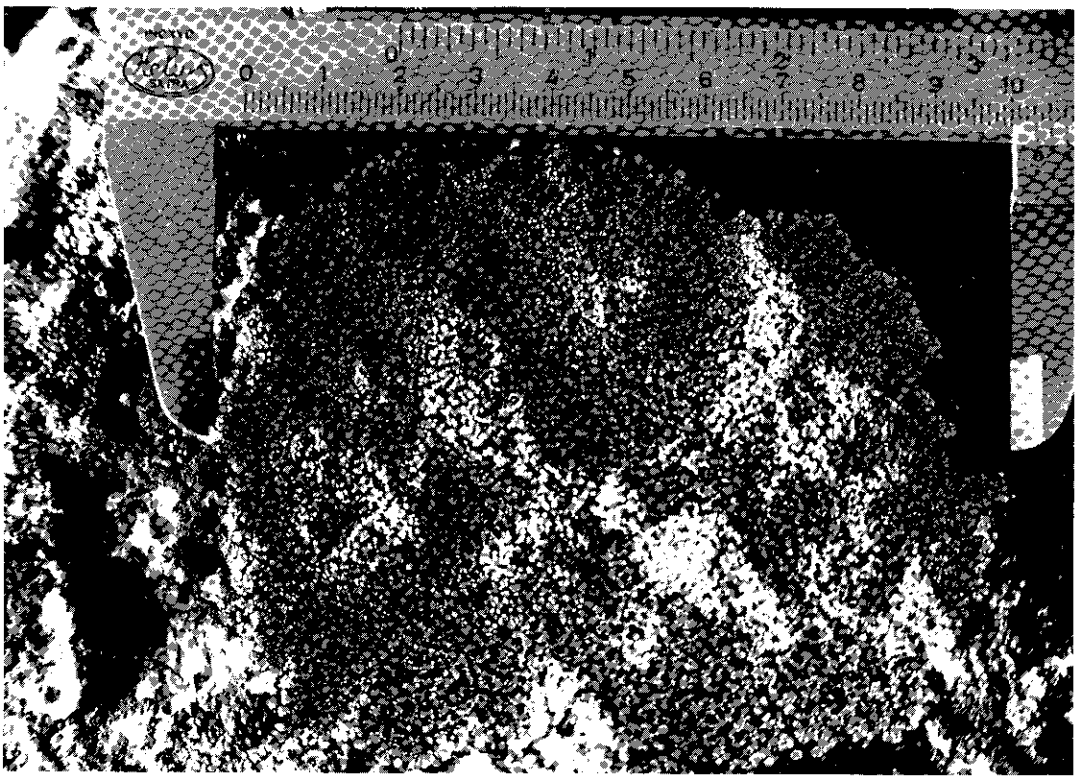

Figure 3. Thallus of *R. geographicum s.l.*, on an early Indian Basin substrate, Stroud Basin, Wind River Range, Wyoming.

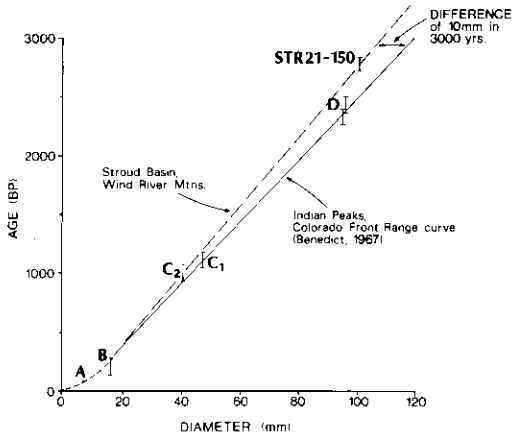

Figure 4. Tentative growth curve (dashed line) for *R. geographicum s.l.* Wind River Range, Wyoming compared with the Front Range (solid line) in Colorado (Benedict 1967; 1968). For the Colorado curve maximum lichen diameters were measured on historically dated cairns (A), debris-flow levees (B), prehistoric game-drive systems (C) and ground moraine (D) deposited at the close of the Triple Lakes (early Neoglacial) advance. The Wyoming curve is based on a similar great-growth period (Mahaney 1978) and outwash radiocarbon dated at 2760 ± 110 yrs BP. Vertical lines on all radiocarbon dates show the statistical errors.

750 km to the southeast. As more deposits are dated by radiocarbon other workers should be able to test the time-size relationships discussed herein, and refine the curve to a considerable degree.

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