Quaternary History of Red Mountain Creek Valley and its Relation to the Rio Grande Glacier System Near Creede, CO

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Introduction

Twenty six moraines lie within the area of contact between the Rio Grande glacier system and the Red Mountain Creek glacier. Their presence indicates a complex history of glaciation in the Late Pleistocene and is contradictory to Atwood and Mather's theory (1932) that the two were confluent during the last phase of glaciation. The age relationships can be analyzed through weathering information such as mafic weathering rinds and clay mineral development in soil profiles.

Field and Laboratory Methods

In the field, detailed mapping was conducted with the aid of air photos. A surficial geologic map was constructed from the field data and air photo analysis. A series of eighteen Rio Grande moraines butt against a series of eight distinct Red Mountain Creek moraines about 0.8km outside the mouth of Red Mountain Creek Valley. Four sites were selected at moraine crests with equal vegetation cover for soil profile analysis on the premise that they were of differing ages. Field relationships and the assumption that moraines at the end of a series might represent a previous high stand and that a more recent event might be represented by the moraines further upvalley led to the designation of Site#1 as "old" Rio Grande (RIO), Site#2 as "old" Red Mountain Creek (RMC), Site#3 as "young" Rio Grande, and Site#4 as "young" Red Mountain Creek (Fig.1). The relative development of soils and mafic weathering rinds were expected to reflect the variations in age because given more time, thicker soils with greater clay percents are formed and more clasts are altered thus creating a thicker weathering rind. Soil samples were collected from different depths within the pit for sedimentary and X-ray analysis and weathering rinds were measured from twenty mafic clasts collected on the surface of the features within ten meters of the pit. An additional weathering rind site was chosen at the halfway point between Site#1 and Site#3 to determine if there were more than two possible events in the Rio Grande system.

The soil samples were initially wet sieved to separate the sand and mud fractions. The sand fraction was then dry sieved at half-phi intervals from -1ϕ to $4\ \phi$ using a Rho-tap. Phi sizes were obtained for the mud fraction through hydrometer analysis as described by Folk (1968). The program Supermud was used for statistical analysis of the data to determine the percent sand, silt, and clay. The clay percent was then plotted against depth to demonstrate the weathering profile at each site (Fig. 2). The data from the sedimentary analysis was then plotted on a Ternary diagram to show the character of the tills in the field area (Fig. 3).

An aliquot split from mud fraction was centrofuged to obtain a less than $2\mu m$ suspension. Oriented slides were prepared for X-ray diffraction by using the method of Kinter and Diamond (1956). All samples were subjected to five treatments in order to decipher the mineralogy: 1) Air drying 2) Potassium (K^+) saturation 3) Ethylene Glycol atmosphere [after 1 and 2] 4) Magnesium (Mg^{++}) and glycerol saturation 5)

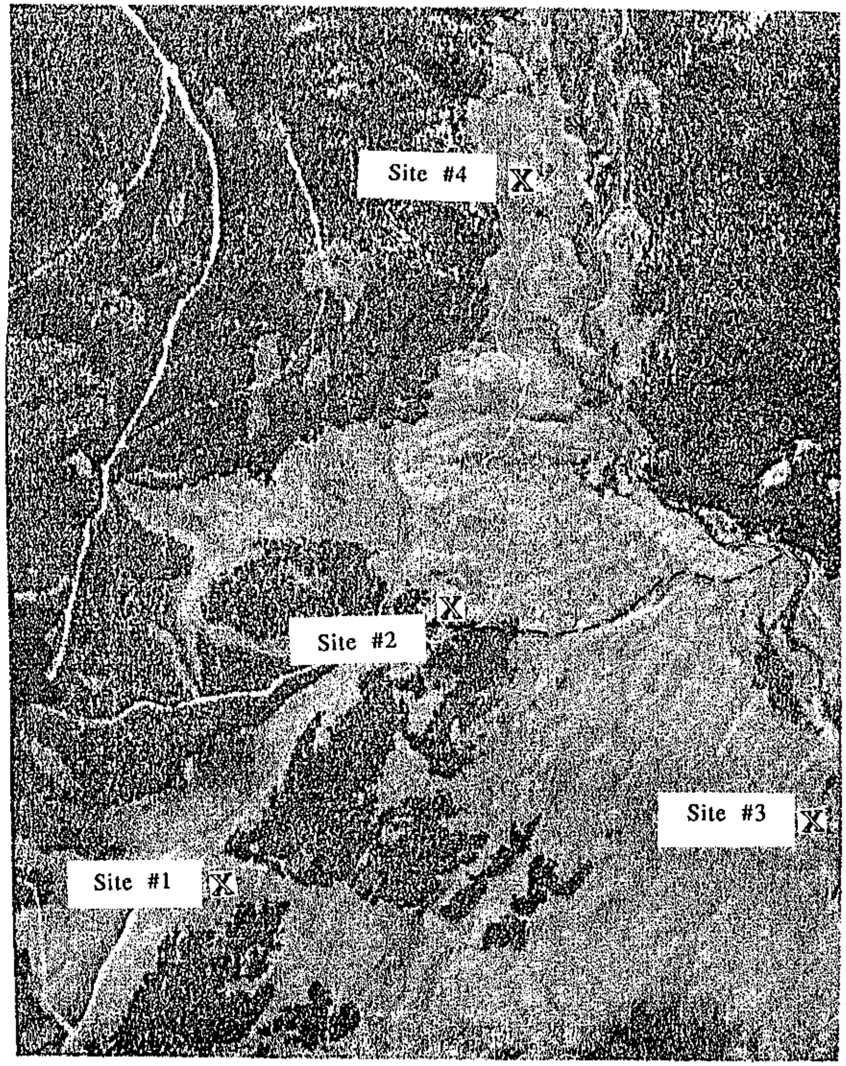


Figure 1.- The dashed line represents the possible contact between Red Mountain Creek moraines and Rio Grande moraines. The sites shown were selected for soil studies.

Figure 2. - Numbers correspond to sites.

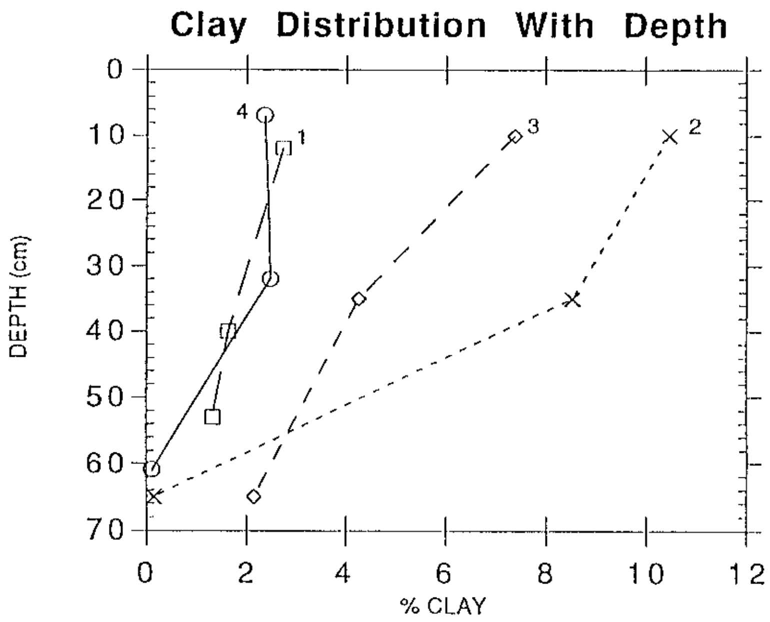
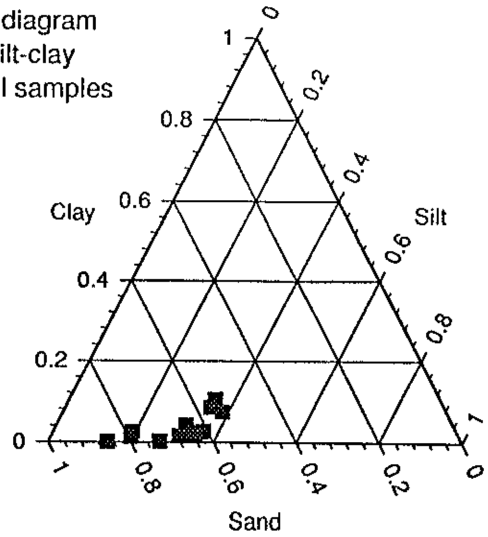


Figure 3. Ternary diagram expressing sand-silt-clay percentages of soil samples in study area.



Heating to 350°C. The samples were X-rayed from 1.5° to 32° 2θ using a Scintag 2000 X-ray diffraction system.

The mafic weathering rind data was analyzed for means and standard deviations. A 95% confidence limit was calculated for those means, and the data clearly separates into two populations (Fig.4).

Results

The air photo analysis and the field mapping revealed a series of eighteen Rio Grande moraines angled at about 40° to a series of eight Red Mountain Creek moraines. The tills of the two systems are usually distinct because the Rio Grande system has origins in the crystalline and metamorphosed Needle Mountains while the Red Mountain system's source rocks are mostly tuffs from the local caulderas. However, in the area where the moraines converge, there is no such distinction, as each system probably cannibalized the till of the other thus making the two homogeneous in that area.

As mentioned previously, the mafic weathering rind data separates into two distinct populations when the rind thickness is plotted against the location with error bars representing a 95% confidence interval (Fig. 4).

The X-ray diffraction analysis reveals basic similarities in all of the soils such as the presence in varying degrees of a mixed-layer clay, smectite, illite, and in most cases, kaolinite.
The presence of the mixed-layer clay is obvious in Fig.5b because a 13.7A (001) peak in the air dried spectrum expands to 18.4A (001) after treatment with Mg^{++} and glycerol instead of the usual 14A-18A expansion expected with solitary smectite. A second reflection of the mixed-layer clay shows up at 3.58A (005). The mixed-layer is seen again with Fig.5c when the 13.95A (001) peak in the air dried spectrum expands to 19.29A (001) with reflections at 6.43A (003) and 3.216A (006) after treatment with Mg^{++} and glycerol. Smectite is best seen in Fig.5a when the 14A (001) air peak expands to exactly 18A (001) upon Mg++ saturation and treatment with glycerol. According to Brindley and Brown(1980), this is the definitive characteristic of smectite. Further evidence that this is smectite comes from another smectite reflection which is seen at 3.575A (005). Illite can be seen in all the spectra in Fig.5 at about 10.050A (001). It is illite because the peak's value does not change with any of the treatments and it has reflections at 9.931A (001), 4.979A (002), and 3.327A (003) in Fig.5a. Kaolinite can be seen in Fig.5a&c at a spacing of 7.1A (001) and 3.57A (002).

There are differences revealed by the X-ray analysis as well. Soils of Red Mountain Creek origin tend to have vermiculite in addition to smectite and mixed-layer clay. Vermiculite can be seen as a residual peak on the Mg++ and glycerol spectrum in Fig.5a at 14.012A (001). This expresses a diagnostic character of vermiculite; namely that it can accept only one plane of glycerol molecules due to its high layer charge and thus, does not expand as much as smectite. Therefore, the smectite expanded and left the vermiculite peak behind at 14.012A. Another basic difference in the two characters of the soils lies in the greater abundance of kaolinite in the Red Mountain Creek soils. The difference in abundance of kaolinite can be seen by comparing Fig.5a and Fig.5b at 7.1A. There is no kaolinite present in the Rio Grande sample taken from a depth of 63 cm, but there is a strong kaolinite peak in the sample from a depth of 32 cm in a Red Mountain Creek soil. After examining all of the X-ray scans, there seems to be a trend of decreasing abundance of vermiculite and kaolinite with increasing depth in the soil profiles of Red

Figure 4. MAFIC WEATHERING RINDS

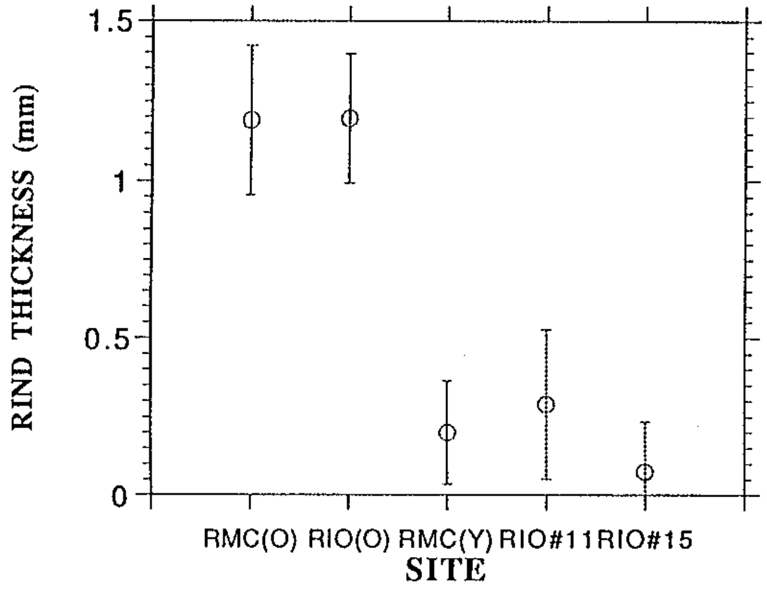
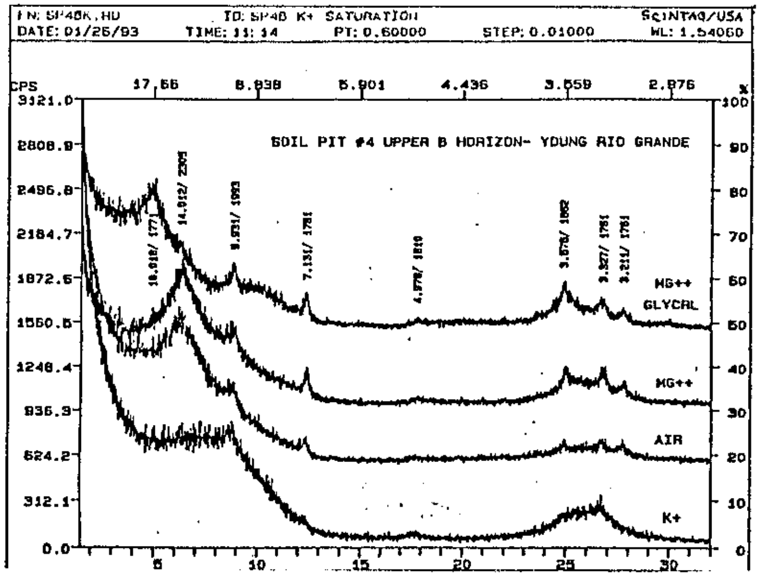
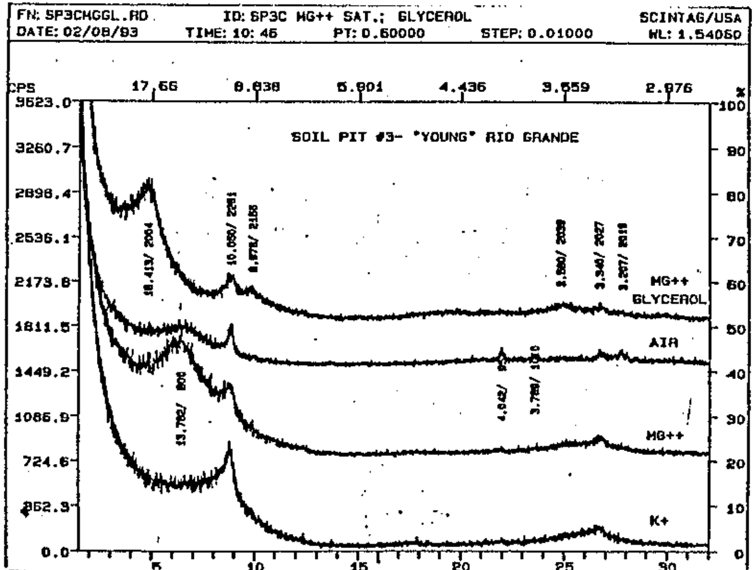


Figure 5 a-c.

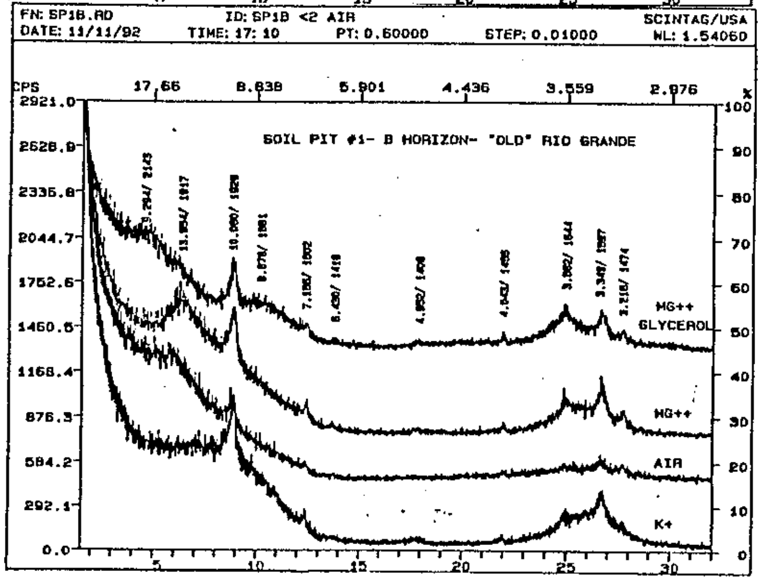
a.



b.



c.



Mountain Creek. The same trend holds for the kaolinite present in the Rio Grande soils but the relative abundance at equal depths within the two types displays the same trend as the given example.

Discussion

The presence of the moraines previously described prove that the two glacier systems were not confluent in the last phase of glaciation. This is further substantiated by the mafic weathering rind data, as it separated into two separate populations thus suggesting two distinct ages of till in each of the valleys (Fig.4). Thicker rinds suggest a greater amount of weathering which is usually accomplished with time since the clasts were of similar lithology and have fairly non-variable rates of weathering. From the X-ray analysis, it can be said that the two valleys have different weathering patterns. Decreasing amounts of vermiculite and/or kaolinite with depth possibly indicate clay mineral formation due to post-depositional weathering. At this time, it is difficult to say definitively that there are two distinct ages based on the X-ray data. However, Site#1 and Site #2 appear to have more intense smectite peaks than their counterparts. The bedrock in both glaciers' source areas is mostly tuff (volcanic glass) from the cauldera complexes which weathers primarily to smectite. This allows the speculation that there might be two different ages represented by the soils. If this is true, it only adds evidence that the two glaciers were not confluent, and possibly they did not converge at all in Late Pleistocene history.

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Late Pleistocene history of glacial Lake Atwood, San Juan Mountains, Colorado

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Introduction. The glacial history of the San Juan Mountain Range, located in southwestern Colorado, was first discussed in a 1932 paper (Atwood and Mather). The two men produced a surficial map of the entire range, covering 20,000 square km, as well as a reconstruction of the most recent glaciation, which roughly coincides with the continental Wisconsinan event. Located within the eastern part of the range near the present-day Hinsdale and Mineral County line, Atwood and Mather mapped a glacial lake dammed by ice emerging from South Clear Creek Valley. The purpose of my project was threefold. First, I considered the physiography and sediment distribution of the North Clear Creek Park area and compared my findings to those of Atwood and Mather (1932). The subsequent surficial geologic map enabled me to decipher broad patterns of sedimentation in glacial Lake Atwood. I then reconstructed the paleoflow dynamics of the lake through a detailed sedimentological analysis of glaciolacustrine sediments, including paleocurrent indicators in coarse-grained turbidity deposits. Finally, in conjunction with the work of Scott McMillin, Maria Panfil and Denise Muriceack (this volume), catastrophic drainage of the lake was considered - a grande finale to Late Pleistocene glacial events in the area. Paleomagnetic data was used as a geochronologic correlation tool to place the existence of glacial Lake Atwood within the context of regional glaciation in the Rocky Mountains.

Surficial Mapping. Deltaic deposits consist of massively bedded sand, gravel and cobbles within which individual beds dip at angles from 10-17°, with an azimuth of 050° NE; both direction and dip angles suggest these sediments are the topset component of a classic Gilbert-type delta (Gilbert 1885). Although the foreset/topset contact was not seen in the sediments, the deltaic foreslope is dramatically evident both in the field and in air photos, marking the contact. The elevation of the maximum and most persistent lake stand is thus fixed at 10,150 ft.. No other such contacts were found suggesting additional significant lake stillstands. Scott McMillin (1993) identified two possible spillways carved in bedrock along the eastern edge of Santa Maria Canyon; one located at an elevation of 10,150 ft.(3093 m) and the other at 10,070 ft.(3069 m). The higher spillway confirms the prominent lake level to which the delta was graded. A kame terrace located approximately 1.5 km southwest of the delta front suggests ice overtopped a lateral moraine and bedrock, and the stagnant ice became the major source for deltaic sediment and meltwater entering the lake. Another large area of outwash material exists in the northern portion of the paleobasin, beyond the mouth of North Clear Creek.

Fine-grained lacustrine deposits exist in two clusters: a southern exposure near the ice contact/lake margin, and a northern group within the foreset slope of the delta. No other rhythmically-bedded sediments were discovered. Massive clays exist at two other locations, and are likely the result of slumped lacustrine deposits from the basin sides. (Figure 1)

Sediment Analysis. Six sections of rhythmically-bedded sands, silts and clays totalling over 14 meters of stratigraphic section were studied. Sediment samples were collected and grain size analysis performed with a laser particle counter. Sections were divided into facies based on sand and clay percentages, presence of massive or rippled sand beds, and deformation features. TOTAL Theodolite Station data revealed that the rhythmite sections spread out over 41 meters of vertical space, but no overlap exists from one site to another.

In the southern rhythmite exposures, many factors suggest that turbidity underflows - surge currents - were the primary force in distributing sediment into the lake. At least half of the total stratigraphic section is dominated by sand in the form of thin laminae within silts and clays, massive layers up to 14 cm thick, and cross-bedded ripple laminae that show paleoflow in a west/northwesterly direction. Varves are couplets deposited within the time frame of exactly one year: summer silts through underflow in the hypolimnion are dominated by gravity, topography and sediment availability, and winter clays are distributed by over- and interflow and settle slowly and evenly over the entire basin (Smith and Ashley, 1985 and Ashley, 1975). The difference between the two mechanisms creates a sharp contact between the summer and winter layers. Fining upward sequences between silts and clays are dominant in glacial Lake Atwood and suggest that the deposits are surge rhythmites deposited by a single flow mechanism (underflow). The large amounts of silt, even in the finer 'clay' portion of the sequences, as well as the numerous sand and silt laminae within a single fining upward sequence, confirm the dominance of underflow in sediment distribution. Some winter clay layers do exist; they have a higher clay content compared to the fine portion of the surge rhythmites, and are distinguished by sharp contacts above and below. The thicknesses of these occasional clay