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COMMENTS ON "LATE PLEISTOCENE AGE OF THE TYPE TEMPLE LAKE MORAINE, WIND RIVER RANGE, WYOMING, U.S.A." BY G. A. ZIELINSKI AND P. T. DAVIS

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Gregory A. Zielinski and P. Thompson Davis have recently reviewed the age of the *type* Temple Lake moraine in the Wind River Range of western Wyoming and the chronology in Temple Lake Valley. They used lithostratigraphic, organic carbon, and radiocarbon data from two cores to argue for a late glacial (~12,000 yr BP) age for the "Temple Lake" moraines. While this is a commendable piece of research, the authors fail to cite and discuss a number of previously published papers that provide important information on the "Temple Lake problem", which is not unique to the Southern Wind River Mountains.

Because the Temple Lake moraines have been assigned ages ranging from late Pleistocene (Moss, 1951) to early Neoglacial (Richmond, 1965a), I (Mahaney, 1978) suggested the stratigraphic name "Temple Lake" be changed to "early". Benedict (1973) renamed the Temple Lake moraines in the Front Range of Colorado to avoid tenuous correlations with the Wind River Mountains. My own work in the Wind River Mountains beginning in 1972 [(Temple Lake, Indian Basin, Titcomb Lakes, Stroud Basin and Mammoth Basin (Fig. 1)], eventually led to the elimination of the term "Temple Lake" (Mahaney, 1984) because of the age uncertainty and ambiguity involving several contrary reports.

The moraines at Temple Lake are representative of the ~3000 m moraines that are considered to have been emplaced by recessional stillstands (Mahaney, 1978) of ice. They have distinctly deeper soil cover and more pronounced weathering characteristics on boulders and cobbles relative to younger moraines and mass-wasting deposits found upvalley at slightly higher elevations (Mahaney *et al.*, 1984a, 1984b). In Titcomb Basin (Fig. 1), to the north of Temple Lake, moraines encircling upper Titcomb Lake were assigned to the late Pinedale substage (Mahaney, 1978) on the basis of increases in soil thickness and more advanced weathering characteristics, even though cores from bogs on the moraine surfaces gave ^{14}C ages of ~8000 yr BP. As Zielinski and Davis (1987) have shown, there is usually a lower core section that is composed mostly of inorganic sediments and impossible to date by radiocarbon, leaving the investigator to estimate rates of sedimentation and hence an extrapolated age for the base of the core. That this seems to be a rather typical problem in other alpine areas is attested to by a discussion in Mahaney (1987a) for moraines of a similar age (late glacial) on Mount Kenya in East Africa. Presumably the Lower Temple Lake Core 7 and Rapid Lake Core 85-1, as described by Zielinski and Davis (1987), have basal sections that may be older than 12,000 yr BP.

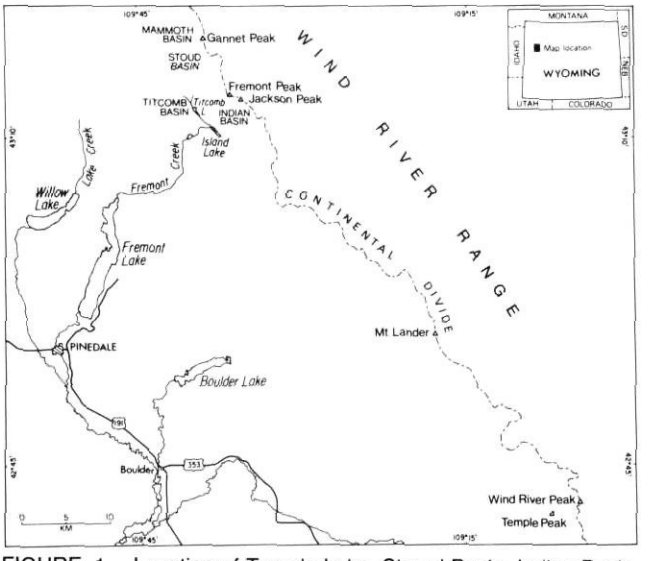

FIGURE 1. Location of Temple Lake, Stroud Basin, Indian Basin, Mammoth Basin and Titcomb Lakes, Wind River Range, Wyoming.

Localisation de Temple Lake, Stroud Basin, Indian Basin, Mammoth Basin et des Titcomb Lakes, Wind River Range, au Wyoming.

The later Pleistocene and Holocene chronologies for the Temple Lake Valley (and the Wind River Range in general) described in Figure 2 (Zielinski and Davis, 1987) are incomplete (Fig. 2). In 1984b, Mahaney *et al.* described a sequence of moraines in Indian Basin, to the north of Temple Lake, and named the early Neoglacial till *Indian Basin* (Fig. 1 for location; Fig. 2 for stratigraphy). Details on the soil stratigraphy, weathering characteristics and lichenometry of these deposits is in Mahaney (1984). It is perhaps important to point out here that most deposits described as "early" are in fact equivalent to Indian Basin (based on the author's field observations). While no dates are available for the beginning of the Indian Basin advance, a date of 3050 ± 120 yr BP (GaK-6024) was determined on whole-soil organic matter in the Ab horizon of a buried till near upper Titcomb Lake (Fig. 1) (Mahaney, 1981). Melting of Neoglacial ice at the end of the Indian Basin advance produced higher lake levels in upper Titcomb Lake and in the outlet channel below the moraines encircling the lake

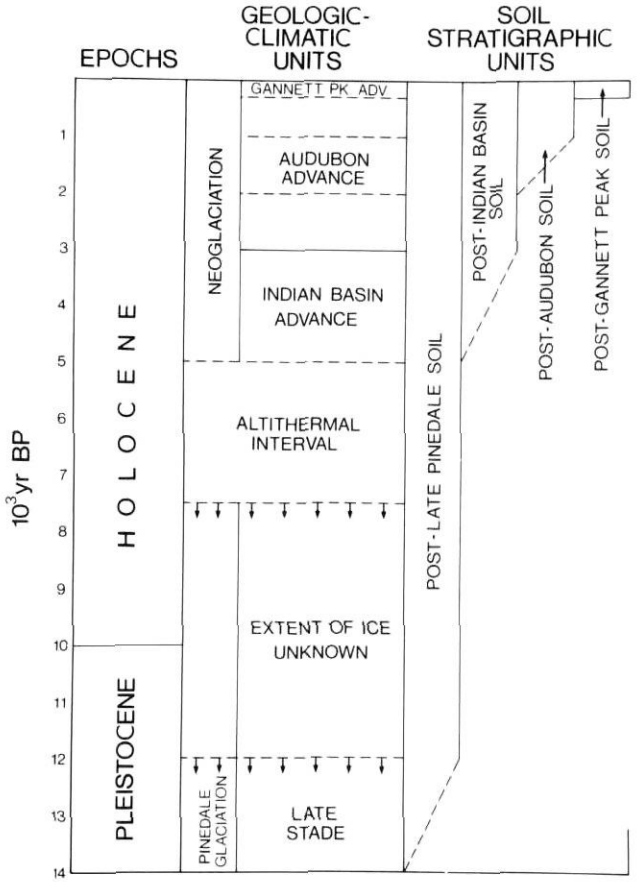

FIGURE 2. Correlation diagram for late Pleistocene and Holocene deposits in the alpine belt of the Wind River Range. Unit boundaries are drawn on maximum or minimum dates from nonglacial sediments. Dashes denote boundaries which lack radiometric control and arrows indicate directions in which boundaries are likely to shift when dates become available. Altithermal and Neoglacial terms are informal whereas others are formal. The minimum age of the Late Pinedale stade as determined by Zielinski and Davis (1987) is at least 3000 yr BP older than suggested by Mahaney *et al.* (1984a).

Diagramme de corrélation pour les dépôts du Pléistocène et de l'Holocène de la zone alpine du Wind River Range. Les limites entre les unités ont été déterminées à partir des datations maximales et minimales faites sur des sédiments non glaciaires. Les tirets représentent des limites pour lesquelles on n'a pas de datation radiométrique; les flèches donnent la direction que pourraient prendre les limites lorsque les datations auront été effectuées. Les termes de l'altithermal et du néoglaciaire sont non officiels, mais les autres le sont. La date minimale du stade du Pinedale supérieur déterminée par Zielinski et Davis (1987) est au moins de 3000 ans BP plus ancienne que celle qui a été proposée par Mahaney et al. *(1984a).*

(Mahaney, 1978). This event led to the deposition of 51 cm of lacustrine sand and burial of the dark-brown (10YR 3/3m; 10YR 6/3d) soil surface[1]. The clay mineralogy of this buried A horizon showed it contained higher vermiculite (relative to the lacustrine unit) indicating that it might be inherited from the wetter and warmer Alithermal Interval (Mahaney, 1981).

In Stroud Basin, to the north of Titcomb Lakes, a sequence of Indian Basin moraines dammed large lakes, the drainage from which led to the emplacement of outwash fans that have been ^{14}C dated at 2760 ± 100 yr BP (GaK-9597) (Mahaney, 1987b). Thus, the evidence suggests the minimum age of these moraines is likely ~3000 yr BP or slightly younger. In Indian Basin a thin cover of colluvium buries a soil formed in ground moraine of Indian Basin age (Mahaney *et al.*, 1984b). The ^{14}C age of 1570 ± 110 yr BP (GaK-8524) for this buried A horizon shows that surface instability that led to mass movement and emplacement of the colluvium occurred during the beginning of the Audubon advance (which emplaced till in most major cirques). The very fact that an Ab horizon exists below the colluvium indicates an interval of at least several centuries for a soil to form following emplacement of the till (see Mahaney, 1978, for discussion of time required for soil formation).

After field observations in several cirques over 10 field seasons I eventually arrived at the conclusion that the Audubon advance [first identified in the Front Range of Colorado by Benedict (1967, 1968); and Mahaney, (1970, 1972)] led to the emplacement of tills with exactly the same degree of post-depositional alteration as those of the Wind River Range. The topographic positions of these deposits, their soil and lichen covers, and weathering characteristics are documented in Mahaney (1978, 1981, 1984 and 1987b and Mahaney *et al.*, 1984a, 1984b).

While it is important to finally have radiocarbon dates on cores from Rapid, Miller, and Temple Lake (Fig. 1, Zielinski and Davis, 1987), it is important to note that moraine positions adjacent to Temple Glacier, and age designations as they reconstruct them, do not reflect the situation I observed there. In the first instance, the Gannett Peak moraine shown in Figure 3 is actually a compound moraine (*i.e.* an end moraine of more than one age emplaced partly during the Audubon and Gannett Peak advances). For another, some of the ground moraine below this end moraine appears to belong to the Indian Basin advance (on the basis of soil thickness and horizon complexity; *ca* 60 cm thick and a A1/B/Cox profile; compare to profiles described in Mahaney, 1978). To the northeast of the Gannett (not Gannet as in Fig. 2, Zielinski and Davis, 1987) Peak moraine, a protalus rampart (Fig. 3) also carries a soil and vegetation cover very typical of Indian Basin deposits. Lichen sizes on stones on the deposit surface give values of 110 mm for *Rhizocarpon geographicum* s.l. indicating an age of ~3000 yr BP (Mahaney, 1987b). The Neoglacial record in Temple Cirque is nowhere near as complete as in Indian Basin to the north. Below the Harrower Glacier moraines of all three advances provide a setting (Mahaney, 1984) in which one can see clearly the results of climatic change since the middle Holocene.

1. Colors follow Oyama and Takehara (1970); moist (m) and dry (d).

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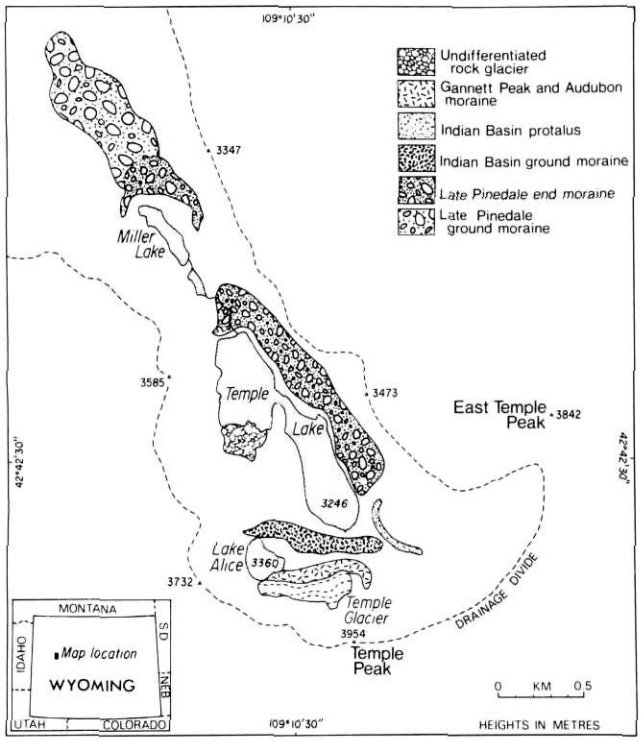

FIGURE 3. Neoglacial deposits in Temple Cirque, southern Wind River Mountains.

Les dépôts néoglaciaires du Temple Cirque, du sud des Wind River Mountains.

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