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LETTER TO THE EDITOR

Comments on "Soil Development Parameters in the Absence of a Chronosequence in a Glaciated Basin of the White Mountains, California-Nevada," by T. W. Swanson, D. L. Elliott-Fisk, and R. J. Southard

Swanson *et al.*'s (1993) recently published report on soils formed on glacial deposits in the basin of Chiatovich Creek in the White Mountains focuses on development of soil properties with time and does not discuss glacial stratigraphy (in press in another journal). The report contains a geologic map that is based on the glacial stratigraphy developed by Elliott-Fisk (1987) for the White Mountains and uses the mapped units to select soil sampling sites. However, the report omits stratigraphic and age data contained in several publications by me and my co-workers on deposits in areas that overlap with Swanson *et al.*'s study area and on deposits in the type locality of one of their glaciations. Based on this work in Fish Lake Valley, on the east side of the White Mountains, I believe that the ages and the glacial origin of most of Swanson *et al.*'s (1993) mapped deposits of the older glacial units—the Dyer and the Indian—are incorrect. As a consequence, I also question Swanson *et al.*'s interpretations based on some of the soils formed on deposits of the Indian glaciation.

Since 1987, I have mapped Fish Lake Valley and the lower flanks of the White Mountains and with others have conducted geomorphic, neotectonic, and soil studies in this area to interpret the history of the northern Furnace Creek fault zone, which bounds the east side of the White Mountains (Reheis, 1991, 1992; Reheis *et al.*, 1993a; and map in review). These maps present abundant data on the stratigraphy and age of alluvial fans and other Pliocene and Quaternary deposits. Preliminary discussions of stratigraphy, neotectonics, and soil genesis were published in the guidebook for the 1991 Friends of the Pleistocene field trip to Fish Lake Valley (Reheis *et al.*, 1991; Slate, 1991; Sawyer, 1991; Harden *et al.*, 1991; Gillespie, 1991).

Since work began on my project, I have periodically communicated with Elliott-Fisk (Swanson's thesis adviser) and her co-workers and have deliberately not worked high in the mountains to avoid duplication of effort. We have been in conflict, despite my efforts at communication, over some major aspects of Elliott-Fisk's (1987) glacial stratigraphy since November 1987, when we met in the field to discuss the geology in the areas of mutual overlap. These areas include both that shown in Figure 1 and the range front near Perry Aiken and McAfee creeks, about 18 km.

PROBLEMS WITH STRATIGRAPHY AND MAPPING

Deposits of the Dyer Glaciation

One of the oldest glaciations of Swanson *et al.* (1993), the Dyer glaciation, is not represented by glacial deposits at its type locality. The Dyer glaciation was named by Elliott-Fisk (1987, p. 311) for a ". . . massive deposit of till at the mouth of Perry Aiken Creek [that] forms an uplifted fan surface. . . ." She thought it was correlative to the Sherwin Till of the Sierra Nevada and mapped it along the range front from Perry Aiken Creek southward about 4 km to McAfee Creek, where "glacial outwash and till" (p. 316) overlie a tephra (found, but undated, by Elliott-Fisk). This deposit at McAfee Creek actually consists of about 70 m of stratified alluvium and debris-flow deposits, including thick layers of reworked Bishop ash that may have been in part deposited as a delta at the edge of a pluvial lake (Reheis *et al.*, 1993b). These deposits include layers of well-sorted, cross-bedded tephra and sandy gravel and layers of matrix-supported subangular to well-rounded pebble to boulder gravel (Slate, 1991, 1992; Reheis *et al.*, 1991).

We term this alluvial unit either the alluvium of McAfee Creek, where it consists mostly of debris flows, or old alluvial gravel (unit Qg, Fig. 1), where it consists mostly of alluvium deposits. It is widespread in both unglaciated and glaciated drainages tributary to Fish Lake Valley. In many places, the unit overlies or is interbedded with reworked 770,000-yr-old Bishop ash (Reheis, 1991, 1992; Reheis *et al.*, 1993b).

Other "deposits of the Dyer glaciation" shown by Elliott-Fisk (1987, Figs. 3 and 7) near Perry Aiken Creek consist of fan deposits of four different ages, including (1) deposits that predate the Bishop ash, (2) the post-770,000-yr-old alluvium of McAfee Creek, (3) the middle

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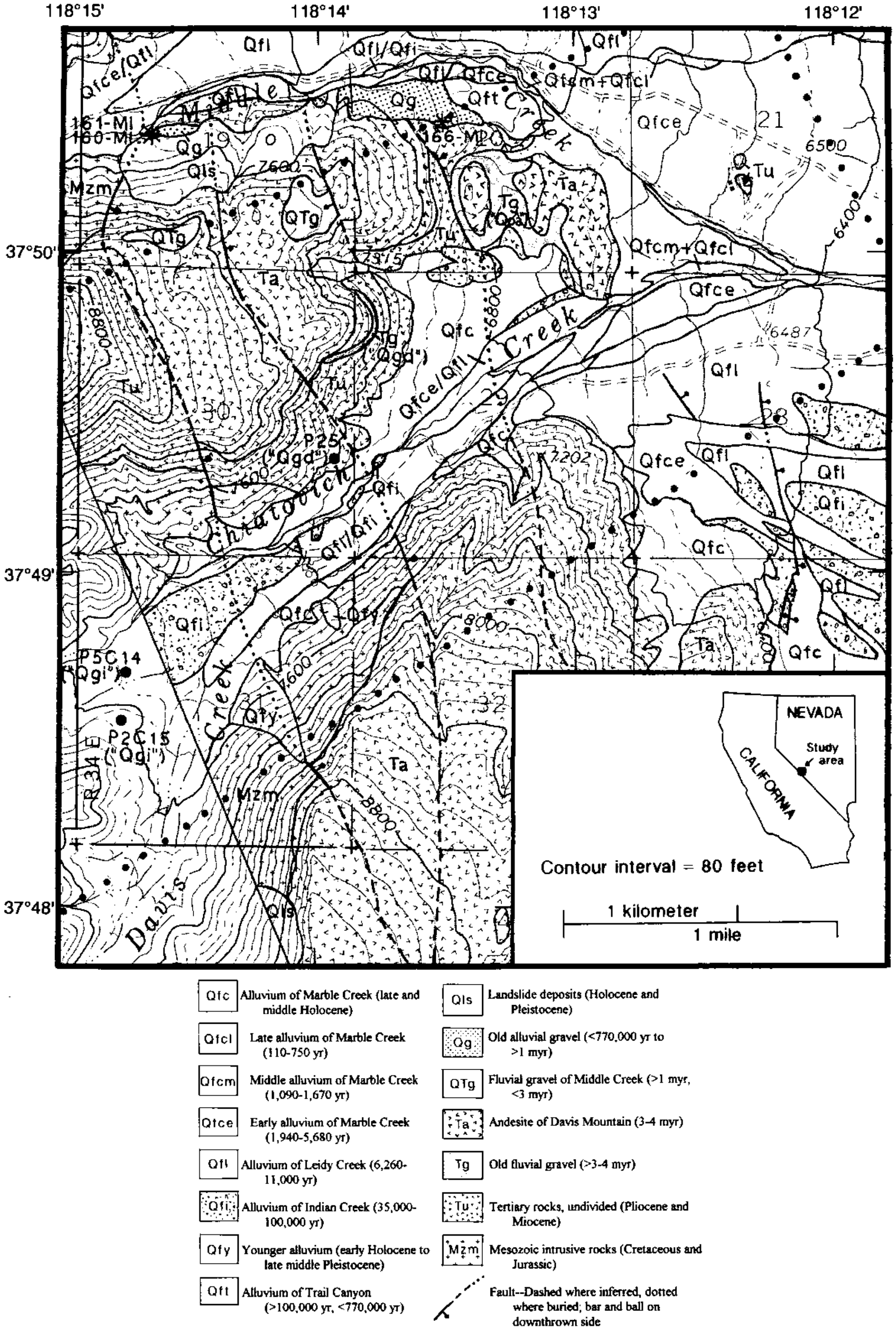

FIG. 1. Geologic map of the lower valleys of Chiatovich and Middle creeks, Fish Lake Valley, Nevada, modified from Reheis *et al.* (1993a). Triangular area in southwestern corner, outside our limit of mapping, shows approximate locations (dots) and units of two sample sites in unit Qgi of Swanson *et al.* (1993, Fig. 2). Locations of their site P25 and "Qgd" and "Qoa" units north of Chiatovich Creek are also shown. Heavy dotted line shows approximate outline of eastern part of their map. Detailed descriptions and age control for units are given in Reheis *et al.* (1993); many ages reported earlier (Slate, 1991, 1992). Combined map symbols (Qfcm + Qfcl, hachured areas) used where two map units are closely interspersed. Fractional map symbols (Qfl/Qfi) used where a thin veneer of a younger unit overlies an older unit. Tephra localities (asterisks) are designated 160-, 161-, and 166-MI (Reheis *et al.*, 1993).

Pleistocene alluvium of Trail Canyon (same as unit Qft, Fig. 1), and (4) the ~100,000- to 35,000-yr-old alluvium of Indian Creek (unit Qfi, Fig. 1). The alluvial character of these four units is well expressed in deposits that are exposed in many drainages incised into the Perry Aiken fan and other fans to the south. These relations were illustrated as Figure 3 of Reheis *et al.* (1991, p. 10). In summary, deposits at the type locality of the "Dyer glaciation" are not glacial but are fan deposits whose ages collectively span about a million years.

Unit Qgd on Swanson *et al.*'s (1993, Fig. 2) map shows "glacial erratics of the Dyer glaciation" in two areas on the north side of Chiatovich Creek. The lower of the two areas (their site P25, shown on Fig. 1 of this report) consists of scattered boulders of adamellite that rest on andesite bedrock (unit Tu, Fig. 1). These boulders are obviously not *in situ,* but the mechanism of transport need not be glacial; the nearest source outcrop (unit Mzm, Fig. 1) is only about 300 m to the west. The higher of the two areas of unit Qgd wraps around a bedrock ridge (unit Tp of their Fig. 2; contact between units Ta and Tu, Fig. 1 of this report). This outcrop pattern exists because "Qgd" here is actually a Tertiary fluvial deposit (unit Tg, Fig. 1) with rounded clasts that is interbedded between andesite and basalt flows (previously mapped by Robinson and Crowder, 1973). This fluvial deposit is downfaulted to the east, where it crops out between Middle Creek and Chiatovich Creek (Fig. 1) and locally displays a reddened, baked zone at the contact with the overlying andesite. These relations were shown by Reheis *et al.* (1991, Fig. 4, p. 13). In the eastern area, Swanson *et al.* have mapped our unit Tg as their older alluvium (unit Qoa). In summary, the "glacial erratics of the Dyer glaciation" include erratic boulders of unknown origin and alluvium interbedded with Tertiary volcanic rocks.

Deposits of the Indian Glaciation

The Indian glaciation was inferred to be pre-Tahoe in age by Elliott-Fisk (1987) and estimated to range in age from 328,000 to 220,000 yr by Swanson *et al.* (1993). Deposits of the Indian glaciation (unit Qgi) on their map are mostly west of the map area of Figure 1; however, I have done reconnaissance mapping (not shown) farther west. The area of overlap includes two deposits of unit Qgi in the blank southwestern part of Figure 1 and one deposit south of Chiatovich Creek just west of the map edge; these three deposits are referred to by Swanson and others (1993, p. 193) as "erosional surfaces associated with the Indian glaciation."

The northern area of unit Qgi is on the valley floor of Chiatovich Creek and stands as much as 12 m above the modern channel. At soil site P5C14 of Swanson *et al.* (1993, Fig. 7), this unit is reported to be about 50 cm thick. This area of "Qgi" extends east into our unit Qfi in Figure 1. Although bedding is not well exposed, the Qfi deposit here has a planar surface, subrounded clasts, and soil and surface-weathering characteristics similar to those of the alluvium of Indian Creek elsewhere (unit Qfi). The Qfi deposits in Fish Lake Valley are dated at between 100,000 and 35,000 yr on the basis of two tephra samples and one thermoluminescence age (Reheis *et al.*, 1993a; Slate, 1991, 1992). Along Chiatovich Creek, the Qfi deposit is at least 10 m thick and is locally buried by the early Holocene alluvium of Leidy Creek (unit Qfl, Fig. 1); near site P5C14, the poorly exposed deposit appears to be at least 6 m thick. Although this area of unit Qgi of Swanson *et al.* might conceivably be outwash or reworked outwash, it almost certainly is much younger that the 328,000- to 220,000-yr estimated age of the Indian glaciation (Swanson *et al.*, 1993, Table 1).

Unit Qgi at site P2C15 is at the junction of the valleys of Chiatovich and Davis creeks against the valley wall (Fig. 1). From topographic contours, the surface of unit Qgi here stands more than 25 m above the surface of the northern area of Qgi. Around site P2C15, the deposit is small and poorly exposed. South of this site, the deposit is thin and bedrock is locally exposed; north of the site, the deposit appears to be at least 15 m thick. It is littered with subangular to subrounded boulders 2 m or more in diameter and hence might be interpreted as old till; however, it also appears to have remnants of a planar surface, suggesting alluvium deposition. The surface boulders are much more weathered than those of the northern Qgi deposit. The surface of the southern deposit of Qgi is about 40 m above the modern stream channel. This height is significant because it is the same as that of the top of unit Qg of Reheis *et al.* (1993a) above Middle Creek to the north (Fig. 1). At locality 160- and 161-MI, lenses of Glass Mountain (~1,000,000 yr) tephra and probable Bishop ash (770,000 yr) separated by a buried soil occur within a 13-m-thick section of alluvium, mostly subrounded to well-rounded pebble to cobble gravel and sand. The alluvium is overlain by 3 m of bouldery debris flows. A bouldery, poorly exposed outcrop of unit Qg to the east (locality 166-MI) also contains a lens of Glass Mountain tephra near its base. A third outcrop of unit Qg at Dry Creek, 2 km north of the map edge, exposes moderately sorted, crossbedded pebbly sand containing Bishop ash (Reheis *et al.*, 1993a) overlain by debris flows with boulders more than 2 m in diameter. All of these sites were shown and discussed by Reheis *et al.* (1991, Fig. 4, pp. 12–14), although tephra correlations have been refined since then. Because Chiatovich and Middle creeks join a few kilometers downstream of site P2C15 and locality 160- and 161-MI (Fig. 1), incised depositional surfaces at the same height above these streams should be similar in age. Thus, the southern deposit of Qgi (site P2C15) of Swanson *et al.* (1993) may be correlative to unit Qg of Reheis *et al.* (1993a), which is early Pleistocene to early middle Pleistocene in age.

A third mapped deposit of the Indian glaciation includes soil site P3C18 (Fig. 2 of Swanson *et al.*, 1993), west of the previous two deposits and beyond the area of Figure 1. This deposit appears to consist mostly of side-slope fan and colluvial sediment graded to a level below the upper surface of the deposit at site P2C15, but possibly a somewhat higher level than the deposit at site P5C14. At site P3C18, the mapped deposit appears to be older than that at site P2C15 based on clast weathering. The morphology of the deposit at site P3C18 on a topographic map and aerial photographs suggests that it is a debris cone or small tributary fan deposited against the valley wall by a steep north-flowing stream. This interpretation is supported by the observation that the clasts are nearly all of one lithology, a low-biotite quartz monzonite like the bedrock farther upslope (unit Kab on Swanson *et al.*'s map). If it were a mainstream deposit, it should contain abundant clasts of hornblende-biotite adamellite and granite (unit Jag on their map) that dominate the bedrock in the headwaters of South Fork Chiatovich Creek.

In summary, I believe that the three downvalley deposits of the middle Pleistocene Indian glaciation mapped by Swanson *et al.* include at least two different alluvial and colluvial deposits possibly ranging from early Pleistocene to early late Pleistocene in age. Moreover, where best exposed, these deposits are many meters thick and do not represent "residual bedrock surfaces" as repeatedly stated by Swanson *et al.* (1993, pp. 191–193 and Table 3).

Less Critical Mapping Problems

The andesite of Davis Mountain, unit Qta of Swanson *et al.* (1993, Fig. 2), is Tertiary in age (Reheis *et al.*, 1993a). K-Ar ages of 3–4 myr were reported and discussed by Reheis *et al.* (1991, Table 1, pp. 32 and 40).

The northwest-striking fault shown on the same figure is internally inconsistent. The fault is shown to offset both unit Qa (undifferentiated alluvium) and deposits of the Perry Aiken glaciation (both outwash and moraines) near the South Fork Chiatovich Creek, but is buried by these same units to the north. I have mapped (Fig. 1 and Reheis *et al.*, 1993a) other parallel faults west of the range front, but the throw of these faults is down to the east (opposite to the fault in question) and they have been mostly inactive during the Quaternary.

IMPLICATIONS FOR SOIL INTERPRETATIONS

The purpose of Swanson *et al.*'s paper is to show age-related changes in properties of soils formed on glacial deposits. I believe that the downvalley deposits attributed to the Indian glaciation are of two or more ages and origins. If my interpretations are correct, they help to explain inconsistencies in the published data.

These inconsistencies are obscured because the figures and tables in Swanson *et al.* (1993) show data only for selected soil profiles and commonly display data from different profiles for each type of analysis. For example, four of the soil profiles in unit Qgi are described as shallow soils formed on residual bedrock surfaces. Particle-size data are shown for two of these soils (Fig. 7) and Fe and Al data for all four (Table 3), but their profile development index (PDI) values are neither discussed nor used in the calculation of the PDI rate curve (Fig. 12, Swanson *et al.*, 1993). In fact, this curve is based on data for only 8 of the 19 soils in Table 3 and of the 26 sites shown on Figure 2, not counting two sites on "erratics of the Dyer glaciation." This selective display makes it impossible to assess soil variability or problems due to other factors. Perhaps the authors did not use the PDI data for the downvalley soils on unit Qgi because they thought that erosion caused the development of these soils to be weaker than it should be for the estimated middle Pleistocene age of the Indian glaciation. However, my mapping suggests that one of these profiles (P5C14) formed on alluvium of late Pleistocene age and another (P2C15) formed on gravelly deposits as old as early Pleistocene. Hence, variations in the age of the deposits may be partly responsible for anomalous trends in the data.

The soils discussed by Swanson *et al.* apparently formed on a variety of materials. My mapping indicates that downvalley "deposits of the Indian glaciation" are mostly alluvium. In contrast, deposits mapped as drift of younger glaciations higher in the valley of the South Fork Chiatovich Creek appear to be mostly till at the soil sites (Fig. 2, Swanson *et al.*, 1993). Although the authors discuss possible differences in the mineralogy of the soil parent material (p. 187), they do not discuss differences due to deposit type. Thus, it is possible that the downvalley soils on unit Qgi, noted as having twice as much clay as soils on till of the next younger glaciation (p. 193), could have formed on debris flows with more initial clay than in till or outwash. This possibility cannot be assessed because no data are shown for particle size of horizons deeper than the Bt or BCt horizons of soils on Indian "glacial deposits."

In summary, my interpretations suggest that trends in soil development presented by Swanson *et al.* are based on data from different types of deposits. Downvalley sites on "deposits of the Indian glaciation" appear to be located on alluvium that may range in age from early to late Pleistocene. No soils are reported for deposits of the "Dyer glaciation," but "glacial erratics of the Dyer glaciation" consist at one site of erratic boulders of unknown origin and at another site of Tertiary fluvial deposits interbedded with volcanic rocks. The type locality of this "glaciation" near Dyer, Nevada, is composed of several different alluvial-fan deposits ranging in age from more than 770,000 yr to possibly as young as 35,000 yr.

That we have conflicting opinions about the origins and ages of the deposits in the lower valley of Chiatovich Creek is not surprising. However, the authors do not acknowledge the existence of divergent opinions, despite knowledge of these other opinions from several previous communications and despite the fact that our publications contain radiometric ages and tephra identifications that have direct bearing on their work.

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