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LETTERS TO THE EDITOR

Comment on "Pleistocene Glaciation of Volcano Ajusco, Central Mexico, and Comparison with the Standard Mexican Glacial Sequence" by Sidney E. White and Salvatore Valastro, Jr.

The observations of a Pleistocene glacial sequence for volcano Ajusco that includes deposits of three glaciations, two Neoglacial advances, and associated periglacial activity by White and Valastro (1984) is no doubt an important addition to the "Standard Mexican glacial sequence."

The purpose of this letter is to call attention to some reconstructions of the late Quaternary glaciations of the highest volcanoes of the Cordillera Neovolcánica de México. Apart from the standard Mexican glacial sequence published by White (1962 a, b) two decades ago, a chronostratigraphy based on comprehensive research on La Malinche Volcano, Pico de Orizaba, Iztaccíhuatl, Popocatépetl, and Nevado de Toluca volcano has been elaborated (Heine, 1971, 1973a, b, c, 1975, 1976a, b, 1978, 1980, 1983a, b, 1984; Heine and Ohngemach, 1976). Different late Quaternary stratigraphic successions for each volcano can be recognized within the area (Fig. 1). The slopes of the volcanoes are dissected by barrancas (erosion gullies), radiating from the upper parts of the forest belt and descending to the basins. Thus the stratigraphic successions can easily be traced from one barranca to another by different layers of glacial and periglacial deposits, paleosols, debris, fluvial gravels and sands, and loess-like so-called "toba" sediments which are interbedded with tephra (the term tephra pertains to all pyroclastic fragments, such as fine and coarse ash, lapilli, volcanic bombs, and blocks), lava flows, and ignimbrite deposits. Different tephra layers as well as some paleosols are of great use as stratigraphic markers within the late Quaternary deposits of the volcanoes. In determining the stratigraphic succession of tephra, both field characteristics and laboratory examinations were carried out. Radiocarbon dating of tephra layers has been restricted to charcoal logs and branches imbedded in the volcanic deposits. In addition to these data paleosols, wood fragments from gravels, peat, and calcrete (caliche) deposits were dated by radiocarbon. Other age determinations of the late Quaternary deposits are being attempted through studies in archaeology and prehistory. Pollen studies in cores of sediments in small volcanic craters, maars, and lakes (Ohngemach and Straka, 1983) cover the time span of approximately 35,000 to 0 yr BP. The results are compared with the chronology of the glacial deposits. Furthermore, relative age-dating methods have been used to demonstrate age differences in the till sequence; such relative dating methods include topographic position, morphologic shape of the moraines, rock-weathering parameters, thickness of eolian "toba" sediments, soil properties (Miehlich, 1974), and vegetation cover (including lichen data of Holocene glacial and periglacial deposits).

The chronology of the late Quaternary glacial deposits is summarized in Figure 2. Tills with poorly preserved moraine forms are those of the M I glacier advance between 36,000 and >32,000 yr B.P. and of tills deposited during the M II glaciation about 12,000 yr B.P. Lateral and end moraines deposited during the M III glaciation between 10,000 and 8500 yr B.P. show well-preserved morainal forms, as do the Holocene Neoglacial deposits which are divisible into two advances (M IV; 3000–2000 yr B.P.; M V, Little Ice Age). In the cor-

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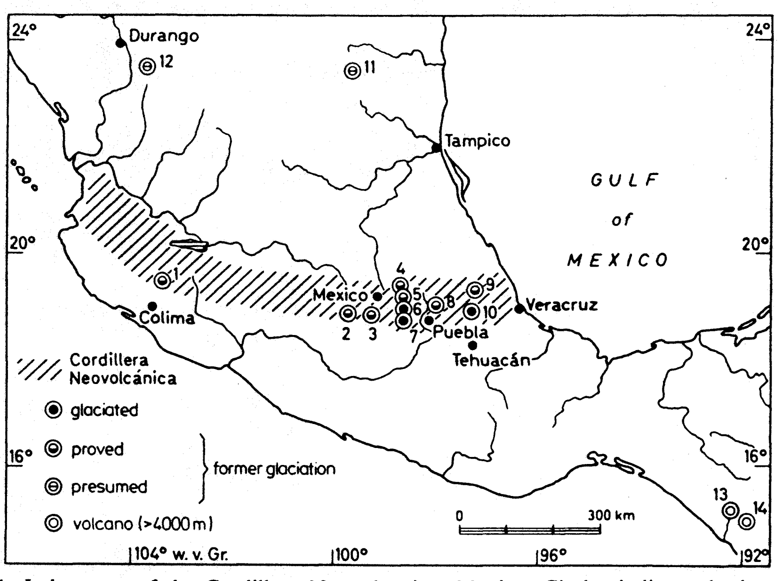

FIG. 1. Index map of the Cordillera Neovolcánica, Mexico. Circles indicate the location of the volcanoes: 1, Nevado de Colima; 2 Nevado de Toluca; 3, Ajusco; 4, Tláloc; 5, Telapón; 6, Iztaccíhuatl; 7, Popocatépetl; 8, La Malinche; 9, Cofre de Perote; 10, Pico de Orizaba; 11, Cerro Peña Nevada; 12, Durango mountaneous area; 13, Tacaná; 14, Tajumulco.

relation diagram (Fig. 2) most geologic–climatic unit boundaries are based either on maximum or minimum radiocarbon dates or on relative-age criteria. In most cases radiometric controls are very reliable and the presented boundaries will likely not be shifted on the time bar.

Comparisons of the standard Mexican glacial sequence (White, 1962a, b) and the Pleistocene glacial sequence for volcano Ajusco (White and Valastro, 1984) with our above-mentioned late Quaternary chronostratigraphy suggest that certain glaciations on Ajusco compare with those on other volcanoes of the Cordillera Neovolcánica de México. The Marqués glaciation probably is equivalent to an early M I glacier advance of our stratigraphy and thus may be dated to about 36,000 to >32,000 yr B.P. The Santo Tomás glaciation on Ajusco, too, appears to be equivalent to the M I glaciation, because in the Santo Tomás till, well-developed soil profiles have formed; this soil formation is similar to our fBo1 paleosol with an age of 26,000 to about 16,000 yr B.P. The Albergue glaciation equals the M III glaciation, which means that the Albergue glaciation can be dated between 10,000 and 8500 yr B.P. These data are in good agreement with the observation by White and Valastro (1984). The two Neoglacial advances on Ajusco are matched with the M IV glaciation of around 3000 to 2000 yr B.P. according to the height of the moraines above sea level (Heine, 1976b).

In an effort to determine radiocarbon ages of the glaciations on Ajusco volcano, organic matter in buried soils was obtained from different exposures by White and Valastro (1984). According to them the radiocarbon ages appear to provide minimum ages for the Marqués glaciation and for an advance and retreat of the Santo Tomás glaciers because of possible unrecognized contamination (p. 28). According to our experience with buried soils, the reliability of radiocarbon ages is relatively good. So, if we put the stratigraphic units with the given radiocarbon ages of Ajusco volcano into our chronostratigraphy (Fig. 3), the radiocarbon ages fit very well, apart from the

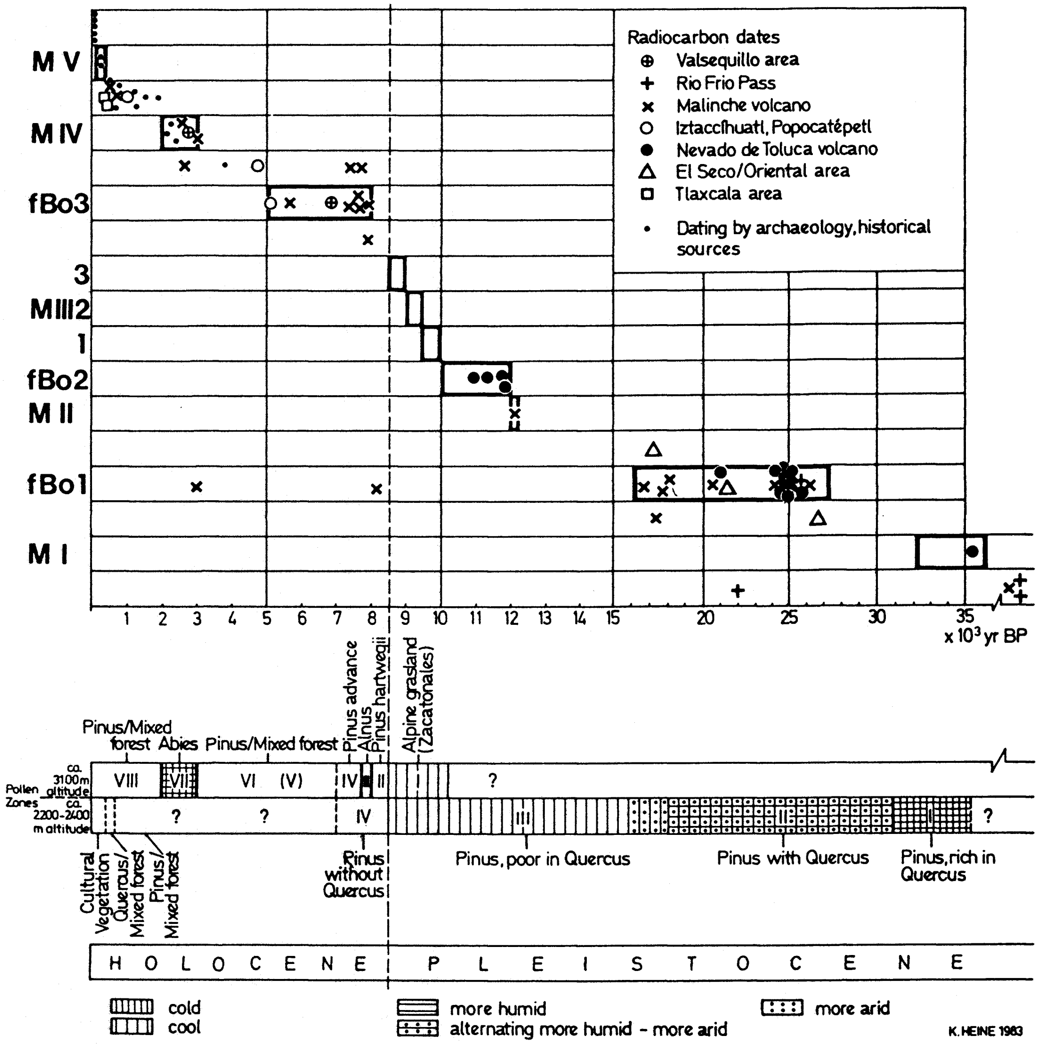

FIG. 2. Correlation diagram. Geologic–climatic unit boundaries are based on radiocarbon ages, tephrochronologic correlations, soil development, pollen analyses, sedimentologic criteria, and topographic position. The pollen zones refer to Ohngemach and Straka (1983). Till and/or moraines of the glaciations are numbered: M I, M II, M III (1, 2, 3), M IV, and M V. The paleosols are fBo1, fBo2, and fBo3.

section D (volcanic and colluvial deposits and Marqués till in Valle de Doberman). If we assume that in section D the exposed till does not belong to the Marqués glaciation, the radiocarbon age of about 27,000 yr B.P. is equivalent to our fBo1 paleosol and must not be considered a minimum age because of contamination.

The difference between the greater number of glaciations on the higher volcanoes in the east than on Ajusco is understandable in terms of the difference not only in size and height (White and Valastro, 1984) but also in distance from the Gulf of Mexico. Our M II glacier advance occurred around 12,100 yr B.P., but only on the high volcanoes east of the basin of Mexico (Heine, 1983a, 1984); the M II glacial episode is characterized by a short duration of presumably less than 200 yr and was caused

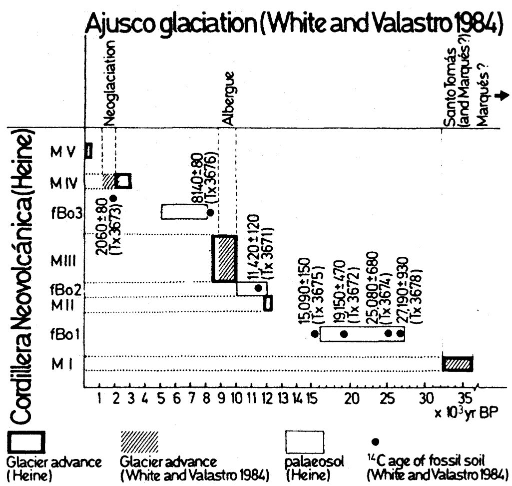

FIG. 3. Preliminary comparison of the Ajusco glacial sequence (White and Valastro, 1984) with that of the Cordillera Neovolcánica.

by intense precipitation rather than by a temperature decrease. The nonexistence of the M II glaciation on Ajusco confirms our observations. The M V glaciation of the Little Ice Age affected only the volcanoes with altitudes over 4000 m (Heine, 1976b). Thus, the M I glaciation, the M III glacier advances, and the M IV glaciation are represented by moraines and/or tills on Ajusco; these three mentioned glaciations are also well recorded on the pollen diagrams (Ohngemach and Straka, 1983).

Finally, I suggest that all conclusions should be considered preliminary. Nevertheless, our work has uncovered data about the late Quaternary Mexican glacial sequence that are not discussed by White and Valastro (1984). I feel it worth mentioning our results because they require reevaluation of the standard Mexican glacial sequence presented by White and Valastro.

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KLAUS HEINE
Lehrstuhl Physische Geographie
Universität Regensburg
D-8400 Regensburg,
Federal Republic of Germany