very large comets may have masses on the order of 10^{19} g and could thus make a significant contribution to the content of the Martian atmosphere, given suitable impacts (*4*).

Finally, the presence of water vapor in the atmosphere of Mars does not imply that liquid water exists on the planet's surface. The reason is evident from inspection of Fig. 2, which is a phase diagram of water. At the likely range of values for the Martian surface pressure (5 to 12 mb) there is only a very restricted temperature domain in which liquid water will be stable.

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References and Notes

1. H. Spinrad, G. Münch, L. D. Kaplan, *Astrophys. J.* **137**, 1319 (1963).
2. L. D. Kaplan, G. Münch, H. Spinrad, *ibid.* **139**, 1 (1964).
3. R. A. Schorn, H. Spinrad, R. C. Moore, H. J. Smith, L. P. Giver, *ibid.* **147**, 743 (1967).
4. T. Owen, *ibid.* **146**, 257 (1966).
5. R. B. Leighton and B. C. Murray, *Science* **153**, 136 (1966); B. T. O'Leary and D. G. Rea, *ibid.* **155**, 317 (1967).
6. Actually, of course, it is the solar lines that are displaced as a result of reflection by the moving planet. The terrestrial lines have identical positions in the two sets of observations since they are formed in our own atmosphere, at rest with respect to the observer. There is no evidence on these spectrograms for a Fraunhofer line at 8189 angstroms, suspected in earlier work on Venus [T. Owen, *Astrophys. J.* **150**, L121 (1967)]. Such a line would have to have an equivalent width less than 2 milliangstroms, to escape detection and thus seems an unlikely explanation for observations of water vapor absorption on Venus reported at this wavelength.
7. L. Delbouille and G. Roland, *Photometric Atlas of the Solar Spectrum from λ7498 to λ12016* (Memoires de la Societe Royale des Sciences de Liege, special vol. 4, Liege, Belgium, 1963).
8. D. H. Rank, U. Fink, J. V. Foltz, T. A. Wiggins, *Astrophys. J.* **140**, 366 (1964).
9. P. A. Jansson and C. L. Korb, *J. Quant. Spectros. Radiative Trans.* **8**, 1399 (1968).
10. M. J. S. Belton, A. L. Broadfoot, D. M. Hunten, *J. Geophys. Res.* **73**, 4795 (1968); T. Owen and H. P. Mason, *Proceedings of the Symposium on Physics of the Moon and planets*, Kiev, U.S.S.R., 15 to 22 October 1968, in press. One meter-atmosphere is the amount of gas in a path 1 m long at atmospheric pressure and a temperature of 273°K.
11. D. H. Rank, personal communication. See also D. H. Rank, B. S. Rao, P. Sitaram, A. F. Slomba, T. A. Wiggins, *J. Opt. Soc. Amer.* **52**, 1004 (1962).
12. G. Fjeldbo, W. C. Fjeldbo, V. R. Eshelman, *J. Geophys. Res.* **71**, 2307 (1966).
13. We thank Dr. H. J. Smith for the opportunity to use the facilities of the McDonald Observatory and Dr. A. A. Hoag for the opportunity to use the facilities of the Kitt Peak National Observatory. Kitt Peak National Observatory is operated by the Association of Universities for Research in Astronomy, Inc., under contract with the NSF. Supported by NASA under contract No. NASW 1863. Contribution from the Kitt Peak National Observatory No. 458. McDonald Observatory Contribution No. 446.
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Glossopterid Leaves from the Middle Jurassic of Oaxaca, Mexico

Abstract. *Leaves indistinguishable from those of the late Paleozoic genus* Glossopteris *occur in Middle Jurassic beds in the State of Oaxaca, Mexico. If they are biologically related to the Permo-Carboniferous* Glossopteris, *the occurrence in Mexico is the latest report of the genus. Alternatively, these leaves may have belonged to another group of plants with foliage similar to that of* Glossopteris, *but with a different reproductive structure.*

Plants of the genus *Glossopteris* are important constituents of the late Paleozoic Gondwanaland floras, now found as fossils in Southern Hemisphere continents and India. The disjunct distribution of *Glossopteris*, along with that of other plant and animal genera, is one of the pieces of evidence used to indicate that once continuous biota became separated by a pulling apart of continental masses.

According to some workers, the distribution of fossil *Glossopteris* is not confined only to those regions cited above. There are reports of the occurrence of *Glossopteris* leaves from the Upper Permian of northern Russia (*1*) and the Rhaetian (uppermost Triassic) of Tonkin (*2*) and east Greenland (*3*). Florin (*4*) and Harris (*5*) subsequently suggested a cycadean relation of the Rhaetic leaves.

Wieland (*6*) reported on a flora from the Mixteca Alta in the State of Oaxaca, Mexico; he considered these deposits to be Liassic (Lower Jurassic) in age. Among the plant remains, the most abundant are leaves of cycadophytes, principally of the genera *Otozamites* and *Pterophyllum*. Williamsonian cones were also found, as well as ferns of the genera *Sphenopteris, Coniopteris, Cladophlebis*, and others. In his report Wieland figured entire, spatulate leaves that he tentatively identified as *Glossopteris*. He had only a few leaves, and his identifications were uncertain, as witnessed by the question marks used with the generic name. In fact, it is impossible to determine the nature of the venation in his specimens. In addition to the presumed *Glossopteris*, Wieland also figured a few foliar structures identified as *Sagenopteris*. In no case, however, was there more than one blade attached to a compound leaf.

I have recently resumed collecting plant fossils in localities quite close to those of Wieland (*7*). Plants are derived from coarse sandy shales of the Zorrillo and Simón formations, both Middle Jurassic and separated by the Taberna Formation which includes Jurassic ammonites (*8*). The flora is also typically Middle Jurassic, comparable to that reported by Wieland. These recent collections yielded hundreds of compressed leaves of the *Glossopteris* type. Preservational details are fine enough to allow a precise comparison with *Glossopteris*. The longest complete leaf measures close to 40 cm in length (Fig. 1A), although certain incomplete specimens (Fig. 1B) suggest that some of the leaves are even longer. The smallest entire specimen is 7 cm long (Fig. 1C), and slightly more than 2 cm wide at the broadest part. Some of the large leaves may exceed 7 cm in width. Lateral veins diverge from the midrib at angles ranging from almost 90° to about 45°. There is considerable variation in this angle even in the same leaf, with those near the base and apex arising at a steeper angle than those near the middle of the leaf. Anastomoses are not frequent, but are consistent (Fig. 1D).

There is a range in shape as well, but in all instances the leaf is broadest above the middle. Tips may range from rounded obtuse to acuminate. Intergradations in size and shape are close and it is impossible to detect more than one distinct morphological type. Variation most likely was influenced by age and by the position on the parent plant. It is not possible to recognize more than one grouping of characters, and quite likely only one species is represented. There is no mistaking these glossopterid leaves for the Rhaetic ones from Greenland and Sweden that are now called *Anthrophyopsis* (*5*). Leaves of the latter genus are like those of the cycadean *Ctenis*, except that *Ctenis* is pinnately divided.

An alternative explanation, of course,

is to regard these foliar structures as leaflets of *Sagenopteris*, a common Jurassic seed plant. It is not uncommon to find detached leaflets of *Sagenopteris* that give the appearance of foliage of *Glossopteris*. In such situations, however, there is almost always evidence of at least some of the compound leaves with more than one leaflet attached. Considering the number of leaves found in the Oaxaca beds, the fact that there is no hint of compound sagenopterid foliage seems significant. In fact, I suspect that the "leaflets" of *Sagenopteris* described by Wieland are actually glossopterid foliage.

There are at least two ways to interpret the occurrence of glossopterid leaves in these Middle Jurassic deposits. One is to regard the plants bearing these leaves as naturally related to the assemblage of plants among the Glossopteridaceae, and to consider their occurrence in Mexico as an extension of their distribution both geologically and geographically. Certainly the time difference between the last occurrence of bona fide *Glossopteris* in the southern part of the Western Hemisphere and the Oaxacan occurrence is sufficient to allow such a migration.

A second interpretation is to regard the plants that bore glossopterid foliage as remotely related or completely unrelated to the earlier *Glossopteris*. The leaf form, for one thing, is a fairly simple, generalized type, and it is not inconceivable for this type of leaf to have been borne on plants of more than one group. Certainly the discrepancy in time and distance would tend to make one consider that the Mexican plants most likely belong to a different natural assemblage of plants. In fact, even among the Permo-Carboniferous glossopterids, there are a number of kinds of fruiting structures supposedly attached to plants with glossopterid foliage, further suggesting that more than one natural group of plants were involved.

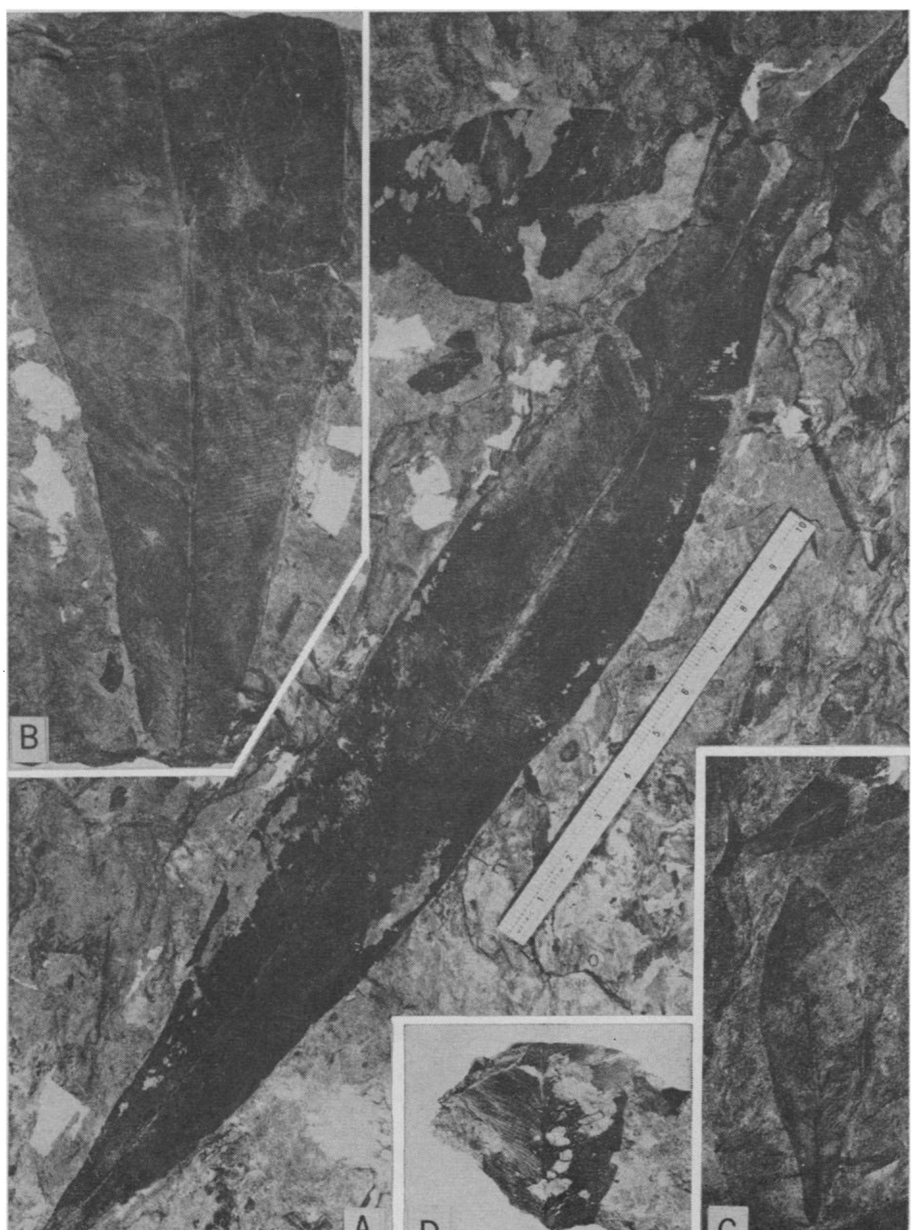

Fig. 1. Middle Jurassic glossopterid foliage from Oaxaca, Mexico (× ⅔). (A) Entire leaf with acuminate tip. (B) Basal portion of a large leaf. (C) Entire small leaf. (D) Portion of leaf with anastomosing lateral veins.

The real proof, of course, depends on a knowledge of the rest of the plant from Oaxaca. If it can be established that the Mexican plants had the same kinds of reproductive structures as those found among certain of the Southern Hemisphere glossopterids, then there will be no doubting their relationships to components of the Gondwana floras. The discovery among the Oaxaca fossils of an unusual type of branched fructification, preliminary studies of which indicate that the fossils might have belonged to the same plants that bore the glossopterid leaves, adds support to the second interpretation.

It must be emphasized, however, that although the Oaxacan fossils represent the latest occurrence of glossopterid leaves in the fossil record the flora in these Middle Jurassic deposits is definitely not a typical Gondwana flora. In all other respects it possesses typical Middle Jurassic components, similar to those found in Yorkshire, England, and the Rajmahal Hills, India.

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References and Notes

1. V. Amalitzky, *Comp. Rend.*, p. 131 (1901).
2. R. Zeiller, *Étud. Gîtes Min. Fr.* (1902–1903).
3. T. M. Harris, *Medd. Grønland* **85**, part 3 (1932).
4. R. Florin, *Kgl. Svenska Vetenskapsakad. Handl. Ser. 3* **12**, part 5 (1933).
5. T. M. Harris, *Medd. Grønland* **112**, part 2 (1937).
6. G. R. Wieland, *Bol. Inst. Geol. Méx.* **31** (1914–1916).
7. T. Delevoryas, *Discovery* **2**, part 1 (1966).
8. H. K. Erben, *20th Congr. Geol. Int. Publ.* (1956).
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