SECONDARY PHLOEM TISSUE PRESERVED AS CHARCOAL FROM THE LOWER PERMIAN OF THE BRAZILIAN PARANA BASIN (RIO BONITO FORMATION)

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ABSTRACT: The preservation of fossil wood is enhanced by the presence of lignin in the xylem tissue. The occurrence of phloem tissue in the fossil record is rare because its preservation is hindered by the thin-walled structure of the conducting cells, the physical instability favoring the collapse of the sieve cells following damage and the generally insubstantial phloem production by the cambium. Furthermore, Paleozoic stems are frequently decorticated, precluding secondary phloem observation. During a wildfire the phloem tissue can deteriorate or solidify, generating a formless mass of glassy charred tissue. However, good preservation occurs if the plant tissues have been slowly dried prior to charring. Specific environmental conditions are thus required to yield informative charcoalified plant material. The study area comprises the Faxinal Coalfield, a former opencast mine located at the southeastern outcrop belt of the Rio Bonito Formation of the Paraná Basin, Rio Grande do Sul state, southern Brazil (30°15′52.6″S, 51°41′53.8″W), where the peat accumulated under post-glacial conditions during the Late Paleozoic Ice Age. A tonstein bed dated at 291 ± 1.3 Ma, corresponding to the late Sakmarian, is interlayered in the upper coal seam (S) and contains abundant compressed fossil leaves of the *Glossopteris* Flora. Charcoalified wood fragments come from the coal associated with the base and the top of the tonstein bed. The lower charcoal horizon contains highly compressed charred logs (fusain transition fossils) up to 21.8 x 13.4 cm, indicating that the woody vegetation burned in growth position during extensive, low temperature surface wildfires. The upper charcoalified material is mostly composed of smaller fragments up to 16.4 x 5.7 cm. The material has been analyzed under scanning electron microscopy and identified as *Agathoxylon* Hartig. It showed homogenized cell walls, indicating burning temperatures higher than 325ºC, but not higher than 400ºC given the low reflectance values and the preservation of fragile plant tissue. The phloem tissue is composed of thin-walled sieve cells, thick-walled fibers, and axial and radial uniseriate parenchyma. The extraordinary preservation shows sieve cells with pores grouped in conspicuous sieve areas occurring on lateral cell walls. Sieve cells are inferred to be arranged in tangential layers alternating with mixed rows of fibers and scarce parenchyma. The preservation of secondary phloem in organic association with the gymnospermous *Agathoxylon* wood-type is a first paleobotanical record for this fossil-genus. The smaller fragments from the upper horizon are mostly composed by secondary phloem only and probably represent bark layers shed during less intense fire events. This xeromorphic pattern has been reported for Antarctic glossopterids and is related with adaptative responses to the frequent environmental disturbances affecting the forest, such as recurrent wildfires due to environmental dryness.

Keywords: Macroscopic charcoal, Fusain transition fossils, Coal-forming environment, Paleowildfires, *Glossopteris* Flora.