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Weltrichia sp. from the Late Triassic Amisan Formation of Nampo Group, Korea

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Abstract: Since 1984, the author has been studying the Daedong flora and has collected a large number of fossil plants from the Amisan Formation of Nampo Group distributed in Chungnam Coal-Field. One of the fossil plants was bennettitalean male flower, which was collected in 1986. The author described it as *Weltrichia* sp. The occurrence of *Weltrichia* sp. is the first record in the Early Mesozoic Daedong flora of Korea.

Keywords: Amisan Formation, bennettitalean male flower, *Weltrichia*

Introduction

Bennettitales are well represented in the Mesozoic fossil floras of Europe, Asia and North and South America by vegetative and reproductive remains of extinct genera (Oishi, 1940; Harris, 1969; Watson and Sincock, 1992; Barboni and Dutra, 2013). The plants included in the Bennettitales extend from the Triassic to the Cretaceous and occur in both hemispheres (Talyor et al., 2009). However, recently McLoughlin et al. (2011) reported *Ptilophyllum muelleri* (Ettingshan) comb nov. from the Oligocene of Australia as a last of the Bennettitales. The presence of bennettitalean leaves in the Cenozoic beds of Australia indicates that they were a few survivors from the Mesozoic flora in the Gondwana land as a relic. If the result of study of McLoughlin et al. (2011) is accepted here, the stratigraphic range of Bennettitales extends from the Triassic to the Oligocene of Cenozoic.

The reproductive organs of the Bennettitales include both monosporangiate and biosporangiate forms as mentioned by Taylor et al. (2009), The former includes male reproductive organs of *Weltrichia* Braun and female reproductive organs of *Williamsonia* Carruthers, and the latter are grouped in *Williamsoniella* Thomas (Harris, 1969; Barboni and Dutra, 2013).

Weltrichia is the name assigned to pollen bearing organs of the Williamsiniaceae belonging to Cycadeoidales or Bennettitales (Delevoryas, 1991; Talyor et al., 2009). They were originally included within the genus *Williamsonia*, but Harris (1969) transferred these pollen bearing organs to the genus *Weltrichia* Braun (Delevoryas, 1991).

So far as is known twenty one species of *Weltrichia* have been described from the Upper Triassic to the Lower Cretaceous beds in the Northern and Southern Hemispheres (Li et al., 2004; Pineda et al., 2011).

In Asia the occurrence of *Weltrichia* was very rare, three species has been known in the Upper Triassic to the Jurassic strata (Li et al., 2004). Despite the large number of bennettitalean leaves from the Daedong Supergroup of Korea (Oishi, 1940; Kim, 1993, 2001), the fossil record of *Weltrichia* have not been known.

Since Kawasaki's (1925, 1926, 1939) monographs were published, some short papers on the plant fossils of the Nampo Group have been published by several authors (Kim, 1989, 1990, 2001; Kim and Kimura, 1988; Kim et al., 2004, 2005; Kim and Roh, 2008; Kimura et al., 1982; Kimura and Kim, 1988, 1989).

This paper deals with the description of *Weltrichia* sp. first found in the Amisan Formation of Nampo Group. The specimen here examined will be kept at

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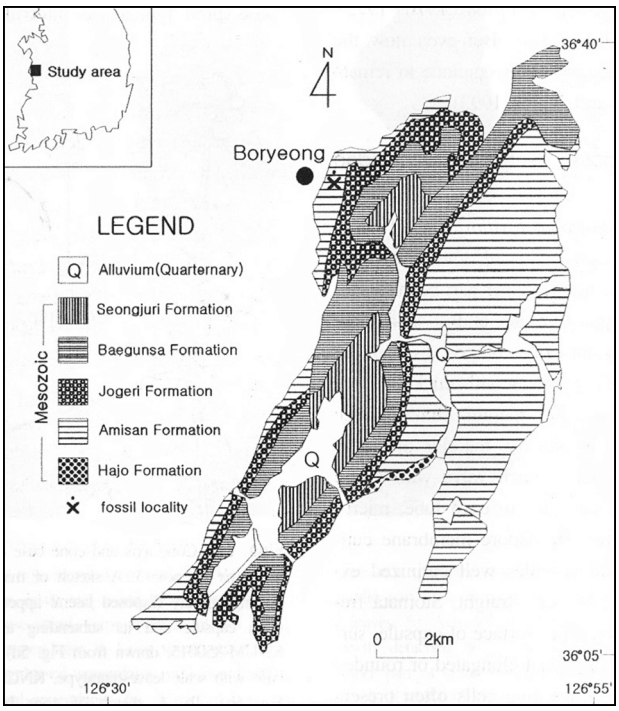

Fig. 1. Geological map of study area (after Suh et al., 1980, modified in part) and fossil locality.

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Stratigraphy

The Nampo Group is distributed in the Chungnam Sedimentary Basin of southwestern part of the Chungcheongnam-do, and consists of a 3,000 m thick sequence of terrestrial sediments (Reedman and Um, 1975).

Since Shimamura's (1931) geological investigation on the Chungnam Sedimentary Basin, some geological studies were carried out by Korean geologists. The correlation of stratigraphic sequence of the Nampo Group was made by Suh et al. (1980). According to Suh et al. (1980), the Nampo Group is subdivided into five formations, i.e., the Hajo, Amisan, Jogyeri, Baegunsa and Seongjuri Formations in ascending order. The main fossil locality is shown in Fig. 1.

Recently, facies analysis of the Hajo Fotmation was made by Lee and Chung (2010). According to them, the Hajo Formation is interpreted to have been deposited at the talus/upper fan delta environment in early stage; it might have been deposited in the alternating environments of upper and middle fan delta in middle stage, and it seems to have been deposited in alternating environments of middle and lower fan delta in late stage.

The geological age of the Amisan Formation based on the fossil plants and conchostracans has been considered to be the Late Triassic (Kimura and Kim, 1984, 1988, 1989; Kobayashi, 1975; Kim, 1993). However, recently Egawa and Lee (2011) mentioned that the age of the Nampo Group is middle Jurassic (157-140 Ma) which is based on the K-Ar dating of illites collected from the Amisan Formation. Accordingly, both the results of palaeontological study and K-Ar dating do not correspond with each other.

Systematic description

Genus: *Weltrichia* Braun 1847 emended Harris 1969

Type species: *Welterichia mirabilis* Braun 1849

Weltrichia sp.

Fig. 2. Fossil male flower of *Weltrichia* sp. (Reg. no. AM-431) occurred from the Amisan Formation.

Description: Specimen is preserved as impression state. The specimen consists of a massive cup more or less obliquely compressed, 2.9 cm in diameter dividing above into equal lobes; the depth of cup is uncertain, because the basal part of cup is missing. Preserved lobes are 10 in number, but originally they are supposed to be 14 in number, exceeding 1.2 cm in length and 4 mm in width. Apex of lobe is not known. Margins are entire. No appendages are recognized.

Material: Reg. no. AM-431.

Locality: Inkstone quarry of Myeongam, Dongdae-dong, Boryong-si, Chungcheongnam-do, Korea (36°20'08"N, 120°37'40"E).

Distribution and occurrence: In the Nampo Group, a single specimen was obtained from one locality of the Amisan Formation.

Remarks: The general features of this flower are safely referable to the male flower of *Weltrichia* redescribed by Harris (1969) from the Jurassic Yorkshire beds. According to Harris (1969), bennettitalean male flower consists of a massive cup dividing above into numerous lobes. Inner side of cup bearing pollen sacs, pollen sacs where are known consisting of two equal valves, each valve with a single row of microsporangia opening on to inner face. However, The present flower is represented by its reverse side, So that the auther could not observe such appendage as pollen sacs supposed to be seen on the adaxial side of their lobes. Due to lack of details of the microsporangia it cannot be assigned a new or existing species. Accordingly the author regard it as *Weltrichia* sp.

This flower closely resembles in number of lobe and size that of *Weltrichia* sp. described by Kimura and Ohana (1989) from the Upper Jurassic Oginohama Formation of Japan.

Discussion

As mentioned by Watson and Sincock (1992), Harris (1969) revived the use of the neglected genus *Weltrichia* for bennettitalean male flowers, at the same time restricting use of the genus *Williamsonia* to female flowers. The taxonomic diversity of *Weltrichia* has been recognized in the Triassic to the Cretaceous, but it appears to be more abundant to the Jurassic (Stewart and Rothwell, 1993).

According to Li et al. (2004), and Pineda et al. (2011), seventeen species of *Weltrichia* have been found in the Jurassic Yorkshire beds of England, Rajmahal beds of India, and the Jurassic beds of Mexico. Among them, *Williamsonia mexicana* was originally described by Wieland (1914-16) from the Jurassic of Mexico, and later it has been transferred to the *Weltrichia mexicana* by Harris (1969). Delevoryas and Gould (1973) reexamined the specimen of *Weltrichia mexicana,* and mentioned that *W. mexicana* is not a cone. At any rate most species have been known in the Jurassic beds. However, the fossil record of *Weltrichia* from the Triassic beds is generally very rare, and four species are listed in Table 1 of Li et al. (2004).

Flower is very difficult to be preserved as a fossil to compare with leaves and stems of plants, due to its relatively rare in quantity as well as its lower solidity. Also, the condition of flower being preserved as a fossil is considered the same throughout all the time. Judging from the abundant occurrence of *Weltrichia* in the Jurassic age than the Triassic age, it is inferred that the bennettitaleans might have been quite flourished in the Jurassic age than the Triassic age under warm humid tropical to subtropical climate

around the world. As already mentioned by McLoughlin and Pott (2009b), and Barboni and Dutra (2013), the abundant occurrence of Bennettitales in the Jurassic means it is more correct to call it "the age of Bennettitales", instead of the age of cycads.

Weltrichia is often associated with bennettitalean leave. For example, *Weltrichia pecten* is associated with *Ptilophyllum pecten* leaves. The Korean *Weltrichia* sp. herein described is associated with various types of *Pterophyllum* leaves. However, none of them have been found in organic connection with *Weltrichia* sp.

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