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DENDROLOGICAL CHARACTERISTICS OF SUBRECENT FOSSIL PLANT REMAINS FROM THE UZON CALDERA IN KAMCHATKA (EASTERN RUSSIA)

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Abstract: The article presents fossilized plant remains from the Uzon caldera in Kamchatka for the first time. A problematic plant remain from diatomite, undetermined plant bulbs and several pieces of silicified herbs and wood as small stems and branches were recognized. Based on microscopic structure, one piece of stem was attributed to the genus *Salix* L. All presented fossils are silicified, connected to the former volcanic activity of the Uzon caldera.

INTRODUCTION

The Uzon Volcano forms a part of the Uzon-Geyzer volcano-tectonic depression positioned in central part of the Eastern Volcanic Belt of the Kamchatka Peninsula. The caldera of the Uzon Volcano represents a volcano-tectonic cauldron (9x12 km wide). The relatively flat caldera bottom lies 650 m above the sea level and raises up to 950 m above sea level at the eastern part of the caldera (Fig. 1). The altitude of the highest point of the crater rim is 1617 m above the sea level.

The Uzon Volcano belongs to active volcanoes, in spite of the fact that no historical eruption is known. Recently, the activity of the volcano is expressed by significant heat input from the depth and extensive solfatar activity on thermal fields. The hidden bottom of the caldera is made by basalts and covered by a layer of sediments that consists predominately of humid ash gravels with siltstones and clay beds. The specific structure of the caldera bottom, where the permeable layers are underlain by basalts with low infiltration capability, combined with high amount of rainfalls in this region and significant heat input, led to the formation of an extensive hydrothermal system that involves waters of different composition and temperature (Benning and Mountain 1996).

Heat input, presence of biologically active agents, extensive circulation and mixing of groundwaters and surface waters and a special caldera shape form in the Uzon Caldera a special microclimate, different from the other parts of Kamchatka. In the past, the areas of similar characteristics have been often centres of the death and fossilisation of different organisms. As such places are recently often used for palaeoecological interpretations, it is very important to study recent analogous areas in order to predict the influence of the volcanic and hydrothermal activity on flora and fauna composition.

GEOLOGICAL EVOLUTION OF THE UZON VOLCANO

The following description of geological evolution of Uzon is based on the studies done by Brayceva *et al.* (1968), Averyev *et al.* (1971), Brayceva *et al.* (1974), Karpov (1989), Leonov *et al.* (1991), Neshetaeva *et al.* (1994), Grib (1998), Vergasova *et al.* (1998), Zolotarev *et al.* (1998). The Uzon Volcano started to form during Pleistocene (370 000–750 000 ybf). At that time, a huge shield volcano arose at the region of the recent volcano-tectonic depression. Volcanic products of this volcano represented by olivine-pyroxene and pyroxen-plagioclase basalts are exposed at the western part of the caldera. During Middle and Late Pleistocene number of eruptions destroyed the shield volcano and the caldera has been formed. 225 000–270 000 ybf ago a stratovolcano formed at the western part of the caldera. Basicity of products of the stratovolcano (two-pyroxene basalts with olivine) was lower when compared to the original shield volcano. During upper Late Pleistocene (175 000–225 000 ybf) a cummulative crater producing acid lavas existed at the eastern part. Huge layers of vitric ignimbrites of different colours and structures formed to the south and north of the caldera. Pemza layer (situated recently in the eastern part of caldera) formed in the crater.

Volcanic activity continued in Late Pleistocene (70 000–100 000 ybf) at the western part of the complex. At that time Uzon-Geyzer volcano-tectonic depression and the Uzon cauldron received the recent shape. After decreasing of volcano-effusive activity the caldera bottom was covered by large lakes. Sedimentary fill of the caldera started to form that time (Melekseev *et al.* 1974, p. 181). Lake basins existed in the caldera 40 000–70 000 ybf ago. The caldera recent shape was influenced by great ignimbrite explosions in the western part of the caldera. Buried soils below ignimbrites near the Kronocké Lake were dated to

36 600±1000 ybf (Egorova 1993). Palynological analysis in the layers below ignimbrites at the Bezymjannaja and Unana rivers provided Upper Pleistocene age, corresponding to the Kazancev interglacial age (Egorova 1993).

10 000–30 000 years ago the region was tectonically reactivated and at the east-south-east part of the caldera the dacite cone of the Gora Belaja Hill formed. Acid volcanism of the Gora Belaja Hill was accompanied by the pemza extrusion and the agglomerate flows. In that time also andesite-basalt pyroclastic material was extruded and in result the maar lake Dalnoje formed. Besides the volcanic activity, the lacustrine-fluvial sedimentation continued and recent hydrothermal system has been established. Kraeva *et al.* (1979) described 3 phases of the lake evolution. Tuff layers, sandstones and gravels gradually sedimented in the lakes. The material came from the surrounding cones and caldera walls. During Holocene sedimentary filling changed with climate. Sedimentation of diatoms at the early stages was followed by the clastic sedimentation. Lacustrine-swampy types of sedimentation were also often present. A unique undetermined plant remain (Pl. 1, fig. 1) was found at the Mt. Belaya.

PALAEOBOTANIC AND BOTANIC ENVIRONMENT

Palynological analyses, like analysis of diatoms (Egorova 1993), show floristic changes beginning at the end of the late Pleistocene. Bush and tree pollen associations (*Betula costatae*, *Alnaster* and rarely *Pinus pumila*) prevail (46%) in the basal sediments. Other pollen components are presented by herbs (16%, mostly with Compositae), ferns, *Lycopodium* and moss spores. *Abies* is missing at all. Diatoms represent a slightly temperate assemblage with 98% of eurytherm species and only 1% being supposed to be a south boreal species. The arctic and arcto-boreal species are absent. More temperate assemblage was recorded in the left affluent of the Shumnaya River – south boreal species form 6% of the total diatom assemblage. The diatoms proved the Pleistocene climatic optimum.

Younger sediments, developed around the Khloridnoe and the Fumarolnoe Lakes (places of finds of fossilized wood), contain a peat assemblage typical of colder conditions. Herbs (Cyperaceae, Gramineae, *Artemisia*) prevail in the pollen spectrum (more than 50% of total species number), spores are represented by 32% (with 96% of moss species), trees are completely missing and bush plants form 17% only. This is an assemblage typical of glacial climate. The existence of lakes in the ice vicinity is supposed – wet conditions could be assumed by the presence of *Salix*.

The last glacial climatic phase has been at climax 13 000 –11 000 years before present. Palynological analysis of the buried soil just below the Mt. Belaya shows poor living conditions during the last glacial phase (which could be in relation with the Norilsk phase of northern Siberia and/or with the late Dryas in Europe). The climate is supposed to be dry and cold. Bushes (30%) are represented by *Alnaster* (80%) and *Betula nana* (20%). At the beginning of Holocene, the lake water level decreases and the erosion is apparent. Contemporaneous lakes at the Uzon Caldera are the only relicts of the last glacial phase. Egorova (1993) divided Holocene plant assemblages into five complexes:

I. 10,300–9,200 years before present (ybp) – grass and bush
II. 9,200–6,000 ybp – bush with dominant *Alnaster*, *Betula* forest
III. 6,500–4,500 ybp – *Betula* forest prevails
IV. 4,500–2,500 ybp – bush, *Alnaster*, *Pinus pumila*, *Betula*
V. 2,500– 0 ybp – new phase of *Betula* forest.

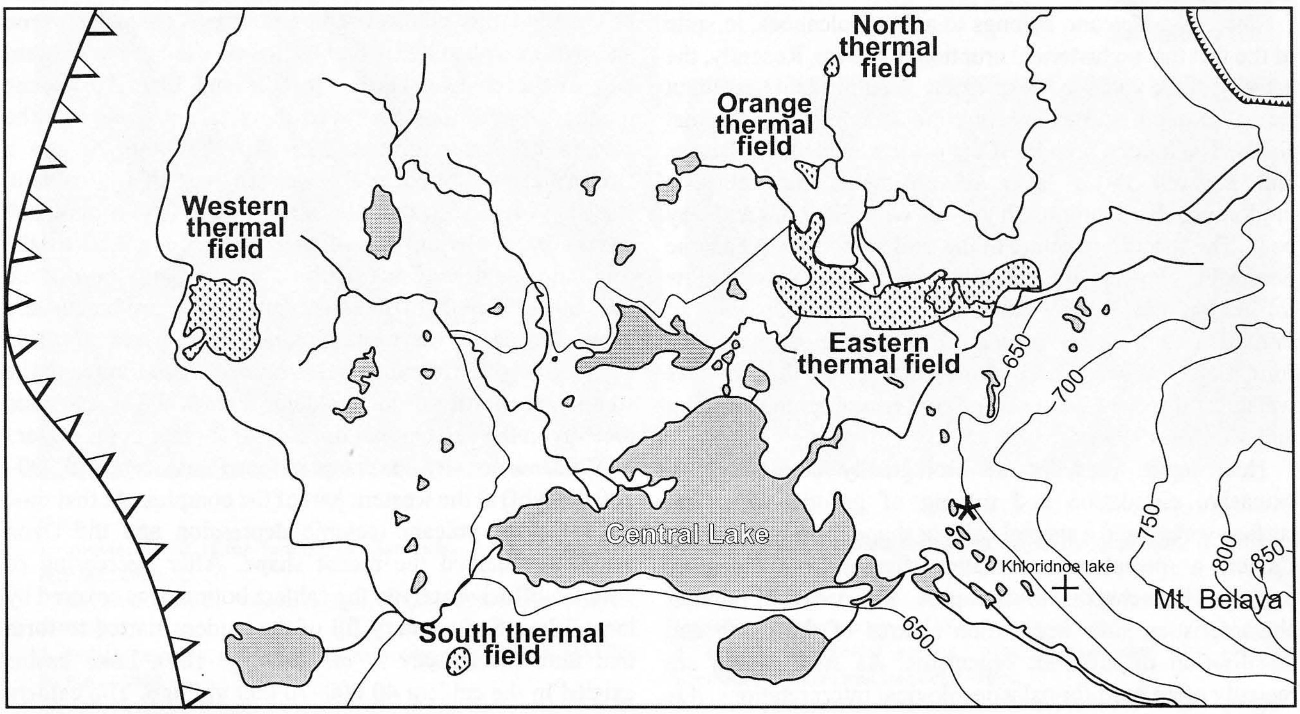

Fig. 1. Schematic sketch of western part of Uzon Caldera in Kamchatka (after Karpov 1989).
★ - mineralized bulbs, + - fossilized wood.

Two/three thousand years before present, the explosion at the Khloridnoe Lake buried a soil horizon (Karpov pers. comm.). However, the radiometric dating shows a large divergence (several thousand years). It is clear that the diagenetic processes and temperature rise changed these data. Palynological analysis of sediments containing fossilised woods and bulbs (see Pl. 1, figs. 4 and 5) show a rise of bush plants (50%–38% *Alnaster*, *Pinus pumila* 20%, *Betula* 36%) and grass 22% (Gramineae, Ericaceae, Cyperaceae). This is a typical assemblage of the IVth complex sensu Egorova (1993).

DENDROLOGICAL CHARACTERISTICS

Our dendrological study deals with a single relatively well preserved piece of fossilized wood.

The piece of wood (No. IGP-Ka. 2000/1) is silicified, 40 mm wide, 70 mm long and light beige in colour. Microscopically, the wood shows a diffuse to semi-ring porous pattern with growth rings 1–3.5 mm wide (Pl. 1, fig. 7). The vessels are round to oval in cross-section, mainly solitary, but also in radial multiples of 2, 3, or rarely of 4. The early wood pores are about 55 μm in tangential diameter, the late wood pores are 20–30 μm in tangential diameter. The vessel elements are limited by simple perforation plates, the intervascular pits are bordered, hexagonal, alternate, quite dense, 7–10 μm in diameter (Pl. 1, fig. 8). The fibres are libriform, polygonal in cross-section, tracheids are missing. The axial parenchyma is apotracheal diffuse. The rays are heterogeneous (Pl. 1, fig. 9), uniseriate (Pl. 1, fig. 8), up to 14 cells (240 μm) high. They are about 20 in number per transversal horizontal mm. The ray cell dimensions (tangential height × tangential width × radial length) are: 8–23 μm × 8–20 μm × 35–75 μm.

The features discussed above, especially diffuse to semi-ring porous wood pattern, simple perforation plates and uniseriate heterogeneous rays, are typical of the genus *Salix* L. (e.g., Schweingrüber 1978). In spite of the fact that this genus is quite reliable, the attribution to a concrete species remains problematic. Therefore, we prefer to leave our determination at the generic level only.

CONCLUSIONS

We presented several fossilized plant remains from the Uzon Caldera of Kamchatka: a problematic plant remain from diatomite (in this area, for the first time in such a type of rock), plant bulbs and silicified herbaceous and wood pieces as small stems and branches. One piece of silicified wood stem was identified as a willow (*Salix* L.).

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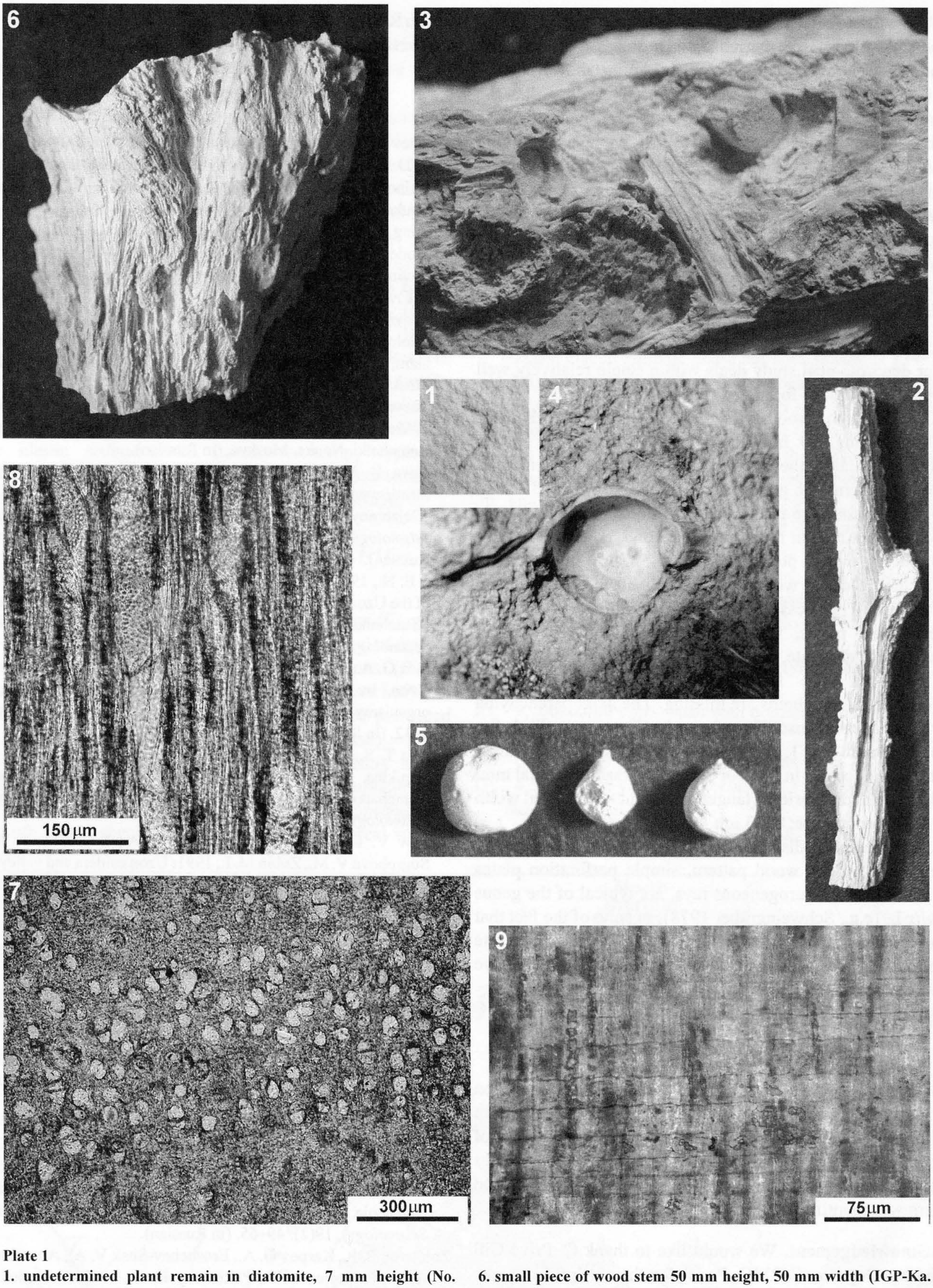

Plate 1

1. undetermined plant remain in diatomite, 7 mm height (No. IGP-Ka. 2000/2),

2. silicified branch, 70 mm height, 7 mm width (No. IGP-Ka. 2000/3),

3. herbaceous stem, piece of rock 150 mm length, 70 mm height (No. IGP-Ka. 2000/4),

4. cast of a silicified bulb, 20 mm length, 15 mm width (No. IGP-Ka. 2000/5),

5. three isolated bulbs, 10–13 mm height, 10–15 mm width (Nos IGP-Ka. 2000/6-8),

6. small piece of wood stem 50 mm height, 50 mm width (IGP-Ka. 2000/9),

7. wood of *Salix* L. (No. IGP-Ka. 2000/1) – transversal section: transition between latewood and earlywood vessels,

8. same – tangential section: note intervascular pits, simple perforation plates and uniseriate rays,

9. same – radial section: heterogeneous uniseriate rays with upright cells in the middle and procumbent cells in the lower part.

All specimens are deposited in the Palaeontological collections of Institute of Geology and Palaeontology, Charles University, Prague.