Effects of the Tunguska explosion on the wood of surviving conifers.

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Introduction.

The data on trees damaged by the Tunguska explosion can give information on many aspects of the event as, for example, the energy emitted and the height of the explosion, the characteristics of the shock and thermal waves, etc. The effects on the forest as a whole are examined in another contribution[1]. Here, the effects of the explosion on the wood of single trees are studied focusing the attention on the formation of what we call *"light"* (in weight) rings. Many authors prefer to name them "*clear"* (light-colored) or *"friable".*

Often it is said that there is no reason to continue studies on the Tunguska event because what was not found in the elapsed century cannot be found now, when many traces of the event are cancelled. This opinion does not take into account that the reduction of traces can be compensated adopting new techniques and instrumentation, that could allow us to discover facts previously overlooked. This is the case of the well-known phenomenon of light ring formation.

In the seasonal growth of a normal tree ring we can distinguish early, transitional and late wood. Early wood has clear, large tracheids with thin walls, while the tracheids of late wood are darker, smaller and with thicker walls. Often, between these two extremes a gradual transformation corresponding to the transitional wood can be observed. Early wood, having a smaller proportion of cell wall substance per unit of volume than the late wood in the same ring, has a lower density. A sharp decrease of the average summer temperature or a severe drought can prevent the formation of late wood and can give origin to a tree ring *less dense, less colored* and *more friable* than the other rings. Due to the climatic origin of this effect, its diffusion affects the trees of at least a *regional* area.

In 1958, Yu.M Emelyanov[2] discovered the "light" rings in the Tunguska site as a *local* effect concentrated in a radius of a few tens of kilometers from the epicenter. Many researchers have subsequently studied this phenomenon (see, for example[3][4][5]) concluding that the formation of light rings in the Tunguska site is due to partial or full tree defoliation. For many years the light rings were studied essentially using traditional optical instruments[2][3][4]. More powerful technique, as e.g. X-ray microdensitometry, used by E.A. Vaganov et al. has allowed to extend and to correct previous results[5].

Method.

Our investigation is carried out combining optical microscopy observation with the use of Computerized Axial Tomography (CAT). To our knowledge, it is the first time that CAT technique is used in Tunguska studies. The lighter growth rings have a lower density and a greater transparency. Therefore, in direct

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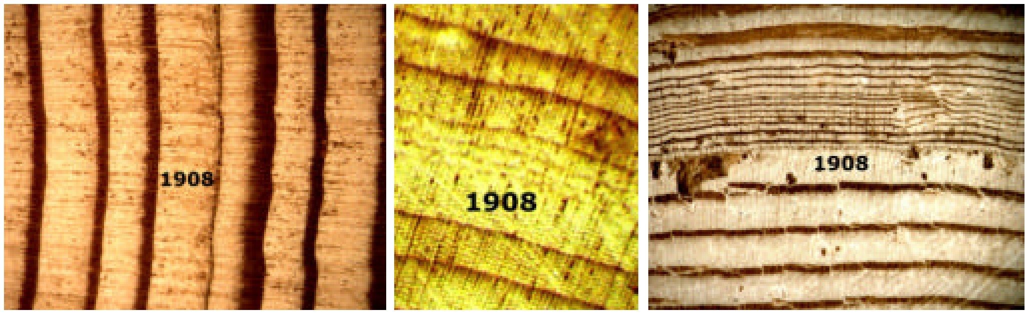
[1] V. I. Kharuk et al. (2006), Analysis of the forest cover…, IAC'06, Moscow, Contr. 13.17.
[2] Yu.M. Emelyanov, V.I. Nekrasov (1960), DAN SSSR, vol. 135, Nº5, pp. 1266-1269.
[3] A.A. Kartashev (1971), NPO Fakel, Novosibirsk, pp. 72-87.
[4] I.K. Doroshin (2005), Tungusskii Vestnik Nº16, Tomsk, pp. 28-52.
[5] E.A.. Vaganov et al. (2004), Astrobiology, Vol. 4 Nº 3 pp. 391-399.



Figs. 1, 2, and 3 (from left to right): Light rings in spruce, Siberian pine and larch.

CAT images the less dense wood transmits more light and appears black (note that for a more immediate comparison with the results of visual observations, we give here CAT image negatives, where light rings appear white). The CAT methodology allowed us to observe, in a few minutes, hundreds of horizontal (Figs. 7, 9, 10) and vertical (Fig.8) stem sections. A great advantage of this method is its non-invasive character: the tree samples remain integer, ready for further studies. Tens of conifer stems taken in different places of the Tunguska site have been examined. Often CAT images revealed the presence of light rings in trees where their friable character would be easily overlooked using only optical instruments.

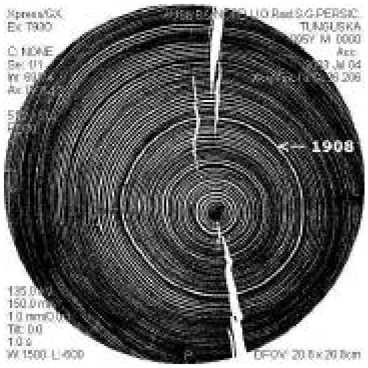
Results and conclusions.

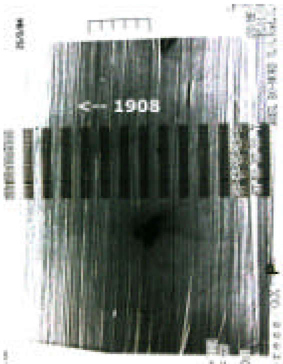
1) We found that each species of the Tunguska conifers can have light rings. Therefore, the largely accepted opinion that this phenomenon is present only in larches[3][4] should be abandoned. In Figs. 1, 2 and 3 we show light 1908 rings observed respectively in a spruce (*Picea obovata*), in a Siberian pine (*Pinus cembra*) and in a larch (*Larix sibirica*).

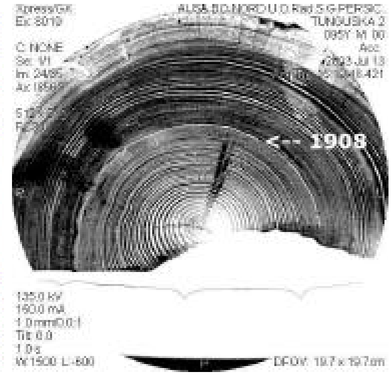
2) The formation of light rings in the explosion site is much more frequent than it is usually thought. Light rings can be found well outside the region plotted in Kartashev's map[3][4] and also in places inside this region where Emelyanov and Kartashev noted their absence. For example, Figs. 1 and 2 show portions of tree sections taken nearby the lake Cheko where Kartashev indicated light rings as absent.

3) In some tree stems, we observed only one light ring in 1908, while from 1909 normal early and late wood is present (Fig. 1). In other tree stems there

Figs. 4, 5 and 6: Provenance of the spruce and its preparation to CAT examination.







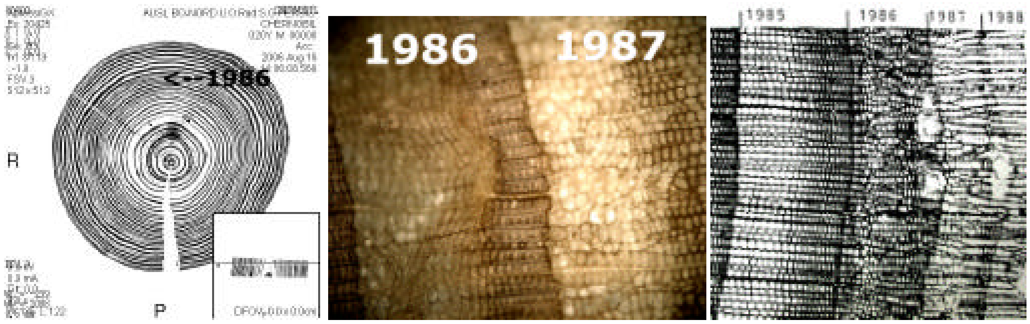
Figs. 7 and 8: CAT sections of the spruce. *Fig. 9: CAT section of the "twin" larch.*

is a group of consecutive light rings: Fig. 2 shows light rings in 1908-1910 and normal density wood from 1911. This case should not be confused with what is seen in Fig. 3, where eleven depressed rings with normal early and late wood follow the 1908 light ring.

CAT analyses clearly and rapidly lead to the same conclusions. Fig. 1 shows a small portion of the spruce stem collected by the Tunguska99 expedition near the lake Cheko, on the shore of the ingoing branch of the river Kimchu (Fig. 4). In Fig. 5 the whole sample (height = 30 cm, diameter = 29.5 cm) is ready for CAT analyses. Fig. 6 shows the unusual patient quietly waiting its turn in the Radiological section of the San Giovanni in Persiceto hospital. In less than one minute, we obtained 74 images of horizontal sections of this spruce stem at a distance of 0.8 mm one from the other. In Figs 7 and 8 a horizontal and a vertical sections of the stem are shown. The clear light ring is immediately found and ring count confirms its age. Fig. 9 shows a horizontal section of one stem of the famous "twin" larch surviving the 1908 catastrophe near the epicentre and known from the times of Kulik's expeditions. Eleven depressed rings follow the 1908 light ring, seen in Figs. 3 and 9. From 1920, normal rings with a clear seasonal alternation of early and late tracheids are observed.

4) We have examined conifer samples that underwent the consequences of the Chernobyl explosion (26 April 1986) making comparisons with the Tunguska case. There are similarities and differences between these two cases. Both the explosions caused defoliation due to similar mechanical and thermal effects. However, the Chernobyl catastrophe is characterized by the emission of high doses of ionizing radiations absent in Tunguska.

The effects of the Chernobyl explosion on a black pine stem cut in 1998 are shown in Figs. 10 and 11. These figures reveal that the 1986 ring have the early wood darker than the corresponding wood in preceding and



Figs. 10, 11and 12: Chernobyl's wood samples analysed in Bologna and Trondheim.

following years. A similar situation was observed in the case of a Chernobyl *Pinus sylvestris* stem studied by a Russian-Norwegian cooperation[6]. Its wood, wounded by high radioactive contamination, produced heavier tracheids from the time of the accident thus forming a dark ring in 1986, as shown in Fig. 12. In 1987 and 1988, the latewood cell walls of this tree lacked thickening and the corresponding annual rings, seen in Fig.12, are clear and light. A microscopic examination of the anatomical structure of our sample (Fig. 11) clearly shows that the tracheid rows of the 1986 early wood are highly disordered and often interrupted as happens in the presence of ionizing radiation.

Acknowledgments.

We are very thankful to the members of the Radiological unit of the San Giovanni in Persiceto hospital for their help and benevolence. The guidance of G.V. Andreev and N.D. Nesvetailo in the search for wood samples in the Tunguska site is gratefully acknowledged. We have the pleasure to thank N.N. Kovaliukh and V. Skripkin that have offered us the Chernobyl tree samples. We are grateful to I.K. Doroshin and N.I. Goltsova for generously sharing the results of their works and for useful discussions. We are thankful to N.V. Kolesnikova for her valuable help in preparing the Russian version of the present contribution.

[6] L. Skuterud, N.I. Goltsova et al. (1994), Sci. Total Environ., vol. 157, 1-3, pp. 387-397.