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Life under Supernovae. Story of the Cordillera Pine Forest

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Abstract

The article presents the first direct evidence of the influence of supernova flashes on the biosphere. Geochemistry and paleontology have not yet provided convincing data on the life response to disasters in the Milky Way Galaxy. This gap was eliminated through tree ring analysis of bristlecone pine from the Cordilleras responded to seven supernova outbursts in 185-1604 AD. The author used the superposed epoch method to process data at the 11 longest dendrochronologies, based on the results of measurement of annual growth of about 300 trees. The main finding is the growth depression in high-mountain population caused by supernova outbursts lasted for 20 - 30 years after the event. Moreover, in most cases, drastic growth reduction occurred one year prior to the event. In some cases, the annual tree ring increment exceeded the normal range many years after the event, and, consequently, it could be concluded that plant response was associated with the ozone layer depletion.

Keywords

Supernova, Bristlecone Pine Trees, Cordillera, Plant Response, Ozone Layer Depletion

1. Introduction

The important question of whether the biosphere, a product of solar activity, is affected or not affected by other Milky Way bodies, was positively answered as early as in 1950 by O. H. Schindewolf, a German paleontologist [1], who hypothesized about the impact of supernova explosions on the growth and development of living organisms. In recent years, when it was discovered that 60-iron of cosmic origin is widespread in the latest sediments on the ocean floor, the problem of dependence of life on supernovae attracts more and more attention

[2]-[12]. However, so far only indirect evidence of their influence on evolution has been obtained, which is the coincidence of the time of isotope deposition with changes in environmental conditions and rearrangements within the flora and the fauna. The situation of uncertainty in reconstructions of the past is reflected in the expressions typical for the corresponding publications: "radiation from supernovae could have ionized the atmosphere", "ionization of the atmosphere by supernovae may lead", "supernovae could have altered", "explosions might have triggered mutations", "a supernova would have grievous effects", "supernovae may have played a little-known role", "an interesting coincidence" and so on. It is significant that the authors of the final report "Near-Earth Supernova Explosions: Evidence, Implications, and Opportunities" submitted to the 2020 Decadal Survey on Astronomy and Astrophysics U.S. National Academies of Sciences, Engineering, and Medicine, were limited to a simple statement in the chapter "Possible Biological Effects", that "A supernova at 10 pc would surely be very dangerous for the biosphere, but a distinctive signature remains to be found in the geological record" [13].

The first step towards the identification of traces of a supernovae on Earth did B.P. Konstantinov and G.E. Kocharov [14]. In 1965 they proposed to reconstruct the modulation parameters of galactic cosmic rays from the ^{14}C and ^{10}Be records. This idea encouraged a pioneer study by N.V. Lovelius on the response of the Turkestan juniper (*J. turkestanica* Kom.) to recent supernova outbursts [15]. Nevertheless, the studies in this direction were suspended for more than 30 years. In 1974, ^{14}C content was determined in the annular rings of 400-year-old trees, and these data demonstrated sharp increases corresponding in time to SN 1572 and SN 1604 supernovae [16], thus confirming the possibility of detecting the supernovae remnants in the planet envelopes. Shortly afterwards, due to determination of ^{10}Be content in the Greenland ice core [17], signs of supernova explosion that occurred 10,000 to 40,000 years ago were found, and this supernova was very close to the Solar system [ca. 150 light years] [18] [19]. Additional information on ^{10}Be, ^{14}C, and ^{36}Cl levels definitely confirmed the hypothesis of a supernova outburst occurring about 35,000 years ago [20] [21]. Later it has been found that galactic cosmic rays bring Fe isotopes to the Earth [22] [23], and abnormally high concentrations of this atom may correspond to accelerated biota speciation [24] [25]. Currently available methods of fauna reconstruction, however, are not sufficiently accurate to give data for an unambiguous explanation of temporal coincidence of geochemical and paleontological changes. Obviously, direct evidence is required to confirm real existence of the phenomenon that is similar in nature to the effect predicted by O. H. Schindewolf. The results of the study of the modern forest [26] indicate the possibility of solving this problem.

It took a long time to go from properly designed experiments with very scarce data at hand to the discovery of most convincing evidence, that is, tree response as recorded in the pattern of annual rings. Below follows the first description of the consequences of the seven known events of cosmic ray generation during the period of 185-1604 based on the analysis of more than 1000 tree ring series from the longest-living plant species, *i.e.*, bristlecone pine (*Pinus longaeva* D.K. Bailey). The analysis revealed previously unknown reactions of living organisms in the long period after the supernova outbreak and in the year before the outbreak, which indicates the existence of some new type of energy for science.

2. Material and Methods

As of now, a group of seven different supernova explosions, all going on at the same time, has been rather definitely identified by the criteria of long and multiple observations, fixed position in the firmament, unusual brightness, small galactic latitude, and the existence of remnants in the Milky Way (**Table 1**).

SN 1006 was the brightest observed supernova in recorded history, reaching in brightness a quarter or even half of the moon and giving a shadow in the daytime. SN 1054 was also seen during the daytime and exceeded roughly sixteen times the brightness of Venus.

The impact hypotheses testing consisted of the following stages: 1) The choice of an indicator that should have a long life expectancy and high sensitivity to changes in habitat, 2) Response detection, 3) Verification of the significance of the established ties, 4) The creation of the generalized model, 5) Explanation of the discovered patterns.

Pinus longaeva D.K. Bailey, a long-living species of bristlecone pine tree found in the Cordilleras, is the best object to examine for effects of supernova explosions in the biosphere. In this case, several dendrochronologies derived from mainly living ancient trees can be used (**Table 2**), thereby improving the conclusion validity. Arid climate and mountain habitat of the species increase the chance for the cosmic signals to be captured.

Generalized tree-ring data were analyzed by the method of Superposed Epoch Analysis [33]. Tree ring width values were averaged for each individual epoch and for all populations.

3. Results

As follows from the analysis of the generalized data, the supernova outbursts are

Table 1. Well known supernovae.

Year	Constellation	Visibility period	Apparent visual magnitude (brightness)	Distance, ly	Place of observation
185	Centaurus	>20 months	from −2 to −8	3000 - 8000	China, Korea
393	Scorpios	8 months	From 0 to −3	4000 - 34,000	China
1006	Lupus	>3 years	from −7 to −9	7000	China, Japan, Egypt, Khwarezm, Iraq, Morocco, Yemen, Switzerland
1054	Taurus	21 months	−6	6000 - 7000	China, Japan, Near East
1181	Cassiopeia	6 months	From 0 to −1	6500 - 8500	China, Japan
1572	Cassiopeia	18 months	−4	7500 - 10,000	China, Korea, Europe
1604	Ophiuchus	12 months	−3	20,000	China, Korea, India, Europe

Source: Data from [27]-[32].

Table 2. Number of pine trees studied.

Chronology	Originator	Place	Supernova						
			185	393	1006	1054	1181	1572	1604
Methuselah Walk	D.A. Graybill	California	27	26	29	31	33	55	54
Sheep Mountain	D.A. Graybill	California	6	14	22	21	28	38	39
White Mountains	C.W. Ferguson, E. Schulman, H.C. Fritts	California	9	13	15	16	15	13	31
Indian Garden	D.A. Graybill	Nevada	21	19	22	18	20	26	27
Hill	D.A. Graybill	Nevada	6	14	27	27	29	36	35
Mammoth Creek	D.A. Graybill	Utah	3	4	19	20	29	31	32
Spring Mountains Lower	D.A. Graybill	Nevada	-	2	19	22	26	36	36
Wild Horse Ridge	D.A. Graybill	Utah	-	3	18	17	18	23	23
	Total:		72	95	171	172	198	258	277

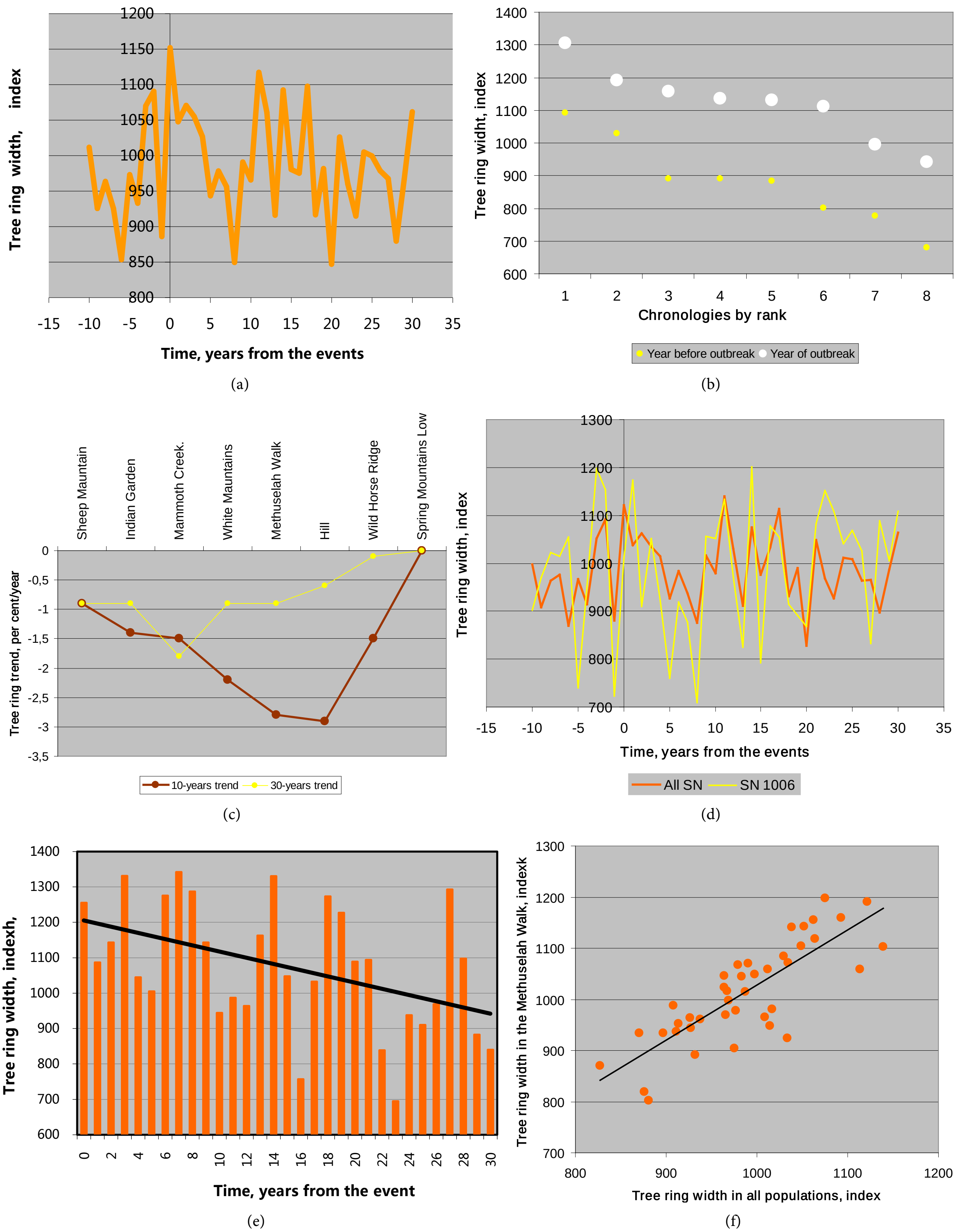
Source: National Centers for Environmental Information [https://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring].

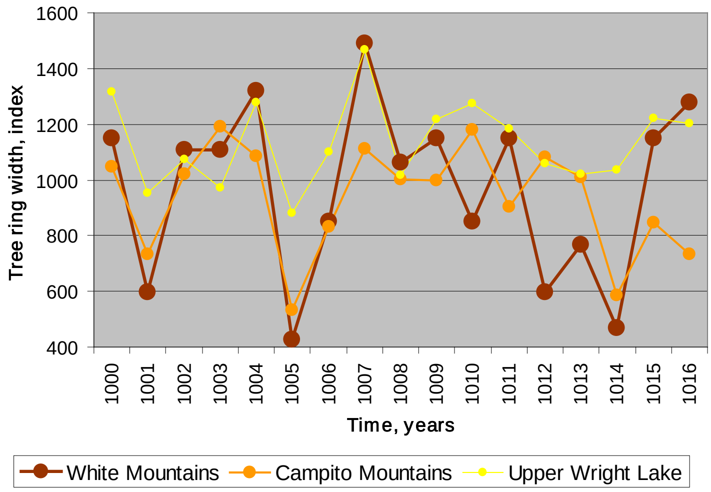
preceded by serious deterioration in the state of bristlecone pines, which is then followed by a one-year rise, and by a long-term depression thereafter (Figure 1(a)). Indices of radial growth, determined by more than 1200 tree rings, have significant differences during the outbreak time and previous years (Figure 1(b)).

Drastic growth rate variations prior to and immediately after supernova appearance should be considered a characteristic tree response, since such changes are noted in 86% series. Naturally, this abnormality was maximally expressed (up to 73%) during SN 1006, the most powerful outburst, and recorded in all the populations studied. Post-outburst annual growth was always characterized by significant negative trends (Figure 1(c)). These characteristics of plant response to the galactic signal are most prominent in the case of SN 1006 outburst (Figure 1(d)). Another supernova outburst, the second in power, had similar long-term consequences, that is, growth depression (Figure 1(e)). By comparing tree-ring chronologies, we could find out that the Methuselah Walk population of pine trees growing on dolomite-derived soils of the White Mountains, California, at an altitude of about 3000 m most completely reflects species sensitivity to the cosmic effect (Figure 1(f)). A similar effect of long-term tree growth depression can be seen from the chronologies of the awning pines, which are not so long, especially in the case of the SN 1006 outburst (Figure 1(g)).

4. Conclusions

In theory, three factors could affect the pine tree growth during post-supernova outbreak periods: variations in the solar activity, abnormal cosmic radiation, and atmosphere disturbance regimes. Values of ^{10}Be concentration [21] demonstrate that the level of total solar radiation did not change during supernova outbursts. The process of photosynthesis should have been depressed in response to high-energy ionizing particles and gamma quanta, as well as to UV-radiation, which is enhanced when the ozone layer is destructed. Coniferous trees are





(g)

Figure 1. (a) General picture of annual tree growth before and after the supernova outburst compiled from all chronologies; (b) Tree ring width before and after the outbreaks. The difference is significant according the Mann-Whitney non-parametric U-test; (c) Tree growth trends in different populations; (d) Tree rings showing the effect of all SN and SN 1006. Synchronization is observed 1 year prior to the event; (e) Pine response to SN 185 outburst; (f) Correlation between annual increments in all populations and in the population of Methuselah Walk. Correlation coefficient 0.81; (g) Radial growth increment in the bristlecone pine tree of the White Mountains, the Campito Mountains and the Upper Wrigh Lake populations prior to and after SN 1006 outburst. Source: data-based calculations.

known to be devoid of resistance to such impacts. The most sensitive is needle rudiments, where the membrane systems of the cytoplasm and the nuclear chromatin-protein structures are damaged; mature needles age prematurely and die. As for pre-supernova outbreak, it is as yet unclear what causes regular decrease of tree growth. Apparently, we face a manifestation of the unknown energy. It should be added that the recently discovered dependence of the growth of modern forest on cosmic rays did not receive the necessary explanation [34].

The analysis of tree response to extreme cosmic impacts reveals certain years of excessive growth on the background of long-lasting growth depression, which may well be indicative of the predominance of reversible biological effects and the leading role of physical and chemical changes in the atmosphere. The results of examination of very old trees demonstrate pre- and post-actions of the supernova explosions, which are expressed in the short-term and long-lasting depression of their growth. These phenomena are associated with radiation of different nature. In the majority of dendrochronologies, the effects of SN 1006, the brightest of all supernovae, are most expressive.

Strong disturbances in the Earth's environment before and after the supernova explosions should have had the greatest impact on life in the biosphere.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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