A MULTITRACER STUDY ON PEAT PROFILES FROM TUNGUSKA, SIBERIA

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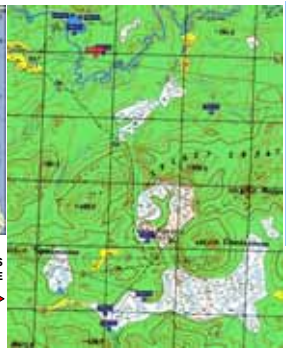
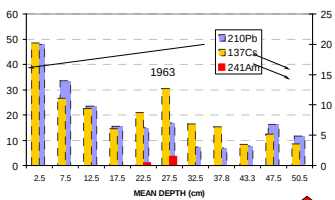


MAP OF TUNGUSKA REGION AND SAMPLING LOCATIONS (CORE SAMPLINGS AT THE RED LABELLED POINT). THE MAP IS IN KGB COORDINATES.

LAKE CHEKO AND RAKETKA PEAT BOG WHERE PEAT CORES HAVE BEEN SAMPLED in 1999 and 2002 (ABOUT 8 km N-NW FROM THE EPICENTRE)

SPECIFIC ACTIVITIES OF NATURAL AND ARTIFICIAL RADIONUCLIDES (Bq/kg) IN KEM21 PEAT PROFILE



THE MOBILITY OF ELEMENTS IN PEAT BOGS

The chemical environment of peat bogs, usually acidic in the case of ombrotrophic (rain-fed) ones, promotes the remobilization of some elements along the peat column. This behaviour is typically shown by Cesium-137 (see diagram above) which displays a maximum at the peat surface, beside the one at about 27.5 cm, i.e. the 1963 peak previously discussed.

Owing to its mobility, traces of Cesium-137 are found even at depths corresponding to the XIX century, which is anachronistic, since its emissions to the environment started on the small scale in 1945.

As concerns the Cesium-137 surface maximum, it is believed to be caused by upward relocation promoted by living *Sphagnum moss;* in fact Cesium is known to mimic essential element K (*see diagram on the right*). Downward displacement is due to percolation of the dissolved radionuclide through peat pore water. The very low levels detected in the deepest layers analysed as well as the good preservation of the 1963 peak are thought to be due to the permafrost (at about – 40 cm in the bog sampled) limiting a major remobilisation through freezing.

For Lead-210, which is known to be far less mobile in peat, its maximum at the top is explained by its continuous supply from atmospheric deposition, its decrease and progressive disintegration in the deeper/older layers being caused by physical decay, according to its half-life of 22 years. This is the principle on which lead-210 radiodating is based.

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THE FACTS:

In the early morning of 30th June 1908, a powerful explosion (10-15 Mton of energy) over the basin of the Podkamennaya Tunguska river flattened 2150±50 km² of Siberian *taiga*. For more than ninety years, Tunguska was, and still is a conundrum.....

Despite great efforts, the main question, i.e. **the nature of the Tunguska Cosmic Body (TCB), which caused the explosion, is still open**.

LONGO et al., Probable asteroidal origin of the Tunguska Cosmic Body, Astronomy and Astrophysics, 1081-1097 (2001).

THE EFFECTS OBSERVED AT THE TIME OF THE EVENT:

Picture taken by KULIK in 1928

- OBSERVED AND HEARED EXPLOSION
- SEISMIC EFFECTS RECORDED AT SEVERAL MONITORING STATIONS
- ANOMALIES IN ATMOSPHERIC PRESSURE
- OPTICAL (AEROSOL DISPERSION) AND MAGNETIC EFFECTS WITHIN THE ATMOSPHERE

Destroyed 2165 km² forest (50-60 km in estension)

1000 km² area burned – abated 60 million trees

TUNGUSKA EPICENTRE : 63°53' N; 101°53' E

The area affected compared to Rome region

RADIONUCLIDIC and PALINOLOGICAL DATA:

Environmental radioactivity data in continental Siberia are still very limited.

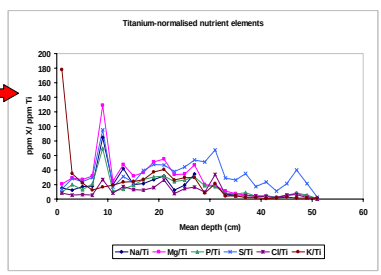
Peat cores from Tunguska taiga are analysed by non–destructive HPGe γ-SPECTROMETRY for several radionuclides, i.e. naturally-occurring Lead-210 and Potassium-40 as well as artificial Cesium-137 and Americium-241.

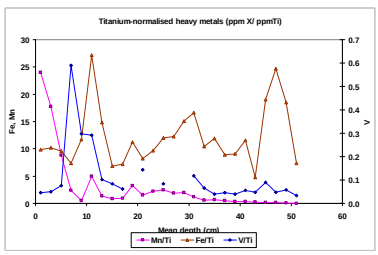
Data presented concerns only KEM21 CORE collected in 1999, while the analysis of a second core collected in 2002 in the same bog is presently in progress.

Lead-210 data treatment allowed to estimate a mean annual atmospheric flux for this radionuclide of 211 Bq m^{-2} yr^{-1}, a rather high value associated with the strongly continental characteristics of this site and to its emanation of Radon-222 from the crustal materials.

Lead-210 radiochronology by the "*constant rate of supply*" model locates the 1908 level at a depth of approximately 42 cm. Lead-210 dating has been confirmed by the occurrence of a peak of artificial radionuclide Cesium-137 accompanied by trace Americium-241 at a peat depth corresponding to a layer dated 1963. Cesium-137 activity peak has long being recognised as a useful temporal horizon for dating recent deposits and is associated to the maximum fallout caused by massive nuclear weapon testing in the atmosphere culminated in 1963. At a the same depth of 42 cm palinological analysis shows both a peak of total pollens and Sphagnum spores counts as shown in the diagrams on the right. This large discontinuity has been attributed to the catastrophic effects of the shockwave of Tunguska Cosmic Body on the area possibly causing a huge resuspension of biological particles in the area. The diagram shows also another abrupt collapse of tree pollens counting at –55 cm, probably in connection with a documented local forest fire in 1870. This is supported by a peak of larger charcoal particles (> 125 μm) at the same depth (not shown). This age/depth value was employed to integrate Lead-210 data at depths where its concentration was below detection limits.

Cesium-137 inventory back-dated to 1963 amounts to 4.6 kBq/m^{-2} and is in agreement with the deposition of weapon test fallout on the global scale. The low inventory is indicative of the remoteness of the area investigated which seems to be indirectly affected by anthropic emissions to the atmosphere as a result of global tropospheric circulation. As concerns the contribution of other radioactive emission sources from Russian/Siberian locations of documented existence (i.e. Krasnoyarsk-26 Chemical Combine) no apparent influence has been so far detected. Neither Tchernobyl traces could be found owing to the absence of the Cesium-134, isotope usually employed to this scope, owing to its decay. It must be noted, however, that Siberia was upwind the accident location, therefore the radioactive cloud might have contributed not more than 15% to the Cesium-137 inventory in areas east of Belarus, as estimated by Sukhorokov et al.



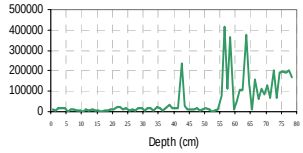


WHY IS TUNGUSKA PEAT BOG INTERESTING?

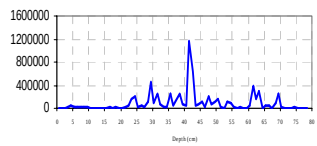
- **MAY CONTRIBUTE TO TUNGUSKA COSMIC BODY UNDERSTANDING**
- **ARCHIVE OF ATMOSPHERIC TRACE COMPONENTS IN A REMOTE AND SCARCELY INVESTIGATED AREA (ASIATIC-EUROPEAN CONTINENTAL BACKGROUND CONDITIONS)**
- **STRONGLY INTERDISCIPLINARY FRAMEWORK**
- **SIBERIA : VAST AND POORLY STUDIED CONTINENT OWING TO LEAST ACCESSIBILITY! PLAYS A RELEVANT (possibly leading) ROLE IN PLANETARY GLOBAL CLIMATIC CHANGE AND ENVIRONMENTAL DYNAMICS**

RAKETKA PEAT BOG AT ABOUT 500 m FROM THE SHORE LAKE

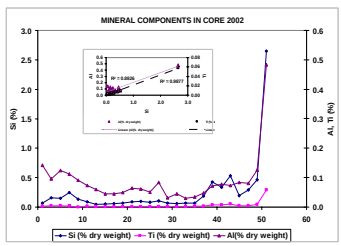
N° Total Pollen grains/cm^3

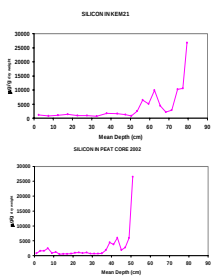


N° Sphagnum spores/cm^3



PIXE MULTIELEMENTAL ANALYSIS



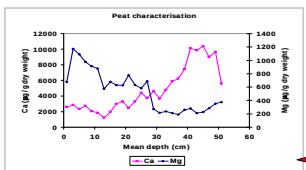


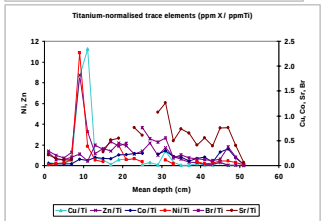
Both the sampled cores are presently under examination by PIXE (Proton Induced X-ray Emission) analysis at the LNL-INFN Van de Graaff accelerator facility.

The data herein presented are still preliminary and have been carried out on pelletized whole-peat samples previously dessiccated at 30°C; values refer to triplicate pellets for each layer. Unfortunately, owing to a failure of the experimental set-up, most of the compositional data so far collected concerns the more recent core of 2002, for which ash content, radiodating and palinology are not available yet. For the next months research planning includes not only the completion of the analysis already effected, but also the application of Micro-beam PIXE technique to peat samples in order to carry out single particles elemental analysis

ENRICHMENT FACTORS OF ELEMENTS IN THE 2002 PEAT CORE CALCULATED AGAINST BOWEN's MEAN ELEMENTAL CONCENTRATIONS IN SOIL

	Al	Na	P	S	Cl	K	Ca	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Br
Mean	2	21	106	241	511	8	55	6	43	15	2	98	21	179	75	140
σ	2	19	89	139	8	12	30	7	136	28	1	56	48	452	95	93
min	1	0	6	20	55	0	3	2	1	0	1	14	2	4	1	10
MAX	9	85	437	681	6	63	113	33	494	120	3	211	227	1874	486	383





A tentative comparison of the two cores by means of Silicon concentration/depth profile (*see diagrams above*) shows a very similar trend, but a large difference is found in the depth along which the profile is developed, i.e. within 80 cm in the older core and within 50 cm in the 2002 Core, collected at some tenths of meters apart from the former, showing a lower biomass accumulation. Silicon has been chosen for comparison as a reference element for its conservative behaviour. On this arbitrary, but reasonable basis, we expect to find the 1908 layer of 2002 Core between 25 and 30 cm. Unfortunately the chemical information so far available does not allow to detect any chemical signal unambiguously connected to Tunguska Cosmic Body.

Calcium profile seems to indicate that the present bog is ombrotrophic as confirmed by the dominating presence of *Sphagnum moss.* Transition from either minerotrophic fen or forest soil is observed in the first half of the XIX century, possibly related to a huge local forest fire in 1870, as shown by several element concentration profiles.

The chemical signature for this peat core shows some interesting features, such as a remarkable peak (well-defined also in concentration profiles and not only in the Titanium-normalised values here reported) of some elements in the layer between – 8 and - 10 cm, which is thought to be due to wind-transported dust. This is in agreement with periodic strong wind storms reported in the region. The shifted position of the peak for some elements with depth, i.e. Copper, suggests their higher mobility in the reducing/acidic environment of *sphagnum* peat.

It is interesting to note that the higher enrichment factor of some elements peaks in some of the elements, i.e. Nickel, Cobalt and Copper, might be associated to extraction and industrial activity in this part of Siberia, known as Evenkia, where geological prospections have indicated the occurrence of abundant resources spanning from coal and gas to gold as well as diamonds and non ferrous metals.