CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

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**Third African elephant meeting**
**Gigiri, Kenya**
**1-3 November 2010**

## DETERMINATION OF AGE AND ORIGIN OF AFRICAN ELEPHANT IVORY

1. The information attached concerning a project to determine the age and geographical origin of African elephant ivory, was provided by CITES Management Authority of Germany.

2. The information pertains to agenda item 10 of the provisional agenda of the third African elephant meeting.



# Determination of Age and Geographical Origin of African Elephant Ivory

**3rd African Elephant Meeting (01st to 3rd November 2010)**

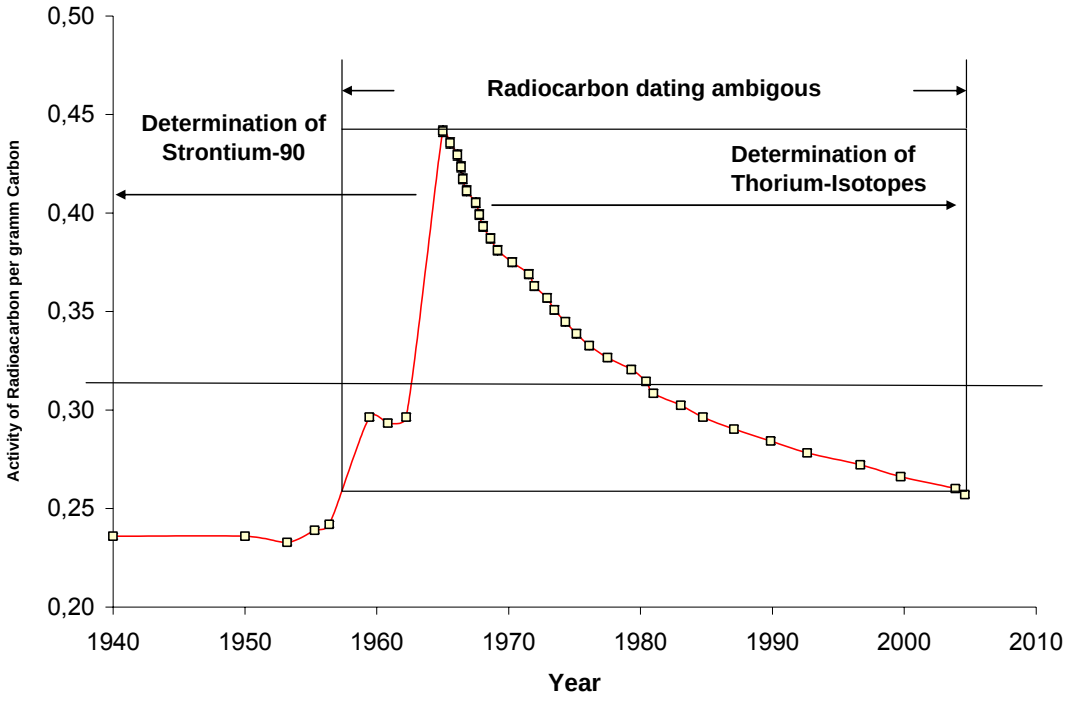
**Gigiri, Kenya**

## Part 1:

## Dating of Ivory from Elephant Tusks Compiling Isotope Profiles of $^{14}C$, $^{90}Sr$, $^{228}Th$ and $^{232}Th$

### Initial Position

Radiocarbon dating is considered to be a standard method of dating archaeological findings of biological origin. Thereby the content of the radiocarbon isotope $^{14}C$ has to be determined. If it is to determine, whether the death of an organism has occurred a short time ago or several decades ago radiocarbon dating is principally not able to show an unambiguous result. This is due to the shape of the radiocarbon bombing curve (see figure below) showing the change of specific activity of radiocarbon in organisms against time caused. The period of time dating ambiguously ranges from about 1957 up to the present. This period is of special interest for objective evidence of illegal dealt ivory.




The principle of radiocarbon dating is to determine the specific activity of radiocarbon $^{14}C/C$ analysing a representative sample of ivory and to relate the result to a certain date including a range of uncertainty applying the radiocarbon bombing curve. This date corresponds to the time of death of the analysed elephant. If for example the result of an analysis is 0.32 Becquerel per gram of carbon two periods of the date of death are possible; the first one is about 1962 and the second one is about 1980. To decide which of them is correct the determination of the activity of $^{90}Sr$ per gram of calcium $^{90}Sr/Ca$ and of $^{228}Th/^{232}Th$ is reasonable. $^{90}Sr$ was not evidenced in the environment at global scale before about 1955 because the most significant source of releases of $^{90}Sr$ to food chains of vertebrae is nuclear weapon testing. If a significantly increased value of $^{90}Sr/Ca$ is detected a time of death can be calculated ranging between 1960 and 1970. Lower values of $^{90}Sr/Ca$ indicate a time of death before 1960 or after 1980. If the value of $^{90}Sr/Ca$ is below the detection limit, the time of death is considered to be below 1955. $^{228}Th$ and $^{232}Th$ are naturally occurring radionuclides of the thorium decay series. Analyses of human bone tissue show that the activity ratio of $^{228}Th/^{232}Th$ is significantly above unity if the death occurs not too far in the past. If the time of death is dated back several decades the ratio of $^{228}Th/^{232}Th$ approximates to unity. As the chemical composition of ivory is similar to that of human bone tissue it is to be assumed that the same relation exists. If, for the example given above, the ratio of $^{228}Th/^{232}Th$ is about unity a time of death of about 1960 or earlier is calculated. If the ratio of $^{228}Th/^{232}Th$ is significantly above unity the death occurred not before about 1990. Therefore a combination of the results of analyses of these radionuclides the correct time of death can be calculated with a sufficient high degree of certainty. In

addition to this errors can be detected much easier combining the results of three single analyses per each sample. Therefore the assessment of the time of death is only recommendable applying the isotope profiles of $^{14}C$, $^{90}Sr$, $^{228}Th$ and $^{232}Th$. At present the analyses are executed as follows:

**State of the art**

1. Determination of the specific activity of radiocarbon ($^{14}C/C$)

The ivory sample contains the element carbon consisting of the isotopes $^{12}C$, $^{13}C$ and $^{14}C$. Carbon is released form the sample as Carbon dioxide by combustion and subsequently accumulated as carbonate. From this carbonate the carbon is released as carbon dioxide and is stored in a suitable scintillation cocktail. This scintillation cocktail enables the detection of ionising radiation caused by the □-decay of $^{14}C$ applying liquid scintillation counting (LSC). From the result of LSC the pMC-value (percentage modern carbon) can be calculated. In addition to LSC the determination of the amount of the stable carbon stored in the scintillation cocktail is necessary.

2. Determination of the specific activity of $^{90}Sr$ related to the element Calcium ($^{90}Sr/Ca$)

$^{90}Sr/Ca$ is determined from analysis of the residue of the combustion of the $^{14}C$ analysis. At present only a part of the residue can be used for the determination of $^{90}Sr/Ca$ because the rest is needed to execute the thorium analysis. $^{90}Sr$ is purified from several interfering radionuclides mainly $^{40}K$ applying ion exchange chromatography. The detection of the ionising radiation caused by □-decays of both $^{90}Sr$ in radioactive equilibrium to $^{90}Y$ is performed applying low-level-□-counting with gas filled detectors. From the result of counting the activity of $^{90}Sr$ can be calculated.

3. Determination of activity ratio of $^{228}Th/^{232}Th$

The activity ratio of $^{228}Th$ and $^{232}Th$ is determined form analysis of the residue of the combustion from the $^{14}C$ analysis. The element thorium is purified applying several steps. Due to the high content of phosphates the chemical yield of thorium is limited to about 60%. The detection of the □-emitters $^{228}Th$ and $^{232}Th$ is done applying □spectrometry with silicon detectors. Form the results of □spectrometry the activity ratio of $^{228}Th$ and $^{232}Th$ is calculated.

**Operational procedure**

June 2010 to December 2010

- Acquisition of independently dated samples of ivory from elephants including a wide range of ages as possible
- Acquisition of one or two tusks to plot a curve of distribution of isotope distribution
- Optimisation of the $^{14}C/C$-analyses with a view to a more accurate determination of the amount of stable carbon stored in the liquid scintillation cocktail
- Combination of $^{90}Sr$ and thorium analysis to enable the analysis of higher sample amounts
- Increasing the chemical yield of the thorium analysis above 60%

January 2011 to December 2011

- Survey of the significant separation of $^{40}K$ from the $^{90}Sr$-preparation as most important interfering radionuclide
- Validation of the combined method of isotope profiles of $^{14}C$, $^{90}Sr$, $^{228}Th$ and $^{232}Th$
- Screening of ivory with respect to further radionuclides e.g. $^{137}Cs$, $^{210}Pb$, $^{238}Pu$, $^{239/240}Pu$, $^{241}Pu$ to study the opportunity of enhancement of dating.

January 2012 to December 2012

- Validation of isotope profile method applying independent dated samples.
- Plot of a curve to show the isotope distribution in a whole tusk.
- Analyses of about 20 unknown ivory samples for statistical purposes.
- Testing of the method of isotope profiles of $^{14}C$, $^{90}Sr$, $^{228}Th$ and $^{232}Th$ to tissues of other species e.g. tortoise shell, coat, rhino horn.

## Part 2:

## Creation of a reference database for elephant ivory (geographic origin)

### Level of knowledge

The isotope enrichment of certain chemical elements in the tusks or bone material of animals is a good method to reliably identify the origin of elephant ivory. As opposed to other forensic procedures such as the DNA analysis, the isotopic analysis has the advantage of allowing insights into the origin of elephant ivory from crafted material. Additionally, the isotope database offers information on the geographic origin of other species of similar trophic level (e.g. rhinoceroses). Furthermore, the isotopic composition is insensitive to external factors such as pollution, radiation and chemical reagents which might, knowingly or unknowingly, strongly limit the options of DNA analysis methods.

The geographic origin of ivory is determined by a combination of various geochemical routine analyses. Most common and most successful is the determination of the isotopic composition of the element strontium (Sr). But the composition of the stable isotopes carbon (C), nitrogen (N), oxygen (O), hydrogen (H) and sulphur (S) also allows a reliable assessment of the provenance. Elephants ingest the biologically available isotopes with the food they eat. The isotopic composition of the element strontium for example, which can be found in the food, consists of the isotopes $^{87}Sr$ (a product of the natural decay of $^{87}Rb$) and $^{86}Sr$. Their ratio is determined by the chemical composition of the geological subsoil: young volcanic regions such as the East African Rift are characterized by a low $^{87}Sr/^{86}Sr$ ratio, whereas older parts of the earth's crust have a high $^{87}Sr/^{86}Sr$ ratio. Carbon and nitrogen isotopes can serve as indicators of the nutritional composition or the climate zone. A very low $\delta^{13}C$ ratio indicates densely forested habitats, a high ratio is indicative of savannah landscapes. In a similar way, a low $\delta^{15}N$ ratio suggests humid conditions, whereas in drier elephant habitats a rather high ratio can be expected. Hence a relatively correct determination of origin is possible by defining the composition of the tusks.

Since 1995, the spatial distribution of the elephant populations in Africa and their numbers have been monitored on a regular basis by an expert panel of the International Union for Conservation of Nature (IUCN) and published in status reports. The data contained in the status reports consists of vector data which spatially represent the range of the different populations and thus provides information on the geology, vegetation and precipitations. This spatial data as well as the georeferenced ivory samples from museums and collections allow the setup of a reference database for the proof of origin of ivory. In the course of the project, the historic material will be complemented by recent samples from African states with elephant populations. Isotope distribution maps of elephant ivory can be generated using geostatistic procedures (the so-called "kriging").

### Necessity

In the 1980s, the international trade in ivory led to a dramatic decrease of the population in many African countries. In 1989 the international community listed the African Elephant on Appendix I of CITES and thus prohibited any commercial ivory trade. The strict trade prohibition and effective protective measures allowed the elephant populations in some African countries to recover, above all in Eastern and Southern Africa where they are increasing at an average annual rate of 4 %. Due to the stable or even growing numbers of animals in Southern Africa, in 1997 the populations of Botswana, Namibia and Zimbabwe and in 2000 the population of South Africa were downgraded to CITES Appendix II. While maintaining strict protection, these countries were given the opportunity to deal with elephant products. Nevertheless, so far CITES has only allowed onetime sales and does not allow free trade of products made of elephant ivory. One of the main arguments for the quasi trade prohibition is the fact that it is very difficult to distinguish legal ivory from illegal ivory in the markets, so that the legal ivory trade would provide a perfect cover for smuggling.

Besides the Asian elephant is clearly more endangered than the two African species. All populations of the Asian elephant are listed on Appendix I of CITES. Thus, a distinction has to be made as to whether the ivory comes from African or Asian elephants. At the moment, there is no objective supportive control instrument for the CITES contract community meeting court standards. In this context, setting up a reference database for the proof of origin of ivory can help determine the provenance of illegal ivory in order to better focus support in the enforcement and conservation measures on an international level.

The data in ETIS (Elephant Trade Information System), the information and surveillance program for trade and smuggle of elephant products furthermore show that since 2004 the illegal trade in ivory has been growing in some Central African countries. Since the 10th conference of the parties of CITES (Resolution Conf. 10.10) ETIS is being used by TRAFFIC, a joint wildlife conservation program of the WWF and the IUCN. The constant diminution of the elephant populations of the Ivory Coast, the Democratic Republic of Congo and the Central African Republic since 1981 implies that especially in those countries animals are killed by poaching. Therefore long-term preservation of the elephant populations of Western and Central Africa will only be possible with a control mechanism that helps identifying the geographical provenance of confiscated ivory by means of an ivory reference database. In addition to ETIS, this is the only way to create objective transparency with regards to the provenance of ivory in international forums like CITES. This transparency will help avoid lengthy and therefore expensive discussions and negotiation processes and, where required, will create legal compliance during implementation. Additionally the planned project will help to specify and implement the regional action plan of the Central Africa Forests Commission (COMIFAC) at a time when Germany chairs the Congo Basin Forest Partnership.

**Objectives of the research and development project**

- Creation of the ivory reference database:

  Establishing a method that can be used to determine the origin of ivory and to check the accuracy of the designation of origin.

- Implementation of the reference database for the protection of species:

  The elephant ivory reference database will be suggested to national authorities and the international community of states as a support to enforcement.

**Sub-projects/Activities in order to reach the objectives**

Setup of an elephant ivory reference database:

- Documenting and analysing existing examinations of other relevant studies.
- Collecting elephant ivory reference samples.
- Mobilizing big game hunters in Europe in order to obtain certified reference samples of African elephant ivory.
- Laboratory measurement and cataloguing of the isotope signals extracted from the samples.
- Consolidation of existing reference databases on geology and vegetation.
- Setup of a geographical information system that spatially represents the factors geology, climate, vegetation and elephant population.
- Statistical analysis of the isotope signals and spatial distribution pattern of the reference samples by means of abiotic factors.
- Consolidation of the above results and setup of the reference database and an isotope distribution map of elephant ivory.

Implementation of the reference database for the protection of species:

- Getting in touch with potential partners from sectors relevant to the national and international implementation of the reference database.
- Participation in national/ international meetings /conferences in order to discuss particular elements of the reference database and its applications and to consult with other interest groups.
- Publication of results of the development process in relevant professional publications.
- Accompanying PR activities.
- Publication of a manual on structure and applications of the reference database in English (on CD, on the internet and as a script of the Federal Agency for Nature Conservation).

2010 International Year of Biodiversity

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Bonn, 27 October 2010

Dear colleagues,

At 15th Conference of the Parties of the Convention (CoP 15) on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in Doha (Qatar) in March 2010 the legal and illegal trade in ivory had been a significant topic on the agenda of this conference. The problem of smuggling and intermixing legal with illegal ivory is still persisting and exact methods for determination are still not widely developed and available. More specifically CoP 15 Doc 44.1 (Monitoring of illegal trade in ivory and other elephant specimen), which had been discussed in Doha, responds to this matter and states that the origin and age of the ivory contraband is an important aspect of current smuggling. In paragraph 26 the document indicates that DNA profiling for identification of the geographical source is of great significance and it would be most useful if it could be combined with the age identification of the ivory.

The German Federal Agency for Nature Conservation (FANC) as Germany's CITES Management Authority is currently supporting a research project on methods for age determination of raw ivory. A new method shall be developed and tested based on isotop analysis, not only using radiocarbon testing but also combining it with the analysis of various nuclides (Sr-90, Th-228, Th-232 and others) for a greater preciseness of the results.

Additionally we would like to amend this research project with a study on the identification of the geographical source of ivory also based on the analysis of isotopes.
For the verification of the methods to be developed for determination of age and geographical source sufficient testing and reference material is essential. The material has to meet either both or one of the following conditions:

- The year of death of the elephant should be known as exactly as possible
- The country where the elephant lived must definitely be known

As Germany is not in possession of enough ivory samples that meet these preconditions we would like to ask for your kind assistance. If you would like to support this important research project we would appreciate if you could provide us with ivory samples meeting the above-mentioned conditions. We need to have samples of a minimum weight of 15 grams and – if possible – one whole tusk. The contact persons at the FANC who will be in charge of the project are Mrs Hornig (hornigk@bfn.de) and Mrs Denkl (denklc@bfn.de).

Provided that you would agree to cooperate with us on this important initiative we would very much appreciate if you could revert back to us at your earliest convenience, providing us with the specific details of the ivory (exporter's address, description (whole tusk or part), net mass, country of origin, source) in order to allow us to issue an CITES import permit.

Yours respectfully

Dir. & Prof. Dr. Dietrich Jelden
Head CITES Management Authority