

# Analysis of carbon in sediments using FNAA

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**Introduction:** Oceans absorb around a third of the carbon dioxide (CO<sub>2</sub>) produced by humans and reduces the impact of climate change<sup>1</sup>. A significant part of absorbed CO<sub>2</sub> is deposited in coastal marine sediments.

The analysis of carbon in sediments provides valuable information on present and past ecosystem functioning, carbon sequestration and the global carbon cycle. Information obtained by nuclear and nuclear related techniques, when applied together in analysis and dating of marine sediments help us understand the fate of carbon in sediments, thus enabling carbon storage assessment and evaluation of cumulative effects between eutrophication, heavy metal loadings, sea warming, acidification and potential of sediments to sequester carbon.

Carbon in coastal marine sediments may be of organic or inorganic origin. Primary bioproduction in life forms such as algae and phytoplankton are the main source of the organic carbon. The CO<sub>2</sub> which these organisms absorb from the atmosphere directly or from the CO<sub>2</sub> dissolved in the sea will be sequestered by sediments after they die and sink to the sea bottom. Other sources of organic carbon are organic matter transported to the sea by rivers or by atmospheric deposition, organic pollutants, decay of marine organisms, excretions of marine organisms etc. The main source of inorganic carbon are shell making organisms such as plankton and foraminifera, and calcite excreted from the sea when oversaturated. On long time scale these sediments compress and harden into limestone and other sedimentary carbonate rock.

Sediments respond to climate changes in two ways: i) with greater accumulation rate due to increased bio-production and greater precipitation of calcite in warmer sea; ii) with shift in isotope signature (e.g. delta<sup>13</sup>C and delta<sup>18</sup>O) reflecting change in sea temperatures, primary bioproduction and absorption of atmospheric CO<sub>2</sub>.

In order to understand the cumulative effect of marine processes it is necessary to determine total carbon, organic and inorganic carbon in sediments. The main advantage of fast neutron activation analysis (FNAA) over other analytical methods for carbon determination is that it is nondestructive and rapid. This might be very important for analysis of

sediment cores which normally yield very small samples usually used for many different types of measurements. Unfortunately, separation of organic from inorganic carbon demand some sample pretreatment, either by removing inorganic carbon by acid, or organic carbon by ignition on 500–550 °C.

Here we will present the development of FNAA method with associated alpha particle or tagged neutrons for rapid analysis of carbon in small sediment samples (weighting below 100 g).

**Methods:** The tagged neutrons method is described below.

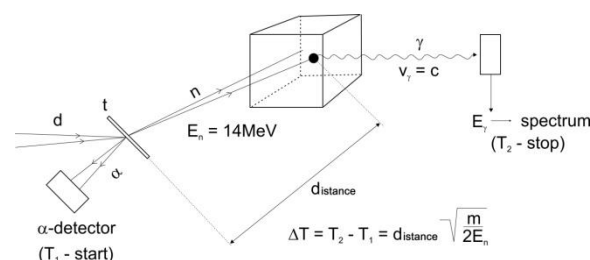


Figure 1: A schematic representation of the tagged neutrons method. For each characteristic gamma ray measured by the gamma detector and produced by the “tagged” neutron, the time-of-flight of the neutron was also measured. The alpha particle was detected at a time  $T_1$  while the gamma ray at the time  $T_2$ . The time difference  $T_2 - T_1$  is proportional to the distance traveled by the neutron beam ( $m$  is neutron mass,  $d$  is distance,  $E_n$  is neutron energy while  $E_\gamma$  is gamma ray energy).

**Results:** Carbon content measured by the FNAA-AAP will be presented for samples obtained from the Black Sea during the IAEA expedition organized by Institute of Oceanology “Fridtjof Nansen” IO-BAS, Varna, Bulgaria on Sep. 26, 2018 with vessel Academic.

**References:** [1] C.L. Sabine et al. (2004) The Oceanic Sink for Anthropogenic CO<sub>2</sub>, *Science*; 305: 367-371.