Investigation of the chemical composition of bottom sediments of the North Pacific

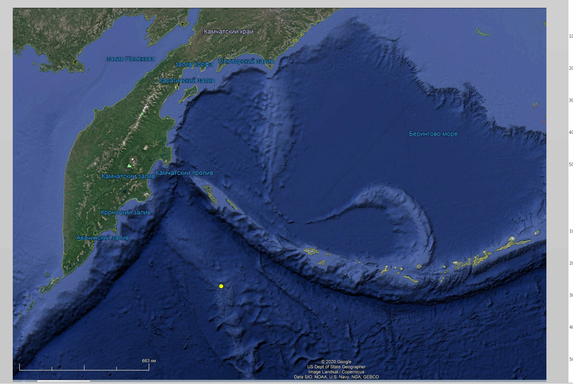
Ivan Kirichenko (IGM SB RAS iskirichenko@igm.nsc.ru)
Dr Sergey Gorbarenko (V.I. Il'ichev Pacific Oceanological Institute)

Abstract

The chemical composition of the bottom sediments of Bering Sea (north-west of the Pacific) was measured by method of X-ray fluorescence analysis using synchrotron radiation (SRXRF) at the collective station, VEPP 3 (Institute of Nuclear Physics, SB RAS). Column length is 560 cm. The study of the chemical composition of this column is a continuation of large-scale work aimed at studying the climate of the North Pacific.
The aim of the work is to construct several climate change schemes for the Bering Sea and the subarctic of the Pacific for the characteristic time slices of the last two glacier-ice cycles: the maximum of the last glaciation, the Marine Isotope Stage 4 (MIS 4), the maximum of the last interglacial glaciation (MIS 5.5), the maximum of the penultimate glaciation (Heinrich event 11, MIS 6.2) and the warmest possible MIS 6.5. The general characteristic patterns of orbital and millennial environmental, climate and ventilation changes in the Bering Sea and the Pacific subarctic that have occurred during global climate change over the last two glaciation-ice cycles (190-0 thousand years ago) will be established. Analysis of mutual influence of environment and climate parameters between the subarctic of the Pacific Ocean and the Bering Sea over the last 190 thousand years.
The experiment is aimed at studying the distribution of chemical elements, markers of paleoclimatic changes along the core of bottom sediments in order to identify orbital and rapid climate changes in the last two cycles of glaciation-icing. And also to clarify the role of the region in changes in the palaeoceanology of the world's oceans and in the interaction of water and atmosphere that had occurred during orbital and millennial climate changes.
As part of the work were obtained distributions of chemical elements (from K to Mo for K-series and U, Th, Pb for L-series) along the column under study in 1 cm steps. The conducted cluster analysis showed the presence of two large groups of elements. The first one reflects the terrigenous component of the sediment (K, Rb, Nb, Th, Y, Zr, Mo, Ti, Fe, etc.) and the second - biogenic (Ca, Sr, U, Ge, As, Br). In the Fourier and wavelet spectra of the distribution of the chemical elements were found periodically components comparable with periods of D-O events.

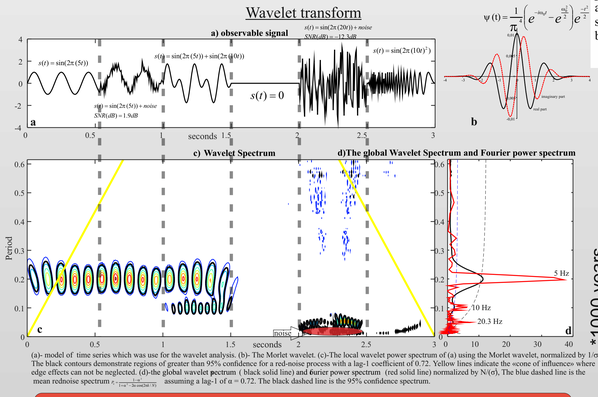
Introduction

The trace elements local distribution data, particularly (U, P, Br, Mo, BiSi et all) in the bottom sediments of lake and oceans reflects the conditions of those sediments formation, and correlates with changes in paleoclimatic conditions. In papers [Colman et all, 1995; Goldberg et all, 2000, etc.] established that the concentrations of some elements contained in the bottom sediments of ocean and lakes, in particular BiSi, Sr / Ba, Sr / Rb, Ti, U et al., reflect changes in insolation caused by periodic oscillations parameters Earth's orbit (Milankovitch cycles). Our research focuses on the study of the spatial distribution of chemical elements in the bottom sediments of North Pacific.
The purpose of this research is determination the centure-to-thousand scale oscillations in the concentration of chemical elements in the sediments of North Pacific. Column LV 76-21-1 was selected on the international Russian-Chinese expedition on the ship "Academician M.A. Lavrent'ev" in 2016 : 51°34N, 167°16 E. at a depth of 2771 meters



Materials and Methods

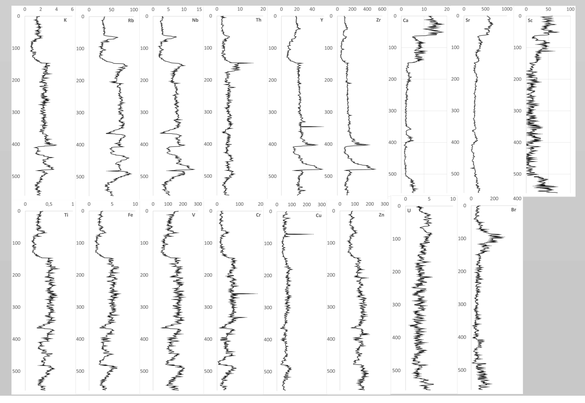
To determine concentrations of chemical elements along the core profile of bottom sediments, was applied the method XRF using synchrotron radiation.Samples for XRFA were produced using the technique described in [Phedorin et al., 1998, 2000].A samples with a 30 mg were compressed into tablets 5 mm in diameter and 0.13 g cm-2 in surface density. The tablets were irradiated with a polarized beam of synchrotron radiation of the VEPP-3 storage ring.The energy of primary excitation was 23 keV.
A wide range of elements have been defined K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Ga, As, Se, Br, Rb, Sr, Y, Zr, Nb, Mo, U, Th (L-series).As a sample comparison (using the external calibration technique) the following was used BIL-1.
The analysis of the distribution of chemical elements along the columns of bottom sediments of thermal lakes was carried out by the method of cluster, wavelet and Fourier analysis Wavelet analysis was carried out using the developed program code for calculation of wavelet and Fourier spectra, based on published data [Torrence et al., 1997] in matlab software package. For the interpretation of the wavelet analysis data, a projection of the W(a,b) spectrum, which is a surface, on the plane (a,b), with isolines showing the change of the wavelet transformation amplitude intensity on different scales and their localization in the time domain, was constructed.



(a)- moded of time series which was use for the wavelet analysis. (b)- The Morlet wavelet. (c)-The local wavelet power spectrum of (a) using the Morlet wavelet, normalized by $1/\sigma^2$. The black contours demonstrate regions of greater than 95% confidence for a red-noise process with a lag-1 coefficient of 0.72. Yellow lines indicate the scone of influences where edge effects can not be neglected. (d)-the global wavelet pectrum (black solid line) and ûurier power spectrum (red solid line) normalized by N/(σ), The blue dashed line is the mean rednoise spectrum $P_k = \frac{\sigma^2(1-\alpha^2)}{|1-\alpha e^{2\pi i k/N}|^2}$ assuming a lag-1 of α = 0.72. The black dashed line is the 95% confidence spectrum.

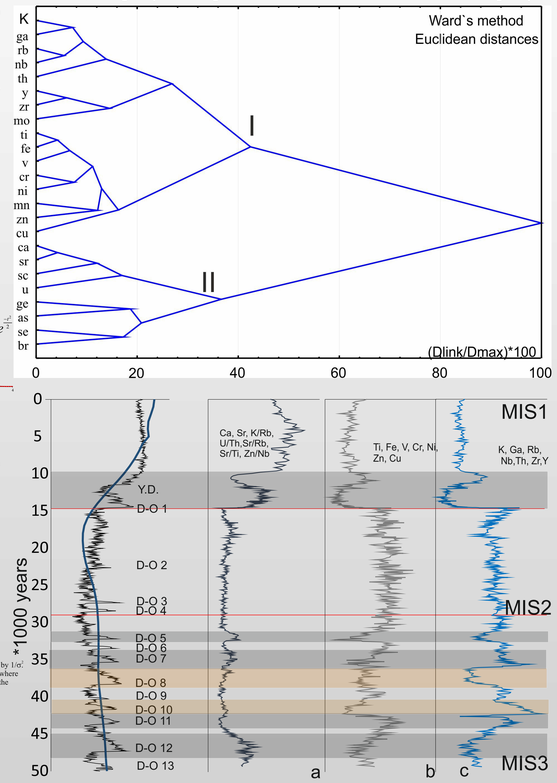
Results

We got data on the distribution of chemical elements in the cores of sediments by XRF by an resolution - 1cm; the average rate of sedimentation in the elevated parts of the Academic mountain range is 0,113 mm / year, then the time resolution is 90 years. Distributions of the most representative chemical elements along the bottom sediment

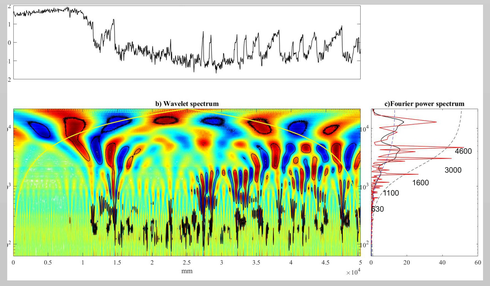


Results

Cluster analysis for the distribution of chemical elements showed the presence of two large groups: terrigenous elements and organogenic. In this case, the group of terrigenous elements is divided into two subgroups

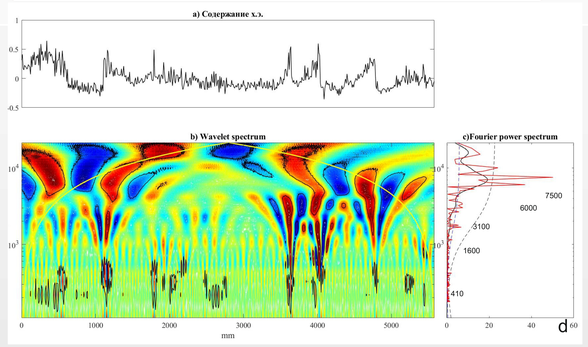


The figure shows different climate proxy relative to the oxygen-18 distribution curve of Greenland ice(thin black curve-Dansgaard–Oeschger even) and Specmap(thick blue line).The data were renormalized to vary between 0 and 1. a- stack is an average of the dimensionless profiles of Ca, Sr, K/Rb,U/Th,Sr/Rb, Sr/Ti, Zn/Nb; b-Ti, Fe, V, Cr, Ni, Zn, Cu; c-K, Ga, Rb, Nb,Th, Zr,Y

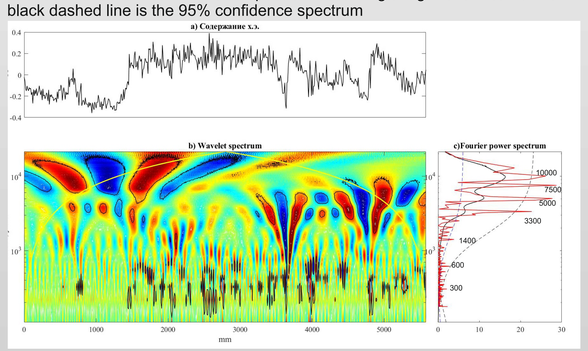


Wavelet spectrum D-O events. The designations are shown in the following figure

Results



The local wavelet power spectrum of K/Rb events using the Morlet wavelet, normalized by $1/\sigma^2$. The black contours demonstrate regions of greater than 95% confidence for a red-noise process with a lag-1 coefficient of 0.72. Yellow lines indicate the «cone of influence» where edge effects can not be neglected. (d)-the global wavelet spectrum(black solid line) and fourier power spectrum (red solid line) normalized by $N/(\sigma^2)$, The blue dashed line is the mean rednoise spectrum assuming a lag-1 of α = 0.72. The black dashed line is the 95% confidence spectrum



Wavelet spectrum Fe.

Conclusion

A study of the distribution of chemical elements in the bottom sediments of the North Pacific Ocean revealed the presence of element groups. The first group of elements (Ca, Sr, K/Rb,U/Th,Sr/Rb) correlates with the d-o event, while the second group (Ti, Fe, V, Cr, Ni, Zn, Cu,K, Ga, Rb, Nb,Th, Zr,Y) is in the antiphase with them.
A wavelet analysis of the distribution of chemical elements revealed the presence in their spectra of significant periodic components comparable with periods of D-O events.

Acknowledgements

This work was supported of the grant "Interaction of orbital and millennial changes in the environment and hydrology of the Bering Sea and Sub-Arctic, Pacific Ocean for the last two cycles of glaciation and glaciation under global climate variations" № 19-05-00663. The study was carried out as part of government assignment(Projects No. VIII.72.2.3 (0330-2016-0011