Mexico

Meetings
Two oral presentations by Mexican participants were given in the Third GEOTRACES Model-Synergy Workshop (November 13-17, 2011, Barcelona, Spain).

Two poster presentations devoted to marine trace element biogeochemistry, related to GEOTRACES program were presented on the 11th International Conference on the Biogeochemistry of Trace Elements (July 3-7, 2011, Florence, Italy).

Cruises
R/V "Francisco de Ulloa" (CICESE, Ensenada, Mexico) was used to deploy an automated sediment trap in Soledad (San Lázaro) Basin located in the Gulf of Ulloa, west off Baja California peninsula, as well as another automated sediment trap in the Alfonso Basin (La Paz Bay, south-western Gulf of California) to collect settling particulate matter for further major and trace element analyses and vertical particulate element fluxes calculation. Both traps were programmed for July 2011 - August 2012 time series.

R/V " Río Suchiate" (Mexican Navy) was used in September and October 2011 in the western Gulf of California, in front of Santa Rosalía copper mining region to collect surface sediments and sediment cores. These samples are necessary for geochemical studies of heavy metal pollution of the marine environment occurred as a consequence of ancient mining, as well as for the assessment of the combined impact of anthropogenic sources and water column oxygen minimum zone influence on the geochemistry of redox-sensitive trace elements with special attention to uranium and lanthanides.

New funding
There is no direct funding for GEOTRACES activities in Mexico. However, GEOTRACES related projects obtained financial support from CONACyT (Mexican Council for Science and Technology) fundamental research fund. Limited financial support for the research and educational centers in the National Polytechnic Institute of Mexico system is also available.

Ongoing projects
a) CONACyT funding:
1. "Biogeochemistry of trace metals in the southern part of the Southern California Bight: a region influenced by the California Current, upwelling and anthropogenic inputs". Multidisciplinary project awarded to Universidad Autónoma de Baja California, Mexico with the funding of $2,500,000 pesos (P.I.- Dr. Francisco Delgadillo-Hinojosa; duration: 2010-2013).

Many trace metal distributions in the water column of the coastal zone are strongly controlled by biological (e.g. photosynthesis, respiration) and physical (e.g. upwelling, horizontal transport, vertical mixing) processes. However, in some cases, anthropogenic inputs of metals from adjacent land masses may be more significant than natural sources and processes. Consequently, the relative contributions of those natural and anthropogenic processes need to be determined in order to resolve their influence on trace metal concentrations in neritic or coastal waters, as well as their fluxes to oceanic waters. This proposal is designed to distinguish the impact of natural and anthropogenic inputs of selected trace metals (Fe, Cd, Mn and Cu) into the southern part of the Southern California Bight (SSCB), a region which is influenced by the California Current, seasonal upwelling and relatively constant anthropogenic inputs from the Mexican city of Ensenada. The main aims of this project are 1) to determine the spatial distribution and seasonal variability of Fe, Mn, Cu and Cd concentrations in the water column and sediments in the SSCB and 2) to identify and quantify the fluxes associated with the different sources of these metals (atmospheric, benthic and

anthropogenic) to the SSCB.

2. “Atmospheric fluxes of bioactive metals and their solubility in the Gulf of California: a scene towards climate change”. Multidisciplinary project awarded to Universidad Autónoma de Baja California, Mexico, with the funding of $3,619,000 pesos (P.I.- Dr. José A. Segovia-Zavala; duration: 2012-2015).

Atmospheric deposition of macronutrients and micronutrients sets important controls on marine ecology and biogeochemistry. Atmospheric fluxes have been varying during time due to climate change and human influences. Contemporary patterns of marine biogeochemistry may to some degree reflect variations in time of the atmospheric input of nutrients. Modeling studies suggest that changes in climate and land use practices over recent decades may have altered dust fluxes and thus aeolian contributions to open ocean regions affecting the ocean biogeochemistry. It has been demonstrated that atmospheric contribution of bioactive metals (e.g., Fe and Mn) towards the open ocean is capable to modulate the marine biogeochemistry and productivity, as well as the sequestration of CO_2 from the atmosphere towards the ocean. Surprisingly, despite its importance, the role of the aerosols in the biogeochemical cycles of the trace elements in the oceanic margins has not been adequately evaluated. These limits include estuaries, continental shelf and marginal seas, which are regions that generate an important fraction of primary organic productivity. Especially, the Gulf of California (GC), one of the most productive semi-enclosed seas of the world, has not been sufficiently studied from the perspective of the biogeochemistry trace metals, including important bioactive elements such as Fe, Mn, Co and Cu. Therefore, the main goals of this project are: 1) to determine the spatial distribution and seasonal variability of atmospheric fluxes of particles and associate metals (Fe, Mn, Cu and Co), as well as to identify processes that control the concentration of these trace elements in the surface layer of this enclosed sea; 2) To evaluate the natural contributions of metals from the surrounding deserts, its solubility in the surface layer and its impact on the GC primary organic production; 3) To generate a conceptual model that will allow to design scenarios of possible impact produced by the intensification of El Niño and La Niña phenomena, which increase with climate change. The expected results would help designing managing and conservation strategies for productive seas of Mexico and other parts of the world.

b) Funding from “Secretaría de Investigación y Posgrado” of the National Polytechnic Institute of Mexico (Instituto Politécnico Nacional).

1. Multidisciplinary project “Geochemical and ecotoxicological evaluation of the contamination state by heavy metals of the coastal environment of Santa Rosalía mining region (Southern Baja California)”, with the funding of $750,000 pesos (P.I.- Dr. Evgueni Shumilin; duration: 2011-2012)

New results

Scientific highlights

The geochemical behavior of As, Hg and other trace elements from geothermal sources in the shallow marine ecosystem of the Santispac mangroves and lagoon, as well as the Mapachitos shallow submarine hydrothermal area of the Concepción Bay (western Gulf of California) was characterized. The obtained data show that intertidal geothermal springs and hydrothermal vents are the main source of As and Hg in water, sediment and algae of the Santispac area of the bay. Arsenic remained largely in the dissolved fraction. This element spread a longer distance from the source and precipitated only in the close vicinity of a hot spring or hydrothermal vent. In contrast to As, Hg was rapidly deposited in sediments near the discharge point and did not contaminate the surrounding area waters. The organic, sulfide rich sediments, catched some quantities of the mentioned elements, while the rest of these escaped with tidal waters to the lagoon and adjacent

part of the Concepción Bay. The brown seaweed *Sargassum sinicola* from the intertidal hot springs of the Santispac bight area, accumulates large quantities of As (168 mg kg^{-1}), and is also enriched in Cs, Ge, Hg and Sb. The *Sargassum sinicola* collected near hydrothermal vents displays larger quantities of As (above 600 mg kg^{-1}), surpassing its common concentration in the genus *Sargassum* by an order of magnitude. In contrast to As, the seaweed does not significantly accumulate Hg.

M.S. and Ph.D. theses related to local "GEOTRACES" problems.

Choumiline K., 2011. Geochemistry of settling particulate matter and recent sediments of Alfonso Basin, La Paz Bay". M.S. Thesis. Centro Interdisciplinario de Ciencias Marinas - Instituto Politécnico Nacional, La Paz, Baja California Sur, Mexico, 143 p (in Spanish).

Posada Ayala I.H., 2011. Environmental geochemistry of the San Antonio mining district, sediments of the arroyos of San Juan de Los Planes Basin and continental shelf of the La Ventana Bay, Baja California Sur, Mexico. M.S. Thesis. Centro Interdisciplinario de Ciencias Marinas - Instituto Politécnico Nacional, La Paz, Baja California Sur, Mexico, 211 p (in Spanish).

Vázquez Figueroa V., 2011. Geochemical characterization of the surficial marine sediments of the Wagner and Consag Basins, Northern Gulf of California". Universidad Nacional Autónoma de México (UNAM), Mexico City, Mexico (in Spanish).

Renteria Cano M., 2011. Trace elements in the zooplankton of the northern and central parts of the Gulf of California. Ph.D. Thesis. Centro Interdisciplinario de Ciencias Marinas - Instituto Politécnico Nacional, La Paz, Baja California Sur, Mexico, 193 p (in Spanish).

Leal Acosta, M.L., 2012. Influence of geothermal and hydrothermal sources on the biogeochemistry of trace elements in Concepción Bay, Gulf of California. Ph.D. Thesis. Centro Interdisciplinario de Ciencias Marinas - Instituto Politécnico Nacional, La Paz, Baja California Sur, Mexico, 328 p (in Spanish).

Publications

Journal articles

Rentería-Cano M.E., Sánchez-Velasco L., Shumilin E., Lavín M.F., J.Gómez-Gutiérrez, 2011. Major and trace elements in zooplankton from the Northern Gulf of California during summer. Biological Trace Element Research, 142: 848-864.

Segovia-Zavala J.A., Delgadillo-Hinojosa F., Lares-Reyes M.L., Huerta-Diaz M.A., Munoz-Barbosa A., Santa María del Angel E., Torres-Delgado E.V. and S.A. Sanudo-Wilhelmy, 2011. Vertical distribution of dissolved iron, copper, and cadmium in Ballenas Channel, Gulf of California. Ciencias Marinas, 37 (4 A): 457-469.

Shumilin E., Gordeev V., Rodriguez Figueroa G., Demina L., K.Choumilin, 2011. Assessment of geochemical mobility of metals in surface sediments of the Santa Rosalía mining region, western Gulf of California. Archives of Environmental Contamination and Toxicology. 60:8-25.ISSN: 0090-4341.

Shumilin E., Rodríguez-Figueroa G., Sapozhnikov D., Yuri Sapozhnikov Yu. and K. Choumiline, 2012. Anthropogenic and authigenic uranium in the marine sediments of the Central Gulf of California adjacent to the Santa Rosalía mining region. Archives of Environmental Contamination and Toxicology. DOI : 10.1007/s00244-012-9776-1.

Shumilin E., Rodríguez Figueroa G., Sapozhnikov D. and N. Mirlean, 2012.Vertical profiles of cobalt and zinc in the marine sediments of the Gulf of California in front of the Santa Rosalía mining region, Mexico. J. Iberian Geology (accepted).

Other activities

During the interaction by correspondence and exchange of ideas between the Mexican researchers who wish to participate in the "GEOTRACES" activities, the following specific

interests and challenges of the forming “GEOTRACES-Mexico” national programme were defined:

1. Coastal studies are of most importance at the present moment due to increasing anthropogenic impact.
2. Geothermal and hydrothermal inputs of trace elements into the marine environment and their impact on the related ecosystems are under-estimated and/or under-investigated.
3. The need of training the scientific and technical personal of Mexico in the reliable determination of the key trace elements and isotopes (TEIs) in estuarine and sea waters under clean conditions suggests the search of scientific advising from the principal participants of the “GEOTRACES” international programme, as well as further involvement in the intercalibration activities.
4. The participation of the representatives of Mexico in international R/V cruises in the Pacific and Atlantic Oceans is strongly desired, especially in those devoted to the distribution and source determination of TEIs from the deep submarine hydrothermal fields off North-western Mexico; as well focusing on the importance of redox-sensitive TEIs in the Oxygen Minimum Zone, which extends from the Northern Chile and Peru zones to the Mexican part of the Pacific Ocean.

Submitted by: Evgueni Choumiline