ANNUAL REPORT ON GEOTRACES ACTIVITIES IN MEXICO

April 1st, 2020 to April 30th, 2021

GEOTRACES relevant scientific results

- The Baja California Peninsula could be an important source of dust and Fe to the Gulf of California during the warm months.

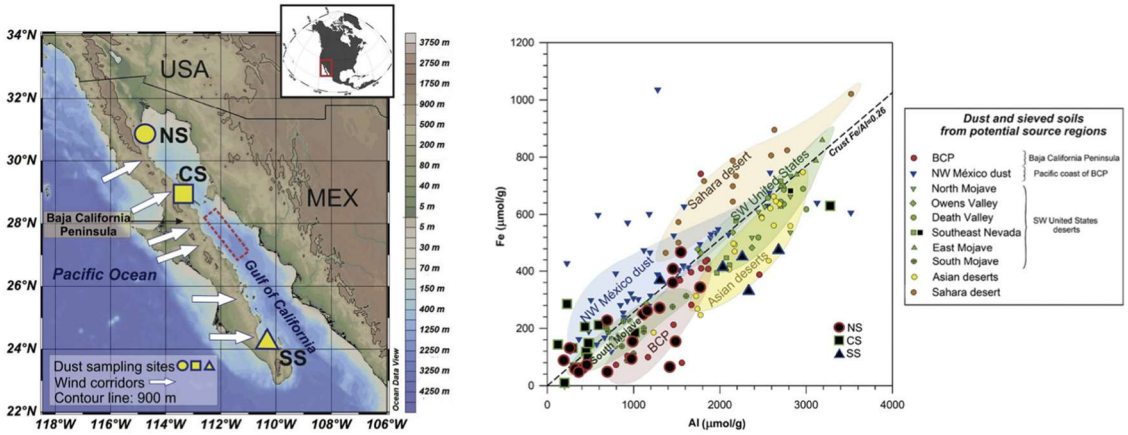

Fig. 1. Iron versus aluminum in dust samples collected at the west coast of the Gulf of California (GC). The shaded areas represent the typical metal composition (Fe and Al) of dust and/or sieved soils from the potential source regions.

The seasonal and spatial variability of atmospheric mineral dust deposition and Fe fluxes along the west coast of the Gulf of California (GC) were measured. Meteorological data and dust samples, collected from June 2010 to October 2013 at three sites of the eastern side of Baja California Peninsula (BPC), evidenced an across-BCP wind component (W-E) during the warm season (May–September), suggesting that winds crossing the BCP from west to east were an important source of variability. Dust deposition at the northern and center sites were significantly higher during the warm season, revealing that the BCP could be an important source of dust and Fe to the GC during this season. An analysis of the total Fe concentration and Fe/Al ratios also suggest that the BCP and the Mojave Desert are potential sources of the dust arriving to the northern and central region of the GC. Total averages of dust and Fe fluxes were comparable to those reported for other marginal seas (e.g., Mediterranean, Aqaba) similarly influenced by inputs of mineral dust from the surrounding deserts. A comparison between fluxes show that atmospheric soluble Fe inputs are equivalent to between 6 ± 4% (cool season) and 71 ± 40% (warm season) of the dissolved Fe supplied by upwelling. Thereby, during the warm season, when the GC is warmer and strongly stratified, atmospheric deposition represents a significant source of soluble Fe. This supply of Fe would be enough to meet the requirements of N2-fixing primary producers that reside in the oligotrophic surface waters of the GC during summer.

- Mo_D in a hypersaline system showed a non-conservative behavior relative to salinity.

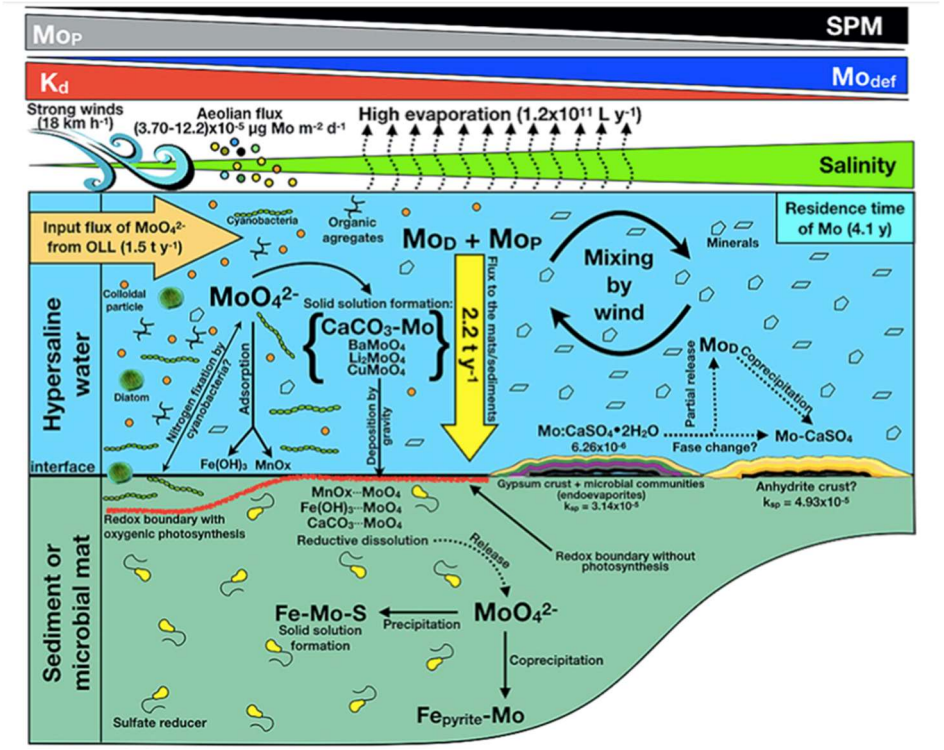

Fig. 2. Conceptual model of the potential Mo removal mechanisms from the hypersaline water column to the sediments and microbial mats examined in the study of Valdivieso-Ojeda et al. (2020) conducted on Ojo de Liebre Lagoon and evaporation ponds of the Guerrero Negro saltern, Baja California Peninsula, Mexico.

Valdivieso-Ojeda, J.A., Huerta-Diaz, M.A., Delgadillo-Hinojosa, F. (2020). Non-conservative behavior of dissolved molybdenum in hypersaline waters of the Guerrero Negro saltern, Mexico. Applied Geochemistry, 115, 104565. doi: 10.1016/j.apgeochem.2020.104565

Trace metal distribution and speciation studies in hypersaline systems are scarce because of the difficulty in measuring low metal concentrations in high salinity waters. In this study dissolved molybdenum (Mo_D) was measured in samples collected in one of these systems. Mo_D concentrations were well below those predicted from simple seawater evaporation, indicating non-conservative behavior of Mo_D relative to salinity. The magnitude of the removal process was reflected in both the high calculated Mo_D fluxes toward the sediment/microbial mat (2.2 ton yr^{-1}), and the very short residence time of Mo_D (4.1 yr) in the water column of the evaporation ponds. These findings suggest that sediments/microbial mats and also gypsum from current hypersaline environments act as important, but as yet unquantified, Mo_D sinks. Removal of Mo_D in hypersaline environments may have been especially important during the geological past, when these environments were more prevalent and extensive, and thus capable of influencing the global Mo cycle as well as, indirectly, the nitrogen cycle.

Current projects

- Total and pyritic trace metals in sediments applied to the evaluation of paleoredox and paleoenvironmental conditions in marine systems. Project awarded to Universidad Autónoma de Baja California, Mexico. P.I. Dr. Miguel Angel Huerta Díaz (2015-2020).
- Atmospheric fluxes of bioactive metals and their solubility in the Gulf of California: a scene towards climate change. Multidisciplinary project financed by CONACyT (PI: Dr. Francisco Delgadillo Hinojosa; 2015-2020).
- Biological response of phytoplankton community to iron and vitamin B12 and their implication to the formation and presistence of Harmful Algal Blooms in Mexican coastal waters. Multidisciplinary project financed by CONACyT. PI: Dr. Mary Carmen Ruiz de la Torre (2017-2020).
- Mass balance of dissolved iron in Todos Santos Bay, Baja California: Biological responses of phytoplankton and biogeochemical implications. Project awarded by Universidad Autónoma de Baja California, Mexico. PI: Dr. Miguel Ángel Huerta Díaz (2018-2020).

GEOTRACES-relevant publications

- Celis-Hernández, O., Giron-Garcia, M.P., Ontiveros-Cuadras, J.F., Canales-Delgadillo, J.C., Pérez-Ceballos, R.Y., Ward, R.D., Acevedo-Gonzales, O., Armstrong-Altrin, J.S., Merino-Ibarra, M. (2020). Environmental risk of trace elements in mangrove ecosystems: An assessment of natural vs oil and urban inputs. Science of the Total Environment, 730, 138643. https://doi.org/10.1016/j.scitotenv.2020.138643
- Delgadillo-Hinojosa, F., Félix-Bermúdez, A., Torres-Delgado, E. V., Durazo, R., Camacho-Ibar, V., Mejía, A., Ruiz, M.C., Linacre, L. (2020). Impacts of the 2014-2015 warm-water anomalies on nutrients, chlorophyll-a and hydrographic conditions in the coastal zone of northern Baja California. Journal of Geophysical Research: Oceans, 125(12), e2020JC016473. https://doi.org/10.1029/2020JC016473
- Dótor-Almazán A., Gold-Bouchot G., Lamas-Cosío E., Huerta-Diaz M.A., Ceja-Moreno V., Oceguera-Vargas I., Zapata-Pérez O., Arcega-Cabrera F. (2020) Spatial and temporal distribution of trace metals in shallow marine sediments of the Yucatan Shelf, Gulf of Mexico. Bulletin of Environmental Contamination and Toxicology (in press). doi: 10.1007/s00128-021-03170-2.
- Félix-Bermúdez, A., Delgadillo-Hinojosa, F., Torres-Delgado, E. V., & Muñoz-Barbosa, A. (2020). Does sea surface temperature affect solubility of iron in mineral dust? The Gulf of California as a case study. Journal of Geophysical Research: Oceans, 125(9), e2019JC015999. https://doi.org/10.1029/2019JC015999
- García-Orozco, J, Huerta-Diaz, MA, Valdivieso-Ojeda, J, Delgadillo-Hinojosa, F, Mejía-Piña, KG, Árcega-Cabrera, F. (2020). A novel method to measure calcium carbonate with portable X-ray fluorescence instrumentation and its application to Gulf of Mexico surficial sediments. Sedimentary Geology, 105724. doi: 10.1016/j.sedgeo.2020.105724.
- González-De Zayas, R. Rossi, S., Hernández-Fernández, L., Velázquez-Ochoa, R. Soares, M., Merino-Ibarra, M. Castillo-Sandoval, F.S., Soto-Jiménez, M. (2020). Stable isotopes used to assess pollution impacts on coastal and marine ecosystems of Cuba and México.

Regional Studies in Marine Science, 39, 101413. https://doi.org/10.1016/j.rsma.2020.101413
- Muñoz-Barbosa, A, Delgadillo-Hinojosa, F, Torres-Delgado, EV, Félix-Bermúdez, A, Castro, R (2020). Bajacalifornian dust deposition and atmospheric input of iron to the Gulf of California during the summer. Marine Chemistry, 103850. https://doi.org/10.1016/j.marchem.2020.103850
- Ramos-de-la-Cruz, R., Pajares, S., Merino-Ibarra, M., Monreal-Gómez, M.A., Coria-Monter, E. (2021). Distribution of nitrogen-cycling genes in an oxygen-depleted cyclonic eddy in the Alfonso Basin, Gulf of California. Marine & Freshwater Research. https://doi.org/10.1071/MF20074
- Valdivieso-Ojeda, J.A., Huerta-Diaz, M.A., Delgadillo-Hinojosa, F. (2020). Non-conservative behavior of dissolved molybdenum in hypersaline waters of the Guerrero Negro saltern, Mexico. Applied Geochemistry, 115, 104565. doi: 10.1016/j.apgeochem.2020.104565
- Valdivieso-Ojeda, J.A., Huerta-Díaz, M.A., Delgadillo-Hinojosa, F., Otero, X.L., Arenas-Islas, D., García-Orozco, J. (2021). Sediment trace metal levels in the Ojo de Liebre Lagoonal Complex (Baja California, Mexico), a marine wildlife protected area. Marine Pollution Bulletin, 363: 341 –354. doi: 10.1016/j.marpolbul.2021.112097
- Valdivieso-Ojeda J.A., Huerta-Diaz M.A., Delgadillo-Hinojosa F., Otero X.L., Arenas-Islas D. and García-Orozco J. (2021) Sediment trace metal levels in the Ojo de Liebre Lagoonal Complex (Baja California, Mexico), a marine wildlife protected area. Marine Pollution Bulletin, 165, 112097. doi: 10.1016/j.marpolbul.2021.112097.

GEOTRACES PhD and Master theses

- Arenas Islas, Diana (2021) Determination of arsenic and mercury levels in sediments and microbial mats from hypersaline environments: Biogeochemical implications. Ph.D. thesis - Universidad Autónoma de Baja California. (In Spanish)
- Pérez Mendieta, R. (2021). Atmospheric flux of mineral dust and copper to the Gulf of California central region: spatial and temporal variability and implications. M.Sc. thesis - Universidad Autónoma de Baja California. (In Spanish)
- Cervantes Flores, Karla Roxana (2021). Degrees of trace metal pyritization in Gulf of Mexico deep sediments. M.Sc. thesis - Universidad Autónoma de Baja California. (In Spanish)

GEOTRACES presentations in international conferences

- Camacho-Ibar, V.F., Valencia, A., Hakspiel, C., Velasquez, J., Avila-López, C., Muñoz-Anderson, M., Lee, E. Inorganic nutrients in the deep-water region of the Gulf of Mexico: what have we learnt from a baseline study of the CIGoM project. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA
- Cervantes, G., Hernández-Ayón, J.M., Zirino, A., Herzka, S.Z., Camacho-Ibar, V.F., Montes, I., Sudre, J., Delgado, J. A new characterization of the upper waters of the central Gulf of Mexico based on water mass hydrographic and biogeochemical characteristics. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA
- Contreras-Pacheco, Y.V., Herguera, J.C., Herzka, S.Z., Bobadilla, D., Barradas, M.R., Quintanilla, G. Elemental and isotopic composition of particular organic carbon and

nitrogen in the Gulf of Mexico. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA

- Hakspiel, C., Camacho-Ibar, V., Valencia A. Mesoscale drives inorganic nutrient dynamics in two areas of the Mexican off-shore of the Gulf of Mexico. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA
- Hernandez-Ayon, J.M., Delgado, J., Cervantes, G., Tanahara, S., Montes, I., Sudre, J., Herzka, S.Z., Camacho-Ibar, V.F. Increase of Caribbean water incursion into the Gulf of Mexico: The need in biogeochemistry studies of a new characterization of the upper waters of the central Gulf of Mexico. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA
- Lee, E., Camacho-Ibar, V.F., Velasquez, J., Valencia, A. Effect of mesoscale eddies on the vertical distribution of dissolved inorganic nutrients in open waters of the Gulf of Mexico during a warm and a cold season. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA
- Linacre, L., Lara-Lara, R., Mirabal-Gómez, U., Bazan-Guzmán, C. Pico-phytoplankton dynamics during contrasting seasonal conditions in two regions of Gulf of Mexico. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA
- Valencia-Gasti, J.A., Camacho-Ibar, V.F., Hernández-Ayon, J.M., Barbero, L. Outflow of Gulf of Mexico waters below 600 m through the Western Yucatan Channel suggested by biogeochemical tracers and hydrography. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA
- Velasquez, J. Camacho-Ibar, V.F., Lee, E. Valencia, A., Trasviña-Castro, A. Control of mesoscale eddies on the vertical nitrate distribution and the nitracline shape and depth in open ocean waters of the Gulf of Mexico. Ocean Sciences meeting, 16-21 February 2020. San Diego, CA, USA

Contributors to the report

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