Regionalization of natural and artificial radionuclides in marine sediments of the Southern Gulf of Mexico

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Introduction

This paper summarizes the results of regional studies of radioactivity (^{40}K and ^{137}Cs) in marine sediments of the Southern Gulf of Mexico. These investigations were initiated in 1993 and the first results were published by Rodríguez-Espinosa P.F *et al.*, in 1998, 1999a, 1999b and 1999c. They found that the ^{137}Cs, ^{40}K and ^{214}Bi concentrations measured in five sediment-cores sampled in the southern Gulf of Mexico are similar to those reported in the world inventory for same type of marine sediments. As would be expected, the radioactivity concentrations measured vary as a function of sedimentary environment. The highest ^{40}K concentrations are associated mainly with the sediments of the Panuco River, whose drainage basin inputs sediments from the Sierra Madre Oriental and Central Mexico, where intensive agricultural practices and heavy use of fertilizers take place. The mid-range ^{40}K concentrations were measured in sediments of the Grijalva-Usumacinta river fan, and reflected the characteristic properties of the Cenozoic and Paleozoic metamorphic rocks of its drainage basin. Finally, the highest ^{137}Cs concentrations found in the sediment-cores of the Grijalva-Usumacinta river fan sediments result from the higher

rainfall (3,000 mm.yr^{-1}) over its much greater drainage basin size, relative to that of the Pánuco River.

In this paper we now present the results of ^{40}K and ^{137}Cs concentrations in another twelve sediment-cores sampled in the Southern Gulf of Mexico. These new radioactivity concentration values will aid to further understand the nature and regional distribution of radioactivity in Southern Gulf of Mexico marine sediments.

Methods

Twenty five USNEL Box sediment-cores were collected in water depths between 20 to 2,000 m in the Southern Gulf of Mexico of which twelve of them are reported in this paper. The USNEL Box sediment-cores were collected aboard the R/V Justo Sierra during the OGMEX XI, XII and XIII oceanographic cruises, during the summers of 1993, 1994 and 1995 (Figure 1).

The 30-cm deep sediment-cores were sub-sampled in 2-cm thick slides, and frozen for later analyses. Sediment sub-samples were analyzed by XRD to determine mineral composition. The natural ^{40}K and artificial ^{137}Cs radionuclide concentrations were measured using a Ge-Hp Gamma-Spectrometer, and counting for 50-60,000 seconds with a ± 5 % uncertainty (95 % confidence limit). The measurements were made at the Laboratorio de Vigilancia Radiológica Ambiental del Centro at Cienfuegos, Cuba.

Results

We report natural and artificial radioactivity concentrations in twelve of the twenty-five sediment cores sampled. These results are representative of the regional radioactivity concentrations in the Southern Gulf of Mexico.

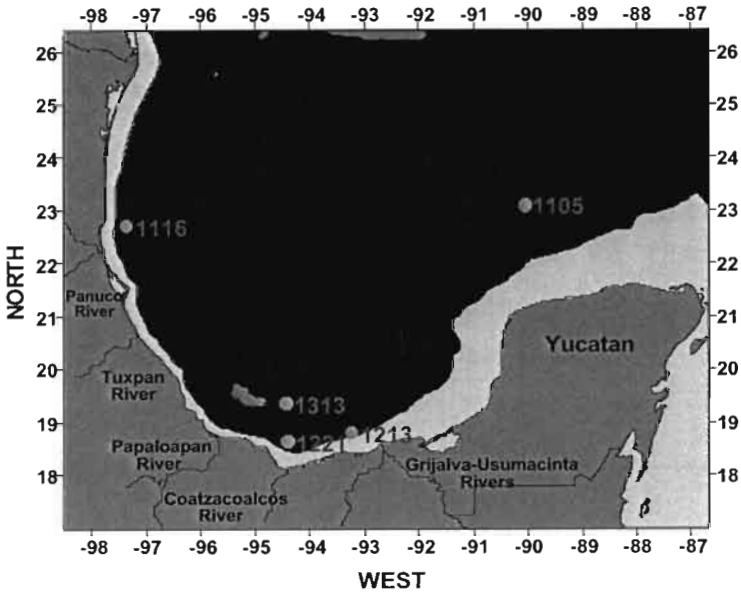


Figure 1
Sediment samples collected in the Gulf of Mexico during 1993, 1994 and 1995.

The ^{137}Cs and ^{40}K concentrations measured range from 2 to 6.5 $Bq.kg^{-1}$ and 100 to 800 $Bq.kg^{-1}$, respectively. The highest ^{137}Cs concentrations were found in the sediments of the Grijalva-Usumacinta river fan at 75 meters depth (stations 1213 and 1210). The lowest ^{137}Cs concentrations were found in the Yucatan Escarpment, in the intermediate carbonate and terrigenous regions at 100 m. (station 1221) and in the maximum depth sampled at 2000 m (station 1313).

The lowest ^{40}K (150-175 $Bq.kg^{-1}$) concentration was found in the Yucatan Escarpment sediments in the southeast Gulf of Mexico. This is basically a carbonated region with no-river influence (station 1105). The highest ^{40}K concentration (700-1000 $Bq.kg^{-1}$) was found in the southwest Gulf of Mexico in the Pánuco river fan (station 1116). The mid-range concentrations of ^{137}Cs (4-5 $Bq.kg^{-1}$) and ^{40}K (400-700 $Bq.kg^{-1}$) were found in the sediments of the southwestern continental shelf, in the Pánuco river fan (Figure 2). Figure 2 is a scatter diagram showing the concentration of ^{137}Cs vs ^{40}K.

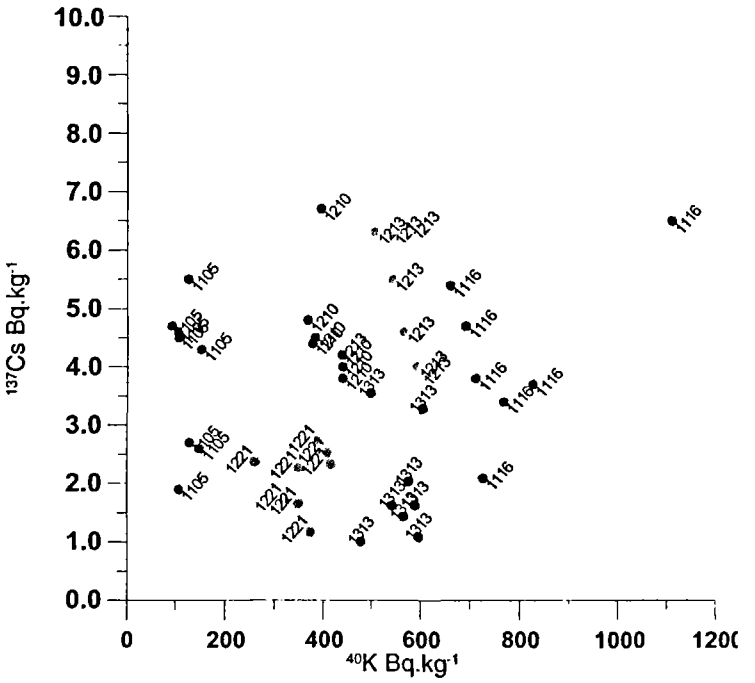


Figure 2
^{137}Cs vs ^{40}K concentrations in marine sediment cores sampled in the Gulf of Mexico.

Figure 3 shows the ^{137}Cs vs ^{40}K concentrations for the same data of figure 2 including error bars. This figure allows us to visualize the instrumental error associated with each measured value and to associate the different radioactivity concentration types with the different sedimentary provinces within the study area, including the influence of the big rivers.

In Figure 4 we show the error bars for the mean ^{137}Cs and ^{40}K concentrations. This figure provides a clear picture of the regional radioactivity distribution in marine sediments of the Southern Gulf of Mexico.

Figure 5 shows a plot of our mean data values compared to the different ^{137}Cs vs ^{40}K concentrations in marine sediments from other

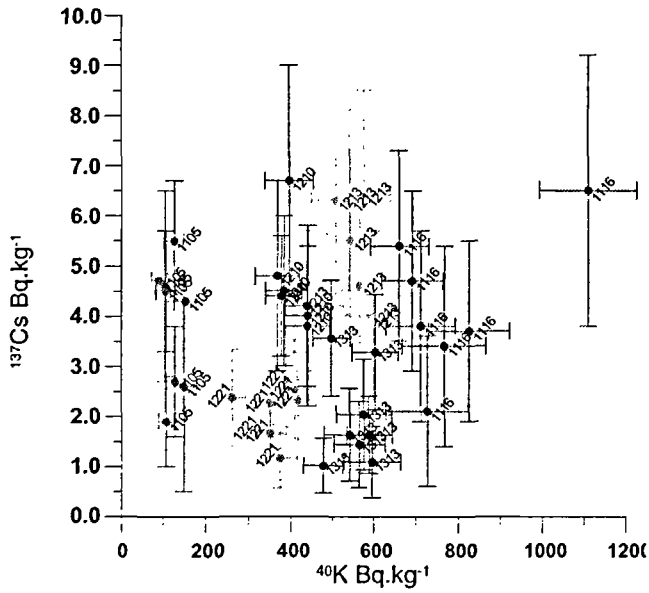


Figure 3
^{137}Cs vs ^{40}K concentrations error bars in marine sediment cores sampled in the Gulf of Mexico.

regions of the word oceans (Yu *et al.*, 1994; Albrecht and Beer, 1997; Pujol and Sánchez, 1997; Alonso *et al.*, 1998; Pérez-Sabino *et al.*, 1999.

Conclusions

Our results corroborate the findings reported by Rodríguez-Espinosa *et al.*, in 1998; 1999a; 1999b and 1999c, namely that the ^{137}Cs and ^{40}K concentrations measured in the sediment-cores sampled in the Southern Gulf of Mexico are similar to those reported in the world inventory for same type of marine sediments.

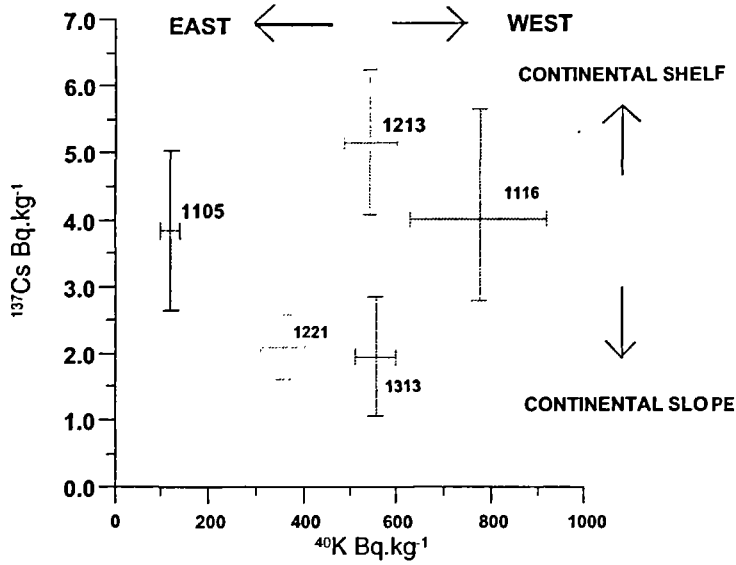


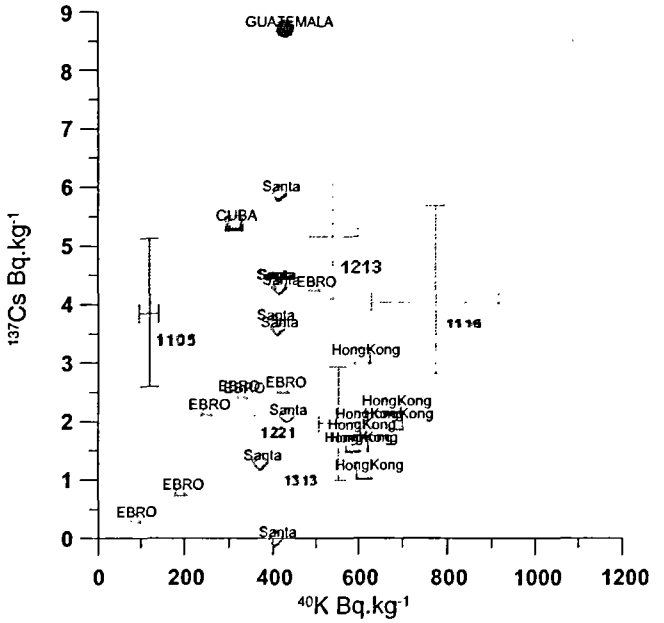
Figure 4
^{137}Cs vs ^{40}K mean concentrations of five marine sediment cores of the Southern Gulf of Mexico.

As would be expected, the radioactivity concentrations measured vary as a function of sedimentary environment.

The highest ^{40}K concentrations are associated mainly with the sediments of the Pánuco River, whose drainage basin inputs sediments from the Sierra Madre Oriental and Central Mexico, where intensive agricultural practices and heavy use of fertilizers takes place.

The mid-range ^{40}K concentrations were measured in sediments of the Grijalva-Usumacinta river fan, and reflected the characteristic properties of the Cenozoic and Paleozoic metamorphic rocks of its drainage basin.

The highest ^{137}Cs concentrations found in the sediment-cores of the Grijalva-Usumacinta river fan sediments result from the higher rainfall (3,000 mm. yr^{-1}) over its much greater drainage basin size, relative to that of the Pánuco River.



I Figure 5
Concentrations of ^{137}Cs vs ^{40}K in sediment cores from different locations of the World.

Finally the highest ^{137}Cs are found in continental shelf sediments, and the lowest in continental slope sediments.

Aknowledgements

Ing. Hector Cartas Radiometría y Contéo del Laboratorio de Vigilancia Radiológica Ambiental del Centro, Cienfuegos, Cuba. This research was sponsored by the Grupo de Estudios Oceanográficos, Centro de Investigación en Ciencia Aplicada y Tecnología Avanzada, The Comisión de Operación y Fomento de Actividades Académicas of the Instituto Politécnico Nacional and Dr. Elva Escobar Briones of the Universidad Nacional Autonoma de México for support the time of the O/V Justo Sierra UNAM for the DGAPA UNAM IN 213197, 217298 and finally CONACYT G27777B PÑ-50.

Bibliography

ALBRECHT A., BEER J., 1997 – Assessment of Radionuclide Distribution in Continental Shelf Sediments (the Gulf of Taranto, Mediterranean Sea). *Radioprotection-Colloques*, 32 C2: 277-285.

ALONSO H. C., DÍAZ A. M., MUÑOZ C. A., SUAREZ MORELL E., CLARO M R., 1998 – Levels of Radioactivity in the Cuban Marine Environment. *Radiation Protection Dosimetry*, 75 (1-4): 69-70.

DAVIES D.K., MOORE W.R., 1970 – Dispersal of Mississippi sediment in the Gulf of Mexico. *Jour. Sed. Petrology*, 40 (1): 339-353.

DAVIES D. K., 1972 – Mineralogy, petrology and derivation of sands and silts of the continental slope, rise and abyssal plain of the Gulf of Mexico. *Jour. Sed. Petrology*, 42 (1): 59-65.

PÉREZ-SABINO J. F., OLIVA DE SANDOVAL B. E., OROZCO-CHILEL R. M., AGUILAR SANDOVAL E., 1999 – "Radioactive Contamination of the Guatemalan Marine Environment". *In: International Symposium on Marine Pollution*, Monaco, 5-9 October 1998 (OIEA ISSN 1011-4289, Vienna, 1999): 550-552.

PUJOL T. LI., SÁNCHEZ C. J.A., 1997 – Radioactividad del Agua Superficial y los Sedimentos en la Cuenca del Ebro: Utilización del Tritio como Radiotrazador en el Tramo Catalán. *Radioprotección* 5 (15): 95-103.

RODRÍGUEZ ESPINOSA P. F., VIDAL LORANDI F. V., VIDAL LORANDI V. M. V., 1998 – "Natural and Artificial Radionuclides in Southern of Gulf of Mexico Marine Sediments". *In: International Symposium on Marine Pollution*, Monaco, 5-9 October 1998 (OIEA ISSN 1011-4289, Vienna, 1999): 612-613.

RODRÍGUEZ ESPINOSA P. F., VIDAL LORANDI F.V., VIDAL LORANDI V.M.V., 1999a – "Natural and Artificial Radionuclides in Southern of Gulf of Mexico Marine Sediments". *In: International Symposium on Marine Pollution*, Monaco, 5-9 October 1998 (OIEA ISSN 1011-4289, Vienna, 1999): 555-556.

RODRÍGUEZ ESPINOSA P. F., VIDAL LORANDI F.V., VIDAL LORANDI V.M.V., 1999b – "On the Concentration and Distribution of Natural (^{40}K, ^{214}Bi and ^{210}Pb) and Artificial (^{137}Cs) Radionuclides in Marine Sediments of The Southern Gulf of Mexico". *In: International Symposium on Nuclear and Related Techniques in Agriculture, Industry and Environment.* Proceeding of the 2nd NURT, V Workshop on Nuclear Physics, Havana, 26-29 October 1998 (ISBN 959-7136-04-X): 1-4.

RODRÍGUEZ ESPINOSA P. F., VIDAL F. V., VIDAL V. M. V., 1999c – "Radioactivity in sediments of the Western, Southern and Central-Eastern Gulf of Mexico". *In: EOS Trans.*, AGU, 80 (49), Ocean Sciences Meet. Suppl.: p OS14.

RODRÍGUEZ ESPINOSA P. F., VIDAL F. V., VIDAL V. M. V., 1996 – *Estudio de la Concentración y Distribución de Radionúclidos Naturales y Artificiales en Sedimentos Marinos del Golfo de México.* Informe Final IIE/UREN/13/5586/I01/F., 374 p.

VAN ANDEL TJ. H., 1960 – Sources and Dispersion of Holocene Sediments, in North west Gulf of Mexico. *Am. Assoc. Petroleum Geologists*, 1: 34-55.

YU K. N., GUAN Z. J., STOKES M. J., YOUNG E. C. M., 1994 – Natural and Artificial Radionuclides in Seabed Sediments of Hong Kong. *Nucl. Geophys.*, 8 (1): 45-48.