

The sediment-water interface is characterized by high biological activity and steep concentration gradients of many chemical species. Ordinary chemical analysis in these steep gradients is often impossible to perform with sufficient depth resolution, and the only alternative is to use microsensors. Presently, electrochemical microsensors for O₂, pH, N₂O, dissolved sulfide, and redox potential have been used in marine research, and in fresh water environments it is furthermore possible to analyze NO₃⁻ and NH₄⁺. Work is currently being conducted to expand the arsenal with a microsensor for dissolved inorganic carbon (CO₂ or bicarbonate). In addition to the chemical sensors fiber-optic light sensors for irradiance and scalar irradiance have been developed. Chemical microsensors with optical signal detection (optrodes) have been developed, and such optical sensors may in the future significantly expand our arsenal of chemical species which can be analyzed.

The analysis of by use of microsensors may be performed on sediment cores brought to the laboratory, but it is also possible to do in situ analysis. Simple in situ analysis at shallow water depth can be done with laboratory equipment which is brought to the field, but analysis in the deep sea requires sophisticated computerized equipment. Jens Gundersen and Bo Barker Jørgensen in our group have developed a lander which can be used down to 6000 m water depth and which can record 8 simultaneous microprofiles at 25 µm depth resolution. The microsensors which have been used until now are those for O₂, pH, and dissolved sulfide. The microsensors are identical to those used in the laboratory except that they are pressure compensated by a flexible rubber bulb filled with paraffin oil. Even in the deep sea, profiles can be recorded with extreme accuracy in terms of both concentration and spatial resolution. Among the interesting results obtained from the deep sea work is the finding that the analysis of near-interface pore water chemistry on sediment cores brought to the surface and exposed to atmospheric pressure will result in very erroneous results.

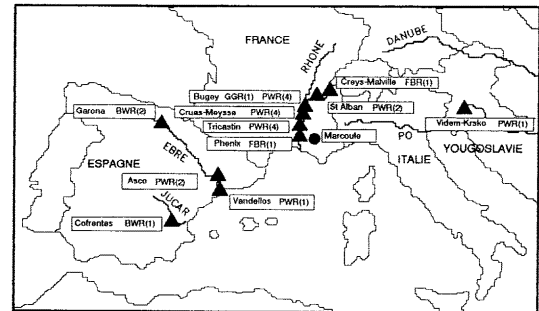
Sediments from shallow depths are exposed to daylight, and the photosynthetic activity by microorganisms within the uppermost sediment layers very much affects the pore water chemistry and thereby all microbial metabolism. We have previously shown how photosynthesis in sediments by use of microsensors can be analyzed at 0.1 mm depth resolution. The transformation and assimilation of inorganic nitrogen species were studied in various types of biofilms and sediments using ¹⁵N and microsensor methods. By use of microsensors for O₂, N₂O, and NO₃⁻ it was possible to localize the depth horizons active in nitrification and denitrification, and it was also possible to obtain depth profiles of reaction rates. Nitrification occurred in the oxic surface layer, and in dark incubated sediments it was sometimes possible to distinguish two distinct nitrification maxima where the upper one located near the sediment surface was based on NH₄⁺ from the waterphase and the lower one just above the oxic-anoxic interface was based on diffusion from deeper sediment layers. Some of the formed NO₃⁻ diffused out of the sediment (uncoupled nitrification) whereas the rest diffused down into anoxic layers where it was denitrified (coupled nitrification-denitrification). Denitrification was always restricted to the deeper anoxic or almost anoxic layers where NO₃⁻ was the most favorable electron acceptor present. The denitrification zone could be extremely thin (< 100 µm) at low NO₃⁻ concentrations in the overlying water and at low nitrification rates, but could also be several millimeters thick at high NO₃⁻. The concentration of NO₃⁻ in any specific layer was not limiting denitrification as long as more than ca. 10 µM NO₃⁻ was present. Photosynthetic biofilms exhibited pronounced diurnal cycles in assimilation of NO₃⁻, nitrification, and denitrification. Denitrification in the photic zone stopped when the sediment was illuminated and oxygen was produced by photosynthesis, but denitrification started immediately again after darkening and onset of anoxic conditions. A new ¹⁵N isotope method, which is based on monitoring the frequency of ¹⁵JN₂, ¹⁴JN₂, and ¹⁴JN₂ in N₂ gas evolved after adding ¹⁵NO₃⁻ to the overlying water, was used to determine rates of nitrification and denitrification. Determination of total nitrification rates was only possible when also the isotope dilution in waterphase NO₃⁻ was monitored. This new isotope technique has for the first time enabled us to do determinations of nitrification and denitrification (including coupled nitrification-denitrification) in all types of biofilms and sediments without the addition of artifact-creating artificial inhibitors of metabolic processes. Investigations of a thick photosynthetic biofilm showed that coupled nitrification-denitrification was two times higher during illumination than during darkness due to better oxygen conditions for nitrification. Denitrification based on NO₃⁻ in the overlying water was reduced to about half during illumination due to the longer diffusion path to the denitrifying anoxic layers. Assimilation by the microflora was high in the light and remained high for many hours after darkening. This high rate of dark NO₃⁻ assimilation has previously erroneously been interpreted as dissimilatory reduction to NH₄⁺ as mediated by strictly anaerobic bacteria.

Lors de la réunion du Comité de Radioactivité Marine durant le Congrès Assemblée plénière de la CIESM à Athènes (1988) il a été décidé de promouvoir un programme sur le thème : Inventaire Global de la Radioactivité de la Mer Méditerranée (Mer Noire et détroit de Gibraltar y compris) ayant pour sigle GIRMED. Un tel programme est apparu essentiel pour répondre aux recommandations de la Convention de Barcelone pour la protection de la mer Méditerranée contre la pollution chronique ainsi que pour l'évaluation des conséquences d'une éventuelle contamination accidentelle de l'environnement marin comme ce fut le cas après l'accident de Tchernobyl.

Les principaux objectifs de GIRMED sont :

- l'intercalibration des mesures réalisées dans les laboratoires impliqués dans des programmes nationaux de surveillance radiologique,
- la cartographie spatio-temporelle des niveaux de radioactivité des principaux radio éléments artificiels dans l'eau, les sédiments et les organismes marins,
- la sélection de bioindicateurs représentatifs des niveaux de radioactivité,
- l'étude des transferts des radioéléments aux populations humaines via des composantes marines, et
- l'évaluation des coefficients de partage entre l'eau, les sédiments et les organismes marins.

Ce projet repose sur la collaboration de 15 laboratoires de 8 pays méditerranéens. De 1988 à 1992 ces laboratoires ont participé à un programme d'assurance qualité de leur mesures par l'intermédiaire d'exercices d'intercalibration. En parallèle l'inventaire des sources de rejets de radioéléments dans l'environnement marin méditerranéen a été réalisé et une base de données des mesures réalisées dans l'environnement a été mise en place. La deuxième phase conduira à l'estimation des doses pour les populations concernées par les sources de radioactivité en Méditerranée.



Centrales nucléaires (▲) et centre de retraitement (●) au 1/1/91 (bassin occidental).

EAU DE MER				Alp	Ru	Cs	Ag	Sb	Ce
Pays	Lieu	Date							
FRANCE	côtes	4/86 à 9/87		X	X				X
MONACO	côtes	5/86 à 6/86		X	X				X
ROUMANIE	Estuaire Danube	10/87				X	X		
	côtes	5/86 à 7/90				X	X		
SEDIMENT MARIN				Alp	Ru	Cs	Ag	Sb	Ce
Pays	Lieu	Date							
FRANCE	côtes	11/86 à 3/91		X	X	X	X	X	X
MONACO	Cannes	2/87				X			
GRECE	Milos	12/86		X	X				
ROUMANIE	côtes	5/86 à 11/90		X	X				
TURQUIE	Akkuyu	6/89				X			
ALGUES				Alp	Ru	Cs	Ag	Sb	Ce
Pays	Lieu	Date							
TURQUIE	Noire	7/86 à 1/89			X	X			
ROUMANIE	côtes	10/86 à 7/90		X	X	X	X		X
FRANCE	côtes	6/86 à 9/87			X	X	X	X	X
MONACO	côtes	1/86 à 2/87			X	X	X		
GRECE	Milos	12/86		X	X				
ROUMANIE	côtes	7/90		X	X				
TURQUIE	Akkuyu	6/89				X			
	Noire	7/86 à 6/89				X			
POSIDONIE				Alp	Ru	Cs	Ag	Sb	Ce
Pays	Lieu	Date							
FRANCE	côtes	1/86 à 6/91		X	X	X	X	X	X
GRECE	Milos	12/86		X	X				
MATIERE EN SUSPENSION				Alp	Ru	Cs	Ag	Sb	Ce
Pays	Lieu	Date							
FRANCE	rhône	9 à 3/87		X	X	X	X		
MONACO	Monaco offsh	4/86 à 6/86		X	X	X			X
ITALIE	La Spezia	7/86		X	X				
MOLLUSQUES BIVALVES				Alp	Ru	Cs	Ag	Sb	Ce
Pays	Lieu	Date							
ROUMANIE	côtes	6/87 à 6/89		X	X	X			
FRANCE	côtes	1/83 à 9/91		X	X	X	X	X	X
MONACO	côtes	5/86 12/86		X	X	X	X	X	X
ROUMANIE	côtes	8/86 à 5/90		X	X	X			X
TURQUIE	Bosphore	5/86 à 2/87				X	X	X	
	Noire	2/87 à 2/88				X	X	X	
POISSONS				Alp	Ru	Cs	Ag	Sb	Ce
Pays	Lieu	Date							
FRANCE	Thau	3/86 à 9/88			X	X	X	X	X
	Beaulieu	2/86 à 8/88			X	X	X	X	X
	Nice	6/86 à 9/91			X	X	X	X	X
TURQUIE	Marmara	5/86 à 1/87			X	X			
	Noire	12/86 1/87			X	X			
	Bosphore	5/86			X	X			
GRECE	Milos	12/86		X	X				
ROUMANIE	Constanta	6/87 à 6/89				X			

Etat de la base de données GIRMED. Classement par type d'échantillons et pays pour la période 1986-1991. Alp : émetteurs alpha soit ²³⁹U, ²⁴⁰Pu, ²⁴¹Am, ²⁴²Re, ²⁴³Am, ²⁴⁴Am, ²⁴⁵Am, ²⁴⁶Cm, ²⁴⁷Cm, ²⁴⁸Cm, ²⁴⁹Bk, ²⁵⁰Bk, ²⁵¹Cf, ²⁵²Cf, ²⁵³Cf, ²⁵⁴Cf, ²⁵⁵Cf, ²⁵⁶Cf, ²⁵⁷Cf, ²⁵⁸Cf, ²⁵⁹Cf, ²⁶⁰Cf, ²⁶¹Cf, ²⁶²Cf, ²⁶³Cf, ²⁶⁴Cf, ²⁶⁵Cf, ²⁶⁶Cf, ²⁶⁷Cf, ²⁶⁸Cf, ²⁶⁹Cf, ²⁷⁰Cf, ²⁷¹Cf, ²⁷²Cf, ²⁷³Cf, ²⁷⁴Cf, ²⁷⁵Cf, ²⁷⁶Cf, ²⁷⁷Cf, ²⁷⁸Cf, ²⁷⁹Cf, ²⁸⁰Cf, ²⁸¹Cf, ²⁸²Cf, ²⁸³Cf, ²⁸⁴Cf, ²⁸⁵Cf, ²⁸⁶Cf, ²⁸⁷Cf, ²⁸⁸Cf, ²⁸⁹Cf, ²⁹⁰Cf, ²⁹¹Cf, ²⁹²Cf, ²⁹³Cf, ²⁹⁴Cf, ²⁹⁵Cf, ²⁹⁶Cf, ²⁹⁷Cf, ²⁹⁸Cf, ²⁹⁹Cf, ³⁰⁰Cf, ³⁰¹Cf, ³⁰²Cf, ³⁰³Cf, ³⁰⁴Cf, ³⁰⁵Cf, ³⁰⁶Cf, ³⁰⁷Cf, ³⁰⁸Cf, ³⁰⁹Cf, ³¹⁰Cf, ³¹¹Cf, ³¹²Cf, ³¹³Cf, ³¹⁴Cf, ³¹⁵Cf, ³¹⁶Cf, ³¹⁷Cf, ³¹⁸Cf, ³¹⁹Cf, ³²⁰Cf, ³²¹Cf, ³²²Cf, ³²³Cf, ³²⁴Cf, ³²⁵Cf, ³²⁶Cf, ³²⁷Cf, ³²⁸Cf, ³²⁹Cf, ³³⁰Cf, ³³¹Cf, ³³²Cf, ³³³Cf, ³³⁴Cf, ³³⁵Cf, ³³⁶Cf, ³³⁷Cf, ³³⁸Cf, ³³⁹Cf, ³⁴⁰Cf, ³⁴¹Cf, ³⁴²Cf, ³⁴³Cf, ³⁴⁴Cf, ³⁴⁵Cf, ³⁴⁶Cf, ³⁴⁷Cf, ³⁴⁸Cf, ³⁴⁹Cf, ³⁵⁰Cf, ³⁵¹Cf, ³⁵²Cf, ³⁵³Cf, ³⁵⁴Cf, ³⁵⁵Cf, ³⁵⁶Cf, ³⁵⁷Cf, ³⁵⁸Cf, ³⁵⁹Cf, ³⁶⁰Cf, ³⁶¹Cf, ³⁶²Cf, ³⁶³Cf, ³⁶⁴Cf, ³⁶⁵Cf, ³⁶⁶Cf, ³⁶⁷Cf, ³⁶⁸Cf, ³⁶⁹Cf, ³⁷⁰Cf, ³⁷¹Cf, ³⁷²Cf, ³⁷³Cf, ³⁷⁴Cf, ³⁷⁵Cf, ³⁷⁶Cf, ³⁷⁷Cf, ³⁷⁸Cf, ³⁷⁹Cf, ³⁸⁰Cf, ³⁸¹Cf, ³⁸²Cf, ³⁸³Cf, ³⁸⁴Cf, ³⁸⁵Cf, ³⁸⁶Cf, ³⁸⁷Cf, ³⁸⁸Cf, ³⁸⁹Cf, ³⁹⁰Cf, ³⁹¹Cf, ³⁹²Cf, ³⁹³Cf, ³⁹⁴Cf, ³⁹⁵Cf, ³⁹⁶Cf, ³⁹⁷Cf, ³⁹⁸Cf, ³⁹⁹Cf, ⁴⁰⁰Cf, ⁴⁰¹Cf, ⁴⁰²Cf, ⁴⁰³Cf, ⁴⁰⁴Cf, ⁴⁰⁵Cf, ⁴⁰⁶Cf, ⁴⁰⁷Cf, ⁴⁰⁸Cf, ⁴⁰⁹Cf, ⁴¹⁰Cf, ⁴¹¹Cf, ⁴¹²Cf, ⁴¹³Cf, ⁴¹⁴Cf, ⁴¹⁵Cf, ⁴¹⁶Cf, ⁴¹⁷Cf, ⁴¹⁸Cf, ⁴¹⁹Cf, ⁴²⁰Cf, ⁴²¹Cf, ⁴²²Cf, ⁴²³Cf, ⁴²⁴Cf, ⁴²⁵Cf, ⁴²⁶Cf, ⁴²⁷Cf, ⁴²⁸Cf, ⁴²⁹Cf, ⁴³⁰Cf, ⁴³¹Cf, ⁴³²Cf, ⁴³³Cf, ⁴³⁴Cf, ⁴³⁵Cf, ⁴³⁶Cf, ⁴³⁷Cf, ⁴³⁸Cf, ⁴³⁹Cf, ⁴⁴⁰Cf, ⁴⁴¹Cf, ⁴⁴²Cf, ⁴⁴³Cf, ⁴⁴⁴Cf, ⁴⁴⁵Cf, ⁴⁴⁶Cf, ⁴⁴⁷Cf, ⁴⁴⁸Cf, ⁴⁴⁹Cf, ⁴⁵⁰Cf, ⁴⁵¹Cf, ⁴⁵²Cf, ⁴⁵³Cf, ⁴⁵⁴Cf, ⁴⁵⁵Cf, ⁴⁵⁶Cf, ⁴⁵⁷Cf, ⁴⁵⁸Cf, ⁴⁵⁹Cf, ⁴⁶⁰Cf, ⁴⁶¹Cf, ⁴⁶²Cf, ⁴⁶³Cf, ⁴⁶⁴Cf, ⁴⁶⁵Cf, ⁴⁶⁶Cf, ⁴⁶⁷Cf, ⁴⁶⁸Cf, ⁴⁶⁹Cf, ⁴⁷⁰Cf, ⁴⁷¹Cf, ⁴⁷²Cf, ⁴⁷³Cf, ⁴⁷⁴Cf, ⁴⁷⁵Cf, ⁴⁷⁶Cf, ⁴⁷⁷Cf, ⁴⁷⁸Cf, ⁴⁷⁹Cf, ⁴⁸⁰Cf, ⁴⁸¹Cf, ⁴⁸²Cf, ⁴⁸³Cf, ⁴⁸⁴Cf, ⁴⁸⁵Cf, ⁴⁸⁶Cf, ⁴⁸⁷Cf, ⁴⁸⁸Cf, ⁴⁸⁹Cf, ⁴⁹⁰Cf, ⁴⁹¹Cf, ⁴⁹²Cf, ⁴⁹³Cf, ⁴⁹⁴Cf, ⁴⁹⁵Cf, ⁴⁹⁶Cf, ⁴⁹⁷Cf, ⁴⁹⁸Cf, ⁴⁹⁹Cf, ⁵⁰⁰Cf, ⁵⁰¹Cf, ⁵⁰²Cf, ⁵⁰³Cf, ⁵⁰⁴Cf, ⁵⁰⁵Cf, ⁵⁰⁶Cf, ⁵⁰⁷Cf, ⁵⁰⁸Cf, ⁵⁰⁹Cf, ⁵¹⁰Cf, ⁵¹¹Cf, ⁵¹²Cf, ⁵¹³Cf, ⁵¹⁴Cf, ⁵¹⁵Cf, ⁵¹⁶Cf, ⁵¹⁷Cf, ⁵¹⁸Cf, ⁵¹⁹Cf, ⁵²⁰Cf, ⁵²¹Cf, ⁵²²Cf, ⁵²³Cf, ⁵²⁴Cf, ⁵²⁵Cf, ⁵²⁶Cf, ⁵²⁷Cf, ⁵²⁸Cf, ⁵²⁹Cf, ⁵³⁰Cf, ⁵³¹Cf, ⁵³²Cf, ⁵³³Cf, ⁵³⁴Cf, ⁵³⁵Cf, ⁵³⁶Cf, ⁵³⁷Cf, ⁵³⁸Cf, ⁵³⁹Cf, ⁵⁴⁰Cf, ⁵⁴¹Cf, ⁵⁴²Cf, ⁵⁴³Cf, ⁵⁴⁴Cf, ⁵⁴⁵Cf, ⁵⁴⁶Cf, ⁵⁴⁷Cf, ⁵⁴⁸Cf, ⁵⁴⁹Cf, ⁵⁵⁰Cf, ⁵⁵¹Cf, ⁵⁵²Cf, ⁵⁵³Cf, ⁵⁵⁴Cf, ⁵⁵⁵Cf, ⁵⁵⁶Cf, ⁵⁵⁷Cf, ⁵⁵⁸Cf, ⁵⁵⁹Cf, ⁵⁶⁰Cf, ⁵⁶¹Cf, ⁵⁶²Cf, ⁵⁶³Cf, ⁵⁶⁴Cf, ⁵⁶⁵Cf, ⁵⁶⁶Cf, ⁵⁶⁷Cf, ⁵⁶⁸Cf, ⁵⁶⁹Cf, ⁵⁷⁰Cf, ⁵⁷¹Cf, ⁵⁷²Cf, ⁵⁷³Cf, ⁵⁷⁴Cf, ⁵⁷⁵Cf, ⁵⁷⁶Cf, ⁵⁷⁷Cf, ⁵⁷⁸Cf, ⁵⁷⁹Cf, ⁵⁸⁰Cf, ⁵⁸¹Cf, ⁵⁸²Cf, ⁵⁸³Cf, ⁵⁸⁴Cf, ⁵⁸⁵Cf, ⁵⁸⁶Cf, ⁵⁸⁷Cf, ⁵⁸⁸Cf, ⁵⁸⁹Cf, ⁵⁹⁰Cf, ⁵⁹¹Cf, ⁵⁹²Cf, ⁵⁹³Cf, ⁵⁹⁴Cf, ⁵⁹⁵Cf, ⁵⁹⁶Cf, ⁵⁹⁷Cf, ⁵⁹⁸Cf, ⁵⁹⁹Cf, ⁶⁰⁰Cf, ⁶⁰¹Cf, ⁶⁰²Cf, ⁶⁰³Cf, ⁶⁰⁴Cf, ⁶⁰⁵Cf, ⁶⁰⁶Cf, ⁶⁰⁷Cf, ⁶⁰⁸Cf, ⁶⁰⁹Cf, ⁶¹⁰Cf, ⁶¹¹Cf, ⁶¹²Cf, ⁶¹³Cf, ⁶¹⁴Cf, ⁶¹⁵Cf, ⁶¹⁶Cf, ⁶¹⁷Cf, ⁶¹⁸Cf, ⁶¹⁹Cf, ⁶²⁰Cf, ⁶²¹Cf, ⁶²²Cf, ⁶²³Cf, ⁶²⁴Cf, ⁶²⁵Cf, ⁶²⁶Cf, ⁶²⁷Cf, ⁶²⁸Cf, ⁶²⁹Cf, ⁶³⁰Cf, ⁶³¹Cf, ⁶³²Cf, ⁶³³Cf, ⁶³⁴Cf, ⁶³⁵Cf, ⁶³⁶Cf, ⁶³⁷Cf, ⁶³⁸Cf, ⁶³⁹Cf, ⁶⁴⁰Cf, ⁶⁴¹Cf, ⁶⁴²Cf, ⁶⁴³Cf, ⁶⁴⁴Cf, ⁶⁴⁵Cf, ⁶⁴⁶Cf, ⁶⁴⁷Cf, ⁶⁴⁸Cf, ⁶⁴⁹Cf, ⁶⁵⁰Cf, ⁶⁵¹Cf, ⁶⁵²Cf, ⁶⁵³Cf, ⁶⁵⁴Cf, ⁶⁵⁵Cf, ⁶⁵⁶Cf, ⁶⁵⁷Cf, ⁶⁵⁸Cf, ⁶⁵⁹Cf, ⁶⁶⁰Cf, ⁶⁶¹Cf, ⁶⁶²Cf, ⁶⁶³Cf, ⁶⁶⁴Cf, ⁶⁶⁵Cf, ⁶⁶⁶Cf, ⁶⁶⁷Cf, ⁶⁶⁸Cf, ⁶⁶⁹Cf, ⁶⁷⁰Cf, ⁶⁷¹Cf, ⁶⁷²Cf, ⁶⁷³Cf, ⁶⁷⁴Cf, ⁶⁷⁵Cf, ⁶⁷⁶Cf, ⁶⁷⁷Cf, ⁶⁷⁸Cf, ⁶⁷⁹Cf, ⁶⁸⁰Cf, ⁶⁸¹Cf, ⁶⁸²Cf, ⁶⁸³Cf, ⁶⁸⁴Cf, ⁶⁸⁵Cf, ⁶⁸⁶Cf, ⁶⁸⁷Cf, ⁶⁸⁸Cf, ⁶⁸⁹Cf, ⁶⁹⁰Cf, ⁶⁹¹Cf, ⁶⁹²Cf, ⁶⁹³Cf, ⁶⁹⁴Cf, ⁶⁹⁵Cf, ⁶⁹⁶Cf, ⁶⁹⁷Cf, ⁶⁹⁸Cf, ⁶⁹⁹Cf, ⁷⁰⁰Cf, ⁷⁰¹Cf, ⁷⁰²Cf, ⁷⁰³Cf, ⁷⁰⁴Cf, ⁷⁰⁵Cf, ⁷⁰⁶Cf, ⁷⁰⁷Cf, ⁷⁰⁸Cf, ⁷⁰⁹Cf, ⁷¹⁰Cf, ⁷¹¹Cf, ⁷¹²Cf, ⁷¹³Cf, ⁷¹⁴Cf, ⁷¹⁵Cf, ⁷¹⁶Cf, ⁷¹⁷Cf, ⁷¹⁸Cf, ⁷¹⁹Cf, ⁷²⁰Cf, ⁷²¹Cf, ⁷²²Cf, ⁷²³Cf, ⁷²⁴Cf, ⁷²⁵Cf, ⁷²⁶Cf, ⁷²⁷Cf, ⁷²⁸Cf, ⁷²⁹Cf, ⁷³⁰Cf, ⁷³¹Cf, ⁷³²Cf, ⁷³³Cf, ⁷³⁴Cf, ⁷³⁵Cf, ⁷³⁶Cf, ⁷³⁷Cf, ⁷³⁸Cf, ⁷³⁹Cf, ⁷⁴⁰Cf, ⁷⁴¹Cf, ⁷⁴²Cf, ⁷⁴³Cf, ⁷⁴⁴Cf, ⁷⁴⁵Cf, ⁷⁴⁶Cf, ⁷⁴⁷Cf, ⁷⁴⁸Cf, ⁷⁴⁹Cf, ⁷⁵⁰Cf, ⁷⁵¹Cf, ⁷⁵²Cf, ⁷⁵³Cf, ⁷⁵⁴Cf, ⁷⁵⁵Cf, ⁷⁵⁶Cf, ⁷⁵⁷Cf, ⁷⁵⁸Cf, ⁷⁵⁹Cf, ⁷⁶⁰Cf, ⁷⁶¹Cf, ⁷⁶²Cf, ⁷⁶³Cf, ⁷⁶⁴Cf, ⁷⁶⁵Cf, ⁷⁶⁶Cf, ⁷⁶⁷Cf, ⁷⁶⁸Cf, ⁷⁶⁹Cf, ⁷⁷⁰Cf, ⁷⁷¹Cf, ⁷⁷²Cf, ⁷⁷³Cf, ⁷⁷⁴Cf, ⁷⁷⁵Cf, ⁷⁷⁶Cf, ⁷⁷⁷Cf, ⁷⁷⁸Cf, ⁷⁷⁹Cf, ⁷⁸⁰Cf, ⁷⁸¹Cf, ⁷⁸²Cf, ⁷⁸³Cf, ⁷⁸⁴Cf, ⁷⁸⁵Cf, ⁷⁸⁶Cf, ⁷⁸⁷Cf, ⁷⁸⁸Cf,