CHERNOBYL FALLOUT OVER France / THE SPECIFIC SITUATION OF THE ALPINE ENVIRONMENT

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ABSTRACT

The CRIIRAD laboratory (Commission for Independent Research and Information on Radioactivity) has collected 152 soil samples (0 to 40 centimeters deep) all over France. Sampling sites were carefully selected in order to ensure a precise evaluation of the initial 137 Cs Chernobyl fallout (selection criteria : flat ground, undisturbed by human activities, with small vegetal cover). Samples were analyzed by gamma spectrometry on a EG&G ORTEC germanium detector. Sampling took place between 1987 and 1993. 134 Cs from Chernobyl was still measurable so that the use of a typical 137/134 Cs ratio allowed to distinguish the amount of 137 Cs associated with Chernobyl from that due to fallout from the fifties and sixties nuclear tests.

A 137 Cs Chernobyl fallout map of the French territory has been drawn up. The fallout levels are closely correlated with both the trajectory of the radioactive cloud and the amount of rainfall between the first and fifth of May 1986. The fallout intensity lies between our detection limit (120 Bq/m^2) and a maximal figure of 34 600 Bq/m^2 for 137 Cs. Many levels recorded in the eastern part of France exceed 7 300 Bq/m^2, a value originally considered by the French authorities as the upper level registered in France. These data show that in one third of the French territory countermeasures should have been taken in order to reduce doses from ingestion of contaminated food.

Since the Summer of 1996, the CRIIRAD laboratory has undertaken a specific soil sampling programme in the French, Italian, Swiss and Austrian Alps, in order to study Chernobyl associated contamination of soil at high altitudes (above 1 600 m).
In situ radioactive monitoring of gamma radiation and laboratory analysis of 40 collected soil samples show a 137 Cs contamination exceeding 10 000 Bq/kg and sometimes 100 000 Bq/kg. The extreme heterogeneity of soil contamination requires a new radioprotection approach, very different from that appropriate to low altitude situations.
Gamma spectrometry analysis of mushrooms has demonstrated that in 1997 some species still exceeded the 600 Bq/kg limit established in Europe for 137 Cs contamination of food after the Chernobyl accident.
Americium-241 contamination as high as 154 Bq/kg in Alpine soils highlights the problem of transuranian contamination. The study opens new approaches in the field of specific air pollutant behavior in a high altitude mountainous environment.

INTRODUCTION

A few days after the Chernobyl accident had occurred, the position of French authorities was to deny the impact of Chernobyl fallout over France. On May 6th 1986, the French Department of Agriculture stated : "*Due to the far distance from Chernobyl, France has been totally spared from any radioactive fallout from the accident".*

A few month later a group of scientists and citizens created a non governmental organization called CRIIRAD (Commission for Independent Research and Information on Radioactivity). CRIIRAD

runs an independent laboratory whose first task was to evaluate the level of Chernobyl fallout in France.

METHODS AND MATERIALS

First Campaign (1987-1993)

Between 1987 and 1993, the CRIIRAD laboratory has collected soil samples on 152 sites all over France. Sampling sites were carefully selected in order to ensure a precise evaluation of the initial caesium-137 from Chernobyl fallout (selection criteria : flat ground, undisturbed by human activities, with small vegetal cover). On each site, a 36.3 cm^2 metallic core sampler has been used to extract 3 cores at the 3 corners of a 1 meter equilateral triangle. Samples were cut at 0-5 cm, 5-10 cm and then by 5 or 10 cm layers up to a depth of 40 cm.

For each layer, all 3 samples were mixed, dried (at least one night at 90 °C), sieved at 2 mm in order to separate gravels and roots. The material was then ground into powder and bottled in standard counting pots (depending on the amount of material different pots were used : Marinelli : 560 cm^3, Petri dishes : 66 cm^3).

Samples were analyzed by gamma spectrometry on EG&G ORTEC germanium detectors. Caesium 134 from Chernobyl was still measurable so that the use of a typical 137/134 Cs ratio allowed to distinguish the amount of 137 Cs associated with Chernobyl from that due to the fallout from the nuclear tests of the fifties and sixties. The reference date for reporting caesium-137 (from Chernobyl) activities was the 1st of May 1986.

Second Campaign (1996-1997)

During summer 1996 and 1997, the CRIIRAD laboratory has undertaken a specific soil sampling programme in the French, Italian, Swiss and Austrian Alps, in order to study Chernobyl associated contamination of soil at high altitudes (over 1 600 m). The topic was to conduct a preliminary study of the specific redistribution of contamination in the Alpine environment.
In situ radioactive monitoring of gamma radiation was performed locally in order to identify hot spots. In 1996 a small Geiger Muller Counter was used (QUARTEX). Since July 1997, the local team used a professional NaI scintillometer (SPP2 manufactured by SAPHYMO).

Soil sampling has been limited to a depth of 3 to 13 centimeters (depending on total thickness of soil) using a 300 cm^2 metallic core sampler. In some cases only 70 cm^2 samples were taken with a small spade in order to limit the amount of material to be carried back to the laboratory. Samples were put in plastic bags and carried to the CRIIRAD laboratory. Gamma fluxes were measured again at the CRIIRAD laboratory in order to optimize personnel radioprotection.

In 1996 some samples were analyzed without drying in order to keep a good detection limit for radionuclides with volatile behavior but the majority of samples have been dried before analysis in order to keep a good level of homogenization. After analysis all samples were dried (at least one night at 90 °C) in order to express results as Becquerels/kg dry.

Dried samples have been sieved at 2 mm in order to separate gravels and roots. The material has been ground into powder and bottled in standard counting pots (depending on the amount of material different pots were used : Marinelli : 560 cm^3, Petri dishes : 66 cm^3).

Counting took place on EGG-ORTEC, GMX-N, HPGe spectrometers. Typical counting time was around 60 000 seconds. The reference date for reporting activities was the date of sampling.

The CRIIRAD gamma spectrometry laboratory regularly participates in French (OPRI) and international (IAEA) programs of intercomparison and is approved and certified by the French Department of Health.

RESULTS

First Campaign

Caesium-137 deposition originating from Chernobyl is reported in table 1 (locality, department, results expressed in Bq/m^2 with reference date 1st of May 1986, sampling date) . A 137 Cs from Chernobyl fallout map of the French territory has been drawn up (fig 1). The fallout levels are closely correlated with both the trajectory of the radioactive cloud and the amount of rainfall between the first and fifth of May 1986.

The fallout intensity lies between our detection limit (120 Bq/m^2) and a maximal figure of 34 600 Bq/m^2 for 137 Cs. Many figures in the eastern part of France exceeded 7 300 Bq/m^2, a value originally considered by the French authorities as the upper level registered in France.

Many caesium-137 deposition levels in the eastern part of France exceed 2 600 Bq/m^2. The amount of iodine-131 in the radioactive cloud was about 5 to 10 times higher than the amount of caesium-137. It is therefore possible to consider that each site with 2 600 Bq/m^2 of caesium-137 received at least 13 000 Bq/m^2 of iodine-131. The National Radiological Protection Board (NRPB, England) considered that above an iodine-131 deposition of 13 000 Bq/m^2 countermeasures have to be taken in order to protect young children (according to NRPB models 13 000 Bq/m^2 of iodine-131 may induce a dose exceeding 50 mSv to the thyroid gland for 1 year old children with specific alimentary habits). In 1986, the organ dose limit was 15 mSv according to French legislation. CRIIRAD map show that at least in the eastern quarter of the French territory countermeasures should have been taken in order to reduce doses from ingestion of contaminated food.

Massic activities of cesium 137 in the upper layer of soils were the following :

- From a few Bq/kg to a few tens of Bq/kg in the western part of France. Most of it came from global fallout from the atmospheric testing of nuclear weapons. In fact, the radioactive cloud from Chernobyl covered the whole territory of France on May 1st 1986, but it immediately went backward to the east. From the Atlantic border of the Pyrenees to Brittany an anticyclone strongly limited radioactive deposition. In the central part of France (from the eastern part of the Pyrenees to Nord Pas-de-Calais), Chernobyl deposition was relatively low due to a small amount of rainfall.
- From a few tens of Bq/kg up to a few hundreds of Bq/kg in the most affected areas of the eastern part of France from Corsica to Alsace. Above these areas, the contaminated clouds remained longer and in many places high rainfall levels increased radioactive deposition.

Second Campaign

Five artificial gamma emitters have been detected in the 40 samples collected in the Alps (caesium 137 and 134, americium-241, cobalt-60 and antimony-125). As cobalt-60 and antimony-125 were detected in a very limited number of samples with low activities close to the detection limit, they are not included in the report.

For all 40 samples, sampling date, sample location (country, department, area, site, height above sea leve) and activities for caesium-137, caesium-134 and americium-241 are reported in table 2 (results expressed in Bq/kg dry at the date of sampling). Sampling sites are plotted on a map (Fig 2).

Caesium-137

Total caesium-137 activities run between 54 Bq/kg dry and 545 000 Bq/kg dry. On the most active spots, caesium 137 activities reach high levels well above 1 000 Bq/kg dry :

- 35 samples had activities above 1 000 Bq/kg dry,
- 29 samples had activities above 10 000 Bq/kg dry,
- 8 samples had activities above 100 000 Bq/kg dry.

These figures have to be compared to those measured by the CRIIRAD laboratory during phase 1 in fairly flat places (around 10 Bq/kg dry in the western part of France, a few hundreds of Bq/kg dry in the eastern part of France).

With caesium activities above 10 000 Bq/kg and in some cases 100 000 Bq/kg, soil samples should be considered as radioactive waste. According to the French Protection Office Against Ionizing Radiation (OPRI) :

- Soil above 100 000 Bq/kg have to be considered as radioactive waste (class A) and sent to the designed repository in Soulaines. This is the case for 8 samples from Mercantour (French Alps), Cervin and Cortina d'Ampezzo areas (Italian Alps) and Hohe Tauern (Austrian Alps),
- Soil between 10 000 and 100 000 Bq/kg may be considered as Very Low Radioactive Waste for which a specific repository has to be designed in France.

Caesium-134

Caesium-134 has been found in 37 sites, with activities above 1 000 Bq/kg dry in 11 sites. Using 137 Cs / 134 Cs Chernobyl isotopic ratio, it is possible to show that the caesium-137 contamination was largely due to the Chernobyl accident. For all samples with caesium-137 activities above 10 000 Bq/kg dry, more than 80 % of cesium was due to Chernobyl Fallout. The remaining part probably came from nuclear testing fallout.

Americium-241

Americium-241 has been detected in 21 samples with activities between 3 and 154 Bq/kg dry. The highest level has been measured in the Italian Alps (Cortina d'Ampezzo). Measurement of low levels of americium 241 is difficult using gamma spectrometry (weak 59.5 keV gamma line), therefore these results have to be considered as a preliminary evaluation. Measured activities are nonetheless 1 000 times above current levels (known impact of atmospheric fallout from nuclear

tests). Americium-241 is usually associated with plutonium isotopes. A preliminary measurement of alpha emitting isotopes of plutonium has been carried out by the Laboratory of Physics of the University of Bremen (Germany). Plutonium-238 and plutonium 239/240 activities were respectively 1.5 and 131 Bq/kg dry in the sample collected in the Vallée des Merveilles (French Alps) were the CRIIRAD laboratory measured 54 Bq/kg dry for Americium-241. The plutonium isotopic ratio is in good agreement with the ratio associated with atmospheric fallout from nuclear testing but a more detailed study would be necessary in order to evaluate transuranian contamination in the Alps.

DISCUSSION

First Campaign

CRIIRAD 1987-1993 cartography of Chernobyl fallout over France remains a unique document because of the number of samples collected (152) and the fact that caesium-134 was still measurable at the time of completion of this map. CRIIRAD map shows that French administration should have taken countermeasures in order to protect people from the Chernobyl fallout. In march 2001, CRIIRAD and an association of thyroid sick people (AFMT) with more than 50 ill people have gone to court because of the lack of protection against radiation after the Chernobyl accident.

Official institutions in France still provide a false or incomplete evaluation of the Chernobyl fallout. In the recent "*ATLAS of caesium deposition on Europe after the Chernobyl accident"* published by the EC in 1998, the map for France is still made off 35 measurements of soil provided by OPRI and IPSN. On this map, the total caesium-137 deposition in the south-east of France is below 4 000 Bq/m^2, while in this part of France, CRIIRAD measured Chernobyl caesium-137 deposition exceeding 30 000 Bq/m^2.

CRIIRAD has undertaken in 1999-2000 a detailed mapping of residual caesium-137 ground contamination in France and part of Europe (3 000 onsite measurements) which may be published in the near future.

Second Campaign

The 1996-1997 campaign shows the extreme heterogeneity of soil contamination in the Alpine Environment which requires a new radioprotection approach, very different from that appropriate to low altitude situations. It opens new approaches in the field of specific air pollutant behavior in a high altitude mountainous environment.

The initial deposition of radioactive airborne pollutants from Chernobyl and other sources seems quite specific in the Alps. This is probably due to many factors:

- the Chernobyl accident released radioactive material at a height of 2 000 m, therefore mountainous sites might have been in direct contact with air pollutants,
- mountainous sites usually receive higher wet depositions because of increased levels of rainfall and / or snow,
- in hilly areas, the ground surface under influence of atmospheric fallout is higher than in flat areas.

The most peculiar fact is the redistribution of deposited material in mountainous environments. The highest hot spots have been measured at heights between 1 500 and 2 800 meters above sea level. In May 1986 most of the areas studied here where covered with snow. When snow melted, nuclides were carried away by water. As water flew through peculiar pathways (depending on geomorphology, vegetal cover and soil permeability) small surfaces received and fixed nuclides that were initially distributed over very large areas. These preliminary findings should be studied in more details in the future. They nevertheless indicate that a nuclear catastrophe such as Chernobyl can durably affect mountainous environments situated more than 1 000 kilometers away from the accident.

People exposure to radiation from the remaining caesium-137 in the Alps might be in some circumstances non negligible. Even if hot spots extension is limited to a few square meters, such spots are numerous and spread over the whole Alps from the South-east of France to Austria. In the Restefond area (French Alps), on a hot spot with 255 000 Bq/kg of caesium-137, CRIIRAD team measured a gamma doserate[1] of 8,4 µSv/h. A tourist spending one night on this spot would receive a dose of 67 microSieverts. A tourist spending 15 nights camping there might exceed 1 000 microSieverts (maximal annual limit over one year). Even between hot spots, the omnipresence of caesium increases the natural background. In the Mercantour area for example CRIIRAD team measured a mean doserate of 0.22 µSv/h[2] at 1 m above ground. For a professional (shepherd, forester) spending 8 hours a day, 145 days a year in this area, the annual dose could be 255 microSieverts

Exposure through ingestion of contaminated foods should also be considered. CRIIRAD laboratory has conducted Gamma spectrometry analysis of mushrooms collected in 1996 and 1997 in the Mercantour area (French Alps). Some species still exceeded the 600 Bq/kg limit established in Europe for caesium-137 contamination of food after the Chernobyl accident. The highest level of caesium-137 was measured in *Tricholoma terreum* (September 1997 : Boreon forest : 3 195 Bq/kg wet). With an annual consumption of one kilogram of such mushrooms the dose due to ingestion would be around 33 microSieverts, for a higher consumption rate of 12 kilograms it would be 400 microSieverts. These figures are respectively around 7 and 80 microSieverts if the mushrooms have a medium contamination (600 Bq/kg wet corresponding to the global average of species such *as Lactarius deliciosus, Lepista nuda* etc..).

These preliminary evaluations show that more than 10 years after the Chernobyl accident, people exposition to radiation in the Alps remains non negligible. In very usual situations people still receive doses exceeding 10 microSieverts per year (limit above which exposure to radiation is considered as non negligible). In more peculiar cases, while still realistic, dose levels might get closer and even exceed the maximal annual level of 1 mSv/year.

[1] Value measured with a gamma proportional counter, LB 123 manufactured by BERTHOLD
[2] Natural background contribution as been subtracted.

Table 1 : 1987-1993 CRIIRAD measurements : caesium-137 deposition from Chernobyl (reference date 1st of May 1986)

Locality	Department	Caesium 137 (Bq/m²)	Sampling date
Malafretaz	1	12 809	16/02/90
Attignat	1	10 059	16/02/90
Belley	1	9 631	22/04/92
Jayat	1	4 468	16/02/90
Bregnier-Cordon	1	4 043	22/04/92
Vérizieu	1	2 814	05/04/90
Saint-Benoit	1	2 652	22/04/92
Mélan	4	31 820	01/05/88
Mison	4	24 060	02/04/88
Thoard	4	6 760	01/05/88
Salerans	5	17 120	14/05/88
Veynes	5	10 410	01/10/90
Gap	5	8 975	06/05/90
Embrun	5	7 830	11/06/89
Briançon	5	820	29/10/90
Saorge	6	28 940	31/12/87
Mirabel	7	12 260	20/01/89
Saint-Désirat	7	8 000	03/01/89
Viviers	7	7 890	17/11/88
Satilieu	7	4 973	07/12/89
Saint-Clair	7	4 431	07/12/89
Annonay	7	4 140	03/01/89
Boulieu-les-Annonay	7	2 065	07/12/89
Nogent-sur-Seine	10	1 060	23/11/87
La Rochelle	17	< 500	17/01/88
Ghisonaccia-gare	20	31 760	12/07/88
Vallica	20	15 700	10/07/88
Castirla	20	10 690	17/07/88
Costa	20	3 870	24/06/88
Bastia	20	3 120	13/07/88
Ajaccio	20	1 940	14/07/88
Filitosa	20	970	14/07/88
Vandoncourt	25	8 547	11/07/90
Montbéliard	25	7 759	07/07/90
Félines	26	18 780	08/11/87
Saint-Laurent-en-Royans	26	6 980	04/04/88
Codolet	30	3 680	22/05/88
Tullins	38	9 874	17/05/90
Saint-Jean-de-Moirans	38	7 250	17/05/90
Voreppe	38	5 655	17/05/90
Saint-Martin-de-Clelles	38	5 500	06/12/87
Malville	38	3 617	06/04/90
Clairvaux-les-Lacs	39	34 640	10/07/88
Champagnole	39	13 900	20/09/88
Censeau	39	9 564	26/04/91
Montmorot	39	7 580	19/09/89
Lavangeot	39	5 044	18/09/89
Saint-Amour	39	2 790	23/10/91
Dole	39	2 760	23/12/88
Saint-Genest-Malifaux	42	4 180	26/01/88
Le Bessat	42	910	13/01/88
Sainte-Sigolène	43	1 870	15/10/88
Saint-Jean-de-Braye	45	< 254	24/09/89
Orléans	45	658	03/11/89
Autry-le-Chatel	45	280	23/06/89
Laspeyre	47	< 289	14/11/89
Saint-Sixte	47	< 264	15/11/89
Vandœuvre-les-Nancy	54	5 555	16/05/91
Le Faouet	56	< 510	05/06/88
Roncourt	57	9 850	31/12/88
Metz	57	3 209	11/03/92
Uckange	57	2 490	21/10/89
Vic-en-Bigorre	65	< 215	15/03/89
Strasbourg	67	32 200	13/05/88
Diebolsheim	67	30 261	08/02/90
Schiltigheim	67	26 360	10/08/88
Erstein	67	11 528	18/01/90
Ostwald	67	9 600	10/08/88
Diemeringen	67	9 504	23/01/90
Saales	67	8 675	09/02/90

Locality	Department	Caesium 137 (Bq/m²)	Sampling date
Alteckendorf	67	4 366	23/01/90
Haguenau	67	4 339	22/01/90
Reischoffen	67	4 253	19/01/90
Gambsheim	67	4 043	24/01/90
Romanswiller	67	3 920	03/08/88
Sarre-Union	67	3 610	03/08/88
Entzheim	67	3 404	18/01/90
Rothau	67	3 249	14/02/90
Jetterswiller	67	3 240	03/08/88
Ebersheim	67	3 010	08/02/90
Wissembourg	67	2 974	19/01/90
Barr	67	2 579	09/02/90
Sundhouse	67	2 503	08/02/90
Wimmenau	67	2 168	07/06/90
Mundolsheim	67	2 143	06/06/90
Lauterbourg	67	1 536	19/01/90
Oberbronn	67	1 324	22/01/90
Stattmatten	67	1 104	24/01/90
Saverne	67	1 078	23/01/90
Linthal	68	20 200	13/05/88
Kruth	68	18 780	13/11/90
Durmenach	68	17 140	04/08/88
Sainte-Marie-aux-Mines	68	15 330	16/11/90
Le Bonhomme	68	14 919	16/11/90
Lutterbach	68	14 400	12/05/88
Neumatten	68	12 476	18/03/91
Aubure	68	12 222	16/11/90
Turckheim	68	11 361	12/03/91
Guebwiller	68	11 311	11/03/91
Oderen	68	9 562	13/11/90
Geishouse	68	9 043	15/11/90
Bitschwiller	68	8 592	12/11/90
Breitenbach	68	8 280	16/11/90
Kaysersberg	68	8 233	12/03/91
Wattwiller	68	7 965	12/11/90
Kiffis	68	6 516	19/03/91
Mittlach	68	6 134	14/03/91
Husseren	68	5 370	14/11/90
Wolfgantzen	68	5 338	21/03/91
Fessenheim	68	5 246	26/01/90
Michelbach-le-Haut	68	4 894	20/03/91
Saint-Louis	68	4 643	19/03/91
Altkirch	68	4 628	20/03/91
Schlierbach	68	4 141	15/03/91
Ribeauvillé	68	4 120	13/02/91
Sewen	68	3 565	15/11/90
Rumersheim-le-Haut	68	3 235	27/08/89
Colmar	68	3 186	13/03/91
Mulhouse	68	3 179	15/03/91
Rouffach	68	3 037	13/03/91
Baldersheim	68	2 842	14/03/91
Bilzheim	68	2 680	22/07/89
Saint-Hippolyte	68	2 560	19/07/88
Oberentzen	68	2 418	12/03/91
Geiswasser	68	1 840	25/07/89
Meyenheim	68	979	13/03/91
Saint-Priest	69	8 162	19/11/90
Fontaines-sur-Saône	69	4 813	19/09/89
Beaujeu	69	2 330	27/05/91
Luxeuil-les-Bains	70	3 859	18/09/89
Frahier-et-Chatebier	70	3 834	07/07/90
Usinens	74	7 620	15/10/88
Semnoz	74	4 250	15/10/88
Donzac	82	< 283	15/11/89
Castelmayran	82	< 222	18/05/89
Montaigu	82	< 217	16/11/89
Lacoste	82	< 151	14/11/89
Espalais	82	< 118	13/11/89
Espermont	82	361	19/05/89
Montauban	82	290	22/02/90

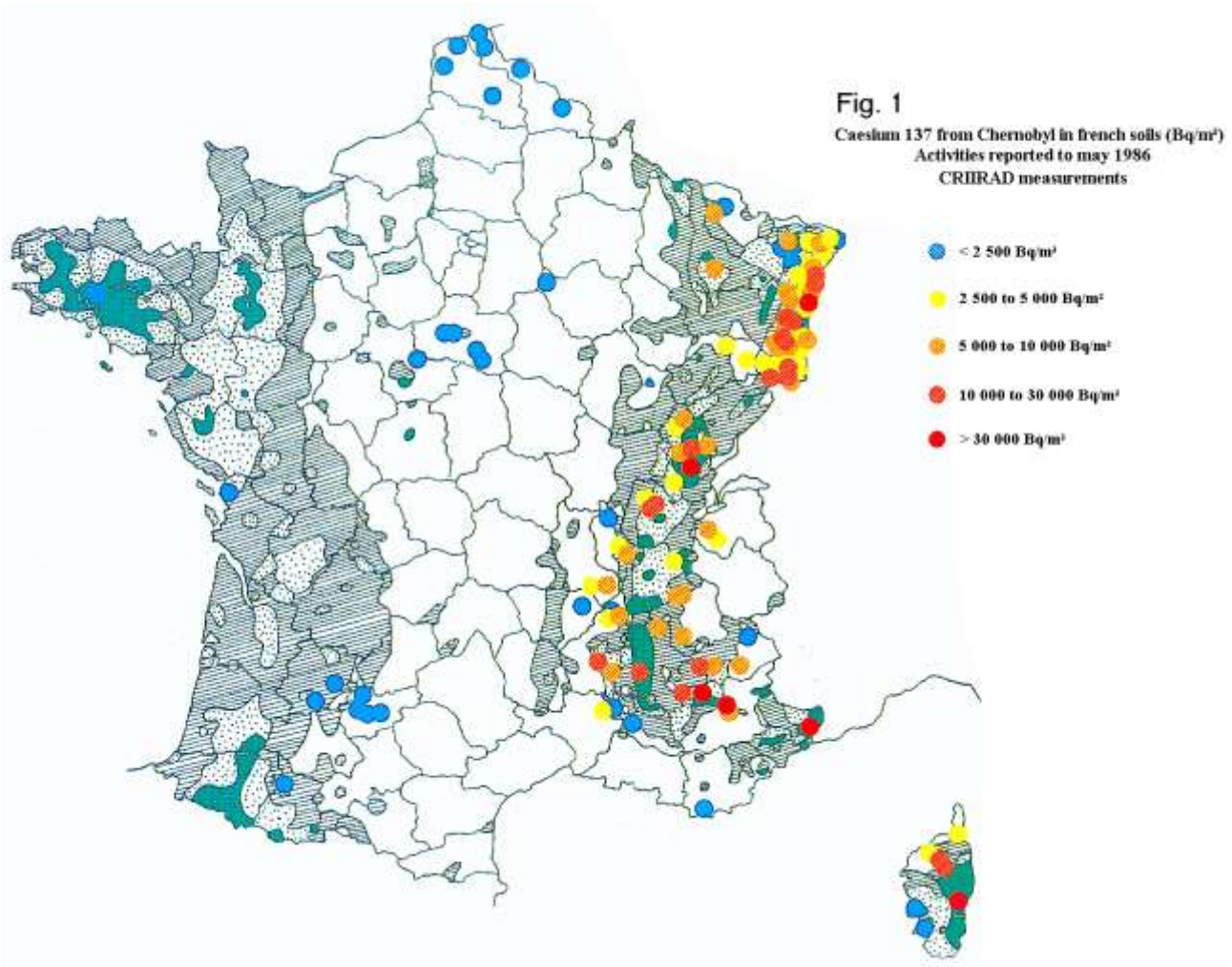
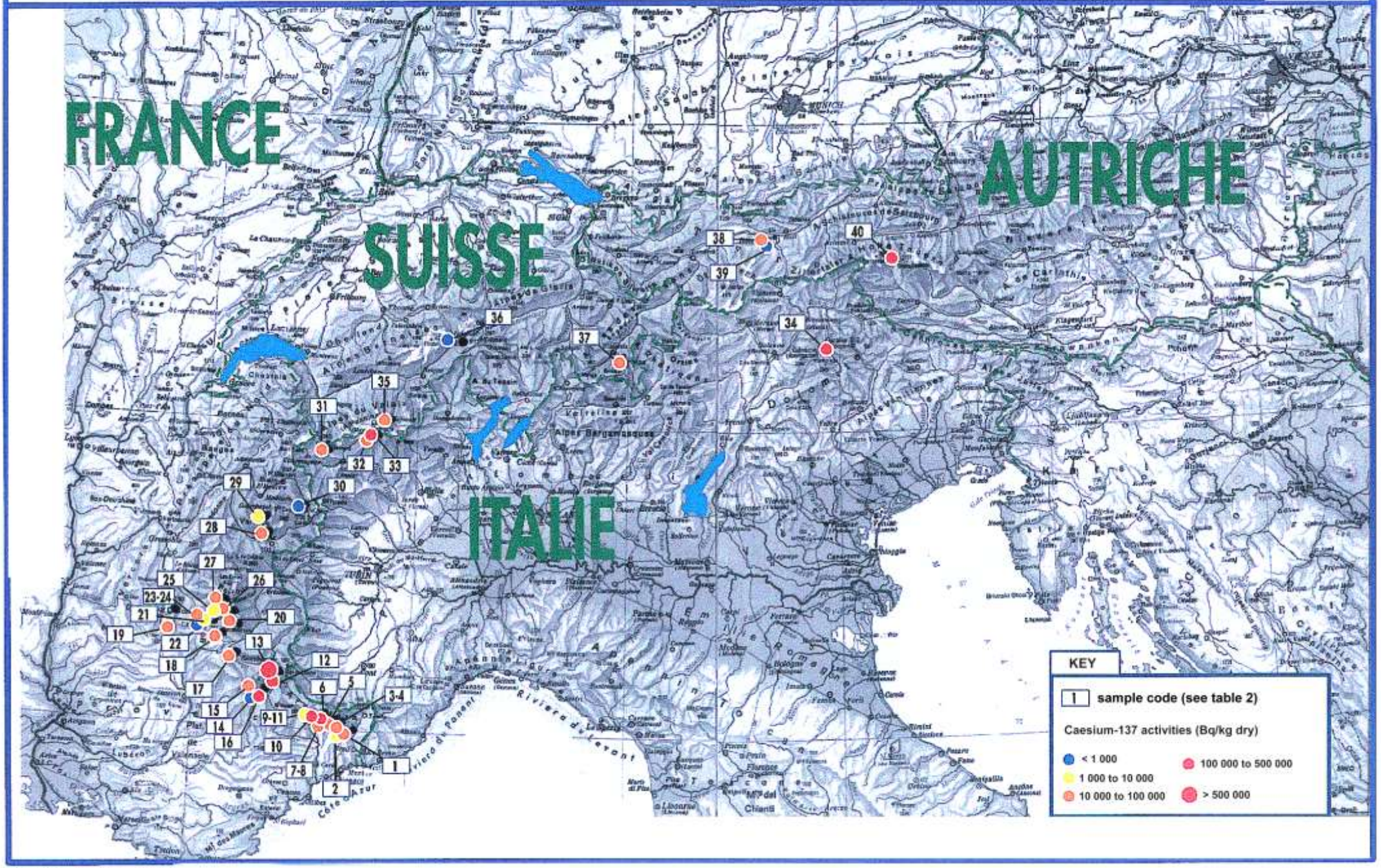


Fig. 1
Caesium 137 from Chernobyl in french soils (Bq/m²)
Activities reported to may 1986
CRIIRAD measurements
< 2 500 Bq/m²
2 500 to 5 000 Bq/m²
5 000 to 10 000 Bq/m²
10 000 to 30 000 Bq/m²
> 30 000 Bq/m²

TABLE 2 : SOILS IN THE ALPS - CAESIUM 137-134 AND AMERICIUM 241 / Activities in Bq/kg dry / CRIIRAD MEASUREMENTS 1996 - 1997

Map Code	Sampling date	Country	Zone	Place	Altitude (m)	Caesium 137	Caesium 134	Americium 241
13	21/09/97	France	Mercantour (North)	Col de Restefond	2 490	545 000 ± 55 000	7 840 ± 830	35 ± 30
6	29/07/96	France	Mercantour (South)	Col Mercière	2 310	368 000 ± 37 000	7 281 ± 748	40 ± 17
12	08/10/97	France	Mercantour (North)	Col de Restefond	2 490	255 000 ± 26 000	3 538 ± 363	< 5
40	13/08/97	Austria	Hohe Tauern	Grossglockner Hochalpenstrasse	2 435	163 000 ± 17 000	2 411 ± 248	22 ± 8
34	12/08/97	Italy	Passo di Falzarego	Passo Di Valparola	2 175	158 000 ± 16 000	2 093 ± 238	154 ± 41
10	25/07/96	France	Mercantour (South)	La Lombarde	2 165	150 000 ± 15 000	3 043 ± 315	26 ± 9
16	07/10/97	France	Mercantour (North)	Lac d' Allos	2 245	143 000 ± 14 500	2 019 ± 220	< 11
33	03/08/97	Italy	Cervin South	North de Plan Maison	2 730	107 000 ± 11 000	1 562 ± 165	< 5
19	22/07/97	France	Dévoluy	Pied du pic de Bure	2 150	89 000 ± 9 000	1 338 ± 152	< 9
20	17/07/97	France	Massif des Ecrins	Les Rougnous de Prapic	2 525	66 000 ± 6 700	997 ± 107	< 4
35	15/08/97	Switzerland	Cervin North	Alpage de Zermatt	2 380	64 300 ± 6 600	890 ± 120	< 16
17	12/07/97	France	Grand Morgon	Cirque de Morgon	2 085	64 100 ± 6 500	952 ± 101	20 ± 6
31	03/08/97	Italy	Grand St-Bernard	Secteur South	2 420	63 000 ± 6 400	920 ± 103	< 7
4	31/07/96	France	Mercantour (South)	Vacherie du Boréon	1 670	58 000 ± 5 900	1 164 ± 125	6.1 ± 5.7
3	31/07/96	France	Mercantour (South)	Boréon	2 270	53 700 ± 5 400	1 056 ± 111	11 ± 4
28	30/07/97	France	Vanoise (South)	Lac de la Partie	2 445	50 300 ± 5 100	646 ± 67	46 ± 7
18	06/07/97	France	Massif des Ecrins	Alpage de Fleurendon	2 100	47 200 ± 4 800	719 ± 77	4.3 ± 4.3
26	15/09/96	France	Massif des Ecrins	Col de la Vallette	2 430	46 600 ± 4 700	899 ± 94	11 ± 4
23	28/09/96	France	Massif des Ecrins	Col de la Pisse (South)	2 297	44 100 ± 4 500	855 ± 92	< 5
24	28/09/96	France	Massif des Ecrins	Col de la Pisse (North)	2 385	43 000 ± 4 300	807 ± 86	8.3 ± 4.1
27	15/09/96	France	Massif des Ecrins	Gioberney (replat Tirière)	2 280	28 800 ± 2 900	532 ± 58	< 1.1
15	07/10/97	France	Mercantour (North)	Parking Lac d' Allos	2 130	26 700 ± 2 700	377 ± 42	< 3
7	28/07/96	France	Mercantour (South)	Isola 2000	2 220	25 200 ± 2 600	492 ± 52	16 ± 4
1	02/08/96	France	Mercantour (South)	Vallée des Merveilles	2 375	22 800 ± 2 300	371 ± 39	54 ± 7
5	30/07/96	France	Mercantour (South)	North col de Salèse	2 300	20 700 ± 2 100	399 ± 42	6.7 ± 2.4
32	03/08/97	Italy	Cervin South	Cervinia (parking)	1 970	18 000 ± 1 800	269 ± 30	< 2
37	11/08/97	Switzerland	Secteur de St-Moritz		2 430	17 700 ± 1 800	249 ± 33	9.4 ± 6.2
8	28/07/96	France	Mercantour (South)	Isola 2000	2 200	14 800 ± 1 500	300 ± 35	< 3
38	13/08/97	Austria	Secteur d'Innsbruck	Lusens	2 158	13 500 ± 1 400	185 ± 23	3.6 ± 2.9
21	07/09/97	France	Massif des Ecrins	Forêt de la Lozière	1 720	8 780 ± 910	117 ± 17	< 4
9	25/07/96	France	Mercantour (South)	La Lombarde	2 220	5 060 ± 520	91 ± 11	3.1 ± 1.6
25	15/09/96	France	Massif des Ecrins	Crupillouse	2 660	5 000 ± 520	74 ± 10	5.1 ± 2.6
2	31/07/96	France	Mercantour (South)	Boréon	2 325	4 250 ± 450	64 ± 10	38 ± 9
29	31/07/97	France	Roselend	Cormet de Roselend	2 160	2 450 ± 260	1 ± 0.8	16 ± 3
11	25/07/96	France	Mercantour (South)	La Lombarde	2 220	1 280 ± 140	23 ± 4	< 1
36	14/08/97	Switzerland	Secteur d'Interlaken	Grimsel Pass	2 190	444 ± 50	2 ± 1.8	< 3
22	07/09/97	France	Massif des Ecrins	Forêt de la Lozière	1 722	318 ± 37	< 1	< 2
30	31/07/97	France	Val d'Isère	Col de l' Iseran	2 765	149 ± 17	< 0.4	< 1
14	07/10/97	France	Mercantour (North)	Allos St-Roch	1 525	89 ± 10	1 ± 0.3	< 1
39	13/08/97	Austria	Secteur d'Innsbruck	(à 100 m du village)	1 735	54 ± 9	< 1.6	< 2

Fig. 2 : Caesium-137 activities (Bq/kg dry) in the upper layer of soil in the Alps
CRIIRAD measurements 1996 - 1997



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