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**RADON EXHALATIVE PROPERTIES,
RADIOELEMENT CONTENT AND RARE EARTH
ELEMENT COMPOSITION OF NAMURIAN
PHOSPHORITE DEPOSITS, CO. CLARE.**

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SUMMARY

The Namurian phosphorite deposits of northwest Co. Clare, whose reserves in beds over 30cm thick are estimated at 3 million tonnes, are shown to have uranium and rare earth element contents comparable with those reported for phosphorites in the USA and Russia. As a consequence of their inherently high and laterally persistent uranium content (average 160ppm U) they are amenable to exploration using either active or passive soil gas radon survey techniques. Under favourable circumstances, the presence of buried phosphorite can be detected at depths of 50m or more.

Both the phosphorites and their uraniumiferous shale host rocks represent a geologically well-defined radon source. While there are no centres of population built directly on the phosphorite outcrop, it is recommended that the dispersed dwellings that do exist in the area should be monitored to determine the extent of indoor radon exposure of the occupants as a matter of priority.

P.J. O'Connor
September, 1994.

INTRODUCTION

Under the stimulus of EU funding (Contract PU05.2014/77), the phosphorite deposits of Co. Clare were assessed in terms of their uranium and rare earth potential (O'Connor and Pyne 1978; 1986). This assessment involved the analysis by neutron activation of representative drill core sections, obtained during an earlier investigation of these phosphorites in 1976-1977 by the Geological Survey of Ireland (summary in Notholt and Highley 1979). Ground investigations over the main phosphorite occurrences were also undertaken to assess their response using (i) airborne radiometric surveys and (ii) soil gas radon surveys. The results of this work are presented here.

GEOLOGY

The phosphorites of northwest Co. Clare (Fig. 1) occur towards the base of a condensed Namurian sequence, the Clare Shale Formation (Hodson and Lewarne 1961). This Formation represents the northern margin of a middle Carboniferous sedimentary basin, the axis of which corresponds approximately to the present-day line of the Shannon estuary. Successively younger beds of the Namurian sequence overlap to the north and, in the Lisdoonvarna area, where Namurian shales lie unconformably on Lower Carboniferous (Viséan) limestones, a major non-sequence can be demonstrated.

Regionally, the Clare Shale Formation dips gently to the south or southwest; folding is restricted to broad flexures whose axes dip gently to the west-southwest, and no major faulting is known to occur.

The phosphorites are found within the lowest 6m of the Clare Shale Formation (Fig. 2). Mineralogically, they consist of about 60% fluorapatite set in a matrix of calcite (20%), silica (13%), pyrite (2.5%) and carbonaceous matter (1.5%). They occur as bands and lenses up to 1.4m thick at the junction of the Cahermacon Shale Member and the overlying Phosphate Shale Member (viz. the Cahermacon Phosphate), and also as nodules within the Cahermacon Shale Member. There is also found throughout the area a thin (less than 15cm) pyritic, conglomeratic phosphate - the Zero Phosphate. The Zero Phosphate, probably an intraformational phosphate, is generally found near the base of the Phosphate Shale Member. However, it is also found lying directly on top of the Cahermacon Phosphate, and even directly on top of Viséan limestone as is the case north of Lisdoonvarna.

Reserves of phosphorite (20-25% P_2O_5), in beds of over 30cm thick, are estimated at 3 million tonnes by the Geological Survey of Ireland (GSI records); the phosphorite occurs in three areas as follows (Fig. 1):

- | | | |
|-------------------------|---|--|
| Doolin | - | a phosphorite lens, partly worked out by underground mining, contains reserves of 0.3m tonnes. |
| Noughaval | - | the phosphorite here, partly worked out by opencast methods, contains reserves of 0.5m tonnes. |
| Cohy - Ballykeel | - | the phosphorite of this area has not been worked previously and reserves are estimated at about 2.2m tonnes. |

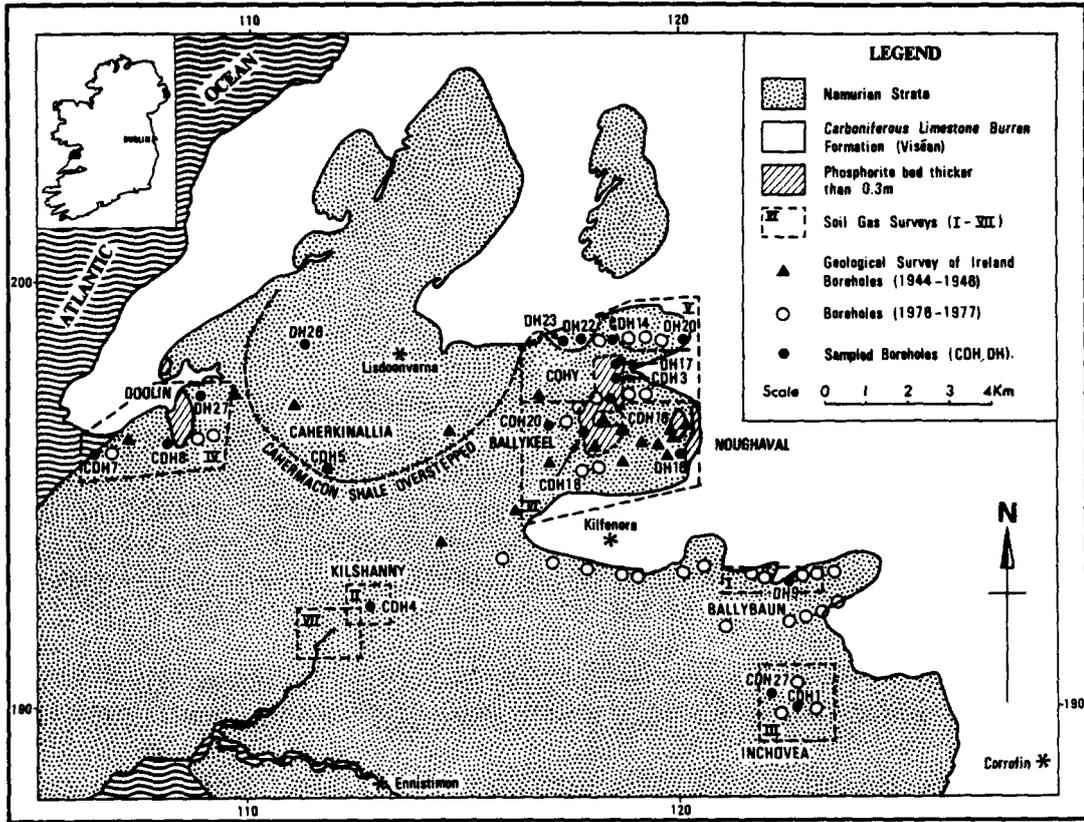


Figure 1 The phosphorite deposits of northwest Co. Clare (after the work of the Geological Survey of Ireland) showing borehole locations and alpha-cup grid outlines.

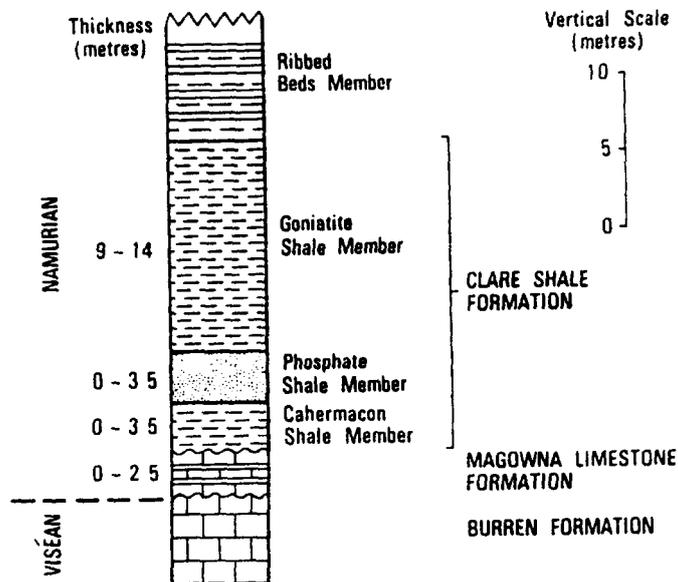


Figure 2 Generalised stratigraphical succession in northwest Co. Clare.

SAMPLING AND ANALYTICAL METHODS

Drill core was chosen from 18 boreholes which represented all the lithologies of interest over the whole of the area (Fig. 1). These included phosphorites (sand-grade, conglomeratic, and pyritic varieties), phosphatic shales, shales with discrete nodules of phosphorite, non-phosphatic shales, and limestones (phosphatic and non-phosphatic).

The core was split longitudinally, one half retained and the other half crushed and milled to -100 mesh in an agate Tema mill. The samples were sent to the Liverpool and Manchester Universities research reactor at Risley (UK) for neutron activation analysis. A total of 119 samples were analysed by an epithermal neutron counting technique for uranium. 15 samples were analysed by epithermal neutron activation for uranium and thorium (details of the method are given in O'Connor *et al.* 1981). The precision of each U-Th analysis, which represents the weighted mean of results obtained by comparing the few most intense lines of ^{239}Np and ^{233}Pa spectra in the 200 to 400 KeV region for sample and standards, was found to be $\pm 10\%$ with a lower limit of reliable detection of 1 ppm; potassium in these samples was determined by normal mixed spectrum neutron activation analysis. One sample of phosphorite (78-1115) was analysed quantitatively for all 14 rare earth elements by neutron activation using a group radiochemical separation scheme (Duffield and Gilmore 1979).

Carborne radiometric surveys were carried out using gross count scintillometry; the results and method are reported in O'Connor (1981). Soil gas radon surveys were carried out using (i) passive alpha-particle film detectors supplied and processed by Gammaero Associates Ltd. and (ii) *in situ* active grab sampling followed by alpha scintillation counting at the Physics Dept., University College Dublin.

RESULTS

Ground Investigations

Ground surveys over some of the main phosphorite occurrences were undertaken to assess their response using

- (a) Carborne radiometric surveys,
- (b) In situ soil gas radon measurements (active sampling),
- (c) Passive soil gas alpha-detectors.

Carborne Radiometric Survey

The results of a carborne radiometric reconnaissance of the Clare phosphorites are reported in O'Connor (1981). High readings were recorded by the gross-count scintillometer when known (outcropping or sub-outcropping) phosphatic horizons were traversed. No further significant deposits of phosphorite were detected in the course of the survey.

In Situ Soil Gas Radon Measurements

Prior to the widespread placement of passive alpha-particle detectors ("Track Etch" cups) in soils of the region, the radon exhalative properties of the phosphorites and phosphatic shales were assessed in areas of variable glacial overburden thickness. Measurements at 10 pre-selected sites were made. The exceptionally wet winter conditions had left the soils and glacial overburden of the area very water-logged, and in low-lying areas fields were still flooded. Because of this, sampling difficulties were anticipated, as radon is quite soluble in the interstitial waters of saturated soil. However, in spite of such adverse conditions, it proved possible to collect gas samples which were subsequently analysed by means of alpha scintillation counting.

Table 1. In situ soil gas radon concentrations (active sampling)

Sample	Date	Location (Townland)	Grid Reference	Soil Gas Radon Content (pCi/l)*
1	28.2.78	Teergonean	R 081 969	2060
2	28.2.78	Teergonean	R 082 968	1315
3	28.2.78	Teergonean	R 082 968	600
4	1.3.78	Clifden	R 257 885	2810
5	1.3.78	Ballyclancahill	R 218 930	9653
6	9.3.78	Ballyclancahill	R 218 930	24260
7	9.3.78	Ballybaun	R 212 930	6560
8	15.3.78	Toormore	R 222 900	1030
9	15.3.78	Knockaneden	R 227 898	2215
10	15.3.78	Toormore	R 225 906	96

* Determinations by alpha scintillation counting at the Dept. of Physics, University College Dublin (Note 1pCi/l = 37 Bq/m³).

The radon concentrations (Table 1) are expressed in picocuries per litre (pCi/l). Concentrations in the range of 500-1500 pCi/l are typical of Irish soils and are not remarkable. The radon content of samples 5 and 6 (at site of borehole DH9; alpha cup site 275) and sample 7 (600m west of borehole DH9; alpha cup site 278) is undoubtedly anomalous: it is to be expected that "fair weather" radon levels at these locations will be found to be even greater.

The radon-emanating properties of phosphorite were also measured in the laboratory on a 1.6kg sample recovered from the Roadford-Doolin outcrop. A measured radon exhalation rate of 128 atom/m²/sec showed the phosphorite to be a moderately good exhaler of radon. It was considered likely that the phosphorites could be detected at depth and their suboutcrop defined by careful soil gas radon surveys. This conclusion was further checked by follow-up shallow soil surveys using passive alpha detectors.

Passive Alpha-Cup Surveys

Alpha-cup surveys, using passive film detectors, were carried out in seven test areas (Fig. 1). A total of 246 plastic cups, each with a sensitive alpha-particle detecting film strip, were placed in an inverted position in the ground in holes 60-75cm deep on grids with a 200m x 200m spacing. The holes were back-filled (to cut down atmospheric dilution), marked, and left for a minimum of four weeks. The cups were then recovered and the film sent for processing to Gammaero Associates Inc.

The results, expressed in tracks per square millimetre (T/mm²), are tabulated in Appendix 1 and plotted in Figures 3 and 4. The alpha track density recorded on each film is proportional to the local radon gas concentration in the soil; the results for all the films are normalised to a 30-day exposure. The

readings range from 4 to 9980 T/mm² for the seven areas. Areas I, IV, V, and VI, are located in the northern part of the region where phosphorite outcrops at surface or occurs at shallow depth; in areas II, III, and VII the phosphorite is encountered at 40-50m depth in boreholes.

Area I - Ballybaun (30 detectors): this area straddles the limestone-shale boundary and represents a region where there is good geological control. A large amplitude anomaly, trending northeastwards, is centred on grid point 275 (borehole DH9); the depth to phosphorite at this point is 12m. Coincident active radon anomalies of 9635 and 24,260 pCi/l were measured in grab samples at this location (Samples 5 and 6, Table 1). Another alpha cup anomaly of 3294 T/mm² is centred on grid point 278 where active radon measurements recorded 6560 pCi/l (Sample 7, Table 1).

Area II - Kilshanny (25 detectors): a large northeasterly-trending alpha-cup anomaly of maximum 2208 T/mm² is centred on grid point 307. A 16cm band of phosphorite was intersected in borehole CDH4 (to the northeast) at a depth of 51m.

Area III - Inchovea (63 detectors): an anomaly of maximum 3012 T/mm² is located at grid point 322: phosphorite occurs at depths of 40-45m in this region (boreholes CDH1 and CDH27).

Area IV - Doolin (84 detectors): the main alpha-cup anomalies occur in the northwestern part of the region in the Doolin area where phosphorite is close to the surface: maxima of 3979 T/mm² and 3680 T/mm² were recorded at grid points 386 and 395 respectively. In the southern part of the region no anomalies were found: borehole data (CDH7 and CDH8) indicate that thin phosphorite bands (5-10cm) are present at depths of 40-50m.

Area V and VI - Cohy-Ballykeel (441 detectors): two contiguous grids are located over the thicker phosphorite beds which are intersected in boreholes at depths of 10-45m (Appendix 2). The main alpha-cup anomalies occur in an arcuate pattern at the margins of the grid, particularly in the south and east where the phosphorite outcrops at surface or occurs at shallow depth. A maximum value of 9990 T/mm² is located at grid point 224, while numerous values in the range 2000-4000 T/mm² were recorded.

Area VII - Curraghdoo (63 detectors): the grid is located to the southwest of Area II. Phosphorite occurs at depth in excess of 50m. A distinct E-W anomaly is centred on grid points 722-725 with a maximum value of 1392 T/mm². NNE-trending anomalies were recorded in the western half of the area.

The results of the alpha-cup surveys show that it is a viable phosphorite prospecting technique in the terrain of Co. Clare. Even in adverse soil conditions, the passive alpha-particle detectors were successful in detecting radon emanating from uraniferous phosphorites and phosphatic shales, particularly at shallow depths (<15 metres). At depths of up to 50m, in the southern part of the region, phosphorites could still be detected under certain circumstances, perhaps where favourable structures assisted the upward migration of radon in soil gas.

Radioelement Abundances

The purpose of the analytical work was to determine the degree of uranium enrichment and to examine the lateral variation, if any, in the uranium content of all lithologies. A detailed account and tabulation

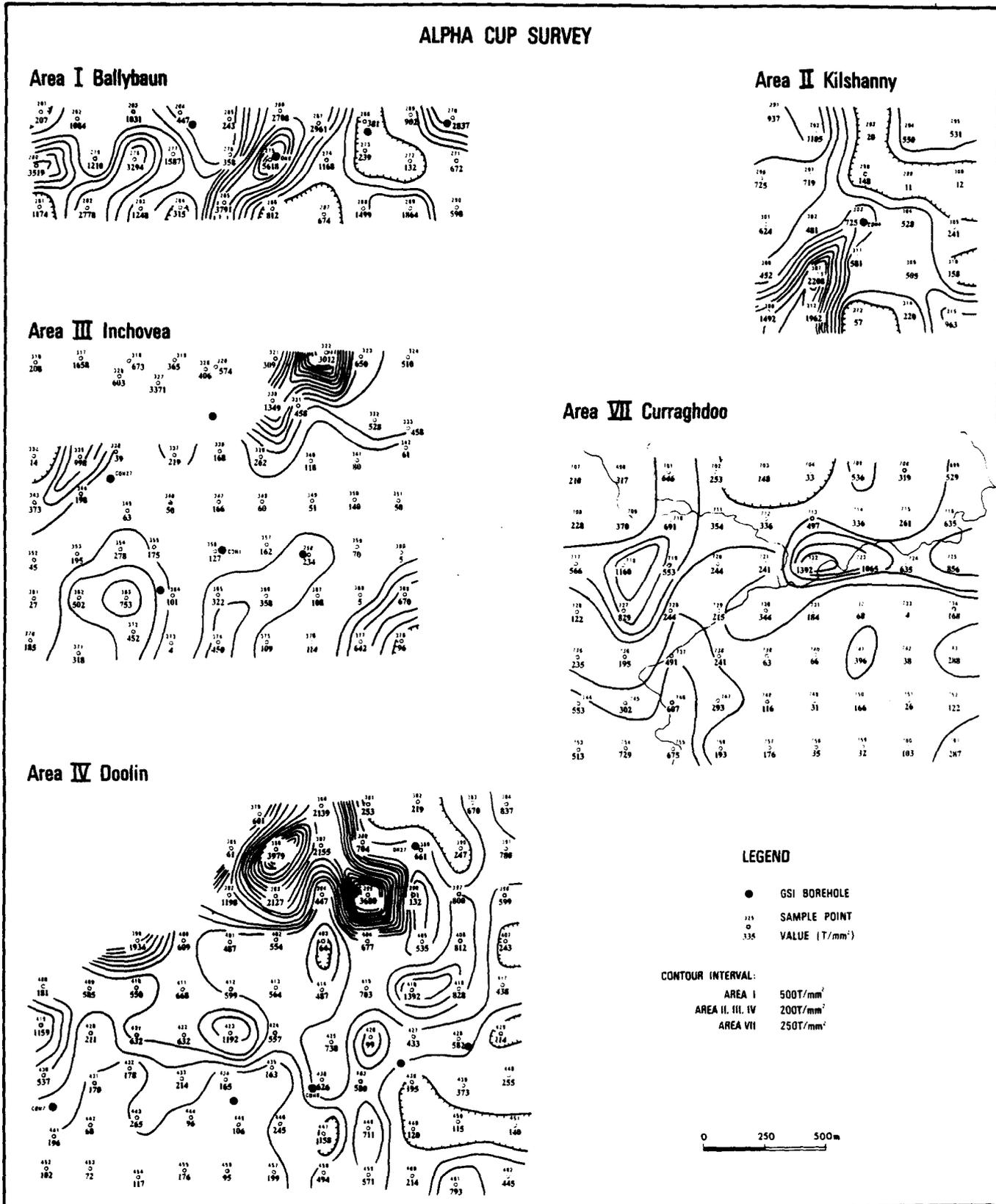


Figure 3 Contoured alpha-cup grids (areas I-IV, VII) indicative of radon flux in soils overlying Namurian strata in northwest Co. Clare. Grid locations are shown in Fig. 1.

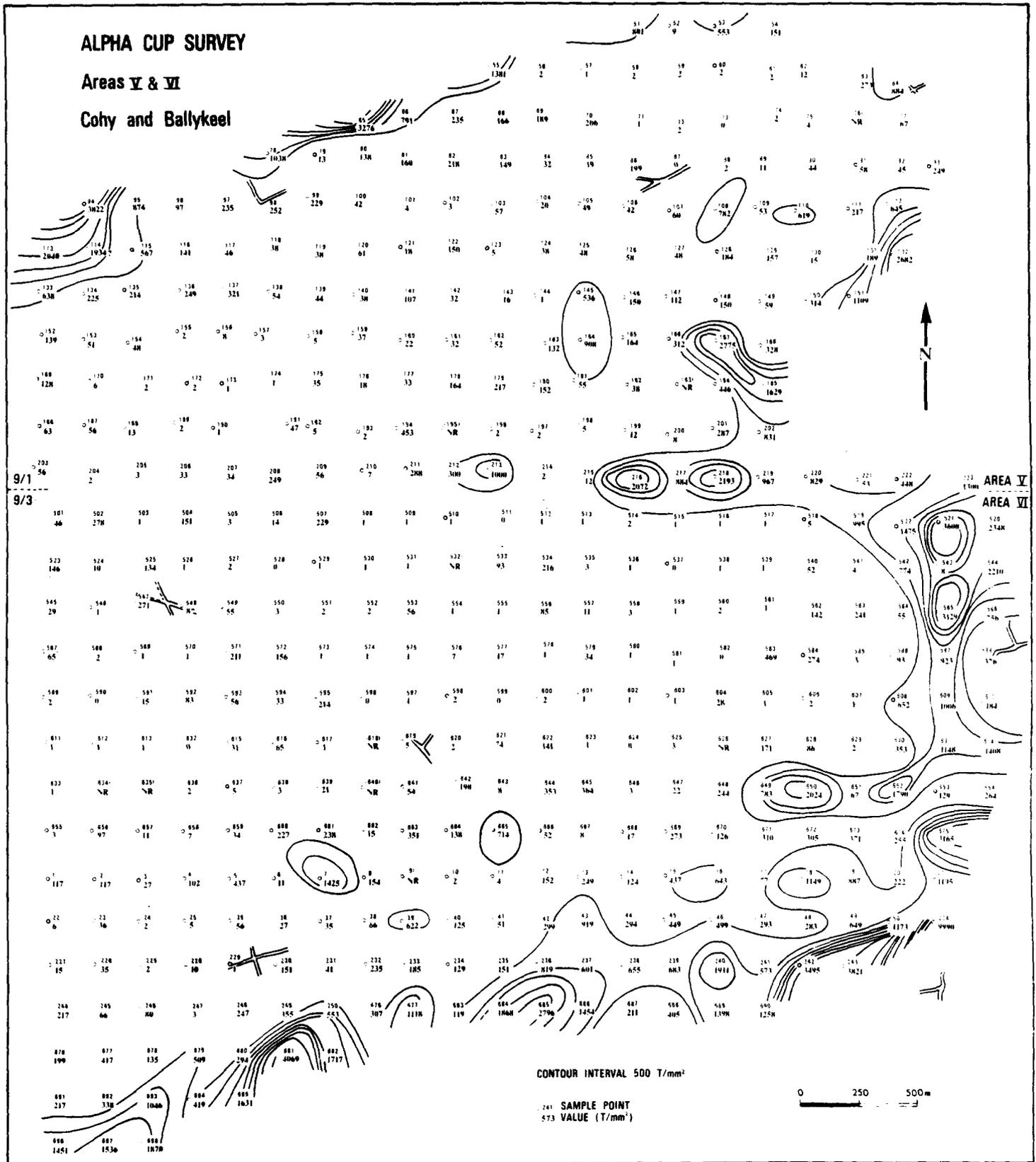


Figure 4 Contoured alpha-cup grids (areas V and VI) indicative of radon flux in soils overlying Namurian strata in northwest Co. Clare. Grid locations are shown in Fig. 1.

statistics are presented in Table 2.

Uranium enrichment, associated with fluorapatite contents of up to 60%, is seen to be concentrated in the phosphorites and, to a lesser extent, in phosphatic shales, where U contents are up to 40 times those prevailing in typical shales (Table 2). Where a shale interval contains an anomalously high U content it is generally stratigraphically adjacent, or very close, to a phosphorite horizon. The uranium concentration of phosphorites was found to be laterally persistent with no significant lateral variation. The Clare limestones (calcarenes) contain negligible amounts of uranium.

TABLE 2 Uranium content (in ppm) of lithologies from Co. Clare and elsewhere

	n	Mean \pm s.d. (ppm)	Range (ppm)	Reference
Clare phosphorites	50	158 \pm 42	57-302	This report
Clare phosphatic shales	25	94 \pm 83	28-376	This report
Clare shales	29	22 \pm 8	10-36	This report
Clare limestones	15	8 \pm 3	3-12	This report
Marine phosphorites	-	-	50-300	McKelvey 1956
Russian platform shales	178	4.1	-	Baranov <i>et al.</i> 1956
Marine black shales	-	20	-	Swanson 1961
Russian platform limestones	128	2.1	-	Baranov <i>et al.</i> 1956

The results of epithermal neutron activation analysis (for U, Th and K) on 15 core samples are also presented in Appendix 2. These results confirm the U concentration levels in the phosphorites. It is also clear that the Th content of the phosphorites is in the range of 4-10 ppm while that of the shales is 8-16 ppm; both values are typical for such lithologies (Wedepohl 1969). The K content of the shales ranges from 1.8% to 3.6%, while all of the phosphorites sampled contain less than 1% K.

Rare Earth Element Abundances

Abundance data for all 14 rare earth elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) are presented in Table 3 for Clare phosphorite (sample 78-1115) together with comparative data for other rock types.

In terms of their REE content, the Clare phosphorites are comparable to the Magdalena Bay phosphorite (Column C, Table 3). Phosphorites, in general, show considerable REE enrichment compared to values for average igneous rocks. The accumulation of REE in phosphorites appears to be related to diagenetic processes and to the presence of carbonaceous matter (of presumed organic origin).

The results relating to the radioelement and REE abundances of the Clare phosphorites have also been summarised by O'Connor and Pyne (1986).

TABLE 3. Rare-earth element content (in ppm) of Clare phosphorite and other rocks

	(a)	(b)	(c)	(d)	(e)
La	69.3 ± 1.7	95	56	32	42
Ce	135 ± 4	192	102	73	81
Pr	15.6 ± 1.2	36	14.5	7.9	10
Nd	94.2 ± 5.2	133	57	33	40
Sm	12.1 ± 1.5	29	11.2	5.7	7.6
Eu	4.5 ± 0.2	4	2.8	1.24	1.5
Gd	16.6 ± 1.1	31	15	5.2	7.2
Tb	2.5 ± 0.1	4	2.1	0.85	1.1
Dy	14.7 ± 0.3	21	12.3	-	5.8
Ho	2.0 ± 0.1	5	3.3	1.04	1.4
Er	8.0 ± 1.2	14	9	3.4	3.9
Tm	1.0 ± 0.2	3	1.06	0.50	0.62
Yb	4.9 ± 0.2	13	6.7	3.1	3.7
Lu	0.73 ± 0.04	3	1.2	0.48	0.61

- (a) Clare phosphorite sample 78-1115 (analysis by instrumental neutron activation at the Risley Reactor, U.K.).
- (b) Average of 21 phosphorite samples from Russian Platform (Semenov *et al.* 1962).
- (c) Phosphorite, Magdalena Bay (Goldberg *et al.* 1963).
- (d) Composite of 40 North American shales (Haskin and Haskin 1966).
- (e) Weighted average of igneous rocks (in Wedepohl, K.H., Handbook of Geochemistry 1969).

CONCLUSION

In northwest Co. Clare, reserves of phosphorite are estimated at 3 million tonnes. The rare earth element content of the phosphorite is typical of such rocks. The uranium content of these phosphorites is laterally persistent and averages about 150 ppm which is also comparable to other phosphorites. If 100% recovery of uranium was possible, this would amount to 450 tonnes of uranium metal. Buried phosphorites and phosphatic shales are easily delineated using radon in soil gas surveys and, under favourable circumstances, can be detected at depths of 50m or more.

In terms of public health, the phosphorites are moderately good exhalers of radon and the rock should not be used in house construction. While there are no centres or population sited directly on the phosphorite outcrop, dwellings in the general area should be surveyed to determine the extent of the indoor radon exposure of occupants. Recent investigations of soil gas radon concentrations and indoor radon levels in the karstic limestone terrain of Co. Galway (O'Connor *et al.* 1993) support the view that housing developments on these Carboniferous rock sequences should be targeted as a matter of priority for indoor radon monitoring.

ACKNOWLEDGEMENTS

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APPENDIX 1

ALPHA-CUP SURVEY RESULTS

APPENDIX I ALPHA-CUP SURVEY RESULTS (TRACKS/mm²)

Cup No.	T/mm ²	Cup No.	T/mm ²	Cup No.	T/mm ²	Cup No.	T/mm ²
Area I		292	1105	324	510	357	162
261	207	293	20	325	NR	358	234
262	1084	294	550	326	603	359	70
263	1031	295	531	327	3371	360	5
264	447	296	725	328	406	361	27
265	243	297	719	329	NR	362	502
266	2708	298	148	330	1349	363	753
267	2961	299	11	331	458	364	101
268	381	300	12	332	528	365	322
269	902	301	624	333	458	366	358
270	2837	302	481	334	14	367	108
271	672	303	725	335	998	368	5
272	132	304	528	336	39	369	670
273	239	305	241	337	219	370	185
274	1168	306	452	338	168	371	318
275	5618	307	2208	339	262	372	452
276	358	308	1492	340	118	373	4
277	1587	309	505	341	80	374	450
278	3294	310	158	342	61	375	109
279	1210	311	581	343	373	376	114
280	3519	312	1962	344	198	377	642
281	1174	313	57	345	63	378	96
282	2778	314	220	346	50	Area IV	
283	1248	315	963	347	166	379	601
284	315	Area III		348	60	380	2139
285	2791	316	208	349	51	381	253
286	812	317	1658	350	140	382	219
287	674	318	673	351	50	383	670
288	1499	319	365	352	45	384	837
289	1864	320	574	353	195	385	61
290	598	321	309	354	278	386	3979
Area II		322	3012	355	175	387	2155
291	937	323	650	256	127	388	704

APPENDIX I ALPHA-CUP SURVEY RESULTS (TRACKS/mm²)

Cup No.	T/mm ²	Cup No.	T/mm ²	Cup No.	T/mm ²	Cup No.	T/mm ²
389	661	422	632	455	176	24	2
390	247	423	1192	456	95	25	5
391	780	424	557	457	199	-	-
392	1198	425	738	458	494	35	56
393	2127	426	99	459	571	36	27
394	447	427	433	460	214	37	35
395	3680	428	582	461	793	38	66
396	132	429	114	462	445	39	622
397	800	430	537	463	580	40	125
398	599	431	170	Areas V and VI		41	51
399	1934	432	178	1	117	42	299
400	609	433	214	2	117	43	919
401	487	434	165	3	27	44	294
402	554	435	163	4	102	45	449
403	164	436	626	5	437	46	499
404	677	437	NR	6	11	47	293
405	535	438	195	7	1425	48	283
406	812	439	373	8	154	49	649
407	243	440	255	9	NR	50	1173
408	181	441	196	10	2	51	801
409	585	442	68	11	4	52	9
410	550	443	265	12	152	53	553
411	668	444	96	13	249	54	151
412	599	445	106	14	124	55	1381
413	564	446	245	15	437	56	2
414	487	447	158	16	643	57	1
415	703	448	711	17	77	58	2
416	1392	449	120	18	1149	59	2
417	438	450	115	19	887	60	2
418	828	451	140	20	222	61	2
419	1159	452	102	21	1195	62	12
420	211	453	72	22	6	63	273
421	632	454	117	23	36	64	884

APPENDIX I ALPHA-CUP SURVEY RESULTS (TRACKS/mm²)

Cup No.	T/mm ²						
65	3276	97	235	129	157	161	32
66	791	98	252	130	15	162	52
67	235	99	229	131	189	163	132
68	166	100	42	132	2689	164	908
69	189	101	4	133	638	165	164
70	206	102	3	134	225	166	312
71	1	103	57	135	214	167	2775
72	2	104	20	136	249	168	328
73	0	105	49	137	321	169	128
74	2	106	42	138	54	170	6
75	4	107	60	139	44	171	2
76	NR	108	782	140	38	172	2
77	67	109	53	141	107	173	1
78	1038	110	619	142	32	174	1
79	13	111	217	143	16	175	35
80	138	112	645	144	1	176	18
81	160	113	2040	145	536	177	33
82	218	114	1934	146	150	178	164
83	149	115	567	147	112	179	217
84	32	116	141	148	150	180	152
85	19	117	46	149	59	181	55
86	199	118	38	150	314	182	38
87	0	119	38	151	1109	183	NR
88	2	120	61	152	139	184	446
89	11	121	18	153	51	185	1629
90	44	122	150	154	48	186	63
91	58	123	5	155	2	187	56
92	45	124	38	156	8	188	13
93	249	125	48	157	3	189	2
94	3822	126	58	158	5	190	1
95	874	127	48	159	37	191	47
96	97	128	184	160	22	192	5

APPENDIX 1 ALPHA-CUP SURVEY RESULTS (TRACKS/mm²)

Cup No.	T/mm ²						
193	2	226	35	507	229	540	52
194	453	227	15	508	1	541	4
195	NR	228	10	509	1	542	774
196	2	229	1	510	1	543	8
197	2	230	151	511	0	544	2210
198	5	231	41	512	1	545	29
199	12	232	235	513	1	546	1
200	8	233	185	514	2	547	271
201	287	234	129	515	1	548	8
202	831	235	151	516	1	549	55
203	56	236	819	517	1	550	3
204	2	237	601	518	5	551	2
205	3	238	655	519	995	552	2
206	33	239	683	520	2348	553	56
207	34	240	1911	521	3600	554	1
208	249	241	573	522	1474	555	1
209	56	242	3495	523	146	556	85
210	7	243	3821	524	10	557	11
211	288	244	217	525	134	558	3
212	300	245	66	526	1	559	0
213	1000	246	80	527	2	560	2
214	2	247	3	528	0	561	1
215	12	248	247	529	1	562	142
216	2072	249	355	530	1	563	241
217	884	250	553	531	1	564	55
218	2193	476	307	532	NR	565	3129
219	967	477	1118	533	93	566	756
220	829	501	46	534	216	567	65
221	53	502	278	535	3	568	2
222	448	503	1	536	1	569	1
223	1300	504	151	537	0	570	1
224	9990	505	3	538	1	571	211
225	2	506	143	539	1	572	156

APPENDIX 1 ALPHA-CUP SURVEY RESULTS (TRACKS/mm²)

Cup No.	T/mm ²	Cup No.	T/mm ²	Cup No.	T/mm ²	Cup No.	T/mm ²
573	1	606	2	639	21	672	305
574	1	607	1	640	NR	673	371
575	1	608	652	641	54	674	255
576	7	609	1006	642	190	675	3165
577	17	610	184	643	9	676	199
578	1	611	1	644	353	677	417
579	34	612	1	645	364	678	135
580	1	613	1	646	3	679	509
581	1	614	1408	647	22	680	294
582	0	615	31	648	244	381	4069
583	469	616	65	649	783	682	1717
584	274	617	1	650	2024	683	119
585	3	618	NR	651	671	684	1868
586	93	619	5	652	1790	685	2796
587	923	620	2	653	129	686	1454
588	376	621	74	654	264	687	211
589	2	622	141	655	3	688	405
590	0	623	1	656	97	689	1398
591	15	624	0	657	11	690	1258
592	83	625	3	658	7	691	217
593	56	626	NR	659	34	692	338
594	33	627	171	660	227	693	1046
595	214	628	86	661	238	694	419
596	0	629	2	662	15	695	1631
597	1	630	353	663	351	696	1451
598	2	631	1148	664	138	697	1536
599	1	632	0	665	714	698	1870
500	2	633	1	666	52	Area VII	
601	1	634	NR	667	8	496	317
602	1	635	NR	668	17	699	529
603	1	636	2	669	273	701	646
604	28	637	5	670	126	702	253
605	1	638	3	671	310	703	148

APPENDIX I ALPHA-CUP SURVEY RESULTS (TRACKS/mm²)

Cup No.	T/mm ²	Cup No.	T/mm ²
704	33	736	195
705	536	737	491
706	319	738	241
707	210	739	63
708	228	740	66
709	370	741	396
710	691	742	38
711	354	743	288
712	336	744	553
713	497	745	302
714	336	746	607
715	261	747	293
716	635	748	116
717	566	749	31
718	1160	750	166
719	553	751	26
720	244	752	122
721	241	753	513
722	1392	754	729
723	1065	755	675
724	635	756	193
725	856	757	176
726	122	758	35
727	829	759	32
728	244	760	103
729	215	761	287
730	344	End of Data	
731	184		
732	68		
733	4		
734	168		
735	235		

APPENDIX 2

NEUTRON ACTIVATION ANALYSES

APPENDIX 2: NEUTRON ACTIVATION ANALYSES**Kilshanny area (CDH 4)**

Only one borehole was drilled in this area, and four samples analysed. A 16cm band of phosphate contains 203 ppm U, while the shale below it contains 42 ppm U. Another shale interval contains 12 ppm U and a calcarenite contains 6 ppm U.

Caherkinallia area (CDH 5)

Only one borehole was drilled here also, and two samples analysed. A 7.5cm band of pyritic phosphate conglomerate contains 169 ppm U, while the underlying calcarenite contains 6 ppm U.

Lisdoonvarna area (DH 26)

Again, only one hole was drilled here and three samples analysed. A 3cm band of phosphate contains 175 ppm U, while the shale and limestone contain 19 ppm U and 5 ppm U respectively.

Doolin (CDH 7, CDH 8, DH 27)

These three boreholes are in the vicinity of the old underground phosphate mine at Roadford; a total of 19 samples were analysed.

CDH 8, from which 7 samples were analysed, contains two thin phosphorite bands; the upper band, 9.5 cm thick, contains 180 ppm U, while the lower, 6cm thick, contains 157 ppm U. The 54cm of shales with phosphate nodules below the lower phosphate contain 140 ppm U. The other four analyses were of shales (21 ppm, 36 ppm and 34 ppm U) and calcarenite (12 ppm U).

CDH 7, the westernmost hole in this area, provided six samples for analysis. Again, two thin, but distinctive, phosphate bands are present; the upper, which is 5cm thick and pyritic, contains 181 ppm U, while the lower which is 6cm thick and conglomeratic, contains 211 ppm U. However, the 9cm of shale between these two phosphate bands contains 376 ppm U. Although there is a 2cm thick pyritic phosphate band within this shale, the remaining 7cm is non-phosphatic. The other three samples were of shales (17 ppm U), phosphatic shales (54 ppm U), and calcarenites (6 ppm U).

DH 27, sited north of the Roadford phosphate mine, yielded six samples for analysis. A 4.5cm band of phosphate contains 164 ppm U, while another phosphate band, 3.5cm thick and 4cm below the first, contains 302 ppm U. The intervening 4cm of phosphatic mudstone contains 132 ppm U. Other analyses were of shales (18 ppm U), phosphatic shales (63 ppm U), and calcarenite (12 ppm U).

Inchovea area (CDH 1, CDH 27)

Core from two holes in this area provided 17 samples, 11 from CDH 1 and 6 from CDH 27. In CDH 1 the lithologies analysed were the Zero Phosphate and the overlying shales; in CDH 27 the Zero Phosphate and the underlying lithologies were analysed.

In CDH 1 the Zero Phosphate is 4cm thick and contains 85 ppm U; another thin (2.5cm) phosphate interval contains 104 ppm U. The remaining 9 samples, all of shale, contain between 10 and 34 ppm U.

The Zero Phosphate in CDH 27 is also 4cm thick and contains 76 ppm U; below this, 22cm of shale contains 69 ppm U. There is then another 5cm of phosphorite with 134 ppm U, a slightly phosphatic shale (22.5cm) with 188 ppm U, another thin (3cm) phosphate band with 190 ppm U and, the lowest interval analysed, 20.5cm of shale with minor phosphate contains 89 ppm U.

Cohy - Ballykeel area (DH 16, 17, 20, 22, 23; CDH 3, 14, 16, 18, 20)

74 core samples were analysed from the 10 holes chosen in this area.

In DH 23 three sections of core were analysed; a 20cm section of phosphate contains 142 ppm U; the 99cm of shales above the phosphate contain 18 ppm U, while the interval below the phosphate (30cm of calcarenite) contains 8 ppm U.

5 samples were selected from DH 22 which lies east of DH 23. The Cahermacon Phosphate here is 10.5cm thick and contains 161 ppm U. The Zero Phosphate is only 1cm thick and contains 65 ppm U. The two shale intervals chosen contain 19 and 30 ppm U, while the basal calcarenite contains 7 ppm U.

Further east is CDH 14, from which 6 samples were analysed. Here the Cahermacon Phosphate is 5cm thick and contains 135 ppm U. The overlying shale (21.5cm thick) contains only 20 ppm U, while another phosphate band immediately overlying this shale is 8.5cm thick and contains 150 ppm U; this upper phosphate probably includes the Zero Phosphate. Two other shale intervals contain 29 ppm and 20 ppm U, while the basal calcarenite contains 11 ppm U.

In the northeastern corner of the area DH 20 provided four samples. The Cahermacon Phosphate is 5cm thick and contains 203 ppm U; the Zero Phosphate, lying directly on top of the Cahermacon is only 1cm thick and contains 213 ppm U. The shales above the Zero Phosphate contain 15 ppm U while the basal calcarenite contains 11 ppm U.

10 samples were chosen from DH 17 which contains 43cm of Cahermacon Phosphate; four 10cm long sections of this interval were analysed and contained 167, 146, 138 and 138 ppm U (average 147 ppm U). The Zero Phosphate lies 7cm above the Cahermacon and is 4cm thick; it contains 160 ppm U, while the intervening 7cm of shale contains 23 ppm U. 89cm of shale above the Zero Phosphate contains 20 ppm, while two intervals of shale below the Cahermacon Phosphate both contain 35 ppm U. The basal calcarenite below the shales contains 9 ppm U.

In CDH 3, just south of DH 17, 17 samples were analysed; one of these is a 71cm interval of Cahermacon Phosphate; this was the thickest band of phosphate encountered during the 1976/77 drilling. Six 10cm, and one 11cm intervals of the Cahermacon Phosphate were analysed; these contain 150, 162, 169, 157, 132, 144 and 188 ppm U (average 157 ppm U). The Zero Phosphate is 2cm thick, contains 217 ppm U and lies 12cm above the Cahermacon Phosphate; there is no analysis for this 12cm shale available. A thin (3cm) conglomeratic phosphate layer 70cm above the Zero Phosphate contains 82 ppm U. A 26cm shale interval immediately below the Cahermacon Phosphate contains 168 ppm U, while the 36cm of shale with phosphate nodules immediately beneath this contains 101 ppm U. Four other shale intervals below this contain 33, 30, 30 and 60 ppm U, while two samples of calcarenite contain 8 and 3 ppm U.

South of CDH 3, CDH 16 provided ten samples for analysis. The Cahermacon Phosphate is 39.5cm thick and the four subdivisions of this horizon, (one of 9.5cm, three of 10cm each), contain 161, 145, 130 and 154 ppm U (average 147 ppm U). The overlying 8cm of shale contains 36 ppm U; the Zero Phosphate lies directly on this shale, is 7cm thick, and contains 192 ppm U. A 52cm section of shale immediately below the Cahermacon contains 158 ppm U while two other shale intervals below this contain 53 and 39 ppm U. The basal calcarenite contains 4 ppm U.

CDH 18, which is southwest of CDH 16, had 7 samples sent for analysis. Six of these were 10cm sections of the Cahermacon Phosphate which is 60cm thick here. These contain (from top to base) 173, 198, 173, 143, 141, and 156 ppm U (average 164 ppm U). A 5cm band of mudstone and phosphate immediately below this contains 249 ppm U.

7 samples were selected from CDH 20 which lies west of CDH 18. Here the Cahermacon Phosphate is only 5cm thick and contains 203 ppm U. The Zero Phosphate is 6cm thick and contains 172 ppm U, while the 1.5cm of mudstone between these two phosphate horizons contains 34 ppm U. The shale above the Zero Phosphate contains 12 ppm U. There is a 29cm section of phosphatic shale below the Cahermacon Phosphate which contains 86 ppm U, while a thin (1.5cm) phosphate below this contains 57 ppm U. The lowest interval analysed, 31cm of shale, contains 29 ppm U.

CDH 16, the most southeasterly of the holes drilled in the area, was sited adjacent to the abandoned opencast phosphate mine at Noughaval. Five samples were sent for analysis. The Cahermacon Phosphate is 50cm thick and contains 154 ppm U. The shale immediately above, which is 52cm thick, contains 53 ppm U; above this there is a 48cm shale interval with minor phosphate (? Zero) which contains only 33 ppm U. The 72cm of phosphatic shales below the Cahermacon Phosphate contain 28 ppm U, and the basal calcarenite contains 12 ppm U.

RESULTS OF DELAYED NEUTRON ACTIVATION ANALYSIS FOR URANIUM

Sample Number	Borehole Number	Grid Reference	Area	Depth (metres)		Interval Length	U(ppm)	Lithology
				From	to			
78-1001	CDH 4	R128925	Kilshanny	49.72	50.82	1.10m	12	Shales, occasionally phosphatic, minor limestone
78-1002	CDH 4	R128925	Kilshanny	50.82	50.98	16cm	203	Phosphate (Zero and Cahermacon)
78-1003	CDH 4	R128925	Kilshanny	50.98	52.00	1.02m	42	Shale
78-1004	CDH 4	R128925	Kilshanny	52.00	52.40	40cm	6	Calcarenite with phosphate grains
78-1037	CDH 5	R118957	Caherkinallia	65.98	65.965	7.5cm	169	Phosphate (Zero and, possibly Cahermacon)
78-1038	CDH 5	R118957	Caherkinallia	65.965	66.51	54.5cm	3	Calcarenite, phosphatic
78-1055	DH 26	R113985	Lisdoonvarna	23.86	24.73	87cm	19	Shale with minor phosphate
78-1056	DH 26	R113985	Lisdoonvarna	24.73	24.76	3cm	175	Phosphate
78-1057	DH 26	R113985	Lisdoonvarna	24.76	25.01	25cm	5	Calcarenite
78-1071	CDH 7	R064959	Doolin	39.35	40.65	1.30m	17	Shale, some limestone
78-1072	CDH 7	R064959	Doolin	40.65	40.70	5cm	181	Phosphate (Zero)
78-1073	CDH 7	R064959	Doolin	40.70	40.79	9cm	376	Shale and Phosphate
78-1074	CDH 7	R064959	Doolin	40.79	40.85	6cm	211	Phosphate (Cahermacon)
78-1075	CDH 7	R064959	Doolin	40.85	41.68	83cm	54	Shales, phosphatic
78-1076	CDH 7	R064959	Doolin	41.68	42.25	57cm	6	Calcarenite with phosphatic grains
78-1064	CDH 8	R080962	Doolin	51.57	51.855	28.5cm	21	Shales with minor phosphate
78-1065	CDH 8	R080962	Doolin	51.855	51.95	9.5cm	180	Phosphate (Zero)
78-1066	CDH 8	R080962	Doolin	51.95	52.01	6cm	36	Shale
78-1067	CDH 8	R080962	Doolin	52.01	52.07	6cm	157	Phosphate, conglomeratic
78-1068	CDH 8	R080962	Doolin	52.07	52.61	54cm	140	Shales, largely phosphatic
78-1069	CDH 8	R080962	Doolin	52.61	53.22	61cm	34	Shale with limestone band
78-1070	CDH 8	R080962	Doolin	53.30	53.555	25.5cm	12	Calcarenite

Sample Number	Borehole Number	Grid Reference	Area	Depth (metres)		Interval Length	U(ppm)	Lithology
				From	to			
78-1058	DH 27	R087972	Doolin	9.38	10.565	18.5cm	18	Shales
78-1059	DH 27	R087972	Doolin	10.565	10.61	4.5cm	164	Phosphate
78-1060	DH 27	R087972	Doolin	10.61	10.65	4cm	132	Mudstone, phosphatic
78-1061	DH 27	R087972	Doolin	10.65	10.685	3.5cm	302	Phosphate
78-1062	DH 27	R087972	Doolin	10.685	11.405	72cm	63	Shales, phosphatic
78-1063	DH 27	R087972	Doolin	11.405	11.90	49.5cm	12	Calcarenite, phosphatic
78-1007	CDH 1	R227901	Inchovea	35.05	38.10	3.05m	11	Shale
78-1008	CDH 1	R227901	Inchovea	38.10	41.06	2.96m	14	Shale, minor limestone
78-1009	CDH 1	R227901	Inchovea	41.06	41.98	92cm	10	Shale
78-1010	CDH 1	R227901	Inchovea	41.98	42.075	9.5cm	21	Shale, minor pyrite & phosphate
78-1011	CDH 1	R227901	Inchovea	42.075	43.29	1.21m	16	Shale
78-1012	CDH 1	R227901	Inchovea	43.29	43.365	7.5cm	12	Shales;pyrite/phosphate nodular
78-1013	CDH 1	R227901	Inchovea	43.365	43.58	21.5cm	16	Shale
78-1014	CDH 1	R227901	Inchovea	43.58	45.085	1.505m	17	Shale
78-1015	CDH 1	R227901	Inchovea	45.085	45.11	2.5cm	104	Phosphate, granular
78-1016	CDH 1	R227901	Inchovea	45.11	46.82	71cm	34	Shale, phosphate granules
78-1017	CDH 1	R227901	Inchovea	46.82	46.86	4cm	85	Phosphate (Zero)
78-1018	CDH 27	R223904	Inchovea	40.58	40.62	4cm	76	Phosphate (Zero)
78-1019	CDH 27	R223904	Inchovea	40.62	40.84	22cm	69	Shale
78-1020	CDH 27	R223904	Inchovea	40.84	40.89	5cm	134	Phosphate (Cahermacon)
78-1021	CDH 27	R223904	Inchovea	40.89	41.115	22.5cm	188	Shale, slightly phosphatic
78-1022	CDH 27	R223904	Inchovea	41.115	41.145	3cm	190	Phosphate
78-1033	CDH 27	R223904	Inchovea	41.145	41.35	20.5cm	89	Shale, minor phosphate
78-1082	DH 23	R172985	Cohy - Ballykeel	8.175	9.165	99cm	18	Shale, minimal phosphate
78-1083	DH 23	R172985	Cohy - Ballykeel	9.165	9.365	20cm	142	Phosphate (Cahermacon)
78-1084	DH 23	R172985	Cohy - Ballykeel	9.365	9.65	28.5cm	8	Calcarenite, phosphatic

Sample Number	Borehole Number	Grid Reference	Area	Depth (metres)		Interval Length	U(ppm)	Lithology
				From	to			
78-1077	DH 22	R177987	Cohy - Ballykeel	12.32	13.06	74cm	19	Shale
78-1078	DH 22	R177987	Cohy - Ballykeel	13.06	13.07	1cm	65	Phosphate (Zero)
78-1079	DH 22	R177987	Cohy - Ballykeel	13.07	13.15	8cm	30	Shale
78-1080	DH 22	R177987	Cohy - Ballykeel	13.15	13.255	10.5cm	161	Phosphate (Cahermacon)
78-1081	DH 22	R177987	Cohy - Ballykeel	13.255	13.433	18cm	7	Calcarenite
78-1094	CDH 14	R184986	Cohy - Ballykeel	18.86	18.965	10.5cm	29	Shale, phosphatic
78-1095	CDH 14	R184986	Cohy - Ballykeel	18.965	19.05	8.5cm	150	Phosphate
78-1096	CDH 14	R184986	Cohy - Ballykeel	19.05	19.265	21.5cm	20	Shale, pyritic
78-1097	CDH 14	R184986	Cohy - Ballykeel	19.265	19.315	5cm	135	Phosphate (Cahermacon)
78-1098	CDH 14	R184986	Cohy - Ballykeel	19.315	19.57	25.5cm	40	Shale with phosphatic nodules
78-1099	CDH 14	R184986	Cohy - Ballykeel	19.57	20.16	59cm	11	Calcarenite, phosphate grains
78-1085	DH 20	R200986	Cohy - Ballykeel	9.195	10.435	1.24m	15	Shales, phosphatic
78-1086	DH 20	R200986	Cohy - Ballykeel	10.435	10.445	1cm	213	Phosphate (Zero)
78-1087	DH 20	R200986	Cohy - Ballykeel	10.445	10.495	5cm	203	Phosphate (Cahermacon)
78-1088	DH 20	R200986	Cohy - Ballykeel	10.495	10.65	15.5cm	11	Calcarenite
77-0342	DH 17	R183978	Cohy - Ballykeel	15.25	16.14	89cm	20	Shale
77-0343	DH 17	R183978	Cohy - Ballykeel	16.14	16.18	4cm	160	Phosphate (Zero)
77-0344	DH 17	R183978	Cohy - Ballykeel	16.18	16.25	7cm	23	Shale
77-0345	DH 17	R183978	Cohy - Ballykeel	16.25	16.35	10cm	167)	Phosphate (Cahermacon)
77-0346	DH 17	R183978	Cohy - Ballykeel	16.35	16.45	10cm	146)	
77-0347	DH 17	R183978	Cohy - Ballykeel	16.45	16.55	10cm	138)	
77-0348	DH 17	R183978	Cohy - Ballykeel	16.55	16.65	10cm	138)	
77-0350A	DH 17	R183978	Cohy - Ballykeel	16.65	17.425	77.5cm	35	Shale, nodular and phosphatic
77-0351A	DH 17	R183978	Cohy - Ballykeel	17.425	17.62	19.5cm	35	Shale, nodular and phosphatic
77-0349	DH 17	R183978	Cohy - Ballykeel	17.62	18.04	42cm	9	Calcarenite
77-0362	CDH 3	R18529773	Cohy - Ballykeel	19.10	19.13	3cm	82	Phosphate, conglomeratic
77-0363	CDH 3	R18529773	Cohy - Ballykeel	19.83	19.85	2cm	217	Phosphate (Zero)

Sample Number	Borehole Number	Grid Reference	Area	Depth (metres)		Interval Length	U(ppm)	Lithology
				From	to			
77-0334	CDH 3	R18529773	Cohy - Ballykeel	19.97	20.08	11cm	150)	
77-0333	CDH 3	R18529773	Cohy - Ballykeel	20.08	20.18	10cm	162)	
77-0332	CDH 3	R18529773	Cohy - Ballykeel	20.18	20.28	10cm	169)	Phosphate
77-0331	CDH 3	R18529773	Cohy - Ballykeel	20.28	20.38	10cm	157)	(Cahermacon)
77-0330	CDH 3	R18529773	Cohy - Ballykeel	20.38	20.48	10cm	132)	Av. 157 ppm U.
77-0329	CDH 3	R18529773	Cohy - Ballykeel	20.48	20.58	10cm	144)	
77-0328	CDH 3	R18529773	Cohy - Ballykeel	20.58	20.68	10cm	188)	
77-0327	CDH 3	R18529773	Cohy - Ballykeel	20.68	20.94	26cm	168	Shale
77-0326	CDH 3	R18529773	Cohy - Ballykeel	20.94	21.30	36cm	101	Shale, phosphate nodules
77-0325	CDH 3	R18529773	Cohy - Ballykeel	21.30	21.625	32.5cm	33	Shale, phosphatic
77-0324	CDH 3	R18529773	Cohy - Ballykeel	21.625	22.025	40cm	30	Shale, phosphatic
77-0323	CDH 3	R18529773	Cohy - Ballykeel	22.025	22.48	45.5cm	30	Shale, phosphatic
77-0322	CDH 3	R18529773	Cohy - Ballykeel	22.48	22.55	7cm	69	Shale and limestone, phosphatic
77-0321	CDH 3	R18529773	Cohy - Ballykeel	22.55	23.04	49cm	8	Calcarenite
77-0320	CDH 3	R18529773	Cohy - Ballykeel	23.04	23.50	46cm	3	Calcarenite
77-0352	CDH 16	R18429731	Cohy - Ballykeel	23.175	23.245	7cm	192	Phosphate (Zero)
77-0353	CDH 16	R18429731	Cohy - Ballykeel	23.245	23.335	9cm	36	Shale, pyritic
77-0354	CDH 16	R18429731	Cohy - Ballykeel	23.335	23.43	9.5cm	161)	
77-0355	CDH 16	R18429731	Cohy - Ballykeel	23.43	23.53	10cm	145)	Phosphate (Cahermacon)
77-0356	CDH 16	R18429731	Cohy - Ballykeel	23.53	23.63	10cm	130)	Average 147 ppm U.
77-0357	CDH 16	R18429731	Cohy - Ballykeel	23.63	23.73	10cm	154)	
77-0358	CDH 16	R18429731	Cohy - Ballykeel	23.73	24.25	52cm	158	Mudstone and Shale; phosphate
77-0359	CDH 16	R18429731	Cohy - Ballykeel	24.25	25.075	82.5cm	53	Shale, phosphatic
77-0360	CDH 16	R18429731	Cohy - Ballykeel	25.075	25.925	85cm	39	Shale, phosphatic
77-0361	CDH 16	R18429731	Cohy - Ballykeel	25.925	26.48	56cm	4	Calcarenite

Sample Number	Borehole Number	Grid Reference	Area	Depth (metres) From to		Interval Length	U(ppm)	Lithology
77-0335	CDH 18	R17809653	Cohy - Ballykeel	45.16	45.26	10cm	173)	
77-0336	CDH 18	R17809653	Cohy - Ballykeel	45.26	45.36	10cm	198)	
77-0337	CDH 18	R17809653	Cohy - Ballykeel	45.36	45.46	10cm	173)	Phosphate (Cahermacon) Average 164 ppm U.
77-0338	CDH 18	R17809653	Cohy - Ballykeel	45.46	45.56	10cm	143)	
77-0339	CDH 18	R17809653	Cohy - Ballykeel	45.56	45.66	10cm	141)	
77-0340	CDH 18	R17809653	Cohy - Ballykeel	45.66	45.76	10cm	156)	
77-0341	CDH 18	R17809653	Cohy - Ballykeel	45.76	45.81	5cm	249	
78-1100	CDH 20	R170967	Cohy - Ballykeel	43.62	44.08	46cm	12	Shale, minor phosphate
78-1101	CDH 20	R170967	Cohy - Ballykeel	44.08	44.14	6cm	172	Phosphate (Zero)
78-1102	CDH 20	R170967	Cohy - Ballykeel	44.14	44.155	1.5cm	34	Mudstone
78-1103	CDH 20	R170967	Cohy - Ballykeel	44.155	44.205	5cm	203	Phosphate (Cahermacon)
78-1104	CDH 20	R170967	Cohy - Ballykeel	44.205	44.495	29cm	86	Shale, phosphatic
78-1105	CDH 20	R170967	Cohy - Ballykeel	44.495	45.51	1.5cm	57	Phosphate
78-1106	CDH 20	R170967	Cohy - Ballykeel	45.51	45.82	31cm	29	Shale
78-1089	DH 16	R201959	Cohy - Ballykeel	12.31	12.79	48cm	33	Shales, minor phosphate
78-1090	DH 16	R201959	Cohy - Ballykeel	12.79	13.31	52cm	53	Shale
78-1091	DH 16	R201959	Cohy - Ballykeel	13.31	13.81	50cm	154	Phosphate (Cahermacon)
78-1092	DH 16	R201959	Cohy - Ballykeel	13.81	15.53	72cm	28	Shales, phosphatic
78-1093	DH 16	R201959	Cohy - Ballykeel	15.53	15.78	25cm	12	Calcarenite

RESULTS OF EPITHERMAL NEUTRON ANALYSIS FOR URANIUM, THORIUM, AND POTASSIUM

Sample Number*	Borehole Number	Grid Reference	Area	Depth(metres) from to	Interval Length	U(ppm)	Th(ppm)	K(%)	Lithology
78-1002	CDH 4	R128925	Kilshanny	50.82 50.98	16cm	342±20	6.8±1.5	0.223± 0.028	Phosphate (Zero and Cahermacon) Shale
78-1003	CDH 4	R128925	Kilshanny	50.98 52.00	1.02m	73.7±2.5	8.1±0.5	1.80 ± 0.08	
78-1115	DH 27	R087972	Doolin	10.565 11.405	84cm	141±5	9.6±0.9	2.88 ± 0.10	Phosphate and phosphatic shales
78-1113	CDH 1	R227901	Inchovea	35.05 46.82	11.77m	29.3±1.4	14.5±0.5	2.69 ± 0.10	Shale
78-1017	CDH 1	R227901	Inchovea	46.82 46.86	4cm	153 ± 8	4.6±1.2	0.672±0.033	Phosphate (Zero)
78-1018	CDH 27	R223904	Inchovea	40.58 40.62	4cm	136 ± 6	6.9±1.1	0.947±0.04	Phosphate (Zero)
78-1019	CDH 27	R223904	Inchovea	40.62 40.84	22cm	116 ± 5	15.0±0.7	2.79 ±0.10	Shale
78-1020	CDH 27	R223904	Inchovea	40.84 40.89	5cm	227 ± 11	7.2±1.2	0.913±0.04	Phosphate (Cahermacon)
78-1114	CDH 27	R223904	Inchovea	40.89 41.35	46cm	246 ± 12	9.4±0.8	1.89±0.08	Shale, phosphatic
77-0342	DH 17	R183978	Cohy-Ballykeel	15.25 16.14	89cm	34.7± 1.4	15.1±2.0	3.45±0.10	Shale
77-0343	DH 17	R183978	Cohy-Ballykeel	16.14 16.18	4cm	299 ± 19	15.0±2.0	1.54±0.06	Phosphate (Zero)
77-0344	DH 17	R183978	Cohy-Ballykeel	16.18 16.25	7cm	38.0± 2.0	15.8±0.8	3.60±0.12	Shale
78-1111	DH 17	R183978	Cohy-Ballykeel	16.25 16.65	40cm	254 ± 10	6.1±1.2	0.18±0.024	Phosphate (Cahermacon)
78-1112	DH 17	R183978	Cohy-Ballykeel	16.65 17.62	97cm	62.8± 2.5	7.3±0.4	1.64±0.06	Shale
77-0349	DH 17	R183978	Cohy-Ballykeel	17.62 18.04	42cm	14.1± 0.6	1.8±0.2	0.136±0.022	Calcarenite

*Samples 78-1111 to 78-1115 are composite.