

ΟΡΥΚΤΟΛΟΓΙΑ.— **Geochemistry of bottom sediments from the Kalloni gulf (Lesbos Island, Greece), by A. E. Kelepertsis** *.

Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Λουκᾶ Μούσουλου.

A B S T R A C T

Analysis of mineralogy and chemistry of bottom sediments in Kalloni gulf, Lesbos island, has shown :

1. Sediment texture is related to water depth,
2. concentrations of major elements are related to clay, organic, C, CaCO_3 , quartz, and feldspars of sediments,
3. concentrations of trace elements are related to clay since the detrital fraction contribution to bulk sediment is always greater than the non-detrital fraction contribution,
4. anomalous Cr and Ni concentrations in the sediments are related to the presence of ultrabasic rocks with Cr deposits at the area near Vasilika.

I N T R O D U C T I O N

This is an investigation of bottom sediments in the Kalloni gulf. The investigation was concerned with the geochemistry of the sediments. Samples were collected along four sections, shown on figure 1.

In general, gravelly sediment occurs on the shore, muddy sediment is confined to the basin, and sandy sediment occurs in patches along the shore and accross the mouth of inlets.

Silicate minerals are derived from lithologies comprising the areas adjacent to the Kalloni gulf. Organic matter is probably the remains of terrestrial and or marine plants and animals.

Fragments of molluscs, and echinoderm shells and foraminifera tests, probably are the source of CaCO_3 .

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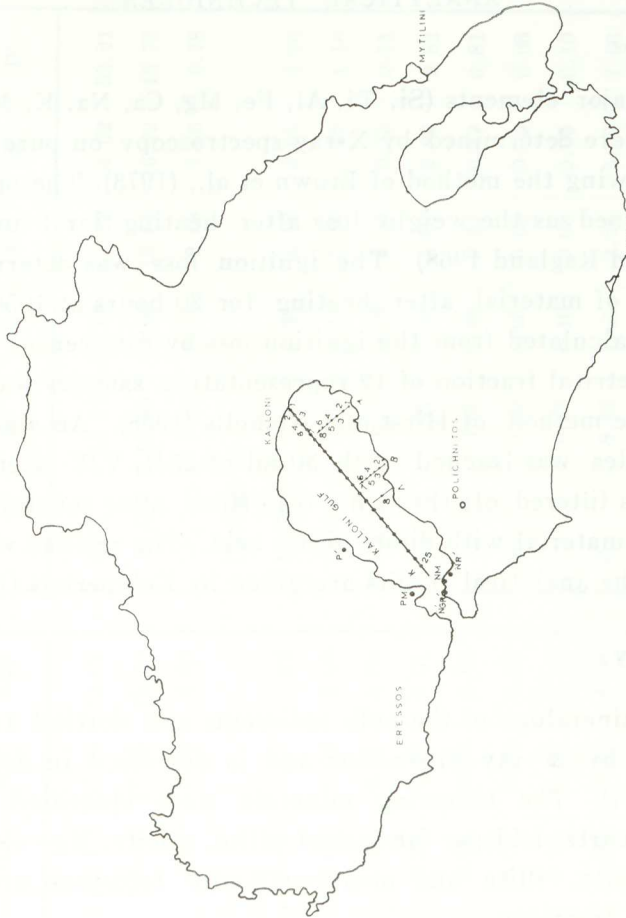
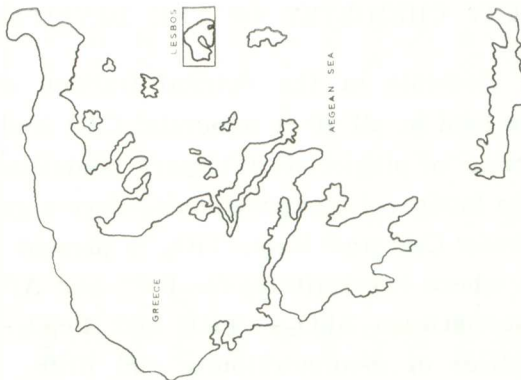


Fig. 1.



ANALYTICAL TECHNIQUES

Chemistry.

The major elements (Si, Ti, Al, Fe, Mg, Ca, Na, K, Mn, P) of the sediments were determined by X-ray spectroscopy on pure rock powder pellets following the method of Brown et al., (1973). The organic matter was determined as the weight loss after heating for 1 hour at 350°C. (Billings and Ragland 1968). The ignition loss was determined as the weight loss of material after heating for 20 hours at 1050°C. Mineral water was calculated from the ignition loss by difference.

The detrital fraction of 12 representative samples was determined by using the method of Hirst and Nicholls (1958). An amount of 3 grs of the samples was leached with 30 ml of 25% V/V acetic acid. The solution was filtered off through a 0.45 filter after several washings of the detrital material with dilute acetic acid. The residue was dried and weighed. The analytical results are given by Kelepertsis (1977).

Mineralogy.

The mineralogy of the bulk sediments and detrital fractions was determined by X-ray diffraction and is described in detail by Kelepertsis (1977). The following minerals were identified in the bulk samples: quartz, feldspar (andesine), illite, calcite, Mg-calcite, and aragonite. Quartz, illite and montmorillonite feldspars are present in the detrital fractions.

MAJOR ELEMENT CHEMISTRY OF THE DETRITAL FRACTIONS

The major elements in the detrital fraction are presented in Table 1. K₂O is held in all 10 Å minerals. CaO and Na₂O are both present in the lattice of plagioclase feldspars (andesine). Some CaO is also present in the lattice of montmorillonite since a geochemical correlation exists between CaO and MgO. TiO₂ is present in the lattice of all clay minerals where it substitutes for Fe³⁺ and Al³⁺. (Geochemical correlations exist between Al₂O₃ — TiO₂ and Fe₂O₃ — TiO₂). MgO is present in the lattice of montmorillonite and illite. The distribution of MnO resembles that of MgO and Fe₂O₃.

T A B L E 1

Chemical analyses of the detrital fractions (in % by weight).

	K1	K2	K7	K11	K13	K14	K25
SiO ₂	61.02	55.42	56.14	54.26	55.48	53.70	55.63
Al ₂ O ₃	15.40	14.89	16.22	16.21	16.09	15.93	15.59
Fe ₂ O ₃	4.75	6.72	6.93	7.05	7.10	7.09	6.60
(Total)							
MgO	3.31	3.34	3.37	3.55	3.52	3.52	3.32
CaO	2.60	1.72	1.12	1.01	1.02	1.04	1.50
Na ₂ O	2.18	0.89	0.84	0.73	0.78	0.71	0.98
K ₂ O	3.37	2.69	3.04	2.94	2.89	2.80	3.01
TiO ₂	0.73	0.83	0.85	0.82	0.84	0.82	0.84
MnO	0.08	0.08	0.08	0.09	0.08	0.08	0.08
P ₂ O ₅	0.09	0.10	0.11	0.10	0.10	0.09	0.12
C	2.18	5.43	4.30	4.97	5.00	6.27	4.08
H ₂ O	3.41	7.08	6.52	7.80	7.02	7.30	8.35

	A5	A8	B1	B6	B9
SiO ₂	53.77	54.68	67.22	54.02	53.21
Al ₂ O ₃	15.69	15.96	12.87	16.22	15.73
Fe ₂ O ₃	7.08	6.83	2.69	7.06	6.78
(Total)					
MgO	3.55	3.31	2.18	3.65	3.30
CaO	1.14	1.14	1.58	1.22	1.16
Na ₂ O	0.77	0.82	2.56	0.75	0.74
K ₂ O	2.77	2.98	4.63	2.86	2.82
TiO ₂	0.80	0.83	0.47	0.79	0.81
MnO	0.09	0.08	0.08	0.09	0.08
P ₂ O ₅	0.09	0.10	0.08	0.09	0.10
C	8.46	7.65	2.26	5.32	7.66
H ₂ O	5.32	5.23	3.15	7.81	6.94
Total	99.53	99.61	99.77	99.88	99.33

TRACE ELEMENT CHEMISTRY OF THE TOTAL ROCKS

Table 2 shows trace element associations in the sediments under study. The trace element chemistry of the bottom sediments of the Kalloni gulf has been investigated in terms of detrital and non-detrital trace element contents. The following elements were determined: V, Nd, Ce, Cr, Ni, Cu, Zn, Rb, Ba, Sc, Sr, Y, Zr, La, Nb.

From table 2 it is obvious that in the sediments analysed all trace elements are detrital in origin since the contribution of the detrital fraction element contents to the whole rock is greater than the non-detrital contribution. The distribution of trace elements between detrital and non-detrital phases indicates the terrigenous nature of sedimentation in the Kalloni gulf.

Trace cations leached during the 25% V/V acetic acid treatments (Hirst and Nicholls 1958) of the samples are derived from any or all of the following sites:

- 1) substituting for Ca in the carbonate lattice;
- 2) entrapped within lattice imperfection or as inclusions in the carbonate minerals;
- 3) absorbed on the surfaces of any of the minerals, particularly the clay minerals;
- 4) within lattice sites in the clay minerals;
- 5) from unidentified organic or amorphous material; and
- 6) possibly in some pure phases that are below detection by the X-ray diffraction method.

Table 2 shows that the calcium carbonate grains are absorbing significant amounts of Cr, Ni, which are much higher than the Cr, Ni, contents of pure carbonate rocks given by Turekian and Wedepohl 1961. No experimental evidence is known to test this hypothesis for the elements. The possibility of increased adsorption by the fine-grained carbonate exists. Chave (1965) has suggested that carbonate grains are rapidly coated by organic material from sea water. This organic material may adsorb cations from sea water. The cations would be then released by acid treatment. Clay minerals are capable of adsorbing large quantities of trace elements on cation exchange sites, but trace elements are

T A B L E 2

(Data in ppm by wt) - Trace element contents of the detrital, carbonate fraction and the total rocks.

	K ₁				K ₂				K ₇			
	A*	B*	C*	D*	A	B	C	D	A	B	C	D
V	87	81.77	85	0.0	122	102	120	18	131	116.38	125	8.62
Nd	24	22.56	43	20.44	22	18.39	32	13.61	37	32.87	46	13.13
Ce	431	405.09	105	0.0	395	330.3	427	0.0	420	406.61	433	26.39
Cr	2047	1923.98	2049	125.02	607	507.5	678	170.5	366	325.15	426	100.9
Ni	182	171.06	231	59.94	236	197.32	248	50.68	218	193.67	224	30.33
Cu	37	34.78	38	3.22	43	35.95	46	10.05	43	38.2	44	5.8
Zn	65	61.09	58	0.0	100	83.61	97	13.39	104	92.39	90	0.0
Rb	143	134.41	136	1.59	159	132.9	137	4.1	178	158.14	163	4.9
Ba	1992	1872.3	1940	67.7	1010	844.5	928	83.5	1084	963.03	1012	49
Sc	10	9.4	10	0.6	16	13.38	29	15.62	20	17.77	26	8.2
Sr	702	659.81	694	334.19	361	301.8	666	364.2	335	297.6	427	129
Y	17	15.98	23	7.02	25	20.9	26	5.1	21	18.66	24	5.34
Zr	312	293.25	281	0.0	285	238.3	228	0.0	257	228.32	218	0.0
La	66	62.03	65	2.97	60	50.17	56	5.83	60	53.3	75	21.7
Nb	21	19.74	21	1.26	30	25.08	30	4.92	26	23.1	27	3.9

A* = Absolute detrital trace element contents

B* = Contribution of the detrital fraction trace element contents to the total rock

C* = Total trace element contents

D* = Soluble fraction trace element contents (by difference).

Table 2 (continued)

	K11				K13				K25			
	A	B	C	D	A	B	C	D	A	B	C	D
V	442	424.48	423	0.0	439	419.08	423	3.92	422	403.43	421	17.57
Nd	32	27.98	43	15.02	37	31.7	50	18.3	37	31.37	40	8.63
Ce	424	408.44	421	42.56	427	408.8	433	24.2	423	404.28	407	2.72
Cr	385	336.68	446	109.32	420	359.81	477	147.19	471	399.3	546	146.69
Ni	244	213.38	245	31.62	247	211.6	255	43.4	200	169.56	241	41.44
Cu	43	37.6	44	6.4	43	36.84	43	6.46	42	35.61	47	11.39
Zn	410	96.2	87	0.0	414	97.66	400	2.34	89	75.45	77	1.55
Rb	479	456.54	460	3.46	474	449.07	459	9.93	465	439.89	452	12.11
Ba	998	872.75	895	22.25	998	854.99	898	43.01	4480	4000.4	4443	112.6
Sc	17	14.87	23	8.13	15	12.85	22	9.45	15	12.72	27	14.28
Sr	300	262.35	390	427.65	292	250.46	395	144.84	391	331.49	601	269.51
Y	26	22.74	23	0.26	27	23.43	28	4.87	25	21.2	26	4.8
Zr	256	223.87	240	0.0	260	222.74	220	0.0	271	229.75	224	0.0
La	67	58.59	57	0.0	57	48.83	78	29.17	51	43.24	64	20.76
Nb	28	24.49	26	1.51	29	24.84	26	1.46	25	21.2	27	5.8

Table 2 (continued)

	B1				B6				B7			
	A	B	C	D	A	B	C	D	A	B	C	D
V	56	46.02	55	8.98	437	442.07	423	10.93	145	115.83	127	10.17
Nd	36	29.58	33	3.42	32	26.18	45	18.82	30	23.96	38	14.04
Ce	124	101.9	97	0.0	126	103.07	110	6.93	109	87.07	105	17.93
Cr	546	448.7	626	177.3	418	341.92	446	104.08	403	321.92	477	155.08
Ni	111	91.22	139	47.78	245	200.4	238	37.59	233	186.12	229	42.88
Cu	30	24.65	36	11.35	42	34.36	46	11.64	42	33.55	46	12.45
Zn	32	26.3	33	6.7	112	91.60	96	4.38	116	92.66	103	10.34
Rb	146	119.98	136	16.02	172	140.7	156	15.3	173	138.19	153	14.81
Ba	1263	1037.9	1253	215	994	772.2	858	85.81	1006	803.59	926	122.41
Sc	3	2.47	14	11.53	19	15.54	28	12.46	21	16.77	21	4.23
Sr	391	321.32	639	317.68	296	242.13	505	262.87	313	250.02	530	279.98
Y	23	18.9	30	11.1	25	20.25	25	4.55	24	19.17	26	6.83
Zr	307	252.3	266	13.71	251	205.3	206	0.68	254	202.9	204	1.1
La	72	59.2	83	23.83	52	42.54	76	33.46	54	43.14	67	23.86
Nb	21	17.26	20	2.74	26	21.27	26	4.73	30	23.96	28	4.04

Table 2 (continued)

	A5				A8				K14			
	A	B	C	D	A	B	C	D	A	B	C	D
V	127	400.55	149	18.45	133	109.6	120	10.44	139	119.47	146	26.53
Nd	33	26.13	38	11.87	38	31.31	42	10.69	121	103.99	124	20.01
Ce	132	104.5	109	4.5	133	109.6	105	0.0	34	29.22	36	6.78
Cr	468	370.52	510	139.48	396	326.3	447	120.7	416	357.6	457	99.45
Ni	278	220.09	274	53.91	229	188.7	321	42.3	247	212.3	257	44.7
Cu	44	34.83	44	9.17	43	35.4	45	9.57	43	36.66	42	5.04
Zn	111	87.88	88	0.12	101	83.22	76	0.0	109	93.69	109	15.31
Rb	172	136.17	147	10.83	175	144.2	152	7.8	175	150.4	159	8.6
Ba	991	784.6	858	73.43	1095	902.3	914	11.7	974	837.15	865	27.85
Sc	20	15.83	29	13.17	20	16.48	15	0.0	19	16.33	22	5.67
Sr	298	235.93	518	282.07	330	271.9	451	179.1	292	250.97	410	159.03
Y	24	19	24	5.0	23	18.95	25	6.05	24	20.63	28	7.37
Zr	258	204.26	193	0.0	262	215.9	208	0.0	258	221.75	231	9.25
La	65	51.46	53	1.54	58	47.8	74	26.2	55	47.27	63	15.73
Nb	27	21.38	25	3.62	28	23.07	25	1.93	30	25.79	29	3.21

more readily adsorbed by organic matter due to the higher cation exchange capacity of organic matter. (Schnitzer 1965; Grim 1968).

The Sr content in the non-detrital fraction is consistent with the presence of biogenic and carbonate debris. The Sr content in the detrital fraction appears to be determined by the distribution of illite. (A correlation exists between detrital Sr contents and K_2O contents).

The contents of Ni and Cr in the detrital fraction are much higher than the Cr, Ni contents of sediments, reported in the literature by many other workers (Turekian and Wedepohl, 1961).

This is due to the presence of detrital chromite grains and Ni bearing minerals. It is known that chromite ores associated with

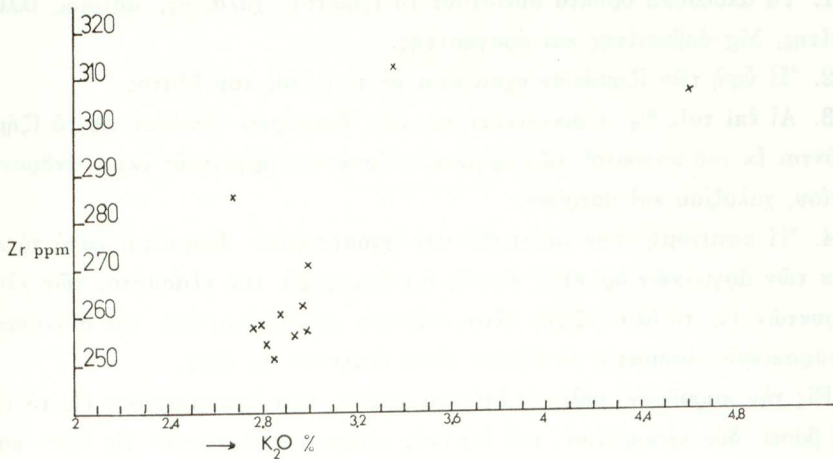


Fig. 2.

ultrabasic rocks (peridotites) are present in the surrounding area. (Hecht 1972). Basic and ultrabasic rocks are the most rich in Ni and Cr rocks, since these elements are precipitated during the early stages of magma crystallization with olivine.

Zr is almost entirely detrital in origin, since for 8 samples the soluble fraction contribution is zero. Figure 2 shows that clay minerals (mica, illite) are not the only factor controlling the distribution of Zr in the detrital fraction. Detrital zircon grains may also be present.

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Π Ε Ρ Ι Λ Η Ψ Ι Σ

Εἰς τὴν παροῦσαν ἐργασίαν μελετᾶται ἡ ὀρυκτολογικὴ σύστασις καὶ ἡ γεωχημεία ἰζημάτων ἐκ τοῦ πυθμένος τῆς θαλάσσης τοῦ κόλπου Καλλονῆς τῆς νήσου Λέσβου. Τὰ ἀποτελέσματα τῆς παρουσίας μελέτης εἶναι τὰ κάτωθι :

1. Τὰ ἀκόλουθα ὀρυκτὰ συνιστοῦν τὰ ἰζήματα : χαλαζίας, ἄστριοι, ἰλλίτης, ἄσβεστίτης, Mg-ἄσβεστίτης καὶ ἄραγωνίτης.

2. Ἡ ὑφὴ τῶν ἰζημάτων σχετίζεται μὲ τὸ βάθος τοῦ ὕδατος.

3. Αἱ ἐπὶ τοῖς % περιεκτικότητες τῶν διαφόρων ὀξειδίων εἰς τὰ ἰζήματα ἐξαρτῶνται ἐκ τοῦ ποσοστοῦ τῶν ἀργιλικῶν ὀρυκτῶν, ὀργανικῆς ὕλης, ἀνθρακικοῦ ἄσβεστιοῦ, χαλαζίου καὶ ἀστρίων.

4. Ἡ κατανομὴ τῶν μελετηθέντων ἰχνοστοιχείων ἐξαρτᾶται κατὰ τὸ πλεῖστον ἐκ τῶν ἀργιλικῶν ὀρυκτῶν ἐπειδὴ ἡ συνεισφορὰ τοῦ κλάσματος τῶν κλαστικῶν ὀρυκτῶν εἰς τὸ ὅλον ἰζήμα εἶναι πάντοτε μεγαλύτερη ἀπὸ τὴν συνεισφορὰν τοῦ ἀνθρακικοῦ κλάσματος τὸ ὁποῖον εἶναι διαλυτὸν εἰς ὄξεα.

Εἰς τὴν παροῦσαν μελέτην ἐγένετο μελέτη τῶν ἰχνοστοιχείων εἰς τὸ ἴζημα ἐπὶ τῇ βάσει δύο κλασμάτων τοῦ (α) ἐνὸς κλάσματος διαλυτοῦ εἰς ὄξεα καλουμένου ἀνθρακικοῦ καὶ (β) ἐνὸς κλάσματος μὴ διαλυτοῦ εἰς ὄξεα καλουμένου κλαστικοῦ.

5. Αἱ ἀνώμαλοι τιμαὶ Cr καὶ Ni εἰς τὰ ἰζήματα σχετίζονται μὲ τὴν παρουσίαν ὑπερβασικῶν πετρωμάτων εἰς τὴν περιοχὴν Βασιλικῶν.

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