Canadian Mineralogist
Vol. 22, pp. 443-446 (1984)

JEFFREYITE, $(Ca,Na)_2(Be,Al)Si_2(O,OH)_7$, A NEW MINERAL SPECIES AND ITS RELATION TO THE MELILITE GROUP

JOEL D. GRICE AND GEORGE W. ROBINSON

Mineral Sciences Division, National Museum of Natural Sciences, Ottawa, Ontario K1A 0M8

ABSTRACT

Jeffreyite, a new species from the Jeffrey mine, Quebec, occurs as small micaceous aggregates associated with grossular in a rodingitized granite dyke. It forms clear, colorless, pseudotetragonal plates up to 1.2 × 1.2 × 0.02 mm. The forms include the pinacoid {001}and a prism, {110}. The mineral is brittle, with perfect {001} and {110} cleavages. Hardness 5. Density (g/cm^3) is 2.99(2) (meas.) and 2.98 (calc.). Its crystals are optically biaxial negative, α 1.625(2), β 1.641(2), γ 1.643(2); $2V_x$ (meas.) 40(2)°, $2V_x$ (calc.) 39°; the orientation of the indicatrix is $X \| c$ and $Y \| a$. It is orthorhombic, with space group $C222_1$, a 14.90(1), b 14.90(1), c 40.41(8) Å and Z = 64. The strongest X-ray powder-diffraction lines [d in Å (I)(hkl)] are: 10.13(20)(004), 5.21(30)(220), 5.00(40)(008,026), 3.62(30)(228), 2.993(90)(408), 2.774(100)(428), 2.541(70)(00.16,444), 2.360(40)(620), 2.323(30)(448), 2.229(40)(608), 1.866(40)(800) and 1.755(50)(660). Electron-microprobe analyses gave SiO_2 46.7, Al_2O_3 2.8, CaO 37.4, and Na_2O 2.3. Atomic-absorption analysis gave BeO 8.1 and TGA gave H_2O 1.8 (total 99.1). This yields $(Ca_{1.69}Na_{0.19})_{\Sigma 1.88}(Be_{0.82}Al_{0.14})_{\Sigma 0.96}Si_{1.97}(O_{6.49}OH_{0.51})_{\Sigma 7}$ or, ideally, $(Ca,Na)_2(Be,Al)Si_2(O,OH)_7$. The name refers to the type locality.

Keywords: jeffreyite, new mineral species, calcium–beryllium silicate, rodingite, Jeffrey mine, Quebec.

SOMMAIRE

La jeffreyite, nouvelle espèce minérale provenant de la mine Jeffrey, au Québec, se présente en petits agrégats micacés associés au grossulaire dans un dyke de granite rodingitisé. Elle forme des plaquettes pseudotétragonales transparentes, incolores, pouvant atteindre 1.2 × 1.2 × 0.02 mm, qui comprennent deux formes: le pinacoïde {001}et un prisme, {110}. Elle est cassante et présente les clivages parfaits {001} et {110}; sa dureté est de 5. Sa densité est de 2.99(2) (mes.) et 2.98 (calc.). Ses cristaux sont optiquement biaxes négatifs, α 1.625(2), β 1.641(2), γ 1.643(2); $2V_x$(mes.) 40(2)°, $2V_x$ (calc.) 39°; l'orientation de l'ellipsoïde est $X \| c$ et $Y \| a$. La jeffreyite est orthorhombique, groupe spatial $C222_1$, avec a 14.90(1), b 14.90(1), c 40.41(8) Å et Z = 64. Les raies de diffraction des rayons X les plus intenses [d en Å, (I)(hkl)] sont: 10.13(20)(004), 5.21(30)(220), 5.00(40)(008,026), 3.62(30)(228), 2.993(90)(408), 2.774(100)(428), 2.541(70)(00.16,444), 2.360(40)(620), 2.323(30)(448), 2.229(40)(608), 1.866(40)(800) et 1.755(50)(660). Les analyses à la microsonde électronique ont donné SiO_2 46.7, Al_2O_3 2.8, CaO 37.4, et Na_2O 2.3. L'analyse par absorption atomique a donné BeO 8.1 et ATG a donné H_2O 1.8 (total 99.1). On en tire $(Ca_{1.69}Na_{0.19})_{\Sigma 1.88}(Be_{0.82}Al_{0.14})_{\Sigma 0.96}Si_{1.97}(O_{6.49}OH_{0.51})_{\Sigma 7}$ ou, idéalement, $(Ca,Na)_2(Be,Al)Si_2(O,OH)_7$. Le nom correspond à la localité type.

Mots-clés: jeffreyite, nouvelle espèce minérale, silicate de calcium et de béryllium, rodingite, mine Jeffrey, Québec.

INTRODUCTION

The Jeffrey mine, located at Asbestos, Shipton Township, Richmond County, Quebec, is the second largest asbestos deposit in the world (after Asbest, U.S.S.R.). Over sixty species have been identified from this locality, many of which are described by Grice & Williams (1979). This is the second new species to be described. Both jeffreyite and spertiniite (Grice & Gasparrini 1981) were submitted as unknowns by Mr. F. Spertini, Chief Geologist at the Jeffrey mine, Johns-Manville Canada Incorporated, to one of the authors (J.D.G.).

Jeffreyite is named for the Jeffrey mine, the type locality. Both the name and data have been approved by the International Mineralogical Association Commission on New Minerals and Mineral Names. The type material consists of a few milligrams of material preserved at the National Museum of Natural Sciences, Ottawa (NMNS #48740).

OCCURRENCE

Jeffreyite is a very rare mineral, found in a cavity in a rodingitized granite dyke exposed in the Jeffrey open pit. These dykes have undergone extensive calcium metasomatism, resulting in a large number of calcium silicates such as diopside, grossular, vesuvianite, pectolite, prehnite, wollastonite, zoisite and now the recently discovered jeffreyite. Wares & Martin (1980) gave details of the petrology of these dykes.

The few jeffreyite crystals found are associated with clear, colorless grossular. Although only a small amount of this mineral has been found to date, it could easily be overlooked or mistaken for a mica. Hence it may be more common than presently represented.

FIG. 1. Platy crystals of jeffreyite associated with a light-colored grossular crystal. The width of field of view is 5 mm.

PHYSICAL AND OPTICAL PROPERTIES

Jeffreyite occurs as thin pseudotetragonal plates up to 1.2×1.2×0.02 mm, almost micaceous in appearance (Fig. 1). It is brittle, with perfect {001} and {110} cleavages and hardness approximately 5. Jeffreyite is clear and colorless but the crystals, as originally found, have a brownish cast due to a fungal coating that can be removed by washing for 20 minutes in a PLASMOD radio-frequency-induced oxygen-plasma generator. Jeffreyite does not fluoresce in ultraviolet radiation, and it is not readily soluble in 20% HCl.

To determine the density, three different grains were suspended in a methylene iodide – methyl alcohol solution at 21°C; the density of the matching solution was measured in a 2-cm^3 pycnometer. The resulting measured density, 2.99(2) g/cm^3, compares well with the calculated density, 2.98 g/cm^3.

TABLE 1. THE NOMENCLATURE OF MELILITE-GROUP MINERALS

SPECIES NAME	IDEAL CHEMICAL FORMULA	SPACE GROUP	UNIT CELL a, b	c	Z
åkermanite	$Ca_2MgSi_2O_7$	$P\bar{4}2_1m$	7.84	5.01	2
gehlenite	$Ca_2Al(AlSi)O_7$	$P\bar{4}2_1m$	7.71	5.11	2
hardystonite	$Ca_2ZnSi_2O_7$	$P\bar{4}2_1m$	7.85	5.00	2
gugiaite	$Ca_2BeSi_2O_7$	$P\bar{4}2_1m$	7.48	5.04	2
jeffreyite	$(Ca,Na)_2(Be,Al)Si_2(O,OH)_7$	$C222_1$	14.9	40.4	64
meliphanite	$CaNaBeSi_2O_6F$	$I\bar{4}$	10.6	9.90	8
leucophanite	$CaNaBeSi_2O_6F$	$P2_12_12_1$	7.39	9.98	4

TABLE 2. COMPARISON OF JEFFREYITE, GUGIAITE, MELIPHANITE AND LEUCOPHANITE POWDER PATTERNS

JEFFREYITE[1]				GUGIAITE[2]			MELIPHANITE[3]			LEUCOPHANITE[4]		
hkl	*d*calc	*d*obs	*I*	*hkl*	*d*obs	*I*	*hkl*	*d*obs	*I*	*hkl*	*d*obs	*I*
004	10.10	10.13	2	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	110?	7.91	1	-	-	-
220	5.27	5.21	3	110	5.25	4	020	5.25	1	011	5.95	2
008	5.05	5.00	4	001	5.04	2	002	4.94	1	002	4.99	1
026	5.00			-	-	-	-	-	-	-	-	-
310	4.71	4.70	1	-	-	-	-	-	-	111	4.64	2
118	4.55	4.47	½	-	-	-	-	-	-	-	-	-
314	4.27	4.26	½	-	-	-	121	4.24	2	-	-	-
226	4.15	4.14	1	-	-	-	112	4.10	1	012	4.13	1
400	3.73	3.75	½	200	3.70	3	-	-	-	-	-	-
228	3.65	3.62	3	111	3.61	3	202	3.59	4	112	3.60	5
404	3.50	3.50	½	-	-	-	-	-	-	-	-	-
420	3.33	3.33	1	210	3.31	2	130 / 031	3.32	1	120	3.31	1
-	-	-	-	-	-	-	-	-	-	121	3.14	2
-	-	-	-	-	-	-	-	-	-	-	-	-
20.12	3.07	3.09	½	-	-	-	-	-	-	-	-	-
408	2.998	2.993	9	201	2.970	4	222	2.96	5	022	2.97	5
510	2.922	2.905	1	-	-	-	-	-	-	-	-	-
22.12	2.838	2.838	2	-	-	-	023	2.79	-	-	-	-
-	-	-	-	-	-	-	231		-	-	-	-
428	2.781	2.774	10	211	2.765	10	132	2.75	10	122	2.75	10
02.14	2.692	2.720	1	-	-	-	123	2.70	1	-	-	-
440	2.634	2.633	2	-	-	-	040	2.63	2	220	2.61	2
350	2.556	2.576	2	-	-	-	-	-	-	-	-	-
444	2.549	2.541	6	002	2.518	2	-	-	-	-	-	-
00.16	2.526			002	2.518	2	004	2.47	-	004	2.49	1
-	-	-	-	-	-	-	223		-	023	2.47	1
620	2.356	2.360	4	310	2.359	4	-	-	-	031	2.39	1
-	-	-	-	-	-	-	133	2.346	4	014	2.36	1
448	2.336	2.323	3	221	2.341	3	114	2.342	4	123	2.34	2
22.16	2.278	2.272	½	112	2.315	4	241	2.316	4	310	2.31	4
-	-	-	-	-	-	-	-	-	-	222	2.28	1
-	-	-	-	-	-	-	-	-	-	131	2.27	1
-	-	-	-	-	-	-	-	-	-	-	-	-
608	2.229	2.229	4	301	2.242	3	024	2.232	1	-	-	-
-	-	-	-	-	-	-	332 / 233	2.212	2	114	2.21	2
-	-	-	-	-	-	-	-	-	-	032	2.20	4
628	2.135	2.143	1	311	2.208	4	-	-	-	132 / 024	2.10	1
40.16	2.091	2.115	½	320	2.115	3	-	-	-			
640	2.066	2.051	1	202	2.066	3	-	-	-	-	-	-
42.16	2.013	2.020	2	-	-	-	-	-	-	-	-	-
60.12	2.000	2.001	2	212	1.990	4	-	1.978	4	-	1.98	4
648	1.913	1.906	½	321	1.900	1	-	1.909	1	-	-	-
800	1.863	1.866	4	400	1.851	2	-	1.845	3	-	1.83	2
820	1.807	1.809	2	220	1.794	1	-	1.804	3	-	-	-
660	1.756	1.755	5	302	1.747	2	-	1.753	3	-	1.73	2
62.16	1.723	1.716	2	-	-	-	-	-	-	-	-	-
828	1.701	1.704	1	411	1.709	7	-	1.702	5	-	-	-
840	1.666	1.666	2	003	1.695	4	-	-	-	-	1.69	5
80.12	1.630	1.631	2	-	-	-	-	-	-	-	-	-
-	-	1.593	½	322	1.580	1	-	-	-	-	-	-
-	-	1.560	½	-	-	-	-	-	-	-	1.57	2
40.24	1.535	1.535	1	-	-	-	-	-	-	-	-	-
-	-	1.511	1	-	-	-	-	-	-	-	-	-
84.12	1.493	1.493	-	402	1.485	7	-	-	-	-	-	-
684	1.474	1.473	½	-	-	-	-	1.473	1	-	1.47	2
-	-	1.453	½	-	-	-	-	-	-	-	-	-
-	-	1.435	2	322	1.431	1	-	-	-	-	-	-
-	-	1.417	1	223	1.420	2	-	-	-	-	-	-
-	-	1.385	½	442	1.376	2	-	1.395	2	-	-	-
-	-	1.364	½	-	-	-	-	-	-	-	-	-
10.48	1.334	1.335	3	521	1.327	1	-	1.334	1	-	-	-
880	1.317	1.318	2	440	1.311	1	-	1.315	1	-	1.32	3
-	-	1.290	1	-	-	-	-	-	-	-	-	-
-	-	1.255	½	004	1.256	2	-	-	-	-	-	-
-	-	1.244	2	-	-	-	-	-	-	-	-	-
-	-	1.225	½	104	1.220	2	-	1.216	1	-	-	-
-	-	1.209	½	-	-	-	-	-	-	-	-	-
-	-	1.147	½	-	-	-	-	1.144	1	-	-	-
-	-	1.135	½	541	1.128	2	-	1.133	1	-	-	-
-	-	1.114	½	304	1.110	1	-	-	-	-	-	-
-	-	1.102	½	602	1.101	1	-	1.091	2	-	-	-
-	-	1.079	½	-	-	-	-	-	-	-	-	-
-	-	1.072	½	324	1.064	3	-	-	-	-	-	-
-	-	1.055	½	542	1.051	3	-	-	-	-	-	-

[1] Jeffrey mine, Asbestos, Québec. CuKα radiation, a=b=14.90, c=40.41 Å (present study). [2] Gugia, China (PDF 15-199). [3] Stoko Langesundsfjord, Norway (PDF 17-204). [4] Eikaholmen, Langesundsfjord, Norway (PDF 18-711).

Optical measurements on jeffreyite were made on a spindle stage with sodium light (λ 589 nm). It is

biaxial negative, α 1.625(2), β 1.641(2), γ 1.643(2). The $2V_x$ (measured) is 40(2)°, which compares well with $2V_x$ (calculated) of 39°. The optical orientation is *Y* parallel to *a* and *X* parallel to *c*. Twinning was observed on (100). The Gladstone–Dale calculations yield K_C 0.211 and K_P 0.214 using the constants of Mandarino (1981). This indicates superior agreement between analytical and physical data (Mandarino 1979).

TABLE 3. THE COMPOSITION OF JEFFREYITE

	1	2	3	4	5	6	7	8	9	MEAN
SiO_2	47.3	46.2	47.1	45.8	46.4	46.9	46.4	46.4	47.5	46.7(5)
Al_2O_3	3.0	3.2	2.7	3.0	2.8	2.5	2.7	2.7	2.7	2.8(2)
CaO	37.2	37.1	37.2	37.6	37.2	37.6	37.8	36.9	38.1	37.4(4)
BeO*	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
Na_2O	2.0	1.2	3.5	1.9	1.5	3.1	1.8	2.7	2.8	2.3(7)
H_2O**	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Total	99.4	97.6	100.4	98.2	97.8	100.0	98.6	98.6	101.0	99.1

* AA. Analyst, J.-L. Bouvier, Geological Survey of Canada.
** TGA. Analyst, J. Argo, Canadian Conservation Institute.
The remainder of the data were obtained by electron microprobe.

Crystallography

Jeffreyite crystals have a simple morphology. The observed forms on the plates include the pinacoid {001} and a prism, {110}.

X-ray studies and subsequent chemical analyses show jeffreyite to be closely related to gugiaite, meliphanite and leucophanite, all members of the melilite group. The nomenclature of this group is summarized in Table 1. The X-ray precession photographs show that this mineral is pseudotetragonal, with subcell dimensions $a = b = 7.5$ Å, $c = 5.0$ Å. The true cell, although dimensionally tetragonal ($a = b$), is actually orthorhombic in space group $C222_1$. The conditions for nonextinction that indicate this space group are: *hkl* with $h+k = 2n$, *0kl* with $k = 2n$ and *00l* with $l = 2n$. The cell dimensions were refined using X-ray powder-diffraction data obtained from a 114.6-mm-diameter Debye–Scherrer camera and Cu$K\alpha$ radiation. The refined unit-cell parameters and volume are *a* 14.90(1), *b* 14.90(1), *c* 40.41(8) Å and *V* 8971(30) Å^3 with $Z = 64$. The X-ray powder-diffraction data for jeffreyite, as well as the closely related powder patterns of gugiaite, meliphanite and leucophanite, are given in Table 2. The X-ray powder pattern of jeffreyite has several diffraction lines in addition to those reported for gugiaite and a few weak lines that distinguish it from all three minerals, gugiaite, meliphanite and leucophanite. The *d* values for these diffraction lines are 10.13, 4.70, 3.50, 3.09, 2.905, 2.576, 2.143, 2.020, 1.716, 1.666, 1.631, 1.535, 1.511, 1.290 and 1.244 Å; in addition, there are several weaker reflections.

Chemical Composition

Wavelength-dispersion analyses for Na,Al,Si and Ca were obtained using an ARL-SEMQ electron microprobe at an operating voltage of 15 kV and a beam current of 0.1×10^{-6} amperes. Quartz, albite and anorthite of known composition were used as standards for Si, Na, and Ca and Al, respectively. No other elements with atomic numbers greater than nine are present. The data were corrected by the Tracor–Northern ZAF (version 11, 1981) computer program, and the results are presented in Table 3. BeO was determined by atomic-absorption spectrophotometry and H_2O by thermal gravimetric analysis. The 1.8 wt.% H_2O was driven off in one step between 770 and 1000°C. The low totals may be due in part to volatilization of light elements during analysis.

Using the mean composition given in Table 3, the chemical formula calculated on the basis of 7(O,OH) is $(Ca_{1.69}Na_{0.19})_{\Sigma 1.88}(Be_{0.82}Al_{0.14})_{\Sigma 0.96}Si_{1.97}[O_{6.49}(OH)_{0.51}]_{\Sigma 7}$ or, ideally, $(Ca,Na)_2(Be,Al)Si_2(O,OH)_7$.

Discussion

Jeffreyite is a member of the melilite group. Within this group, jeffreyite is chemically similar to gugiaite, meliphanite and leucophanite, all of which contain essential calcium, beryllium and silicon (Tables 1, 4). Since analyses of meliphanite show a considerable range of Ca and Na, but always with Ca > Na, Fleischer (1963) suggested that the species gugiaite was unnecessary as it is simply a Na-poor, F-poor end member of meliphanite. Now that the meliphanite and gugiaite structures have been solved, it has become evident that these minerals are distinct species. Gugiaite is isostructural with åkermanite $Ca_2MgSi_2O_7$ (Kimata & Ohashi 1982), with Be oc-

TABLE 4. REPORTED COMPOSITIONS OF JEFFREYITE, GUGIAITE, MELIPHANITE AND LEUCOPHANITE

	JEFFREYITE[1]	GUGIAITE[2]	MELIPHANITE[3]	LEUCOPHANITE[4]
SiO_2	46.7	44.90	43.60	48.50
Al_2O_3	2.8	2.17	4.61	0.45
Fe_2O_3	n.d.*	0.11	–	–
MnO	n.d.	0.07	–	–
MgO	n.d.	0.38	0.16	0.27
CaO	37.4	40.09	29.56	22.94
BeO	8.1	9.49	9.80	10.03
Na_2O	2.3	0.72	7.98	12.42
K_2O	n.d.	0.20	0.23	–
H_2O	1.8	1.26	–	1.08
F	n.d.	0.25	5.43	5.04
O≡F	–	0.11	2.29	2.48
Total	99.1	99.79	99.08	99.15

1. Present Study. 2. Gugiaite, Gugia, China. Total includes Cl 0.18, P_2O_5 0.08, volatile matter 0.04, O≡Cl 0.17 (Peng Chui-jui *et al.* 1962). 3. Meliphanite, Langesundsfjord, Norway (Brögger 1890b). 4. Leucophanite, Langesundsfjord, Norway (Brögger 1890a). * n.d. not detected.

cupying the Mg site of åkermanite. The crystal structure of meliphanite is closely related to that of åkermanite. Although the tetrahedral framework essentially remains the same, there are some interesting substitutional changes. Be in the meliphanite structure does not occupy the corresponding Mg site of åkermanite as it did in gugiaite. Instead, the Be occupies one of the åkermanite Si sites and one Si site in meliphanite is the Mg site in åkermanite. In the supercell of meliphanite, the Ca and Na are no longer found in a single site, as is the Ca in åkermanite; there are now two distinct sites, one occupied by Ca and the other occupied primarily by Na. Also, F in meliphanite has a distinct atomic position from that of any of the oxygen atoms (Dal Negro *et al.* 1967). Leucophanite is dimorphous with meliphanite; its structure (Cannillo *et al.* 1967) is closely related to that of meliphanite. The relationship of the jeffreyite structure to that of meliphanite and leucophanite is presently unknown. The close relationship in symmetry and cell size of the jeffreyite subcell to that of gugiaite has already been discussed (Table 1); because of this relationship, it is evident that the subcell structure of jeffreyite must be very similar to the structure of gugiaite. The large supercell of jeffreyite is most likely due to the ordering of some or all of the minor constituents sodium, aluminum and the hydroxyl ion into distinct atomic positions. In the empirical formula, there is approximately one-eighth of a Na atom, one-eighth of an Al atom and one-half of an OH ion. With 64 formula units in the unit cell these lesser constituents give rise to the possibility of additional unique atomic sites within space group $C222_1$. Since the minor constituents Na, Al and OH may be of structural importance, they have been left in the ideal chemical formula given in Table 1.

Acknowledgements

The authors are indebted to P. Roeder and D. Kempson for use of the Queen's University microprobe. We also thank I. Wainwright and J. Argo at the Canadian Conservation Institute for cleaning the samples in oxygen plasma and for the TGA analysis, and J.-L. Bouvier, of the Geological Survey of Canada, who provided the AA analysis for beryllium.

References

Brögger, W.C. (1890a): Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite. Leukophan. *Z. Krist. Mineral.* **16,** 246-278.

_____ (1890b): Die Mineralien der Syenitpegmatitgänge des südnorwegischen Augit- und Nephelinsyenite. Melinophan. *Z. Krist. Mineral.* **16,** 279-293.

Cannillo, E., Giuseppetti, G. & Tazzoli, V. (1967): The crystal structure of leucophanite. *Acta Cryst.* **23,** 255-259.

Dal Negro, A., Rossi, G. & Ungaretti, L. (1967): The crystal structure of meliphanite. *Acta Cryst.* **23,** 260-264.

Fleischer, M. (1963): New mineral names. *Amer. Mineral.* **48,** 209-217.

Grice, J.D. & Gasparrini, E. (1981): Spertiniite, $Cu(OH)_2$, a new mineral from the Jeffrey mine, Quebec. *Can. Mineral.* **19,** 337-340.

_____ & Williams, R. (1979): The Jeffrey mine, Asbestos, Quebec. *Mineral. Rec.* **10,** 69-80.

Kimata, M. & Ohashi, H. (1982): The crystal structure of synthetic gugiaite, $Ca_2BeSi_2O_7$. *Neues Jahrb. Mineral. Abh.* **143,** 210-222.

Mandarino, J.A. (1979): The Gladstone–Dale relationship. III. Some general applications. *Can. Mineral.* **17,** 71-76.

_____ (1981): The Gladstone-Dale relationship. IV. The compatibility concept and its application. *Can. Mineral.* **19,** 441-450.

Peng, Chi-jui, Tsao, Rung-lung, & Zou, Zu-rung (1962): Gugiaite, $Ca_2BeSi_2O_7$, a new beryllium mineral and its relation to the melilite group. *Scientia Sinica* (Peking) **11,** 977-988.

Wares, R.P. & Martin, R.F. (1980): Rodingitization of granite and serpentinite in the Jeffrey mine, Asbestos, Quebec. *Can. Mineral.* **18,** 231-240.

Received June 29, 1983, revised manuscript accepted September 20, 1983.