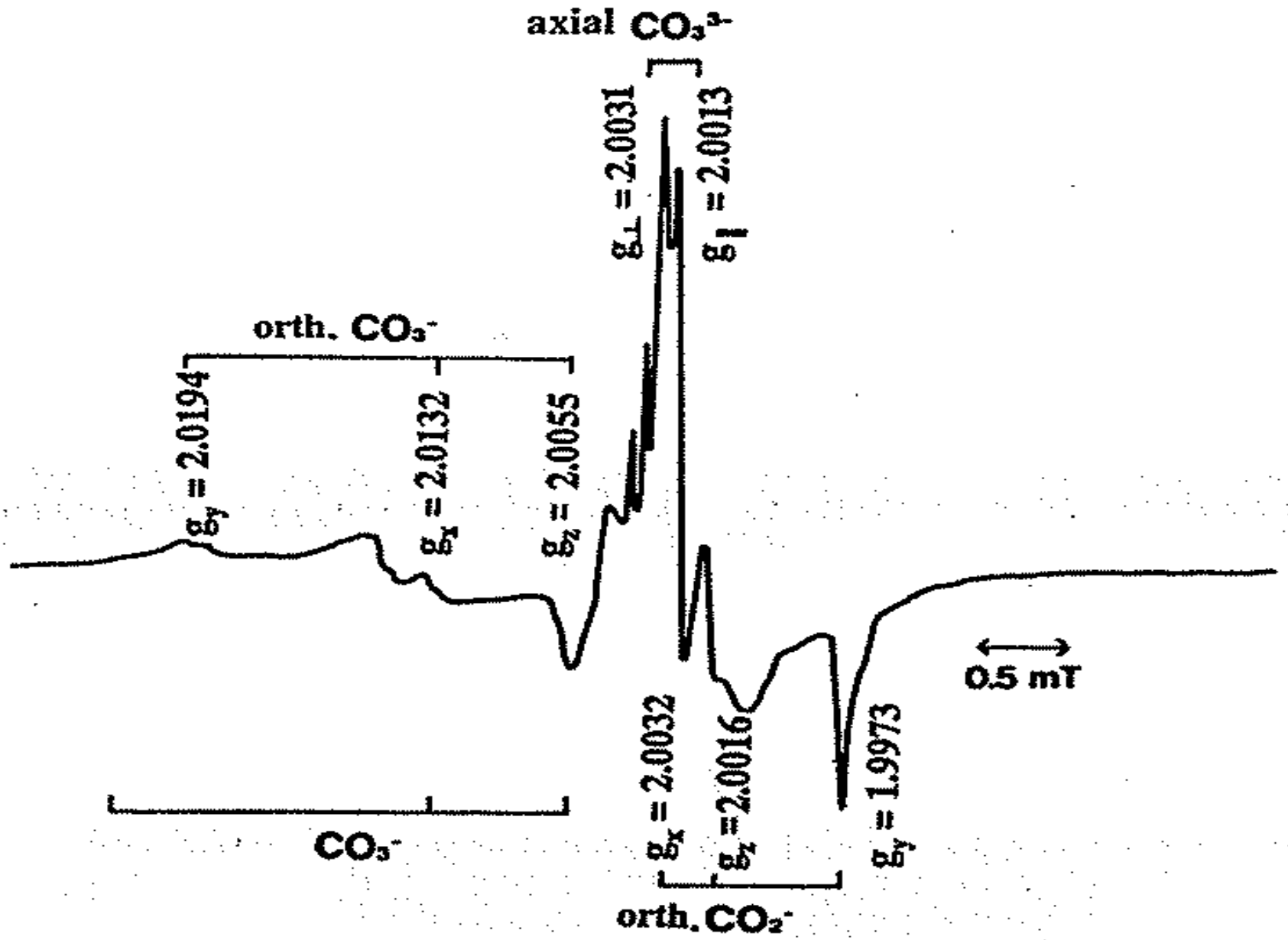

Figure 5.3 ESR spectrum of pure synthetic $CaCO_3$ powders after γ–irradiation at room temperature. The signal positions of CO_3^{3-}, CO_3^- and CO_2^- centers are indicated with their *g* factors.

Table 5.1 ESR parameters of carbonate radicals in irradiated carbonate minerals.

Species	Materials [a]	g factors [b]				A-tensor (mT)			Ref.
		g_{zz}	g_{xx}	g_{yy}	g_{av} [c]	A_{zz}	A_{xx}	A_{yy}	
CO_3^{3-} axial	N–calcite	$g_{\parallel}$=2.0013	$g_{\perp}$=2.0031		2.0025	17.12	11.13 (^{13}C)		1
	S–calcite	$g_{\parallel}$=2.0016	$g_{\perp}$=2.0032		2.0027				2
	S–calcite		$g_{\perp}$=2.0034				$A_{\perp}$=10.9		3
CO_3^{3-}–Y^{3+}	N–calcite	2.0012	2.0024	2.0038	2.0025	18.83	12.61	12.61 (^{13}C)	4
						0.31	0.35	0.29 (^{89}Y)	
HCO_3^{2-}	N–calcite	2.00197	2.00387	2.00502	2.00362	2.78	3.55	4.48 (^{1}H)	5
CO_3^{3-}–Li^{+}	S–calcite	$g_{\parallel}$=2.0012	$g_{\perp}$=2.0031		2.0025	0.40	0.26 (^{7}Li)		6
CO_3^{-} orth.	N–calcite	2.0055	2.0132	2.0194	2.0127				7
	N–calcite	2.0164	2.0142	2.0126	2.0144				8
		2.0163	2.0143	2.0128	2.0145				8
	S–calcite	2.0056	2.0100	2.0180	2.0112	1.37	1.08	1.03 (^{13}C)	3
	S–calcite	2.0056	2.0100	2.0210	2.0122	1.37	1.08	1.05 (^{13}C)	3
	S–calcite	2.0055	2.0092	2.0222	2.0123	1.39	1.08	0.95 (^{13}C)	3
	$KHCO_3$	2.0066	2.0086	2.0184	2.0112	1.4	1.0	1.0 (^{13}C)	9
CO_3^{-} axial	N–calcite	$g_{\parallel}$=2.0051	$g_{\perp}$=2.0162		2.0125	1.31	0.94 (^{13}C)		1
CO_3^{-} iso.	S–calcite·H_2O				g_{iso}=2.0115		A_{iso}=1.14 (^{13}C)		10
CO_2^{-} orth.	N–calcite	2.0016	2.0032	1.9973	2.0007	17.73	13.46	13.17 (^{13}C)	11
	N–calcite	2.0016	2.0032	1.9971	2.0006				12
		2.0026	2.0018	1.9972	2.0005				8
	S–calcite	2.0015	2.0032	1.9974	2.0007	18.9	15.8	15.6 (^{13}C)	3
CO_2^{-} axial	N–calcite	$g_{\parallel}$=2.0032	$g_{\perp}$=1.9994		2.0007	13.46	15.59 (^{13}C)		13
	N–calcite	$g_{\parallel}$=2.0028	$g_{\perp}$=1.9991		2.0003				8
	N–calcite	$g_{\parallel}$=2.0031	$g_{\perp}$=1.9994		2.0006				8
	S–calcite	$g_{\parallel}$=2.0032	$g_{\perp}$=1.9995		2.0007	α–irradiation			14
CO_2^{-} iso.	S–calcite				g_{iso}=2.0008		A_{iso}=14.9 (^{13}C)		3
	S–calcite·H_2O				g_{iso}=2.0006		A_{iso}=14.8 (^{13}C)		10
	aragonite				g_{iso}=2.0007				15
CO_2^{-}–F^{-}	N–calcite	2.0022	2.0035	1.9980	2.0012	4.39	9.31	4.39 (^{19}F)	16
CO_2H	$KHCO_3$	2.0012	2.0031	1.9971	2.0005	14.2	17.9	13.3 (^{13}C)	9
CO_2^{-} orth.	HCOONa	2.0014	2.0032	1.9975	2.0007	19.5	15.5	15.1 (^{13}C)	17

a) N: natural, S: synthetic.
b) For orthorhombic symmetry g_{zz}, g_{xx} and g_{yy} and for axial symmetry $g_{\parallel}$ and $g_{\perp}$ are given.
c) Calculated using $g_{av} = [(g_{zz}^2 + g_{xx}^2 + g_{yy}^2)/3]^{1/2}$ or $g_{av} = [(g_{\parallel}^2 + 2g_{\perp}^2)/3]^{1/2}$ for convenience (see Section 2.4.3).

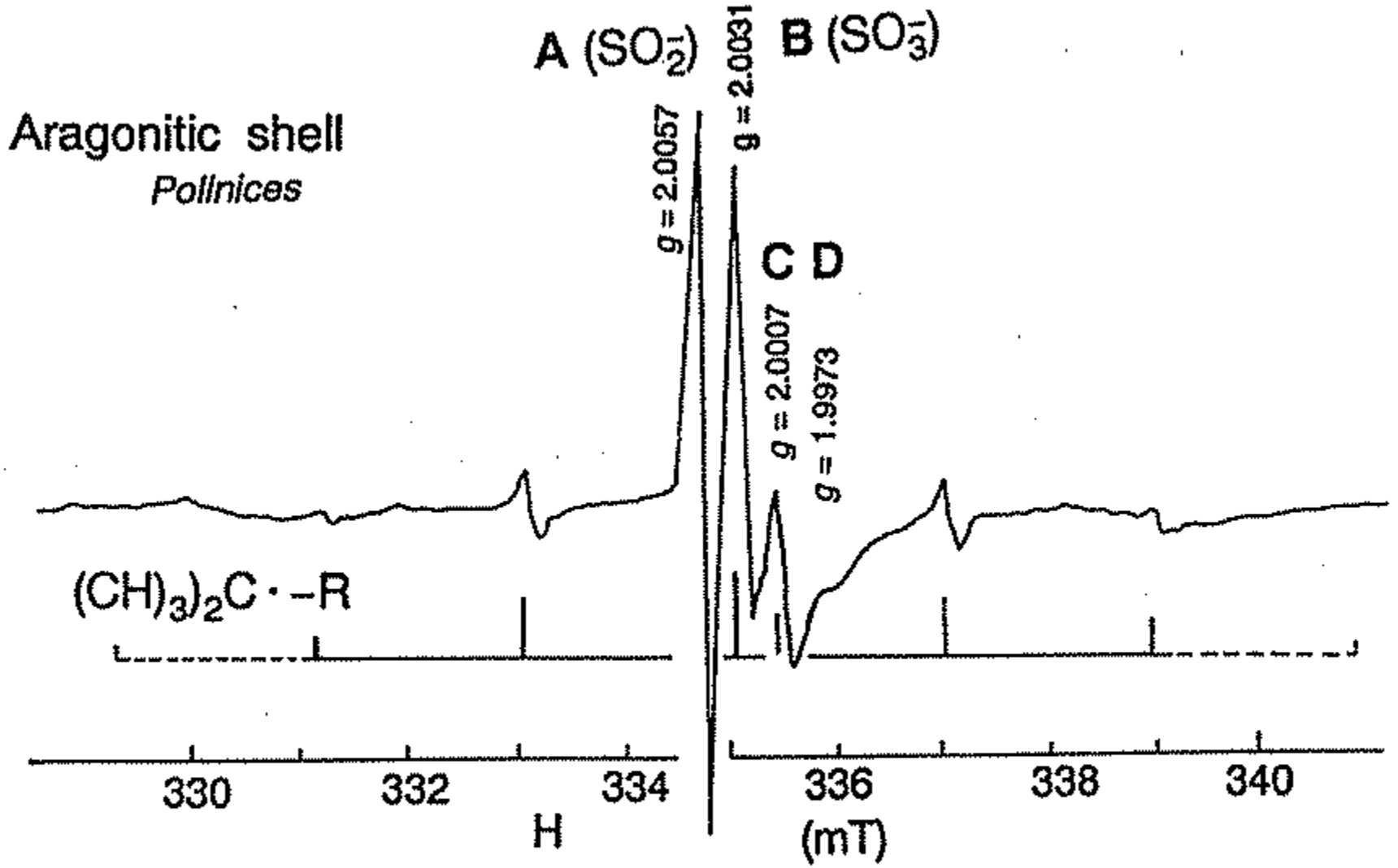

Figure 6.3 ESR spectrum of an aragonitic shell (*Polinices*) of about 65,000 years BP. The septet signal due to the hf interaction associated with isopropyl radicals is observed in addition to four signals indicated by A, B, C and D (g_A = 2.0057, g_B=2.0031, g_C = 2.0007 and g_D = 1.9973).

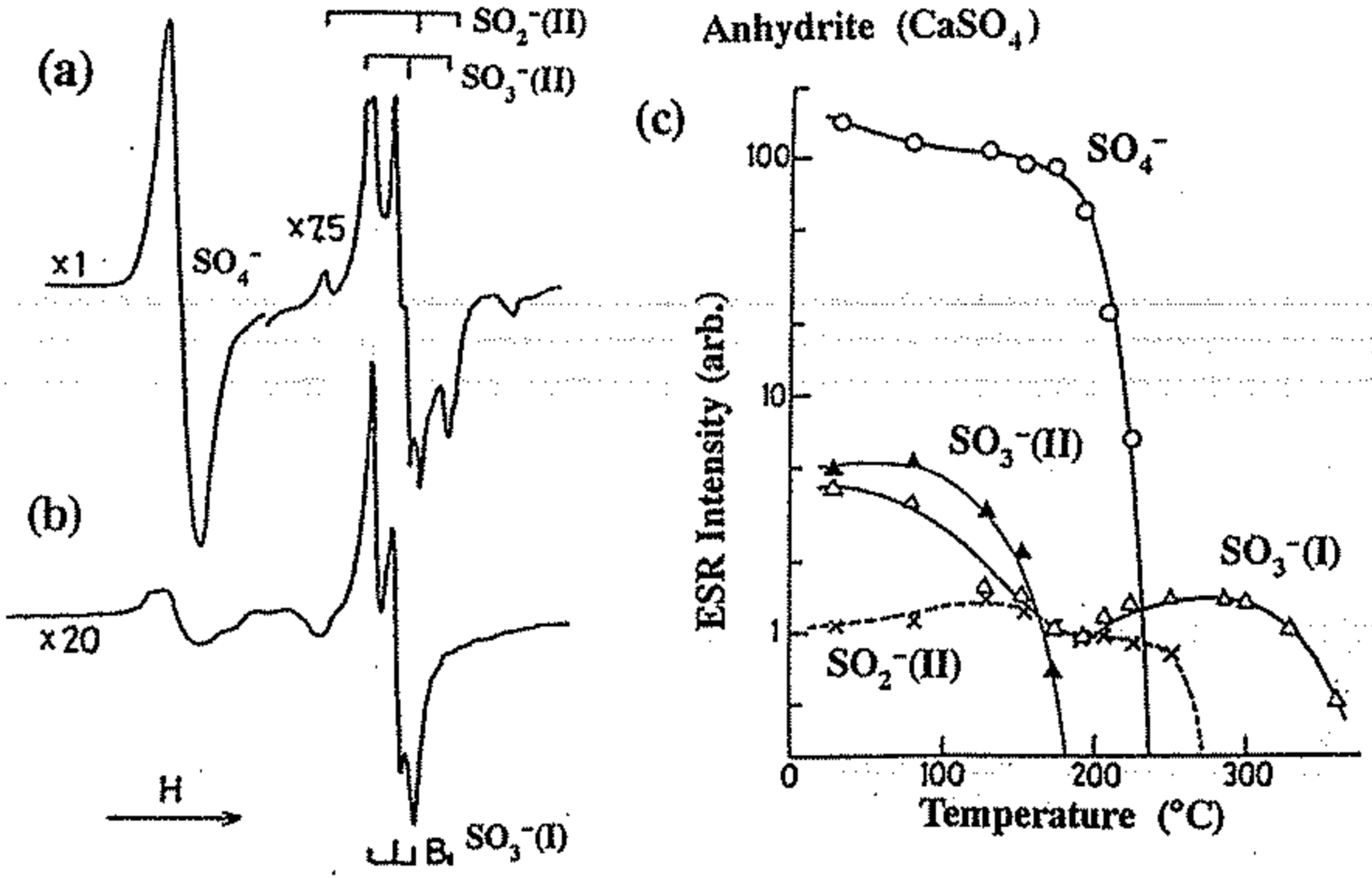

Figure 7.2 ESR spectra of γ–irradiated anhydrite powder containing (a) 0.2% and (b) 0.01% alkali. (c) Isochronal annealing of the signals.

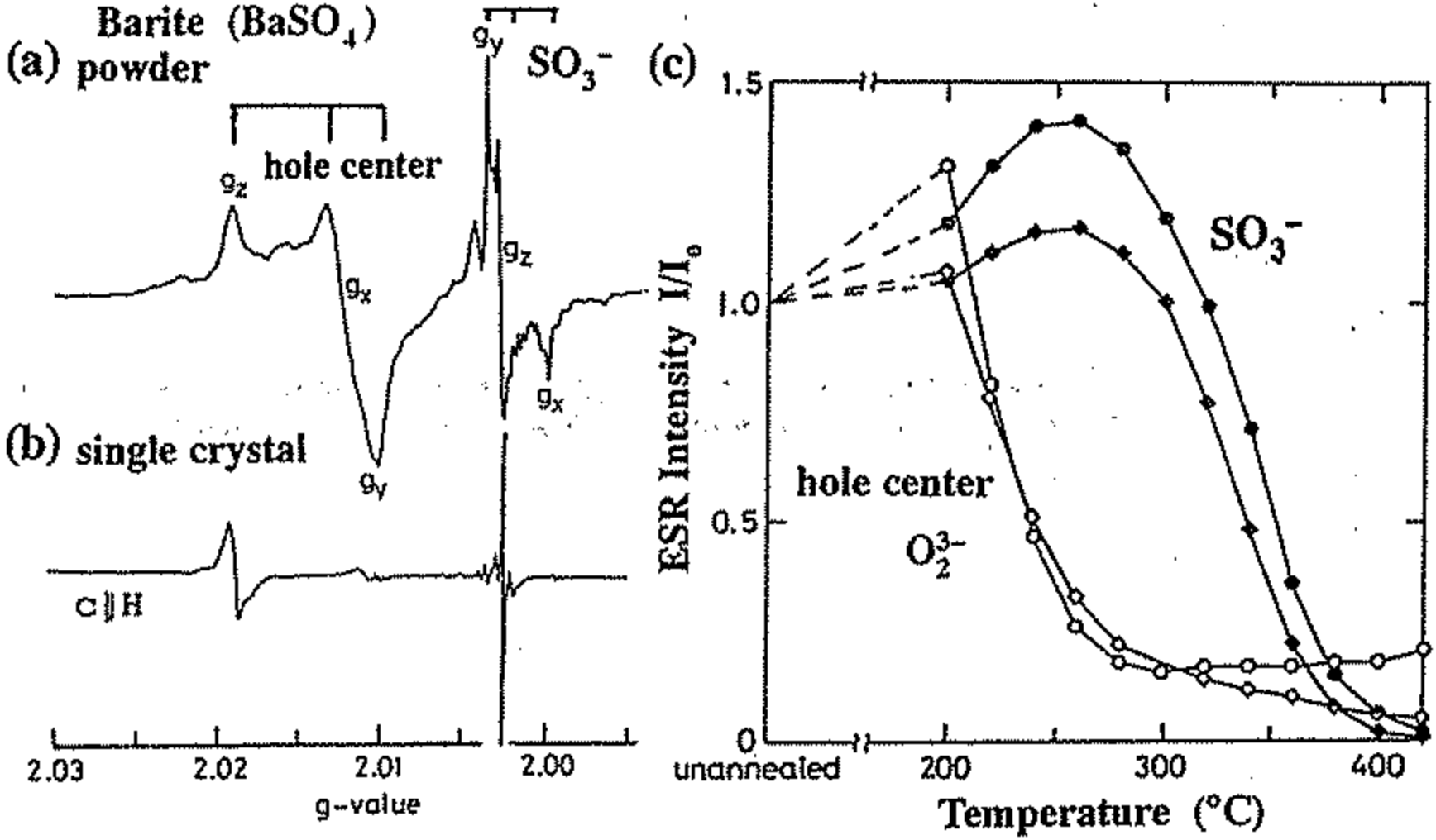
Barite ($BaSO_4$)
(a) powder
hole center
g_z
g_x
g_y
SO_3^-
g_y
g_z
g_x
(b) single crystal
c ∥ H
2.03
2.02
2.01
2.00
g-value
(c)
1.5
1.0
0.5
0
ESR Intensity I/I_0
SO_3^-
hole center
O_2^{3-}
unannealed
200
300
400
Temperature (°C)

Table 7.1 ESR parameters of defects assigned in irradiated anhydrite ($CaSO_4$), barite ($BaSO_4$) and celestite ($SrSO_4$).

Defects *)	g factors				A tensor (mT)			Ref.
	g_{zz}	g_{xx}	g_{yy}	g_{av} **)	A_{zz}	A_{xx}	A_{yy}	
Anhydrite ($CaSO_4$)								
SO_4^-	$g_\parallel = 2.011$		$g_\perp = 2.012$	2.0117	A_{iso}=1.44 (^{33}S)			1
$SO_4^-\cdot V_{Ca}$(I) a)	2.0395	2.0006	2.0091	2.0165				2
$SO_4^-\cdot V_{Ca}$(II) a)	2.0256	2.0011	2.0084	2.0117				2
SO_3^-(I)	2.0048	2.0038	2.0029	2.0038	no hf line			1
SO_3^-(I)	2.0025	2.0031	2.0041	2.0032	12.1	10.7	9.6 (^{33}S)	3
SO_3^-(I)	2.0020	2.0042	2.0036	2.0033				4
SO_3^-(II)	2.0050	2.0035	2.0018	2.0034				1
SO_3^-(II)	2.0022	2.0039	2.0041	2.0034	13.1	9.3	9.4 (^{33}S)	3
SO_3^-(II)	2.0012	2.0040	2.0022	2.0025				4
SO_2^-(I)	2.0058	2.0022	2.0092	2.0057				4
SO_2^-(II)	2.0058	2.0020	2.0098	2.0059				4
SO_2^-(II)	2.0066	2.0031	2.0015	2.0037	no hf line			1
SO_2^- b)	2.005	2.003	2.008	2.0053				5
SSO^- b)	2.009	2.003	2.016	2.0093				5
SSO_3^- b)	2.003	2.028	2.023	2.018				5
SSO_3^-	2.0114	2.0270	2.0218	2.0201				4
PO_4^{2-} b)	$g_\parallel = 2.014$		$g_\perp = 2.018$	2.0167	$A_\parallel$=2.9		$A_\perp$=2.8	5
PO_3^{2-} b)	$g_\parallel = 2.0012$		$g_\perp = 2.0036$	2.0028	$A_\parallel$=56.6		$A_\perp$=49.9	5
PO_3^{2-}(I)				$g_{iso} = 2.0027$	A_{iso}=47.4 (^{31}P)			3
PO_3^{2-}(II)				$g_{iso} = 2.0027$	A_{iso}=44.8 (^{31}P)			3
O^- b)	$g_\parallel = 2.011$		$g_\perp = 2.019$	2.0163				5
O_2^-(I)	2.0238	1.9940	1.9950	2.0043				4
O_2^-(II)	2.0176	1.9940	1.9950	2.0022				4
O_3^-(I)	2.0056	2.0140	2.0144	2.0113				4
O_3^-(III)	2.0102	2.0112	2.0116	2.0110				4
O_2^{3-}–Y^{3+}	2.0122	2.0029	2.0262	2.0138	0.49	0.63	0.49 (^{89}Y)	6
O_2^{3-}–B^{3+}	2.0120	2.0086	2.0122	2.0109	0.92	1.17	0.90 (^{11}B)	4
S_2^- b)	$g_\parallel = 2.74$		$g_\perp$ (not measured)					5

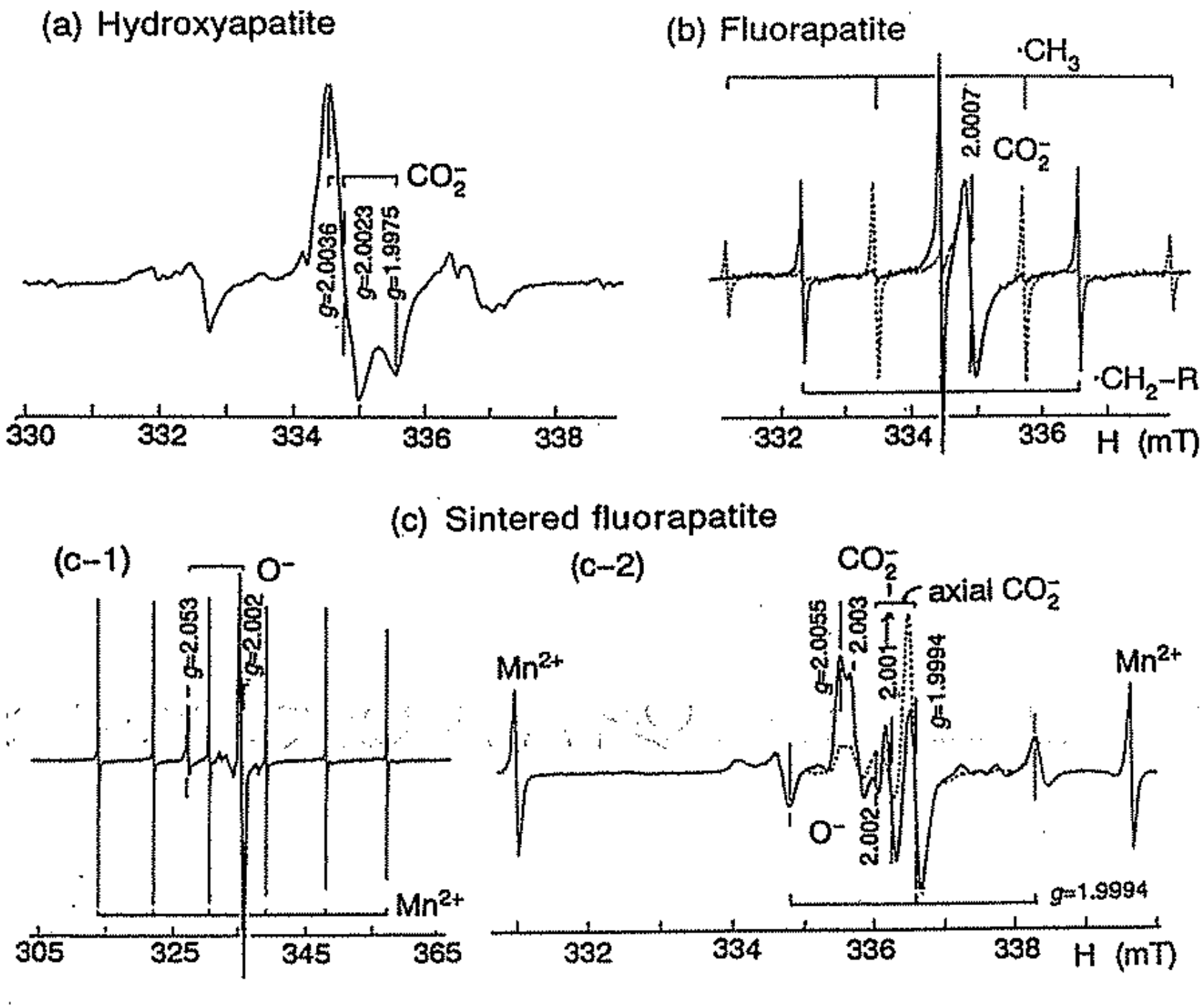
(a) Hydroxyapatite
CO_2^-
g=2.0036
g=2.0023
g=1.9975
330
332
334
336
338
(b) Fluorapatite
·CH_3
2.0007
CO_2^-
·CH_2–R
332
334
336
H (mT)
(c) Sintered fluorapatite
(c–1)
O^-
g=2.053
g=2.002
Mn^{2+}
305
325
345
365
(c–2)
CO_2^-
axial CO_2^-
g=2.0055
2.003
2.001
g=1.9994
Mn^{2+}
Mn^{2+}
O^-
2.002
g=1.9994
332
334
336
338
H (mT)

Table 8.1 ESR parameters of defects in irradiated synthetic apatites.

Model	g factor			A–tensor in mT			Material	Ref.
	g_1 ($g_\parallel$)	g_2	g_3 ($g_\perp$)	A_1	A_2	A_3		
CO_2^- orthorhombic	2.0023	2.0036	1.9975				OH–apatite	1
	2.0015	2.0030	1.9970	15.9	16.4	19.9 (^{13}C)	C–apatite (B) [a]	2
	2.0017	2.0031	1.9972				C–apatite (B) [a]	3
	2.0018	2.0034	1.9971				C–apatite (A) [a]	4
	2.0024	2.0035	1.998	20.5	17.5	16.4 (^{13}C)	C–apatite (A) [a]	5
CO_2^- axial	2.003		1.999				sin–F–apatite [b]	1
CO_2^- isotropic	2.0007			A_{iso}=14.8 (^{13}C)			F–apatite	1
	2.0007			A_{iso}=14.7 (^{13}C)			C–apatite	2,3
CO_3^- axial	2.0060	2.0170	2.0084	A_{iso}=1.3 (^{13}C)			C–apatite (B) [a]	2
	2.0066	2.0178	2.0087				C–apatite (B) [a]	3
CO_3^- rotating	2.0115			A_{iso}=1.12 (^{13}C)			C–apatite (B) [a]	2,3
O^-	2.0276	2.0406	2.0330				C–apatite (B) [a]	2
	2.0018		2.0683	0.56	0.59 (^{1}H)		OH–apatite	6
O^- at an F^- site	2.002		2.053				sin–F–apatite	1
	2.0018		2.0522	0.70	0.03 (^{19}F)		F–apatite	7
O_2^-	2.06	2.001	2.001				OH–apatite	8
O^{3-} at three F^- vacancies	1.9983		1.9994	3.2	2.1 (^{19}F)		F–apatite	7
	1.9995		2.0000	0.41	0.27 (^{19}F)		F–apatite	7
Hole center [c]	2.0068	2.0032	2.0148				OH–apatite	9
SO_2^-	2.0055						sin–F–apatite	1
$\cdot CH_3$	2.0026	quartet		2.3 (^{13}C)			F–apatite	1
$\cdot CH_2$–R	2.0033	triplet		2.1 (^{13}C)			F–apatite	1