SUMMARY OF RESEARCH RESULTS ON BACTERIAL DEGRADATION OF TRIFLUOROACETATE (TFA), NOVEMBER, 1994 - MAY, 1995

by Ronald S. Oremland, Leah Matheson, Janet Guidetti, Jeffra Schaefer, *and* Pieter T. Visscher.

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Summary of Research Results on Bacterial Degradation of Trifluoroacetate (TFA), November, 1994 - May, 1995.

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ABSTRACT

A summary of experimental results on the degradation of trifluoroacetate is presented. Experiments were conducted with a variety of materials, including freshwater and estuarine sediments, sediments from an alkaline, hypersaline environment, and from agricultural soils. Results with several pure cultures of a diversity of bacteria with regard to their ability to degrade trifluoroacetate are also presented.

INTRODUCTION

The 3 pages of attached graphs refer to successful TFA (trifluoroacetate) experiments which were conducted during October, 1993 and March, 1994. The Searsville Lake $^{14}CH_4$ data appeared in Visscher and others, 1994 but the TFA, difluoroacetate (DFA), monofluoroacetate (MFA), and acetate data have not been published. Neither have the March, 1994 data from the Palo Alto Marsh site (sulfate or nitrate as electron acceptors). For completeness, we have included the results from our 1994 paper in this summary.

We have divided the summary results into four sections: sediment slurry experiments (table 1), small subcore experiments (table 2), experiments with bacterial cultures (table 3), and a fourth section on the effects of unlabeled TFA upon bacterial growth of some of the tested cultures. These tables indicate that most of our experiments have not noted the production of radiolabeled gases from ^{14}C-TFA.

SIGNIFICANT FINDINGS

The degradation of 2-^{14}C-TFA was observed to occur under methanogenic conditions (fig. 1), sulfate reducing conditions (fig. 2), but not under nitrate-respiring conditions (fig. 3). In this last case, degradation of TFA took place after all the nitrogen oxides were depleted. Aside from some minor production of $^{14}CH_4$ observed with Mono Lake

sediments (table 2) as well as the earlier work conducted with San Francisco Bay saltmarsh and Searsville Lake material (table 1), and some fluoroform production in our *Thiobacillus* strain number ASN1 culture, we have not observed any further activity.

REFERENCES

Visscher, P.T., Culbertson, C.W., and Oremland, R.S. 1994: Degradation of trifluoroacetate in oxic and anoxic sediments. Nature, vol. 369, p. 729 - 731.

TABLE I. SEDIMENT SLURRY EXPERIMENTS
(20ml slurries in 57ml serum bottles; approximately 90% water by weight)

< D.L. = Less than detection limit of thermal conductivity detector (~0.1μmoles/headspace)
TMA = Trimethylamine
TFA = Trifluoroacetate
Numbers in parenthesis ( ) indicate standard deviation of triplicate sample
^{14}C-TFA specific activity = 54μCi/μmol

Site	Date	^{14}C-TFA labeled Carbon	Electron Acceptor Added	Electron Donor Added	Incubation Time (days)	^{14}C Gas Phase Products (% Conversion from ^{14}C-TFA)			CH_4 Production after 8-12 day incubation (μmoles/headspace)	CO_2 Production after 8-12 day incubation (μmoles/headsapce)
						$^{14}CH_4$	$^{14}CO_2$	$^{14}CHF_3$		
Palo Alto Saltmarsh	9/2/93	2 (1.85μCi)	SO_4 MoO_4		10	67.6 (3.7)	0	0	17.9 (2.1)	52.3 (6.6)
" "	9/2/93	2 (1.85μCi)	SO_4		12	0	0	0	1.2 (0.9)	123.8 (12.9)
" "	9/2/93	2 (1.85μCi)	SO_4 BES		10	0	0	0	3.8 (1.2)	44.2 (3.2)
" "	9/14/93	2 (1.85μCi)	none		8	73 (3.3)	0	0	39.2 (4.1)	112.8 (10.7)
" "	11/10/93	2 (4.8μCi)	none		8	80.2 (8.7)	0	0	52.3 (5.3)	96.2 (11.4)
" "	11/24/93	2 (1.85μCi)	SO_4		18	0	0	0	8.3 (2.0)	211.7 (6.9)
" "	11/24/93	2 (1.85μCi)	SO_4 BES		18	0	0	0	0.9 (0.6)	168.7 (10.1)
" "	11/24/93	2 (0.925μCi)	SO_4		18	0	0.1 (0.2)	0	2.2 (2.0)	187.4 (8.4)
" "	11/24/93	2 (0.925μCi)	SO_4 BES		18	0	0.2 (0.2)	0	1.4 (0.3)	171.5 (12.4)
" "	11/24/93	2 (0.463μCi)	SO_4		18	0	12.2 (3.9)	0	4.3 (0.8)	128.6 (2.9)
" "	11/24/93	2 (0.185μCi)	SO_4		18	0	7.8 (6.4)	0	8.7 (1.1)	205.8 (17.2)
" "	12/6/93	2 (0.925μCi)	SO_4		27	0	1.0 (0.3)	0	0.8 (0.2)	148.7 (14.6)
" "	12/6/93	2 (0.463μCi)	SO_4		27	0	9.7 (2.2)	0	2.1 (0.3)	198.4 (9.3)
" "	12/6/93	2 (0.925μCi)	NO_3		15	0	0	0	7.2 (0.4)	317.4 (21.5)
" "	12/6/93	2 (0.463μCi)	NO_3		15	0	0	0	20.3 (348.6)	348.6 (34.6)
" "	12/6/93	2 (0.925μCi)	O_2		27	0	0	0	< D.L.	61.7 (5.8)
" "	12/6/93	2 (0.463μCi)	O_2		27	0	0	2.4 (0.3)	< D.L.	47.9 (7.2)
" "	12/6/93	2 (0.925μCi)	MnO_2		27	0	0	0	0.6 (0.3)	98.6 (12.5)
" "	12/6/93	2 (0.463μCi)	MnO_2		27	0	0	0	0.4 (0.4)	138.6 (45.7)
" "	12/6/93	2 (0.925μCi)	FeNTA		15	0	0	0	4.9 (2.2)	63.4 (32.0)
" "	12/6/93	2 (0.463μCi)	FeNTA		15	0	0	0	0.8 (0.3)	87.9 (20.4)

SEDIMENT SLURRIES - Page 2

Site	Date	^{14}C-TFA labeled Carbon	Electron Acceptor Added	Electron Donor Added	Incubation Time (days)	^{14}C Gas Phase Products (% Conversion from ^{14}C-TFA)			CH_4 Production after 8-12 day incubation (µmoles/headspace)	CO_2 Production after 8-12 day incubation (µmoles/headsapce)
						$^{14}CH_4$	$^{14}CO_2$	$^{14}CHF_3$		
Palo Alto Saltmarsh	12 6 93	2 (0.925µCi)	none		15	69.9 (1.6)	1.7 (0.4)	0	61.4 (12.6)	82.6 (4.6)
" "	12 6 93	2 (0.463µCi)	none		15	86.9 (2.8)	0	0	52.3 (5.6)	94.5 (3.7)
" "	12 6 93	2 (0.463µCi)	O_2		15	0	0	1.9 (1.5)	< D.L.	43.8 (2.2)
" "	12 6 93	2 (0.185µCi)	O_2		15	0	0	25.5 (23.7)	< D.L.	36.9 (4.3)
" "	1 12 94	2 (0.463µCi)	NO_3		11	0	8.6 (0.4)	0	1.2 (0.4)	88.3 (4.9)
" "	1 12 94	2 (0.185µCi)	NO_3		11	0	10.2 (1.0)	0	0.7 (0.3)	108.5 (7.3)
" "	3 7 94	2 (1.0µCi)	none	H_2	18	3.6 (1.8)	0	0	86.5 (7.2)	148.6 (20.6)
" "	3 7 94	2 (0.5µCi)	none	H_2	18	5.4 (4.4)	0	0	72.4 (4.3)	194.4 (58.6)
" "	3 7 94	2 (1.0µCi)	NO_3	H_2	18	0	0	0	12.8 (2.8)	87.3 (12.7)
" "	3 7 94	2 (0.5µCi)	NO_3	H_2	18	0	0	0	23.4 (3.6)	168.4 (31.3)
" "	3 10 94	2 (0.2µCi)	SO_4		19	0	8.38 (4.43)	0	0.32 (0.02)	135.67 (4.76)
" "	3 10 94	2 (0.2µCi)	NO_3		19		2.47 (2.16)	3.59 (6.22)	0.04 (0)	49.33 (1.71)
" "	4 12 94	2 (2µCi)	SO_4		20	0	0	0	0.30 (0.11)	363 (103)
" "	5 11 94	2 (2µCi)	SO_4		13	0	71.7 (1.4)	0	< D.L.	931 (199)
" "	6 7 94	2 (0.16µCi)	NO_3		31	0	0.5 (.9)	0	< D.L.	163 (24)
" "	6 7 94	2 (0.4µCi)	NO_3		31	0	58.3 (68.4)	0	< D.L.	150 (30)
" "	6 7 94	2 (0.8µCi)	NO_3		31	0	163 (76)	0	< D.L.	163 (12)
" "	6 7 94	2 (1.6µCi)	NO_3		31	0	45 (80)	0	< D.L.	160 (11)
" "	7 12 94	2 (0.8µCi)	NO_3 (continual addition)		17	0	0	0	< D.L.	36.11 (1.89)
" "	7 12 94	2 (0.8µCi)	O_2		17	0	0	0	< D.L.	697 (55)
" "	12 9 94	2 (1µCi)	SO_4		18	0	0	0	0.15 (0.01)	62.9 (14)
" "	12 9 94	2	none		18	0	0	0	4.33 (0.34)	38.9 (4.5)
" "	12 9 94	1	SO_4		18	0	0	0	0.12 (0.02)	45.3 (6.5)
" "	12 9 94	1	none		18	0	0	0	4.45 (0.49)	40.4 (6.0)
" "	12 28 94	2 (0.76µCi)	SO_4		36	0	0	0	73.9 (1.26)	128 (7.3)
" "	12 28 94	2 (0.76µCi)	none		36	0	0	0	114 (1.81)	149 (2.19)

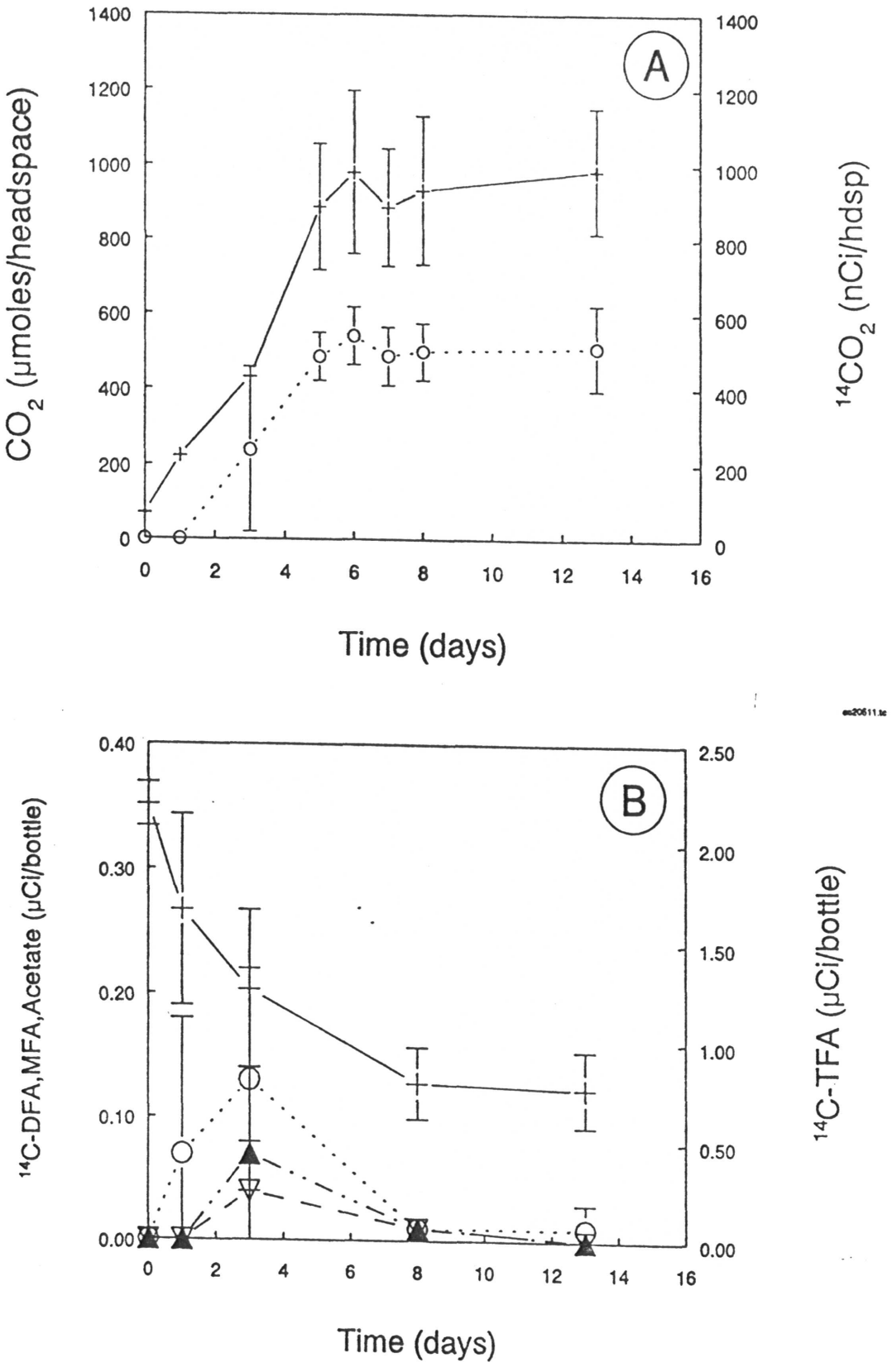

Figure 2: Degradation of 2-^{14}C-TFA in San Francisco Bay saltmarsh sediment slurries incubated under sulfate reducing conditions. A) Gaseous products. Symbols: CO_2 (+), $^{14}CO_2$ (o); methane was not produced. B) ^{14}C-soluble products. Symbols: TFA (+), DFA (o), MFA (▲), acetate (▽). Symbols represent the mean of three slurries and bars indicate ± 1 std. dev.

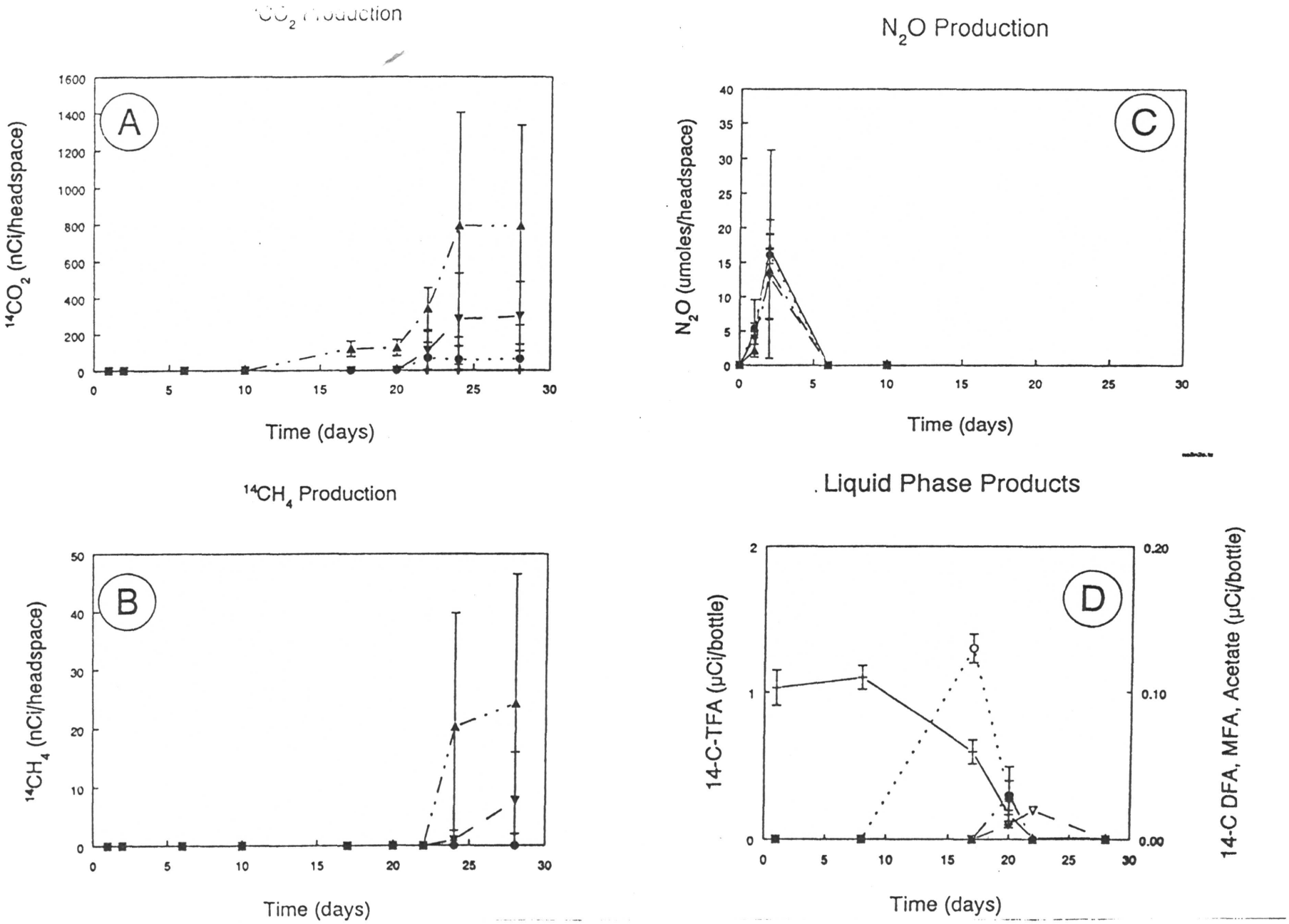

Figure 3: Degradation of ^{14}C-TFA in San Francisco Bay saltmarsh slurries incubated under nitrate-reducing conditions. Four different concentrations of ^{14}C-TFA were employed: 0.15 μM (+), 0.37 μM (●), 0.74 μM (▲), and 1.48 μM (▼). Symbols refer to panels A, B, and C. A) Production of $^{14}CO_2$ at the four different TFA concentrations. B) Production of $^{14}CH_4$ at the four different TFA concentrations. C) Production of N_2O at the four different TFA concentrations. D) Liquid phase products during incubation of slurries with 0.74 μM ^{14}C-TFA (~ 800 nCi/20 ml slurry). Symbols: TFA (+), DFA (o), MFA (▲), acetate (▽). All symbols represent the mean of three slurries and bars indicate ± 1 std. dev.

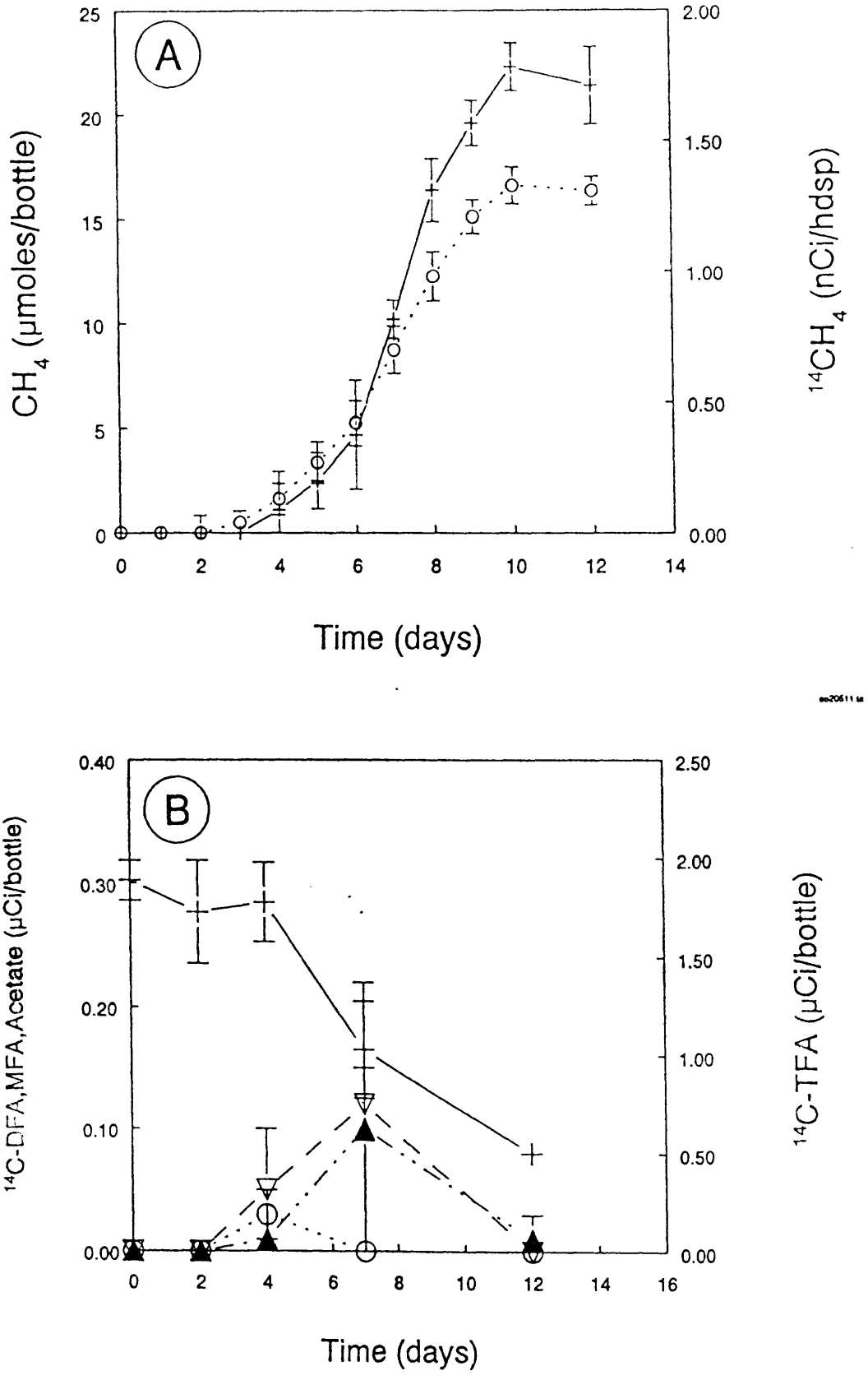

Figure 1: Degradation of ^{14}C-TFA in Searsville Lake sediment slurries under methanogenic conditions. A) Gaseous products. Symbols: CH_4 (+), $^{14}CH_4$ (o); B) ^{14}C-soluble products. Symbols: TFA (+), DFA (o), MFA (▲), acetate (▽). Symbols represent the mean of three slurries and bars indicate ± 1 std. dev.

The following bacteria have been screened for TFA inhibitory effects: *Geobacter metallireducens* GS-15, *Desulfuromonas acetoxidans*, *Desulfobacter curvatus*, *Methanosarcina mazei* S6; *Methanosarcina barkeri* 227. All were grown with acetate except *Methanosarcina mazei* S6 which was grown with TMA.

Results: No inhibitory effects observed.

San Francisco Marina	5/12/95	2 (0.24μCi)	none		23	0	0	0	0.34 (0.51)	43.21 (12.70)
" "	5/12/95	2 (0.24μCi)	SO_4		23	0	0	0	< D.L.	40.70 (9.31)
" "	5/12/95	2 (0.24μCi)	none	TMA	23	0	0	0	121.78 (6.58)	53.50 (6.28)
" "	5/12/95	2 (0.24μCi)	O_2		23	0	0	0	< D.L.	76.58 (13.12)
Bolinas Bay South (various depths)	6/7/95	2 (0.2μCi)	none		ongoing					

TABLE III. PURE CULTURES + 2-14C-TFA

Culture	Date	Experiment Type	Conditions	Incubation Time (days)	^{14}C Gas Phase Products (% Conversion from ^{14}C-TFA)		
					$^{14}CH_4$	$^{14}CO_2$	$^{14}CHF_3$
Thiobacillus ASN1	3/22/95	Cell Suspension	oxic to anoxic; $+NO_3$; carbonate buffer	22	0	0	4.54 (0.80)
Thiobacillus ASN1	5/10/95	Cell Suspension	oxic to anoxic; $+NO_3$; $Na_2S+S_2O_3$; +acetate; Tris buffer	21	0	0	0
SES-3	2/8/95	Cell Suspension	$+H_2$; +Acetate; $+NO_3$	1	0	0	0
" "	" "	" "	$+N_2$; $+NO_3$	1	0	0	0
" "	" "	" "	$+N_2$; $+NO_3$; +acetate	1	0	0	0
" "	" "	" "	$+H_2$; $+NO_3$	1	0	0	0
" "	" "	" "	$+H_2$; $+NO_3$; +acetate	1	0	0	0
" "	" "	" "	$+H_2$	1	0	0	0
Geobacter metallireducens GS-15	4/10/95	Growing Culture	+acetate	28	0	0	0
Desulfuromonas acetoxidans	4/18/95	Growing Culture	+acetate	20	0	0	0
Desulfobacter curvatus	4/28/95	Growing Culture	+acetate	17	0	0	0

IV. MINIMUM INHIBITORY CONCENTRATION EXPERIMENTS

A range of TFA concentrations (100nM to 1mM) were added to growing cultures to determine if the addition of TFA results in inhibition of growth.

TABLE II. SMALL CORE EXPERIMENTS
(3cc cores in 13ml serum bottles)

< D.L. = Less than detection limit of thermal conductivity detector (~0.1μmoles/headspace)
TMA = Trimethylamine
TFA = Trifluoroacetate
Numbers in parenthesis ( ) indicate standard deviation of triplicate sample
^{14}C-TFA specific activity = 54μCi/μmol

Site	Date	^{14}C-TFA (labeled Carbon)	Electron Acceptor Added	Electron Donor Added	Incubation Time (days)	^{14}C Gas Phase Products (% Conversion from ^{14}C-TFA)			CH_4 Production after 8-10 day incubation (μmoles/headspace)	CO_2 Production after 8-10 day incubation (μmoles/headsapce)
						$^{14}CH_4$	$^{14}CO_2$	$^{14}CHF_3$		
Mono Lake Brown Mat (0-1.5cm)	7/25/94	2 (0.4μci)	O_2		6	24 (14)	0	0	2.25 (0.70)	36.68 (6.62)
(2-5cm)	7/25/94	2 (0.8μCi)	none		6	7 (0)	0	0	3.31 (0.57)	10.43 (0.51)
(5-8cm)	7/25/94	2 (0.8μCi)	none		6	5 (1)			< D.L.	2.46 (0.04)
Mono Lake Green Mat (0-1.5cm)	7/25/94	2 (0.4μci)	O_2		29	0	0	0	1.59 (0.06)	27.93 (5.85)
(2-5cm)	7/25/94	2 (0.8μCi)	none		29	0	0	0	4.86 (2.36)	15.73 (2.90)
(5-8cm)	7/25/94	2 (0.8μCi)	none		29	0			< D.L.	4.19 (0.79)
Mono Lake Brown Mat (0-1cm)	8/15/94	2 (0.4μci)	O_2		70	0	0	0	10.29 (3.26)	16.37 (1.74)
(1-3cm)	8/15/94	2 (0.4μci)	none		70	0	0	0	3.45 (0.82)	3.63 (0.20)
(3-5.5cm)	8/15/94	2 (0.4μci)	none		70	0	0	0	< D.L.	0.81 (0.28)
(5-7cm)	8/15/94	2 (0.4μci)	none		70	0	0	0	< D.L.	0.63 (0.07)
Mono Lake Green Mat (0-2cm)	8/15/94	2 (0.4μci)	O_2		70	0	0	0	11.24 (2.23)	17.99 (1.90)
(2-4cm)	8/15/94	2 (0.4μci)	none		70	0	0	0	9.66 (3.30)	11.67 (0.47)
Palo Alto Saltmarsh	4/5/95	2 (0.2μCi)	none		42	0	0	0	67.74 (7.75)	135.73 (4.77)
(various depths)	6/7/95	2 (0.2μCi)	none		ongoing					
(modified Winogradsky at various depths)	6/7/95	2 (0.2μCi)	none		ongoing					

SEDIMENT SLURRIES - Page 3

Site	Date	^{14}C-TFA labeled Carbon	Electron Acceptor Added	Electron Donor Added	Incubation Time (days)	^{14}C Gas Phase Products (% Conversion from ^{14}C-TFA)			CH_4 Production after 8-12 day incubation (µmoles/headspace)	CO_2 Production after 8-12 day incubation (µmoles/headsapce)
						$^{14}CH_4$	$^{14}CO_2$	$^{14}CHF_3$		
Palo Alto Saltmarsh	12/28/94	1 (1µCi)	SO_4		36	0	0	0	63.3 (3.65)	134 (8.04)
" "	12/28/94	1 (1µCi)	none		36	0	0	0	112 (13.6)	140 (11.09)
" "	12/28/94	2 (0.38µCi)	SO_4		36	0	0	0	67.38 (8.33)	96.79 (7.54)
" "	12/28/94	2 (0.38µCi)	none		36	0	0	0	110.47 (2.51)	148.64 (1.74)
" "	12/28/94	1 (0.5µCi)	SO_4		36	0	0	0	72.89 (1.65)	130.94 (3.30)
" "	12/28/94	1 (0.5µCi)	none		36	0	0	0	119.33 (1.57)	153.29 (3.62)
" "	1/24/95	1 (0.5µci)	SO_4		41	0	0	0	0.65 (0.29)	73.13 (24.38)
" "	1/24/95	1 (0.5µCi)	SO_4	H_2	41	0	0	0	338 (81.9)	0 (0)
" "	1/24/95	2 (0.5µCi)	SO_4		41	0	0	0	0.33 (0.14)	67.72 (2.19)
" "	1/24/95	2 (0.5µCi)	SO_4	H_2	41	0	0	0	332 (74.5)	0 (0)
" "	1/24/95	1 (0.5µCi)	none		41	0	0	0	1.20 (0.24)	63.26 (4.38)
" "	1/24/95	1 (0.5µCi)	none	H_2	41	0	0	0	342 (2.01)	0 (0)
" "	1/24/95	2 (0.5µCi)	none		41	0	0	0	1.43 (0.26)	67.33 (1.01)
" "	1/24/95	2 (0.5µCi)	none	H_2	41	0	0	0	348 (12.1)	0 (0)
" "	3/23/95	2 (0.8µCi)	SO_4		55	0	0	0	0.17 (0.06)	89.5 (1.41)
" "	3/23/95	2 (0.8µCi)	NO_3		55	0	0	0	< D.L.	124.92 (16.13)
" "	3/23/95	2 (0.8µCi)	NO_3 (+MoO_4, +BES)		55	0	0	0	< D.L.	91.2 (1.85)
Palo Alto Saltmarsh (0-4.5cm)	5/3/95	2 (0.4µCi)	none		26	0	0	0	< D.L.	213 (29.8)
" "	5/3/95	2 (0.4µCi)	SO_4		26	0	0	0	< D.L.	197 (27.9)
" "	5/3/95	2 (0.4µCi)	MnO_2		26	0	0	0	< D.L.	119 (9.21)
" "	5/3/95	2 (0.4µCi)	none	TMA	26	0	0	0	395 (19.8)	274 (4.02)
" "	5/3/95	2 (0.4µCi)	FeNTA		26	0	0	0	< D.L.	272 (42.2)
(4.5-9cm)	5/3/95	2 (0.4µCi)	none		26	0	0	0	< D.L.	95.9 (55)
" "	5/3/95	2 (0.4µCi)	SO_4		26	0	0	0	< D.L.	130 (4.02)
(9-12.5cm)	5/3/95	2 (0.4µCi)	none		26	0	0	0	< D.L.	109 (8.04)
" "	5/3/95	2 (0.4µCi)	SO_4		26	0	0	0	< D.L.	125 (10.5)
(25-30cm)	5/3/95	2 (0.4µCi)	none		26	0	0	0	< D.L.	113 (10.1)
" "	5/3/95	2 (0.4µCi)	SO_4		26	0	0	0	< D.L.	110 (5.32)
Palo Alto Saltmarsh	5/17/95	2 (0.8µCi)	O_2		ongoing					
" "	5/23/95	2 (0.79µCi)	none		ongoing					

SEDIMENT SLURRIES - Page 5

Site	Date	^{14}C-TFA labeled Carbon	Electron Acceptor Added	Electron Donor Added	Incubation Time (days)	^{14}C Gas Phase Products (% Conversion from ^{14}C-TFA)			CH_4 Production after 8-12 day incubation (µmoles/headspace)	CO_2 Production after 8-12 day incubation (µmoles/headsapce)
						$^{14}CH_4$	$^{14}CO_2$	$^{14}CHF_3$		
Sherman Island	4/1/94	2 (10.2µCi)	NO_3		10	0	0.42 (0.12)	0	< D.L.	66.74 (0.74)
Bolinas Bay South	5/25/95	2 (0.79µCi)	none		ongoing					
" "	5/25/95	2 (0.79µCi)	SO_4		ongoing					
" "	5/25/95	2 (0.79µCi)	none	TMA	ongoing					
Bolinas Bay North	5/26/95	2 (0.79µCi)	none		ongoing					
" "	5/26/95	2 (0.79µCi)	SO_4		ongoing					
" "	5/26/95	2 (0.79µCi)	none	TMA	ongoing					

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Site	Date	^{14}C-TFA labeled Carbon	Electron Acceptor Added	Electron Donor Added	Incubation Time (days)	^{14}C Gas Phase Products (% Conversion from ^{14}C-TFA)			CH_4 Production after 8-12 day incubation (µmoles/headspace)	CO_2 Production after 8-12 day incubation (µmoles/headsapce)
						$^{14}CH_4$	$^{14}CO_2$	$^{14}CHF_3$		
Palo Alto Saltmarsh	5/23/95	2 (0.79µCi)	SO_4		ongoing					
" "	6/5/95	2 (0.79µCi)	none		ongoing					
" "	6/5/95	2 (0.79µCi)	SO_4		ongoing					
" "	6/5/95	2 (0.79µCi)	none	TMA	ongoing					
Searsville Lake	10/6/93	2 (1.85µCi)	none		12	70.8 (11.3)	0	0	21.4 (5.3)	73.4 (8.1)
" "	10/6/93	2 (1.85µCi)	SO_4 MoO_4 BES		12	0	0	0	4.3 (2.0)	29.4 (5.7)
" "	10/6/93	2 (1.85µCi)	SO_4 MoO_4		12	62.7 (8.6)	0	0	14.4 (2.1)	158.6 (12)
" "	1/6/94	2 (0.925µCi)	none		18	44.8 (2.6)	0	0	49.2 (4.3)	84.8 (6.8)
" "	1/6/94	2 (0.463µCi)	none		18	52.3 (3.9)	0	0	67.9 (8.8)	53.2 (12.9)
" "	1/6/94	2 (0.925µCi)	SO_4		18	0	2.3 (0.7)	0	2.1 (0.2)	96.4 (18.6)
" "	1/6/94	2 (0.463µCi)	SO_4		18	0	17.1 (8.3)	0	3.4 (0.4)	79.7 (6.7)
" "	1/6/94	2 (0.925µCi)	NO_3		18	0	0	0	1.8 (0.4)	142.4 (8.4)
" "	1/6/94	2 (0.463µCi)	NO_3		18	0	0	0	6.7 (1.1)	156.1 (6.9)
" "	1/18/95	1 (1µCi)	none		23	0	0	0	109 (29.8)	153 (21.1)
" "	1/18/95	1 (0.5µCi)	none		23	0	0	0	98.67	30.97
" "	1/18/95	2 (0.76µCi)	none		23	0	0	0	98.4 (24)	151 (19.3)
" "	1/18/95	2 (0.38µCi)	none		23	0	0	0	83.12 (18.95)	136.28 (13.64)
" "	5/23/95	2 (79µCi)	none		ongoing					
" "	5/23/95	2 (79µCi)	none	TMA	ongoing					
Sherman Island	2/16/94	2 (1.0µCi)	none		23	0.9 (0.2)	0	0	26.7 (1.1)	62.8 (6.3)
" "	2/16/94	2 (0.5µCi)	none		23	0	0	0	41.3 (6.9)	52.1 (7.9)
" "	2/16/94	2 (1.0µCi)	NO_3		23	0	0	0	2.3 (0.5)	82.1 (2.3)
" "	2/16/94	2 (0.5µCi)	NO_3		23	0	0	0	8.3 (4.2)	67.7 (5.5)
" "	4/1/94	2 (4µCi)	NO_3		10	0	0.51 (0.05)	0	< D.L.	69.10 (2.90)