APPENDIX G
SUMMARY OF LITERATURE SOLUBILITY STUDIES

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<u>SUMMARY OF LITERATURE SOLUBILITY STUDIES</u>

1.0 INTRODUCTION

To obtain relevant solubility data on the actinides of interest, a literature search was conducted and solubility studies on actinide-bearing solids (e.g., $Pu(OH)_3$, UO_2) were compiled into a data base. The data base Attachment 1 contains records that provide information on the solid phase, solution composition, solution description (e.g., dilute, saline or brine), actinide concentration in solution, pH, Eh or atmospheric conditions, temperature, equilibration time of the experimental run, method employed to determine the solubility (e.g., equilibrium approached from an oversaturated solution, calculated with a geochemical code, etc), and reference for the study. Most of the results tabulated in Attachment 1 are presented graphically for the actinides Thorium (Th), Uranium (U), Neptunium (Np), Plutonium (Pu), and Americium (Am) in coordinates of log molar concentration (molar (M) = moles/liter) versus pH.

2.0 THORIUM

Thorium is only stable in the IV valence state in the natural environment. Solubility is usually controlled by thorianite (ThO_2). $Th(OH)_4$ may initially precipitate from an oversaturated solution, but it will age to the more stable ThO_2 (Brookins, 1988).

Figure G-1 summarizes data on Th solubility in saline and brine chloride solutions as reported by Felmy et al. (1991). The solubility of the Th precipitate decreases approximately 6 orders of magnitude over the pH interval of 3 to 6, followed by a flattening of the trend above a pH of 6. Precipitates obtained from these experiments were analyzed by x-ray diffraction (XRD) techniques and found to be amorphous to x-rays until they had been aged for about a year. Some of the 372-day precipitate obtained from the 3M NaCl experiment displayed an XRD pattern similar to crystalline ThO_2. However, these samples do not show significantly different solubilities, and Felmy et al. (1991) concluded that an amorphous phase still controls the solubility despite the presence of some crystalline precipitate.

Based on thermodynamic solubility calculations at 25°C and 1 atm in dilute solutions (e.g., Langmuir and Herman, 1980), the thorianite (crystalline ThO_2) solubility trend lies 4 to 5 orders of magnitude below the trend of the amorphous hydrous Th oxide indicated on Figure G-1. As Th occurs in transuranic waste primarily as oxides (Weiner, 1995), and the hydrous Th oxide is more soluble than the crystalline oxide form, solubility data on Figure G-1 represent a conservative (upper bound) estimate of Th solubility.

3.0 URANIUM

The dominant valence states for U in the natural environment are IV and VI. Uranium (VI) is much more soluble that U (IV), and has a strong affinity for carbonate complexation. Important solubility-controlling minerals include uraninite (UO_2) for U (IV), and schoepite ($UO_3 \cdot 2H_2O$) for

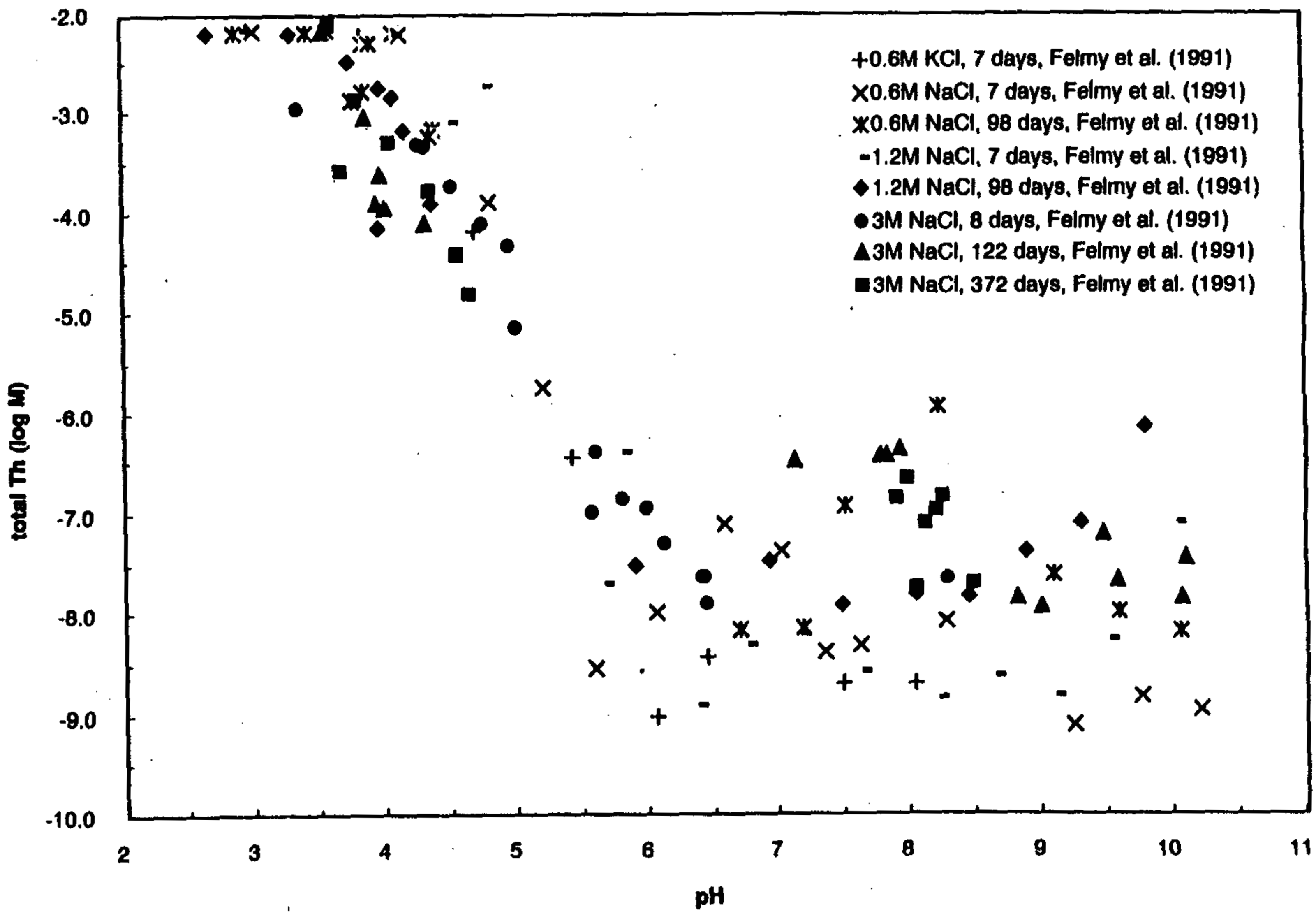


Figure G-1
Hydrous Th(IV) Oxide Solubility as a Function of pH for dilute and Brine Solutions

U (VI). The presence of organic materials and corrodable metals in the repository environment will probably restrict U to the IV state.

Figure G-2 summarizes U solubility data for uraninite (UO_2). Solubility data reported by Parks and Pohl (1988) for UO_2 at 100 and 150°C in dilute NaCl solution (0.1 M) indicate a decrease in the concentration of U from -7 to -9.5 log M as pH increases from 1 to 7. Gray (1986) investigated the solubility of unirradiated UO_2 fuel-rod pellets in a saturated NaCl brine of pH 6.2 to 6.4 and reported U concentrations of -7 to -8 log M, about 1.5 to 2.5 orders of magnitude lower than UO_2 solubility values in dilute NaCl solutions. The solubility data of Gray (1986) serve as a conservative estimate of U concentrations in Salado brine, because the solubility of UO_2 increases with temperature and the solubility data were obtained at elevated temperatures, relative to the ambient temperature of about 30°C in the WIPP repository horizon.

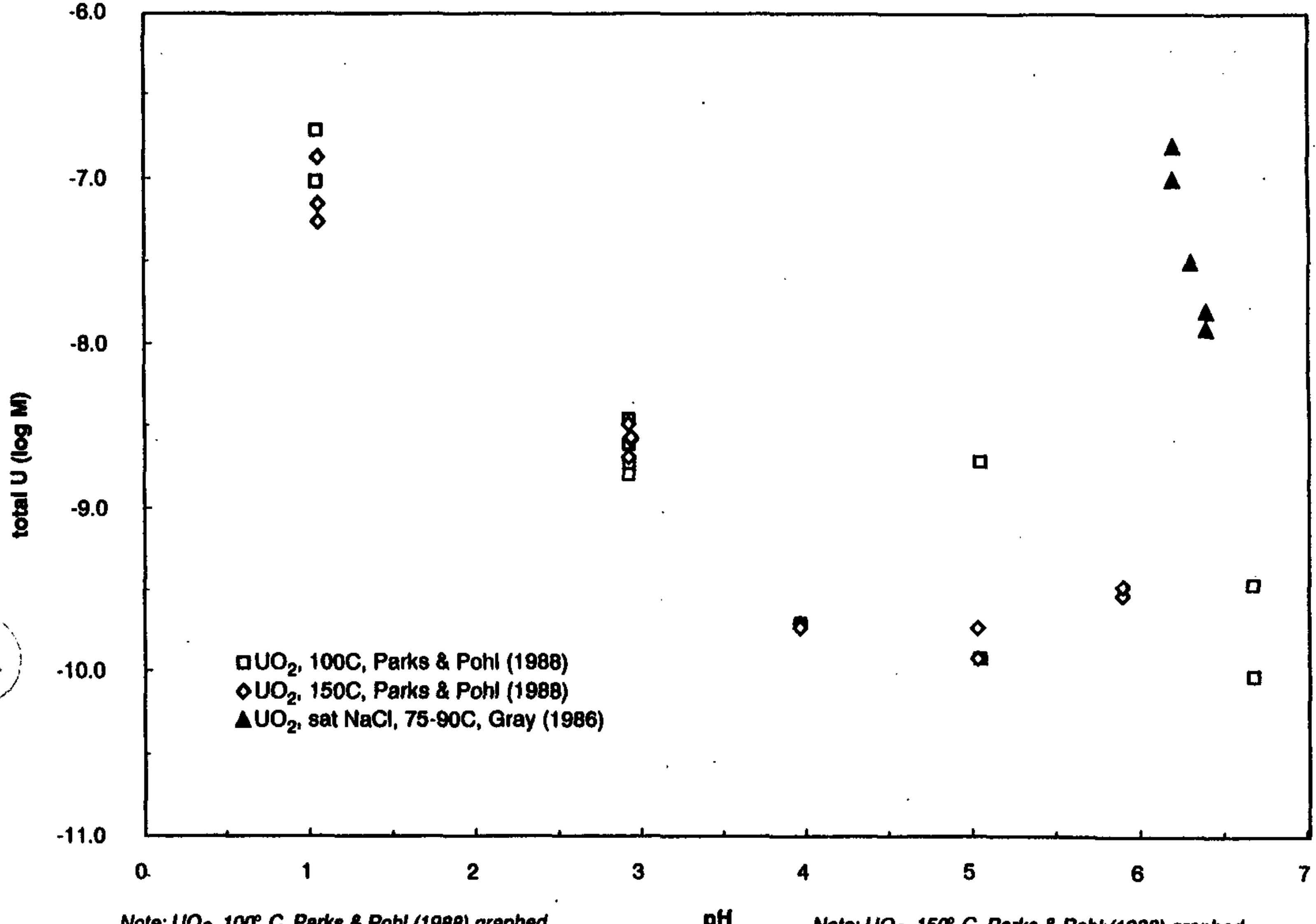
Figure G-3 summarizes U solubility data for schoepite ($UO_3 \cdot 2H_2O$) in $HClO_4$ solutions at 25°C. Krupka et al. (1985) obtained solubility data that indicate a decrease in the U concentration from -2 to -5 log M as pH increased from 3 to 9. This trend was followed by an increase of similar magnitude in the U concentration over the pH interval of 9 to 12. Bruno and Sandino (1989) conducted solubility experiments with amorphous and crystalline $UO_3 \cdot 2H_2O$, which show the amorphous schoepite to be one to two orders of magnitude more soluble than the crystalline form. Solubility studies for schoepite in saturated NaCl brine were not found. However, based on the studies presented on Figure G-2 for UO_2, it is expected that schoepite solubility in Salado brine will be 1 to 2 orders of magnitude greater than the dilute solution data on Figure G-3.

4.0 NEPTUNIUM

The dominant valence states for Np in the natural environment are IV, V, and VI. As is the case with U and Pu, Np solubilities are highly dependent on valence state. Np (IV) is expected to dominate in the reducing repository environment, with solubility being controlled by crystalline NpO_2. Other forms of Np (IV) such as amprphous NpO_2, $NpO_2 \cdot xH_2O$, and $Np(OH)_4$ will age to crystalline NpO_2. An important Np(V) solubility-controlling phase is NpO_2OH.

Figure G-4 summarizes Np (IV) solubility data for NpO_2 and $NpO_2 \cdot xH_2O$ in dilute solutions and NaCl brines. The studies of Rai and Strickert (1980) and Rai et al. (1982) at 25°C show a decrease in Np concentration from -5.5 to -6.5 log M as pH increases from about 2 to 6. The data of Kim et al. (1985b) were obtained in 1M and 5M NaCl solutions at 20 to 25° C. The runs at pH of 5 to 6 resulted in Np concentrations of about -4.5 log M, and those at a pH of 7.5 to 8 show a Np concentration of about -6 log M. Ionic strength does not appear to affect the solubility of Np in these 1M and 5M runs, but a comparison of these data over the pH range of 5 to 6 with the data of Rai and Strickert (1980) suggests the solubility of NpO_2 is increased by about 1.5 orders of magnitude in NaCl solutions of moderate to high ionic strength.

Pryke and Rees (1987) investigated the solubility of $NpO_2 \cdot xH_2O$ in solutions equilibrated with concrete at ambient temperature. Results on Figure G-4 show an apparent decrease in the Np concentration of about one-half log unit as the pH increase from 10 to 13. Comparing the studies of Pryke and Rees (1987) and Rai and Strickert (1980), it appears that the data of Pryke and Rees (1987) anchor the projected trend of the data of Rai and Strickert (1980).



Note: UO_2, 100° C, Parks & Pohl (1988) graphed data does not include 3 outlying points: (E922, F922), (E923, F923) and (E924, F924).

Note: UO_2, 150° C, Parks & Pohl (1988) graphed data does not include 4 outlying points: (E939, F939), (E940, F940), (E941, F941) and (E942, F942).

Figure G-2
UO_2 Solubility as a Function of pH for Dilute and Brine Solutions

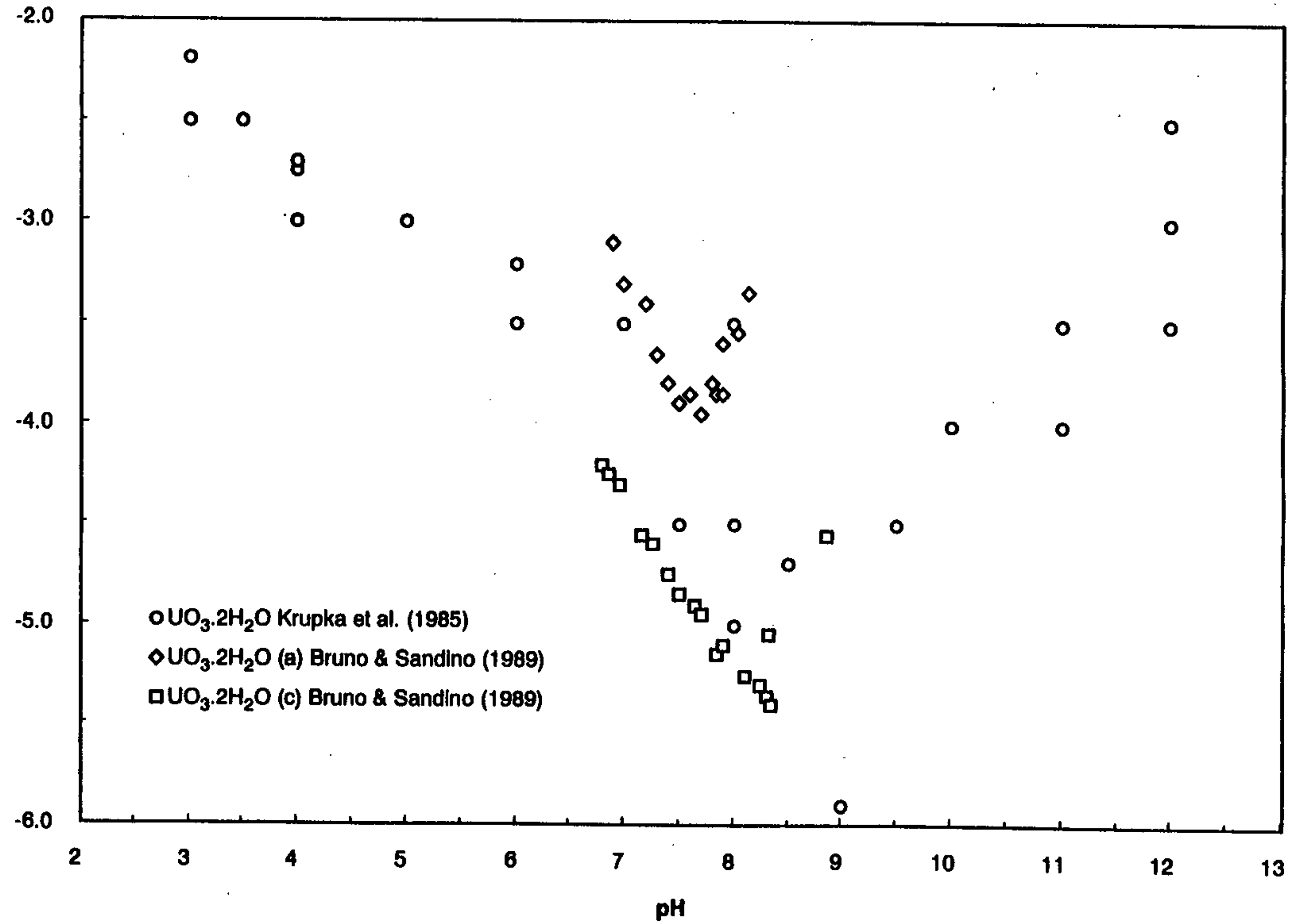


Figure G-3
UO_3:$2H_2O$ Solubility as a Function of pH for Dilute Solutions

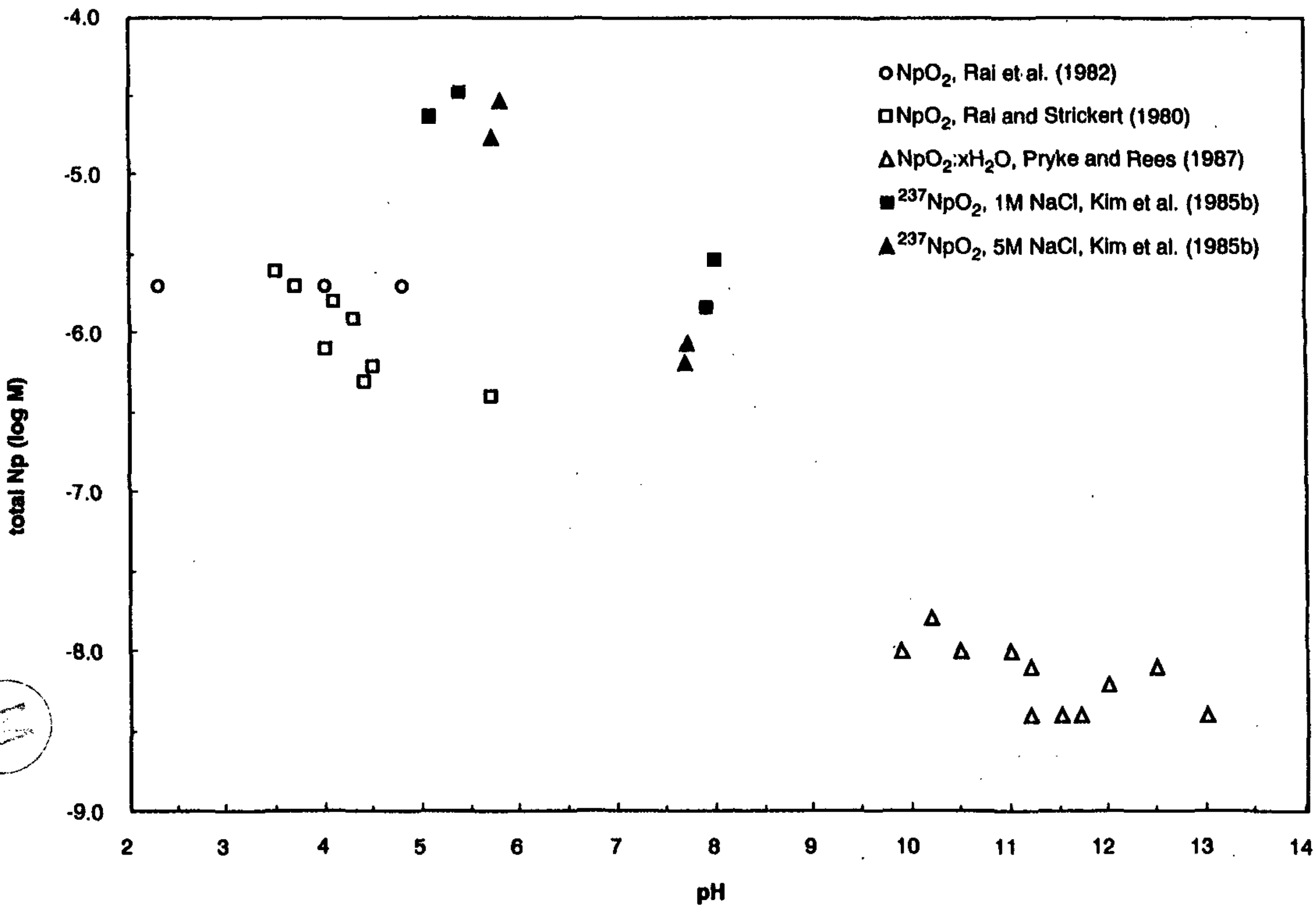


Figure G-4
NpO_2 Solubility as a Function of pH for Dilute, Saline, and Brine Solutions

Results for Np (V) solubility studies are plotted on Figure G-5. Ewart et al. (1985) investigated the solubility of NpO_2OH in cement-equilibrated water. Results for this study illustrate a rapid decrease in the Np concentration from about -5 to -9.5 log M between a pH of 9 to 13. Solubility studies on NpO_2OH in $NaClO_4$ and NaCl solutions were conducted by Kim et al. (1985b) at 20 to 25°C. Results for NpO_2OH in 1M $NaClO_4$ indicate a decrease in the Np concentration from -2 to -6 log M over the pH interval 6 to 11, followed by increasing Np concentration over the pH interval of 11 to 13. The solubility of NpO_2OH in 1M and 5M NaCl solutions is about 2.5 orders of magnitude lower at a pH of about 6.5, relative to the 1M $NaClO_4$ study. This suggests that Np (V) may be reduced to Np (IV) in the NaCl solutions, resulting in solubility control by NpO_2 rather than NpO_2OH. Additional solubility studies by Neck et al. (1992) with NpO_2OH in dilute solution and 1M and 3M $NaClO_4$ solutions indicate decreasing Np concentrations as pH increases from about 7 to 11.5 followed by a rise in the Np concentration as pH increase to 14. In comparing the dilute and 3M brine results of Neck et al. (1992), it is of interest that the 3M results indicate NpO_2OH solubility is about an order of magnitude lower in the brine relative to the dilute solution, which is in contrast to results presented on Figure G-4 for NpO_2.

5.0 PLUTONIUM

Plutonium displays the most complex behavior of the five actinides of interest because of the four (III, IV, V, and VI) possible valence states. In a reducing environment, the solubility-controlling phases are probably $Pu(OH)_3$, $PuO_2{\bullet}xH_2O$, PuO_2, or $Pu(OH)_4$. Pu may be controlled in an oxidizing environment by $PuO_2(OH)_2$.

Figure G-6 summarizes Pu (III) solubility data. Rai et al. (1987) measured the Pu concentrations in deionized water and Permian Basin brines at 23°C in contact with amorphous $^{239}Pu(OH)_3$. Results for runs with deionized water show a decrease in Pu concentration from about -3.5 to -10 log M as pH increases from 6 to 9, followed by a flat data trend between pH 9 and 13 that indicates a Pu concentration of about -9.5 log M. A similar trend is observed for Pu concentration in Permian Basin brine, although the Pu concentration appears slightly greater above a pH of 7 relative to the deionized water runs. Based on the measured pH value for the Permian Basin brines, the solubility of $^{239}Pu(OH)_3$ does not appear to be affected greatly by changes in ionic strength of the solutions. However, Felmy et al. (1989) presented the preliminary data of Rai et al. (1987) with pH values of the Permian Basin brines recalculated to account for the difference in liquid junction potential between the solutions and standards. The recalculated pH values were one to two pH units greater than the measured values, which shifts the $^{239}Pu(OH)_3$ sample points in Figure G-6 to the right and suggests the amorphous hydroxide is two to three orders of magnitude more soluble in the brines at the recalculated pH, relative to deionized water.

$Pu(OH)_4$ solubility data for dilute solutions and a NaCl saturated brine are given on Figure G-7. Ewart et al. (1985) investigated the solubility of $Pu(OH)_4$ in cement-equilibrated water over the pH interval of 7 to 13. Their results show a decrease in Pu concentration from about -5.5 to -10.5 as pH increases to 12. Rai et al. (1980) presented results on the solubility of amorphous $^{239}Pu(OH)_4$ at 25°C that show Pu concentration decreases from about -4.5 to -7.5 log M as pH increases from 3 to 8. Flambard et al. (1986) conducted experiments on the solubility of $Pu(OH)_4$ in H_2O saturated with NaCl at 23°C over a pH interval of 1 to 10. Their limited data set show no significant difference in solubility relative to data sets obtained with dilute solutions at a pH of about 5. However, the comparison of the data sets at pH 10 indicates that the Pu concentration

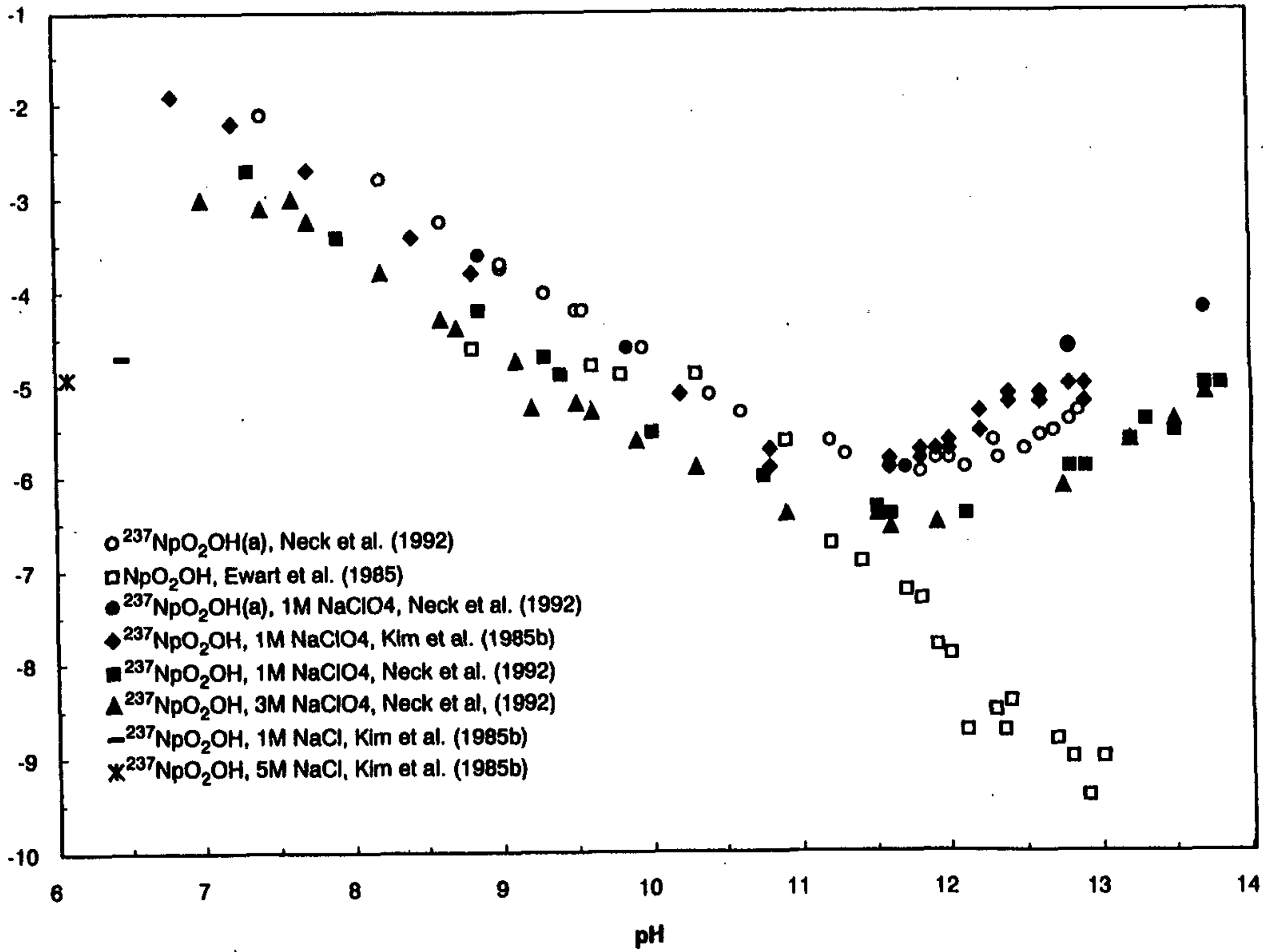


Figure G-5
NpO_2OH Solubility as a Function of pH for Dilute, Saline, and Brine Solutions

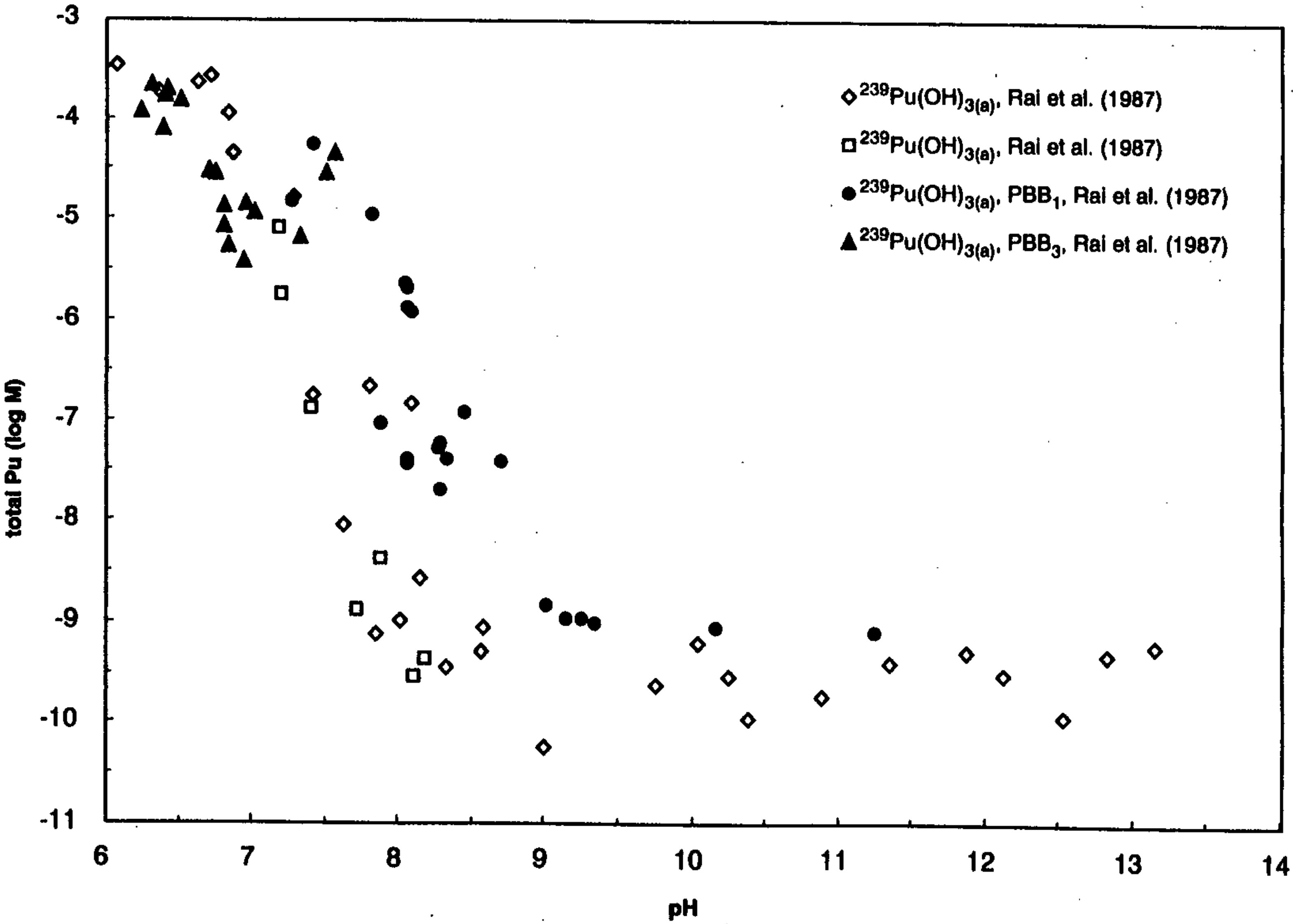


Figure G-6
Amorphous $^{239}Pu(OH)_3$ Solubility as a Function of pH for Dilute Brine and Solutions

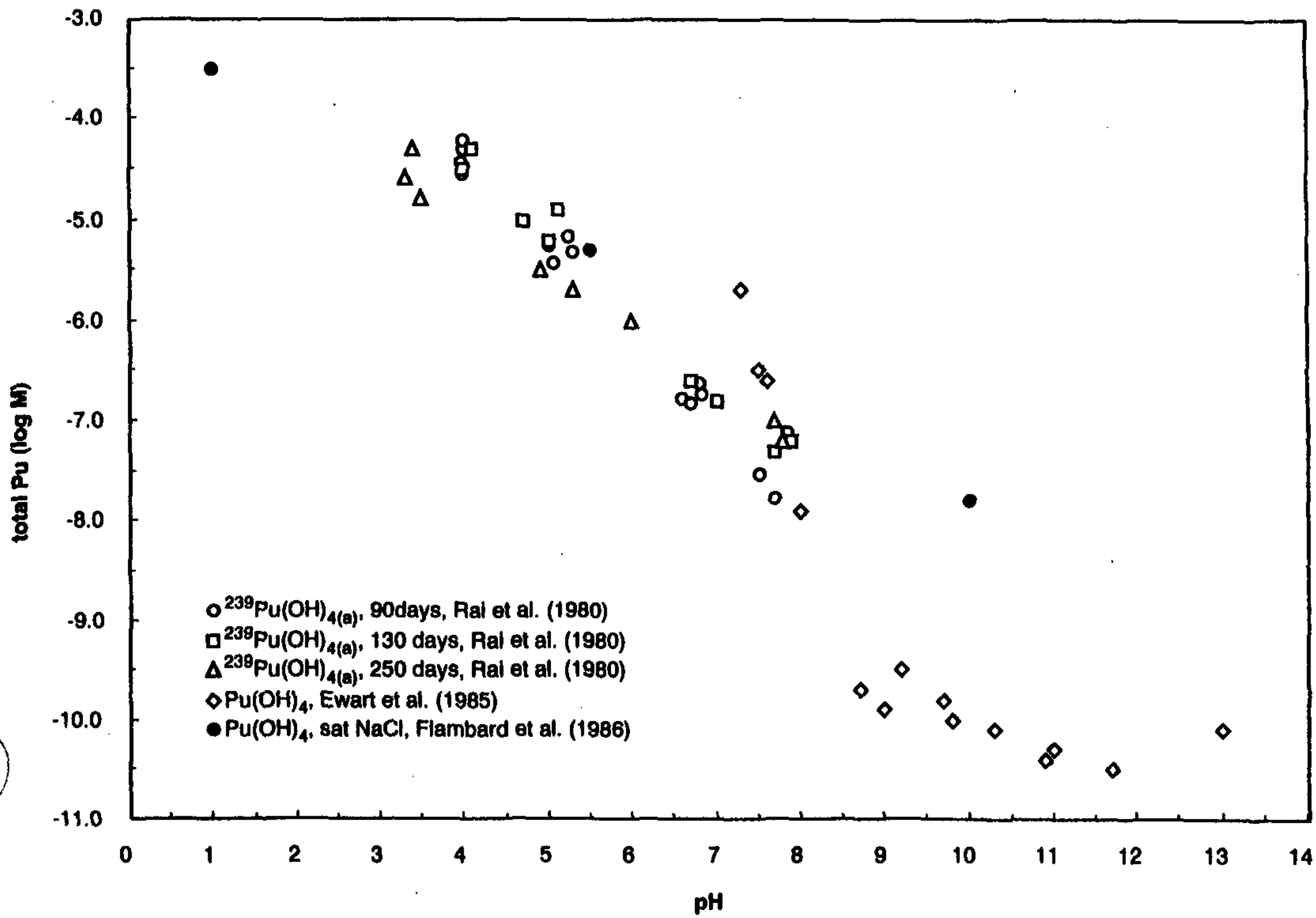


Figure G-7
Amorphous $Pu(OH)_4$ Solubility as a Function of pH for Dilute and Brine Solutions

is about two orders of magnitude greater in the brine relative to the dilute solution used by Ewart et al. (1985).

Figure G-8 summarizes solubility studies carried out by Kim et al. (1985a) and Kim et al. (1985b) with $^{238}PuO_2$ in dilute solutions and NaCl brines. The solubility of $^{238}PuO_2$ in a 0.1M NaCl solution decreases sharply from -5.5 to -7 log M over the pH interval of about 3 to 3.5, followed by an apparent increase in Pu concentration to about -6 log M as the pH rises to 5.5. Data points for the 3M and 5M NaCl brines indicate an increase in Pu concentration as pH increases. These observed trends are the opposite of most actinide solubility trends, which show decreasing actinide concentrations with increasing pH. Kim et al. (1985a) attributed the enhanced solubility to radiolysis effects and colloid formation.

Solubility data for $^{239}PuO_2$ are summarized on Figure G-9. The data reported by Rai et al. (1980) on $^{239}PuO_2$ solubility in dilute solutions shows a decrease in Pu concentration from approximately -5 to -9 log M as pH increases from about 3 to 8. Solubility data reported by Kim et al. (1985b) for $^{239}PuO_2$ follow a decreasing trend that is parallel to the data of Rai et al. (1980) but at Pu concentrations that are one to two orders of magnitude lower over the pH interval of 4 to 6.5. The large difference in the solubility of $^{239}PuO_2$ obtained by these two independent studies may be due to variation in the degree of crystallinity of the $^{239}PuO_2$ solid used in the experiments. Additional solubility studies with $^{239}PuO_2$ were carried out by Kim et al. (1985b) using 5M NaCl solutions, and these data plot below the dilute solution data obtained by Kim et al. (1985b) between pH 3.5 and 5 but then converge around a pH of 7.

Data on the solubility of $PuO_2{\bullet}xH_2O$ and $^{238}PuO_2(OH)_2$ in dilute solutions are summarized on Figure G-10. Pryke and Rees (1987) examined the solubility of $PuO_2{\bullet}xH_2O$ in cement-equilibrated solutions adjusted to selected pH values with HCl. Their data show a sharp decrease in Pu concentration from about -6 to -10 log M as pH increases from 7 to 9, followed by a shallow decrease as pH rises to 12. Solubility data for Pu (VI) was investigated by Kim et al. (1985b) using $^{238}PuO_2(OH)_2$. The data of Kim et al. (1985b) indicate a decrease in the Pu concentration from about -4 to -8.5 as the pH increases from about 5.5 to 10. Above a pH of 10, the solubility trend for $^{238}PuO_2(OH)_2$ shows a slight increase in Pu concentration.

6.0 AMERICIUM

Americium can be present in the natural environment in the III, IV, and V valence states. The valence state with the largest stability field is the III state.

Figure G-11 summarizes data on the solubility of $Am(OH)_3$. Rai et al. (1983) investigated the solubility of amorphous $^{241}Am(OH)_3$ in dilute solutions adjusted with HCl or NaOH to set pH, and the solubility of amorphous $^{243}Am(OH)_3$ in a pure H_2O solution that had pH adjusted with HCl or tetrapropyl NH_4OH. These data sets indicate a decrease in Am concentration from approximately -4 to -10 log M as the pH increases from about 7 to 10. Above a pH of 10, the trend of the plotted solubility points is essentially flat, and the Am concentration is maintained at around -10 log M.

Kim et al (1985b) examined the solubility of $Am(OH)_3$ in a 0.1M $NaClO_4$ solution and their data follow a trend similar to the data of Rai et al. (1983), but for a given pH the solubility data of

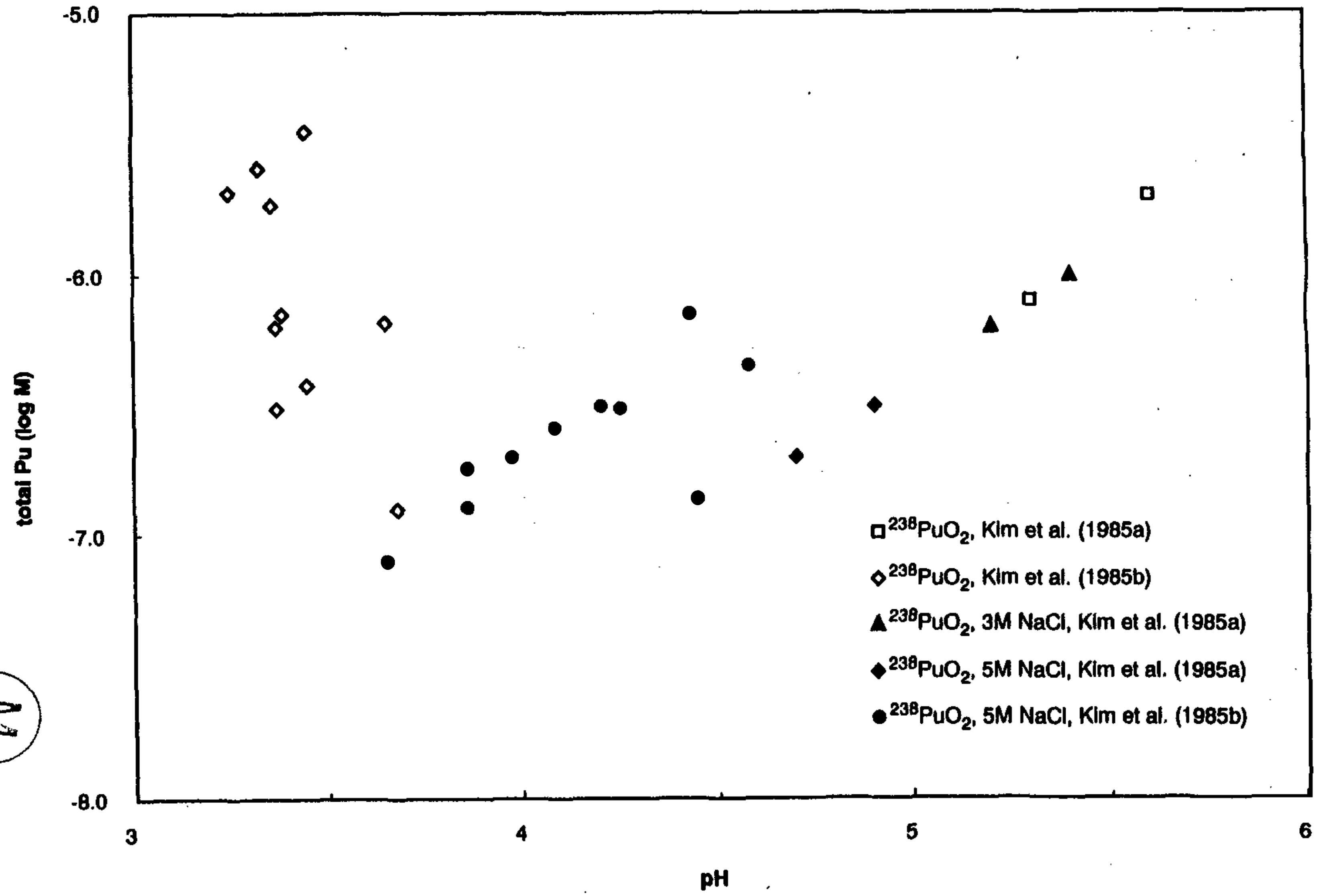


Figure G-8
$^{238}PuO_2$ Solubility as a Function of pH for Dilute and Brine Solutions

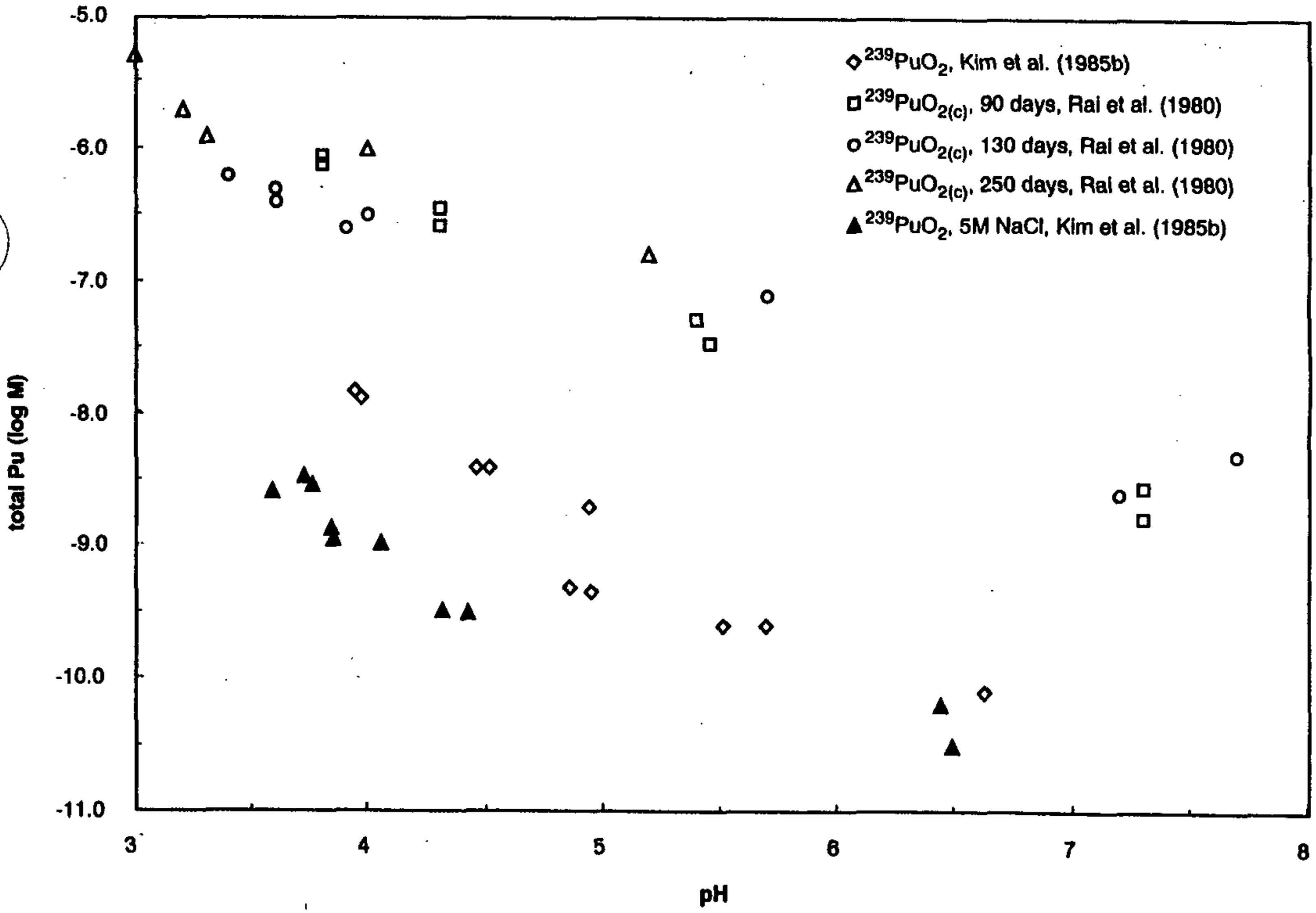


Figure G-9
$^{239}PuO_2$ Solubility as a Function of pH for Dilute and Brine Solutions

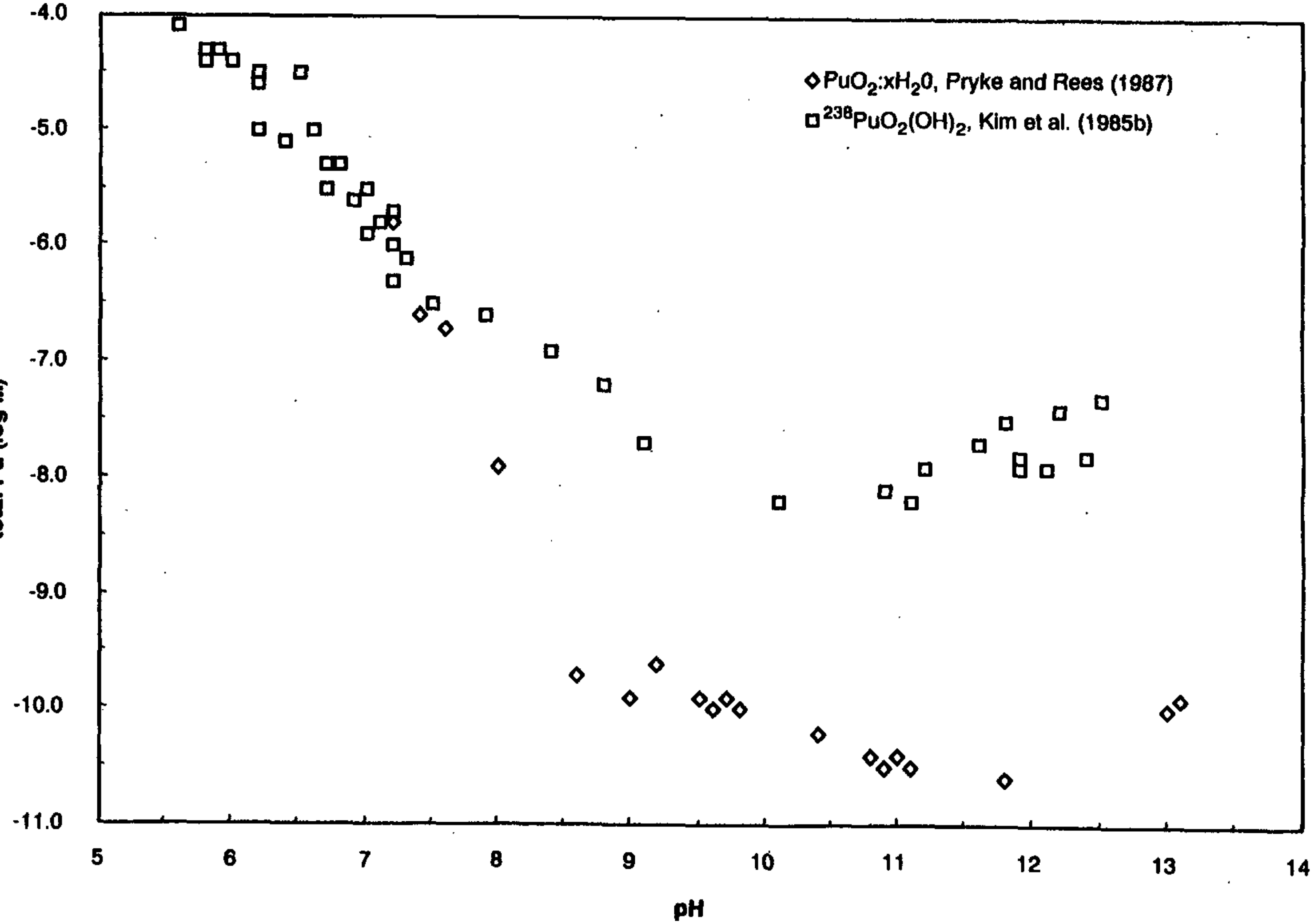


Figure G-10
$PuO_2 \cdot x\ H_2O$ and $PuO_2\ (OH)_2$ Solubilities as a Function of pH for Dilute Solutions

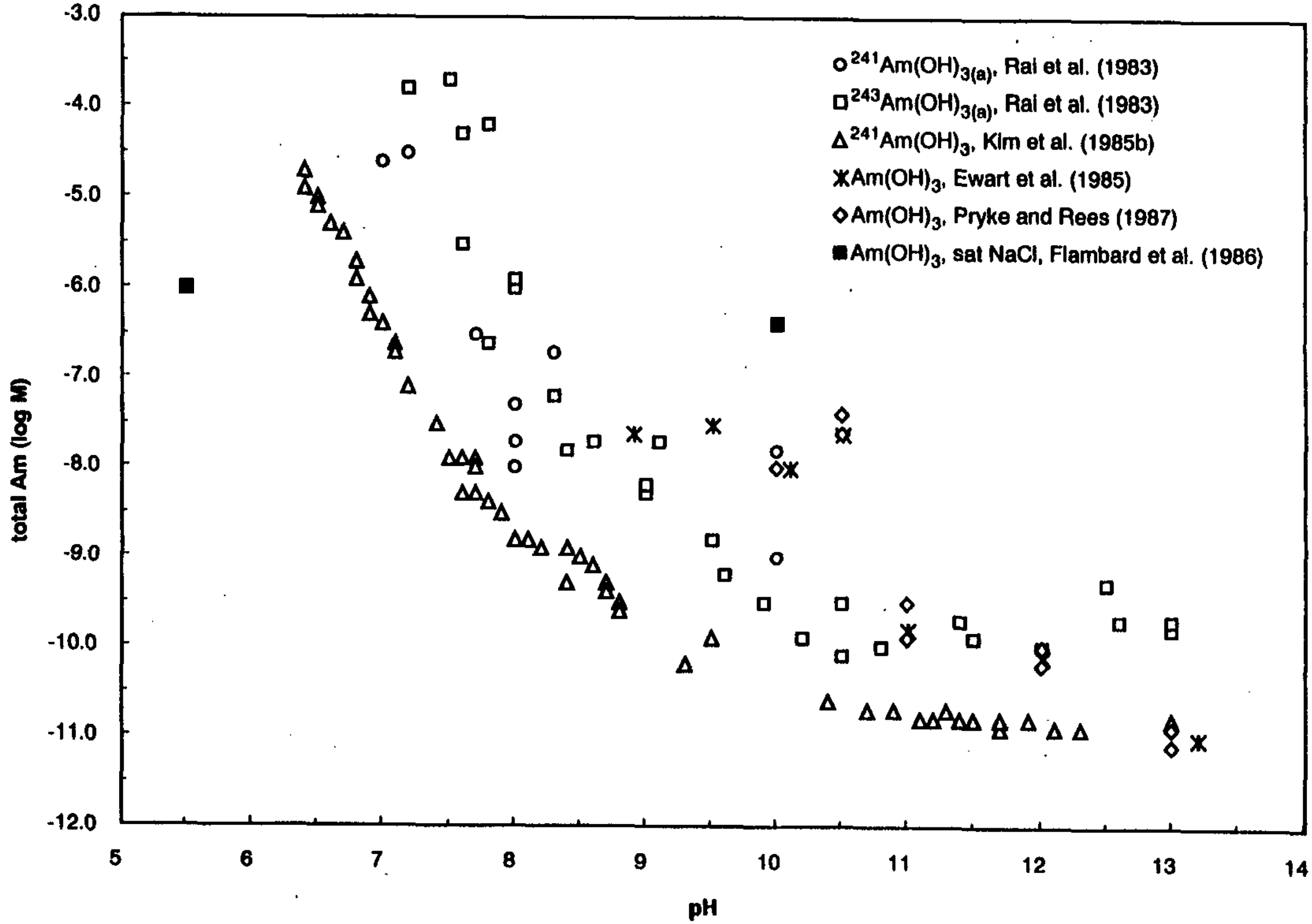


Figure G-11
$Am(OH)_3$ Solubility as a Function of pH for Dilute and Brine Solutions

Kim et al. (1985b) are about 0.5 to 1 order of magnitude lower (Figure G-11). This may indicate that the hydroxide used by Kim et al. (1985b) was aged to a microcrystalline form, relative to the amorphous form used by Rai et al. (1983).

Ewart et al. (1985) investigated the solubility of $Am(OH)_3$ in cement-equilibrated solutions and their results show an abrupt decrease in the Am concentration from about -8 to -10 log M between a pH of 10.5 to 11 (Figure G-11). The data of Pryke and Rees (1987) were also obtained with cement-equilibrated solutions and their results closely follow the trend of data reported by Ewart et al. (1985).

Flambard et al. (1986) reported limited data on the solubility of $Am(OH)_3$ in a saturated NaCl solution (Figure G-11). Their two data points on Figure G-11 suggest a slight decrease in solubility as pH increases from 5.5 to 10. Based on their data point at a pH of 10, the solubility of $Am(OH)_3$ may be 1.5 to 3 orders of magnitude greater in saturated NaCl brines relative to dilute solutions.

Figure G-12 summarizes solubility data for the Am (IV) and Am (V) solids AmO_2, AmO_2OH, and $AmOHCO_3$. Kim et al. (1985b) reported limited data on AmO_2 in 0.5 and 5M NaCl solutions over the pH range of 3.5 to 5. The overlap of data point at a pH near 4 suggests that ionic strength does not have a strong effect on the solubility of AmO_2 in this pH interval. Kim et al. (1985b) also looked at the solubility of AmO_2OH in 5M NaCl solution, and their results indicate a decrease in Am concentration from about -4 to -8 over the pH interval of 8 to 13.

Solubility studies on amorphous $AmOHCO_3$ carried out by Pryke and Rees (1987) show a decrease in Am concentration from about -4.5 to -7.5 as pH increases from 7 to 9.5 (Figure G-12). Similar studies carried out by Felmy et al. (1990) indicate significantly lower Am concentration of -8 to -8.5 log M over the pH range of 7 to 9, due to the aging of their precipitates to crystalline $AmOHCO_3$. The convergence of these independent data sets at a pH near 9.5 is due to the instability of $AmOHCO_3$ above a pH of 9.5 as $Am(OH)_3$ becomes the stable phase.

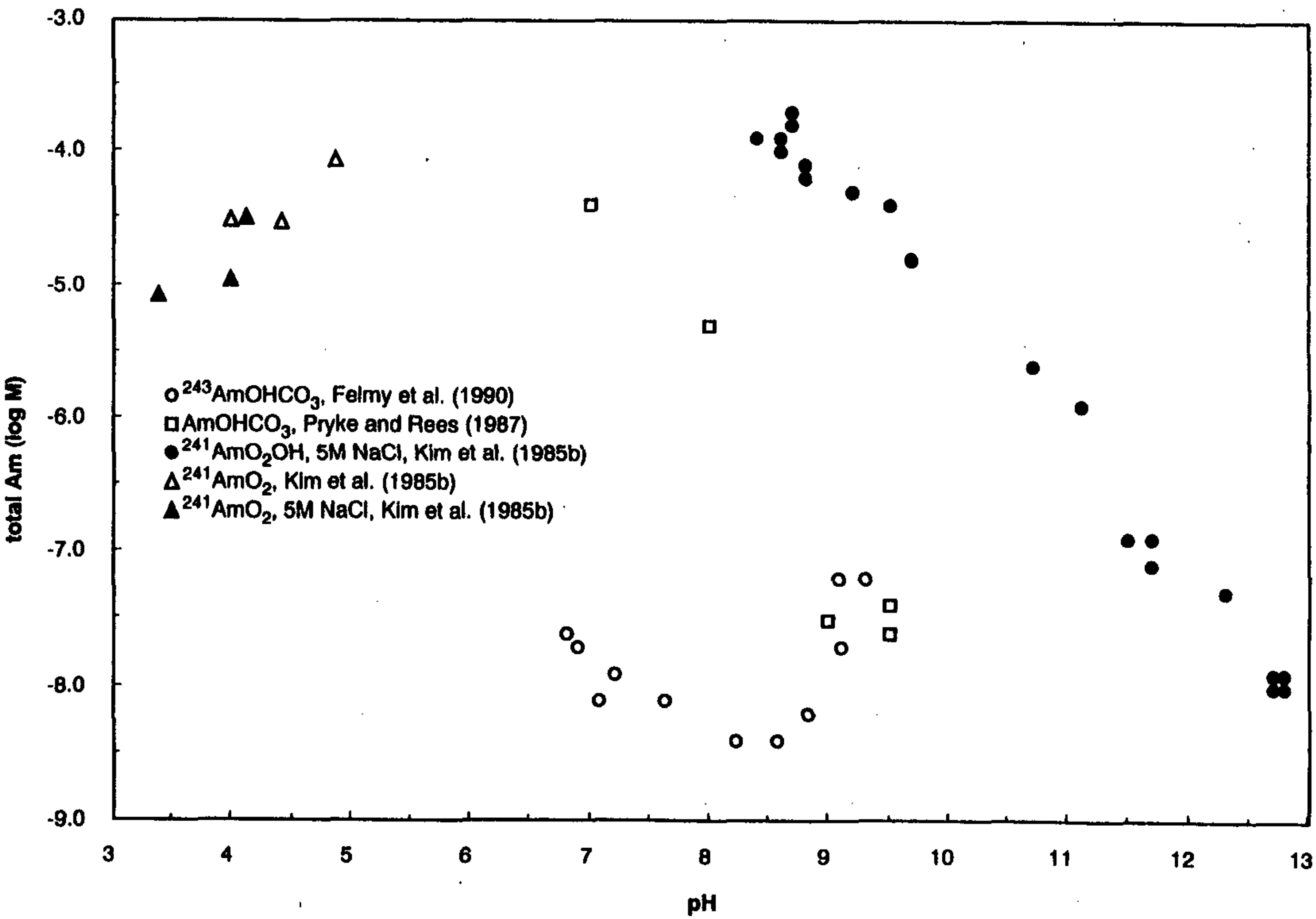


Figure G-12
$AmOHCO_3$, AmO_2OH, and AmO_2 Solubilities as a Function of pH for Dilute and Brine Solutions

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APPENDIX G
ACTINIDE SOLUBILITY DATA BASE
ATTACHMENT 1

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ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Am	amorphous 241am(oh)3	h2o+1.5E-3Mcacl2 + hcl or naoh to adjust pH	dilute	7	-4.6	oversaturation	7	air atm	22	Rai et al., 1983	1,2,6
				8	-6						
				10	-7.8						
Am	amorphous 241am(oh)3	h2o+1.5E-3Mcacl2 + hcl or naoh to adjust pH	dilute	7.7	-6.5	undersaturation	4	air atm	22	Rai et al., 1983	1,2,6,8
				7.2	-4.5		7				
				8.3	-6.7		7				
				10	-9		7				
				8	-7.3		11				
				8	-7.7		14				
				8	-8		26-28				
Am	amorphous 243am(oh)3	h2o + hcl or tetrapropyl nh4oh to adjust pH	dilute	7.8	-4.2	oversaturation	7	ar+n2 atm	22	Rai et al., 1983	1,2
				7.8	-6.6						
				8.3	-7.2						
				9.1	-7.7						
Am	amorphous 243am(oh)3	h2o + hcl or tetrapropyl nh4oh to adjust pH	dilute	7.5	-3.7	undersaturation	3	ar+n2 atm	22	Rai et al., 1983	1,2
				8	-6		3				
				9	-8.3		3				
				9.6	-9.2		3				
				10.2	-9.9		3				
				10.8	-10		3				
				11.5	-9.9		3				
				12	-10		3				
				13	-9.8		3				
				7.6	-4.3		7				
				8	-5.9		7				
				8.6	-7.7		7				
				9	-8.2		7				
				9.5	-8.8		7				
				9.9	-9.5		7				
				10.5	-10.1		7				
				11.5	-9.9		7				
				12.6	-9.7		7				
				13	-9.7		7				
				7.2	-3.8		23				
				7.6	-5.5		23				
				8.4	-7.8		23				
				10.5	-9.5		23				
				11.4	-9.7		23				
				12	-10		23				
				12.5	-9.3		23				
Am	241am(oh)3	h2o + 0.1M naclo4	dilute	6.4	-4.7	undersaturation	NA	ar atm	25	Kim et al., 1985b	1,17
				6.4	-4.9						
				6.5	-5						
				6.5	-5.1						
				6.6	-5.3						
				6.7	-5.4						
				6.8	-5.7						
				6.8	-5.9						
				6.9	-6.1						
				6.9	-6.3						
				7	-6.4						
				7.1	-6.6						

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Am	241am(oh)3	h2o + 0.1M naclo4	dilute	7.1	-6.7	undersaturation	NA	ar atm	25	Kim et al., 1985b	1,17
				7.2	-7.1						
				7.4	-7.5						
				7.5	-7.9						
				7.6	-7.9						
				7.7	-7.9						
				7.7	-8						
				7.6	-8.3						
				7.7	-8.3						
				7.8	-8.4						
				7.9	-8.5						
				8	-8.6						
				8.1	-8.8						
				8.2	-8.9						
				8.4	-8.9						
				8.4	-9.3						
				8.5	-9						
				8.6	-9.1						
				8.7	-9.3						
				8.7	-9.4						
				8.8	-9.5						
				8.8	-9.6						
				9.3	-10.2						
				9.5	-9.9						
				10.4	-10.6						
				10.7	-10.7						
				10.9	-10.7						
				11.1	-10.8						
				11.1	-10.8						
				11.2	-10.8						
				11.3	-10.7						
				11.4	-10.8						
				11.5	-10.8						
				11.7	-10.9						
				11.7	-10.8						
				11.9	-10.8						
				12.1	-10.9						
				12.3	-10.9						
				13	-10.8						
Am	crystalline am(oh)3	h2o + 0.1M naclo4	dilute	7	-4.3	calculated	NA	ar atm	25	Silva, 1984	1
				8	-7						
				9	-8.2						
				10	-8.2						
Am	am(oh)3	h2o saturated with nacl	brine	1	>-2.8	undersaturation	NA	NA	25	Rambard et al., 1986	4,10
				5.5	-6						
				10	-6.4						
Am	am(oh)3	cement-equilibrated water + hcl or naoh	dilute	8.9	-7.6	oversaturation	0.02	200	NA	Ewart et al., 1985	1,16
				9.5	-7.5						
				10.1	-8						
				10.5	-7.6						
				11	-9.8						
				12	-10.1						
				13.2	-11						

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Am	am(oh)3	deionized water equilibrated with crushed cement,	dilute	10	-8	oversaturation	0.02	200 mV in	ambient	Pryke and Rees, 1987	1, 21
		composition(M): ca+2=1E-2; na+=5E-5; mg+2=5E-6;		10.5	-7.4			n2 atm at			
		cl-=2E-3; so4-2=3E-3; co3-2=3E-5; pH=12; pH adjusted with		10.5	-7.6			pH = 12			
		hcl or naoh. I = 0.04 M		11	-9.5						
				11	-9.9						
				12	-10						
				12	-10.2						
				13	-10.9						
				13	-11.1						
Am	243amco3 (SB)	h2o + 0.01 M nahco3	dilute	6.8	-7.6	oversaturation	66	10-3 atm CO2 in Ar	ambient	Felmy et al., 1990.	1,2
				6.89	-7.7						
				7.08	-8.1						
				7.21	-7.9						
				7.63	-8.1						
				8.22	-8.4						
				8.57	-8.4						
				8.83	-8.2						
				9.09	-7.2						
				9.11	-7.7						
				9.3	-7.2						
Am	crystalline amohco3	h2o + 0.1M naclo4 + E-3.5atm co2	dilute	6	-4.5	calculated	NA	ar+co2 atm	25	Silva, 1984	1
				7	-7.3						
				8	-9.1						
				8.5	-9.3						
				9	-9.1						
				10	-8.2						
Am	crystalline amohco3	h2o + 0.1M naclo4 + 2E-3M co3	dilute	6	-6.3	calculated	NA	ar+co2 atm	25	Silva, 1984	1
				7	-8						
				8	-9.1						
				9	-9.7						
				10	-9.3						
Am	amohco3	deionized water equilibrated with crushed cement,	dilute	7	-4.4	oversaturation	0.02	200 mV in	ambient	Pryke and Rees, 1987	1, 21
		composition(M): ca+2=1E-2; na+=5E-5; mg+2=5E-6;		8	-5.3			n2 atm at			
		cl-=2E-3; so4-2=3E-3; co3-2=3E-5; pH=12; pH adjusted with		9	-7.5			pH = 12			
		hcl or naoh. I = 0.04 M		9.5	-7.4						
				9.5	-7.6						
Am	241amo2oh	h2o + 5M nacl	brine	8.4	-3.9	undersaturated	NA	ar atm	25	Kim et al., 1985b	1,17
				8.6	-3.9						
				8.6	-4						
				8.7	-3.7						
				8.7	-3.8						
				8.8	-4.1						
				8.8	-4.2						
				9.2	-4.3						
				9.5	-4.4						
				9.7	-4.8						
				10.7	-5.6						
				11.1	-5.9						
				11.5	-6.9						

APPENDIX G
ATTACHMENT #1

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Am	241amo2	h2o + 0.1M nacl	dilute	11.7	-6.9	undersaturated	160	ar atm	22	Kim et al., 1985b	4,20
				11.7	-7.1						
				12.3	-7.3						
				12.7	-7.9						
				12.7	-8						
				12.8	-7.9						
				12.8	-8						
				4	-4.51						
				4.42	-4.53						
				4.88	-4.06						
Am	241amo2	h2o + 5M nacl	brine	3.39	-5.08	undersaturated	160	ar atm	22	Kim et al., 1985b	4,20
				4.12	-4.49						
				3.99	-4.95						
Am	243am-doped PNL 76-68 glass	nacl brine, WIPP brine B	brine	NA	-8.72	undersaturation	2	13.8MPa ar	150	Westsik et al., 1983	1,12,13,14
					-9.19		4				
					-8.65		8				
					-8.94		16				
					-8.99		32				
Am	ILW solidified with bitumen	h2o sat w/ca(oh)2,fe(oh)2,nacl,tbp,dbp,edta,cit&ox	brine	NA	-9.64	undersaturation	41	NA	NA	Marx and Keiling, 1989	4,18
Cm	244cm-doped PNL 76-68 glass	nacl brine, WIPP brine B	brine	NA	-10.03	undersaturation	2	13.8MPa ar	150	Westsik et al., 1983	1,12,13,14
					-9.99		8				
					-10		16				
					-10.47		32				
Np	npo2:xh2o	deionized water equilibrated with crushed cement,	dilute	9.9	-8	oversaturation	1	-400 mV in	ambient	Pryke and Rees, 1987	1, 21
		composition(M): ca+2=1E-2; na+=5E-5; mg+2=5E-6;		10.2	-7.8			in n2 atm at			
		cl-=2E-3; so4-2=3E-3; co3-2=3E-5; pH=12; pH adjusted with		10.5	-8			pH = 12			
		hcl or naoh. I = 0.04 M		11	-8						
				11.2	-8.1						
				11.2	-8.4						
				11.5	-8.4						
				11.7	-8.4						
				12	-8.2						
				12.5	-8.1						
				13	-8.4						
Np	237np-doped PNL 76-68 glass	nacl brine, WIPP brine B	brine	NA	-6.17	undersaturation	2	13.8MPa ar	150	Westsik et al., 1983	1,12,13,14
					-6		4				
					-5.98		8				
					-6.11		16				
					-6.11		32				
Np	237np-doped PNL 76-68 glass	h2o+1.5E-3Mcacl2+E-3Mquinhydrone + hcl or naoh	dilute	6.8	-6.7	undersaturation	5	296	25	Rai et al., 1982	1,2
				6	-6.7		5	343			
				5.2	-6.3		5	391			
				3.9	-6.3		5	467			
				2.8	-5.8		5	533			
				6.5	-6.3		41	314			
				4.8	-6.1		41	414			
				3.8	-5.6		41	473			
				6.4	-6		67-83	320			
				5.3	-6		67-83	385			
				4.3	-5.7		67-83	444			
				5.8	-5.7		288-302	355			

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Np	237np-doped PNL 76-68 glass	h2o+1.5E-3Mcacl2+E-3Mquinhydrone + hcl or naoh	dilute	4.4	-5.4	undersaturation	288-302	438	25	Rai et al., 1982	1,2
Np	237np-doped PNL 76-68 glass	h2o+1.5E-3Mcacl2+E-3Mquinhydrone + hcl or naoh	dilute	3	-5.4	undersaturation	NA	NA	NA	Rai and Strickert, 1980	1,5
				3.2	-5.5						
				4.1	-6.1						
				4.8	-6.1						
				6.3	-6.7						
				6.7	-6.8						
				6.8	-6.8						
				6.9	-6.7						
Np	237npo2	h2o+1.5E-3Mcacl2+E-3Mquinhydrone + hcl or naoh	dilute	4.8	-5.7	undersaturation	54	414	25	Rai et al., 1982	1,5
				4	-5.7			462			
				2.3	-5.7			562			
Np	237npo2	h2o+1.5E-3Mcacl2+E-3Mquinhydrone + hcl or naoh	dilute	3.5	-5.6	undersaturation	NA	NA	NA	Rai and Strickert, 1980	1,5
				3.7	-5.7						
				4	-6.1						
				4.1	-5.8						
				4.3	-5.9						
				4.4	-6.3						
				4.5	-6.2						
				5.7	-6.4						
Np	237npo2	h2o + 1M nacl	saline	5.4	-4.48	undersaturation	118	ar atm	25	Kim et al., 1985b	4,20
				5.08	-4.63		118				
				7.91	-5.83		72				
				7.99	-5.54		72				
Np	237npo2	h2o + 5M nacl	brine	5.82	-4.53	undersaturation	118	ar atm	25	Kim et al., 1985b	4,20
				5.72	-4.77		118				
				7.69	-6.19		72				
				7.72	-6.07		72				
Np	npo2oh	cement-equilibrated water + hcl or naoh	dilute	8.8	-4.6	oversaturation	1	200	NA	Ewart et al., 1985	1,16
				9.6	-4.8						
				9.8	-4.9						
				10.3	-4.9						
				10.9	-5.6						
				11.2	-6.7						
				11.4	-6.9						
				11.7	-7.2						
				11.8	-7.3						
				11.9	-7.8						
				12	-7.9						
				12.1	-8.7						
				12.3	-8.5						
				12.4	-8.7						
				12.4	-8.4						
				12.7	-8.8						
				12.8	-9						
				12.9	-9.4						
				13	-9						
Np	npo2oh	h2o sat w/ ca(oh)2, fe(oh)2 and nacl	brine	NA	-3.62	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Np	npo2oh	h2o sat w/ ca(oh)2, fe(oh)2, nacl and TBP	brine	NA	-5.26	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Np	npo2oh	h2o sat w/ ca(oh)2, fe(oh)2, nacl and DBP	brine	NA	-5.26	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Np	npo2oh	h2o sat w/ ca(oh)2, fe(oh)2, nacl and EDTA	brine	NA	-3.76	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Np	npo2oh	h2o sat w/ ca(oh)2, fe(oh)2, nacl and citrate	brine	NA	-3.14	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Np	npo2oh	h2o sat w/ ca(oh)2, fe(oh)2, nacl and oxalate	brine	NA	-3	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18

APPENDIX G
ATTACHMENT #1

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Np	237npo2oh	h2o + 1M naclo4	saline	6.6	-1.9	undersaturation	NA	ar atm	25	Kim et al., 1985b	1,17
				7.2	-2.2						
				7.7	-2.7						
				8.4	-3.4						
				8.8	-3.8						
				10.2	-5.1						
				10.8	-5.7						
				10.8	-5.9						
				11.6	-5.8						
				11.6	-5.9						
				11.8	-5.8						
				11.8	-5.7						
				11.9	-5.7						
				12	-5.6						
				12	-5.7						
				12.2	-5.3						
				12.2	-5.5						
				12.4	-5.1						
				12.4	-5.2						
				12.6	-5.1						
				12.6	-5.2						
				12.6	-5						
				12.9	-5						
				12.9	-5.2						
				12.8	-4.6						
Np	237npo2oh	h2o + 1M nacl	saline	6.44	-4.7	undersaturation	14	ar atm	22	Kim et al., 1985b	4,19
Np	237npo2oh	h2o + 5M nacl	brine	6.07	-4.91	undersaturation	14	ar atm	22	Kim et al., 1985b	4,19
Np	237npo2oh (amorphous)	np237,10-30mg dissolved as npo2clo4 in 0.1M naclo4	dilute	7.4	-2.1	oversaturation	1-2	ar atm	25	Neck et al., 1992	1,20
				8.2	-2.8						
				8.6	-3.25						
				9	-3.75						
				9	-3.7						
				9.3	-4						
				9.5	-4.2						
				9.55	-4.2						
				9.95	-4.6						
				10.4	-5.1						
				10.6	-5.3						
				11.2	-5.6						
				11.3	-5.75						
				11.6	-5.9						
				11.8	-5.95						
				11.9	-5.8						
				12	-5.8						
				12.1	-5.9						
				12.3	-5.6						
				12.3	-5.8						
				12.5	-5.7						
				12.6	-5.55						
				12.7	-5.5						
				12.8	-5.4						
				12.9	-5.3						

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Np	237npo2oh (amorphous)	np237,10-30mg dissolved as npo2clo4 in 1.0M naclo4	saline	8.85	-3.6	oversaturation	1-2	ar atm	25	Neck et al., 1992	1,20
				9.85	-4.6						
				11.7	-5.9						
				13.7	-4.2						
Np	237npo2oh (aged, grey-white ppt)	np237,10-30mg dissolved as npo2clo4 in 1.0M naclo4	saline	7.3	-2.7	oversaturation	14-28	ar atm	25	Neck et al., 1992	1,20
				7.9	-3.4						
				8.85	-4.2						
				9.3	-4.7						
				9.4	-4.9						
				10	-5.5						
				10.8	-6						
				11.5	-6.33						
				11.6	-6.4						
				12.1	-6.4						
				12.8	-5.9						
				12.9	-5.9						
				13.2	-5.6						
				13.3	-5.4						
				13.5	-5.5						
				13.7	-5						
				13.8	-5						
Np	237npo2oh (aged, grey-white ppt)	np237,10-30mg dissolved as npo2clo4 in 3.0M naclo4	brine	7	-3	oversaturation	14-28	ar atm	25	Neck et al., 1992	1,20
				7.4	-3.1						
				7.6	-3						
				7.7	-3.25						
				8.2	-3.8						
				8.6	-4.3						
				8.7	-4.4						
				9.1	-4.75						
				9.2	-5.25						
				9.5	-5.2						
				9.6	-5.3						
				9.9	-5.6						
				10.3	-5.9						
				10.9	-6.4						
				11.5	-6.4						
				11.6	-6.55						
				11.9	-6.5						
				12.8	-6.1						
				13.2	-5.6						
				13.5	-5.4						
				13.7	-5.1						
Pu	puo2:xh2o	deionized water equilibrated with crushed cement, composition(M): ca+2=1E-2; na+=5E-5; mg+2=5E-6; cl-=2E-3; so4-2=3E-3; co3-2=3E-5; pH=12; pH adjusted with hcl or naoh. I = 0.04 M	dilute	7.2	-5.8	oversaturation	0.02	-300 mV in ar/5%h2 atm at pH = 12	ambient	Pryke and Rees, 1987	1, 21
				7.4	-6.6						
				7.6	-6.7						
				8	-7.9						
				8.6	-9.7						
				9	-9.9						
				9.2	-9.6						
				9.5	-9.9						
				9.6	-10						

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Pu	puo2:xh2o	deionized water equilibrated with crushed cement, composition(M): ca+2=1E-2; na+=5E-5; mg+2=5E-6; cl-=2E-3; so4-2=3E-3; co3-2=3E-5; pH=12; pH adjusted with hcl or naoh. I = 0.04 M	dilute	9.7	-9.9	oversaturation	0.02	-300 mV in ar/5%h2 atm at pH = 12	ambient	Pryke and Rees, 1987	1, 21
				9.8	-10						
				10.4	-10.2						
				10.8	-10.4						
				10.9	-10.5						
				11	-10.4						
				11.1	-10.5						
				11.8	-10.6						
				13	-10						
				13.1	-9.9						
Pu	239pu-doped PNL 76-68 glass	nacl brine, WIPP brine B	brine	NA	-8.74	undersaturation	2	13.8MPa ar	150	Westsik et al., 1983	1,12,13,14
				NA	-8.67		4				
				NA	-8.49		8				
				NA	-8.65		16				
				NA	-8.67		32				
Pu	amorphous 239pu(oh)3	h2o + hcl or naoh to adjust pH	dilute	7.85	-9.11	oversaturation	8	-402	23	Rai et al., 1987	2,4
				8.14	-8.57		12	-359			
				10	-9.21		12	-417			
				8.57	-9.05		12	-339			
				8.32	-9.45		13	-283			
				8.99	-10.23		13	-331			
				10.2	-9.54		13	-219			
				10.4	-9.95		13	-233			
				10.9	-9.73		13	-207			
				11.4	-9.39		13	-262			
				11.9	-9.29		13	-293			
				12.1	-9.52		13	-266			
				12.5	-9.93		13	-190			
				12.8	-9.31		13	-237			
				13.2	-9.23		13	-281			
				7.63	-8.04		22	-340			
				6.08	-3.46		2	-185			
				6.36	-3.73		2	-256			
				7.41	-6.74		2	-335			
				6.71	-3.56		2	-310			
				6.86	-4.33		7	-294			
				6.83	-3.95		7	-355			
				6.62	-3.64		8	-278			
				7.8	-6.66		8	-352			
				8.08	-6.83		8	-311			
				7.28	-4.77		8	-282			
				9.76	-9.61		10	-194			
				8.01	-8.99		24	-238			
				8.56	-9.28		24	-295			
Pu	amorphous 239pu(oh)3	h2o + hcl or naoh to adjust pH	dilute	7.19	-5.75	undersaturation	21	-273	23	Rai et al., 1987	2,4
				7.18	-5.09		21	-314			
				7.4	-6.88		21	-310			
				7.71	-8.88		21	-305			
				7.87	-8.37		21	-322			
				8.18	-9.36		21	-330			
				8.1	-9.54		21	-327			
Pu	amorphous 239pu(oh)3	PBB1 + hcl or naoh to adjust pH	brine	7.26	-4.83	oversaturation	3	-267	23	Rai et al., 1987	2,4
				8.06	-5.87		3	-288			

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Pu	amorphous 239pu(oh)3	PBB1 + hcl or naoh to adjust pH	brine	7.41	-4.24	oversaturation	7	-293	23	Rai et al., 1987	2,4
				7.82	-4.94		7	-310			
				8.04	-5.64		7	-310			
				8.05	-5.68		7	-289			
				8.45	-6.93		7	-297			
				8.7	-7.4		7	-301			
				9.01	-8.84		7	-311			
				9.34	-9		7	-334			
				10.2	-9.06		7	-324			
				11.3	-9.09		7	-387			
				8.08	-5.91		14	-269			
Pu	amorphous 239pu(oh)3	PBB1 + hcl or naoh to adjust pH	brine	7.88	-7.03	undersaturation	13	-284	23	Rai et al., 1987	2,4
				8.28	-7.23		19	-268			
				8.28	-7.68		19	-252			
				8.06	-7.39		19	-230			
				8.05	-7.42		19	-218			
				8.32	-7.36		19	-276			
				8.26	-7.28		19	-251			
				9.15	-8.97		19	-338			
				9.25	-8.97		19	-362			
Pu	amorphous 239pu(oh)3	PBB3 + hcl or naoh to adjust pH	brine	6.32	-3.66	oversaturation	3	-244	23	Rai et al., 1987	2,4,11
				6.5	-3.82		3	-262			
				6.41	-3.7		8	-287			
				6.4	-3.77		8	-287			
				6.24	-3.93		8	-285			
				6.95	-4.85		8	-333			
				7.01	-4.92		8	-330			
				7.5	-4.53		8	-355			
				7.57	-4.34		8	-357			
				6.39	-4.09		10	-256			
				6.8	-4.87		10	-286			
Pu	amorphous 239pu(oh)3	PBB3 + hcl or naoh to adjust pH	brine	6.7	-4.52	undersaturation	14	-301	23	Rai et al., 1987	2,4,11
				6.75	-4.53			-302			
				6.81	-5.05			-367			
				6.83	-5.25			-303			
				6.94	-5.42			-303			
				7.32	-5.18			-307			
Pu	238puo2	h2o+0.1Mnacl pH adjusted with hno3?	dilute	5.3	-6.1	undersaturation	120	air atm	25	Kim et al., 1985a	1,7
				5.6	-5.7		210				
Pu	238puo2	h2o+0.5Mnacl pH adjusted with hno3?	saline	5.7	-5.7	undersaturation	120	air atm	25	Kim et al., 1985a	1,7
				5.9	-5.5		210				
Pu	238puo2	h2o+1Mnacl pH adjusted with hno3?	saline	5.4	-5.9	undersaturation	120	air atm	25	Kim et al., 1985a	1,7
				5.7	-5.7		210				
Pu	238puo2	h2o+3Mnacl pH adjusted with hno3?	brine	5.2	-6.2	undersaturation	120	air atm	25	Kim et al., 1985a	1,7
				5.4	-6		210				
Pu	238puo2	h2o+5Mnacl pH adjusted with hno3?	brine	4.7	-6.7	undersaturation	120	air atm	25	Kim et al., 1985a	1,7
				4.9	-6.5		210				
Pu	238puo2	h2o+ 0.1Mnacl	dilute	3.25	-5.66	undersaturation	120	ar atm	21	Kim et al., 1985b	4,20
				3.37	-6.51						
				3.45	-5.46						
				3.45	-6.42						
				3.37	-6.2						
				3.33	-5.59						

APPENDIX G
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ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Pu	238puo2	h2o+ 0.1Mnacl	dilute	3.68	-6.9	undersaturation	120	ar atm	21	Kim et al., 1985b	4,20
				3.36	-5.73						
				3.65	-6.18						
				3.39	-6.15						
Pu	238puo2	h2o+5Mnacl	brine	3.65	:7.1	undersaturation	120	ar atm	22	Kim et al., 1985b	4,20
				3.86	-6.74						
				3.97	-6.7						
				4.2	-6.5						
				3.86	-6.69						
				4.25	-6.51						
				4.43	-6.15						
				4.08	-6.59						
				4.58	-6.35						
				4.45	-6.86						
Pu	239puo2	h2o+0.1Mnacl pH adjusted with hno3?	dilute	2.48	-8.8	undersaturation	250	air atm	25	Kim et al., 1985a	1,7
Pu	239puo2	h2o+0.5Mnacl pH adjusted with hno3?	saline	2.8	-8.5	undersaturation	250	air atm	25	Kim et al., 1985a	1,7
Pu	239puo2	h2o+1Mnacl pH adjusted with hno3?	saline	2.7	-8.7	undersaturation	250	air atm	25	Kim et al., 1985a	1,7
Pu	239puo2	h2o+3Mnacl pH adjusted with hno3?	brine	2.2	-9.2	undersaturation	250	air atm	25	Kim et al., 1985a	1,7
Pu	239puo2	h2o+5Mnacl pH adjusted with hno3?	brine	2.2	-9.2	undersaturation	250	air atm	25	Kim et al., 1985a	1,7
Pu	239puo2	h2o+ 0.1M nacl	dilute	3.97	-7.88	undersaturation	250	ar atm	21	Kim et al., 1985b	4,20
				3.94	-7.83						
				4.51	-8.4						
				4.46	-8.4						
				4.94	-8.7						
				5.69	-9.6						
				4.85	-9.3						
				4.95	-9.34						
				6.63	-10.1						
				5.51	-9.6						
Pu	239puo2	h2o+5Mnacl	brine	3.76	-8.53	undersaturation	250	ar atm	24	Kim et al., 1985b	4,20
				3.72	-8.47						
				3.85	-8.95						
				3.58	-8.58						
				4.31	-9.48						
				4.42	-9.51						
				4.05	-8.98						
				3.84	-8.86						
				6.49	-10.5						
				6.44	-10.2						
Pu	239puo2(c)	h2o+0.0015Mcacl2	dilute	3.8	-6.12	undersaturation	90	air atm	25	Rai et al., 1980	4,5
				3.8	-6.05						
				4.3	-6.57						
				4.3	-6.44						
				5.4	-7.29						
				5.45	-7.47						
				7.3	-8.55						
				7.3	-8.78						
Pu	239puo2(c)	h2o+0.0015Mcacl2	dilute	3.4	-6.2	undersaturation	130	air atm	25	Rai et al., 1980	1,15
				3.6	-6.3						
				3.6	-6.4						
				4	-6.5						
				3.9	-6.6						
				5.7	-7.1						

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Pu	239puo2(c)	h2o+0.0015Mcacl2	dilute	7.2	-8.6	undersaturation	130	air atm	25	Rai et al., 1980	1,15
				7.7	-8.3						
Pu	239puo2(c)	h2o+0.0015Mcacl2	dilute	3	-5.3	undersaturation	250	air atm	25	Rai et al., 1980	1,15
				3.2	-5.7						
				3.3	-5.9						
				4	-6						
				5.2	-6.8						
Pu	freshly declad spent fuel	PBB1	brine	NA	-8.5	undersaturation	5	air atm	25-30	Gray, 1986	1,2,9
				NA	-8.6		5				
				NA	-8.7		14				
				NA	-8.8		14				
				NA	-8.8		28				
				NA	-8.9		28				
				NA	-8.8		60				
				NA	-8.9		60				
Pu	previously declad spent fuel	PBB1	brine	NA	-7.4	undersaturation	5	air atm	25-30	Gray, 1986	1,2,9
				NA	-8		5				
				NA	-7.8		14				
				NA	-7.7		28				
				NA	-8.3		28				
				NA	-7.5		60				
				NA	-8.3		60				
				NA	-7.5		90				
				NA	-8.4		120				
				NA	-7.2		180				
				NA	-7.6		180				
Pu	ILW solidified with bitumen	h2o sat w/ca(oh)2,fe(oh)2,nacl,tbp,dbp,edta,cit&ox	brine	NA	-9.13	undersaturation	41	NA	NA	Marx and Keiling, 1989	4,18
Pu	pu(oh)4	h2o saturated w/ ca(oh)2, fe(oh)2 and nacl	brine	NA	-7.6	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Pu	pu(oh)4	h2o saturated w/ ca(oh)2, fe(oh)2, nacl and TBP	brine	NA	-7.8	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Pu	pu(oh)4	h2o saturated w/ ca(oh)2, fe(oh)2, nacl and DBP	brine	NA	-6.8	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Pu	pu(oh)4	h2o saturated w/ ca(oh)2, fe(oh)2, nacl and EDTA	brine	NA	-5	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Pu	pu(oh)4	h2o saturated w/ ca(oh)2, fe(oh)2, nacl and citrate	brine	NA	-4.9	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Pu	pu(oh)4	h2o saturated w/ ca(oh)2, fe(oh)2, nacl and oxalate	brine	NA	-6.4	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
Pu	pu(oh)4	h2o saturated with nacl	brine	1	-3.5	undersaturation	NA	NA	25	Flambard et al., 1986	4,10
				5.5	-5.3						
				10	-7.8						
Pu	239pu(oh)4(a)	h2o+0.0015Mcacl2	dilute	3.95	-4.44	undersaturation	90	air atm	25	Rai et al., 1980	4,15
				4	-4.54						
				4	-4.31						
				4	-4.22						
				5	-5.25						
				5.05	-5.44						
				5.25	-5.17						
				5.3	-5.31						
				6.6	-6.77						
				6.7	-6.83						
				6.8	-6.63						
				6.83	-6.73						
				7.5	-7.54						
				7.7	-7.77						
				7.85	-7.11						

APPENDIX G
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ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Pu	239pu(oh)4(a)	h2o+0.0015Mcacl2	dilute	4	-4.5	undersaturation	130	air atm	25	Rai et al., 1980	1,15
				4.1	-4.3						
				4.7	-5						
				5	-5.2						
				5.1	-4.9						
				6.7	-6.6						
				7	-6.8						
				7.7	-7.3						
				7.9	-7.2						
Pu	239pu(oh)4(a)	h2o+0.0015Mcacl2	dilute	3.3	-4.6	undersaturation	250	air atm	25	Rai et al., 1980	1,15
				3.4	-4.3						
				3.5	-4.8						
				4.9	-5.5						
				5.3	-5.7						
				6	-6						
				7.7	-7						
				7.8	-7.2						
Pu	pu(oh)4	cement-equilibrated water + hcl or naoh	dilute	7.3	-5.7	oversaturation	0.02	-300	NA	Ewart et al., 1985	1,16
				7.5	-6.5						
				7.6	-6.6						
				8	-7.9						
				8.7	-9.7						
				9	-9.9						
				9.2	-9.5						
				9.7	-9.8						
				9.8	-10						
				10.3	-10.1						
				10.9	-10.4						
				11	-10.3						
				11.7	-10.5						
				13	-10.1						
Pu	pu(oh)4??	cement-equilibrated water + E-5M D-saccharic	dilute	12	-5.14	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-4M D-saccharic	dilute	12	-5.14	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-3M D-saccharic	dilute	12	-5.09	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-2M D-saccharic	dilute	12	-5.04	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-5M D-gluconic	dilute	12	-7.15	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-4M D-gluconic	dilute	12	-6.25	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-3M D-gluconic	dilute	12	-5.24	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-2M D-gluconic	dilute	12	-5.19	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-5M glutaric	dilute	12	-7.28	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-4M glutaric	dilute	12	-6.62	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-3M glutaric	dilute	12	-6.22	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-2M glutaric	dilute	12	-5.59	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-5M glyceric	dilute	12	-7.4	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-4M glyceric	dilute	12	-6.74	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-3M glyceric	dilute	12	-6.2	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-2M glyceric	dilute	12	-5.98	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-5M glycolic	dilute	12	-8.19	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-4M glycolic	dilute	12	-7.33	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-3M glycolic	dilute	12	-6.82	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-2M glycolic	dilute	12	-6.27	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-5M glyoxylic	dilute	12	-8.48	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-4M glyoxylic	dilute	12	-7.39	oversaturation	0.02	200	80	Cross et al., 1989	4,16

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Pu	pu(oh)4??	cement-equilibrated water + E-3M glyoxylic	dilute	12	-6.92	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	pu(oh)4??	cement-equilibrated water + E-2M glyoxylic	dilute	12	-6.59	oversaturation	0.02	200	80	Cross et al., 1989	4,16
Pu	238puo2(oh)2	h2O + 0.1M naclo4	dilute	5.6	-4.1	undersaturation	NA	ar atm	25	Kim et al., 1985b	1,17
				5.8	-4.3						
				5.8	-4.4						
				5.9	-4.3						
				6	-4.4						
				6.2	-4.5						
				6.2	-4.6						
				6.5	-4.5						
				6.2	-5						
				6.4	-5.1						
				6.6	-5						
				6.7	-5.3						
				6.7	-5.5						
				6.8	-5.3						
				6.9	-5.6						
				7	-5.5						
				7	-5.9						
				7.1	-5.8						
				7.2	-5.7						
				7.2	-6						
				7.2	-6.3						
				7.3	-6.1						
				7.5	-6.5						
				7.9	-6.6						
				8.4	-6.9						
				8.8	-7.2						
				9.1	-7.7						
				10.1	-8.2						
				10.9	-8.1						
				11.1	-8.2						
				11.2	-7.9						
				11.6	-7.7						
				11.8	-7.5						
				11.9	-7.8						
				11.9	-7.9						
				12.1	-7.9						
				12.2	-7.4						
				12.4	-7.8						
				12.5	-7.3						
Th	thorianite-tho2	h2o	dilute	2	-6	calculated	NA	NA	25	Langmuir and Herman, 1980	1
				5-9	-14						
Th	thorianite-tho2	h2o+1ppm(c2o4(oxalate)	dilute	2	-5	calculated	NA	NA	25	Langmuir and Herman, 1980	1
				4.5	-6						
				7-9	-14						
Th	thorianite-tho2	h2o+0.1ppm(EDTA	dilute	2-5	-6	calculated	NA	NA	25	Langmuir and Herman, 1980	1
				8.5	-14						
Th	thorianite-tho2	h2o+0.2ppm(f	dilute	2	-5.5	calculated	NA	NA	25	Langmuir and Herman, 1980	1
				5-7	-14						
Th	thorianite-tho2	h2o+0.1ppm(po4	dilute	2	-6	calculated	NA	NA	25	Langmuir and Herman, 1980	1
				4	-9.5						
				7.5	-14						

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ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Th	thorianite-tho2	h2o+100ppm(so4	dilute	2	-3.5	calculated	NA	NA	25	Langmuir and Herman, 1980	1
				5-7.5	-14						
Th	thorianite-tho2	h2o+10ppm(cl+2.5ppm(no3+100ppm(so4+0.3ppm(f+0.1ppm (po4	dilute	2	-4	calculated	NA	NA	25	Langmuir and Herman, 1980	1
				4	-9.5						
				7-8.5	-14						
Th	hydrous thorium (IV) oxide	h2o + 0.6M KCl	saline	3.83	-2.19	undersaturation	7	ar atm	ambient	Felmy et al., 1991	2
				4.68	-4.17						
				5.42	-6.43						
				6.05	-9						
				6.44	-8.41						
				7.48	-8.68						
				8.03	-8.67						
Th	hydrous thorium (IV) oxide	h2o + 0.6M NaCl	saline	3.02	-2.15	undersaturation	7	ar atm	ambient	Felmy et al., 1991	2
				3.69	-2.16		7				
				4.09	-2.17		7				
				4.14	-2.19		7				
				4.81	-3.87		7				
				5.21	-5.73		7				
				5.59	-8.53		7				
				6.06	-7.97		7				
				6.58	-7.08		7				
				7.01	-7.36		7				
				7.34	-8.38		7				
				7.61	-8.3		7				
				8.26	-8.07		7				
				9.23	-9.09		7				
				9.74	-8.82		7				
				10.2	-8.95		7				
				2.87	-2.17		98				
				3.42	-2.18		98				
				3.86	-2.29		98				
				3.91	-2.28		98				
				4.38	-3.14		98				
				3.86	-2.77		98				
				3.77	-2.86		98				
				4.35	-3.21		98				
				6.69	-8.15		98				
				7.18	-8.12		98				
				7.5	-6.92		98				
				8.21	-5.92		98				
				9.08	-7.6		98				
				9.58	-7.97		98				
				10.04	-8.16		98				
Th	hydrous thorium (IV) oxide	h2o + 1.2M NaCl	saline	2.94	-2.16	undersaturation	7	ar atm	ambient	Felmy et al., 1991	2
				3.58	-2.16		7				
				4.1	-2.2		7				
				4.52	-3.09		7				
				4.79	-2.73		7				
				5.68	-7.69		7				
				5.83	-6.39		7				
				6.38	-8.9		7				
				6.76	-8.3		7				

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Th	hydrous thorium (IV) oxide	h2o + 1.2M NaCl	saline	7.16	-8.2	undersaturation	7	ar atm	ambient	Felmy et al., 1991	2
				7.63	-8.57		7				
				8.21	-8.83		7				
				8.64	-8.62		7				
				9.09	-8.8		7				
				9.52	-8.25		7				
				10.03	-7.1		7				
				2.67	-2.2		98				
				3.3	-2.19		98				
				3.76	-2.48		98				
				4.17	-3.16		98				
				4.37	-3.9		98				
				4.08	-2.83		98				
				3.99	-2.75		98				
				3.97	-4.13		98				
				5.91	-7.51		98				
				6.92	-7.46		98				
				7.47	-7.9		98				
				8.05	-7.8		98				
				8.44	-7.82		98				
				8.86	-7.38		98				
				9.3	-7.08		98				
				9.8	-6.14		98				
Th	hydrous thorium (IV) oxide	h2o + 3M NaCl	brine	3.36	-2.95	undersaturation	8	ar atm	ambient	Felmy et al., 1991	2
				4.27	-3.3		8				
				4.32	-3.33		8				
				4.52	-3.71		8				
				4.76	-4.09		8				
				4.96	-4.32		8				
				5	-5.13		8				
				5.58	-6.96		8				
				5.61	-6.39		8				
				5.81	-6.84		8				
				5.99	-6.94		8				
				6.12	-7.28		8				
				6.41	-7.61		8				
				6.42	-7.62		8				
				6.44	-7.89		8				
				8.27	-7.64		8				
				3.56	-2.17		122				
				3.87	-3.03		122				
				3.98	-3.61		122				
				3.95	-3.9		122				
				4.02	-3.94		122				
				4.32	-4.1		122				
				7.12	-6.47		122				
				7.77	-6.44		122				
				7.82	-6.43		122				
				7.93	-6.37		122				
				8.82	-7.84		122				
				9	-7.92		122				
				9.47	-7.2		122				
				9.58	-7.66		122				

APPENDIX G
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ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
Th	hydrous thorium (IV) oxide	h2o + 3M NaCl	brine	10.06	-7.83	undersaturation	122	ar atm	ambient	Felmy et al., 1991	2
				10.1	-7.45		122				
				3.61	-2.09		372				
				3.69	-3.56		372				
				3.81	-2.87		372				
				4.05	-3.28		372				
				4.36	-3.77		372				
				4.56	-4.4		372				
				4.65	-4.79		372				
				7.89	-6.85		372				
				7.98	-6.66		372				
				8.2	-6.96		372				
				8.11	-7.09		372				
				8.04	-7.73		372				
				8.05	-7.73		372				
				8.24	-6.63		372				
				8.48	-7.68		372				
U	233u-doped PNL 76-68 glass	nacl brine, WIPP brine B	brine	NA	-6	undersaturation	2	13.8MPa ar	150	Westsik et al., 1983	1,12,13,14
				NA	-6.13		4				
				NA	-6.1		8				
				NA	-6.03		16				
				NA	-6.15		32				
U	uraninite-uo2	h2o	dilute	2	-10.2	calculated	NA	<200	25	Langmuir, 1978	1
				4	-13			<200			
				9	-8.8			<-100			
U	uraninite-uo2	h2o+E-2atmPco2	dilute	8	-10	calculated	NA	<-200	25	Langmuir, 1978	1
				8	-4			0			
U	uraninite-uo2	h2o+E-3.5atmPco2	dilute	8	-10	calculated	NA	<-100	25	Langmuir, 1978	1
				8	-4			100			
U	uraninite-uo2	h2o+E-2atmPco2+E-6M[po4	dilute	6	-12	calculated	NA	<-100	25	Langmuir, 1978	1
				6	-4			150			
U	uraninite-uo2	h2o+0.11125Mhcl	dilute	1.04	-6.717	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
				1.04	-7.022						
U	uraninite-uo2	h2o+1.51E-3Mhcl+0.098Mnacl	dilute	2.92	-8.452	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
				2.92	-8.733						
U	uraninite-uo2	h2o+1.22E-3Mhcl	dilute	2.93	-8.598	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
				2.93	-8.786						
U	uraninite-uo2	h2o+9.366E-6Mhcl	dilute	5.03	-8.704	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
				5.03	-9.914						
U	uraninite-uo2	h2o+1.136E-3Mhcl	dilute	3.95	-9.695	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o	dilute	6.67	-9.463	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
				6.67	-10.015						
U	uraninite-uo2	h2o+0.01097Mhcl	dilute	2.01	-9.381	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+1.26E-3Mhcl	dilute	1.85	-9.377	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+0.01569Mnaoh+0.0866Mnacl	dilute	1.04	-9.583	undersaturation	NA	h2=50MPa	100	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+0.11125Mhcl	dilute	1.05	-6.875	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
				1.05	-7.147						
				1.05	-7.259						
U	uraninite-uo2	h2o+1.51E-3Mhcl+0.098Mnacl	dilute	2.93	-8.479	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
				2.93	-8.676						
U	uraninite-uo2	h2o+1.22E-3Mhcl	dilute	2.94	-8.57	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
				2.94	-8.557						
U	uraninite-uo2	h2o+9.366E-6Mhcl	dilute	5.02	-9.733	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
U	uraninite-uo2	h2o+9.366E-6Mhcl	dilute	5.02	-9.914	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+1.136E-3Mhcl	dilute	3.95	-9.704	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
				3.95	-9.733						
U	uraninite-uo2	h2o	dilute	5.89	-9.532	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
				5.89	-9.474						
U	uraninite-uo2	h2o+0.01097Mhcl	dilute	2.01	-9.347	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
				2.01	-9.263						
U	uraninite-uo2	h2o+1.26E-3Mhcl	dilute	1.86	-9.335	undersaturation	NA	h2=50MPa	150	Parks and Pohl, 1988	3,4
				1.86	-9.422						
U	uraninite-uo2	h2o+0.11125Mhcl	dilute	1.08	-7.075	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				1.08	-7.2						
				1.08	-7.45						
U	uraninite-uo2	h2o+1.51E-3Mhcl+0.098Mnacl	dilute	2.95	-8.507	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				2.95	-8.514						
U	uraninite-uo2	h2o+1.22E-3Mhcl	dilute	2.94	-8.256	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				2.94	-8.652						
U	uraninite-uo2	h2o+9.366E-6Mhcl	dilute	5.01	-8.283	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				5.01	-9.714						
U	uraninite-uo2	h2o+1.136E-3Mhcl	dilute	3.95	-9.403	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				3.95	-9.551						
U	uraninite-uo2	h2o	dilute	5.64	-9.474	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				5.64	-9.598						
U	uraninite-uo2	h2o+0.01097Mhcl	dilute	2.02	-9.237	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				2.02	-9.598						
U	uraninite-uo2	h2o+1.26E-3Mhcl	dilute	1.87	-9.098	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				1.87	-9.335						
U	uraninite-uo2	h2o+1.00E-3Mhcl+0.0988Mnacl	dilute	3.43	-8.652	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				3.43	-8.468						
U	uraninite-uo2	h2o+0.0342Mhcl+0.0662Mnacl	dilute	1.6	-8.013	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				1.6	-8.021						
U	uraninite-uo2	h2o+3.07E-3Mhcl+0.0969Mnacl	dilute	2.64	-8.839	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+3.17E-4Mhcl+0.0992Mnacl	dilute	3.59	-9.034	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+0.0601Mhcl+0.0399Mnacl	dilute	2.35	-8.885	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				2.35	-9.175						
U	uraninite-uo2	h2o+0.0601Mhcl+0.0399Mnacl+1.23E-5uo2(no3)2	dilute	1.35	-8.067	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				1.35	-8.228						
U	uraninite-uo2	h2o+0.01569Mnaoh+0.0866Mnacl	dilute	9.3	-9.024	undersaturation	NA	h2=50MPa	200	Parks and Pohl, 1988	3,4
				9.3	-9.189						
U	uraninite-uo2	h2o+0.11125Mhcl	dilute	1.14	-7.132	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
				1.14	-6.466						
				1.14	-7.117						
U	uraninite-uo2	h2o+1.51E-3Mhcl+0.098Mnacl	dilute	3.02	-8.437	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
				3.02	-8.413						
U	uraninite-uo2	h2o+1.22E-3Mhcl	dilute	2.94	-8.305	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
				2.94	-8.621						
U	uraninite-uo2	h2o+9.366E-6Mhcl	dilute	5	-9.82	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
				5	-9.644						
U	uraninite-uo2	h2o+1.136E-3Mhcl	dilute	3.95	-9.473	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o	dilute	5.55	-9.519	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+0.01097Mhcl	dilute	2.04	-8.917	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
				2.04	-9.531						

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
U	uraninite-uo2	h2o+1.26E-3Mhcl	dilute	1.89	-8.774	undersaturation	NA	h2=50MPa	250	Parks and Pohl, 1988	3,4
				1.89	-8.889						
U	uraninite-uo2	h2o+0.11125Mhcl	dilute	1.23	-6.096	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				1.23	-6.128						
				1.23	-6.056						
				1.23	-6.121						
U	uraninite-uo2	h2o+1.51E-3Mhcl+0.098Mnacl	dilute	3.12	-7.945	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				3.12	-8.089						
U	uraninite-uo2	h2o+1.22E-3Mhcl	dilute	2.95	-8.146	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
U	uraninite-uo2	h2o+9.366E-6Mhcl	dilute	4.99	-9.502	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				4.99	-9.502						
U	uraninite-uo2	h2o+1.136E-3Mhcl	dilute	3.96	-9.036	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				3.96	-9.82						
U	uraninite-uo2	h2o	dilute	5.57	-9.39	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				5.57	-9.403						
U	uraninite-uo2	h2o+0.01097Mhcl	dilute	2.07	-8.339	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				2.07	-9.297						
U	uraninite-uo2	h2o+1.26E-3Mhcl	dilute	1.93	-8.774	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				1.93	-8.652						
U	uraninite-uo2	h2o+1.00E-3Mhcl+0.0988Mnacl	dilute	3.59	-8.544	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				3.59	-8.479						
U	uraninite-uo2	h2o+0.0342Mhcl+0.0662Mnacl	dilute	1.75	-7.761	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				1.75	-7.88						
U	uraninite-uo2	h2o+3.07E-3Mhcl+0.0969Mnacl	dilute	2.8	-8.287	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				2.8	-8.532						
U	uraninite-uo2	h2o+3.17E-4Mhcl+0.0992Mnacl	dilute	3.76	-8.275	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				3.76	-8.977						
U	uraninite-uo2	h2o+0.0601Mhcl+0.0399Mnacl	dilute	2.51	-8.623	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				2.51	-8.531						
U	uraninite-uo2	h2o+0.0601Mhcl+0.0399Mnacl+1.23E-5uo2(no3)2	dilute	1.5	-7.191	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
				1.5	-7.464						
U	uraninite-uo2	h2o+0.01569Mnaoh+0.0866Mnacl	dilute	9.07	-9.387	undersaturation	NA	h2=50MPa	300	Parks and Pohl, 1988	3,4
U	uraninite-uo2	saturated NaCl solution	brine	6.2	-6.8	undersaturation	NA	air	75-90	Gray, 1986	1,2,9
				6.2	-7						
				6.3	-7.5						
				6.4	-7.9						
				6.4	-7.8						
				6.4	-7.8						
U	carnotite-k2(uo2)2(vo4)2	h2o+E-2atmPco2+E-3Mk+E-6M(v	dilute	3	-2.5	calculated	NA	NA	25	Langmuir, 1978	1
				6	-7.5			>100			
				8.5	-1			>50			
U	carnotite-k2(uo2)2(vo4)2	h2o+E-3.5atmPco2+E-3Mk+E-6M(v	dilute	3	-2.5	calculated	NA	NA	25	Langmuir, 1978	1
				7	-9			>100			
				9	-4			>50			
U	tyuyamunite-ca(uo2)2(vo4)2	h2o+E-2atmPco2+E-2.7Mca+E-6M(v	dilute	3	-2	calculated	NA	NA	25	Langmuir, 1978	1
				6	-7						
				8.5	-1						
U	tyuyamunite-ca(uo2)2(vo4)2	h2o+E-3.5atmPco2+E-2.7Mca+E-6M(v	dilute	3	-2	calculated	NA	NA	25	Langmuir, 1978	1
				7	-8						
				9	-3.5						
U	autunite-ca(uo2)2(po4)2	h2o+E-2atmPco2+E-2.7Mca+E-6M(po4	dilute	7	-4	calculated	NA	NA	25	Langmuir, 1978	1
				9.5	0						
U	autunite-ca(uo2)2(po4)2	h2o+E-3.5atmPco2+E-2.7Mca+E-6M(po4	dilute	7	-6	calculated	NA	NA	25	Langmuir, 1978	1

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
U	autunite-ca(uo2)2(po4)2	h2o+E-3.5atmPco2+E-2.7Mca+E-6M(po4	dilute	10	-0.5	calculated	NA	NA	25	Langmuir, 1978	1
U	k-autunite-k2(uo2)2(po4)2	h2o+E-2atmPco2+E-3Mk+E-6M(po4	dilute	6	-6	calculated	NA	NA	25	Langmuir, 1978	1
				9.5	0						
U	k-autunite-k2(uo2)2(po4)2	h2o+E-3.5atmPco2+E-3Mk+E-6M(po4	dilute	6	-7	calculated	NA	NA	25	Langmuir, 1978	1
				10	-1.5						
U	schoepite-uo3.2h2o(syn)	h2o + hclo4 or tetramethyl nh4oh to adjust pH	dilute	3.5	-2.5	oversaturation	9	ox	25	Krupka et al., 1985	1,2
				4	-3		9				
				6	-3.5		9				
				8	-4.5		9				
				11	-4		9				
				12	-3		9				
				3	-2.2		14-53				
				4	-2.7		14-53				
				5	-3		14-53				
				6	-3.2		14-53				
				7	-3.5		14-53				
				8	-3.5		14-53				
				10	-4		14-53				
				11	-3.5		14-53				
				12	-2.5		14-53				
U	schoepite-uo3.2h2o(syn)	h2o + hclo4 or tetramethyl nh4oh to adjust pH	dilute	4	-2.75	undersaturation	14	ox	25	Krupka et al., 1985	1,2
				8	-5		14				
				9	-5.9		14				
				11	-4		14				
				12	-3.5		14				
				3	-2.5		14-53				
				4	-2.7		14-53				
				5	-3		14-53				
				7.5	-4.5		14-53				
				8.5	-4.7		14-53				
				9.5	-4.5		14-53				
				11	-3.5		14-53				
				12	-3.5		14-53				
U	schoepite-uo3.2h2o(a)	h2o + 0.5M naclo4	dilute	6.9	-3.1	undersaturation	NA	n2 atm	25	Bruno and Sandino, 1989	1,17
				7	-3.3						
				7.2	-3.4						
				7.3	-3.65						
				7.4	-3.8						
				7.5	-3.9						
				7.6	-3.85						
				7.7	-3.95						
				7.8	-3.8						
				7.85	-3.85						
				7.9	-3.85						
				7.9	-3.6						
				8.05	-3.55						
				8.15	-3.35						
U	schoepite-uo3.2h2o(c)	h2o + 0.5M naclo4	dilute	6.8	-4.2	undersaturation	NA	n2 atm	25	Bruno and Sandino, 1989	1,17
				6.85	-4.25						
				6.95	-4.3						
				7.15	-4.55						
				7.25	-4.6						
				7.4	-4.75						

APPENDIX G
ATTACHMENT #1

ACTINIDE	SOLID	SOLUTION COMPOSITION	SOLUTION DESCRIPTION	pH	SOLUBILITY (log M)	METHOD	EQtime (days)	Eh (mV) or atm	T (oC)	REFERENCE	NOTES
U	schoepite-uo3.2h2o(c)	h2o + 0.5M naclo4	dilute	7.5	-4.85	undersaturation	NA	n2 atm	25	Bruno and Sandino, 1989	1,17
				7.65	-4.9						
				7.7	-4.95						
				7.85	-5.15						
				7.9	-5.1						
				8.1	-5.25						
				8.25	-5.3						
				8.3	-5.35						
				8.35	-5.4						
				8.33	-5.05						
				8.85	-4.55						
U	na2u2o7	h2o sat w/ ca(oh)2, fe(oh)2, and nacl	brine	NA	-4.69	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
U	na2u2o7	h2o sat w/ ca(oh)2, fe(oh)2, nacl and TBP	brine	NA	-4.98	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
U	na2u2o7	h2o sat w/ ca(oh)2, fe(oh)2, nacl and DBP	brine	NA	-4.34	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
U	na2u2o7	h2o sat w/ ca(oh)2, fe(oh)2, nacl and EDTA	brine	NA	-3.26	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
U	na2u2o7	h2o sat w/ ca(oh)2, fe(oh)2, nacl and citrate	brine	NA	-3.51	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
U	na2u2o7	h2o sat w/ ca(oh)2, fe(oh)2, nacl and oxalate	brine	NA	-3.69	undersaturation	NA	NA	NA	Marx and Keiling, 1989	4,18
U	freshly declad spent fuel	PBB1	brine	NA	-6.7	undersaturation	5	air atm	25-30	Gray, 1986	1,2,9
				NA	-5.7		5				
				NA	-5.4		14				
				NA	-5.6		14				
				NA	-5.3		28				
				NA	-4.9		28				
				NA	-4.9		60				
				NA	-4.8		60				
U	previously declad spent fuel	PBB1	brine	NA	-4.2	undersaturation	5	air atm	25-30	Gray, 1986	1,2,9
				NA	-4.3		5				
				NA	-4.1		14				
				NA	-3.9		28				
				NA	-4		28				
				NA	-3.9		60				
				NA	-4.5		60				
				NA	-4		90				
				NA	-4.2		120				
				NA	-4		180				
				NA	-4.8		180				
U	uo2	PBB1	brine	NA	-6.4	undersaturation	5	air atm	25-30	Gray, 1986	1,2,9
				NA	-6.3		14				
				NA	-6.2		28				
				NA	-6		60				

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NOTES

1 = data obtained from graphical results
2 = concentration in 18A filtrate
3 = concentration in 2000A filtrate
4 = data obtained from tabulated results
5 = concentration in 150A filtrate
6 = some solutions contained 10mg caco3
7 = concentration in 10A filtrate
8 = in pH solutions <7, essentially all am(oh)3 dissolved
i.e., maximum am+3 = E-3
9 = pH of sample not reported, initial pH = 6.2 to 6.4
10 = concentration in 20A filtrate
11 = PBB3 is similar to BSEP brines
12 = nonfiltered solutions acidified with HNO3
13 = log M calculated from normalized release value
14 = glass wt loss increased linearly with time
15 = concentration in 1000A filtrate
16 = actinide conc in solution determined by difference
between added conc and activity of 18A filtered ppt
17 = filter size unknown
18 = no details on the experimental conditions
19 = concentration in 13A filtrate
20 = concentration in 2200A filtrate
21 = ultrafiltration noted; size unknown
NA = not available

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