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## APPENDIX

Table A-1 Effect of solution pH on the Ca/DTPMPA precipitate molar ratio

| pH of solution | Mole Ca / Mole Phosphonate |
|----------------|----------------------------|
| 3              | 1.85                       |
| 4              | 2.15                       |
| 5              | 2.60                       |
| 6              | 2.89                       |
| 7              | 2.89                       |
| 8              | 2.88                       |
| 9              | 2.96                       |
| 10             | 3.22                       |
| 11             | 3.84                       |
| 12             | 4.51                       |

Table A-2 Effect of settling temperature on the Ca/DTPMPA molar ratio under different solution pH

| Solution pH | 20°C | 30°C | 60°C |
|-------------|------|------|------|
| 4           | 2.15 | 3.47 | 3.29 |
| 6           | 2.90 | 3.95 | 4.51 |
| 7           | 2.90 | 4.31 | 4.78 |
| 8           | 2.89 | 4.31 | 4.74 |
| 10          | 3.22 | 4.83 | 4.81 |

Table A-3 Effect of Ca/DTPMPA molar ratio on equilibrium solubility

| Ca/DTPMPA Molar Ratio in precipitate | Equilibrium Solubility Concentration (ppm) |
|--------------------------------------|--|
| 1.86                                 | 5,034                                      |
| 2.15                                 | 1,878                                      |
| 2.61                                 | 977  |
| 2.90                                 | 787  |
| 2.90                                 | 747  |
| 2.89                                 | 698  |
| 2.96                                 | 656  |
| 3.22                                 | 552  |
| 3.84                                 | 477  |
| 4.51                                 | 269  |

Table A-4 Effect of precipitate molar ratio on the release of DTPMPA in micromodel experiments

Injection rate : 0.05 ml/min  
 Elution : DI water, pH 6.3

| Pore volume | DTPMPA concentration in effluence of different precipitate molar ratio (ppm) |          |        |
|-------------|--|----------|--------|
|             | 2:1  | 2.9:1    | 4.5:1  |
| 0           |  |          |        |
| 10          | 1,298.10   | 1,191.87 | 107.58 |
| 20          | 328.88   | 245.82   | 98.55  |
| 30          | 230.52   | 191.71   | 98.75  |
| 40          | 224.37   | 103.88   | 97.93  |
| 50          | 224.82   | 50.69    | 97.62  |
| 60          | 189.40   | 40.67    | 87.61  |
| 70          | 191.95   | 36.92    | 87.61  |
| 80          | 146.42   | 34.73    | 87.61  |
| 90          | 107.10   | 29.10    | 80.41  |
| 100         | 99.85  | 27.22    | 61.01  |
| 110         | 97.27  | 26.91    | 48.81  |
| 120         | 91.06  | 25.34    | 48.50  |
| 130         | 88.86  | 22.53    | 41.61  |
| 140         | 74.47  | 20.02    | 33.17  |
| 150         | 69.77  | 19.71    | 27.53  |
| 160         | 68.21  | 15.33    | 19.71  |
| 170         | 63.52  | 10.95    | 17.21  |
| 180         | 57.88  | 10.64    | 15.02  |
| 190         | 59.45  | 10.64    | 14.08  |

Table A-5 Effect of dissolving liquid pH on the DTPMPA release rate in micromodel

Injection rate : 0.05 ml/min

Ca/DTPMPA molar ratio : 2.9:1

| Pore volume | DTPMPA concentration in effluence of different dissolving liquid pH (ppm) |          |        |
|-------------|---|----------|--------|
|             | 2   | 6.3      | 10     |
| 0           |   |          |        |
| 10          | 5,318.20  | 1,191.87 | 808.44 |
| 20          | 792.99  | 245.82   | 251.23 |
| 30          | 197.10  | 191.71   | 196.49 |
| 40          | 137.05  | 103.88   | 117.26 |
| 50          | 103.17  | 50.69    | 72.85  |
| 60          | 78.85   | 40.67    | 57.88  |
| 70          | 50.25   | 36.92    | 49.44  |
| 80          | 45.61   | 34.73    | 41.93  |
| 90          | 37.88   | 29.10    | 37.55  |
| 100         | 33.50   | 27.22    | 37.23  |
| 110         | 26.49   | 26.91    | 35.67  |
| 120         | 22.21   | 25.34    | 31.11  |
| 130         | 19.09   | 22.53    | 29.72  |
| 140         | 17.14   | 20.02    | 27.85  |
| 150         | 12.86   | 19.71    | 21.59  |
| 160         | 11.52   | 15.33    | 20.34  |
| 170         |   | 10.95    | 19.09  |
| 180         |   | 10.64    | 19.40  |
| 190         |   | 10.64    | 19.06  |

Table A-6 Effectiveness of phosphonate release of different types of phosphonates in micromodel

Injection rate : 0.05 ml/min  
 Elution : DI water, pH 6.3

| Pore volume | Phosphonates concentration in effluent of different phosphonate types (ppm) |        |          |
|-------------|---|--------|----------|
|             | ATMP  | HEDP   | DTPMPA   |
| 0           |   |        |          |
| 10          | 12,028.00   | 405.10 | 1,298.10 |
| 20          | 2,839.00  | 297.33 | 328.88   |
| 30          | 1,927.36  | 204.00 | 230.52   |
| 40          | 1,878.33  | 32.67  | 224.37   |
| 50          | 1,103.33  | 8.12   | 224.82   |
| 60          | 650.00  | 6.20   | 189.40   |
| 70          | 437.19  | 4.05   | 191.95   |
| 80          | 458.51  | 3.13   | 146.42   |
| 90          | 187.94  | 3.21   | 107.10   |
| 100         | 135.95  | 3.37   | 99.85    |
| 110         | 128.97  | 3.72   | 97.27    |
| 120         | 143.95  | 3.67   | 91.06    |
| 130         | 120.49  | 3.31   | 88.86    |
| 140         | 98.10   | 3.31   | 74.47    |
| 150         | 85.90   | 3.15   | 69.77    |
| 160         | 84.04   | 3.24   | 68.21    |
| 170         | 84.15   | 3.09   | 63.52    |
| 180         | 84.37   | 3.05   | 57.88    |
| 190         | 84.01   | 3.18   | 59.45    |



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