Table S1 Room-temperature magnetic properties of magnetite from MTB, iron bacteria, chemical synthesis, and natural sediments

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Strain or source | Sample description | Crystal morphology | Length (nm) | Aspect ratio (L/W) | *B*c(mT) | *B*cr (mT) | *B*cr/*B*c | *M*rs/*M*s | References |
| *Magnetospirillum magnetotacticum* strain MS-1 | Whole cells (MS) | Cuboctahedral | 45.3 | 1.11 | 26.8 | 27.6 | 1.02 | 0.53 | (Moskowitz et al., 1988) |
| Isolated magnetosomes (MSmag) | Cuboctahedral | 45.3 | 1.11 | 3.7 | 16.6 | 4.49 | 0.41 |  |
| *Magnetosprillum gryphiswaldense* strain MSR-1 | Whole cells (MSR) | Cuboctahedral | 44.7 | 1.0 | 16.9 | 18.9 | 1.12 | 0.54 | (Katzmann et al., 2013) |
| *Magnetovibrio blakemorei* strain MV-1 | Whole cells (MV) | Elongated, cuboctahedral | 60.0 | 1.50 | 28.5 | 48.5 | 1.7 | 0.48 | (Moskowitz et al., 1989) |
| *Magnetospira* sp. QH-2 | Whole cells (QH) | Elongated, cuboctahedral | 81.0 | 1.40 | 29 | 36.1 | 1.24 | 0.55 | (Zhu et al., 2010) |
| *Magnetospirillum sp*. XM-1 | Whole cells (XM) | Elongated, cuboctahedral | 47.2 | 1.18 | 31.0 | 41.78 | 1.35 | 0.47 | (Wang et al., 2015) |
| *Candidatus* Magnetococcus yuandaducum strain YDC-1 | Whole cells (YDC) | Elongated, prismatic | 108.0 | 1.56 | 41 | 50.2 | 1.22 | 0.49 | (Lin & Pan, 2009) |
| *Magnetospirillum magneticum* strain AMB-1 | Whole cells (AMB, unoriented) | Elongated, cuboctahedral | 49.3 | 1.20 | 30.5 | 37.4 | 1.23 | 0.5 | (Li et al., 2012) |
| Whole cells (AMB0, Oriented, 0 degree) | 32.0 | 32.5 | 1.02 | 0.84 | (Li et al., 2013) |
| Whole cells (AMB30, Oriented, 30 degree) | 31.9 | 33.6 | 1.06 | 0.75 |
| Whole cells (AMB45, Oriented, 45 degree) | 31.6 | 35.2 | 1.11 | 0.64 |
| Whole cells (AMB60, Oriented, 60 degree) | 30.7 | 38.0 | 1.24 | 0.49 |
| Whole cells (AMB75, Oriented, 75 degree) | 27.0 | 42.4 | 1.57 | 0.33 |
| Whole cells (AMB90, Oriented, 90 degree) | 20.5 | 45.1 | 2.20 | 0.24 |
| Isolated magnetosomes (A1a) | 25.2 | 33.8 | 1.34 | 0.43 | (Li et al., 2012) |
| Isolated magnetosomes (A1b) | 23.2 | 31.2 | 1.34 | 0.44 |
| Isolated magnetosomes (A1c) | 21.3 | 29.6 | 1.39 | 0.44 |
| Isolated magnetosomes (A2a) | 9.2 | 15.1 | 1.64 | 0.24 |
| Isolated magnetosomes (A2b) | 15.8 | 25.1 | 1.59 | 0.32 |
| Isolated magnetosomes (A2c) | 15 | 23.6 | 1.57 | 0.33 |
| Isolated magnetosomes (A3a) | 7.9 | 14.7 | 1.86 | 0.22 |
| Isolated magnetosomes (A3b) | 15.4 | 24.4 | 1.58 | 0.32 |
| Isolated magnetosomes (A3c) | 15.3 | 24.4 | 1.59 | 0.32 |
| Whole cells (Anaerobic culture, ANS) |  | 46.4 | 1.28 | 22.0 | 31.3 | 1.42 | 0.45 | (Li & Pan, 2012) |
| Whole cells (Aerobic static culture, AS) |  | 45.1 | 1.27 | 16.1 | 22.0 | 1.37 | 0.44 |
| Whole cells (Aerobic 80-rpm culture, A80) |  | 38.5 | 1.18 | 10.6 | 16.8 | 1.59 | 0.38 |
| Whole cells (Aerobic 120-rpm culture, A120) |  | 35.0 | 1.12 | 5.2 | 9.3 | 1.80 | 0.31 |
| Whole cells (Culture without Co2+, Co(0)) |  | 29.0 | 1.19 | 18.8 | 28.7 | 1.53 | 0.46 | (Li et al., 2016) |
| Whole cells (Culture with 2.1µM of Co2+, Co(2.1)) |  | 41.6 | 1.20 | 30.6 | 38.1 | 1.24 | 0.54 |
|  | Whole cells (Culture with 12.1µM of Co2+, Co(12.1)) |  | 44.5 | 1.25 | 31.5 | 41.4 | 1.31 | 0.52 |
| *Candidatus* Magnetobacterium casensis strain MYR-1 | Whole cells (MYR, Unoriented) | Elongated, bullet-shaped | 104.0 | 2.74 | 54.5 | 61 | 1.12 | 0.59 | (Li et al., 2010) |
| Whole cells (MYR0, Oriented, 0 degree) | 104.0 | 2.74 | 57 | 57.5 | 1.01 | 0.86 |
| Whole cells (MYR45, Oriented, 45 degree) | 104.0 | 2.74 | 56.6 | 60.7 | 1.07 | 0.67 |
| Whole cells (MYR90, Oriented, 90 degree) | 104.0 | 2.74 | 31.4 | 74.1 | 2.36 | 0.23 |
| Strain THC-1 | **Whole cells (THC)** | **Elongated, prismatic** | **70.6** | **1.67** | **36.3** | **44.9** | **1.24** | **0.49** | **This study** |
| *Geobacter metallireducens* GS-15 | Freeze-dried powder (GS) | Equidimensional | 9 | - | 0.8 | 30 | - | - | (Moskowitz et al., 1988) |
| *Geobacter metallireducens* GS-15 | Nontraditional 668-h culture, Freeze-dried powder (GS668) | Equidimensional, and tabular | 20-200 | 1-2.9 | 8 | - | - | 0.26 | (Vali et al., 2004) |
| *Acidovorax* sp. strain BoFeN1 | Freeze-dried powder (BoFeN) | Equidimensional | 55 | 1 | 10.2 | 19.3 | 1.89 | 0.23 | (Miot et al., 2014) |
| Chemical synthesis | Diluted in kaolin to 1% by volume (CS37) | Cubic | 37 | 1 | 10 | 26.6 | - | - | (Dunlop, 1986) |
| Diluted in kaolin to 1% by volume (CS76) | 76 | 1 | 15.3 | 27.6 | - | - |
| Diluted in kaolin to 1% by volume (CS100) | 100 | 1 | 17.8 | 30.8 | - | - |
| Diluted in kaolin to 1% by volume (CS220) | 220 | 1 | 21.8 | 39.6 | - | - |
| Diluted in CaF2 to 1% by weight (CS120) | Equidimensional | 120 | 1 | 22.9 | 33.3 | 1.44 | 0.41 | (Özdemir & Banerjee, 1982) |
| Diluted in CaF2 to 1% by weight (CS25) | 25 | 1 | 19.6 | 30.3 | 1.55 | 0.27 |
| Diluted in CaF2 to 1% by weight (CS190) | 190 | 1 | 18.7 | 33.4 | 1.79 | 0.26 |
| Diluted in CaF2 to 1% by weight (CS995) | 995 | 1 | 30.3 | 42.0 | 1.39 | 0.34 |
| Diluted in kaolin to 1% by volume (CS200) | Acicular | 200 | 6.67 | 32.5 | - | - | 0.46 | (Dunlop, 1972) |
| Diluted in alumina to less than 1% by weight (CS350) | 350 | 8.75 | 44.0 | 60.0 | 1.36 | 0.45 | (Levi & Merrill, 1978) |
| Sediments rich in MTB  (Surface sediments from Lake Chiemsee, Germany) | C03-04 (depth 4 cmbwf) | - | - | - | 20.6 | 45.2 | 2.19 | 0.27 | (Pan et al., 2005a) |
| PA06 (depth 3 cmbwf) | - | - | - | 21.6 | 45.8 | 2.12 | 0.30 |
| K01-a (depth 2 cmbwf) | - | - | - | 23.2 | 44.8 | 1.93 | 0.32 |
| Sediments rich in magnetofossils  (DL04 sediment core from the Dali Lake in Inner Mongolia, China, Holocene Warm Period sediments) | DL670 (670 cmbwf, 6.95 ka BP) | - | - | - | 23.2 | 49.8 | 2.15 | 0.25 | (Liu et al., 2015) |
| DL750 (750 cmbwf, 9.46 ka BP) | - | - | - | 21.8 | 50.5 | 2.32 | 0.23 |
| Sediments rich in magnetofossils  (ODP Hole 738B from the southern Kerguelen Plateau, Indian Ocean, Eocene pelagic biogenic sedimentation) | 738B-3H-5-115 (20.65 mbsf) | - | - | - | 20.19 | 30.65 | 1.518 | 0.419 | (Roberts et al., 2011) |
| 738B-3H-6-120 (22.2 mbsf) | - | - | - | 20.93 | 31.71 | 1.515 | 0.424 |
| 738B-4H-2-127 (25.77 mbsf) | - | - | - | 27.84 | 45.17 | 1.622 | 0.452 |
| 738B-4H-3-58 (26.58 mbsf) | - | - | - | 26.14 | 40.92 | 1.565 | 0.436 |
| 738B-4H-4-85 (28.35 mbsf) | - | - | - | 27.69 | 41.96 | 1.515 | 0.437 |
| 738B-4H-5-60 (29.6 mbsf) | - | - | - | 28.48 | 44.08 | 1.548 | 0.457 |
| 738B-4H-6-130 (31.8 mbsf) | - | - | - | 30.18 | 45.94 | 1.522 | 0.455 |
| 738B-5H-1-130 (33.8 mbsf) | - | - | - | 33.59 | 49.6 | 1.477 | 0.478 |
| 738B-5H-2-145 (33.45 mbsf) | - | - | - | 33.75 | 50.41 | 1.494 | 0.470 |
| 738B-5H-3-130 (36.8 mbsf) | - | - | - | 29.18 | 42.08 | 1.442 | 0.477 |
| 738B-5H-4-132 (38.32 mbsf) | - | - | - | 24.07 | 35.43 | 1.472 | 0.463 |
| 738B-5H-5-131 (39.81 mbsf) | - | - | - | 27.42 | 39.61 | 1.445 | 0.426 |
| 738B-5H-7-5 (41.55 mbsf) | - | - | - | 22.48 | 36.36 | 1.617 | 0.485 |

Table 2 Low-temperature magnetic properties of magnetite from MTB, iron bacteria, chemical synthesis, and natural sediments

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Strain or source | Sample description | δ-ratio | *δZFC* | *δFC* | *Tv* | References |
| *Magnetospirillum magnetotacticum* strain MS-1 | Whole cells (MS) | 2.667 | 0.060 | 0.160 | 101 | (Moskowitz et al., 1993) |
| *Magnetovibrio blakemorei* strain MV-1 | Whole cells (MV1, wet) | 4.000 | 0.060 | 0.240 | 110 |
| *Magnetovibrio blakemorei* strain MV-1 | Whole cells (MV1, freeze-dried) | 4.750 | 0.040 | 0.190 | 101 |
| *Magnetovibrio blakemorei* strain MV-2 | Whole cells (MV2, wet) | 2.400 | 0.100 | 0.240 | 110 |
|  | Powder, diluted in CaF2 to 2% by weight, Oxidized | 0.921 | 0.191 | 0.176 | - |
| Isolated magnetosome | Powder, diluted in CaF2 to 2% by weight, Oxidized | 0.929 | 0.225 | 0.209 | - |
| Powder, diluted in CaF2 to 2% by weight, Oxidized | 1.001 | 0.261 | 0.261 | - |
| Uncultured MTB (mixture) | Whole cells (P2) | 2.333 | 0.060 | 0.140 | 100 | (Pan et al., 2005b) |
| Uncultured MTB (mixture) | Whole cells (P3) | 3.667 | 0.030 | 0.110 | 100 | (Pan et al., 2005b) |
| *Magnetosprillum gryphiswaldense* strain MSR-1 | Whole cells (MSR) | 1.395 | 0.362 | 0.505 | 104 | (Ding et al., 2010) |
| *Magnetospira* sp. QH-2 | Whole cells (QH) | 1.484 | 0.287 | 0.426 | 108 | (Zhu et al., 2010) |
| *Candidatus* Magnetococcus yuandaducum strain YDC-1 | Whole cells (YDC) | 2.028 | 0.176 | 0.357 | 108 | (Lin & Pan, 2009) |
| *Candidatus* Magnetobacterium casensis strain MYR-1 | Whole cells (MYR, Unoriented) | 3.112 | 0.038 | 0.117 | 98 | (Li et al., 2010) |
| *Magnetospirillum magneticum* strain AMB-1 | Whole cells (AMB, unoriented) | 4.811 | 0.056 | 0.268 | 104 | (Li et al., 2012) |
| Whole cells (AMB0, Oriented, 0 degree) | 13.0 | 0.072 | 0.0055 | 102 | (Li et al., 2013) |
| Whole cells (AMB90, Oriented, 90 degree) | 1.8 | 0.36 | 0.20 | 102 |
| Isolated magnetosomes (A1a) | 1.617 | 0.162 | 0.262 | 102 | (Li et al., 2012) |
| Isolated magnetosomes (A1b) | 1.862 | 0.138 | 0.257 | 102 |
| Isolated magnetosomes (A1c) | 2.606 | 0.092 | 0.240 | 102 |
| Isolated magnetosomes (A2a) | 1.198 | 0.353 | 0.423 | 102 |
| Isolated magnetosomes (A2b) | 1.336 | 0.220 | 0.294 | 102 |
| Isolated magnetosomes (A2c) | 1.500 | 0.176 | 0.264 | 102 |
| Isolated magnetosomes (A3a) | 1.314 | 0.287 | 0.377 | 102 |
| Isolated magnetosomes (A3b) | 1.342 | 0.234 | 0.314 | 102 |
| Isolated magnetosomes (A3c) | 1.388 | 0.209 | 0.290 | 102 |
| *Magnetospirillum magneticum* strain AMB-1 | Whole cells (Anaerobic culture, ANS) | 2.38 | 0.166 | 0.395 | 108 | (Li & Pan, 2012) |
|  | Whole cells (Aerobic static culture, AS) | 3.05 | 0.116 | 0.353 | 106 |
|  | Whole cells (Aerobic 80-rpm culture, A80) | 2.77 | 0.133 | 0.369 | 104 |
|  | Whole cells (Aerobic 120-rpm culture, A120) | 1.60 | 0.295 | 0.472 | 98 |
|  | Whole cells (Culture without Co2+, Co(0)) | 2.20 | 0.20 | 0.444 | 108 | (Li et al., 2016) |
|  | Whole cells (Culture with 2.1µM of Co2+, Co(2.1)) | 4.90 | 0.047 | 0.230 | 104 |
|  | Whole cells (Culture with 12.1µM of Co2+, Co(12.1)) | 3.1 | 0.042 | 0.13 | 100 |
| *Magnetospirillum sp*. XM-1 | Whole cells (XM) | 3.82 | 0.039 | 0.147 | 98 | (Wang et al., 2015) |
| Strain THC-1 | **Whole cells (THC)** | **1.397** | **0.304** | **0.425** | **112** | **This study** |
| *Geobacter metallireducens* GS-15 | Nontraditional 34-d culture, Freeze-dried powder (GS34) | 1.667 | 0.090 | 0.150 | - | (Vali et al., 2004) |
| *Geobacter metallireducens* GS-15 | Nontraditional 668-h culture, Freeze-dried powder (GS668) | 1.111 | 0.090 | 0.100 | - | (Vali et al., 2004) |
| Chemical synthesis | Magnetite\_37 nm (M37) | 1.263 | 0.380 | 0.480 | 120 | (Moskowitz et al., 1993) |
| Magnetite\_100 nm (M100) | 1.288 | 0.520 | 0.670 | 120 |
| Magnetite\_210 nm (M210) | 1.049 | 0.820 | 0.860 | 120 |
| Magnetite\_1000 nm (M1000) | 1.023 | 0.880 | 0.900 | 120 |
| Sediments rich in MTB (Surface sediments from Lake Chiemsee, Germany) | Freeze-dried surface sediments from Lake Chiemsee | 1.460 | 0.265 | 0.387 | 110 | (Pan et al., 2005a) |
| Air-dried surface sediments from Lake Chiemsee | 1.265 | 0.246 | 0.311 | 105 |
| Sediments rich in magnetofossils  (Samples from the Blake/Bahama Outer Ridge, western North Atlantic Ocean) | 88-10P\_29.5 (Core 88-10P, water depth 3820 m, 29.5 cmbsf) | 1.49 | 0.0937 | 0.139 | - | (Housen & Moskowitz, 2006) |
| 88-10P\_52 (Core 88-10P, water depth 3820 m, 52 cmbsf) | 1.44 | 0.111 | 0.159 | - |
| 88-10P\_69 (Core 88-10P, water depth 3820 m, 69 cmbsf) | 1.46 | 0.113 | 0.164 | - |
| GGC-24\_15 (Core GGC-24, water depth 4250 m, 15 cmbsf) | 1.35 | 0.113 | 0.153 | - |
| GGC-24\_37 (Core GGC-24, water depth 4250 m, 15 cmbsf) | 1.52 | 0.110 | 0.168 | - |
| Sediments rich in magnetofossils  (DL04 sediment core from the Dali Lake in Inner Mongolia, China, Holocene Warm Period sediments) | DL670 (670 cmbwf, 6.95 ka BP) | 0.96 | 0.185 | 0.178 | 100 | (Liu et al., 2015) |
| DL750 (750 cmbwf, 9.46 ka BP) | 0.95 | 0.230 | 0.220 | 100 |

Room-temperature magnetic parameters (*Bc*, *Bcr*, *Bcr*/*Bc*, and *Mrs*/*Ms*) of magnetite samples from MTB are from Moskowitz et al. (1989) (whole-cell sample of MV-1), Moskowitz et al. (1993) (whole-cell and isolated magnetosome samples of MS-1), Lin & Pan (2009) (whole-cell sample of YDC-1), Zhu et al. (2010) (whole-cell sample of QH-2), Li et al. (2010) (unoriented and oriented whole-cell samples of MYR-1), Li et al., 2012 (whole-cell and isolated magnetosome samples of AMB-1), Li & Pan (2012) (whole-cell samples of AMB-1 grown under different oxygen conditions), Katzmann et al. (2013) (whole-cell sample of MSR-1), Li et al. (2013) (Oriented whole-cell sample of AMB-1), Wang et al. (2013) (whole-cell sample of XM-1), Li et al. (2016) (whole-cell samples of AMB-1 grown under different cobalt concentrations), and this study (whole-cell sample of THC-1). Room-temperature magnetic parameters of magnetite samples from extracellularly synthesis by iron reducing bacteria are from Moskowitz et al. (1989) (GS-1) and Vali et al. (2004) (GS-15, non-traditional 668-h culture), by iron oxidizing bacteria are from Miot et al. (2014) (BoFeN1). Room-temperature magnetic parameters of magnetite samples from chemical synthesis are from Dunlop (1972) (acicular magnetite, 200 nm), Levis & Merrill (1978) (acicular magnetite, 350 nm), Özdemir & Banerjee (1982) (equidimensional magnetite, 25, 120, 190, and 995 nm) and Dunlop (1986) (cubic magnetite, 37, 76, 100, and 220 nm). Room-temperature magnetic parameters of natural samples rich in MTB or magnetofossils are from Pan et al. (2005b) (surface sediments from Lake Chiemsee, Germany), Liu et al. (2014) (DL670 and DL750), and Roberts et al. (2011) (ODP Hole 738B). Low-temperature magnetic parameters (*Tv*, *δFC*, and *δZFC*) of magnetite samples from MTB are from Moskowtiz et al. (1993) (whole-cell samples of MS-1, MV-1, MV-2, and isolated magnetosome samples of MS-1), Pan et al. (2005a) (whole-cell samples of uncultured MTB, P2 and P3), Ding et al. (2010) (whole-cell sample of MSR-1), Zhu et al. (2010) (whole-cell sample of QH-2), Lin & Pan (2009) (whole-cell sample of YDC-1), Li et al. (2010) (whole-cell sample of MYR-1), Li et al. (2012) (whole-cell and isolated magnetosome samples of AMB-1), Li et al. (2013) (oriented whole-cell samples of AMB-1), Li & Pan (2012) (whole-cell samples of AMB-1 grown under different oxygen conditions), Li et al. (2016) (whole-cell samples of AMB-1 grown under different cobalt conditions), Wang et al. (2015) (whole-cell sample of XM-1), this study (whole-cell sample of THC-1).

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