Off-axis electron holography of bacterial cells and

magnetic nanoparticles in liquid

Supplementary Information

Figure 1A shows a bright-field (BF) transmission electron microscope (TEM) image of an enclosed bacterial cell of *M. magneticum* in liquid recorded at 200 kV on an FEI Tecnai microscope. **Figure 1B** shows magnetosome chains that are either partially submersed in liquid or reside on the boundary of liquid and a bubble. Displacement and bubbling of the liquid serve as indicators that liquid is still present. **Figure 1C** shows amorphization of magnetosome magnetite nanocrystals after prolonged exposure to the electron beam.

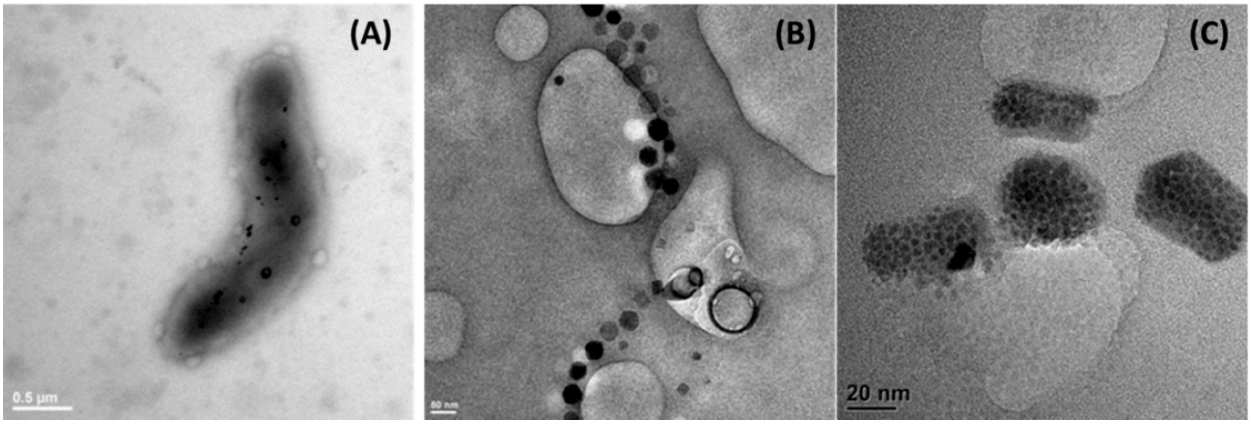

Figure S1. Cells of *M. magneticum* imaged with the fluid cell. BF TEM images of a bacterial cell of *M. magneticum* in liquid recorded at a microscope accelerating voltage of 200 kV: (A) enclosed bacterial cell; (B) magnetosome chain released from a cell upon lysis; (C) amorphization of magnetosome magnetite nanocrystals observed after prolonged exposure to the electron beam.

Figure S2 shows an off-axis electron hologram and a reconstructed phase image of a liquid-filled area that contains bacterial debris and a single magnetosome nanocrystal. The inset in **Fig. S2A** shows that the holographic interference fringes have good contrast. The phase image in **Fig. S2B** provides information about local variations in thickness and atomic number, but is also affected by features from the reference wave, which was obtained from the sample itself.

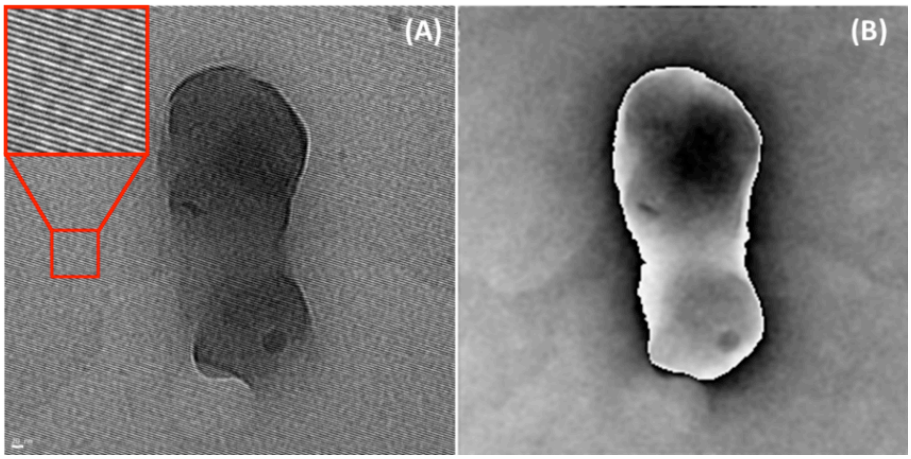

Figure S2. Electron holography and a reconstructed phase image of a cell fragment. Off-axis electron hologram and reconstructed phase image of enclosed bacterial debris containing a single magnetosome particle. (A) Displacement of liquid reveals a partially dried cell with a thin layer of liquid; (B) Corresponding (wrapped) reconstructed phase image.

Dose rate comparison for Lorentz and Normal mode, measured by using the luminescent screen of the microscope. For the experiments reported here, the microscope is used in Lorentz mode. Since the objective lens does not focus the electrons, the dose rate can be lower as compared to that in a normal mode. Let us compare dose rates in Lorentz mode and normal mode conditions:

Round shape illumination, spot size (sp) 3, gun lens 2.4, vacuum area, the values are measured by the large luminescent screen:

In normal mode the dose rate is 47 e/(Å^{2}s) at magnification of 36, 000 ×;

in Lorentz mode the dose rate is 38 e/(Å^{2}s) at 34,000 ×.

The small difference is likely due to the slight magnification offset between the two setups.

At the same time, comparison of **round** and **elliptical** illumination Sp 3, elliptical beam set up with condenser stigmator to x=1.

In normal mode the dose rate is: 46 e/(Å^{2}s) at 36, 000 ×;

in Lorentz mode the dose rate is : 4.1 /(Å^{2}s) at 34,000×.

The difference can be attributed to the lack of objective lens that does not focus the electrons in Lorentz mode and the fact that condenser lens stretches the beam to a higher aspect ratio. Here both the magnification and spot size are important, since in holography experiments the

beam is normally spread on the screen to the same width, but the magnification is changed with regard to the size of the object, as summarized in **Table 1**.

	22,000 ×	34,000 ×	55,000 ×	90,000 ×
Spot size 2	5.6	8.4	12.6	20
Spot size 3	2.7	4.1	6.2	9.5
Spot size 4	1.4	2.1	3.2	5

Table 1. Dose rate as a function of magnification and spot size. The values are shown in e/(Å^{2}s) for Lorentz mode, elliptical illumination, GL 2.4.

It is worth noting, that while the dose rate on the specimen from the imaging in Lorentz mode carried out using elliptical illumination and spot size 3 (or 4) is low, our current results should not be compared to a low-dose imaging directly.

Off-axis electron holograms were also recorded using a Gatan K2 direct electron detector at room temperature in Lorentz mode. The electron biprism was operated at 101 V and holograms were acquired using spot size 4 and an acquisition time of 6 s. **Figure S3A** shows a BF TEM image recorded using the K2 camera and spot size 4. **Figure S3B** shows an off-axis electron hologram recorded from the marked region in **Fig. S3A**. Electron-beam-induced damage is reduced when using spot size 4, while the interference fringes have sufficient contrast.

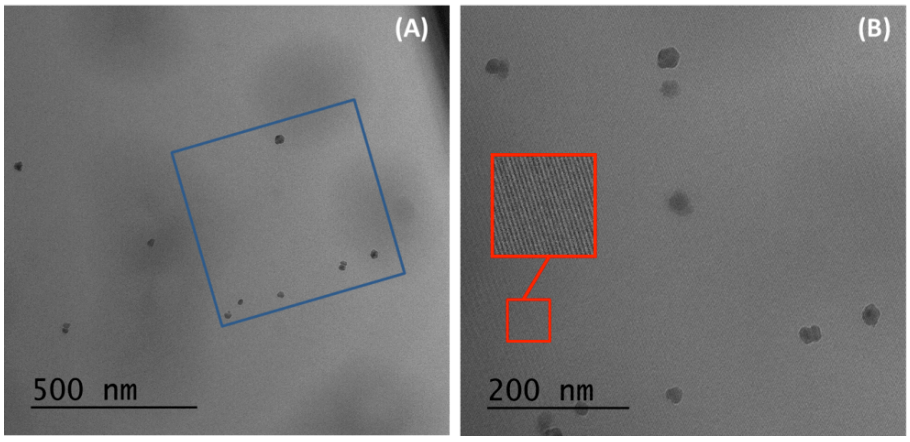

Figure S3. **Use of Gatan K2 camera for electron holography experiments with the fluid cell.** (A) BF TEM image recorded in Lorentz mode using spot size 4; (B) Off-axis electron hologram recorded from the marked region in (A).