Table S1: Illustrative comparison of geometric current densities achieved by pure cultures in bioelectrochemical systems (BES)[§].

Strain [Reference]	*j*/A m^{-2}[†]	Strain [Reference]	*j*/A m^{-2}[†]
Clostridium beijerinckii[1]	13.00[‡]	*Thermincola ferriacetica*[2, MFC]	0.400
Clostridium butyricum[1]	13.00[‡]	*Geobacter bremensis*[3]	0.300
Geobacter sulfurreducens[This work]	11.60	*Pseudomonas aeruginosa*[4, MFC]	0.264
Geobacter sulfurreducens[5]	9.00	*Geobacter metallireducens*[6]	0.256
Geoalkalibacter subterraneus[7]	8.92[§]	*Natrialba magadii*[8, MFC]	0.220
Geoalkalibacter subterraneus[9]	8.45[§]	*Comamonas denitrificans*[10, MFC]	0.200
Geobacter sulfurreducens[11]	8.40	*Bacillus subtilis*[12,MFC]	0.178
Geobacter sulfurreducens[11]	8.00	*Saccharomyces cerevisiae*[13, MFC]	0.160
Geoalkalibacter ferrihydriticus[14]	8.30	*Desulfuromonas acetoxidans*[6]	0.158
Geobacter sulfurreducens[11]	8.00	*Escherichia coli*[4, MFC]	0.147
Thermincola ferriacetica[15]	8.00	*Shewanella putrefaciens*[16]	0.120
Geoalkalibacter subterraneus[This work]	**5.06**	*Citrobacter sp.* XS-1[17, MFC]	0.098
Geobacter sulfurreducens[18]	5.00	*Shewanella oneidensis*[19]	0.079
Geoalkalibacter subterraneus[9]	4.50[§]	*Pseudomonas alcaliphila*[20, MFC]	0.070
Geobacter sulfurreducens[21]	3.40	*Proteus hauseri*[22, MFC]	0.065
Geoalkalibacter subterraneus[14]	3.30	*Thermincola potens*[23, MFC]	0.064
Geobacter sulfurreducens[24]	3.15	*Corynebacterium sp.* MFC03[25, MFC]	0.063
Gluconobacter oxydans[26]	2.61	*Pseudomonas aeruginosa*[27]	0.060
Proteus vulgaris[28, MFC]	1.23	*Klebsiella sp.* ME17[29, MFC]	0.057
Geopsychrobacter electrodiphilus[30]	1.21	*Geothrix fermentans*[31]	0.050
Klebsiella pneumoniae[32, MFC]	1.20	*Pseudomonas aeruginosa*[33]	0.036
Geobacter sulfurreducens[34]	1.00	*Klebsiella pneumoniae*[35]	0.032
Rhodopseudomonas palustris[36, MFC]	0.81	*Rhodoferax ferrireducens*[37]	0.031
Geobacter sulfurreducens[38]	0.75	*Desulfobulbus propionicus*[39]	0.028
Ochrobactrum anthropi[40]	0.70	*Enterobacter aerogenes*[33]	0.025
Geobacter sulfurreducens[24]	0.69	*Clostridium acetobutylicum*[41, MFC]	0.024
Haloferax volcani[8, MFC]	0.50	*Enterobacter aerogenes*[42, MFC]	0.010
Enterobacter cloacae[43, MFC]	0.49	*Saccharomyces cerevisiae*[44]	0.009
Desulfitobacterium hafniense[45, MFC]	0.46	*Escherichia coli*[8, MFC]	0.006
Shewanella oneidensis[46]	0.42	*Rhodopseudomonas palustris*[47, MFC]	>0.001

[†]Current densities from well defined surface area planar electrodes. Therefore, 3D-porous materials were not considered in this compilation; [‡]Combination of suspended fermentative bacteria and electrocatalytic anode materials as reported in[48]; [§]Non pure culture studies showing *Geoalkalibacter* dominated electroactive biofilms derived from environmental samples included here due to the lack of information on pure culture studies on *Geoalkalibacter subterraneus*; [MFC]Non potentiostatic controlled microbial fuel cells studies included here for sake of completeness although they do not assure similar biological and environmental conditions for both electrodes[49]. ARB able to produce significant current densities and thick (>40 μm) biofilms are highlighted in red.

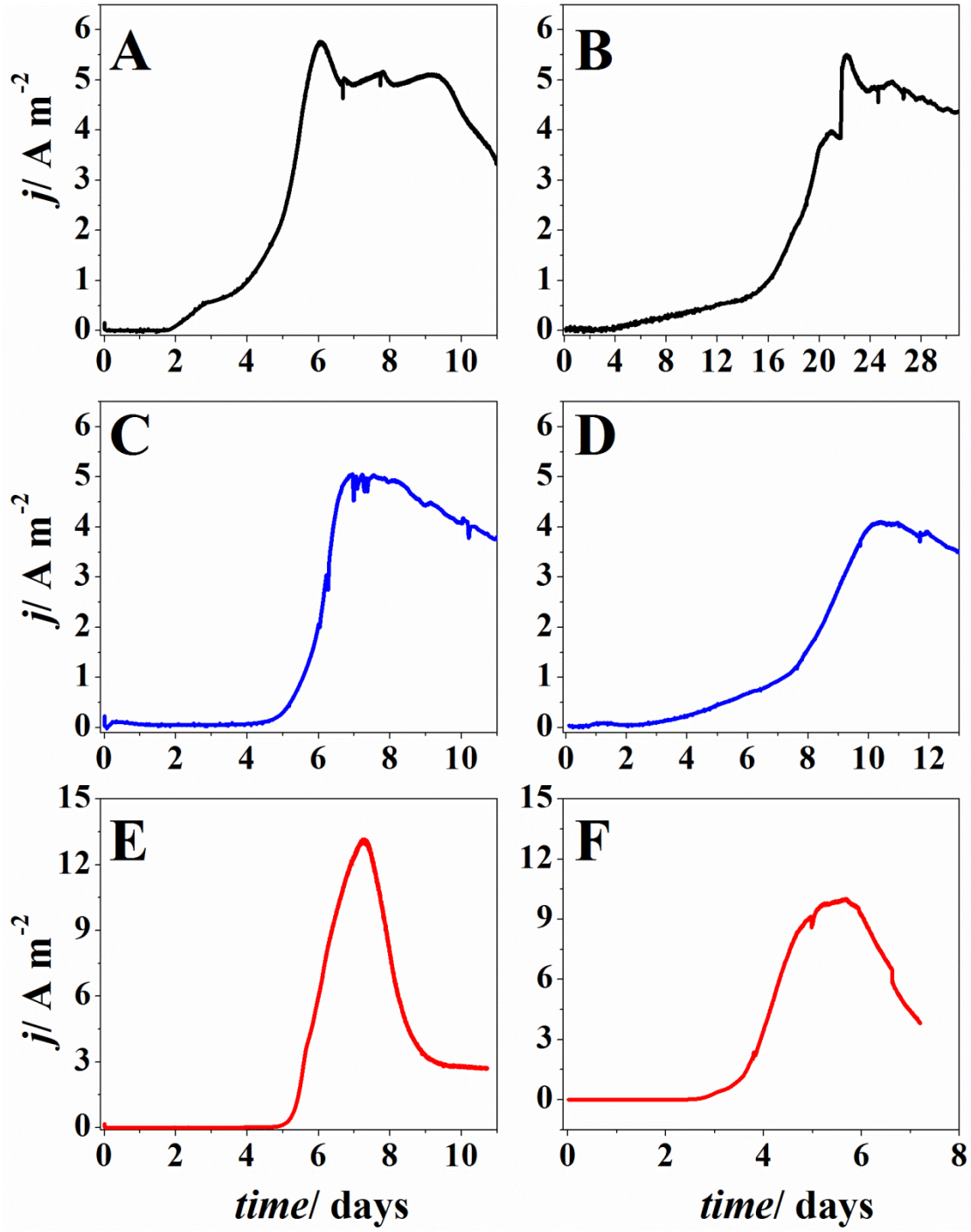

Fig. S1 Exemplary chronoamperometric (CA) measurements of experimental replicates of electroactive biofilms grown on planar graphite electrodes (15 cm^2) at an applied potential of +200 V vs. SCE (KCl 3.0 M). *Geoalkalibacter subterraneus* biofilms grown in (A-B) Starkey medium with 35 g/L NaCl and in (C-D) FRR medium with 17 g/L NaCl and for comparison (E-F) shows *Geobacter sulfurreducens* biofilms grown in DSMZ medium No. 826 (see Experimental section for details).

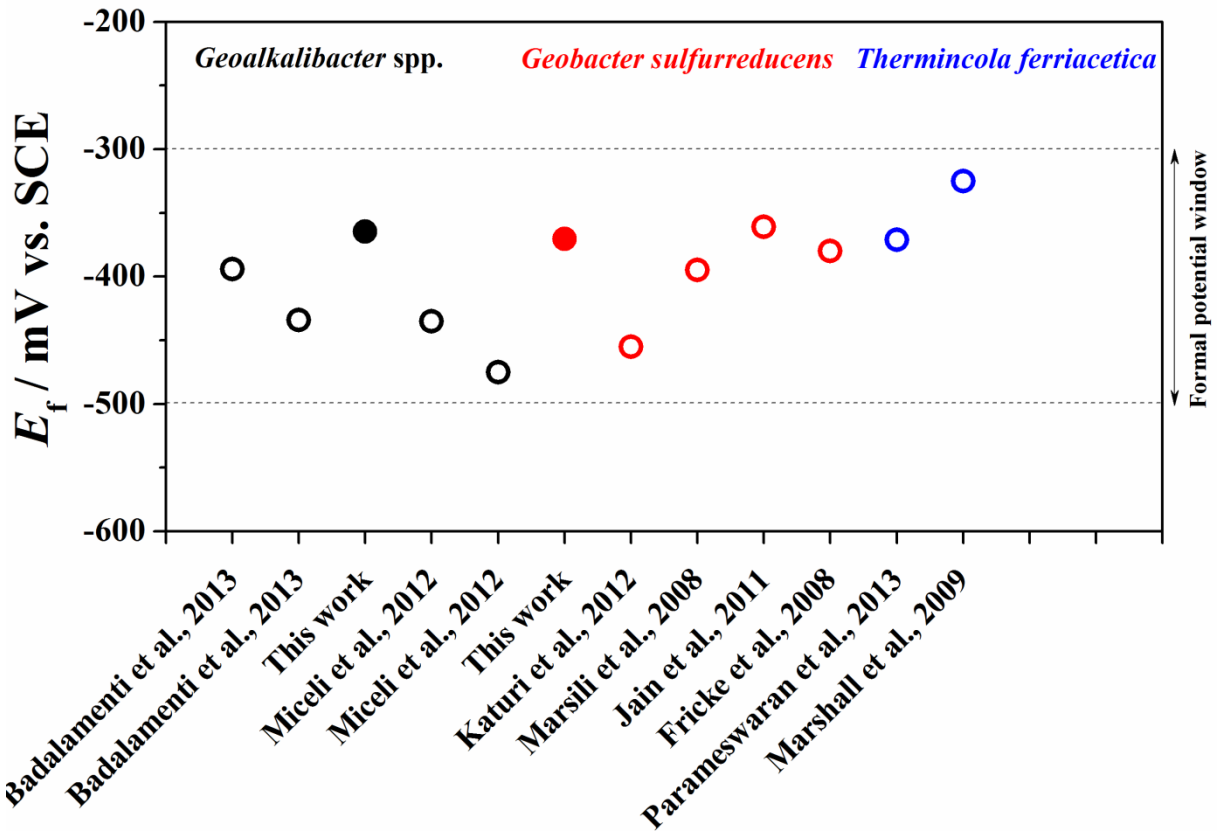

Fig. S2 Comparison of DET formal potentials (E_f) for bacteria capable of producing significant current densities and illustrating a sigmoidal shape during turnover conditions in CV measurements. Idea illustration based on[50].

Table S2: Comparison of experimental parameters used in this study and by Badalamenti *et al.*[14] showing pure culture electroactive biofilms of *Glk. subterraneus*.

Parameter	This study		Badalamenti *et al.*[14]
Current density during CA* in A/m^2	4.68 ± 0.54	4.57 ± 0.67	3.3
Applied potential in mV vs. SCE	+200	+200	-200
Temperature in °C	37	37	40
Salinity given as NaCl in g/L	35	17	17
pH value	7.0	7.0	7.0
BES architecture	Half-cell	Half-cell	Two-chamber
Coulombic efficiency in %	114 ± 14	110±1	55-119
Sodium acetate concentration in mM	10	10	20

*CA: chronoamperometry

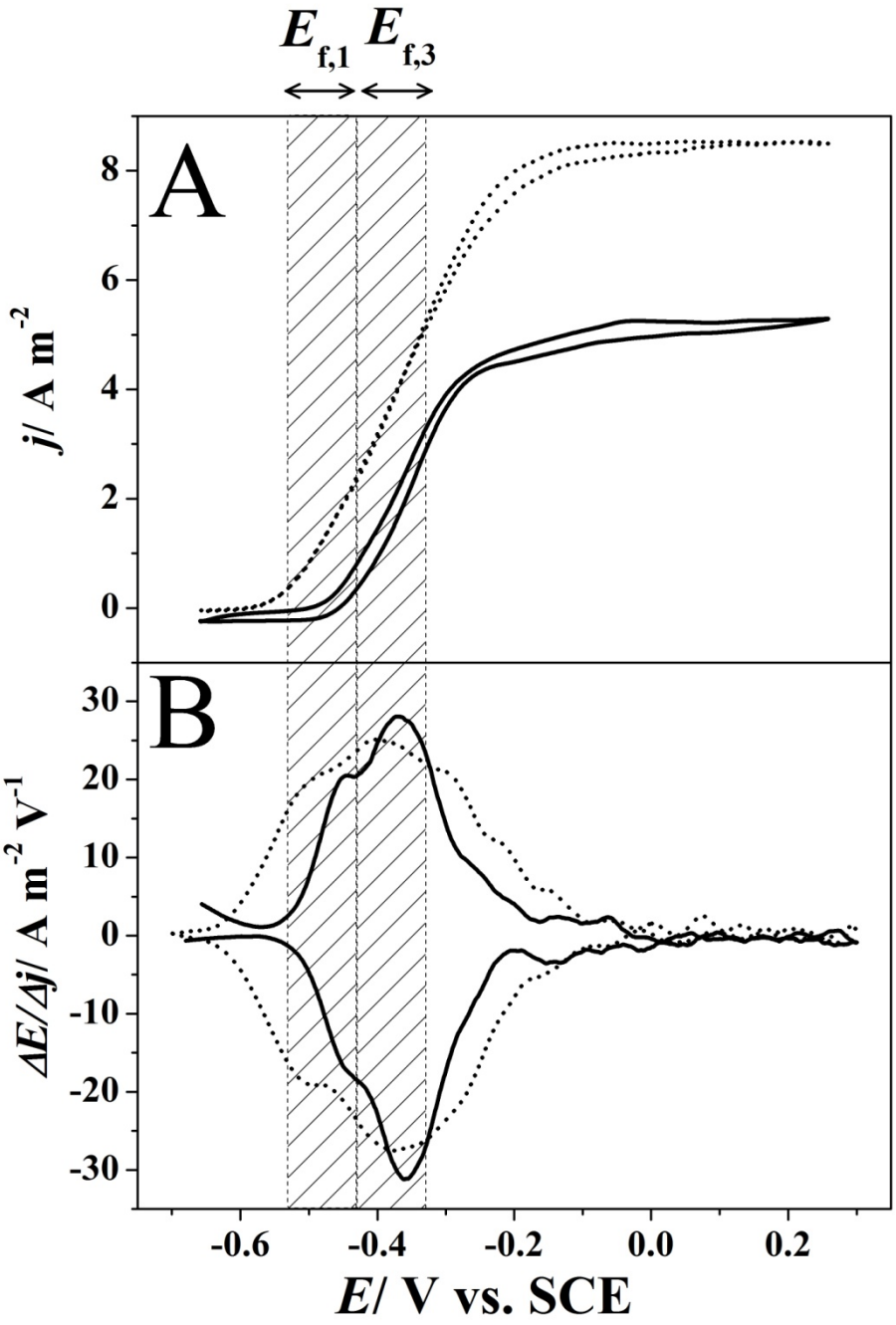

Fig. S3 A) Turnover cyclic voltammetry (CV) comparison of electroactive biofilms of *Geoalkalibacter subterraneus* (continuous line) and *Geobacter sulfurreducens* (dotted line) grown on graphite plate electrodes (15 cm^2) and in B) their respective first derivative. Double head arrows on the top indicate potential windows for formal potentials $E_{f,1}$ and $E_{f,3}$.

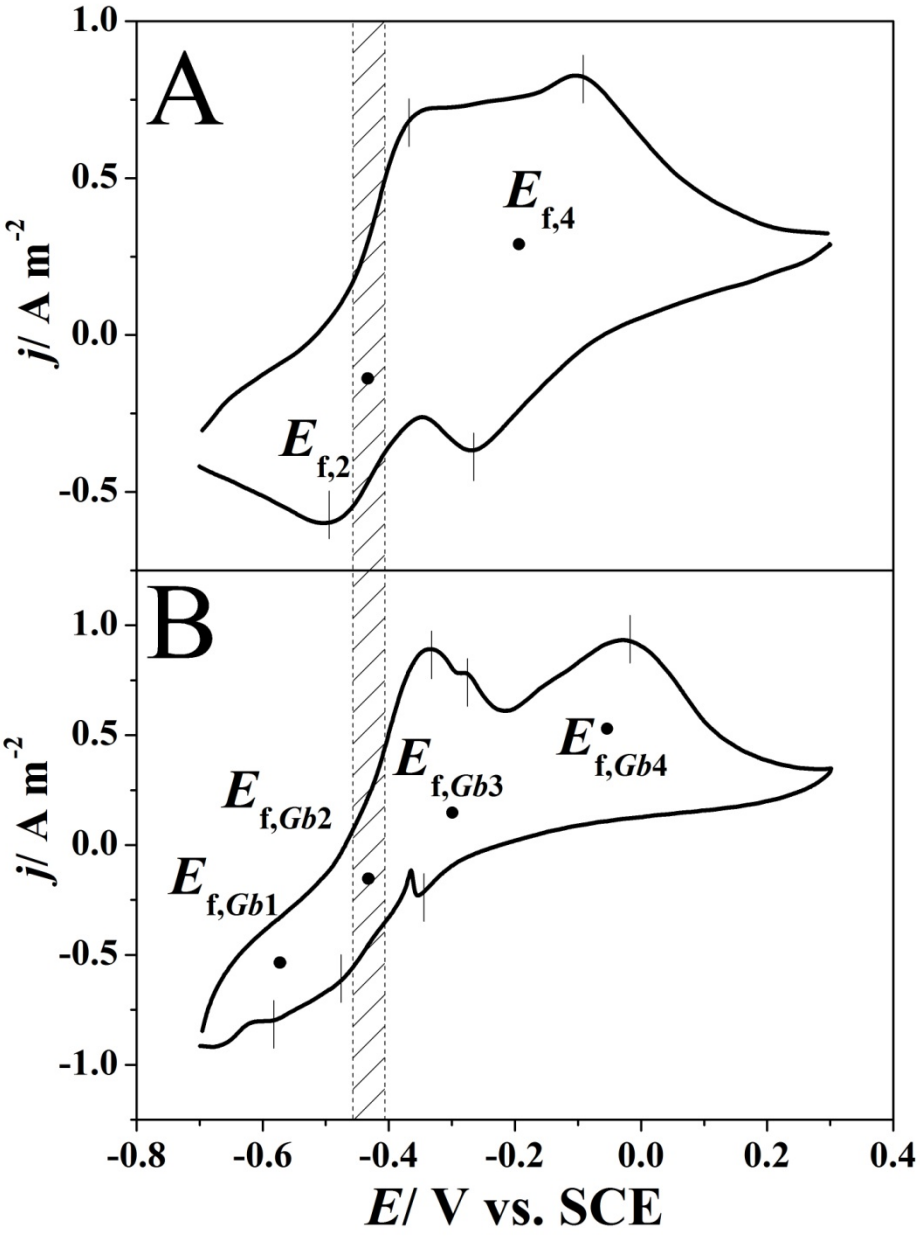

Fig. S4 Comparison of substrate deprived non-turnover cyclic voltammetry of electroactive biofilms. A) *Geoalkalibacter subterraneus* and B) *Geobacter sulfurreducens* immersed in growth medium without electron donor or any other compound capable of being detected in CV. Description: substrate depleted medium was replenished for the respective medium for *Glk. subterraneus* and *Gb. sulfurreducens* strains after substrate consumption during the first CA cycle. These media lacked electron donor/acceptor, trace element solutions, vitamin solution, selenite-tungstate solution, resazurin, yeast extract or any other compound that could give a signal while performing CV. Vertical dashed column indicates common formal potential found for both bacteria possibly indicating a similar DET mechanism.

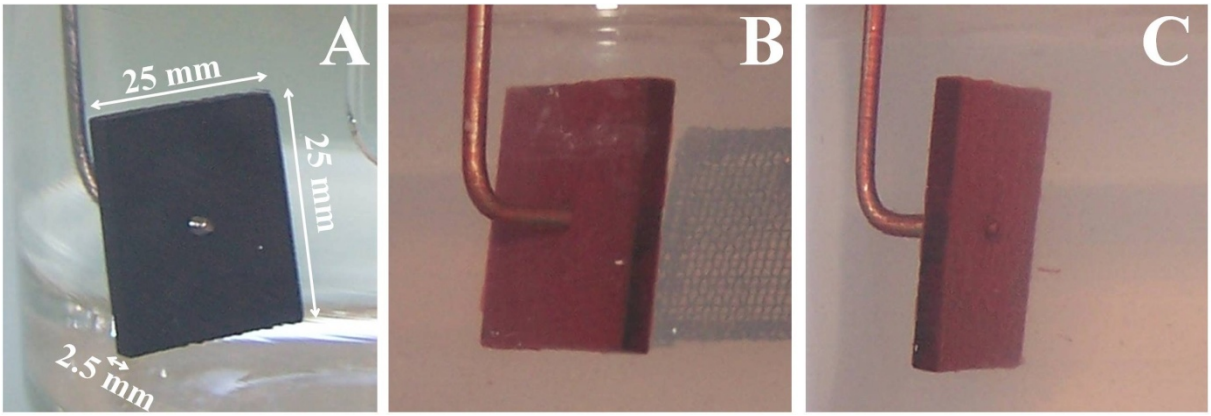

Fig. S5 Photographs of graphite working electrode before and after a visible reddish biofilm formation by *Geoalkalibacter subterraneus* (red color very likely caused by hemes[51]). A) Bare graphite electrode; B) Graphite electrode completely covered by the biofilm. In this photograph only the side of the graphite working electrode opposite to the Pt/Ir counter electrode is shown and C) The side of the graphite electrode facing the counter electrode showing completely biofilm coverage.

Table S3: PHLIP Analysis of mature electroactive biofilms.

Strain	Electrode coverage/ %	Thickness/ µm
Geoalkalibacter subterraneus	23 ± 7	76 ± 7
Geobacter sulfurreducens†	31 ± 16	46 ± 22
Graphite‡	5 ± 2	20 ± 1

†Positive biofilm control and ‡Negative biofilm control

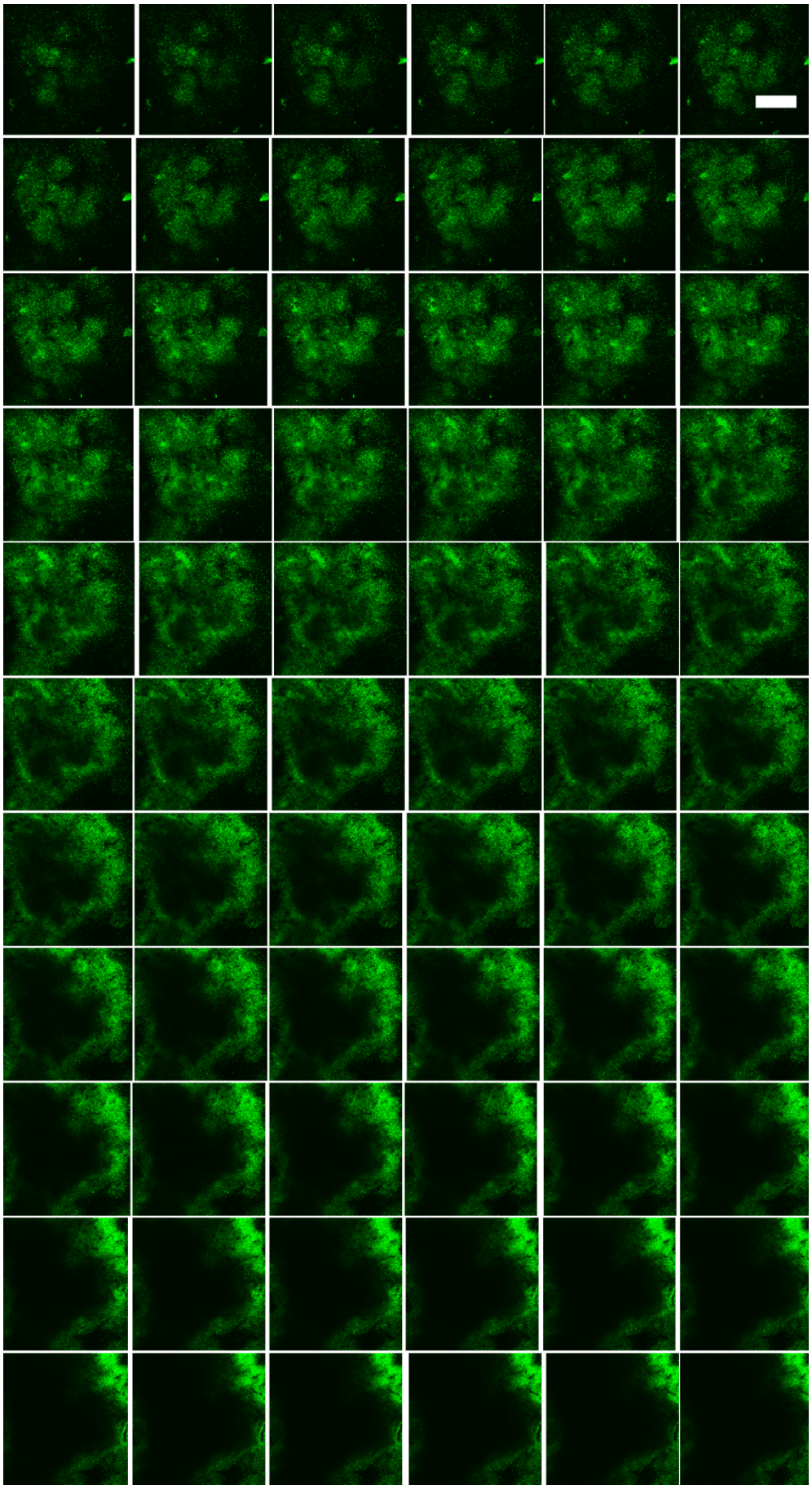

Fig. S6 Stack of metabolically active 1-µm slices of a *Glk. subterraneus* biofilm. Bar:120 µm.

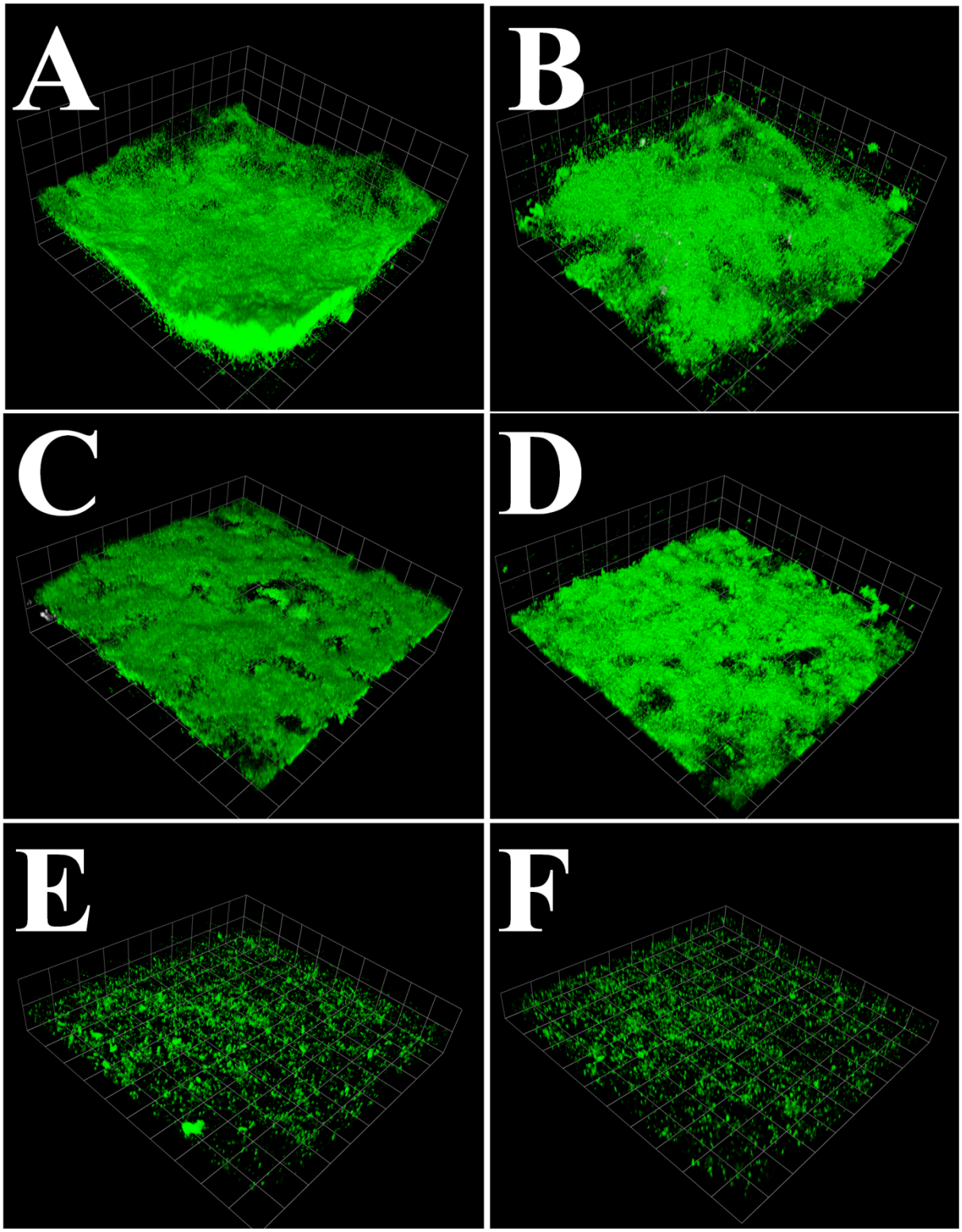

Fig. S7 Exemplary Volocity® 3D reconstructions of CLSM slices of electroactive biofilms. A-B) *Geoalkalibacter subterraneus*, C-D) *Geobacter sulfurreducens* and E-F) Graphite electrode not potentiostatically controlled from Table S3 (1 unit = 1 little square edge = 37.51 µm, the observed surface was thus 375 µm × 375 µm).

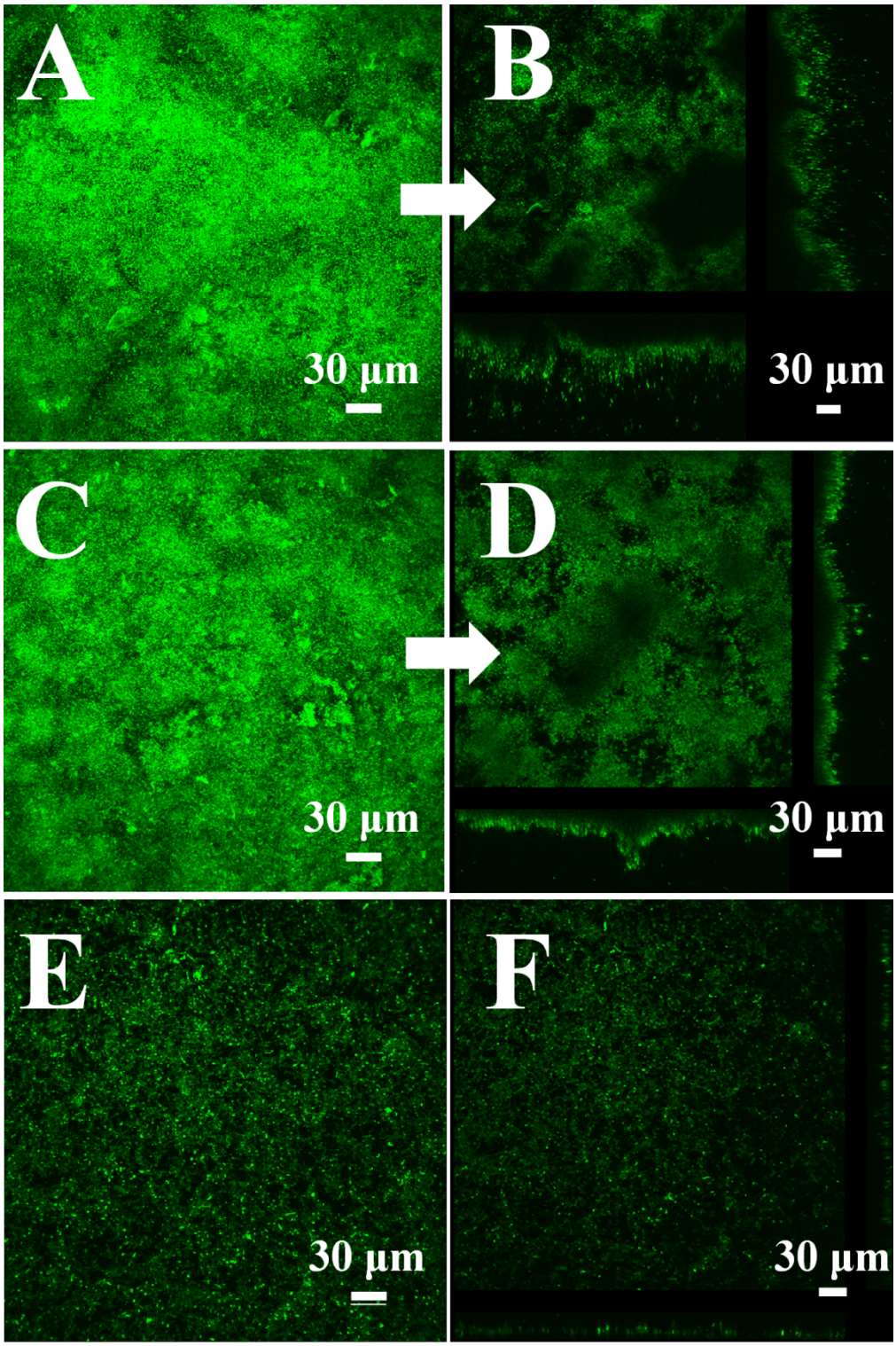

Figure S8: Exemplary confocal laser scanning microscopy of (A-B) *Geoalkalibacter subterraneus* and (C-D) *Geobacter sulfurreducens* biofilms grown on graphite plate electrodes potentiostatically controlled. E-F) Negative control electrode not potentiostatically controlled illustrating a lack of biofilm growth on the electrode surface. Maximum intensity projections: A, C and E. Orthogonal cross sections of single slices through the biofilm with top and right panels representing perpendicular slices: B, D and F.

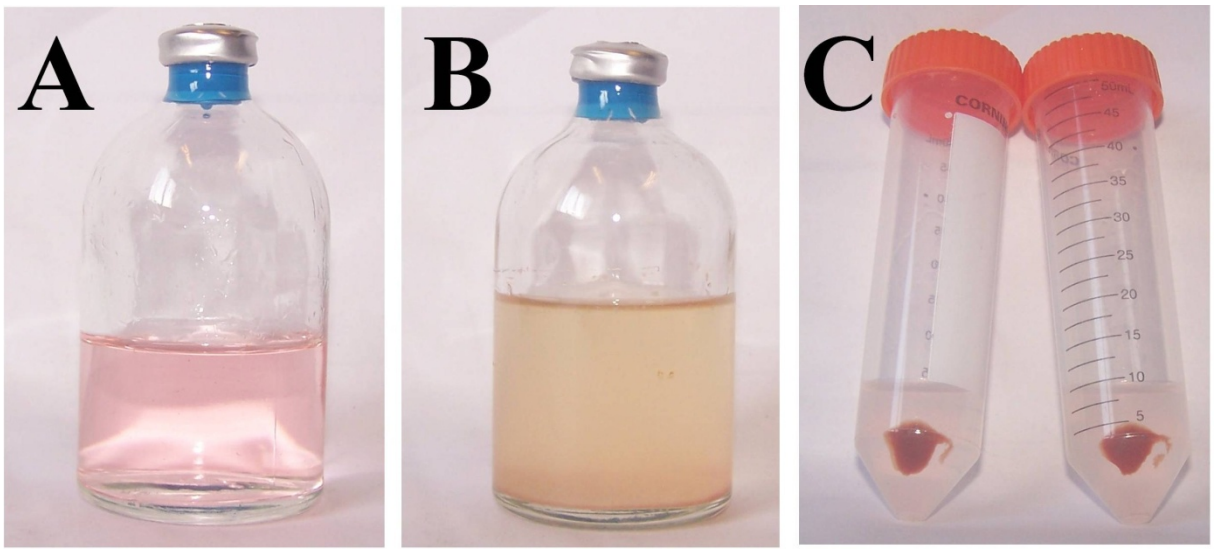

Fig. S9 A) FRR[52] medium in serum bottle modified from the Hungate technique[53] for the growth of *Geoalkalibacter subterraneus*; B) FRR medium inoculated with 20% v/v of *Geoalkalibacter subterraneus* cells incubated anaerobically at 37°C after gently shaking (Orbital shaker, Model 3540, Bioblock, Fisher Scientific SAS, F67403 Illkirch, Cedex, France) for 48 h; and C) Harvested *Geoalkalibacter subterraneus* cells by centrifugation at 3000 rpm during 10 min.

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