



HAL
open science

Precipitation of greigite and pyrite induced by Thermococcales: an advantage to live in Fe- and S-rich environments?

A. Gorlas, T. Mariotte, L. Morey, C. Truong, S. Bernard, J.-m. Guigner, J. Oberto, F. Baudin, G. Landrot, C. Baya, et al.

► To cite this version:

A. Gorlas, T. Mariotte, L. Morey, C. Truong, S. Bernard, et al.. Precipitation of greigite and pyrite induced by Thermococcales: an advantage to live in Fe- and S-rich environments?. *Environmental Microbiology*, 2022, 24 (2), pp.626-642. 10.1111/1462-2920.15915 . hal-03560043v1

HAL Id: hal-03560043

<https://hal.science/hal-03560043v1>

Submitted on 16 Nov 2022 (v1), last revised 7 Feb 2022 (v2)

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

1 *Precipitation of greigite and pyrite by Thermococcales: Ensuring survival in Fe- and S-rich*
2 *environments*

3
4 A. Gorlas^{1*}, L. Morey¹, T. Mariotte¹, C. Truong², S. Bernard², J-M Guigner², J. Oberto¹, F.
5 Baudin³, G. Landrot⁴, C. Baya², P. Le Pape², G. Morin², P. Forterre¹ and F. Guyot^{2, 5}.

6
7
8
9 ¹Université Paris-Saclay, CEA, CNRS, Institute for Integrative Biology of the Cell (I2BC),
10 91198, Gif-sur-Yvette, France.

11 ²Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie, UMR 7590 - CNRS,
12 Sorbonne Université, Museum National d'Histoire Naturelle, IRD, 75252 Paris Cedex 05,
13 France.

14 ³Institut des Sciences de la Terre de Paris, UMR 7193 – Sorbonne Université - CNRS, 75252
15 Paris Cedex 05, France.

16 ⁴Synchrotron SOLEIL - SAMBA beamline – 91190 Saint-Aubin, France.

17 ⁵Institut Universitaire de France (IUF).

18
19
20 Correspondence: Aurore Gorlas

21 aurore.gorlas@i2bc.paris-saclay.fr

22 Phone number: +33-(0)1-69-15-30-59

Fax: +33-(0)1-69-15-78-08

23
24
25 **Abstract**

26

27 Hydrothermal deep-sea vents, one of the most extreme environments for life on Earth, are
28 iron- and sulfur-rich anaerobic systems. Whereas FeS₂ pyrite is abiotically formed in the
29 interior of active sulfide chimneys at high temperatures (> 250°C), a major stock of FeS₂
30 pyrite is also produced in the cooler middle layers of the chimneys at lower temperatures (<
31 150°C) by a still unknown mechanism. *Thermococcales*, a major family of archaea inhabiting
32 these extreme environments, have been shown to rapidly produce abundant quantities of FeS₂
33 from the hydrothermal fluid at 85°C, suggesting that they may contribute to the formation of
34 “low temperature” FeS₂ pyrite in their ecosystem. In this study, we show that this mechanism,
35 which induces a massive cell mortality, operates in *Thermococcus kodakarensis* only when
36 zero-valent sulfur is directly available as sulfur vesicles. Significant amounts of Fe₃S₄ greigite
37 nanocrystals are then formed extracellularly nucleating on iron-phosphate-bearing
38 extracellular materials presumably resulting from cell lysis. Those pyrite and greigite
39 mineralizations allow the formation of a 3D structure composed of pyrite-mineralized cells
40 and vesicles remnants within a matrix consisting mostly of greigite nanocrystals. Starting
41 from this state, we observe that a new generation of cells grew in this medium a priori not
42 adapted to cell growth. We propose that greigite precipitation on phosphate-loaded former cell
43 materials induces the release of phosphates and organic compounds thus making them
44 available to a few surviving non-mineralized cells hence allowing production of new alive
45 cells. This suggests that biologically induced iron-sulfides mineralization could be part of a
46 survival strategy employed by *Thermococcales* to cope in strongly mineralizing high-
47 temperature hydrothermal environments.

48

49 **Keywords**

50 Biomineralization, Pyrite, Greigite, Hyperthermophiles, *Thermococcales*, Adaptation

51