FAR-DEEP

Fennoscandia Arctic Russia – Drilling Early Earth Project
Northwest Russia

Goal & Scientific Objective

The main scientific goals of the FAR-DEEP project are: (i) to establish a well characterised, well dated, well archived section for the period 2500-2000 Ma; (ii) to document the changes in the biosphere and the geosphere associated with the rise in atmospheric oxygen; and (iii) to develop a self-consistent model to explain the genesis and timing of the establishment of the modern aerobic Earth System.
Applied objectives of the research having potential significant economic implications include (i) the search for natural nanoscale allotropes of carbon such as graphene and fullerenes (ii) the assessment of controls of oldest-known global phosphogenesis episode and formation of phosphorites, and (iii) the establishment of drivers leading to redox sensitive trace metal enrichments in organic rich sedimentary rocks.

Operational Achievements

At three sites, fifteen holes were drilled and range in depth from 92 to 503 m. A total of 3650 meters of core were recovered.

Pechenga Greenstone belt: 6 holes

Imandra/Varzuga Greenstone Belt: 3 holes

Onega Basin: 6 holes

Red colored Jatuli siltstones

Web & Media Resources

http://far-deep.icdp-online.org/

http://www.geo.uni-potsdam.de/icdp_homepage/highlights/highlight02_FARDEEP.html

Timeline

2006 ICDP proposal submission

2007 (May – October) drilling operations

Principal Investigators

Victor A. Melezhik, Geological Survey of Norway

Aivo Lepland, Geological Survey of Norway

Data & Sample Access

FAR-DEEP cores are stored at the Geological Survey of Norway, and core inspection and sampling parties are organized once or twice a year (for details, contact Aivo.lepland@ngu.no).

Scientific Findings

Sedimentary rocks of the Seidorechka and Polisarka Formations at the bottom of the FAR-DEEP stratigraphic succession captured Earth's initial oxygenation and show the disappearance of mass-independently fractionated sulfur isotopes at the transition of Seidorechka and Polisarka formations at c 2.44 Ga.

Dolostones and halite-anhydrite evaporite rocks from the Tulomozero Formation recovered in the Onega Paleobasin demonstrate build-up of sizable seawater sulfate reservoir at 2.0 Ga reaching 1/3 of present day sulfate concentration.

Organic carbon rich sediments of the 1.98 Ga Zaonega Formation in the Onega Basin (popularly known as "shungite") bear evidence for establishment of sulfur bacteria habitats triggering phosphorite formation in response to the oxygenation of the Earth. The Zaonega rocks also demonstrate that fluctuating basinal redox condition and changes from oxygenated to euxinic water column can cause major sediment enrichments in redox sensitive element, but indicate overall oxygenated conditions. Detailed carbon and sulfur isotope profiles of the Zaonega Formation show that these proxy records are strongly influenced by basinal processes that complicate the deciphering of global geochemical cycles as recorded in Zaonega rocks.

Key Publications

Kump, L.R., Junium, C., Arthur, M.A., Brasier, A., Fallick, A., Melezhik, V., Lepland, A., Crne, A.A. & Luo, G., 2011. Isotopic evidence for massive oxidation of organic matter following the great oxidation event. Science, 334: 1694-1696.

Lepland, A., Joosu, L., Kirsimäe, K., Prave, A.R., Romashkin, A.E., Črne, A.E., Martin, A.P., Fallick, A.E., Somelar, P., Üpraus, K., Mänd, K., Roberts, N.M.W., van Zuilen, M.A., Wirth, R. & Schreiber, A., 2014: Potential influence of sulphur bacteria on Palaeoproterozoic phosphogenesis. Nature Geoscience, 7: 20-24.

Melezhik, V. A., Lepland, A., Romashkin, A. E., Rychanchik, D. V., Mesli, M., Finne, R. E., Conze, R., and the FAR-DEEP Scientists (2010): The Great Oxidation Event Recorded in Paleoproterozoic Rocks from Fennoscandia. Scientific Drilling 9 23-29. doi: 10.2204/ iodp.sd.9.04.2010

Melezhik, V.A.; Prave, A.R.; Hanski, E.J.; Fallick, A.E.; Lepland, A.; Kump, L.R.; Strauss, H. (eds.) (2013): Reading the Archive of Earth's Oxygenation. Volume 1: The Palaeoproterozoic of Fennoscandia as Context for the Fennoscandian Arctic Russia - Drilling Early Earth Project. Springer, ISBN 978-3-642-29681-9 1 490pp. doi:10.1007/978-3-642-29682-6

Melezhik, V.A.; Prave, A.R.; Hanski, E.J.; Fallick, A.E.; Lepland, A.; Kump, L.R.; Strauss, H. (eds.) (2013): Reading the Archive of Earth's Oxygenation. Volume 2: The Core Archive of the Fennoscandian Arctic Russia - Drilling Early Earth Project. Springer, ISBN 978-3-642-29658-1 2 556pp. doi:10.1007/978-3-642-29659-8

Melezhik, V.A.; Prave, A.R.; Hanski, E.J.; Fallick, A.E.; Lepland, A.; Kump, L.R.; Strauss, H. (eds.) (2013): Reading the Archive of Earth's Oxygenation. Volume 3: Global Events and the Fennoscandian Arctic Russia - Drilling Early Earth Project. Springer, ISBN 978-3-642-29669-7 3 506pp. doi:10.1007/978-3-642-29670-3

Paiste, K., Lepland, A., Zerkle, A. L., Kirsimäe, K., Kreitsmann, T., Mänd, K., Romashkin, A. E., Rychanchik, D. V., & Prave, A. R., 2020: Identifying global vs. basinal controls on Paleoproterozoic organic carbon and sulfur isotope records. Earth-Science Reviews, 207: p. 103230.

Qu, Y., Crne, A.E., Lepland, A. & Van Zuilen, M.A., 2012: Methanotrophy in a Paleoproterozoic oil field ecosystem, Zaonega Formation, Karelia, Russia. Geobiology, 10: 467-478.

Reuschel, M., Melezhik, V. H., Whitehouse, M. J., Lepland, A, Fallick, A.E. Strauss, H., Isotopic evidence for a sizeable seawater sulfate reservoir at 2.1Ga, Precambrian Research, Volume 192, 2012, Pages 78-88, ISSN 0301-9268

Van Zuilen, M.A., Fliegel, D., Wirth, R., Lepland, A., Qu, Y., Schreiber, A., Romashkin, A.E. & Philippot, P., 2012: Mineral-templated growth of natural graphite films. Geochimica et Cosmochimica Acta, 83: 252-262.

Warke, M. R., Di Rocco, T., Zerkle, A. L., Lepland, A., Prave, A. R., Martin, A. P., Ueno, Y., Condon, D. J., & Claire, M. W., 2020: The Great Oxidation Event preceded a Paleoproterozoic "snowball Earth". Proceedings of the National Academy of Sciences, p. 202003090.