Frontiers in Earth Sciences

2

Victor A. Melezhik *Editor-in-Chief*
Anthony R. Prave · Anthony E. Fallick
Eero J. Hanski · Aivo Lepland
Lee R. Kump · Harald Strauss *Editors*

Reading the Archive of Earth's Oxygenation

Volume 2: The Core Archive of the Fennoscandian Arctic Russia – Drilling Early Earth Project

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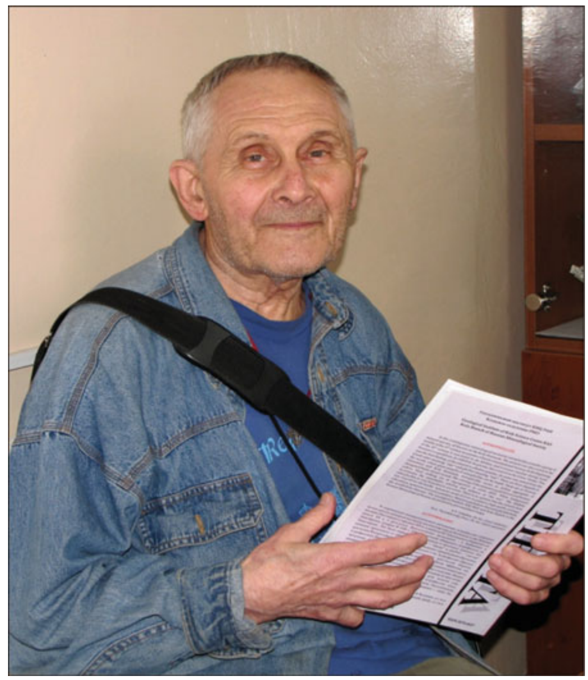
Dedication

The editors respectfully dedicate this three-volume treatise to Dr. Alexander Predovsky of the Geological Institute of the Russian Academy of Sciences in Apatity. He is one of the earliest explorers of the Precambrian geology in Russian Fennoscandia, and his half century of active work on the geochemistry of sedimentary and igneous rocks provided important foundations for the current understanding of Palaeoproterozoic stratigraphy, geochemistry of sedimentary and volcanic processes and ore formation in the region.



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The idea of making an atlas with comprehensive descriptions and illustrations of the Palaeoproterozoic rocks from the Fennoscandian Shield was initiated in 2009 during a workshop held in Trondheim, Norway, under the auspices of the International Continental Scientific Drilling Program (ICDP). Starting from this workshop, a plan was developed and finalised. Chris Bendall, Senior Editor for Springer, is acknowledged for encouragement and editorial supervision of the project.

The three-volume set has three major underpinnings. The first is many years of research in Precambrian geology of the Fennoscandian Shield by many workers, and we acknowledge particularly the support of the Geological Survey of Norway; the University of Oulu, Finland; and the Institute of Geology, Petrozavodsk, Russia.

The second is the unique core material obtained during the drilling operations by the Fennoscandian Arctic Russia – Drilling Early Earth Project (FAR-DEEP). The drilling operations were largely supported by the ICDP and by additional funding from several other agencies and institutions. We are grateful for the financial support to the Norwegian Research Council (NFR), the German Research Council (DFG), the National Science Foundation (NSF), the NASA Astrobiology Institutes, the Geological Survey of Norway (NGU) and the Centre of Excellence in Geobiology, the University of Bergen, Norway. The core archive and associated analytical work were supported by NGU, the Scottish Universities Environmental Research Centre (SUERC) and by the Pennsylvanian State University.

The third is a multidisciplinary approach to investigate complicated geological processes. This was provided by the international scientific community and we acknowledge the support of many universities in Scandinavia, Europe and the USA.

Many individuals helped in the preparation of the drilling operations and offered logistical support. We are sincerely grateful to Anatoly Borisov (Kola Geological Information and Laboratory Centre) for providing geological assistance for precise positioning of drillholes in unexposed, boggy and forested terrains in the Imandra/Varzuga Greenstone Belt. Stanislav Sokolov (Kola Mining Metallurgical Company) is acknowledged for logistic support and geological guidance in the Pechenga Greenstone Belt. Logistical organisation of the drilling operations and core transport across national borders by the State Company Mineral, St. Petersburg, Russia, is appreciated. The Finnish company, SMOY, performed the drilling.

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To be embedded in the family of science always requires sacrifices such as time lost in family contact. We wish to extend our gratitude to our families for patience, understanding and constant encouragement.

Finally and most importantly, the editors wish to thank those colleagues and students who will use and read these books or some parts of them. We hope that this will encourage them to reach a more complete understanding of those processes that played an important role in the irreversible modification of Earth's surface environments and in shaping the face of our emerging aerobic planet. We would also like to thank those scientists who will use the offered advantage of rich illustrative material linked to the core collection to undertake new research projects.

Preface to Volume 2

Earth's present-day environments are the outcome of a 4.5-billion-year period of evolution reflecting the interaction of global-scale geological and biological processes. Punctuating that evolution were several extraordinary events and episodes that perturbed the entire Earth system and led to the creation of new environmental conditions, sometimes even to fundamental changes in how planet Earth operated. One of the earliest and arguably the greatest of these events was a substantial increase (orders of magnitude) in the atmospheric oxygen abundance, sometimes referred to as the Great Oxidation Event. Given our present knowledge, this oxygenation of the terrestrial atmosphere and the surface ocean, during the Palaeoproterozoic Era between 2.4 and 2.0 billion years ago, irreversibly changed the course of Earth's evolution. Understanding why and how it happened and what its consequences were are among the most challenging problems in Earth sciences.

The three-volume treatise entitled "Reading the Archive of Earth's Oxygenation" (1) provides a comprehensive review of the Palaeoproterozoic Eon with an emphasis on the Fennoscandian Shield geology; (2) serves as an initial report of the preliminary analysis of one of the finest lithological and geochemical archives of early Palaeoproterozoic Earth history, created under the auspices of the International Continental Scientific Drilling Programme (ICDP); (3) synthesises the current state of our understanding of aspects of early Palaeoproterozoic events coincident with and likely related to Earth's progressive oxygenation with an emphasis on still-unresolved problems that are ripe for and to be addressed by future research. Combining this information in three coherent volumes offers an unprecedented cohesive and comprehensive elucidation of the Great Oxidation Event and related global upheavals that eventually led to the emergence of the modern aerobic Earth System.

The format of these books centres on high-quality photo-documentation of Fennoscandian Arctic Russia – Drilling Early Earth Project (FAR-DEEP) cores and natural exposures of the Palaeoproterozoic rocks of the Fennoscandian Shield. The photos are linked to geochemical data sets, summary figures and maps, time-slice reconstructions of basinal and palaeoenvironmental settings that document the response of the Earth system to the Great Oxidation Event. The emphasis on a thorough, well-illustrated characterisation of rocks reflects the importance of sedimentary and volcanic structures that form a basis for interpreting ancient depositional environments, and chemical, physical and biological processes operating on Earth's surface. Most of the structural features are sufficiently complex as to challenge the description by other than a visual representation, and high-quality photographs are themselves a primary resource for presenting essential information. Although nothing can replace the wealth of information that a geologist can obtain from examining an outcrop first hand, the utility of photographs offers the next best source of data for assessing and evaluating palaeoenvironmental reconstructions. This three-volume treatise will, thus, act as an information source and guide to other researchers and help them identify and interpret such features elsewhere, and will serve as an illustrated guidebook to the Precambrian for geology students.

Finally, the three-volume treatise provides a link to the FAR-DEEP core collection archived at the Geological Survey of Norway. These drillcores are a unique resource that can be used to solve the outstanding problems in understanding the causes and consequences of the multiple processes associated with the progressive oxygenation of terrestrial environments. It is anticipated that the well-archived core will provide the geological foundation for future research aimed at testing and generating new ideas about the Palaeoproterozoic Earth. The three-volume treatise will be of interest to researchers involved directly in studying this hallmark period in Earth history, as well as professionals and students interested in Earth System evolution in general.

Volume 2: "The Core Archive of the Fennoscandian Arctic Russia – Drilling Early Earth Project" provides a description of the newly generated archive hosting ICDP's FAR-DEEP drill cores through key geological formations in Russian Fennoscandia. The book contains several hundred high-quality, representative photographs illustrating 3,650 m of fresh, uncontaminated core documenting a series of global palaeoenvironmental upheavals linked to the Great Oxidation Event. The core exhibits sedimentary and volcanic formations that record a transition from anoxic to oxic Earth surface environments, the first global glaciation (the Huronian glaciation), an unprecedented perturbation of the global carbon cycle (the Lomagundi-Jatulian Event), a radical increase in the size of the seawater sulphate reservoir, an apparent upper mantle oxidising event, the Earth's earliest documented sedimentary phosphates, one of the greatest accumulations of organic matter (the Shunga Event) and generation of the Earth's earliest supergiant petroleum deposit. The volume highlights the potential of the FAR-DEEP core archive for future research of the Great Oxidation Event and the biogeochemical cycles operating during that time.

Welcome to the illustrative journey through one of the most exciting periods of planet Earth!

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Part V

FAR-DEEP Core Archive and Database

5.1 FAR-DEEP Core Archive and Database

Aivo Lepland, Melanie Mesli, Ronald Conze, Karl Fabian, Anthony E. Fallick, and L.R. Kump

The collection of FAR-DEEP (Fennoscandian Arctic Russia Drilling Early Earth Project) cores includes material from 15 drill holes through 2,500–2,000 Ma sedimentary and volcanic successions in Russian Fennoscandia amounting to a total core length of 3,650 m, the recovered material provides one of the best available rock records for studying the major environmental upheavals during the early Palaeoproterozoic, and for assessing timing, causes and effects of the rise of atmospheric oxygen (Melezhik et al. 2010). The great scientific promise that the FAR-DEEP material holds for current and future studies of the Palaeoproterozoic Earth calls for a dedicated cataloguing system that facilitates an easy capture of generated technical, geological and geochemical data on the cores, and provides means for effective sharing of information among researchers. In order to make the unique material available for future studies, all cores and related documentation have been thoroughly archived in the core repository and the database, respectively. This archive is linked tightly to the user-friendly and Web-accessible database system serving as an essential gateway for exploring the full potential of the material.

5.1.1 Drilling Information System and Core Archive

The technical and geological data gathered during the FAR-DEEP drilling operations and throughout the subsequent archiving and research phases have been catalogued using the Drilling Information System (DIS; Fig. 5.1) developed by the Operational Support Group at the International Continental Scientific Drilling Program (ICDP). This system has been employed in many ICDP and IODP (Integrated Ocean Drilling Program) projects since 1998 to catalogue the drilling and core information. The DIS contains a toolkit that allows the user to build customised data management systems and environments and infrastructures for drilling projects (Conze et al. 2007, 2010). It has tools to define, generate and administrate data structures, a graphical user interface, a Web interface and other elements necessary for a drilling information management system. A central component of the DIS is a set of generic data structures (templates) and dictionaries for scientific drilling purposes. These templates and dictionaries can be adapted and modified to meet project needs, for example to capture cuttings data, hard-rock core data, long-term monitoring data and engineering data. The graphical user interface is utilized to generate input forms for entering data (Fig. 5.2), report templates and data views. Other tools allow the user to build specific data import modules (data pumps) and to generate customised internet Web pages documenting progress during the project. To visualise data, the DIS generates Scalable Vector Graphics, which are used in tools such as the Downhole-Measurement-Profile-Builder and the Lithological-Profile-Builder.

The deployment of the DIS is highly scalable, ranging from a standalone installation on a laptop with runtime versions of Microsoft Access® and Microsoft SQL Server®[1], to a client–server installation with one or more DIS database servers and several client computers (Fig. 5.3). All client computers can either be connected directly to the DIS server on the network, or through the XDIS Web interface. During the course of FAR-DEEP, the database structure and the set-up of input forms have been continuously updated to meet the specific needs of the project. Data entry during the drilling campaign in the field (May–October 2007) primarily included technical information about drilling progress and

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[1] Microsoft Access and Microsoft SQL Server are either registered trademarks or trademarks of Microsoft Corporation in the United States and/or other countries.

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sectioning and placement of core into core boxes. Daily transfer of notes by drillers and on-site geologists into the database in the field facilitated the correction of occasional inconsistencies and secured correct recording of depths and other parameters. Core box images and preliminary lithostratigraphic descriptions provided an immediate overview of the obtained rock record. To secure all these recordings and to update the central database and the Web portal, a cell phone was used to connect the field laptop to the internet (Fig. 5.3) and the entire database, including numerical data, text data and images, was uploaded to the ICDP server in Potsdam on a daily basis.

The core archive process at the repository of the Geological Survey of Norway (NGU) started in March 2008, and was completed in December 2008. The archiving included (1) high-resolution photographing of core boxes in dry and wet conditions (Fig. 5.4), (2) magnetic susceptibility measurements of whole round core at c. 0.2 m intervals using a Bartington ring sensor, (3) core splitting by sawing, (4) image scanning of split (slabbed) core (Fig. 5.5), (5) detailed lithological description (Fig. 5.4), and (6) routine sampling at intervals of about 7 m for general geochemical and petrographic characterisation of the core. All core boxes have been documented throughout the whole core processing and sampling period. The individual core sections are stored in certain slots of core boxes as shown in Fig. 5.3. The boxes are aligned in portrait orientation with top at the upper left corner of the box. The flat faces of the split core sections have been scanned digitally using the DMT CoreScan® Colour I[2] before sampling (Fig. 5.5). The original images are generated as bitmap (bmp) files using a resolution of 5 pixel/mm and full RGB colour values. For the Web presentation these images have been reduced to smaller JPG image files.

5.1.2 FAR-DEEP Samples

Access to samples from the FAR-DEEP cores requires the submission of a sample request that details the information about the planned project, applied methods, funding situation and timeline of the study, and specifies the core intervals to be sampled. The exact positions of requested samples can be defined either by using the descriptions, images and analytical data available on the Web without a visit to the repository, or by working directly with cores in the core repository. Upon approval of the request by the project's principle investigator (PI), the details about the requested samples are entered into the DIS creating a unique number for each new sample. This ID allows to identify any sample, and to search for the sample related information about expedition, site and hole, core and section, box and slot number, interval in section, core depth, requesting researcher and the purpose of the sample request. The same array of information is printed on the sample label (Fig. 5.6). Two sets of these labels are printed; one is placed on a sample bag and the other is affixed to the slot divider in the core box, next to the sample. To facilitate the visual tracking of distributed samples, and to show the core sections that are still available for sampling, the core boxes are photographed during each sampling session (Fig. 5.4). This photographing is done after pencil marking the samples on cores and affixing the labels on slot dividers, but before the extraction. Only after the completion of these steps the samples can be extracted from the cores. A record is also made in DIS if a sample with unique ID is further divided into different parts (subsamples and aliquots) for various analyses on splits of the same sample. A strict sampling procedure secures a full track record of sample distribution, essential for planning new research initiatives on the FAR-DEEP material, and for avoiding overlapping projects and conflicts of interest.

The ICDP and the Integrated Ocean Drilling Program (IODP) are using the same naming conventions for addressing any recovered material related to a certain drillhole as a common standard. In case of FAR-DEEP, a label starts with the expedition number 5,018 followed by the site number, and drillhole ID, e.g. 5018_1_A represents the first drillhole at site 1. The cores and sections are numbered accordingly: e.g. 5018_1_A_3_2 representing the second section of the third core run. In addition, all cores and all samples taken will have unique identifiers assigned, an International Geo Sample Number (IGSN). The IGSN system is operated by an international consortium of science operators, research institutions and geological survey organizations. Any IGSN can be resolved through the internet to display information about the identified sample. IGSNs allow unambiguous identification and referencing and can be used to link samples to associated metadata about the original project, core repository, laboratory, and analytical data (Lehnert and Klump 2008).

5.1.3 FAR-DEEP Archive Samples, Dataset and Analytical Methods

The archive sample set consisting of 554 specimens was analysed for whole-rock major and trace elements, carbonate composition, C and S abundances, and was used for making thin sections. Selected specimens were analysed for isotopic composition of S in sulphides, C in organic matter, and C, O and Sr in carbonates. All documentation obtained during the

[2] DMT CoreScan is either a registered trademark or trademark of Deutsche Montan Technologie GmbH & Co.KG in Germany and/or other countries.

archiving process including stratigraphic logs, general geochemical and isotopic datasets and magnetic susceptibility profiles was catalogued using the DIS. Tables of geochemical data (Fig. 5.7) and stratigraphic logs were available for the FAR-DEEP partners on the password protected Web site (Fig. 5.8) prior to the main research phase that started with the sampling party at the NGU's core repository in March 2009. Although the archiving documentation resulted in a dataset with great scientific value in itself, its main purpose was to provide a general overview of cores to be used for planning specific projects and detailed sampling schemes. A significant part of this documentation on the FAR-DEEP cores obtained during archiving including lithostratigraphic descriptions, major and trace element data and magnetic susceptibility profiles is presented in core description chapters of this book.

5.1.3.1 Magnetic Susceptibility Measurements

K. Fabian

Magnetic susceptibility on whole cores was measured using a Bartington MS2 with ring sensors MS2C/D = 68 mm or MS2C/D = 133 mm. Measurements were taken at ~20 cm intervals with 10 s integration time. Measurement positions were chosen such that within a range of ± D the cylindrical core was completely intact without cracks or other volume defects. This ensures that >95% of the sensor volume-response curve is covered by the sample and each susceptibility measurement represents an average over the same volume.

The instrument reading K′ is then corrected for the ratio between core diameter (d = 51 mm) and the sensor diameter (D) using the relations given in the MS2 instrument manual. The corresponding correction factors f are f = 1.4 for D = 68 mm and f = 0.33 for D = 133 mm. The diameter corrected K* values are calculated using

$$K^* = K'/f$$

These K* values represent precise relative volume susceptibilities, which are consistent between different sensors and different cores. To obtain absolute magnetic susceptibility (K) in SI, these K* values must be calibrated using homogenous cores of known susceptibility. Using density corrected sand samples, cross-calibrated to MnO_2 using a MS2B sensor, we determined a calibration factor of $\beta = 11.7 \pm 0.7$, such that estimates of absolute volume susceptibility K can be obtained from

$$K = \beta K^*$$

To avoid calibration errors, all data plots use the internally consistent relative susceptibility K*. Note that volume susceptibility K is a pure number without unit, but depends on the unit system used. Here we use SI units and numerical values are typically given in mSI, e.g. K = 100 μSI = $100*10^{-6}$ SI.

5.1.3.2 Acid-Soluble Major and Trace Element Analysis of Carbonates by ICP-AES

Acid-soluble (10% HCl) Fe, Ca, Mg, Mn and Sr concentrations were determined by inductively coupled plasma-atomic emission spectrometry (ICP-AES) at NGU using a Thermo Jarrell Ash ICP 61 instrument, with detection limits for Fe, Mg, Ca, Mn and Sr being 5, 100, 200, 0.2 and 2 $\mu g \cdot g^{-1}$, respectively. The precision (1σ), including element extraction, was ± 10%.

5.1.3.3 Major and Trace Element Analysis by XRF

Major and trace elements were determined by X-ray fluorescence spectrometry (XRF) at the NGU, using a Philips PW 1480 X-ray spectrometer equipped with a Rh X-ray tube. For major elements 0.6 g of pre-ignited (1,000°C) fine-ground sample material was mixed with 4.2 g $Li_2B_4O_7$ and fused to a bead in a CLAISSE FLUXER-BIS. For trace element analysis 1.2 g (±0.005 g) of Hoechst wax and 5.4 g (±0.005 g) of sample were mixed in a Spex Mixer/Mill for at least 1 min. The mixture was then pressed to a pellet in a Herzog pelletizing press (approx. 20kN, time = 20 s). Detection limits for major element oxides were 0.01 % except for SiO_2 (0.5%), Al_2O_3 (0.02%), MgO (0.04%) and Na_2O (0.1%). Detection limits for trace elements were ≤ 10 $\mu g \cdot g^{-1}$ except for Ce (20 $\mu g \cdot g^{-1}$), Sb (15 $\mu g \cdot g^{-1}$), Hg (20 $\mu g \cdot g^{-1}$), Tl (20 $\mu g \cdot g^{-1}$), I (10 $\mu g \cdot g^{-1}$), Cl (0.05%), F (0.1%) and S (0.02%). The precision (1σ) was typically around 2 % for the major oxides present.

5.1.3.4 Carbon and Sulphur Analysis by CS Elemental Analyser

The Leco SC-444 analyser at the NGU was employed for measuring the concentration of total carbon (TC), total organic carbon (TOC) and total sulphur (TS) using 100–350 mg of powdered samples. The TOC content was determined on acid-treated (10% HCl) material. Detection limits for TS, TC and TOC were 0.01 wt.%, 0.07 wt.% and

0.1 wt.%, respectively, and the precision was < 2.5% (1σ) for TC, and < 10% (1σ) for TS and TOC.

5.1.3.5 Carbon and Oxygen Isotope Analyses of Carbonates

A.E. Fallick

Carbon isotope analyses of whole-rock carbonate samples were performed at the Scottish Universities Environmental Research Centre (SUERC) in Glasgow, using the phosphoric acid method of McCrea (1950), modified by Rosenbaum and Sheppard (1986) for operation at high temperature. C isotope ratios in carbonate of the bulk rock sample were measured on purified CO_2 released from a sample weight equivalent to 1–2 mg carbonate. The mass spectrometer was either a triple collector, dual inlet VG SIRA 10 or a triple collector continuous-flow AP 2003. Analyses were calibrated against NBS 19 and reproducibility (1σ) was generally better than ± 0.2 ‰. Carbon isotope data are reported in per mil (‰) relative to the V-PDB standard.

5.1.3.6 Carbon Isotope Analysis of Organic Carbon

L. Kump

Prior to extraction, the samples were gently washed with deionised distilled water to remove any surface contamination. 5–10 g samples were then milled with a Retsch PM100 Ball Mill resulting in a homogeneous powdered sample (size ~75 µm). The powdered samples were decarbonated in centrifuge tubes using HCl (10 %) for 24 h and rinsed repeatedly to remove acidity (checked with pH paper). The samples were then freeze-dried for analysis. For carbon isotope ratio determination a continuous flow Elemental Analyzer (COSTECH ECS4010)-Isotope Ratio Mass Spectrometer (EA-IRMS: Thermo Delta Plus) system via an open split interface (CONFLO III) was employed. Sample sizes varied from 1 to 30 mg depending on organic carbon content. Approximately 10 mg of V_2O_5 was added to aid combustion. Carbon isotope data are reported in per mil (‰) relative to the V-PDB standard.

5.1.4 FAR-DEEP Information on the Web

The FAR-DEEP project is represented by a project Web site (http://far-deep.icdp-online.org) on the ICDP Web portal (http://www.icdp-online.org). This platform has been used to provide basic information about the project (e.g. the proposal, who are the principal investigators (PIs), and who are the members of the central science team). It was utilized to distribute news and daily updates for the interested general public including representatives of printed and electronic media. Parallel to the public platform an internal area (Fig. 5.8) has been created to provide more detailed information about the visited sites, drilled holes, recovered core, lithological descriptions, and distributed samples along with common reference data sets authorized by the FAR-DEEP Central Science Team. The science team members were permitted to download these data sets and add the results of their own analyses enabling all members to share the available information. During the operational drilling phase, the core handling and sampling, and the following moratorium period only the registered members of the FAR-DEEP science team had access to core data (‘Internal Data FARDEEP’).

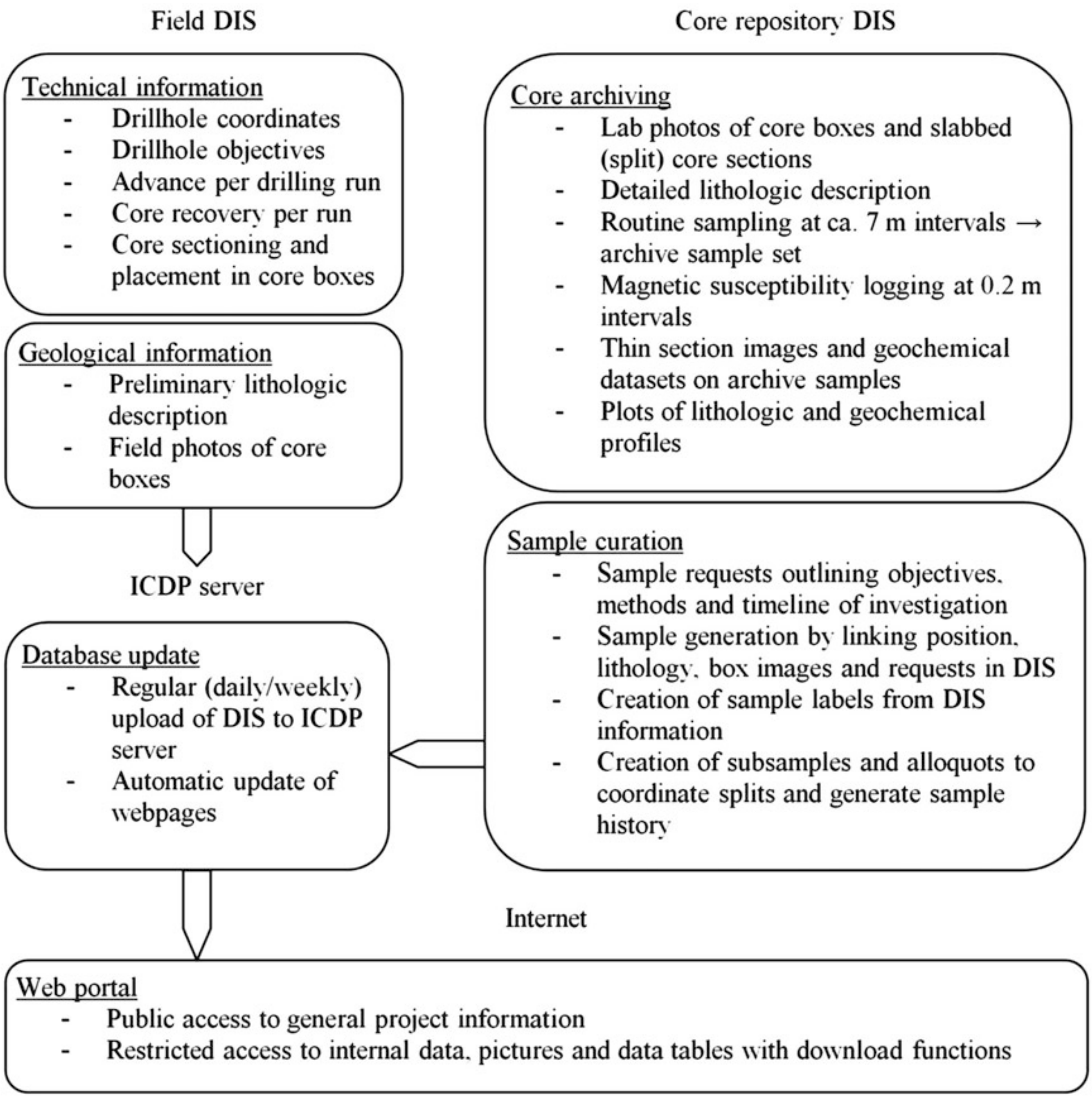


Fig. 5.1 A scheme showing the conceptual design and functions of the drilling information system (DIS), and various data types entered during the course of drilling-based research projects both in the field and in the core repository

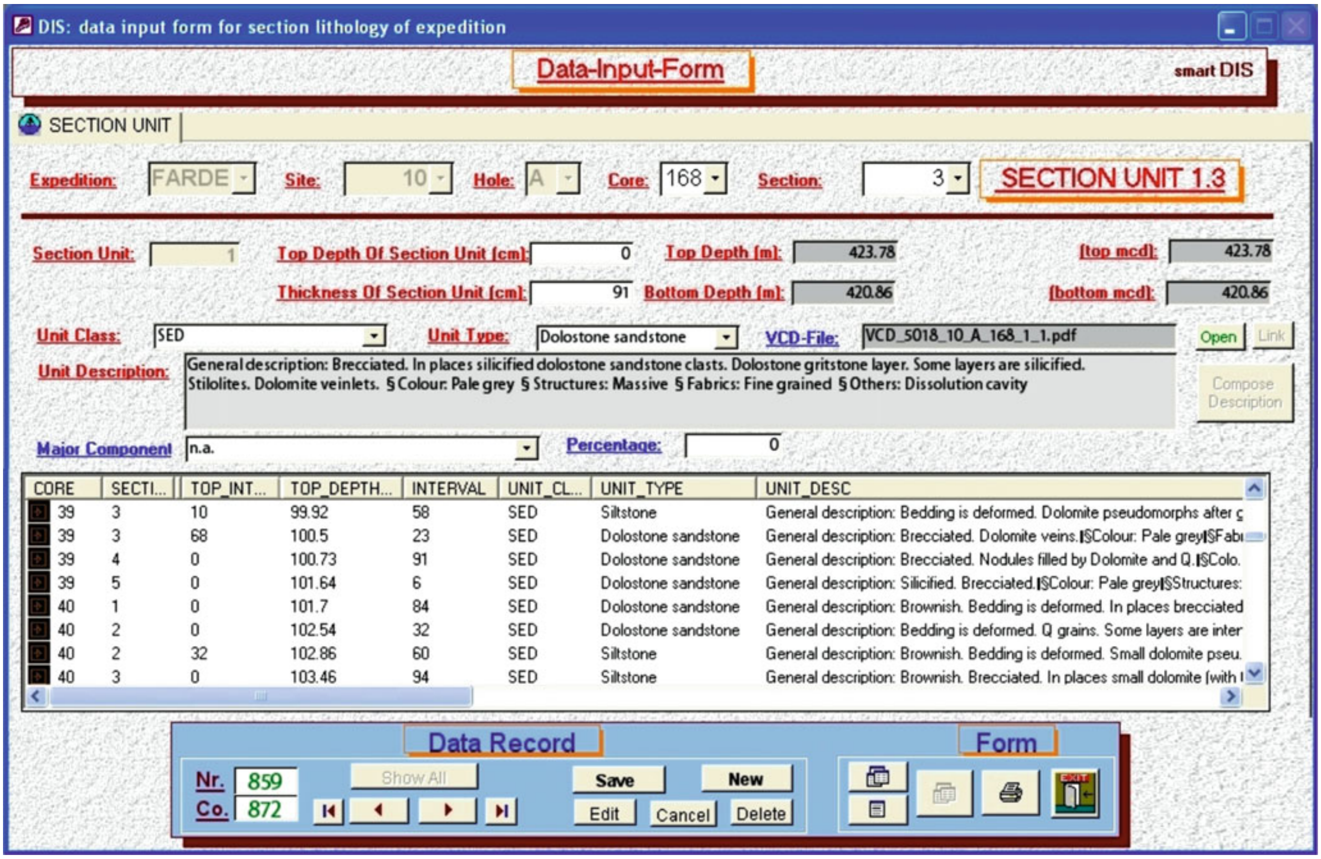


Fig. 5.2 Screenshot of the DIS data-input-form for entering lithologic descriptions of defined core intervals

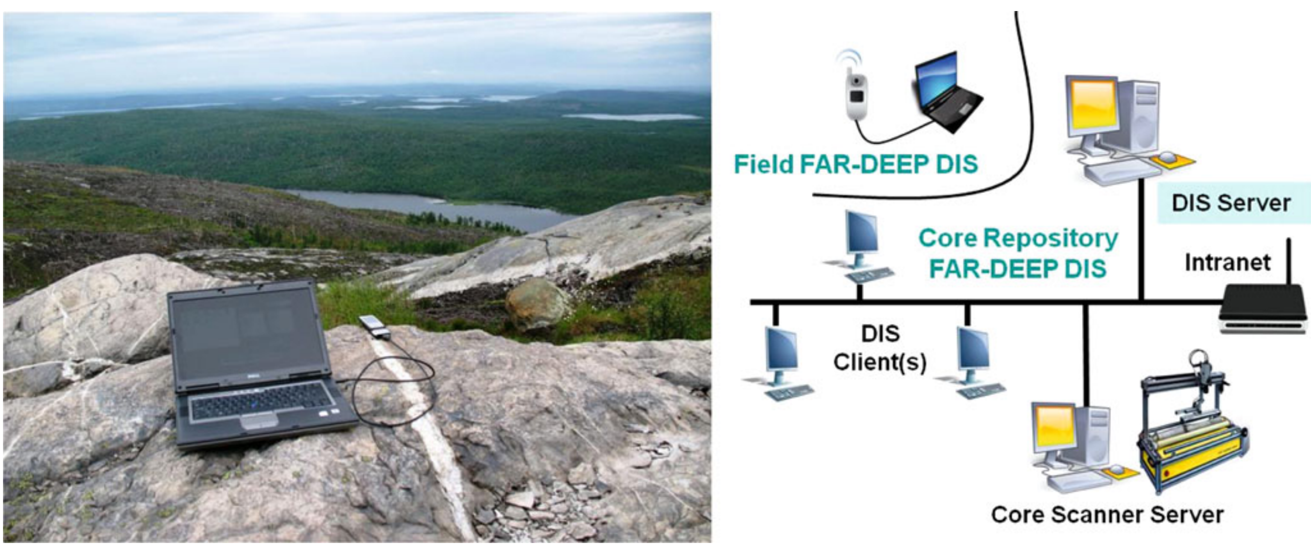


Fig. 5.3 To the *left*: The cell phone was used during the field expedition for the transfer of data from the FAR-DEEP DIS server installed on a standalone laptop to the central ICDP server in Potsdam (Photo from the hill top (best cell phone signal) in the Pechenga Greenstone Belt near the Russian-Norwegian border). To the *right*: Diagram showing the configuration of the local area network at the NGU core repository during core processing and sampling

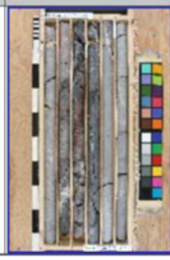
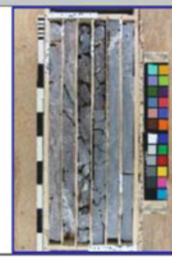
Box #	Corrected Depth Interval of Box (m)	Field 2007 whole round core	Lab 2008 whole round core (dry)	Lab 2008 whole round core (wet)	Lab 2008 split core with sample spots	Lab 2009 split core after sampling
17	101.64 - 107.21					
Box - Slot	Core - Section	@ cm in Section ~ Top - Bottom Depth (m)		Rock Class : Rock Type	Description	
17 - 1	39 - 5	0 - 6	101.64 - 101.7	SED : Dolostone sandstone	Colour: Pale grey §Structures: Parallel bedded §Fabrics: Fine grained, Silicified. Brecciated.	
17 - 1	40 - 1	0 - 84	101.7 - 102.54	SED : Dolostone sandstone	Colour: Grey §Structures: Parallel bedded §Fabrics: Fine grained; Medium grained, Brownish. Bedding is deformed. In places brecciated. Nodules filled by Dolomite. Intensively silicified layers. Q veins with Hematite. Q veinlets with Dolomite.	
17 - 2	40 - 2	0 - 32	102.54 - 102.86	SED : Dolostone sandstone	Colour: Pale grey §Structures: Parallel bedded §Fabrics: Fine grained; Medium grained, Bedding is deformed. Q grains. Some layers are intensively silicified.	
17 - 2	40 - 2	32 - 92	102.86 - 103.46	SED : Siltstone	Colour: Grey §Structures: Parallel bedded, Brownish. Bedding is deformed. Small dolomite pseudomorphs after gypsum. Dolomite veins with talc	

Fig. 5.4 Screenshot from the FAR-DEEP internal data webpage showing an example set of images of core box 17 from hole 10A including the initial lithological description of the core

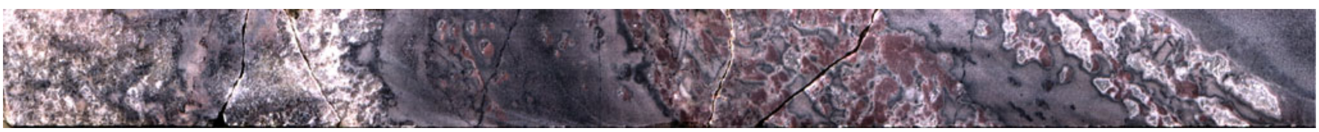


Fig. 5.5 Example of a 53 cm long scanned core section from drillhole 10A

SBM003106964

ICDP FAR-DEEP Expedition 2007

Exp. /Site/ H /Core/ T/Sec/Half /Interval

5018 10 A 40 Z 2 W 0.0 - 13.0

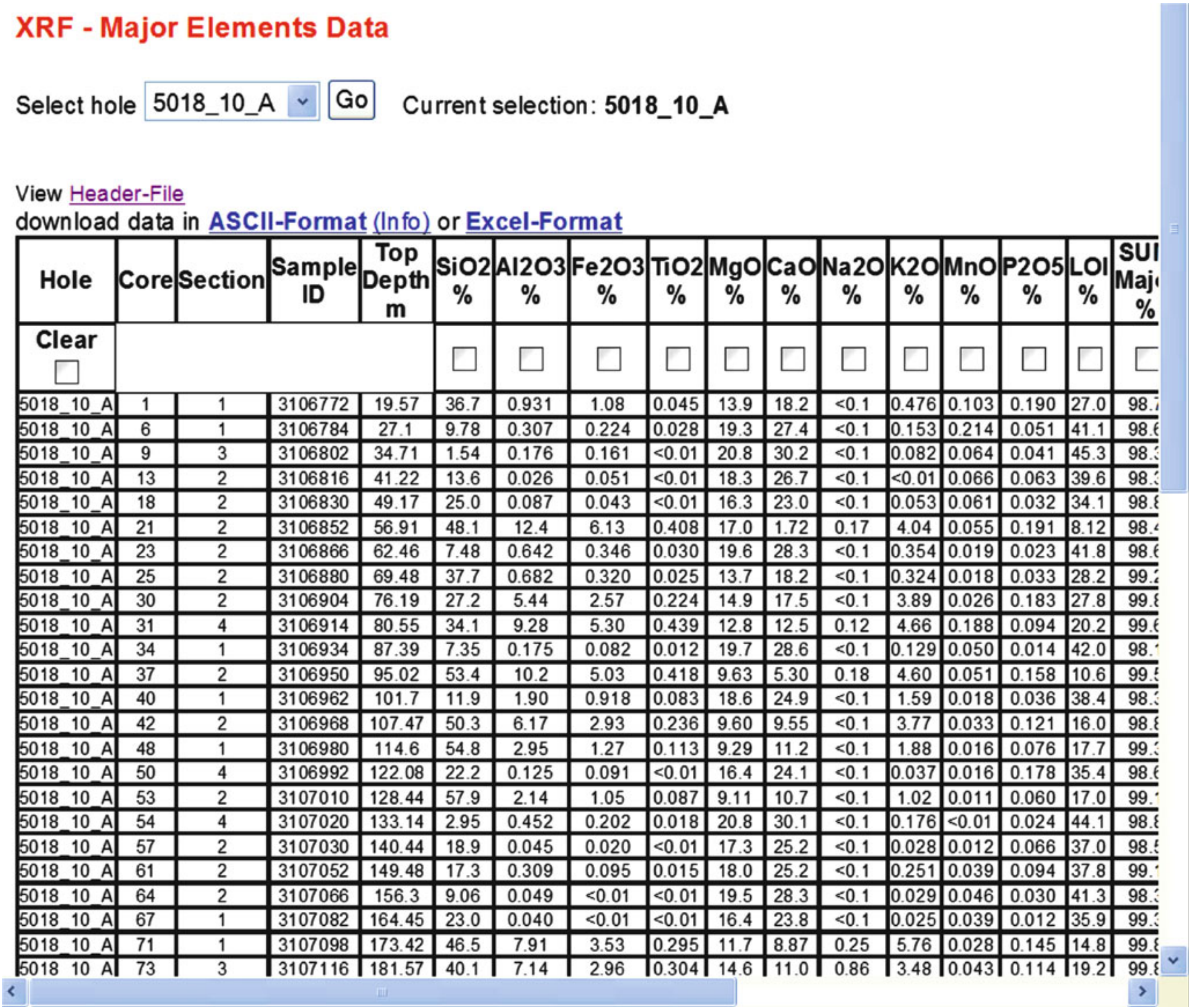
MSP0001 A Depth:**102.54**

Box: **17 -2**

Victor Melezhik

11/14/2008 1:29:31 PM

Fig. 5.6 Example of a printed sample label. From *top*: Unique sample identifier, same as bar code, expedition title, sample label, sample request number (bar code *below*), drilling depth (m), core box and slot number, name of sample request proponent, date and time of sampling



XRF - Major Elements Data

Select hole 5018_10_A Go Current selection: **5018_10_A**

View Header-File
download data in ASCII-Format (Info) or Excel-Format

Hole	Core	Section	Sample ID	Top Depth m	SiO2 %	Al2O3 %	Fe2O3 %	TiO2 %	MgO %	CaO %	Na2O %	K2O %	MnO %	P2O5 %	LOI %	SUI Maj %
Clear																
5018_10_A	1	1	3106772	19.57	36.7	0.931	1.08	0.045	13.9	18.2	<0.1	0.476	0.103	0.190	27.0	98.7
5018_10_A	6	1	3106784	27.1	9.78	0.307	0.224	0.028	19.3	27.4	<0.1	0.153	0.214	0.051	41.1	98.6
5018_10_A	9	3	3106802	34.71	1.54	0.176	0.161	<0.01	20.8	30.2	<0.1	0.082	0.064	0.041	45.3	98.3
5018_10_A	13	2	3106816	41.22	13.6	0.026	0.051	<0.01	18.3	26.7	<0.1	<0.01	0.066	0.063	39.6	98.3
5018_10_A	18	2	3106830	49.17	25.0	0.087	0.043	<0.01	16.3	23.0	<0.1	0.053	0.061	0.032	34.1	98.8
5018_10_A	21	2	3106852	56.91	48.1	12.4	6.13	0.408	17.0	1.72	0.17	4.04	0.055	0.191	8.12	98.4
5018_10_A	23	2	3106866	62.46	7.48	0.642	0.346	0.030	19.6	28.3	<0.1	0.354	0.019	0.023	41.8	98.6
5018_10_A	25	2	3106880	69.48	37.7	0.682	0.320	0.025	13.7	18.2	<0.1	0.324	0.018	0.033	28.2	99.2
5018_10_A	30	2	3106904	76.19	27.2	5.44	2.57	0.224	14.9	17.5	<0.1	3.89	0.026	0.183	27.8	99.8
5018_10_A	31	4	3106914	80.55	34.1	9.28	5.30	0.439	12.8	12.5	0.12	4.66	0.188	0.094	20.2	99.6
5018_10_A	34	1	3106934	87.39	7.35	0.175	0.082	0.012	19.7	28.6	<0.1	0.129	0.050	0.014	42.0	98.1
5018_10_A	37	2	3106950	95.02	53.4	10.2	5.03	0.418	9.63	5.30	0.18	4.60	0.051	0.158	10.6	99.5
5018_10_A	40	1	3106962	101.7	11.9	1.90	0.918	0.083	18.6	24.9	<0.1	1.59	0.018	0.036	38.4	98.3
5018_10_A	42	2	3106968	107.47	50.3	6.17	2.93	0.236	9.60	9.55	<0.1	3.77	0.033	0.121	16.0	98.8
5018_10_A	48	1	3106980	114.6	54.8	2.95	1.27	0.113	9.29	11.2	<0.1	1.88	0.016	0.076	17.7	99.3
5018_10_A	50	4	3106992	122.08	22.2	0.125	0.091	<0.01	16.4	24.1	<0.1	0.037	0.016	0.178	35.4	98.6
5018_10_A	53	2	3107010	128.44	57.9	2.14	1.05	0.087	9.11	10.7	<0.1	1.02	0.011	0.060	17.0	99.1
5018_10_A	54	4	3107020	133.14	2.95	0.452	0.202	0.018	20.8	30.1	<0.1	0.176	<0.01	0.024	44.1	98.8
5018_10_A	57	2	3107030	140.44	18.9	0.045	0.020	<0.01	17.3	25.2	<0.1	0.028	0.012	0.066	37.0	98.5
5018_10_A	61	2	3107052	149.48	17.3	0.309	0.095	0.015	18.0	25.2	<0.1	0.251	0.039	0.094	37.8	99.1
5018_10_A	64	2	3107066	156.3	9.06	0.049	<0.01	<0.01	19.5	28.3	<0.1	0.029	0.046	0.030	41.3	98.3
5018_10_A	67	1	3107082	164.45	23.0	0.040	<0.01	<0.01	16.4	23.8	<0.1	0.025	0.039	0.012	35.9	99.3
5018_10_A	71	1	3107098	173.42	46.5	7.91	3.53	0.295	11.7	8.87	0.25	5.76	0.028	0.145	14.8	99.8
5018_10_A	73	3	3107116	181.57	40.1	7.14	2.96	0.304	14.6	11.0	0.86	3.48	0.043	0.114	19.2	99.8

Fig. 5.7 Screenshot from the FAR-DEEP internal data webpage showing an example set of available geochemical data on cores