



BASE –

Eight ICDP boreholes and three tunnels
through 3.7 km of Early Archean
shallow-water strata
investigate the setting of early life

Christoph Heubeck, Universität Jena (Germany)
Nic Beukes, Univ. Johannesburg,
and ICDP co-proponents

April 26, 2022



BASE

Barberton

Archaean

Surface

Environments



ICDP

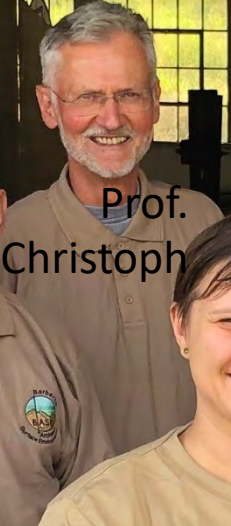
International
Continental
Drilling
Program



Victor



Prof. Nic



Prof. Christoph



Astrid



Tony



Derek



Thikho



Chris



Ryan



Dora



Rodney



Phumi

Barberton Archaeological Surface Environments

Geological Research in the Barberton-Makhonjwa Mountains

Barberton Archaeological Surface Environments

Early Earth History and the Spreading of Life on a Young Planet

This talk

- Introduction and Fundamentals
- Setup, Objectives, Drilling Design
- Operations Update
- First Results

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Are we alone ?



Looking for life on a (formerly) similar neighboring planet; fossilized or extant.

https://exoplanetarchive.ipac.caltech.edu

NASA EXOPLANET ARCHIVE
A SERVICE OF NASA EXOPLANET SCIENCE INSTITUTE

Home About Us Data Tools Support Login

5,005 Confirmed Planets 03/16/2022

203 TESS Confirmed Planets 03/16/2022

5,459 TESS Project Candidates 03/22/2022

View more Planet and Candidate statistics

Explore the Archive

Name or Coordinates Search

Optional Radius (arcsec) Advanced Search

Transit Surveys 130,041,578 Light Curves

TESS Launched in April 2018, TESS is surveying the sky for two years to find transiting exoplanets around the brightest stars near Earth.

Confirmed Planets →

ExoFOP-TESS →

Project Candidates → Community Candidates →

TESS Kepler K2 KELT UKIRT

Tools & Services

Build a Query (TAP) →

Build a Query (API) →

Transit and Ephemeris Service → Periodogram →

EXOFAST: Transit and RV Fitting → Predicted Observables for Exoplanets (POE) →

Work with Data

Planetary Systems → Planetary Systems Composite Data →

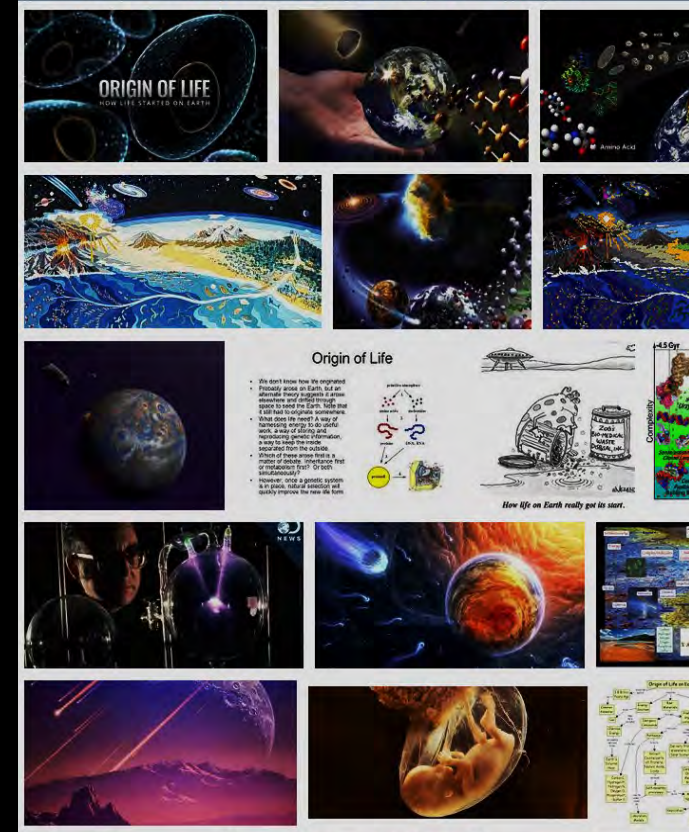
Pre-generated Plots → ExoFOP →

Transmission Spectroscopy → Emission Spectroscopy →

Microlensing Planets → Direct Imaging →

5,000+ Alien Worlds and Counting
March 21, 2022 - New Data
Thirty years after the first exoplanets were found around a pulsar, the NASA Exoplanet Archive has reached a major milestone. This week's 65 new planets bring our total confirmed planet count to **5,005!** (Click for details)

Looking for habitable worlds beyond our own planetary system.

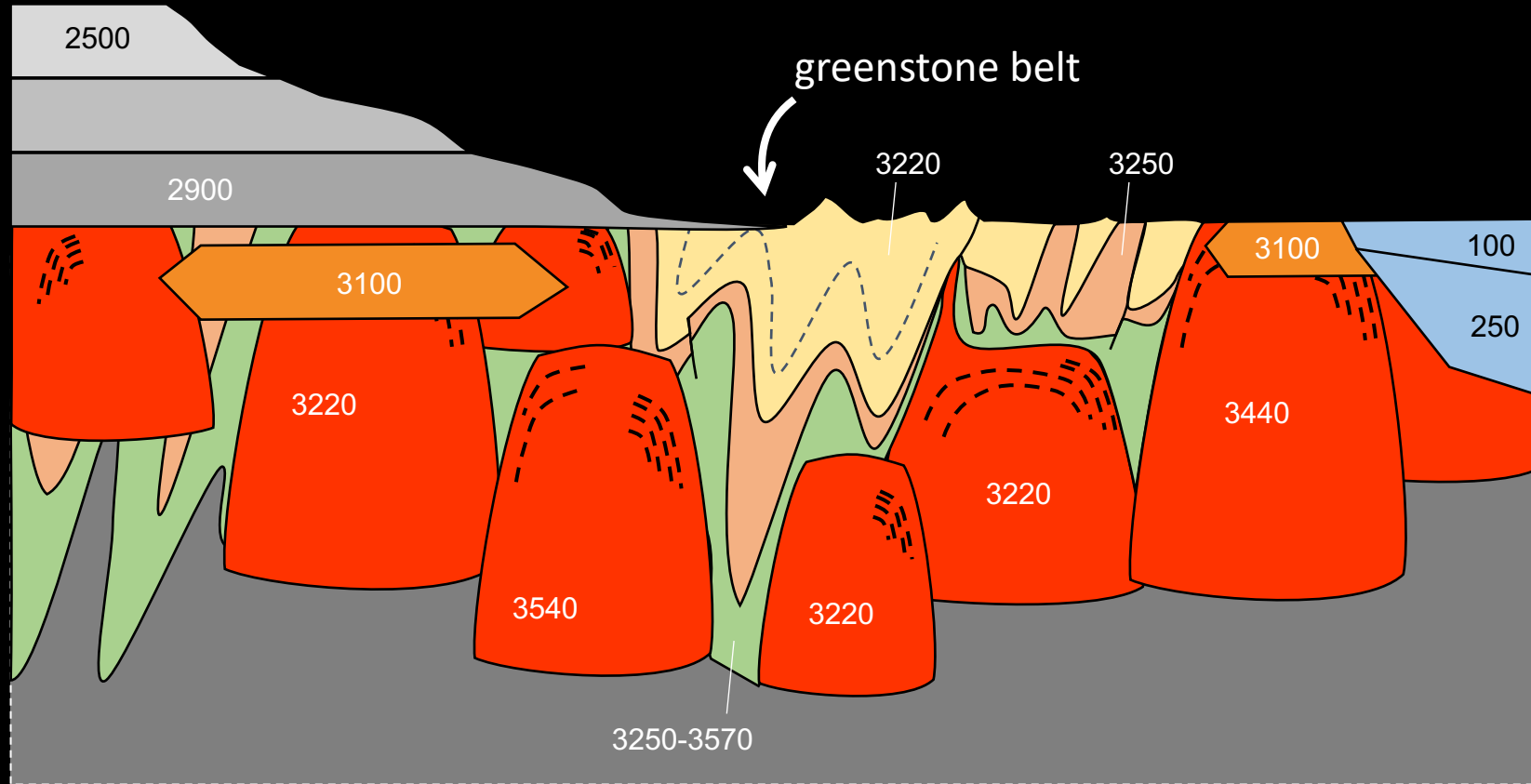


Is „making life“ easy ? Does it form almost necessarily, given sufficient time and space, - or not ?

We know of one planet where life has formed



The few remnants of its early history are incomplete and weathered



Cratonic Basement

- „sheet“ granites
- diapiric tonalites / trondjemite / granodiorites with marginal gneiss fabric

Greenstone Belt Units

- volcanic and sedimentary strata of greenstone belts

Other

- young cover (Triassic - Quaternary)
- cratonic cover

Consequently, we know little about early Earth

Life

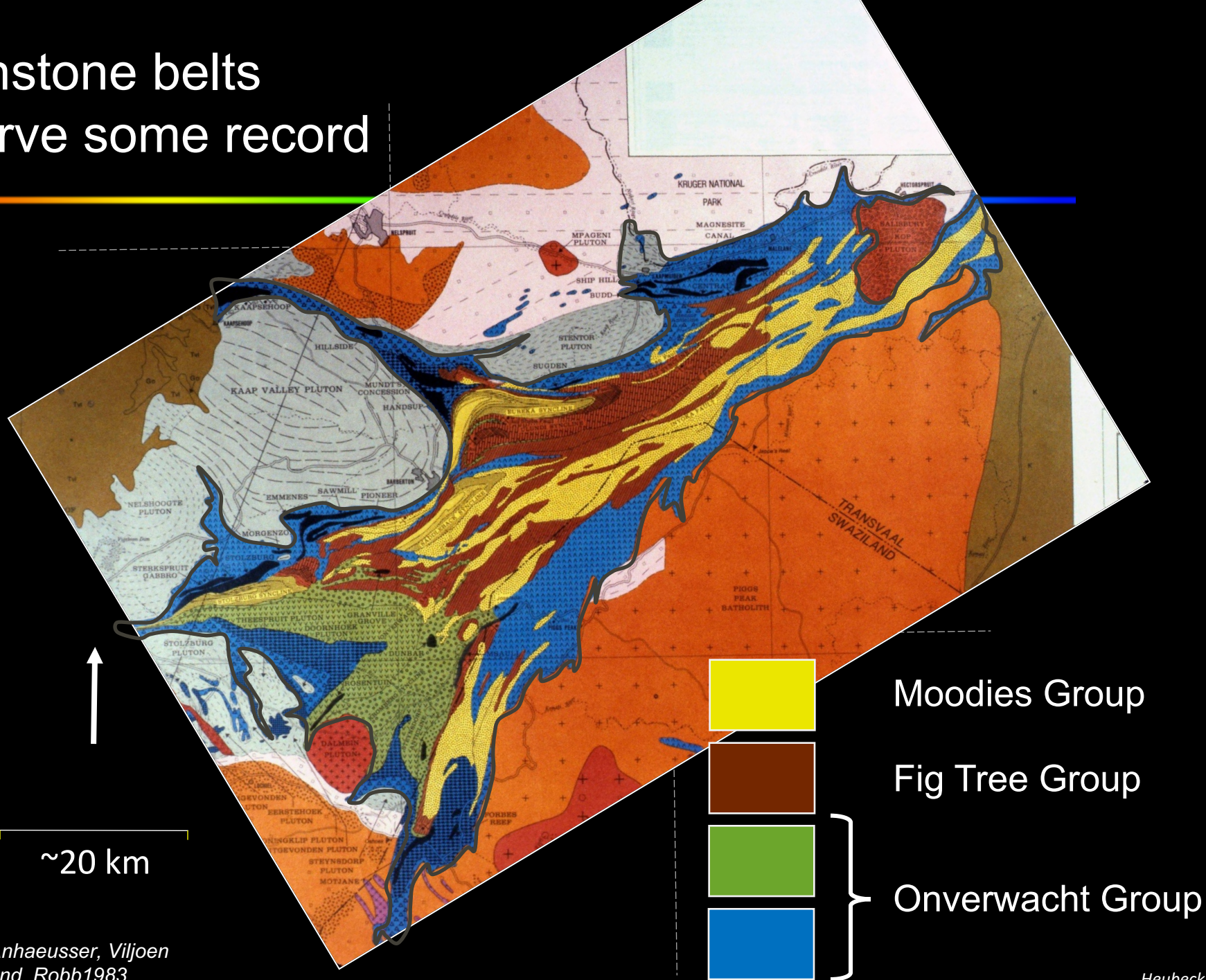


Continents
Atmosphere
Coasts
Oceans

Climate, Weather
Effects of solar radiation
Volcanism
Tides, Moon, Earth Spin

Meteorite Impacts

Greenstone belts preserve some record

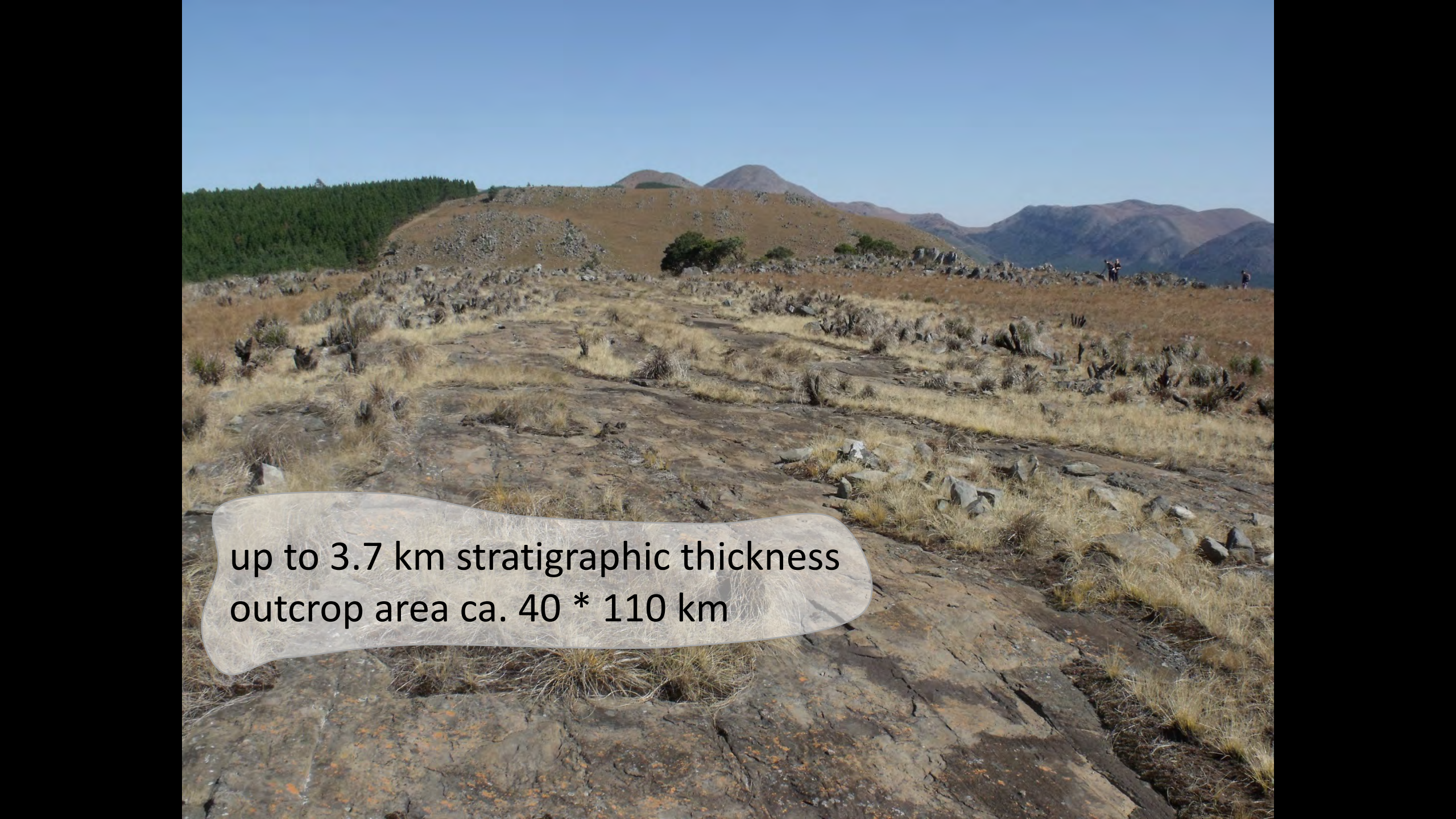


Anhaeusser, Viljoen
and Robb 1983

Heubeck, Univ. Jena

The Moodies Group, 3.22 Ga,
is an ideal target for early-
Earth studies






up to 3.7 km stratigraphic thickness
outcrop area ca. 40 * 110 km

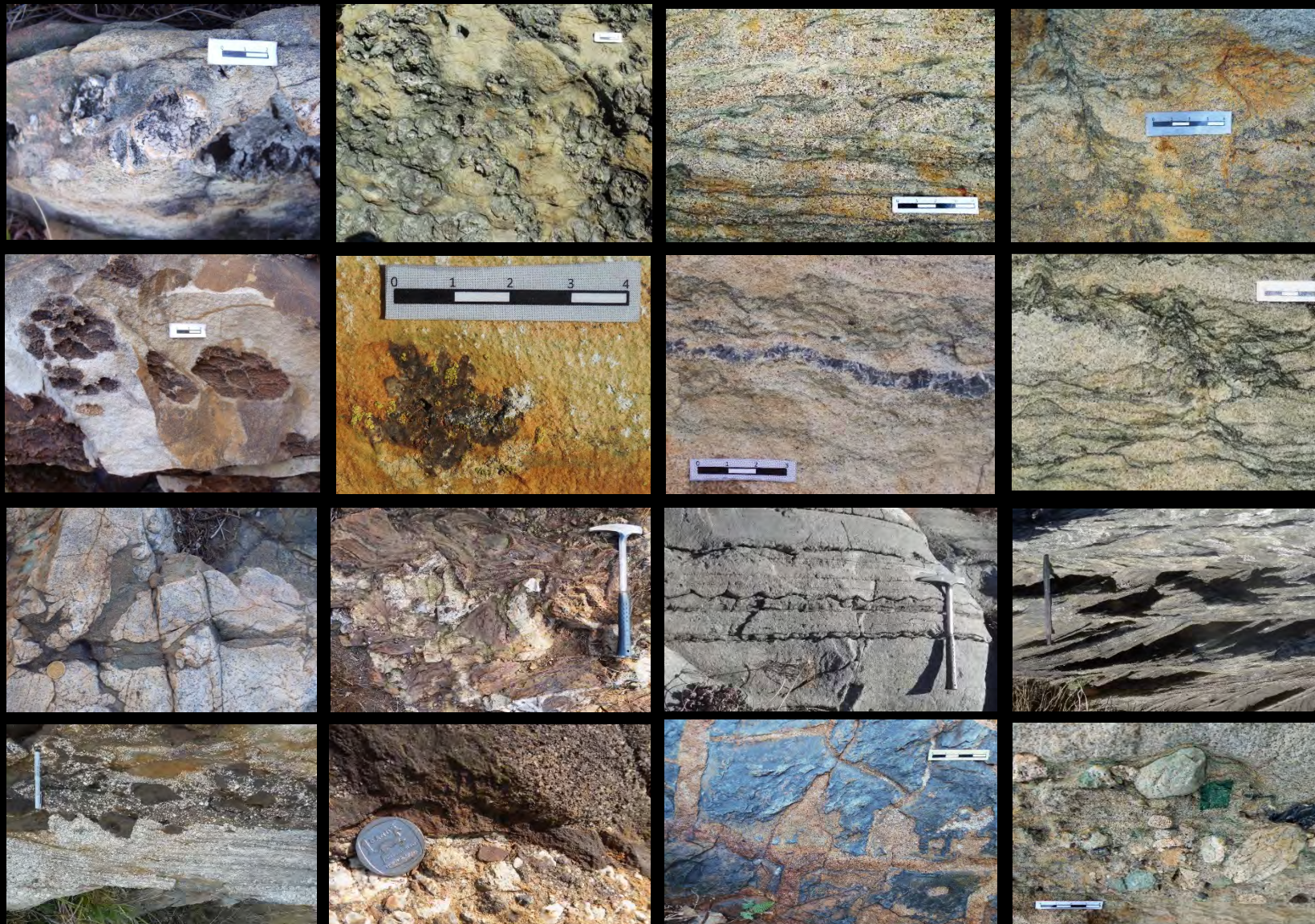


up to 1,700 m relief
most strata dip subvertically



Range of depositional environments
terrestrial-marine transitions

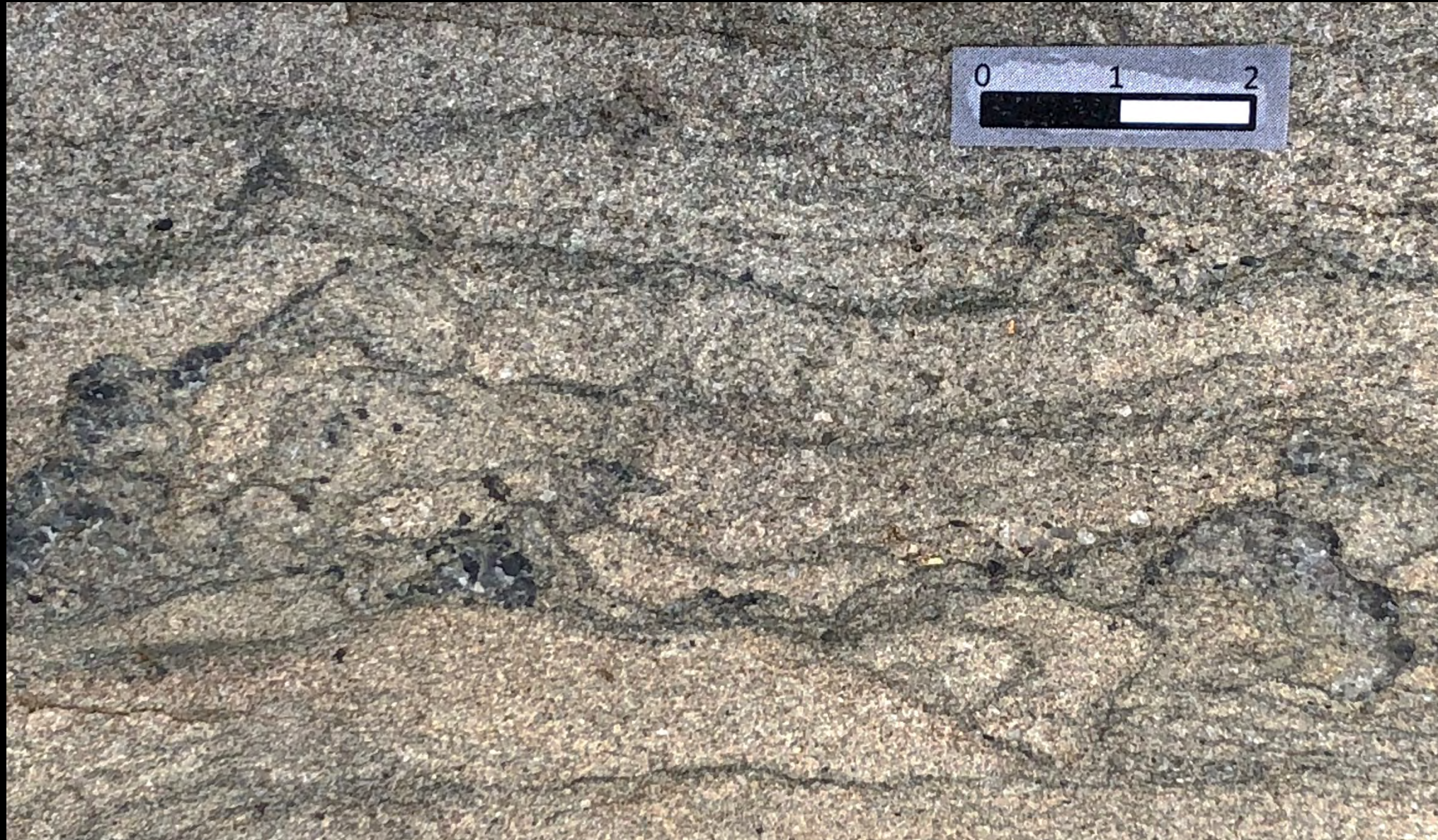
A plethora of physical, chemical and biological structures



Fossilized microbial mats



Fossilized microbial mats



Recent, Tunisia



Recent, Tunisia



-
- Introduction and Fundamentals
 - Setup, Objectives, Drilling Design
 - First Results
 - Concluding Remarks ...

Our workplace for 9 months: The BIAS Hall, downtown Barberton



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Our workplace for 9 months: The BIAS Hall, downtown Barberton



The Need to Drill

Moodies strata are ...

... weathered where continuous

... discontinuous where unweathered

Scientific Objectives

(1) Prodelta facies

- (tidal ?) rhythmicity
- origin of clay minerals
- relationship of BIFs to tidal microbial mats

(2) Microbial mats in tidal sandstones

- C-isotope microstratigraphy
- microbial preservation pathways; early diagenetic chert
- 3-D morphometry of filamentous microfabrics
- organic-walled macrospheres ?
- coastal O₂ production rates
- early evolution of the N cycle
- regional thermal overprint

(3) Paleosols

- terrestrial weathering and role of early diagenesis
- global consequences

(4) Global Surface Environments

- redox conditions (SO₄; redox-sensitive metal isotopes)
- T and composition of ocean water and early diagenetic fluids

(5) Paleomagnetism

- strength of the Earth's magnetic field
- magnetostratigraphy

(6) Magmatism and basin dynamics

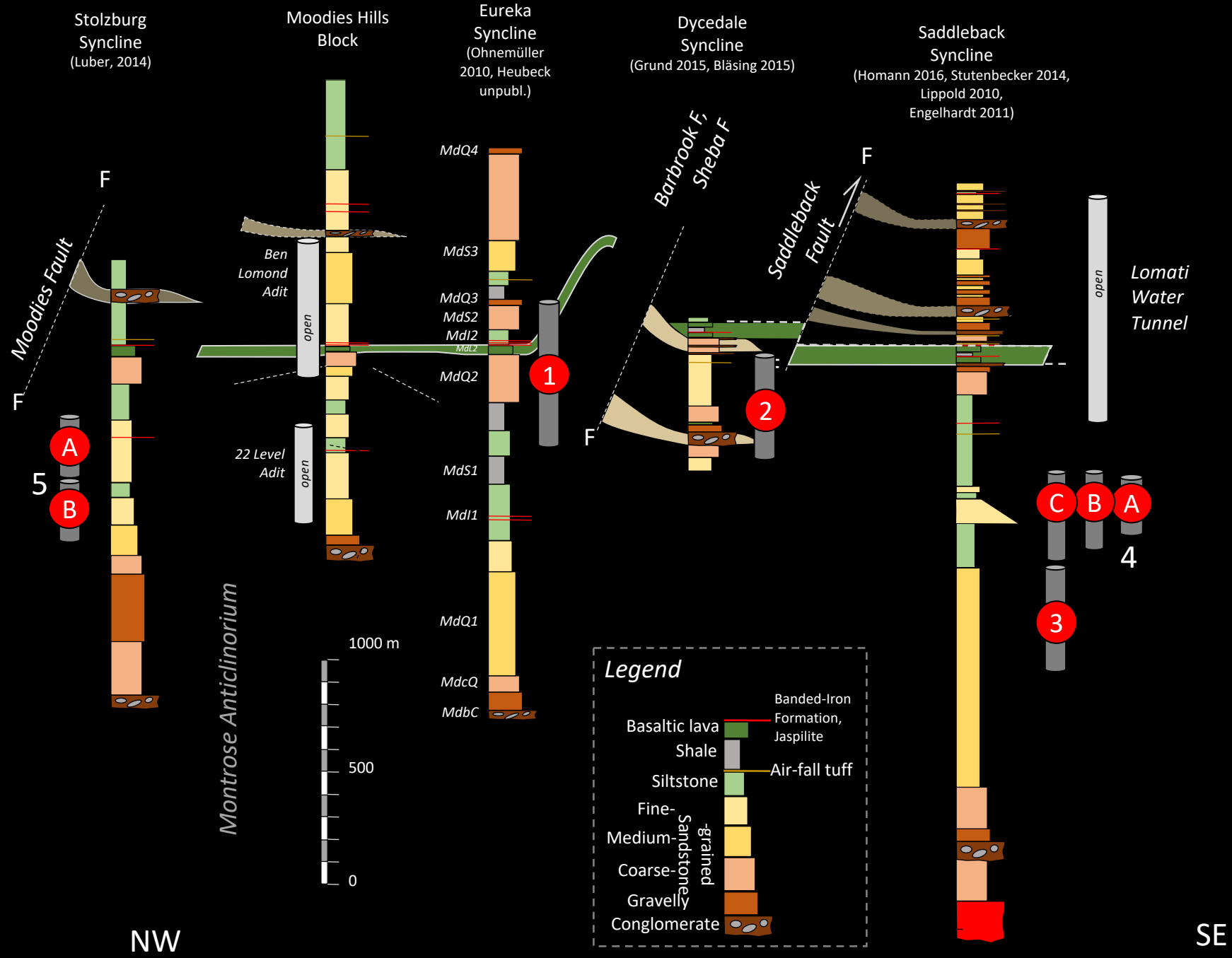
- Association between basaltic lava, stockwork intrusions in unconsolidated sandstones and a lakkolith; hydrothermal halos ?

(7) Geochronology

- Quantification of sedimentation rate and basin subsidence through high-precision U-Pb dating of tuffs, Ir flux

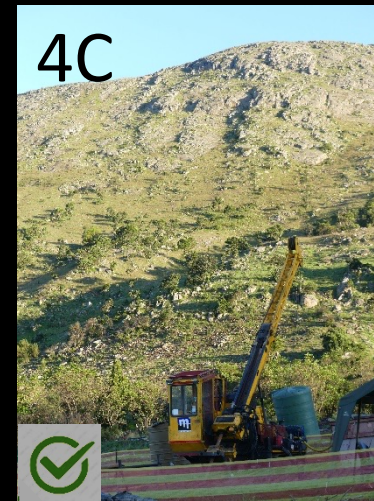
Scientific Objectives

- (1) Prodelta facies
- (2) Microbial mats in tidal sandstones
- (3) Paleosols
- (4) Global Surface Environments
- (5) Paleomagnetism
- (6) Magmatism and basin dynamics
- (7) Geochronology

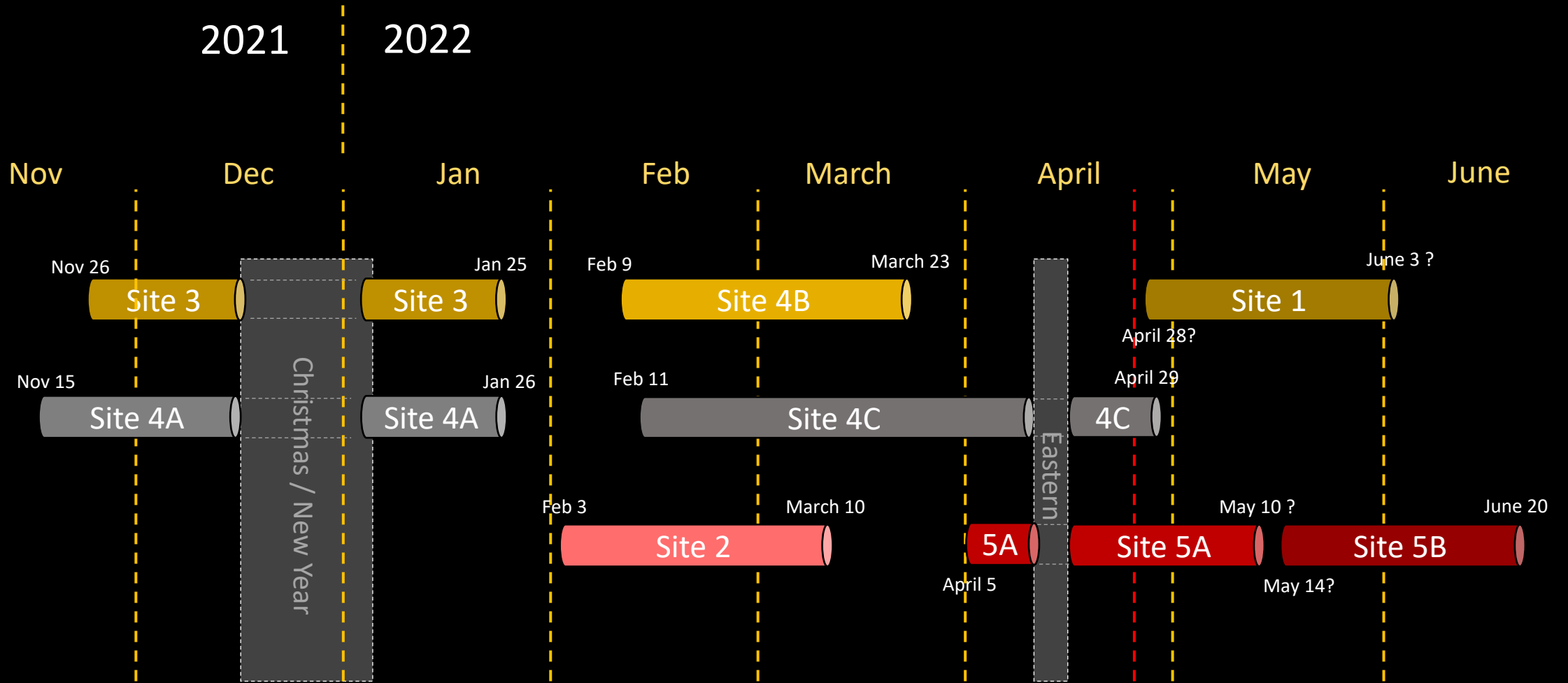


-
- Introduction and Fundamentals
 - Setup, Objections, Drilling Design
 - **Operations Update**
 - First Results

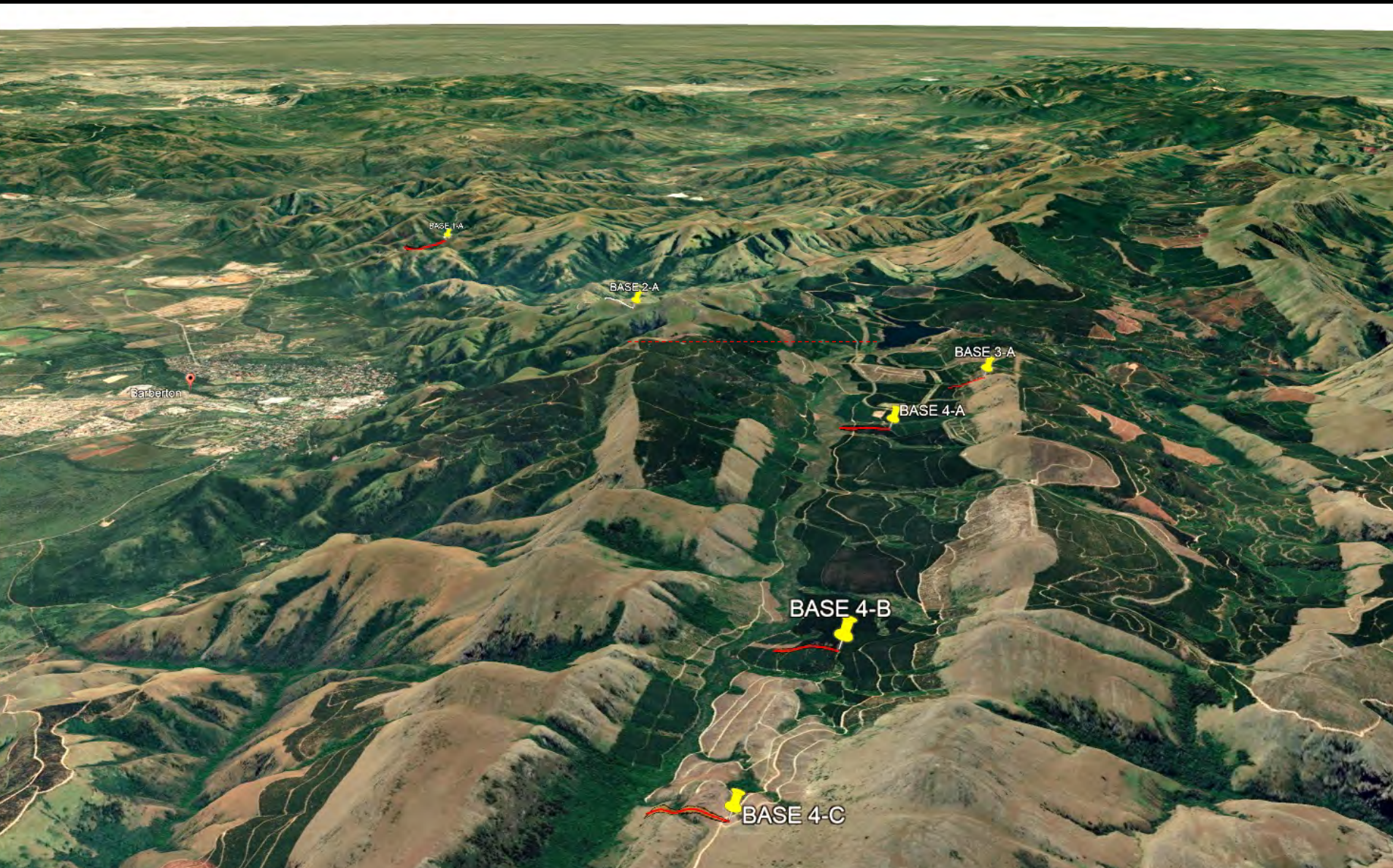
Diverse, interesting drill sites



Drilling Schedule



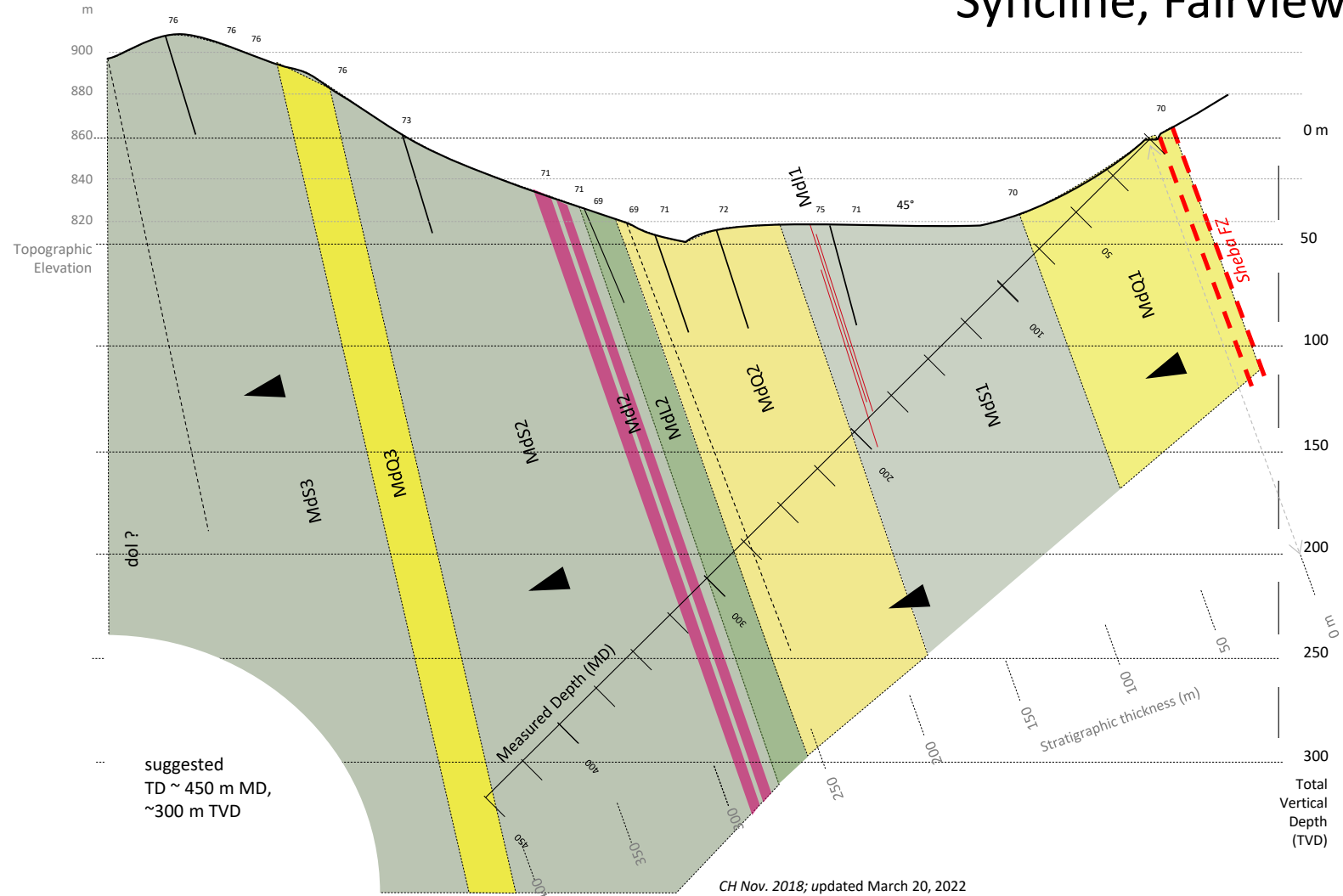
Drilling Locations



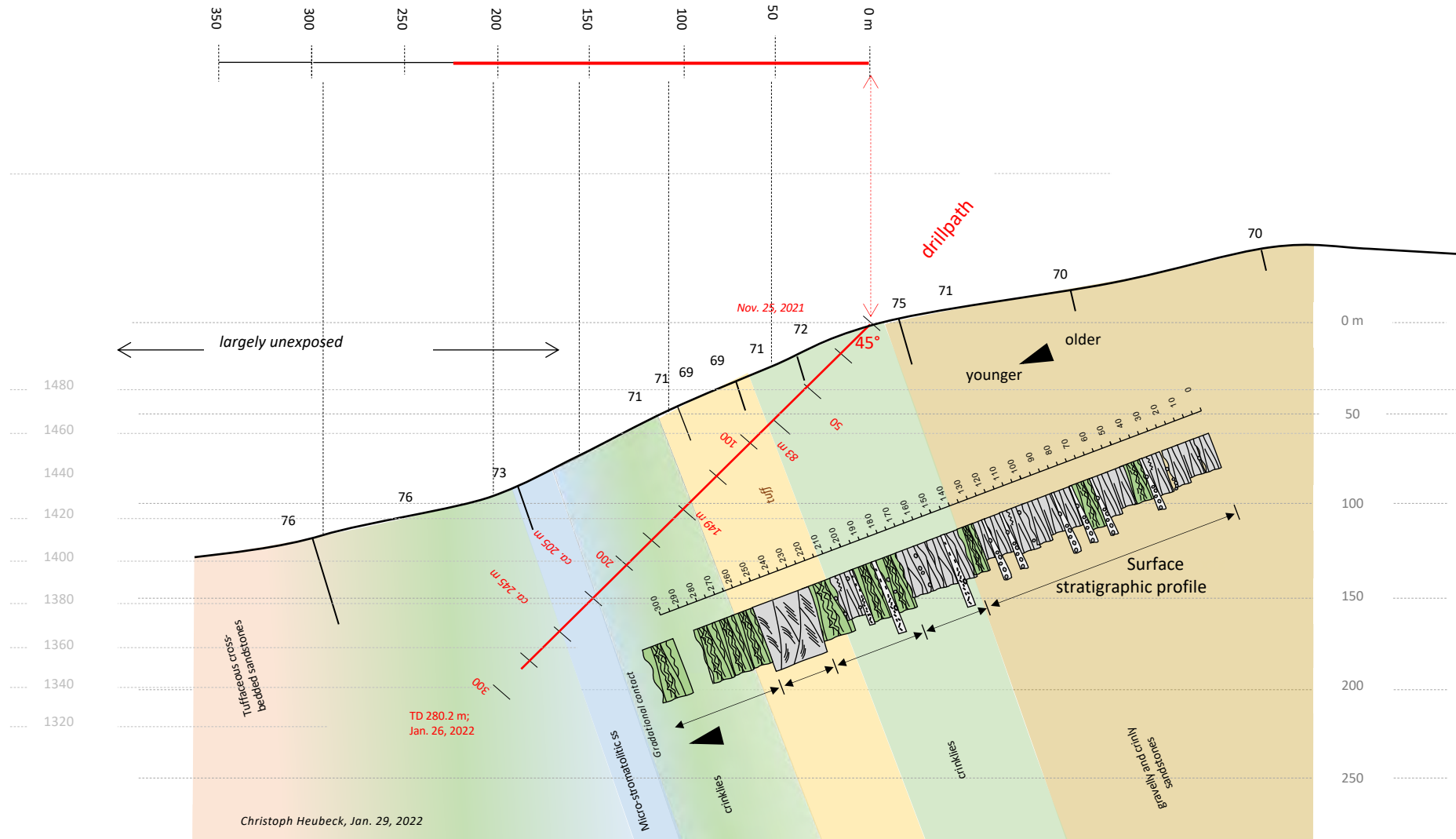
Drilling Locations



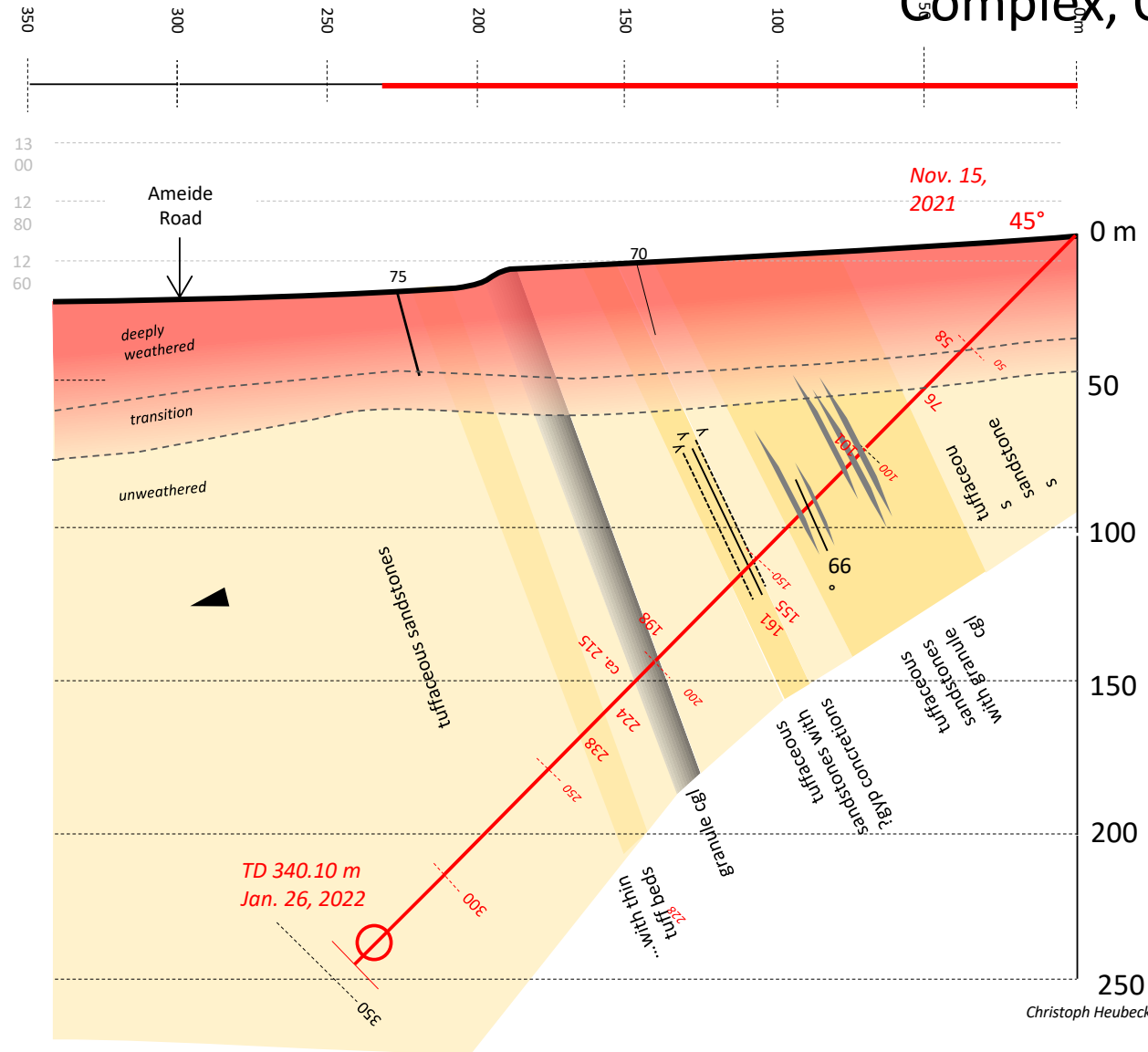
Pre-drill geological cross section, Site 1 (east limb Eureka Syncline, Fairview)



Post-drill geological cross section, Site 3 (MdQ1 of Saddleback Syncline, Farm Oosterbeek)

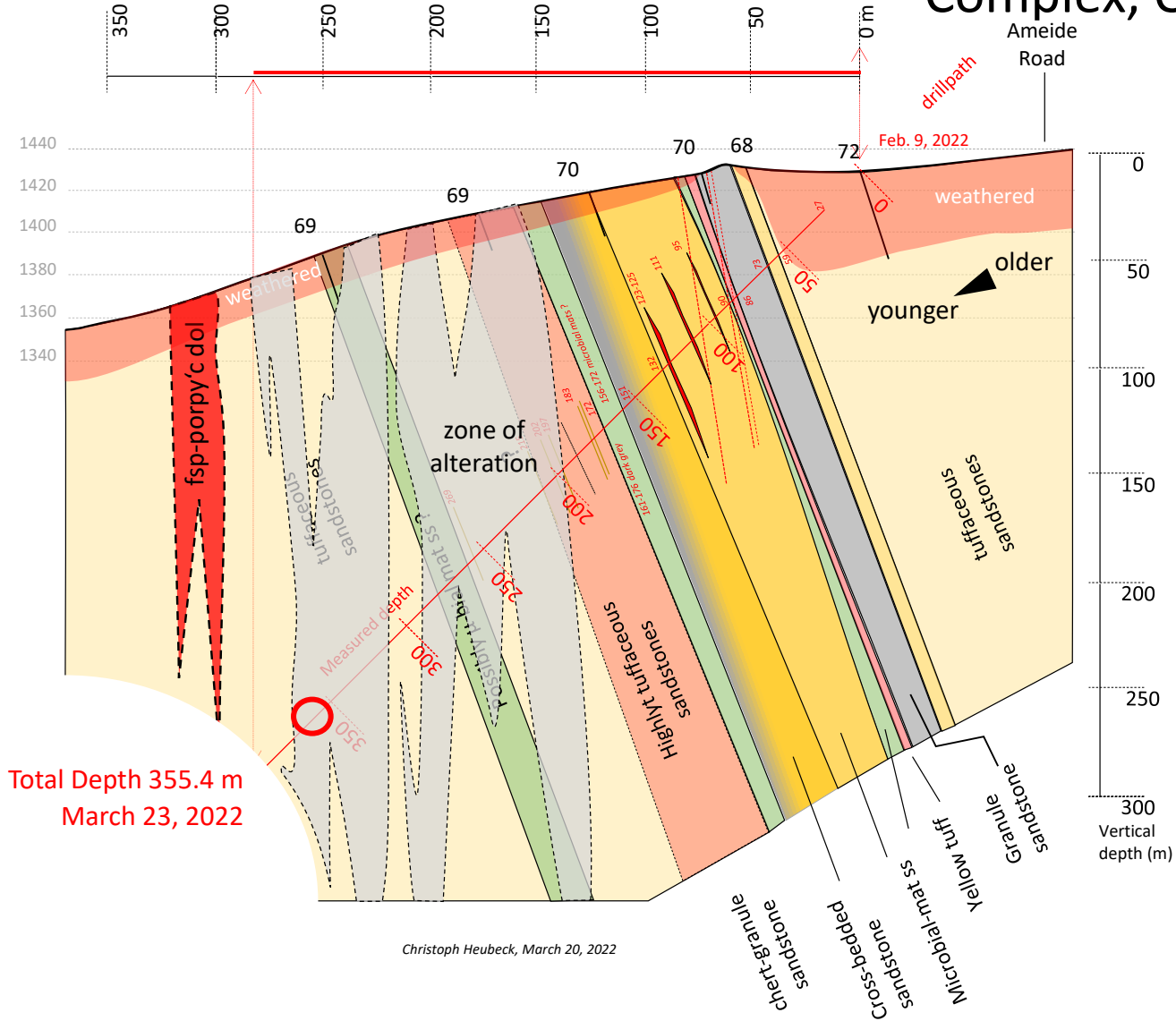


Post-drill geological cross section, Site 4A (Distal Lomati Delta Complex, Oosterbeek)



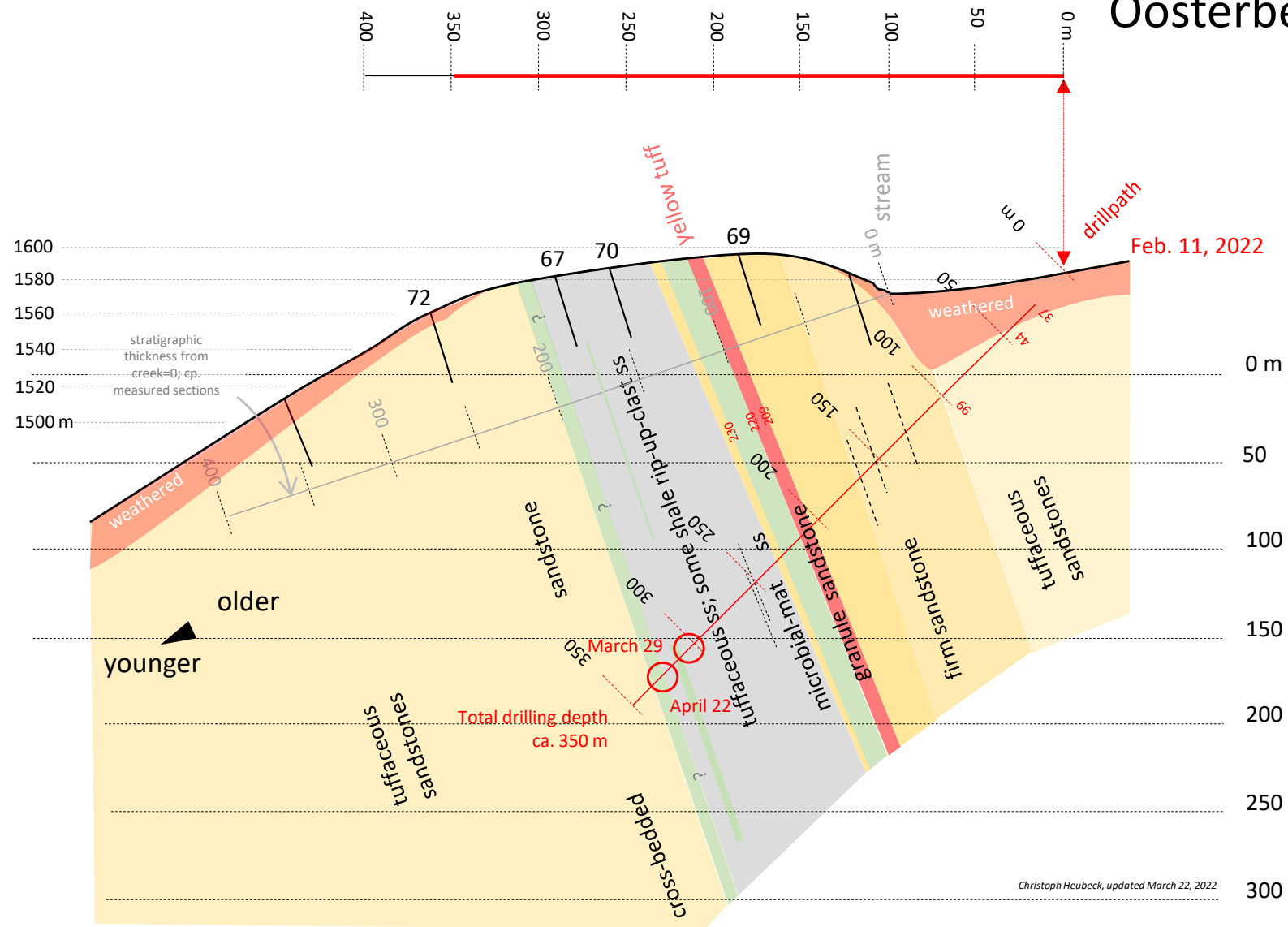
Christoph Heubeck, Jan. 29, 2022

Post-drill geological cross section, Site 4B (Middle Lomati Delta Complex, Oosterbeek)

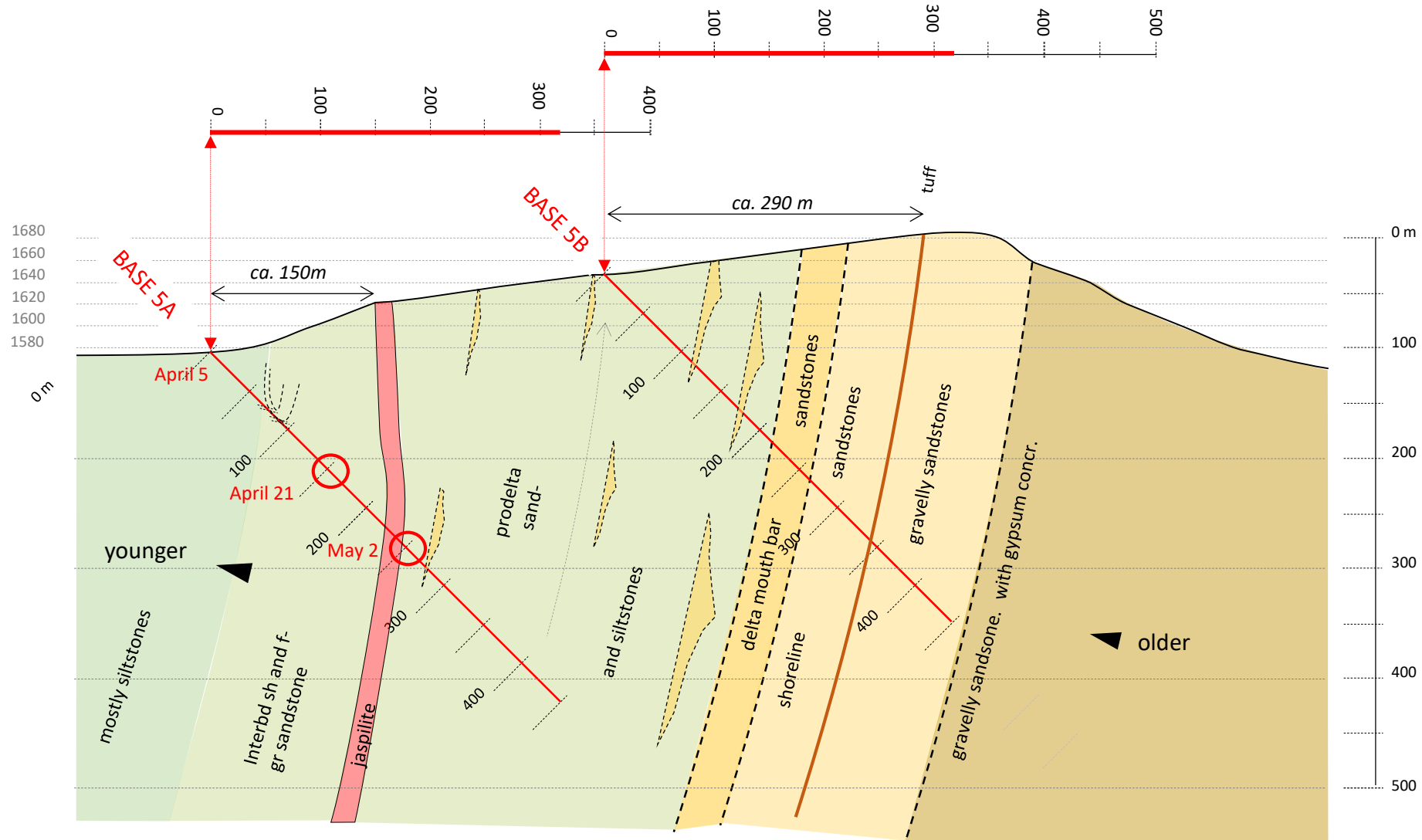


Christoph Heubeck, March 20, 2022

Geological cross section, Site 4C (Proximal Lomati Delta Complex, Oosterbeek)



Geological cross section, Site 5 (eastern Stolzburg Syncline, Farm Belvue)



TD to spudding a new borehole takes 10 days



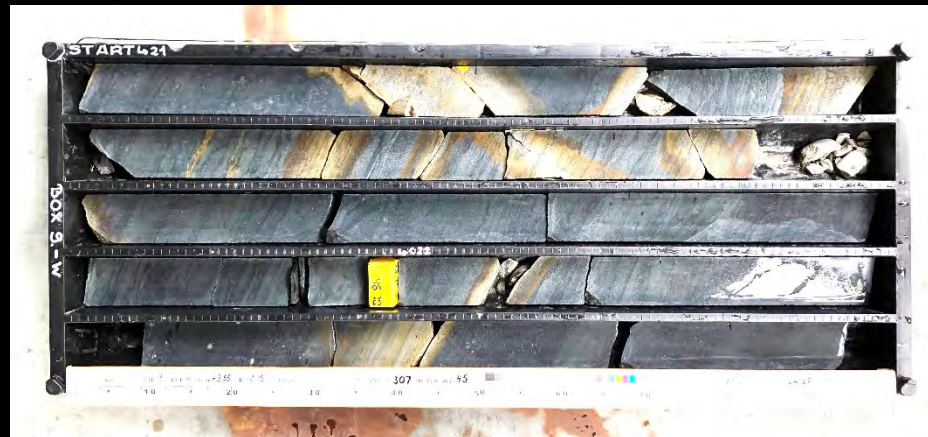
Currently ca. 1750, finally 3100 m of core



Rhythmically bedded tuffaceous-shaly sandstones



Coarse-grained granular chertarenites



Microbial-mat-laminated sandstone („crinklies“)

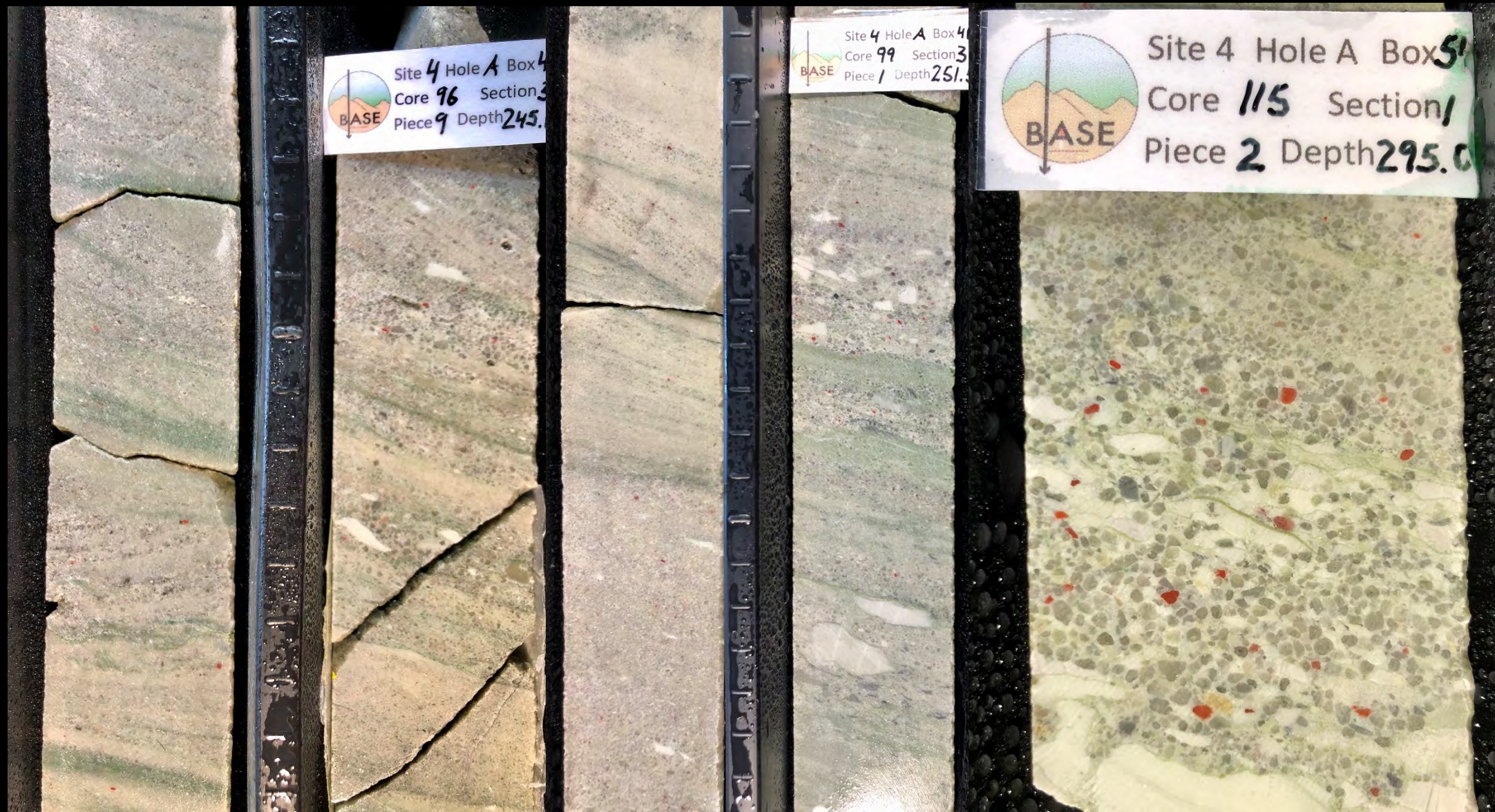


Chert-clast-dominated cobble conglomerates

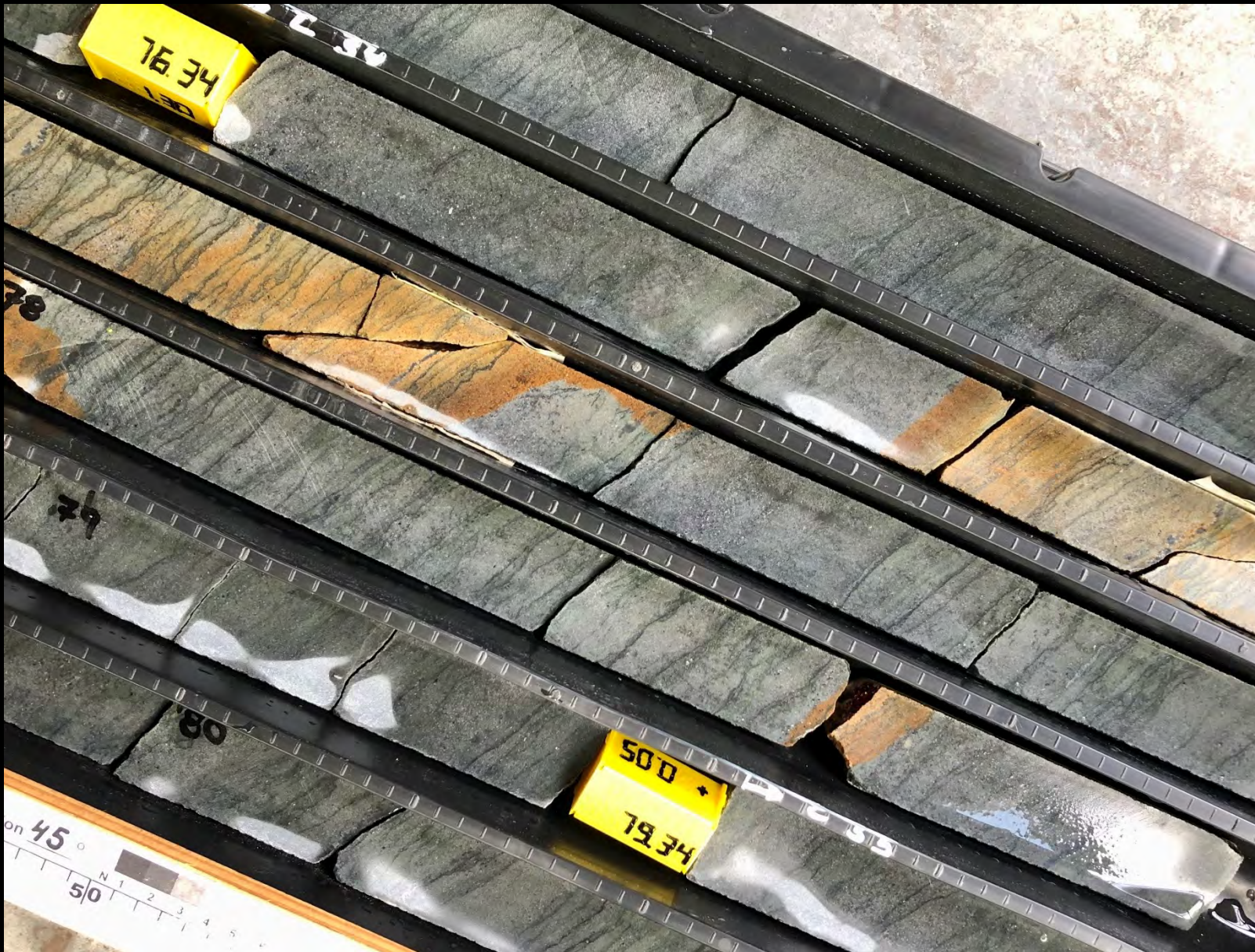
Results: Polymict / shale clast / tuff-clast cgl



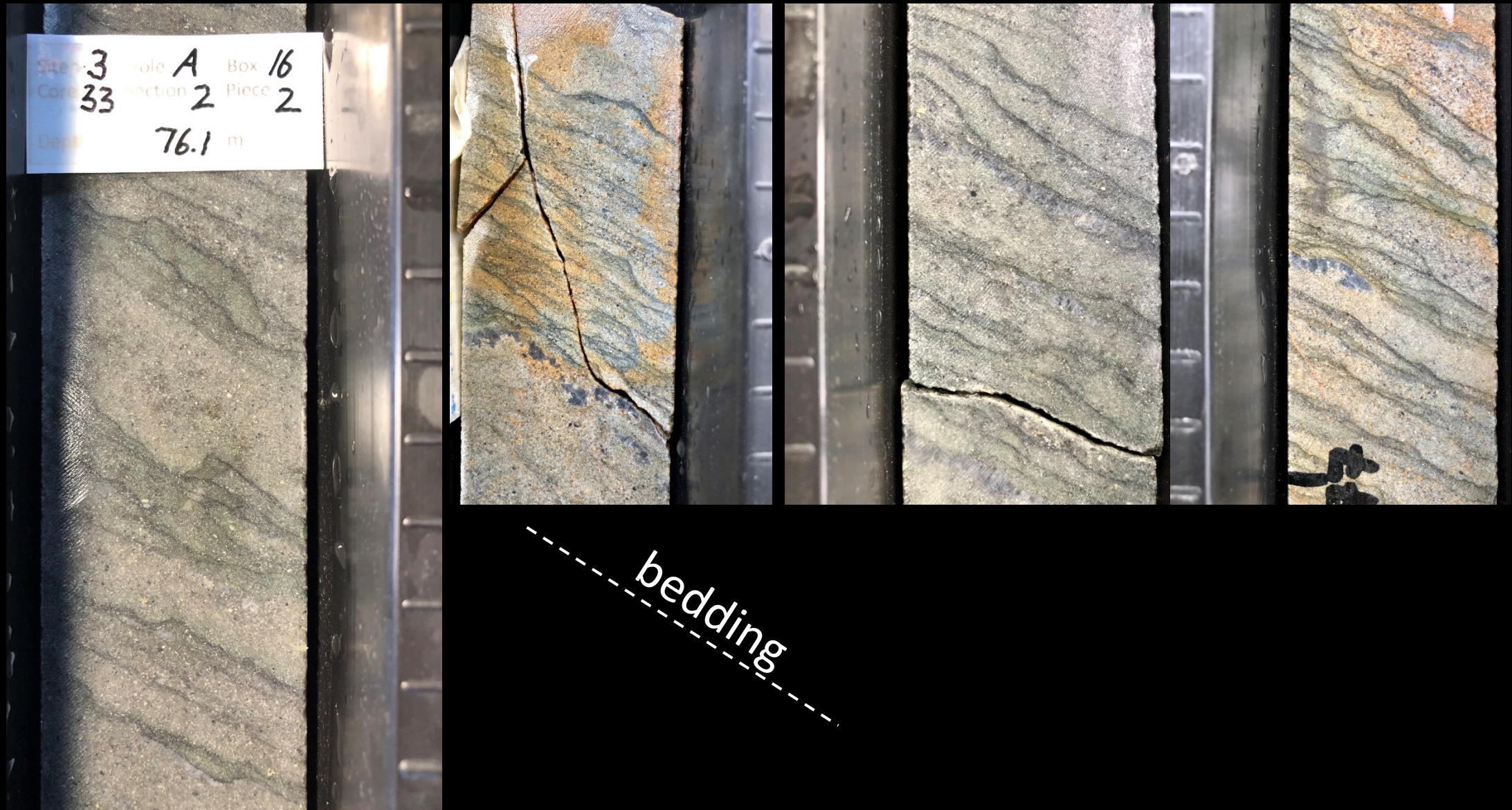
Results: Tuffaceous, matrix-rich sandstones



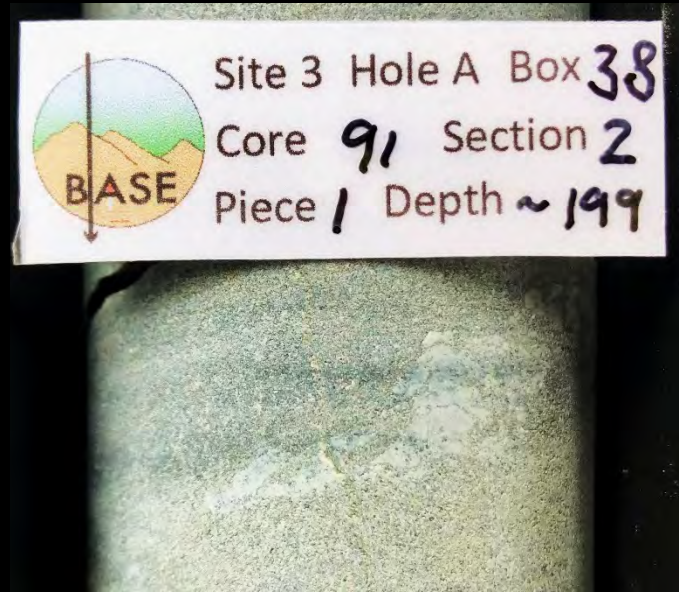
Results: Microbially laminated sandstone



Results: Microbially laminated sandstone



Results: Stromatolitic sandstone



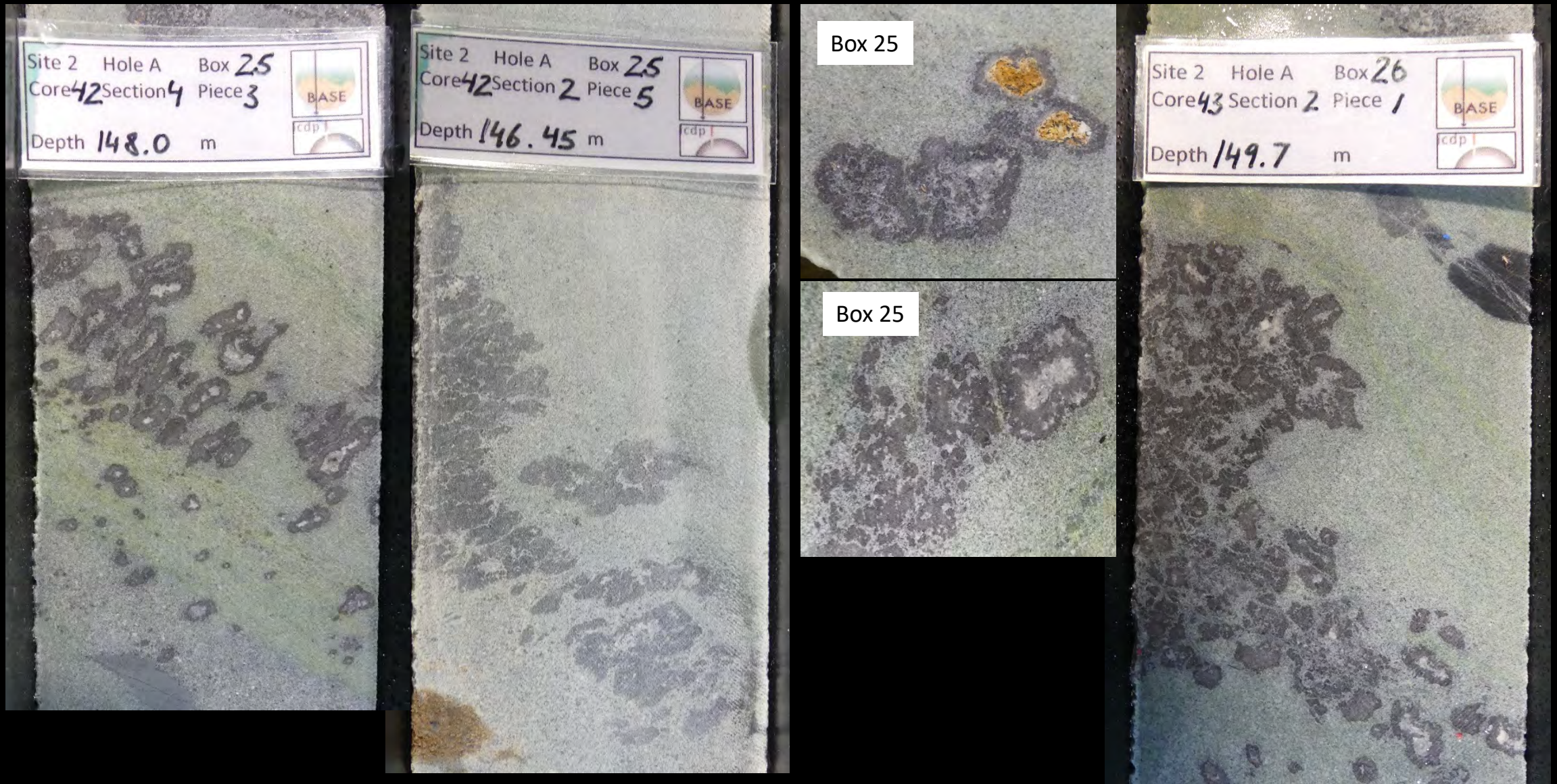
Results: ... also known from outcrop



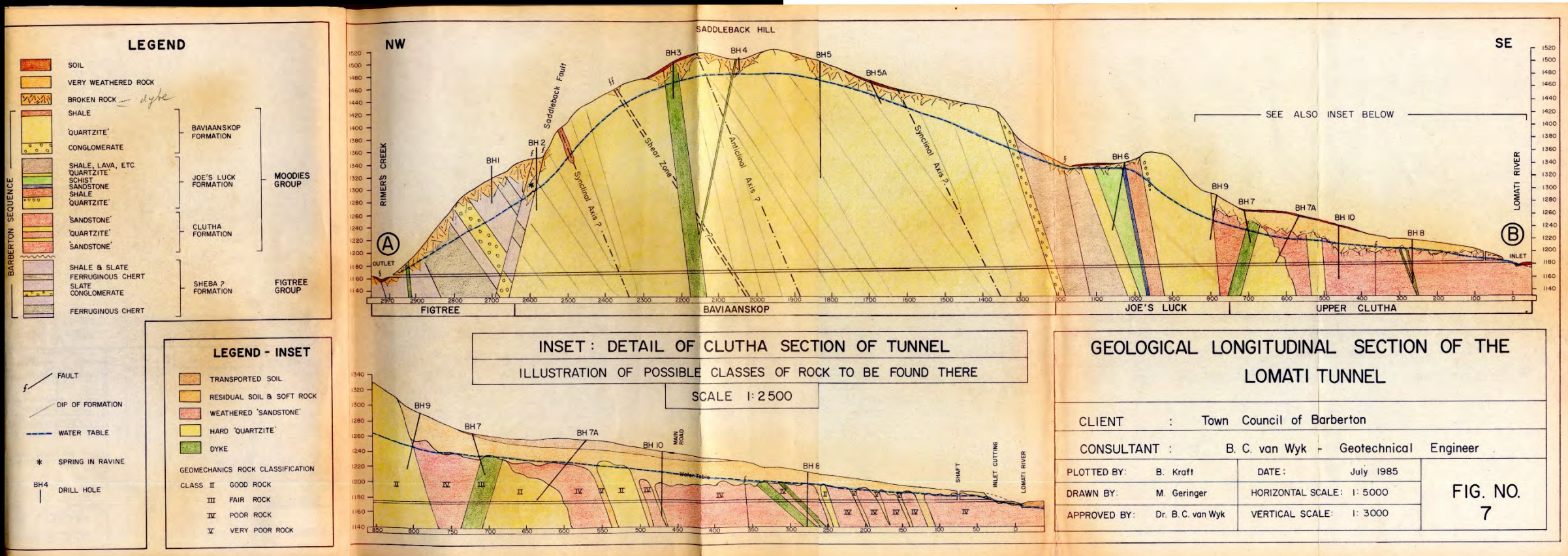
Multiple „Vadose Alteration Zones“ (VAZ)



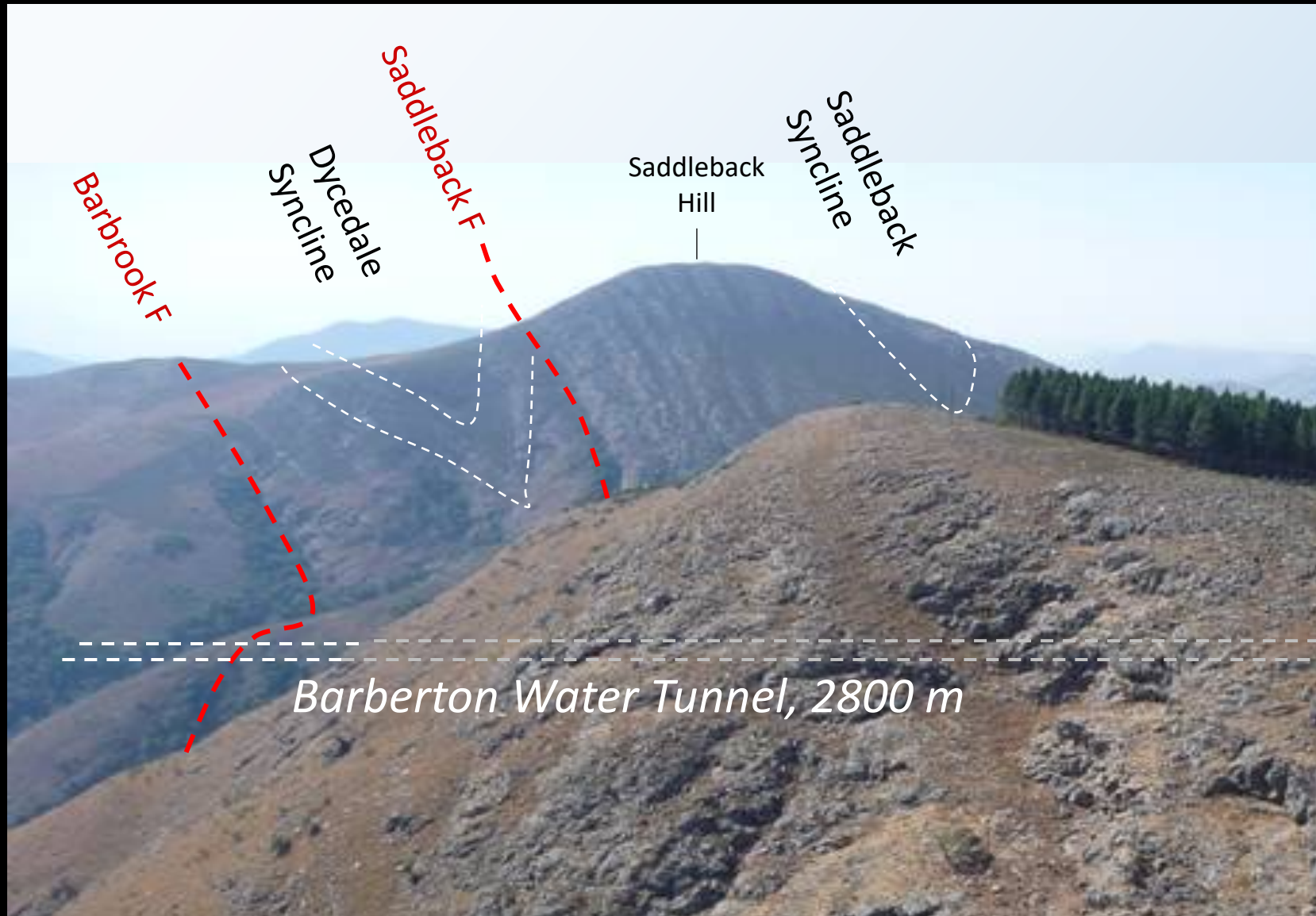
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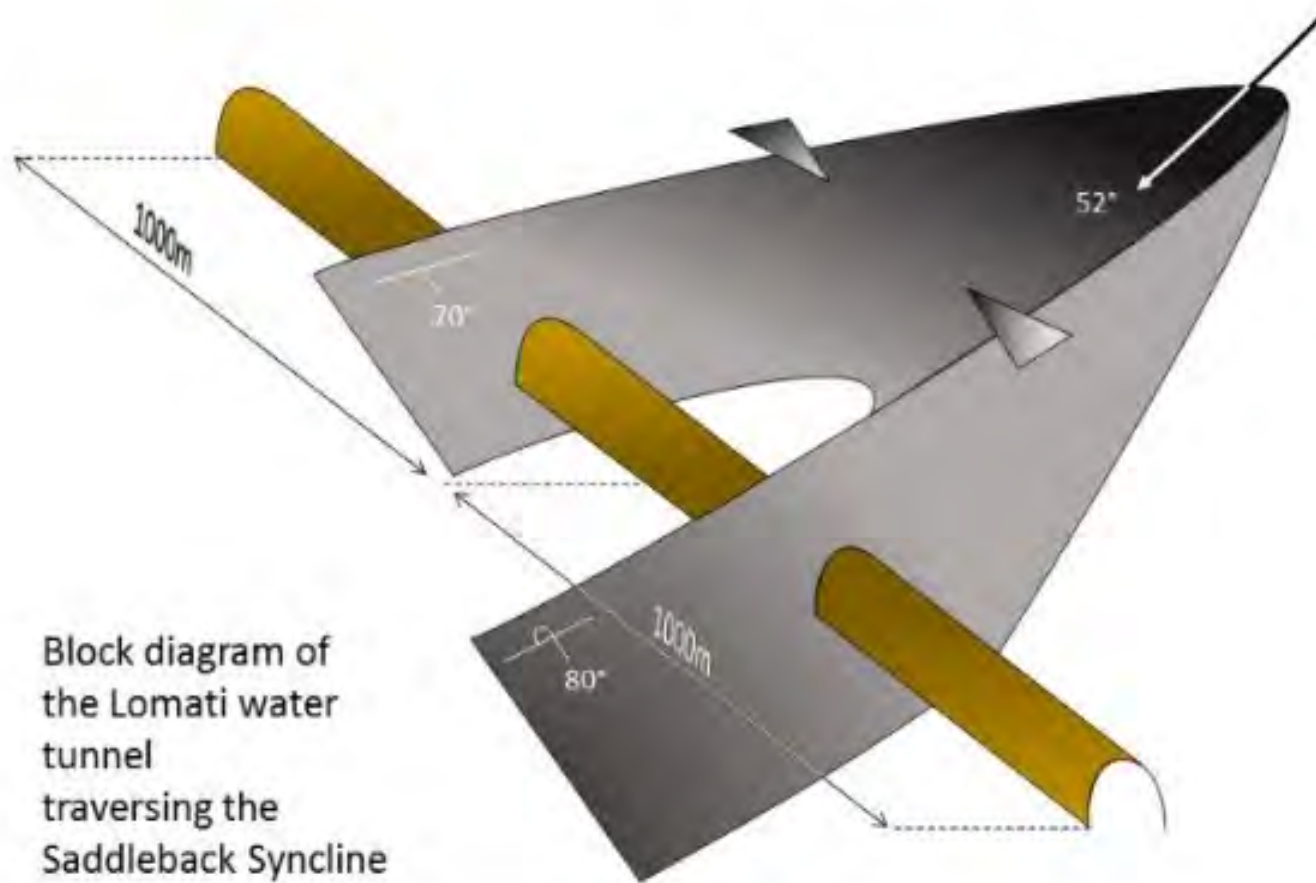
Sampling of three tunnels



Sampling in the Barberton water tunnel



Sampling of three tunnels





ca. 400 m. Small, soda-straw-type stalactite from spray-concrete roof



ca. 600 m; open tunnel. Water mark at ca. 160 cm water depth. Wet ceiling



1020 (foreground; wire mesh only) – 1040 (background; U-frames and spray-concrete) m



ca. 1200 m; soda-straw-type stalactites



1980 m; dark calcite stalactites



2100 m; dripping water; shallow



dry walls and ceiling from ca. 2600 m



ca. 2700 m; dry tunnel walls



ca. 2750m; splintery black schists

Results: Tunnel Sampling



Results: Lomati Water Tunnel



94 samples, incl.
jaspilites, shales
and tuffs

Results: Tunnel Sampling; Agnes Mine



Results: Tunnel Sampling: Agnes Mine



Tunnel Sampling: Agnes Mine



Results: Drilled lengths

Site 1: May-June ca. 450 m ?

Site 2: Done 368 m

Site 3: Done 280 m

Site 4A: Done 340 m

Site 4B: Done 355 m

Site 4C: April 29 ca. 350 m

Site 5 A: in progress ca. 470 m ?

Site 5 B: May-June ca. 470 m ?

... plus samples from three tunnels !

Results aside from Geology: School Outreach



Training of young professionals



Tours four university classes, colleagues



Univ. Orange Free State



Univ. Mpumalanga



Univ. Johannesburg



Univ. Montpellier



Univ. Mpumalanga

Visits to schools, universities; partic. in conferences



Univ. Mpumalanga



Barberton High School

The roles of BASE in the World Heritage Site



Tours for local and international tourist groups



Information material for the general public



Geological Research in the Barberton-Makhonjwa Mountains

Early Earth History and the Spreading of Life on a Young Planet

This is taxpayer's money at work:

For the common benefit of the UNESCO Makhonjwa Mountains World Heritage Site, Barberton, Mbombela Municipality, Mpumalanga Province, South Africa, and curious people worldwide.

Logos: icdp, M, JSPS, DFG, NASA, fnfs, HARVARD

This borehole

This is one of eight boreholes which are currently being drilled in the Barberton-Makhonjwa Mountains. We will drill into this hill and through the tilted rock layers for about 490 m.

At this site, we hope to learn how quickly rocks weathered in a hot atmosphere with acid rain, how some bacteria fed on gypsum grains, how other bacteria fared living in a volcano-studded delta, and how high and frequent the daily and monthly tides were.

Geological Cross Section (Prediction)

Drilling and research are jointly financed by a group of international government research organizations and universities in which South Africa is a member. Half of the core will remain in South Africa.

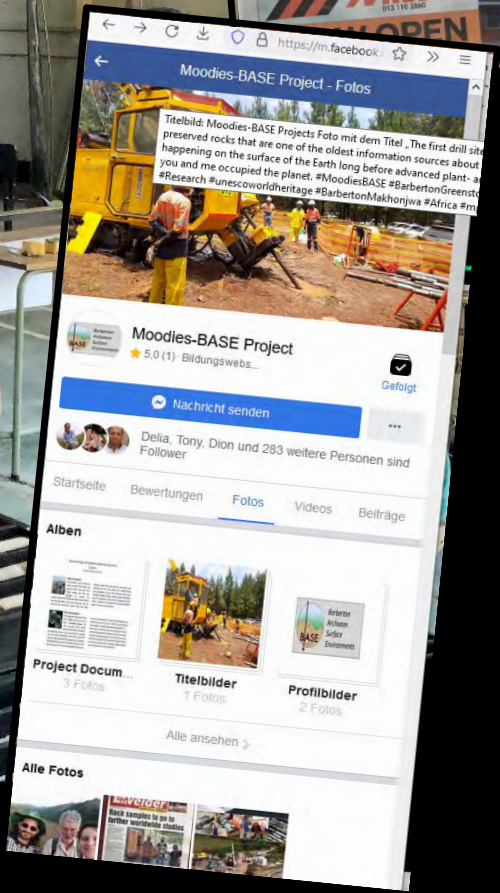
The project employs many students in South Africa and worldwide who will do research on the cores. We will drill here until the middle of March, 2022, and leave the site as we occupied it, or better.

Scientific Drilling for Knowledge

The rocks in these mountains are former sediments and volcanic rocks which are among the very oldest on Earth and are famous worldwide. They were originally laid down in coastal plains, along shores, in tidal settings, and deltas. They also contain bacteria fossils. By studying these strata, we can learn under which conditions life spread on Earth and perhaps on other planets.

But most rocks are weathered or covered by grassland. Geologists therefore made maps of the various rock types at the surface to determine where to drill best for fresh and continuous cores of different and interesting rock types. Much care was taken to stay away from areas that were altered by hot fluids and which may have carried up gold or other metals. This research has therefore no economic consequences.

Two movies (CNN, BBC)



Four regional radio stations



Biweekly newsletter, ICDP webpage, MoD

Jena, March 26, 2022

Barberton, March 12, 2022

Barberton, February 26, 2022

The BASE Newsletter, vol. 3, issue 5

The BASE Newsletter, vol. 3, issue 4

On two consecutive days, we sampled the Ben Lomond (a Princeton) and the 22-level tunnels of Agnes Mine, thank friendly permission by the operator, Galaxy. Both tunnels traverse at nearly right angle through ca. 2 km thick subvertical strata of the Moodies Hills Block west of Barberton. Because we have no boreholes in this tectonic unit and exposures there are either poor or access difficult, the stratigraphically controlled samples will provide a valuable addition to the BASE cores. While a team from UJ (Nic, Hervé) focused on jaspilites and BIFs, the onsite team collected wall rock at regularly spaced intervals.

The section head of education and research of the Gem Embassy Pretoria, Dr. Kieffer, visited us for a full day. She informed herself on our objectives and the WHS in which we drill, saw the exhibition and core processing facilities, visited the three active drillsites, and then toured the entire length of the R40 Geotrail to the Eswatini border - a full day indeed. Because Dr. Kieffer is not only a diplomat but also a biologist by training, she readily grasped our concepts and questions (metabolisms, environmental parameters, rates in deep time etc.), so that our conversations were profound and efficient.

We continue to run three rigs at Sites 2, 4B and 4C, all drilling NQ diameter cores. As of the time of writing, the rigs at Sites 4B and 4C are at 136 and 112 m MD, respectively, drilling stratigraphically upwards at approx 15 m / day through cross-bedded tuffaceous sandstones at the base of the Lomati Delta. The rig at Site 2, currently at 245 m, penetrated ca. 30 m of shoreline sandstones with abundant early-diagenetic gypsumiferous concretionary crusts (shown left) and presently progresses through gravelly, sandy and shaly coastal-plain strata at about 20 m / day. All cores are of very good to excellent quality, and rates are better than predicted. We bring the cores down in the late afternoon and mostly orient, label, slab, photograph and describe them the following day.

Phumi, Christoph, and Rod frequently give talks or interviews and lead tour groups to the highly accessible Site 2, located next to a parking lot on the R40 road. The event to the left shows the informal part of an evening presentation by Christoph to the local Rotary Club chapter. Despite the appearance to the contrary, our team building activities do not usually frequent the local pubs; rather, we either hike on weekends in the beautiful mountains or check out the strata in the vicinity of the drillsites.

Frohes Forschen!
Frohes Forschen!

Follow our da
Christoph He

Follow our da

MessageOfTheDay

To add a new MoD, upload your photo using "File Upload" in the sidebar, assign upload date (=date MoD) and file type UN. Then, in "New Message", use the text fields below to select that picture and add text.

LAST MESSAGE NEW MESSAGE

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	1 M	2	3	4	5
Bar...	Sin...	Bor...	Thi...	Su...	CH...	Uni...
6	7	8	9	10	11	12
Th...	Bor...	We...	Sc...	Th...	MD...	Ita...
13	14	15	16	17	18	19
Pal...	Aft...	Thi...	4B...	We...	Cor...	Pre...
20	21	22	23	24	25	26
We...	Tau...	In p...	Th...	In h...	Rig...	Bor...
27	28	29	30	31	1 Ap	2
Chr...	A g...	Sit...	Bro...	4C...	Sit...	Th...

2022_03_17: Excursion into a fault and sampling validation from site...

icdp | INTERNATIONAL CONTINENTAL SCIENTIFIC DRILLING PROGRAM

EC/AOG MEETING COMING SOON

PROFILE SUPPORT PROJECTS PROPOSALS MEMBERS FACTS SEARCH LOGIN

SOCIETAL CHALLENGES

CLIMATE & ECOSYSTEMS

Paleoclimate
Deep Life
Impact Structures
Volcanoes

SUSTAINABLE GEORESOURCES

Deep Life
Volcanoes
Element Cycles
Plate Margins

NATURAL HAZARDS

Faults
Volcanoes
Impact Structures
Plate Margins

HIGHLIGHTS

EARTH'S OLDEST LIVING LANDSCAPE SPOTTED IN SOUTH AFRICAN ROCK CORES

SCIENCE NEWS ON ICDP PROJECT BASE

SCIENTIFIC DRILLING OF CRETACEOUS SONGLIAO BASIN

Academic seminar successfully held in Beijing

GRIND-ECT

GRIND Namibia is back in Berlin - Spandau core repository.

ALL News as RSS feed

2022_03_27

Christoph left the team on March 25; Brooke J will arrive on Monday.

2022_03_26

Borehole 4B in the middle Lomati Delta terminated on Wed, March 23, at 355.4 m depth.

2022_03_25

Rig NF90 moved from Site 2 to Site 5 over 40 km, mostly on forest roads.

2022_03_24

In his farewell talk to the Barberton Branch of the Geol. Soc. S. Africa, Christoph summarized the...

2022_03_23

The engineers gave us four hours to traverse the 2780 m long Lomati water tunnel.

2022_03_22

In preparation of planned sampling of the Lomati water tunnel, we checked its access road...

2022_03_21

Taufeeq Dhansya from the Council for Geosciences in Pretoria visited us for two days. We did some...

2022_03_20

We have moderate to good success to be present in the news media. The Lowvelder is a regional...

2022_03_19

Pre-drill meeting for site 1 in the Elephant's Kloof section of Fairview Mine, Eureka Syncline.

-
- Introduction and Fundamentals
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People people people

- Outstanding local partnership with UJ
- Privilege of drilling in a WHS
- Perfect setup in the BIAS Hall
- Wonderful, diverse onsite team
- Strong Barberton community support
- Responsive, interested drilling contractor

The nucleus of a future WHS Visitor's Center ?



The World Heritage Site

Stewardship

Appreciation

Knowledge

Awareness

The future ...

- End of drilling campaign and core processing in June 2022
- Shipping to ICDP core facilities in Berlin-Spandau in July / August
- Core scanning, XRF sampling, illustrations / documentation in fall 2022
- Sampling workshop December or January

To learn more



Phumelele Mashele: Outreach, Publicity, Education

Facebook: Moodies-BASE Project

moodiesbaseproject@gmail.com

or subscribe to the newsletter

