



BASE

-

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

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

June 2, 2022



BASE

Barberton

Archaean

Surface

Environments



ICDP

International
Continental Scientific
Drilling
Program

BASE Onsite Geoscience Team



2017 ICDP Workshop participants \cong BASE Science Team



Science Management Board

Christoph Heubeck	Jena University	Germany
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This talk

- Introduction and Fundamentals
- The Moodies Group
- Setup, Objectives, Drilling Design
- Operations Update
- First Results
- Outlook

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We know little about early Earth



Continents
Atmosphere(s)
Coasts
Oceans

Climate, Weather
Intensity and Consequences of Solar Radiation
Volcanism
Tides, Moon, Earth Spin

Meteorite Impacts

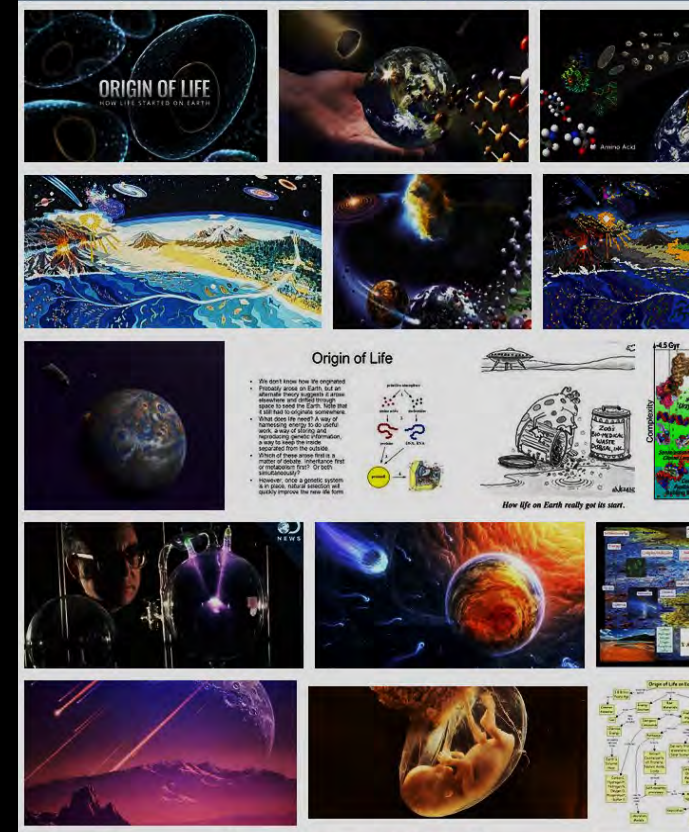
Are we alone ?



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

A screenshot of the NASA Exoplanet Archive website. The page features a dark blue header with the NASA logo and the text "NASA EXOPLANET ARCHIVE A SERVICE OF NASA EXOPLANET SCIENCE INSTITUTE". Below the header, there are navigation tabs for Home, About Us, Data, Tools, Support, and Login. The main content area includes several statistics: "5,005 Confirmed Planets", "203 TESS Confirmed Planets", and "5,459 TESS Project Candidates". There is a search bar with the text "Name or Coordinates" and a "Search" button. A section titled "5,000+ Alien Worlds and Counting" mentions "March 21, 2022 - New Data" and states that thirty years after the first exoplanet was found, the archive has reached a major milestone. The page also features a "Transit Surveys" section with a "TESS" logo and a "Tools & Services" section with various search and analysis options.

Looking for habitable worlds beyond our own planetary system.

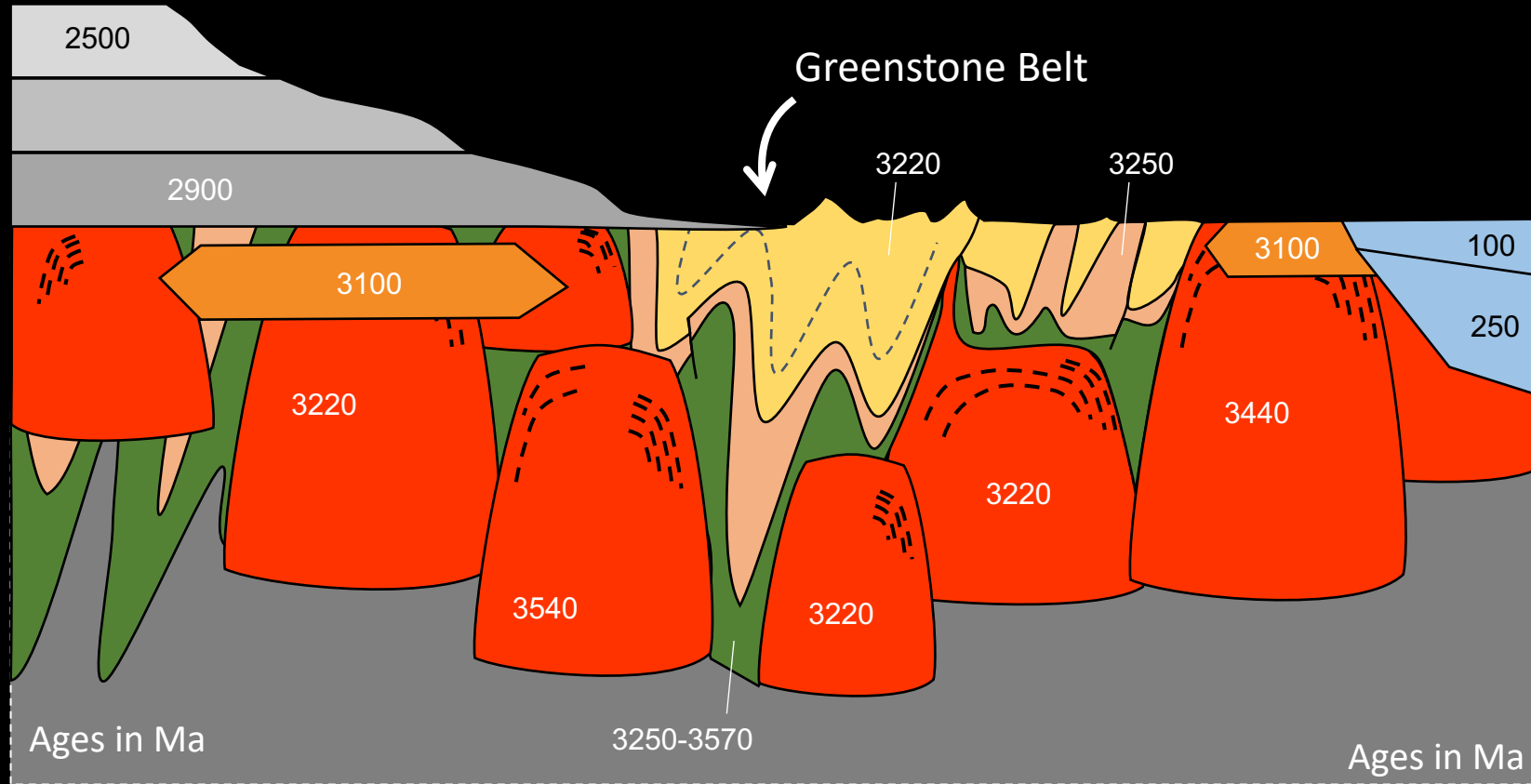


Is „making life“ easy ? Does it form almost necessarily, given sufficient time and space, - or is it exceedingly rare ?

We know of one planet where life has formed



Greenstone Belts: Remnants of early surface records



Cratonic Basement

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

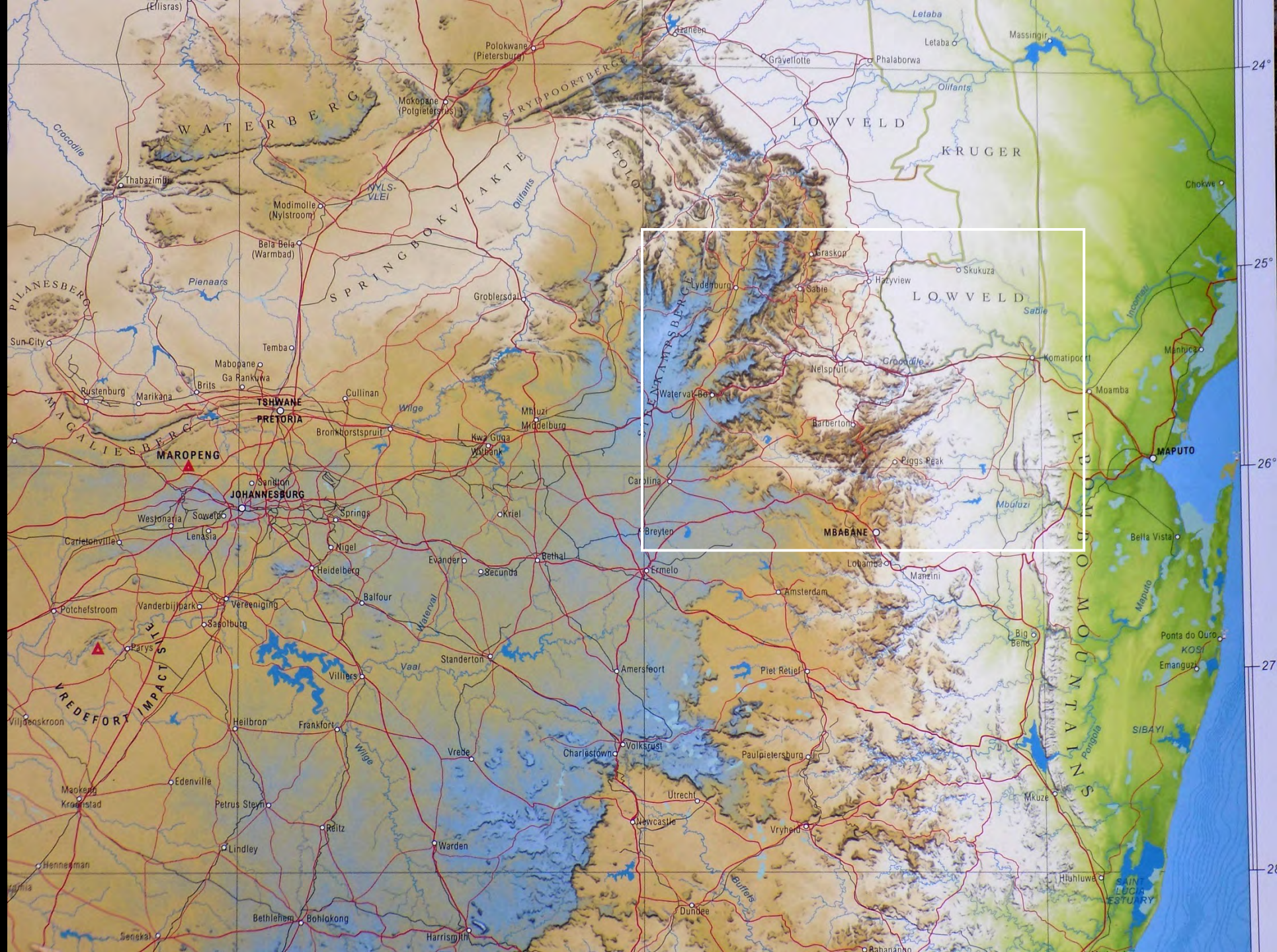
Greenstone Belt Units

- volcanic and
- sedimentary strata of greenstone belt
-

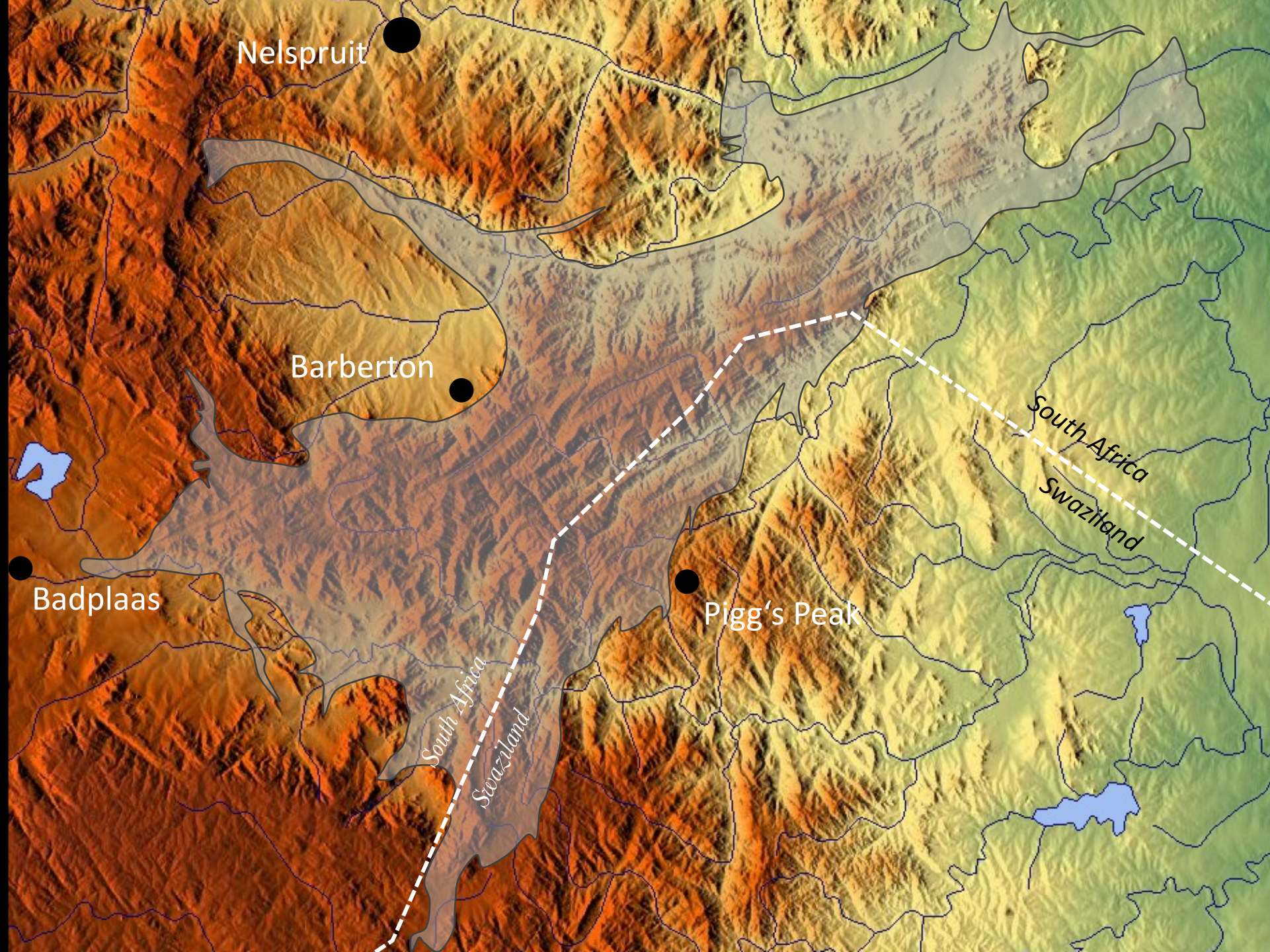
Other

- young cover (Triassic - Quaternary)
- cratonic cover









Nelspruit

Barberton

Badplaas

Pigg's Peak

South Africa

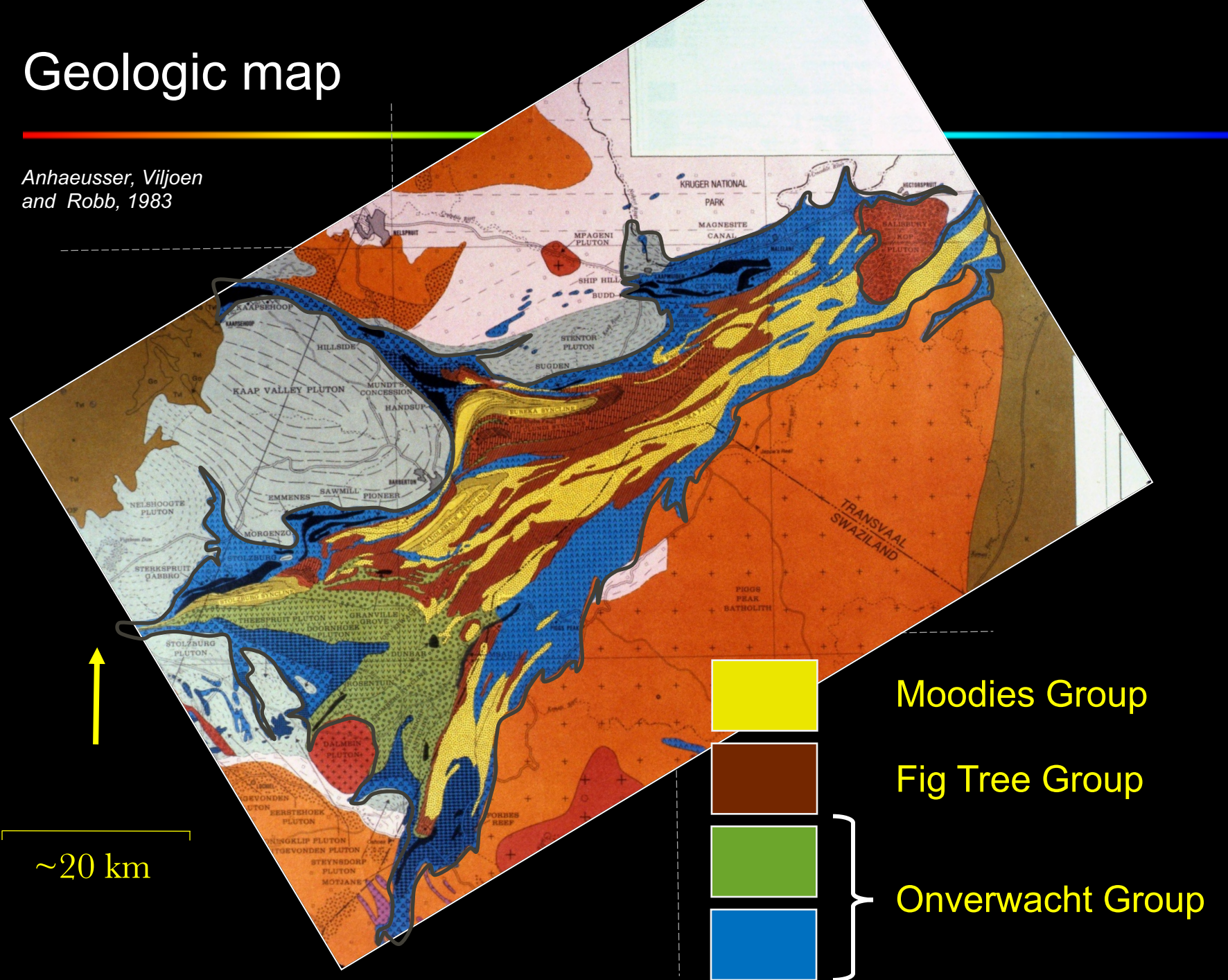
Swaziland

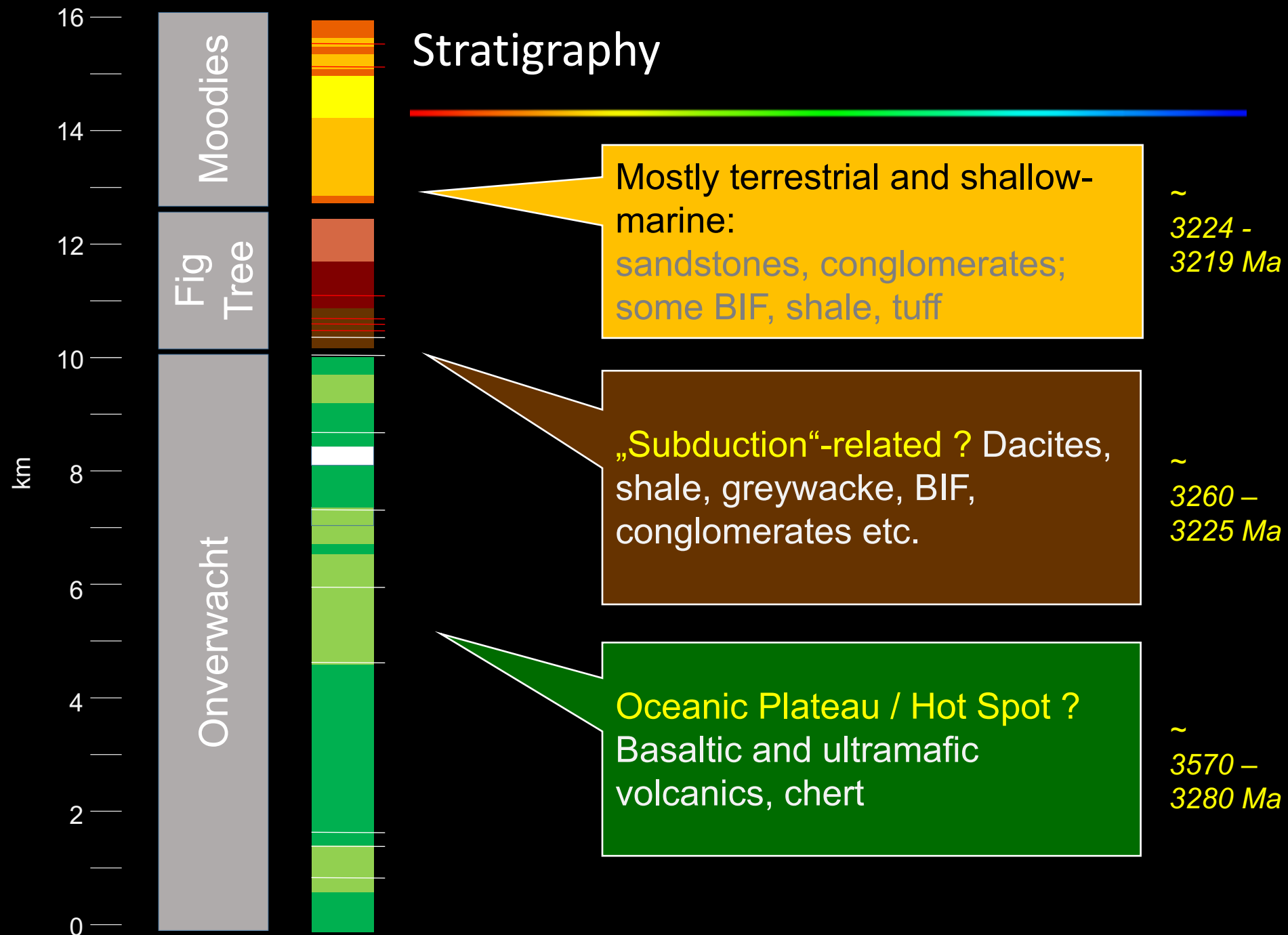
South Africa

Swaziland

Geologic map

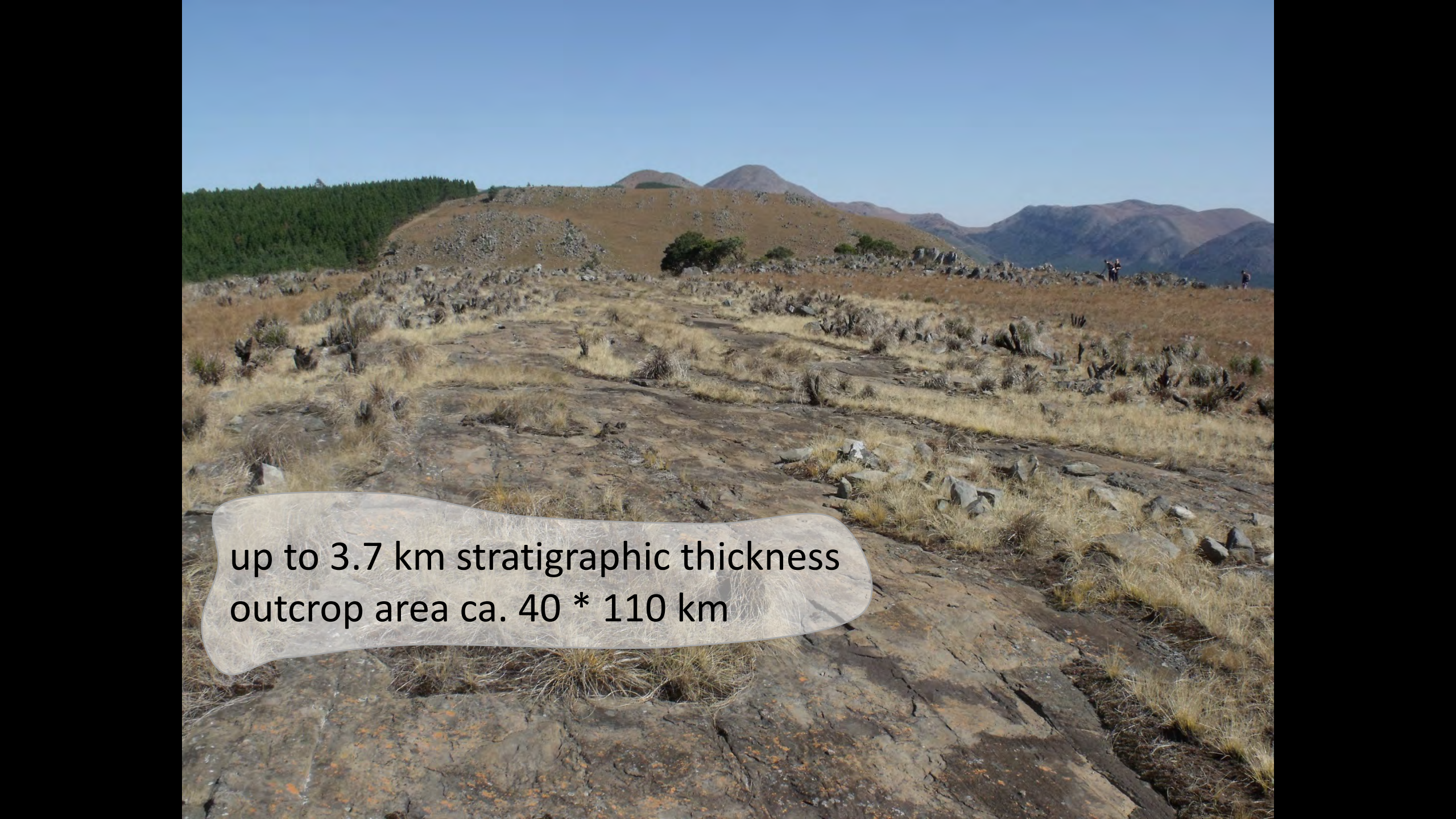
Anhaeusser, Viljoen
and Robb, 1983






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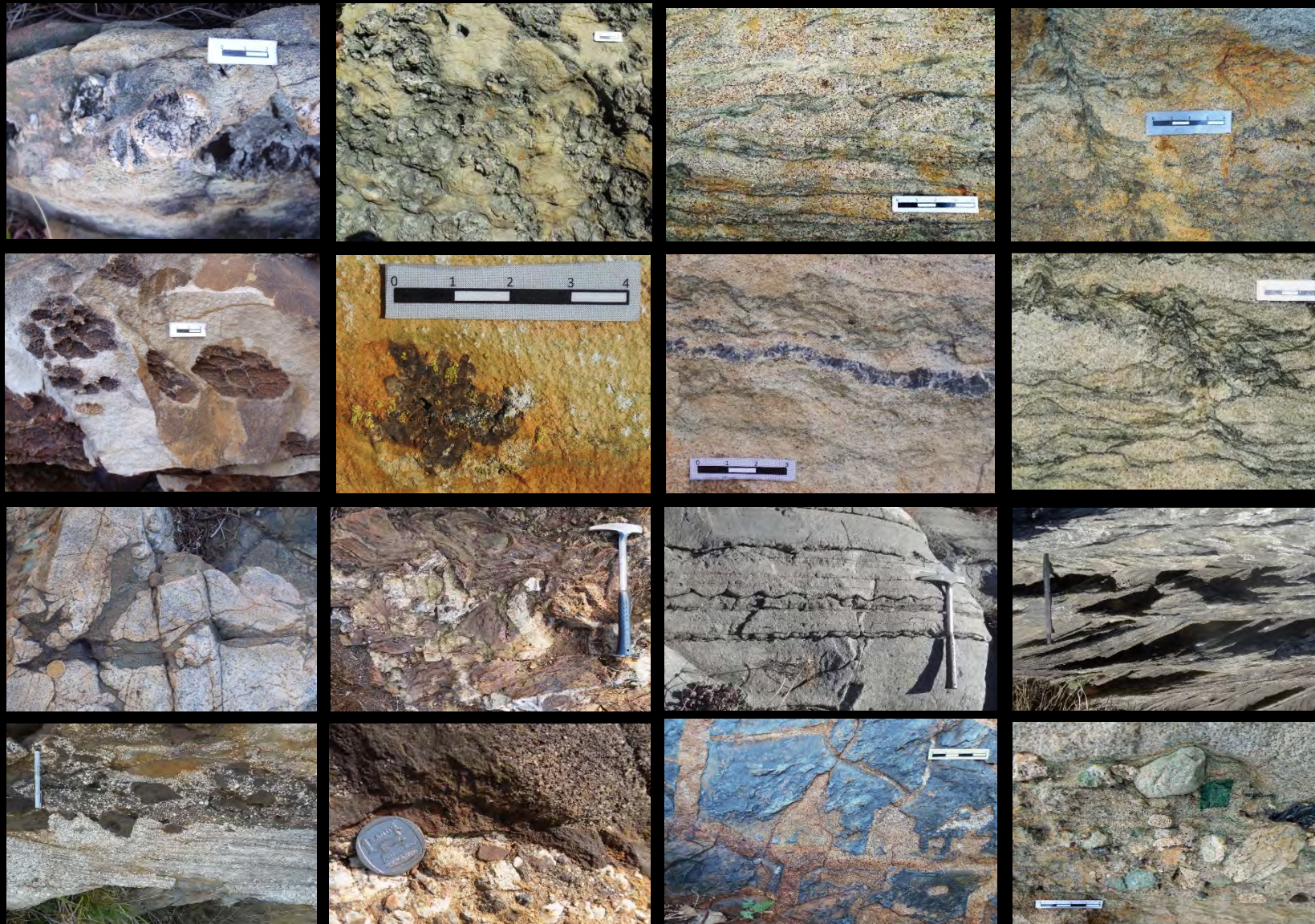


up to 3.7 km stratigraphic thickness
outcrop area ca. 40 * 110 km



up to 1,700 m relief
most strata dip subvertically

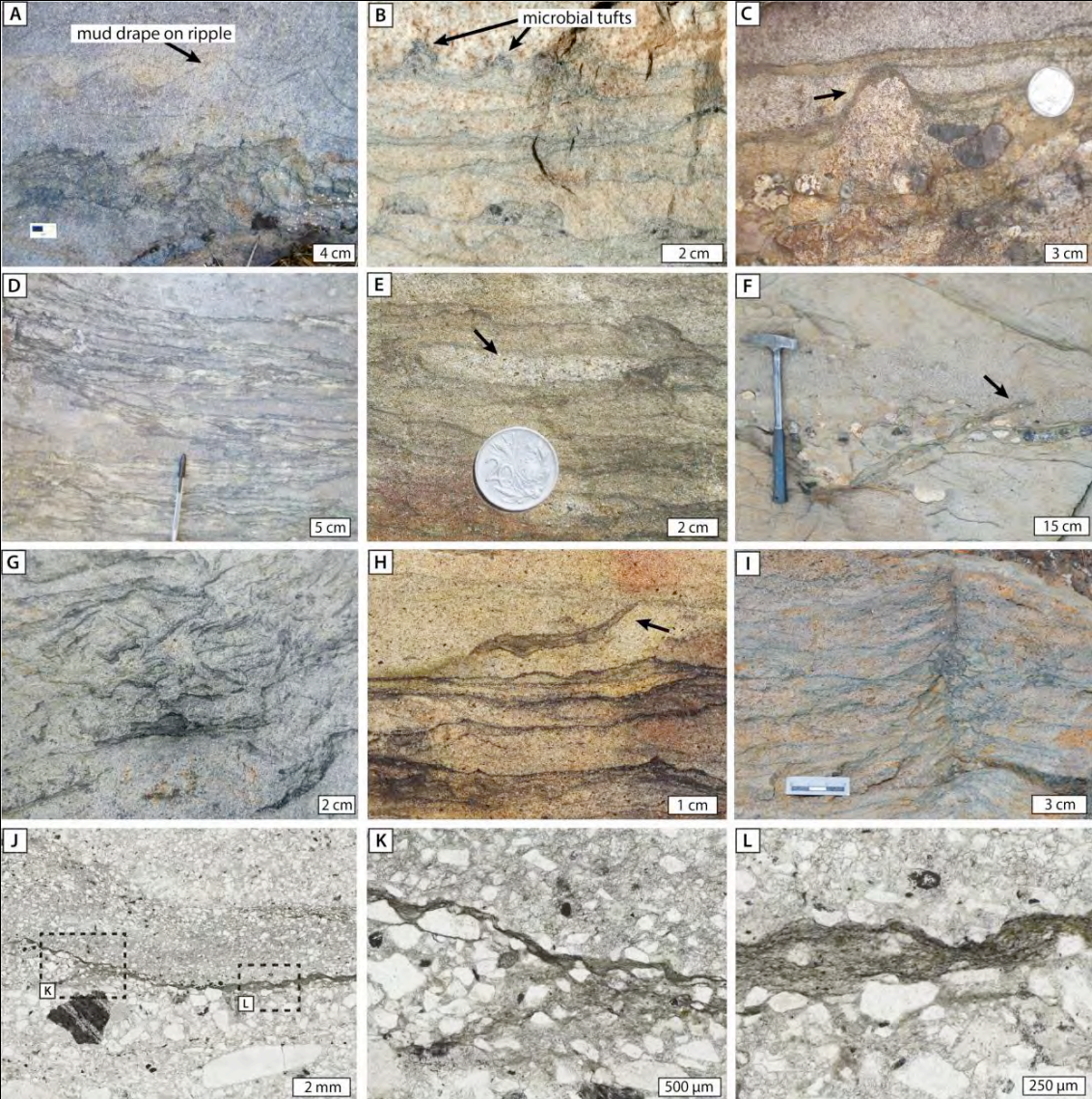
Abundant diverse sedimentary structures



Fossilized microbial mats



Fossilized microbial mats




... likely (an-)oxygenic photosynthesizers

Recent, Tunisia



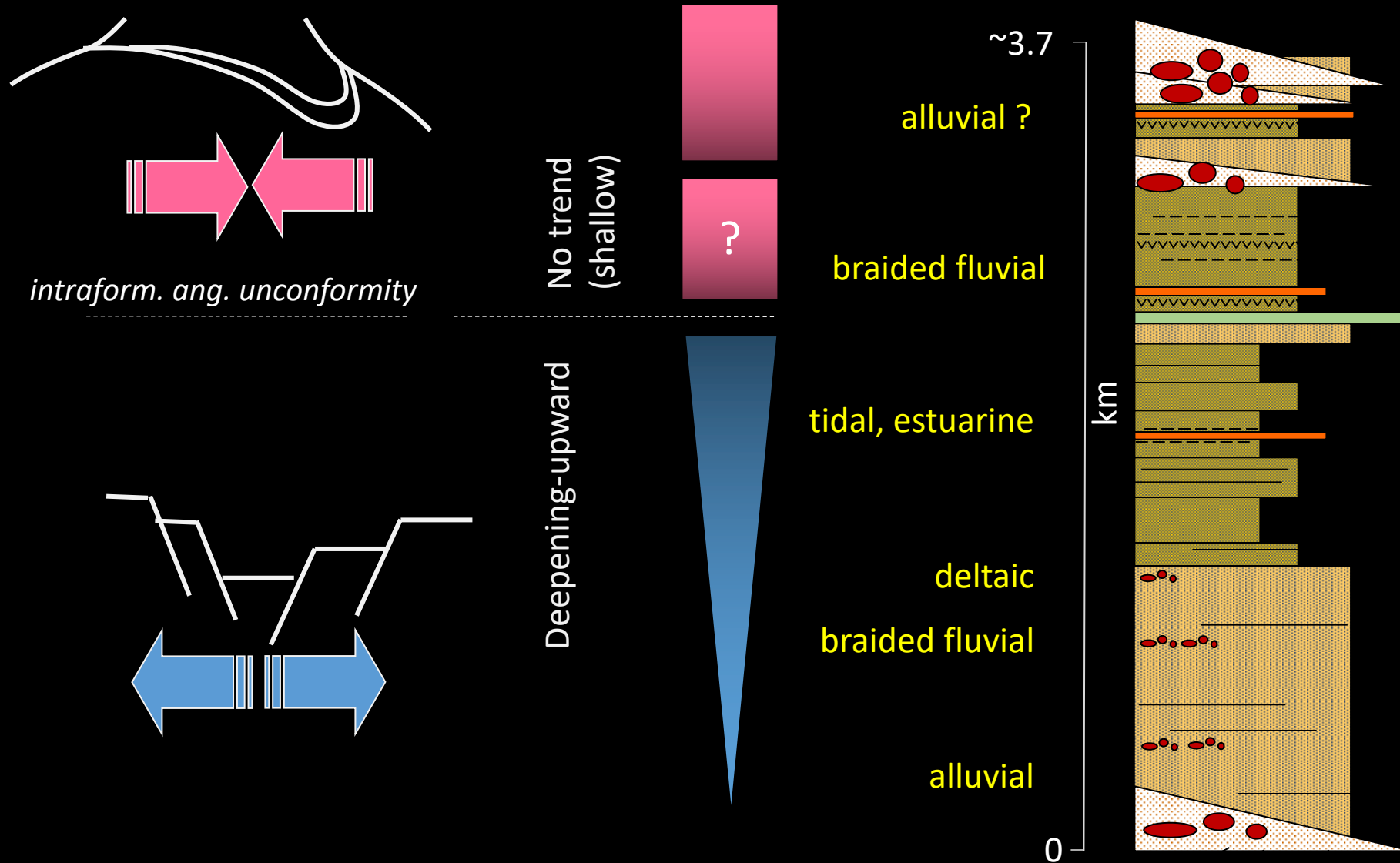
Recent, Tunisia



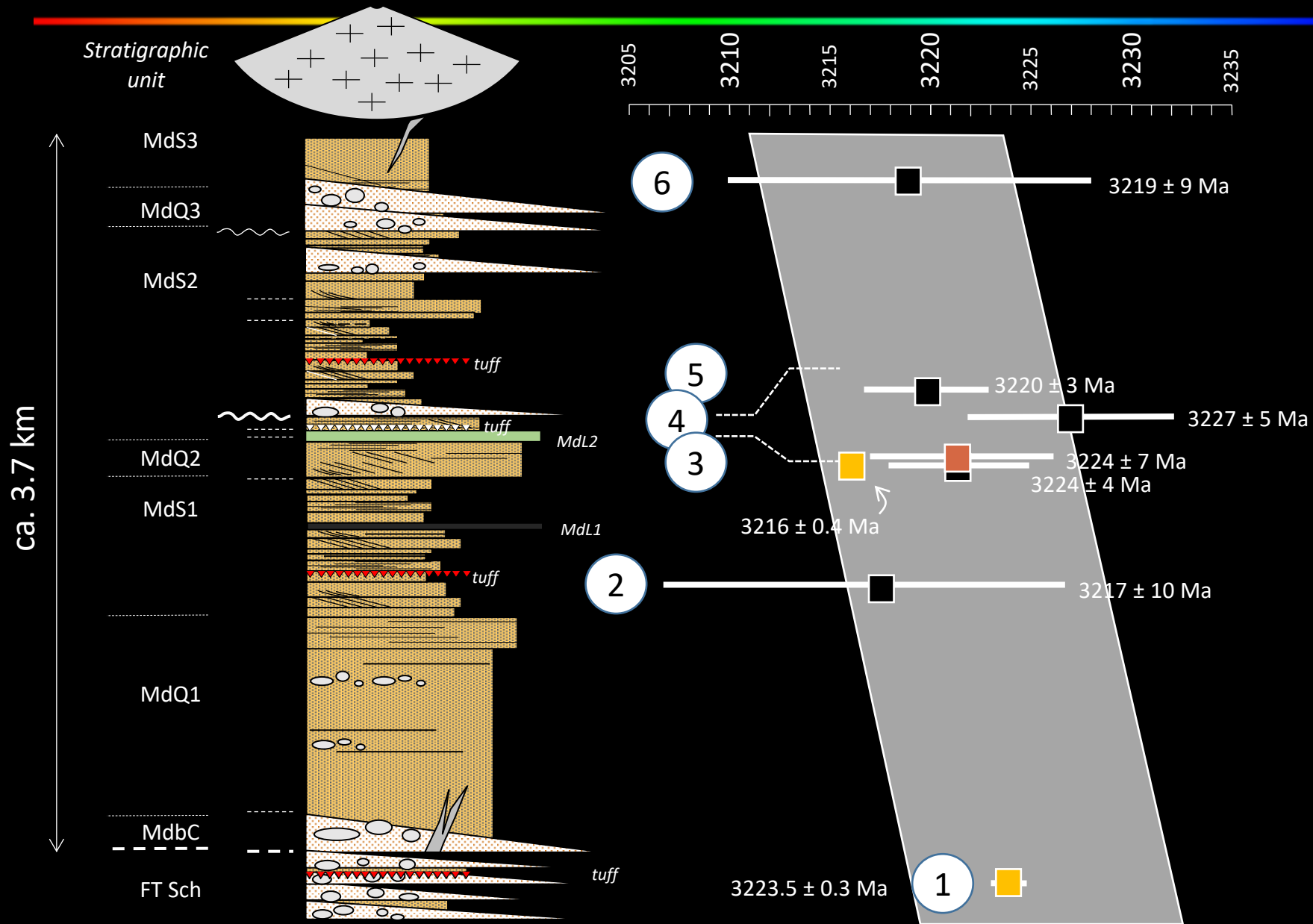


Range of depositional environments
terrestrial-marine transitions

Moodies Group strata record greenstone belt dynamics



High temporal resolution



The Need to Drill

Moodies strata are ...

... weathered where continuous

... discontinuous where unweathered

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Scientific Objectives

(1) Prodelta facies

- (tidal ?) rhythmicity
- origin of clay minerals
- relationship of j and 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 acritarchs ?
- 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

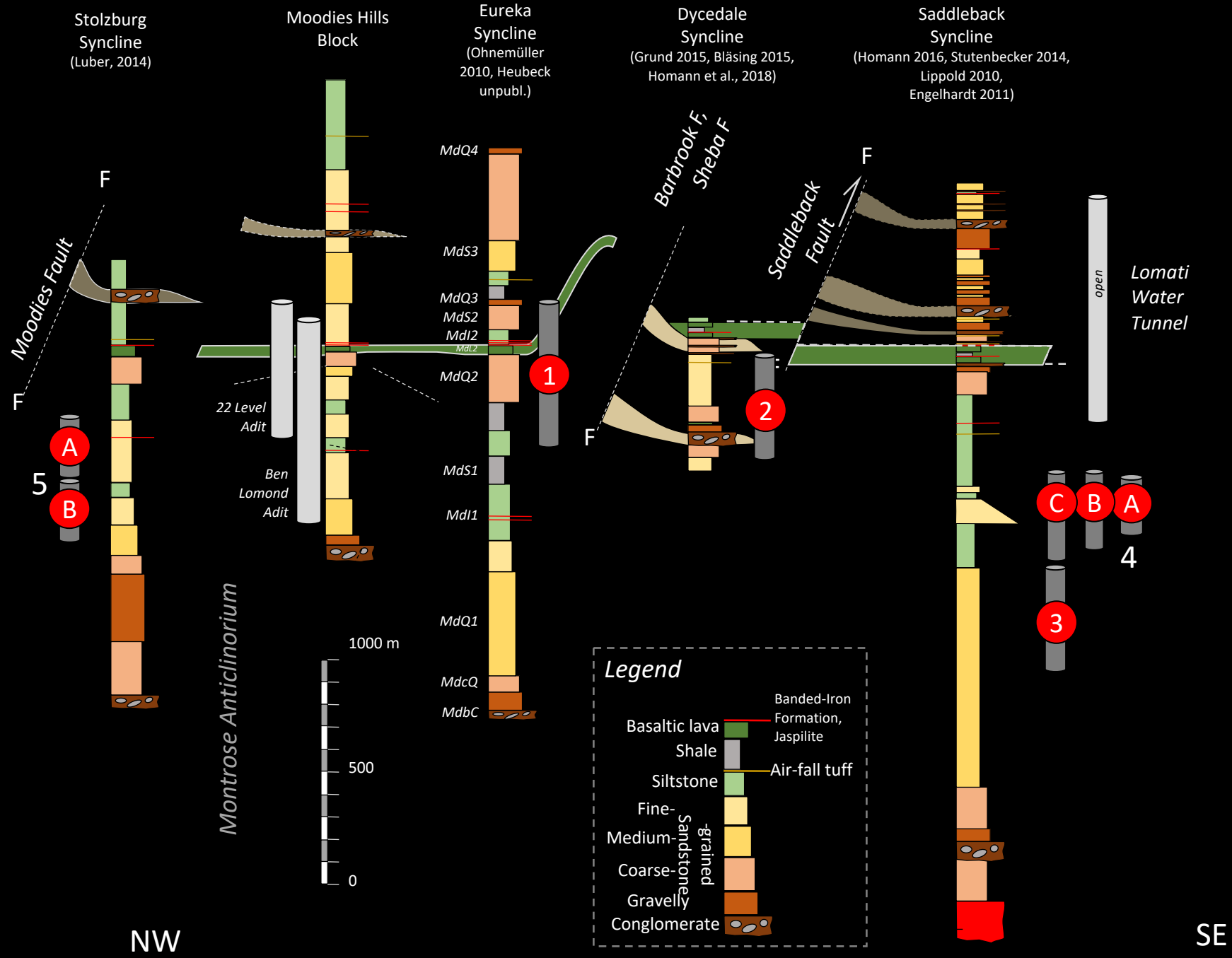
- strength of the Earth's magnetic field
- magnetostratigraphy

(6) Magmatism and basin dynamics

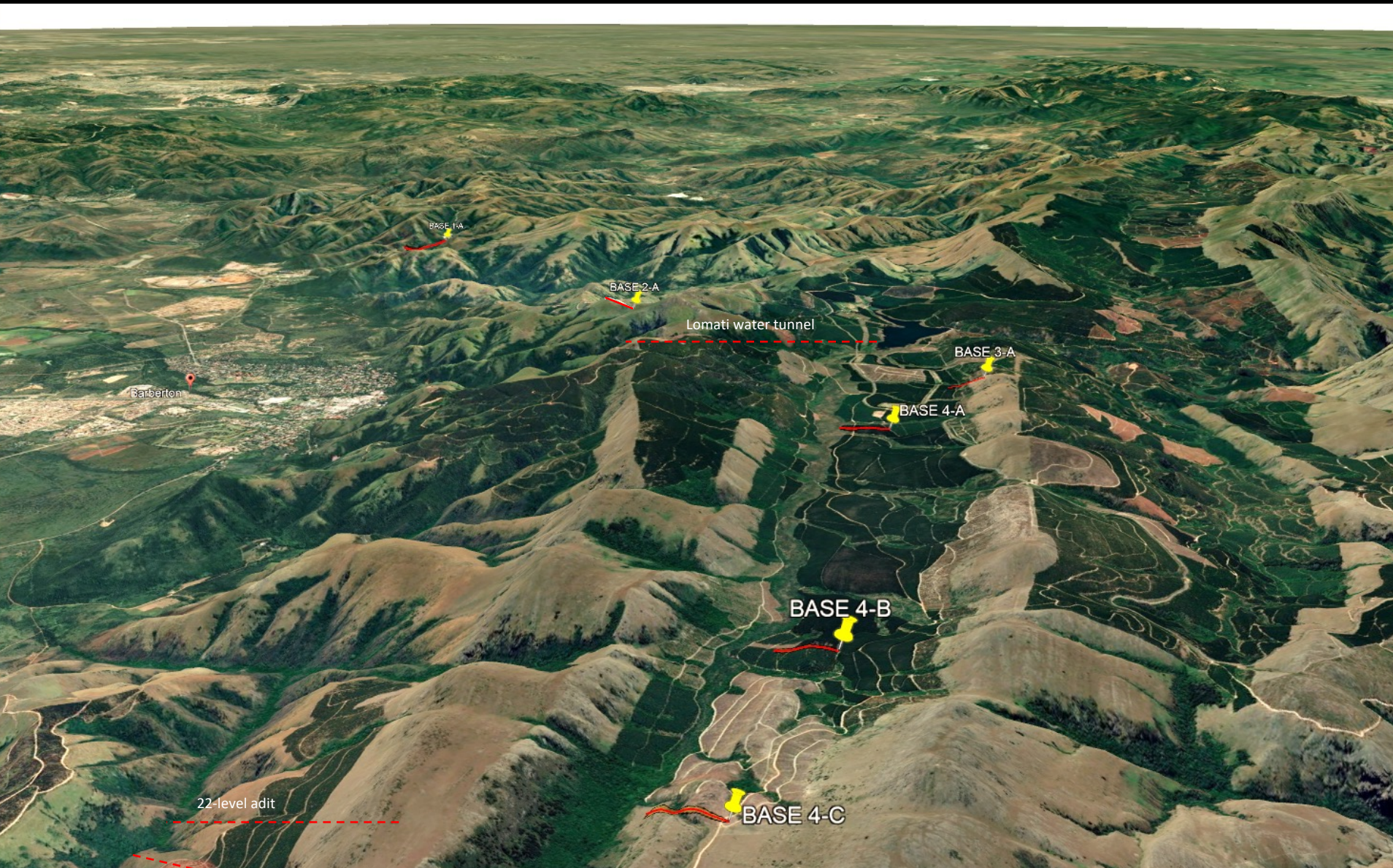
- Association between basaltic lava, stockwork intrusions in unconsolidated sandstones and a major sill; hydrothermal halos ?

(7) Geochronology

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



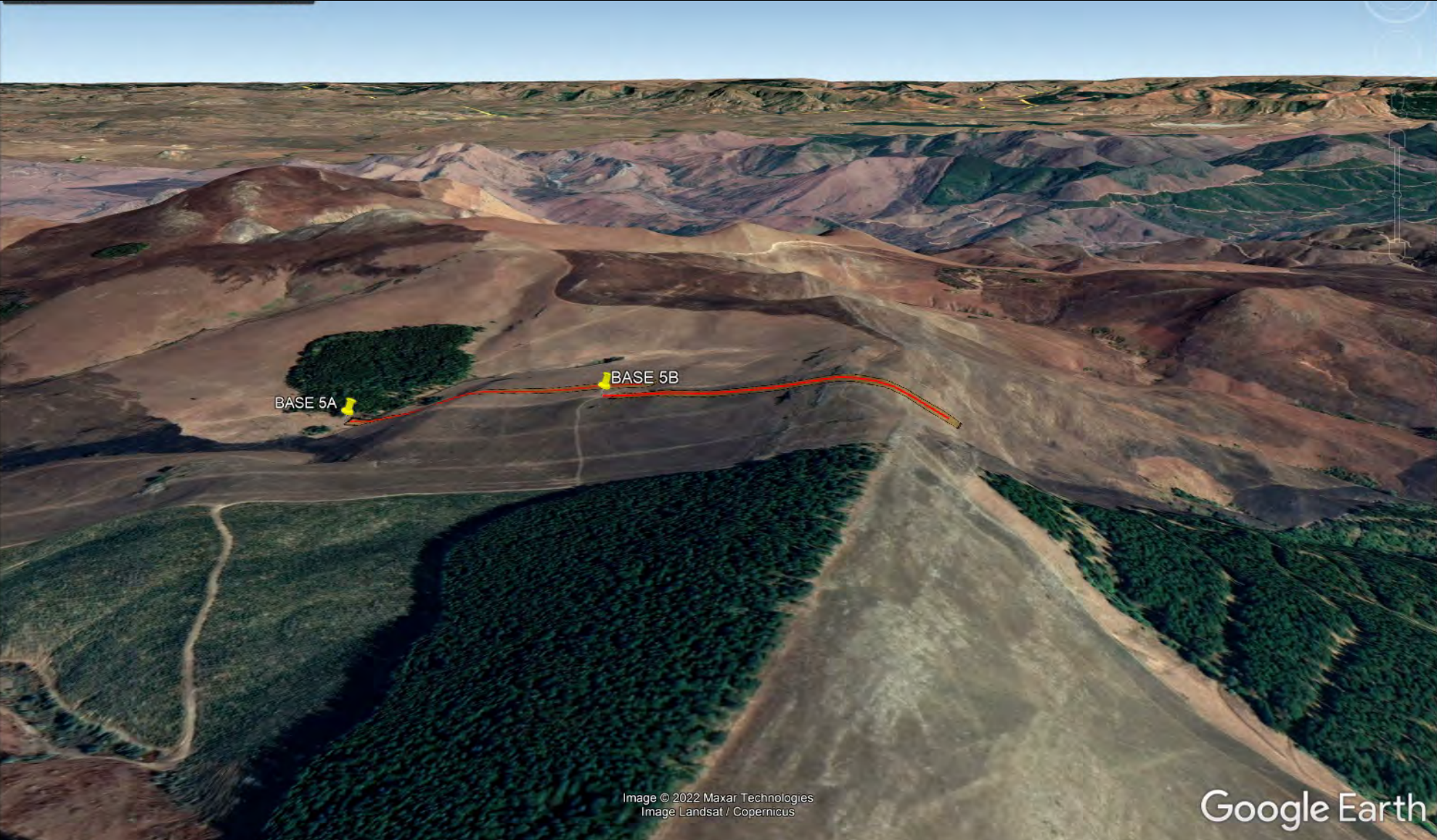
Drilling Locations



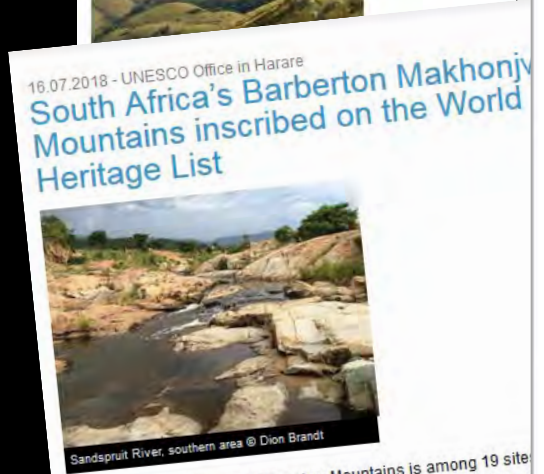
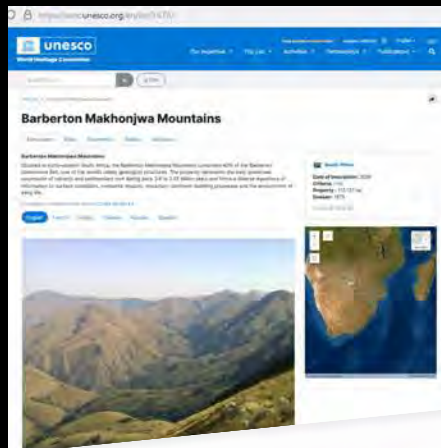
Drilling Locations



Drilling Locations

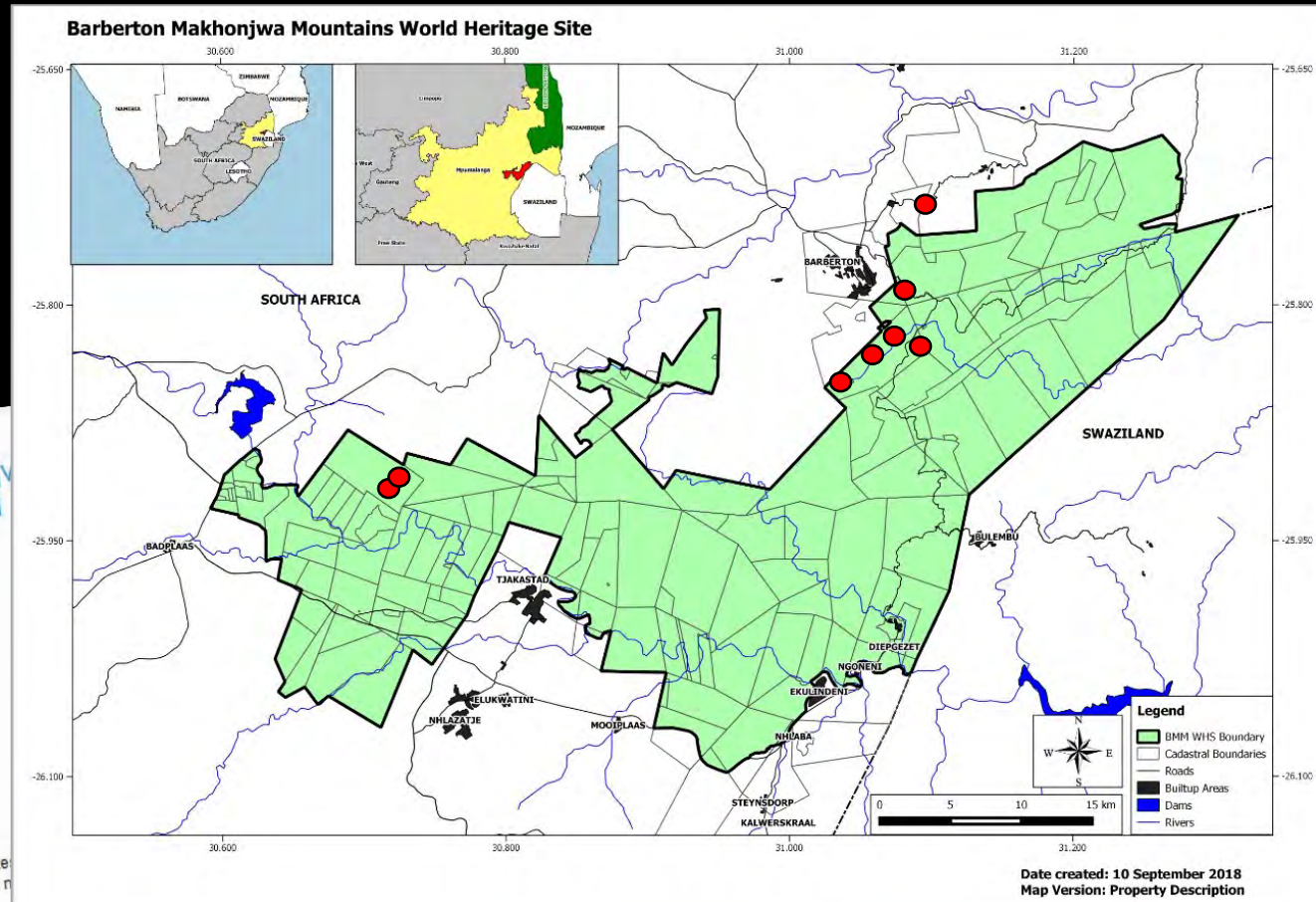


Drilling in a WHS, formerly a gold mining province

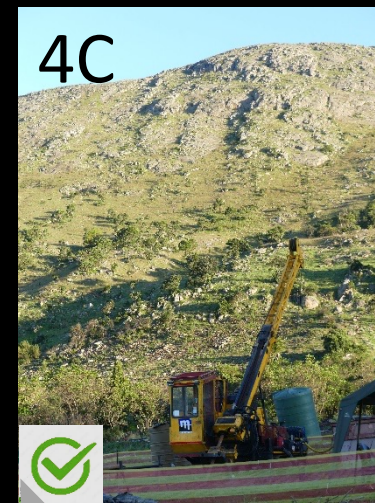


South Africa's Barberton Makhonjwa Mountains is among 19 sites World Heritage List during the 42nd World Heritage Committee meeting in Manama, Bahrain from 24th June 2018 to 4th July 2018.

Situated in north-eastern South Africa, the site comprises 40% of the Barberton Greenstone Belt, one of the world's oldest geological structures. The Barberton Makhonjwa Mountains represents the best-preserved succession of volcanic and sedimentary rock dating back 3.6 to 3.25 billion years, when the first continents were starting to form on the primitive Earth. It features meteor-impact fallback breccias resulting from the impact of meteorites formed just after the Great Bombardment (4.6 to



Diverse, interesting drill sites



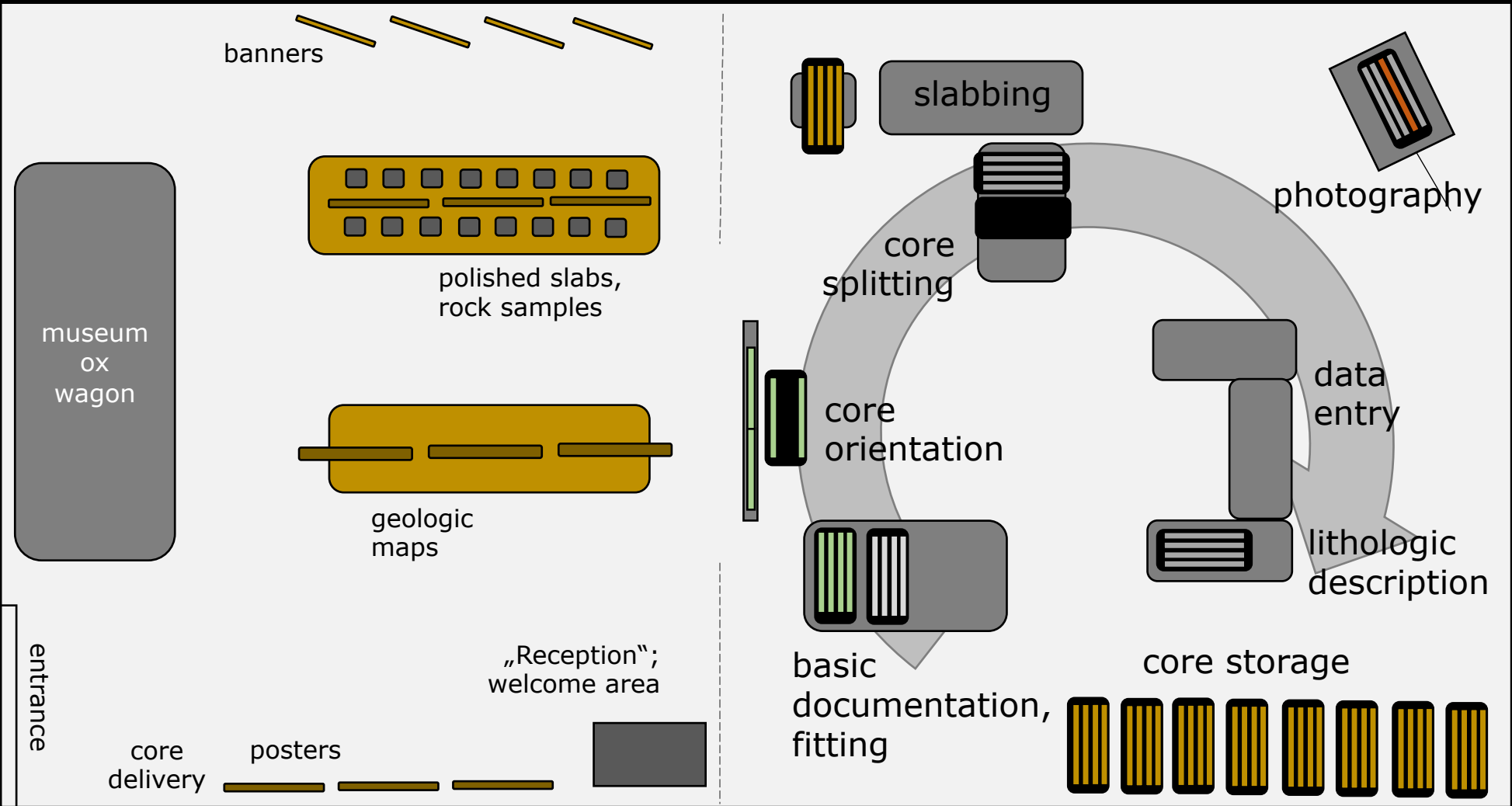
Our workplace for 9 months: The BIAS Hall, downtown Barberton



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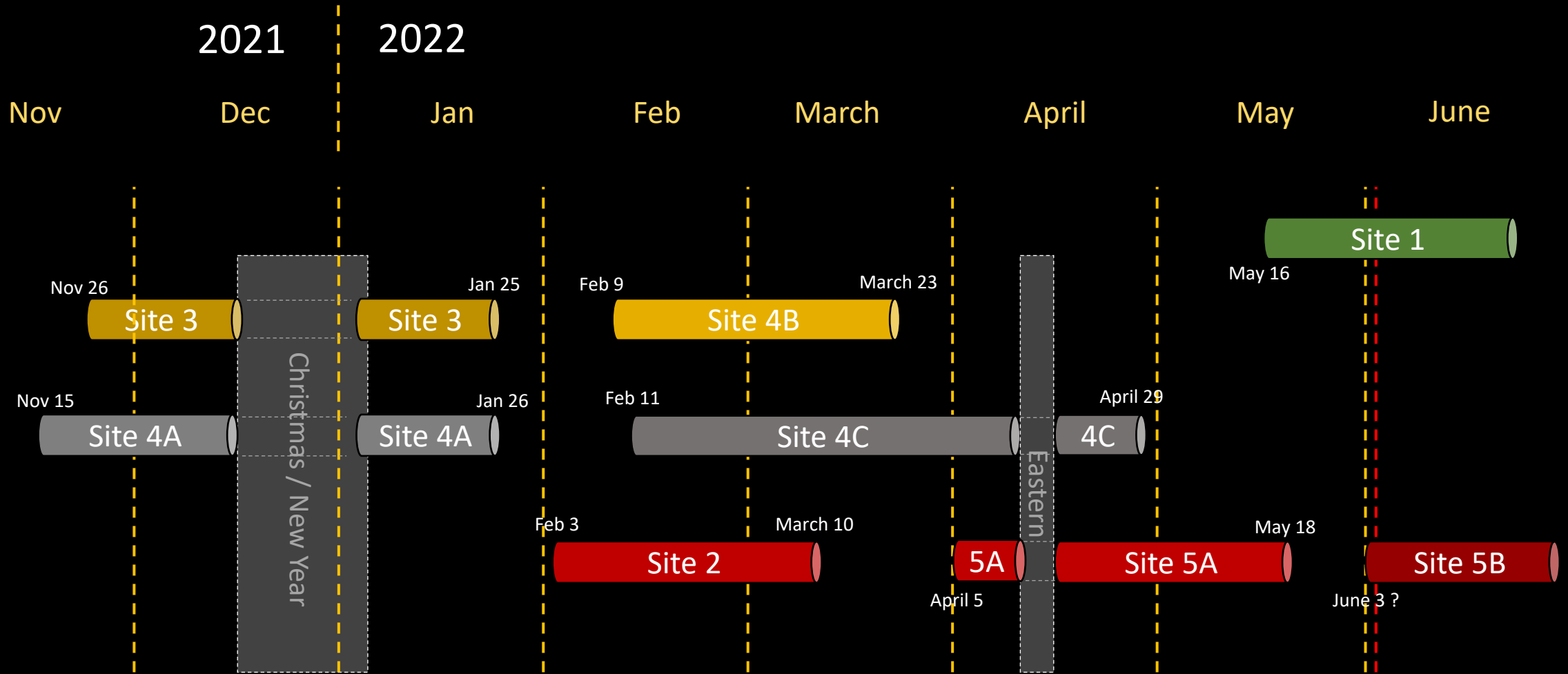
Our workplace for 9 months: The BIAS Hall, downtown Barberton



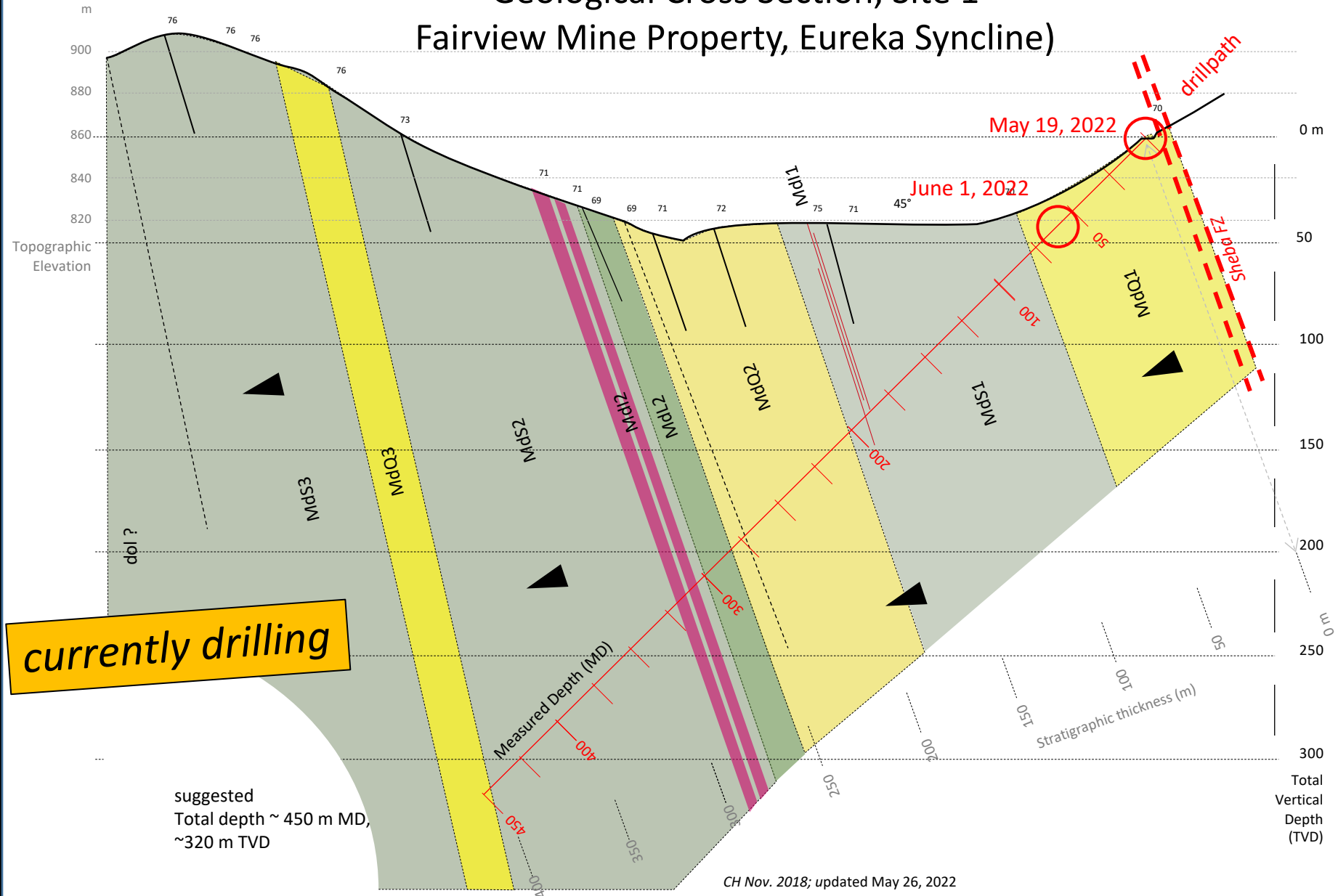
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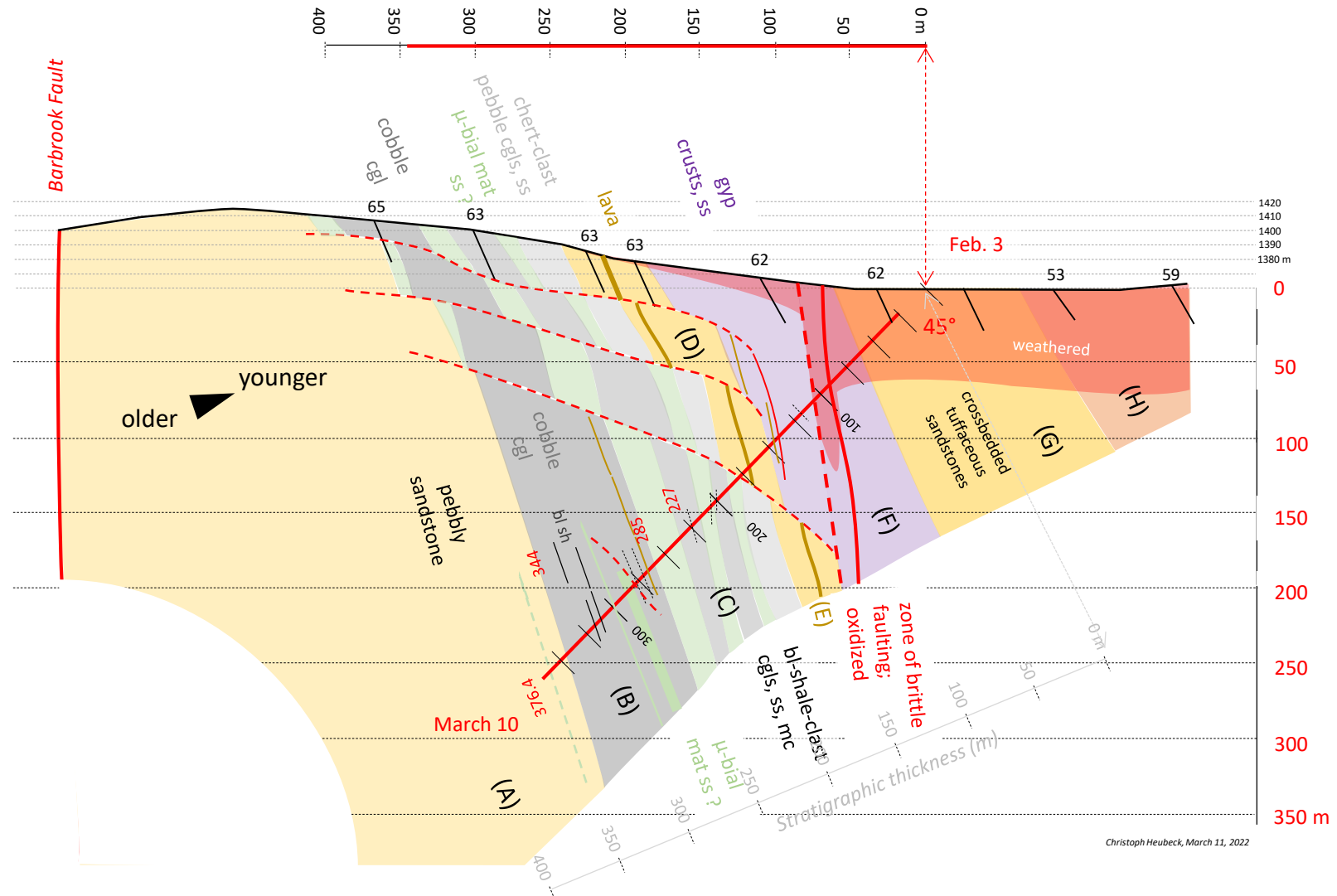
Drilling Schedule



Geological Cross Section, Site 1 Fairview Mine Property, Eureka Syncline)

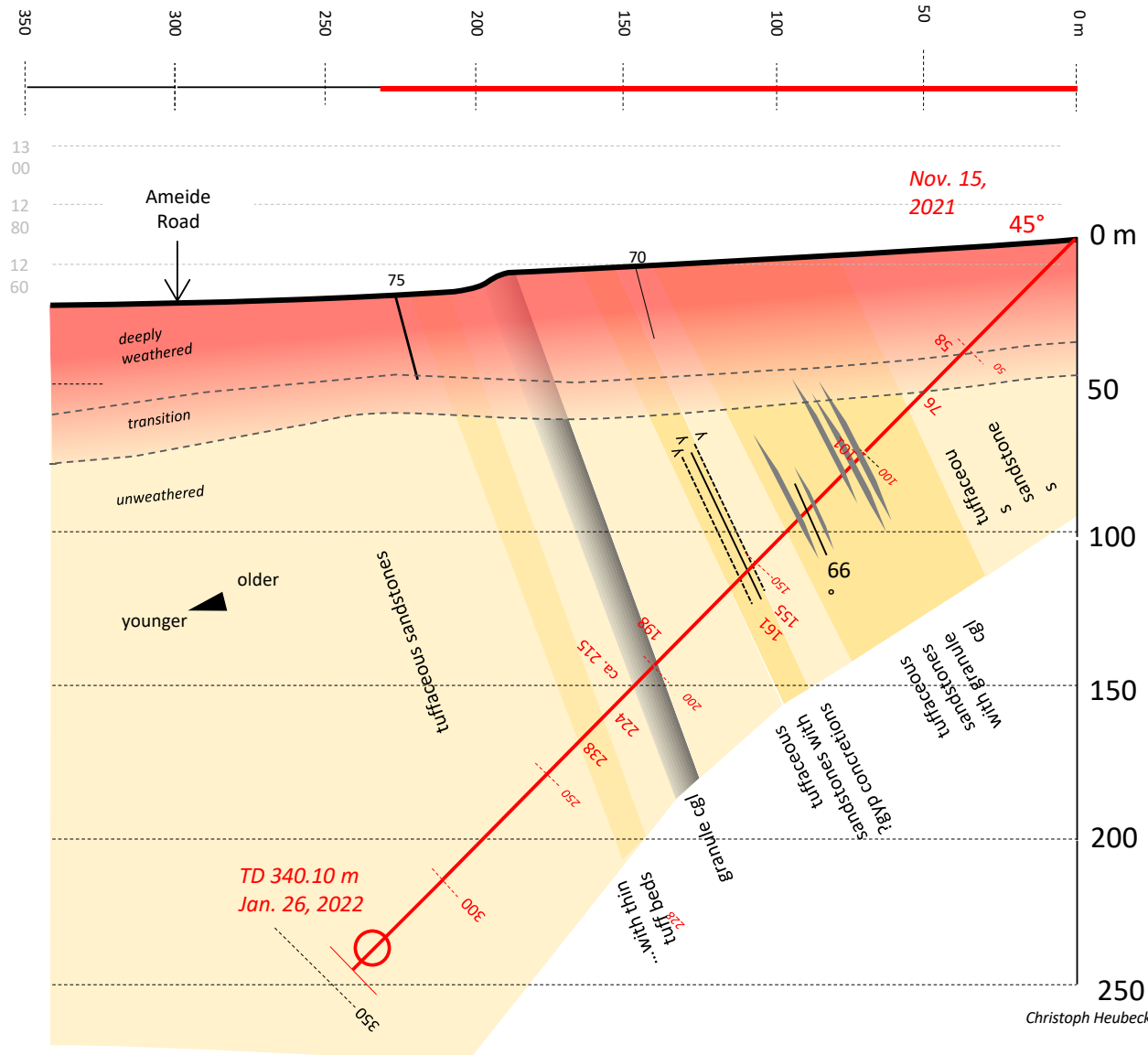


Post-drill geological cross section, Site 2 (Dycedale Syncline, Farm Dycedale)



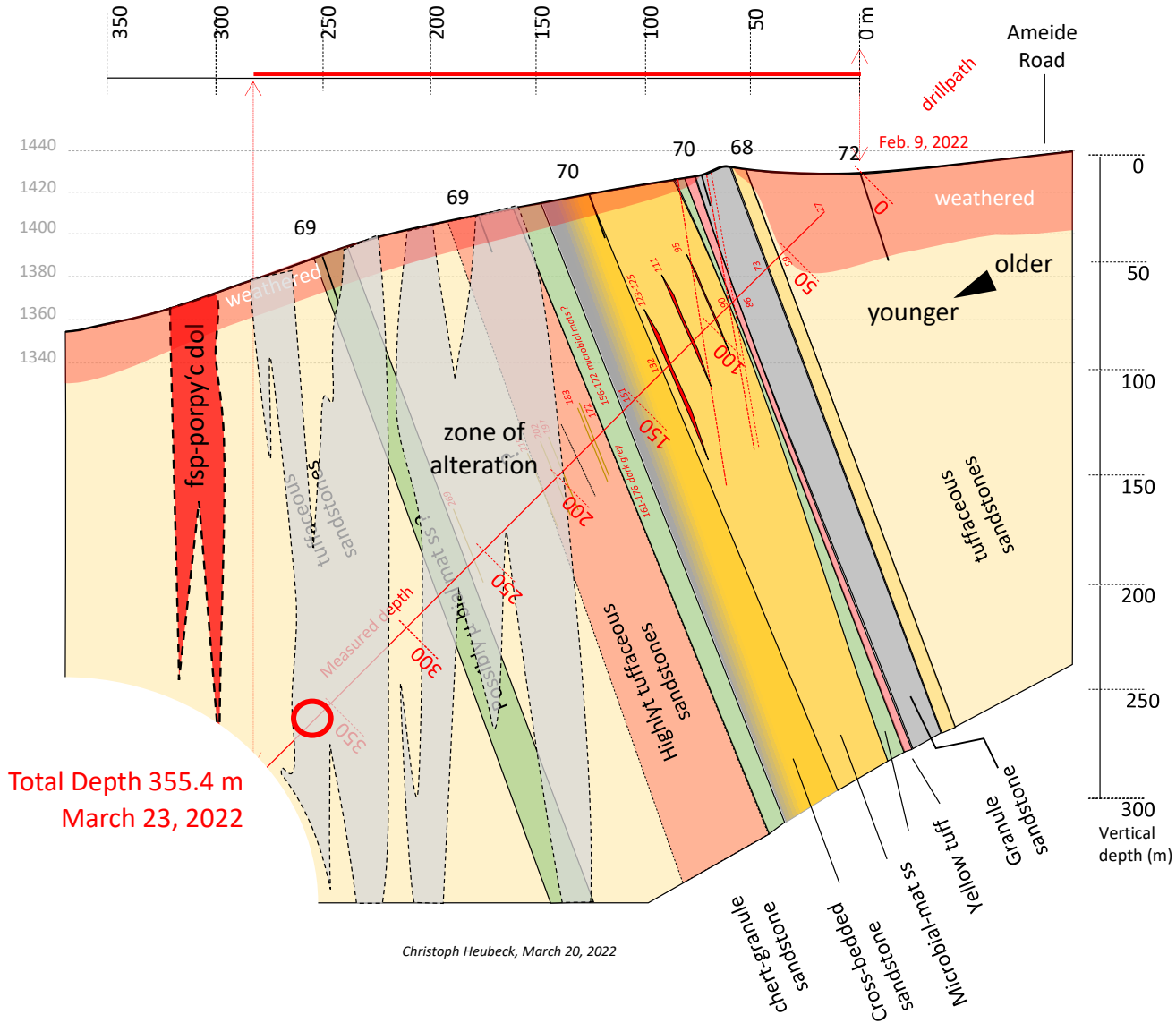
Christoph Heubeck, March 11, 2022

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

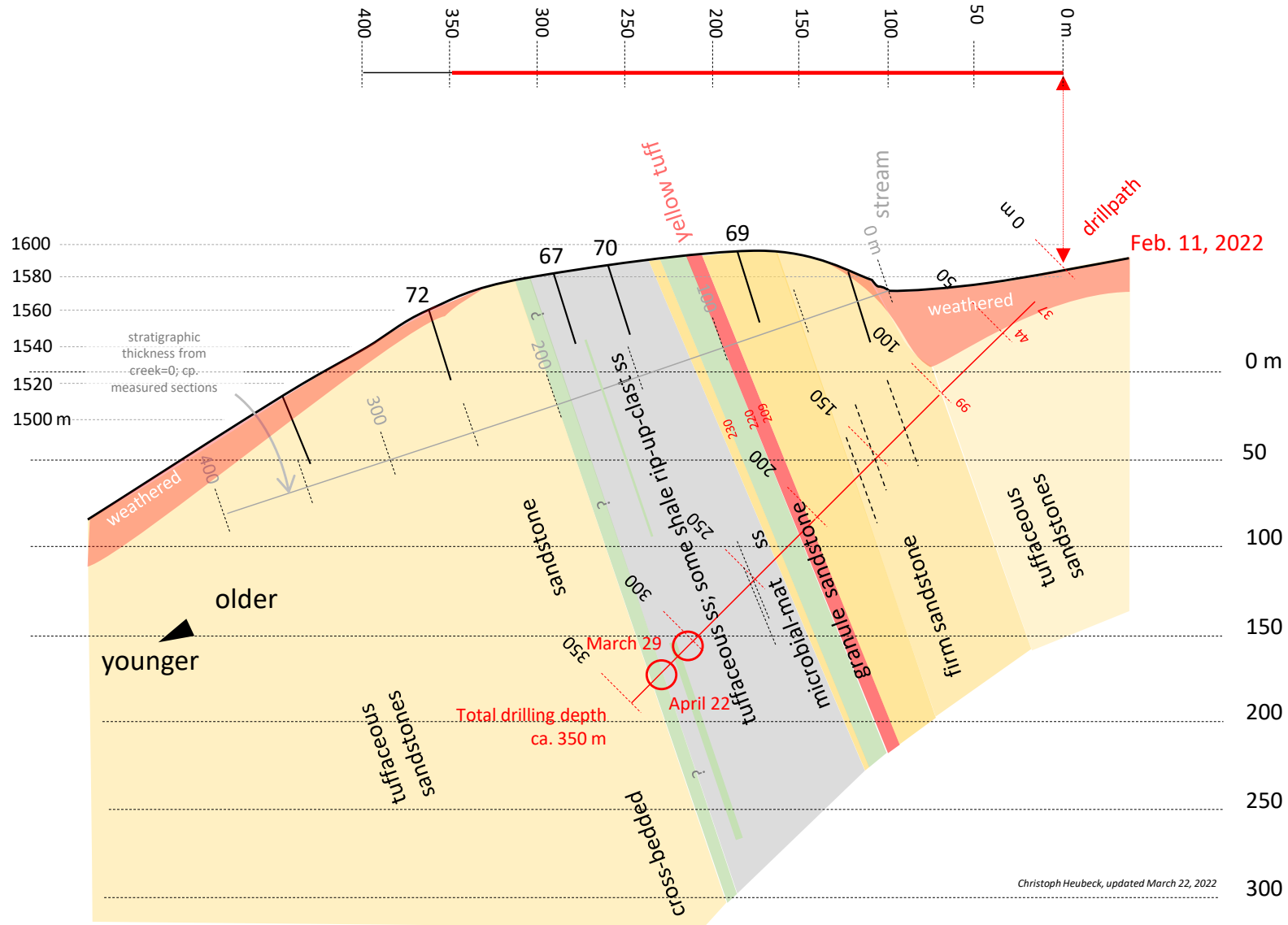


Christoph Heubeck, Jan. 29, 2022

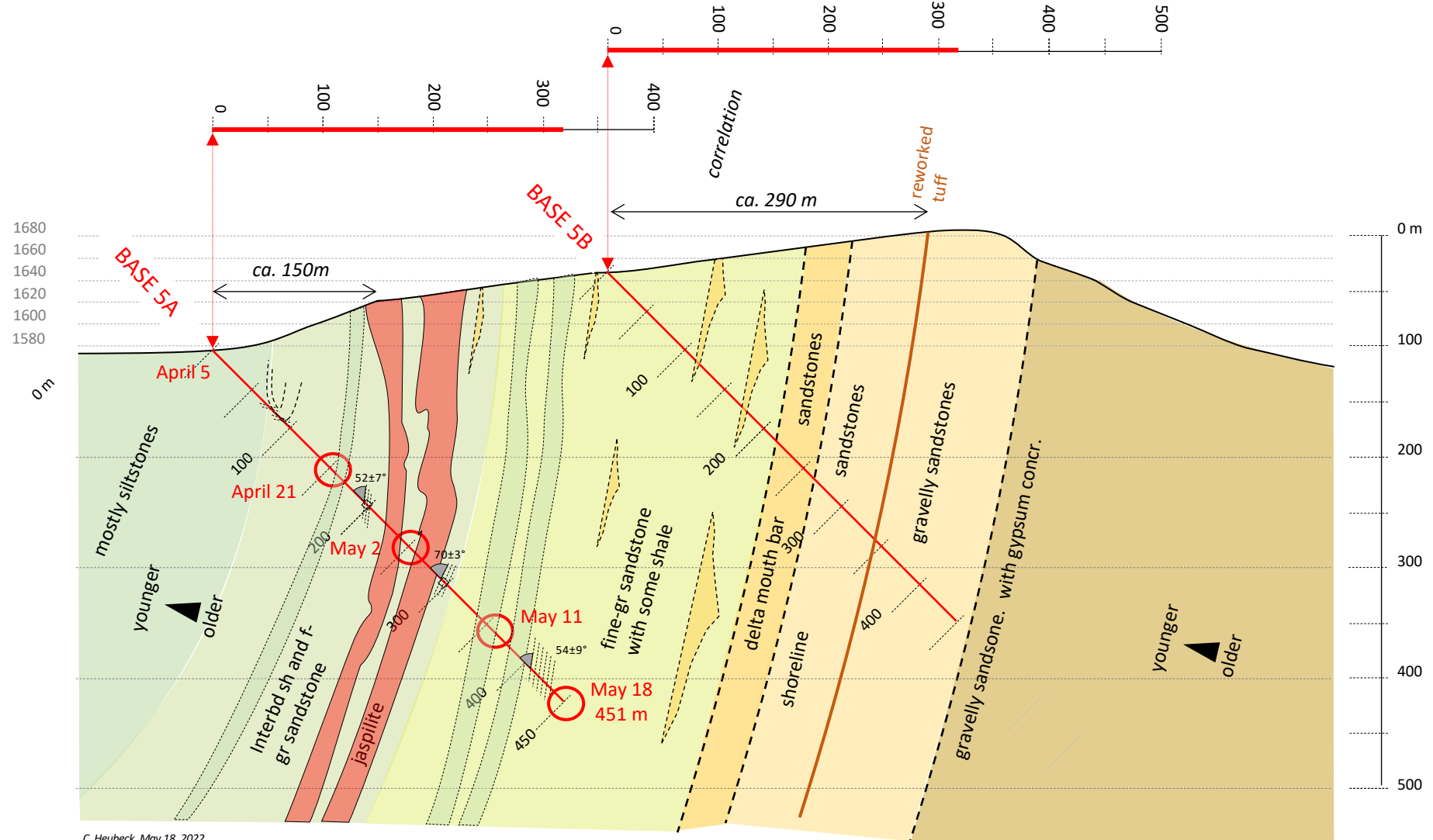
Post-drill geological cross section, Site 4B (Middle Lomati Delta Complex, Oosterbeek)



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



Geological Cross Section, Sites 5 A and B (eastern Stolzburg Syncline)



TD to spudding a new borehole takes 10 days



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Results: Core Recovery



ca. 3200 m core when completed

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:	Done	351 m
Site 5 A:	Done	451 m
<i>Site 5 B:</i>	<i>June-July ?</i>	<i>ca. 470 m ?</i>

... plus ca. 160 samples from three tunnels

Currently ca. 2500 m



Rhythmically bedded tuffaceous-shaly sandstones



Coarse-grained granuly chertarenites



Microbial-mat-laminated sandstone („crinklies“)

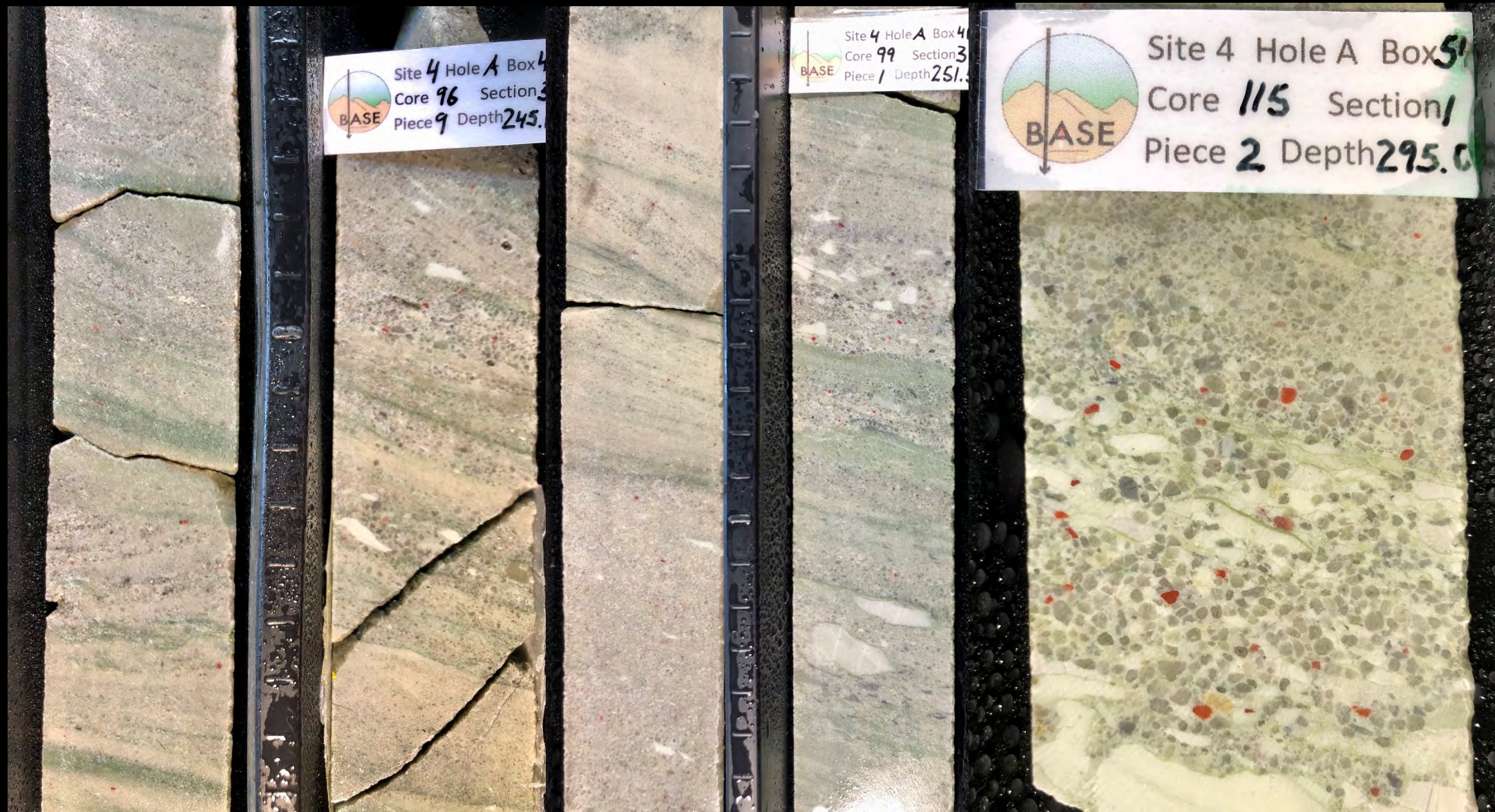


Chert-clast-dominated cobble conglomerates

Results: Polymict, shale clast or tuff-clast conglomerates



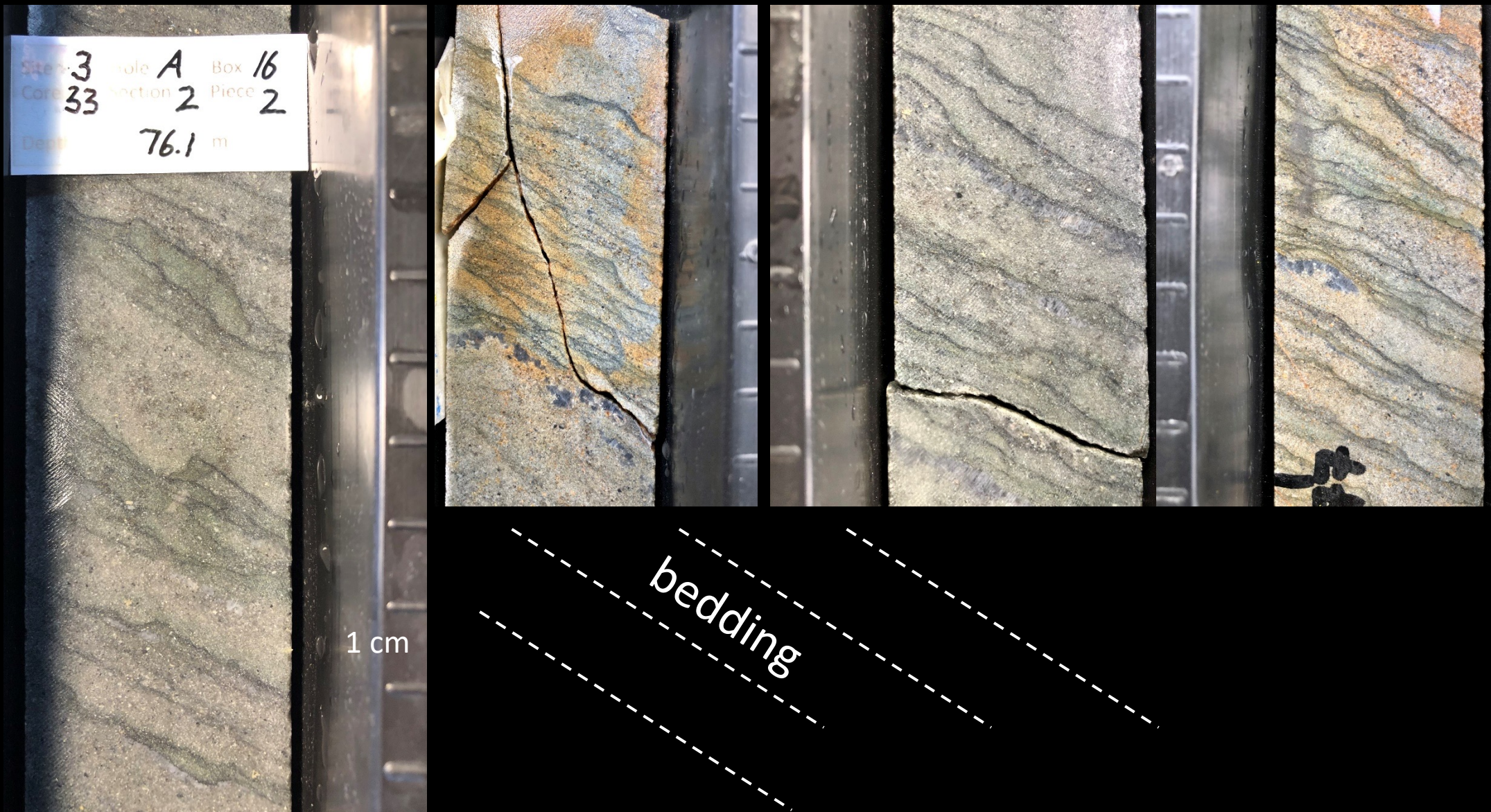
Results: Tuffaceous, matrix-rich sandstones



Results: Microbially laminated sandstone



Results: Microbially laminated sandstone



Results: „Stromatolitic“ (?) sandstone



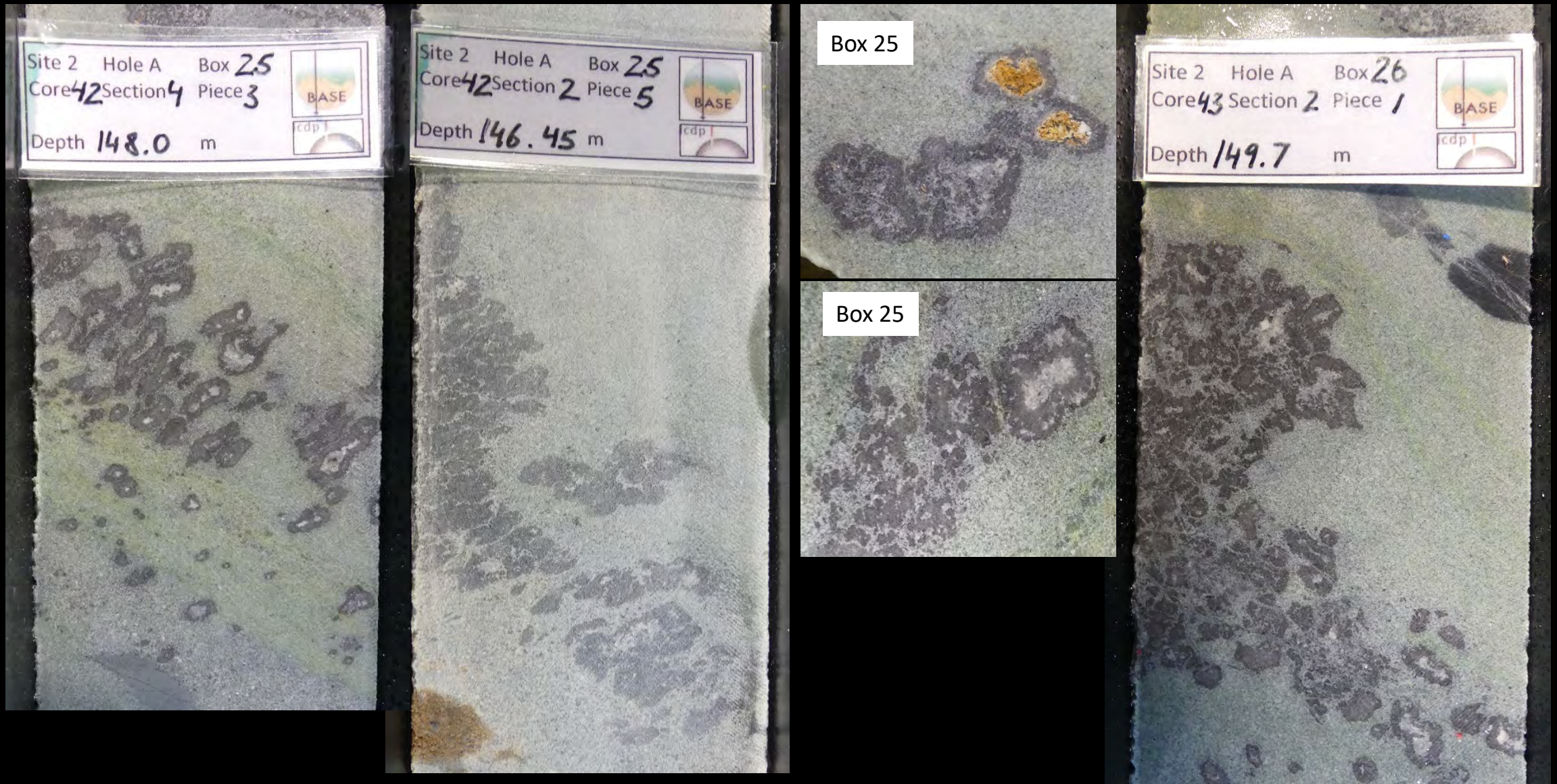
Results: ... also known from outcrop



Multiple „Vadose Alteration Zones“ (VAZ)



Multiple „Vadose Alteration Zones“ (VAZ)

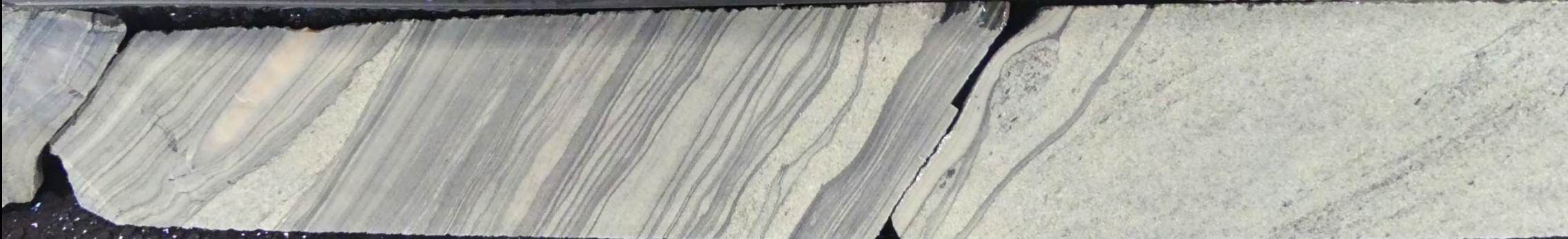
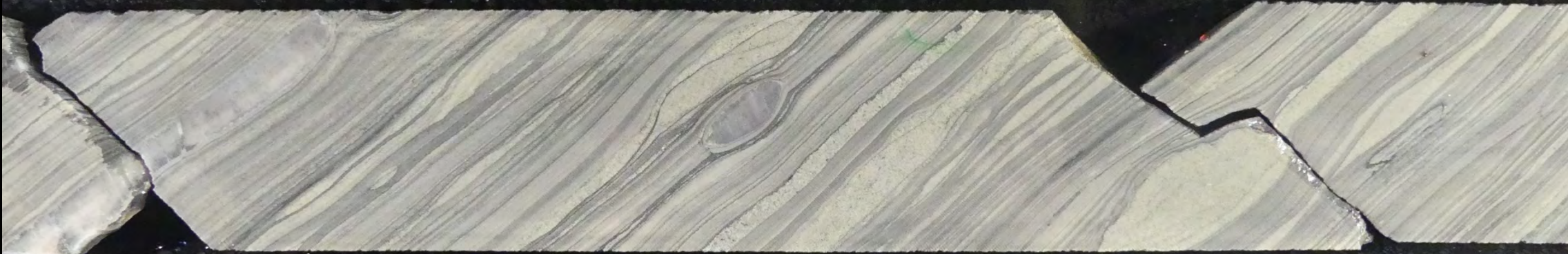


Rhythmically laminated shale and siltstone



Site 5 Hole A Box 35
Core Section 3 Piece 3
Depth 201.4 m

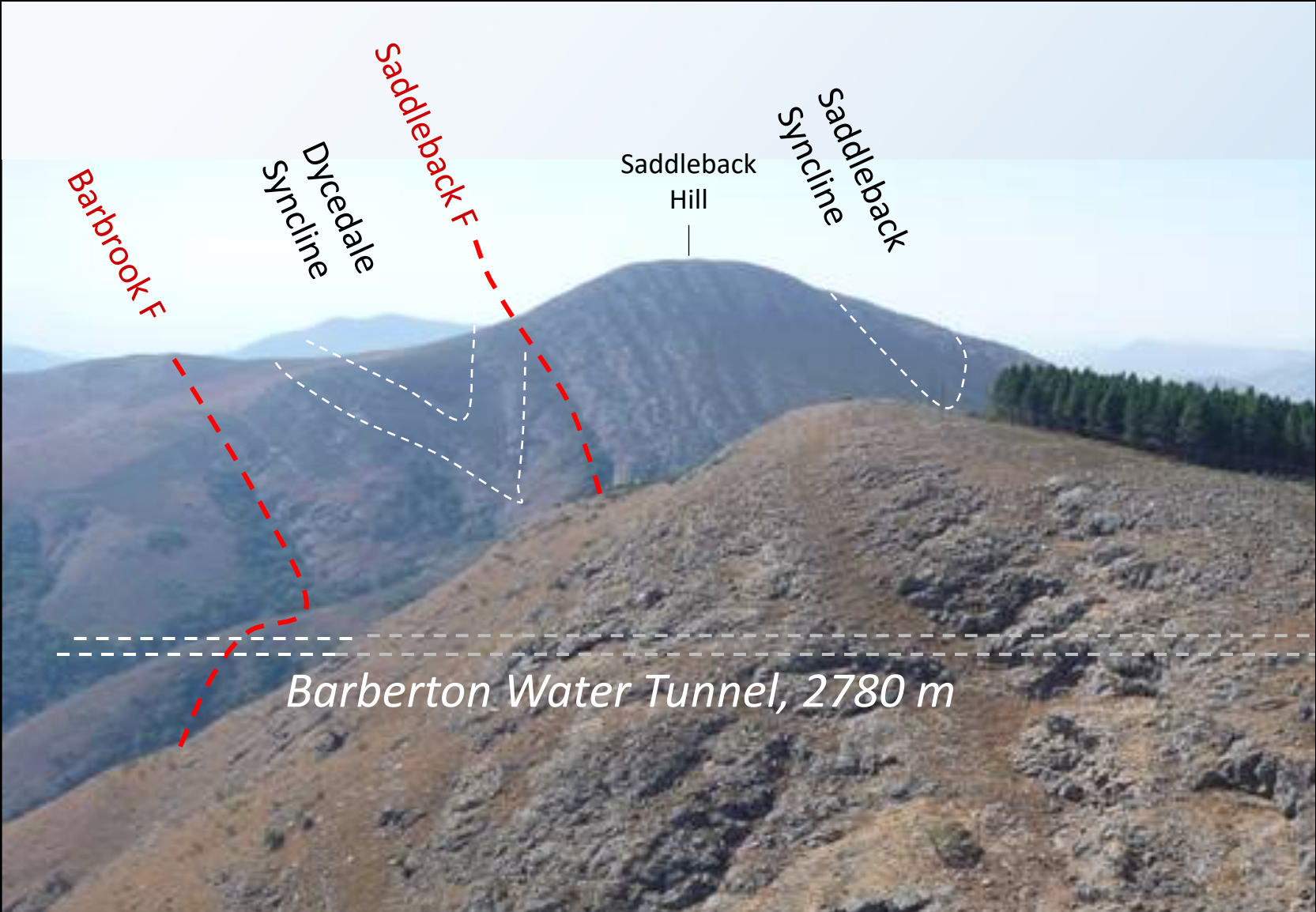
PLATE



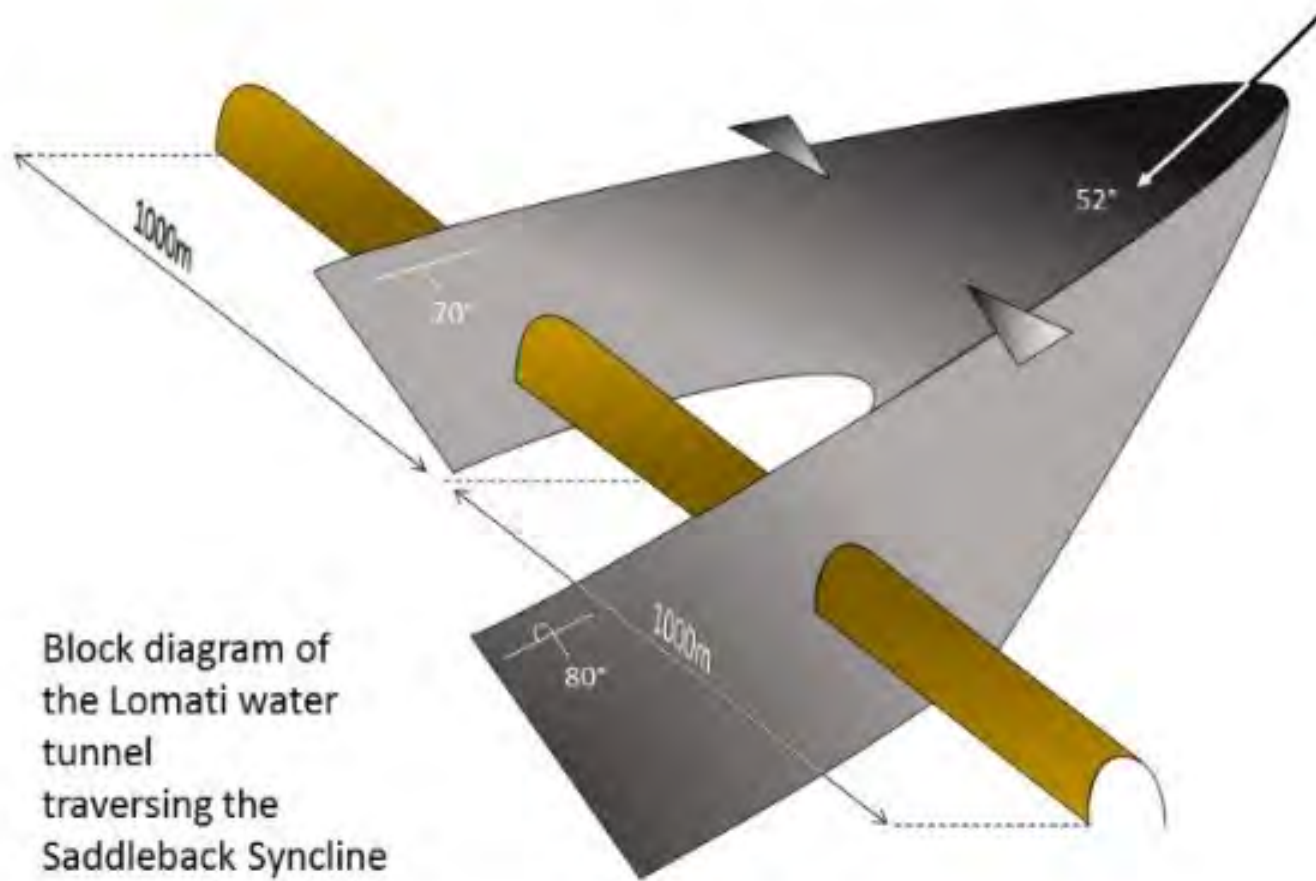
Jaspilites and minor BIF



Tunnel Sampling: Lomati water tunnel



Tunnel Sampling: Lomati water tunnel



A steeply plunging tight syncline in Moodies strata



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

Tunnel Sampling: Lomati water tunnel



Results: Tunnel Sampling: Agnes Mine

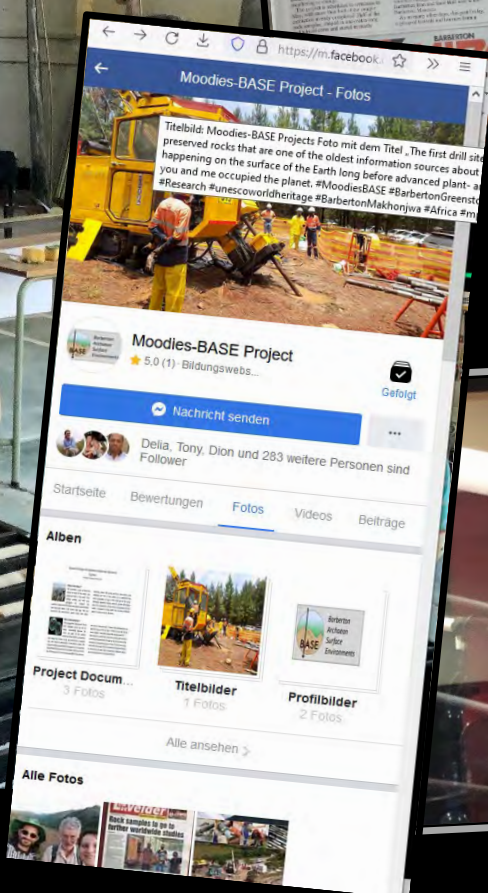


Two mine tunnels, each of ca. 1000 m length, traversing upper Moodies strata at nearly right angle

ICDP aside Geology: School Outreach



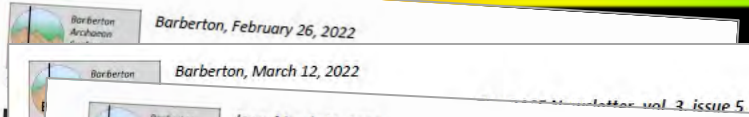
Outreach: Movies, radio, social media



Tours for local and international groups



Updates: Biweekly newsletter, ICDP webpage, MoD



4 Jena, May 22, 2022

The BASE Newsletter, vol. 3, issue 10



Our drilling contractor, Master Drilling, allocated a new rig to Site 1. It was offloaded at a Fairview Mine parking lot on May 11, rolled up to the drillsite in a hairpin turn on the following quiet Saturday, and spudded on May 16. As of May 19, the rig had drilled to 19 m using PQ diameter, installed casing, and was preparing to continue in HQ diameter. Our drill core will be inspected and approved by mine geologists before transported to the BIAS Hall. Site BASE-1 will be the stratigraphically highest and our only borehole in the Eureka Syncline, and also the only one to drill through Mdl1, Moodies Lava, and Mdl2. We are looking forward to a long, variable, maybe even spectacular core.



Borehole 5A finished at 451.22 m on Wednesday, May 18, just beyond the planned 450 m. After leaving the spectacularly laminated, ca. 50 m thick Mdl1 jaspillite-shale around 382 m, it drilled through thick medium- to fine-grained sandstones with tuffaceous laminae to ca. 403 m, followed by the same lithology, interbedded with soft-sediment-deformed black shale. The rig set aside to make space for the logging vehicle on May 20 but a mechanical problem will delay borehole logging to early next week. The rig will likely move to the correlative site 5B, only 300 m down dip, after the upcoming long weekend.



A European BASE group, including S. Lalonde, M. Homann, P. Sansjofre, T. Bontognali and their students and associates visited Barberton May 15-18. The onsite team expertly showed them around. The group packed a field trip with outcrops inspection, a tour of the BIAS Hall cores on display and the exhibition, and a field visit to the remote Site 5A into this short time. Rumor has it that some Karaoke fun was had as well. The group liked what they saw, learned a lot, and left inspired and motivated to do Moodies research!



Because the BIAS Hall is part of the Barberton Museum, the onsite geoscience team participated in the International Museum Day on May 15 by opening its gates and making cores and exhibition accessible to interested locals and visitors. Behind the hall, the traditional gold panning contest found enthusiastic participants but we do not know whether BASE geoscience team members participated.

Frohes Forschen!
Christoph Heubeck and Nic Beukes

Follow our daily updates on <https://www.icdp-online.org/projects/world/africa/moodies-s-africa/daily-news/>

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.

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
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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_27 ALL News as RSS feed
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.

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Outlook, 1



Inventory



Palletizing



Transport



Shipping



Core storage

- End of June: End of drilling campaign and core processing
- July / August: Shipping to ICDP core facilities in Berlin

Outlook, 2

- Fall 2022: Core scanning, XRF scanning, overview sampling, core documentation
- 1st quarter 2023: Workshop (Berlin) and core sampling

Outlook, 3



Nucleus of a future WHS Visitor's Center ?



To learn more



Phumelele Mashele: Education, Outreach, Publicity

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... or subscribe to the newsletter by contacting me
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