Lithological Description of Drill Core Molycorp EC-49 Johnson County, Nebraska

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Kansas Geological Survey

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Subject: Lithological Description of drill core Molycorp EC-49 August 1, 2025

Location: Johnson County, Nebraska
Lat/long: 40.245908, -96.177430
Archival location: Conservation and Survey Division, University of Nebraska

This memo provides a detailed lithological description and photographic documentation of a portion of drill core Molycorp EC-49, spanning footages 320.0' and 796.0' (boxes 2-49). This core was described as part of the U.S. Department of Energy (DOE) Office of Fossil Energy and Carbon Management (FECM)'s Carbon Ore, Rare Earth and Critical Minerals (CORE-CM) Initiative for U.S. Basins (DE-FOA-0002364). The core was selected to evaluate Pennsylvanian strata in support of critical mineral potential, coal-related stratigraphy, and carbon ore systems in the Midcontinent. Core Molycorp EC-49 was measured and described by KGS Assistant Scientist Dr. Stephan Oborny and contributes to the geologic and geochemical characterization of the Cherokee-Forest City Basin.

Molycorp EC-49 Lithological Description and Details

320.0'-~338.5' Predominantly very micaceous fine sand with mud drapes. Bar-to-tidal. Some sulfur rich concretions are observed in the middle.
~338.5'-~342.85' Wackestone
~342.85'-344.85' Silty argillaceous shale. Basal 6" fossiliferous
344.85'-347.3' Tidal wave at top, lenticular in bottom half
347.3'-349.8' Black shale with an abundance of Brachiopoda and fish scales. Derbyia Brachiopoda at 347.85'.
349.8'-352.5' Tidal. Wavy-flaser bedded above 350.7'. Lenticular below 350.7'.
352.5'-353.9' No Core Recovery
353.9'-354.9' Coaly like black shale with bi-valves.
354.9'-365.35' Shale. Lenticular tidal in top down to ~358'. Below 358' rare laminar drapes. Gray-to-dark gray
365.35'-368.8' Crinoidal fossiliferous wackestone-to-packstone.
368.8'-370.4' Black shale. Noneffervescent. No PO^4. No siderite. Fine silt and bivalves. Rhizolithic in middle part. Lowe 2" coaly.
370.4'-~372.3' Silty brachiopod rich limestone.
~372.3'-374.15' Siltstone. Argillaceous.
374.15'-374.55' Limestone.
374.55'-376.4 Tan-to-greenish lenticular tidal silt.
376.4'-414.0' appears to be part of one genetic package when walking the core. May be split into an A & B.
376.4'-381.65' Chalky limestone with some mud drapes in lower foot due to gradual contact.
381.65'-382.0' Silty fossiliferous shale.
~383.0'-386.7' Sandy (vf) limestone. Brachiopods and crinoids very common.
386.7'-387.65' Dark gray-to-black crinoidal shale. Silty. Basal inch smells like other coaly shales, but this shale has marine fossils throughout.
387.65'-~392.25' Lime with mud drapes and crinoids except for upper 2'. Upper 2' appears to have Osagia-coated grains. Sharp lower contact.
~392.25'-~392.75' Fossiliferous calc shale. Black and coaly in lower inch.

~392.75’-~393.65’ Limestone.

~393.65’-394.25’ Coaly black shale. Derbyia brachiopods and bryozoans.

394.25’-~397.6’ Fossiliferous wackestone. Upper 6’ is grainstone.

~397.6’-409.3’ Limestone. Feels silty. Visible foresets. Could be shoaled interval. Thin pack-to-grain common throughout.

409.3’-~411.0’ Calcareous silt-to-silty lime with an abundance of fossils. Crinoids, etc. The upper half is argillaceous.

~411.0’-414.0’ Silty shale. The upper half is calcareous and effervescent, whereas the lower half is black and non-effervescent with coaly habit to it.

414.0’-462.95’ Appears to be part of one genetic package when walking the core.

414.0’-416.45’ Wack-to-packstone. Very dense and gray.

416.45’-~417.1’ Calcareous shale

~417.1’-425.0’ Very calcareous silty shale. Sulfur contact observed at 417.1’

425.0’-428.0’ Calcareous shale.

428.0’-432.05’ Wackestone. Upper 1.5’ composed of lime intraclasts and is rhizolithic. Slightly chalky with moldic porosity in upper part.

432.05’-432.6’ Dark shale. Lower half is black. No PO^4 or siderite visible.

432.6’-~433.3’ Argillic wackestone.

~433.3’-~440.4’ Calc shale with lime tongues.

~440.4’-441.4’ Argillaceous wackestone with bacterial mats in bottom 3”.

441.4’-443.5’ Calc shale.

443.5’-444.7’ Mudstone. Swells.

444.7’-447.45’ Wack-to-pack. Very dense and gray. Crinoidal with fusulinids.

447.45’-453.4’ Non calcareous silty shale. No reaction to HCl. Slightly calcareous between 448.6’ and 449’.

453.4’-458.6’ Predominantly fusulinid bearing wackestone. Argillaceous between 454.6’-455.25’ and 456.0’-456.5’. Crinoids, bryozoans and brachiopods are common throughout.

458.6’-462.95’ Calc shale.458.6’-459.4’ is most calcareous; gray green in color. 459.4’-462.7’ is black, less calcareous than above, No PO^4 or siderite observed. 462.7’-462.95’ coaliferous.

462.95’-514.3’ Appears to be part of one genetic package when walking the core.

462.95’-467.7’ Interval is consistently gray in color throughout. Dense and fusulinid rich. Argillaceous between 463.9’-464.5’ and 465.8’-466.4’.

467.7’-468.85’ Silty Shale. Upper 6” calcareous with possible rhizoliths. ~2” tongue of lime near bottom.

468.85’-~473.35’ Chalky lime.

~473.35’-~475.7’ Coaliferous black shale. The lower half is fossiliferous and gradational. No PO^4, No Siderite.

~473.9’-475.7’ Argillic Wackestone. Crinoidal.

475.7’-477.7’ Mostly fossiliferous calcareous shale. Tongue of well-developed lime composed of Osagia coated fossil debris between 476.8’ and 477.4’.

477.7’-508.1’ Interval is predominantly chalky. Abundance of fusulinids. Shale parting @ 487.6’-487.9’. Lowest 5’ has weak dissolution drapes and a couple of stylolites.

508.1’-~511.0’ Packstone-to-wackestone. Brachiopoda and fusulinids are common.

~511.0’-514.3’ Shale. Black and coaliferous except for top ~0.8’ which is gray in color. No PO^4, No Siderite.

514.3’-515.8’ Wackestone. Crinoidal.

515.8’-528.15’ Calcareous silty shale. Lime intraclasts in lowest foot. Bacterial mat in lowest few inches. Upper 5” fossiliferous.

528.15’-534.8’ Limestone dominated with crinoids and fusulinids. 528.15’-529.4’ Dense Wackestone. 529.4’-533.2’ Argillaceous lime w green shale drapes. 533.2-534.8 Argillaceous lime w/ maroon shale drapes.

534.8’-~540’ Lenticular tidal calc silty shale w/ calc burrows in upper foot. Gray in color.

~540’-552.0’ Maroon calc shale. Non-pedogenic. Some tidal drapes visible throughout with marine fossils. Maroon coloration could be due to fresh oxygenated ground water migration though there appears to be caliche at its base.

552.0’-554.0’ Green calc shale.

554.0’-555.4’ Fossiliferous lime w/crinoids. Green coloration. Upper contact is complicated but sharp.

555.4’-549.7’ Silty calc shale. Lenticular tidal.

~559.7’-565.2’ Silty shale. No HCl reaction.

565.2’-565.35’ Weak coal.

565.35-~567.5 Silty shale. No reaction to HCl. Rhizoliths.

~567.5-575.75 Dark gray silty shale, plant material. No reaction to HCl.

575.75-576.6 Crinoidal Packstone w/ 2” shale drape in middle.

576.6-577.3 Non calcareous shale.

577.3-582.0 Crinoidal wack-to-pack. lower 3” appears silty.

582’-588.5’ No Drill Core.

Note: Box 29 was identified by drillers as containing footages 582-597. This exceeds the 10.0’ that can be accommodated in the box, which requires a loss of at least 5.0’. A loss of drill core is not noted in the Molycorp EC-49 driller’s shift report, dated 2025.6.2. In measuring down from above in the core and measuring up from below, we find a discrepancy of 6.5’ in Box 29. This agrees with a loss of core. Alternatively, it may indicate an incorrect stem count by the drillers. I’ve placed a “Missing Core” wood block in Box 29 at a position coinciding with the base of a core barrel spring clamp impression on the drill core.

588.5’-589.65’ Packstone.

589.65’-589.75’ Fossiliferous Shale.

589.75’-590.6’ Grainstone. Fossiliferous.

590.6’-592.0’ Black shale. No PO^4. No siderite. Fossiliferous at base.

592.0’-592.75’ Wackestone. Dark blackish in color.

592.75’-593.0’ Black reworked shale observed at sharp contact. Flooding surface.

593.0’-680.55’ Appears to be part of one genetic package when walking the core.

593.0’-594.8’ Calc shale. Paleosol. 393-394 mottled maroon green. 593-594.8 maroon.

594.8’-599.0’ Wackestone with evidence for great deal of dissolution infilled by green shale. Lime fragments appear rounded in most parts but there are the odd brecciated fragments.

599.0’-603.0’ Oolitic grainstone.

603.0’-603.6’ Gray green calc shale w/ lime stringers in upper half.

603.6’-607.3’ Packstone-to-grainstone. Apparent meteoric alteration in lower 2/3 but not at upper contact. Conclusion…possibly hydrothermal. See comment @ 613.0’.

607.3’-609.0’ Wackestone w/ shale partings.

609.0’-609.55’ Dark black crinoidal shale. Some Fe replacement in crinoids.

609.55’-610.6’ Crinoidal wacke-to-packstone. Some Fe replacement in crinoids.

610.6’-613.0’ Calc shale. Gray in color above 612.0’. Maroon in color below 612.0’.

613.0’-619.6’ The interval from 613’-615.9’ is maroon. Identical in color to the maroon paleosols; however, it is a fossiliferous carbonate. Minimal porosity if any. No vugs or evidence of meteoric alteration apart from the maroon shale overlying it. Oolitic below 616.0. Perhaps Fe replacement at or near surface during overlying paleosol formation.

619.6’-~626.4’ Basically a marl. The whole interval maintains a dark green shale with lime that appears to cut bedding planes. Abundant crinoids in this interval. Fusulinids at top. Diverse fauna throughout. Fe-replacement of crinoids in parts.

~626.4’-628.3’ Very calcareous gray-green shale.

~628.3’-629.2’ Wackestone w/visible bryozoans.

629.2’-632.9’ Calcareous shale (paleosol). 629.2’-630.0’ green. 630’-631.3’ maroon. 631.3’-631.8’ green. Tongue of grainstone between 629.5’ and 629.7’.

632.9’-639.8’ Similar to 643.45’-652.4’ below (i.e., mottled wackestone with numerous shale drapes). This interval is, however, more stylolitic than that below. Stylolites are most abundant in the upper half. The lowest foot has green shale drapes throughout that are similar in color to the underlying shale package. 637.8’-639’… unique blackish shale with rolled or possibly reworked lime.

639.8’-642.05’ Gray calcareous shale.

642.05’-642.3’ Tongue of grainstone.

642.3’-643.45’ Gray calcareous shale.

643.45’-652.4’ Mottled wackestone with numerous shale drapes.

652.4’-655.25’ Paleosol. The top foot is green, and the bottom foot is maroon. Mottled g/m in the middle part. Lime filled burrows throughout.

655.25’-666.0’ No Core Recovered.

666.0-‘667.45’ Oolitic-to-ooid grainstone.

667.45’-670.3’ Tan wackestone. Stylolites w/ Brachiopoda common.

670.3’-~679.1’ Gray blue wackestone. Crinoids and brachs are visible. Dissolution seams and weakly developed stylolites in parts.

~679.1’-680.55’ Fissile black shale. PO^4 Lamina in upper 6”.

680.55’-682.15’ Dark gray-blue dense wackestone.

682.15’-683.2’ Calc shale. Upper half black. Bryzoans on upper surface.

683.2’-702.0’ Wackestone w/ packstone in upper foot. Increasingly more argillaceous in lower half starting at about 695.0’

702.0’-704.55’ Gray green calc shale.

704.55’-707.25’ Wackestone w/pack in lower 0.5’

707.25’-716.0’ Calc shale. Gray from 707.25’-~712.0’. 12.0’-716’ maroon in color.

716.0’-722.0’ Wackestone with maroon filled voids from meteoric alteration/dissolution.

722.0’-722.7’ Rounded pebblestones. The largest is ~2cm in diameter.

722.7’-724.6’ Fusulinid packstone with meteoric alteration like that observed between 716’-722’.

724.6-‘731.0’ Highly fragmented but appears to be reworked at the contact with underlying “young mafics”. Much clay is observed between 731’ and 737’.

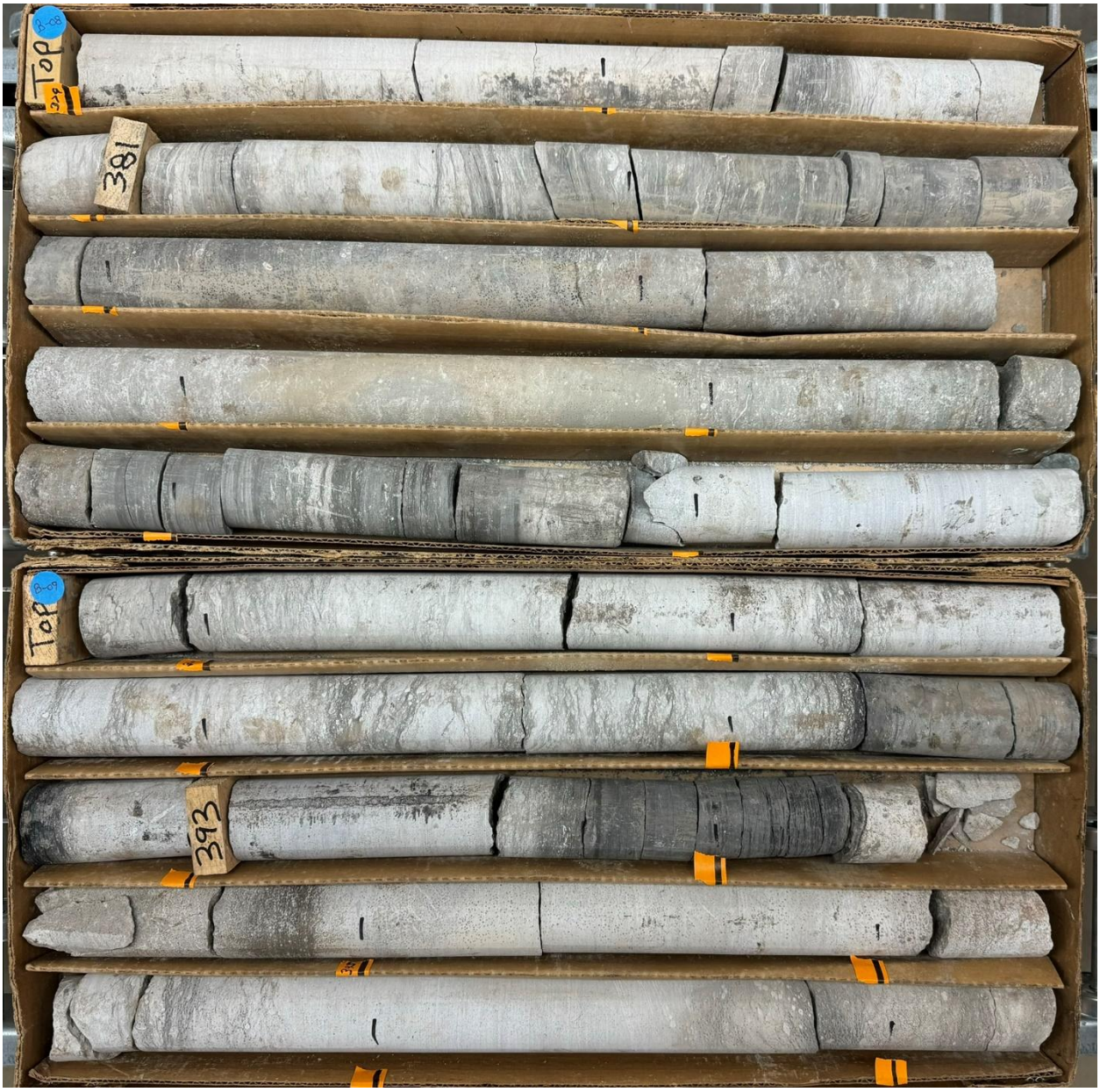
737.0’-796.0’ Identified as “young mafics” by prior studies. The interval appears to contain quartzite in parts and may be metasedimentary in nature. A disconformity is observed at 737.0’ which agrees with prior drill core records; however, given the metasedimentary nature of what is underlying the disconformity we are unable to establish an age relationship. Possible lamproite vein observed in Box 48. Samples collected at 761.3’-761.45’ and 779.05’-779.2’ for review by KU faculty, Dr. Andreas Moeller (photos available at end of document).

Molycorp EC-49 Drill Core Photos

Boxes are labeled in the top left corner of each box with numbered blue stickers. Images are in order from box 2 through box 49. Core is boxed in engineering style.


Top
Lost
2 ft.


Top
364
Top
375


B-8
Top
381
B-9
Top
393


B-10
Top
405
B-11
Top
415

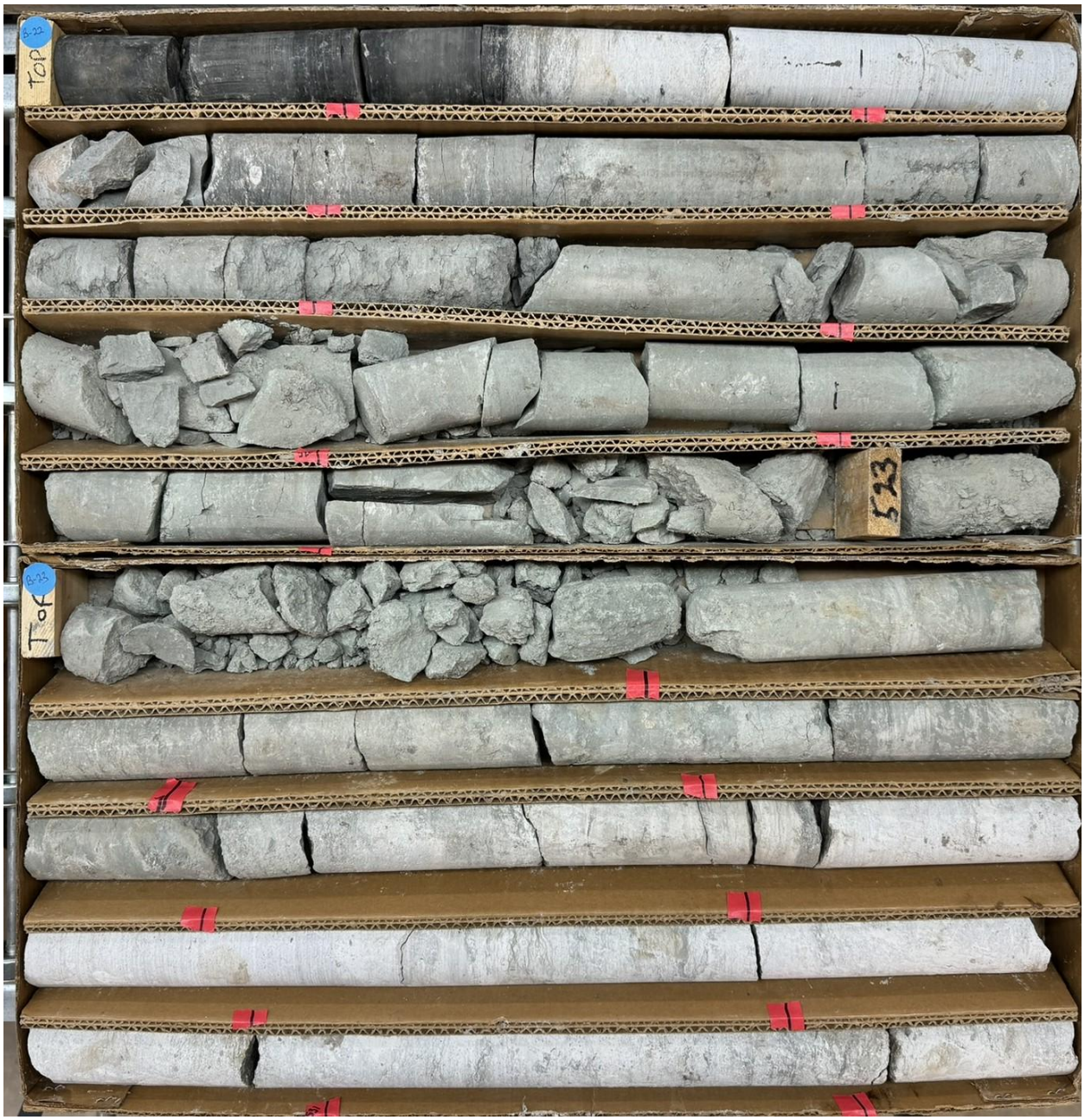

B-A
Top
425
B-B
Top
435


Top
413
Top
453


Top
Top
47h
47h

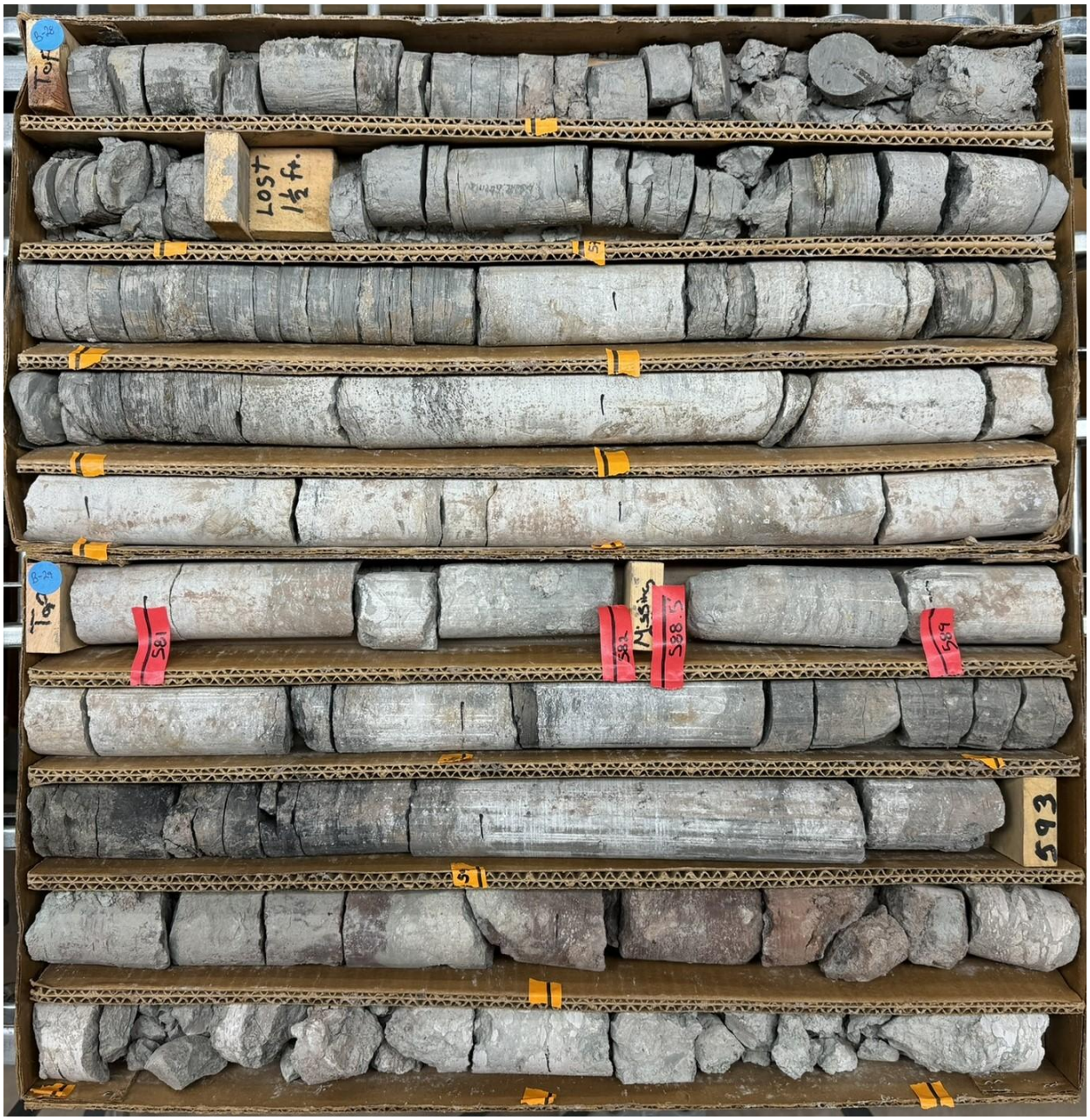

B-18
484
B-19


B-20
TOP
494
B-21
TOP
505


B-22
TOP
523
B-23
Top


Top
535
Top
545


556
565


B-28
Top
LOST
1½ ft.
B-29
Top
581
582
538.5
585
563


Top
609
Top
613


Top
679
Top
625


B34
Top
635
B35
Top
645


Top
666
655
Loss of
~10.75'
Top
680


Top
685
Top
695+


B-40
Top
705
B-41
Top
715


Top
725
Top
730
735


Top
1745
Top
1755


Top
757
760
Top
765
766
770
775


Top
783
Top
791
796

Placeholder on side

Sample taken out

Samples EC-49 core Lamproite?

Placeholder on side

Sample taken out

Samples EC-49 core Lamproite?