



Mining the IODP Database for Relationships Between Lithology and Physical, Chemical, and Magnetic Properties

Laurel B. Childress, Gary D. Acton, Vincent P. Percuoco, Margaret Hastedt

International Ocean Discovery Program, Texas A&M University, College Station TX 77845, USA

INTRODUCTION

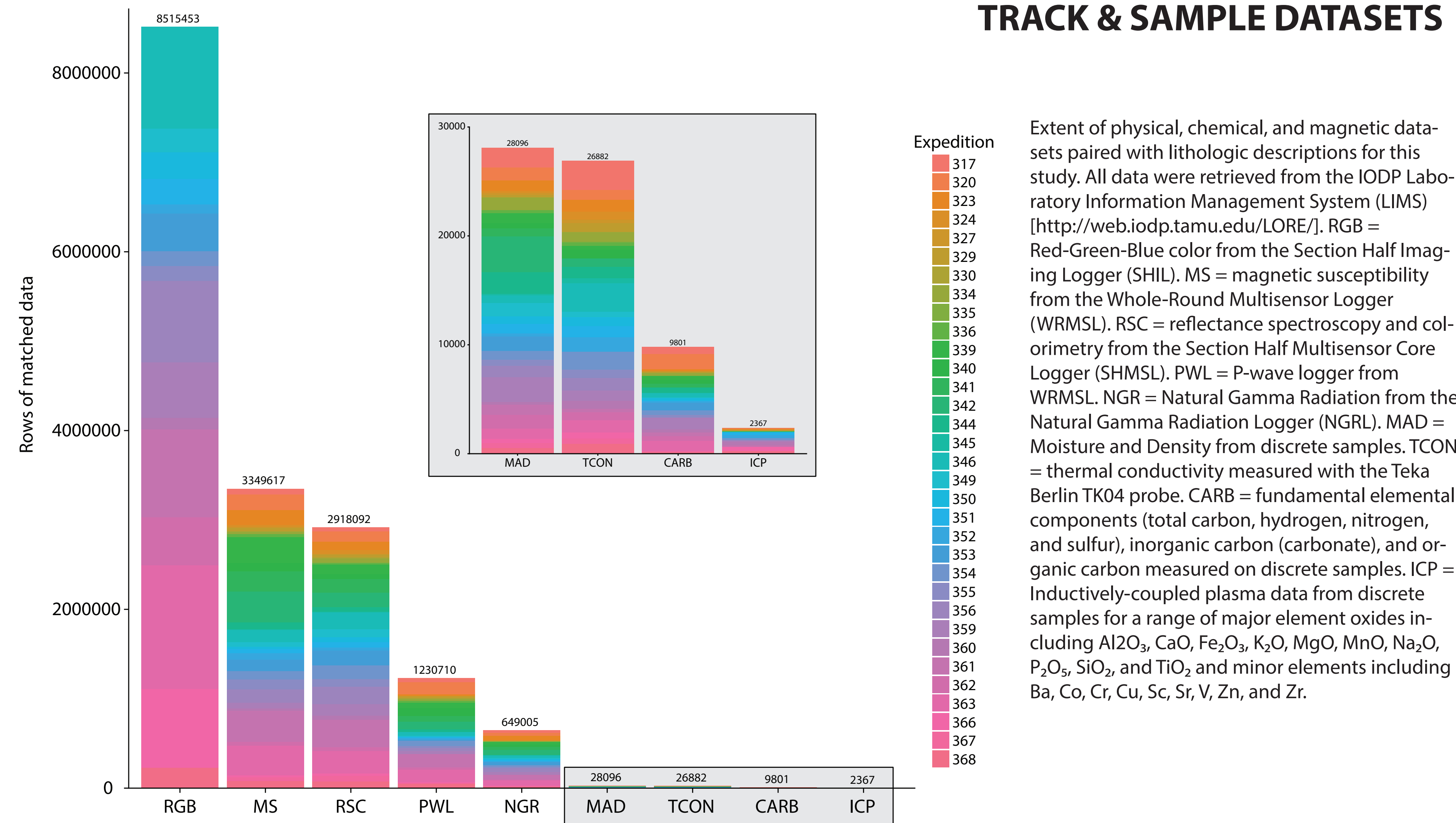
During each International Ocean Discovery Program (IODP) expedition a vast array of data, typically amounting to hundreds of gigabytes to several terabytes of information, are collected from drill cores. These data include physical, chemical, and magnetic properties and digital images collected continuously or every few centimeters along the cores using automated track systems, as well as a variety of analyses conducted on discrete subsamples taken from the cores.

Our goal in this study is to mine these data for interrelationships that would otherwise be difficult to assess given the way the data are partitioned by specific property within the database. In particular, we extract basic lithologic information from the complex array of descriptive information and then tie that information to all other observations in order to characterize the physical, chemical, and magnetic properties of a myriad of lithologies.

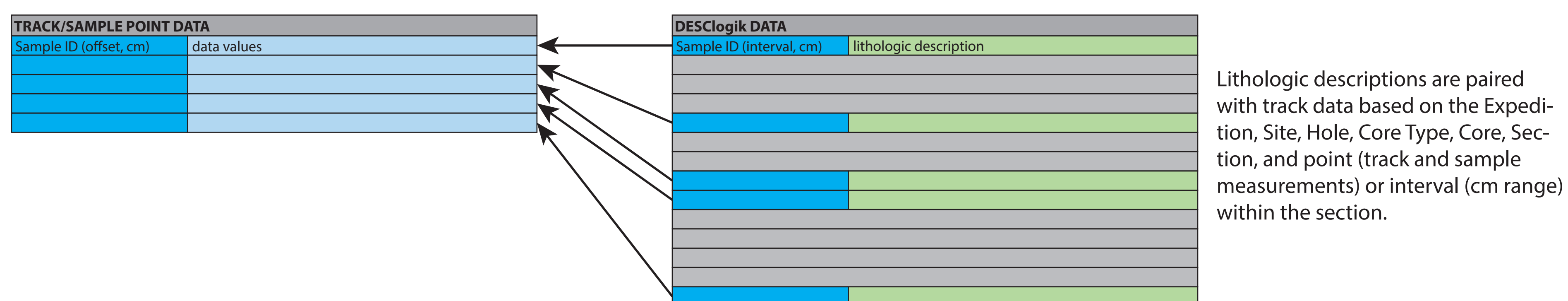
EXPEDITIONS

| | | | |
|--|---------------------|--|---------------------|
| 317 Canterbury Basin Sea Level | (Nov 2009–Jan 2010) | 349 South China Sea Tectonics | (Jan–Mar 2014) |
| 320 Pacific Equatorial Age Transect | (Mar–May 2009) | 350 Izu-Bonin-Mariana Rear Arc | (Mar–May 2014) |
| 323 Bering Sea Paleooceanography | (Jul–Sep 2009) | 351 Izu-Bonin-Mariana Arc Origins | (May–Jul 2014) |
| 324 Shatsky Rise Formation | (Sep–Nov 2009) | 352 Izu-Bonin-Mariana Forearc | (Jul–Sep 2014) |
| 327 Juan de Fuca Ridge-Flank Hydrogeology | (Jul–Sep 2010) | 353 Indian Monsoon Rainfall | (Nov 2014–Jan 2015) |
| 329 South Pacific Gyre Subseafloor Life | (Oct–Dec 2010) | 354 Bengal Fan | (Jan–Mar 2015) |
| 330 Louisville Seamount Trail | (Dec 2010–Feb 2011) | 355 Arabian Sea Monsoon | (Mar–May 2015) |
| 334 Costa Rica Seismogenesis Project (CRISP-A1) | (Mar–Apr 2011) | 356 Indonesian Throughflow | (Jul–Sep 2015) |
| 335 Superfast Spreading Rate Crust 4 | (Apr–Jun 2011) | 359 Maldives Monsoon and Sea Level | (Sep–Nov 2015) |
| 336 Mid-Atlantic Ridge Microbiology | (Sep–Nov 2011) | 360 SW Indian Ridge Lower Crust and Moho | (Nov 2015–Jan 2016) |
| 339 Mediterranean Outflow | (Nov 2011–Jan 2012) | 361 South African Climates (Aguilhas LGM Density Profile) | (Jan–Mar 2016) |
| 340 Lesser Antilles Volcanism and Landslides | (Mar–Apr 2012) | 362 Sumatra Seismogenic Zone | (Aug–Oct 2016) |
| 341 Southern Alaska Margin | (May–Jul 2013) | 363 Western Pacific Warm Pool | (Oct–Dec 2016) |
| 342 Paleogene Newfoundland Sediment Drifts | (Jun–Jul 2012) | 366 Mariana Convergent Margin & S Chamorro Seamount | (Dec 2016–Feb 2017) |
| 344 Costa Rica Seismogenesis Project (CRISP-A2) | (Oct–Dec 2012) | 367 South China Sea Rifted Margin | (Feb–Apr 2017) |
| 345 Hess Deep Plutonic Crust | (Dec 2012–Feb 2013) | 368 South China Sea Rifted Margin | (Apr–Jun 2017) |
| 346 Asian Monsoon | (Jul–Sep 2013) | | |

TRACK & SAMPLE DATASETS



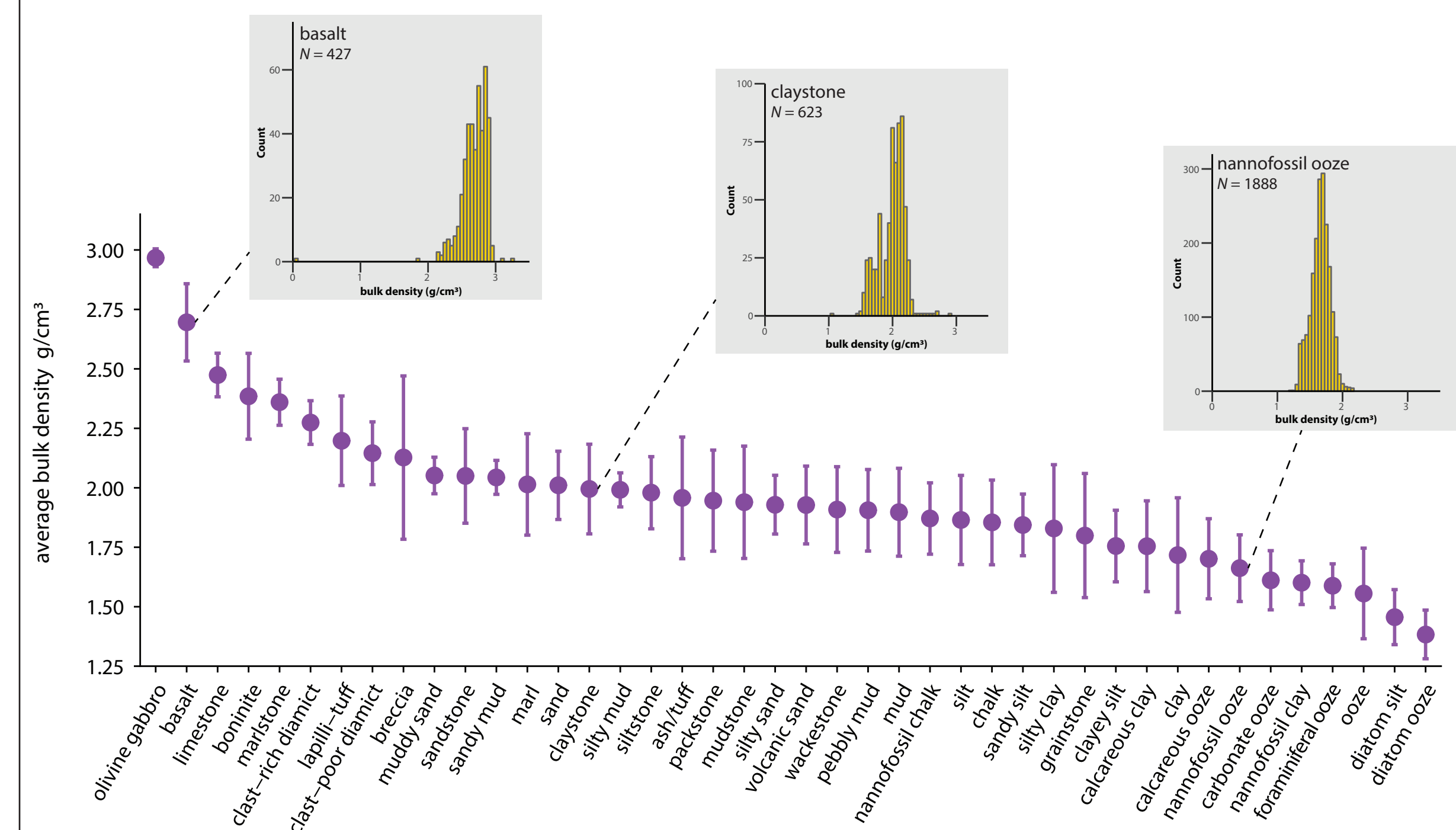
DATASET & LITHOLOGY PAIRING



The lithologic data are taken from DESClogik workbooks available from LIMS. Descriptive terminology varies amongst the expeditions, but generally lithologies are described with a principal name that may have major modifiers given as prefixes and minor modifiers as suffixes. For sedimentary rocks, the major modifier generally infers a composition that is >25% and minor modifiers are for compositions between 10-25% (Mazzullo and Graham, 1988, Handbook for Shipboard Sedimentologists). Hence, a lithology such as a "nannofossil ooze with diatoms" is an ooze composed of >25% nannofossils and 10-25% diatoms.

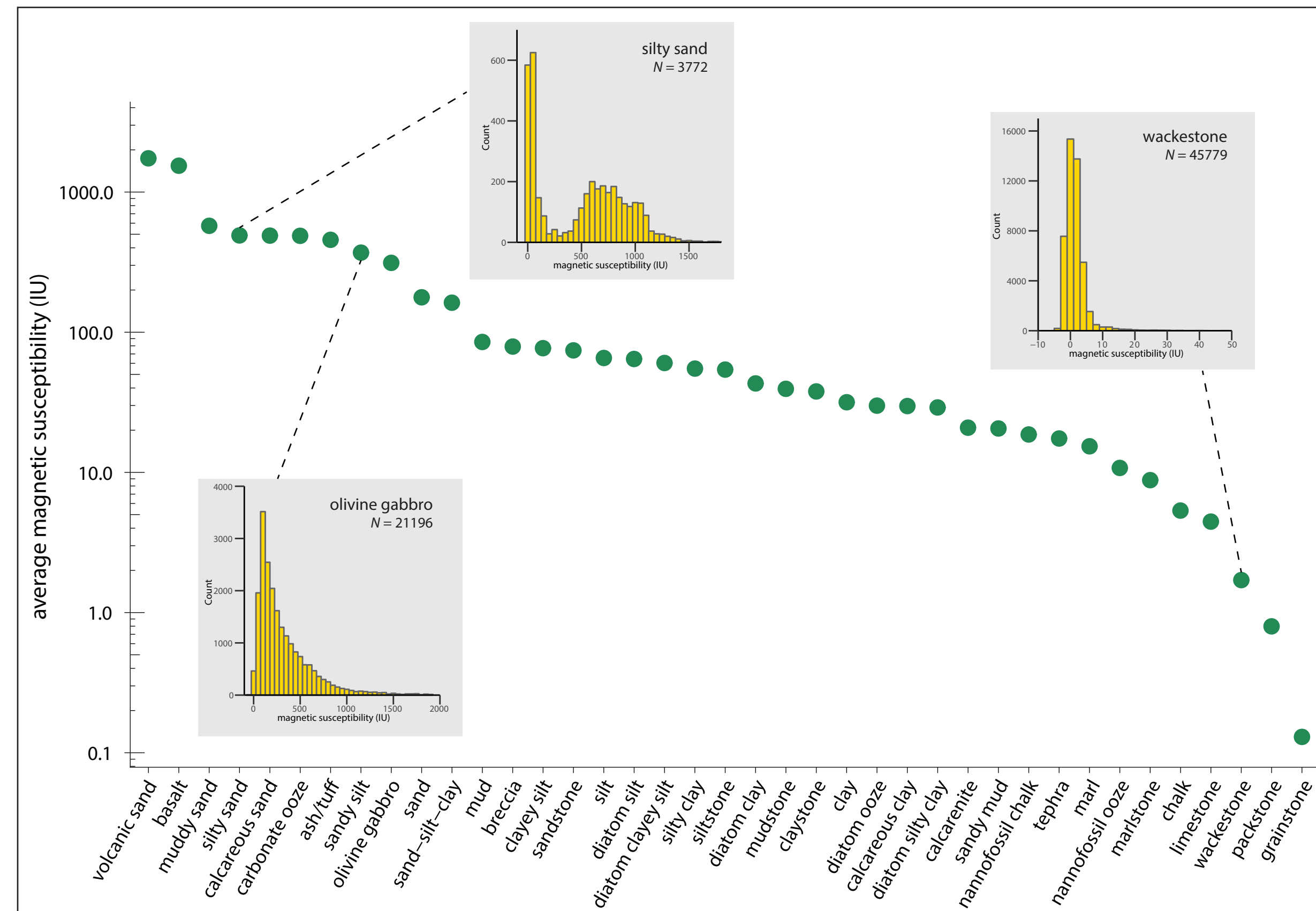
Lithologies across multiple expeditions are merged into three main columns that give the lithology prefix, the principal (or dominant) lithology, and the lithology suffix. While these three columns of lithologic data are used in the analyses shown here, all lithologic description data recorded in the DESClogik workbook tab is paired to the track/sample data. Each file is also paired with pertinent metadata, such as the Latitude, Longitude, and Water Depth.

Characterization of Physical Properties by Lithology



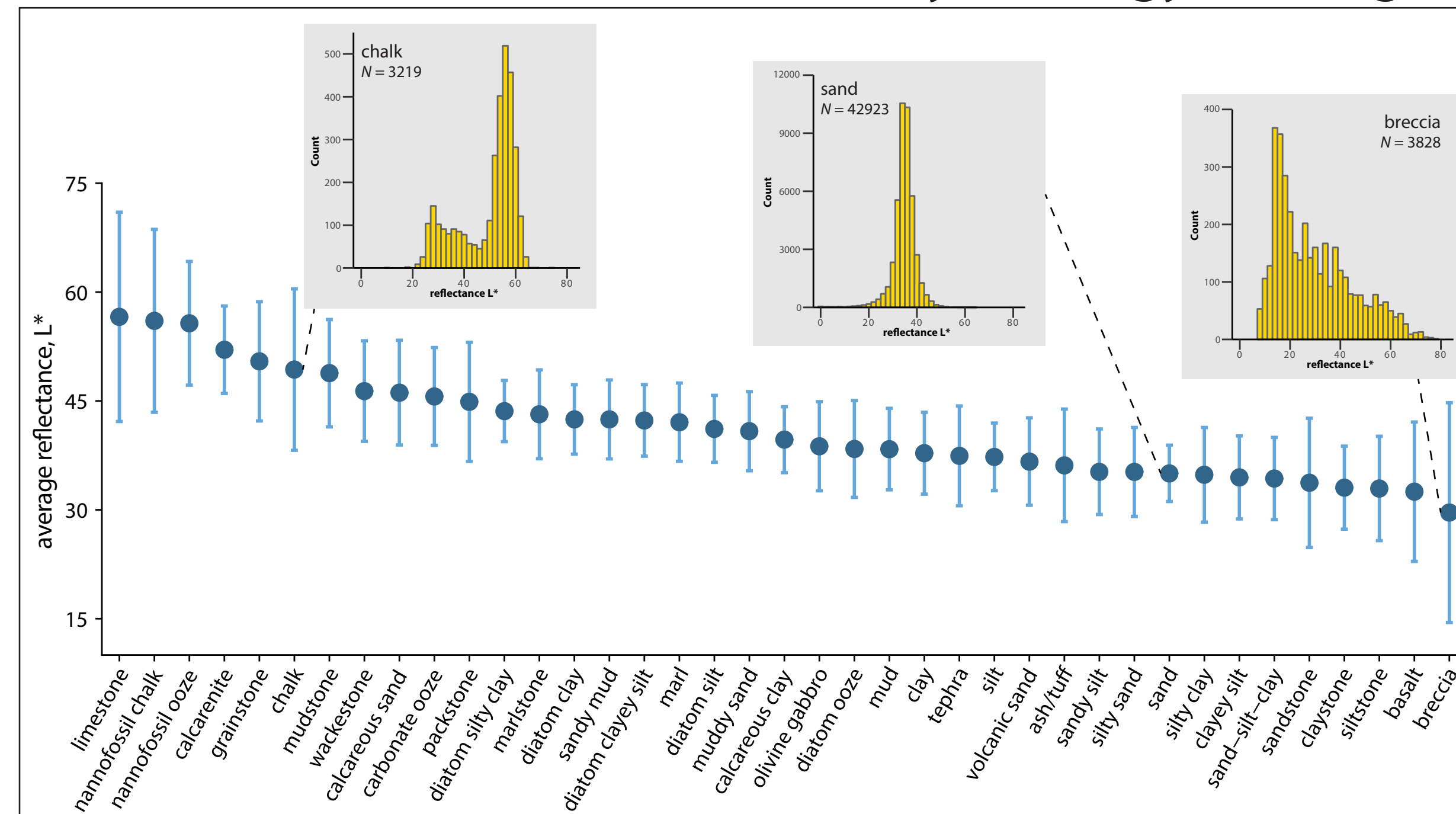
The MAD Density values for discrete samples are plotted versus the primary lithology, providing estimates and uncertainties (standard deviations) for those lithologies that have at least 50 observations. Histograms illustrate results for three lithologies, each with several hundreds of observations.

Characterization of Magnetic Properties by Lithology



The magnetic susceptibility values for whole-round core sections measured on WRMSL are plotted versus the primary lithology. Note the large number of observations per lithology relative to the MAD density shown above. Uncertainties are not shown because they would be skewed on the log plot and because the distributions of susceptibilities for some lithologies can be multi-modal, as shown in the histograms.

Characterization of Color Reflectance by Lithology and Magnetic Susceptibility



The lightness data (L*, where L*=0 is black and L*=100 is white) collected from the color reflectance (spectrophotometry) measured along the surface of the archive-half core sections using SHMSL are plotted versus the same primary lithologies as shown above for the magnetic susceptibility. The lighter sediments are generally more carbonate-rich, given the very light color of CaCO₃. Hence, both L* and magnetic susceptibility can be proxies for carbonate content. As more clay is incorporated into carbonate-rich sediments, they become darker. L* can therefore also be a good proxy for ice volume and temperature in some areas like the northern Atlantic; during glacial periods more clay is pushed into the oceans by ice sheets producing darker sediment and, during interglacials, sediments are instead composed mainly of the CaCO₃ tests of microfossils, and thus have very light color. The alternations of darker and lighter sediments can mimic the variations seen in global oxygen isotope stacks.

SUMMARY

The coupling of track and sample data with lithology provides the means to:

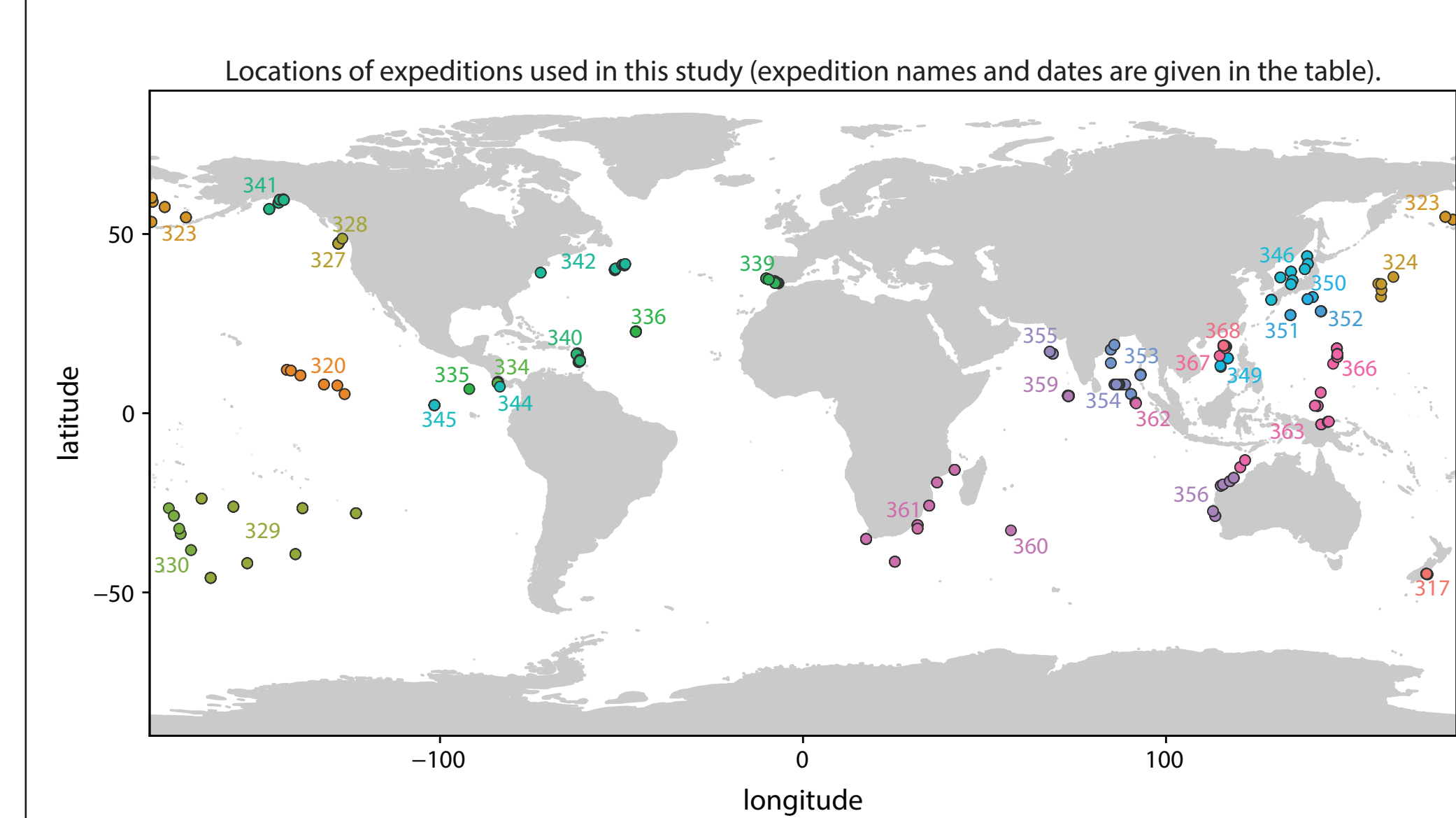
- characterize the physical, magnetic, and chemical properties of common lithologies,
- investigate data connections that may be useful as proxies or for testing hypotheses,
- confirm expected relationships and identify outliers for quality assessment and quality control (QA/QC), with the goal of improving the shipboard instruments and analysis methods.

While we have gathered observations from 33 expeditions from nine track/samples measurement datasets and combined them with lithology, this is only a small part of the ever-growing mountain of observations from *JOIDES Resolution* expeditions. Our goal is to further process and clean the data from the 33 expeditions, add observations from other measurements, and then make the data available (as text files with tabular comma separated values) on an open access database, along with example scripts (e.g., like the R, Python, and Microsoft Power BI scripts used in this study) for analyzing and plotting the data. Methods we are developing will be used to expand the data mining efforts to other expeditions (once out of moratorium) and may eventually be applied for real-time assessment of data as it is collected on future expeditions.

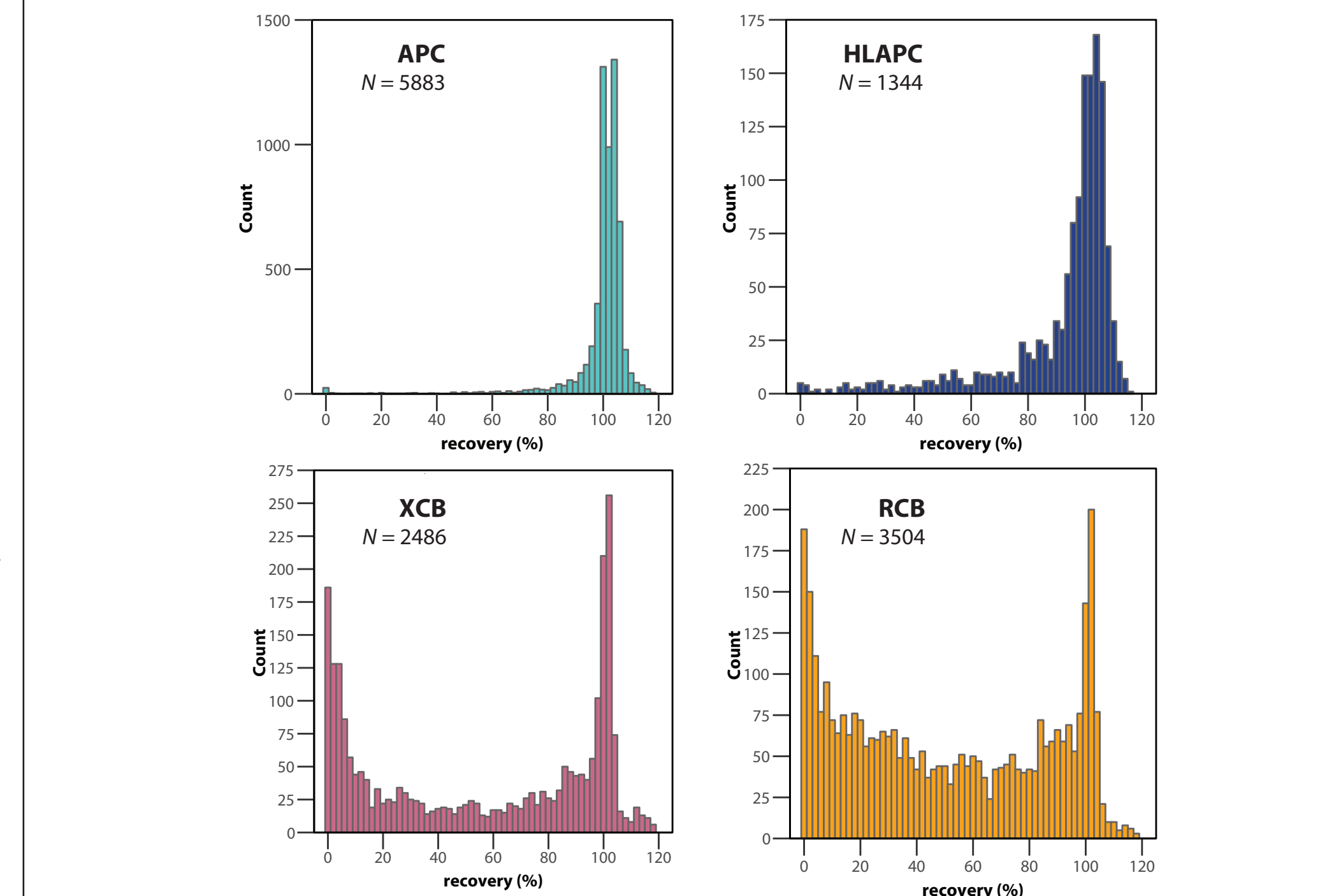
REFERENCES:

All data were retrieved from the IODP Laboratory Information Management System (LIMS) [http://web.iodp.tamu.edu/LORE/] for the expeditions listed in the table. Full citation information for the "Proceedings" volumes for these expeditions are available at <http://publications.iodp.org/>. Mazzullo, J., and Graham, A.G. (Eds.), 1988. Handbook for Shipboard Sedimentologists. ODP Technical Note, 8.

CORING-DRILLING INFORMATION



Locations of expeditions used in this study (expedition names and dates are given in the table). Depth below seafloor (CSF-A m) where use of the APC (green) or HLAPC (blue) is discontinued in favor of another coring system (e.g., XCB, RCB). Holes not using APC/HLAPC, or exclusively using APC/HLAPC are not included. Expeditions include those in the table. Bin size = 50. Total counts = 156.



Recovery by coring type. APC = advanced piston corer. HLAPC = half-length advanced piston corer. XCB = extended core barrel. RCB = rotary core barrel. Recovery greater than 120% not included; may be the result of fall-in rather than recovery. Expeditions include only those in the table. A more extensive investigation of the success of the coring systems is being done by H. Evans and B. Clement (2019, in progress).

