GEOLOGICAL SURVEY OF CANADA

OPEN FILE 5118

Report on cores 2004-024 15 and 16, DesBarres Canyon area, SW Grand Banks

D. J.W. Piper, T. Lawrence, K. Gould, R. Noftall

2006

Natural Resources Canada Ressources naturelles Canada

Canada

GEOLOGICAL SURVEY OF CANADA

OPEN FILE 5118

Report on cores 2004-024 15 and 16, DesBarres Canyon area, SW Grand Banks

D. J.W. Piper, T. Lawrence, K. Gould, R. Noftall

2006

Available from
Geological Survey of Canada, Atlantic
1 Challenger Drive
Dartmouth, NS B2Y 4A2

Piper, D.J.W., Lawrence, T., Gould, K., Noftall, R.
2006: Report on cores 2004-024 15 and 16, DesBarres Canyon area, SW Grand Banks, Geological Survey of Canada, Open File 5118, 27p.

Geological Survey of Canada project X-27 East Coast offshore geohazards

Authors' addresses:
David J.W. Piper, Teri Lawrence, Kathleen Gould, and Ryan Noftall
Geological Survey of Canada (Atlantic), Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, B2Y 4A2

for further information, contact dpiper@nrcan.gc.ca

Preface:
This Open File report complements an earlier report by Piper and Gould (2004) on geohazard assessment on the Southwest Grand Banks slope in the area of the South Whale Basin. It summarizes the new findings from two piston cores collected in the area in summer 2004 and also provides detailed down-core descriptions of the cores reported by Piper and Gould (2004).

Reference:
Piper, D.J.W. & Gould, K. 2004. Late Quaternary geological history of the continental slope, South Whale Basin, and implications for hydrocarbon development. *Geological Survey of Canada*, *Current Research* 2004-D1, 13 pp.

Acknowledgements: Core processing is managed by Kate Jarrett, GSC Atlantic. Project X-27 is funded by the Geological Survey of Canada, Program for Energy Research and Development project 532211, and the Natural Sciences and Engineering Research Council of Canada Can-COSTA Collaborative Research Project. Calvin Campbell provided a wide range of technical support and reviewed this manuscript.

Introduction

Shallow geohazards have been investigated on the Southwest Grand Banks Slope as one case study in a regional appraisal of slope geohazards on the southeastern Canadian margin (Piper et al. 2003; Mosher et al. 2004). Preliminary results in the vicinity of DesBarres Canyon (Fig. 1) have been reported by Piper and Gould (2004) based on piston cores collected in 2001, which show rapid variations in sediment thickness over the past 14 ka and evidence for sediment failure triggered by canyon erosion.

During CCGS Hudson expedition 2004-024, two additional piston cores were collected in the same area to resolve some outstanding issues. Core 15 was collected from an area that appeared to have a condensed section in high-resolution seismic-reflection profile, in anticipation of penetrating deeper in the stratigraphic section and finding the well-dated Heinrich event 2 (H2) marker (Piper and Skene, 1998). Core 16 was collected from the levee adjacent to DesBarres Canyon to investigate whether there was a stratigraphic record of sand spillover from the adjacent canyon. Elsewhere, sandy horizons on the slope have been shown to be preferred horizons of sediment failure (Campbell 2000).

Methods

Piston cores and Huntec DTS sparker data were collected on the 2004-024 Geological Survey of Canada cruise on CCGS Hudson. Each unopened core was analysed by a Geotek multi-sensor track device to measure bulk density, P-wave velocity and magnetic susceptibility at an interval of 1 cm. Discrete P-wave velocity and shear strength measurements were taken in 10 cm intervals where possible on split cores. Colour was measured using a Minolta Spectrophotometer at 5 cm intervals on the split core face, with measurements expressed in terms of the L*, a* and b* values following ASTM E308-85 and E1164-02. The Huntec DTS sparker system was towed about 100 m below the sea surface and profiles were interpreted using paper copies. All ages in this report are in radiocarbon years; cited radiocarbon dates are corrected for marine reservoir effect, but not calibrated. X-ray diffraction was carried out on powdered bulk samples in randomly-oriented mounts and the peak areas of illite (10Å), quartz (4.26Å), calcite (3.04Å) and dolomite (2.89Å) were determined.

Results

Huntec DTS sparker profiles

The Huntec sparker profile collected through core site 15 is correlated with the seismic stratigraphy proposed by Piper and Gould (2004), as shown in Figure 2. The regional RED reflector is recognised at the core site on the basis of over- and underlying reflector character. This allows a further correlation of the PINK and the approximate GOLD reflectors. The identification of GOLD is also supported by an unconformable relationship just to the south of the area in Figure 2.

In addition, a Huntec profile was collected to extend the 2001 profile at 750 m water depth on the continental slope southeast of DesBarres Canyon up the continental slope (Fig. 2). This new profile shows that stratified sediment thins out rapidly in a water depth of 650 - 700 m (Fig. 3).

Cores

Core 15 (Fig. 4) was collected from the continental slope just north of DesBarres Canyon at 1045 mbsl (Fig. 1). Comparison with the trigger weight core suggests there is about 1 m of sediment missing from the top of the piston core. It consists predominantly of mud with abundant very fine sand beds from 6 to 8.3 m. The shear strength profile shows a steady down-core increase of 2 – 2.5 kPa/m, compared with a shear strength gradient of 1.7 kPa/m on the Scotian Slope (Jenner et al., 2006). The section penetrated one bed rich in detrital carbonate at 5.85 m, identified by abundant silt-sized carbonate grains, and coincident peaks in the L* colour values and magnetic susceptibility. The sub-bottom depth suggests this is Heinrich layer 1 (or H1) based on correlation with cores from Piper and Gould (2004). A second carbonate-rich muddy silt with scattered granules occurs at 7.01 m, with a corresponding peak in magnetic susceptibility. It is argued below that this bed is probably H2. Above H1 is a 1-m-thick interval of chocolate-brown mud, recognised from higher values in the colour a* trace, containing common mud clasts of the same colour that appear well dispersed and are interpreted as ice-rafted. Rare ice-rafted granules are also present in this interval. An overlying horizon, rich in sand and granules and with higher bulk density occurs at 1 m, and compares well with the Younger Dryas layer in cores from Piper and Gould (2004).

The section between H1 and H2 consists of beds of fine sand to coarse silt, of thicknesses of 1 to 30 cm, with thin interbedded mud and some bioturbation. Many of the beds have sharp bases, in some cases erosional, and graded tops and appear to be turbidites. A sharp-based sand bed directly underlies H1 and another sand bed immediately overlies H1. H2 is underlain by a thick sand bed, which appears to grade up into the carbonate-rich silt at 701-702 cm. There is also a discontinuous, possibly bioturbated, tan mud at 728-729 cm. This tan mud, together with the H1 and H2 beds, contains significant amounts of detrital dolomite (Table 1), characteristic of Heinrich layers derived from Hudson Strait (Andrews and Tedesco, 1992). Many of the sand beds contain a few sorted mollusc shell fragments and a sample at 8.2 m has yielded a radiocarbon age of 43830 ± 970 (TO-12443; 43.4 ka reservoir corrected).

Core 16 was taken on the nose of a ridge northwest of deep DesBarres Canyon at 1072 mbsl. Huntec sparker data collected at the site was very poor in quality because of interference of the water- surface reflection artefact. The core penetrates a likely Heinrich event at 2.4 m, presumably H1 based on L* colour peaks, detrital carbonate, and a small magnetic susceptibility peak (Fig. 5). At 5.18 m there is a sharp contact between massive mud and highly mottled mud with iron-monosulphides. This abrupt increase in the degree of diagenesis may be evidence for an unconformity, and corresponds to and increase in shear strength from just over 10 kPa to around 20 kPa. The shear strength at the base of the core is similar to that at the base of Core 15.

Discussion

The new cores can be readily correlated with the 2001 cores of Piper and Gould (2004). Both new cores have a clear H1 marker overlain by chocolate-brown mud and passing up into a sandier interval interpreted as the Younger Dryas. The thick chocolate-brown mud interval in core 15 can be correlated on the basis of the a* colour trace (Fig. 6) to the entire section beneath the Younger Dryas sandy interval in MD95-3031, suggesting that the sandy interval at 3.8 m in core 15 is equivalent to the Younger Dryas (Fig. 7). Core 15 also contains a carbonate-rich silt interpreted as H2 at 701-702 cm. The radiocarbon date of 43.4 ka at 820 cm suggests that both H3 and H4 could be present in the core below H2. The carbonate-rich tan layer at 729 cm is tentatively correlated with H4, because H3 is much less abundant on the southeast Canadian margin (Rashid et al. 2003).

The recognition of the chocolate-brown mud with ice-rafted mud clasts of similar colour led to a re-examination of cores 37 and 38 described by Piper and Gould (2004) and a revision of the detailed correlation of these cores with the dated section in MD95-2031 (Figs. 6, 7). This mud interval is presumably related to sediment plume discharge and rapid ice retreat somewhere on the Grand Banks or Northeast Newfoundland Shelf. No correlative facies is found in Orphan Basin and Flemish Pass, suggesting that the ice may have been derived from the south coast of Newfoundland. There is evidence for a late ice advance at about 12 ka on St Pierre Slope (Bonifay and Piper, 1988) and a little earlier in Halibut Channel (Moran and Fader, 1997), that terminated with the collapse of the Avalon Peninsula ice dome. The chocolate-brown mud is tentatively correlated with retreat of ice off southeastern Newfoundland.

Unlike in the vicinity of the Narwhal well site, 25 km to the northwest, the Holocene section at both cores 15 and 16 is quite thin. The boundary between thick Holocene and thin Holocene recognised by Piper and Gould (2004) thus lies northwest of DesBarres Canyon and not in the canyon itself, as they tentatively suggested. It is possible that tidally influenced currents concentrated in DesBarres Canyon may have resulted in the thinner section here.

Core 15 confirmed the presence of a condensed section, as seen in Huntec profile, right back to the GOLD reflector. The section between the Younger Dryas and H1 is of the same thickness as in cores 34 and 35 on the southeast side of DesBarres Canyon, but the section between H1 and the radiocarbon date of 43.4 ka is exceptionally thin. This suggests that some of the sand beds with irregular sharp bases were transported by erosive currents and/or that some failure took place in the alternating sand and mud beds in this interval. Whether there was significant winnowing by a proto-Labrador current is uncertain.

Core 16 is situated on the highest point of the ridge adjacent to DesBarres Canyon. It has strikingly less sand than core 15 in the section immediately below H1 (visual description confirmed by bulk density plot). This suggests that the process leading to sand deposition in core 15 is related to direct supply across the upper slope from the continental shelf. In the case of core 16, available bathymetry suggests that sand crossing the upper slope would be intersected by the head of DesBarres Canyon (Fig. 1) and transferred to deep water. Core 16 shows that any turbidity currents flowing down DesBarres Canyon immediately before H1 were not sufficiently thick to deposit sand at the core site approximately 1000 m above the canyon floor.

The Huntec seismic-reflection profiles on the mid- to upper slope (650 - 750 mbsl) (Fig. 3 and Fig. 5 of Piper and Gould, 2004) shows that it is the higher amplitude reflection packages, corresponding to muds with silt or sand beds in cores, that thin out most rapidly towards the upper slope. This is consistent with the observation of a condensed section in the sandy interval below H1 in core 15.

If the 43.4 ka date is correct, then the regional GOLD unconformity and high amplitude reflections represent a prolonged period of sediment by-pass on parts of the upper and middle continental slope, rather than a single regional failure as suggested by Piper and Gould (2004). It also casts doubt on the chronology of the PINK reflector proposed by Piper and Gould (2004). The underlying regional RED reflector passes upslope into a major till tongue (Fig. 3) and may thus correspond to the MIS 6 glaciation, rather than the MIS 4 glaciation as proposed by Piper and Gould (2004) .

Conclusions

Two new cores from the DesBarres Canyon region confirm the complexity of slope sedimentation in the region. Core 15 penetrated a condensed sandy section corresponding to the time interval from 45 ka to 14 ka, apparently related to transport of sand off the shelf and down the upper slope. A significant chocolate-brown proglacial mud with ice-rafted detritus was deposited in the region between Heinrich event 1 and the Younger Dryas.

References

Andrews, J.T. and Tedesco, K. 1992. Detrital carbonate-rich sediments, northwestern Labrador Sea: implications for ice-sheet dynamics and iceberg rafting (Heinrich) events in the North Atlantic. Geology, v. 20, p. 1087-1090.

Bonifay, D. and Piper, D.J.W., 1988. Probable Late Wisconsinan ice margin on the upper continental slope off St. Pierre Bank, eastern Canada. Canadian Journal of Earth Sciences, v. 25, p. 853-865.

Campbell, D.C., 2000. Relationship of sediment properties to failure horizons for a small area of the Scotian Slope. Geological Survey of Canada, Current Research, 2000-D08, 7p.

Jenner, K.A., Piper, D.J.W., Campbell, D.C. and Mosher, D.C., 2006. Lithofacies and origin of late Quaternary mass transport deposits in submarine canyons, central Scotian Slope, Canada. Sedimentology (in press)

Moran, K. and Fader, G.B.J., 1997. Glacial and glaciomarine sedimentation, Halibut Channel, Grand Banks of Newfoundland. In: Davies, T.A. (ed.), Glaciated continental margins, an atlas of acoustic images. Chapman and Hall, London, pp. 217-221.

Mosher, D.C., Piper, D.J.W., Campbell, D.C., and Jenner, K.A., 2004. Near surface geology and sediment-failure geohazards of the central Scotian Slope. American Association of Petroleum Geologists Bulletin, v. 88, p. 705-723.

Piper, D.J.W. and Gould, K. 2004. Late Quaternary geological history of the continental slope, South Whale Basin, and implications for hydrocarbon development. *Geological Survey of Canada, Current Research* 2004-D1, 13 pp.

Piper, D.J.W. and Skene, K.I., 1998. Latest Pleistocene ice-rafting events on the Scotian Margin (eastern Canada) and their relationship to Heinrich events. Paleoceanography, v. 13, p. 205-214.

Piper, D.J.W., Mosher, D.C., Gauley, B.J., Jenner, K. & Campbell, D.C., 2003. The chronology and recurrence of submarine mass movements on the continental slope off southeastern Canada. In: Locat, J. & Mienert, J., Submarine mass movements and their consequences. Kluwer, Dordrecht, 299-306.

Rashid, H., Hesse, R. and Piper, D.J.W. 2003. Distribution, thickness and origin of Heinrich layer 3 in the Labrador Sea. Earth and Planetary Science Letters, v. 205, p. 281-293

Table 1: Abundance of quartz, calcite and dolomite at selected horizons

Core and depth	Strat. horizon	Mineral Quartz	Net Area (Cps x 2-Theta °) Calcite	Dolomite	Illite
2004024.015PC.75cm	?YD	50	244	92	n.d.
2004024.015PC.589cm	H1	60	161	65	n.d.
2004024.015PC.701cm	H2	40	142	40	n.d.
2004024.015PC.702cm	H2	65	134	50	n.d.
2004024.015PC.728cm	?H4	43	117	28	n.d.
2004024.015PC.730cm	?H4	36	112	24	n.d.
2004024.015PC.959cm	?	57	219	39	n.d.
2004024.016PC.241cm	H1	74	206	92	n.d.

n.d. = not determined. Values of >20 are thought to be significant.

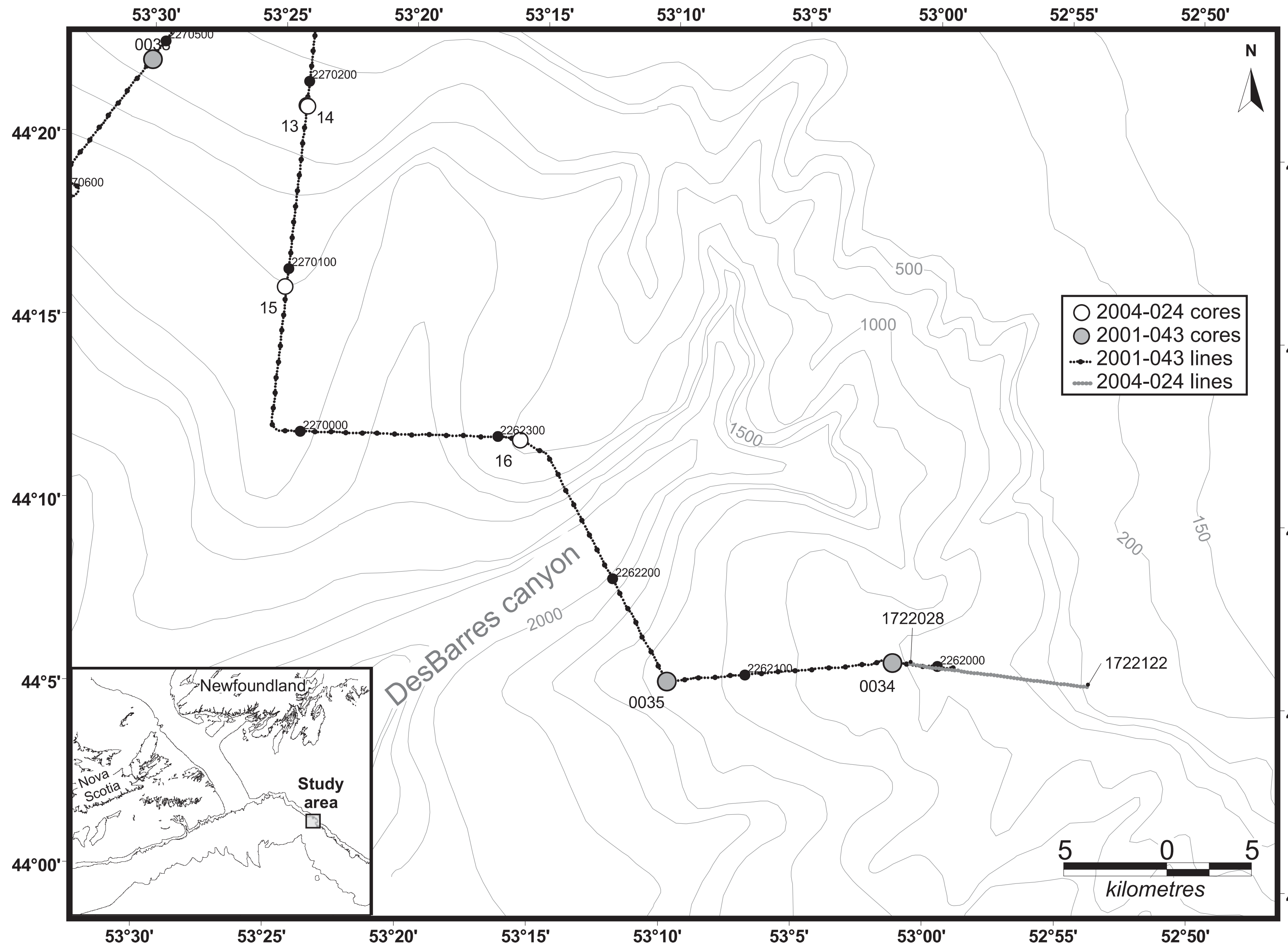


Figure 1. *Location map showing the continental slope near DesBarres Canyon and location of piston cores and seismic profiles (bathymetry in metres).*

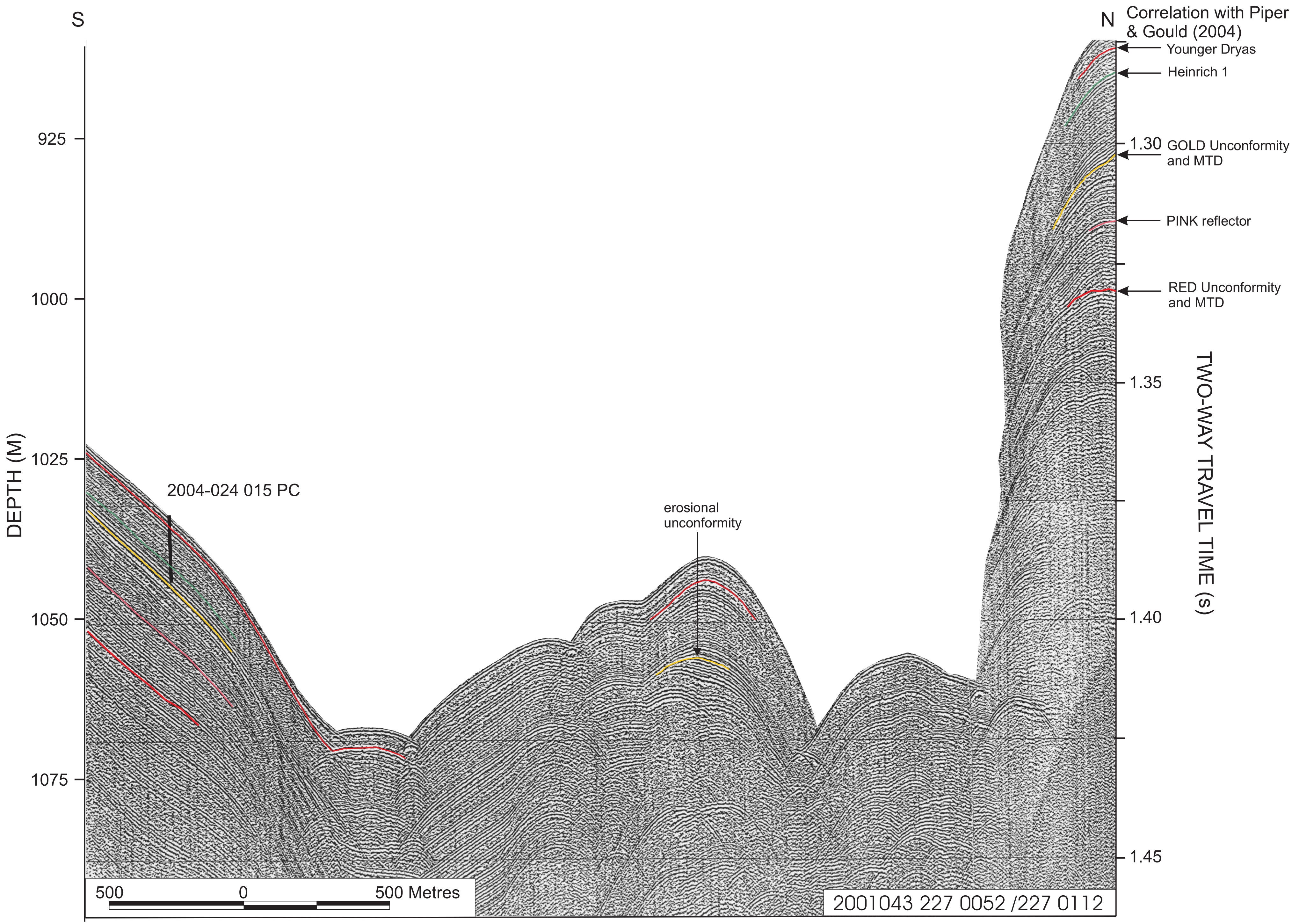


Figure 2. Huntec sparker profile through core site 2004024 - 015.

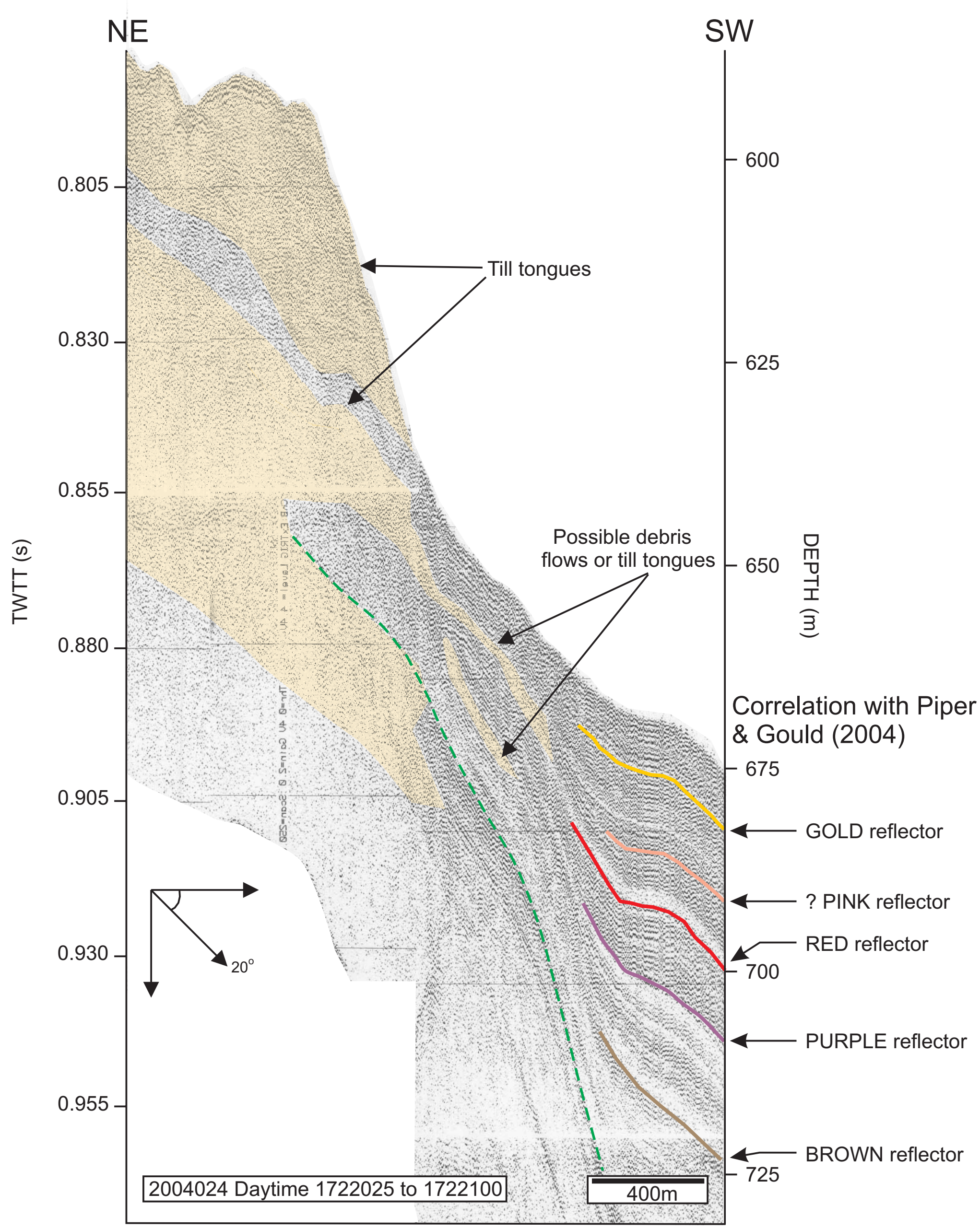


Figure 3: *Upper slope Huntec seismic profile showing transition from till to stratified sediment.*

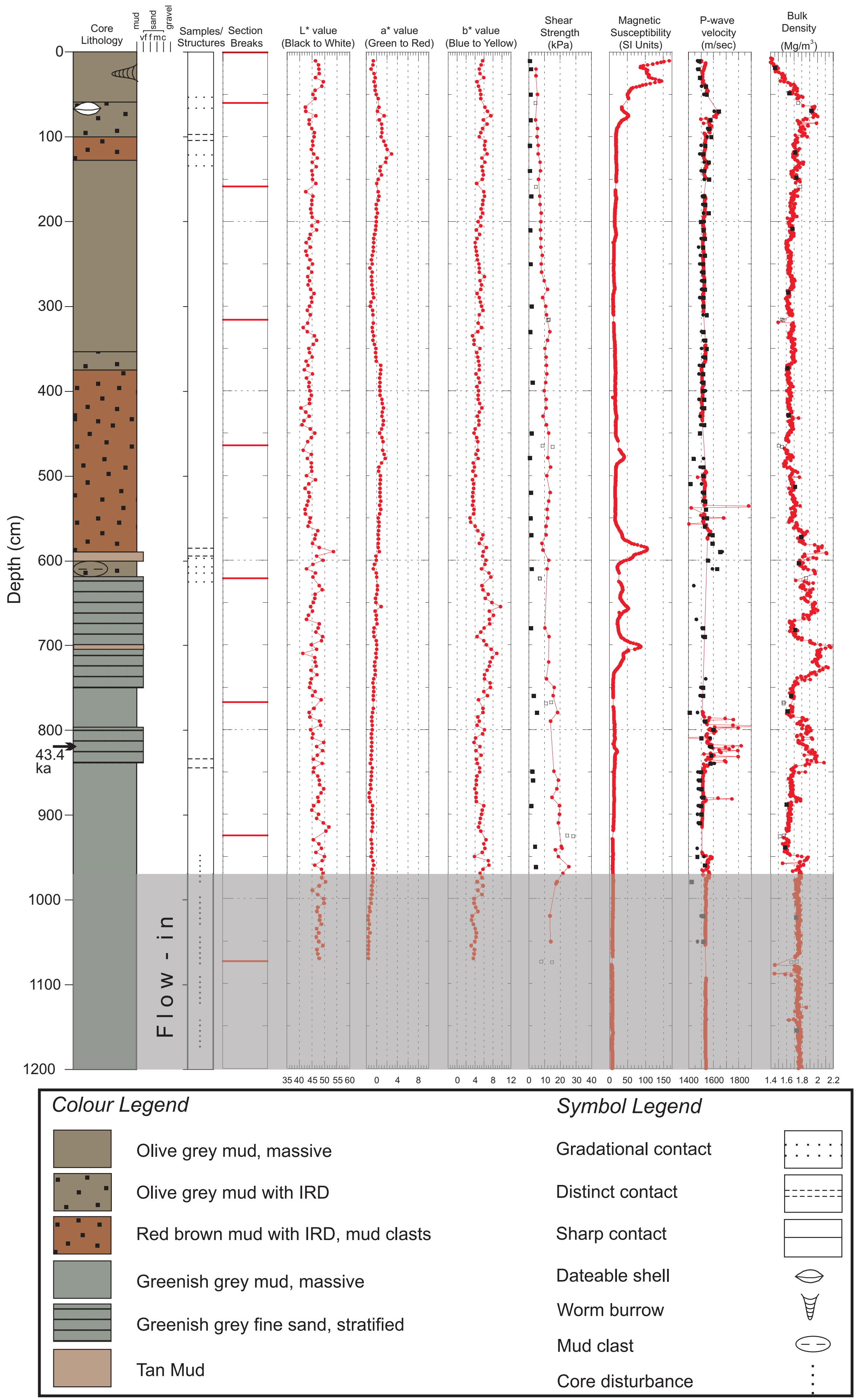


***Figure 4:** Detailed core plot summary of Hudson 2004024 piston core 015.*

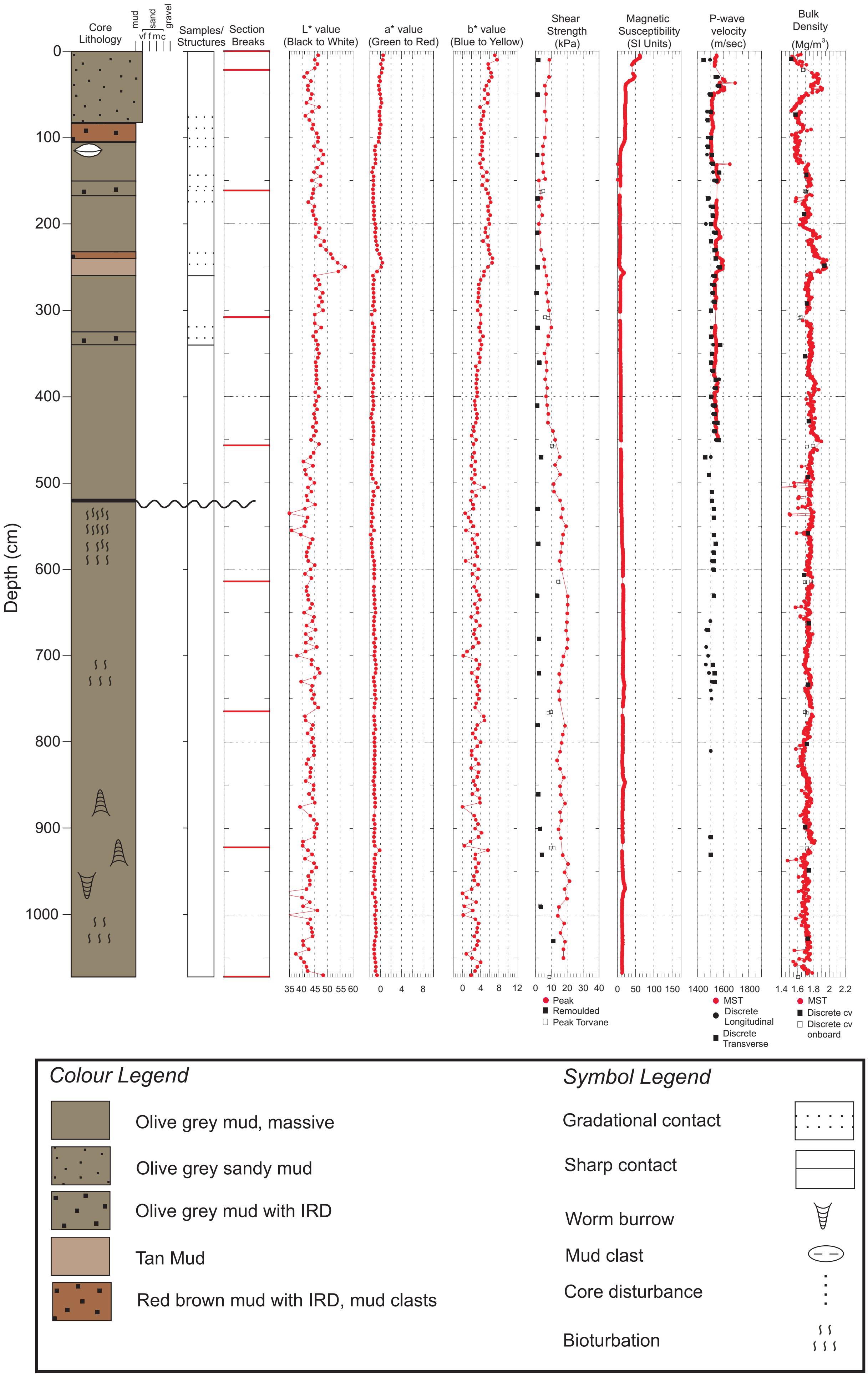


Figure 5. *Downcore plot summary of Hudson 2004024 piston core 016.*

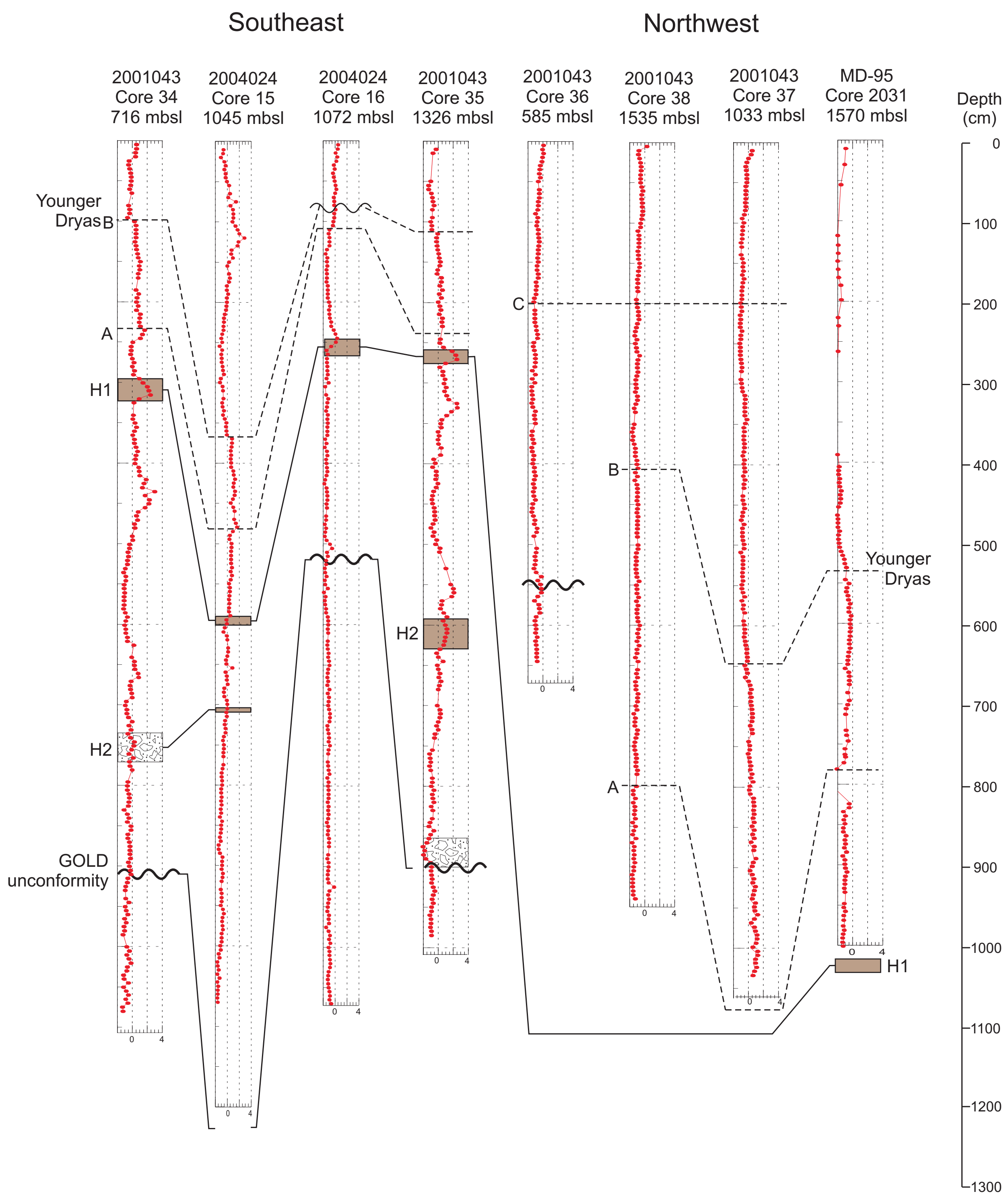


Figure 6: *Correlation of a* colour trace in the Holocene section of all cores. (See Piper & Gould 2004 for location of* ***N****orthwest cores)*

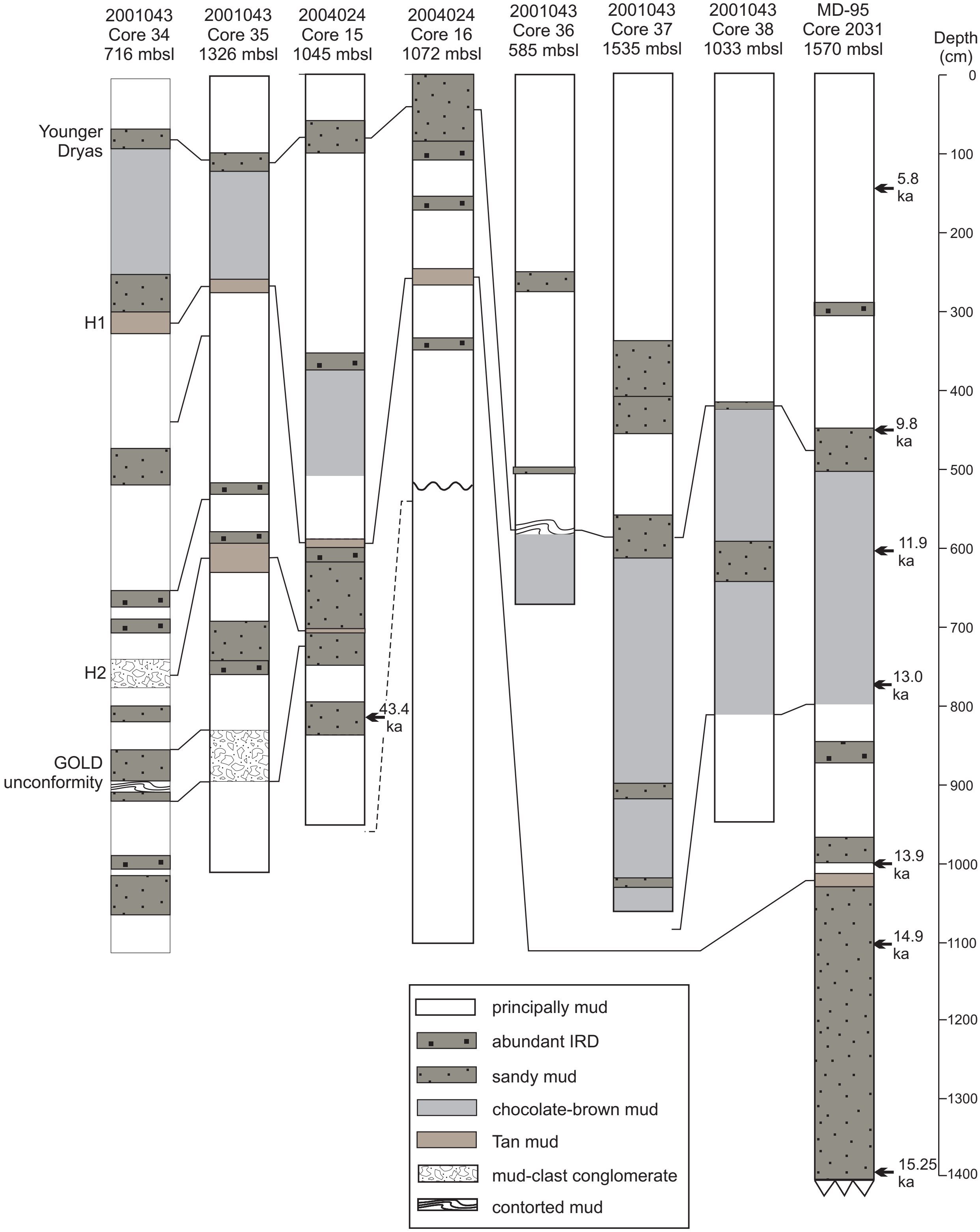


Figure 7: *Summary correlation of all cores.*

APPENDIX

Detailed core descriptions of cores 2001-043-

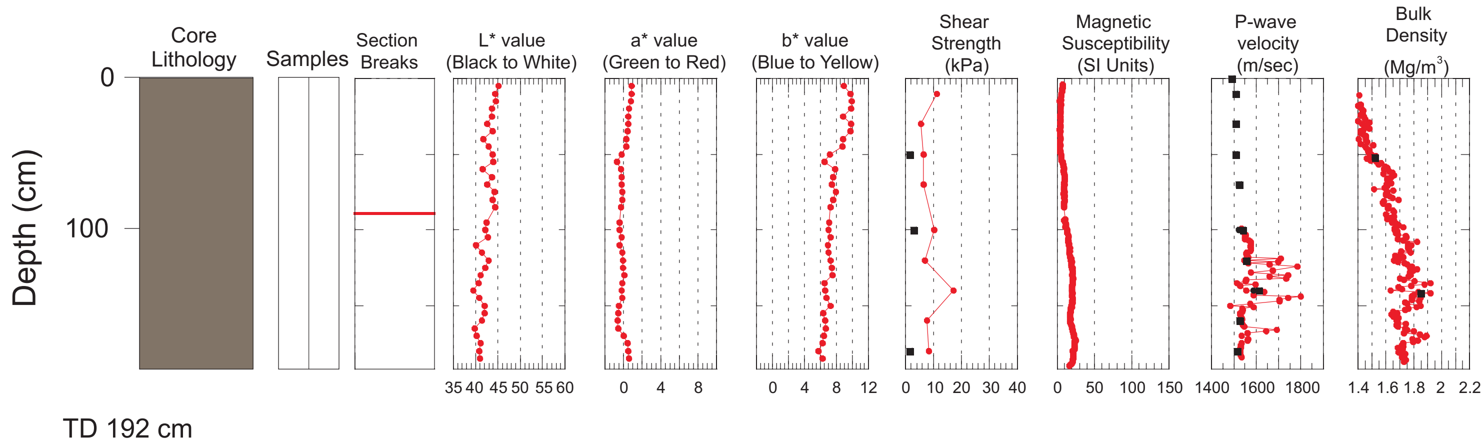
34
35
36
37
38

Erosional Contact	
Lamination/Thin Beds	
Core Disturbance	
Radiocarbon Date	
Grain Size Subsample	●
Bulk Density Subsample	▲
Atterberg Limit Subsample	■
Gas Subsample	G
Geomechanical Subsample	M
Shell Hash	

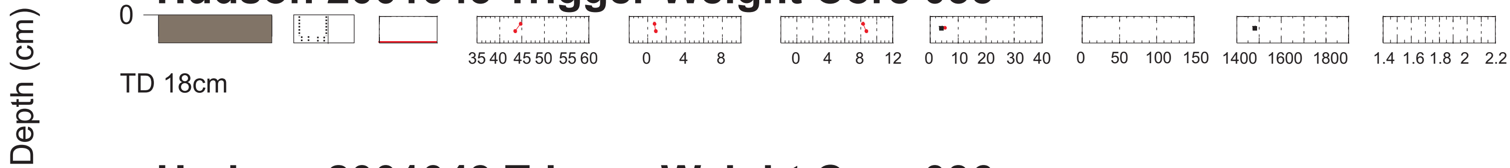
Colour Legend

- Foram Ooze
- Olive Grey Mud (Ogm)
- Olive Grey Sandy Mud (Ogm1)
- Olive Grey Mud with Ice-Rafted Detritus (Ogm2)
- Brick Red Mud (Brm)
- Red Brown Mud (Rbm)
- Red Brown Sandy Mud (Rbm1)
- Red Brown Mud with Ice-Rafted Detritus (Rbm2)
- Brown or Grey Mud (Bgm)
- Brown or Grey Sandy Mud (Bgm1)
- Brown or Grey Mud with Ice-Rafted Detritus (Bgm2)
- Grey Brown Mud (Gbm)
- Grey Brown Mud, sandy (Gbm1)
- Grey Brown Mud, withIce Rafted Detritus (Gbm2)
- Heinrich Event
- Coarse Sand or Gravel
- Debris Flow
- Mudclast Conglomerate
- Diamicton
- Folded Mud Block

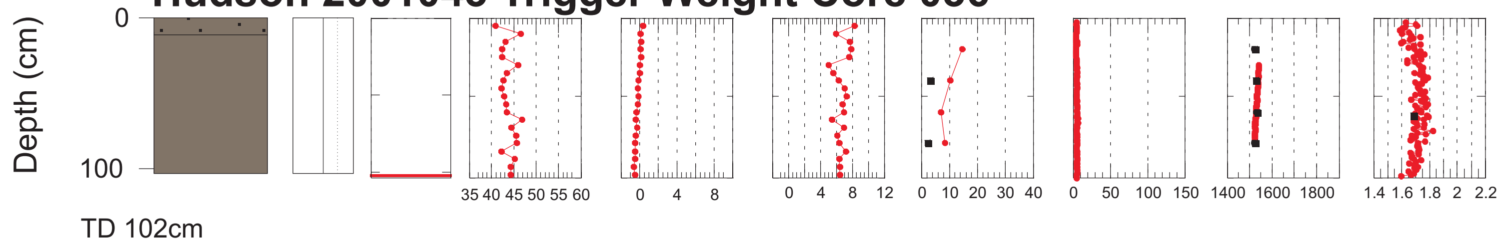
Hudson 2001043 Trigger Weight Core 034



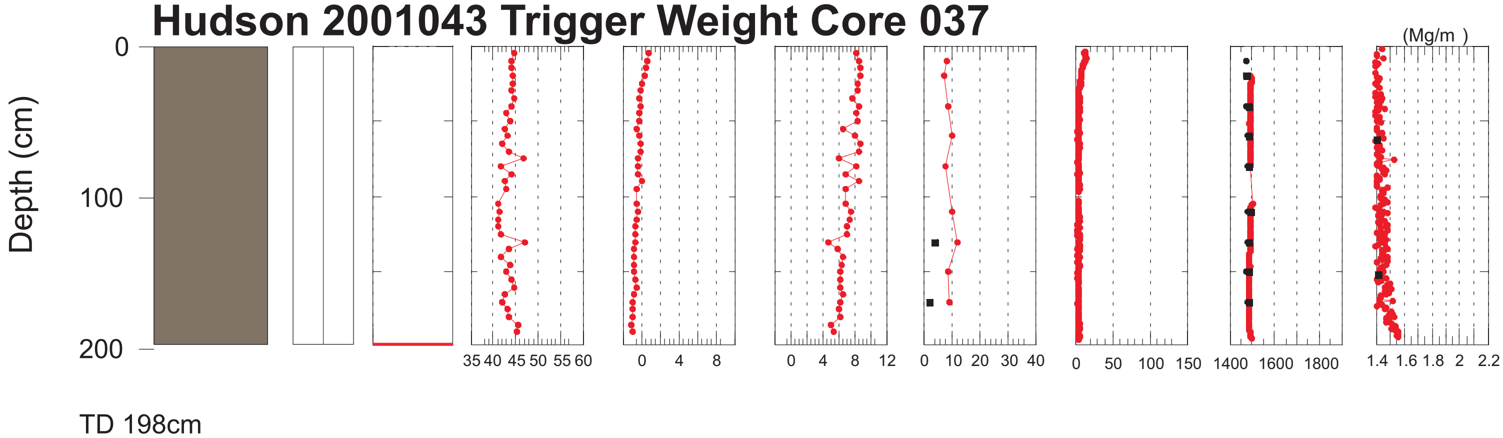
Hudson 2001043 Trigger Weight Core 035



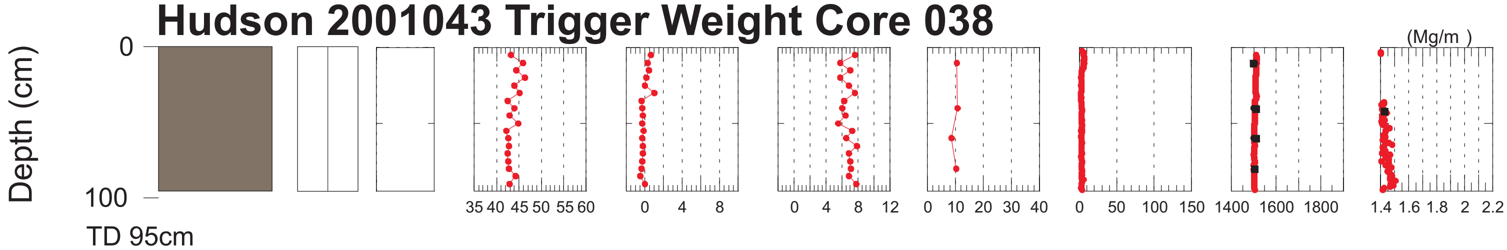
Hudson 2001043 Trigger Weight Core 036



Hudson 2001043 Trigger Weight Core 037



Hudson 2001043 Trigger Weight Core 038



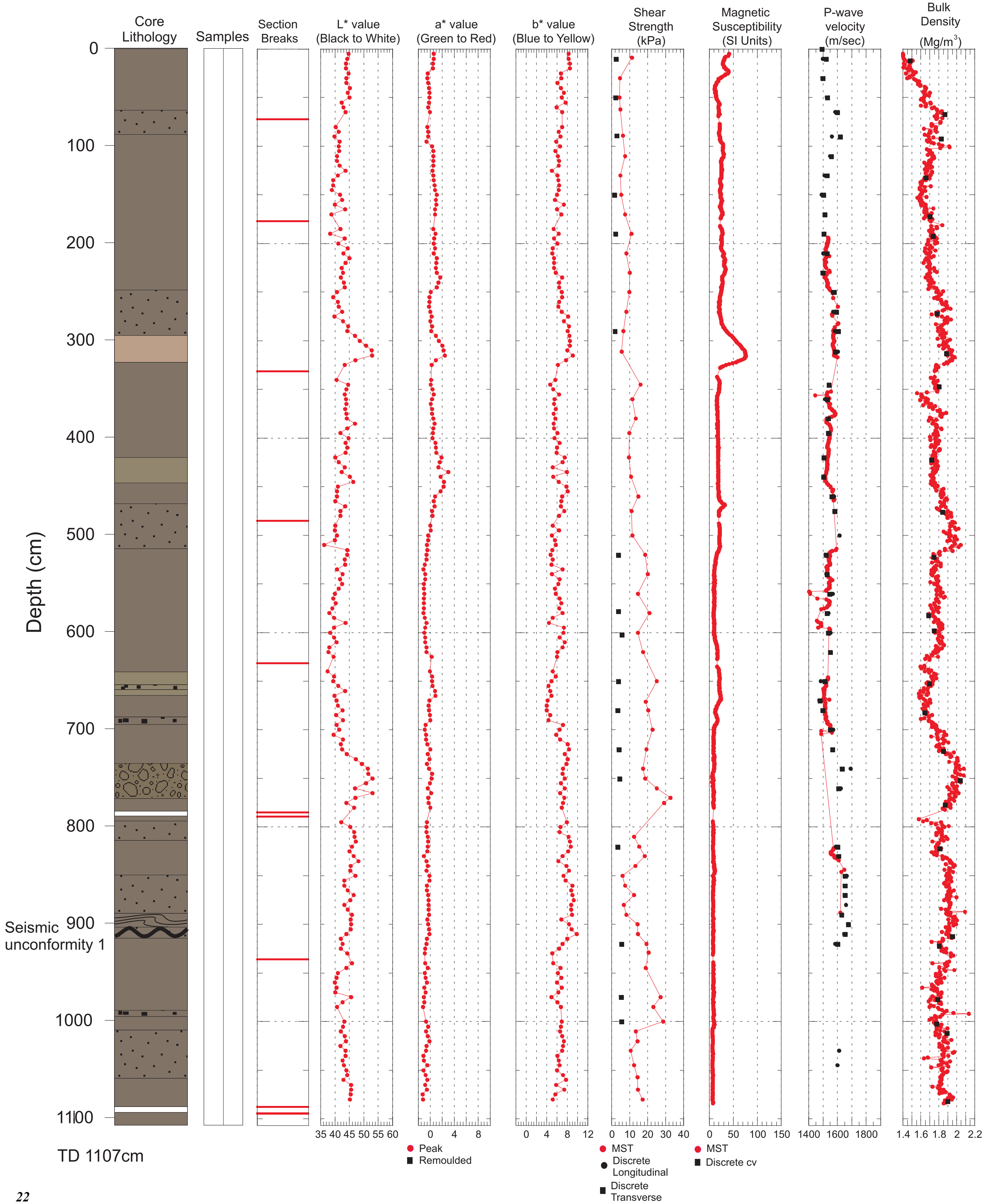
● Peak
■ Remoulded

● MST
● Discrete Longitudinal
■ Discrete Transverse

● MST
■ Discrete cv

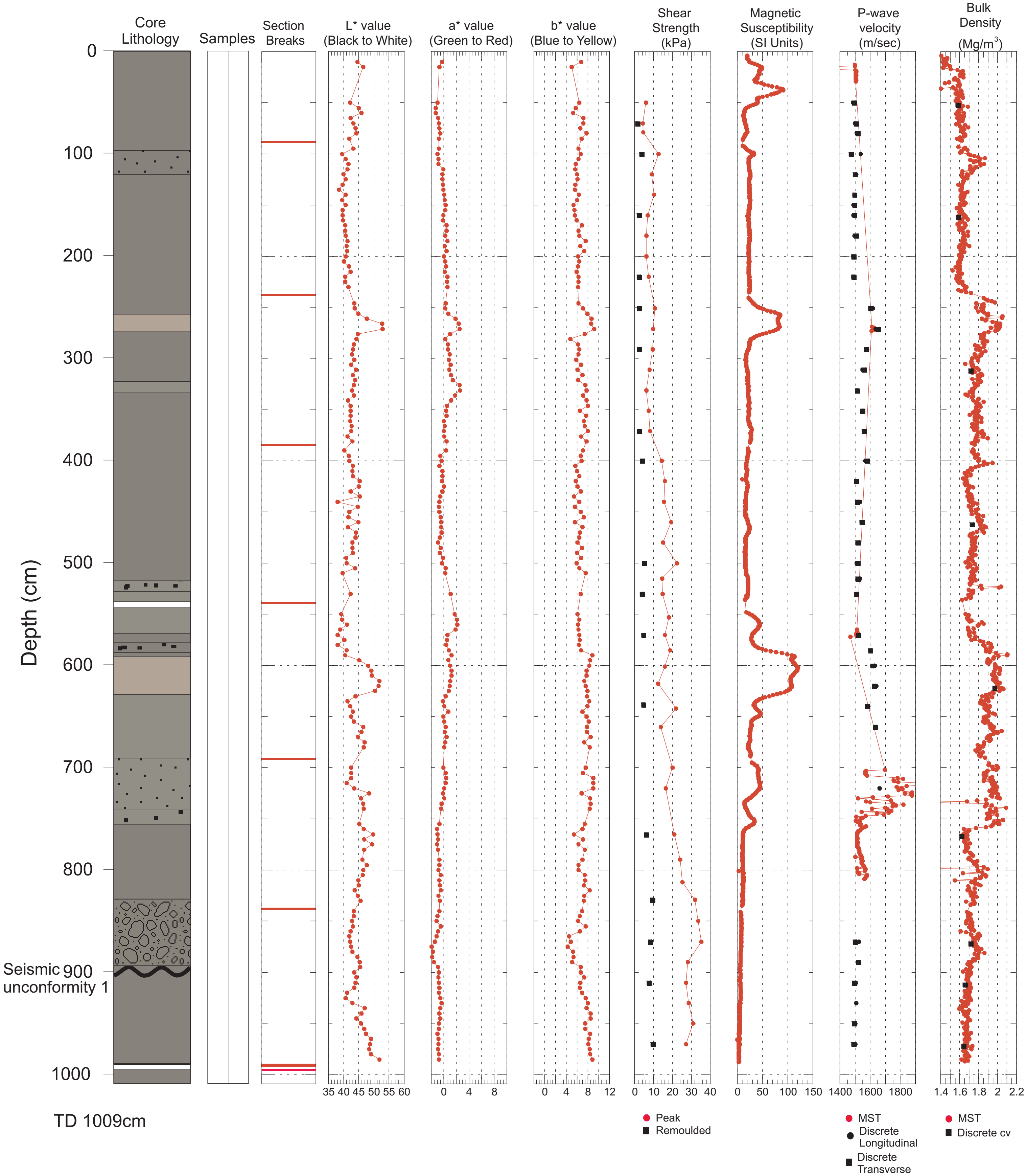
Hudson 2001043 Piston Core 034

TD 1107cm 44°06.0988 N 53°01.3391 W; Water Depth 716 m



Hudson 2001043 Piston Core 035

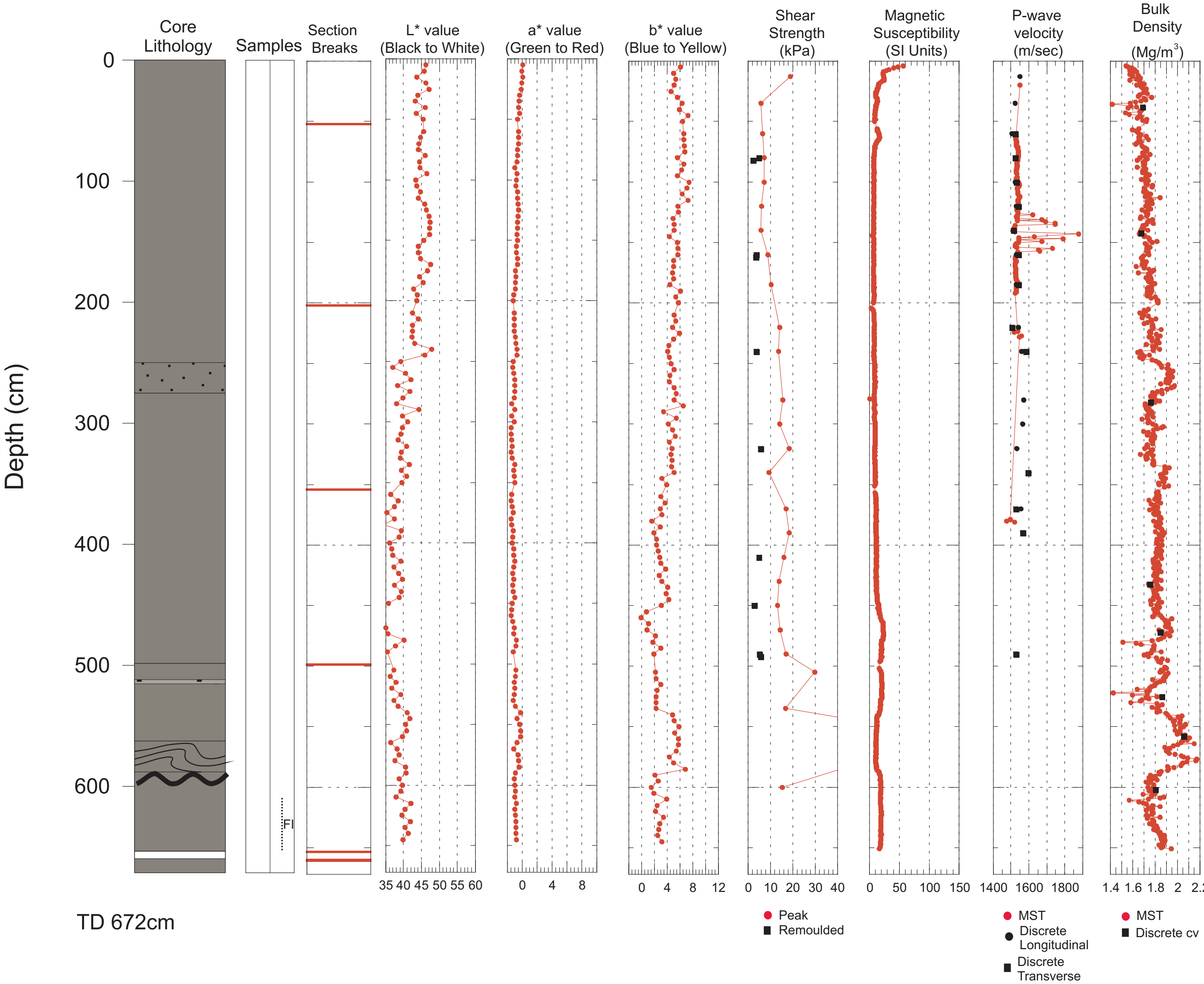
TD 1009cm 44°05.4417 N 53°09.8933 W; Water Depth 1326 m



TD 1009cm

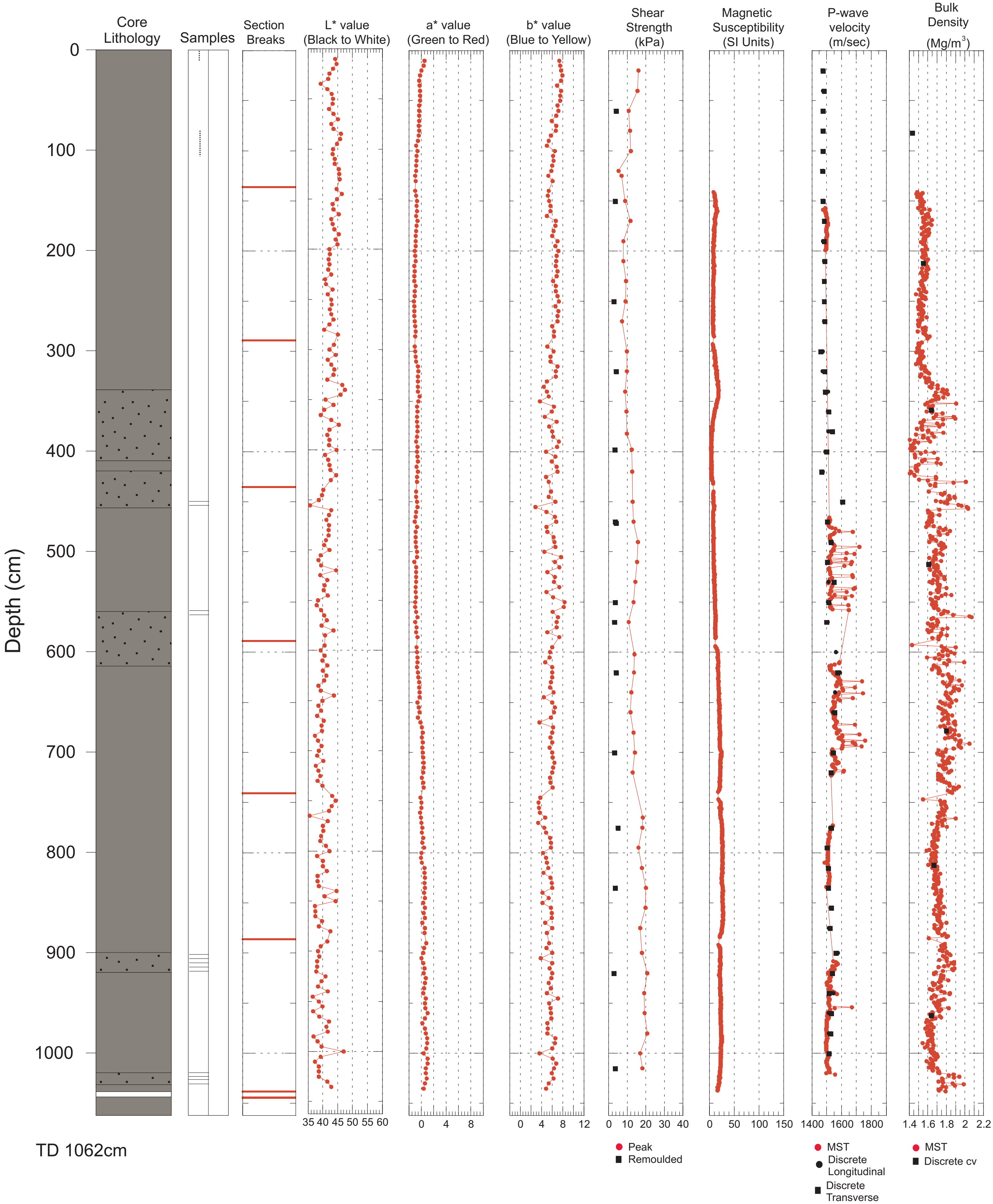
Hudson 2001043 Piston Core 036

TD 672 cm   44°25.7994 N   53°37.8154 W;   Water Depth 585 m



Hudson 2001043 Piston Core 037

TD 1062cm 44°19.7120 N 53°36.4827 W; Water depth 1535 m



Hudson 2001043 Piston Core 038

TD 950 cm   42°22.0479 N   53°30.1086 W;   Water Depth 1033 m