Bringing deep-sea ichnology into the classroom using IODP Expedition 339 core digital images

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Introduction

Although the most known ichnofossils are vertebrate footprints (particularly dinosaurs), ichnology encompass the study an incredible diversity of trace fossils such as burrows produced by marine organisms in soft sediments. Several authors have conducted trace fossil research analyzing deep-sea cores obtained during Ocean Drilling Program (ODP), Deep Sea Drilling Project (DSDP), Integrated Ocean Drilling Program, and International Ocean Discovery Program (IODP) expeditions.

These international scientific ocean drilling programs have now operated over 50 years resulting in a huge collection of high-quality deep-sea sediments cores. IODP Expedition 339 had two inter-related objectives to recover continuous sedimentary sequences for: (i) studying the Contourite Depositional System (CDS) formed by the Mediterranean Outflow Water (MOW); and (ii) reconstructing North Atlantic climate variability on orbital and suborbital time scales.

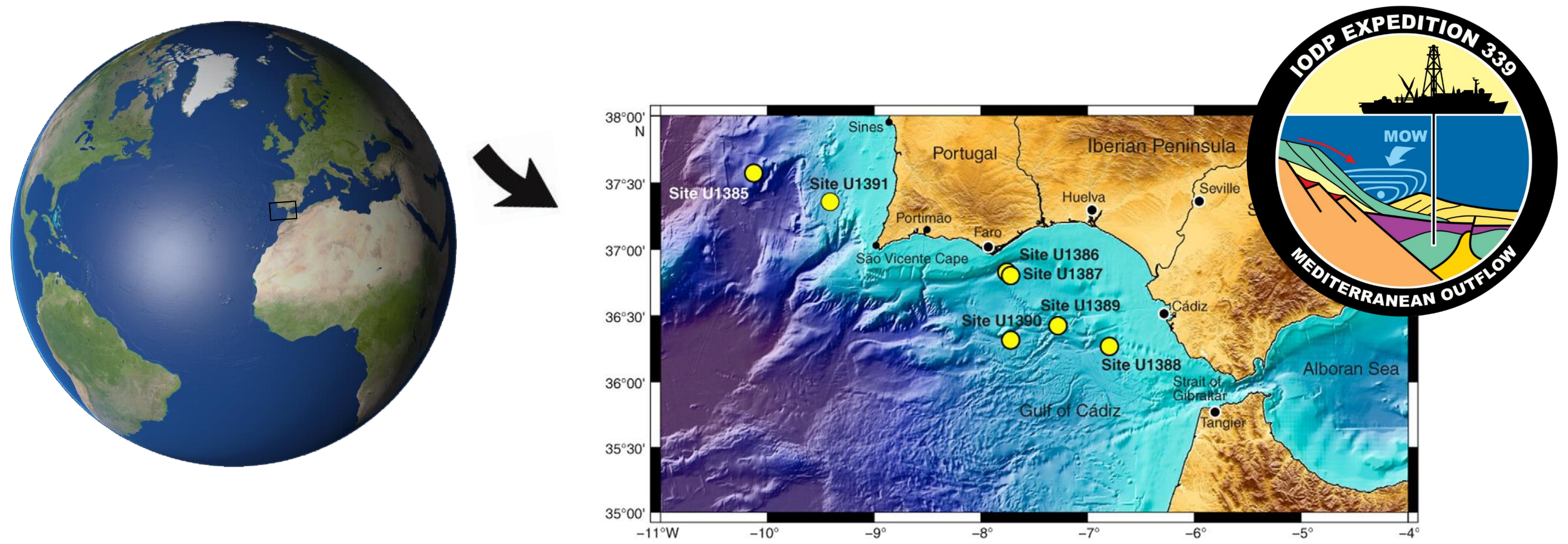

Fig. 1. IODP *Expedition 339 sites in the Gulf of Cádiz andWest Iberian margin, shown as yellow solid circles.*

IODP Expedition 339 recovered 5447 m of core (Figure 1) . Once the 9.5-meter long cores arrived from the seafloor, the technicians labelled and cut them into 1.5-meter sections. Next, they split the cores into two halves, the "working half", which scientists sample and use aboard the drilling platform, and the "archive half", which is kept in untouched condition after being visually described and photographed with a digital imaging system (Figure 2).

This work presents some examples of how high-resolution IODP Expedition 339 core digital images, available through the LIMS online database, can be used, by secondary school students and teachers, to enable the study of bioturbation in marine sediments.

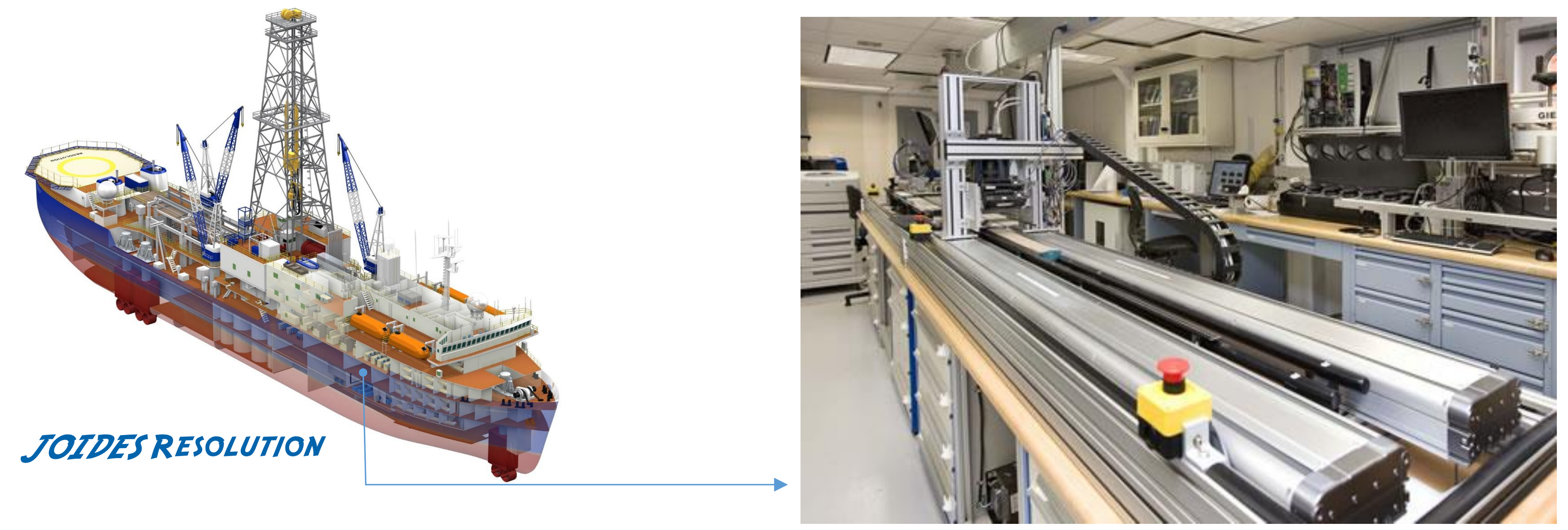

Fig. 2. Section Half Imaging Logger (SHIL) aboard the *JOIDES Resolution*

Methods

A | Looking for info and downloading the core photos and digital images

Reading the Expedition Proceedings Volume (Figure 3) is always a good way of starting collecting information about it. Then, it is time to download the cores photos and digital images from the LIMS online database (Figure 4). There are several types of photos and images that can be downloaded, such as: whole-core photos, digital images of core sections and close-up photographs.

Expedition 339

Fig. 3. IODP Expedition 339 Proceedings Volume

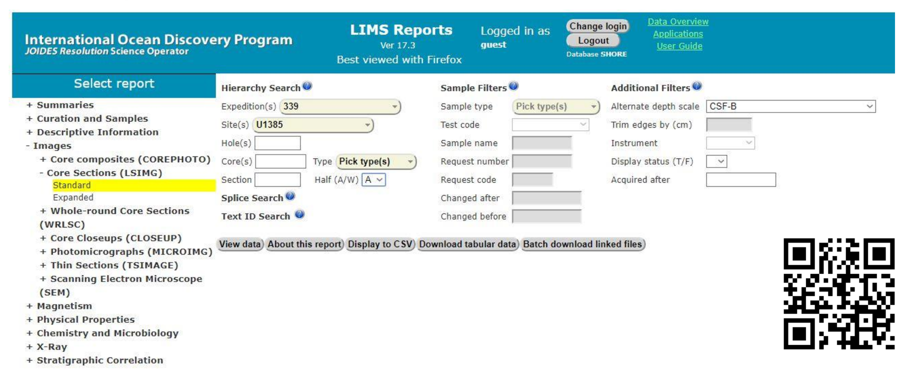

Fig. 4. LIMS database Online Reports

Methods

We present an adaptation of the three step methodology proposed by Dorador et al. (2014a,b) that included some image adjustments to improve the trace fossils visualization (B1). Next we propose the determination of the degree of bioturbation (B2). And finally the identification of bioturbational structures (B3).
This methodology is really easy to implement even by non specialists, such as secondary school students and teachers.

B1 | Enhancing the colours of the high-resolution core photos and digital images

UsingGNU Image Manipulation Program - there is a great variety of adjustments such as balance, brightness-contrast, threshold, levels, curves to enhance the colours of the high-resolution core photos and digital images GIMP -. We propose a sequence of adjustments (levels, brightness and saturation) to increase the visibility of the ichnofossils (Figure 5).

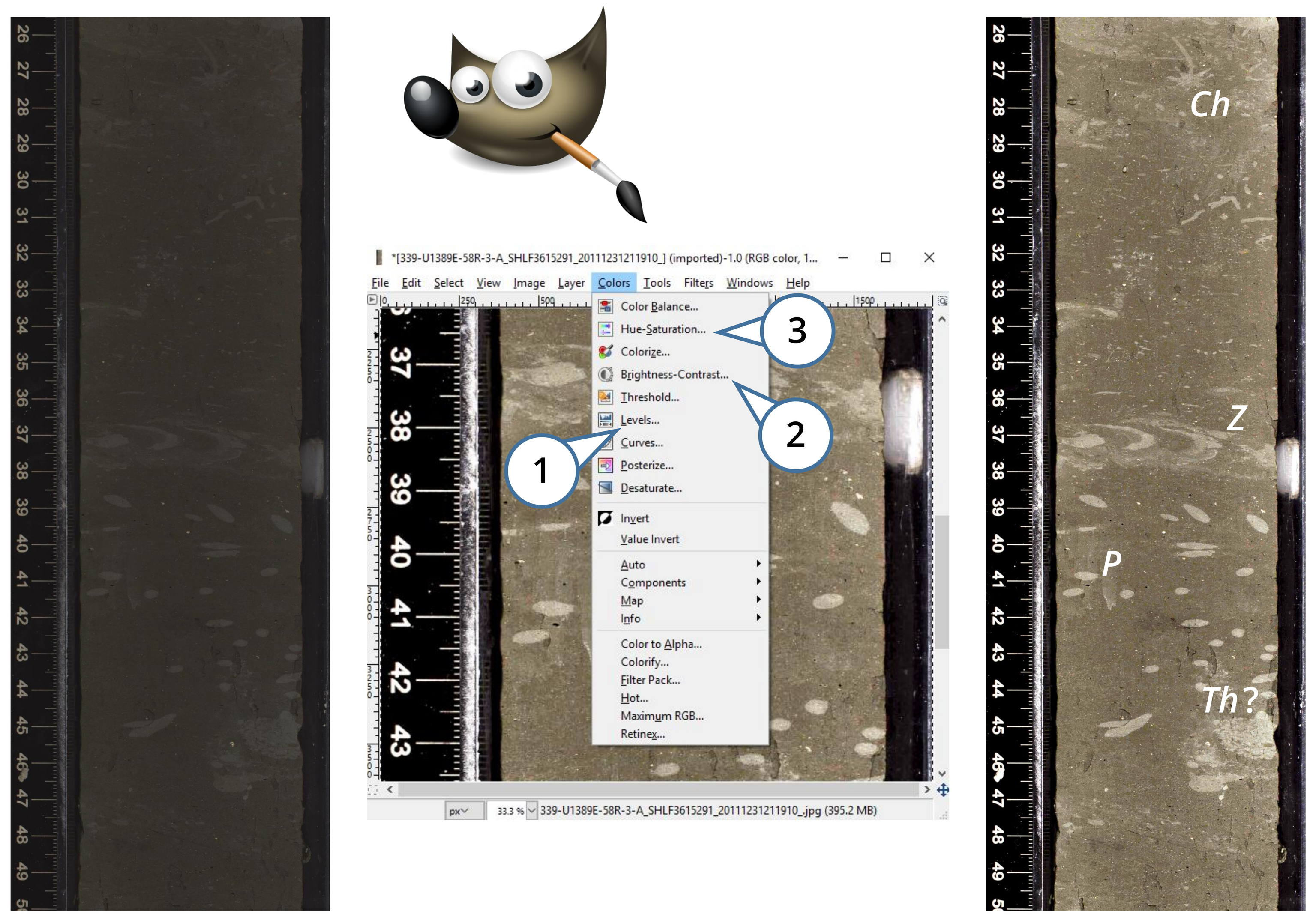

Fig. 5. Original composite line scan image of core 339-U1389E-58R-3-A (left) and after being enhanced using the free GIMP software (right). Ch, *Chondrites*; P, *Planolites*; Th?, *Thalassinoides*; Z, *Zoophycos*.

B2 and B3 | Bioturbation quantification and identification of trace fossils

To estimate the degree of bioturbation researchers commonly use indices such as bioturbation and ichnofabric indices (e.g. Droser and Bottjer, 1986; Taylor and Goldring, 1993). This approach has become a very useful tool in paleoenvironmental reconstruction studies. Several authors (Wetzel and Uchman, 2012; Knaust, 2017) have detailed descriptions of the most common trace fossils in marine cores.

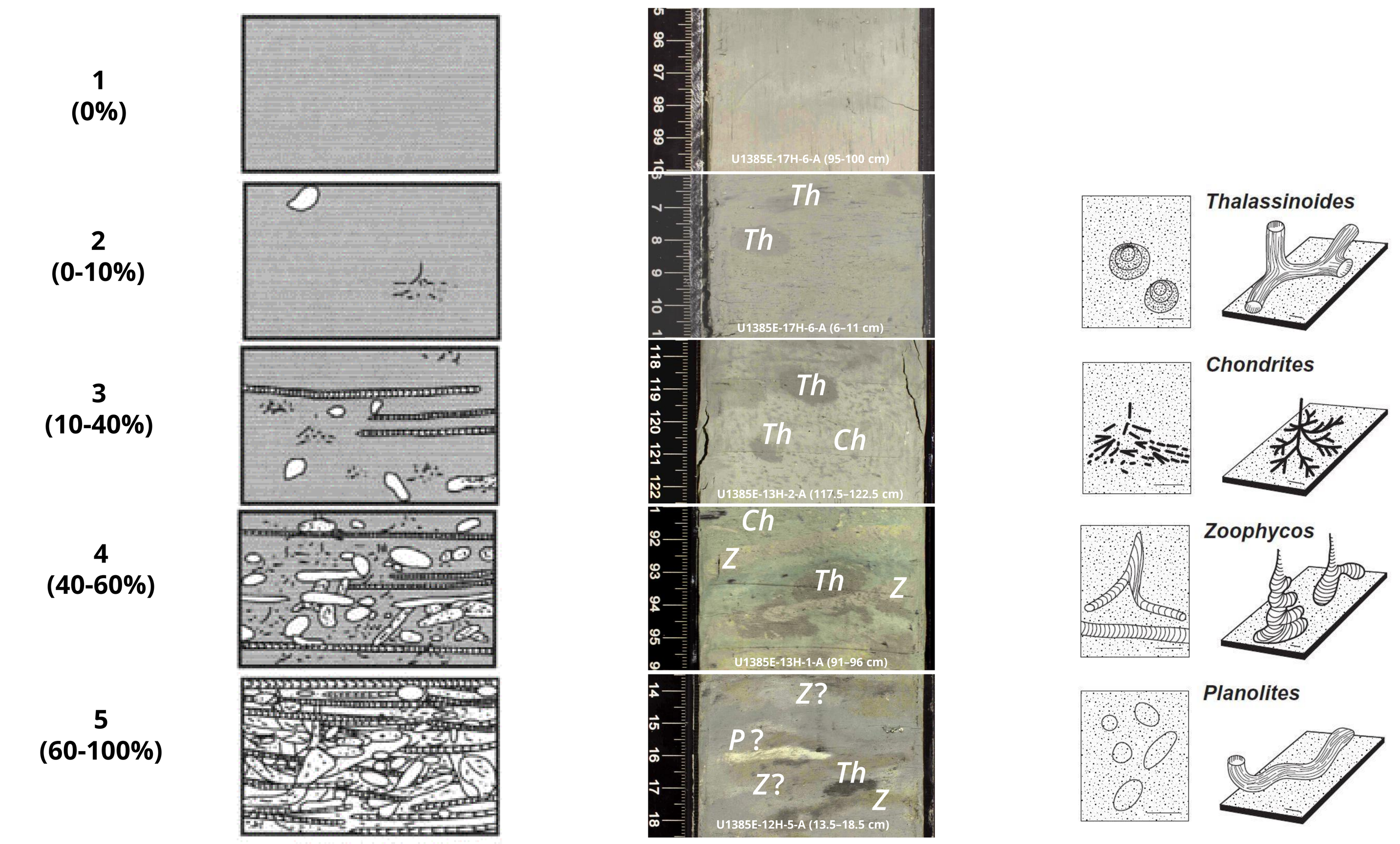

Fig. 6. Ichnofabric indices according to McIlroy (2004), processed IODP 339 high resolution core digital images (adapted from Dorador and Rodríguez-Tovar, 2018) and schematic drawings of trace fossils commonly found in marine cores (Wetzel and Uchman, 2012).

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Some examples

The *Zoophycos* Ichnofacies (Figure 5). Trace fossils include *Chondrites* (*Ch*), *Cosmorhaphe* (*Cr*), *Helminthopsis* (*H*), *Phycosiphon* (*Ph*), *Planolites* (*P*), *Scolicia* (*Sc*), *Spirophyton* (Sp), *Thalassinoides* (*Th*), and *Zoophycos* (*Z*).

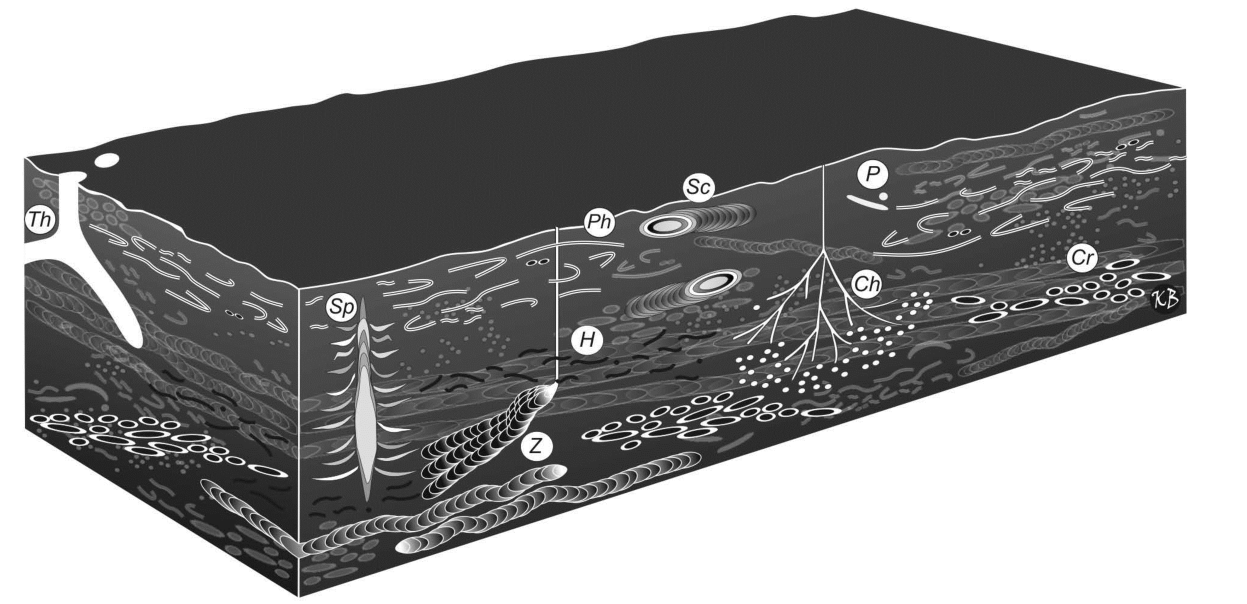
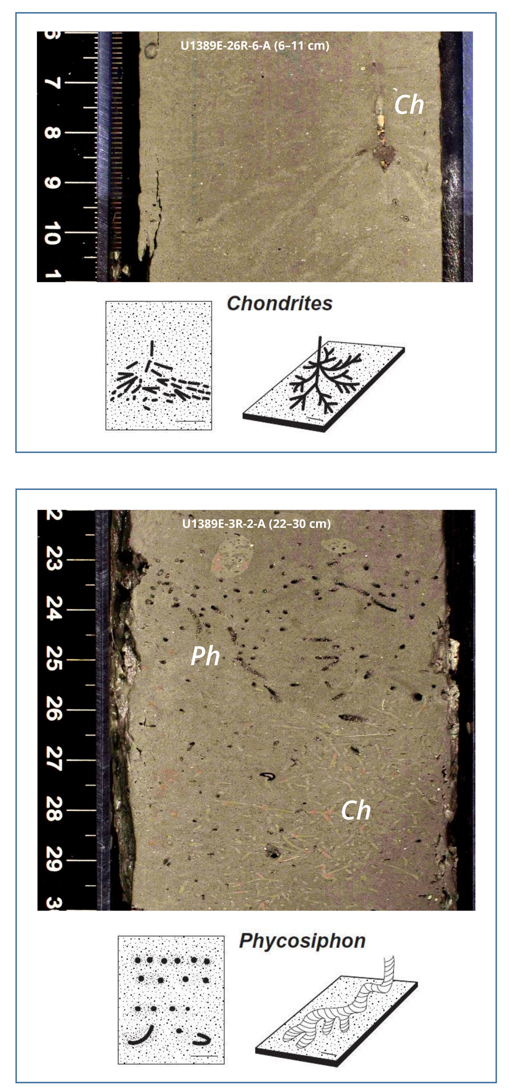
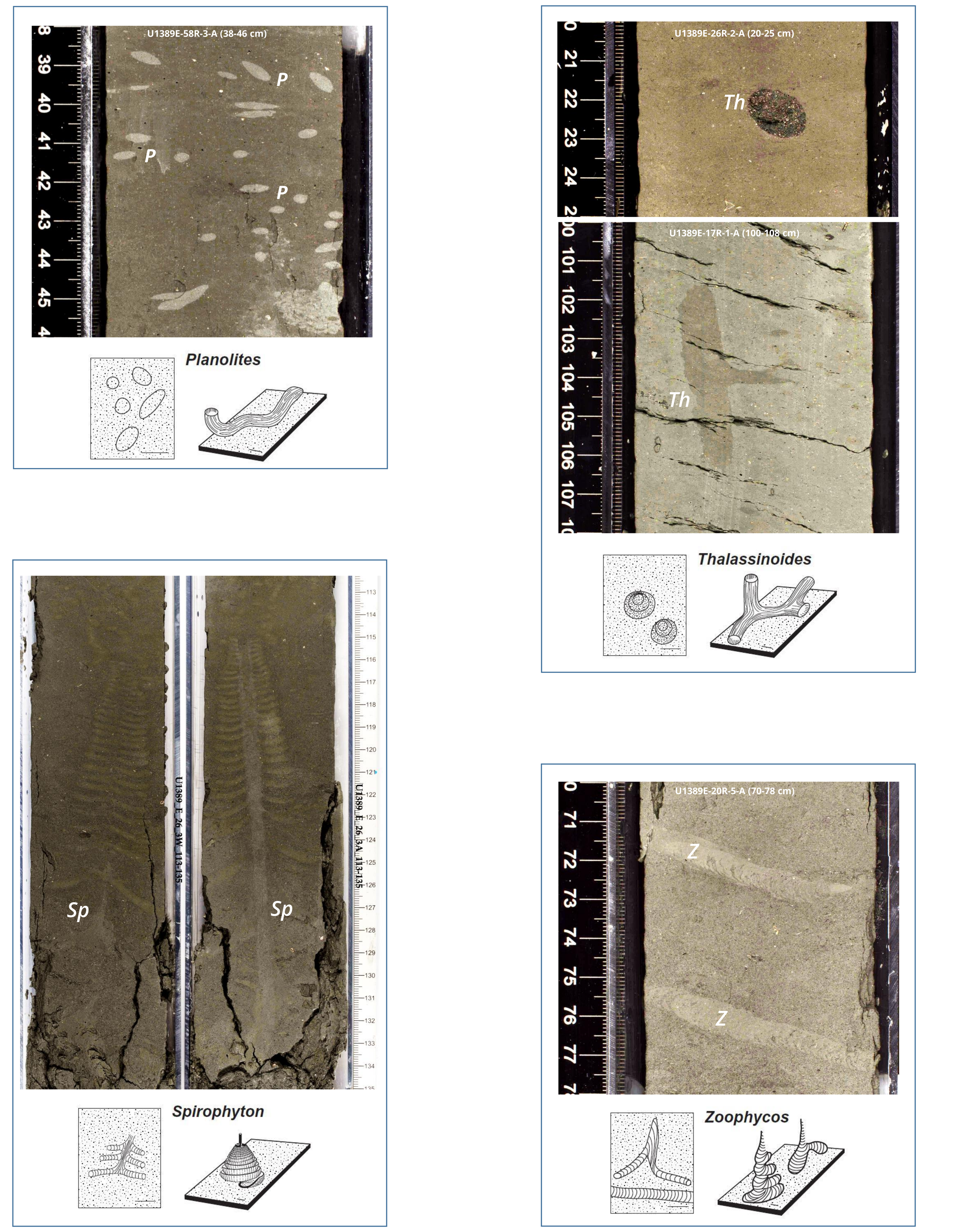
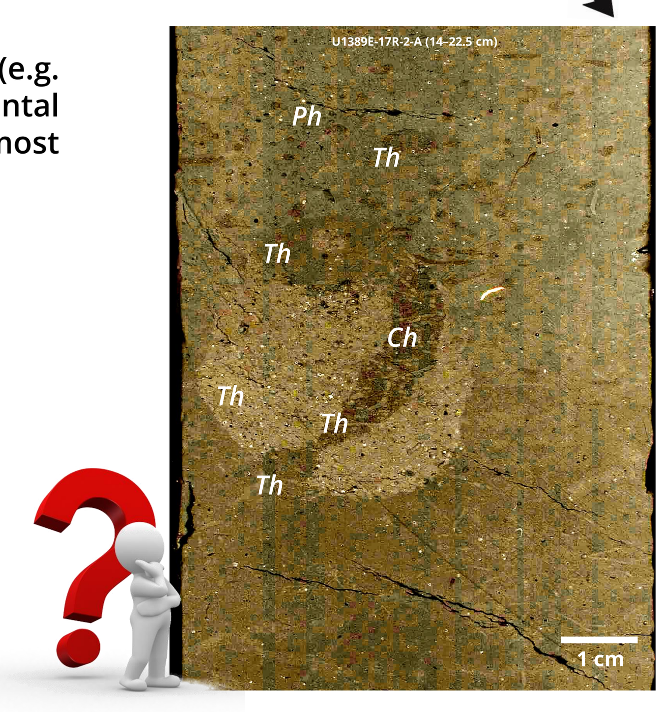


Fig. 5. Diagram of the *Zoophycos* Ichnofacies (MacEachern *et al.*, 2007).





Cross-cutting relationships



References

Buatois, L. A. & Mángano, M.G. (2011) *Ichnology: Organism-Substrate Interactions in Space and Time*. Cambridge University Press, New York, 358p.

Dorador, J. & Rodríguez-Tovar, F. J. (2018) High-resolution image treatment in ichnological core analysis: Initial steps, advances and prospects. *Earth-Science Reviews*, 177, 226–237.

Dorador, J., Rodríguez-Tovar, F. J. and IODP Expedition 339 Scientists (2014a) Digital image treatment applied to ichnological analysis of marine core sediments. *Facies* 60, 39–44.

Dorador, J., Rodríguez-Tovar, F.J. and IODP Expedition 339 Scientists (2014b) Quantitative estimation of bioturbation based on digital image analysis. *Marine Geology*, 349, 55–60.

Droser, M. L. and Bottjer, D. J. (1986) A semiquantitative field classification of ichnofabric. *J. Sediment. Petrol.*, 56, 558–559.

Hernández-Molina, F. J., Stow, D., Alvarez-Zarikian, C. and Expedition IODP 339 Scientists (2013) IODP Expedition 339 in the Gulf of Cadiz and off West Iberia: decoding the environmental significance of the Mediterranean outflow water and its global influence. *Sci. Drill.*, 16:1–11. doi:10.5194/sd-16-1-2013

Knaust, D. (2017) Atlas of trace fossils in well core: appearance, taxonomy and interpretation. Springer, Cham, Switzerland, 209p.

MacEachern, J., Pemberton, G., Gingras, M. & Bann, K. L. (2007) The ichnofacies concept: a fifty-year retrospective. In: Miller, III, W. (Ed.) Trace Fossils: Concepts, Problems, Prospects. Elsevier, Amsterdam, 50-75.

McIlroy, D. (2004) Some ichnological concepts, methodologies, applications and frontiers. In: D. McIlroy, (Ed.), The application of ichnology to palaeoinvironmental and stratigraphic analysis. *Geol. Soc.., London, Special Publ.*, 228, 3-27.

Stow, D.A.V., Hernández-Molina, F.J., Alvarez Zarikian, C.A. and the Expedition 339 Scientists (2013) Proc. IODP, 339: Tokyo (Integrated Ocean Drilling Program Management International, Inc.). doi:10.2204/iodp.proc.339.2013

Taylor, A. M. & Goldring, R. (1993) Description and analysis of bioturbation and ichnofabric. J. Geol. Soc. Lond. 150, 141–148.

Wetzel, A. & Uchman, A. (2012) Hemipelagic and pelagic basin plains. In: Knaust, D., Bromley, R.G. (Eds.), Trace Fossils as Indicators of Sedimentary Environments. *Developments in Sedimentology*, 64. Elsevier, Amsterdam, 673–701.