Physical properties of sediments from Madeira Abyssal plain : results from ODP Leg 157

Propiedades físicas de los sedimentos de la LLanura abisal de Madeira: Resultados del ODP Leg 157

J. Baraza (*) and ODP Leg 157 Shipboard Scientific Party

* CSIC - Instituto de Ciencias del Mar. PA Juan de Borbón s/n. 08039 Barcelona

ABSTRACT

Physical properties measured on cores from drill Sites of ODP Leg 157 reveal that the different turbidites of Madeira Abyssal Plain have a distinct physical signal. Major differences result from the compositional variations among the three main types of turbidites (volcanic, organic-rich, and calcareous), and from changes in the carbonate content in the pelagic intervals.

Key words: *Ocean Drilling Program, Madeira Abyssal Plain, physical properties, multi-sensor track, logging.*

RESUMEN

Las propiedades físicas medidas en los testigos recuperados de los sondeos del Leg 157 de ODP revelan que las diferentes turbiditas existentes en la Llanura Abisal de Madeira presentan una señal física característica. Las principales diferencias resultan de las variaciones composicionales entre los tres tipos principales de turbiditas (volcánicas, orgánicas y calcáreas), así como por cambios en el contenido en carbonato en los intervalos pelágicos.

Palabras clave: *Perforación oceánica, LLanura Abisal de Madeira, propiedades físicas, sensores, logging.*

Geogaceta, 20 (2) (1996), 405-407
ISSN: 0213683X

Introduction

ODP Leg 157 drilled three sites (950 to 952) in the Madeira Abyssal Plain (MAP) (Fig. 1), which reveal a detailed history of organic, calcareous and volcaniclastic turbidite deposition that began between 11.3 and 15 My (Shipboard Scientific Party, 1996). The specific objectives of the physical properties measurements program of Leg 157 were to provide a high resolution data set of the physical signals recorded in the sediments, and to determine the effect of sedimentologic,textural and compositional changes (i.e., turbiditic vs. volcaniclastic, vs. pelagic sediments) on the sediment physical properties.

Methods

Continuous, nondestructive, high-resolution measurements of different properties on whole-round core sections were obtained from the Multi-Sensor Track (MST). Point measurements on the split cores included shear strength and P-wave velocity. Throughout the core, index properties: water content (w); bulk density (γ); dry density (γ_d); grain density (G_s); porosity (n); and void ratio (e) were calculated. For methodology details see Shipboard Scientific Party, 1993 and 1994.

Lithology of drilled sediments

The complete sedimentary sequence of the abyssal plain, comprising four lithologic units, was obtained on Site 950; Sites 951 and 952 only drilled Unit I. There are three main , characteristically-coloured, types of turbidites: a) volcanic (gray) from the nearby volcanic islands; b) organic-rich (green) from the African margin; and c) calcareous (white) from the seamounts west of the MAP. All three are fine-grained, occasionally have silty bases, and only some of the calcareous have coarse, foraminiferal sand bases.

Unit I (0-314 mbsf): Pleistocene to middle Miocene (0-13.6 My.) turbidites, interbedded with pelagic oozes, mixed sediments and clays, with calcium carbonate contents between 40-608. Below 150 mbsf calcium carbonate content on the pelagic intervals decreases to 10-40%. On Site 952 between 380-405.5 mbsf, several thick sands occur, grading into thick turbidite muds.

Unit II (314-332 mbsf): Middle Miocene (13.6-15 My.) massive calcarenite with shallow water carbonate Clasts and benthic foraminifers.

Unit III (332-370 mbsf): Middle Miocene to middle Eocene(15 to 47 My.) red pelagic clays with thin nannofossil clayey interbeds and volcanic-ash bands.

Unit IV (370-381 mbsf): two depositional units of dark volcanic siltstone and sandstone separated by clay.

Physical properties

The upper units drilled at Sites 950 to 952 display typical downhole profiles of increasing bulk density and decreasing porosity and water content with depth, suggesting that the dominant physical process within the upper 200 mbsf is gravitational compaction from overburden pressure. Between 150-350 mbsf, a lower range of variation of index properties downhole is observed, which is

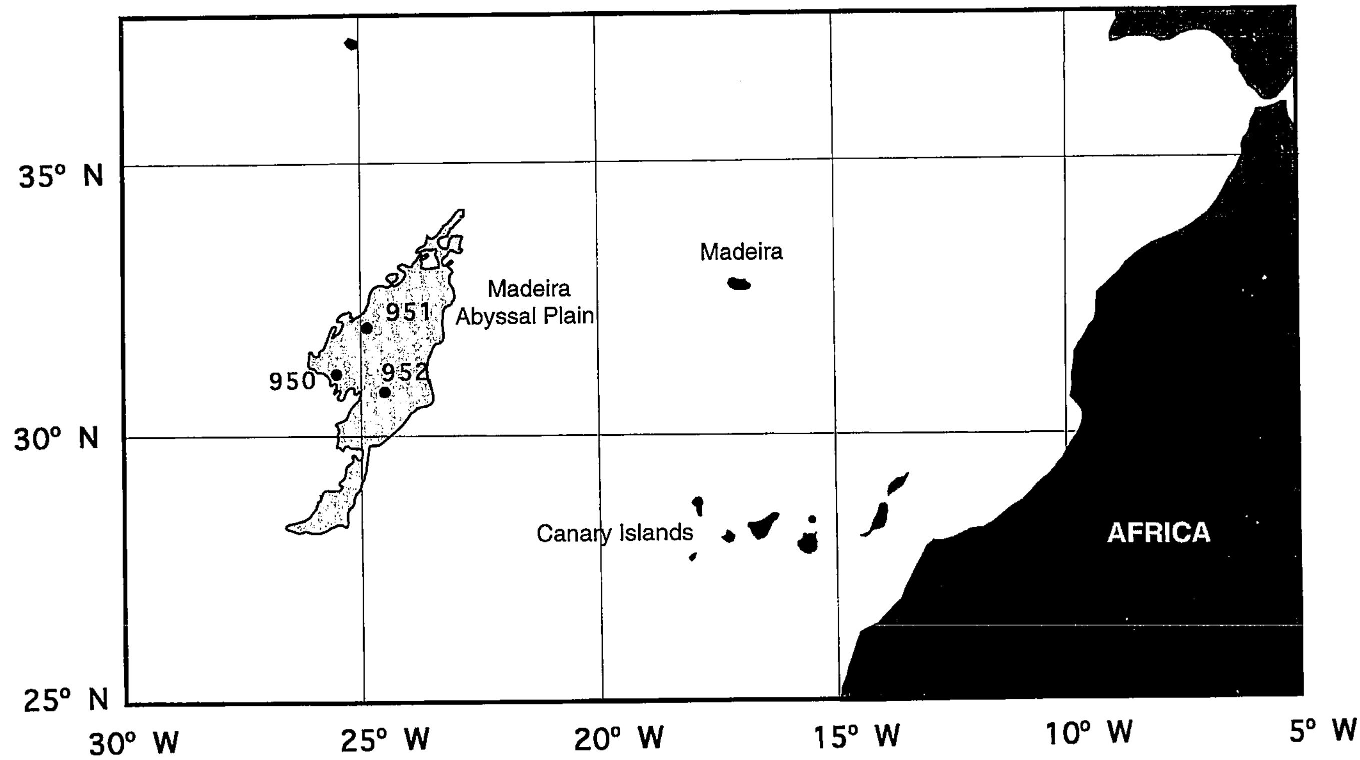

Fig. 1.- Map showing the location of Madeira Abyssal Plain and the locations of the three Sites drilled during Leg 157. Shaded area indicates the total extent of flat, ponded sediments.

Fig. 1.- Mapa que muestra la situación de la llanura Abisal de Madeira y la localización de los sondeos perforados durante el Leg 157. La zona sombreada indica le extensión total de los sedimentos horizontales del fondo de la cuenca.

reflected in a minor increase, and even slight decrease, of bulk density and the opposite variation for water content and porosity. This tendency is sharply interrupted at about 310 mbsf on Site 950 by the presence of a strongly lithified calcareous sandstone overlying red clay and volcanic sand intervals, which result in strong contrasts in the density and porosity downhole profiles within a short core interval. Similarly, at the base of Site 951 coarse-grained sandy turbidites and debris flow intervals produce well-marked peaks of density increase, as well as porosity and water content decrease on the downhole trend of index properties. Some differences between the three Sites are reflected on the Grain Density profile, which (unlike water content and bulk density) usually does not have a typical depth trend. The major differences consist on larger grain density values on the upper 60 m of the sedimentary column for Site 950, reflecting a major dominance of volcanic turbidites along that interval. Variations in Grain Density for all three cores below 140 m and 280-310 m reflect compositional changes related with a decrease on carbonate and silica content.

MST data show a high-resolution, continuous downcore variation of physical properties. The GRAPE density data show a large number of spikes which may actually correspond to fine- scale lithologic variations. The larger spikes correspond to relatively coarse-grained (silty) bases of either volcanic or calcareous turbidite intervals having densities between 1.8 to > 2.0 g/cc, interbedded between the lower density (avg. 1.65-1.70 g/cc), organic-rich turbidites. The general trend of GRAPE density shows a downcore increase from 1.50 g/cc near the mudline to 1.82 g/cc at about 120 mbsf, where a marked decrease in GRAPE density occurs. Intervals with different downcore trends or sharp changes of GRAPE density allow to define geotechnical subunits within Lithological Units.

Magnetic susceptibility profiles show numerous high-amplitude spikes that are related to lithologic or compositional variations. Peaks of high magnetic susceptibility having values of over 110*10-6 SI units correlate with intervals of volcanic turbidites which are much more common above 250 mbsf. These levels are also characterised by relative lows in GRAPE density and P-wave velocity, two parameters that commonly show similar trends through all the measured core intervals. In contrast, organic-rich turbidites show low magnetic susceptibility and high density and velocity. Intervals of calcareous and intermediate type turbidites have typical physical property values between the organic and volcanic intervals.

Strength data from the three holes show a general increase downcore from near 0 kPa (1. 5 mbsf) to 40 kPa (85 mbsf), and 200-230 kPa (200-260 mbsf), but also a wide data scatter below 120 mbsf, corresponding to lithologic changes and to limitations of the methods used. Low strength values (50-100 kPa) in the interval between 200-220 mbsf in Hole 950A, correspond to the weaker nannofossil-rich beds. In Hole 951, a slightly decreasing trend and a large scattering are observed from 200 to 260 mbsf. Whereas in Hole 952, the deep calcareous turbidites are stronger than the interbedded clay-rich turbidites, sug-gesting a change in the primary com-position or perhaps the diagenetic history.

Conclusions

In general, physical properties variations on Sites 950 to 952 define intervals that agree closely with the lithostratigraphic units or that indicate further compositional changes within the sediment, allowing to define geotechnical subunits within the main lithologic units. Volumetric magnetic susceptibility trends downcore are generally useful for lithology interpretation and stratigraphic correlations between holes are especially interesting for defining volcanic turbidite intervals. In general, volcanic turbidite levels are characterised by very high magnetic susceptibility, compared to the rest of sediment types, as well as by low density and velocity.

Acknowledgments

This work is a small part of the initial results obtained during drilling on ODP Leg 157. Specical gratitude is expressed to the co-chiefs Phil Weaver and Hans Schmincke, the physical properties team (Bernie Coackley, Tomas Funck and Julie Hood) and the ODP technical staff. Susana Lebreiro provided the updated lithologic logs. This work is also a contribution to STEAM, MAST II Project (Ref. MS2/CT/94/0083). Funding was provided by CICYT (Ref. AMB94-1281-E). We thank Gemma Ercilla for her helpful suggestions.

References

Shipboard Scientific Party, 1996. Schmincke, H.U., Weaver, P.P.E., Firth, J., *et al.*, Proc. ODP, Init. Reports, 157. College Station, TX (Ocean Drilling Program) (in press).

Shipboard Scientific Party, 1993. Explanatory Notes in Thiede,J., Mhyre, A., Firth, J., *et al.*, pros. ODP, Init. Reports, 151: College Station, TX (Ocean Drilling Program).

Shipboard Scientific Party, 1994. Explanatory Notes in Shipley, T., Ogawa, U., Blum, P., , et al., Proc. ODP, Init. Reports, 156: College Station, TX (Ocean Drilling Program).

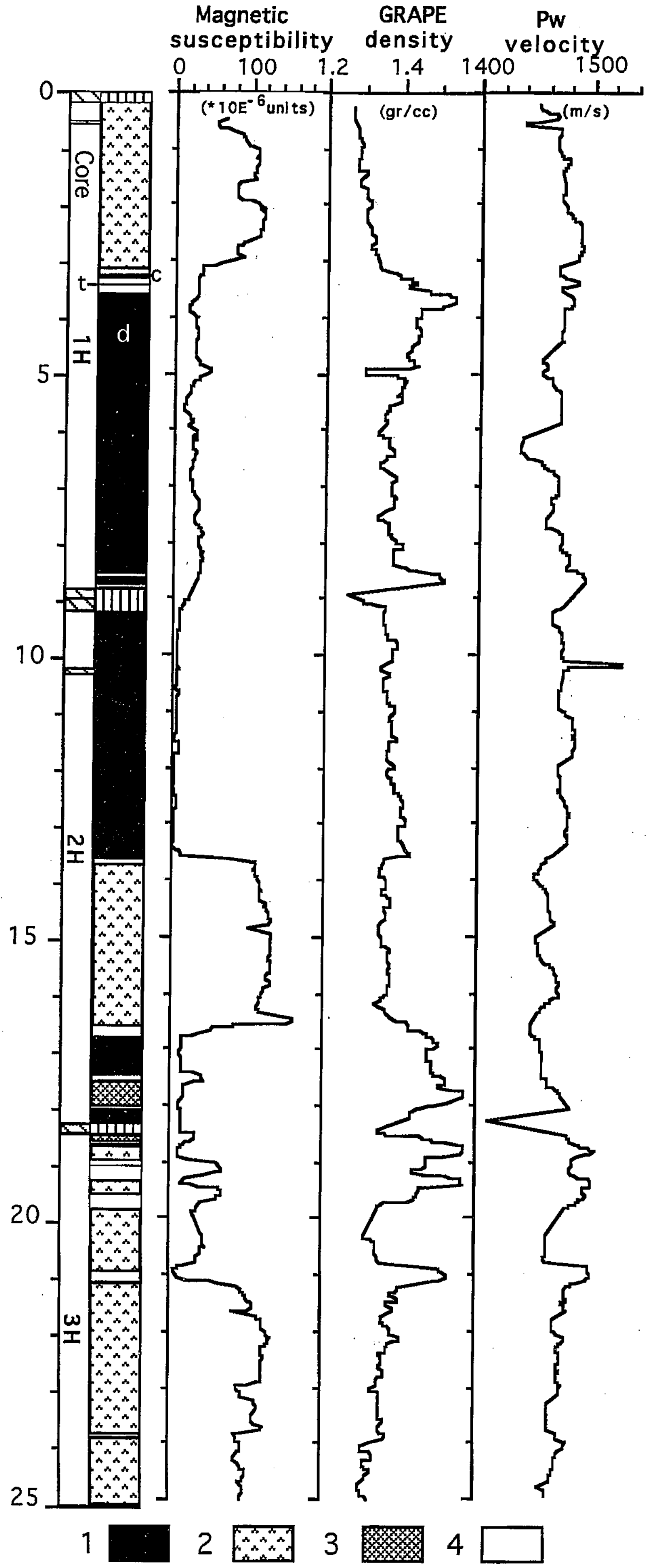

Fig. 2.- Lithologic log and MST record (magnetic susceptibility, GRAPE density, and P-wave velocity) of the upper 25 mbsf of Site 950. Legend: 1: Green (organic-rich) turbidite; 2: Gray (volcanic) turbidite; 3: White (calcareous) turbidite; 4: Pelagic ooze, marl and clay

Fig. 2.- Columna litológica y regristro del sensor MST (susceptibilidad magnética, densidad GRAPE, y velocidad de ondas-P). Leyenda: 1:turbiditas verdes(organicas); 2:turbiditas grises (volcánicas); 3:turbiditas blancas (calcáreas); 4:Oozes pelágicos,margas y arcillas.