

Maar-diatreme infill features recorded in borehole imaging

Características del relleno de un maar-diatrema a partir del registro de imágenes de sondeo

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Abstract: Oriented borehole images recorded with an ultrasonic acoustic televiewer and continuous coring recovery has allowed the characterization of different facies and volcanic processes involved in the infill of a maar-diatreme volcano type. Maar-diatremes are associated with strong explosions throughout most of their development, focused along feeder dikes and generally attributed to magma-water interaction. In the case study of Camp dels Ninots maar-diatreme (Girona, Spain) we have recognized four facies types located in the center of the maar-diatreme: volcanic ash, phreatomagmatic breccia with lithics and juveniles, vesicular pyroclasts (scoria), massive basalt or welded pyroclastic fragments. Ultrasonic televiewer images allow to characterize the different volcanic facies, since they display a different degree of reflectivity and textures. Other features such as fracturing and grain size can be directly measured on the images.

Keywords: Maar-diatreme, Wireline coring, Borehole imaging, Geophysical logging measurements, Phreatomagmatism.

Resumen: El registro de imágenes orientadas de sondeo junto con la recuperación continua de testigos han permitido caracterizar las diferentes facies y los procesos volcánicos implicados en el relleno volcanosedimentario de un volcán de tipo maar-diatrema. Los maares-diatrema están asociados con fuertes explosiones, donde la mayor parte de su desarrollo esta centrado a lo largo del dique de alimentación y generalmente atribuido a freatomagmatismo producto de la interacción del magma con el agua. En el caso de estudio del Camp dels Ninots maar-diatrema (Girona, España), se reconocen cuatro facies principales a partir de un sondeo realizado en el centro del maar-diatrema: cenizas volcánicas, brecha freatomagmática con líticos, piroclastos vesiculados (escorias), basaltos masivos o piroclastos soldados. En las imágenes del televiewer acústico es posible caracterizar las diferentes facies, ya que estas presentan diferentes grados de reflectividad y texturas. Otras características tales como fracturación y tamaño de grano se pueden cuantificar también a partir de las imágenes.

Palabras clave: Maar-diatrema, Perforación wireline, Testificación geofísica, Imágenes orientadas de sondeo, Freatomagmatismo.

INTRODUCTION

Borehole imaging is a powerful technique that helps to identify centimeter to millimeter-size features on the borehole wall. Typically, such features include layering and bedding, other sedimentary, diagenetic and tectonic structures, but its potential use goes far beyond these examples. We have successfully applied borehole imaging in a continental volcanic context, particularly that of maar-diatreme structures. In this study we describe images from a hole (CP-2, see Miró et al, this volume) drilled using a wireline coring in the Camp dels Ninots maar-diatreme (CNMD) (Girona, Spain). The infill of the volcanic deposits of this maar-diatreme and its structure is the goal of this contribution.

GEOLOGICAL SETTINGS

The Camp dels Ninots maar-diatreme is a Pliocene

volcano located just SW of Caldes de Malavella village (Girona province, Spain). This volcanic structure belongs to the Catalan Volcanic Zone (CVZ), one of the volcanic provinces of the European Rift System (Martí et al., 1992) (Fig. 1). The tectonic evolution of this volcanic region was controlled by a system of NW–SE extensional Neogene faults leading to the formation of several fault bounded basins (Bolós et al., 2015). The faults bounding of the La Selva Basin (Fig. 1) contain maar-diatreme such as La Crosa de Sant Dalmai (Bolós et al., 2012) and the CNMD case study.

Compositionally, the rocks of this volcanic region are mainly basanites and alkaline basalts. Hydromagmatic events have been common in the CVZ giving rise to a large variety of eruptive sequences and morphologies despite the usual monotony in magma composition (Martí et al., 2011).

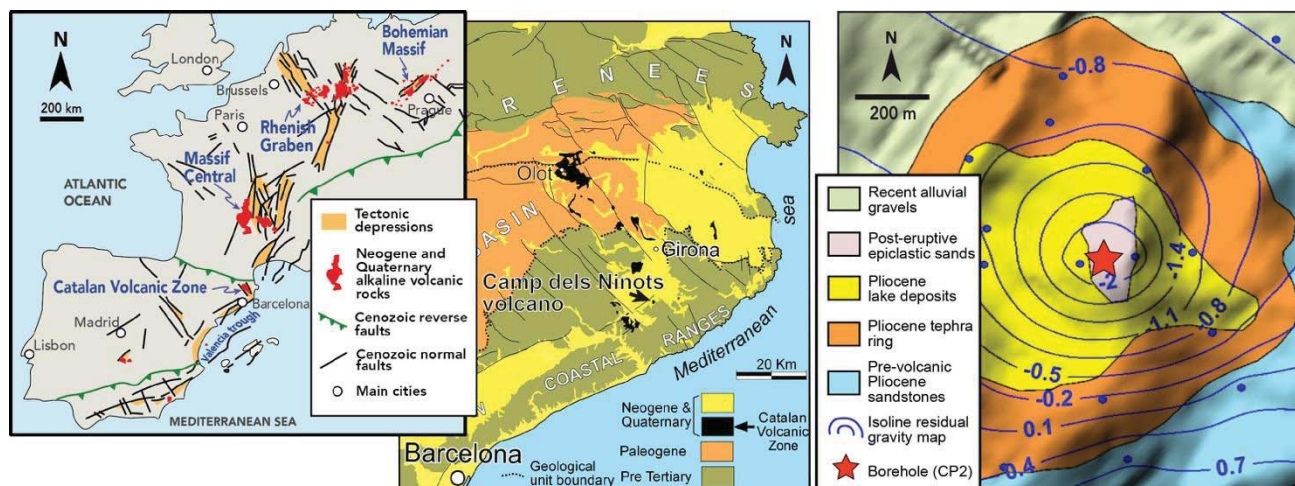


FIGURA 1. Geological settings of the Camp dels Ninots maar-diatreme (CNMD). Left: Location of the Catalan Volcanic Zone in the European Rift System (modified from Bolós et al., 2015). Center: Situation in the Catalan Volcanic Zone. Right: Geological map of the CNMD with indication of the isoline residual gravity map and location of CP2 borehole in the center of the gravimetric anomaly (modified from Oms et al., 2015).

Vehí et al. (1999) identified and described for first time the morphology of CNMD, which had remained largely unknown since it hardly has any geomorphological evidence of the original tephra ring. More recently, Oms et al. (2015) have reported a detailed geological study of the maar structure based on several drill cores and 9 electrical resistivity tomography cross sections. The geology at CNMD area includes: (1) basement rocks (granites and few schists) of Late Carboniferous – Permian age and (2) Pliocene arkose sands, clays and gravels of the La Selva Basin alluvial fan systems that may be up to 150 m thick. At CNMD the contact between these two geological units is a fault zone that recharges the Pliocene aquifer. Post volcanic sediments include lacustrine strata that accumulated within the maar-diatreme.

METHODS

According to the results obtained from gravity and electrical tomography data reported by Oms et al. (2015), we chose a drill site that was successfully cored (145 m depth) in the center of the diatreme. The main scientific goal was to obtain a complete record of the entire proximal (i.e. central) facies section of the diatreme. A complete set of geophysical logging measurements including oriented ultrasonic borehole images was acquired. Borehole images were processed in order to enhance geological and textural features. Borehole images displayed together with core images, allowed us to orient the cores and also to characterize in detail volcanic rocks facies and features (Figure 2). Finally, we could also characterize the type of rocks in zones of low core recovery. Static processing of the ultrasonic borehole images was also useful to determine changes in lithology and texture along the borehole section of the volcanic deposits analyzed in this study.

RESULTS AND DISCUSSION

We identified four volcanic facies in the drill core and correspondence with distinctive features, reflectivity and rock textures displayed on borehole images (Fig. 2). The first facies corresponds to thin layers of ash. The example shown in Figure 2a is located at a depth of 85.80 m and is interpreted as a pyroclastic base surge deposit formed during the highest explosive phase of the phreatomagmatic eruption. This depth corresponds to the upper part of the diatreme and therefore to the most stratified deposits of the internal structure of maar-diatremes.

The second facies type is breccia having a varying amount of juvenile basaltic rocks and country rock lithic clasts. This is the most abundant facies along the borehole. Figure 2a shows a case of dominance of juvenile fragments. Figure 2b shows a 25 cm lithic of granites embedded in a country rock lithic-rich breccia with scarce juvenile fragments.

The third type of facies is welded pyroclastic fragments of massive appearance. In the ultrasonic acoustic televiewer they appear very reflective and fractured (Fig. 2c). This facies is dominant in the deeper part of the borehole which suggest that low explosivity occurred in the deeper part of the studied record (i.e. first eruptive phases).

Finally, the fourth facies type belongs to vesicular pyroclasts (scoria). This facies present singular textures in the imaging logs (Fig. 2d), with very low reflectivity patches (vesicles) alternating with a more reflective basaltic rock.

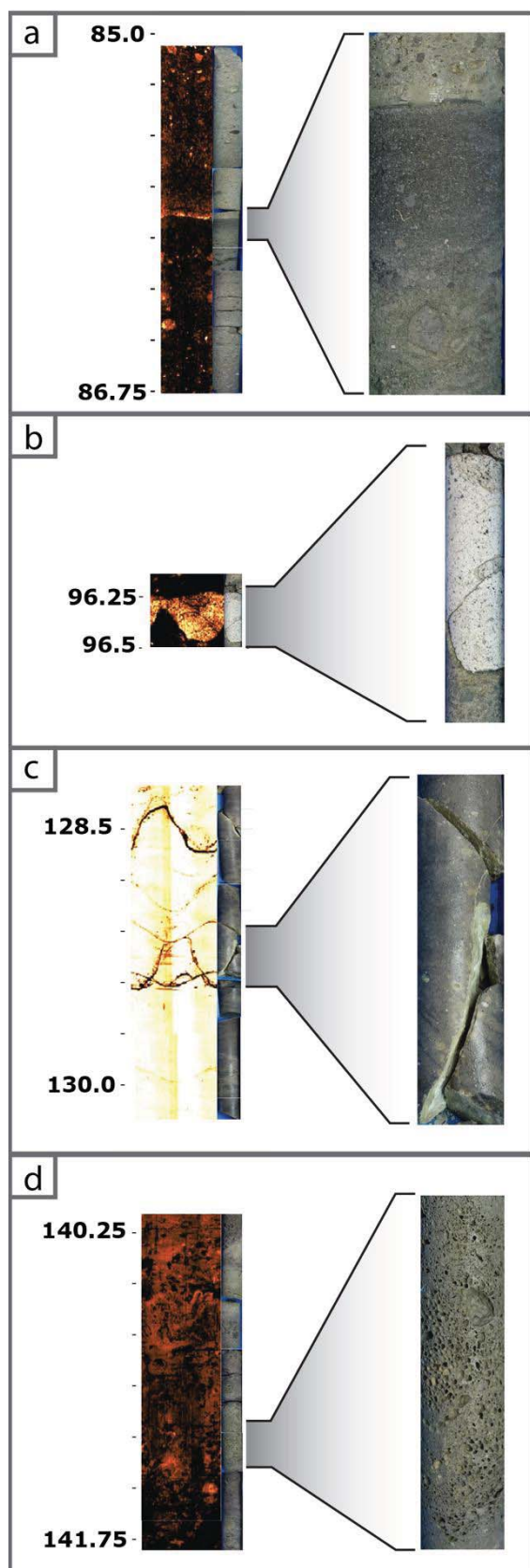


FIGURE 2. Ultrasonic acoustic televiewer and detailed core picture (left and right respectively) of the CP2 well showing the identified facies types of the Camp dels Ninots maar-diatreme. a) thin layer of ash and phreatomagmatic breccia, consisting of a mixture of intrusive juvenile and country rock fragments, mainly Paleozoic granites. b) detail of a Paleozoic granite lithic. c) massive basalt consisting of welded pyroclastic fragments. d) vesicular pyroclasts (scoria).

CONCLUSIONS

Borehole imaging and wireline logging at CP2 borehole have been successfully applied to volcanic deposits and facies characterization. Moreover, we have successfully established a correlation between cores and borehole ultrasonic televiewer oriented images. Several facies types can be easily characterized both on cores and on borehole images: thin ash layers, phreatomagmatic breccia (containing both intrusive juvenile and country rock fragments), massive basalt and vesicular pyroclasts (scoria). Borehole imaging techniques and logging data could therefore be successfully used for volcanic facies characterization at depth especially in sections of low or no core recovery. On this high quality borehole images detailed interpretations and measurements can be performed.

ACKNOWLEDGEMENTS

Projects 2014-100575 from Departament de Cultura de and SGR2014-901 from AGAUR (both from Generalitat de Catalunya) financed the drilling campaigns. The Town Council of Caldes de Malavella for provided logistics and Mr. Jaume Pla permitted us to work in his property. Borehole images were processed with Techlog software (Schlumberger).

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