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Quantitative Characterization of Oligocene-Miocene Carbonate Mound Morphology from 3D Seismic Data: Applications to Geologic Modeling, East Java Basin, Indonesia

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Abstract

The High Density MC3D seismic survey, acquired by PGS in 2003 over the North Madura platform, is excellent data for quantitative interpretation of carbonate buildups. Detailed imaging of the growth histories of Oligocene-Miocene carbonate buildups provides insight into geometric parameters characteristic of platform initiation, development, and demise. Mound initiation occurs with development of small (<100 m to 500 m diameter), closely spaced, domal buildups, which become the nuclei for the formation of intermediate mounds (2 km to 3 km diameter). Nucleation mounds build concentrically to form intermediate mounds, which selectively coalesce into amalgamated platforms (>5 km diameter), become isolated platforms of varying size (<5 km diameter), or die off altogether.

The high resolution and quality of the seismic data enable visualization and quantitative analysis of geometry, orientation, and spatial distribution of nucleation and intermediate mounds, suggesting models for development of mounds in platform, basinal, and channelized regions. Seismic Discontinuity time-slices datumed at the base of the carbonate section provide clear images of mound morphology at discrete growth steps in each of these regions. Other seismic attributes (e.g., isochron) can be exploited by innovative volume interpretation techniques for extracting mound features and calculating geometric attributes such as mound area, aspect ratio, orientation, etc. directly from the seismic data. The resulting data provide dimensional, spatial, and seismic facies characteristics of carbonate buildups for conditioning geologic models. Additional ties to well and outcrop data improve prediction of reservoir presence, quality, and distribution.

Introduction

This study utilizes the PGS HD-MC3D seismic survey (PGS, 2003) to examine the evolution of Burdigalian (early Miocene) age carbonate build ups on the North Madura platform in north central East Java Basin (Figure 1). In addition to visualizing the features of carbonate mounds in the seismic data, the aim of this study was to derive and compile a comprehensive database of quantitative dimensional and geometric data for various growth stages of Burdigalian mounds directly from 3D seismic data (Figure 2). This database improves the understanding of the evolution of carbonate mounds of this age and capabilities for predicting the size, shape, and distribution of Burdigalian mounds. It is also a resource for conditioning and populating geologic models in analogous areas where seismic data is limited.

The HD-MC3D survey covers a portion of the 200+ km in length Oligo-miocene North Madura carbonate platform (Figure 1B). It is a high resolution survey with spectacular imaging of the Tertiary carbonate section, as well as clastic intervals and structural features (Figure 3). Examples of the details of the early Miocene section imaged in the survey are shown in Figure 1 in a discontinuity time slice (Figure 1D) and a shaded relief map of the time surface for the Burdigalian interval (Figure 1E).

In the North Madura area, the Burdigalian section sits between 3000 and 4000 ft TVDSS (Figure 3). It is an interval characterized by large amalgamated and isolated platform growth, with multiple stages of growth evident in the seismic data.