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3D Seismic Geomorphological Analysis of Submarine-fan Turbidite Reservoir Distributions and Shape Variations Using Seismic Facies and Sedimentological Information: Examples from Active Margin Basins

O. Takano, M. Nishimura, T. Tsuji, JAPEX Research Center, T. Saeki and T. Fujii, Japan Oil, Gas and Metals National Corporation

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Abstract

Recent development of 3D seismic technology enables to visualize three-dimensional distributions of subsurface reservoir rock bodies. It is expected that linking this technology to sedimentological concept and methods such as depositional systems and sequence stratigraphy leads to realistic and efficient solutions in reservoir distribution analysis, since such genetic process information provides a guideline for better interpretation and evaluation. This study attempted to analyze 3D seismic geomorphology of submarine-fan turbidite reservoirs by integrating sedimentological methods and 3D seismic technique. As case study examples, total 40 stratigraphic horizons in four fields, where the major depositional system is submarine-fan turbidite system, were selected in active margin basins mainly around Japan. Detailed distribution analysis and sedimentological interpretation were conducted on 3D seismic data by displaying sediment bodies, using seismic facies, amplitude volume and various seismic attribute data to determine finer depositional elements of submarine fans. In the seismic facies mapping, software that categorized seismic trace shapes as an element of seismic facies was used for mapping seismic facies distributions. Subsequently, the shape of the displayed and interpreted submarine fans was categorized qualitatively, and the dimensions were measured quantitatively. In this study, four types of submarine-fan shape were identified (Type I, II, III and IV) as major morphology of active margin submarine fans. Type I represents a sandy radial fan type, containing distributary channels and depositional lobes. Type II represents an elongated muddy channel-levee type, which comprises elongated sandy channels and muddy levees. Type III represents a mixture of Type I and Type II, consisting of a leveed channel at the proximal part and a terminal fan at the distal part. Type IV represents a large mound type, which is composed of muddy sediments. These results are expected to be a useful tool for submarine-fan turbidite reservoir exploration and development in active margin basins.

Introduction

Recent development of 3D seismic technology enables to obtain realistic subsurface geologic data and to visualize three-dimensional distributions of geologic bodies using seismic attributes and 3D visualization techniques. Traditional subsurface analysis based on one-dimensional and two-dimensional data required estimation for areas that were not covered by data. In contrast, 3D seismic technology enables to obtain actual three-dimensional morphology, structure and distribution of geologic bodies without any estimation. From this aspect, the 3D seismic technology has been widely applied for recent hydrocarbon exploration and development projects, and provides strong impacts on reservoir distribution analysis, production management and reservoir characterization works.

This paper focuses on sedimentological usage of 3D seismic technology, which can be applied for reservoir distribution analysis and reservoir characterization works. First, this paper reviews a historical background for the relationships between 3D seismic technology and sedimentology, introducing the development of the "seismic geomorphology[1]" concept. Subsequently, as an actual application example, this study selects submarine fan system, and presents the results of seismic geomorphological analysis for submarine-fan turbidite sandstone reservoir distributions with special reference to submarine-fan shape variations in a tectonically active area.

Seismic geomorphology as an integration of sedimentology and 3D seismic technology

There have been close relationships between sedimentology and 3D seismic technology since 1970's (**Fig. 1**). In 1970's, the development of 2D seismic technology resulted in the concept of "seismic stratigraphy[2]". Subsequently, in the late 1080's, the