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Crustal structure in Chile and Okhotsk Sea regions

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ABSTRACT

In the region of Chile the refraction and wide angle reflection migration, applied to CINCA seismic data, enable to reveal some new peculiarities of the crustal structure which do not agree with the simplified classical model of the oceanic lithosphere subduction. A fault zone separated the oceanic and continental crusts are imaged in the migration section. A subhorizontal detachment is found in the continental crust. In the Okhotsk Sea region the reinterpretation of the old DSS data shows a block structure of the crust and a complicated system of faults along the Kuril Islands and between the Sakhalin Island and the South-Okhotsk basin. The crustal type changes: the basin crust is of oceanic type whereas in all other parts of the Okhotsk Sea it is of continental or subcontinental types. The lower velocities are typical of the middle crust of the Ockotsk Sea but along both sides of the Kuril Islands high velocity bodies are intruded in the crust showing the process of crustal basification. In the uppermost mantle beneath the Sakhalin Island a reflected boundary dipping from the Moho to a depth of 50 km is revealed.

1. Introduction

The paper has two aspects: (1) to show some peculiarities of the crustal structure in two different transition zones between the Pacific and continents, Chile and Okhotsk regions, and (2) to present new methods of the refraction and wide-angle reflection data interpretations which enable to make the results more informative.

Traditionally at the Deep Seismic Sounding (DSS) or wide-angle seismic profiling only velocity cross-sections of the crust and upper mantle are determined. For this purpose travel-times of the refracted and reflected waves are used, that is the kinematic interpretation of the data. The dynamic (phase and amplitude) interpretation of seismic records is limited to calculating synthetic seismograms for simple velocity models and to a comparison between these seismograms and complicated observed wave fields.

A new perspective direction in processing DSS records is migration of refracted and wide-angle reflected waves and construction of seismic images similar to the reflection (CDP) cross-sections. It is difficult to get such images with the algorithms developed in CDP method. Some attempts are made to get the Moho images from the normal move out corrected section created from the wide-angle reflections data (Sakoulina et al., 2000; Carbonell et al., 2002; Creaser and Spence, 2005). A strict solution of this problem both for the wide-angle reflections, and for the refracted waves is given in the papers (Pilipenko, 1991; Pylypenko and Goncharov, 2000). The received algorithms were used successfully at DSS data processing for different regions (Pilipenko et al., 1999; Pavlenkova et al., 2003). Below the results of refracted and wide-angle reflected wave migration along the profile CINCA95–7 in area of Chile are presented.

A reinterpretation of the old DSS data, made in 50–60 s of the last century in the Okhotsk Sea region, are also considered in this paper using new methodological approaches. This work improves reliability of the velocity models and enables to get new information on the crustal structure in this active continental margin.

2. The Chile region

Long-term works under the CINCA project have been directed on complex research of the earth's crust and the upper mantle in the transition zone from Pacific Ocean (plate Nazca) to the continent (the Central Andes). Under this project in 1995 the wide angle reflected and refracted waves researches have been conducted along several profiles crossing the Chile Trench and the continental slope with an average length of profile in 300–400 km. The observations were made by Free University of Berlin and the GeoForschungCenter of Potsdam (Patzwahl et al., 1999).

2.1. The characteristic of the experimental material; velocity models of the crust

The CINCA95 observations consisted of a series of the land stations exposed along the profiles with an interval of 3–6 km. They recorded airguns moved along the sea parts of the profiles (one of the profile, CINCA95-7, is shown in Fig. 1). As a result each station had been received records with distance between the traces in 100–200 m. A

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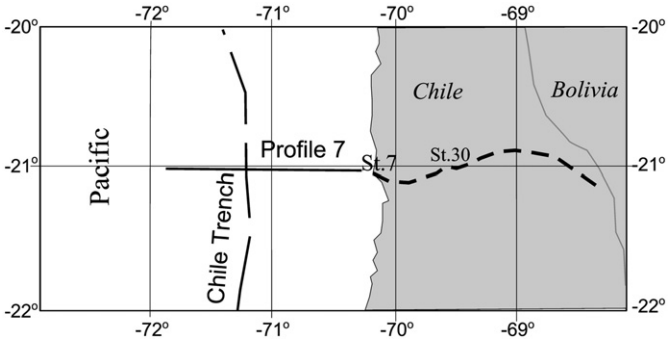

Fig. 1. The location map for the seismic profile 7 of the CINCA95 onshore/offshore wide-angle seismic experiment (Patzwahl et al., 1999). The marine airgun line is shown together with the land profile (dashed curve) of the recorders.

disadvantage of this system is an absence of the reversed observations and of records on small distances from a source (in an interval between the station and the coastal line).

In Fig. 2 examples of seismic records received on the profile 7 are given for two stations: St 7 (the station point SP = 183 km) and St.30 (SP 264). The record-sections are made by a principle of reciprocal points when the seismic stations play a role of a source, and the airguns — a role of recording stations.

The record-section of the St.7 is typical of the observations at distances from the coast up to 80–100 km. At the first arrivals the refracted waves off the basement (wave Pg) with velocities of 6.0–6.5 km/s are recorded. At the secondary arrivals a dominating wave is reflection from the M boundary, PmP. Other phases, basically, at distances from a source of 60–90 km are also allocated, but they are not regular. These waves are non-comparable to the wave off the Moho on amplitude, they are much weaker.

At stations more removed from the coastal line another wave picture is observed (Fig. 2). The waves from the basement and from the Moho are recorded here as multiphase groups among which it is difficult to trace the first arrivals or extended phases. At a distance of 180 km at the first arrivals the wave Pn refracted in the mantle is recorded. The travel-times of this wave are deformed due to the

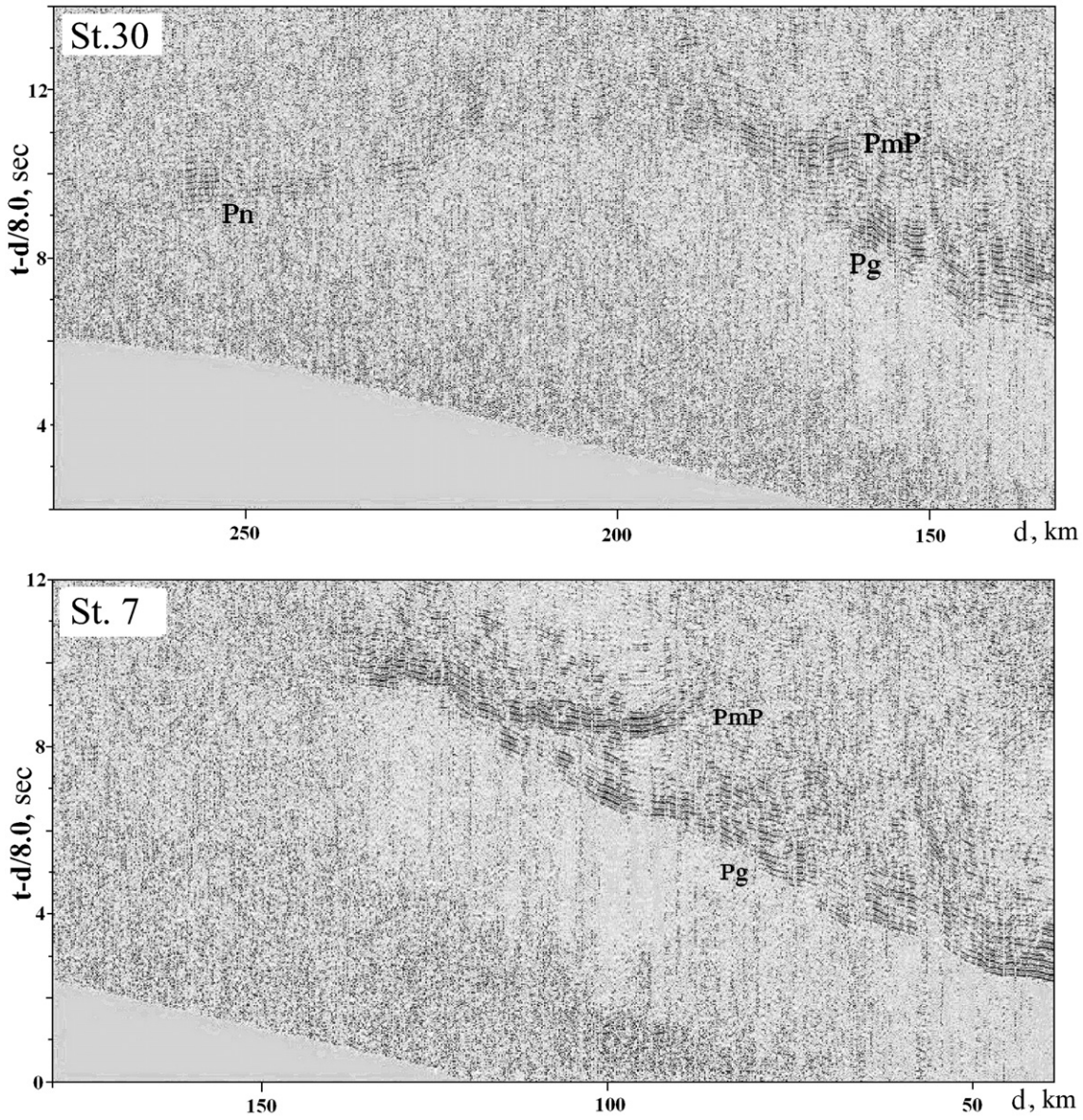

Fig. 2. Record-sections from the stations 7 and 30 along the profile 7 (Fig. 1), reduction velocity of 8.0 km/s. Pg is refracting within the crust, PmP is reflecting off the Moho and Pn is the mantle refraction.