Structure of the South-Eastern Nechako Basin, British Columbia: Results of Seismic Interpretation and First-Arrival Tomographic Inversion*

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Abstract

Reinterpretation of Canadian Hunter seismic reflection profiles provides new insight into the complex structure, stratigraphy and tectonic history of the southeastern Nechako Basin. The basin, which contains predominantly Mesozoic sedimentary and volcanic rocks, is overlain by Eocene and Neogene volcanic rocks and Pleistocene glacial deposits that mask the underlying geology. New results reveal details of how Cretaceous sedimentary and volcanic rocks, deformed during pre-Eocene transpression, were re-activated and cut by NW-SE trending strike-slip faults related to Eocene transtension. First-arrival tomographic models provide new information on the structure and velocity of the near-surface volcanic rocks. The focusing of model rays allows for estimation of the thickness of the Endako Group in the vicinity of well b-82-C, and may elsewhere provide information on the thickness of the Neogene and Eocene volcanic rocks.

Introduction

The Nechako Basin is an Early Cretaceous to Oligocene basin located in the interior plateau of southern British Columbia (Figure 1), between the Rocky and Coast mountains. The sedimentary basin formed over, and in part from, the accreted terranes of the western Canadian Cordillera, where the oceanic Cache Creek Terrane separates the Stikine and Quesnel volcanic arc terranes (Struik and MacIntyre, 2001). Westward-directed thrusting at the boundary between the Stikine and Cache Creek terranes occurred prior to 165 Ma (Schiarizza and MacIntyre, 1999). Transpressional tectonic processes were dominant until the Eocene, when there was a shift to a dextral transtensional regime (Price, 1994) with accompanying volcanism. The basin is bounded by the Cretaceous Skeena Arch to the north, the Coast Mountains and Eocene Yalakom fault to the west, the Cretaceous Tyaughton Basin to the south and the Eocene Fraser fault to the east. The major Yalakom and Fraser faults are associated with the episode of Eocene transtension.

The basin is extensively blanketed by volcanic rocks of the Eocene Endako and Ootsa Lake groups and the Neogene Chilcotin Group, and Pleistocene glacial deposits (e.g., Riddell, 2006), making interpretation of the basin's underlying stratigraphy and structure difficult.

This presentation focuses on the block A (Hayward and Calvert, 2008) and block D (Not presented in this abstract) regions (Figure 1), and re-evaluates the stratigraphy, structure and tectonic history of the south-eastern Nechako Basin, primarily from the interpretation of more than 1,650 km of Canadian Hunter seismic reflection profiles (reprocessed in 2006 by Arcis) and tomographic inversions of first-arrivals. Interpretation is aided by integration with all relevant geological and geophysical data, including well logs, geological maps and potential field data.

Stratigraphy and Structure of Nechako Basin Block A

Near well d-94-G, a sub-basin containing ~2 km of middle/late Albian to Cenomanian sedimentary rocks of the Taylor Creek Group overlies the Spences Bridge andesitic basement. These rocks, which form a broad faulted anticline that plunges to the northwest, are truncated against basement to the northeast by a southwest-dipping, low-angle primary fault (A; Figure 2).

In the region of well b-82-C, a sub-basin containing ~1.5 km of Albian sedimentary rocks (Riddell et al., 2007) overlies granitic basement. Northwest of well b-82-C, basement is thrust towards the southeast (E; Figure 2). To the west, this thrust is truncated by northwest trending strike-slip faults (F; Figure 2) that are connected to Eocene faults mapped to the south.

Preliminary Tectonic Model for Block A

In the region of well d-94-G, Cretaceous rocks were folded and faulted in the hanging wall of a low-angle northeast-directed thrust fault. Some of these structures were reactivated during Eocene dextral transtension, likely contemporaneous with motion on the Yalakom fault system, suggesting that motion was directed to the northwest. The Spences Bridge Group basement to the southwest of fault A was at this time juxtaposed against shallow basement to the northeast.

Northwest of well b-82-C, the age of thrusting (E; Figure 2) between the basement to the north and the sedimentary sub-basin to the south is in question. If thrusting is Cretaceous in age, then this structure has been later cut by NW-SE Eocene dextral strike-slip faults. However, seismic interpretation suggests that the thrust may cut the Eocene Endako Group, requiring motion of a younger age. If the thrust is of Eocene age, then it could represent a compressional transfer zone between Eocene dextral strike-slip faults. This conclusion would be contrary to northeast-trending extensional faults that commonly link northwest-trending, dextral strike-slip faults (e.g., Struik, 1993) in the Canadian Cordillera. The preliminary interpretation is that the thrust is a Cretaceous compressional structure, which has been cut and reactivated during Eocene transtension.

Results of First-Arrival Tomographic Inversion in the Vicinity of Well b-82-C

First-arrival tomographic inversion (Aldridge and Oldenburg, 1993) derives an estimate of the seismic P-wave velocity from the seismic travel times. Velocity models derived from several Canadian Hunter reflection lines reveal structures in near-surface rocks that are poorly imaged by seismic reflection profiles.

The top of well b-82-C sampled ~220 m of Endako Group volcanic rocks, which have a velocity of ~2,400 to 3,400 m/s (Figure 3b). The maximum ray density here occurs in a high velocity sandstone at ~255 m immediately below the base of the volcanic layer (Figure 3a), demonstrating that ray density can provide useful constraints on the volcanic thickness adjacent to well b-82-C.

The depth to the layer of maximum ray density varies across the region, and provides information on the thickness and properties of near-surface rocks, such as the Endako Group in the vicinity of well b-82-C. Elsewhere, where the base of volcanic rocks is greater than the depth of penetration of first-arrivals, the surface of maximum ray density may represent a change in geophysical and geological properties at a boundary within the volcanic rocks. Further testing is required to determine if this surface represents in some areas the contact between volcanic rocks of the Endako Group and the younger Chilcotin Group.

Conclusions

New interpretations of the southeastern Nechako Basin reveal that:

1. The sub-basin in the vicinity of well d-94-G contains Cretaceous sedimentary and volcanic rocks, which were deformed during pre-Eocene transpression in to a northwest striking faulted anticline, thrust along a low angle fault towards the northeast. These faults were
1. Reactivated during Eocene transtension.
2. Thrust faulting of the basement towards the southeast, over Cretaceous sedimentary rocks of the well b-82-C sub-basin was likely of Cretaceous age. This fault was cut by northwest trending strike-slip faults during Eocene transtension.
3. First-arrival tomographic models are useful for mapping the thickness of the Eocene volcanic rocks in the vicinity of well b-82-C and provide new information on the structure and velocity of near-surface rocks.

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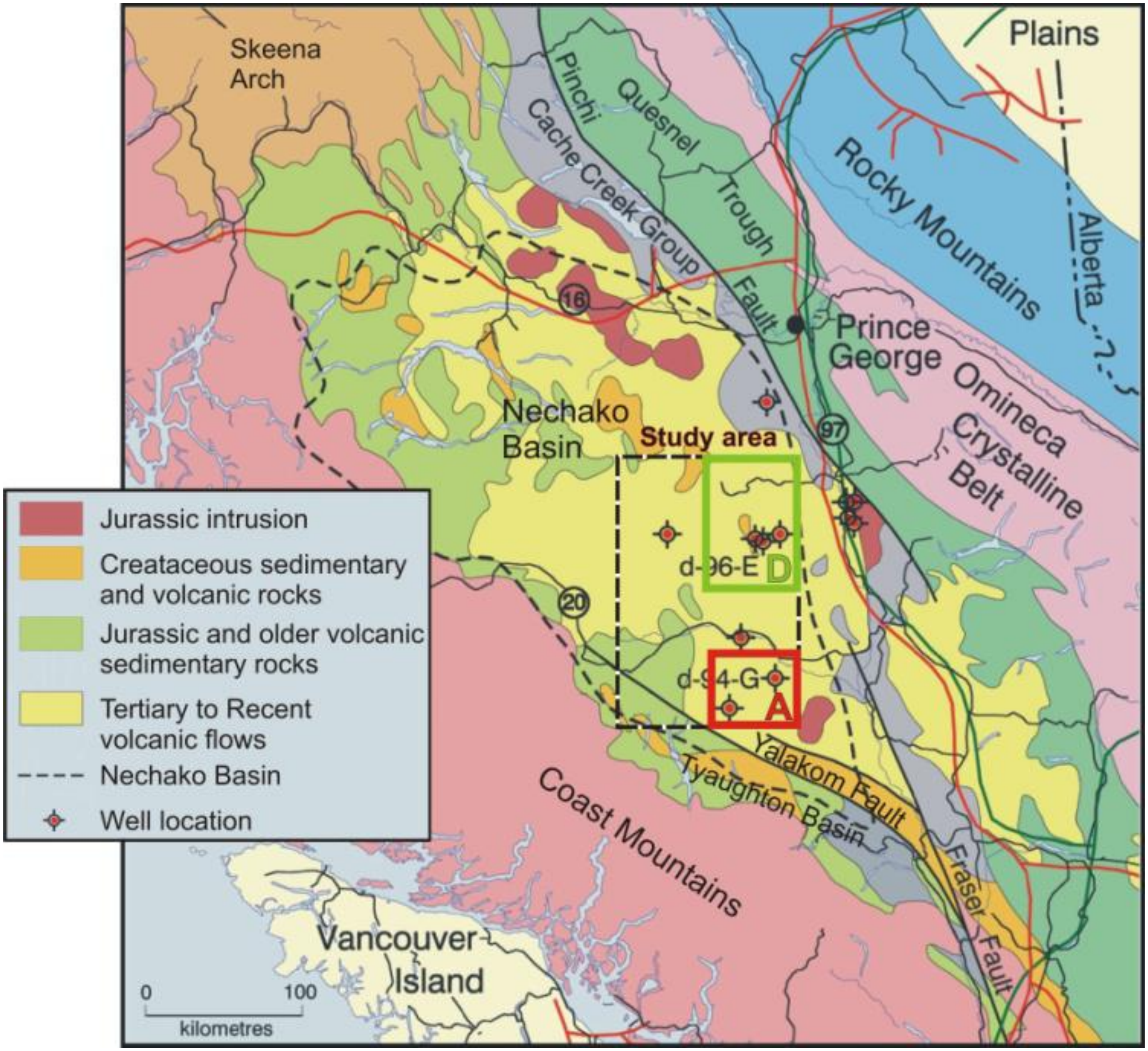

Figure 1. Location of the Nechako Basin and simplified geology of its western Canadian Cordillera setting. Red and green boxes show blocks A and D. Black dashed box shows the broader study area.

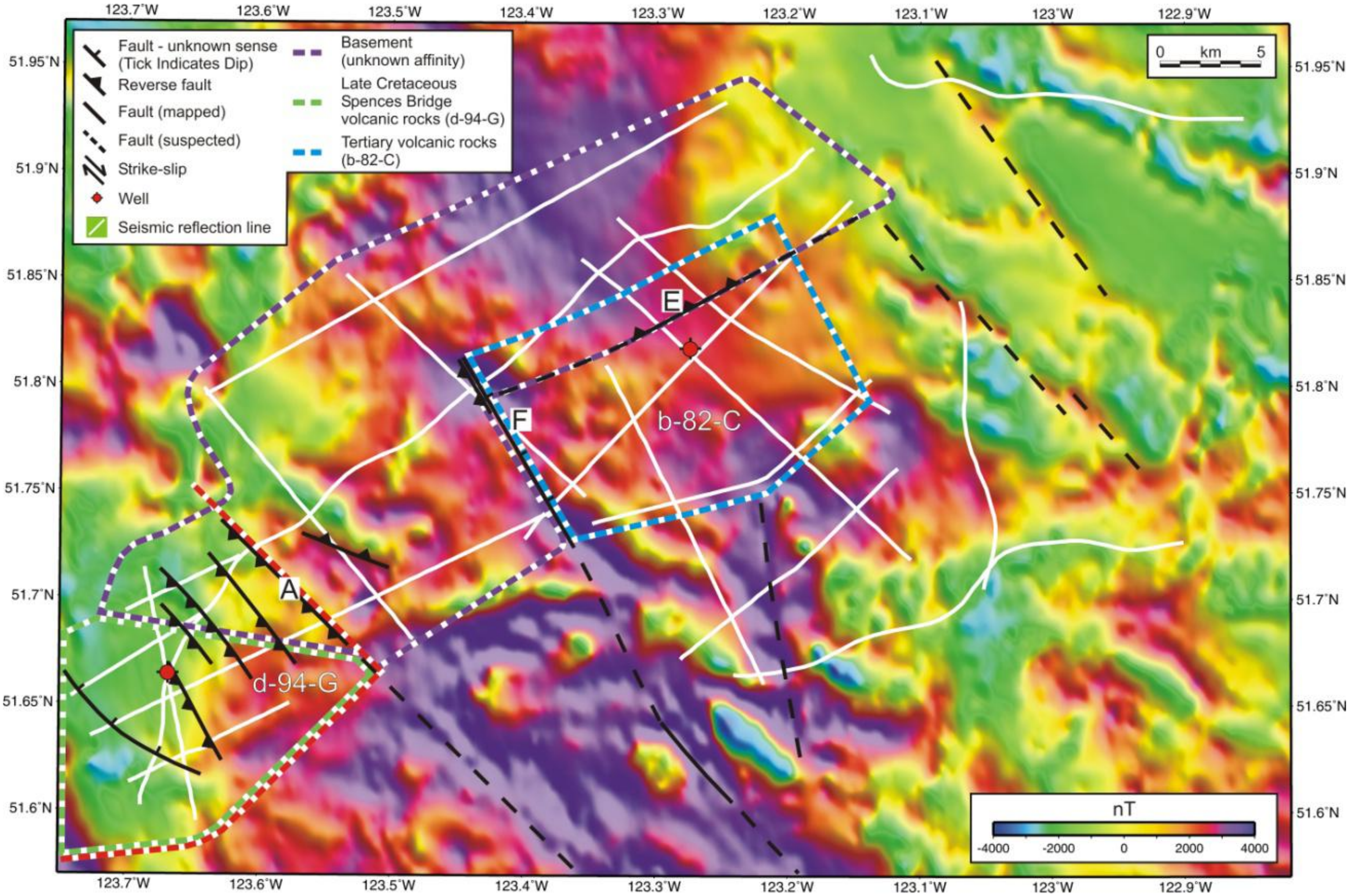

Figure 2. Structure of block A: overlain on the total magnetic field (illumination from the southwest). Heavy red and blue dashed lines show the seismic reflection profile constrained sub-basins adjacent to wells d-94-G and b-82-C. Heavy dashed coloured lines indicate basement affinity. Heavy black lines show regional faults (Riddell, 2006).

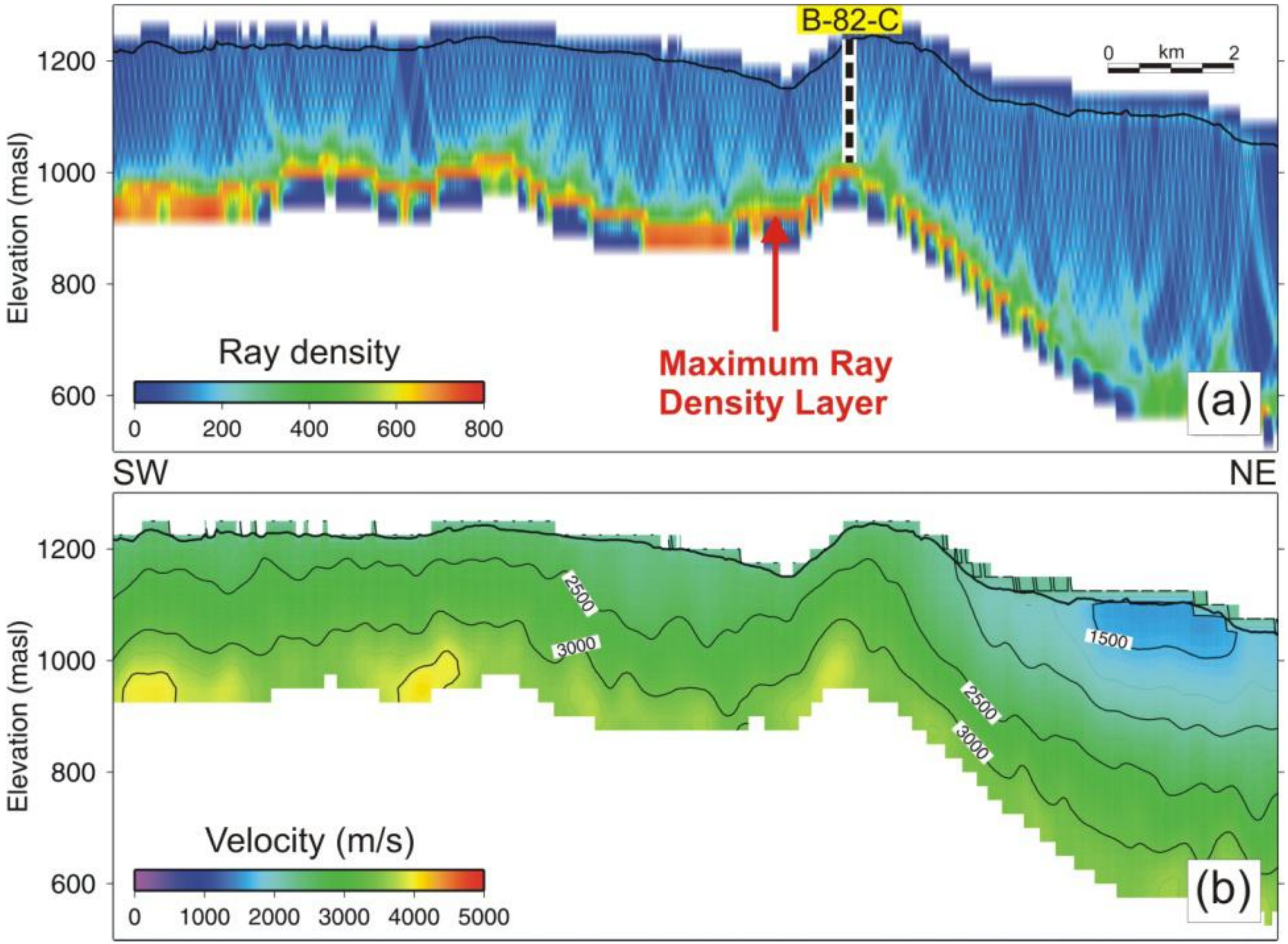

Figure 3. First-arrival tomographic inversion model for seismic reflection section through well b-82-C (a) ray density (b) velocity.