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Stable estimate of velocity anomalies around Grimsey Lineament (Tjornes Fracture Zone, Iceland) with Differentiated Tomography

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Iceland with its shelf is an anomalous part of the Mid-Atlantic Ridge. Transform motion occurs north of Iceland below the sea along three main parallel WNW fault zones offsetting the plate boundary to the WNW north of Iceland. These faults define the Tjornes Fracture Zone (TFZ) with high seismicity and epicenters of large earthquakes. Seismic imaging accross Grimsey Lineament (GL) has been carried out to 15 km depth by applying the new Differentiated Approach (DA) of tomography. The basis of DA is step-by-step selection of the most highly-resolved components of the solution during the inversion process. Algebraic, statistical criteria and the stable regularization guide the selection. The velocity structure has been obtained by inversion of travel time residuals on the basis of P-wave arrivals, recorded at 16 temporary analogue stations from August 1986 to September 1989 and Icelandic earthquake reports. Before inverting the real data set, DA had been checked by processing synthetic data, which were calculated for the assumed TFZ model constructed from gravity, bathymetry and morphology information. DA proved successful in reconstructing the initial large-scale inhomogeneity assumed along GL. Application of DA to the observed residuals clearly shows the following features of the GL seismic model. Strong low velocities correlate with clusters of earthquake swarms in the western part of GL from sea floor down to 15 km depth. The eastern part is characterized by a high velocity zone in central Axarfjordur. We found that across GL near [66.4N, 17.15W] a weak low-velocity zone to the SW changes NE-ward to a distinct high-velocity zone, which probably reduces the seismic activity there. Similar velocities were reported by a previous tomography study based on standard inversion of local earthquake data recorded by the permanent SIL network from January 1994 to December 2002. The SIL data set included more than 44 000 P-phase pickings while our data set consists of only about 4000 rays. This illustrates the capability of DA of obtaining reliable results for complex structures with strong heterogeneity under such limited conditions of the experiment, where the coverage by seismometers is sparse and the number of events is not so large. Further applications promise compromises to be achieved between resources and the demand to explore detailed seismic structures.