TESTIMONIALS TO ISC

International Seismological Centre

8. Forensic seismology

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Fifty years ago a new branch of seismology—forensic seismology—came into existence: seismologists were asked to leave their ivory towers and become advisers to governments on the capacity of seismology to verify a Comprehensive Nuclear Test Ban; that is to answer the question: how effective would seismological methods be for the detection and recognition of underground explosions? Seismologists were ill-equipped to answer this question. Consequently research programmes in the new seismology were initiated in several countries. In the UK most such research has been carried out at Blacknest, a laboratory that is part of the Atomic Weapons Establishment (AWE).

Although research in forensic seismology has brought many improvements in the processing and analysis of seismological recordings, much of the basic research by the Blacknest group on travel times and magnitudes has made use of observations from the Bulletins of the ISC.

The Bulletin is the most comprehensive catalogue of seismic disturbances available and almost all research projects begin with a search of the Bulletin for observations from suitable earthquakes and explosions. The Blacknest group has used observations from the Bulletin to refine P travel-times tables particularly to allow for departures from the simple 1D Earth model and so reduce bias in epicentre estimates. P amplitudes reported to the Bulletins have been used to investigate maximum-likelihood methods of correcting for bias in magnitudes below mb 5.5. Such a bias arises because of stations where, by chance, the signal is below the noise level, hence no amplitude or period is reported. This loss of low-amplitude observations means that magnitudes estimated only from the reported amplitudes are biased high. The task of distinguishing between earthquakes and possible explosions requires inter alia unbiased magnitudes.

The effect of the loss of below average amplitudes is illustrated in the Figure by a comparison of the distribution of ISC mb, and those estimated by maximum-likelihood methods (mbML). Taking the mbML estimates to be unbiased, the effect of loss of the low-amplitude observations at low magnitudes is in the increase of the apparent number of earthquakes over the true number at magnitudes greater than ISC mb 4.6 and underestimation of the number at lower magnitudes.

Finally, being the most comprehensive, the Bulletin is most suitable for estimating global seismicity. Work by the Blacknest group suggests that there are around 8,000 earthquakes each year with magnitudes of mb 4.0 and greater; mb 4.0 being equivalent to say a 0.25–1.0 kt explosion.

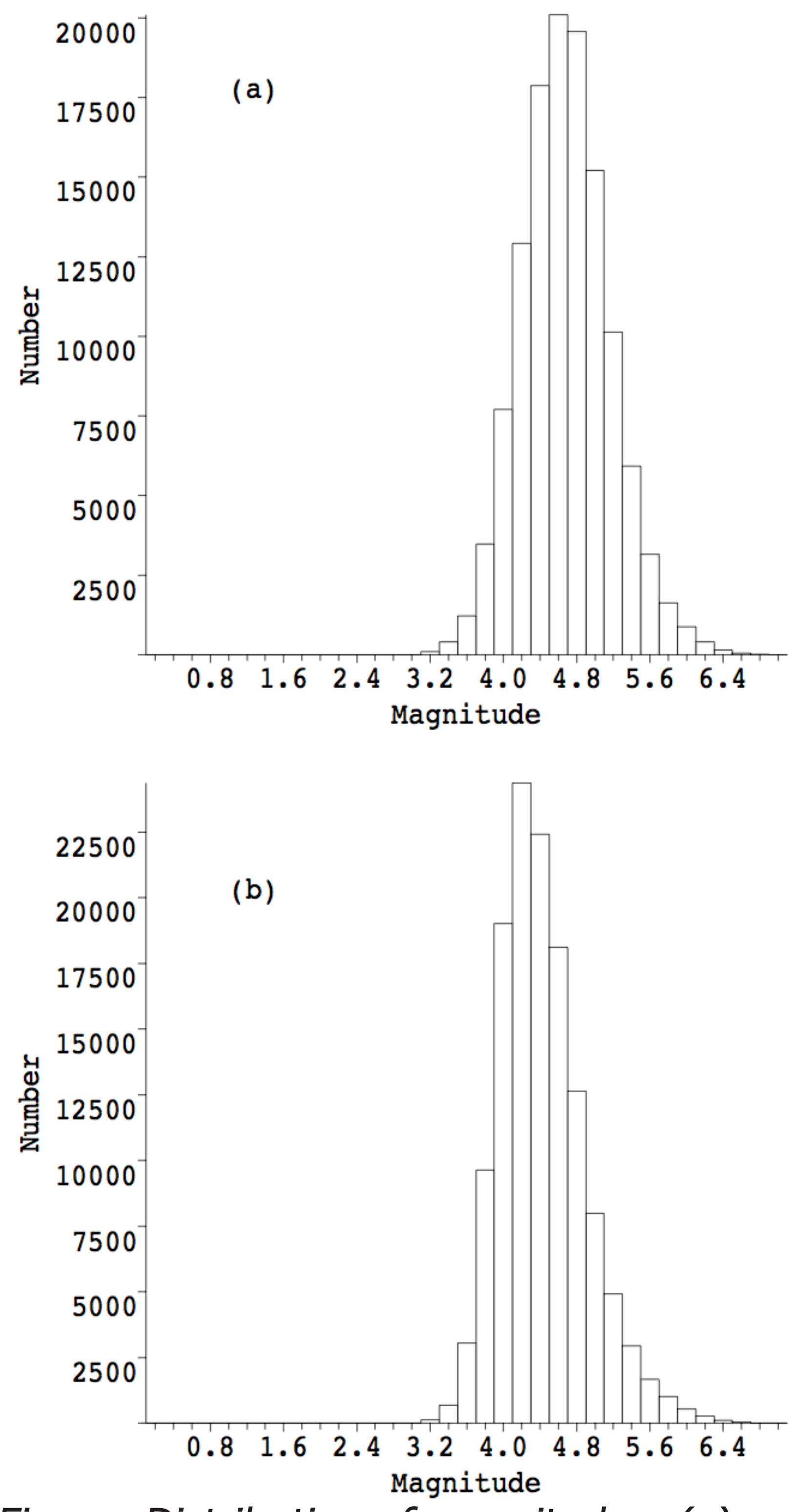

Figure: Distribution of magnitudes: (a) ISC mb; (b) mbML. Total number of magnitudes in each distribution is 130,000.

9. Regional tomographic studies in Mediterranean

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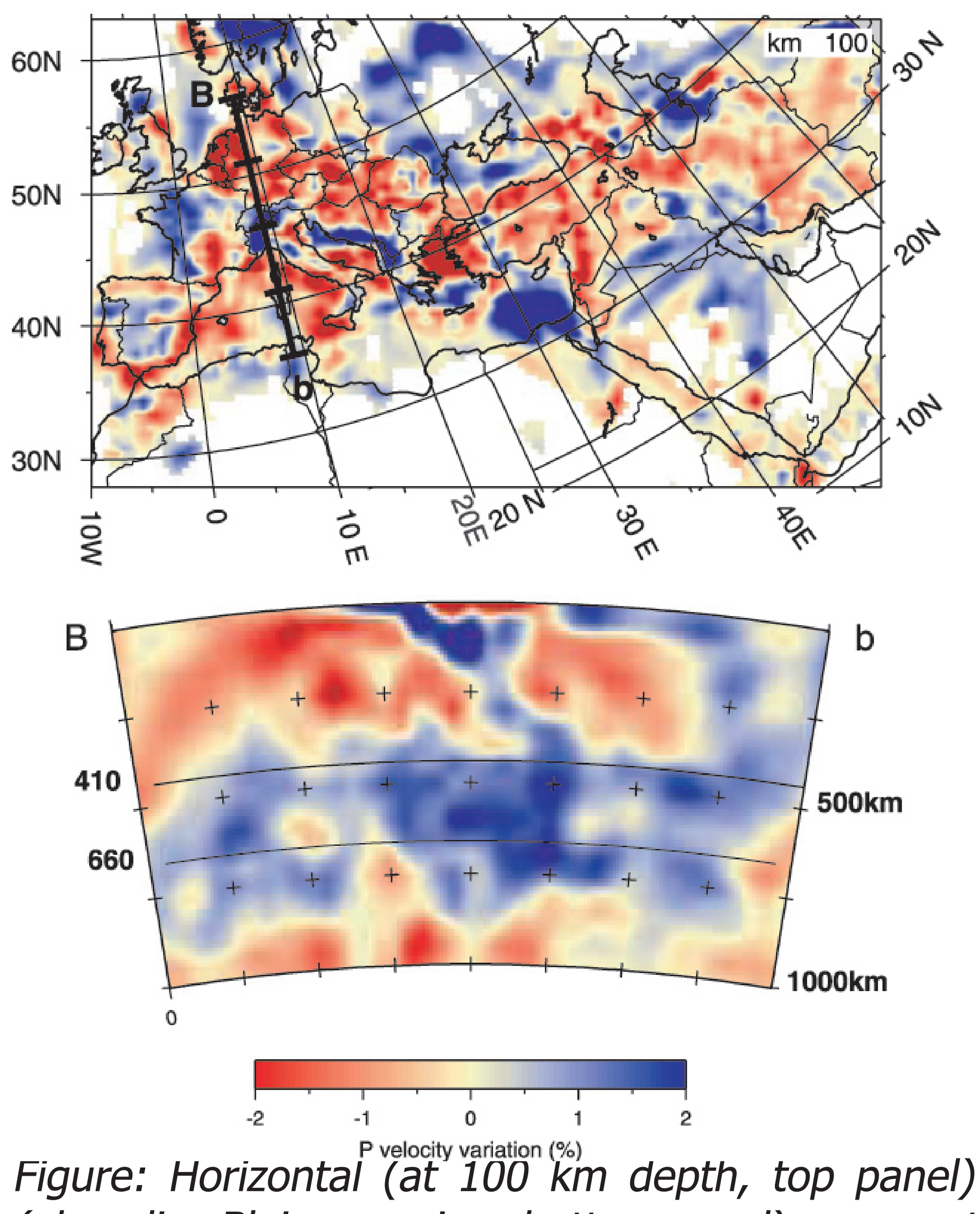

Figure: Horizontal (at 100 km depth, top panel) and vertical (along line Bb in map view, bottom panel) cross sections of three-dimensional P-wave speed tomographic model of upper mantle structure under Europe and the Mediterranean derived after inversion of arrival times from the ISC Bulletin. Fast wave speed material (represented by blue shades) presumably cold and due to past subduction under the Alps appears to have been injected into the upper mantle, and feeds a reservoir in the mantle transition zone before sinking below.

Data from the ISC are used at Istituto Nazionale di Geofisica e Vulcanologia (INGV) as the most comprehensive international compilation of seismicity. While Italian earthquakes are well represented in the national catalog based on data from the 280-station real-time telemetric network, the ISC represents the most complete source available of parametric data for continental and global scale studies. Europe and the Mediterranean represent specific interest regions for INGV, and widespread seismicity extended over many political boundaries make data collection across borders essential for geophysical studies. Arrival times from the ISC Bulletin are being used to study deep earth structure by means of body-wave travel time tomography. Recent developments include numerical finite-difference calculation of P travel times - deemed necessary in the highly heterogeneous models of crust and upper mantle in this region - and nonlinear inversion to update structural images. Complicated Moho undulations under Alps and Apennines, and remains of recent and almost extinct subduction are revealed by travel time data with unmatched sharpness and provide critical information to understand geodynamic processes.

References: Piromallo, C. and A. Morelli, 2003. P wave tomography of the mantle under the Alpine-Mediterranean area. J. Geophys. Res., 108, B2, 2065.

10. Regional tomographic studies in Siberia and Mongolia

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The travel times reported by the International Seismological Center are used to investigate regional mantle structures beneath many different regions (e.g. Pamir-Hindukish, Iran, Africa, Middle East, Europe, Siberia-Mongolia etc). The ISC catalogue is an enormous data bank which provides rich information for exploration of the Earth at different scales. The undoubted advantage of the ISC data is their continuance over several decades and their global coverage. No local network can provide such a long duration of observations.

In our investigations we try to consider any information from the ISC catalogue which may be related to seismic structure in the study regions. In particular, for studying the upper mantle structure we use P and S travel times from worldwide seismicity recorded by stations in the study area (direct scheme) and times from events in the study area recorded by worldwide stations (inverse scheme). In cases of both dense networks and active regional seismicity (e.g., in the Middle East area, Koulakov et al., GJI, 2006), it is possible using Pg, Sg, Pn and Sn phases to derive the crustal structure and the Moho depth. We use also pP and sS phases for better relocation of sources and PP and SS phases to study "blank" areas (where neither seismicity, nor stations are available).

The most recent study which uses different sorts of data covers large area of Siberia and Mongolia. The southern part of the region is seismically active, and the inverse/direct teleseismic schemes are rather effective there. For the northern parts (Siberian craton and West Siberian plane) where neither seismicity, nor stations are available, the resulting seismic structure is based on using PP phases with reflection points lying inside the study region. The resulting seismic structure shows clear signature of thick lithosphere of the Siberian craton (high velocity). Beneath the craton we observe higher temperature zone (low velocity) which seems to flow up to the surface around the craton perimeter. The strongest low velocity anomalies at shallowest depth coincide with manifestations of recent basalt volcanism in Sayan and Hangay.

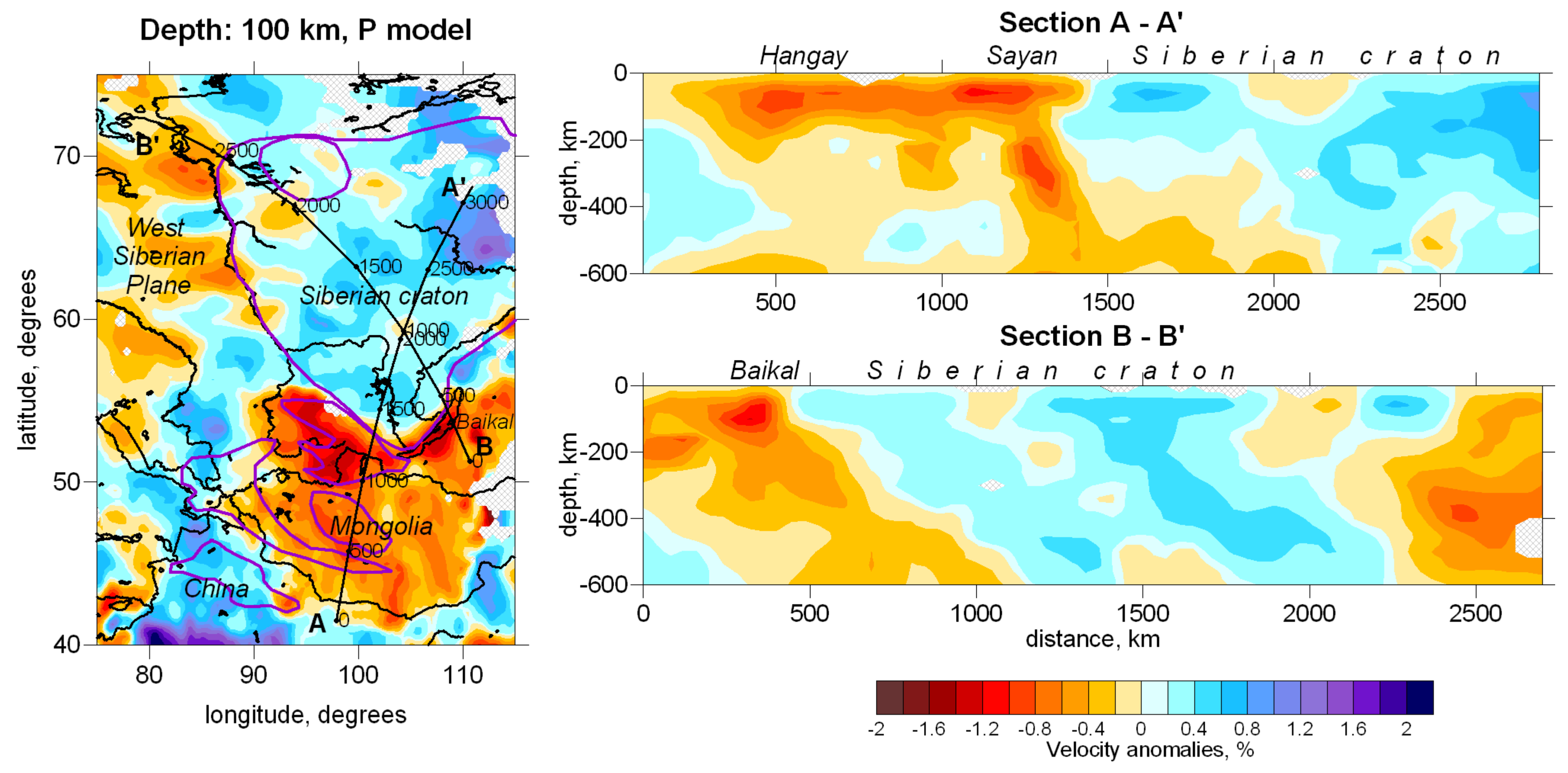

Figure: P velocity anomalies beneath Siberia and Mongolia from regional tomographic inversion of the ISC data presented at 100 km depth (left plot) and two vertical sections