s. In the transition zone and in the Pannonian basin, the first positive phase on the receiver functions is converted *Ps* phase from the shallow discontinuity. Therefore, under these stations the presence of a significant sedimentary layer can be observed between 0.4 and 1.0 s delay time.

Results of the Moho depth obtained from migrated receiver functions and results of deep refraction experiment ALP 2002 generally agree under the Dinarides and in the Pannonian basin area. However, there are differences in the transition zone which can be observed under stations Cro_06 to Cro_09. Disagreement could be caused by velocity anomalies in the upper crust, and high velocity contrast between upper and lower crust in the transition zone. Geophysical model of Alp07 profile already implied that Adriatic microplate is subducting under the Pannonian segment. According to the results of receiver functions, the change in Moho depth occurs between stations Cro_05 and Cro_06, therefore the subduction is observed on the northeastern part of the Dinarides.

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SEQUENTIAL TECHNIQUE FOR JOINT INVERSION OF GRAVIMETRIC AND SEISMIC DATA APPLIED TO THE SICILIAN AREA

S. Panepinto[1], M. Calò[1,2], C. Dorbath[2], A. D'Alessandro[3], G. D'Anna[3], D. Luzio[1]

1 Dipartimento C.F.T.A. Università di Palermo

2 IRD-IPGS, Strasbourg

3 INGV, CNT, Roma

A procedure for the construction of 3D velocity-density models and earthquake relocation by integrated inversion of P and S wave traveltimes and Bouguer anomaly distribution was applied to a large data set concerning the Sicilian area and portions of the surrounding basins. In order to cut down the data and the number of model parameters, the seismic data set was subdivided into two subsets for separate inversions. The obtained results were later on joined by the WAM (Weighted Average Model) technique. This is a post-processing technique proposed by M. Calò et al. (2008) by which numerous tomographic models, relative to a same data set with different selection of a-priori inversion parameters as well as to different data set, are unified in a common 3D grid. The Fig. 1 shows the total investigated volume that was obtained through the merging of two WAM tomographic inversions relative to the two above cited subsets. The first data set concerns 28873 P and 9990 S arrival times of 1800 earthquakes located in the area 14°30' E - 17°E, 37°N - 41°N while the second data set contains 31250 and 13588 S arrival-times related to 1951 events located in the area 11° E - 15°48' E, 36°30'N - 39°N. The selected events were recorded at least by 10 stations in the period 1981-2005 and marked by RMS < 0.50 s. The second data set was integrated with P-wave traveltimes picked in seismic profiles relative to the high density W.A.R.R. and D.S.S. experiments carried out in the study region since the earlier 1970. The Bouguer anomaly data set contains values (g_b) interpolated into the nodes of a 8x8 km regular grid covering the area 12° E - 16°01' E, 37°30' N - 38°31' N.

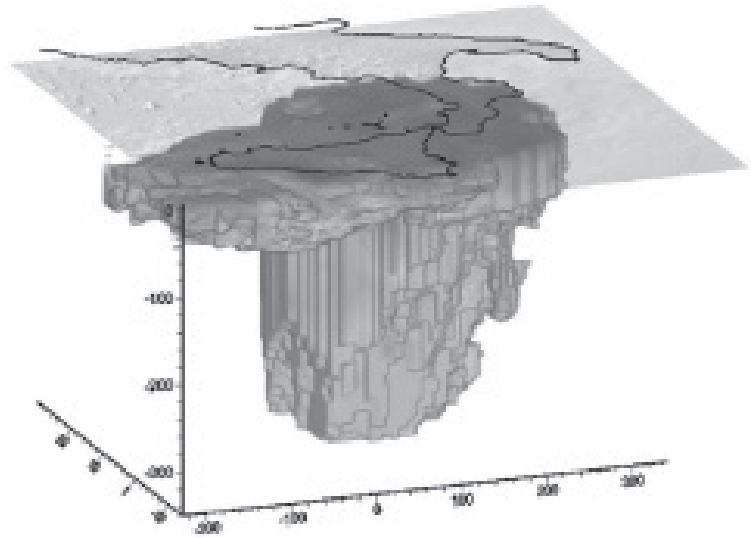

Fig. 1 - The picture shows the total investigated volume of the study area characterized with a DWS >100.

The applied procedure allows to integrate seismic and gravimetric data inversions with a sequential technique in order to avoid the problematic optimization of the relative weights to assign to the different type of data. In the following, the main steps of the procedure are summarized. Since the Vs model is often much less constrained by the experimental data than the Vp model, a first classic tomographic inversion provides just a preliminary Vp model and a first ipocentral relocation. The Vp model is then converted into a pseudo-Vs model, through a Vs-Vp correlation law (Eq. 2) proposed by Brocher (2005). This last one is used, jointly to the Vp model and to the first relocation results, as input for the first WAM inversion that provides the first Vp, Vs and Vp/Vs models and a new ipocentral relocation of the iteration cicle.

The results previously obtained are used to derive two density distributions (ρ_p,ρ_s) associated to the Vp and Vs models respectively, by the empirical Brocher's equations:

$$\rho\left(g/cm^3\right) = 1.6612\, V_P - 0.4721\, V_P^2 + 0.0671\, V_P^3 - 0.0043\, V_P^4 + 0.000106\, V_P^5 \qquad (1)$$

$$V_S\left(km/s\right) = 0.7858 - 1.2344\, V_P + 0.7949\, V_P^2 - 0.1238\, V_P^3 + 0.0064\, V_P^4 \qquad (2)$$

These density models are statistically compared, in spatial and wave number domains, and the distribution of their average value $\bar{\rho} = \frac{\sigma_p \rho_p + \sigma_s \rho_s}{\sigma_p + \sigma_s}$ is determined. In the previous formula σ_p and σ_s are the standard deviation distributions of ρ_p and ρ_s obtained, from Eq. 1 and 2, by using the simple propagation rule for normal distributed errors, and the Vp and Vs standard deviation distributions determined by the WAM topographic technique. Afterwards, two extreme density distributions are calculated using the following relation:

$$\rho_{ext} = \bar{\rho} \pm k\left(\frac{\sigma_p^{\,2} + \sigma_s^{\,2}}{\sigma_p + \sigma_s}\right) \qquad (3)$$

where the k index depends on the selected confidence level used to define the uncertainty of the velocity distributions. In the equation 3 it doesn't take into account typical dispersion of the empirical correlations $\rho \rightarrow V_p$ and $\rho \rightarrow V_s$ to force the constraining effect of the gravimetric data. The gravimetric effects of the mean density model ($\bar{g}_c$), maximum density model ($g_c^{\max}$) and minimum density model ($g_c^{\min}$) have been calculated using the 3GRAINS code, implemented by Snopek and Casten (2006). The program uses the Nagy formula (1966) to calculate the gravity attraction of right rectangular prisms. In order to significantly reduce the border effects the 3GRAINS program by itself automatically extends the edge blocks into "infinity". It has been attributed to these blocks density values that take into account the real trend of the main lithospheric structures in a surrounding zone about 300 km wide. The Figs. 2 and 3 clearly suggest the necessity to correct this initial density model. Probably, these corrections will not be consistent with the trend and the dispersion of the aforesaid empirical correlations.

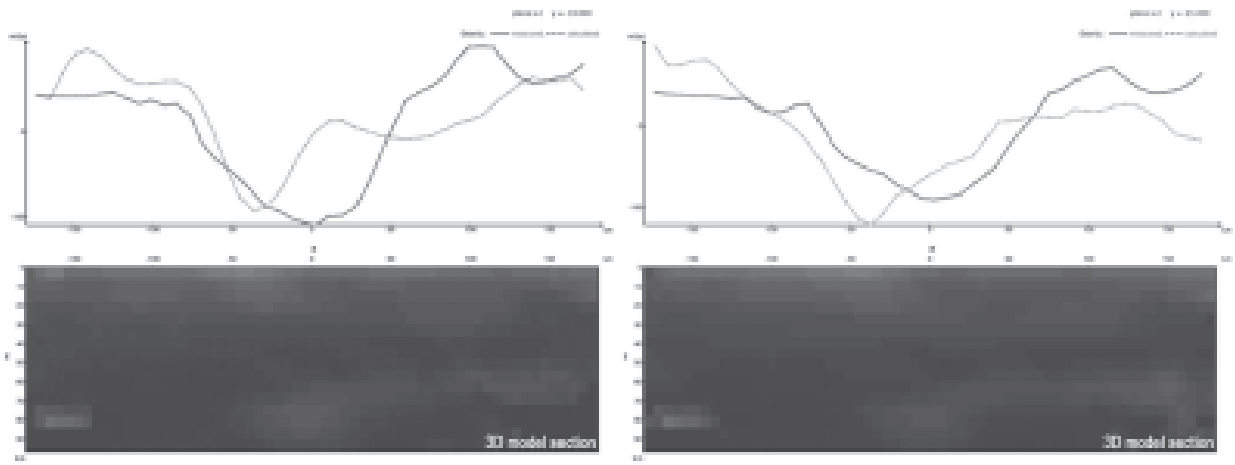

Fig. 2 - Bouguer anomaly (solid line) and calculated gravimetric effects (dashed line) relative to: two West-Est sections of the density model and to the first iteration.

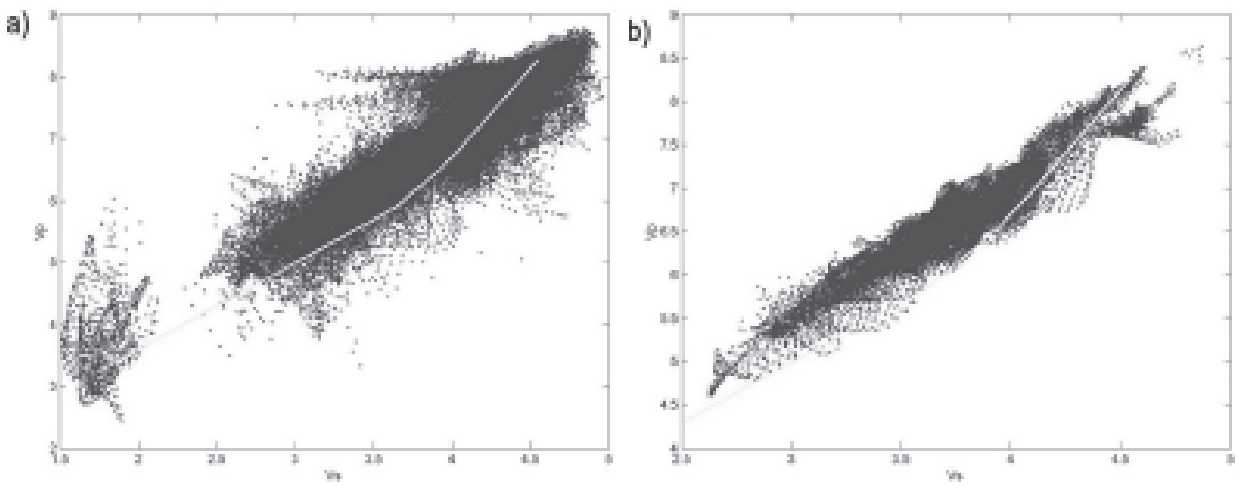

Fig. 3 - Scatter plot of the correlation $V_s \rightarrow V_p$ with a superposition of the Brocher's relationships (solid line). a): DWS>1000; b): DWS>5000.

After the spatial analysis of the gravimetric residues distribution (g_b - $\overline{g}_c$) it has been determined the minimum norm density correction vector. This vector was chosen among all those that generate gravimetric effects between g_c^{max} and g_c^{min}. The correction distribution is used both to make small corrections to the Brocher's density-velocity correlation equations (ρ-Vp, ρ-Vs), averaged on a very extended experimental case study, and to determine two correction vectors for Vp and Vs models respectively, through the previous Eq. (2) and the following Brocher's equation:

$$V_P(km/s) = 39.128\,\rho - 63.064\,\rho^2 + 37.083\,\rho^3 - 9.1819\,\rho^4 + 0.8228\,\rho^5 \qquad (4)$$

Using the corrected Vp and Vs distributions as input for a new tomographic inversion the velocity and density models are iteratively upgraded. The application of the proposed procedure to the Sicilian area underlined the necessity of the integration of these different kinds physical information to construct lithospheric models, although the seismic problem seemed to be a priori well constrained. Furthermore, it allowed to highlight some velocity and density features that could play a crucial rule for the reconstruction of the geodynamic evolution of the study area.

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THE NANGA PARBAT-HARAMOSH MONITORING NETWORK

G. Poretti[1], C. Calligaris[2], S. Tariq[3], Hawas Khan[4], F. Zubair[3]

1 University of Trieste, Italy – DMI

2 University of Trieste, Italy – DiSGAM

3 Bahria University, Pakistan - DE&ES

4 Karakorum International University, Gilgit – DES

Introduction. If the Himalayas are a land of extremes from the topographical, geophysical and geological point of view (Windley, 1984, 1988), the Karakorum is a land of superlatives, having the highest concentration of mountains over 8000 metres, having the longest glaciers outside of the poles, being the source of one of the longest rivers. From the geophysical point of view it contains the largest gravity anomalies (Poretti et al., 1983) and thickness of the earth crust (75 km) (Finetti et al., 1978, 1983) and the highest values of deflection of the vertical. It also contains the highest relief (4000 metres from the Indus plains to the summit of Nanga Parbat). It seems also that this area is subject to the highest uplift. This has been mentioned by many authors who derived it

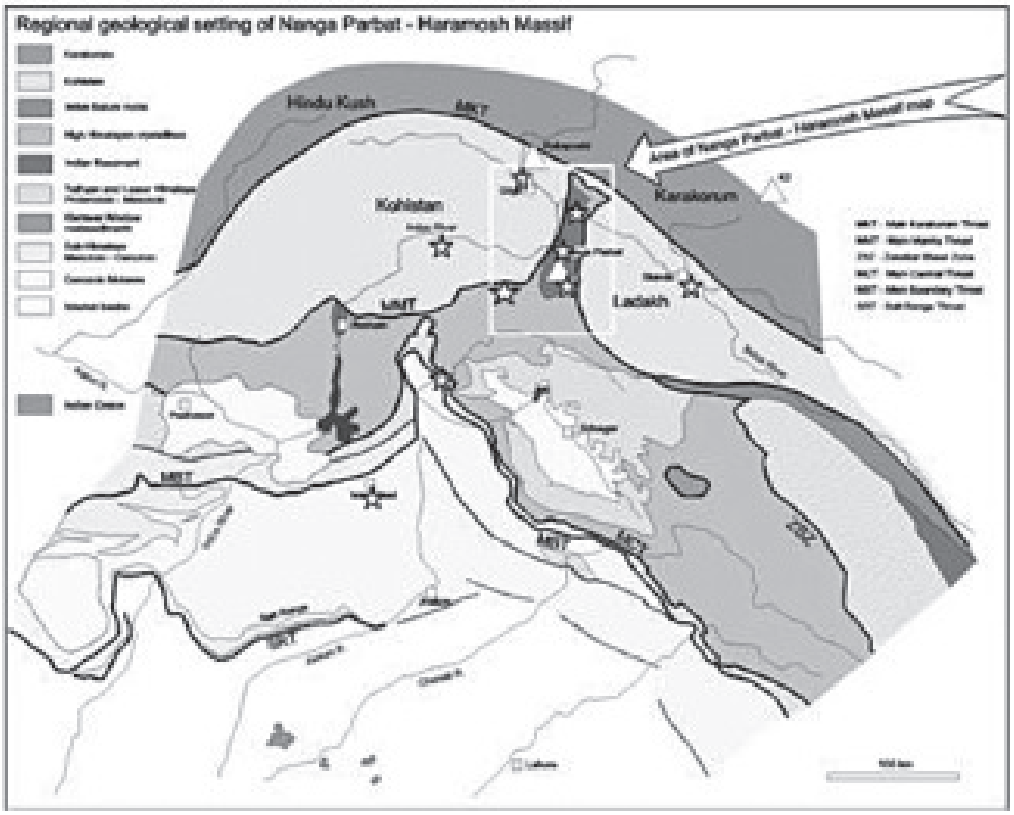

Fig. 1. Regional geological setting of the Nanga Parbat-Haramosh massif (modified after Gansser [1964]; Coward, et. al., [1988]; Searle, et. al., [1988]; Greco and Spencer, [1993].