Results: Subbasalt model

If the chosen relationships are valid everywhere the two joint inversion strategies provide results of similar quality (Fig.3; Columns 3-4). However, high data misfit for the gravity indicates that the different data sets are not adequately weighted for the joint inversion with fixed parameter relationships. If the resistivity of the basalt is reduced, in the model the joint inversion with fixed relationships generates significantly too high resistivities for the basalt (Fig.5; Column 2). In contrast, resistivities derived from the adaptive scheme are lower and more similar to the one of the synthetic model (Fig.5; Column 3).

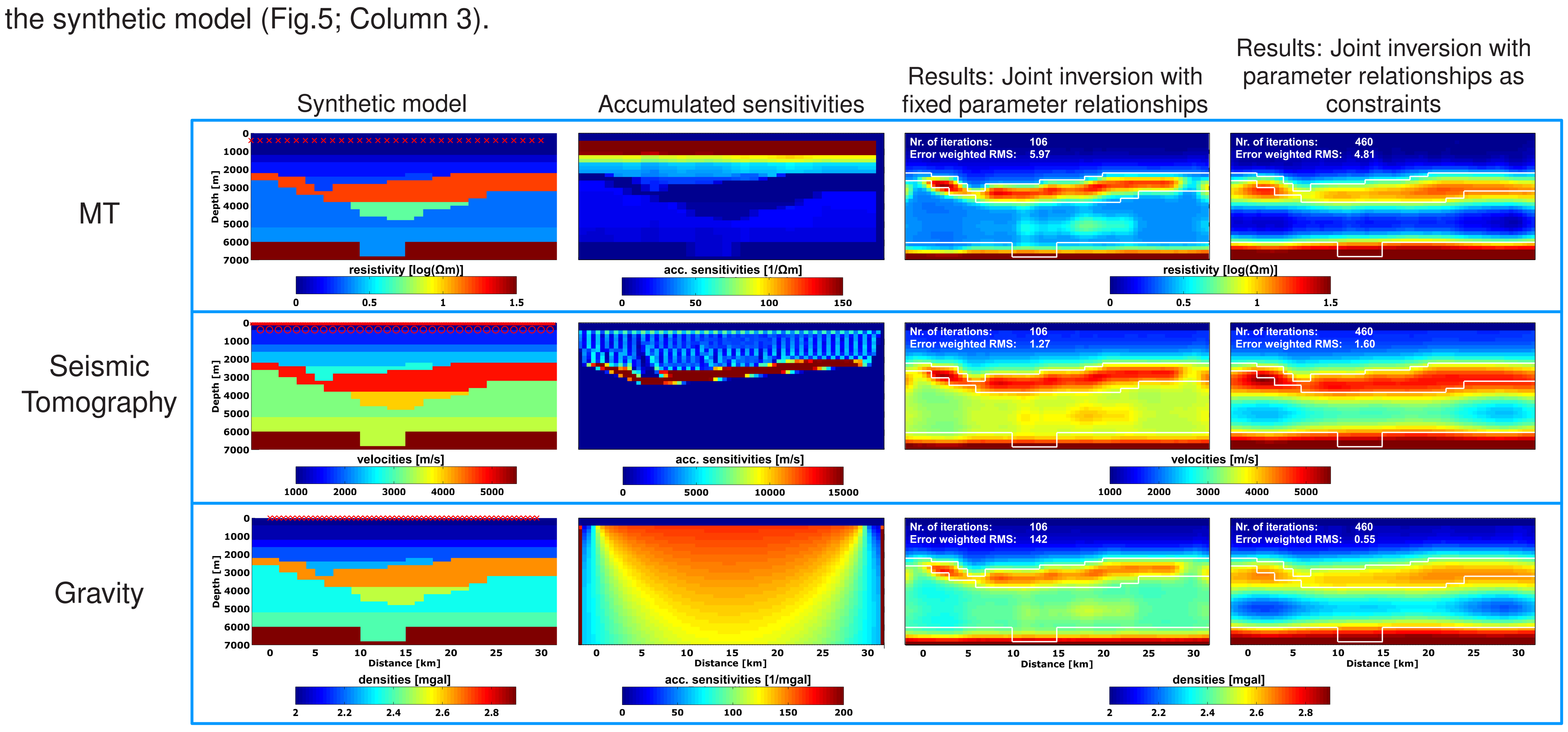

Fig.3: *First column: 2-D subbasalt model. In this model the structure with high resistivity, velocities and densities represents a basalt layer intruded into sediments. Positions of MT stations (x), shots (x), receivers (o) and gravity (x) stations are marked in the parameter models of the associated method. Second column: Summed sensitivities (coverage) for the three methods. Third to fourth column: Final results from the two joint inversion schemes. White lines sketch the boundaries of the basalt layer and the crystalline basement.*

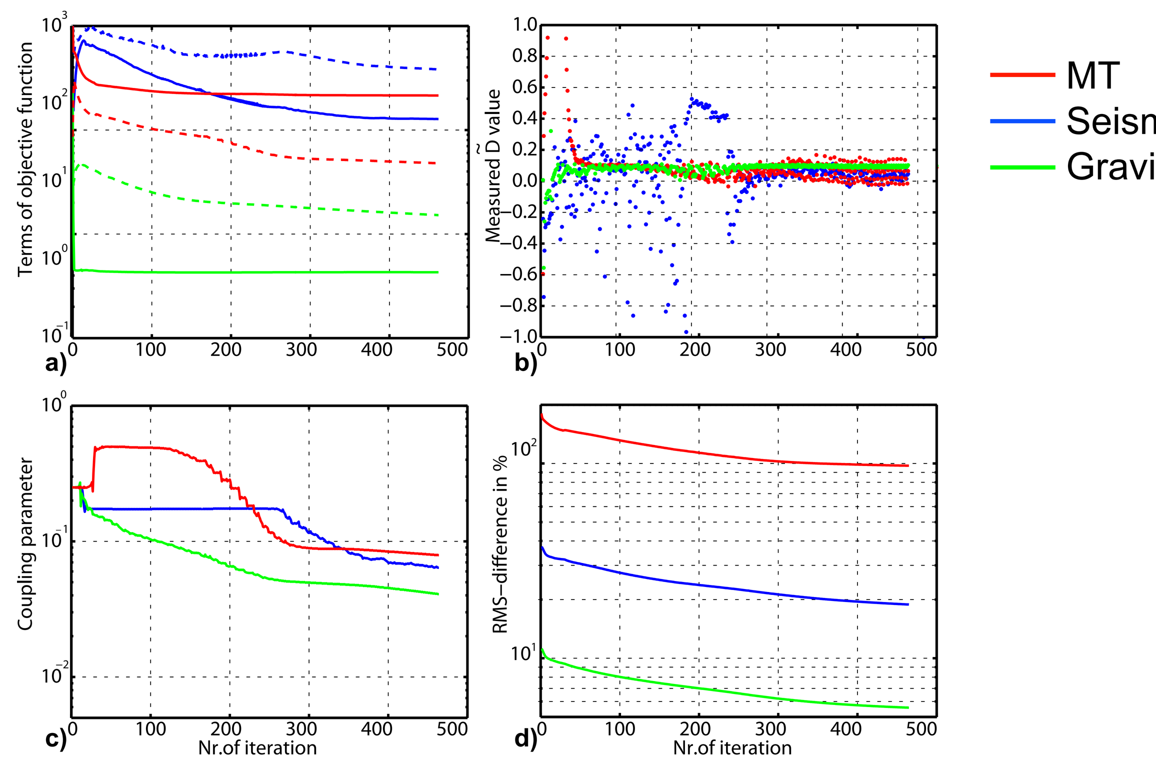

Fig.4: *The following parameters are plotted against the number of iterations for adaptive joint inversion results in Fig. 3, Column 4. a) Data terms $\Phi_{(d)}$ (continuous lines) and the smoothing terms $\Phi_{(m)}$ (dashed lines) of the objective functions. b) Ratios $\tilde{D}_k = \Delta\Phi^{Constr..k}_{(d+m)} / \Delta\Phi^{Ref..k}_{(d+m)}$ of the incremental changes of the total objective functions for inversions without and with coupling constraints. c) Coupling parameters μ. d) Normalized model misfits.*

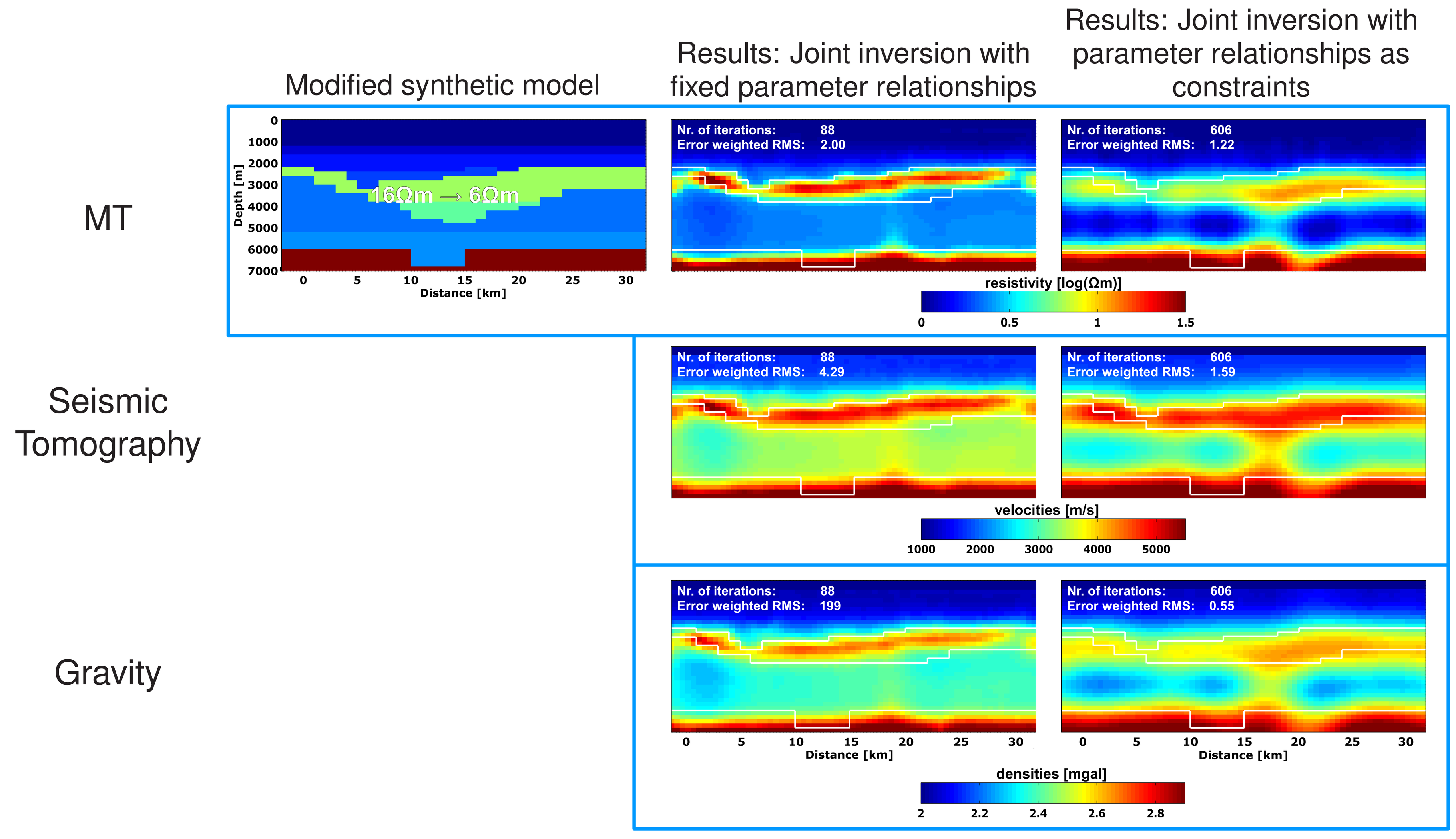

Fig.5: *Final joint inversion results for a synthetic model, for which the physical parameters of the basalt layer are not linked by the chosen relationship. First column: The resistivities in the subbasalt model in Fig.3 are reduced from 16 to 6 Ωm. Second and third column: Final results from the two joint inversion schemes.*

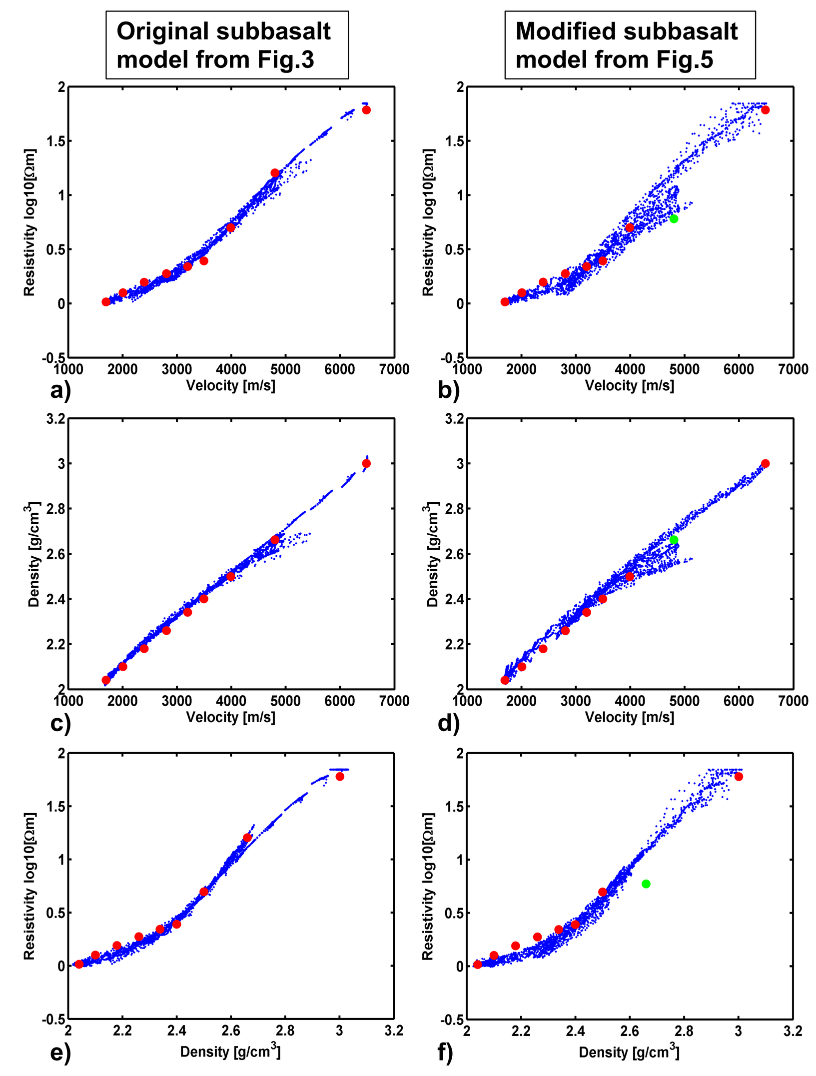

Fig.6: *Parameters of inversion cells are plotted against each other for the final results of the adaptive joint inversion scheme. Blue and red dots show the physical parameters from the final inversion results and from the synthetic model, respectively. Green dots show the parameters of the basalt layer, for which the resistivity has been reduced to 6 Ωm.*

For the model with the reduced resistivity distribution of the densities are aligned along the considered resistivity-density relationship and not - like it would be correct - along the velocity-density relationship (Figs.6d and f). Due to the low resolution of the gravity inversion two equivalent solutions with low data misfits exist and the wrong solution is chosen by the adaptive algorithm.

Results: Salt model

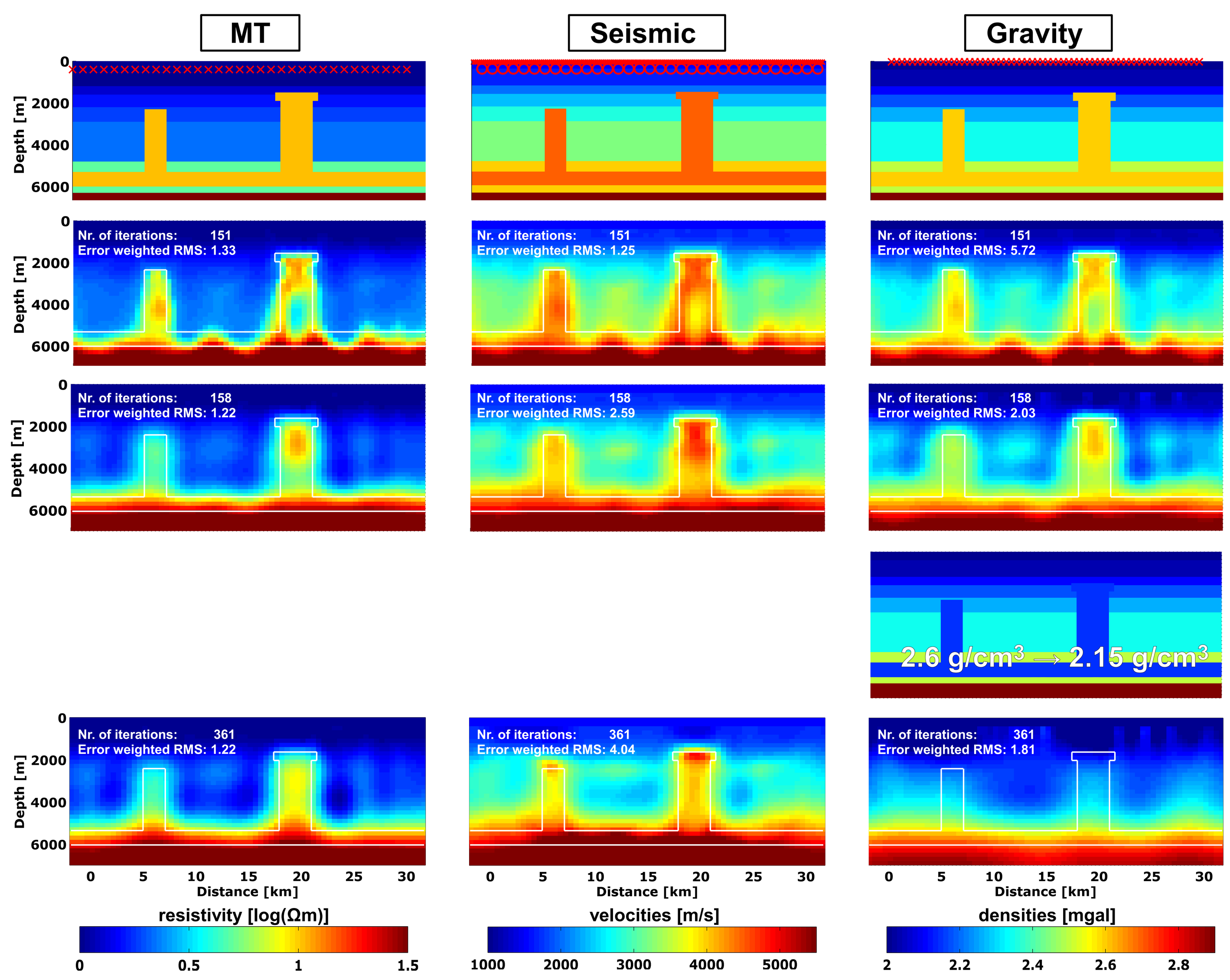

Fig.7: *Joint inversion results from a synthetic salt model. First row: Resistivities, velocities and densities of the synthetic model. Everywhere in the model the chosen parameter relationships are valid resulting in unrealistic high density values of 2.6 g/cm^3 for the salt structure. Circles highlight locations of OBS stations and crosses highlight positions of MT stations, shots and gravity stations. Second and third row: Final results from a joint inversion for which parameter relationships are considered in the Jacobian matrix and from the adaptive joint inversion scheme, respectively. Fourth row: Modified salt model in which the density of the salt is lowered to realistic value of 2.15 g/cm^3. Fifth row: Final results for this modified model from the adaptive joint inversion scheme. White lines outline the locations of the salt structure.*

If the parameter relationships are everywhere valid some artifacts are present in the final model from the joint inversion with fixed parameter links (Fig.7; Row 2): These artifacts may originate from inadequate seismic ray paths. In the final model from our adaptive scheme such artifacts are not present (Fig.7; Row 3), however, the model is smoother and the left dome is characterized by slightly too low resistivity, velocity and density values. For the model with the reduced density final results of our adaptive scheme still show high resistivity and high velocity anomalies that coincide with the salt dome structures (Fig.7; Row 5). At the same time high density anomalies are not present.

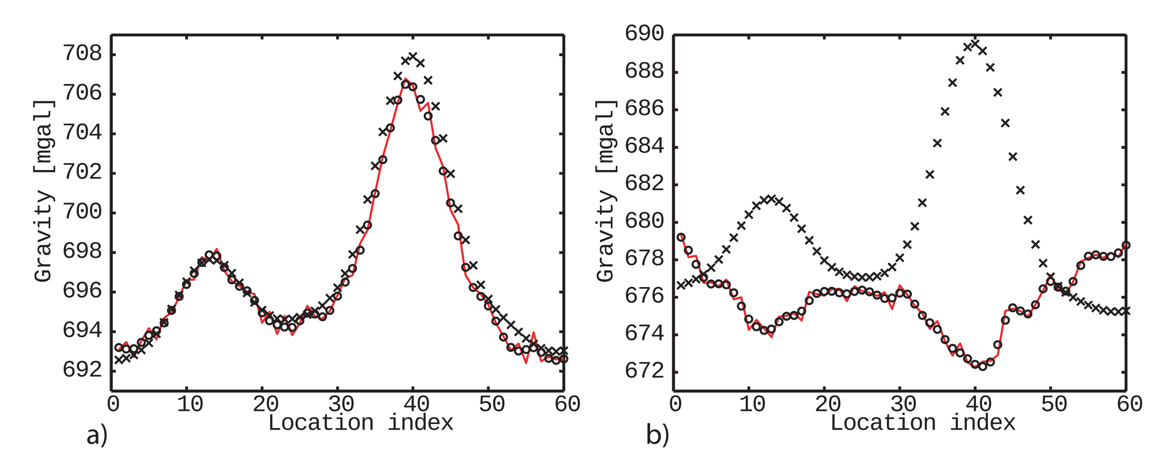

Fig.8: *a) and b) show the gravity responses for the salt models presented in the first and fourth row of Fig.7, respectively. Observed data responses are shown as red lines. Calculated responses from the two different joint inversions are indicated with crosses (parameter relationships are considered in the Jacobian matrix) and circles (parameter relationships are implemented as constraints and coupling is adaptive).*

Conclusion

Joint inversion with adaptive coupling strengths:

- Inversion process is robust and inversion results are stable. Final results are similar for different choices of D (rate of adaption) and $\tilde{L}$ (number of previous iterations, whose information is used in the regression) and for different starting models.
- Weighting of data sets is not required.
- Provides more reliable results if the assumed relationship is partly imprecise or invalid.

References

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- Vermeesch, P. M., J. V. Morgan, G. L. Christeson, P. J. Barton and A. Surendra, 2009. Three-dimensional joint inversion of traveltime and gravity data across the Chicxulub impact crater: Journal of Geophysical Research, 114, B02105.