GNGTS 2018

Tema 1

Geodinamica

sessione 1.1

Sismicità in Italia tra studi sismologici, geologici e geodetici

Convenor: P. Galli, L. Valoroso e L. Improta

RETRACE-3D PROJECT, A MULTIDISCIPLINARY APPROACH FOR THE CONSTRUCTION OF A 3D CRUSTAL MODEL: FIRST RESULTS AND SEISMOTECTONIC IMPLICATIONS

D. Scrocca[1], R. Basili[2], S. Bigi[1], L. Bonini[2], R. Bonomo[3], M. Buttinelli[2], F. Capotorti[3], S. Castenetto[4], G.P. Cavinato[1], M. Chiappini[2], C. D'Ambrogi[3], D. Di Bucci[4], M. Di Filippo[1], M. Di Nezza[2], F. Ferri[3], R. Giuliani[4], F.E. Maesano[2], M. Marino[3], M.T. Mariucci[2], L. Minelli[2], P. Montone[2], L. Petracchini[1], M. Tiberti[2], F. Villani[2]

[1] *Consiglio Nazionale delle Ricerche - IGAG, Italy*
[2] *Istituto Nazionale di Geofisica e Vulcanologia, Italy*
[3] *Istituto Superiore per la Protezione e la Ricerca Ambientale - Servizio Geologico d'Italia, Italy*
[4] *Dipartimento della Protezione Civile, Italy*

The RETRACE-3D (centRal italy EarThquakes integRAted Crustal modEl) Project has been launched with the ambitious goal to build, as first result, a new, robust, 3D geological model of broad consensus of the area struck by the 2016-2018 Central Italy seismic sequence (e.g., Chiaraluce *et al*., 2017; Scognamiglio *et al*., 2018). The development of a high-quality 3D subsurface structural model will serve as a reference for further applications including, for instance: i) the possible improvement of velocity models currently used to locate the seismicity in its crustal volume and ii) the elaboration of dynamic models of the recognized seismogenic structures.

To achieve these results, the RETRACE-3D Project blends together in a synergic way the multi-disciplinary skills of a large community of scholars (see details at www.retrace3d.it/Gruppo.html) made up by more than 60 researchers and experts from the Italian National Research Council (CNR Institutes IGAG and IREA), the National Institute of Geophysics and Volcanology, the Geological Survey of Italy (Department of ISPRA), and the National Civil Protection Department.

In the past, the study area (more than 5,000 km2 wide) was investigated for hydrocarbon exploration purposes through the acquisition of a large number of 2D seismic reflection profiles, gravimetric and aeromagnetic data, together with the drilling of some scattered wells. These existing datasets were kindly made available by ENI and TOTAL companies in the frame of their participation to the National Service of Civil Protection. Moreover, the RETRACE-3D Project dataset also includes geological, geophysical and satellite data deriving from the institutional activities of the involved research institutes.

The RETRACE-3D Project has been organized in several work packages (WPs).

WP0 Data management - All the datasets, with some additional resources (e.g. literature, task reports), are shared through a project-dedicated repository and meta-data catalogue, with restricted user access to confidential data. The final results will be shared via the RETRACE-3D web site.

WP1 Data preparation - The project structure includes a step of data preparation, to provide the participants with common harmonized and ready-to-use datasets. They are organized as input and comparison datasets, used respectively in WP2-WP3 and WP4.

WP2 Shallow crustal model – This WP is devoted to the construction of a preliminary 3D crustal model mainly based on the interpretation of seismic reflection profiles, well data, surface geological constraints integrated with the analysis and modeling of gravimetric data;

WP3 Model extended to seismogenic depths – The 3D model generated with the WP2 is then extended to seismogenic depths integrating the preliminary model with further information coming from Local Earthquakes Tomography (LET), thermal and rheological data, gravity and magnetic crustal modeling.

WP4 Final crustal model - The final step consists of a geometric and kinematic validation (e.g., balancing and analogical modeling) and a cross-check against comparison datasets (e.g., SAR, GPS, coseismic surficial effects, seismogenic sources characteristics, Quaternary geology-geomorphology-neotectonics, seismic catalogues) not used during the modeling phases.

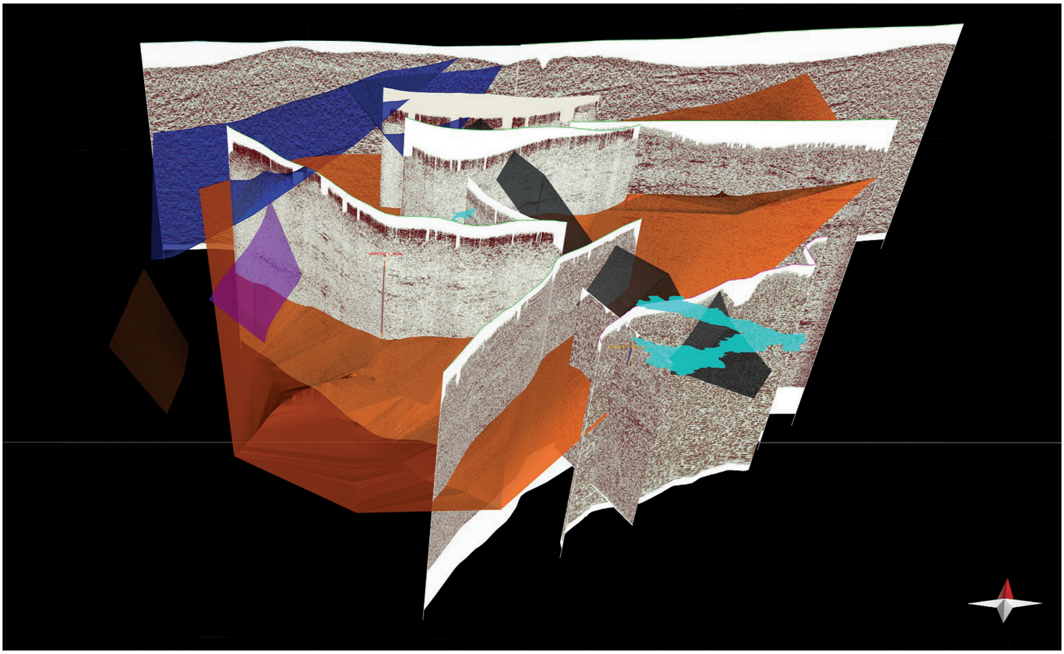

Fig. 1 - 3D geological model in time domain based on integrated interpretation of deep borehole data, seismic reflection profiles, and surface geological information.

The adopted workflow has been designed to maximize the information and constraints from multidisciplinary datasets and the benefits deriving from the interaction among a great number of researchers from different disciplines. This approach, although time consuming, is expected to overcome the weaknesses that generally are observed in common 2D or 3D not multidisciplinary studies.

The final 3D model will serve as a starting point for following geo-mechanical numerical simulations and will be able to give answers to many different geological and seismological issues.

In this contribution, the first results of the research activities carried out within WP2 are presented together with a first discussion about some seismotectonic implications. These results derive from the integrated interpretation of deep borehole data, seismic reflection profiles, and surface geological information combined with the analysis of gravimetric and magnetic data.

The interpretation step required a preliminary phase of data preparation where the ample set of data was quality-checked and homogenized to make it ready for further elaborations. As an example, the existing geological data have been harmonized and codified according to a defined regional stratigraphic and structural scheme, while a datum shift has been applied, where required, to the different seismic vintages to refer all the data to a chosen seismic reference datum.

Furthermore, a careful review of the available velocity data, derived from well and seismic data, provided fundamental constraints to elaborate synthetic well logs and a 3D velocity model that will be used to depth-convert the model from the time domain.

The preliminary 3D model, resulting from WP2 team efforts, describes the overall structural architecture of the investigated area (Fig. 1). It also provides new hints on the structural style controlling the geological setting of the study area, which is still a matter of scientific debate within the scientific community (among many others, Ghisetti *et al*., 1993; Bigi *et al*., 2013; Scisciani *et al*., 2014; Lavecchia *et al*., 2017; Pizzi *et al*., 2017; Buttinelli *et al*., 2018; Porreca *et al*., 2018) Moreover, the relationships between the geometry of the structural discontinuities inherited from previous tectonic regimes (e.g., Jurassic and Miocene faults and late Miocene-Pliocene thrusts) and the distribution of the 2016-2018 seismic events suggest that some of the preexisting faults may have been reactivated in the present day extensional regime. Such evidences, and the related faults segmentation, also have strong implications for a potential review of the seismic hazard in the area.

In conclusion, we believe that an added value of RETRACE-3D is represented by the development of a multi -expertise coordinated working group, formally organized, in which the different teams operate in a synergic way to gain altogether a shared result. Being this activity developed in the frame of the civil protection field of interest, it has also a societal value. Moreover, the large number of involved investigators from different research institutes as well as the publication of main results on mainstream platforms makes the project objective much more easily accessible also for civil protection purposes, representing the outcome of a large and qualified community idea. Finally, the framework of integrated activities and the internal organization realized by RETRACE-3D also represents a “ready-to-go tool” that could be easily exported for the achievement of similar objectives in others areas.

Acknowledgments. RETRACE-3D is a project developed in the frame of a formal agreement among the Civil Protection Department and some of its Competence Centers (for details, see the project website www.retrace3d.it). This collaboration was promoted by the scientists during the first days of the Central Italy seismic emergency, in 2016. Carlo Doglioni is acknowledged for having conceived the first idea of the project.
Authors are involved in the tasks: 2.1 Seismic interpretation, 2.2 Preliminary 3D model Time domain, 2.3 Velocity model, 2.4 Depth conversion, and 2.5 Grav-Mag modeling.

References

Bigi S., Casero P., Chiarabba C., and Di Bucci D.; 2013: *Contrasting surface active faults and deep seismogenic sources unveiled by the 2009 L’Aquila earthquake sequence (Italy)*. Terra Nova, 25(1), 21–29. https://doi.org/10.1111/ter.12000.

Buttinelli M., Pezzo G., Valoroso L., De Gori P. and Chiarabba C.; 2018: *Tectonics inversions, fault segmentation and triggering mechanisms in the central Apennines normal fault system: insights from high-resolution velocity models*. Tectonics, 37. https://doi.org/10.1029/2018TC005053.

Chiaraluce L., Di Stefano R., Tinti E., Scognamiglio L., Michele M., Casarotti E., Cattaneo M., De Gori P., Chiarabba C., Monachesi G., Lombardi A., Valoroso L., Latorre D., Marzorati S.; 2017: The 2016 Central Italy Seismic Sequence: A First Look at the Mainshocks, Aftershocks, and Source Models. Seismological Research Letters ; 88 (3): 757–771. doi: https://doi.org/10.1785/0220160221.

Ghisetti F., Barchi M., Bally A.W., Moretti I. and Vezzani L.; 1993: Conflicting balanced structural sections across the Central Apennines (Italy): problems and implications. In *Generation, accumulation and production of Europe’s hydrocarbons III* (pp. 219-231). Springer, Berlin, Heidelberg.

Lavecchia G., Adinolfi G.M., de Nardis, R., Ferrarini F., Cirillo D., Brozzetti F., De Matteis R., Festa G. and Zollo A.; 2017: *Multidisciplinary inferences on a newly recognized active east-dipping extensional system in central Italy*. Terra Nova, 29(1), 77-89.

Pizzi A., Di Domenica A., Gallovič F., Luzi L. and Puglia R.; 2017: Fault segmentation as constraint to the occurrence of the main shocks of the 2016 Central Italy seismic sequence. Tectonics, 36, 2370–2387. https://doi.org/10.1002/2017TC004652.

Porreca M., Minelli G., Ercoli M., Brobia A., Mancinelli P., Cruciani F., Giorgetti C., Carboni F., Mirabella F., Cavinato G., Cannata A., Pauselli C. and Cannata, A. ; 2018: *Seismic Reflection Profiles and Subsurface Geology of the Area Interested by the 2016–2017 Earthquake Sequence (Central Italy)*. Tectonics, 37(4), 1116-1137. https://doi.org/10.1002/2017TC004915.

Scisciani V., Agostini S., Calamita F., Pace P., Cilli A., Giori I. and Paltrinieri W.; 2014: *Positive inversion tectonics in foreland fold-and-thrust belts: A reappraisal of the Umbria-Marche northern Apennines (Central Italy) by integrating geological and geophysical data*. Tectonophysics, 637, 218–237. https://doi.org/10.1016/j.tecto.2014.10.010.

Scognamiglio L., Tinti E., Casarotti E., Pucci S., Villani F., Cocco M., Magnoni F., Michelini A. and Dreger D.; 2018: Complex Fault Geometry and Rupture Dynamics of the MW 6.5, 30 October 2016, Central Italy Earthquake. Journal of Geophysical Research: Solid Earth, 123, 2943–2964. https://doi.org/10.1002/2018JB015603.