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Geologically driven seismic reprocessing: the Val d'Agri case history

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ABSTRACT A case history is presented describing the revision of the 3D seismic volume for an onshore hydrocarbon field in Italy. One of the key elements for the success of the project was the contribution of the geological information to seismic data processing and imaging, which was deemed since the beginning as an indispensable guide to drive and constraint the seismic reprocessing. In particular, two critical steps in which the integration between geology and geophysics played a relevant role are discussed here: the estimation of static corrections for data preconditioning before imaging, and the velocity model building for depth imaging. The paper includes also a proposal for a stratigraphic revision of the allochthonous sequence of the Val d'Agri area. The outcomes of the project comprised the release of a reprocessed seismic volume in time domain, the creation of the first Pre-Stack Depth Migrated volume of the field, together with the revision of some stratigraphic boundaries, and created the conditions for a revision of the geological model of the field. The project lasted approximately two years and was executed by a multidisciplinary group comprising geophysicists, geologists, sedimentologists, and structuralists. The collaboration with Shell, joint venture partner, was also an important factor for the success of the project.

Key words: seismic time processing, static correction, depth imaging, seismic velocity model building, petroleum system, stratigraphy.

1. Introduction

The integration of heterogeneous data and the implementation of integrated multidisciplinary projects are crucial factors for increasing and spreading knowledge inside organisations, and for optimising processes in terms of costs, time, and quality. In the specific field of hydrocarbon exploration, sharing information coming from various geological and geophysical disciplines can lead to the development of more robust models, able of honouring as much as possible all available data and returning predictions with a high industrial value.

Such integration is favoured also by the considerable amount of data, information, methodologies, and skills that the industry has at its disposal.

Of particular interest is, therefore, the case of this integrated project which includes exploration, geological and geophysical services, carried out recently by Eni, and aimed at revising the model of the Italian onshore reservoir located in Val d'Agri, Basilicata (Fig. 1).

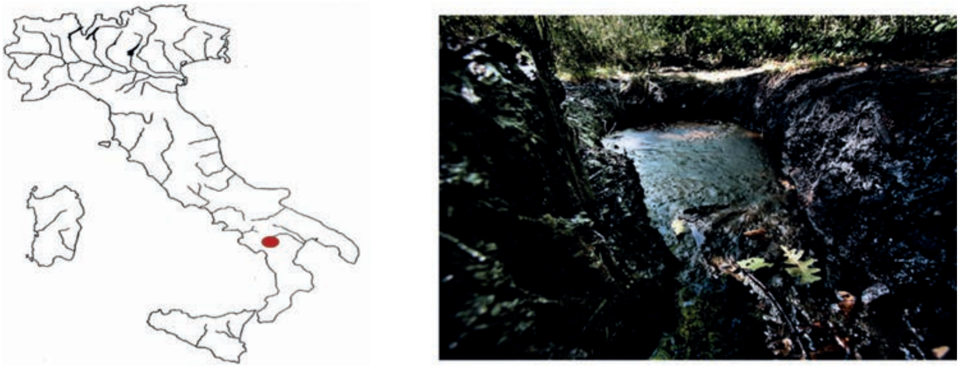


Fig. 1 - Val d’Agri field location and natural oil seeps in the area.

Val d’Agri is the largest onshore oil and gas field in Europe, with an approximate daily production of 70,000 barrels, accounting for about 5% of the entire hydrocarbon demand of Italy. Although the existence of hydrocarbons in Basilicata was known since ancient time, due to the presence of natural oil seeps, it was not before 1988 that hydrocarbon reserves were confirmed by the first exploration well drilled by Agip, now Eni.

The hydrocarbon field has been investigated by two 3D seismic surveys: Monte Alpi, acquired in 1994, and Cerro Falcone, acquired in 2000, for a total of 600 km^2 (Fig. 2). These surveys were processed several times starting from 1994 to 2005, by applying the most up-to-date technologies available at the time of each reprocessing.

More than 80 wells have been drilled during the life of the field, drains included. The availability of new data, new seismic processing techniques, and more abundant computing resources, led to the decision to set up an integrated project aimed at jointly revise the geological model and the supporting seismic volumes.

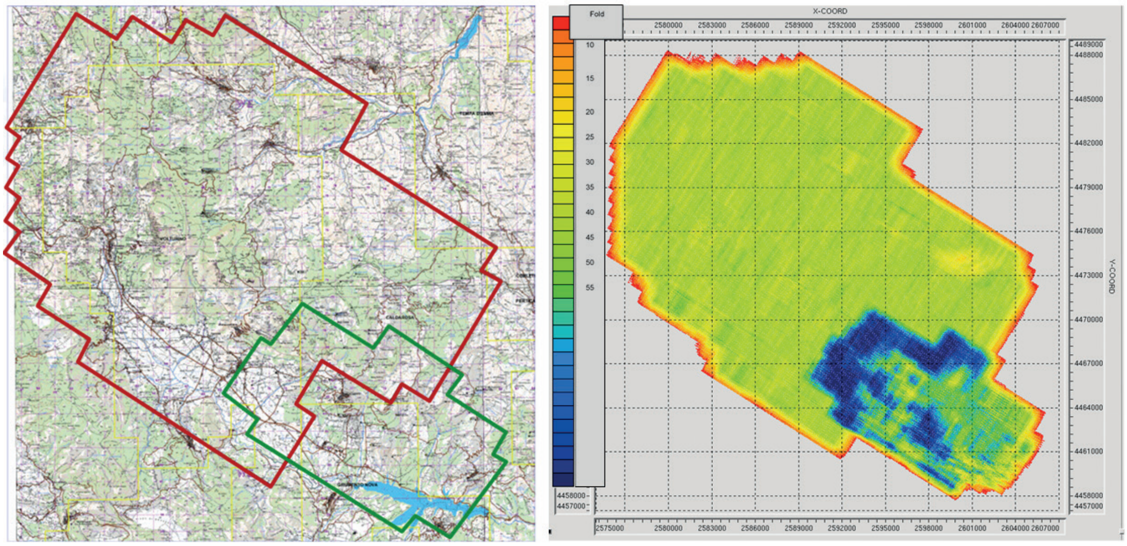


Fig. 2 - Cerro Falcone and Monte Alpi 3D seismic surveys: location map and fold of coverage.

2. Geological framework

The Val d'Agri area, located in the Lucania region, in southern Italy, is a Quaternary basin developed within the southern Apennines thrust and fold belt during the extensional tectonic phases. This chain is the result of complex and multiphase tectonic events, formed during Tertiary collision of the African and Euro-Asian plates and opening of the Mediterranean Sea. The present architecture is derived from the deformation of different Mesozoic-Paleogene palaeogeographic domains which characterised the southern margin of Neotethys. The palinspastic restoration proposed by Mostardini *et al*. (1986) recognises four main palaeogeographic domains: Tyrrhenian basin, Apenninic platform, Lagonegro basin, and Apulian platform (PAI, i.e. Piattaforma Apula Interna).

At the beginning of Neogene, with the opening of Mediterranean Sea, the PAI was gradually involved in the Apennine orogeny due to eastward migration of the thrust fault belt (Bertello *et al*., 2010). A large part of it was affected by an intense subsidence with the creation of a foredeep, dominated by deep water siliciclastic sedimentation.

At the present day, the tectonic architecture is composed by a lowermost para-autochthonous unit formed by a carbonate system named PAI, tectonically overlaid by thick and deformed allochthonous sequence derived from basin and platform internal domains. In particular, the main involved tectonic unit is the Lagonegro unit sandwiched between the Apennine platform and Tertiary strongly deformed, siliciclastic foredeep sediments informally called Irpinia units, as described by Carubelli *et al*. (2010).

In the Val d'Agri area the buried PAI is generally constituted by shallow water Mesozoic and Tertiary carbonates, covered by Pliocene foredeep deposits. The PAI has been extensively explored, since it represents the main target of hydrocarbon exploration in the southern Apennines.

3. Stratigraphy

The stratigraphic section of the area can be divided into two parts: the upper one, constituted by Thyrrenian basin, Apennine platform and Lagonegro basin terrains, well known because they extensively outcrop in the region; the lower one, much less known since it is present only in subsurface, constituted of Tertiary foredeep sequences, which represent the object of this description since they allow us to understand the evolution of the Apenninic thrust belt in time and space (Fig. 3).

To improve the stratigraphic resolution, the conventional stratigraphic tools such as biostratigraphy (from Foraminifera and Calcareous Nannofossils analysis) have been integrated with mineralogical and geochemical analysis in order to collect information about diagenesis, differences in sediment supplies and fluids characterisation.

3.1. Irpina 1 unit

Synorogenic unit deposited during the Early (?) Serravallian in a piggy back basin on Lagonegro substratum. It mainly consists of varicoloured shales (red, green, grey, or grey-greenish), locally silty, and with occasional fine sandstone intercalations. The foraminifera assemblage is generally very poor and is characterised by very scattered and/or absent age diagnostic species.

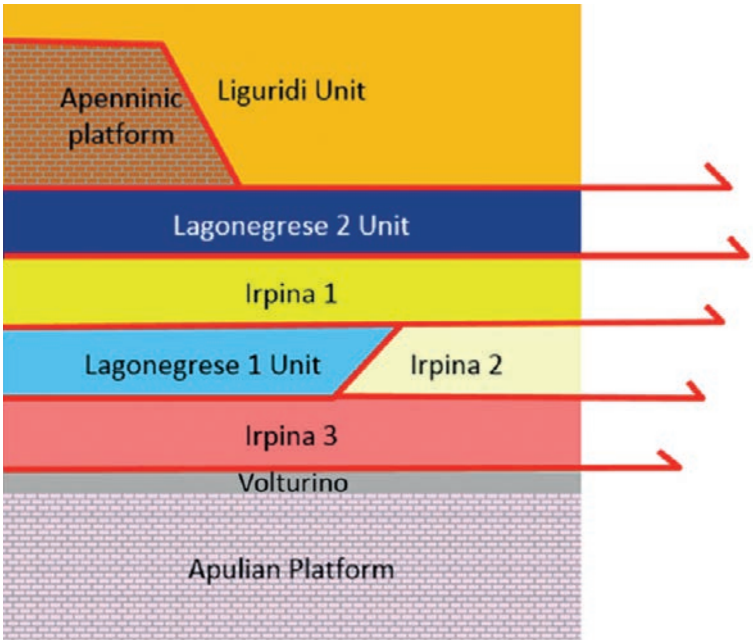


Fig. 3 - Val d'Agri tectono-stratigraphic scheme.

3.2. Irpina 2 unit

Terrigenous unit deposited probably on Lagonegro substratum during the Middle Miocene. It is characterised by grey-green silty shale with thin intercalations of hazelnut colour limestone and grey quartz-sandstone with carbonatic cement. Two lithotypes of limestone are present, mudstone/wackstone with Radiolaria, probably clasts of conglomerate, and an autochthonous facies, an hemipelagic mudstone/wackstone with Globigerinidae.

3.3. Irpina 3 unit

Allochthonous unit represented by Middle Miocene terrigenous slope facies, including olistostromes and olistoliths. It is characterised by grey, grey-greenish and varicoloured shale with qz-feldspatic sandstone, with rounded/sub-rounded grains, and argillaceous matrix-supported polygenic calcareous conglomerate intercalations. The unit is mostly represented by a clay chaotic facies with calcareous olistoliths, often with diameters greater than 100 m in olistostromes thicker than 450 m belonging to the carbonate platform successions. In a sequential overthrusting of allochthonous nappes scenario, these olistostromes should be generated by gravity dismantlement of PAI successions.

3.4. Volturino Formation

This formation represents the autochthonous Early Pliocene succession covering Apulian carbonates. It is mostly represented by foredeep turbiditic sequences, progressively migrating north-eastwards. This turbiditic basin was generated by subsidence phenomena due to the formation of the Apenninic chain. The 2010 original description of this formation was upgraded to include Early Pliocene slope and deactivation turbiditic system facies (Volturino Fm. Superiore member).

The formation, generally present only in subsurface successions, is characterised mainly by grey, grey-greenish and varicolored silty shale, with sporadic intercalation of light grey qz-feldspatic sandstone, hemipelagic argillaceous mudstone/wackstone with globigerinids levels sometimes present.

4. Petroleum system

The whole petroleum system lies in the Mesozoic carbonatic sequence:

- the source rock is related to syn-rift extension regime, which created the accommodation space where thick anoxic shallow water limestone deposited (more than 500 m);
- the reservoir consists of Cretaceous-Miocene limestone of the PAI, and its efficiency is strongly related to the type of depositional facies. The Albian–Cenomanian sequence is generally characterised by low inter-crystalline porosity, but reservoir quality can improve in presence of karst fractures. The Senonian shallow-water limestone generally has low porosity, of intra-granular and mouldic type. In contrast, the layers containing rudist fossils have relatively good properties due to intra-fossil porosity. Porosity is also associated to the fractures network related to the main tectonic events affecting the PAI;
- finally, the Lower Pliocene shales and marls overlying the PAI can partly contribute to the sealing of the Cretaceous play, that is guaranteed by Irpine units.

The trap of the field, probably formed during the Upper Pliocene-Pleistocene, consists of a large scale transpressive structure bounded by NW-SE high-angle reverse faults.

5. Seismic data reprocessing workflow

The complex Val d'Agri geological and morphological scenario, together with the presence of anthropic activities in the area, heavily conditioned the seismic acquisition operations resulting in poor quality of the acquired seismic data. Accordingly, the reprocessing of the seismic data for an improved pre-conditioning was one of the main targets of this integrated project.

Among various data processing steps applied (Fig. 4), the most critical was probably the static correction, which is described in the next paragraph. Nonetheless, it might be worth briefly mentioning some of them for their importance in this reprocessing.

Noise attenuation: Val d'Agri raw seismic data are affected by extremely heterogeneous types of noise, see the data sample shown in Fig. 5; among them, the low frequency ground roll noise is probably the strongest and most difficult noise to remove, together with spikes (high amplitude noise bursts), air blast, and high frequency random noise. The denoise approach used in the past implied heavily filtering of the data (i.e. cutting the low frequency to remove the

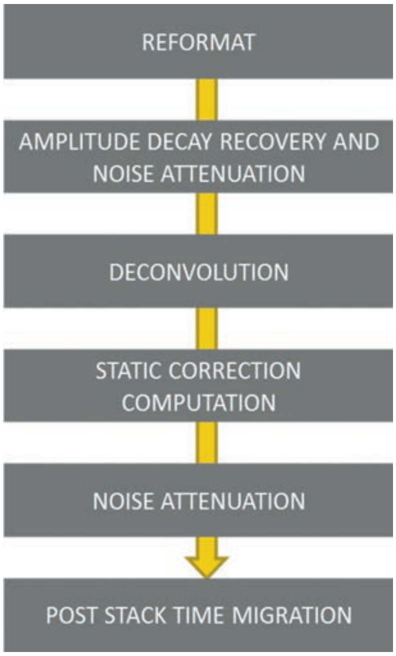


Fig. 4 - Simplified time processing sequence.

ground roll) and to apply a pre-stack gain to mitigate the detrimental influence of spikes and high frequency noise. The acquisition of further information from new wells and the conclusions drawn by various studies carried out in the past highlighted the importance of preserving the low frequency content to better characterise the reservoir. The new denoise approach adopted in this reprocessing tackled the problem in different data domains (common shot, common receiver, cross-spread, common midpoint) by making use of different tools, removing the strongest noise step by step, and at the same time preserving any weak signal and the low frequency content. Two noise attenuation phases were applied, either pre- and post- deconvolution.

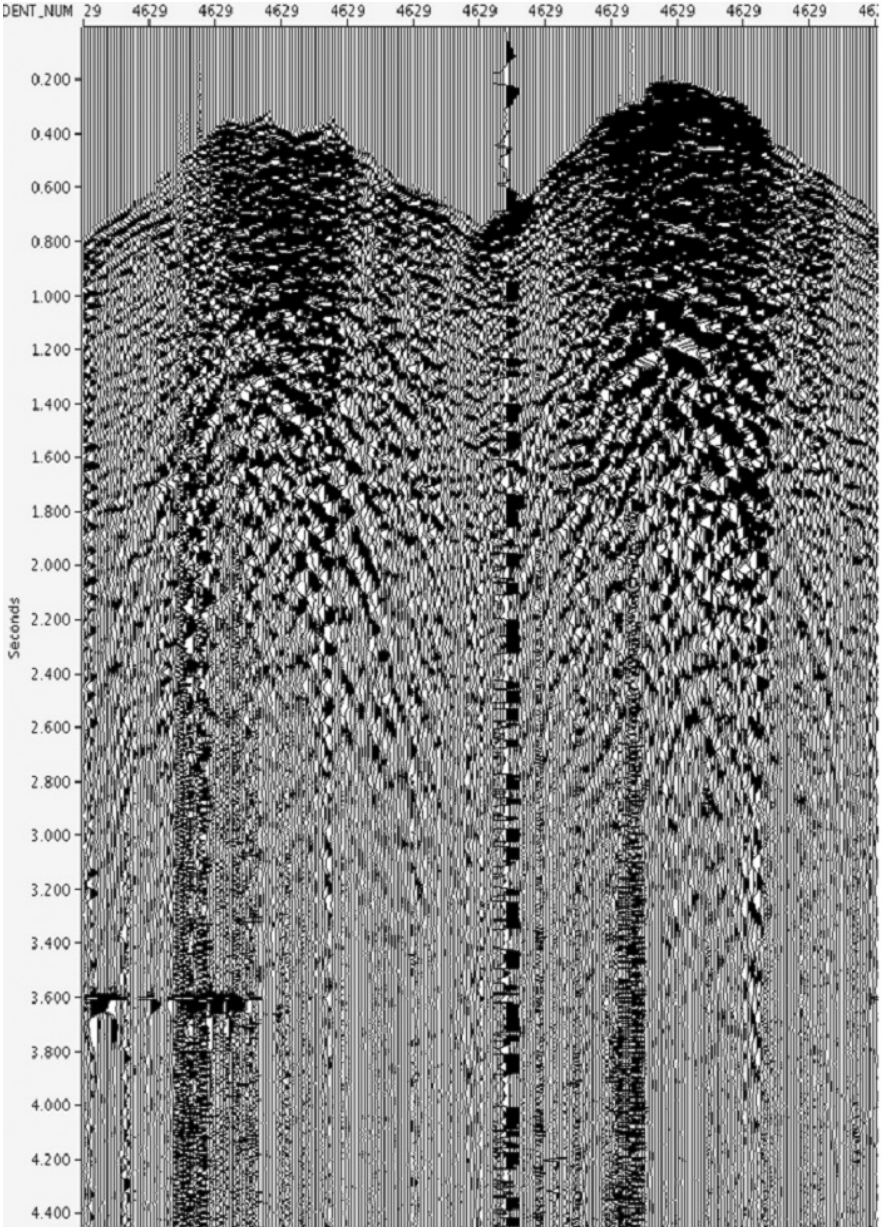


Fig. 5 - Example of raw shot of Val d'Agri data set.

Amplitude decay due to spherical divergence: in order to better preserve the amplitude content of the data, a geometrical spreading correction was applied instead of a Root Mean Square (RMS) gain as it was done in the past.

Deconvolution: deconvolution improves the temporal resolution of the seismic data and attenuates most of the multiple energy that reverberates with short periodicity. Here a surface consistent spiking deconvolution was applied to take into account the variations of the seismic data characteristics due to the variable near surface conditions, while in the previous processing, with different processing steps applied and lack of low frequency content, the surface consistent deconvolution tests did not give the desired results and, then, a trace by trace spiking deconvolution was chosen.

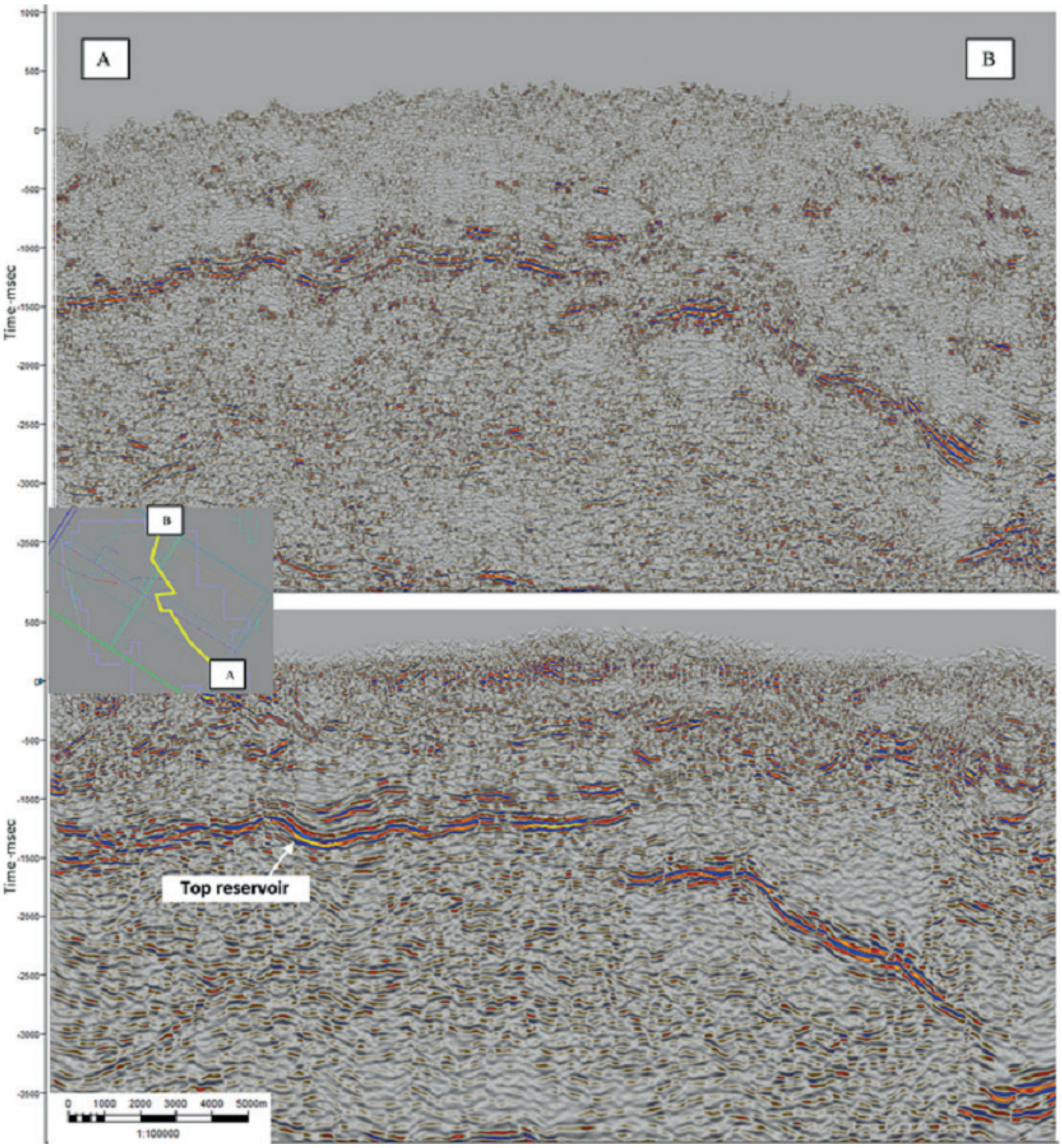


Fig. 6 - Comparison between legacy and reprocessed data.

Pre-stack migration: the severe irregularities of the acquisition geometry, caused by environmental restrictions, resulted in a very irregular fold of coverage and offset distribution (especially at the shortest offsets), strongly reducing the effectiveness of pre-stack time and depth migration. As a consequence, all the legacy processing delivered post-stack time migrated volumes only. Nowadays smart interpolation tools, such as 5D (along inline, cross-line, offset, azimuth and time) pre-stack interpolation, are available to mitigate the above problems. 5D interpolation/regularisation not only allowed the use of Pre-Stack Time Migration (PSTM) but also enabled the application of PSTM in the Offset Vector Tile (OVT) domain, where traces are arranged in groups according to offset and azimuth attributes. PSTM in OVT domain has the advantage of migrating traces within narrow azimuth ranges, resulting in a better focusing of the seismic events.

A comparison between time imaging from legacy and reprocessed data is shown in Fig. 6.

6. Time reprocessing: static corrections

In reflection seismic, statics, as described by Rogers *et al*. (1981), are defined as time shifts individually applied to each seismic trace in the data set to compensate for i) the effects of differences in the elevations of both shots and receivers caused by irregular topography, and ii) near surface velocity variations. Static corrections estimation is one of the most time-consuming steps of the processing flow of onshore data sets, since it requires an accurate near surface velocity model definition, that is the correct Replacement Velocity (RV), used to compute the statics traveltimes from the surface to the datum plane (Fig. 7).

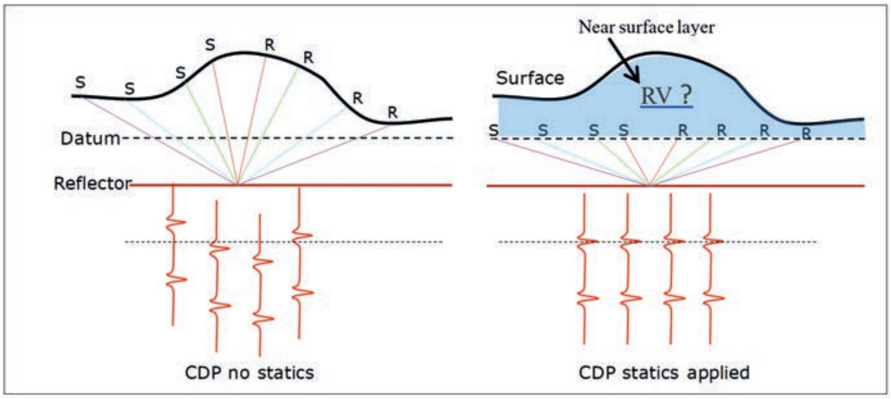


Fig. 7 - Static corrections.

In the Val d’Agri area, static corrections play a particularly important role, due to three main reasons: the wide elevation range (topographic elevation spans from 530 to 1830 m above sea level), the wide range of velocities of geological units in the near surface (from 1700 m/s up to 5700 m/s), and the very complex geological setting.

In the past, static correction computation in this area was approached by using the elevation methodology, and statics were computed as a function of shot and receiver elevations and a space variant RV estimated from the geophysical and geological information available at that time.

In the new reprocessing, statics computation was carried out by jointly using two different methodologies: a "geophysical" approach, where the near surface velocity model was based on the analysis of the first breaks of the seismic traces, and a "geological" approach (elevation statics), where geological data were used to generate a near surface model and compute an average velocity map.

6.1. Geophysical approach to statics computation

The geophysical approach to statics computation is based on the use of the first arrivals to generate a near surface velocity model (Fig. 8).

Tomographic inversion of first-arrival travel-times was applied to derive the near surface space variant velocity model. The weathering velocity was derived from up-holes shots. The application of the static corrections calculated by this methodology resulted in improved stack focusing, a confirmation that the short period component of the static was well resolved; however, local unreliable modifications of the structural asset of the main reflections indicated that a better estimate of long period statics was needed.

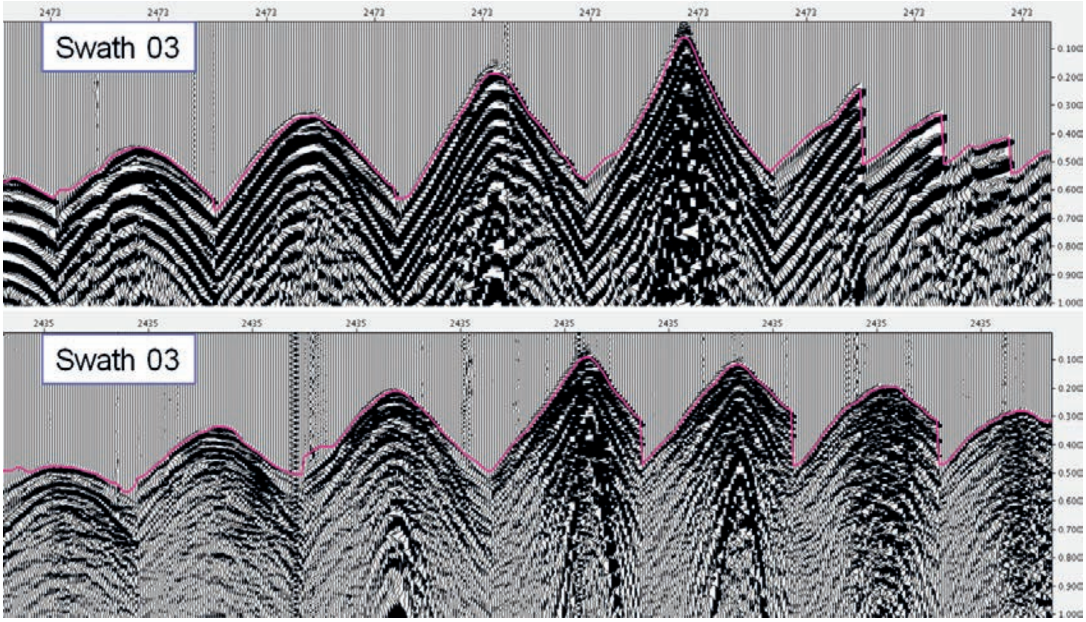


Fig. 8 - Shots with picking of first breaks, in purple.

6.2. Geological approach to statics computation

The main goal of this approach was to use geological information to generate a near surface geological model (Fig. 9), and derive an average velocity map from surface to datum. The data used to build the model were: topographic digital elevation model of the area, geological maps of the outcropping formations, well data, shallow wells for near surface velocity estimation (up holes), geological cross-sections across the Val d'Agri area, and interpretation made on 3D seismics.

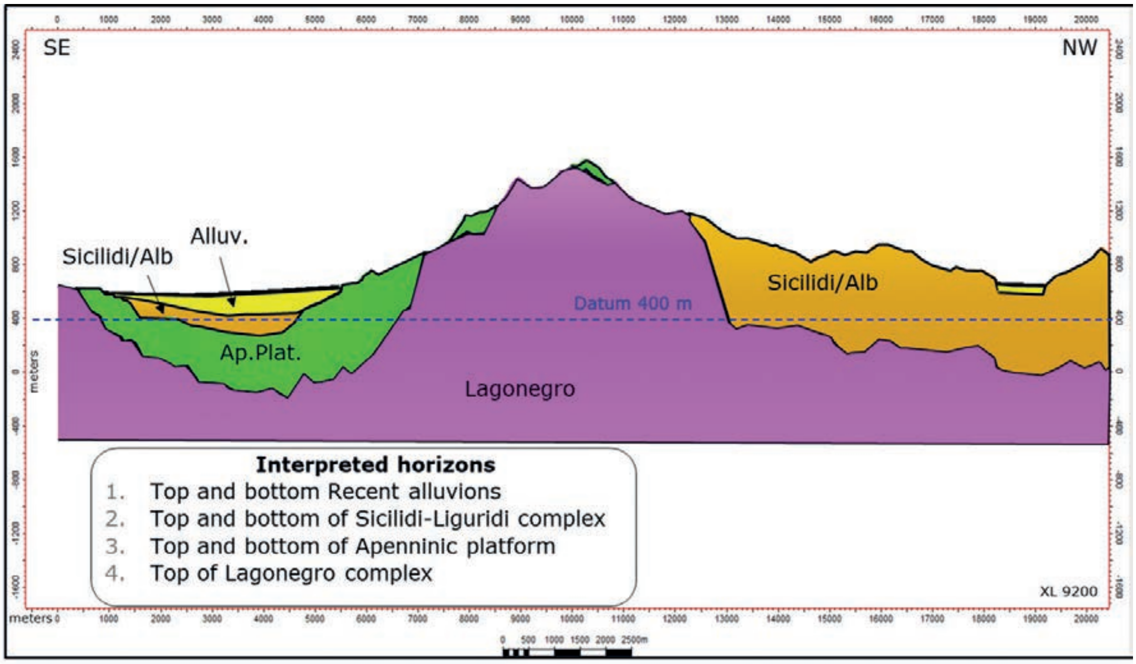


Fig. 9 - Near surface depth model.

The near surface geology consists of four units interpreted considering the geological setting and the rocks interval-velocity ranges.

Recent alluvial deposits: the areal distribution of this unit was based on the geological maps. Top and bottom of the alluvial body were interpreted in Two Way Time (TWT) on seismic 3D volume, and the velocity field was obtained from up-holes information.

Sicilidi-Liguridi complex: this unit comprises Albidona and Gorgoglione Tertiary flysches. The TWT calibrated interpretation was used to generate the isochrone map, converted to depth using geological maps and available wells. Interval velocities were derived from well data.

Apenninic platform**:** this unit is present in a restricted portion of the area, but it plays an important role for statics computation, given its high interval velocity when compared to the surrounding geological units. Also for this unit, TWT calibrated interpretation and well data were used.

Lagonegro complex: the Lagonegro complex is composed by four chaotically superimposed units with very different interval velocities: Galestrino, Scisti Silicei, Calcari con Selce, and Monte Facito, characterised by sudden lateral and vertical velocity variations. The estimation of the interval velocity model started with the analysis of 14 up-holes drilled on the outcropping Lagonegro complex; however, since the up-holes do not reach the datum plane (distance between up-hole TD and datum plane ranges from 230 to 840 m), wells remained the most reliable data for the velocity assessment. Well data were statistically analysed deriving the average velocity for each unit. Geometries of the top and bottom of Lagonegro complex and their units were derived from several geological information, including six geological cross-sections.

Unlike what happened for the short period statics, this geological approach provided reliable long period statics, but suffered from lack of details at short period scale. Consequently, it was decided to combine the two approaches in order to get the best from both, obtaining what is called "hybrid statics".

6.3. Hybrid statics

The geophysical and geological approach to statics estimation resulted in two different RV maps, shown in Fig. 10: the map on the left, derived from the geological approach, represents the low frequency trend of the RV, whilst the map on the right, derived from tomographic information, shows the high frequency component.

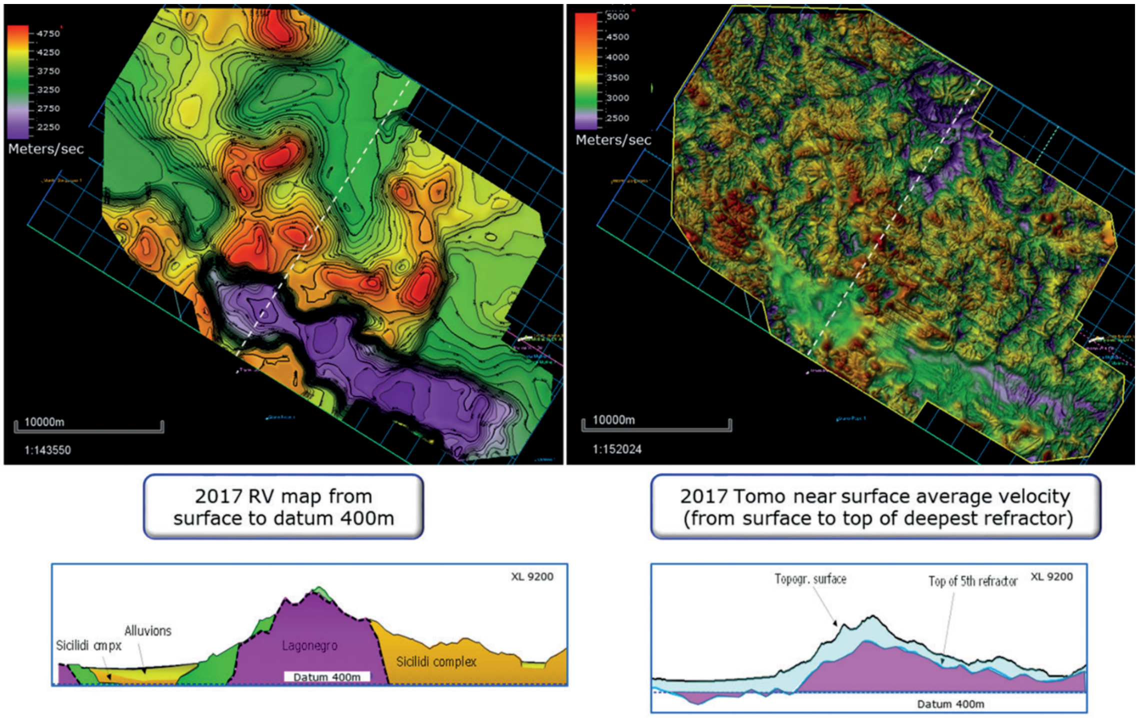


Fig. 10 - Elevation and tomographic RV maps.

The procedure used to combine the two velocity models is shown in Fig. 11: the red line represents the RV derived from geological model, while the green line derives from tomography.

The trend of the green line (black dotted line) was computed and subtracted from the red line. The resulting curve was summed to the green one, resulting in the blue line, which represents the final average velocity from surface to datum (the hybrid RV). Accordingly, the high frequency velocity variations from tomography were superimposed, after appropriate rescaling, to the low frequency velocity trend provided by the geological model, resulting in the final RV map (Fig. 12).

A comparison between a seismic section with elevation statics and the same after hybrid statics application highlights the improvement of the reflector representing the top of the Cretaceous carbonatic platform, the most reflective seismic surface on the sections at about 1.4 s TWT (Fig. 13).

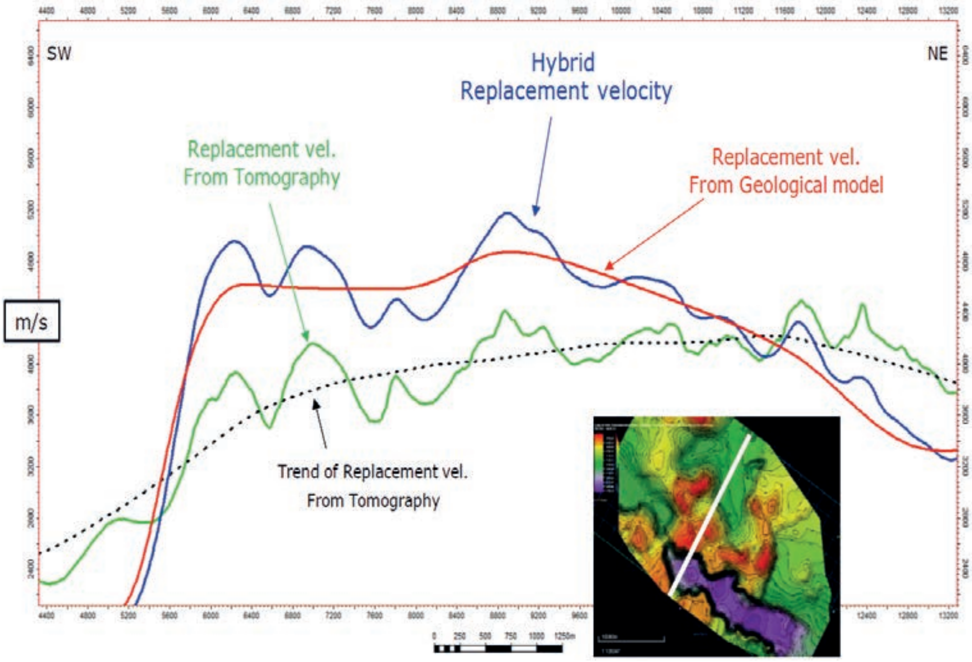


Fig. 11 - Elevation and tomographic RV combination.

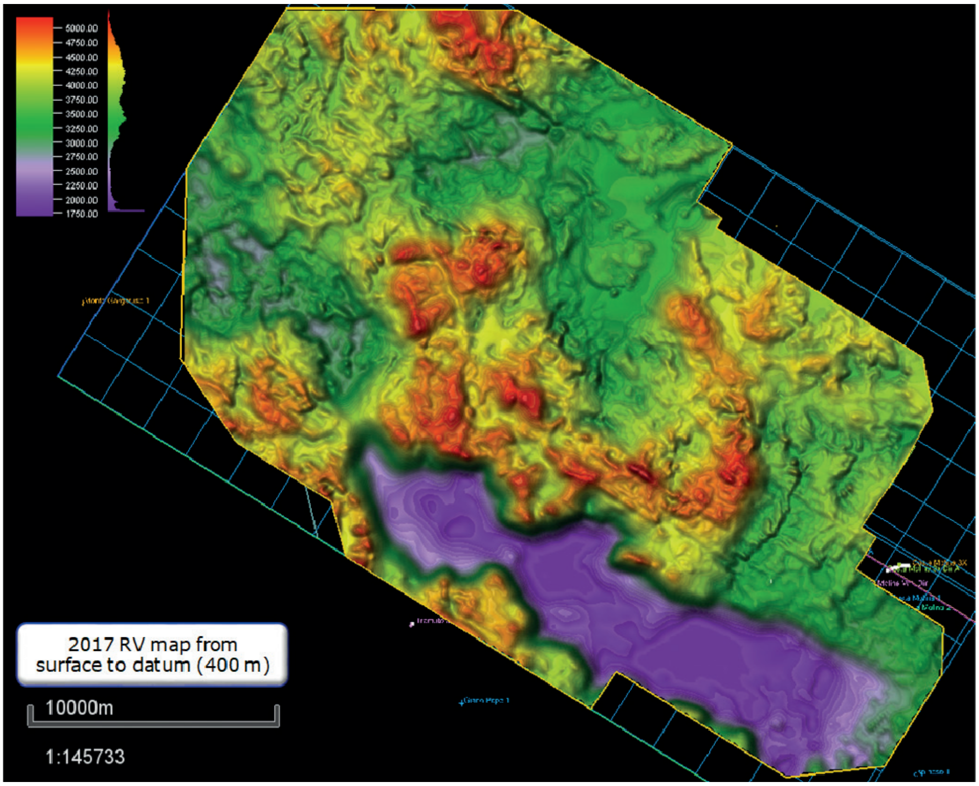


Fig. 12 - Final RV map.

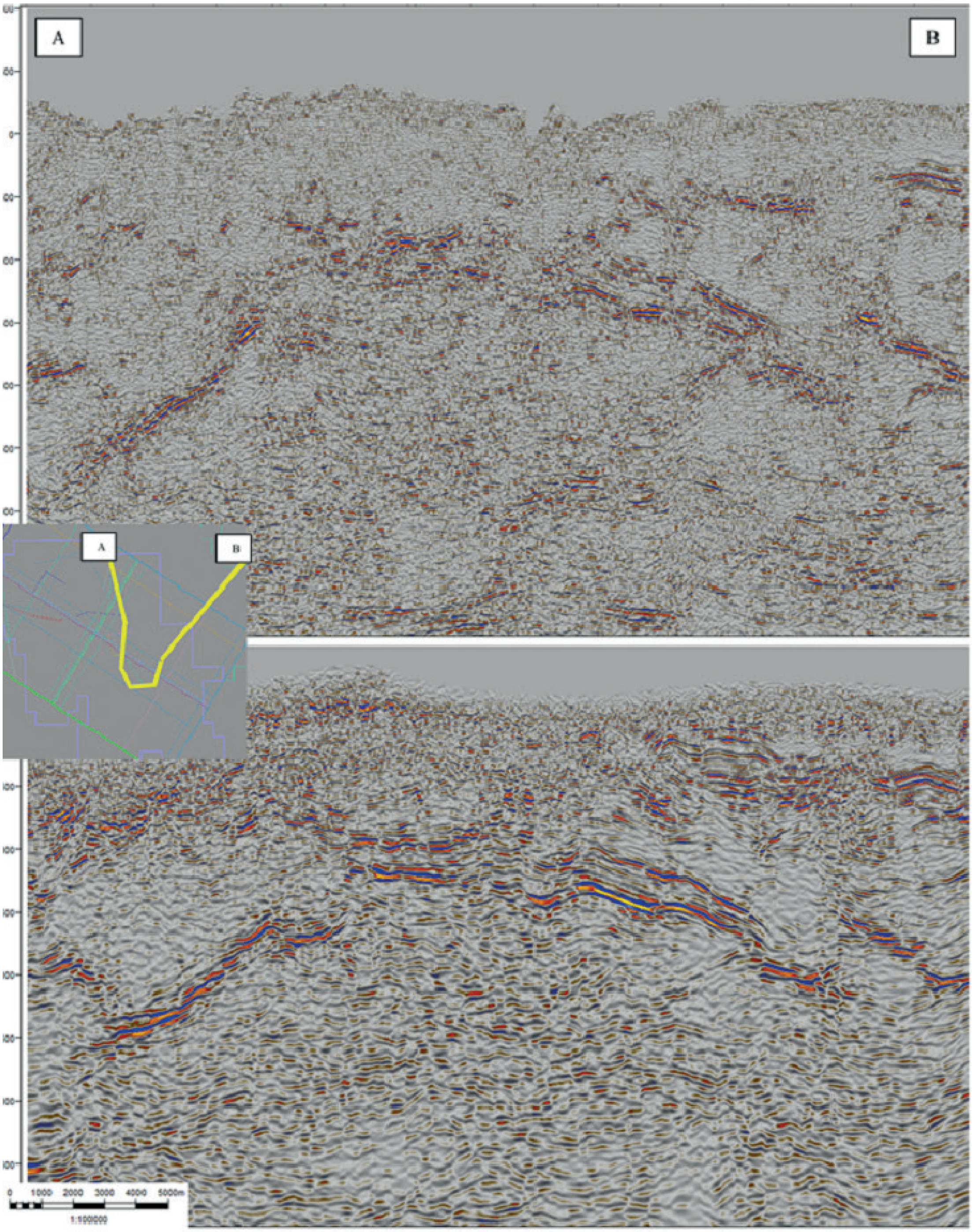


Fig. 13 - Seismic section with legacy elevation statics (above) and seismic section with hybrid statics (below).

Although the approach of combining the low frequency trend with the high frequency component of the RV field is not new in seismic data processing practice, the added value in this project was given by the close integration between geology and geophysics.

7. Depth imaging

Among the various steps needed to migrate a seismic volume in depth domain, the velocity volume building is the most integrated phase, where the contribution of non-seismic data, such as well data, is crucial to get a reliable velocity volume.

The conventional approach to the velocity volume building is based on the evaluation of flatness of the seismic Common Reflection Point Gathers (CRG) as QC of the seismic velocities (Fig. 14).

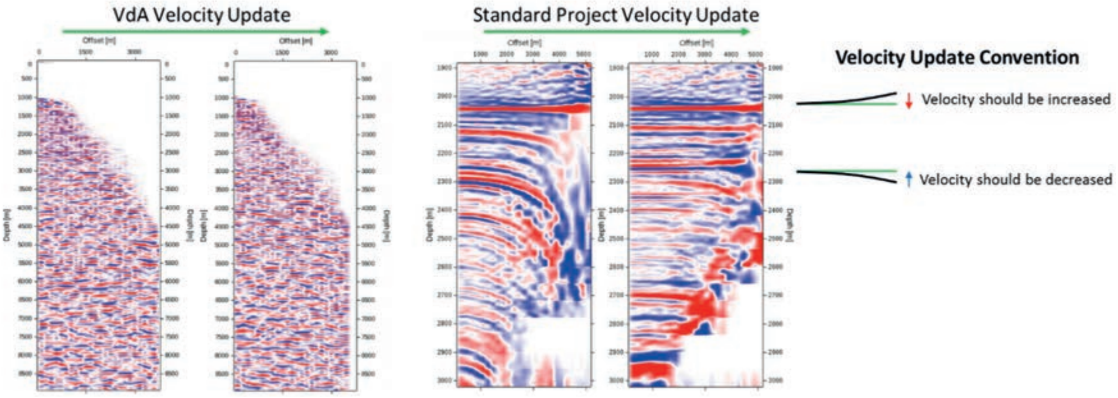
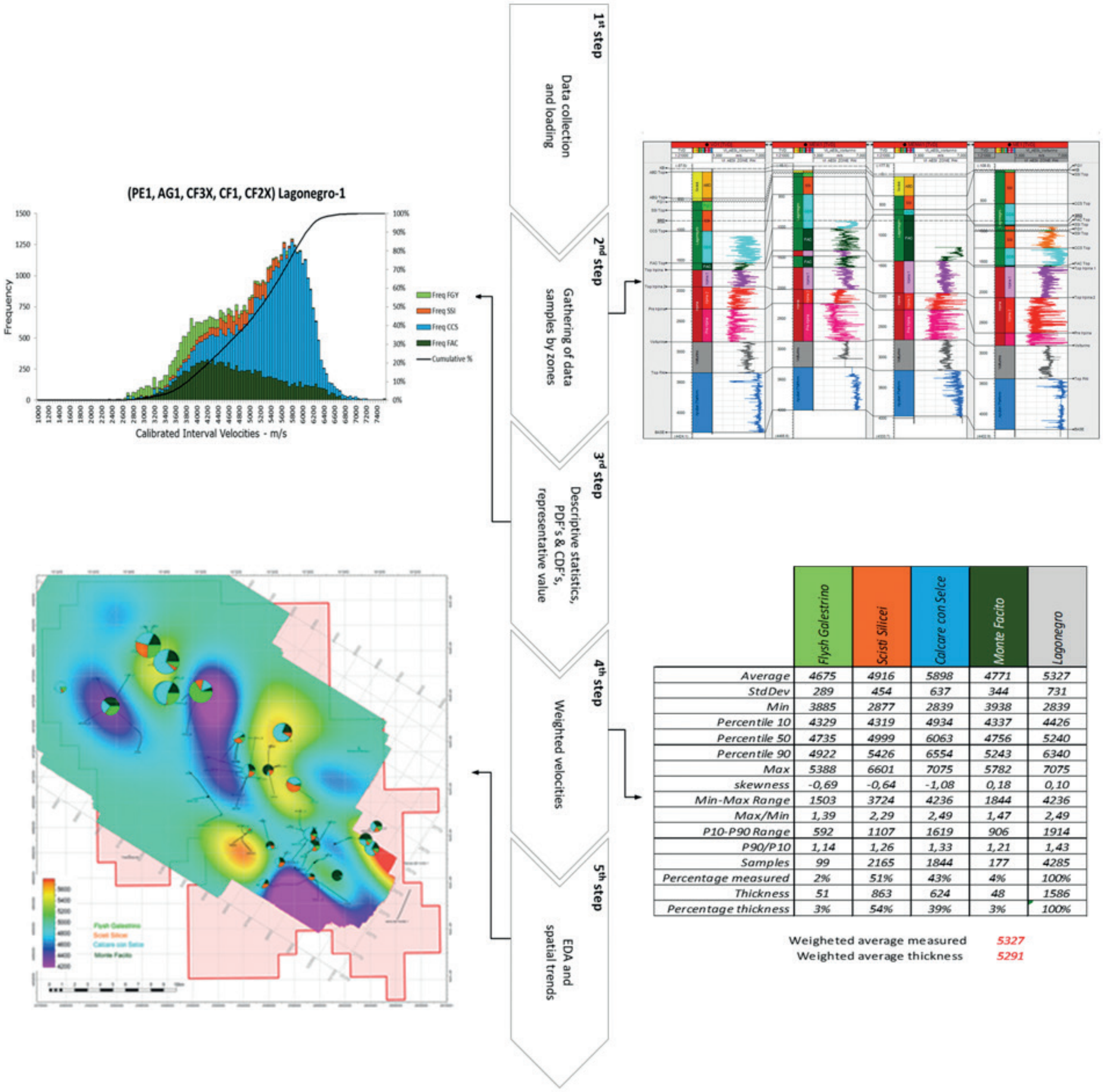


Fig. 14 - Gathers examples: common reflection gathers of Val d'Agri data set (on the left) and standard quality common reflection gathers (on the right).

This method was not applicable here due to the poor quality of the seismic data and a non-conventional approach was applied, primarily based on well information. The two main steps can be summarised as follows.

7.1. Statistical analysis of calibrated velocities

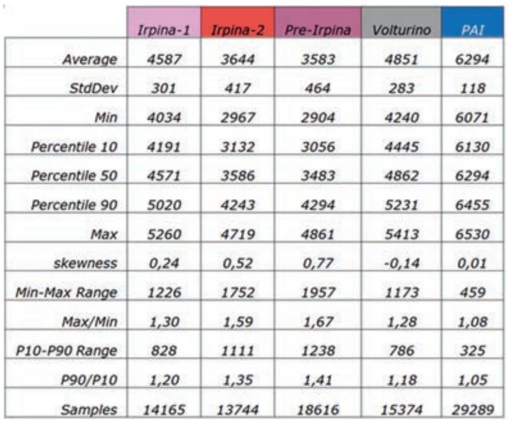
This step was aimed at identifying the lateral and vertical trends of seismic velocities, providing quantitative basis to constrain interval velocities in terms of central tendency (mean, mode, median), range and probability of occurrence (Figs. 15 and 16). First, at each well, a velocity function was derived from the recorded compressional sonic log and subsequently calibrated to VSP data through the drift curve correction. The second step was, then, to define the main stratigraphic zones; the whole volume was divided into six stratigraphic zones: Lagonegro, Irpina-1, Irpina-2, Irpina-3, Volturino, and PAI. Lagonegro was further subdivided into four units: Monte Facito (FAC), Calcare con Selce (CCS), Scisti Silicei (SSI), and Flysch Galestrino (FYG). Then, for each stratigraphic unit, a descriptive statistic of the velocity data was generated, identifying their representative statistical moments, building their related probability density functions. In case of partial lack of velocity data (due in turn to a partial lack of sonic log information), the gap was filled by deriving the information from a statically analysis of the stratigraphy in the adjacent wells. Extrapolation of well information was attempted through the implementation of simple Kriging algorithm using various variographies. However, the resulting



	Flysh Galestrino	Scisti Silicei	Calcare con Selce	Monte Facito	Lagonegro
Average	4675	4916	5898	4771	5327
StdDev	289	454	637	344	731
Min	3885	2877	2839	3938	2839
Percentile 10	4329	4319	4934	4337	4426
Percentile 50	4735	4999	6063	4756	5240
Percentile 90	4922	5426	6554	5243	6340
Max	5388	6601	7075	5782	7075
skewness	-0,69	-0,64	-1,08	0,18	0,10
Min-Max Range	1503	3724	4236	1844	4236
Max/Min	1,39	2,29	2,49	1,47	2,49
P10-P90 Range	592	1107	1619	906	1914
P90/P10	1,14	1,26	1,33	1,21	1,43
Samples	99	2165	1844	177	4285
Percentage measured	2%	51%	43%	4%	100%
Thickness	51	863	624	48	1586
Percentage thickness	3%	54%	39%	3%	100%

Weigheted average measured 5327
Weighted average thickness 5291

Fig. 15 - Methodology scheme for geostatistical analysis.



	Irpina-1	Irpina-2	Pre-Irpina	Volturino	PAI
Average	4587	3644	3583	4851	6294
StdDev	301	417	464	283	118
Min	4034	2967	2904	4240	6071
Percentile 10	4191	3132	3056	4445	6130
Percentile 50	4571	3586	3483	4862	6294
Percentile 90	5020	4243	4294	5231	6455
Max	5260	4719	4861	5413	6530
skewness	0,24	0,52	0,77	-0,14	0,01
Min-Max Range	1226	1752	1957	1173	459
Max/Min	1,30	1,59	1,67	1,28	1,08
P10-P90 Range	828	1111	1238	786	325
P90/P10	1,20	1,35	1,41	1,18	1,05
Samples	14165	13744	18616	15374	29289

Fig. 16 - Results of statistical analysis for Irpina-1, Irpina-2, Pre-Irpina (renamed during this project in Irpina 3), Volturino, and PAI.

velocity maps gave locally "non-geological" results, leading to the need of better geologically constrain them.

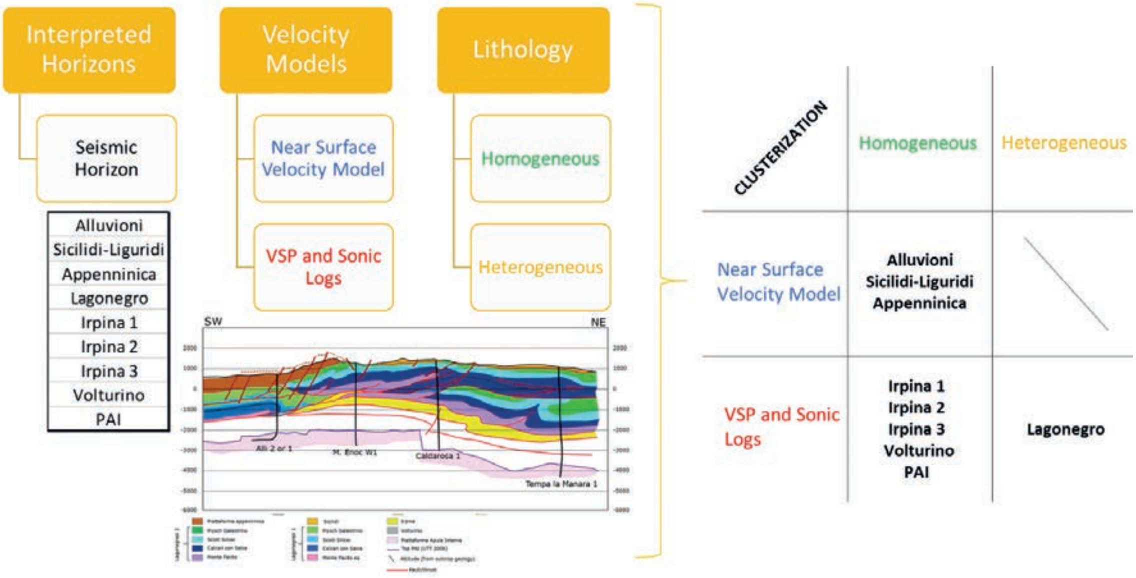
7.2. Geologically driven velocity model building

Three different types of input data were utilised to build the velocity model: a) the legacy seismic interpretation, consisting of 9 TWT horizons; b) the near surface velocity model from surface to datum plane, coming from the above mentioned hybrid statics, and c) wells information – depth markers and calibrated sonic logs statistical analysis – from more than 50 wells (Fig. 17).

According to that input data, the formations were, then, categorised in three clusters:

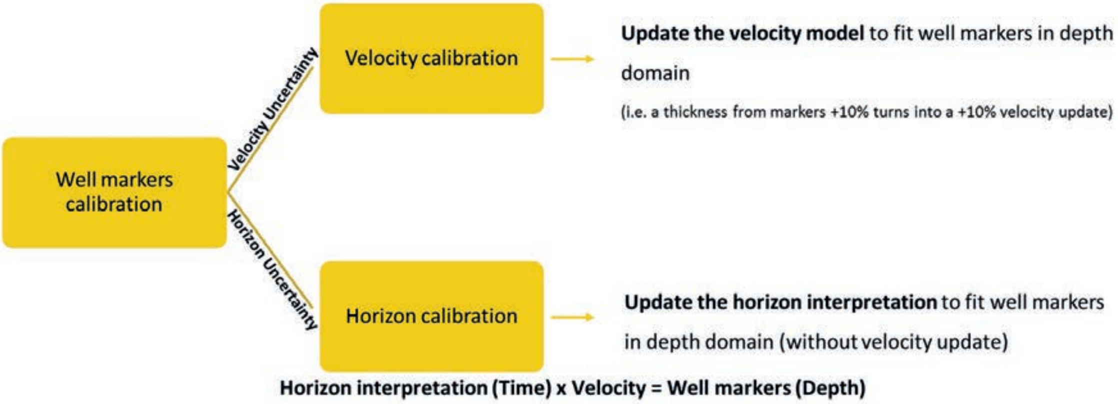
- shallower cluster, inclusive of Alluvioni Fm., Sicilidi Fm., and Apenninic Fm., where velocity information came from statics computation and the lithology is homogenous;
- deeper cluster inclusive of Irpina 1 Fm., Irpina 2 Fm., Irpina 3 Fm., Volturino Fm., and PAI Fm., where velocity information came from VSP and statistical analysis of sonic logs data and the lithology is homogenous;
- Lagonegro Fm., where velocity information came from VSP and sonic logs velocity data and the lithology is heterogeneous.

The time horizons selected to constrain the velocities were converted to depth using the above described velocities and, then, they were calibrated at the wells. The residual misties were related either to incorrect velocities and, at least locally, to inaccurate horizon picking, due to the poor imaging quality. For this reason, a well marker calibration process, derived by a velocity update, was applied in areas with reliable time interpretation; in areas with poor signal-to-noise (S/N) ratio, a horizon calibration was applied modifying the horizon shape without updating the velocity. These two approaches are just the end members of the process and they were used in a combined weighted way during the life of the project (Fig. 18).



CLUSTERIZATION	Homogeneous	Heterogeneous
Near Surface Velocity Model	Alluvioni Sicilidi-Liguridi Appenninica	\
VSP and Sonic Logs	Irpina 1 Irpina 2 Irpina 3 Volturino PAI	Lagonegro

Fig. 17 - Velocity model building scheme.



Update the velocity model to fit well markers in depth domain

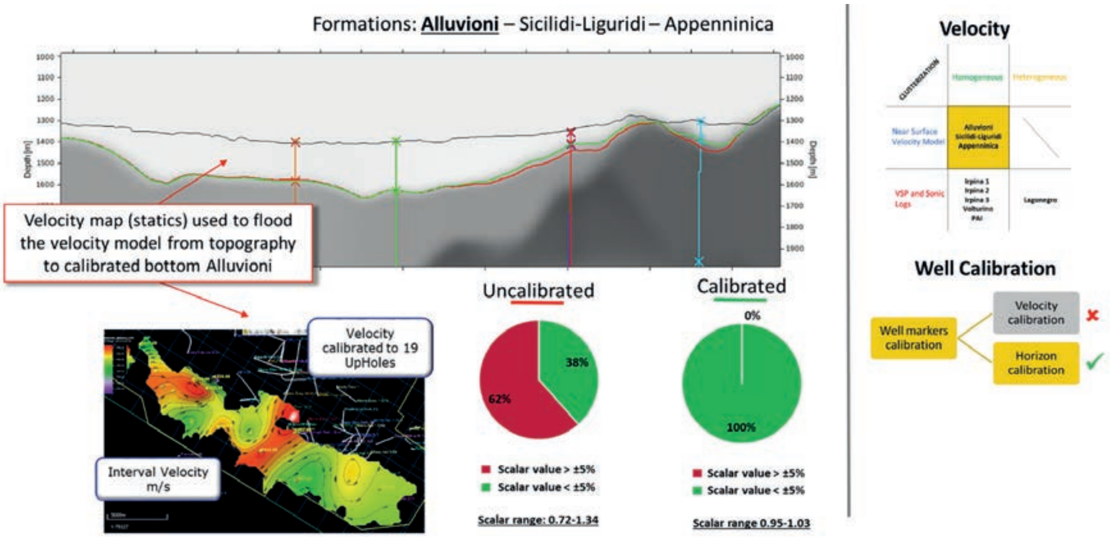
(i.e. a thickness from markers +10% turns into a +10% velocity update)

Update the horizon interpretation to fit well markers in depth domain (without velocity update)

Horizon interpretation (Time) x Velocity = Well markers (Depth)

Fig. 18 - Well calibration.

In details, the calibration for the shallower cluster was done updating the horizon interpretation to fit well markers in depth domain, without updating the velocity; while for the deeper cluster, for each formation the velocity logs showed a sharp Gaussian distribution (Fig. 19), allowing to use the average value as starting point for the next velocity updates.



Velocity map (statics) used to flood the velocity model from topography to calibrated bottom Alluvioni

Velocity calibrated to 19 UpHoles

Fig. 19 - Example of shallower velocity model building for the Alluvioni Fm. The pie charts show the results of mistie analysis before and after the calibration.

Starting from these values, a mixed approach to calibrate the horizons was used, allowing to modify the velocity up to a scaling value in order to include the 70% of sonic well samples and ascribing all the residual mistie to the horizon interpretation, which was modified in order to fit the well markers (Figs. 19 and 20).

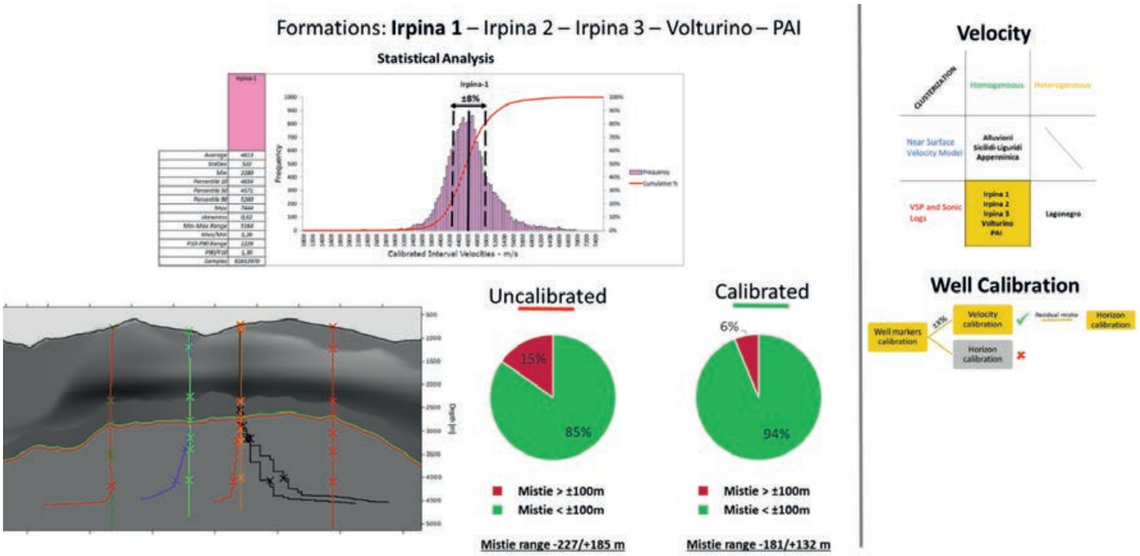


Fig. 20 - Example of shallower velocity model building for the Irpina 1 Fm. The Gaussian curve shows the results of statistical analysis on Irpina 1 sonic logs. The continuous black line indicates the average value of 4613 m/s and the dashed lines indicate the range of calibrated velocity. The pie charts show the results of mistie analysis before and after the calibration.

For the Lagonegro Fm., due to its strong heterogeneity, a simple extrapolation of average velocity values from well was not viable; for this reason, two methods were tested: a 2D simple kriging and a 3D proprietary well interpolator tool. After analysis of residual mistie and qualitative evaluation of the velocity distribution, the latest approach was preferred. Finally, the depth converted horizon was calibrated using a weighted approach, modifying both the velocity field and the horizon interpretation (Fig. 21).

Fig. 22 shows the effect of different velocity models on the final depth imaging.

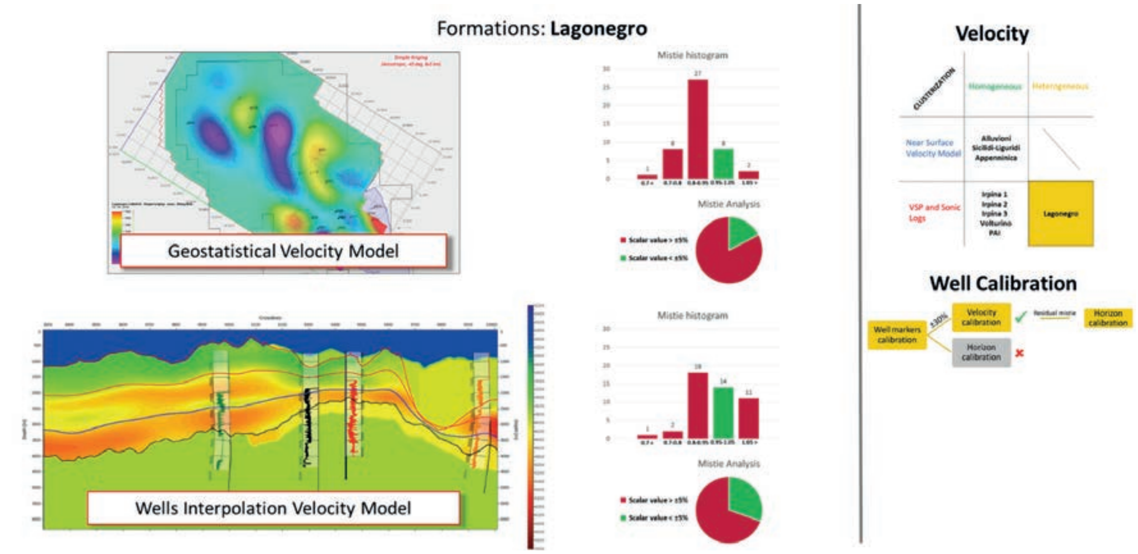


Fig. 21 - Comparison between geostatistical and wells interpolation for the Lagonegro velocity model building and related mistie analyses.

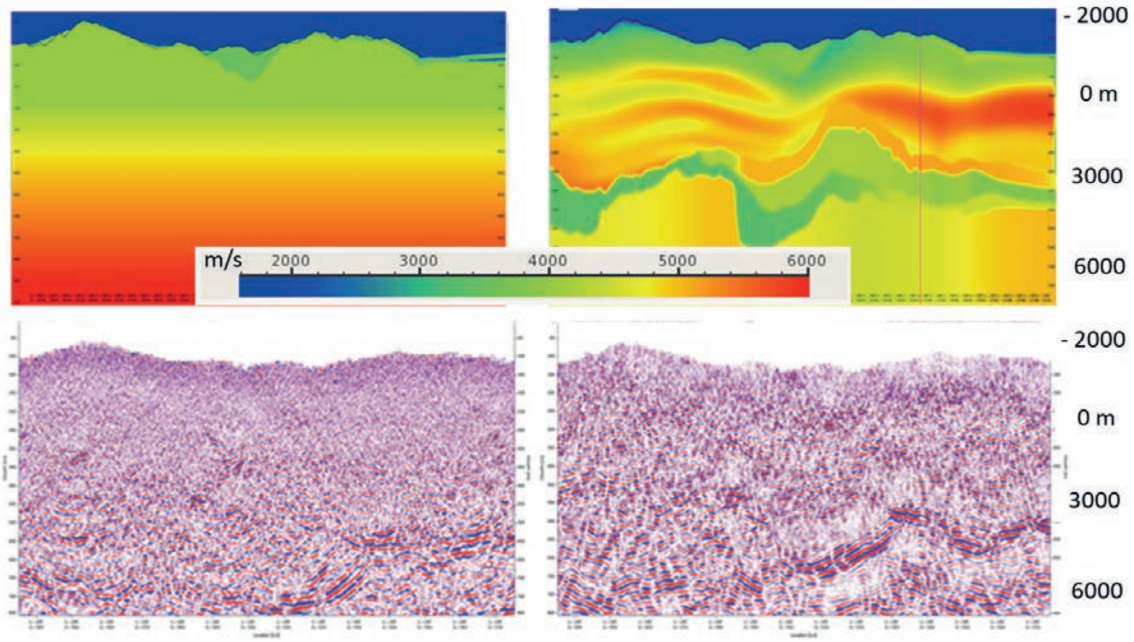


Fig. 22 - Comparison between starting velocity model and related PSDM (left) and final velocity model and related PSDM (right).

8. Conclusions and next steps

The work carried out within the project provided a reprocessed time volume, with a general focusing to the S/N ratio improvement resulting in a greater amount of information, especially at the target level. This volume is currently used to revise the geological model of the area, considering also the revised stratigraphic boundaries.

The first seismic depth volume has also been delivered, and a second depth imaging phase, which was not included in this project, could further improve the imaging in depth.

It is fair to note that the improvement in areas characterised by a very poor data quality is still low, both in time and depth domain; this is probably due to lack of any useful seismic signal content in the raw data, caused by strong acquisition constraints.

The vintage Monte Alpi and Cerro Falcone 3D seismic data sets are definitively outdated for their age and acquisition parameters. However, although the acquisition of a new seismic is believed to be the best solution to improve the quality of the data, the difficulties and costs of acquiring new seismic data in the southern Apennines are well known and, accordingly, a new acquisition is difficult to be realised. In light of these constraints and considering the significant results achieved by the reprocessing, the approach of generating a single and comprehensive model that honours all the geological and geophysical data should be further pursued, taking advantage of the experience gained during the execution of the project.

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