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CROP Project: goals and organization

Progetto CROP: scopi e organizzazione

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ABSTRACT - The CROsta Profonda (CROP) Project started in 1985 as a Strategic Project of the National Research Council (CNR) of Italy. In 1989 AGIP (National Oil Company) and ENEL (National Electricity Board) signed an agreement with CNR to further implement the CROP Project. To date more than 8700 km of seismic profiles have been acquired at sea and 1300 km at land. There are plans to continue this activity in the southern Apennines (Calabria) and in Sicily and to set up a CROP database.

KEY WORDS: CROP Project

RIASSUNTO - Il Progetto CROsta Profonda (CROP) è iniziato nel 1985 come progetto strategico del Consiglio Nazionale delle Ricerche. A partire dal 1989 è stata sottoscritta una convenzione tra AGIP, CNR ed ENEL con lo scopo di intensificare le ricerche di sismica profonda. Ad oggi sono state realizzati 8700 km di linee sismiche in mare e 1300 km a terra. In futuro si prevede di estendere l'attività in Calabria e Sicilia attraverso la realizzazione di altri due profili sismici e di rendere disponibili in dati fin qui realizzati a tutta la comunità scientifica attraverso la realizzazione di una banca dati permanente.

PAROLE CHIAVE: Progetto CROP

1. - INTRODUCTION

As described by MORELLI (this volume), the first program of the CROP Project (CROsta Profonda = Deep Crust) was drawn up between 1982 and 1984 by a scientific commission designated by the National Research Council (CNR).

The main goal of the CROP Project was to study the crustal structure by means of near-vertical reflection (NVR) seismic as in similar projects in the USA (COCORP), in Germany (DEKORP), in France (ECORS), and in the UK (BIRPS). This method is the most used in the industrial exploration of hydrocarbons, and it was adapted to reach crustal depths.

These studies have been implemented on a step-by-step basis:

- Revision of all the existing geological and geophysical data on the area under exploration;
- selection of seismic profile and of the best acquisition parameters;
- new data processing sequence;
- interpretation of the seismic sections, taking into accounts all the geological and geophysical data.

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2. – FIRST PHASE (1985-1988)

The operative phase of the CROP Project began in 1985, thus making CROP one of the first strategic projects of CNR. Project Manager was M. Bernabini.

In this initial phase, the work was focused on the acquisition of crustal seismic profiles, essentially in the Alps, in cooperation with working groups from surrounding countries that were working on the same type of projects.

The first task, in cooperation with the French group (ECORS project), was to study the Western Alps from Turin to Geneva. The Italian scientific group was coordinated by R. Polino (CNR, Torino) and R. Nicolich (Trieste University). After an initial phase of geological studies (revision of all the data available, detailed geological and structural mapping) and geophysical surveys (DSS, gravity, magnetometry), a 300 km long seismic line was chosen, crossing the Col de la Galise (2,999 m). In October-November 1986, the Italian part of the line (93 km) was shot, financed by CNR and, to a small degree, by ENEA (National Agency for Alternative Energy). The sections were interpreted by an Italian-French team leading to a structural model of the western sector of the Alpine chain.

Contemporaneously, in collaboration with the Swiss NRP 20 crustal seismic project, a study along the Central Alps began. The Italian scientific group was coordinated by A. Montrasio (CNR, Milano) and R. Nicolich (Trieste University). In the Italian side, 102 km of seismic profiles, financed entirely by CNR, were shot in September-December 1988 in the Mt. Generoso, Valle dello Spluga and Val Brembana zone.

The final activity of this first phase was the acquisition, in collaboration with ECORS, of a seismic profile in the Western Mediterranean from Provence to NW Sardinia. The Italian part of the profile (185 km) was acquired in October 1988. The group was coordinated by F. Fanucci and R. Nicolich (Trieste University).

CNR's financial contribution to this phase amounted to € 1,627,000.00 and ENEA's totaled around € 103,300.00.

3. – SECOND PHASE (1989-1997)

3.1. - The CNR-AGIP-ENEL Agreements

An important step in the CROP Project was the signature of agreements between CNR and AGIP (National Oil Company), and between CNR and ENEL (National Electric Power Company); these agreements guaranteed a permanent operational structure and adequate joint funds.

The agreements were initially for a 5-year period (1989-1994), but were renewed for further five years (1994-1999). They also stipulated that no information on the seismic profiles could be made public until three years after the end of seismic profile acquisition, in accordance with data protection rules.

3.2. - Project Organization

The organization of the CROP Project is shown in figure 1. The Steering Committee, which is responsible for managing the funds and handling the data, is made up of a representative from each partner.

The representatives of the last Steering Committee were P. Manetti (CNR), A. Burbi (AGIP), and G. Giuseppetti (ENEL). Previous representatives include A. Praturlon and G. Giglia for CNR, G. Paulucci, and G. Bolondi for AGIP and P. Bertacchi and M. Fanelli for ENEL. The representatives are generally assisted by their deputies who are currently M. Bernabini (CNR), L. Bertelli (AGIP), and S. D'Offizi (ENEL). Previous deputies were: E. Cassano (AGIP) and S. Martinetti (ENEL).

The Scientific Panel is responsible for drawing up the programs, including the definition of the sub-projects and technical and scientific requirements, and for monitoring the development of the various projects.

The President of the Scientific Panel is currently C. Doglioni (La Sapienza University, Roma); past Presidents were C. Morelli (Trieste University) and A. Praturlon (Roma Tre University).

The task of the Acquisition and Processing Group (GAP) is to define and to check the parameters and methods of seismic data acquisition and processing in order to guarantee the technical quality and homogeneity of the various CROP profiles. President of the GAP is currently L. Bertelli (AGIP); past President was A. Mazzotti (Milano University).

The sub-project consists of a Profile Group, whose members are researchers of different Earth Science disciplines, coordinated by a director chosen by the Steering Committee.

Several meetings were organized for each sub-project, in order to set up the work plan and evaluate the intermediate and final results.

The proceedings of many of these meetings have been published; they are listed in the references.

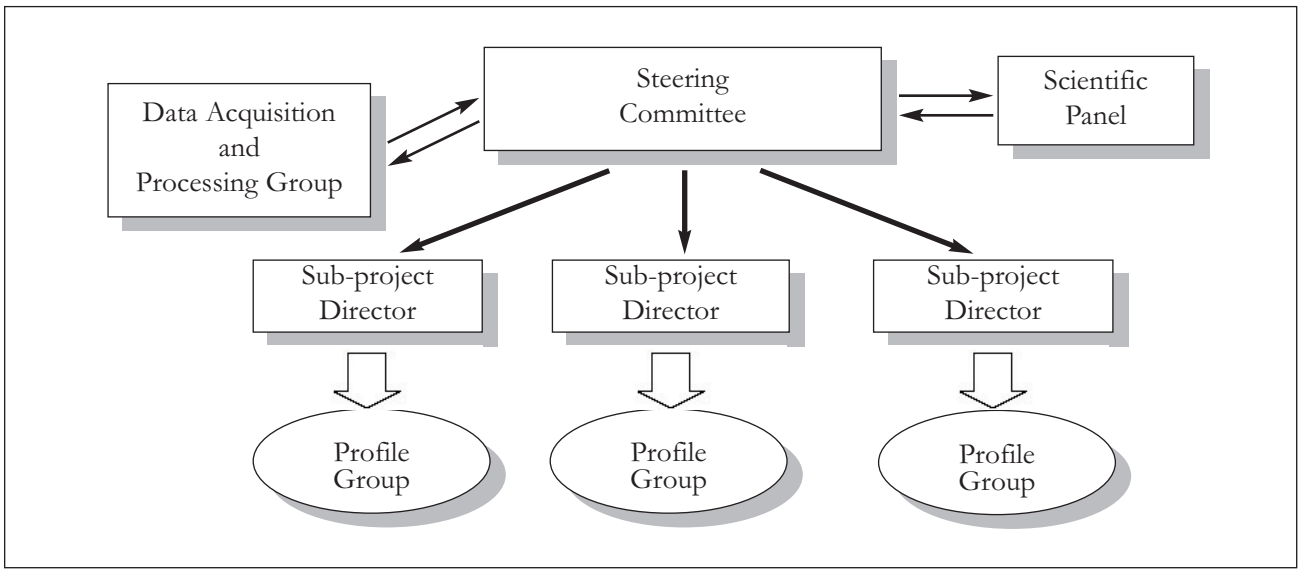

Fig. 1. – Organization of the CROP Project – *Organizzazione del Progetto CROP*

3.3. - The Sub-Projects

The sub-projects organized so far are described briefly, in chronological order of seismic data acquisition (fig. 2).

3.3.1. – *CROP 04 sub-project. Director P. Scandone (Pisa University)*

This sub-project covered the southern Apennines with the acquisition of a seismic profile, 154 km long, and W-E trending, between Agropoli (Tyrrhenian side) and Barletta (Adriatic side). It was recorded using Vibroseis (coverage 12000%) or explosives (single coverage). The acquisition parameters and processing sequence used were the same ones adopted with success in the Alps. The results were not as good in this case because of the different geological structures in the two areas. The seismic section resulted almost without reflections. Subsequently the seismic data were carefully re-processed (see paper on CROP 04); this procedure included: a) noise attenuation operations, b) careful refraction static, c) optimisation of the CMP sorting and d) model-driven velocity analysis.

The main superficial geological structures and the available magnetic, gravimetric, magnetotelluric and seismological data were all taken into consideration during the interpretation of the seismic profile.

3.3.2. – *CROP 03 sub-project. Director M. Barchi (Perugia University), Past-Director G.P. Pialli (Perugia University)*

This sub-project covered the northern Apennines (Toscana, Umbria and Marche regions) with the acquisition (1992-1993) of a seismic profile (about 220 km long) oriented WSW-ENE between Punta Ala (Tyrrhenian side) and Gabicce (Adriatic side).

Compared to the CROP 04 profile, different acquisition parameters were used. An explosive source only was employed (coverage 3200%) and Helidrill techniques were used in a few areas of the chain.

Industrial data processing, by AGIP, gave good results, as events to 15 sec are present in the sections. Wide-angle reflections were recorded along the same profile with powerful shots performed at greater distances. DSS surveys, using fan shooting and gravimetric and magnetotelluric surveys were also carried out along the seismic profile.

3.3.3. – *CROP - MARE 1 and 2 sub-project. Director I. R.Finetti (Trieste University)*

This sub-project, as an acquisition operation, was developed over two different periods. During the first phase (CROP Mare 1, 1991) about 3400 km of seismic profiles were recorded in the Ligurian, Tyrrhenian, and Ionian Seas. During the

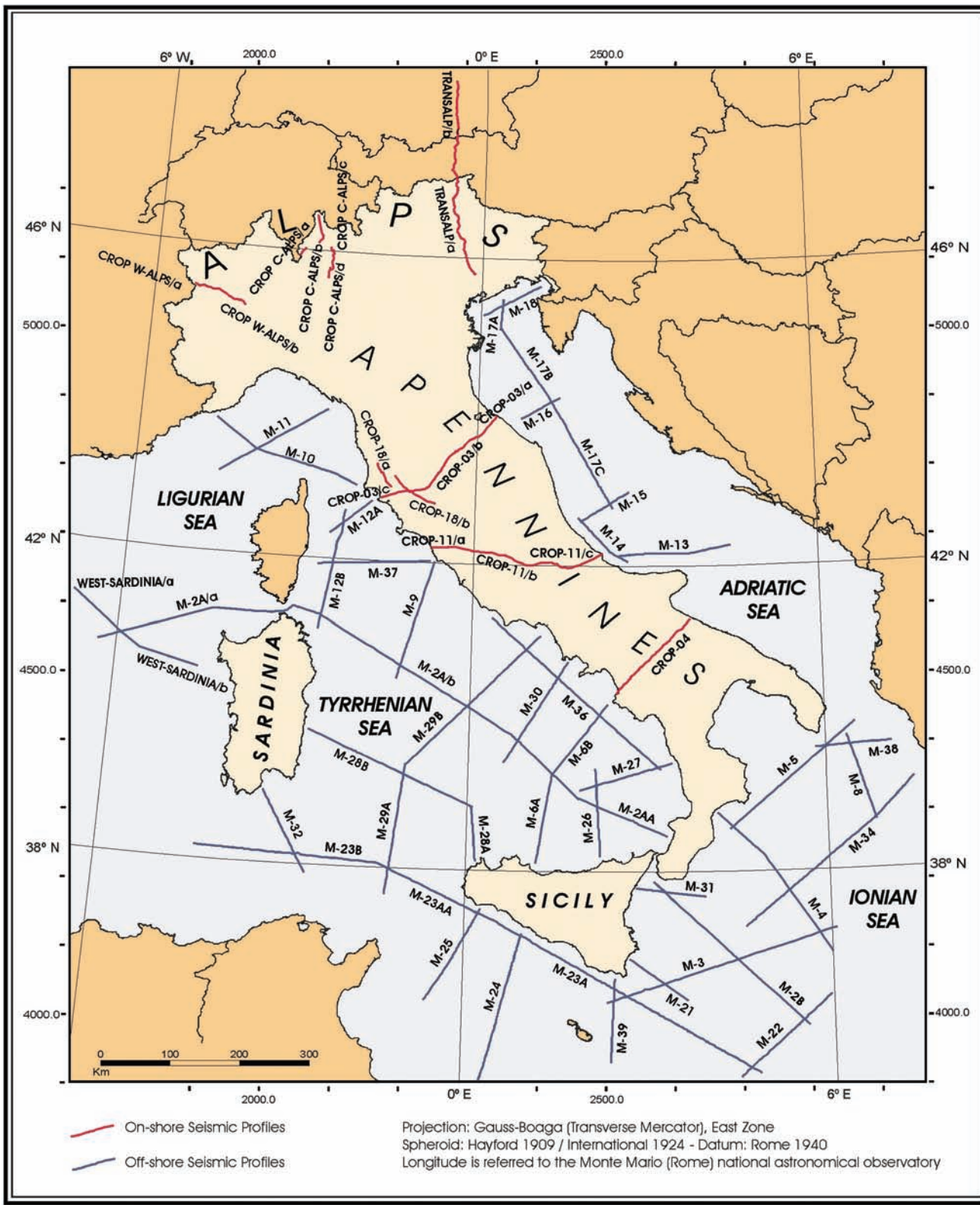

Fig. 2 - CROP Project seismic profiles: location map.
– *Progetto CROP: mappa di posizione dei profili sismici acquisiti.*

second phase (CROP Mare 2, 1993-94), over 5000 km of seismic profiles, were acquired in the southern Tyrrhenian Sea, in the Sardinia Channel, and in the Ionian and Adriatic Seas. Some seismic lines initially planned for the southern Adriatic Sea were not acquired for political and military reasons. The profiles of both phases were acquired by the oceanographic vessel OGS-Explora, using air gun sources.

Data processing was carried out by the OGS (Geophysical Experimental Observatory) and ISMES for the first phase, and by AGIP (Adriatic and Ionian Seas) and ISMES (Tyrrhenian Sea) for the second.

Some data processing, to remove sea-bottom multiples, was performed at Trieste University.

During the acquisition of some seismic profiles, low-frequency seismographs of the Sea-Land Group recorded on-shore the seismic waves generated by off-shore air gun shots (CAIELLI *et alii*, this volume).

3.3.4. - *CROP 11 sub-project. Director M. Parotto (Roma Tre University).*

This sub-project involves the Central Apennines where a W-E trending seismic profile, 260 km long, was acquired between Civitavecchia and Vasto (1996-1999) an explosive source was also used for this seismic profile (coverage 3200-2400%).

Only the first part (on the Tyrrhenian side) was funded by CNR and ENEL; the second part was financially supported by the National Geological Survey and the Ministry for Education, Universities, and Research (MIUR).

The survey was coupled with a re-interpretation of the DSS, gravimetric and seismologic data, and some specific field surveys.

3.3.5. – *CROP 18 sub-project. Director A. Lazzarotto (Siena University). Past director G.P. Pialli (Perugia University).*

This N-S profile, 115 km long, was recorded in central Toscana (1995), between the geothermal areas of Larderello and Mt. Amiata. It was also planned to extend the CROP 03 results southwards; the acquisition parameters and processing sequence of CROP 18 were in fact the same as CROP 03. The funds were provided by ENEL.

Again seismic acquisition is being coupled with a re-interpretation of gravimetric, magnetometric, magnetotelluric, DSS, and heat flux data.

3.3.6. – *TRANSALP Project – CROP 1A sub-project. Director A. Castellarin (Bologna University)*

The overall CROP seismic acquisition program included two seismic profiles across the eastern Alps.

The German (GFZ and Munich University) and Austrian (Leoben University) groups proposed the prosecution of the CROP 1A seismic profile (Treviso – Valle Aurina) through Austria to Munich. This proposal was approved by CROP Steering Committee and was implemented in 1998/1999. The profile, 327 km long, was financially supported by AGIP and CNR for the Italian part. Six seismic profiles, orthogonal to the main profile, were performed. Vibroseis (coverage 6000%) and explosive sources (single coverage) were used.

4. – PROJECT FUNDS

During the second phase of the CROP Project, for a period of 10 years (1989-1999), the financing partners provided a total of € 14,621,380.00 which € 5,840,390.00 were given by CNR, € 4.132.230.00 by AGIP and € 4,648,760.00 by ENEL.

Sixty-eight percent of the total was spent on acquisition of the seismic profiles, 12% on the elaboration of the seismic data, 8% on the financing the profile groups, and the 12% for research, organization and publication of the results. The German and Austrian funds for the TRANSALP Project are not included in the total.

Also funds for some studies connected to the CROP Project and financed by universities, CNR and the Ministry of Education are not included in the total.

5. - CROP 2 PROJECT

In the year 2000 AGIP, CNR and ENEL confirmed their interest in continuing the CROP Project through a 3-years agreement, which can be renewed and which is also open to other public and private entities interested in deep seismic studies.

One of the main goals of the new agreement is to publish this Atlas, which includes all the acquired

seismic lines; this huge seismic data-set gives some idea of the intense activity carried out during the CROP 1 phase.

All the seismic digital data are now being transferred to the Istituto per le Scienze del Mare - CNR Sezione di Bologna, in order to create the new official CROP Data Base. This should encourage private and public researchers to access this valuable seismic data base. The CROP Data Base will be operative during 2004.

This data base was promoted by the three CROP partners to stimulate the scientific community to use this data-set to improve their geological and geodynamic interpretation of the Italian territory.

Another goal of the CROP 2 Project is to financially support the study of the acquired seismic lines, with particular reference to the recently acquired seismic data. The various chapters of this volume will describe all these activities.

Regarding the seismic profiles of recent acquisition, the interpretation of the CROP 18 (crossing the Tuscan geothermal areas) and its relationship with the CROP 03 (Punta Ala-Gabicce) has been started.

In the case of CROP 11 (Civitavecchia-Vasto), acquisition and processing were completed only very recently; this profile is also included in the Atlas. Similarly, the TRANSALP profile, processed by AGIP for the Italian part, is also included in the Atlas, also thanks to the works and the studies of our German and Austrian partners, to whom we are deeply grateful.

Although the main objectives of the CROP 2 Project are those described above, one other goal remains: to plan and organize the acquisition of two seismic lines in Calabria and Sicily.

A profile for Sicily has been proposed by R. Catalano (Palermo University) and S. Merlini (AGIP), between Termini Imerese and Siracusa; a feasibility study is in progress.

G. Bonardi (Napoli University), on the other hand, is currently investigating the most appropriate location for the calabrian profile, considering the available off-shore CROP seismic data.

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