

First Results of a Research Project on Groundwater Resources of Italy: Inventory of Studies and Hydrogeological Maps

Primi risultati di un progetto di ricerca sulle risorse idriche sotterranee: censimento di studi, indagini e carte idrogeologiche realizzate nel territorio nazionale

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ABSTRACT - The purpose of this research project, promoted by APAT *Agenzia per la protezione dell'ambiente e per i servizi tecnici* in 2003, is to collect the hydrogeological maps and the hydrogeological studies published by universities, research institutes and public administrations, and to provide some standard methods in the utilization of data.

The aim is also to define the state of the art on the groundwater resources in the national territory and to specify the activities and the studies which should be realized for a further development of the hydrogeological knowledge.

The main stages of the research are: collection of hydrogeological data, thematic maps and studies on groundwater resources; database elaboration; critical review of the collected data.

Studies and hydrogeological researches from many scientific journals and meeting proceedings have been retrieved. The publications of some research institutes and universities have been collected too.

Up to now over 100 thematic maps at different scales related to groundwater resources of the national territory, or the most important hydrographical basins, single districts and specific hydrostructures have been collected, scanned and stored in a computer, on CD Rom.

The hydrogeological studies and the thematic maps have been organized in specific files of a large database, which represent an important product of this project.

KEY WORDS: Hydrogeology, Groundwater, Thematic Maps, Geodatabase, Italy.

RIASSUNTO - La nota illustra i risultati di un progetto di ricerca promosso nel 2003 da APAT *Agenzia per la protezione dell'ambiente e per i servizi tecnici* con l'obiettivo di effettuare il censimento delle indagini e delle carte idrogeologiche realizzate da strutture pubbliche e istituti di ricerca, di definire gli studi necessari a completare le conoscenze idrogeologiche del territorio nazionale e sviluppare in modo organico e unitario le attività nello specifico settore.

Per il censimento degli studi e delle indagini idrogeologiche e tematiche sono stati utilizzati periodici e riviste scientifiche di interesse settoriale e generale, gli atti di congressi e convegni, le pubblicazioni dei principali istituti di ricerca e Università.

Le carte idrogeologiche e tematiche censite (oltre 100), acquisite mediante scansione, sono state catalogate utilizzando le caratteristiche tipologiche (carte idrogeologiche, piezometriche, delle risorse idriche sotterranee, etc.), la copertura territoriale (territorio nazionale, aree di dimensione sovraregionale, regioni, province, bacini idrografici, specifiche idrostrutture) e la scala di realizzazione (da 1:1.000.000 a 1:25.000). Le carte e i dati sono stati organizzati in specifici archivi. È stato realizzato un Sistema Informativo Territoriale, in fase sperimentale, per verificare il potenziale informativo della documentazione, implementare le informazioni e consentirne una più efficace utilizzazione.

PAROLE CHIAVE: Idrogeologia, Acque sotterranee, Carte tematiche, Geodatabase, Italia.

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1. - INTRODUCTION

Groundwaters represent a strategic resource but often their presence and main characteristics are not sufficiently known. The activities in the specific sector could therefore be directed to define the quantitative and qualitative status of the groundwater resources, to realize experimental monitoring networks, to define the intrinsic vulnerability to pollution and the potential contamination risks.

The recent normative corpus, particularly the legislative decree 152/99, has promoted a new development of the knowledge on groundwater resources of the national territory. A complex of activities finalized to the definition of the environmental state of the groundwater resources through the identification of the aquifers, the definition of hydrogeological conceptual models and the evaluation of the quantitative and qualitative characteristics, have been carried out by the Regions or by the Agencies for the territory and environmental control.

The main goal is now to fix criteria, methods and standards for the collection, elaboration and filing of data, and for the realization of the thematic maps in order to guarantee homogeneity of contents and representation.

The complexity of the activities suggests to develop researches and studies related to specific topics, to identify and to experiment in sample areas criteria and methodologies transferable in other contexts with comparable geological, hydro-geological and environmental characteristics.

A further objective is to keep a global approach to the groundwater resources (quantitative and qualitative characteristics, intrinsic vulnerability, monitoring networks, utilization, real and potential pollution causes) and to define the technical-scientific tools for a correct management and protection.

In this general context a research project has been promoted by APAT. This paper describes the purpose of the research project, the developed activities, the source of information and the main results. The products of the research project and the possibilities of development are described too.

2. - MOTIVATION AND PURPOSE OF THE PROJECT

The project *Censimento della cartografia idrogeologica e individuazione delle modalità di standardizzazione dei dati già esistenti, al fine di sviluppare in modo organi-*

co e unitario attività conoscitive nel settore delle acque sotterranee has been promoted since april 2003.

The purpose of the project is to collect the hydrogeological maps and the hydrogeological studies realized in Italy and to provide standard methods for the utilization of data. The aim is also to define the degree of knowledge on groundwater resources in the national territory and to specify the activities and the studies which should be performed for a further advance of the hydrogeological knowledge.

In the last three decades the hydrogeological knowledge in Italy improved significantly thanks to a lot of studies, researches and maps realized and published by universities, research institutes and public administrations.

Since its beginning the research was intended to collect not only hydrogeological maps and studies but also other thematic maps with a relevant hydrogeological content, such as: isopiezometric contour line maps, geometry and hydrodynamic parameters of aquifers, groundwater mapping and monitoring networks, basic quality and pollution, mathematical flow models and so on. Specific hydrogeological data and other relevant information have been often identified in these documents.

The research project has been planned with the objective to collect firstly the existing, accessible and available data, and to use the tools and the computer methodologies in the diverse phases, particularly from the collection and georeferentiation of data to data base development and processing.

In the realization of the activities no limits regarding the period of the research have been introduced. Therefore the data and the documentation retrieved and collected represent all that available when the inventory has been made.

2.1. - MATERIALS OF THE INVENTORY

2.1.1. - *Hydrogeological studies*

The starting point of this phase of the research has been represented by Internet, the APAT Library and the data and activities of the writer.

Scientific journals have been considered one of the most important source of data and information. The scientific debate has been carried out by means of publications and made possible to identify the degree of knowledge on hydrogeological or connected topics (environment, pollution, hydrochemical data collection, database elaboration).

In this context it is necessary to mention *Acque sotterranee* and *Quaderni di Geologia Applicata* respec-

tively published since 1984 and 1994, characterized by interesting and innovative thematic subjects as standardization of monitoring networks, alternative groundwater resources, risk of pollution, reduction of the points of monitoring by means of geostatistical methodologies and so on.

Moreover *Quaderni di Geologia Applicata* published the proceedings of the meetings realized in 1995 and 1999 by the *Gruppo Nazionale Difesa Catastrofi Idrogeologiche - Consiglio Nazionale delle Ricerche - Linea di Ricerca Valutazione della Vulnerabilità degli Acquiferi* (GNDCI-CNR) in which both the scientific debate of remarkable thickness and the methodological and operative contents have been carried out.

Memorie descrittive della Carta Geologica d'Italia and *Bollettino del Servizio Geologico d'Italia* and other journals which focus on different topics have been considered, because it is important to understand the gradual and progressive presence of papers regarding groundwater resources also in these more typically geological journals.

Proceedings of the main conferences and meetings on hydrogeological problems or other related topics have been collected. They allow to deepen the relations and the connections between the groundwater resources and other aspects for instance the environmental contexts and the land planning.

In order to have a description as extended as possible and representative of the activities developed in the national territory, the publications of some research institutes and universities have been collected too.

First of all it is necessary to mention the C.N.R. *Istituto per lo Studio della Dinamica delle Grandi Masse*, now *Istituto di Scienze Marine - Venezia* owing to the scientific role and a lot of studies and researches on the hydrogeological scheme, the subsidence, the analysis and the control of the water levels in the confined aquifers of the Venice lagoon area.

In the second place the C.N.R. *Istituto di Ricerca per la Protezione Idrogeologica* (CNR-IRPI) particularly of *Cosenza, Perugia, Padova* and *Torino* have been considered. In these areas a lot of subjects and contents of interest for the research have been developed.

With regard to the Universities the position in the territory has been deemed the main characteristic. Therefore *Milano* and *Pavia, Firenze, Napoli, Messina* and *Palermo* Universities have been considered in this phase of the research. To define the general scheme of the activities the publications of the most important groups of research connected with the universities, as for instance the *Gruppo di Ricerca in Geologia Applicata - Università*

degli Studi di Modena active beginning from 1965, have been taken into consideration.

With the goal to complete in the best possible way the information related to the hydrogeological studies over 45 key words from the thesaurus of the APAT Library have been preliminary selected.

The studies and the hydrogeological researches have been organized in specific files. The main scientific journals, conferences and meetings, research institutes and universities, and papers for each key word of the thesaurus of the APAT Library considered in the first phase of the study are shown in tables 1-4.

Tab. 1 - *Main scientific journals: journal title and selected years of publications.*

- Principali riviste scientifiche: titolo della rivista e periodo di pubblicazione considerato.

ACQUA E ARIA	1991-2003
ACQUA - IDROTECNICA	1933-2003
ACQUE SOTTERRANEE	1984-2003
IL QUATERNARIO	1988-1992; 1996 e 1997; 1999-2002
ANNALI MUSEO CIVICO ROVERETO	1985-2002
ATTI TICINESI SCIENZE DELLA TERRA	1972-2001
BOLLETTINO SERVIZIO GEOLOGICO D'ITALIA	1947-1997
BOLLETTINO SOCIETÀ ADRIATICA DI SCIENZE TRIESTE	1874-1999
BOLLETTINO SOCIETÀ GEOLOGICA ITALIANA	1930-2003
GEAM GEOINGEGNERIA AMBIENTALE E MINERARIA	1993-1998
GEOLOGIA APPLICATA E IDROGEOLOGIA	1966-1996
GEOLOGIA TECNICA E AMBIENTALE	1969-2003
GEOLOGICA ROMANA	1966-2002
GEOTECNICA	1954-1966
GROUND WATER	1997
IGEA INGEGNERIA GEOLOGIA ACQUIFERI	1999-2001
L'ENERGIA ELETTRICA	1926-1977
MEMORIE DESCRITTIVE DELLA CARTA GEOLOGICA D'ITALIA	1902-2001
MEMORIE E NOTE IST. GEOL. APPL. UNIVERSITÀ NAPOLI	1949-1983
MEMORIE DI SCIENZE GEOLOGICHE	1912-2002
MEMORIE SOCIETÀ GEOLOGICA ITALIANA	1939-2002
MISCELLANEA SERVIZIO GEOLOGICO NAZIONALE	1987-1992
QUADERNI GEOLOGIA APPLICATA	1994-2003
RIVISTA ITALIANA DI GEOTECNICA	1967-1992; 1999-2000
SIGEA SOCIETÀ ITALIANA DI GEOLOGIA AMBIENTALE	1993-2002
SOCIETÀ ITALIANA SCIENZE NATURALI	1927-1966
STUDI GEOLOGICI CAMERTI	1971-2002
TECNICA ITALIANA	1936-1975
TEVERE	1996-2002
WATER RESOURCES RESEARCH	1974-1979

Tab. 2 - *Main conferences and meetings: title and year.*
- Principali congressi e conferenze: titolo e anno.

IDROGEOLOGIA NEL CAMPO TERMALE E IDROMINERALE	1968
CONVEGNO DI STUDIO: L'ACQUA PER LA PIANA PONTINA. SITUAZIONE E PROSPETTIVE	1977
1° CONVEGNO NAZIONALE SULLA PROTEZIONE E GESTIONE DELLE ACQUE SOTTERRANE: METODOLOGIE, TECNOLOGIE, OBIETTIVI	1990
2° CONVEGNO NAZIONALE SULLA PROTEZIONE E GESTIONE DELLE ACQUE SOTTERRANE: METODOLOGIE, TECNOLOGIE, OBIETTIVI	1995
WORKSHOP NAZIONALE SULLE ACQUE: IL CICLO DELL'ACQUA: PROBLEMI E PROSPETTIVE	1997
CONVEGNO IL RISCHIO IDROGEOLOGICO E LA DIFESA DEL SUOLO	1998
3° CONVEGNO NAZIONALE SULLA PROTEZIONE E GESTIONE DELLE ACQUE SOTTERRANE PER IL III° MILLENNIO	1999
GIORNATA MONDIALE DELL'ACQUA LA SICCA IN ITALIA	2003
IV° CONVEGNO NAZIONALE DEI GIOVANI RICERCATORI	1994
CONVEGNO GRUPPO NAZIONALE GEOLOGIA APPLICATA	1995
6° CONVEGNO NAZIONALE GIOVANI RICERCATORI DI GEOLOGIA APPLICATA	1998
2° SEMINARIO CARTOGRAFIA GEOLOGICA BOLOGNA	1990
4° CONGRESSO EUROPEO SULLA CARTOGRAFIA GEOSCIENTIFICA REGIONALE ED I SISTEMI INFORMATIVI	2003
7ª CONFERENZA NAZIONALE ASITA	2003
6ª CONFERENZA MONDOGIS	2004
2ª CONFERENZA NAZIONALE SINANET	2000
5ª CONFERENZA NAZIONALE AGENZIE AMBIENTALI	2001
7ª CONFERENZA NAZIONALE AGENZIE AMBIENTALI	2003
RICERCHE GEOLOGICHE CORRELATE AMBIENTE	1988
CONSERVATION GEOLOGICAL HERITAGE	1996
FIST GEOITALIA	2001
FIST GEOITALIA	2003
29 nd INTERNATIONAL GEOLOGICAL CONGRESS KYOTO	1994
32 nd INTERNATIONAL GEOLOGICAL CONGRESS FLORENCE	2004
CONGRESSO ORDINE NAZIONALE GEOLOGI	1997

2.1.2. - Hydrogeological maps

With regard to the inventory of the hydrogeological and thematic maps, the APAT Library and the data and activities of the writer have been considered the main sources of information.

Till now over 100 thematic maps have been collected with a scanning procedure and organized in specific files.

The maps can be divided according to the typological characteristics (hydrogeological, isopiezometric contour map, groundwater resources), to the width of the investigated areas (national territory, wide sectors of territory, hydrographical basins, single districts, specific aquifer

system and hydrostructures) and to the scale of representation.

The maps published at regional scale (1:500,000 - 1:250,000) show in general an elevated information content both in relation to groundwater resources and to land planning. A lot of data and information as the groundwater flow directions, the main springs and the spring groups maintain a good level of detail in the representation. The cartographies published at operative scale (1:100,000 - 1:25,000) can be used to solve local problems.

With regard to the width of the investigated area it is necessary to specify that only two thematic maps extended to the entire Italian territory have been retrieved. The *Carta delle manifestazioni termali e dei complessi idrogeologici d'Italia* (BONI *et alii*, 1982) at 1:1,000,000 scale, which describes the main thermal springs and the hydrogeological units, and the *Studio delle risorse in acque sotterranee dell'Italia* at 1:500,000 scale (AA.VV., 1982) which describes four topics for each area: aquifers, groundwater hydrology, groundwater abstraction and balance of resources.

The maps related to wide sectors of territory, for example the *Schema idrogeologico dell'Italia centrale* (BONI *et alii*, 1986) at 1:500,000 scale, the *Carta idrogeologica regionale della pianura padana, veneta e friulana* (GIULIANO *et alii*, 1998) at 1:500,000 scale or the *Carta idrogeologica dell'Italia centro meridionale. Marche e Lazio meridionali, Abruzzo, Molise e Campania* (CELICO, 1983) at 1:400,000 scale have been collected too.

To important hydrographical basins can be

Tab. 3 - *Main research institutes and universities.*
- Principali istituti di ricerca e università.

CNR
CNR IRPI COSENZA
CNR IRPI PADOVA
CNR IRPI PERUGIA
CNR IRPI TORINO
CNR ISTITUTO PER LO STUDIO DELLA DINAMICA DELLE GRANDI MASSE - VENEZIA
PALERMO ISTITUTO DI IDRAULICA
FIRENZE SCIENZE DELLA TERRA
GENOVA GRUPPO GEOFISICA APPLICATA
MESSINA SCIENZE DELLA TERRA
MILANO SCIENZE DELLA TERRA 1998
MILANO SCIENZE DELLA TERRA 2000
MODENA GRUPPO DI RICERCA GEOLOGIA APPLICATA
NAPOLI SCIENZE DELLA TERRA
PAVIA SCIENZE DELLA TERRA

Tab. 4 - Number of papers identified by the key words of the thesaurus of the APAT library.

- Numero di lavori identificati attraverso parole chiave del thesaurus della Biblioteca APAT.

ACQUA - WATER	2057
ACQUIFERO CONFINATO PROFONDO - DEEP CONFINED AQUIFER	1
BACINO IDROGEOLOGICO - HYDROGEOLOGICAL BASIN	2
CARTA A ISOPIEZE - ISOPIEZOMETRIC MAP	1
CARTA IDROCHIMICA - HYDROCHEMICAL MAP	3
CICLO IDROLOGICO - HYDROLOGICAL CYCLE	2
DIREZIONE DI DEFLUSSO - GROUNDWATER FLOW DIRECTION	1
FALDA IN ALLUVIONI - ALLUVIAL AQUIFERS	1
DRASTIC	2
ABBASSAMENTO LIVELLO D'ACQUA - DRAWDOWN	8
COMPLESSO IDROGEOLOGICO - HYDROGEOLOGICAL COMPLEX	1
ABBASSAMENTO DELLA FALDA - AQUIFER DRAWDOWN	15
ACQUA DISPONIBILE - WATER YIELD	23
ACQUIFERO MULTISTRATO - MULTILAYERED AQUIFER	9
ACQUIFERO SUPERFICIALE - SUPERFICIAL WATER BODY	11
ALIMENTAZIONE NATURALE - NATURAL RECHARGE	13
EMUNGIMENTO - PUMPING	4
FALDA SOSPESA - PERCHED AQUIFERS	3
ACQUA SALMASTRA - BRACKISH WATER	17
CARTOGRAFIA AUTOMATIZZATA - DIGITAL CARTOGRAPHY	19
CICLO DELL'ACQUA - HYDROLOGIC CYCLE	18
FALDA FREATICA - PHREATIC WATER	11
FLUSSO IDRICO - STREAMFLOW	22
ACQUA DOLCE - FRESH WATER	58
ACQUA POTABILE - DRINKING WATER	87
ACQUA SOTTERRANEA - GROUNDWATER	609
ACQUA SUPERFICIALE - SURFACE WATER	88
ACQUA TERMALE - THERMAL WATER	168
ACQUIFERO - AQUIFER	415
ALLUVIONALE - ALLUVIAL	147
BACINO IDRICO - WATERSHEDS	40
BANCA DATI - DATABASE	51
BILANCIO IDROLOGICO - SURFACE WATER BALANCE	73
BILANCIO IDROGEOLOGICO - GROUNDWATER BALANCE	66
FALDA LIBERA - UNCONFINED AQUIFER	50
TRIVELLAZIONE - DRILLING	97
ARCHIVIAZIONE DATI - DATA STORAGE	18

referred the *Idrogeomorfologia e risorse idriche del bacino del fiume Arno (Valdarno superiore) - Vulnerabilità all'inquinamento della pianura alluvionale* (AA.VV., 1995) at detailed scale and two maps of the Tiber river basin at 1:200,000 scale; the latter are concerned with lithology, stratigraphy and permeability degrees and groundwater circulation and hydrogeological units (GIULIANO *et alii*, 1981).

It is suitable to mention some maps related both to regional and to provincial districts.

First of all the *Contributo per una carta idrogeologica della Lombardia* (BERETTA, 1986) at 1:500,000 scale, and the *Carta idrogeologica del territorio della Regione Lazio* (BONI *et alii*, 1988), the *Riserve idriche sotterranee della Regione Emilia Romagna* (Regione Emilia Romagna, ENI-AGIP, 1998) and the *Geologia degli acquiferi padani della Regione Lombardia* (Regione Lombardia, ENI Divisione AGIP, 2002) at 1:250,000 scale.

Moreover the *Carta isofreatica. Rilievi del dicembre 1983 e Carta piezometrica. Rilievi del dicembre 1983* (MARI, 1985) at 1:250,000 scale, built by means of the monitoring networks of the unconfined aquifer in the high plain and the confined aquifer units at different depths in the middle-low plain of Regione Veneto have been considered.

In the second place the *Lineamenti idrogeologici della Provincia di Sondrio* (POZZI, 1970) at 1:100,000 scale and the *Idrogeologia della Provincia di Roma* (VENTRIGLIA, 1990) at 1:50,000 scale have been collected.

A lot of studies and researches related to specific aquifer systems and hydrostructures have been realized and published by universities, research institutes and public administrations.

It is necessary to mention the *Carta idrogeologica del massiccio vulcanico dell'Etna* (FERRARA *et alii*, 2001), the *Carta idrogeologica della Campania nord occidentale* (CIVITA *et alii*, 1973) at 1:100,000 scale and the *Carta idrogeologica dell'Altopiano dei Sette Comuni* (AURIGHI *et alii*, 2002) at 1:50,000 scale.

At a more detailed scale the maps retrieved in the *Idrogeologia e risorse idriche del Colle del Montello in provincia di Treviso* (FILECCIA *et alii*, 2002) and in the study *Caratteristiche idrogeologiche della struttura carbonatica di Morigerati (Cilento meridionale)* (Iaccarino *et alii*, 1988) have been collected.

With reference to the maps realized according to standard guidelines the *Carta Idrogeologica d'Italia a scala 1:50.000 Foglio 291 Pergola* (CENTAMORE *et alii*, 1976), *Foglio 611 Mistretta* (FERRARA, 1979) and *Foglio 389 Anagni* (MOTTERAN *et alii*, 1993) have been considered.

In this context it is necessary to mention the results of the research project promoted by the *Servizio Geologico Nazionale* in 2001 with the purpo-

se to apply the guide lines now in force (MARI *et alii*, 1995) in the sample areas representative of the main hydrogeological context of the national territory. The tests of applicability have been realized in the SE sector of the Cimini Mountains, the NE sector of the Sibillini Mountains and two sectors of the Matese and the Tivoli Mountains. According to the characteristics of the research project the scale 1:50,000 and 1:25,000 have been chosen. These maps are not yet available in the definitive version and for this reason not included in the inventory.

Groundwater intrinsic vulnerability maps, mainly realized by the *Gruppo Nazionale Difesa Catastrofi Idrogeologiche - Consiglio Nazionale delle Ricerche* (GNDCI-CNR) have been considered but not yet collected in this phase of the study.

3. - ANALYSIS OF THE HYDROGEOLOGICAL MAPS

The *Guida al rilevamento e alla rappresentazione della Carta idrogeologica d'Italia a scala 1:50.000* (MARI *et alii*, 1995) has been considered as the conceptual model to analyse the collected maps.

The purpose is to verify the presence and the characteristics of some interesting information not only for general or specific topics (scale, width of the investigated area, hydrogeological complexes, hydrochemical parameters, groundwater flow directions) but also for identification of the activities (data of the measurements, data of the analyses) and utilization of computer methodologies (data input, database construction, data elaboration). The main information which have been considered to analyse the maps, the studies and the researches are shown in table 5.

The possibility to use the data and the information of each map, for example the isopiezometric contour lines, the monitoring networks or the hydrogeological complexes, in order to realize new thematic maps could be taken into consideration in the second phase of the research.

4. - GEOGRAPHIC INFORMATION SYSTEM

Computer methodologies have been applied in the various stages of the research.

In the first phase of the study the geographical visualization of the raster data using the scale of representation with bands according to the national standards 1:25,000, 1:50,000, 1:100,000, 1:250,000, 1:500,000 and 1:1,000,000 and the type of the cartography has been worked out.

For the construction of the database the national

territory has been chosen as geographical model of reference according to the criteria of the UTM 33. Four points of orientation (generally the corners of the map) or the overlay of homologous points when the contours of the maps were not well defined have been used.

With the aim to work out the potentiality of the Geographic Information System, in the second phase of the research the hydrogeological maps were analysed to check the main data and information considered in table 5.

The purpose of the Geographic Information System is to verify the documentation upgrades, to improve the information and to obtain a more effective use by matching the data with their real geographic position.

The main thematic maps collected and an example of the preliminary Geographic Information System with different scales of representation are shown in figures 1-6.

The activities to realize the preliminary geodatabase have been developed in collaboration with the *Servizio Cartografico, Relazioni e Documentazione di base - Dipartimento Difesa del suolo - APAT*.

5. - RESULTS AND FUTURE PERSPECTIVES OF THE PROJECT

The main purposes of the research project have been developed broadly.

The hydrogeological studies and the studies with a high hydrogeological content have been collected in specific files, which allow to identify the source of the information. They have been organized according to journals, conferences and meetings, research institutes and universities, as well as many other key words of the thesaurus of the APAT Library.

The hydrogeological maps and the maps with a high hydrogeological content, more than 100, have been computer scanned and organized in specific files that allow to identify the source of the information, the study from which they have been retrieved and the investigated area.

The maps can be divided according to the typological characteristics (hydrogeological, isopiezometric contour map), to the width of the investigated areas (national territory, hydrographical river basin, regional and provincial districts, specific aquifer systems and hydrostructures) and to the scale of representation.

The quantity and the characteristics of data, information and maps retrieved constitute a preliminary geodatabase providing the technical-scientific tool to define the new phases of the research development.

Tab. 5 - *Information extracted from hydrogeological maps, studies and researches.*

- Informazioni riferite alle carte idrogeologiche, agli studi e alle ricerche.

MAP N°
COORDINATES OF THE CORNERS
TYPE OF MAP (hydrogeological, isopiezometric, intrinsic vulnerability,...)
TYPE OF AQUIFER (unconfined, semiconfined, confined, multilayered,...)
SCALE
LOCALIZATION
REGION
PROVINCE
COMMUNE
HYDROGRAFICAL BASIN
WIDTH OF THE INVESTIGATED AREA
TOPOGRAPHICAL MAP
HYDROGEOLOGICAL COMPLEX ELABORATED ON THE BASE OF RELATIVE PERMEABILITY DEGREE
NET RECHARGE
TRAMISSIVITY
WELLS : NUMBER OF WELLS AND WELL CODE, FORMS, AQUIFER, DEPTH OF WATER FROM GROUND LEVEL, WATER LEVEL FROM SEA LEVEL, DYNAMIC LEVEL, DATA OF MEASURE, HYDROCHEMICAL ANALYSES, PARAMETER 1, PARAMETER 2, PARAMETER n, DATA OF ANALYSES
SPRINGS: NUMBER OF SPRING AND SPRING CODE, FORMS, AQUIFER, DISCHARGE RATE, DATA OF MEASURE, HYDROCHEMICAL ANALYSES, PARAMETER 1, PARAMETER 2, PARAMETER n, DATA OF ANALYSES
GROUNDWATER FLOW DIRECTIONS
QUANTITATIVE MONITORING NETWORK
QUALITATIVE MONITORING NETWORK
SPREADSHEET
RASTER AND VECTOR TOPOGRAPHICAL MAP
TITLE OF THE MAP
AUTHORS
YEAR OF PUBLICATION
SOURCE OF INFORMATION (the APAT Library, university, congress)
COPY AVAILABLE (yes or not) AND WHERE
FILE
IMAGE
OBSERVATION

These phases can be pointed out as follows:

- to complete the inventory of the studies and of the hydrogeological maps
 - to extend the inventory to the public administrations as the *Ministero dell'Ambiente e della Tutela del territorio*, the *Regioni* and *Province* and to the *Autorità di Bacino* and the research institutes
 - to identify the studies, the researches and the maps now in progress
 - to collect all the remaining available data
 - to evaluate the data on the base of a conceptual model
 - to define the state of the knowledge on the groundwater resources
 - to propose the activities which should be performed for a better development of the hydrogeological knowledge of the national territory
 - to define Geographic Information System technologies
 - to realize a Web site on groundwater resources.

6. - CONCLUSIONS

Even if the research has been strongly characterized by a specific and disciplinary value, a remarkable quantity of data and information with an elevated added value has been organized.

The data collected could be used by experts in the specific topic (hydrogeology). Moreover these data could be a useful and interesting resource both for geologists, applied geologists, and for researchers on environmental subjects.

The importance of the work of data collection in the research project has been clearly revealed; it allows not only to get a clear idea of the hydrogeological knowledge degree of a specific area but also to verify the progressive development of the knowledge and to compare different methodologies of study and data evaluation.

It is quite clear that the preliminary results of the study, which will be soon available, and the research project could give rise to a new phase of collaboration between technicians, researchers and users of the specific or correlated topics and improve the hydrogeological knowledge of the national territory.

Nowadays the high degree of sophistication attained by computer methodologies makes it opportune to increase scientific collaborations and to diffuse both as soon as possible and in the best possible way the hydrogeological data and information.

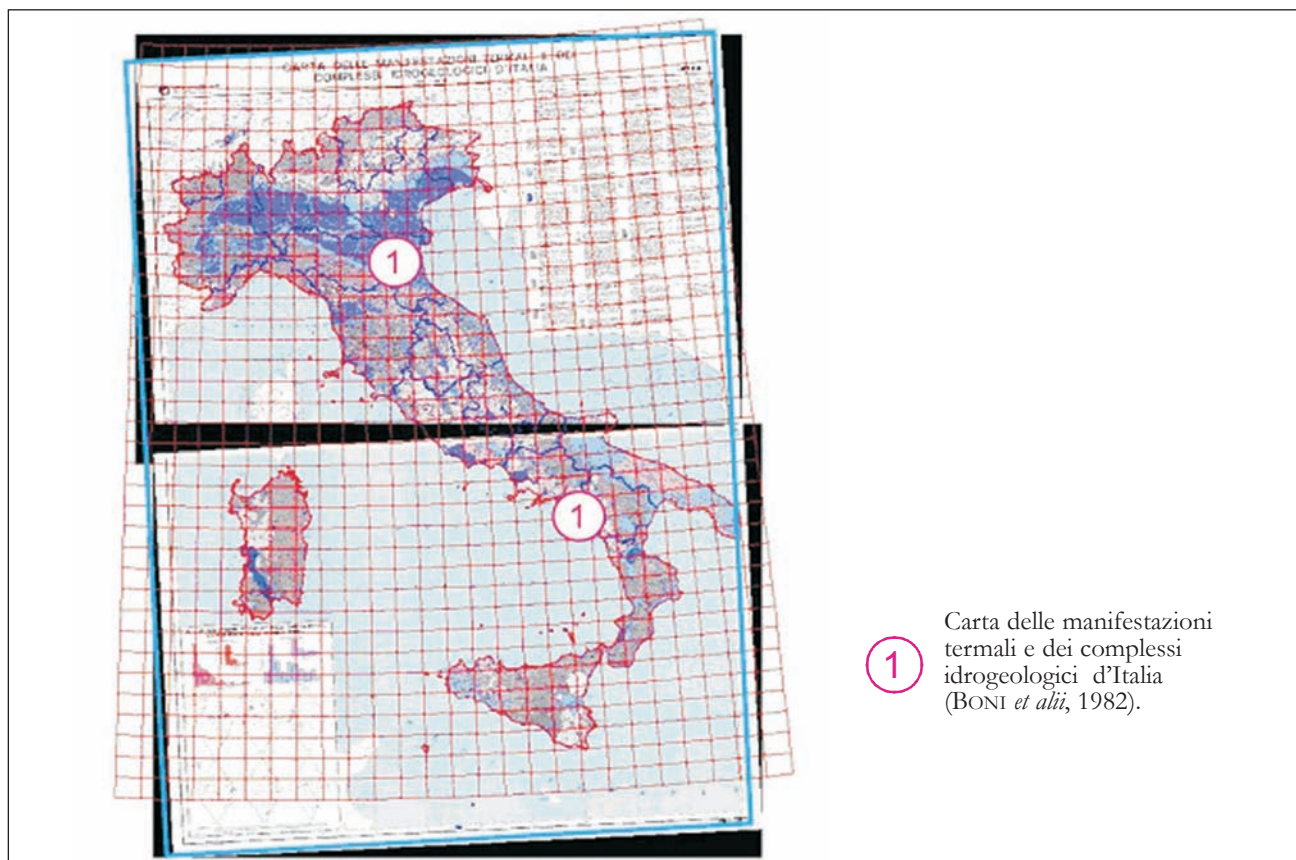


Fig. 1 - Scale 1:1,000,000 map. - Carte a scala 1:1.000.000.

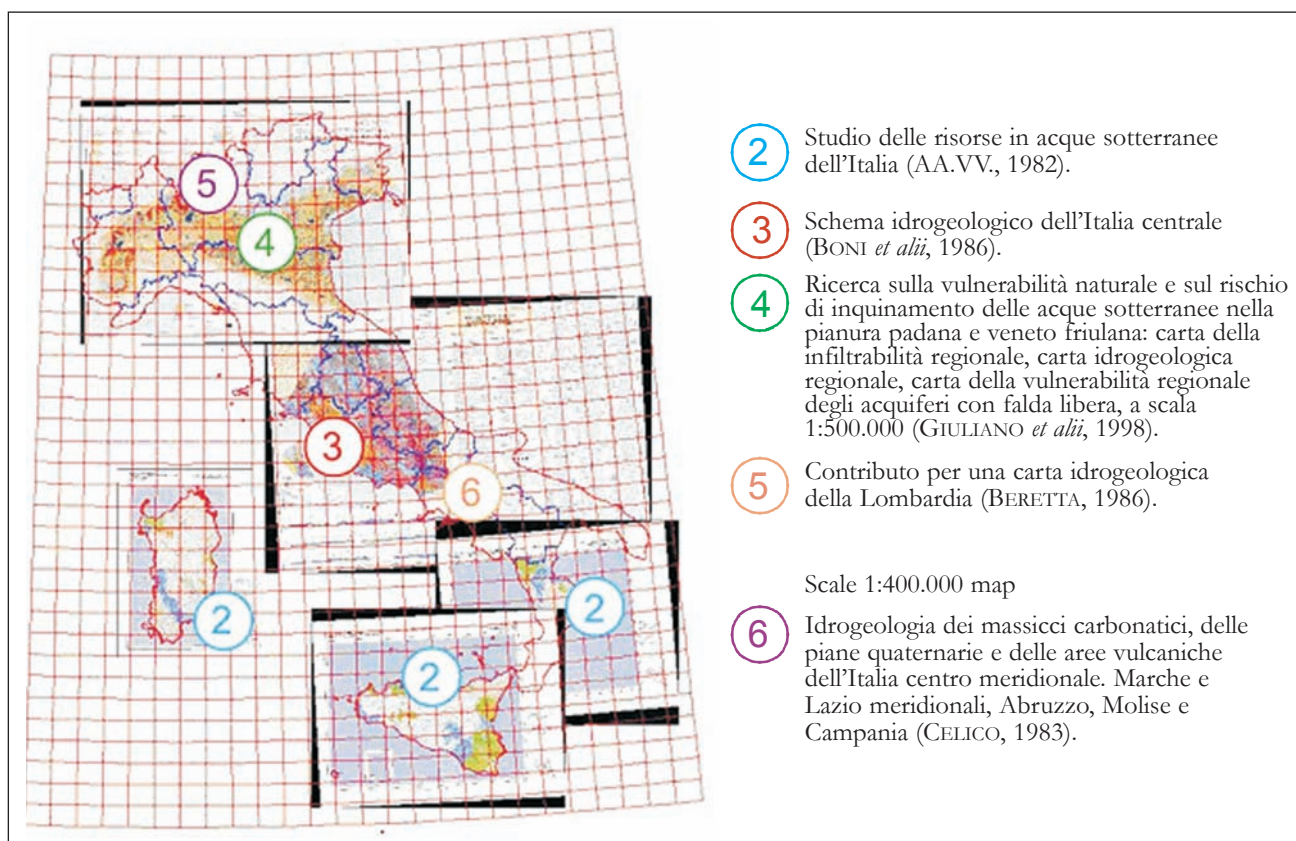


Fig. 2 - Scale 1:500,000 maps. - Carte a scala 1.500.000.

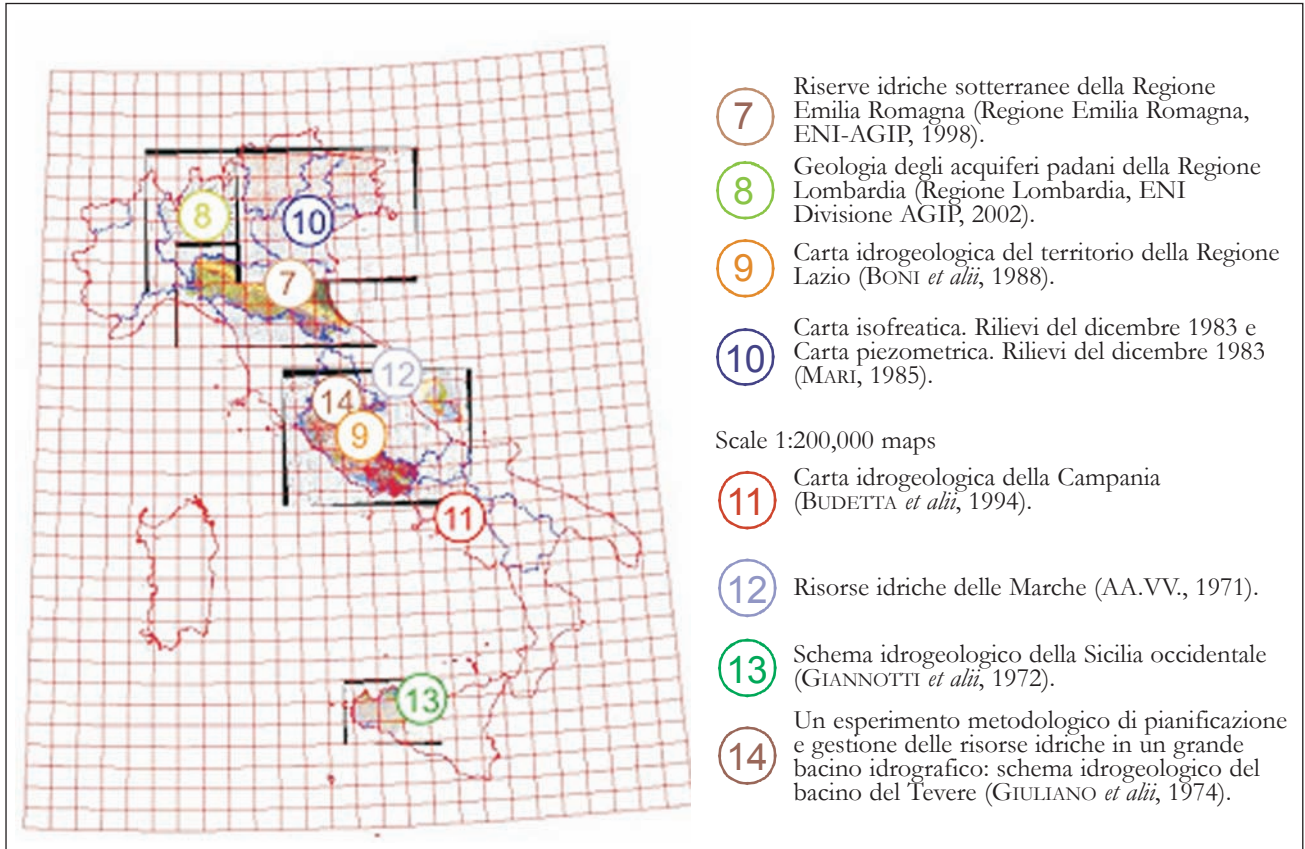


Fig. 3 - Scale 1:250,000 and 1:200,000 maps. - Carte a scala 1:250.000 e 1:200.000.

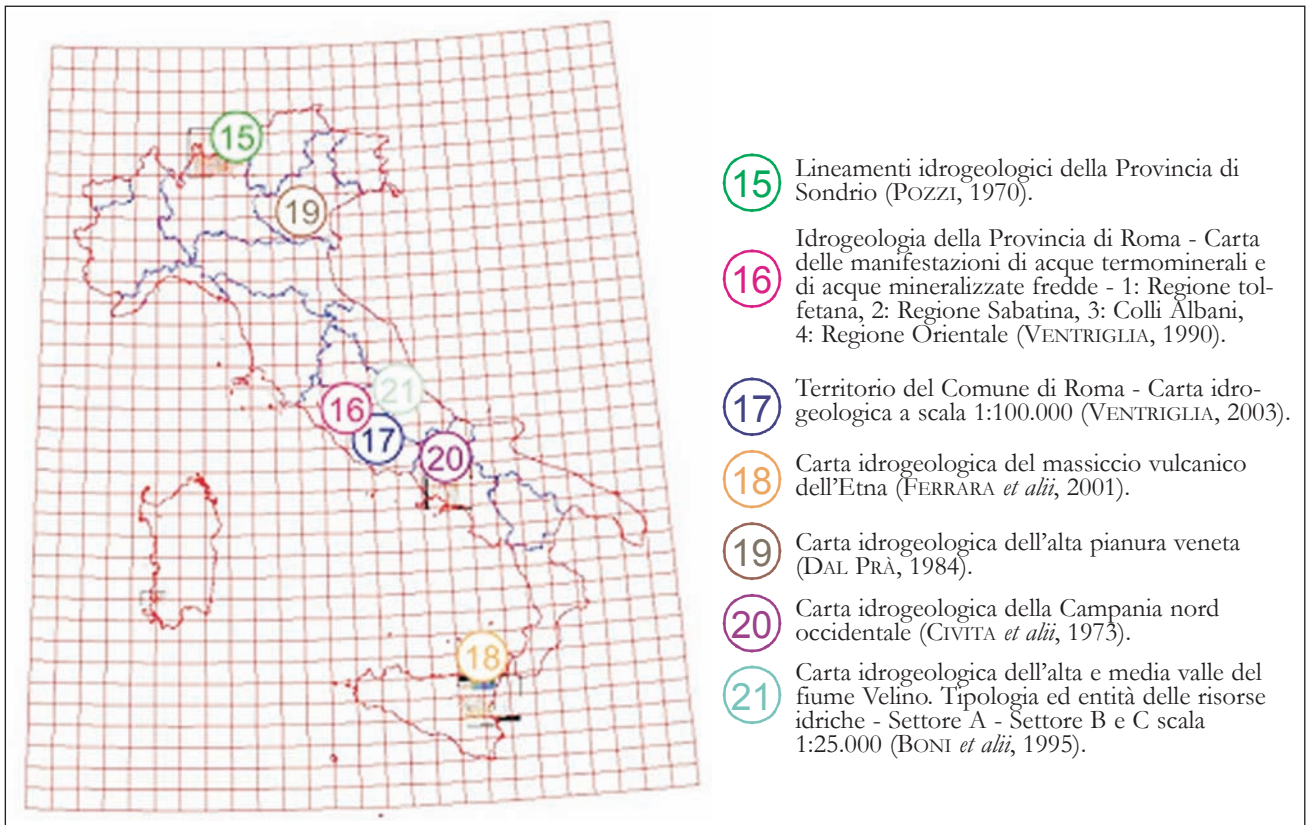


Fig. 4 - Scale 1:100,000 maps. - Carte a scala 1:100.000.

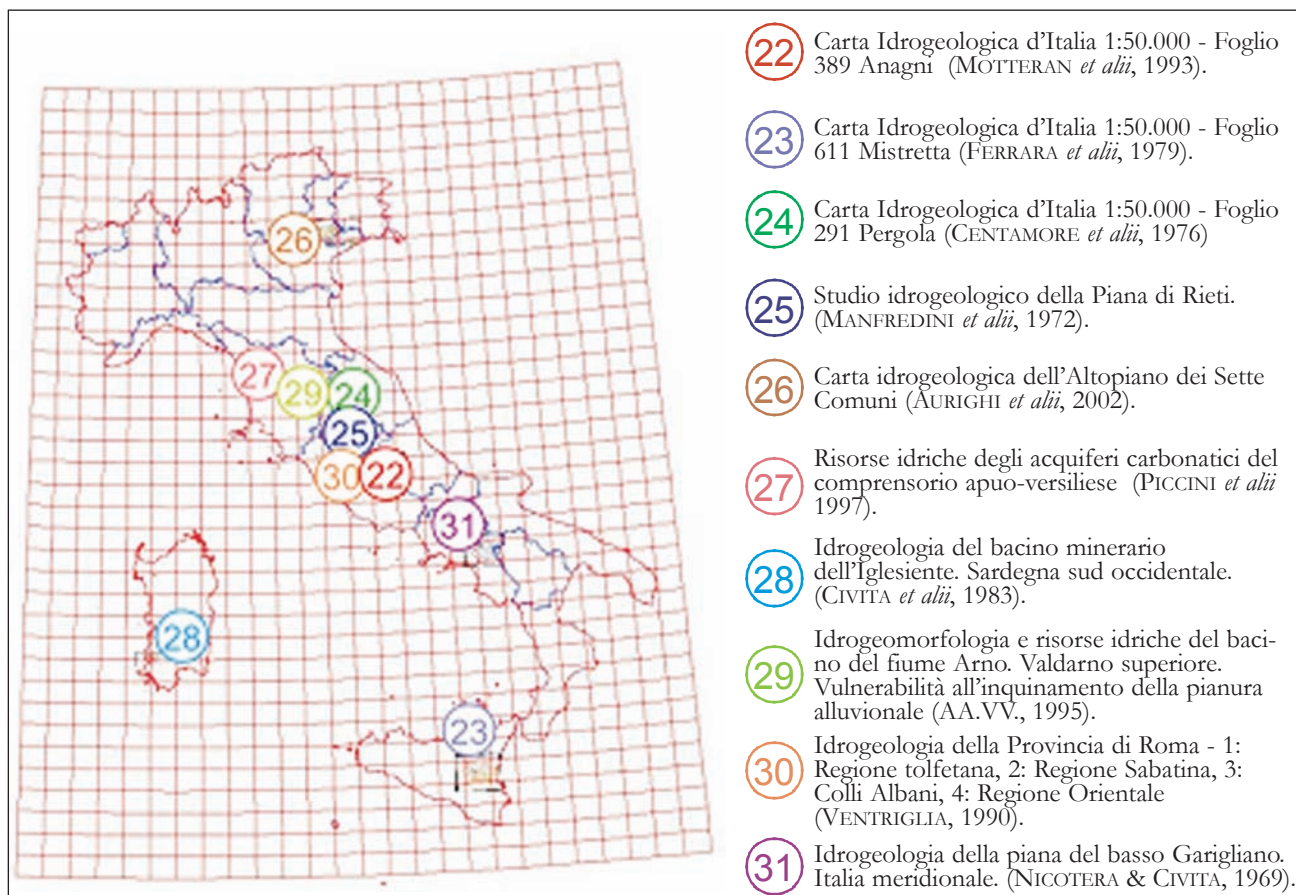


Fig. 5 - Scale 1:50,000 maps. - Carte a scala 1:50.000.

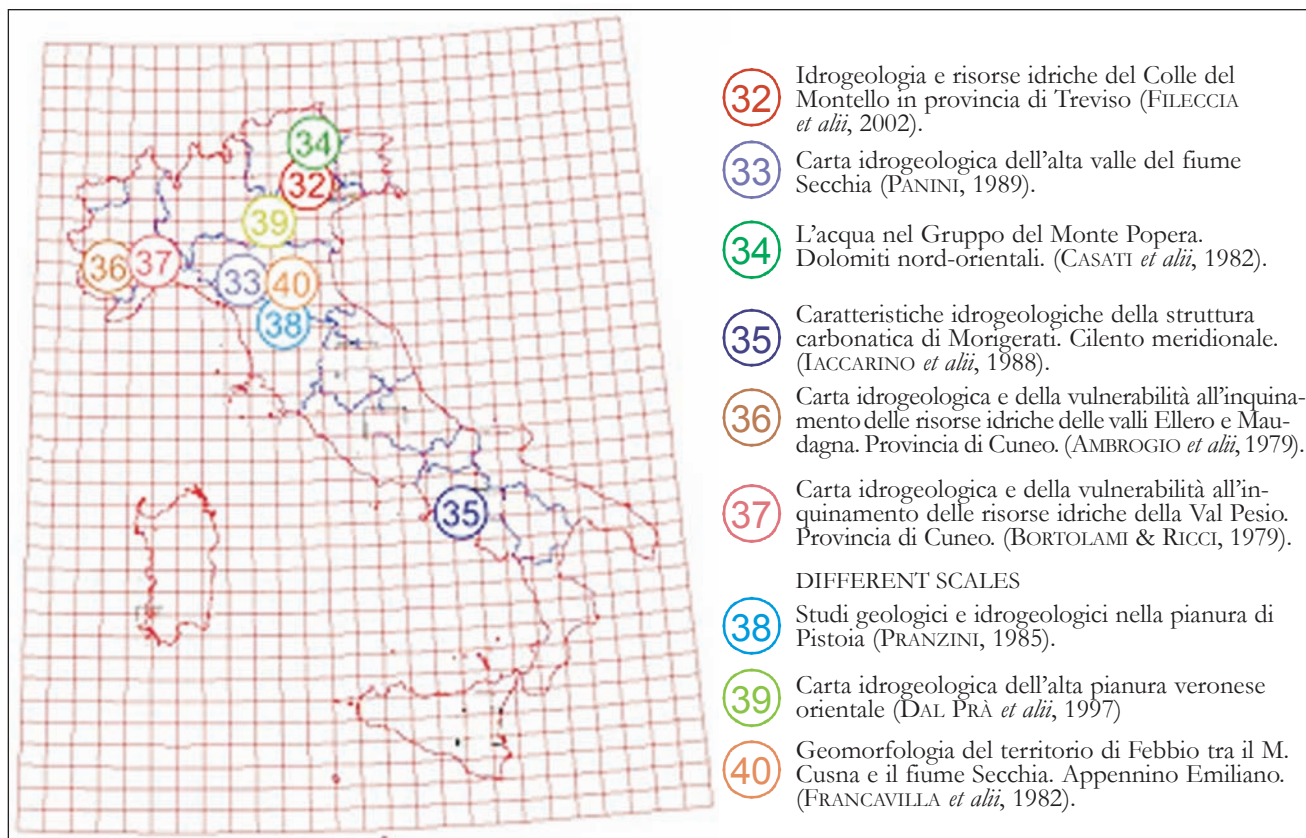


Fig. 6 - Scale 1:25,000 maps. - Carte a scala 1:25.000.

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