HYDROGEOLOGY OF CONTINENTAL SOUTHERN ITALY

(Map I - southern Apennine - Gargano)

Scale 1:300.000

0 5 10 15 20 km

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LEGEND

QUATERNARY COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
1	***Alluvial-coastal complex:*** Mainly incoherent clastic deposits comprising all grain size classes, but with prevailing sandy terms. Different grain sizes lie in lateral and vertical juxtaposition according to the spatial variation of hydraulic energy that controlled their deposition. These deposits form heterogeneous and anisotropic porous aquifers in which a groundwater flow occurs, unique at the large scale and partitioned at the local one. Groundwater flow can have hydraulic interchanges with freshwater bodies and/or with groundwater of the adjoining hydrogeological units.						
2	***Lacustrine complex:*** Mainly silty-clayey deposits of the lacustrine basins developed during the Pleistocene in the southern Apennine chain. Where these deposits are interbedded and/or laterally juxtaposed to the alluvial complex, they can form defined or undefined permeability boundaries.						
3	***Epiclastic continental complex:*** Clastic deposits, frequently cemented, formed by gravity-driven and/or short-range hydraulic transport sediments: active and relict slope talus and fan deposits. Notwithstanding its general heterogeneity and anisotropy, this complex forms aquifers with moderate hydraulic transmissivity in which a high groundwater yield can exist if a recharge from adjoining hydrogeological units occurs (i.e. Conglomerates of Eboli).						
4	***Travertines complex:*** Coherent and pseudo-coherent chemical precipitation deposits of Calcium Bicarbonate, which form tabular bodies at the outlet of basal springs of the main carbonate massifs. These deposits form heterogeneous and anisotropic porous aquifers with a permeability grade ranging from high to medium, according to the mean grain size (sandy in most cases).						

PLIOCENE-QUATERNARY VOLCANIC COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
6	***Ash-fall pyroclastic complex:*** Incoherent deposits comprising lapilli and ashes derived from the explosive activity of the Campanian eruptive centres and, subordinately, of the Vulture volcano. According to the lateral and vertical juxtaposition of different grain size classes, these deposits constitute heterogenous and anisotropic aquifers whose transmissivity is generally low.						
7	***Ash-flow pyroclastic complex:*** Ignimbrite deposits, from welded to scarcely welded, mainly related to the eruptive activity of the Phlegrean Fields (Campanian Ignimbrite *Auct.*, Neapolitan Yellow Tuff *Auct.*, etc.). These deposits form homogeneous and anisotropic aquifers, often characterised locally by a moderate transmissivity.						
8	***Volcanic rock complex:*** Volcanic rocks and cinders derived from the eruptive activity of the Campanian volcanic centres and of the Vulture volcano. According to the genetic mechanism, these deposits constitute very discontinuous aquifers, which lie in lateral and vertical juxtaposition with ash-fall deposits and tuffs, therefore they are delimited by defined and undefined permeability boundaries. The permeability is generally high due to the diffuse jointing related to the lava solidification. Igneous rocks of Punta delle Pietre Nere, in the Gargano area, have also been included.						

PLIOCENE-QUATERNARY MARINE COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
9	***Sandy gravel clastic complex:*** Sandy gravel clastic deposits, from loose to scarcely cemented, formed during the marine regression of the Lower Pleistocene (Bradano Trough sedimentary cycle: Mount Marano sands, Mount Castiglione calcarenites, Irsina conglomerates). Sometimes these deposits can form aquifers with relevant transmissivity, but feeding small springs due to spatial variability of the permeability boundary to the underlying clayey complex, which determines groundwater flow partitioning.						
10	***Clayey complex:*** Deposits comprising marine clays, silty clays and sandy clays, related to the marine transgression occurred during the Upper Pliocene and Lower Pleistocene (Bradano Trough sedimentary cycle). These deposits generate permeability boundaries at the contact with the sandy-conglomeratic complex, to which they stratigraphically underlie, or in contact with the other vertically and/or laterally juxtaposed aquifers.						

LATE-OROGENIC SERIES COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
11	***Molasse complex:*** Molasse deposits, from continental to marine environments, constituted by clays, sandstones and scarcely cemented conglomerates; very thick intercalations of calcareous puddingstones occur in the upper part (Albavilla Unit). These deposits constitute heterogeneous and anisotropic aquifers with a generally scarce groundwater yield. They are usually partitioned in minor groundwater bodies outflowing in springs of local relevance only.						
12	***Messinian evaporitic complex:*** Evaporitic deposits related to chemical precipitation processes of marine water during the Messinian salinity crisis. These deposits form intercalations in the molassic complex and do not constitute aquifers of any relevance, both because of limited extension of the outcrops and because of the permeability grade, ranging from the scarce to the impermeable grades. Nevertheless, runoff after the solution of deposits (brine), which in many cases generates karst phenomena, can infiltrate in other aquifers causing the groundwater pollution.						

SYN-OROGENIC TURBIDITE SERIES COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
13	***Arenaceous-conglomeratic complex:*** Proximal turbidite series, coarsening upward, locally with wildflysch facies, mainly constituted by sandstones and conglomerates (Castelvetere, Mount Sacro and Gorgoglione Formations). The lack of pelitic intercalations in the upper part of the sedimentary series allows a basal groundwater outflow in springs of local relevance (Mount Sacro, Mount della Stella a Mount Centaurino hydrogeological structures, in the southern Campania).						
14	***Arenaceous-calcarenitic-pelitic series complex:*** Turbidite series, from distal to proximal facies, formed by rhythmic bedding of sandstone-pelitic, calcarenite-pelitic and, subordinately, conglomerate and calcarenite-marl terms (Cilento Group, Numidian Flysch, partly Irpinie, Frosolone and Sillo Capo d'Orlando Units). In stratigraphic intervals with abundant pelitic component, an active groundwater flow can occur in the surficial, weathered and more permeable, part of the flysch rock-mass. Instead, where the pelitic component is negligible a deeper and more significant groundwater flow can exist.						
15	***Pelitic-calcareous series complex:*** Turbidite series formed mainly by pelitic-marly terms and subordinately by calcarenites and sandstones, deposited after the tectonic deformation of the carbonate platform palaeo-sedimentary domains (Bifurto and Pietraroja Formations). Depending on the abundance of pelitic terms and to the topographic location, often at the base of the carbonate massifs due to tectonic and gravitational mobilisation, in many cases this complex behaves as a relatively impermeable belt around the carbonate hydrogeological units.						

PALEOGENE CARBONATE SERIES COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
16	***Transitional calcarenitic-marly complex:*** Series comprising mainly calcarenites and calcilutites, with marly intercalations, related to a marine transgression that involved the carbonate platform palaeo-geographic units (Trentinara and Cerchiara Formations, "scaglia" of the Bulgheria-Verbicaro Unit, Cusano and Longano Formations, Punta Lagno Formation, "Pietra Leccese", Adrano calcarenites, Gravina calcarenites, Salento calcarenites). The marly intercalations reduce locally the permeability grade of this hydrogeological complex relatively to the underlying terms of the series.						

MESOZOIC CARBONATE PLATFORM SERIES COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
17	***Carbonate complex of the Apulian platform:*** Carbonate series, deposited from the Jurassic to Upper Cretaceous, with coral reef (Gargano) and back-reef facies (Murge and Salento) comprising limestones and dolomitic limestones with different grades of jointing and development of the karst phenomena. A residual clay level, formed during a continental stage of the Upper Cretaceous ("Terra Rossa"), behaves as aquiclude at the local scale. The permeability grade varies spatially according to the development of the karst phenomena, resulting lower in the Murge and higher in the Salento sectors.						
18	***Carbonate complex of the Matese-Mount Maggiore and Mount Alpi Unit:*** Carbonate series deposited between the Jurassic and Upper Cretaceous, comprising limestones, dolomitic limestones and subordinately dolomites, with a different grade of jointing and development of the karst phenomena. In correspondence of the Middle Cretaceous unconformity, a level of residual bauxite clays behaves as a local aquiclude due to its limited lateral persistence and frequent faulting.						
19	***Dolomite complex of the Matese Mountains-Mount Maggiore Unit:*** Dolomite series, occasionally with intercalations of chert, deposited between the Triassic and Lower Jurassic. This hydrogeological complex, when in contact with the above standing carbonate one, forms an undefined permeability boundary, which can control the outflow of basal groundwater flow circulating in carbonate hydrogeological units, depending on the local tectonic settings.						
20	***Carbonate complex of the Mount Marzano and Maddalena Mountains Units:*** Carbonate series of platform margin facies deposited between the Middle Jurassic and Upper Cretaceous and formed by calcarenites, calcilutites and carbonate reseediments. This hydrogeological complex forms a fractured aquifer without any relevant hydrogeological discontinuity in the series.						
21	***Dolomite complex of the Maddalena Mountains Unit:*** Series formed by crystalline to saccharoidal dolomite deposited between the Triassic and Upper Cretaceous, generated by intense dolomitization processes up to the Cretaceous interval. Notwithstanding its moderate grade of permeability, this hydrogeological complex can host relevant aquifers according to the great expanse of the outcrops.						
22	***Carbonate complex of the Picentino-Taburno Unit:*** Series formed by dolomitic limestones, calcarenites and back reef calcilutites, deposited between the Jurassic and Upper Cretaceous. This series constitutes a fractured aquifer with a hydrogeological discontinuity represented by the marls with Orbitolinae bed (Aptian) to which a perched groundwater flow, feeding many high-altitude springs with moderate discharges, can be related.						
23	***Dolomite-marly complex of the Picentino-Taburno Unit:*** Series formed by massive dolomites, marls, oil shales and thin bedded dolomites, deposited between the Lower and Upper Triassic. This hydrogeological complex, in contact with the above standing carbonate complex, forms an undefined permeability boundary controlling the basal groundwater outflow from the carbonate hydrogeological units, depending on the local tectonic settings.						
24	***Carbonate complex of the Alburno-Cervati-Pollino Unit:*** Series comprising dolomitic limestones, calcarenites and back-reef calcilutites, deposited between the Jurassic and Upper Cretaceous. This hydrogeological complex constitutes a fractured aquifer without relevant hydrogeological discontinuities.						
25	***Dolomite complex of the Alburno-Cervati-Pollino Unit:*** Series formed by dolomite deposited between the Lower and Upper Triassic. This series, in contact with the above standing carbonate complex, forms an undefined permeability boundary, which can control the basal groundwater outflow of the carbonate hydrogeological units, depending on the local tectonic settings.						
26	***Carbonate complex of the Bulgheria-Verbicaro Unit:*** Series of carbonate platform margin and fore-reef facies deposited between the Jurassic and Upper Cretaceous comprising calcarenites, calcirudites, calcilutites and cherty limestones, dolomitic limestones and subordinately Liassic marly intercalations. This series forms an aquifer in which marly intercalations behave as permeability boundaries, from defined to undefined, controlling the basal groundwater outflow of the carbonate hydrogeological units.						
27	***Dolomite complex of the Bulgheria-Verbicaro Unit:*** Series of stromatolitic dolomite deposited during the Upper Triassic. This hydrogeological complex, where in contact with the above standing carbonate complex, can form an undefined permeability boundary controlling the basal groundwater outflow of the carbonate hydrogeological units.						
28	***Carbonate metamorphic complex of the San Donato Unit:*** Hydrogeological complex formed by sedimentary rocks deposited between the Middle Triassic and Cretaceous that subsequently undergone metamorphism. This complex comprises metalimestones, metadolomites and phyllites outcropping from some inliers, under the Hercynian units of the Calabrian Arc. This complex forms fractured aquifers whose groundwater circulation outflows in springs, locally relevant, at the border between the Calabria and Basilicata regions.						

OUTER BASINS SERIES COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
29	***Siliceous-marly complex of the Lagonegro I and II Units:*** Hydrogeological complex formed by the Miocene Facoltoso Formation, deposited in the Middle Triassic, the Siliceous Schists Formation and the Galestrino Flysch, deposited between the Jurassic and Upper Cretaceous. From the bottom: sandstones and shales; jaspers, radiolarites and siliceous shales; calcilutites, marls and siltstones. The occurrence of pelitic and marly intercalations permits a scarce groundwater flow only, which is limited to the surficial weathered and more permeable zone of the rock-mass.						
30	***Cherty-calcareous complex of the Lagonegro I and II Units:*** Series including the "limestones with chert" formation, deposited in the Upper Triassic, and comprising calcilutites with chert nodules and rare intercalations of marls and shales. This hydrogeological complex forms fractured aquifers being locally very relevant (hydrogeological units of the Mounts Sirino and Vitburno in the Basilicata region). The main groundwater flow is confined, at the top and bottom, by the less permeable terms of the Lagonegro Units series.						
31	***Marly-arenaceous-pelitic complex of the Molisanian Units:*** Hydrogeological complex formed by the Miocene Molisanian basin series, comprising calcarenites, siltstones and sandstones in pre-flysch facies, passing upward to the Frosolone sandstones (arenaceous-calcarenitic-pelitic series complex). The occurrence of pelitic intercalations permits a scarce groundwater flow only, limited to the surficial weathered zone of the flysch rock-mass.						
32	***Calcareous-marly complex of the Molisanian Units:*** Hydrogeological complex including the terms of the Molisanian basin series deposited between the Cretaceous and Paleogene, and comprising clastic limestones, marls with turbidite intercalations. This complex can form locally very relevant fractured aquifers, characterised by a mainly basal groundwater flow (hydrogeological units of Mounts Totila and Capraro).						

INNER BASINS SERIES COMPLEXES

		Type of permeability: Porous	Fissured	Karst	Permeability grade: High	Medium	Low
33	***Metapelitic-metacarbonate complex of the Frido Unit:*** Hydrogeological complex comprising metapelites, metalimestones and subordinately quartzites. The continuous occurrence of pelitic terms, as well as the high tectonization grade, prevents the formation of a unitary and significant groundwater flow and permits a scarce groundwater flow only, which is limited to the more permeable surficial weathered zone of the rock-mass. Only in some metalimestone intervals, a more relevant groundwater flow can exist.						
34	***Ophiolitic complex of the Frido Unit:*** This hydrogeological complex represents the lower part of the Frido Unit, formed by a melange containing olistoliths of basic and ultrabasic rocks, occasionally of relevant size, garnet gneiss, amphibolites, which can locally constitute little fractured discontinuous aquifers of a local relevance only.						
35	***Calcareous-pelitic complex of the North-Calabrian Unit:*** Turbidite series, mainly of distal facies, comprising rhythmic calcareous-pelitic (Saraceno Formation) and mainly shale and quartzitic (black shales formation) beddings. The occurrence of pelitic terms and folded structural setting, prevents the formation of a unitary groundwater flow, generally permitting only the formation of a scarce groundwater flow in the surficial and more permeable weathered zone of the flysch rock-mass. More relevant groundwater flow can occur in intervals with prevailing calcarenite terms and in some quartzitic intervals						
36	***Clayey-calcareous complex of the Sicilian Units:*** Hydrogeological complex consisting mainly of varicoloured shales and clays including chaotically calcareous and calcareous-marly olistoliths (Varicoloured Clays). Similar terms are comprised in the less deformed Red Flysch series. Depending on its high gravitational mobility, this complex generally lies in topographic depressions, where it can form the basal impervious belt of the carbonate hydrogeological units, if in lateral contact with them.						

Natural and artificial continental freshwater bodies (> 3 x 10^6 m^3)

SPRINGS

UNTAPPED — *TAPPED*

- $Q_{average} < 0.10\ m^3 s^{-1}$
- $0.10\ m^3 s^{-1} < Q_{average} < 1.00\ m^3 s^{-1}$
- $1.00\ m^3 s^{-1} < Q_{average} < 5.00\ m^3 s^{-1}$
- $5.00\ m^3 s^{-1} < Q_{average}$
- Springs with unknown discharge ($Q < 0.10\ m^3 s^{-1}$)
- Submarine springs
- Well fields

SYMBOLOGY

- Probable limits of springs and groundwater recharge areas, within the hydrogeological units, with hydraulic interchanges.
- Probable limits of springs and groundwater recharge areas, within the hydrogeological units, with negligible hydraulic interchanges.
- Main groundwater flow paths within the outcropping (solid) or buried (dashed/broken) hydrogeological units most relevant to the regional scale.
- Water table contour lines (m a.s.l.).
- Main preferential drainage axes within the hydrogeological units most relevant to the regional scale, reconstructed by field piezometric surveys.
- Principal faults, outcropping (solid) or buried (dashed/broken), significant for the reconstruction of the hydrostructural schemes.
- Principal thrust faults, outcropping (solid) or buried (dashed/broken), significant for the reconstruction of the hydrostructural schemes.
- Boundaries of the administrative regions of southern Italy.

SKETCH OF ITALY

SKETCH MAP

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Derived from the cartographic data of the Military Geographic Institute (I.G.M.) (Authorization n. 5735 of 04.17.03)
SERIES 1501 - EDITION 5-I.G.M. European datum 1950. UTM Projection - 33 zone