Environmental Geology (1996) 27: 135–142

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Mineral waters in Italy

Received: 19 April 1995 / Accepted: 2 August 1995

Abstract The use of spring water as a drinking, therapeutic, and ornamental resource has historical origins that date back to the Romans. The most ancient regulations on "mineral waters" had been enacted in Italy long before the union (1870).

Key words Mineral waters · Spas · Water resources Italy

Introduction

In Italy, consumption of "mineral waters" as a beverage is increasing. In 1992 the home market was about 6.2 million liters, with a per capita consumption of 108 liters. The sources of mineral water nationally include 233 brands and the spas at present number 181 units (Table 1, Figs. 1–3). There is a large variety of physical, chemical, and medicinal characteristics of mineral water, many of which were recognized by the Romans. Here we considered only two mineral waters that have a long historical tradition. The water resources and chemistry of the selected springs refer to aquifers with hydrogeological conditions remarkably different.

Ferrarelle mineral water

The Ferrarelle springs are located on the southeastern edge of the Roccamonfina stratocone volcano (Campania region) close to the northern limits of the Monte Maggiore mesozoic karst unit. The spring area is located near Ricardo (Caserta Province), the nearest municipality to the Ferrarelle catchment and bottling plants.

The Savone River crosses the quaternary volcanic deposits bordering the Monte Maggiore carbonate unit, which identifies a morphological step to the gentle slopes of the volcano. The river and the aquifer in volcanic terrains form a global system on which linear springs occur along the main drainage network. The springs have been known since Oscian and the time of the Etruscan people, and certainly they quenched the thirst of Greeks, Carthaginians, Sannites, Romans, Goths, and Longobards.

Historical information and archaeological finds show unmistakably that the Romans were able to improve that water resource with several catchments and thermal plants. Vitruvio (1st century BC) mentions different acidulous waters in that area which were thought to have special therapeutic power. Later the famous naturalist Plinio the Old (27–79 AD), Cicero, and Horace refer to the same spring water, keeping alive the tradition but not the splendor of the Roman Empire.

The stratigraphy of the catchment area is represented by quaternary volcanoclastic sequences with heterotic continental deposits that overlie a dissected karst bedrock structurally referred to as the Monte Maggiore unit. The spring area is located along a fault zone of two main tectonic systems with NW and SE trends. The Roccamonfina quaternary graben and the related volcanic activity that lasted about 0.25 Ma refer to such a schematic structural frame. The carbonate bedrock is intensely fractured and karstified, while the volcanic cover shows a remarkable anisotrophy due to heterotic facies or phreatomagmatic piroclastic flow and ashfall sequences. The recharge area is mainly related to the southern slopes of the stratocone volcano, while groundwater flow in both karst and volcanic reservoirs is hydraulically connected. A remarkable CO_2 content and calcium and silica concentrations characterize the chemical facies of Ferrarelle groundwater.

Fiuggi mineral water

The town and springs of Fiuggi are located in the middle of the Italian peninsula, 100 km south of Rome, in a

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Table 1 Mineral water in Italy and main water characteristics[a]

Brand name	Location reference number (Fig. 2)	Spring altitude (m)	TDS 180°C (mg l^{-1})	pH	Production (million l yr^{-1})
Piemonte region					
Augusta		240	496		20/30
San Rocco	2	456	392	7.25	10 20
Sovrana	3	240	366	7.32	20/30
Abrau	4	570	132	7.05	<10
Camorei	5	585	276	7.60	10 20
Coralba	6	743	202	7.50	20/30
Garbarino	7	720	111	7.01	70/100
Lurisia	8	1400	34	6.65	70/100
Nuova Gareisa	9	595	126		10 20
Roccolo	10	600	84		<10
Sorg. della Rocca	11	1500	126	7.36	
San Bernardo	12	1000	54	7.70	150/200
San Bernardo (Rocciaviva)	13	1150	42		150/200
Alpia	14	760	53		10 20
Ausonia	15	680	780	5.76	<10
Buvera	16	238	54	7.70	10 20
Crodo Lisiel	17	510	226	7.70	70/100
Gaudenziana	18	900	96	7.85	<10
Gioiosa	19	293	182	7.55	20/30
San Lorenzo	20	700	2282	6.14	<10
Valle d'Oro	21	500	2160		70/100
Vigezzo	22	875	30		10 20
Alpi Cozie	23	900	33	6.50	10 20
Pian della Mussa	24	1432	39	6.75	10 20
Pic	25	400	186	7.68	10 20
San Grato	26	800	1139	6.80	<10
San Michele	27	1400	35	6.80	10 20
Sparea	28	600	24	6.38	10 20
Valmora	29		23	6.70	10 20
Lauretana	30	1050	14	6.10	20/30
Valverde	31	780	37		10 20
Liguria region					
Madonna della Guardia	32	680	101	7.20	10 20
Santa Rita	33	750	591	8.10	30/50
S. Vittoria	34	1380	183	7.45	20/30
Bauda Calizzano	35	980	35	6.30	20/30
Fonte del Lupo	36	398	31	5.90	20/30
Vallechiara	37	398	34		20/30
Lombardia region					
Bracca	38	400	725	7.20	50/70
Flavia	39	400	259	7.34	50/70
Gaverina	40	500	575	7.44	50/70
Limpia	41				200/300
Orobica	42	400	344	7.24	20/30
Pineta	43	700	189	7.60	10 20
Pracastello	44	358	827	7.22	200/300
Prealpi	45	480	330	7.23	20/30
Primula	46	400	368	7.28	50/70
Stella Alpina	47	900	50	7.13	20/30
San Carlo Spinone	48	400	422	7.15	50/70
San Pellegrino	49	358	197	7.71	200/300
Boario	50	217	535	7.35	200/300
Castello di Vallio	51	296	265	7.58	10/20
Linda	52	65	343	7.10	50/70
Sole	53	150	371	7.10	<10
San Silvestro	54	500	1355	7.05	20/30
Tavina	55	70	350	7.10	50/70
Chiarella	56	760	166	7.70	30/50
Daggio	57	1935	48	7.25	70/100
Gajum	58	481	200	7.70	30/50
Leonardo	59	900	60	7.60	70/100
Paraviso	60	907	229	7.45	<10
Sant'Antonio	61	313	162	7.90	150/200
San Francesco	62		134		150/200
San Luigi	63	627	219	7.50	10/20

Table 1 (cont.)

Brand name	Location reference number (Fig. 2)	Spring altitude (m)	TDS 180°C (mg l^{-1})	pH	Production (million l yr^{-1})
Bernina	64	625	37	7.35	30/50
Frisia	65	435	99	7.05	30/50
Levissima	66	1848	68	7.75	>300
Frida	67	271	222	7.75	10/20
Trentino region					
Acqua Imperatore	68	1175	755		10/20
Lavaredo	69	1340	1381	7.60	10/20
Plose	70	1830	26	6.50	10/20
San Vigilio	71	1540	21	6.20	<10
Idrea	72	1250	2422	7.40	<10
Levico-Casara	73	1640	37	6.80	20/30
Pejo	74	1394	85	6.60	100/150
Surgiva	75	1100	38	6.00	20/30
Friuli region					
Goccia di Carnia	76	1370	71	8.08	30/50
Veneto region					
Vena d'Oro	77	452	194	7.70	10/20
Vera	78	60	157	7.80	>300
Guizza	79	20	285	7.40	>300
San Benedetto	80	20	271	7.50	>300
Acquachiara	81	805	125	7.95	70/100
Alba	82	530	36	6.00	10/20
Azzurra	83		377	7.00	<10
Beber	84	725	136	7.70	10/20
Dolomiti	85	640	274	7.65	70/100
Lissa	86	630	180	7.70	10/20
Lonera	87	450	100	8.00	<10
Lora	88	800	154	8.10	150/200
Margherita	89	260	2358	6.30	<10
Regina	90	450	1634	6.40	<10
Balda	91	65	298	7.50	10/20
Emilia-Romagna region					
Cerelia	92	680	382	7.33	20/30
Bonora	93	190	433	7.40	<10
Fontesana	94	150	558	7.15	10/20
Galvanina	95	150	570	7.05	10/20
Sacramora	96	2	563	7.23	30/50
San Giuliano	97	2	571	7.25	30/50
Fonte del Parco	98	900	265	7.01	10/20
Monte Cimone	99	936	109	7.88	20/30
Monteforte	100	716	366	7.25	
San Daniele	101	800	223	7.53	10/20
Tre Fontane	102	800	123	7.38	10/20
Aemilia	103	165	620	7.11	30/50
Ducale	104	950	54	7.80	20/30
Fontechiara	105	164	461	7.65	100/150
Fontenova	106	447	181	7.20	10/20
Lidia	107	200	540	7.00	100/150
Lynx	108	1015	163	7.45	30/50
Madonna della Mercede	109	159	609	7.18	30/50
Montinverno	110	600	615	7.33	<10
Pergoli	111	165	2889	6.45	<10
Riviana	112	300	819	7.81	<10
Rocca Galgana	113	258	251	8.04	10/20
Sant'Andrea	114	200	609	7.65	100/150
S. Moderanno	115	865	364	7.03	10/20
Varanina	116	225	577	7.10	<10
Verdiana	117		350		30/50
Ventasso	118	1006	159	7.77	20/30
Vis	119	590	676	7.65	<10
Toscana region					
Fontemura	120		318	7.40	10/20
Leona	121	144	217	7.00	<10
Perla	122	330	633	7.80	10/20

Table 1 (cont.)

Brand name	Location reference number (Fig. 2)	Spring altitude (m)	TDS 180°C (mg l^{-1})	pH	Production (million l yr^{-1}
Santa Fiora	123	330	625	7.80	10/20
Sapore di Toscana	124	1200	76		<10
Verna	125	960	144	7.50	20/30
Cintoia	126	400	306	7.15	20/30
Fontepatri	127	200	563	7.25	<10
Ilaria	128	30	1988	7.70	
Lentula	129	600	18	7.60	10/20
Palina	130	580	167	7.75	10/20
Panna	131	292	126	7.65	>300
Napoleone	132	375	64	5.75	<10
Amorosa	133	500	22	5.70	20/30
Fonteviva	134	500	49	5.70	20/30
San Carlo	135	300	559	5.76	<10
Corona	136	6	176	6.60	20/30
Generosa	137	140	921	7.11	<10
Pieve	138	42	247	6.70	<10
San Leopoldo	139	125	506	6.54	<10
Tesorino	140	98	741	7.05	20/30
Uliveto	141	12	1000	6.41	200/300
Vallicelle	142	35	488	7.05	10/20
Regina	143	19	16224		<10
Silva	144	850	91	7.80	20/30
San Felice	145	205	199	7.53	<10
Tettuccio	146	29	7171	6.80	<10
Acqua Santa	147	500	3280		<10
Fucoli	148	500	2600	6.80	<10
Sant'Elena	149	550	447	7.40	<10
Umbria region					
Flaminia	150	500	205	7.35	30/50
Fonte Tullia	151	550	227		20/30
Misia	152		249	7.55	<10
Motette	153	700	147	7.40	20/30
Rocchetta	154	536	174	7.78	20/30
Sanfaustino	155	350	1076	6.05	20/30
Santo Raggio	156	424	529	7.29	<10
Sassovivo	157	600	200	7.59	<10
Vasciano	158	400	1440	6.15	<10
Amerino	159	390	407	7.48	<10
Fabia	160	330	402	7.00	200/300
Sangemini	161	380	1059	6.10	200/300
Marche region					
Frasassi	162	322	319	7.40	30/50
San Cassiano	163	325	212	7.70	30/50
Fonte del Gallo	164	638	463	7.80	<10
Fonte di Palme	165	160	460	7.21	<10
Madonna dell' Ambro	166	638	372	7.30	<10
Palmense del Piceno	167	120	578	6.73	<10
Preistorica	168	700	385	8.00	<10
Tinnea	169	700	216	7.65	70/100
Roana	170	1492	103		10/20
San Giacomo	171	539	489	7.22	<10
Santa Lucia	172	228	549	7.19	<10
Cinzia	173	801	289	7.40	<10
Orianna	174	12	465	7.40	<10
Petra Pertusa	175	118	261	7.31	10/20
Val di Meti	176	600	318	7.35	20/30
Lazio region					
Fiuggi	177	590	108	6.50	70/100
San Marco	178	141	1848	6.20	<10
Cottorella	179	400	297	7.30	<10
Appia	180	110	673		30/50
Claudia	181	143	788	5.80	50/70
Egeria	182	20	621		30/50
Giulia	183	143			50/70
Meo	184	200	216	6.67	<10

Table 1 (cont.

Brand name	Location reference number (Fig. 2)	Spring altitude (m)	TDS 180°C (mg l^{-1})	pH	Production (million l yr^{-1})
Regilla	185	768	113	7.60	<10
S.M. Capannelle	186	20	689	5.90	10/20
San Pietro	187	146	673	5.70	10/20
Acqua di Nepi	188	227	508	5.60	30/50
Mineral Neri	189	350	248	6.40	<10
Acetosa San Paolo	190	20	2270		10/20
Abruzzo region					
Santa Croce	191	800	182		20/30
Sponga	192	830	182	7.40	20/30
Santa Reparata	193	589	608	7.15	<10
Campania region					
Telese	194	55	1675	6.38	<10
Ferrarelle	195	111	1597	5.80	>300
Lete	196	300	976	5.94	30/50
Santagata	197	98	1035	6.00	30/50
Acetosella	198	0	820	6.20	<10
Acqua della Madonna	199	6	790	6.80	20/30
Faito	200		319	7.48	50/70
Vesuvio	201	139	1730	6.30	10/20
Don Carlo	202	99	602		70/100
Irno	203	50	893	6.60	
Santo Stefano	204	650	212	7.50	10/20
Vitologatti	205	50	1796	6.37	10/20
Puglia region					
Eureka	206	97	355	7.45	20/30
Paravita	207		510	7.10	<10
Basilicata region					
Cutolo-Rionero	208	656	637	5.80	50/70
Gaudianello	209	640	1189	5.90	100/150
Itala	210	450	515	5.70	<10
La Francesca	211	656	680	5.96	50/70
Toka	212	450	1970	6.10	10/20
Traficante	213	491	1067	6.50	20/30
Visciolo	214	656	560	6.10	50/70
Calabria region					
Certosa (F. Camarda)	215	400	77	6.68	<10
Certosa (F. Perna)	216	400	59		<10
Madonnina della Calabria	217	750	79	6.46	<10
Mangiatorella	218	1200	581	6.39	50/70
Sicilia region					
Acquarossa	219	551	1330		<10
Pozzillo	220	12	1136	6.70	30/50
Ciappazzi	221	12	1530	7.27	50/70
Fontalba	222	920	119	6.80	30/50
Acquabaida	223	550	342	7.00	20/30
Sardegna region					
Giara	224	71	230	6.65	20/30
Levia	225	400	276		150/200
Pura	226	400	245		150/200
Sandalia	227	71	1479	6.87	50/70
Sattai	228	160	249	6.40	10/20
Sant'Angelo	229	400	241		150/200
San Giorgio	230	400	263	6.20	150/200
San Martino	231	270	2967	6.62	10/20
Smeraldina	232	900	171	6.82	10/20
Santa Lucia	233	350	1227		20/30

[a] Data from Annuario Acque Minerali Italiane 1991–92. Ed. Laus, Milano

wooded depression, situated on the southern slope of Simbruini mountains. Some archeological remains demonstrate that the Fiuggi springs were already known and exploited during the Roman period (4th century BC). With the fall of the Roman Empire, the region first became a part of the Roman dukedom, and later on feudal holding

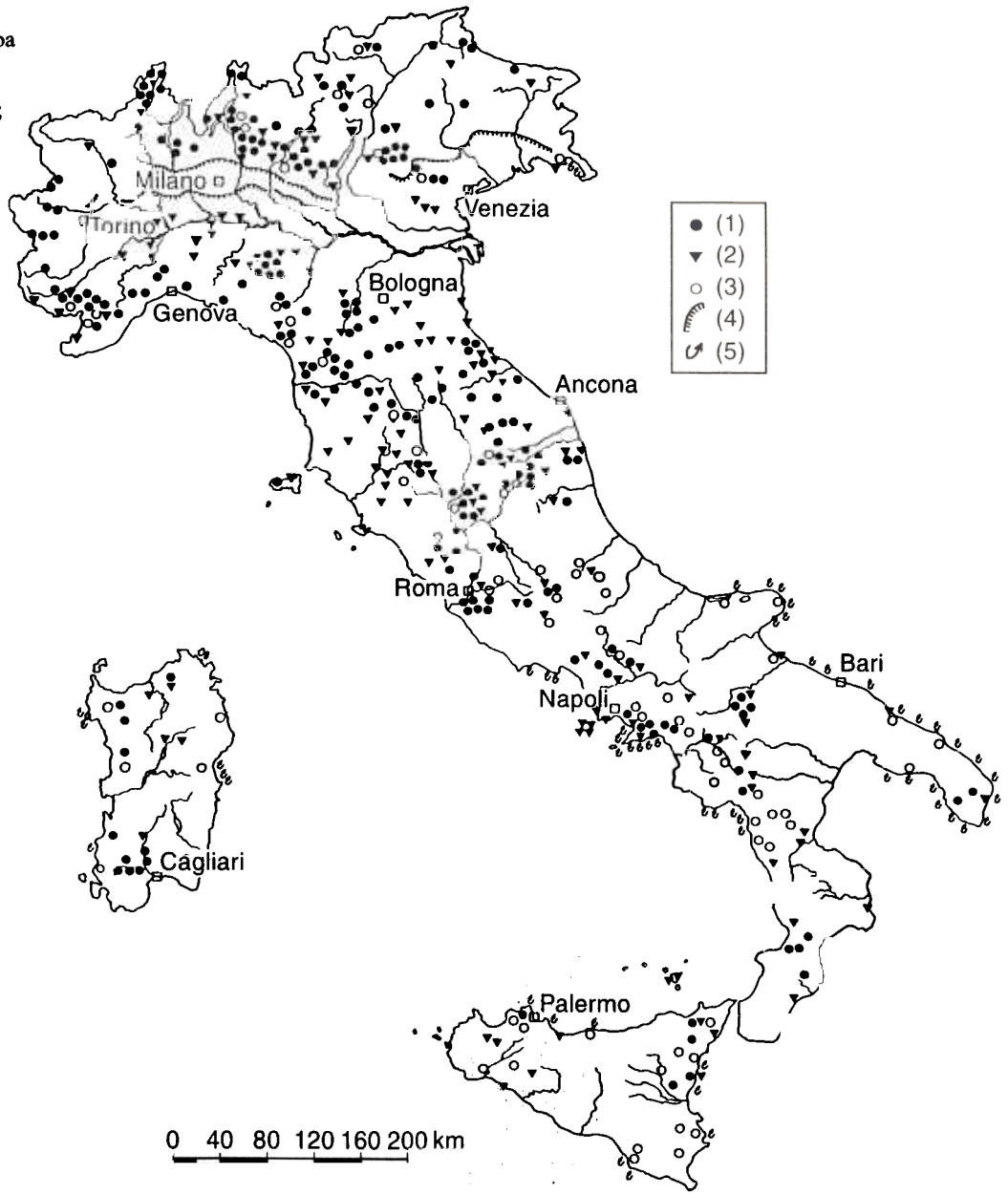


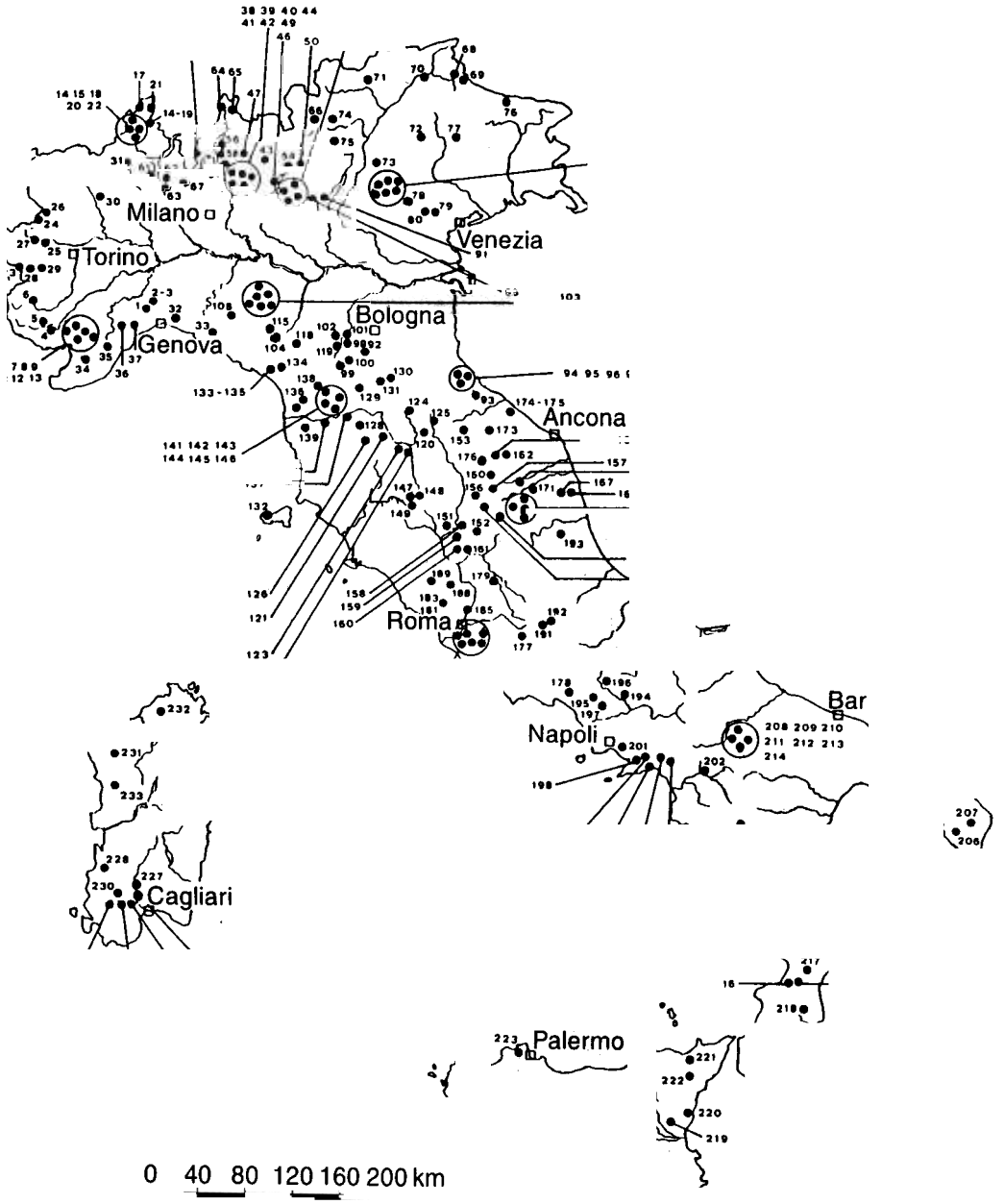
Fig. 1 Location of mineral water catchment areas and spa plants in Italy: (1) catchment area of mineral water and related bottling plant; (2) spa; (3) major spring or group of springs with discharges of 0.5–20 $m^3 s^{-1}$; (4) boundary alignment of Padania springs ("Linea delle risorgive"); (5) submarine spring

of the Pope; in the 1500s the area became a feudal holding of the Colonna family. Fiuggi springs have been mentioned several times in Vatican documents. According to them we know that Pope Bonifacio VIII and the great Michelangelo Buonarroti drank at Fiuggi springs to treat calculous. More recently a number of popes, statesmen, and artists have spent some time in Fiuggi to treat calculous and gout.

Although Fiuggi springs are located in a depressed area within a karst ridge, they are not fed by a karst aquifer. These waters are sustained by a moderate outcrop of volcanic tufa, erupted by Albano volcano, lying on lacustrine sediments that fill the karst depression. Tufa deposits, outcropping over an area of a few square kilometers supply some small springs, the main one of which is named after Pope Bonifacio VIII. The entire outcrop is covered by a flourishing chestnut wood.

Around the springs lies a huge park in which it is possible to drink Fiuggi waters and where cultural and recreational activities take place. Spring discharge, which amounts to only 203 l s^{-1}, is inadequate to meet the increased demand for mineral waters in Italy. During the 1970s, in order to meet the consumer's requirements, a well field was built near the springs which doubled the production of mineral water. The physical and chemical characteristics of Fiuggi water are its acidic pH and very low mineral content.

Fig. 2 Mineral water spring location and reference number (Table 1)



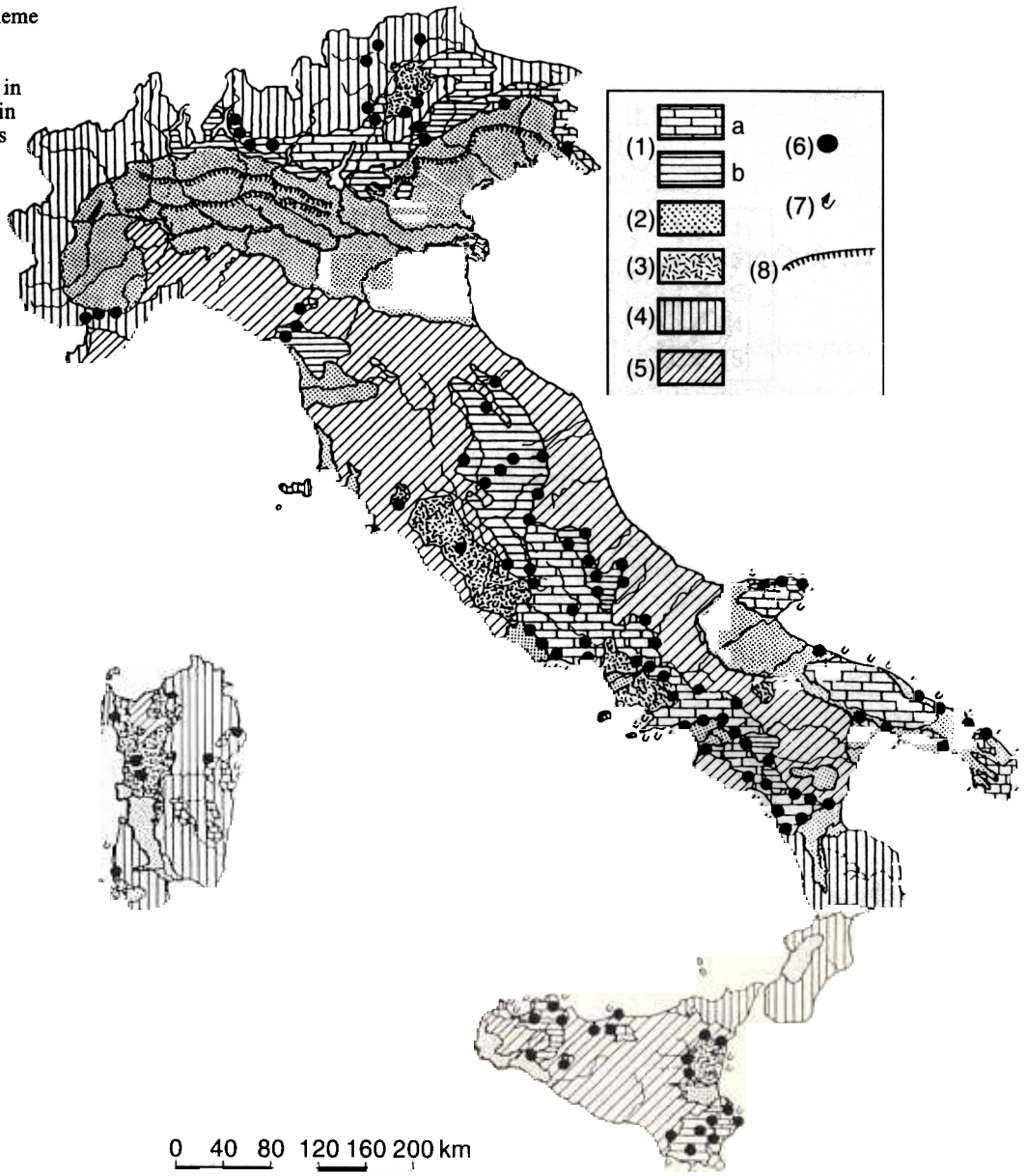


Fig. 3 Regional aquifer scheme of Italy: (1) aquifer in karst terrains—(a) neritic facies; (b) pelagic facies; (2) aquifer in alluvial terrains; (3) aquifer in volcanic terrains; (4) igneous and metamorphic terrains; (5) indifferentiate flysch and ophiolite terrains; (6) spring or group of springs (mean discharge 0.5–18 $m^3 s^{-1}$); (7) submarine spring (discharge unknown); (8) boundary alignment of Padania springs ("Linea delle risorgive")