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1. Introduction

Hydrocarbons are hosted in underground geological formations and they can slowly migrate under the action of the lithostatic load and tectonic activity. Spontaneous hydrocarbon emissions can be detected on the earth surface and have historically drawn man’s attention, and have even been the subject of health or religious cults. The natural hydrocarbon emissions were already well known in the ancient world, in particular during the classical age. Aristotle recalled the kitchen of the Persian Kings fed by natural fossil fuel seeps (Montesauro Veronesi 1585). Lucretius described flammable gaseous emissions in his De Rerum Natuae. Pliny (23 A.D.-79 A.D.) wrote in his Historia Naturalis said that in the Syrian city of Commagene a pond existed expelling a burning loam called “malta” (Bianconi, 1840). In about the whole of Italy the various levels of interest paid to hydrocarbons by local inhabitants and in economic and industrial structure are recognizable in the historical and archeological documentation. During the Renaissance the mud volcano cluster of Sassuolo (meaning “Boulder of the Oil”) near Modena, the largest in Italy, was particularly famous due to the possible medical properties of the their brackish waters (Scicli 1972) . That area was thus the first to be explored and exploited in the second half of the 19th century. The first database compilers acquired field information from the knowledge of salutiferous and religious cults widely known in the ancient specialized literature (Bacci 1571). Local detailed maps and lists of hydrocarbon seepages were compiled in the period 1850-1950 with the purpose of addressing the drilling strategies. The modern studies in Italy begun with the description of many hydrocarbon emissions recorded by Camerana and Galdi (1911; Biasutti 1907) in Emilia Region . Successively the recognition was extended to the whole of Italy (e.g. Camerana et al., 1926). This study phase lasted up to the end of the 1940s (Zuber 1938; Idem 1940) and the last traces of this approach to the research can be found up to 1969 (Martinis 1969; Reeves 1953). The advent of modern geophysical prospection methods (e.g. Accademia Nazionale dei Lincei and Ente Nazionale Idrocarburi 1948) and the growth of new study trends such as the isotopes geochemistry in the two last decades of the past century (Mattavelli et al. 1983; Lindquist 1999; Casero 2004, Bertello et al. 2010) lowered the importance of those former empirical methodologies. Thus no traces of interest can be found in the last modern handbooks dedicated to the petroleum
sciences (ENI 2009). Furthermore, the growing of the anthropogenic impact on the landscape (eg. roads and towns building) erased a great deal of natural evidence of hydrocarbon occurrences. The scientific literature has only recently has renewed its attention to the databases of gas or oil natural emissions and a possible loss of knowledge of sites related to hydrocarbon occurrence. In recent years Martinelli and Judd (2004), Etiope et al. (2009, and references therein) etc. recovered information on the occurrence and chemical composition of gaseous hydrocarbons bubbling in mud volcanoes. Furthermore current scientific literature has devoted attention to some spontaneous gaseous non mud-volcanic emissions as well but a large part of the small or low flow rate methane and oil emissions has been not listed. Since the recovery of the old geographical information and modern geochemical data set can help to achieve a better understanding of the geological phenomena related to deep fluid accumulation and migration (Minissale et al. 2000; Capozzi and Picotti 2010), faulting linked to the crustal stress field, natural greenhouse emissions (Etiope et al. 2009), etc., the present paper is devoted to a first recovery attempt of the available historical as well as recent information on the natural hydrocarbon emissions and to its comparison with the updated findings on Italy’s geological features. A map of hydrocarbon gas seepages has been made and commented together with available analytical data on natural hydrocarbon emissions (see below). Hydrocarbon seepages drove the hydrocarbon exploration strategies and allowed for the discovery of important gas and oil rock sources. Most of the hydrocarbon accumulations are found in the foreland and in foothill areas whereas they are less frequent in mountain chain areas because of tectonic activity or of high heat flow areas. By moving in a subduction zone from the back arc tensive area, through the main thrust area, to the foredeep-foreland area, compression became dominant and newly formed sedimentary sequences were subjected to strong subsidence and compaction. In this kind of ambient the abundant organic matter and its chemical alteration produced hydrocarbons that tend to be squeezed towards the surface, mostly along fault systems. The main gas accumulations are located along a strip parallel to the Apenninic chain (Fig. 1). In particular, in the foredeep main biogenic gas accumulations occur due to high subsidence, sinsedimentary tectonics and turbidite sedimentation. In the Apennine chain gas of thermogenic origin is prevalent due to intense tectonic activity (Mattavelli and Novelli, 1988). Most of the Adriatic and Sicilian oils are high density while the northern Apennine oils are lighter, probably because of a more effective thermal differentiation. Heavy oils originated from Mesozoic rocks while those in the chain have a more diverse origin (Pieri and Mattavelli, 1986). A comparison with the available upper crustal sections reveals main escape conduits along faulted rock volumes. Surface hydrocarbon occurrences are represented by gas and oil seeps and mud volcanoes. At time gas seeps are accompanied by cold or warm water springs due to gas interactions with less deep groundwater circulation paths. Mud volcanoes are well-known gaseous seepages bubbling in a liquid consisting of clay minerals and brackish water. They are chiefly related to areas of tectonic compression characterized by thick sedimentary sequences. Their occurrence is limited to the continental Appeninic chain and Sicily. Some hydrocarbons seeps, sinkholes and mud volcanoes were reported offshore within a few kilometers of the coast and their origin has been recognized to be similar to continental hydrocarbon emissions (Curzi et al. 1998; Camerlenghi and Pini 2009; Fusi et al 2006; Praeg et al. 2009; Holland et al. 2003).
2. Geological framework

Two main tectonic events are responsible for Italy’s present geological setting: 1) extensional tectonics from the Jurassic to the Early Cretaceous; 2) compressional tectonics from the Cretaceous to the Quaternary. The extensional tectonics occurred during the separation of Africa and Europe determining the origin of a new ocean (Tethis). Therefore, the Italian
Advances in Natural Gas Technology

peninsula and Sicily, as a part of an African microplate (Adria or Apulia indenter), was affected by subsidence and fragmentation as an isostatic response to crustal thinning of the passive continental margin. Triassic to early Cretaceous carbonate sediments were mainly deposited during the extensional tectonics that preceded and accompanied the oceanic opening. Euxinic conditions were present before and during this passive margin regime in the Middle-Late Triassic (pre-rifting stage). The Triassic source rocks are formed by thick black limestones and shales and were deposited in lagoons or mainly in narrow discontinuous troughs, originated by rifting and/or transcurrent movements (Catalano and D’Argenio 1982). Compressional tectonics due to the convergence of African and European plates began in the Cretaceous and caused the Alpine orogeny. The Alps and then the Apennines were thus formed and the Italian peninsula took shape. The origin of these chains was complex and occurred during various tectonic phases characterized by different vergences. The Alpine structures, north of the Insilvica line, were piled up onto the European continental margin according to a north-verging and the southern Alps and Apennines were pushed onto the African margin. Southern Alps and the Apennines were formed more recently than the Alps and their origin was mainly due to the Neogene tectonic events (Castellarin et al. 1992; Vai and Martini 2001). In particular, the earliest compressive phases, which occurred during the Aptian-Albian and Cenomanian-Turonian, were accompanied by anoxic events. Nevertheless, Cretaceous organic rich sediments were characterized by a more widespread distribution but distinctly thinner sequences in comparison with Triassic and Jurassic anoxic facies. The deposition of the terrigenous sediments mainly during compressional tectonics was a consequence of the generation of the new mountain belts. These deposits are chiefly formed by thick Tertiary turbidites, deposited in elongated basins parallel to the Apennines chain (Mutti and Ricci Luchè 1972). Anoxic facies were not recognized in Tertiary sequences but the preservation of organic matter deposited in the external part of the turbidites was favored by a rapid burial in the more active subsiding areas (Mattavelli and Novelli, 1988). Thus, the origin and distribution of gas fields in Italy was linked to the Neogene tectonic and sedimentary events related to the Southern Alps and the Apennines sucession. During the Neogene three main tectono-sedimental domains characterized the general framework of Italy: Southern Alps; Apennine chain with its foredeep, the related foreland. Most of the Italian gas fields were discovered in the Neogene turbiditic sequences of the Plio Pleistocene. Condensate gas fields have been also found in the deep Mesozoic carbonate rocks of Northern Italy and some gas accumulations of Central and Southern Italy were found in Late Cretaceous limestones.

3. Liquid hydrocarbons source rocks

At least five important source rocks have been recognized which are distributed in age from Mesozoic to Pleistocene. Three of them were deposited during Mesozoic crustal extension and are mainly oil-prone. The deposition of organic-rich sediments in restricted basins began during the Middle-Late Triassic and Early Jurassic extensional phases pre-dating the break-up of Pangea. Discontinuous anoxic basins developed in the southern Alps, southern Apennines and Sicily (Pieri and Mattavelli, 1986). Hydrocarbon occurrences associated with these sources are usually found in complex carbonate structures along the Apennines thrust-and-fold belt and in the foreland. Two other important source rocks were generated in the foredeep terrigenous units which formed during the Alpine and Apennine Cenozoic orogenesis (Casero 2004; Bertello et al., 2010). The older source rocks are thermogenic gas-prone and are found in the highly tectonized Oligo-Miocene foredeep wedges: gas
Fig. 2. Schematic transects of gas setting across the Apennine Chain (related location are shown in the vignette lying in the lower right corner). A) Ideal, simplified stratigraphic section (after Boccaletti and Martelli 2004, redrawn) showing an average outline of the relationships existing among lithology, tectonics, oil and methane types in the northern Apennine and related foredeep. B) Outline of the structural setting of the northern Appennine Chain (after Picotti and Pazzaglia, fig. 1, redrawn). C) An explaining model for a mud volcano activity in the northern Apennine (Nirano case) (after Bonini 2007, fig 5 and 9, redrawn). D) Hydrocarbon trends geological setting in the Candela-Roseto gas field (after Casero 2004, Plate 4, section 4a bis, redrawn). E) Geological setting of the Tempa Rossa oil field (after Bertello at al. 2010, fig. 6C, redrawn).
occurrences associated with the gas source are mainly concentrated along the northern Apennines margin, in Calabria and Sicily. The younger source rocks are biogenic gas-prone and are located in the outer and recent Plio-Pleistocene foredeeps of Po plain and northern Adriatic Sea. (eg. Casero 2004; Ministero Sviluppo Economico and Assomineraria 2008). About 95% of Italian oils were generated from source rocks related to the first described group (Mattavelli et al 1993). Anyway, no significant reservoired hydrocarbons can be correlated to these deposits due to migration processes linked to the subsequent tectonism. In the Tertiary era the organic content of the flysch shales also generated a minor amount of oil in the northern and southern Apennines. Maturation of the above-mentioned Mesozoic and Tertiary source rocks was induced by regional tectonic factors characterizing the different structural settings. The Late Neogene tectonism had a major role in the fold and thrust belt, both for the burial and maturation of source sediments under thick thrust sheets and for the development of hydrocarbon traps (Mattavelli and Novelli, 1990). However oil was generated during Jurassic-Palaeogene times from Late Triassic sources and could possibly have been preserved by early migration in traps at the top of the carbonate sequence (Casero et al., 1991). Heavy oils are prevalent in the foreland and foredeep domains, whereas light oils prevail in the thrust belt. Thermogenic gas was also generated during oil maturation (Mattavelli et al.1993). (Fig. 2)

4. Gas source rocks

Most of the Italian natural gases have been generated through bacterial fermentation and/or low temperature thermochemical reactions in immature Plio-Pleistocene sediments of the Apennine foredeep (Mattavelli and Novelli 1988). Bacterial gas is characterized by almost pure and isotopically light methane (Mattavelli et al., 1983). Its generation and accumulation is essentially favoured by high sedimentation rates, the deposition of alternating sands and shales, and synsedimentary tectonics, with the early genesis of structural traps (Pieri and Mattavelli 1986). The distribution of discovered original gas reserves is shown in Fig. 1. Thermogenic gas is confined to the thrust belt structural domain, whereas bacterial gas is distributed in the Pliocene-Pleistocene reservoirs of the external thrust belt and of the foredeep. The rapid burial and turbiditic sedimentation associated with very early compressional tectonics represented the ideal conditions for the formation and accumulation of biogenic gases. The peculiarity of the Apennine foredeep is the high percentage of biogenic gas which is great part of the total amount of hydrocarbons discovered over the past half a century in Italy (Mattavelli and Novelli, 1988). A lesser amount of gases was produced by thermal degradation of organic matter at great depths (in general >5000 m) either in the foredeep or in the thrust belts, where a considerable increase in temperature, caused by the emplacement of the thrust sheets, fostered the generation of thermogenic gases. Nevertheless, the tectonic movements, active during the entire Neogene, represent a limiting factor for the preservation of such generated gases. The small quantity (10%) and the uniform make-up of the gases (99% biogenic gases) discovered in the foreland are strictly related to the peculiar characteristics of this tectonic regime. In the immature Tertiary sediments the reduced thickness of the terrigenous deposits generated only a limited amount of bacterial and/or diagenetic gases. On the other hand in Mesozoic sediments, mainly formed by
thick carbonate sequences, the possible present thermogenic gases were lost by diffusion through poorly efficient cap rocks (Mattavelli and Novelli, 1988; Buttinelli et al. 2011). Geochemical and geological evidences indicates that migration and accumulation of gaseous hydrocarbons took place mostly during the Plio-Pleistocene. In particular, migration is still active in the gas fields of the northern Apennine foredeep (Dal Piaz 1959), owing to the presence of thin impervious layers. In this area, in fact, a kind of steady state equilibrium has been reached between losses through diffusion and the continuous supply of newly generated natural gases.

5. Types of gaseous hydrocarbons

Biogenic, mixed, and thermogenic gases were found in Italy. Biogenic gases are usually found in Plio-Pleistocene sediments and are characterized by almost pure and isotopically light methane. The more negative isotopic values accompanied by the absence of heavier homologues were observed in Pleistocene shallow reservoirs. The chemical and isotopic composition of these gases is considered as evidence for their in situ formation through bacterial or diagenetic processes (Schoell 1980, 1983; Mattavelli, et al. 1983). Mixed gases were discovered in reservoirs from Middle Pliocene to Cretaceous and are characterized by a wide range of mixing proportions between biogenic and thermogenic gases. Thermogenic gases migrated from deeper layers and mixed in different amounts with shallower biogenic gases. Thermogenic gases are generally found in the pre-Pliocene reservoirs they are characterized by $^{13}$C/$^{12}$C values ranging from -31 to -51‰. Italian thermogenic gases reflect all stages of maturation of organic matter. Condensate and dry thermogenic gases are enriched in heavy carbon ($^{13}$C/$^{12}$C -31 to -36‰) and Deuterium which indicate a generation from highly mature source rocks (Mattavelli and Novelli, 1988).

6. Hydrocarbon accumulations

Biogenic gas pools were found in shallow marine sands and foredeep turbiditic multi layer sands and sandstones involved in thrust folds and their source is in the interbedded clays. Thermogenic gas pools are in turbiditic sandstones involved in thrust folds in foothill areas. The gas generated at great depth in the flysch, migrated laterally-updip along the inner flank of the folds. Liquid hydrocarbons are reservoired in carbonatic series in foothills and foreland domains. In the foothills belts ther traps are thrust folds. In the foreland the oils are stored in carbonates involved in paleostructures of different nature (Casero 2004; Bertello et al. 2010). Some biogenic gases originated at a very shallow depth (i.e. less than 100 m) mask the exact localization of deep reservoirs and justify the need of geophysical and geochemical prospection to better constrain deep gas accumulations. Sometimes a mixing between very shallow biogenic gas and deep originated methane occurs generating mixing phenomena (Cremonini et al. 2008). In the subaerial environment the same biogenic gases generate and/or use shallow/surfacial systems of fractures and faults as escape paths (Bonori et al. 2000; Castellarin et al. 2006; Cremonini et al. 2010; Cremonini 2010a) and some authors suggested also the possibility of identifying subaerial pockmarks (Curzi et al. 1987; Marabini et al. 1987; Cremonini 2010b). Usual pockmark morphologies are known to exist on the
Adriatic Sea bottom along the Meso Adriatic Depression (Curzi and Veggiani 1985; Curzi et al. 1987; Praeg et al. 2009; Geletti et al. 2008; Mazzotti et al., 1987; Trincardi et al. 2011c), on the Sardinian continental shelf (Dalla Valle and Gamberi 2011) and at the bottom of Lake Garda in northern Italy (Violante and Michetti 2010). Unfortunately, for all of those features no data concerning the seeping gas are available. Other well known morphologies linked to sure shallow gas seepage on the Northern Adriatic sea floor are generating small carbonatic mounds and layers (Conti et al. 2002; Panieri 2006), but also no analytical data are available for these.

7. Comments on database and maps

Historical scientific literature (Camerana et al. 1926; Zuber 1940; Martinis 1969, Fig. 8 and previous references therein; Martinelli 2007) have also reported the location of natural hydrocarbon occurrences not always considered in the recent scientific literature (Martinelli and Judd 2004). In any case, all the available sampling points or historically recognized points have been mapped and shown in figures 3a-d. The location data related the previous figures are recorded in Tables 1 to 4. Due to the fact that the geographical location of the majority of the considered points cannot be gleaned from any other original edited source, the related coordinates were graphically extrapolated and as a consequence each georeferenced location must be understood as the barycentre point of a circular area in a possible location having a radius of up to 5 km in length. The related municipality quoted in the Tables 1 to 4 is the biggest one existing near the location point. Hence, they will be merely indicative even if significant on the scale of the present study. Seepages occurring in Italy are represented by: i) dry gas emissions; ii) gas bubbling in mud-volcanic waters; iii) gas bubbling in ground waters; iv) oil spills; v) aspherals and bitumen; vi) solid waxes. Figure 3 collects the related locations subdivided into four subsets, i.e. gas (Fig. 3a), Oil (Fig. 3b), Solid (Fig. 3c) and Mud-Volcanoes (Fig. 3d). The whole seepage set vs. the structural map of Italy is provided in Fig. 4. The available updated natural gas analyses are collected in Table 5 and their location and kind are shown in Fig. 5. When more than one site reported in the scientific literature was found within the same municipality then the most significant and representative of them or the main centre itself was selected as being representative. The analytical data were kept by the reference sources quoted in Table 5 (Borgia et al. 1988; Minissale et al. 2000; Duchi et al. 2005; Etiope 2007; Heinicke et al. 2010). In some cases, the original analytical strings have been completed by means of data published by the authors referenced in the reported list. Analytical data usually refer to dry gases and to the gases bubbling in mud volcanoes. Some low-depth wells (<200m) drilled close to natural gaseous emissions have been considered as well as some wells characterized by the certain representativeness of local seepages. All the sampling points have been georeferenced. Analytical data have been plotted and are shown in Figure 6. The graphs obtained indicate that only a minority of considered gases has biogenic origin, while all the others are thermogenic or mixed thermo-biogenic. Due to fact that analytical data obtained from the gases sampled in deep industrial wells highlight the same proportions of biogenic and thermogenic gases, we can conclude that the surface seepages are representative of a deep hydrocarbon setting and, in principle, could be still exploited as indicators of deep-seated reservoirs.
| No. | Region     | Province   | Municipality       | Place name                      | θ WGS 84 | λ WGS 84 | Reference                        |
|-----|------------|------------|--------------------|---------------------------------|----------|----------|----------------------------------|
| 1   | Piemonte   | Alessandria| Casale Monferrato  |                                 | 45 08 14| 08 27 03| Camerana et al., 1926           |
| 2   | Piemonte   | Alessandria| **Gabiano**        |                                 | *45 09 38| *08 11 44| Martinis 1969, Fig. 8           |
| 3   | Piemonte   | Alessandria| **Casale Monferrato**|                                | *45 09 52| *08 23 55| Martinis 1969, Fig. 8           |
| 4   | Lombardia  | Pavia      | Casteggio          | Casteggio                       | 45 00 43| 09 07 24| Camerana et al., 1926           |
| 5   | Lombardia  | Pavia      | Salice Terme       | Salice Terme                    | 44 54 51| 09 01 38| Camerana et al., 1926           |
| 6   | Lombardia  | Pavia      | Rivanazzano Terme  | Rile dell’olio                  | 44 55 37| 09 00 51| Camerana et al., 1926           |
| 7   | Lombardia  | Pavia      | **Rocca Susella**  |                                 | *44 55 25| *09 06 49| Martinis 1969, Fig. 8           |
| 8   | Trentino-A.A. | Trento | **Brentonico**     | Castione                         | *45 48 46| *10 57 07| Martinis 1969, Fig. 8           |
| 9   | Trentino-A.A. | Trento | **Ala**            | S. Margherita                    | *45 44 48| *11 04 16| Martinis 1969, Fig. 8           |
| 10  | Veneto     | Belluno    | **Feltre**         |                                 | *45 58 29| *11 49 15| Martinis 1969, Fig. 8           |
| 11  | Friuli V. G. | Udine | **Ovaro**          |                                 | *46 28 34| *12 52 53| Martinis 1969, Fig. 8           |
| 12  | Emilia Romagna | Bologna | Casalfrumanese    | Cà Bordona                       | 44 17 55| 11 37 16| Martinelli 2007, tab 6.1        |
| 13  | Emilia Romagna | Bologna | Castel del Rio    | Molinaccio                       | 44 12 56| 11 30 14| Martinelli 2007, tab 6.1        |
| 14  | Emilia Romagna | Bologna | Castiglione dei Pepoli |                                 | 44 08 35| 11 09 51| Martinelli 2007, tab 6.1        |
| 15  | Emilia Romagna | Bologna | Gaggio Montano    | 5 sites: Rovine Tommasi, Saldine, Cà Masera, Molinaccio, Cà di Riccio | 44 11 53| 10 56 01| Martinelli 2007, tab 6.1        |
| 16  | Emilia Romagna | Bologna | Grizzana Morandi  | Cà Bellavista                     | 44 15 28| 11 09 08| Martinelli 2007, tab 6.1        |
| 17  | Emilia Romagna | Bologna | Lizzano in Belvedere | Greccia                          | 44 09 42| 10 53 38| Martinelli 2007, tab 6.1        |
| 18  | Emilia Romagna | Bologna | Monterenzio       | Casa Domenicali                  | 44 19 31| 11 24 16| Martinelli 2007, tab 6.1        |
| 19  | Emilia Romagna | Bologna | Torretta Terme    | 2 sites: Cà Salgasti, Sasso Cardo. | 44 09 15| 10 58 32| Martinelli 2007, tab 6.1        |
| 20  | Emilia Romagna | Bologna | S. Benedetto Val di Sambro | Castel dell’Alpi                | 44 12 56| 11 14 04| Martinelli 2007, tab 6.1        |
| 21  | Emilia Romagna | Bologna | Sasso Marconi     | Reno river bed                   | 44 23 44| 11 14 53| Martinelli 2007, tab 6.1        |
| 22  | Emilia Romagna | Bologna | Savigno           | Monte Falò                       | 44 23 27| 11 04 29| Martinelli 2007, tab 6.1        |
| 23  | Emilia Romagna | Ferrara | Cento             | Corpo Reno - Casa "Il Gas"      | 44 45 22| 11 18 08| Martinelli 2007, tab 6.1        |
| 24  | Emilia Romagna | Ferrara | Comacchio         | Valli del Mezzano                | 44 40 37| 12 01 44| Cremonini et al. 2008           |
| 25  | Emilia Romagna | Forlì-Cesena | Bagno di Romagna | 3 sites: Termé, Cimitero, S. Martino di Larciano | 43 50 02| 11 57 33| Martinelli 2007, tab 6.1        |
| 26  | Emilia Romagna | Forlì-Cesena | Bertinoro         | Rio Salsol                       | 44 08 56| 12 07 58| Martinelli 2007, tab 6.1        |
| 27  | Emilia Romagna | Forlì-Cesena | Castrocaro Terme  | Bollirone                       | 44 10 20| 11 56 51| Martinelli 2007, tab 6.1        |
| 28  | Emilia Romagna | Forlì-Cesena | Galeata           | 2 sites: Casa Toltie, Rio Suasia | 43 59 48| 11 54 43| Martinelli 2007, tab 6.1        |
| 29  | Emilia Romagna | Forlì-Cesena | Portico e S. Benedetto | Portico di Romagna               | 44 01 31| 11 46 57| Martinis 1969, Fig. 8           |
| No. | Region          | Province       | Municipality                  | Place name                                                                 | φ  WGS 84 | λ  WGS 84 | Reference               |
|-----|-----------------|----------------|------------------------------|----------------------------------------------------------------------------|-----------|-----------|-------------------------|
| 30  | Emilia Romagna  | Forlì-Cesena   | Rocca San Cascaino           | 3 sites: Case Budria, Casalecchio, Fosso di Rinaldo,                        | 44 03 30  | 11 50 30  | Martinelli 2007, tab 6.1 |
| 31  | Emilia Romagna  | Forlì-Cesena   | Sogliano al Rubicone         | Torrente Torchio                                                          | 44 00 18  | 12 18 01  | Martinelli 2007, tab 6.1 |
| 32  | Emilia Romagna  | Forlì-Cesena   | Tredozio                     | Busca                                                                     | 44 04 41  | 11 44 35  | Martinelli 2007, tab 6.1 |
| 33  | Emilia Romagna  | Modena         | Castelvetro di Modena        | S. Luigi                                                                  | 44 30 12  | 10 56 35  | Martinelli 2007, tab 6.1 |
| 34  | Emilia Romagna  | Modena         | Fanano                       | Chiesa di Trignano                                                        | 44 12 39  | 10 50 29  | Martinelli 2007, tab 6.1 |
| 35  | Emilia Romagna  | Modena         | Lama Mocogno                 | 3 sites: Barigazzo, Lagadelle, Case di Sotto                               | 44 18 25  | 10 43 47  | Martinelli 2007, tab 6.1 |
| 36  | Emilia Romagna  | Modena         | Maranello                    | 2 sites: Torre Maina, La Govana                                          | 44 31 31  | 10 51 59  | Martinelli 2007, tab 6.1 |
| 37  | Emilia Romagna  | Modena         | Marano sul Panaro            | Prediera                                                                  | 44 27 21  | 10 57 58  | Martinelli 2007, tab 6.1 |
| 38  | Emilia Romagna  | Modena         | Montefiorino                 | 4 sites: Macognano, Farneta, Il Fuoco, Cà Medole                           | 44 21 31  | 10 37 24  | Martinelli 2007, tab 6.1 |
| 39  | Emilia Romagna  | Modena         | Montese                      | Cà Boschi                                                                 | 44 16 06  | 10 56 27  | Martinelli 2007, tab 6.1 |
| 40  | Emilia Romagna  | Modena         | Palagano                     | Casa Bottega                                                              | 44 19 14  | 10 38 52  | Martinelli 2007, tab 6.1 |
| 41  | Emilia Romagna  | Modena         | San Possidonio               | Fondo Bordina                                                             | 44 53 30  | 10 59 45  | Martinelli 2007, tab 6.1 |
| 42  | Emilia Romagna  | Modena         | Medolla                      |                                                                            | 44 50 55  | 11 04 14  | Gasperi, Pellegrini 1981 |
| 43  | Emilia Romagna  | Modena         | Sassuolo                     | 3 sites: Gozzano, Salsa di sotto, Salvarola                                | 44 32 30  | 10 46 54  | Martinelli 2007, tab 6.1 |
| 44  | Emilia Romagna  | Modena         | Serramazzoni                 | 2 sites: Pozzi dell’olio, Campodolfo                                       | 44 25 33  | 10 47 15  | Martinelli 2007, tab 6.1 |
| 45  | Emilia Romagna  | Modena         | Sestola                      | 5 sites: Troncoscaglia, Bandita, Cà Boldrini, Fontanine, Trignano          | 44 13 50  | 10 46 14  | Martinelli 2007, tab 6.1 |
| 46  | Emilia Romagna  | Parma           | Bardi                        | 3 sites: Ormei, Volpi, Tosca                                              | 44 37 55  | 09 43 53  | Martinelli 2007, tab 6.1 |
| 47  | Emilia Romagna  | Parma           | Berceto                      | 7 sites: Scorza, Costa d’Asino, Molinari, Borgallo, Castellonchio, Macchie di Monte Marino, Lagodignano | 44 30 38  | 09 59 22  | Martinelli 2007, tab 6.1 |
| 48  | Emilia Romagna  | Parma           | Berceto                      | Berceto                                                                   | 44 30 39  | 09 59 24  | Martinis 1969, Fig. 8   |
| 49  | Emilia Romagna  | Parma           | Berceto                      | Castellonchio                                                             | 44 32 59  | 10 00 25  | Martinis 1969, Fig. 8   |
| 50  | Emilia Romagna  | Parma           | Collecchio                   | Cà Ginestra                                                               | 44 45 06  | 10 12 54  | Martinelli 2007, tab 6.1 |
| 51  | Emilia Romagna  | Parma           | Corniglio                    | 3 sites: Miano, Prella, Rividulano                                        | 44 28 33  | 10 05 18  | Martinelli 2007, tab 6.1 |
| 52  | Emilia Romagna  | Parma           | Corniglio                    | Grammatica                                                                | 44 26 21  | 10 05 15  | Martinis 1969, Fig. 8   |
| 53  | Emilia Romagna  | Parma           | Fornovo Taro                 | 4 sites: Riccò, Ozzano, Case Folli, Vallezza                               | 44 41 29  | 10 05 49  | Martinelli 2007, tab 6.1 |
| 54  | Emilia Romagna  | Parma           | Fornovo Taro                 | Vallezza                                                                  | 44 39 36  | 10 09 14  | Martinis 1969, Fig. 8   |
| No. | Region | Province | Municipality | Place name | Reference |
|-----|--------|----------|--------------|------------|-----------|
| 55  | Emilia Romagna | Parma | Medesano | Geologico e Geochemical Setting | www.intechopen.com |
| No. | Region | Province | Municipality | Place name | $\phi$ WGS 84 | $\lambda$ WGS 84 | Reference |
|-----|--------|----------|--------------|------------|---------------|---------------|-----------|
| 84  | Toscana| Firenze  | **S. Casciano Val di Pesa |           | *43 36 26     | *11 09 21     | Martinis 1969, Fig. 8 |
| 85  | Toscana| Siena    | **Poggibonsi |           | *43 30 00     | *11 10 10     | Martinis 1969, Fig. 8 |
| 86  | Toscana| Livorno  | **Collesalvetti |           | *43 30 41     | *10 28 34     | Martinis 1969, Fig. 8 |
| 87  | Toscana| Pisola   | Volterra     |           | *43 25 03     | 10 55 35      | Martinis 1969, Fig. 8 |
| 88  | Toscana| Siena    | Siena        | Montarioso | *43 21 01     | 11 18 37      | Camerana et al., 1926, p 276 |
| 89  | Toscana| Siena    | **Casole d’Elsa |           | *43 19 02     | *11 02 51     | Martinis 1969, Fig. 8 |
| 90  | Toscana| Siena    | **Monteroni d’Arbia |          | *43 15 38     | *11 24 06     | Martinis 1969, Fig. 8 |
| 91  | Toscana| Livorno  | **Suvereto   |           | *43 04 55     | *10 44 57     | Martinis 1969, Fig. 8 |
| 92  | Toscana| Grosseto | **Roccastrada |           | *43 02 56     | *11 10 29     | Martinis 1969, Fig. 8 |
| 93  | Toscana| Grosseto | **Santa Fiora |           | *42 51 29     | *11 34 39     | Martinis 1969, Fig. 8 |
| 94  | Toscana| Grosseto | Grosseto     | Fondo Casone | 42 49 17     | 11 05 58      | Camerana et al., 1926, p 275 |
| 95  | Toscana| Grosseto | Grosseto     | Fondo Tripoli | 42 42 59     | 11 05 14      | Camerana et al., 1926, p 275 |
| 96  | Toscana| Grosseto | Grosseto     | **Marciano  | *42 33 35     | *11 28 40     | Martinis 1969, Fig. 8 |
| 97  | Emilia Romagna| Rimini | **Montefiore Conca |           | *43 54 06     | *12 34 21     | Martinis 1969, Fig. 8 |
| 98  | Emilia Romagna| Rimini | **Novafeltria |           | *43 53 28     | *12 17 35     | Martinis 1969, Fig. 8 |
| 99  | Marche | Ancona   | **Agugliano  |           | *43 32 50     | *13 24 52     | Martinis 1969, Fig. 8 |
| 100 | Marche | Macerata | **Montecosaro |           | *43 19 26     | *13 37 18     | Martinis 1969, Fig. 8 |
| 101 | Marche | Macerata | **Petrullo   |           | *43 10 27     | *13 22 25     | Martinis 1969, Fig. 8 |
| 102 | Marche | Fermo    | **Lapedona   |           | *43 06 05     | *13 44 17     | Martinis 1969, Fig. 8 |
| 103 | Marche | Macerata | **Serrano    |           | *43 01 50     | *13 18 38     | Martinis 1969, Fig. 8 |
| 104 | Marche | Fermo    | **Montefortino|           | *42 54 45     | *13 17 38     | Martinis 1969, Fig. 8 |
| 105 | Marche | Ascoli Piceno | **Force   |           | *42 55 57     | *13 31 04     | Martinis 1969, Fig. 8 |
| 106 | Abruzzo| Teramo   | **Civitella del Tronto | Valle Tronto a N Civitella | *42 47 45     | *13 31 29     | Martinis 1969, Fig. 8 |
| 107 | Marche | Ascoli Piceno | Offida    |           | 42 56 13     | 13 42 01     | Zuber 1940 |
| 108 | Marche | Ascoli Piceno | near Maltignano | Villa Passo | 42 49 57     | 13 41 13     | Camerana et al., 1926 |
| 109 | Umbria| Perugia  | **Gubbio     |           | *43 26 44     | *12 33 16     | Martinis 1969, Fig. 8 |
| 110 | Umbria| Perugia  | Perugia      |           | 43 08 50     | 12 23 59     | Martinis 1969, Fig. 8 |
| 111 | Umbria| Terni    | **Montecastrilli |           | *42 39 49     | *12 24 38     | Martinis 1969, Fig. 8 |
| 112 | Lazio | Rieti    | **Montopoli Sabina |           | *42 13 14     | *12 40 12     | Martinis 1969, Fig. 8 |
| 113 | Lazio | Roma     | **Ostia      |           | *41 44 57     | *12 23 19     | Martinis 1969, Fig. 8 |
| 114 | Lazio | Frosinone | **Pontecorvo |           | *41 27 60     | *13 35 28     | Martinis 1969, Fig. 8 |
| 115 | Abruzzo| Pescara  | **Collecorvino |           | *42 28 13     | *14 02 05     | Martinis 1969, Fig. 8 |
| No.  | Region     | Province   | Municipality       | Place name                        | φ WGS 84 | λ WGS 84 | Reference          |
|------|------------|------------|--------------------|-----------------------------------|----------|----------|--------------------|
| 116  | Abruzzo    | L’Aquila   | **Ofena**          |                                   | *42 18 38 | *13 46 57 | Martinis 1969, Fig. 8 |
| 117  | Abruzzo    | Pescara    | **Bussi sul Tirino |                                   | *42 14 34 | *13 48 16 | Martinis 1969, Fig. 8 |
| 118  | Abruzzo    | L’Aquila   | Avezzano           | Pozzone di Paterno -Fucino        | 42 03 06  | 13 28 51  | Ciotoli et al. 1998 |
| 119  | Abruzzo    | L’Aquila   | **Trasacco**       |                                   | *41 58 33 | *13 34 25 | Martinis 1969, Fig. 8 |
| 120  | Abruzzo    | L’Aquila   | **Pescocostanzo**  |                                   | *41 53 01 | *14 04 03 | Martinis 1969, Fig. 8 |
| 121  | Molise     | Campobasso | **Malfada**        |                                   | *41 58 05 | *14 43 01 | Martinis 1969, Fig. 8 |
| 122  | Molise     | Isernia    | **Rocca Sicura**   |                                   | *41 41 15 | *14 13 17 | Martinis 1969, Fig. 8 |
| 123  | Molise     | Isernia    | **Macchiagodena**  |                                   | *41 35 24 | *14 22 56 | Martinis 1969, Fig. 8 |
| 124  | Molise     | Campobasso | **S. Paolo Matese**|                                   | *41 26 39 | *14 30 42 | Martinis 1969, Fig. 8 |
| 125  | Molise     | Campobasso | **Sepino**         |                                   | *41 22 23 | *14 37 06 | Martinis 1969, Fig. 8 |
| 126  | Campania   | Benevento  | **Morcone**        |                                   | *41 19 51 | *14 44 34 | Martinis 1969, Fig. 8 |
| 127  | Campania   | Avellino   | **Andretta**       |                                   | *40 57 26 | *15 21 09 | Martinis 1969, Fig. 8 |
| 128  | Campania   | Avellino   | **Bagnoli Irpino** |                                   | *40 49 04 | *15 00 40 | Martinis 1969, Fig. 8 |
| 129  | Basilicata | Potenza    | Tramutola          | Cavolo and Agri rivers junction   | 40 20 53 | 15 47 05 | Camerana et al., 1926 |
| 130  | Basilicata | Matera    | Nova Siri          | Fontana di Sant’Alessio           | 40 08 57 | 16 32 29 | Camerana et al., 1926 |
| 131  | Basilicata | Potenza   | Rapolla            | Colle S. Lucia                    | 40 58 37 | 15 40 19 | Camerana et al., 1926 |
| 132  | Basilicata | Matera    | **Pisticci**       |                                   | *40 25 51 | *16 31 31 | Martinis 1969, Fig. 8 |
| 133  | Basilicata | Matera    | **Scanzano Ionico**|                                   | *40 16 12 | *16 40 27 | Martinis 1969, Fig. 8 |
| 134  | Basilicata | Matera    | **Colobraro**      |                                   | *40 10 37 | *16 22 21 | Martinis 1969, Fig. 8 |
| 135  | Calabria   | Cosenza   | **Montegiordano**  |                                   | *40 01 50 | *16 30 43 | Martinis 1969, Fig. 8 |
| 136  | Calabria   | Cosenza   | **Corigliano Calabro** |                               | *39 41 04 | *16 25 31 | Martinis 1969, Fig. 8 |
| 137  | Calabria   | Cosenza   | S. Vincenzo la Costa |                               | 39 21 53 | 16 09 03 | Martinis 1969, Fig. 8 |
| 138  | Calabria   | Crotone   | **Verzino**        |                                   | *39 20 16 | *16 50 13 | Martinis 1969, Fig. 8 |
| 139  | Calabria   | Crotone   | **Cutro**          |                                   | *38 59 17 | *16 59 07 | Martinis 1969, Fig. 8 |
| 140  | Calabria   | Crotone   | **Isola Capo Rizzuto** |                              | *38 59 39 | *17 06 04 | Martinis 1969, Fig. 8 |
| 141  | Calabria   | Reggio    | **Rosarno**        |                                   | *38 30 28 | *16 00 36 | Martinis 1969, Fig. 8 |
| 142  | Calabria   | Reggio    | **Staiti**         |                                   | *37 58 56 | *16 02 52 | Martinis 1969, Fig. 8 |
| 143  | Sicilia    | Messina   | Mistretta          | Castel di Lucio, Rocca Pizzutella | 37 55 46 | 14 21 46 | Camerana et al., 1926 |
| 144  | Sicilia    | Enna      | Cerami             | Monania                           | 37 48 42 | 14 30 31 | Camerana et al., 1926 |
| 145  | Sicilia    | Enna      | Troina             | verso Bronte, Pianezze            | 37 47 10 | 14 36 10 | Camerana et al., 1926 |
| 146  | Sicilia    | Palermo   | Calavutturo        | Pagliuza                          | 37 49 19 | 13 53 28 | Camerana et al., 1926 |
| 147  | Sicilia    | Agrigento | Bivona             | Censo, Casa il Censo              | 37 37 11 | 13 26 22 | Camerana et al., 1926 |
| No. | Region | Province | Municipality         | Place name            | $\varphi$ WGS 84 | $\lambda$ |
|-----|--------|----------|----------------------|-----------------------|-----------------|----------|
| 148 | Sicilia| Palermo  | Bagni di Sclafani    |                       | 37 49 18        | 1        |
| 149 | Sicilia| Enna     | Piazza Armerina       | Piazza Armerina       | 37 23 05        | 1        |
| 150 | Sicilia| Catania  | **Bronte**           |                       | *37 45 21       | *        |
| 151 | Sicilia| Enna     | **Cerami**           |                       | *37 46 18       | *        |
| 152 | Sicilia| Palermo  | **Polizzi Generosa** |                       | *37 50 05       | *        |
| 153 | Sicilia| Trapani  | **Santa Ninfa**      |                       | *37 44 43       | *        |
| 154 | Sicilia| Agrigento|**Sant'Elisabetta**   |                       | *37 27 21       | *        |
| 155 | Sicilia| Enna     | **Valguarnera Caropepe** |                   | *37 28 13       | *        |
| 156 | Sicilia| Catania  | **Raddusa**          |                       | *37 29 56       | *        |
| 157 | Sicilia| Catania  | **Paternò**          |                       | *37 35 52       | *        |
| 158 | Sicilia| Catania  | **Catania**          |                       | *37 24 48       | *        |
| 159 | Sicilia| Siracusa |**Lentini**           |                       | *37 25 35       | *        |
| 160 | Sicilia| Catania  | **Palagonia**        |                       | *37 17 36       | *        |
| 161 | Sicilia| Catania  | **Vizzini**          |                       | *37 09 60       | *        |
| 162 | Sicilia| Siracusa |**Noto**              |                       | *36 55 32       | *        |
| 163 | Sicilia| Caltanissetta|**Caltanissetta**   |                       | *37 23 04       | *        |
| 164 | Sicilia| Agrigento|**Racalmuto**        |                       | *37 19 24       | *        |
| 165 | Sicilia| Agrigento|**Canicatti**        |                       | *37 20 07       | *        |
| 166 | Sicilia| Agrigento|**Ravanusa**         |                       | *37 16 52       | *        |
| 167 | Sicilia| Agrigento|**Campobello di Licata** |                 | *37 15 31       | *        |
| 168 | Sicilia| Agrigento|**Palma di Montechiaro** |             | *37 12 49       | *        |
| 169 | Sardegna| Carbonia-Iglesias|**Iglesias**         |                       | *39 20 36       | *        |

** = the main municipality nearest to the point location (not necessarily coinciding with the real seep location Municipality).  
* = approximate value obtained by means of original map georeferencing.
| order No. | Region      | Province      | Municipality          | Place name        | φ WGS 84 | λ WGS 84 | Note                  | Reference     |
|----------|-------------|---------------|-----------------------|-------------------|---------|---------|------------------------|---------------|
| 1        | Piemonte    | Alessandria  | **Cuccaro Monferrato |                   | *45 00 28 | *08 27 07 |                        | Martinis 1969, fig 8 |
| 2        | Piemonte    | Cuneo         | **S. Vittoria d'Alba  |                   | *44 43 27 | *07 55 23 |                        | Martinis 1969, fig 8 |
| 3        | Lombardia   | Pavia         | **Zavattarello        |                   | *44 53 16 | *09 16 47 |                        | Martinis 1969, fig 8 |
| 4        | Trentino-A. | Trento        | Talo                  | Mollaro           | 46 19 06 | 11 11 02 |                        | Martinis 1969, fig 8 |
| 5        | Veneto      | Belluno       | **Forno di Zoldo      |                   | *46 21 44 | *12 13 25 |                        | Martinis 1969, fig 8 |
| 6        | Emilia Romagna | Piacenza  | **Coli                |                   | *44 44 37 | *09 25 25 |                        | Martinis 1969, fig 8 |
| 7        | Emilia Romagna | Piacenza  | **Morfasso            |                   | *44 43 21 | *09 40 04 |                        | Martinis 1969, fig 8 |
| 8        | Emilia Romagna | Piacenza  | ** Val d’Arda         |                   | *44 50 07 | *09 48 37 |                        | Martinis 1969, fig 8 |
| 9        | Emilia Romagna | Parma   | **Bore                |                   | *44 43 17 | *09 49 39 |                        | Martinis 1969, fig 8 |
| 10       | Emilia Romagna | Parma   | **Bardi               |                   | *44 37 41 | *09 46 12 |                        | Martinis 1969, fig 8 |
| 11       | Emilia Romagna | Reggio Emilia | **Castelnuovo Monti |                   | *44 28 01 | *10 28 44 |                        | Martinis 1969, fig 8 |
| 12       | Emilia Romagna | Modena  | **Maranello            |                   | *44 30 31 | *10 50 08 |                        | Martinis 1969, fig 8 |
| 13       | Emilia Romagna | Bologna  | **Pianoro              |                   | *44 22 46 | *11 18 54 |                        | Martinis 1969, fig 8 |
| 14       | Emilia Romagna | Bologna  | **S. Lazzaro di Savena (S. Ruffillo) |                   | *44 27 38 | *11 26 06 |                        | Martinis 1969, fig 8 |
| 15       | Emilia Romagna | Forlì-Cesena | **Forlì               |                   | *44 15 18 | *12 06 25 | (Not reliable)         | Martinis 1969, fig 8 |
| 16       | Toscana      | Arezzo       | **Pieve S. Stefano    |                   | *43 40 18 | *12 11 15 |                        | Martinis 1969, fig 8 |
| 17       | Toscana      | Siena        | **Pienza              |                   | *43 06 58 | *11 38 14 |                        | Martinis 1969, fig 8 |
| 18       | Marche       | Macerata     | **Sarnano             |                   | *43 00 10 | *13 11 36 |                        | Martinis 1969, fig 8 |
| 19       | Marche       | Macerata     | **Porto S. Elpidio    | Fontespina         | *43 17 33 | *13 49 39 | 1.7km Offshore          | Martinis 1969, fig 8 |
Table 2. List of natural oil occurrence in Italy.

** = the main municipality nearest to the point location (not necessarily coinciding with the real seep location Municipality).
* = approximate value obtained by means of original map georeferencing.

| Order No. | Region | Province | Municipality | Place name | φ WGS 84 | λ WGS 84 |
|-----------|--------|----------|--------------|------------|----------|----------|
| 20        | Lazio  | Frosinone| **Monte S. Giovanni Campano** | *41.3728 | *13.9946 |
| 21        | Lazio  | Frosinone| **Ceccano** | *41.3332 | *13.9946 |
| 22        | Lazio  | Frosinone| **Amaseno** | *41.2722 | *13.9946 |
| 23        | Lazio  | Frosinone| **Arce** | *41.3159 | *13.9946 |
| 24        | Abruzzo | Pescara | **Torre dei Passeri** | *42.1513 | *13.9946 |
| 25        | Abruzzo | Pescara | **Caramanico Terme** | *42.1052 | *14.9946 |
| 26        | Abruzzo | L’Aquila | **Sulmona** | *42.0107 | *13.9946 |
| 27        | Abruzzo | Chieti  | **Scerni** | *42.0520 | *14.9946 |
| 28        | Campania | Avellino | **Guardia Lombardi** | *41.0030 | *15.9946 |
| 29        | Basilicata | Potenza | **Baragiano** | *40.4048 | *15.9946 |
| 30        | Basilicata | Potenza | **Marsico Nuovo** | *40.2645 | *15.9946 |
| 31        | Basilicata | Potenza | **S. Chirico Raparo** | *40.1200 | *16.9946 |
| 32        | Basilicata | Potenza | **Sant’Arcangelo** | *40.1358 | *16.9946 |
| 33        | Basilicata | Cosenza | **Alessandria del Carretto** | *40.0001 | *16.9946 |
| 34        | Calabria | Cosenza | **Campana** | *39.2426 | *16.9946 |
| 35        | Calabria | Crotone | **Belvedere di Spinello** | *39.1459 | *16.9946 |
| 36        | Sicilia | Enna  | **Cerami** | *37.5056 | *14.9946 |
| 37        | Sicilia | Catania | **Bronte** | *37.4804 | *14.9946 |
| 38        | Sicilia | Palermo | **Petreria Sottana** | *37.4428 | *14.9946 |
| 39        | Sicilia | Caltanissetta | **Villalba** | *37.3953 | *13.9946 |
| 40        | Sicilia | Caltanissetta | **Serradifalco** | *37.2535 | *13.9946 |
| 41        | Sicilia | Catania | **Paternò** | *37.2912 | *14.9946 |
| 42        | Sicilia | Catania | **Vizzini** | *37.0803 | *14.9946 |
| 43        | Sicilia | Ragusa | **Ragusa** | *37.0043 | *14.9946 |
| 44        | Sicilia | Ragusa | **Modica** | *36.5510 | *14.9946 |
| 45        | Sicilia | Ragusa | **Ispica** | *36.4606 | *14.9946 |
| No. | Region          | Province | Municipality           | Place name | φ WGS 84 | λ WGS 84 | Reference              |
|-----|-----------------|----------|------------------------|------------|----------|----------|------------------------|
| 1   | Piemonte        | Cuneo    | La Morra               |            | 44 38 23 | 07 56 01 | Martinis 1969, fig 8  |
| 2   | Piemonte        | Cuneo    | Bene Vagienna          |            | 44 32 44 | 07 49 59 | Martinis 1969, fig 8  |
| 3   | Trentino-A.A.   | Trento   | **Molina di Ledro      |            | *45 50 44 | *10 43 33 | Martinis 1969, fig 8  |
| 4   | Lombardia       | Brescia  | **Bedizzole            |            | *45 32 03 | *10 27 05 | Martinis 1969, fig 8  |
| 5   | Lombardia       | Brescia  | **Brescia              |            | *45 33 04 | *10 13 39 | Martinis 1969, fig 8  |
| 6   | Trentino-A.A.   | Trento   | **Pozza di Fassa       |            | *46 26 02 | *11 44 55 | Martinis 1969, fig 8  |
| 7   | Trentino-A.A.   | Rovereto | **Pamarolo             |            | *45 56 27 | *11 00 58 | Martinis 1969, fig 8  |
| 8   | Trentino-A.A.   | Trento   | Taio                   | Mollaro    | 46 17 39 | 11 04 18 | Martinis 1969, fig 8  |
| 9   | Trentino-A.A.   | Trento   | **Pinzolo              |            | *46 08 50 | *10 50 34 | Martinis 1969, fig 8  |
| 10  | Veneto          | Belluno  | **Lozzo di Cadore      |            | *46 29 47 | *12 21 49 | Martinis 1969, fig 8  |
| 11  | Veneto          | Belluno  | **Valle Agordina       |            | *46 18 10 | *12 07 28 | Martinis 1969, fig 8  |
| 12  | Trentino-A.A.   | Trento   | **Fiera di Primiero    |            | *46 13 51 | *11 51 44 | Martinis 1969, fig 8  |
| 13  | Veneto          | Treviso  | **Crespano del Grappa  |            | *45 53 19 | *11 48 13 | Martinis 1969, fig 8  |
| 14  | Friuli V.G.     | Udine    | **Moggio Udinese       |            | *46 27 26 | *13 07 03 | Martinis 1969, fig 8  |
| 15  | Friuli V.G.     | Udine    | **Socchieve            |            | *46 26 27 | *12 45 50 | Martinis 1969, fig 8  |
| 16  | Friuli V.G.     | Pordenone| **Clauzetto            |            | *46 18 50 | *12 55 14 | Martinis 1969, fig 8  |
| 17  | Friuli V.G.     | Udine    | **Reana del Roiale     |            | *46 06 52 | *13 17 15 | Martinis 1969, fig 8  |
| 18  | Friuli V.G.     | Udine    | Resiutta               |            | 46 23 33 | 13 13 07 | Martinis 1969, fig 8  |
| 19  | Friuli V.G.     | Udine    | **Tarcento             |            | *46 12 53 | *13 12 46 | Martinis 1969, fig 8  |
| 20  | Emilia-Romagna  | Bologna  | Savigno                | M. Falò    | 44 23 27 | 11 04 29 | Bombicci 1881         |
| 21  | Toscana         | Siena    | **Colle Val d'Elsa     |            | *43 22 52 | *11 03 48 | Martinis 1969, fig 8  |
| 22  | Marche          | Pesaro-Urbino | **Auditoire     |            | *43 48 45 | *12 33 19 | Martinis 1969, fig 8  |
| 23  | Marche          | Pesaro-Urbino | **Fermignano     |            | *43 39 55 | *12 40 41 | Martinis 1969, fig 8  |
| 24  | Marche          | Ancona   | **Genga                |            | *43 26 03 | *12 57 21 | Martinis 1969, fig 8  |
| 25  | Marche          | Ancona   | **Fabriano             |            | *43 17 60 | *12 52 40 | Martinis 1969, fig 8  |
| 26  | Marche          | Macerata | **Piorac               |            | *43 12 33 | *12 59 27 | Martinis 1969, fig 8  |
| 27  | Abruzzo         | L'Aquila | **Avezzano             |            | *42 00 13 | *13 24 57 | Martinis 1969, fig 8  |
| 28  | Lazio           | Roma     | **Vallepietra          |            | *41 56 07 | *13 11 52 | Martinis 1969, fig 8  |
| 29  | Lazio           | Frosinone| **Guarino              |            | *41 51 35 | *13 19 37 | Martinis 1969, fig 8  |
| 30  | Abruzzo         | L'Aquila | **Civitella Roveto     |            | *41 56 14 | *13 27 31 | Martinis 1969, fig 8  |
| 31  | Lazio           | L'Aquila | **Villa Valle Roveto   |            | *41 49 35 | *13 34 37 | Martinis 1969, fig 8  |
| No. | Region | Province   | Municipality          | Place name          | φ WGS 84 | λ WGS 84  | Reference          |
|-----|--------|------------|-----------------------|---------------------|----------|----------|-------------------|
| 32  | Lazio  | Frosinone  | **Veroli**            |                     | 41 43.20 | 13 31.20 | Martinis 1969, fig 8 |
| 33  | Lazio  | Frosinone  | **Sora**              |                     | 41 44.05 | 13 39.26 | Martinis 1969, fig 8 |
| 34  | Lazio  | Frosinone  | **Rocca d’Arce**      |                     | 41 35.16 | 13 38.19 | Martinis 1969, fig 8 |
| 35  | Lazio  | Frosinone  | **Pastena**           |                     | 41 29.15 | 13 29.25 | Martinis 1969, fig 8 |
| 36  | Lazio  | Frosinone  | **Castrocielo**       |                     | 41 30.55 | 13 40.50 | Martinis 1969, fig 8 |
| 37  | Lazio  | Frosinone  | **Ponte corvo**       |                     | 41 24.15 | 13 39.25 | Martinis 1969, fig 8 |
| 38  | Lazio  | Rieti      | **Amatrice**          |                     | 42 38.01 | 13 14.15 | Martinis 1969, fig 8 |
| 39  | Abruzzo| L’Aquila   | **Scoppito**          |                     | 42 32.01 | 13 21.35 | Martinis 1969, fig 8 |
| 40  | Abruzzo| L’Aquila   | **S. Stefano di Sessanio** |             | 42 18.09 | 13 39.09 | Martinis 1969, fig 8 |
| 41  | Abruzzo| L’Aquila   | **Avezzano**          |                     | 42 10.33 | 13 23.17 | Martinis 1969, fig 8 |
| 42  | Abruzzo| L’Aquila   | **Celano**            |                     | 42 07.30 | 13 28.47 | Martinis 1969, fig 8 |
| 43  | Abruzzo| L’Aquila   | **Celano**            |                     | 42 04.06 | 13 34.14 | Martinis 1969, fig 8 |
| 44  | Abruzzo| L’Aquila   | **Riano**             |                     | 42 06.03 | 13 47.13 | Martinis 1969, fig 8 |
| 45  | Abruzzo| L’Aquila   | **Pratola Peligna**   |                     | 42 05.28 | 13 52.52 | Martinis 1969, fig 8 |
| 46  | Abruzzo| Pescara    | **Caramanico Terme**  |                     | 42 06.49 | 14 02.29 | Martinis 1969, fig 8 |
| 47  | Abruzzo| Chieti     | **Fara San Martino**  |                     | 42 04.32 | 14 06.05 | Martinis 1969, fig 8 |
| 48  | Marche | Ascoli Piceno | **Acquasanta Terme**  |                     | 42 43.48 | 13 26.19 | Martinis 1969, fig 8 |
| 49  | Abruzzo| Termamo    | **Isola del Gran Sasso** |                | 42 31.13 | 13 32.46 | Martinis 1969, fig 8 |
| 50  | Abruzzo| L’Aquila   | **Collelongo**        |                     | 41 52.27 | 13 33.41 | Martinis 1969, fig 8 |
| 51  | Molise | Isernia   | **S. Angelo del Pesco** |              | 41 52.13 | 14 15.15 | Martinis 1969, fig 8 |
| 52  | Molise | Isernia   | **Isernia**           |                     | 41 42.21 | 14 18.58 | Martinis 1969, fig 8 |
| 53  | Molise | Campobasso | **Boiano**            |                     | 41 33.03 | 14 28.34 | Martinis 1969, fig 8 |
| 54  | Campania| Avellino | **Savignaro Irpin**  |                     | 41 12.49 | 15 13.54 | Martinis 1969, fig 8 |
| 55  | Campania| Avellino | **Cardito**           |                     | 41 08.41 | 15 00.59 | Martinis 1969, fig 8 |
| 56  | Puglia | Foggia    | **Anzano di Puglia**  |                     | 41 07.10 | 15 17.53 | Martinis 1969, fig 8 |
| 57  | Campania| Avellino | **Caposele**          |                     | 40 48.31 | 15 16.38 | Martinis 1969, fig 8 |
| 58  | Campania| Salerno  | **Acerno**            |                     | 40 44.58 | 15 03.12 | Martinis 1969, fig 8 |
| 59  | Campania| Salerno  | **Colliano**          |                     | 40 42.48 | 15 16.58 | Martinis 1969, fig 8 |
| 60  | Campania| Salerno  | **Castelcivita**      |                     | 40 27.55 | 15 14.27 | Martinis 1969, fig 8 |
| 61  | Campania| Salerno  | **Bellosguardo**      |                     | 40 24.38 | 15 19.08 | Martinis 1969, fig 8 |
### Table 3. List of solid hydrocarbon occurrence in Italy.

| No. | Region | Province | Municipality             | Place name | φ WGS 84 | λ WGS 84 | Reference            |
|-----|--------|----------|--------------------------|------------|----------|----------|----------------------|
| 62  | Campania | Salerno | **Sacco**                |            | *40 21 20 | *15 26 38 | Martinis 1969, fig 8 |
| 63  | Campania | Salerno | **Trentinara**           |            | *40 22 19 | *15 06 18 | Martinis 1969, fig 8 |
| 64  | Campania | Salerno | **Stio**                 |            | *40 18 14 | *15 14 36 | Martinis 1969, fig 8 |
| 65  | Campania | Salerno | **Vallo della Lucania**  |            | *40 15 25 | *15 21 57 | Martinis 1969, fig 8 |
| 66  | Campania | Salerno | **Castiglione dei Genovesi** |    | *40 43 38 | *14 51 44 | Martinis 1969, fig 8 |
| 67  | Campania | Salerno | **Sanza**                |            | *40 11 44 | *15 37 21 | Martinis 1969, fig 8 |
| 68  | Basilicata | Potenza | **Maratea**              |            | *40 03 11 | *15 39 09 | Martinis 1969, fig 8 |
| 69  | Basilicata | Potenza | **Castelsaraceno**      |            | *40 10 34 | *15 57 11 | Martinis 1969, fig 8 |
| 70  | Basilicata | Matera | **Rotondella**          |            | *40 08 23 | *16 28 56 | Martinis 1969, fig 8 |
| 71  | Sicilia | Messina | **Tripi**                |            | *38 01 24 | *15 04 40 | Martinis 1969, fig 8 |
| 72  | Sicilia | Messina | **Montalbano Elicona**   | *37 59 16  | *14 57 30 | Martinis 1969, fig 8 |
| 73  | Sicilia | Catania | **Maletto**              | *37 49 40  | *14 53 35 | Martinis 1969, fig 8 |
| 74  | Sicilia | Palermo | **Petraila Sottana**     | *37 47 36  | *14 06 14 | Martinis 1969, fig 8 |
| 75  | Sicilia | Palermo | **Sclafani Bagni**      | *37 52 32  | *13 50 50 | Martinis 1969, fig 8 |
| 76  | Sicilia | Palermo | **Montemaggiore Belsito** |    | *37 51 45 | *13 43 48 | Martinis 1969, fig 8 |
| 77  | Sicilia | Palermo | **Vicari**               | *37 50 34  | *13 28 26 | Martinis 1969, fig 8 |
| 78  | Sicilia | Palermo | **Corleone**             | *37 51 25  | *13 20 10 | Martinis 1969, fig 8 |
| 79  | Sicilia | Palermo | **Camporeale**           | *37 54 14  | *13 01 12 | Martinis 1969, fig 8 |
| 80  | Sicilia | Trapani | **Alcamo**               | *37 55 49  | *12 56 20 | Martinis 1969, fig 8 |
| 81  | Sicilia | Palermo | **Palazzo Adriano**     | *37 42 33  | *13 23 14 | Martinis 1969, fig 8 |
| 82  | Sicilia | Agrigento | **Bivona**               | *37 35 24  | *13 33 21 | Martinis 1969, fig 8 |
| 83  | Sicilia | Catania | **Palagonia**            | *37 19 34  | *14 38 16 | Martinis 1969, fig 8 |
| 84  | Sicilia | Catania | **Licodia Eubea**       | *37 11 32  | *14 42 20 | Martinis 1969, fig 8 |
| 85  | Sicilia | Siracusa | **Sortino**             | *37 09 47  | *15 03 09 | Martinis 1969, fig 8 |
| 86  | Sicilia | Ragusa | **Giarratana**           | *37 00 32  | *14 48 24 | Martinis 1969, fig 8 |
| 87  | Sicilia | Ragusa | **Ragusa**              | *36 54 56  | *14 46 25 | Martinis 1969, fig 8 |
| 88  | Sicilia | Ragusa | **Scicli**               | *36 48 54  | *14 42 12 | Martinis 1969, fig 8 |
| 89  | Sicilia | Ragusa | **Modica**              | *36 48 47  | *14 48 24 | Martinis 1969, fig 8 |
| 90  | Sicilia | Siracusa | **Pachino**             | *36 42 28  | *15 04 05 | Martinis 1969, fig 8 |
| 91  | Lombardia | Varese | Besano                   | Besano     | 45 53 23  | 08 53 24 | Martinis 1969, fig 8 |
| No | Region          | Province     | Municipality        | Place name                                      | φ WGS 84 | λ WGS 84 | Note                  | Reference |
|----|----------------|--------------|---------------------|------------------------------------------------|----------|----------|-----------------------|-----------|
| 1  | Emilia Romagna | Bologna      | Casalfiumanese      | Casa Bubano                                     | 44.1505  | 11.2835  |                       | Martinelli, Judd 2004, Table 1 |
| 2  | Emilia Romagna | Bologna      | Casalfiumanese      | Casa Campagnola                                 | 44.2032  | 11.3520  |                       | Martinelli, Judd 2004, Table 1 |
| 3  | Emilia Romagna | Bologna      | Casalfiumanese      | Case Nuove di Riffano                           | 44.1923  | 11.3420  |                       | Martinelli, Judd 2004, Table 1 |
| 4  | Emilia Romagna | Bologna      | Castel S. Pietro Terme | San Martino in Pedriolo                        | 44.2113  | 11.3422  |                       | Martinelli, Judd 2004, Table 1 |
| 5  | Emilia Romagna | Bologna      | Imola               | Bergullo                                        | 44.1832  | 11.4414  |                       | Martinelli, Judd 2004, Table 1 |
| 6  | Emilia Romagna | Bologna      | Imola               | Campo di Fondo                                  | 44.2112  | 11.4250  |                       | Martinelli, Judd 2004, Table 1 |
| 7  | Emilia Romagna | Bologna      | Monterenzio         | Mercatale Dragone Ardito Desio                 | 44.2301  | 11.2618  |                       | Cantelli 1994 |
| 8  | Emilia Romagna | Bologna      | Monterenzio         | San Clemente Dragone, or Sassuno                | 44.2009  | 11.2718  |                       | Martinelli, Judd 2004, Table 1 |
| 9  | Emilia Romagna | Bologna      | Ozzano Emilia       | Montebugnolo                                    | 44.2638  | 11.2825  |                       | Martinelli, Judd 2004, Table 1 |
| 10 | Emilia Romagna | Modena       | Fiorano Modenese    | Salsa (di Monte Ave) di Fiorano                 | 44.3146  | 10.4833  |                       | Camerana, Galdi 1911 |
| 11 | Emilia Romagna | Modena       | Fiorano Modenese    | Nirano                                          | 44.3048  | 10.4925  |                       | Martinelli, Judd 2004, Table 1 |
| 12 | Emilia Romagna | Modena       | Maranello           | Puianello                                       | 44.2836  | 10.5200  |                       | Martinelli, Judd 2004, Table 1 |
| 13 | Emilia Romagna | Modena       | Marano sul Panaro   | Ospitaletto                                     | 44.2611  | 10.5254  |                       | Martinelli, Judd 2004, Table 1 |
| 14 | Emilia Romagna | Modena       | Polinago            | Canalina                                        | 44.2449  | 10.4342  |                       | Martinelli, Judd 2004, Table 1 |
| 15 | Emilia Romagna | Modena       | Sassuolo            | La Rovina di Montegibbio (S. del Rio dei Bagni 1) | 44.3045  | 10.4719  |                       | Camerana, Galdi 1911 |
| 16 | Emilia Romagna | Modena       | Sassuolo            | La Rovina di Montegibbio (S. del Rio dei Bagni 2) | 44.3041  | 10.4748  |                       | Camerana, Galdi 1911 |
| 17 | Emilia Romagna | Modena       | Sassuolo            | La Rovina di Montegibbio (S. "dei Cinghiali")  | 44.3058  | 10.4759  |                       | // |
| No | Region      | Province | Municipality | Place name                                      | $\phi$ WGS 84 | $\lambda$ WGS 84 | Note                          | Reference               |
|----|-------------|----------|--------------|-------------------------------------------------|--------------|----------------|-------------------------------|-------------------------|
| 18 | Emilia Romagna | Modena   | Sassuolo     | La Rovina di Montegibbio (archaeological excavation) | 44 30 47     | 10 47 08       |                                | Borgatti et al. 2010     |
| 19 | Emilia Romagna | Modena   | Sassuolo     | Montegibbio (S. di sotto)                        | 44 30 55     | 10 46 39       |                                | Martinelli, Judd 2004, Table 1 |
| 20 | Emilia Romagna | Modena   | Sassuolo     | Montegibbio (Salsa storica o grande)             | 44 31 07     | 10 46 45       |                                | Camerana et al., 1926    |
| 21 | Emilia Romagna | Modena   | Sassuolo     | Montegibbio (S. di sopra)                        | 44 31 15     | 10 46 43       |                                | Camerana et al., 1926    |
| 22 | Emilia Romagna | Modena   | Serra Mazzoni | Centora-Montardone                              | 44 28 07     | 10 47 42       |                                | Martinelli, Judd 2004, Table 1 |
| 23 | Emilia Romagna | Parma    | Lesignano Bagni | Rivalta                                          | 44 37 45     | 10 19 34       |                                | Martinelli, Judd 2004, Table 1 |
| 24 | Emilia Romagna | Parma    | Traversetolo  | Torre                                            | 44 37 13     | 10 20 19       |                                | Martinelli, Judd 2004, Table 1 |
| 25 | Emilia Romagna | Reggio Emilia | Viano      | Casola - Querciola                              | 44 45 44     | 10 31 38       |                                | Martinelli, Judd 2004, Table 1 |
| 26 | Emilia Romagna | Reggio Emilia | Viano      | Regnano                                         | 44 33 27     | 10 34 34       |                                | Martinelli, Judd 2004, Table 1 |
| 27 | Marche       | Ancona   | Ancona       | Serra de Conti                                  | 43 32 33     | 13 02 12       |                                | Martinelli, Judd 2004, Table 1 |
| 28 | Marche       | Ancona   | Ancona       | Aspio di Ancona                                 | 43 32 00     | 13 30 04       |                                | Martinelli, Judd 2004, Table 1 |
| 29 | Marche       | Ancona   | Maiolati Spontini | Moie                             | 43 30 10     | 13 07 48       |                                | Martinelli, Judd 2004, Table 1 |
| 30 | Marche       | Ancona   | Maiolati Spontini | Contrada Calapigna                       | 43 28 34     | 13 07 13       |                                | Martinelli, Judd 2004, Table 1 |
| 31 | Marche       | Ancona   | Monte Roberto | Monte Roberto                                  | 43 28 50     | 13 08 18       |                                | Martinelli, Judd 2004, Table 1 |
| 32 | Marche       | Ancona   | Osimo        | Santo Stefano                                  | 43 30 30     | 13 27 40       |                                | Martinelli, Judd 2004, Table 1 |
| 33 | Marche       | Ancona   | San Paolo di Jesi | Battinebbia                          | 43 27 27     | 13 10 03       |                                | Martinelli, Judd 2004, Table 1 |
| 34 | Marche       | Ancona   | San Paolo di Jesi | Bagno                                      | 43 27 14     | 13 10 26       |                                | Martinelli, Judd 2004, Table 1 |
| No | Region  | Province    | Municipality | Place name          | φ  WGS 84 | λ  WGS 84 | Note                  | Reference                        |
|----|---------|-------------|--------------|---------------------|-----------|-----------|-----------------------|----------------------------------|
| 35 | Marche  | Ascoli Piceno | Fermo       | Capodarco           | 43 11 19  | 13 45 41 |                       | Martinelli, Judd 2004, Table 1   |
| 36 | Marche  | Ascoli Piceno | Monte Rinaldo | Contra Ba Croce     | 43 01 39  | 13 34 47 |                       | Martinelli, Judd 2004, Table 1   |
| 37 | Marche  | Ascoli Piceno | Offida       | Offida              | 42 56 06  | 13 41 26 |                       | Martinelli, Judd 2004, Table 1   |
| 38 | Marche  | Ascoli Piceno | Rotella      | Madonna di Montemisio | 42 57 14  | 13 33 38 |                       | Martinelli, Judd 2004, Table 1   |
| 39 | Marche  | Ascoli Piceno | Rotella      | Contrada Osteria    | 42 56 47  | 13 32 33 |                       | Martinelli, Judd 2004, Table 1   |
| 40 | Marche  | Ascoli Piceno | Senigallia   | Vallone             | 43 08 18  | 13 43 22 |                       | Martinelli, Judd 2004, Table 1   |
| 41 | Marche  | Macerata     | Macerata     | Mogliano            | 43 11 07  | 13 28 45 |                       | Martinelli, Judd 2004, Table 1   |
| 42 | Marche  | Pesaro-Urbino | Isola del Piano | Isola del Piano     | 43 44 11  | 12 46 57 |                       | Martinelli, Judd 2004, Table 1   |
| 43 | Marche  | Pesaro-Urbino | Petriano     | Petriano            | 43 46 47  | 12 44 02 |                       | Martinelli, Judd 2004, Table 1   |
| 44 | Marche  | Pesaro-Urbino | Saltara      | Saltara             | 43 45 12  | 12 53 50 |                       | Martinelli, Judd 2004, Table 1   |
| 45 | Abruzzo | Chieti       | Frisa        | Frisa               | 42 15 42  | 14 22 03 |                       | Martinelli, Judd 2004, Table 1   |
| 46 | Abruzzo | Chieti       | Poggiofiorito | Poggiofiorito       | 42 15 19  | 14 19 24 |                       | Martinelli, Judd 2004, Table 1   |
| 47 | Abruzzo | Pescara      | Penne        | Picciano            | 42 28 26  | 13 59 27 |                       | Martinelli, Judd 2004, Table 1   |
| 48 | Abruzzo | Teramo       | Bisenti      | Chievano            | 42 32 07  | 13 40 16 |                       | Martinelli, Judd 2004, Table 1   |
| 49 | Abruzzo | Teramo       | Cellino Attanasio | Astelina          | 42 35 08  | 13 51 34 |                       | Martinelli, Judd 2004, Table 1   |
| 50 | Abruzzo | Teramo       | Cellino Attanasio | Pian Palazzo      | 42 35 08  | 13 51 34 |                       | Martinelli, Judd 2004, Table 1   |
| 51 | Abruzzo | Teramo       | Pineto       | Pineto              | 42 36 29  | 14 04 02 |                       | Martinelli, Judd 2004, Table 1   |
| No | Region     | Province | Municipality            | Place name   | \(\varphi\) WGS 84 | \(\lambda\) WGS 84 | Note                  | Reference            |
|----|------------|----------|-------------------------|--------------|---------------------|-------------------|-----------------------|----------------------|
| 52 | Abruzzo    | Teramo   | Torano Nuovo            | Frola        | 42.39 31            | 13.42 14          | Martinelli, Judd 2004, Table 1 |
| 53 | Campania   | Benevento| Castelfrancisco in Misciano | Malvizza   | 41.17 49            | 15.05 06          | Martinelli, Judd 2004, Table 1 |
| 54 | Basilicata | Potenza  | Cancellara              | Contrada Bòfete | 40.43 51       | 15.55 23          | Martinelli, Judd 2004, Table 1 |
| 55 | Calabria   | Cosenza  | San Vincenzo la Costa   | San Sisti    | 39.21 50            | 16.09 04          | Martinelli, Judd 2004, Table 1 |
| 56 | Calabria   | Reggio Calabria | Palizzi       | Rocchette    | 37.55 09            | 15.59 11          | Martinelli, Judd 2004, Table 1 |
| 57 | Sicilia    | Agrigento| Aragona                 | Zorba        | 37.23 32            | 13.37 26          | Martinelli, Judd 2004, Table 1 |
| 58 | Sicilia    | Agrigento| Cammarata              | Cammarata    | 37.37 57            | 13.38 13          | Martinelli, Judd 2004, Table 1 |
| 59 | Sicilia    | Agrigento| Casteltermini           | Casteltermini | 37.32 24        | 13.38 42          | Martinelli, Judd 2004, Table 1 |
| 60 | Sicilia    | Agrigento| Cattolica Eraclea       | Bissana      | 37.26 20            | 13.23 42          | Martinelli, Judd 2004, Table 1 |
| 61 | Sicilia    | Caltanissetta | Caltanissetta  | Xirbi        | 37.29 25            | 14.03 24          | Martinelli, Judd 2004, Table 1 |
| 62 | Sicilia    | Catania  | Paternò                 | Simeto       | 37.33 57            | 14.54 06          | Martinelli, Judd 2004, Table 1 |
| 63 | Sicilia    | Catania  | Paternò                 | Stadio       | 37.33 50            | 14.54 11          | Martinelli, Judd 2004, Table 1 |
| 64 | Sicilia    | Catania  | Paternò                 | Vallone Salato | 37.33 47      | 14.54 15          | Martinelli, Judd 2004, Table 1 |
| 65 | Sicilia    | Enna     | Aidone                  | Aidone       | 37.24 52            | 14.26 47          | Martinelli, Judd 2004, Table 1 |
| 66 | Sicilia    | Enna     | Valguarnera Caropepe    | Valguarnera Caropepe | 37.29 42  | 14.23 20          | Martinelli, Judd 2004, Table 1 |
| 67 | Sicilia    | Enna     | Villarosa               | Villarosa    | 37.35 08            | 14.10 24          | Martinelli, Judd 2004, Table 1 |
| 68 | Sicilia    | Palermo  | Lercara Friddi          | Lercara Friddi | 37.44 51      | 13.36 12          | Martinelli, Judd 2004, Table 1 |
Table 4. List of mud volcanoes known in Italy.

| No | Region | Province | Municipality | Place name | φ WGS 84 | λ WGS 84 | Note                   | Reference                          |
|----|--------|----------|--------------|------------|----------|----------|------------------------|------------------------------------|
| 69 | Sicilia| Palermo | Palazzo Adriano | Palazzo Adriano | 37 40 52 | 13 22 44 |                        | Martinelli, Judd 2004, Table 1     |
| 70 | Puglia | Ionian Sea | Apulian plate | offshore | 39 31 05 | 18 33 02 | inferred location      | Fusi et al. 2006                   |
| 71 | Puglia | Ionian Sea | Apulian plate | offshore | 39 29 07 | 18 27 46 | inferred location      | Fusi et al. 2006                   |
| 72 | Puglia | Ionian Sea | Apulian plate | offshore | 39 22 05 | 18 18 05 | inferred location      | Fusi et al. 2006                   |
| 73 | Calabria| Ionian Sea | Calabrian Outer Arc | offshore | 38 49 25 | 17 23 20 |                        | Fusi et al. 2006                   |
| 74 | Calabria| Ionian Sea | Calabrian Outer Arc | offshore: Pythagoras | 37 48 20 | 17 16 20 |                        | Praeg et al. 2009                  |
| 75 | Calabria| Ionian Sea | Calabrian Outer Arc | offshore: Madonna dello Ionio | 38 12 00 | 16 56 00 |                        | Praeg et al. 2009                  |
| 76 | Sicilia | Canale di Sicilia | Malta Plateau | offshore | 36 36 25 | 14 37 37 | inferred location      | Holland et al. 2003                |
| 77 | Marche | Adriatic Sea |                      | offshore | 43 56 08 | 13 41 54 |                        | Camerlenghi, Pini 2009, Fig.4      |
| 78 | Marche | Adriatic Sea |                      | offshore (Bonaccia Field) | 43 28 51 | 14 22 06 |                        | Curzi et al. 1998, Fig.1           |
| 79 | Lombardia | Mantova | Poggio Rusco | Corte Vulcanello | 44 56 57 | 11 09 17 | Toponym                | Castellarin et al. 2006; Cremonini 2010 |
| 80 | Emilia Romagna | Modena | Finale Emilia | Bollitora (Reno Finalese) | 44 50 23 | 11 22 53 | Toponym                | Cremonini 2010; Cremonini et al. 2010 |
| 81 | Emilia Romagna | Modena | Sassuolo | Sarzola | 44 30 47 | 10 48 29 | Toponym                | //                                  |
| 82 | Piemonte | Torino | Verrua Savoia | Verrua Savoia | 45 09 42 | 08 07 16 | Miocene fossil m.v.    | Clari et al. 2004                   |
| No. | Table reference | Region    | Province | Municipality | Place name          | References                        |
|-----|-----------------|-----------|----------|--------------|---------------------|-----------------------------------|
| 1   | G15             | Emilia Romagna | Bologna   | Castel di Casio | Gaggiola           | Borgia et al. 1988, Tab. 1        |
| 2   | G16             | Emilia Romagna | Bologna   | Gaggio Montano | Gaggio Montano     | Duchi et al. 2005, Tab 5           |
| 3   | G15             | Emilia Romagna | Bologna   | Gaggio Montano | Molinazzo          | Borgia et al. 1988, Tab. 1         |
| 4   | G16             | Emilia Romagna | Bologna   | Grizzana M.   | Ca Bellavista      | Borgia et al. 1988, Tab. 1         |
| 5   | V 5             | Emilia Romagna | Bologna   | Imola         | Bergullo           | Etioppe et al. 2007, Tab.          |
| 6   | V 8             | Emilia Romagna | Bologna   | Monterenzio   | Drag. Sassuno = S. Clemente | Etioppe et al. 2007, Tab. |
| 7   | G 19            | Emilia Romagna | Bologna   | Porretta Terme | Ca Salgastri      | Borgia et al. 1988, Tab. 1         |
| 8   | G 19            | Emilia Romagna | Bologna   | Porretta      | Porretta           | Borgia et al. 1988, Tab. 1; *Minissale et al. 2000, Tab. 2, 3 |
| 9   | G 20            | Emilia Romagna | Bologna   | S. Benedetto V.Sambro | Castel dell’Alpi | Duchi et al. 2005, Tab 5; *Borgia et al. 1988, Tab. 1 |
| 10  | G 23            | Emilia Romagna | Ferrara   | V.Sambro      | Corporeno          | Etioppe et al. 2007, Tab.          |
| 11  | G 24            | Emilia Romagna | Ferrara   | Comacchio     | Valli Mezzano      | Cremonini et al. 2008, Tab. 1      |
| 12  | G 25            | Emilia Romagna | Forlì- Cesena | Bagno di Romagna | Terme di S. Agnese | Duchi et al. 2005, Tab 5           |
| 13  | G 27            | Emilia Romagna | Forlì- Cesena | Castrocaro    | Bolga well         | Capozzi and Picotti 2010, Tab. 3   |
| 14  | G 32            | Emilia Romagna | Forlì- Cesena | Tredozio      | Monte Busca        | Etioppe et al. 2007, Tab.          |
| 15  | G 34            | Emilia Romagna | Modena    | Fanano        | Trignano           | Borgia et al. 1988, Tab.1; *Minissale et al. 2000, Tab. 2, 3 |
| 16  | V 11            | Emilia Romagna | Modena    | Fiorano       | Modenese           | Etioppe et al. 2007, Tab.          |
| 17  | G 35            | Emilia Romagna | Modena    | Lama Mocogno  | Barigazzo          | Borgia et al. 1988, Tab. 1         |
| 18  | V 13            | Emilia Romagna | Modena    | Marano Panaro | Ospitaletto        | Etioppe et al. 2007, Tab.          |
| 19  | V 12            | Emilia Romagna | Modena    | Maranello     | Puianello          | Duchi et al. 2005, Tab 5           |
|   | Region | Province | Town | Town | Source | Notes |
|---|--------|----------|------|------|--------|-------|
|20 | G 36  | Emilia Romagna | Modena | Maranello | Govana | Duchi et al. 2005, Tab 5 |
|21 | G 39  | Emilia Romagna | Modena | Montese | Montese 19 | Borgia et al. 1988, Tab.1 |
|22 | V 19  | Emilia Romagna | Modena | Sassuolo | Montegibbio | Duchi et al. 2005, Tab 5 |
|23 | //    | Emilia Romagna | Modena | Serramazzoni | Selva | Borgia et al. 1988, Tab.1 |
|24 | G 45  | Emilia Romagna | Modena | Sestola | Ca Boldrini Roncoscaglia | Borgia et al. 1988, Tab.1 |
|25 | G 53  | Emilia Romagna | Parma | Fornovo Taro | Vallezza | Borgia et al. 1988, Tab.1 |
|26 | V 23  | Emilia Romagna | Parma | Lesignano Bagni | Rivalta | Etiope et al. 2007, Tab. |
|27 | G 51  | Emilia Romagna | Parma | Corniglio | Miano | Heinicke et al. 2010; *Duchi et al. 2005, Tab 5 |
|28 | G 57  | Emilia Romagna | Parma | Salsomaggiore | Salsomaggiore | Duchi et al. 2005, Tab 5; *Borgia et al. 1988, T. 1 |
|29 | V 24  | Emilia Romagna | Parma | Traversetolo | Torre | Etiope et al. 2007, Tab. |
|30 | //    | Emilia Romagna | Piacenza | Gropparello | Montechino | Etiope et al. 2007, Tab. |
|31 | V 25  | Emilia Romagna | Reggio Emilia | Viano | Casola-Querciola | Duchi et al. 2005, Tab 5 |
|32 | V 26  | Emilia Romagna | Reggio Emilia | Viano | Regnano | Etiope et al. 2007, Tab. |
|33 | //    | Emilia Romagna | Rimini | S. Agata Feltria | Caioletto | Duchi et al. 2005, Tab 5 |
|34 | G 79  | Toscana | Firenze | Firenzuola | Pietramala | Minissale et al. 2000, Tab 2, 3 |
|35 | //    | Toscana | Pistoia | Larciano | Larciano | Duchi et al. 2005, Tab 5 |
|36 | V 51  | Molise | Teramo | Pineto | Pineto | Etiope et al. 2007, Tab. |
|37 | V 53  | Campania | Benevento | Castelfranco Misciano | Malvizza | Etiope et al. 2007, Tab. |
|38 | G 129 | Basilicata | Potenza | Tramutola | Tramutola | Etiope et al. 2007, Tab. |
|39 | V 57  | Sicilia | Agrigento | Aragona | Maccalube | Etiope et al. 2007, Tab. |
|40 | G 147 | Sicilia | Agrigento | Bivona | Censo | Etiope et al. 2007, Tab. 1 |
|41 | V 60  | Sicilia | Agrigento | Cattolica Eraclea | Bissana | Etiope et al. 2002, Tab. 2 |
|42 | V 63  | Sicilia | Catania | Paternò | Salinelle di S. Biagio | Etiope et al. 2002, Tab. 2 |

* = data source.

Table 5A. Analytical data concerning natural gaseous hydrocarbon manifestations in Italy.
| No. | Place name | Lat ° ′′′ | Long ° ′′′ | CH4 % | CO2 % | N2 % | He% | Ar % | δ13C % PDB | δD % SMOW | Origin | Depth (m) |
|-----|------------|----------|----------|-------|-------|------|-----|------|-------------|-----------|--------|-----------|
| 1   | Gaggiola   | 44 10.47 | 10 59 46 | 95.74 | 0.96  | 0.81 | n.a.| n.a. | -36.7       | -141.8    | T      | w+s, 160  |
| 2   | Gaggio Montano | 44 11.53 | 10 56 01 | 99.35 | 0.29  | 0.2  | 0.02| 0.02 | n.a         | n.a       | s      |           |
| 3   | Molinazzo  | 44 12.34 | 11 01 23 | 98.11 | 0.73  | 0.45 | n.a.| n.a. | -32.7       | -129.6    | T      | w+s, 530  |
| 4   | Ca Bellavista | 44 15.28 | 11 09 08 | 98.06 | 1.6   | 0.13 | n.a.| n.a. | -29.1       | -142.8    | T      | w+s, 170  |
| 5   | Bergullo   | 44 18.32 | 11 44 14 | 98.61 | 0.27  | 0.89 | <0.001| 0.02 | -69.43      | -180.2    | B      | mv        |
| 6   | Drag. Sassuno S. Clem. | 44 20.09 | 11 27 18 | 88.85 | 2.9   | 4.15 | <0.001| 0.01 | -58.4       | -219      | M      | mv        |
| 7   | Cà Salgasti | 44 09.15 | 10 58 32 | 98.41 | 0.99  | 0.54 | n.a.| n.a. | -32         | -131      | T      | w+s, 130  |
| 8   | Porretta   | 44 09.04 | 11 58 01 | 99.62 | 0.35  | *0.35| *0.0021| *0.0039 | -31.3       | -138.1    | T      | w, <100   |
| 9   | Castel dell’Alpi | 44 12.56 | 11 14 04 | 94.54 | 4.57  | 0.78 | <0.001| 0.009 | *-37.4      | n.a       | s      |           |
| 10  | Corporesso | 44 45.22 | 11 18 08 | 66.52 | 5.1   | 26.53| <0.001| 0.51 | -65.98      | -174.1    | B      | s         |
| 11  | Valli Mezzano | 44 40.37 | 12 01 44 | 66.81 | 16.03 | 16.73| <0.0027| 0.41 | -76.14      | -223      | B      | s         |
| 12  | Terme di S. Agnese | 43 50.02 | 11 57 33 | 95.85 | 0.32  | 3.7  | 0.006| 0.03 | n.a         | n.a       | s      |           |
| 13  | Bolga well | 44 10.20 | 11 56 51 | 91.68 | 8.32  | n.a. | n.a.| n.a. | -75.5       | -171      | B      | w         |
| 14  | Monte Busca | 44 04.41 | 11 44 35 | 58.44 | 0.45  | 37.96| 0.163| 0.06 | -35.81      | -160.9    | T      | s         |
| 15  | Trignano   | 44 12.39 | 10 50 29 | 98.58 | 0.81  | 0.24 | *0.003| *0.0127 | -31.4       | -141.9    | T      | w+s, <100 |
| 16  | Nirano     | 44 30.48 | 10 49 25 | 98.26 | 0.58  | 0.97 | 0.02 | 0.01 | -45.65      | -185.5    | T      | mv        |
| 17  | Barigazzo  | 44 18.25 | 10 43 47 | 96.49 | 1.83  | 0.21 | n.a.| n.a. | -31.8       | -140.6    | T      | w+s, <100 |
| 18  | Osipalateto | 44 26.11 | 10 52 54 | 96.62 | 2.16  | 1.07 | 0.0026| 1.01 | -45.6       | -183.3    | T      | mv        |
| 19  | Puianello  | 44 28.36 | 10 52 00 | 95.91 | 2.35  | 0.67 | <0.001| 0.008 | n.a         | n.a       | n.a.  | mv        |
| 20  | Govana     | 44 31.31 | 10 51 59 | 89.26 | 0.03  | 10.14| <0.001| 0.11 | n.a         | n.a       | s      |           |
| 21  | Montese 19 | 44 16.06 | 10 56 27 | 97.44 | 0.1   | 0.13 | n.a.| n.a. | -33.2       | -140.3    | T      | w+s, 190  |
| 22  | Monteggibbio | 44 30.55 | 10 46 39 | 98.34 | 0.11  | 1.4  | n.a.| n.a. | 0.006       | n.a       | n.a.  | mv        |
| 23  | Selva      | 44 23.46 | 10 47 38 | 96.41 | 0.07  | 0.32 | n.a.| n.a. | -40.2       | -147.3    | T      | s         |
| 24  | Ca Boldrini Roncosagl | 44 13.50 | 10 46 14 | 93.41 | 1.51  | 0.01 | n.a.| n.a. | -38.8       | -140.6    | T      | w+s, <100 |
| 25  | Vallezza   | 44 41.29 | 10 05 49 | 88.52 | 0.17  | 0.5  | n.a.| n.a. | -40.6       | -150.7    | T      | w+s, 1500 |
| 26  | Rivalta    | 44 37.45 | 10 19 34 | 98.32 | 1.24  | 0.42 | 0.034| 0.01 | -41.38      | -180.6    | T      | mv        |
| 27  | Miano      | 44 29.37 | 10 06 05 | 98.62 | 0.44  | 0.91 | 0.0019| *0.051 | -39.38      | -168.4    | T      | w+s, 1040 |
| 28  | Salsomaggiore | 44 48.58 | 09 58 43 | 98.13 | 0.14  | 0.61 | 0.02 | n.a.| *-48.1      | *-184.2   | M      | s         |
| 29  | Torre      | 44 37.12 | 10 20 17 | 96.79 | 2.73  | 0.4  | 0.0013| 0.01 | -39.1       | n.a       | n.a.  | mv        |
| 30  | Montechino | 44 48.17 | 09 41 21 | 95.3  | 0.05  | 0.42 | 0.0017| 0.01 | -33.98      | -132.6    | T      | w+s, <100 |
Table 5B. Analytical data concerning natural gaseous hydrocarbon manifestations in Italy.

| No. | Place name          | Lat ° ' " | Long ° ' " | CH4 % | CO2 % | N2 % | He%  | Ar % | δ13C % PDB |
|-----|---------------------|-----------|------------|-------|-------|------|------|------|-----------|
| 31  | Casola-Querciola    | 44 45 44  | 10 31 38   | 92,16 | 0,71  | 5,79 | 0,003| 0,066| n.a.      |
| 32  | Regnano            | 44 33 25  | 10 34 34   | 96,78 | 2,12  | 0,92 | 0,0016| 0,01 | -45,7     |
| 33  | Caioletto          | 43 49 11  | 12 10 57   | 97,83 | 0,13  | 1,54 | n.a. | 0,018| n.a.      |
| 34  | Pietramala         | 44 07 14  | 11 22 49   | 93,49 | 0,87  | 0,22 | 0,002| 0,0021| -36,6     |
| 35  | Larciano           | 43 50 00  | 10 53 24   | 97,6  | 0,98  | 1,3  | n.a. | 0,08 | n.a.      |
| 36  | Pineto             | 42 36 52  | 14 03 41   | 94,13 | 0,36  | 5,4  | 0,0016| 0,11 | -73,1     |
| 37  | Malvizza           | 41 17 49  | 15 05 06   | 95,64 | 1,66  | 1,94 | 0,025| 0,03 | -59,0     |
| 38  | Tramutola          | 40 18 56  | 15 47 23   | 82,61 | 2,17  | 15,12| 0,0026| 0,01 | -42,1     |
| 39  | Maccalube          | 37 23 32  | 13 37 26   | 91,2  | 0,73  | 6,46 | 0,0071| n.a. | -48,0     |
| 40  | Censo              | 37 37 11  | 13 26 22   | 86    | 2,2   | 9,66 | 0,0367| n.a. | -35,5     |
| 41  | Bissana            | 37 26 20  | 13 23 42   | 96,2  | 2,9   | 0,83 | 0,0501| n.a. | n.a.      |
| 42  | Salinelle di S. Biagio | 37 33 50  | 14 54 11   | 35,1  | 64,6  | 0,78 | 0,0151| n.a. | n.a.      |

Table reference: G = data from Table 1 (gas), V = data from Table 4 (mud volcano). ° ' " = sexag degrees. % = by volume. Origin: B = biogenic, M= mixed; T= thermogenic. Depth (m): s = gas seep, mv = mud volcano, w = well. n.a. = not available.
Fig. 3A. Map of natural gas seepages in Italy. Coordinates and related references are given in Table 1.
Fig. 3B. Map of natural oil occurrence in Italy. Coordinates and related references are given in Table 2.
Fig. 3C. Map of natural solid hydrocarbon occurrence in Italy. Coordinates and related references are given in Table 3.
Fig. 3D. Map of mud volcanoes in Italy. Coordinates and related references are given in Table 4.
Fig. 4. Relationships existing between Hydrocarbon occurrences and main structural setting of Italy. The structural frame was simplified and redrawn after (CNR 1990; Fantoni and Franciosi 2010, fig. 5).
Fig. 5. Location map of gas seepage points in Italy for which analytical data are available in Table 5.
Fig. 6. Simplified Schoell’s diagram evidencing biogenic, mixed and thermogenic characters of natural gaseous hydrocarbon seepages in Italy. The cluster of Italian hydrocarbon wells analytical data (gray area) is also shown (after Mattavelli and Novelli 1988).

8. Tectonic stress field in Italy and seepages

A stress field map (Montone et al. 2004) can be used (Fig. 7) for a better understanding of active tectonic processes, to understand the behavior of faults recognized by other methods (CNR 1990) and to infer the origin of surficial manifestations of hydrocarbons (Figs. 3 and 8). The map shows that an extensional regime affects most of the Apenninic belt. Conversely, a compressional (or transpressional) regime characterizes the eastern Alps, the eastern side of the northern Apennines, and the South Tyrrenian to Northern Sicilian zone. An abrupt change in stress directions marks the transition between northern and southern Apennines, suggesting that the two arcs are characterized by a different tectonic setting and recent evolution. Present stress field probably have not changed significantly in last 10 kyr; thus hydrocarbon seepages are due to rock fracturing, overpressure phenomena and tectonic pumping processes constantly generated in the upper crustal layers. In particular, the intense tectonization of the orogen (Montone et al., 2004; Picotti and Pazzaglia 2008) can
Fig. 7. Stress field data in Italy (after Montone et al. 2004, redrawn) and crustal carbon dioxide degassing areas (Frezzotti et al. 2009).
be responsible for the high number of hydrocarbon seepages of whole Apennines (Martinelli and Judd 2004; Capozzi and Picotti 2010). The distensive behavior of central Italy is probably responsible for the high heat flow values recorded in the Tuscany and Latium areas unfavourable to hydrocarbon accumulations. The western part of the Italian peninsula is characterized by intense CO₂ degassing activity (Minissale et al 2004). Carbon dioxide is chiefly originated by mantle degassing, and by crustal thermometamorphic reactions (e.g.
Advances in Natural Gas Technology

Chiodini et al. 2004; Frezzotti et al. 2010). Conversely carbon dioxide degassing is lacking in the outer (eastern) flexural domain of the Apennine chain due to higher crustal thickness and to the relatively low geothermal gradient (Buttinelli et al. 2011 and therein references).

9. Conclusions

The mapping of most important gas emissions (Fig.8) shows that the hydrocarbon domain is chiefly located in the core of the raised Apennine belt immediately behind the chain front at the boundary of and its related Plio-Quaternary foredeep, whereas CO$_2$ emissions are located in the Apennine backdeep area. The geographic distribution of important gas accumulations in Italy does not show a highly significant correlation between surface seepages and the exploited reservoirs and it could also suggest the existence of other still unknown deep reservoirs (Pieri 2001) or their small remnants difficult to be checked up. The majority of the hydrocarbon wells is characterized by biogenic gases, while thermogenic methane is predominant in surface seeping, confirming the sealed condition of most of the biogenic reservoirs and that they still have not experienced the complete evolution of organic matter towards the thermogenic terms induced by pressure and temperature.

10. References

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Natural gas is a vital component of the world's supply of energy and an important source of many bulk chemicals and specialty chemicals. It is one of the cleanest, safest, and most useful of all energy sources, and helps to meet the world's rising demand for cleaner energy into the future. However, exploring, producing and bringing gas to the user or converting gas into desired chemicals is a systematical engineering project, and every step requires thorough understanding of gas and the surrounding environment. Any advances in the process link could make a step change in gas industry. There have been increasing efforts in gas industry in recent years. With state-of-the-art contributions by leading experts in the field, this book addressed the technology advances in natural gas industry.

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