Geobotany Studies
Basics, Methods and Case Studies

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The Vegetation of the Maltese Islands

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Contents

Chapter 1
Introduction

In this paper the results of a phytosociological investigations concerning the Maltese Archipelago, represented by some islands localized South of Sicily in the central Mediterranean, are provided. The vegetation of these islands is currently markedly altered by anthropic activities, because this territory was colonized since the Neolithic period (about 7000 years ago) by many peoples, who in the time have degraded its natural landscape. Despite this, these islands show still a relevant environmental interest, especially for the occurrence of a very interesting flora rich in endemisms and rare or relict species, that characterize many relevant plant communities, nowadays many of which are often reduced to small patches. The first our field research dates back to about 45 years ago, when mass tourism in these islands had not yet begun and continued until today. During this period, substantial changes in the landscape have been witnessed, with the increase in urban, industrial and tourist areas, as well as the modification of agricultural lands. From the biogeographical point of view, the Maltese Islands belonging to Holarctic Kingdom, Mediterranean Region, Western Mediterranean Subregion, Italo-Tyrrhenian Province, Sicilian Domain, Pelagian Sector, Maltese District (Brullo et al. 1995). As a whole, the territory has a total extension of 315.6 km^2, with 140 km coastline and is inhabited by a population with a density that exceeds 1500 people per km^2 on the larger island. Besides, most of its surface is used for agricultural activities (51%) or is urbanized (15%), while only 18% is currently covered by natural vegetation (Lanfranco et al. 2013). The topography of the islands is the result of geological, climatic, paleogeographic events that during the last 5–10 million years, since the archipelago emerged from the sea, have affected its surface (Fig. 1.1). The tectonic movements of the continental plates, as well as the repeated exposure of the Islands to erosion and meteoric infiltrations, have considerably altered the surface and the subsoil of these islands, with the formation of well-diversified environments, as incised river valleys, caves, plateaux, karstland, marshs, cliffs, budlands, rocky coasts, islets, dunes, temporary rocky pools, etc. (Figs. 1.2 and 1.3).

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Fig. 1.1 Maltese Islands map from Google Earth (modified)

The Maltese Islands are mainly constitute of sedimentary rocks of marine origin, represented by some types of limestones, marls and clays. The soils are usually very superficial and young, since its evolution is inhibited by the harsh environmental conditions. The climate is Mediterranean dry with two main seasons, a hot dry summer and a mild wet winter.

Unfortunately, as in many other coastal insular territories of the Mediterranean area, also in Malta the strong human pressure plays a fundamental role in the alteration of the original natural landscape. Over the course of time, this has led to the loss of habitats with the rarefaction, sometimes until disappearance, of several wild plant species. It is to keep in mind, that currently there are many species of relevant taxonomic and phytogeographical interest become so rare that, due to threats of various kinds, run serious dangers of extinction. Phytogeographical considerations on the Maltese flora, especially concerning the endemic component, are reported by Lanfranco (1989), Junikka et al. (2006) and Lanfranco et al. (2013), who emphasized that are the most relevant species of this territory and the role by them played.

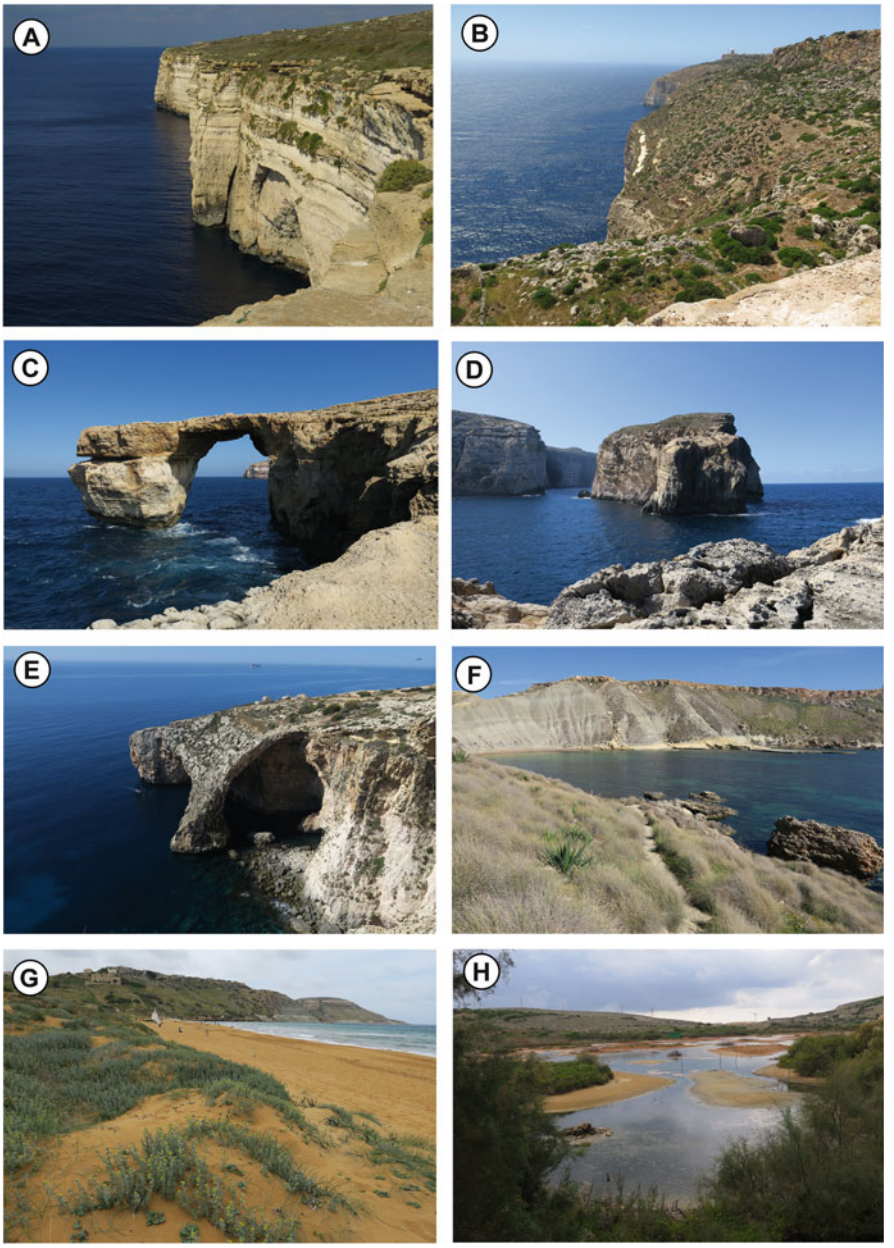

Fig. 1.2 Coastal habitats in the Maltese Islands: (**a**) Cliffs near Mtahleb, Malta, (**b**) Rocky coast near Dingli, Malta, (**c**) Azure Window at Dwejra Bay, Gozo, (**d**) Fungus Rock at Dwejra Bay, Gozo, (**e**) Blue Grotto, Malta, (**f**) Badlands of Gnejna Bay, Malta, (**g**) Dunes of Ramla Bay, Gozo, (**h**) Salt marsh of Ghadira, Malta

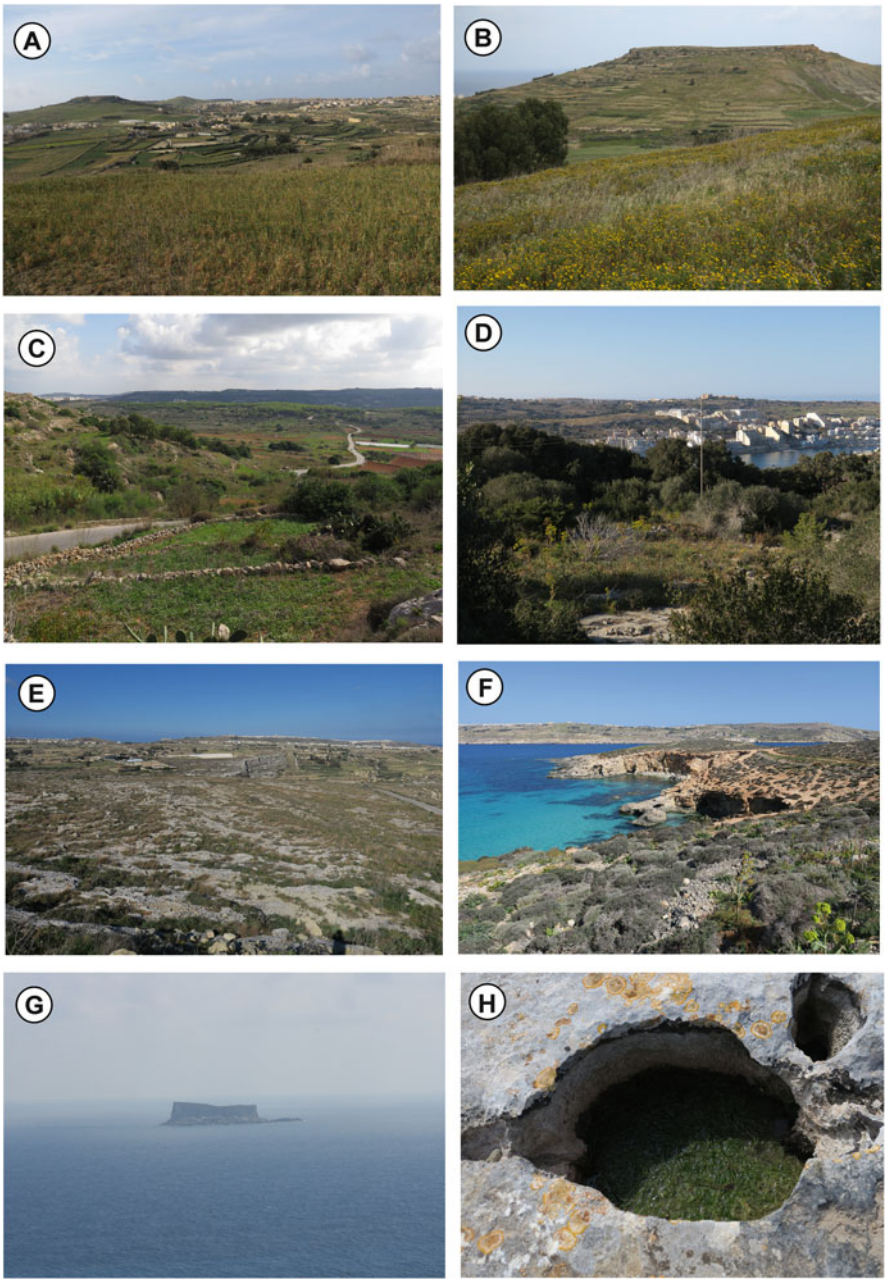

Fig. 1.3 Natural and synanthropic habitats in Malta: (**a**–**b**) Agricoltural landscape in Gozo, (**c**) Agricoltural landscape in Malta, (**d**) Oak woodland near Mellieha, Malta, (**e**) Karstland in Central Malta, (**f**) Rocky coast in Comino, (**g**) Filfla island, (**h**) Rocky pool in Malta

The authors in this book, apart from physiographic (geology, pedology, climate) and floristic information, examine all the plant communities surveyed during their phytosociological investigations on the Maltese Islands. For each association identified, the floristic, ecological, structural and dynamic characteristics, as well as a relevè table, are provided, further the nomenclatural and syntaxonomic aspects are taken into consideration too.

Chapter 2
Physiography

2.1 Geographical Characteristics and History of Malta

According to literature data (Haslam 1969; Schembri 1993) the Maltese Islands consist in a small archipelago aligned along an axis with NW-SE trend, situated in the Central Mediterranean about 96 km to the South of Sicily and about 284 km to Tunisia (Fig. 2.1). The main islands are Malta (245.7 km^2, coord. 35° 55′ 4″ N and 14° 24′ 35″ E), which is the largest and southern, Gozo (67.1 km^2, coord. 36° 2′ 39″ N and 14° 15′ 4″ E), which is the northernmost, and Comino (3.5 km^2, coord. 36° 00′ 45″ N and 14° 19′ 37″ E), which is located between these two islands. They are currently inhabited by about 445,000 people, most of which reside in Malta. Nearby these island there are numerous rocky islets, all uninhabited, among them the most extensive are Cominotto, Filfla, Islands of St. Paul, Fungus Rock, Gallis Roch, Delimara island, Xrobb I-Ghagin Rock, etc. Along the coast bays and inlets, often very deep, which are excellent harbors, are frequent some of which are characterized by sandy beaches. The eastern slopes of the islands are generally represented by low reefs and beaches, while the southern ones are mostly constituted by vertical cliffs, often exceeding 100 m from sea level. In the more depressed coastal stretches, separated from the sea by sandy or silty-clay deposits, are frequent salt marshes, periodically flooded by sea and meteoric waters. Along the low calcareous rocky shoreline often occur chequerboards of rock-cut saltpans, which are used by the local people for salt production as result of the seawater evaporation. It's believed that these saltpans existed since Roman times. The current landscape of the Maltese Islands is characterized by low hills, alternating with terraced plateaux, which are generally furrowed by more or less shallow valleys, locally called "Wied", which were formed prevalently by river erosion in periods characterized by very wet climatic regimes, as during the Pleistocene (Fig. 2.2). This is nothing but the result of tectonic movements and subsequent processes of surface erosion and karsism, which starts on the land immediately after its emersion from the sea. The islands do not reach high altitudes, the highest point in Malta is Ta′ Dmejrek near Dingli at

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Fig. 2.1 Geographical map of the Maltese Islands

253 m, while in Gozo the highest point is Ta′ Dbiegi, reaching 195 m. As concerns the rivers, there are only few small watercourses that flow on the bottom of some valleys mainly during the wet season, which are dry for the rest of the year. In fact, usually no permanent rivers and lakes occur in the Maltese Islands, except of few streams fed by small springs of fresh water, such as those ones at Ras ir-Raħeb near Baħrija and at l-Imtaħleb. Most of the Maltese territory is today under cultivation with crops localized especially in land characterized by terracing with walls that surround them, preventing the soil erosion. Usually, the terrace walls follow the contours of the slopes radiating from the hill top and probably their realization dates back to ancient times and was continued until the nineteenth century. The terrace farming and in general the cultivated areas are more widespread on the freshest and humid slopes of hills and valleys or on flat surfaces where is possible the irrigation. The surfaces constituted by barren rocks very washed out and eroded, however without soil, are covered by a scattered and wild vegetation, represented by small shrubs and grasses. Only in few undisturbed and rocky stands it is still possible to find patches of natural woody vegetation, as maquis, garigues and shrublands.

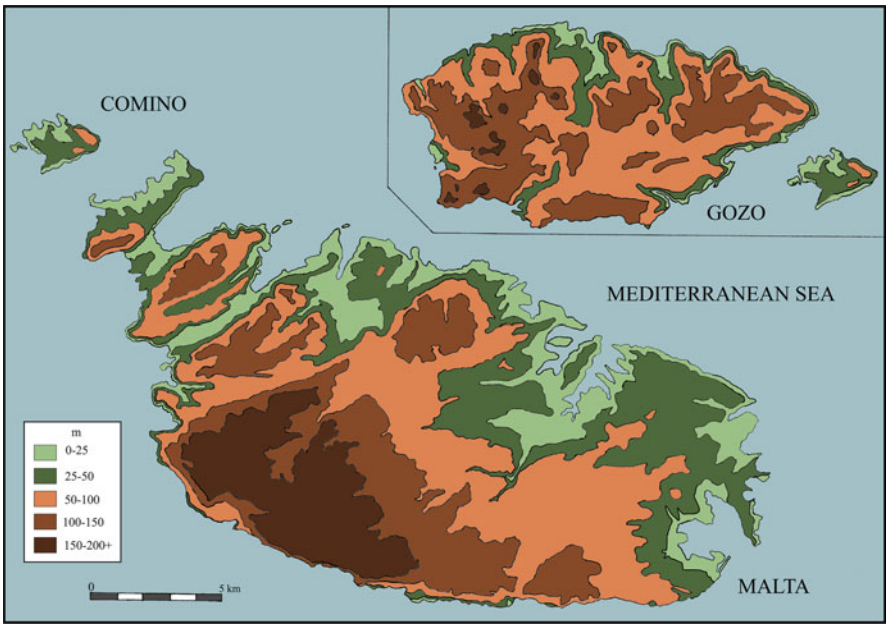

Fig. 2.2 Physical map of the Maltese Islands from ontheworldmap.com (modified)

Besides, examples of natural woodlands, such as those with *Quercus ilex*, today are very rare and can be considered as relicts of the forestal vegetation that originally covered part of these islands. It should be noted that the present landscape of the Maltese Islands is nothing but the result of the anthropic impact that has acted on this territory in the last 7000 years. According to literature (Renfrew 1972; Cutajar 1982), the first human colonization goes back to about 5200 BC and this prehistoric period ended in 750 BC. In particular, the earliest human civilization that reached these islands coming from Sicily dates back to Neolithic period (5200–4400 BC), with people having a hunter-gatherer culture, who probably did not have a strong impact on the natural environment. Towards the end of this period (4500–4100 BC) the population began to practice a primitive agriculture. During the Chalcolithic Age (4200–2500 BC), due to the arrival of other people from Sicily there was a marked improvement in agriculture that became more efficient and intensive, with a spread of pastoral activities. The Chalcolithic civilization of Malta, which is associated to the buildings of megalithic temples, due to intense sheep-grazing caused a depletion of natural resources with the degradation of vegetation cover and consequent denudation of the surfaces for soil loss. This was probably the main cause of the disappearance of this civilization towards 2500 BC, since it triggered off famines and diseases in the population of these islands, as hypothesized by the archaeologists. After 2500 BC, Malta remained unpopulated for several decades, until the arrival of a new migratory flow of people, called builders of Dolmen, who started the Maltese Bronze Age. This new civilization lasted about 1000 years, until 1450 BC,

its end coincides with the eruption of Santorini which caused upheaval throughout the Mediterranean. After up to 750 BC, other peoples arrived in Malta, mainly farmers, who then became fully integrated with the culturally far superior Phoenician civilization, whose population colonized the islands later this date. After this prehistoric period, during which Malta suffered a first devastation of the original vegetal cover, the islands from 218 BC fell under Roman rule, becoming a prosperous colony (Ballou 1893; Cassar 2000). Malta remained part of the Roman Empire until the early sixth century AD. After a brief occupation of Vandals and Ostrogoths, Malta in 535 AD was conquered by the Byzantines, becoming a colony. The successive invasion was that of Muslims that began in 870 AD. The native population was massacred, remaining the island uninhabited for about 150 years. After, the islands were colonized by a Muslim community that, although short-lived, introduced, apart of the language, also many innovative crops and new irrigation techniques, that are still used by farmers. Around 1100, with the expulsion of the Muslims, the Maltese islands returned under Christian rule with the Normans, remaining part of the Kingdom of Sicily for about 440 years. From 1530 to 1798 it was ruled by the Knights of Malta who embellished and fortified the islands, protecting it from the Ottoman invasions. After a brief Napoleonic period, Malta since 1800 became a protectorate of the British Empire which lasted until 1965, when the state of Malta was created.

From this, it can easily deduce that all these historical vicissitudes, dating back to very old periods, have had as a more evident result a devastation of the natural heritage of the islands of the archipelago. In the last decades, due to the demographic and turistic infrastructures increase, these degradation processes of the landscape have had a sharp rise, reducing the areas characterized by natural vegetation, that today are limited to less accessible and unsuitable areas for human activities.

2.2 Geology

The Maltese Islands are constituted of marine sedimentary rocks, mainly represented by limestone, marls and clays, which were deposited during the Oligo-Miocene period (30–5 MA). Geologically, these substrata show close similarities with Tertiary limestones forming the Hyblaean plateau in South Sicily, Lampedusa in the Pelagian Islands and Cyrenaica. This suggests that all these territories were part of the same stratigraphic unit. Discontinuous and various Quaternary deposits occurs above the Tertiary strata, which are represented by infills of depressed surfaces, screes, sands and gravels. The archipelago is linked through the Sicilian Channel to the Hyblaean plateau, that rests on sedimentary platform, forming during the Triassic, of which however do not emerge outcrops. According to Shackleton et al. (1984), these Islands were connected with the Sicilian coast up to the maximum cold stage of the last glacial interval (18,000 BP) (Fig. 2.3). This platform is represented by submarine graben, which reaches a maximum depth of about 200 m and with an average depth of less than 90 m (Magri 2006). Besides, it should

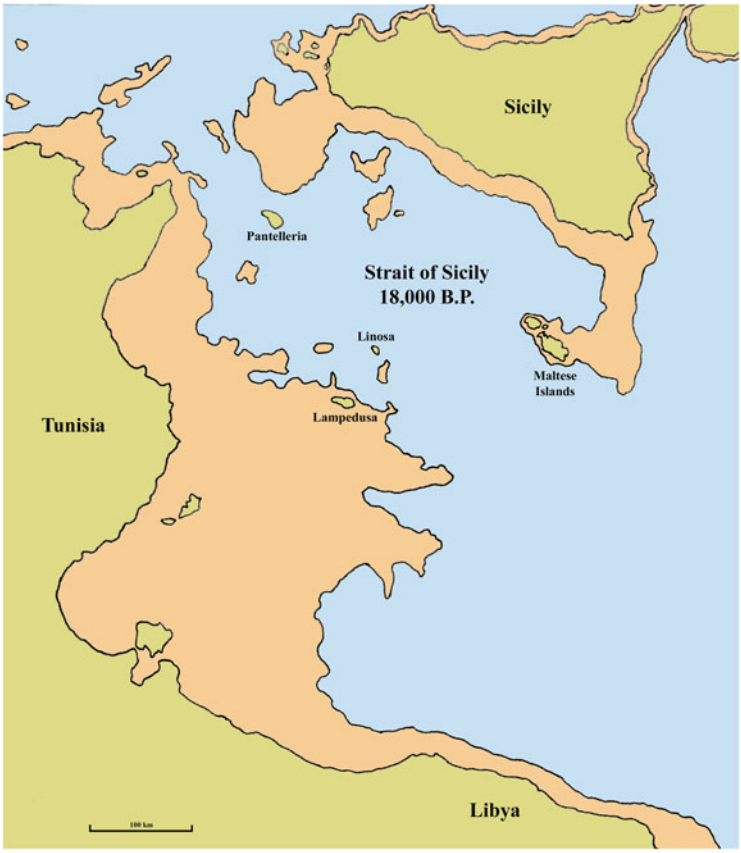

Fig. 2.3 Malta, Sicily and North Africa at lowest sea level during the last glacial maximum from Shackleton et al. (1984) (modified)

be noted that the Malta-Hyblaean platform belongs to Pelagian Block, which is part of African plate. The emersion of the Malta islands above sea level probably occurred between the upper Miocene and the lower Pliocene due to tilting of the NE block of the Malta graben. In fact, no rocks of this time have been observed, indicating therefore their definitive emersion.

As concerns the geology of Maltese islands, several authors have carried out detailed investigations on this topic, with the publication of important litho-stratigraphic, tectonic, morpho-structural and paleogeographic studies, as well as the drafting of geological maps. In particular Spratt (1843) was the first to publish a detailed geological description regarding the Maltese Archipelago, with a topographic map attached, correlated by faults and geological cross section. In a next edition of this work, Spratt (1852, 1854) published also a geological map of Malta and Gozo, made by Right Hon Earl od Ducie. The some revisioned map was later

published by Adams (1870) and by Murray (1890) too. More recently, other geological and lithostratigraphic surveys, often with annexed modern geological maps, have been published by various authors (Hyde 1955; House et al. 1961; Felix 1973; Pedley et al. 1976, 1978; Alexander 1988; Antonelli et al. 1988; Pedley 1993; Hunt 1997; Schembri 1997; Zammit-Maempel 1997; Savona-Ventura 2001; Magri 2006; Cassar 2010; Devoto et al. 2012; Marriner et al. 2012; Eig 2015; Rotevan et al. 2016; Prampolinia et al. 2017). A map on the geology of Maltese Islands is shown in Fig. 2.4. According to this wide literature, the stratigraphic succession of the rocky sediments can be subdivided in five formation (Fig. 2.5). They are here listed in order of decreasing age:

a. Lower Coralline Limestones

This formation is the oldest rock outcrop currently visible in the Maltese Archipelogo and is exposed in strata up to 140 m thick, as in the sea cliffs. It belongs to Chattian (Oligocene) and is constitute by marine sediments deposited between 30 and 25 million years ago, which are rich in coralline algae and fossil animals. On the whole, these substrata show a stratified structure and consist of endurated to strongly endurated limestone. This outcrops occur mainly in the vertical cliffs frequent in south-western coast of Malta and Gozo, while in inland stands are mostly localized along valleys and gorges or faulted inliers, such as at some localities of Malta.

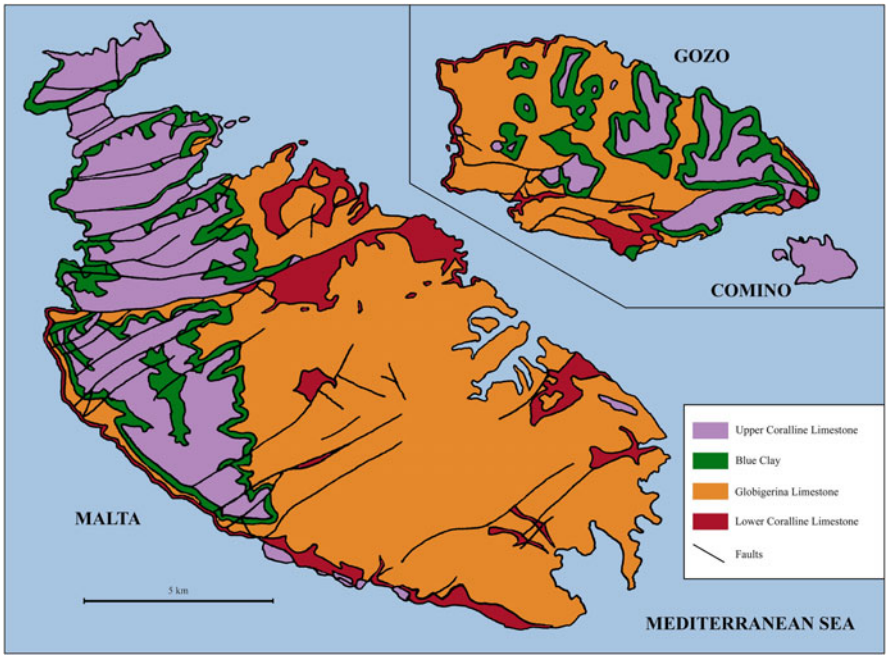

Fig. 2.4 Geological map of the Maltese Islands from House et al. (1961) (modified)

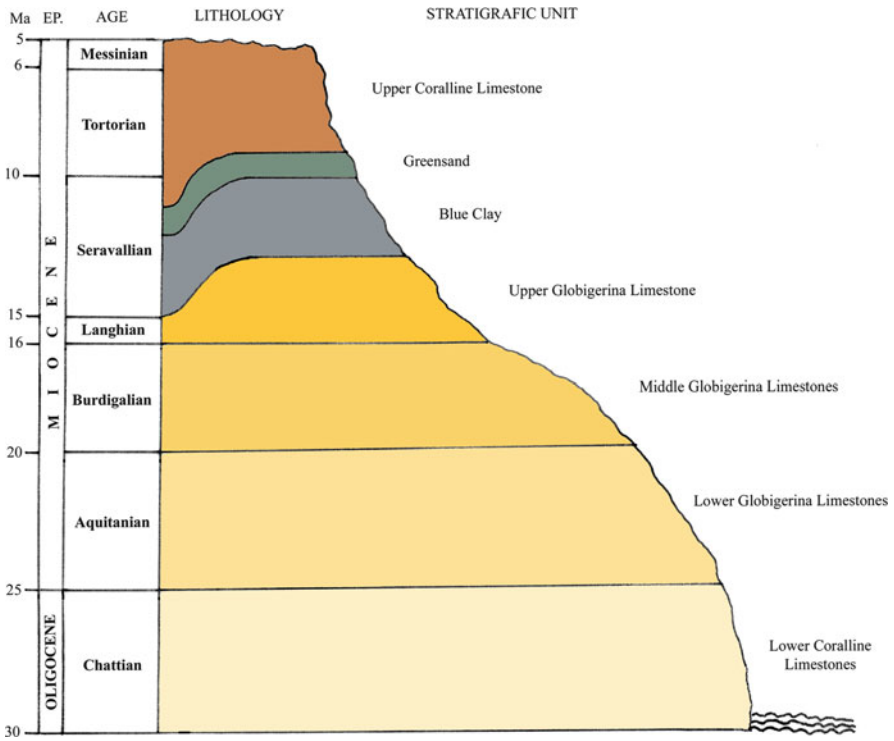

Fig. 2.5 Tectonic stratigraphic unit of the Maltese Islands according to Rotevan et al. (2016)

b. Globigerine Limestones

It is a stratified formation reaching sometime a thicknesser of 207 m, which spans the time between 25 and 13 Ma from Early Miocene to Middle Miocene. The rocks consist of more or less marly limestones, having a fine granulometry, with intercalation of chert, hard-grounds and pebble beds. These sedimentary rocks contain mainly microfossils, mainly Globigerina, and also numerous animal macrofossils, the same applies for the pebble strata. The Globigerine limestones forms usually undulating plains, since the very soft marl is easily eroded by atmospheric agents. These substrata, coinciding with the greater part of the cultivated lands, cover most of the surface of the islands. It is subdivided into three layers by two intervening pebble beds: (1) Lower—Consists of rocks belonging to Aquitanian (25–20); (2) Middle—The rocks rise to the Burdigalian (20–16 Ma); (3) Upper—Characterized by rocks between the Langhian and Seravallian (16–13 Ma).

c. Blue Clays

This formation, consisting in deposits of fine material, with an age that goes from the late Langhian to the early Serravallian (15–10 Ma), which is exposed in layers of thickness up to 65 m. It is constituted by dark marine clay rich in macrofossils, that, due to the strong surface erosion by the rainwater runoff, forming deep furrows on

steep slopes, also for the scarce vegetation that covers these purely clayey surfaces. These badlands, which are often protected by a cap of Upper Coralline Limestone, are quite common in Malta and Gozo. In the central and eastern Malta the Blue clays substrata is absent or rare, since this formation can be removed by erosion or because Upper Coralline Limestone rests directly on Globigerina Limestone. This rock is the only impermeable layer of the Maltese islands.

d. Greensands
It consists of bioclastic limestones rich in glauconite deposited in a warm sea, which is represented by coarse, thickly bedded calcareous sands mixed to clay. The sea bottom in this period had risen and was relatively shallow and sandy. These substrata attaining usually a thickness not more than 1 m, with a maximum of 12 m. The Maltese Greensands deposited between the late Serravallian to the early Tortonian (12–8 Ma) and rest on the Blue Clay, although they are not always associated with the latter.

e. Upper Coralline Limestones
This formation, belonging to Tortonian and Messinian (11–5 Ma), represents the youngest Tertiary substrata occurring in the Maltese islands, reaching a thickness up to 162 m. It consists of a complex of limestones and shows a structure very similar to those one of the Lower Coralline Limestone, which originated from sea bottom with shallow waters. Infact, they are very rich in fossil Coralline algae mixed to numerous macrofossils. The limestones are endurated, with layers completely crystalline, showing at the basis a gradual transition towards Greensands. These rocks occur in Gozo and in western Malta, were they constitute the top of the isolated tabular hills or buttes, originated as a result of surface erosion.

f. Quaternary Rocks
During the Quaternary age, these rocks, that had already emerged from the sea, have undergone an intense alteration due to the action of meteoric phenomena, which have often led to their erosion and modification with terrestrial, aeolian and alluvial deposits. They are mainly represented by loams, breccias, coastal conglomerates, sands, paleosoils and lacustrine deposits. Currently, Pleistocene and Holocene deposits can be found in valleys, caves fissures and along the coast (Trechmann 1938; Shackleton et al. 1984; Hunt 1997; Gambin et al. 1998; Carroll et al. 2012).

2.3 Soils

Pedological investigations (Lang 1960, 1961; Sivarajasingham 1971; Vella 2001, 2005) on the Maltese Islands emphasized that the soils of this country are quite young or immature, due to purely calcareous composition of substrates and uniformly arid climate, their genesis is very slow. Besides, that determined a lack of significant development of a humus horizons. Moreover, for the millenary human activity, which has manipulated and substantially altered the morphology of these

soils, they are quite artificial and difficult to catalog. The principal modes of soil disturbance are removing, plowing, manuring and terracing. For a correct classification of the Maltese Islands soils, the pedologists based their investigations on profiles not disturbed by human activities. In particular, the system proposed by Kubiena (1953) was followed, which allowed the identification of three main types of soil:

a. Xerorendzinas
The Maltese soils are formed from alterations of limestones, that due to high aridity of the climate, show a marked alkalinity, determining a weak evolution with a low humus content. These type of soils can be attributed to Xerorendzina whitish to red marly, with high calcium carbonate content (58–80%) derived from Globigerina limestone. It was considered by Vella (2001) an Entisol, that is a mineral soil with little or no evidence of pedogenetic horizons arising from a short pedogenesis period too.

b. Carbonate Raw Soils
It is also immature soil formed as a result of dry climatic conditions. It is represented by a grey soil with a very high calcium carbonate content (80–90%) and low in organic matter, derived from Greensand, Blue Clay, often mixed with Globigerina limestone and Upper Coralline limestones.

c. Terra Rossa Soils
It is a relict soils formed during the Pleistocene under woodlands and shrublands canopy. This red clayey soil originated when the wetter climate favored the leaching. This soil derived from both types of coralline limestone. Its reddish colour is due to the high iron oxide content. It is characterized by a low calcium carbonate content (2–15%), as well as a low humus content, which however is superior to that of the other soils.

More recently, the soils of the Maltese Islands have been classified by Sammut (2002–2004) according to the World Reference Base for Soil Resources (WRB Classification system). The seven identified soils are the following:

a. Arenosols (AR)
These soils were formed in recent sandy deposits occurring along the shoreline. Currently, they are represented at Ramla Beach (Gozo), as well as at Armier and Mellieha Bay (Malta), with examples also in Comino.

b. Calcisols (CL)
They are widespread in the all archipelago and are characterized by a high calcium carbonate concentration. These soils, very rich in lime, develop usually in countries affected by very dry climatic conditions. They for their dryness and stonyness do not lend much for agricultural use, but if proper cultural practices are made they can become highly productive. In this type of soil the Xerorendzinas can be included.

c. Cambisols (CM)
They are few developed soils showing only a subsoil showing a different colour (browner or redder) than the topsoil, but without other characteristics in the horizons. Cambisols, not frequent in the Maltese territory, they derive from medium and fine tessiture materials of various origins, represented by Quaternary deposits.

d. Leptosols (LP)
Leptosols originate from calcareous lithosols, such as those colonized by dwarf shrublands, in the Maltese islands occur mainly in the top of vertical cliffs and rocky outcrops. These soils are quite thin, since their natural evolution is usually limited by the erosion and generally they are not suitable for crops.

e. Luvisols (LV)
This type of reddish soils are developed in Malta during periods characterized by a wetter climate compared to the current one, like those coinciding with the Pleistocene glaciations. Therefore, they are relict soils having a low concentration of calcium carbonate, which clearly have no connection with the current pedoclimatic regime of these islands. The Luvisols, coinciding with the Terra Rossa Soils, are considered potentially fertile soils, but often require significant cultural actions. In the Maltese Archipelago they are frequent in the karst landscape.

f. Regosols (RG)
They gather soils, with a pedogenesis almost non-existent compared to parent material, which is reflected in completely indistinguishable horizons. In the Maltese Islands, the Spolic Regosols were recognized, which also known as urban soils or technosols, that occur usual in urban and industrial environments. Here, these soils are situated on made ground terraces overlying urban waste material.

g. Vertisols (VR)
This soils are characterized by high content of clay materials, which forms deep cracks in dry season. In Maltse territory they are localized on the Blue Clay outcrops, where the alternation during the year of the wet period with the dry one, causes a recurrent swelling and shrinkage of the silty-clay components, determining a self-mulching of the soil, which is constantly mixed. Therefore, the vertisols show an extremely deep horizon A, without horizon B.

2.4 Climate

The islands of the Maltese Archipelago, located in the central Mediterranean area, are characterized by a typically seasonal climate with very hot dry summers and wet cold winters. According to Rivas-Martinez et al. (2004, 2011), the Maltese territory falls in the Mediterranean pluviseasonal oceanic bioclimate ($Ic <= 21$, $Io > 2.0$) of Thermomediterranean type ($Itc = 350–450$, $Tp(1) > 2150$) with dry ombrotype ($Io = 2.0–3.6$), which is the same of that one of Southern Sicily. As concerns the climate of Malta, it was analyzed in detail by several authors (Mitchell and Dewdney

Table 2.1 Pluvio-thermometric data of Maltese islands weather stations from: (A) Mitchell and Dewdney (1961), (B) Haslam (1969), (C) World Weather Information Service (2013), (D) Luqa Weather Average (2015), (E) Malta Weather (2013), (F) http://www.holiday-weather.com/gozo/averages/, (G) https://it.climate-data.org/location/123259/

Average monthly temperatures for Malta (°C)

	weather station	years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year
A	La Valletta	1841-1957	11.6	11.6	12.7	15	17.7	21.7	25	25	23.3	20.5	16.6	13.9	17.8
B	Malta s.l.	1931-1960	12.3	12.4	13.6	15.4	18.8	23.0	25.4	26.2	24.0	21.1	17.3	14.0	18.6
C	Luqa	1961-1990	12.2	12.4	13.4	15.5	19.1	23.0	25.9	26.3	24.1	20.7	17.0	13.9	18.6
D	Luqa	1981-2010	12.8	12.5	13.9	16.1	19.8	23.9	26.6	27.2	24.7	21.5	17.7	14.4	19.2
E	Balzan	1985-?	13.2	13.0	14.6	16.7	20.4	24.4	27.2	27.7	25.0	21.9	18.8	14.7	19.7
F	Gozo s.l.	?	12.0	12.5	13.5	15.5	19.0	23.0	26.0	26.5	24.0	20.5	17.0	14.0	18.6
G	Ghajnsielem	?	12.1	12.1	13.1	15.1	18.7	22.4	25.2	25.9	23.7	20.3	16.8	13.6	18.2

Average monthly precipitation for Malta (mm)

	weather station	years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	year
A	La Valletta	1841-1957	88.6	65.5	64.1	23.6	10.6	2.3	1.0	4.3	28.5	79.0	90.4	97.3	521.7
B	Malta s.l.	1931-1960	90.6	53.7	41.6	21.7	?	1.8	0.5	7.0	31.1	102.6	67.7	77.9	498.6
C	Luqa	1961-1990	89.0	61.3	40.9	22.5	6.6	3.2	0.4	7.0	40.0	89.7	80.7	112..3	553.3
D	Luqa	1981-2011	98.8	60.1	44.2	20.7	16.0	4.6	0.3	12.8	58.6	82.9	92.3	109.2	595.8
E	Balzan	1985-?	94.7	63.4	37.0	26.3	9.2	5.4	0.2	6.0	67.4	77.2	108.6	107.7	603.1
F	Gozo s.l.	?	89.0	61.0	41.0	23.0	2.0	3.0	0.0	7.0	40.0	90.0	80.0	112.0	553.0
G	Ghajnsielem	?	78.0	50.0	38.0	23.0	8.0	3.0	0.0	5.0	35.0	96.0	80.0	88.0	504.0

1961; Haslam 1969; Chetcuti et al. 1992; Schembri 1997; Galdies 2011), who based on data from the nineteenth century up to a few years ago (1841–2011). As it is can be observed in the Table 2.1, where the pluvio-thermometric data of various weather stations of the Maltese islands (Malta and Gozo) dating to various periods are gathered, the climatic regime affecting this country is very similar to other Mediterranean territories with daily, seasonal and annual fluctuation, usually quite marked. In particular, the lowest temperatures are reached in January and February with monthly average values between 11.6 and 13.2 °C, slightly higher average values occur in March and December (12.7–14.7 °C). Higher values are reached in April–May and October–November with monthly averages of 15.0–21.9 °C, while the highest values are observed during the summertime (June–September) with monthly average of 21.7–27.7 °C, with higher peaks in August. The highest extreme temperature was reached in August 1999 with 43.8 °C, while the lowest ever recorded temperature was recorded in January 1981 with 1.4 °C. The annual precipitations are very variable from year to year, with yearly average for the periods listed in Table 2.1 between 498.6 and 603.1 mm. The high and low record of average annual rainfall is represented by 1031 mm (1859) and 140 mm (1894) respectively. The rainiest months coincide with the autumn ones (October–December) with average monthly values of 70.2–112.0 mm, decreasing slightly from January to February (98.8–50.0 mm). A faster rain decrease occurs from March to August, with minimum values close to zero in July, starting again with heavy rainstorms in September (28.5–67.4 mm). According to Mitchell and Dewdney (1961), despite the Maltese islands have a quite small surface without mountain ranges, the rains have a rather diversified distribution. In fact, during the period 1924–1939 the annual rainfall averages have a higher concentration in the central part of Malta (584–660 mm) with markedly lower values (584–508 mm) in the northern and southern parts, while in Gozo they are higher in the south-eastern part and lower in the north-western one. This is due to the fact that the rainfall is brought by north-westerly winds, whose

conventional effect is strengthened by orographic uplift along the steep north-western coast of the islands. In this type of climate, clearly biseasonal, the rains are undoubtedly the most important element and their distribution pattern in space and time is of vital importance for natural vegetation, agriculture and people. In order to emphasize the biseasonally of this climate, the pluvio-thermic diagrams of some Maltese weather stations, regarding various periods, are drawn after Walter and Lieth (1967). Infact, in the all these diagrams the aridity period in these islands extends from last March to early September coinciding with a range of about 5 months (Fig. 2.6).

Besides, it should be noted that in addition to temperatures and rainfall, the climate of the Maltese islands is also influenced by other meteorological factors, such as winds, atmospheric humidity, evapo-transpiration, sea temperature and

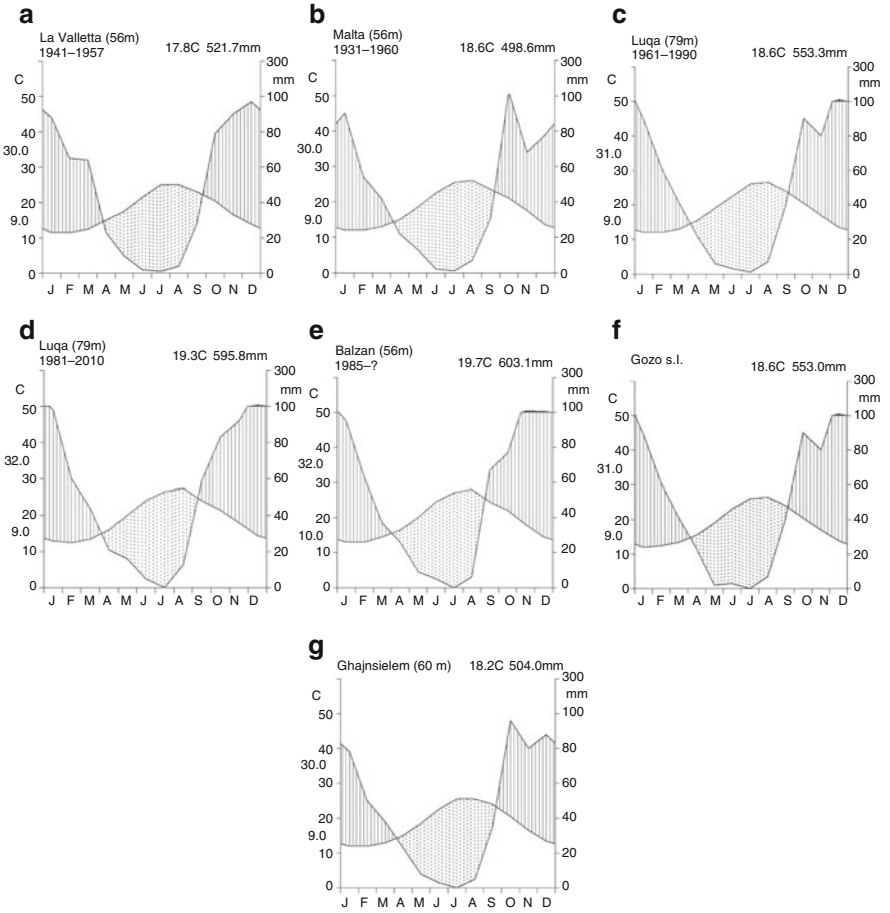

Fig. 2.6 Climograms of some Maltese weather stations, regarding different periods quoted in Table 2.1