The Phyllite-Quartzite Unit Talea Ori Mountains West of Heraklion

Meta-andesite schist of the Phyllite-Quartzite Unit cropping out at Agia Pelagia beach
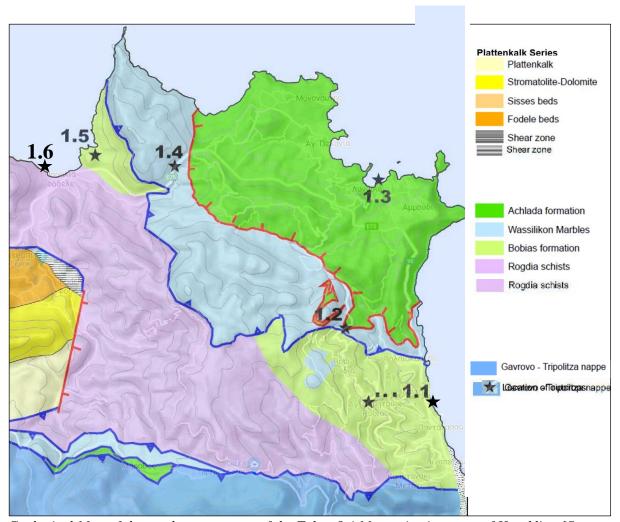
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Berlin, October 2023

Contents

Appendix

1 Introduction to the Phyllite-Quartzite Unit

The Talea Ori is a small mountain range situated between the northern coast and the central mountains of Psiloritis. The Talea Ori mountains is made up largely of Plattenkalk (Platy Marble), but is overlain in the east by a nappe consisting of the Phyllite-Quartzite Unit. While the Phyllite-Quartzite Unit can be found in many parts of Crete and even traced to mainland Greece in the External Hellenides the lithology of the nappe consisting predominantly of metavolcanic rock and siliciclastic turbidites is unique to the Talea Ori mountains.
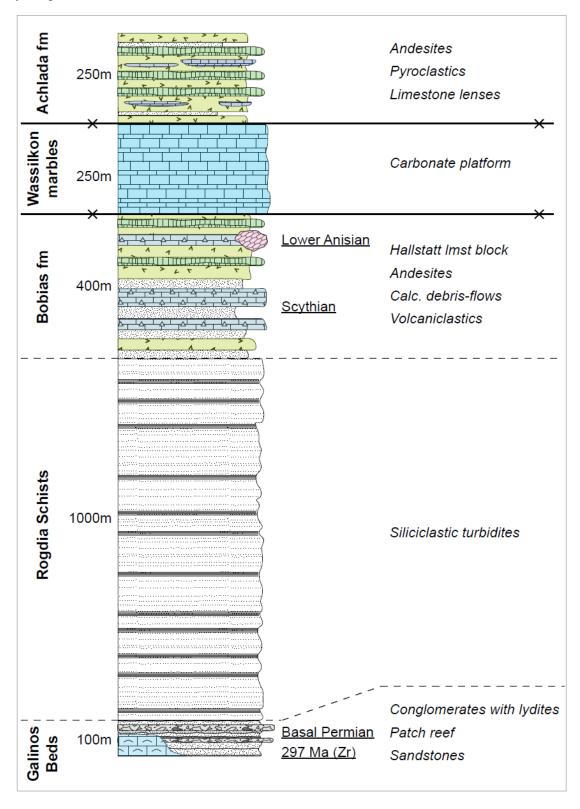
Geological Map of the north eastern part of the Talea Ori Mountains just west of Heraklion [Source: Stampfli, 2010]

1.1 Phyllite-Quarzite Unit s. str.

In general, the Phyllite-Quartzite unit consists mainly of metamorphic siliciclastic rocks (metapelites, metapsammites), marble and metavolcanites. The "unit" is very heterogeneous and can be tectonostratigraphically further divided, but since siliciclastics usually predominate, the term "Phyllite-Quartzite Unit " has persisted to this day (Dornsiepen & Manutsoglu 1994, Jacobshagen 1994).

Although the metasediments of the Phyllite-Quartzite Unit rarely contain macro fossils, rear finds and micro fossils indicate Permian to Triassic ages. The time period from the Upper Carboniferous to the younger Triassic has also been documented by conodonts (Krahl et al. 1983, 1986) and also by recent U–Pb dating of detrital zircons (Seybold L. et al, 2019). Metamorphism indicates typical HP/LT conditions that document subduction. Subduction and mountain building was accompanied by an intensive first foliation and later overprinting by younger foliations. *[Kull 2012]*

Idealized composite section through Phyllite -Quartzite Unit [Stampfi, 2010]

According to Stampfi, 2010 the Phyllit-Quarzite Unit **s. l.** in the Talea Ori mountains can be divided into has four main sub-units (from base to top):

- The Rogdia Schists (Krahl et al. 1988)
- The Bobias formation (Champod & Vandelli, 2010)
- The Wassilikon Marbles
- The Achlada formation

The Rogdia Schists mainly belong to the Phyllite-Quartzite Unit **s. str.** (see Appendix for distinction between Phyllite-Quartzite Unit s. str. and s. l.). However, its upper part along with the other formations can be correlated with the Tyros Unit of Eastern Crete. The palaeogeographic origin of the Phyllite-Quartzite Unit s. str. is generally considered to be at the northern margin of Gondwana and was located to the north of the Plattenkalk Unit *[Seybold L., 2019].*

During the late Carboniferous to late Triassic and the separation of the of European Cimmerian Terrains the Phyllite-Quartzite Unit became part of an accretionary wedge within the declining Paleotethys ocean (see Appendix). During the Eo-Cimmerian collision the Phyllite-Quartzite Unit, which initially formed under deep water conditions was overthrust by Norian carbonate platforms of the Ionian and the Tripolitza series *[Stampfi 2010].*

2   Bobias Formation – Stop 1.1

A: Road cutting near the Pantanassa road exit displaying the Bobias Fm.

An outcrop displaying the Bobias Formation is located on both sides of the main road near the Pantanassa road exit (which is very busy!). Phyllites, dolomite marble and quartzite beds are exposed. Pelagic conodonts within the formation indicate Olenekium age - a stage within the Lower Triassic. Boudinage is particularly recognizable in individual dolomite marble beds. *[Kull, 2012]*

Extension during the Miocene caused shear (top to the north) in the phyllite/schist. Local quartz and carbonate layers are reported to have been stretched into boudins. Preexisting folds from the older compressional event were also extended becoming isoclinal where they can still be recognized. The Phyllite-Quartzite Unit is dominated by chlorites that replaced the original muscovite. Talcum is also present at this location, which is indicated by the softness of the rock at some spots. The talcum has a white powdery streak and has a waxy feel to it. *[Fassoula, 2018 Central Crete Field Trip]*

The Bobias Formation has intercalations of greenish metamorphic greywacke and calcareous beds. The calcareous beds are interpreted as metamorphosed mass-flows such as calci-turbidites, grain-flows or debris-flows. The greenish sediments have intermediate to mafic geochemical composition, indicating them to be derived from the erosion of volcanic rock. This is supported by the occurrence of meta-pyroclastics and meta-andesites further to the North. Geochemical analysis of the volcanics show calc-alkaline affinities, suggesting a nearby volcanic arc. In addition, the presence of the calci-turbidites implies substantial tectonic activity, possibly related to the opening of a back-arc basin (i.e. a synrift setting). Several ages have been obtained from the meta-limestones, which contain rare microfossils. Krahl has found conodonts and ostracods of Early-Middle Triassic age. *[Stampfli, 2010]*

Thick marble and dolomite beds sandwiched between siliciclastic schists

Closeup of previous picture. 1: white and grey streaked marble or dolomite marble, 2: Orange-brown marble reported to contain some chert. The orange-brown colouring could be due to iron oxide content.

1: Marble boudinage, 2: Phyllite (possibly carbonate-silicate schist)

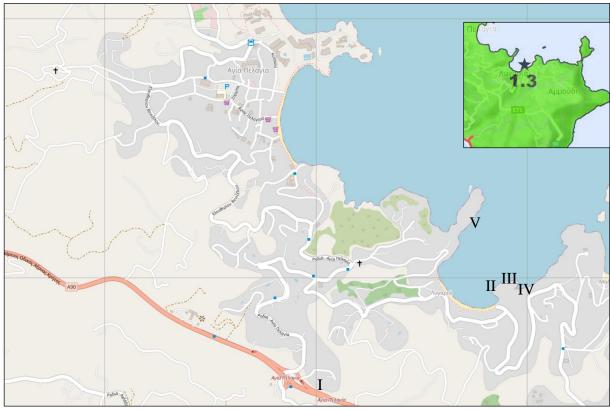*1: Marble boudinage, 2: Phyllite, possibly metamorphic greywacke*

1: Silicate schist possibly containing talcum

3   Achlada Formation – Stop 1.3

Map showing the main road exit Agia Pelagia and location of outcrops. I: Main road cutting, II, III, IV: locations at coast, V: Northeast side of the bay

Main road exit to Agia Pelagia Beach, Lygaria Beach and Madhes village. I: Metamorphic andesite ("green schist")

The Achlada formation consist of an approx. 250m thick series of metamorphic volcanic rock. These are transformed green volcaniclastic rocks, pyroclastic deposits such as tuffs and breccias, and andesites. There are white-grey carbonate lenses, ranging from a few mm up to 1m in thickness, which are reminiscent of the top part of the Bobias formation. The volcanic rock of both the Achlada and Bobias formations have a similar geochemical signature indicating differentiation with calc-alkaline affinity. The Achlada formation is reported to contain HP/LP metamorphic minerals such as Glaucophane, Lawsonite and Pumpellyite *[Stampfi, 2010]*.

3.1   Main Road Cutting

Outcrop I: Metaandesite ("green schist/ blue schist") outcropping at road cutting before the road exit.

Outcrop I, closeup of previous picture. The meta-andesite is reported to contain quartz segregations displaying the mineral Carpholite [Kull, 2012]. However, no visible macroscopic quartz was encountered at this location.

Outcrop I, closeup of previous picture showing metaandesite sample.

3.2 East of Agia Pelagia Beach

Outcrop locations

Outcrop I: The metaandesite becomes beige when weathered. 1: Metaandsite, 2: Talus: possibly a meta-pyroclastic rock (rucksack for scale in centre of picture)

Outcrop I, closeup of previous picture showing the different textures. 1: Meta-andesite 2: Presumably meta-pyroclastic rock containing fragments of other rock (arrow).

Outcrop II: Metaandesite. Owing to the HP/LT metamorphic conditions one would expect see a blue schist. As the schist is green, one could be tempted to use the term "green schist". However, microscopic analysis (of thin sections) would probably reveal a HP/LP mineral parageneses indicating blue schist facies. Dark lines on the surface are thought to be the result of crenulation cleavage, which result from two different phases of deformation and associated foliation.

Outcrop II, closeup of previous picture showing foliated meta-andesite. Scratch (made with hardened steel nail) indicates that the rock is not particularly hard (arrow).

Outcrop III: Meta-andesite. Notice the beige colouring due to weathering (arrow). The "green schist/ blue schist" is reported to have been used by the Minoans as paving stone.
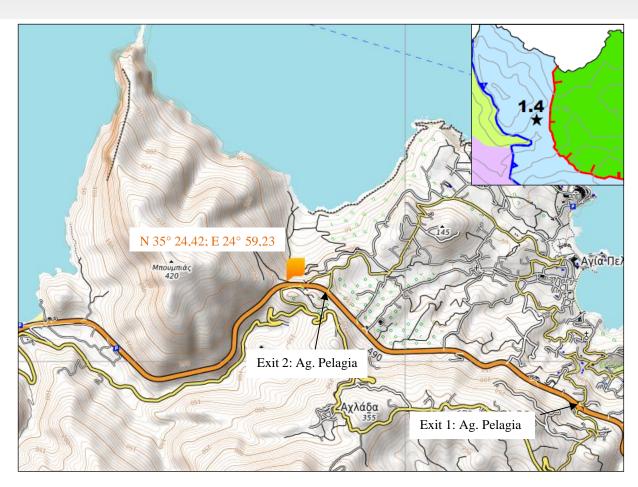
Outcrop V: North-western side of the bay displaying a large horizontal thrust plane within the metavolcanic rock (arrows)

4 Wassilikon Marble – Stop 1.4

Location of main road exits and route to outcrops [source of image: Google Maps]. Orange arrow: access on foot

N 35° 24,42; E 24° 59,23

Exit 2: Ag. Pelagia

Exit 1: Ag. Pelagia

1.5 Bobias Fm.:
Violet schist
(meta-pyroclastic
deposits) on
„green schist"

Thrust plane

1.4
Wassilikon Marble

IV, V

III

II

I

Achlada Fm.

Location of Outcrops. I: Achlada Formation, II: Wassilikon Marble, III and IV: Bobias Formation [Source of image: Google Maps]

4.1 Achlada Formation Underlying the Wassilikon Marble

Outcrop I: Achlada Formation (meta-andesite schist) near the Wassilikon Marble formation.

Outcrop I, Achlada Formation. 1: Marble beds indicate a sedimentary transition to the Wassilikon Marble

Outcrop I, Sample from an intercalated marble bed (notice the scratches made by a steel nail)

4.2   Wassilikon Marble

Outcrop II. Wassilikon Marble displaying karst weathering.

Outcrop II: Near the contact to the Achlada Formation the Wassilikon Marble is brecciated indicating some form of tectonic activity

In between the two previously described formations, there is a large sequence of carbonate, called the Wassilikon marble (1.4). The lower contact, with the Bobias formation, is a thrust dipping to the NE. The upper contact, with the Achlada Formation is somewhat ambiguous conversely discussed in literature. It is undoubtedly a NE-dipping normal fault in the Southern part. However, to the North, some authors mapped a stratigraphic contact, and some others mapped a west-dipping thrust (requiring the Wassilkon Marbles to be a klippe). The Wassilkon Marbles crop out as a monotonous series of at least 250m thickness and are interpreted as a metamorphosed carbonate platform. It consists of foliated massive grey to white (locally pink, yellow or green) marbles. Bedding and sedimentary textures can be observed near the base. The grade of metamorphism is unknown, but it should be high, since it is "embedded" in between two blueschist facies series. The age of the Wassilikon Marble platform is unknown. It could be an Anisian platform associated with the Middle Triassic volcanics (Pelgonian-type sequence) or it could be a Late Triassic – Tertiary platform covering the Phyllite Quarzite Unit s str. *[Stampfi, 2010]*. According to Richter & Kopp, 1983 both the Wassilikon Marble and the Achlada Formations correlate with the Tyros Unit and are therefore Upper Triassic. *[Kull, 2012]*
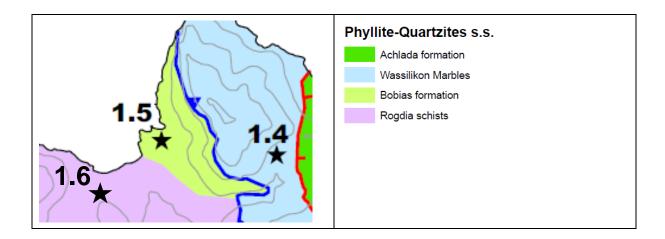
Outcrop II: Dark grey Wassilikon Marble similar in colour and texture to the marble beds in the Achlada Formation.

Outcrop III: Light grey sample of Wassilikon Marble from further up in the section. Notice the orangey intercalations and the large "clast" at the top left.

5   Bobias Formation – Stop 1.5

Within this area the Bodias Fm. is overthrust by the Wassilikon Marble *[Stampfli]*. It consists partly of violet coloured soft rock that appears to be pyroclastic material (see Appendix) and overlies meta-andesite schist. The outcrops III and IV do not resemble the lithology of the Bodias Fm. at Stop 1.1.

Outcrops IV and V, Bodias Fm. Location of outcrops at Fodele Beach near the petrol station.

Outcrop IV, Bodias Fm:. 1: Meta-andesite schist, 2: Violet "meta pyroclastic" rock, 3: Quartz vein

Outcrop IV, Bodias Fm. 1: Closeup of the meta-andesite schist/phyllite

Outcrop IV, Bodias Fm., 2: Closeup of the violet "meta-pyroclastic" rock insitu and as hand sample.

Outcrop IV, Bodias Fm., 3: Sample from the quartz vein. Silvery trail from steel nail indicates mohs hardness 7 (arrow). 4: orange-coloured deposits of iron oxides.

Outcrop V, Bodias Fm. Violet "meta-pyroclastic" deposits. Probably a pyroclastic flow that has been compacted and deformed by metamorphism. The rock is quite soft and well bedded and is reminiscent of volcanic ash welded tuff (see Appendix for similar image). Rucksack for scale (see arrow)

6   Rodigia Schists – Stop 1.6

West of Fodele Beach within the valley of Fodele there is a suitable place to study the Rogdia Schists. 1: a road cutting on a quite road leading from the main road is a suitable place to stop.

Outcrop I, Rogdia Schists: Siliciclastic turbidite consisting of an alternating sequence of sandstone and phyllite. The repetition of the turbidite sandstone beds points to repeated tectonic movement e.g. earthquakes.

Outcrop I, closeup of previous picture. 1: The phyllite consisting of fine-grained sheet silicates

represents the background sedimentation within a deep marine environment. 2: The sand grains of the sandstone were transported by a turbidity current that was triggered by tectonic activity.

Outcrop I, Rogdia Schists 3: Asymmetric boudins enable the direction of shear to be determined. In this case "top to the SE". This fits in well with the general tectonic concept of an asymmetric south vergent anticline. 4: Quartz veins at right angles to the bedding could indicate a phase of extension at an earlier stage of deformation.

Outcrop I, Rogdia Schists 2: Sandstone. A close look at the quartz grains shows the they are slightly elongated probably due to stress perpendicular to the bedding plane but also due to shear stress (arrows)

Outcrop 1: Symmetric boudinage displaying pinch and swell structures due to stretching of a more competent layer (quartz vein) in an incompetent matrix (phyllite). 2: sandstone, 3: Phyllite, 4: Quartz vein at right angles to the bedding could indicate extension at an earlier phase of deformation.

Outcrop II: Rogdia Schists. Thick sandstone beds displaying white deformed veins, which could indicate two different phases of deformation.

Outcrop II, closeup of previous picture showing hand sample with white vein.

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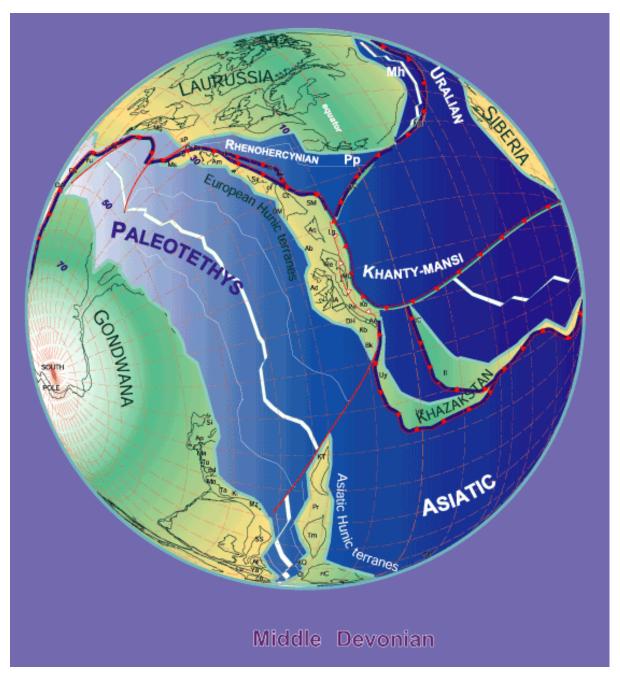
7 Appendix

Geological Time Scale Mesozoic to Cenozoic

Eonothem/Eon	Erathem/Era	System/Period	Series/Epoch	Stage/Age	mya[1]
Phanerozoic	Cenozoic	Neogene	Pliocene	Piacenzian	2.58
				Zanclean	3.600
					5.333
			Miocene	Messinian	7.246
				Tortonian	11.63
				Serravallian	13.82
				Langhian	15.97
				Burdigalian	20.44
				Aquitanian	23.03
		Paleogene	Oligocene	Chattian	27.82
				Rupelian	33.9
			Eocene	Priabonian	37.8
				Bartonian	41.2
				Lutetian	47.8
				Ypresian	56.0
			Paleocene	Thanetian	59.2
				Selandian	61.6
				Danian	66.0
	Mesozoic	Cretaceous	Upper	Maastrichtian	72.1 ± 0.2
				Campanian	83.6 ± 0.2
				Santonian	86.3 ± 0.5
				Coniacian	89.8 ± 0.3
				Turonian	93.9
				Cenomanian	100.5
			Lower	Albian	~113
				Aptian	~125.0
				Barremian	~129.4
				Hauterivian	~132.9
				Valanginian	~139.8
				Berriasian	~145.0

Eonothem/Eon	Erathem/Era	System/Period	Series/Epoch	Stage/Age	mya[1]
Phanerozoic	Mesozoic	Jurassic	Upper	Tithonian	~145.0
				Kimmeridgian	152.1 ± 0.9
				Oxfordian	157.3 ± 1.0
			Middle	Callovian	163.5 ± 1.0
				Bathonian	166.1 ± 1.2
				Bajocian	168.3 ± 1.3
				Aalenian	170.3 ± 1.4
			Lower	Toarcian	174.1 ± 1.0
				Pliensbachian	182.7 ± 0.7
				Sinemurian	190.8 ± 1.0
				Hettangian	199.3 ± 0.3
		Triassic	Upper	Rhaetian	201.3 ± 0.2
				Norian	~208.5
				Carnian	~227.0
			Middle	Ladinian	~237.0
				Anisian	~242.0
			Lower	Olenekian	247.2
				Induan	251.2
					251.902 ± 0.024

The Palaeo-Tethys in Plate Tectonics

The Paleo-Tethys Ocean was an ocean located along the northern margin of the paleocontinent Gondwana that started to open during the Middle Cambrian, grew throughout the Paleozoic, and finally closed during the Late Triassic; existing for about 400 million years.
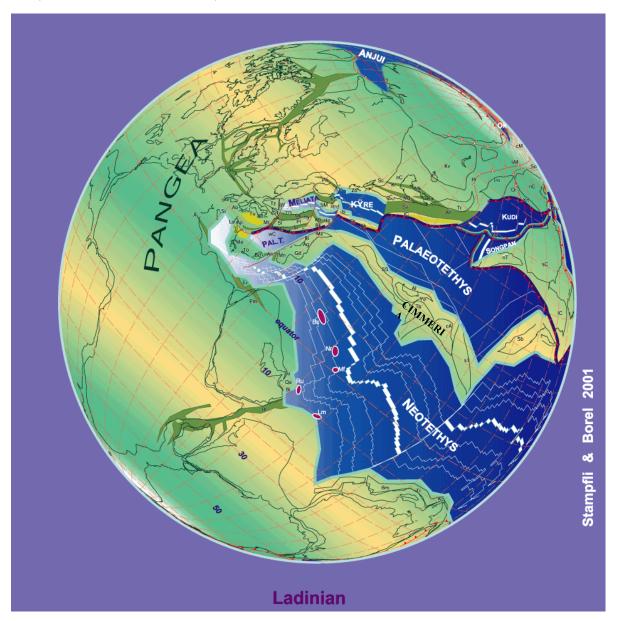

In the Early Carboniferous however, a subduction zone developed south of the European Hunic terranes consuming Paleo-Tethys oceanic crust. Gondwana started moving north, and in the process the western part of the Paleo-Tethys would close.

In the Carboniferous continental collision took place between the Old Red Sandstone Continent and the European Hunic terrane, in North America this is called the Alleghenian orogeny, in Europe the Variscan orogeny. The Rheic Ocean had completely disappeared, and the western Paleo-Tethys was closing.

By the Late Permian, the small elongated Cimmerian plate (today's crust of Turkey, Iran, Tibet and parts of South-East Asia) broke away from Gondwana (now part of Pangaea). South of the Cimmerian
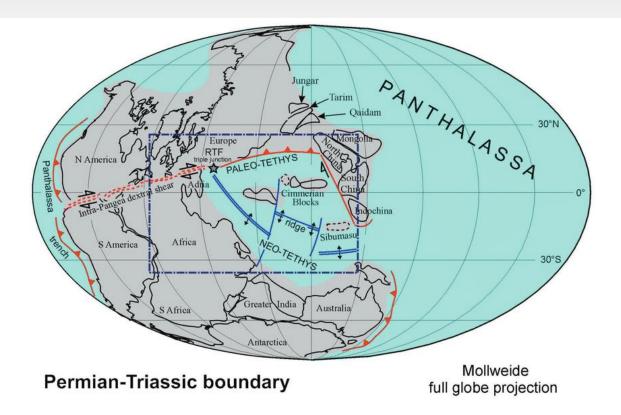
continent a new ocean, the Neotethys, was created. By the Late Triassic, all that was left of the Paleo-Tethys Ocean was a narrow seaway.

As Cimmeria migrated from Gondwana to Eurasia the Paleo-Tethys closed and the Neo-Tethys opened.

In the Early Jurassic epoch, as part of the [Alpine Orogeny](), the oceanic crust of the Paleo-Tethys subducted under the Cimmerian plate, closing the ocean from west to east. A last remnant of Paleo-Tethys Ocean might be an oceanic crust under the Black Sea. (Anatolia, to the sea's south, is a part of the original Cimmerian continent that formed the southern boundary of the Paleo-Tethys.)

The Paleo-Tethys Ocean was located where the Indian Ocean and Southern Asia are today. The Equator ran the length of the sea, giving it a tropical climate. The shores and islands probably supported dense coal forests. *[Wikipedia]*

Global paleogeography (top) and major depositional settings in the southern margin of the Tethys (below) at the time of the Permian-Triassic boundary (about 251 Ma).
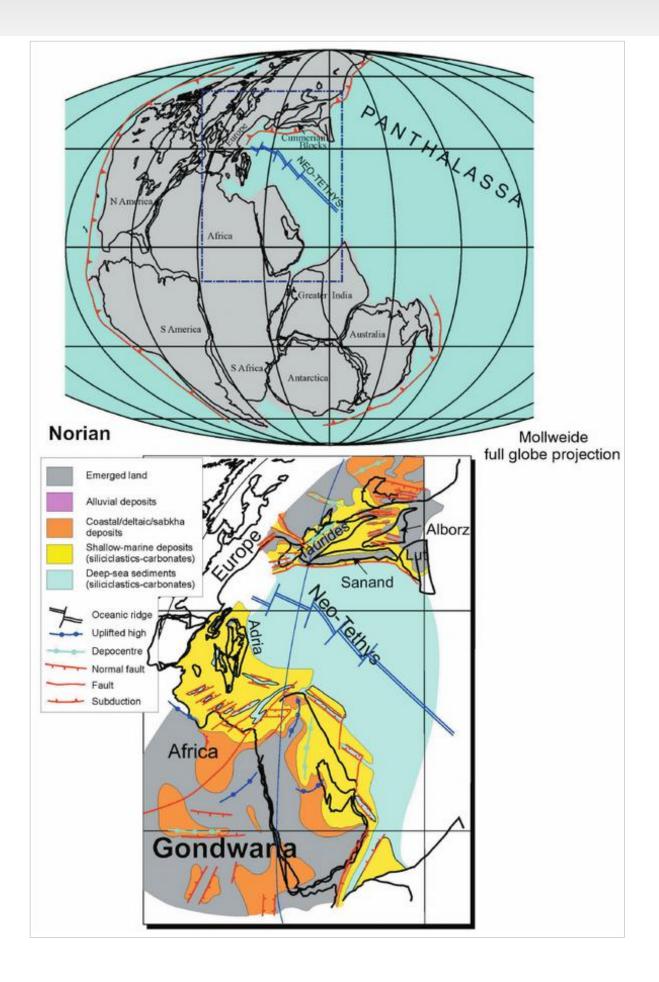
Norian

Mollweide
full globe projection

Figure 7. Global paleogeography (top) and major depositional settings in the southern margin of the Tethys (below) during Norian time (about 205 Ma)

[Source: The Evolution of the Tethys Region throughout the Phanerozoic: A Brief Tectonic Reconstruction Fabrizio Berra and Lucia Angiolini University of Milan, Department of Earth Sciences "A. Desio," Via Mangiagalli 34, 20133 Milan, Italy (e-mail: fabrizio.berra@unimi.it)]

Hellenic orogeny

The Hellenic orogeny is a collective noun referring to multiple mountain building events that shaped the topography of the southern margin of Eurasia into what is now Greece, the Aegean Sea and western Turkey, beginning in the Jurassic. Prior to then the supercontinent, Pangaea, had divided along a divergent boundary into two continents, Gondwana land and Laurasia, separated by a primordial ocean, Paleo-Tethys Ocean. As the two continents continued to break up, Gondwana, pushed by divergent boundaries developing elsewhere, began to drift to the north, closing the sea. As it went it split off a number of smaller land masses, terranes, which preceded it to the north. The Hellenic orogeny is the story of the collision first of these terranes and then of Gondwana, reduced to Africa, with Eurasia, and the closing of Tethys to the Mediterranean. The process has been ongoing since the Jurassic and continues today. *[Wikipedia]*

7.1   Sequence of the orogeny

In the late Jurassic, fragments of continental crust from the small content Cimmeria collided with Eurasia. Earlier, in the mid-Jurassic remnant oceanic crust formed ophiolites along the coast of Cimmeria. The oceanic crust of the Neotethys ocean subducted between the newly compounded Cimmerian-Eurasia continent, but obducted some more ophiolites onto the edge of the Cimmerian crust.

Tectonic activity resumed in the early Cenozoic when the small Apulia plate collided with the Cimmerian-Eurasian rocks causing intense imbrication and the deposition of the Pindos flysch. The final phase of the process came in the Miocene and Pliocene, during the Mesogean orogeny, when the combined Mesogean-African plate subducted beneath what is now Greece, the Aegean and parts of western Turkey. In the process, the Crete and southern Peloponessus core complexes were exhumed to the surface. *[Wikipedia]*
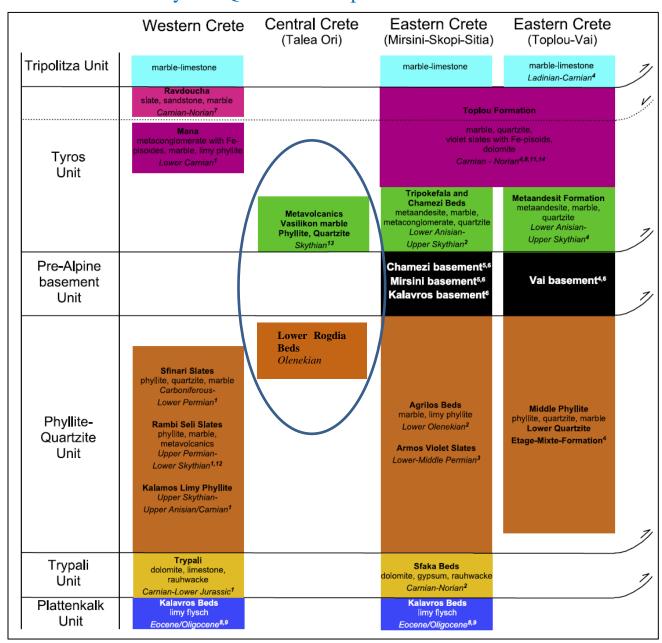
7.2   Structural geology

The Hellenic orogen is made up of three orogenic belts. The Cimmerian orogenic belt in Greece comprises the Serbomacedonian, Circum Rhodope, Axios, Pelagonian and Rhodope zones, while the Bayburt, Sinop, Kirklareli and Sakarya zones are situated in Turkey. The Alpine orogenic belt includes Neo-Tethys oceanic sedimentary rocks, the Pindos-Subpelagonian ophiolites and the External Hellenides. Apatite and zircon analysis in the southern Aegean suggests that metamorphism in the Cenozoic phase of the orogeny never exceeded 300 degrees Celsius. *[Wikipedia]*
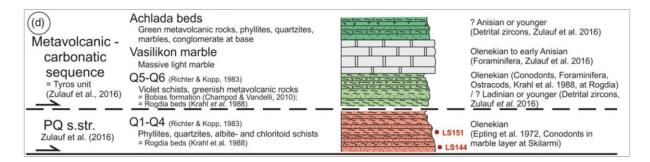
Cimmeria Terrains

Cimmeria was an ancient continent, or, rather, a string of microcontinents or terranes, that rifted from Gondwana in the Southern Hemisphere and was accreted to Eurasia in the Northern Hemisphere. It consisted of parts of present-day Turkey, Iran, Afghanistan, Pakistan, Tibet, China, Myanmar, Thailand, and Malaysia. Cimmeria rifted from the Gondwanan shores of the Paleo-Tethys Ocean during the Carboniferous-earliest Permian and as the Neo-Tethys Ocean opened behind it, during the Permian, the Paleo-Tethys closed in front of it. Cimmeria rifted off Gondwana from east to west, from Australia to the eastern Mediterranean. It stretched across several latitudes and spanned a wide range of climatic zones. *[Wikipedia]*

Overview of the Phyllite-Quartz Unit exposed on Crete

Cretan tectonostratigraphic units occurring between the Plattenkalk and Tripolitza Unit. Keys for age data: 1 Krahl et al., 1983; 2 Krahl et al., 1986; 3 Kozur and Krahl, 1987; 4 Haude,

1989; 5 Franz et al., 2005; 6 Romano et al., 2006; 7 Sannemann and Seidel, 1976; 8 Fytrolakis, 1972; 9 Bonneau, 1973; 10Cayeux, 1902; 11Fytrolakis, 1967; 12Seidel et al., 1982; 13 Krahl et al, 1988; 14 Zulauf et al., 2013. [Source: Zulauf G. et. al., 2014]. Modified after Seybold L. et al., 2019

(d) Stratigraphic column of the different Phyllite-Quartzite tectonostratigraphic units cropping out in the Talea Ori. The given ages are biostratigraphic ages based on the macro- and microfossil records of rocks. [Source: Seybold L. et al., 2019: New constraints from U–Pb dating, Talea Ori, Crete]

Pyroclastic Rocks

https://steemit.com/geology/@sooflauschig/classification-of-pyroclastic-rocks

While plutonic rocks look relatively alike (except for their colour), volcanic rocks can look vastly different from each other, depending on their origin. Volcanism creates different types of materials: pyroclastic rocks and solid rocks. Solid volcanic rocks form from magma (inside the volcano) or from lava (on the Earth's surface). The outflowing of lava requires calm and volatile poor volcanic activity. Pyroclastic rocks though are formed by highly energetic, volatile rich, explosive eruptions. The spontaneous volume increase of gas caused by decompression during ascend from the interior of the Earth literally tears apart the surrounding melt and catapult them away from the crater. Because of their form of deposition, they fall partly into the realm of sedimentary rocks.

Pyroclastic rock	Size [mm]
Ash	<2
Lapilli	2-64
Bombs	>64
Blocks: already solid particles from the volcano	> 64

*Volcanic Bomb.*volcanosareamazing.weebly.com
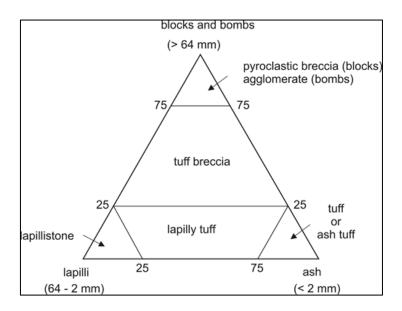

Lapilli. volcanos are amazing.weebly.com

Ash volcanosareamazing.weebly.com

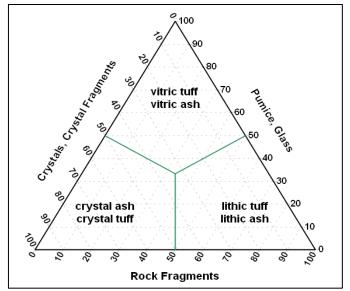*Blocks* volcanosareamazing.weebly.com

Based on the distribution of sizes, pyroclastic rocks can be classified using the following chart.

Classification of pyroclastic rocks using size abundances

(after Fisher, 1966). atlas-hornin.sk

Other than during downfall after ejection, pyroclastic material can be deposited from a pyroclastic flow. Rocks deposited by such process are termed ignimbrite. Ignimbrites commonly include crystals, pumice (frothy magma blobs), lithic fragments (pre-existing, solidified parts of the volcano), and an ash rich matrix.

Pyroclastic rocks can be classified using the fragments that are embedded in the matrix:

Classification of pyroclastic rocks using fragment composition

(afer Pettijohn, 1975) dplot.com

In magmas, gases are dissolved at high pressure, but exsolve as magma rise to the surface. Exolution of gas produces vesicles, or bubbles, in the magma. Mafic pyroclasts with abundant vesicles are called cinder or scoria, whereas felsic vesicular magmas are called pumice. The highly vesicular texture causes pumice to have a density below 1, which means they will float on water. In pumice, the linings of the bubble walls are glassy. Since pumice becomes abraded during transport in a pyroclastic flow, it is common to see triangle-shaped or hourglass-shaped glass shards in the ashy matrix. These are broken bubble walls. Glass shards can also be found in some mafic pyroclastic deposits.

Pumice with highly vesicular texture. geology.com

Unwelded Tuff. sandatlas.org

After deposition, the ignimbrite may compact, if it is hot and thick enough. This process is termed welding. Typically, thin ignimbrites, or the top and the base of thick ignimbrites are not compacted and are termed unwelded. In unwelded rocks, the pumice are still fat and frothy. As more pressure is exerted on the central parts of the flow, the pumice becomes flattened to form fiamme. The greater the pressure, the flatter the pumice become, and the rocks go from

moderately to densely welded. In densely welded rocks, the fiamme may be remelted to form obsidian. The ashy matrix is also compacted during welding. However, crystals and lithic fragments are not flattened, because they are already solid when the ignimbrite is deposited, so either fiamme or ash matrix is commonly wrapped around lithic fragments.

Densely welded tuff with flattened pumice fragments (fiamme) and matrix wrapping around undeformed lithic fragment.
sandatlas.org

Extremely densely welded tuff with recrystallized obsidian fiamme.
volcano.oregonstate.edu