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Ornitholites sp. rinvenuta nella Pesciara (lunghezza 7 cm)

4.1

ANALISI COMPARATIVA

L'ecosistema marino dell'Eocene nella Val d'Alpone (Bolca, San Giovanni Ilarione e Roncà)

Grazie all'ottima conservazione e all'evidente origine marina, la fauna fossile proveniente dalla Pesciara e dal Monte Postale, dalle colline di Roncà (Valle della Chiesa) e da San Giovanni Ilarione (Ciupio, Croce Grande, Bosco del Prete e Pozzani) ha attirato l'interesse internazionale dei filosofi naturalisti a partire dal XVIII secolo. L'interesse congiunto per i pesci di Bolca e i molluschi dei vicini "Monti Veronesi" ha riguardato il dibattito europeo sulla teoria della Terra, come testimoniano gli scritti di Antonio Vallisneri (1725) e Anton Lazzaro Moro (1740). I pesci fossili di Bolca rappresentano certamente la componente più famosa e più studiata dell'assemblaggio fossilifero della Val d'Alpone. Al contrario, gli studi incentrati sui molluschi sono dovuti in primo luogo alla loro maggiore abbondanza e ubiquità e dalla possibilità di confrontare le specie fossili con quelle che vivono nei mari odierni.

Questo confronto è stato oggetto di ricerca nei lavori pionieristici di Vitaliano Donati (1750) e Alberto Fortis (1774), tradotti in francese, inglese e tedesco. L'interesse si è intensificato con le ricerche dei primi geologi Alberto Fortis (1778), Georges Cuvier (1796), Barthélemy Faujas de Saint-Fond (1798), Jean-Baptiste Lamarck, (1802-1806) e Antonio Catullo (1826), per assumere infine la forma moderna nel corso del XIX secolo con gli studi tassonomici e stratigrafici di Alexandre Brongniart (1823), Ferdinand Bayan (1870b), Karl Mayer (1870), Hébert E. e Munier-Chalmas (1877) e Antonio De Gregorio (1880, 1894) e nel ventesimo secolo con Giotto Dainelli (1904-1905, 1915), Paolo Vinassa de Regny (1895-1897), Paul Oppenheim (1896) e Roberto Malaroda (1954).

Ammodernamenti tassonomici si registrano in anni più recenti (Quaggiotto e Mellini 2008; Dominici et al., 2012; Dominici, 2014).

I numerosi affioramenti fossiliferi della Val d'Alpone, iconicamente rappresentati dalle

località di Pesciara, Monte Postale, San Giovanni Ilarione e Roncà, rappresentano un continuum in un'area stratigrafica relativamente piccola che copre un intervallo di tempo compreso tra l'Eocene inferiore (Pesciara e Monte Postale) e l'Eocene medio (San Giovanni Ilarione e Roncà; si veda ad esempio Bayan, 1870a) e da una varietà di ambienti deposizionali che includono ambienti intertidali (Roncà), subtidale poco profondo (Monte Postale, ambiente associato al giacimento dei "pesci di Bolca") e subtidale con profondità compresa tra pochi metri e 20-30 metri (San Giovanni Ilarione).

La Val d'Alpone nella sua interezza fornisce quindi un'immagine ecologica di un ampio gradiente batimetrico, in un intervallo di tempo in cui la Terra ha sperimentato temperature eccezionalmente elevate (Zachos et al., 2001), la biodiversità marina ha raggiunto il suo apice (Lozouet, 2014) dopo un lungo periodo di recupero post estinzione di massa (Kieckhefer et al., 2008), e si sono affermati i gruppi di organismi che dominano i mari moderni. Tra questi, il phylum Mollusca è uno dei principali contributori alla moderna biodiversità marina (Appeltans et al., 2012; Costello e Chaudhary, 2017), che copre un'ampia gamma di nicchie ecologiche (Ponder e Lindberg, 2008) ed è caratterizzato da una eccellente documentazione fossile, che fornisce un utile strumento di confronto nello spazio e nel tempo, su scala globale.

In accordo con le tendenze latitudinali note per i mari attuali (Roy et al., 2004) e con l'ipotesi largamente condivisa che il centro di biodiversità durante l'Eocene fosse situato nella Tetide (Renema et al., 2008; Friedman e Carnevale, 2018), i molluschi della Val d'Alpone indicano una diversità più alta di quella delle celebrate faune del Bacino di Parigi (Sanders et al., 2015; Merle et al., 2016).

Questi ultimi, noti per l'eccellente grado di conservazione e la diversità complessiva (Merle, 2008; Dominici e Zuschin, 2016), costituiscono il principale riferimento per ricostruire le variazioni della biodiversità degli ultimi 65 milioni di anni (Lozouet, 2014).

Nessun'altra località al mondo contiene la varietà di forme conosciute per la Val d'Alpone. Questa unicità è evidenziata dal confronto con località sia dell'Atlantico che tetidee quali, per l'Eocene inferiore: Gan (Francia: Merle 1990; Tomašových *et al.*, 2014), Tremp-Graus (Spagna: Dominici e Kowalke, 2007; 2014) e Lakhra (Pakistan: Merle *et al.*, 2014), e per l'Eocene medio: Grignon (Senders *et al.* 2015), Bribir (Croazia: Dainelli 1904-1905), Noax (Friuli: Dainelli, 1915), e Pamplona (Spagna: Astibia *et al.*, 2018).

In generale, i crostacei hanno una bassa probabilità di essere conservati allo stato fossile e il loro ritrovamento è insolito, quindi la loro abbondante presenza in Val d'Alpone, nota da secoli, è di particolare importanza. I ritrovamenti sono di eccezionale livello sia in Pesciara che a San Giovanni Ilarione. Nell'area di Bolca (Beschinn *et al.*, 2016; 2021), sono state rinvenute associazioni di piccoli brachiuri e anomuri ricche di taxa, associati a coralli, molti dei quali nuovi per la scienza, all'interno di piccole biocostruzioni coeve con gli strati fossiliferi della Pesciara.

Queste associazioni mostrano un'evidente somiglianza con i crostacei che vivono oggi nei mari tropicali dell'area indo-pacifica e soprattutto affinità con le faune dell'Eocene superiore di Budapest (Müller & Collins, 1991). Per quanto riguarda la fauna a decapodi della componente di San Giovanni Ilarione (Ciupio) dell'Eocene medio, storicamente studiata da Bittner (1875, 1883, 1895) su esemplari rinvenuti principalmente nelle collezioni del Museo di Storia Naturale di Vienna (Hyžný & Zorn, 2016, 2020), si nota che la sua diversità

è paragonabile solo a quella di Budapest (Lörenthey & Beurlen, 1929). Evidenti affinità dei crostacei di San Giovanni Ilarione, si riscontrano per l'Europa, con quelli dei dintorni di Palermo (Di Salvo, 1933), Huesca (Spagna) (Zamora *et al.*, 2022), Bacino dell'Hampshire (Regno Unito) (Bell, 1858, Quayle & Collins, 1981), Lillebælt Clay Formation (Danimarca) (Collins & Jakobsen, 2003) e per le Americhe con quelli della Carolina del Nord e del Sud (USA) (Blow & Manning, 1996) e della Formazione di Bateque (Messico) (Schweitzer *et al.* (Messico) (Schweitzer *et al.*, 2006). Nell'area di Roncà (Valle della Chiesa), la maggior parte dei siti storici sono accessibili. Solo uno è attualmente coltivato a kiwi. Per quanto riguarda i siti di San Giovanni Ilarione, solo quello di Cupio è facilmente accessibile, mentre quelli di Croce Grande, Bosco del Prete e Pozzani sono sepolti sotto spessi materiali detritici sopra i quali sono state impiantate colture di pregio (vigneti), il che rende difficile la loro precisa identificazione e delimitazione. Dal 2010 sono attivi scavi paleontologici autorizzati dal Ministero, in Valle della Chiesa e sul Monte Duello.

Confronto con altri siti di importanza mondiale (siti scritti nella WHL UNESCO, Geoparchi, siti nelle Tentative Lists, ecc.)

Category (1) evaluates fossil records of Eocene marine faunas using four criteria:

	Site	1. Diversity	2. Diversity taxonomic of upper level	3. Abundance of specimens	4. Significance Evolution broader than the fossils
FISHES	VAL D'ALPONE Pesciara and Mt. Postale (Italy)	About 260 taxa (potentially not less than 280)	Over 110 families	Deposits extremely productive. Beyond 100,000 specimens extracted to date	First evidence in the paleontological record of ichthyofauna associated with modern type coral reef
	Messel Pit Fossil Site (Germany)	8 taxa	5 o 6 families	Elevated	Evolutionary significance relatively marginal. Location that testifies to the structure of ancient communities' lakes of the European continent
	Mo-Clay (Fur Formation, Denmark)	About 80 taxa	Undefined. Fossiliferous association studied but only marginally	Notelevated	Not definable due to the very limited number of studies dedicated. Over 70% of taxa has not been described yet
	Green River Formation (USA)	31 taxa	20 families	Elevated, especially in relation to the enormous extension of sediments potentially fossiliferous of the Green River Formation	Fish association known more for the Cenozoic of North America
CRUSTACEANS	VAL D'ALPONE Pesciara and Mt. Postale	32 taxa	17 families;	Not elevated	Important contribution to the study of fossil crustaceans from various environments (lagoon, coral reef, inner shelf) with important insights into the evolution of the group
	San Giovanni Ilarione (Italy)	19 taxa	9 families	Elevated	
	Budapest (Hungary)	More than 60 genres (112 taxa)	31 families	Elevated	Fauna of historical importance of different environments that would need systematic revision and photographic testimony
	Huesca-Aragona (Espana)	25 genres (27 taxa)	14 families	Not elevated	At the moment sporadic findings do not allow a global vision of the fauna or for further evolutionary investigation
	Palermo (Italy)	15	8	Sparse	Sporadic findings that highlight similarities with the faunas of western Veneto and Budapest
	Hampshire Basin (United Kingdom)	39	18	Elevated	Faunas known since the last century which present systematic characteristics close to those of southern Europe

CRUSTACEANS	Lillebælt Clay Formation (Denmark)	9	8	Elevated	Fauna known from the last century which shows affinities both with those of England and those of southern Europe
	Bateque Formation (México)	29	14	Unknown	The fauna has affinities with Pacific but also Tethyan faunas
	Nord and South Carolina (USA)	25	13	Sparse	The fauna has greater systematic affinities with European ones than with American ones
MOLLUSCS	VAL D'ALPONE				
	Mt. Postale	65 spp. (Mt. Postale: Ypresian)	36 families (Mt. Postale)	1200 (Mt. Postale: Florence, Padua, Verona, Pisa, Paris)	Eocene roots of modern tropical marine benthos
	San Giovanni Ilarione	519 spp. (San Giovanni Ilarione: Lutetian)	80 families (San Giovanni Ilarione)	2000 (San Giovanni Ilarione: Florence, Pisa, Paris)	
	Roncà (Italy)	176 spp. (Roncà: Bartonian)	58 families (Roncà)	2500 (Roncà: Padua, Florence, Paris)	
	Paris Basin (France)	788 spp. (Grignon: midLutetian) 254 spp. (Grignon)[bulk samples] 718 spp. (Baron: Bartonian)	87 (Grignon: Vienna)[bulk samples]	Consistence of Eocene Paris collections (order of magnitude): 105 specimens 7079 (Grignon: Vienna) [bulk samples]	Eocene roots of modern temperate marine benthos
	Pyrénées-Atlantiques (France)	184 spp. (Gan: Ypresian)[bulk samples]	82 families (Gan: Ypresian)[bulk samples]	8117 (Paris)[bulk samples]	Eocene roots of modern temperate marine benthos
	Friuli (Italy)	169 spp (Noax, Rosazzo)	53 families	1200 (Florence)	Eocene roots of modern tropical marine benthos
	Wadi Al-Hitan (UNESCO Egypt)	Unknown (Priabonian, see Peters 2009, doi: 10.2110/palo.2008.p08-080r)	Unknown (see Peters 2009, doi: 10.2110/palo.2008.p08-080r)	Unknown (see Peters 2009, doi: 10.2110/palo.2008.p08-080r)	Eocene roots of modern tropical marine benthos
	Sobrarbe (UNESCO Spain)	Unknown (Lutetian, see Canudo et al. 2021)	Unknown (see Canudo et al. 2021)	Unknown (see Canudo et al. 2021)	Eocene roots of modern temperate marine benthos

Category (2) evaluates the nature and quality of the fossil archive at each site using five criteria:

	Site	5. Quality of conservation	6 Stratigraphic thickness of the layers containing fossils exposed	7. Geo chronological Constraints	8. Age of fossils	9. Range of environments in which fossils are found
FISHES	VAL D'ALPONE Pesciara and Mt. Postale (Italy)	Exceptional. In addition to the skeletal parts, there are evident traces of the viscera and of the musculature, in addition to embryos and eggs in situ. Finally, there are numerous examples of parasitism and trophic interactions. UNIQUE CONTEXT IN THE PALEONTOLOGICAL MARINE CENOZOIC RECORD		Definite age across the micropaleontological content of carbonate sediments of the succession	Between 50.5 and 48.5 milion years	Environment lagoonbehind the cliff. Coastalenvironment peri-recifal with grasslands, seagrass and algae
	Messel Pit Fossil Site (Germany)	Great			Around 48 milionyears	Maarcraterlake
	Mo-Clay (Fur Formation, Denmark)	Very good preservation only in carbonate nodules. Most of the fish fossils come from diatomites where quality of conservation is not certainly extraordinary. In numerous cases it deals exclusively with skeleton imprints	Some hundreds of meters	Very well bound thanks to numerous Cineritic levels that characterize the sedimentary succession	Between 55 and 54 milion years	Pelagic environment placed at several kilometers from emerged areas in the ancient North Sea
	Green River Formation (USA)	Exceptional, especially for theskeletal parts			About 52 milion years	Various biotopes of a vast lake context
CRUSTACEANS	VAL D'ALPONE Pesciara and Mt. Postale	The quality of conservation in general is good. The crustaceans of Pesciara and Mt. Postale are preserved on slab; those coming from the bioherme (Bolca area) are of modest size represented by carapaces and remains of chelipeds			Early Eocene	Lagoon environment, patch reef
	San Giovanni Ilarione (Italy)	The crustaceans from San Giovanni Ilarione are primarily represented by carapaces			Middle Eocene	Shelf environment

CRUSTACEANS	Budapest (Hungary)	The quality of the preservation is good	Discontinuous outcrops partly in urban areas with a thickness of approximately 100 m		Middle and Late Eocene	Coral and platform environment
	Huesca-Aragona (Spain)	Quality is good; the specimens often retain also the ventral parts	Discontinuous outcrops several meters thick		Eocene	Eocene platform and also external cliff environment
	Palermo (Italy)		Discontinuous outcrops no longer identifiable		Late Eocene	Reefal
	Hampshire Basin (United Kingdom)	The quality of the preservation is not good	Thickness of a few hundred meters		Eocene	Inner shelf
	Lillebælt Clay Formation (Denmark)	The quality of the preservation is very good	Thickness of a few tens of meters (with several discontinuities)	Findings often found in scattered nodules for which it is not possible to trace precise levels	Early/Middle Eocene	Inner shelf
	Bateque Formation (México)	The quality of the preservation is not good	Not reported	Discrepancies in studies to evaluate the precise age of formation	Eocene	Outer shelf
	Nord and South Carolina (USA)	The quality of the preservation is decent	Not reported		Middle Eocene	Inner shelf
MOLLUSCS	VAL D'ALPONE					
	Mt. Postale	Aragonite crystallised in calcite, lithified, only specimens larger than a few mm are preserved; external morphology very well preserved (Mt. Postale, San Giovanni Ilarione, Roncà)	Tens of m-thick succession (Postale) Dm-thick strata, part of a tens of m-thick succession (San Giovanni Ilarione, Roncà)	Biostratigraphic data (mainly large foraminifera)	51-49 Ma (Mt. Postale) 48?-41? Ma (San Giovanni Ilarione) 40-38 Ma (Roncà)	Shallow subtidal back-reef lagoon (Mt. Postale) Shoreface or innershelf (San Giovanni Ilarione) Intertidal or shallow subtidal (Roncà)
	San Giovanni Ilarione					
	Roncà (Italy)					
	Paris Basin (France)	Origine aragonite, unlithified, species smaller than a few mm are preserved; external morphology very well preserved (Grignon, La Guepelle)	Dm-thick shell beds, part of a meters-thick succession (Grignon, La Guepelle)	Sequence stratigraphic data? Biostratigraphy? Unpublished	45-42 Ma (Grignon) 40-38 Ma (La Guepelle)	Shoreface or innershelf (Grignon, La Guepelle)
	Pyrénées-Atlantiques (France)	Origine aragonite, unlithified, species smaller than a few mm are preserved; external morphology very well preserved (Gan)	Dm-thick shell beds, part of a meters-thick succession (Gan)	Biostratigraphy? Unpublished	50-49 Ma (Gan)	Outer shelf (Gan)

MOLLUSCS	Friuli (Italy)	Aragonite crystallised in calcite, lithified, only specimens larger than a few mm are preserved; external morphology very well preserved (Noax, Rosazzo)	Dm-thick shell beds, part of olistoliths (Noax, Rosazzo)	Biostratigraphic data (large foraminifera)	49-47 Ma (Noax, Rosazzo)	Intertidal or shallow subtidal (Noax, Rosazzo)
	Wadi Al-Hitan (UNESCO Egypt)	Aragonite crystallised in calcite, lithified, only specimens larger than a few mm are preserved? (Wadi Al-Hitan)	Dm-thick shell beds part of a tens of m-thick succession (Wadi Al-Hitan)	Sequence stratigraphy (see Peters <i>et al.</i> 2009)	37-36 Ma (Wadi Al-Hitan)	Shoreface (Wadi Al-Hitan)
	Sobrarbe (UNESCO Spain)	Aragonite crystallised in calcite, lithified, only specimens larger than a few mm are preserved?	Unknown, part of a tens of m-thick succession	Sequence stratigraphy? Unpublished (see Moreno-Azanza <i>et al.</i> 2021)	48?-41? Ma (Sobrarbe)	Deltaic, intertidal (Sobrarbe)

Category (3) evaluates permanence and scientific impact for each site using separate criteria for:

	Site	10. Degree of investigation	11. The centrality of fossil associations for the reconstruction of the history of modern tropical marine biodiversity	12. The centrality of the study of fossils for the history of geology and evolutionary biology	13. Scientific Impact	14. Accessibility of the site
FISHES	VAL D'ALPONE Pesciara and Mt. Postale (Italy)	Thorough	Most important site in the world for the interpretation of origin and evolutionary trends of current tropical marine diversity	Yes, the extraordinary relevance for the historical development of life sciences and more recently, of evolutionary biology. The fossil fish of Bolca, since the sixteenth century have played a central role in the interpretation of fossils as ex-live	Extraordinary	Good
	Messel Pit Fossil Site (Germany)	Thorough	None, it is of a lake assemblage	The fish association of Messel, as far as relevance among the fresh-growing associations of the European Cenozoic is not to be considered fundamental for the history of geology and of evolutionary biology	Relevant to the definition of the structure and composition of the fresh fish communities of Europe of the first part of the Cenozoic	Good in some excavationsites

FISHES	Mo-Clay (Fur Formation, Denmark)	Very limited	None. It is about fish association in a temperate marine context (proto-North Sea)	Potentially relevant, not adequately recognized	Potentially relevant, not adequately recognized	Good mostly on the Island of Mors
	Green River Formation (USA)	Thorough	None, it is a lake assemblage	Numerous fish from the Green River Formation have been studied since the famous naturalist E.D. Cope	Very relevant for the definition of the structure and composition of the fresh fish communities of Northern America of the first part of the Cenozoic	Good in some quarries for the extraction (e.g. industrial use) of limestone laminates. The extension of the lake sediments of the Green River Formation is immense
CRUSTACEANS	VAL D'ALPONE					
	Pesciara and Mt. Postale	Sites subject to very accurate inquiries	The great biodiversity and abundance of investigated material allow one to make important comparisons with current tropical faunas.	The remains of the Val d'Alpone allow you to get information about global significance for the study of the evolutionary history of crustaceans. Furthermore, the Pesciara site has a fundamental place in the history of paleontology	High	Accessibility to the sites for visits is variable: The Pesciara is open to the public, the other sites are scattered in the territory with limited accessibility
	San Giovanni Ilarione (Italy)					
	Budapest (Hungary)	Site subject to deeper investigation	The abundance and diversity of the remains found allow one to make some comparisons with current fauna	The material found in Budapest has been known for more than a century and therefore has a historical significance, its wealth allows important comparisons with contemporary faunas in other parts of Europe	High	Accessibility is not simple because in the city of Budapest there are often decommissioned quarries. In some cases, the quarries are not recognizable
	Huesca-Aragona (Spain)	Sites not fully investigates	The small amount of remains allows only superficial considerations to be carried out	The remains found in this part of Spain are still scarce therefore they provide more limited information	Medium	Accessibility not always simple
	Palermo (Italy)	Thorough	The remains found confirm the observations already made for western Veneto and Budapest	The remains have made it possible to expand the distribution area of forms already known from western Veneto and Budapest	Medium	No more accessible

CRUSTACEANS	Hampshire Basin (United Kingdom)	Thorough	Faunas that include still existing families	Faunas partly known for more than a century with affinities with contemporary faunas of southern Europe	High	Accessible
	Lillebælt Clay Formation (Denmark)	Thorough	The fauna highlights affinities on a generic level both with the contemporary English ones and with the Italian and Hungarian ones	Fauna known since the 19 th century but investigated only recently	Medium	Accessible
	Bateque Formation (México)	Thorough	Fauna significant as it developed between the North Pacific and Tethys dispersal zone	Fauna analyzed only recently that shows affinity with faunas of the Tethys and the North Pacific	Medium	Accessible
	Nord and South Carolina (USA)	Only a preliminary analysis	Rich and differentiated fauna but known only from preliminary descriptions	Recently described fauna that highlights affinities with contemporary European ones	Medium	Unknown
MOLLUSCS	VAL D'ALPONE Mt. Postale San Giovanni Ilarione Roncà (Italy)	High: well-established species-level taxonomy, in need of modern revision (Mt. Postale, San Giovanni Ilarione, Roncà); well-established modern stratigraphic setting (Mt. Postale), in need of revision (San Giovanni Ilarione, Roncà)	Best means to measures hallow marine diversity during the early-mid Eocene (51-38 Ma): Neotethyan diversity hotspot	Covering the whole radiation of the forerunner of the modern tropical biota across the early and mid Eocene climatic optimum (Mt. Postale, San Giovanni Ilarione) into the Bartonian cooling (Roncà)	High impact of older literature; in need of modern, peer-reviewed international studies	Badly exposed (Postale) Partly exposed (San Giovanni Ilarione, Roncà)
	Paris Basin (France)	High: well-established species-level taxonomy (Grignon), in need of modern revision (La Guepelle)	Best measure of shallow marine diversity during the middle Eocene (SBZ13-SBZ14, ca. 48-40 Ma): N Atlantic	Covering the radiation of the forerunner of the modern temperate biota across the mid Eocene climatic optimum (Grignon) into the Bartonian cooling (Baron, La Guepelle)	High impact of older literature; partly in need of modern, peer-reviewed international studies	Welle xposed (Grignon, La Guepelle)
	Pyrénées-Atlantiques (France)	Low: species-level taxonomy available only as a list in unpublished studies	Best means to measureshallow marine diversityduring the early Eocene (SBZ11, ca. 50-48 Ma): N Atlantic	Covering the radiation of the forerunner of the modern temperate biota across the early Eocene climatic optimum (Gan)	Absent in older literature and in peer-review papers	Unknown (Gan)

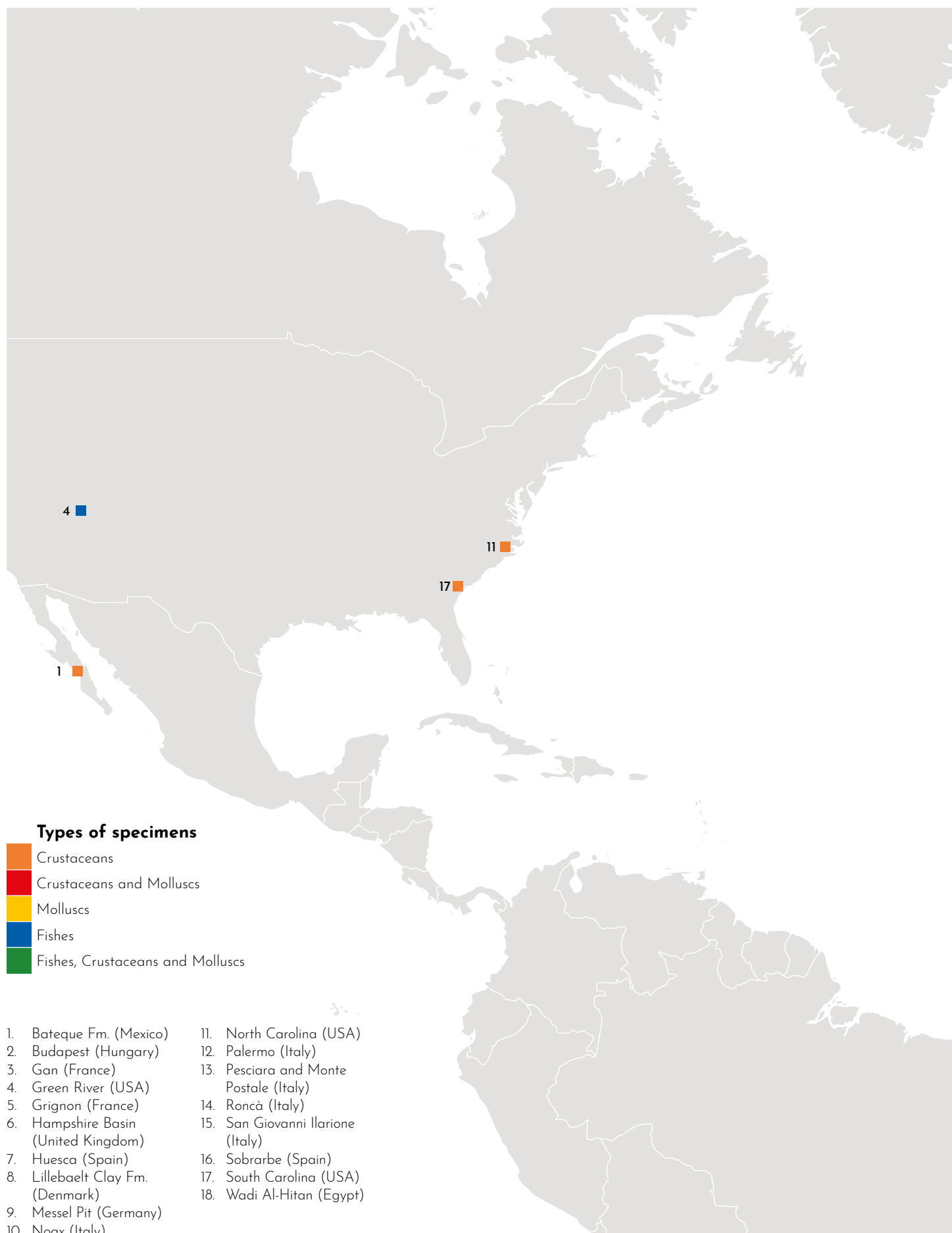
MOLLUSCS	Friuli (Italy)	High: well-established species-level taxonomy, in need of modern revision; well-established modern stratigraphic setting (Noax, Rosazzo)	Best means to measure shallow marine diversity at the passage early-middle Eocene (SBZ12-SBZ13, ca. 48,5-47,5 Ma): Neotethyan diversity hotspot	Covering the radiation of the forerunner of the modern tropical biota across the early-mid Eocene transition (Noax, Rosazzo)	High impact of older literature; in need of modern, peer-reviewed international studies	Partly exposed (Noax, Rosazzo)
	Wadi Al-Hitan (UNESCO Egypt)	Practically zero	Best means to measure shallow marine diversity during the late Eocene cooling (see Peters 2009, doi: 10.2110/palo.2008.p08-080r): Neotethyan diversity hotspot	Covering the radiation of the forerunner of the modern tropical biota during the Priabonian cooling (Wadi Al-Hitan)	Absent in older literature and in peer-review papers	Well-exposed (Wadi Al-Hitan)
	Sobrarbe (UNESCO Spain)	Practically zero	Best means to measure shallow marine diversity during the mid Eocene (see Canudo et al. 2021): N Atlantic	Covering the radiation of the forerunner of the modern temperate biota during the mid Eocene (Wadi Al-Hitan)	Absent in older literature and in peer-review papers	Unknown (Sobrarbe)

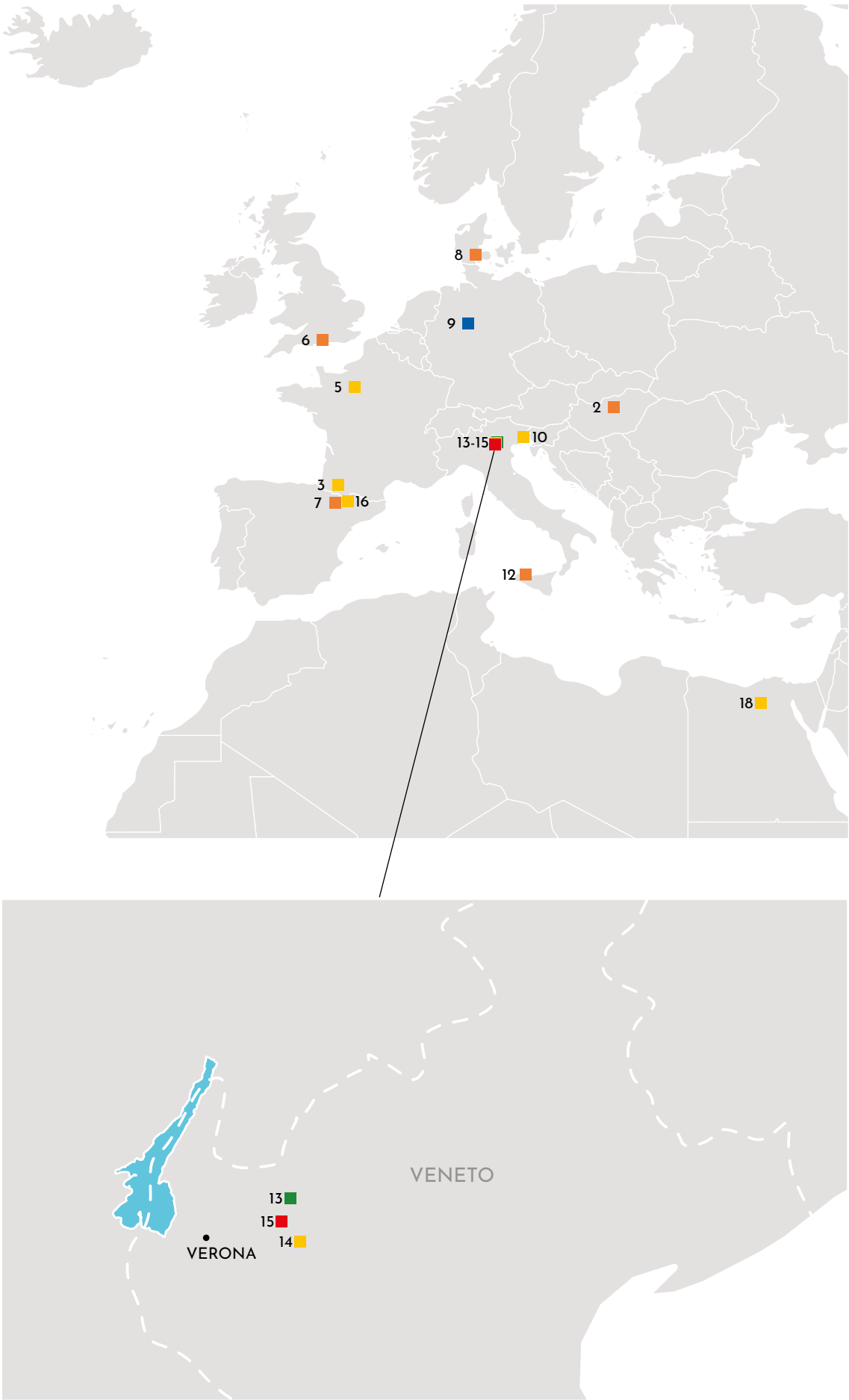


Visita del Comitato Tecnico Scientifico di A.T.S. al Messel Pit Fossil Site (luglio 2022)

4.2

CARTOGRAFIA CON I SITI DI COMPARAZIONE







Sparnodus vulgaris della Pesciara (lunghezza 18 cm)



