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Ulderigo Botti's handbook on stages and sub-stages: a poorly known inventory of the late nineteenth century

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ABSTRACT - Botti's handbook is a poorly known inventory of the stratigraphic units established in the 19th century, written by a contemporary at the end of the century. The handbook constitutes a valuable historiographic source of information on the disorderly process that occurred in the second half of the century for the definition of the stages and sub-stages. The prevailing location of the proposed stratigraphic units in Europe and the increasing number of the introduced names is related to the process of construction of the national geological maps at large scale that took place in the same time. Moreover, Botti's handbook documents the prevailing interest of Italian geologists of the 19th century for the Cenozoic stratigraphy.

Keywords: History of stratigraphy; stages and sub-stages; 19th century.

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1. INTRODUCTION

Stages, the backbone of the chronostratigraphic scale, were primarily introduced in the second half of the nineteenth century. Although many of the stages then established, revised and defined more precisely, are believed to be still valid, the huge amount of terms introduced (about 1000, according to Botti, 1898) created confusion and difficulties at a time when many European countries were grappling with the construction of their first national geological maps at a large scale.

The ratification of the first global stratigraphic scale in 1881, at the second International Geological Congress in Bologna, including the officially approved stages, represents a divide between the pioneering and the modern phases of stratigraphy. Whereas the former was characterized by a disorderly process of defining principles and introducing new units, the latter stand out, on the one hand, by the search of new potential markers and international consensus, through international commissions and committees, and, on the other, by the increasingly complex rules and procedures, also through an ongoing conceptual debate that remains lively today (Aubry et al., 1999; Remane, 2000; Gradstein and Ogg, 2002; Zalasiewicz et al., 2004; Gradstein et al., 2004; Cohen et al., 2013; Pignatti and Papazzoni, 2017).

At the end of the nineteenth century, the need to compile an inventory of the names of the stages hitherto introduced as an useful contribution to geologists and as a premise for a rationalization and correlation, was perceived, almost at the same time, by two scientists, the Swiss Eugène Renevier (1831-1906) and the Italian Ulderigo Botti (1822-1906). These pioneering efforts were preceeded in 1872 by the inventory of Swiss terms by Bernhardt Studer (1794-1887). Renevier published in 1897 the second edition of his "Tableau des terrains sédimentaires" of 1873/4, expanded and accompanied by an explanatory article, "Chronographe géologique", and a "Répertoire stratigraphique polyglotte". Botti, who was apparently unaware of the first edition of the work by Renevier, published his handbook ("Botti U.- Dei piani e sotto-piani in Geologia, Manuale alfabetico ragionato". Adamo D'Andrea, Reggio Calabria) in 1895. In contrast, Renevier took into accout Botti's (1895) work for his "Répertoire" (1897). Botti also produced a second enlarged edition, published in 1898, that strongly draws upon Renevier (1897), with whom, furthermore, he had personal contact.

The two inventories are very different in planning and purpose: that of Botti wanted to be merely a descriptive list prevailingly of stages, with comments. The title of the work, "Dei Piani e Sotto-Piani in Geologia" is accompanied by the subheading "Manuale alfabetico ragionato": it is a an inventory of easy and simple consultation, supplying useful elements for a first approach to the stage /s of the reader's interest, but also

for more detailed studies, through the bibliographic references; in contrast, Renevier attempted to frame all the stage and sedimentary formation names then known within a rational system that would highlight the overlaps and correlations, taking into account the different facies. For this reason, the items considered by the two authors widely differ in number, about 700 (996 in the second edition) in Botti, more than 3,000 in Renevier (1987).

Furthermore, Botti's work was carried out with little resources (perhaps the handbook, in its first edition, was published, entirely or in part, at his own expense), and great difficulty in accessing sources of information, as the author himself admits. In fact, Botti lived in Lecce and Reggio Calabria, two towns of the deep South of Italy far away from the important libraries. Often, the information on stages and substages were derived from secondary sources that were available to Botti, because the difficulty to access all the works in which the stages and sub-stages were established. Conversely, the work of Renevier (1897) ensued from the 6th International Geological Congress (Zürich, 1894), of which Renevier, already founder in 1882 of the Swiss Geological Society, was President and Member of the Commission for the unification of Nomenclature. His work was presented during the 6th session, chaired by Renevier himself, and published as a supplement to the Congress Report.

The "futility" of the great number of the stratigraphic units then produced has been highlighted by Arkell (1956, p. 6), increasing by 6 names his 1933-list of 120 names of Jurassic stages. However, the importance of the Lexicon in stratigraphy and the related catalogues was early recognized by the geological community. Thus, in the International Geological Congress held in 1910 in Stockholm, a Sub-commission for the compilation of an International Stratigraphic Lexicon was created, resuming *de facto* the pioneering work of Renevier and Botti. The alternating vicissitudes of the Lexicon and its sub-commission, that was transferred, after the creation in 1961 of IUGS (International Union of Geological Sciences) to the Stratigraphic Commission ICS-International Commission on Stratigraphy) have been summarized by Reguant (1995). However, it should be noted that until 1977, some 125 volumes were produced, mainly devoted to the names of the stratigraphic units in various countries of the world, issued with the decisive support of the French Centre National de la Recherche Scientifique.

Here, our aim is to re-valuate the handbook of the stages and sub-stages by Ulderigo Botti in the geological context of the time: a work that could have been used more than it probably was, because, presumably, had a limited diffusion, having been printed in a rather small number of copies, in its first edition. Nowadays, most of the libraries of Earth Sciences in the world do not possess Botti's handbook, even in Italy; only a few possess both editions.

2. NATIONAL LARGE-SCALE GEOLOGICAL MAPS AND THE GLOBAL STRATIGRAPHIC SCALE: TWO MAJOR SCIENTIFIC ENDEAVORS IN THE SECOND HALF OF THE 19TH CENTURY

With the publication of the geological map of England in 1815 - an event rightly considered as the starting point for the emergence of geology as an autonomous discipline by Giovanni Capellini (1833-1922), in his inaugural speech at the second International Geological Congress in Bologna (1881) - William Smith (1769-1839) demonstrated the possibility to distinguish rock formations and to correlate them even at a distance mainly by means of their fossils. The number of geological maps at different scales and different regional extension grew in subsequent decades in many European countries, including the Papal States (Laureti, 2011; Matteucci, 2015); in all the major countries of Europe, including Italy, still not unified (see Meetings of Italian Scientists - Capanna, 2014), the need arose for the production of national geological maps at large scale.

On the push of the run-up toward technological progress that characterized in Europe the industrial revolution, the expectation for new mineral resources linked to the acquirement of a systematic and detailed geological knowledge of the national territories was transformed, more or less rapidly in the different countries, in the practical implementation of the national geological mapping.

The impressive increase in the number of stages introduced during the second half of the century, as it appears from Botti's handbook, followed by slight decline in the last decade, testifies to the relationship between the two fundamental contemporary processes of increasing of the geological knowledge, the geological survey and mapping and the construction of the stratigraphic scale.

The project of geological mapping in the different European countries, which entailed a major public financial commitment over a long time-period and the use of a significant work-force and their training in the "écoles des Mines", emphasized the need to increase the knowledge of the stratigraphic meaning of the outcropping rock formations and to have a unified, possibly shared, stratigraphic classification. Through the earliest International Geological Congresses (Paris, 1878; Bologna, 1881; Berlin, 1884), the geological community succeeded in building a shared stratigraphic scale (through the establishment of national committees for analyses and proposals in Paris, the approval of the international stratigraphic scheme in Bologna and the establishment of a stratigraphic international commission in Berlin). This result was possible on the basis both of the then acquired basic concepts of stratigraphic science from prominent scientists (e.g., Steno, Arduino, Werner, d'Orbigny, Oppel, Burckardt, Cuvier, Gressly, Lyell, and others), but also of an intensive work carried out in the previous decades, by a large number of researchers, struggling with an unbelievable puzzle: to establish the horizontal and vertical relationships between the different rock outcrops of the Earth's surface, in a seemingly infinite spectrum

of lithological and paleontological characteristics and geological situations, nearly always problematic from the interpretative point of view.

For this reason, agreeing with Corsi (2003), who considers the process of realization of the national geological maps at a large scale, started and largely completed in the European countries in the second half of the XIX century, as the first example of a "big science" project, we believe that the construction of the stratigraphic scale has been an essential component; indeed, perhaps more properly, it could be considered an example of "big science" project in its own right, both for the enormity of the results, which go far beyond the geological cartographic finalization, such as the reconstruction of the geological history of the Earth and life on it, and the multitude of researchers involved over a long period of time (stratigraphic refinement is still ongoing and still involves, at international level, a multitude of researchers and a stratigraphic international organization).

The stratigraphic research has not had, however, the operational centers (national geological surveys), the significant commitment of resources and the expectations of governments and society, which marked the construction of the national geological maps, although issues related to the history of Earth had, during the 19th century, an enormous popular interest (Hallam, 1983).

3. MAKING ORDER IN THE PUZZLE OF THE VERTICAL RELATIONSHIPS AMONG THE OUTCROPPING ROCKS: THE STRATIGRAPHIC UNITS

The fundamentals of stratigraphy had already been established in the "golden age of geology", the 1790-1820 period, so defined by Adolphe Desmier de Saint Simon, Vicompte d'Archiac (1802-1868) already by the end of the first half of century and later, among others, by Karl Alfred von Zittel (1839-1904) in 1899. Their bases had been put already earlier, both with the law of superposition enunciated in 1669 by Nicholaus Steno (1636-1686) [along with other basic principles, such as those of original horizontality of strata, strata continuity and cross-cutting relationship, as mentioned by Koutsoukos, 2005, at least in part foreshadowed by Leonardo da Vinci (1452-1518) and Georgius Agricola (1494-1555), and with the achieved awareness that there was a stratigraphic order in the outcropping rock bodies tied to the history of the Earth, with the identification of the four-fold subdivision of the crust by Giovanni Arduino (1714-1795), in 1760 and Abraham Gottlob Werner (1750-1817).

In the thirty years from 1790 to 1820, in fact, with the discovery by William Smith of the possibility of characterizing the strata by their content of fossils, correlating outcrops far away through the same fossil content and mapping of the sedimentary sequences, the descriptive stratigraphy began to be considered not only for mining purposes, but also as an instrument for the classification of the sedimentary succession and knowledge of the Earth's history.

In 1842, Alcide Dessalines d'Orbigny (1802-1857), and in 1856, Albert Oppel (1831-1865) introduced the basic concepts of stage and zone.

Recognizing the vertical changes of the fossil assemblages, d'Orbigny, also on the basis of his extraordinarily vast, intercontinental, field experience, exceptional for his times as observed by Rioult (1968), established that the stratified sequence of the Earth could be divided into units characterized by different fossil assemblages, which he called "étages". Because the vertical replacement of the faunas was framed into the catastrophic hypothesis, the succession of stages was evidently associated with a temporal succession. Each stage, also those based on ammonite assemblages, was limited by significant sedimentary discontinuities ("lines de demarcation" between the "successives creations").

D'Orbigny produced, *de facto*, a first global stratigraphic scale, with the Phanerozoic geological record subdivided into 5 periods and 27 "étages" (plus the Recent one: "époque actuelle"), most of which referred to the Jurassic (stages 7 to 16) and to the Cretaceous (17 to 23).

In addition, recognizing the importance of the locality where the "étage" was better represented as an element of comparative reference, he actually introduced the concept of type section ("meilleur type"). It should be emphasized, in our view, that the concept of "meilleur type" is the first expression of the need of the repeatability of the scientific observation (the "mieux" or "plus beaux" type "de gisement" is a well-defined outcrop of a rocky body, tangible and accessible to the hammer of anybody), culturally comparable with the Galilean need of reproducibility of the experiment, cornerstone of the scientific method.

The term zone, moreover, was already used by the same d'Orbigny, often as an alternative to étage, but also as its subdivision based on fossils (d'Orbigny, 1852, p. 426): "... each zone has shown a special fauna, distinct from the ones of the underlying and overlying zones" (from Monty, 1968, p. 697).

Whereas d'Orbigny mainly valorized the discontinuities typical of the marine platform successions, marked by abrupt faunal changes, Oppel based his work on supposed continuous successions with ammonites. Oppel's zones are based on the study of "the vertical distribution of each individual species at many different places ignoring the mineralogic character of the beds" (Oppel, as quoted in Berry, 1987, p. 127). Each zone was characterized by several or many fossil species, one of which usually chosen to be used as the name of the zone. Oppel's zone concept has been quickly acquired as the basis of the modern biostratigraphy, so that, in 1933, Arkell dedicated to Oppel his book on the geology of the Jurassic, recognizing him as the "founder of the zonal stratigraphy." The dedication was shared with William Smith, recognized as the "father of historical geology". However, Oppel's zone conception as "paleontologically identifiable complexes of strata", without (Aubry et al.,

1999; Scott, 2013) or with reference to time (Arkell, 1956; Schindewolf, 1957) has been longly discussed and it is also today, mainly in its dual significance and in its use in modern biostratigraphy (Pignatti and Papazzoni, in press). Anyway, stages are presented by Oppel as "Zonengruppen" and the boundaries between stages are simply boundaries between zones. Oppel's stage concept is asserted by Arkell (1956), who believes useful groupings of zones that "trascend zones horizontally as well vertically and provide a stratigraphic unit of wider use, adapted to inter-continental comparisons and correlations" (1956, p. 7), being the single zones usually considered as having only a regional value.

In addition, in 1838, the concept of facies was introduced by Amanz Gressly (1814-1865), as a result of the fairly widespread awareness that the different types of sedimentary deposits were formed in different depositional environments. As observed by Myall (2004), the diversification of facies both vertically and laterally foreseen by Gressly, "predates the law of the correlation of facies" first proposed in 1894 by Johannes Walther (1860-1937), commonly known as "Walther's law". We also owe to Gressly, considered as one of the founders of stratigraphy (Cross and Homewood, 1997), the distinction between "facies fossils" and "index" or "zone fossils". As evidenced by Middleton (1973), the great influence of Walther's law also resides in the actualistic approach to the study of the sedimentary sequences.

By mid-century, the founding principles of stratigraphy (law of superposition, distinction of the sedimentary deposits both vertically and horizontally, correlation of outcrops far apart through fossils, concept of facies and cultural foundations of the Walther's law) and the elements for a global stratigraphic scale (four-fold subdivision) and its principles, including its dual nature, had been placed. Also the major subdivisions of the stratigraphic scale had been defined by the first half of the century; only three of the Phanerozoic systems were introduced after the 1850: the Neogene and Palaeogene by Moritz Hörnes (1815-1868) in 1853 and Carl Friedrich Naumann (1797-1873), in 1866, respectively (the terms were formally re-introduced by Joaquim Philippe Nery Delgado (1835-1908) and Léon Paul Choffat (1849-1919), in their "Rapport de la Sous-commission portugaise de nomenclature, en vue du Congrès géol. Internat., devant avoir lieu à Berlin en 1884"); the Ordovician by Charles Lapworth (1842 - 1920), in 1879. The framework in which the various rock complexes in their physical and also temporal sequence could be pigeonholed was fully available, even if with several already filled slots, especially by the "étages" of Alcide d'Orbigny.

Although the conceptual fundamentals had been laid, their assimilation and proper use by a number of researchers who worked often on the local geology was uncertain, mainly centered on the real significance of stages. In fact, even after the Bologna Congress, Renevier (1897) attributed to stages only a regional significance, whereas he considered sub-stages (or "assises") without any fundament. Moreover, a certain fluency in the practical introduction of new stratigraphic units was favored by the operating method used for the subdivision of the stratigraphic scale, namely to insert ("impiler", according to Rat, 2006) in each previously defined container (the Erathems/Eras, with the Systems/Periods and these with the Stages/Ages) sedimentary complexes, possibly already well known and with wide regional importance, and giving them global significance. So, in the Cretaceous system, the name of which, given in 1822 by Jean Baptiste d'Omalius d'Halloy (1783-1875), comes from the "craie", a sedimentary complex already well-known throughout Europe, three overlapping lithological levels - "craie chlorite coquillère", "craie marneuse" and "craie blanche" - were the basis for the three of d'Orbigny's stages, the Cenomanian, Turonian and Senonian, the names of which derive from the names of the places of their "meilleur" outcrop.

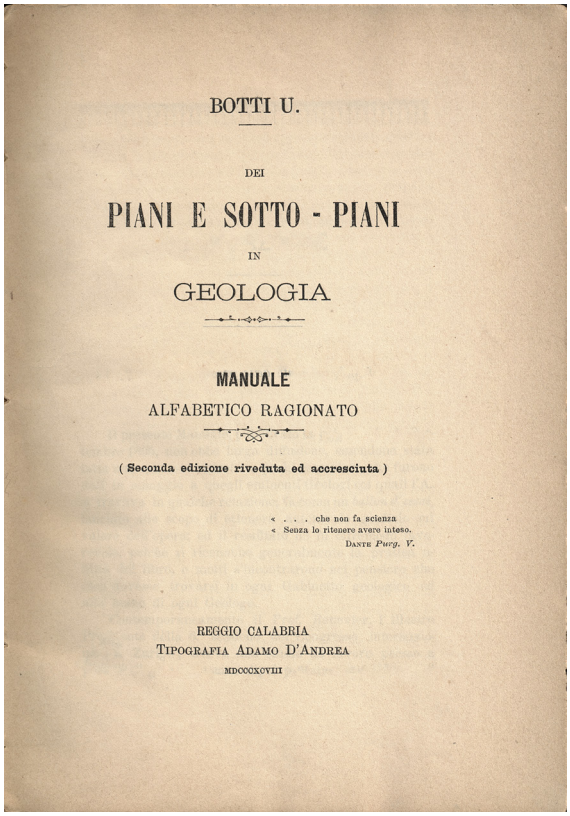
For the subdivision of the Cenozoic, the method introduced in 1833 by Charles Lyell (1797-1875), was quite different: Lyell distinguished periods not on the basis of outcropping sedimentary deposits, but statistically, using the upwards growing number of fossil species whose representatives are still extant.

Anyway, for Botti, the relationship between stage and formation was taken for granted: his handbook describes "the formations to which has been given the name of stage or sub-stage".

In the stratigraphic scale defined at the Bologna Congress (1881), the dual nature of the hierarchical stratigraphic system was clearly marked with the distinction between the codified terms for naming the past geological time periods (Era, Period, Epoch, Age) and the rock bodies deposited in that temporal intervals (Group, System, Series, Stage).The conceptual need to have a set of terms for the rock strata deposited in the same time interval (chronostratigraphic terms) and a different set of terms for the corresponding time intervals (geochronologic terms), already recognized by Oppel, "has been deeply embedded in the language of stratigraphy for more than a century" (Walsh et al., 2004). However, already in 1973, Hedberg believed that the dual nomenclature was unnecessary, even if he stated the opportunity, for simplicity, to retain it. Anyway, the historical use of the term "stage" has been mostly based on an unclear distinction between these conceptual differences; the difficulty of a practical distinction in the use of the term "stage" persists until to day, as evidenced by the discussion around the opportunity of a simplification, even through the abandonment of the chronostratigraphic terms (Harland et al., 1990; Zalasiewicz et al., 2004; Walsh et al., 2004; Carter, 2007).

4. ULDERIGO BOTTI'S HANDBOOK, IN THE TWO EDITIONS OF 1895 AND 1898

The first edition was published in 1895, in a very limited number of copies distributed to the "authoritative


BOTTI U.

DEI

PIANI E SOTTO - PIANI

IN

GEOLOGIA

MANUALE

ALFABETICO RAGIONATO

(Seconda edizione riveduta ed accresciuta)

« . . . che non fa scienza
« Senza lo ritenere avere inteso.
DANTE *Purg. V.*

REGGIO CALABRIA
TIPOGRAFIA ADAMO D'ANDREA
MDCCCXCVIII

Fig. 1 - Title page of Botti's (1898) handbook (II ed.)

geologists" with which the author was in relation, to receive their opinion on the work and on its usefulness, as he wrote explicitly in the preface. The II edition (Fig. 1) received the approval by the French paleontologst Henri Douvillé (1847-1937), who presented Botti's handbook at the "séance du 10 Avril du 1899" of the Société géologique de France.

The author explains the meaning especially of the sub-stage, referring to the decisions of the Congress of Bologna (1881), but feels the need to clarify the relationship between stage, sub-stage and "assise", that, in his opinion, are confused in the literature, and reasonably concludes that the determination of Bologna has to be considered as a hierarchical set: the stage can be divided into sub-stages; the sub-stage can be divided into assises and these latter into strata.

In the second edition (1898), the number of entries rises to more than 900. This significant increase has been possible because Botti learned about the work of Renevier only in its edition of 1897; actually, both Renevier's editions are listed only in the references of Botti's second edition. On the other hand, the two authors came in contact soon after the release of the first edition of Botti's work, as reported in the preface to the second edition.

The fact that, having the entire list of names provided by Renevier, Botti chosed only some of them, is explained as the result of a selection of the names clearly referred to stages and sub-stages, not taking into account the names referred only to formations.

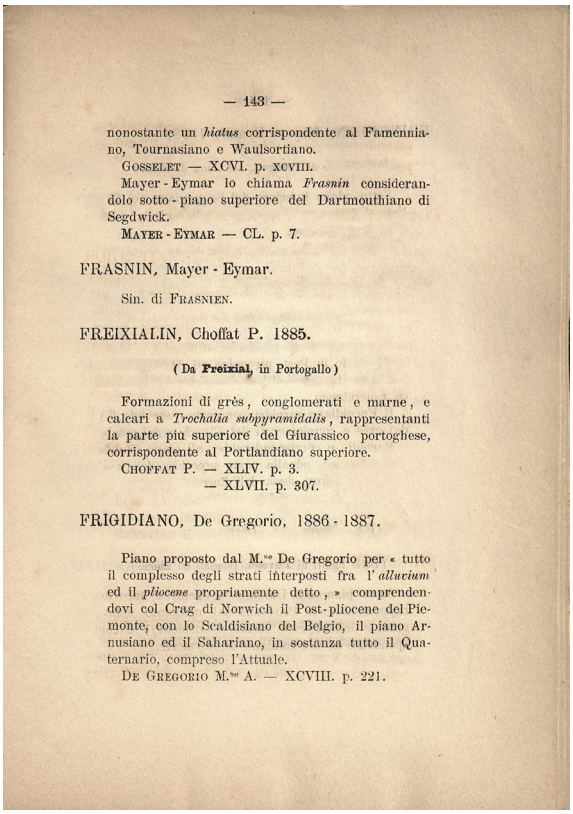
4.1. The preface of the second edition: goals and methods

The preface to the second edition is used by the author to justify its goals on the basis of the approval and consent of the Earth scientists to whom he had submitted the first edition. The author, underlining that Renevier communicated directly to him that he considered his work as not competing with his own, but rather complementary to it, transcribes what Renevier wrote in the preface to his "Répertoire" ("On verra d'ailleurs que les deux publications ne se font point concurrence, car leur plan est trop différent" (Botti, 1898, p. VII). The difference is succinctly but clearly explained by Botti: the "Répertoire" is a comprehensive catalog of all published names of rocky complexes (formations), whereas the "Manuale" only selects the "geological formations to which was given the designation of stages or substages" (all the quoted text, originally in Italian, was translated by the authors); moreover, whereas the work by Renevier gives only the author(s) and the references of the listed items, the handbook by Botti supplies a brief summary ("a small monography"), in addition to the references. The differences highlighted by the author respond to the different objective of Botti's work, i.e., to provide a useful tool for the geologists to orient themselves in the welter of names introduced as new segments of the stratigraphic scale, without the ambition to realize a general interpretative framework; he clarifies that he is aware of the inconsistency or the partial or total overlap of many of the listed stages. As an example, he cites the long list of sub-stages that Karl Mayer (or Mayer-Eymar) (1826-1907) presented at the Fourth Session of the International Geological Congress in London (1888) as an extract of his Cours de Stratigraphie (not published at the date of release of the Handbook); Botti faithfully records them in his handbook, although recognizes their limited success. He underlines also the difficulty of interpreting as stages or sub-stages the many terms with possible stratigraphic significance introduced under different names (e.g., for the same item, Groupe, Système, Assise). He notices, in addition, the low incidence of the resolutions of the Congress of Bologna (1881), which, however, the author tries to follow, also highlighting their lack of clarity, especially as regards the role of the sub-stage.

4.2. The main information supplied by the handbook

As the author states, the handbook is limited to "explain the formations to which the name of stage or sub-stage has been given", highlighting "the essence and chronological graduation" and providing "a small monograph in order precisely to exempt from bibliographical searches those who do not have the chance or the opportunity to resort to the authors, often untraceable even in the largest libraries".

About 700 items are listed in alphabetical order, including, in addition to stages and sub-stages, "the major divisions of the groups, systems and series and the smaller, assises, zones and strata, often not easy to



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nonostante un *hiatus* corrispondente al Famenniano, Tournasiano e Waulsortiano.
GOSSELET — XCVI. p. XCVIII.
Mayer - Eymar lo chiama *Frasnin* considerandolo sotto - piano superiore del Dartmouthiano di Segdwick.
MAYER - EYMAR — CL. p. 7.

FRASNIN, Mayer - Eymar.

Sin. di FRASNIEN.

FREIXIALIN, Choffat P. 1885.

(Da **Freixial**, in Portogallo)

Formazioni di grès, conglomerati e marne, e calcari a *Trochalia subpyramidalis*, rappresentanti la parte più superiore del Giurassico portoghese, corrispondente al Portlandiano superiore.
CHOFFAT P. — XLIV. p. 3.
— XLVII. p. 307.

FRIGIDIANO, De Gregorio, 1886 - 1887.

Piano proposto dal M.se De Gregorio per « tutto il complesso degli strati interposti fra l' *alluvium* ed il *pliocene* propriamente detto, » comprendendovi col Crag di Norwich il Post-pliocene del Piemonte, con lo Scaldisiano del Belgio, il piano Arnusiano ed il Sahariano, in sostanza tutto il Quaternario, compreso l'Attuale.
DE GREGORIO M.se A. — XCVIII. p. 221.

Fig. 2 - A page of Botti's (1898) handbook (II ed.) exhibiting the organization of the entries.

distinguish from the sub-stages, as well as synonyms, equivalents, and so on." (Botti, 1895 p. XI).

In what the author calls "a small monographs", for each entry are given (Fig. 2): name (of stages/sub-stages or other subdivisions), author, year, *derivatio nominis*, a brief description whether or not accompanied by a brief discussion, references and, when the references are more than one, usually a short discussion on the contribution of the cited authors, and, more rarely, a few own observations.

The names of the stages and sub-stages are listed in the original language, as well as the names of localities mentioned in the text, for the author's choice to avoid confusion.

Year of reference and author are often omitted, either for lack of information (as, for example, in the case of the Hyrcannien stage, of which Botti finds mention in a work of Nicholaj Andrusov (1861-1924) published in 1897, or in the case of the most generic terms, which are often only translation synonyms for others (eg. "Attuale", postponed to "Recent" of Lyell). Authors are usually listed by their last name and only rarely the initial of their name is given (there seems to be no specific reason: e.g., in the II edition, d'Orbigny is reported as the author of the Conchylien stage on p. 91 and d'Orbigny A., as the author of the Corallien Stage, p. 93).

The description, often very short (sometimes a couple of lines) provides useful information for the reader, sometimes cross-referring to other item/s of the handbook, always giving the stratigraphic reference, often the most characteristic fossils, as well as geographical and, in some cases, lithological and paleoenvironmental data.

Certain items, considered as most important, such as the Systems, Groups and large depositional complexes (e.g. Flysch, Schlier, Verrucano), considered also for their current stratigraphic attribution, are discussed at length by the author, providing a valuable historical background as well as an examination of the criticisms.

As already mentioned, the second edition, whereas maintaining the same structure, shows an enrichment in the number of entries of about 300 units (296 to be precise), for a total of 996 items.

4.3. Botti's handbook as a historiographical source

Even in the absence of reliable data on the fate of Botti's handbook and its effective practical use by geologists in the last decade of the 19th and in the first half of the 20th centuries, the diffusion of the book probably did not meet his expectations.

However, more than a century after its appearance, Botti's work (and Renevier's) becomes an important historiographical source, both by providing a valuable insight on the stratigraphic research in the 19th century, and as a tool to trace the deep roots of the process that led to the current largely accepted subdivision of the systems/periods into stages/ages.

4.3.1. Geographical distribution

Western Europe was the cradle of stratigraphy. This results also evident from the distribution of the type-localities of the stages and other stratigraphic units defined in the 19th century (Fig. 3a). In fact, even considering only 528 of the names appearing in Botti's handbook (for the other 468, it is neither indicated nor is directly deductible the location's reference), it is noted that 451 locations are European (with a peak for France -153 - followed at a distance, from Great Britain -76-, Germany -74- and Italy -55). Only 96 of them are locad outside of the European continent, with a peak in the North America (52).

The term of GSSP (Global Stratotype Section and Point) has been introduced by Cowrie et al. (1986), a century after the compilation of Botti's catalogue. GSSPs, which define the initiation of each chronostratigraphic interval and the corresponding geochronologic interval for the Phanerozoic and the Latest Proterozoic, require an international consensus, and normally the choice occurs between various outcrops candidates, where the potential markers for global correlation are coincident.

Surprisingly enough, there is a substantial correspondence with location of the GSSPs, signed with a "golden spike", so far ratified or proposed (Fig. 3b) (50 ratified until 2004, 62 in 2013 - *fide* Cohen et al., 2013 - of the 100 stage boundaries illustrated on the ICS International Chronostratigraphic Chart).

According to Ogg (2004), the prevailing Western European location of the GSSPs relates to the historical

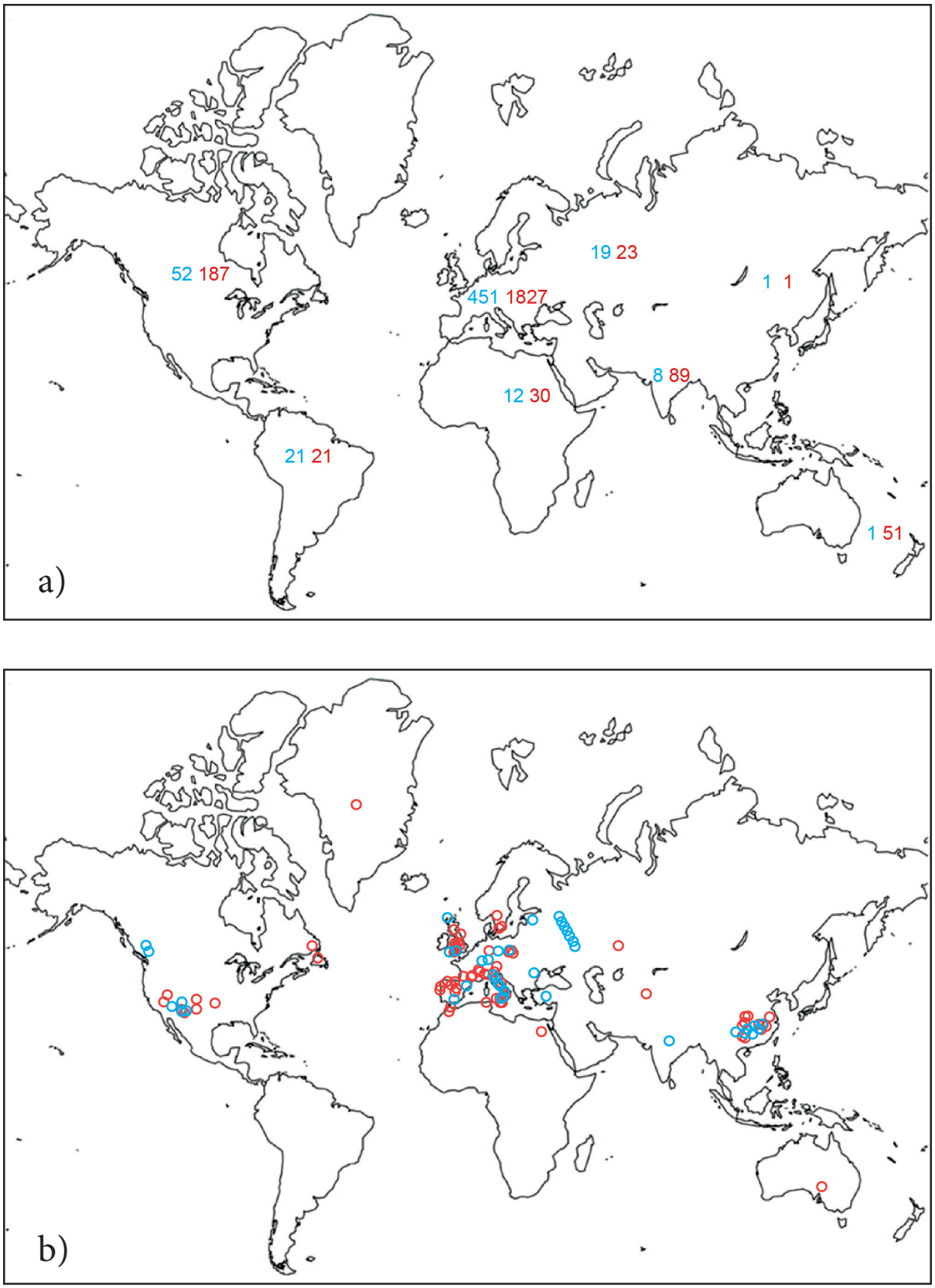

Fig. 3 - Geographic distribution of the reference-localities of: a) the stages and sub-stages listed in Botti's (1898) handbook (blue) and the stages and formations listed by Renevier in 1897 (red); b) the ratified (blue) and proposed (red) GSSPs.

development of the stratigraphic studies, but has been also favored by the good outcrop conditions of fossiliferous sections of the low-latitude shallow seas developed in the area throughout the entire Phanerozoic Eon.

4.3.2. Introduction-timing of the stages

The handbook lists about 200 authors of the stages/ substages or other items. Most of them (164) are limited to one or a few entries (85 authors, 1 entry; 40, 2 entries; 21: 3; 14: 4; 4: 5). The authors of 6 to10 entries are 20. The authors of more than 10 entries are fewer: Renevier (35 entries), Dumont (35), d'Orbigny (23), Mojsisovics (20), Ameghino (17), Thurmann (16), Mayer (15), Dolfuss (14), Murchinson, Munier Chalmas & de Lapparent, de Lapparent, Coquand (13 each), Barrande and Helprin (12 each), Brongniart (11). Only Mayer-Eymar is credited with more than 100 entries (133). Generally, the authors of several stages were experts of one or more intervals of a higher order than the stage. Exceptions are d'Orbigny, Renevier and Mayer-Eymar, who had a general ground plane.

Figure 4 shows the trend over time of the introduction of stages and sub-stages in the 19th century, according to the names listed in Botti's handbook (II edition). The number of the new names introduced substantially increases in the four decades preceeding the two congresses in Paris (1879) and Bologna (1881), exhibits a peak in the 1881-1890 decade and decreases, although remaining relatively high, in the last decade (Fig. 4). The abnormal value recorded in the 1881-1890 decade depends on the large amount of names (133) registered by Botti as introduced by Mayer-Eymar, in his manuscript of 1888. The last period of the century represents the reversal of the trend of establishment of new stratigraphic units, replaced, already in the first decades of the 20th century, by a growing attention to the revision of the existing ones, also trying to ensure them a truly global significance. We have already mentioned the possible relationship between the sharp rise of new names in the decades preceding the Congress of Bologna, with the construction of the national geological maps on a large scale, other than as the natural result of the growing need to give name the different rock complexes and frame them into units with some regional if not global significance.

Also, we should not forget that only around the end of the first half of the century, d'Orbigny and Oppel provided the bases for cultural and methodological reference to the stage and to the zone. In fact, in the early decades of the century, a stratigraphic significance was mainly assigned to the strongly characterized lithologically groups of strata (e.g. "Bituminifère" by d'Omalius d'Halloy (1808), changed by the same author in 1828, in " Anthraxifère ", after the recognition of the true nature of the Carboniferous or Devonian rock outcrops in the Ardennes; or even, "Cristallophyllien", the name given by the same author to the crystalline schists believed to be the oldest rocks of the Earth - even more than the " older granite ", and "whose true nature, the subject of much speculation", according to Botti," perhaps you can never prove it!"). However, in addition to the terms introduced by W. Smith for the division of the Jurassic of England, reported in Botti's handbook, already in 1812 the Purbeckian was introduced by J. Middleton for the uppermost strata of the English Jurassic series, and in 1820, the Parisien (the 25th stage of d'Orbigny), attributed to Georges Cuvier (1769-1832) and Alexandre Brongniart (1770-1840) by Botti. These units can be considered as real forerunners of the stage concept, as introduced a few decades later by d'Orbigny.

4.3.3. Quaternary

The modern difficulties relating to the conception of the Quaternary and its subdivisions (Vai, 1996; Aubry et al., 2005; Gibbard and Cohen, 2008) find their roots in the 19th century, when geologists had to take on the challenge of the interpretation and classification of the depositional products of the more recent history of the Earth, gradually blending from the past to the recent. Of course, the presence of man and his appearance tremendously complicated that challenge, for their cultural and religious conditioning. The different approaches to the most recent period of the Earth's history and to the rocky bodies that document its various phases are reflected by the names proposed for the entire Quaternary and its subdivisions, as listed in the handbook (from the presence of man - e.g.," Anthropique" - and his crucial importance - e.g., "Psychozoic"; "Historique" - to the succession of its products - e.g., "Neolithic" - from the analysis and interpretation of the superficial deposits - e.g., "Alluvial"; " Eluvium "Pre-, Post-glaciaire" - and of their morphologies - e.g.,"Terrazziano" - to their biblical interpretation - e.g., "Diluvial" - from the continental and marine faunas in comparison with those still extant - e.g., "Pleistocene"; "Siciliano" - to the different geographical characteristics - e.g., "Saharien"; "Pampeano").

From the strictly chronostratigraphic point of view, according to Vai (1996, p.vi)" the present state of chronostratigraphic confusion within Quaternary relates to the original Lyell's ambiguious definitions, as well as to proliferation of stage names lacking proper boundary definition". In the entry dedicated to the Pliocene, Botti only register d'Archiac's (1847) description of Lyell's change of position ("The Pliocene was divided by Lyell into New Pliocene or Pleistocene and Ancient Pliocene; but the Pleistocene or Pliostocene was later repudiated by the same Author"); in the entry dedicated to the Quaternary, Botti, whose main research-interest was the Quaternary deposits of Southern Italy, analyzes the issue of the status it deserves ("Quaternary mean literally successive to the Tertiary and then would deserve the value of a Group and would include an Era; but since Lyell, naming it Post-Pliocene, put it together with the overlying Recent to form a post-Tertiary Group, the Quaternary or Post-Pliocene must be considered as the lower System of the Post-Tertiary Group"). The question still remains under discussion (Ogg, 2004; Pillans, 2004;

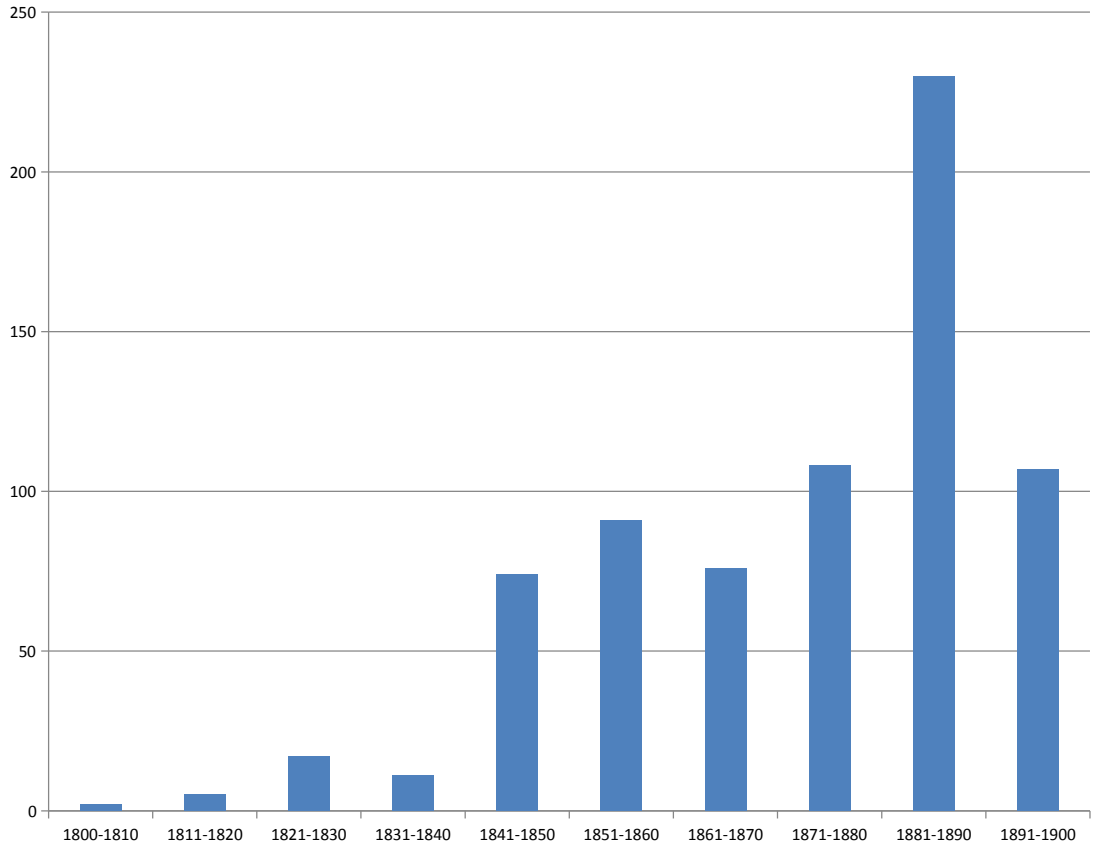

Fig. 4 - Distribution for decades of the rate of introduction of stages and sub-stages, according to Botti's (1898) handbook (II ed.).

Aubry et al., 2005) and is recently complicated by the proposed introduction of a new unit, the Anthropocene, which, according to Gibbard and Cohen (2008)" might be adopted at formal Series/Epoch level, for the time since the start of the Industrial Revolution".

Summarizing the different positions of some authors on the subdivisions of the Quaternary (d'Archiac, de Lapparent, Boule, Rutot, Stella) the author refrains from taking any position, but we can deduce his dissatisfaction about the state of the matter by the favor with which refers to the proposed tripartite subdivision of the Quaternary soils of the North of France by Landrière ("a geologist from Lille"), during a geological excursion in June 1892, bringing order "in the immense chaos of mud, sand and gravel that make up the Quaternary of Western Europe ".

4.3.4. Italian stages and sub-stages

The number of entries (55, unequivocally referred to stages or sub-stages), relating to the Italian territory is quite remarkable, even if far lower than that on the French territory (153). The total number or items (stages and formations) related to the Italian territory recognized by Renevier, is very high (Tab. 1, see Appendix). That large number of entries validates the interest that the Italian territory, particularly the Alps, had in the 19th century in Europe, as also indicated by more than half of the stages registered by Botti originating from non-Italian authors. Next to the names of stages or sub-stages, three items refer to three major sedimentary complexes ("Macigno", "Schlier" and "Verrucano"), of which the author recognizes the problematic state of the stratigraphic attribution, and, contrary to many, of their nature of stratigraphic unit (for the "Macigno" he is totally explicit: it "should be deleted from the stratigraphic nomenclature"). The stratigraphic meaning of the "Macigno", then oscillating between the Cretaceous and the Eocene, is developed also through the entries for the "Etruriano", proposed by Leopoldo Pilla (1805-1848) in 1848, the "Étrurien", introduced later by Lorenzo Pareto (1800-1865) in 1865 and the "Etrurio *sensu stricto*" by Sacco in 1892. Botti furthermore remarks that the "Etrurio" was scarcely used by his contemporaries peers, being generally considered as a synonym of the then most accepted "Ligurien", proposed by Mayer in 1857; Mayer's stage was subsequently criticized at the end of the century by Sacco, who proposed again Pilla's name, albeit in modified form ("Etrurio *sensu stricto*").

The geographical distribution of the Italia stages (Fig. 5) is concentrated in northern Italy, with rare exceptions, demonstrating the peripheral dimension of the southern-central regions at that time. It is noteworthy, also that most of the inventoried stages mainly concern the Cenozoic, including the Quaternary (27 names) and the

Fig. 5 - Geographical distribution of the reference-location of the stages and sub-stages introduced in Italy, from Botti's (1898) handbook (II ed.).

Triassic (12 names). The abundance of Cenozoic stages is related to the abundance and completeness of the Italian outcrops, as confirmed by the numerous of GSSPs ratified or proposed. In the 19th century, the Italian interest in the stratigraphy of the Cenozoic was overwhelming: among the 27 stages/sub-stages registered for the Cenozoic, 15 were proposed by Italian authors, plus the "Ofiolitico", referred to the Miocene by the Tuscan geologist Paolo Savi (1798-1871); those proposed by Italian authors for the Mesozoic are only 7 and the only reference to the Paleozoic is the Verrucano of the Tuscan Paolo Savi. However, of the 16 "Italian" stages proposed in the 19th century which are still in use and whose GSSPs have been already ratified or are under discussion, only three have been introduced by Italian authors: Langhian and Serravallian by Pareto (now the type-locality of the GSSPs of the base of Serravallian, ratified in 2007, is located in the Maltese archipelago); Zanclean, by Giuseppe Seguenza (1833-1889), ratified in 2000.

The Italian authors who proposed new stages in the 19th century are: Leopoldo Pilla: Etrurio (1845); Antonio Stoppani (1824-1891): Raibliano (1860); Giuseppe Seguenza: Zanclean (1868); A. Coppi (1843-1927): Tabiano (1880); Mario Cermenati (1868-1924): Lariano (1890); Guido Bonarelli (1871-1951): Domeriano, Medoliano? (1894); Antonio de Gregorio (1855-1930): Frigidiano, Alpinien, Ghelpin, Grappin (1886-87); Federico Sacco (1864-1948): Fossanien (1886), Gassiniano (1888), Liguriano, Etrurio (*sensu stricto*) (1892); Lorenzo Pareto: Bormidien, Serravallien, Villafranchiano, Langhien, Areneen, Etrurien, Modenais (1865). Moreover, Paolo Savi introduced the Verrucano (1833) and the Ofiolitico (1837).

5. CONCLUSIVE REMARKS

Botti's handbook, as well as Renevier's "Répertoire", is a valuable inventory of the stratigraphic units established during the 19th century, written by a contemporary. Botti's inventory constitutes an important witness to that great collective process which took place mainly in the second half of the century, and led to the first composition of the stratigraphic scale, of which the scheme approved in 1881 at the Bologna International Geological Congress has been a crucial tuning.

Botti's handbook was an important contribution to the geologists of the time, although it was probably less used than it should have. Today, it represents an important historiographical source, available to those who want to deepen their knowledge of the roots and early evolution of the stratigraphic units and their conception, although its limited presence in the geological libraries does not facilitate the access to it.

Finally, the value of the work by Ulderigo Botti should be recognized also in the ligth of the difficult operating condititions in which he achieved it, both financial and limited in access to bibliographic data, as mentioned in the book's preface and shown by some elements of his biography (see Appendix).

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Appendix

Tab. 1 - List of stages, sub-stages and formations with the locality of reference in Italy (from Renevier, 1897). Italicized entries also present in Botti's (1898) handbook. An asterisk identifies the entries present in Botti and missing in Renevier.

***ALPINIEN**, Gregorio A., 1886 Ann. Geol. et Pal.= Aalénien.*
AMMONITICO-ROSSO = Calc. rouge supraliasique d'Italie. Toarcien pelagal.
AMMONITICO-ROSSO SUPERIORE = Tithoniq. à *Pygope diphya* du Vicentin. Portlandien pélagal.
***ANDONIN**, Mayer-Eymar 1881, Class, internat. Terr.; de Andona (Piémont)= Pliocène sup. d'Italie. Astien sup.*
ARDESE-KALK= Calc. triasiq. moy. du Bergamasque. Ladinien.
***ARÉNÉEN**, Pareto 1865, Bull. géol. Fr. XXII, p. 270; de Arena s. Pô (Lombardie) = Plistocène limnal du Bassin du Pô.*
ARGILLE SCAGLIOSE = Argiles écailleuses des Apennins, d'âges divers: Crétacique, Eocène et même Oligocène.
***ARNUSIEN**, Mayer - Eymar 1884, Classif. d. Ter.; du Val d'Arno (Toscane) = Plistocène ancien. Sicilien.*
***ASTIEN**, Rouville 1853, Géol. de Montpellier, p. 185 = Sables d'Asti (Piémont). Pliocène sup.*
AZZAROLA (Dépôt de 1'), Stoppani = Rhétien supér, des Alpes lombardes.
***BADIOTISCH**, Mojsisovics,1869, Verhandl. geol. Reichsanst.; d'un anc. peuple du S Tyrol = Raiblien (1860).*
BARDELLONE = Marne schisteuse du Crétaciq. sup. prés Florence (Toscane).
BARDIGLIO = Marbre triasiq. métamorphique des Alpes Apuennes (Toscane).
BESANO (Scisti di) = Schiste bitumineux à poissons triasiques du Lac de Lugano. Ladinien.
BIANCONE = Calc. blanc des Alpes italiennes. Néocomien pélagal.
BOLCA (Calc. de Mte) = Calc. à poissons éocène du Vicentin. L u t é t i e n *inférieur.*
***BORMIDIEN**, Pareto 1865, Bull. géol. Fr. XXII, p. 220; de Bormida (Piémont) = Oligocène supér. à Num. intermedia. Rupélien.*
BRENDOLA (Marn. de) = Eocène sup. à Bryozoaires du Vicentin. Bartonien supérieur.
CADIBONA (Lignit. d.) = Gisement à *Anthracotherium* de Ligurie. Aquitanien.
***CASSIANON**, Mayer-Eymar 1888, Tabl. Ter. séd. = Carnien inf. Raiblien.*
CASTEL-ARQUATO (C. d.) = Pliocène moy. de N Italie. Plaisancien.
CASTEL-GOMBERTO (C. d.) = Oligocène sup. du Vicentin. Rupélien.
CEPPO = Alluvions anciennes interglaciaires de Lombardie. Sicilien ?
***CORDEVOLISCH**, Mojsisovics 1895, Ac. Wis. Wien CIV; du Cordevole (S Tyrol) = Zone à Trach. Aon. Raiblien inf.*
GIGERGHINA = Grès grossier du Macigno d. Toscane. Oligocène ?
CORNETTONE, Villa 1844 = Flysch calc. à fucoïdes de la Brianza (N Italie). Crétacique ?
CROSARA (Calc. de) = Eocène sup. récifal du Vicentin. Bartonien supérieur.
DEFENDENTE (Dolom. de Sn) = Calc. dolomitique du Lac de Come. Trias sup.
DOLOMIA PRINCIPALE = Hauptdolomit. Calc. dolomitique à *Megalodon Guembeli* des Alpes lombardes. Juvavien.
***DOMÉRIEN**, Bonarelli 1894, Giur. et Lias Lomb. (Acad. Turin XXX); de M.te Domero (Alp. lombardes) = Pliensbachien sup.*
DURGA-KALK = Calcaire récifal liasique de Vénétie et Sarthe. Pliensbachien.
***ESINIEN**, Suess (fide Botti). Niv. de Esino. Ladinien.*
ESINO (Calc. di) = Trias moyen + récifal et pélagal du Lac de Côme. Ladinien.
***ETRURIEN**, Pareto 1865, Bull. géol. Franc. XXII, p. 215 ; de l'Etrurie (Italie) = Macigno de Toscane. Tongrien ?*
****ETRURIO**, Pilla 1845. Da Etruria o Toscana.*
****ETRURIO (stricto sensu)**, Sacco 1892.*
***FASSANISCH**, Mojsisovics 1895, Ac. Wiss. Wien CIV; du Val Fassa (Tyrol) = Unter - Norisch. Ladinien inf.*
***FOSSANIEN**, Sacco 1886, Bull. géol. France XV, p. 27; de Fossano (Piémont) = Pliocène saumâtre marno-sableux du Piémont. Astien supérieur.*
***FRIGIDIANO**, Gregorio 1886, Att. soc. Tosc. Mem. VIII, p. 221 = Glaciaire. Plistocène.*
GALESTRI ou **ARGILLE GALESTRINE** = Crétacique ? argileux de l'Apennin.
GARDA-KALK= Calc. ammonitifère du Cap San Vigilio (Lac de Garda). Aalénien.
***GASSINIEN**, Sacco 1888, Att. Ital. sc. nat. XXXI, p. 291; de Gassino près Turin = Bartonien.*
***GHELPIN**, Grégorio 1886, Ann. Géol. Pal.; de Ghelpa (Vicentin) = Dogger inférieur.*
GORNO (Str. di) = Schistes à *Gervilia bipartita* du Bergamasque (N Italie). Raiblien.
***GRAPPIN**, Gregorio 1886, Mem. Acad. Turin XXXVII; de Mte Grappa (Vénétie) = Aalénien.*
GREZZONI = Calc. triasiques des Apennins et des Alp. Apuennes (Italie). Conchylien ?
***GROEDENON**, Mayer-Eymar 1888, Tab. Ter. séd. = Vosgien infér. Werfénien.*
GUGGIATE (Schist. de) = Rhétien infér. de Lombardie.
****INFRA-LIGURIANO**, Issel A. 1887.*
***JULISCH**, Mojsisovics 1896, Ak. Wiss. Wien CIV; des Alpes Juliennes (Tyrol) = Zone à Trachycer. aonoides. Raiblien.*
***KARNISCH**, Mojsisovics 1869, Verh. geol. Reichsanst., p. 65; des Alpes Carniques. Partie du Trias super., alpin, crue alors la + récente, interverti depuis par l'auteur (voir p. 574). Raiblien.*
***LADINIEN**, Bittner, 1892, Jahrbuch Reichs. XLII, p.387; des Ladini anc. People de S Tyrol= Et.sp. du Conchylien.*
***LANGHIEN**, Pareto 1865, Bull. géol. Fr. XXII, p. 229; des collines Langhe (Piémont) = Miocène moy. du Piémont. Burdigalien (Voir p. 561).*
***LANGOBARDISCH**, Mojsisovics 1895, Akad. Wissen. Wien CIV; de Longobardia, Lombardie = Zone à Trachy. Archelaus. Ladinien.*

***LONGOBARDISCH** Mojsisovics,1895*
***LARIANO**, Cermenati,1890 Sin. Larisch:*
***LARISCH** OU **LARIEN**, Mojsisovics 1869, Jahrb. geol. Reichs.; du Lario, Lac de Côme = Calc. De Esino (Lac de Côme). Ladinien ± récifal.*
LAVERDA (Marne de) = Nummul. supér. du Vicentin. Tongrien (s. *str.)?*
***LIGURIEN**, Mayer-Eymar 1857, Verh. Schw. Nat. Ges. Trogen, p. 182 = Flysch de Ligurie et des Alpes. Tongrien (s. str.).*
***LIGURIANO (stricto sensu)** Sacco, 1892.*
***MACIGNO** = Grès fins du Flysh. Tongrien (s.str.).*
MAJOLICA = Marbre blanc des Alpes lombardes. Malm ou Néocomien ? suiv. les lieux.
***MATÉRIN**, Mayer-Eymar 1877, Bull. geol. Fr. V, p. 2 9 3; de Matera (Ligurie) = Messinien supérieur. Pliocène inférieur.*
MATTAJONE (ital.) = Marn. bleues subapennines. Plaisancien.
MEDOLIANO, Bonarelli? (da Medolo, Monte Domaro in Val Trompia, Brescia*).
***MENDOLIN**, Mayer-Eymar 1888, Tabl. Ter. Sédim. de Mendola, près Lecco (Alpes lombardes) = Balatonien sup. Ladinien.*
***MESSINIEN**, Mayer-Eymar 1867, Cat. Foss. Mus. Zurich, 2e cah., p. 13; de Messine (Sicile) = Pliocène ancien. Prépliocène (voir. p. 560).*
***MODÉNAIS** OU **MODÉNIEN**, Pareto 1865, Bull. géol. Fr. XXII, p. 216; de Modène (Italie). Ligurien à Fucoid. de l'Apennin. Tongrien (s. str.).*
MOLTRASIO (Calc. di) = Lias infér. du Lac de Côme. Sinémurien.
MONTECCHIO - MAGGIORE (Calc. di) = Oligocène infér. du Vicentin. Tongrien pélagal.
***MORTOLIN**, Mayer-Eymar 1888, Tabl. Ter. séd.; de la Mortola pr. Menton = Bartonien sup., plutôt Lutétien.*
***NICEEN**, Pareto 1865, Bull. Soc. geol. Fr. XXII, p.211 de Nice (Alpes marit.) = Nummulitiq. De Nice. Lutétien.*
***OFIOLITICO**, Savi P., 1837 (dal greco ofis serpente, lithos pietra).*
PANCHINA = Calc. coquillier plistocène de Toscane. Sicilien.
***PARETIANO**, Trabucco 1894, Mem. Soc. Tosc. XIII, p. 221; d'après Pareto = Eocène sup. ou Oligocène inf., Niveau de Priabona.*
PERLEDO (Calc. di) = Schisto-calc. triasique à poissons, du Lac de Côme. Ladinien inférieur.
PIETRA-COLOMBINA = Calcaire de Toscane. Crétacique ?
PIETRA-FORTE = Calc. à bâtir de Florence. Crétacique supér. ou moyen.
PIETRA-SERENA = Grès à bâtir de Florence. Crétacique.
***PLAISENCIEN**, Mayer, 1857 (da le marne turchine di Piacenza).*
PLEUROTOMES (Marne à) = Miocène sup. de N Italie. Tortonien.
POSTALE (Calc. di Mte) = Nummulitique infér. du Vicentin. Suessonien pélagal.
PREZZO (Calc. di) = Trias moyen de Lombardie. Virglorien pélagal.
PRIABONA (Calc. di) = Eocène sup. à *Orbitoides* du Vicentin. Bartonien sup. Pélagal.
***PRIABONIEN**, Munier et Lapparent 1893, 3e* édit*. Trait. géol., p. 1219 = Eocène sup. alpin. Bartonien supérieur.*
***RAIBLIEN**, Stoppani 1860, Pal. lomb. 3E s., p. 226, 229; de Raibl (Carinth.) = Et. inf. du Trias supérieur; Carnien (s.str.) 1869 (v. p. 574).*
***RECOARON**, Stur in Mayer-Eymar 1888, Tabl. Ter. sédim.; de Recoaro (Vicentin) = Balatonien infér. Virglorien.*
ROSSO-SUPERIORE = Tithonique à *Pygope diphya* du Vicentin. Portlandien inf. pélagal.
ROVERE-DI-VELO (Calc. di) = Titonico bianco du Lac de Garda (Lombardie); transition du Portlandien au Berriasien pélagaux.
SABLES SERPENTINEUX = Miocène de la Superga, près Turin. Helvétien.
SALESE = Verrucano du Val Trompia (Bergamasque). Permien ?
SALTRIO (Marmo di) = Calcaire liasiq. de la Brianza (Lombard.). Pliensbachien ?
SANGONINI (Et. d.) = Oligocène inf. de Vénétie. Tongrien *(s. str.).*
SASSO-MORTO ou **PIETRA-MORTA** = Macigno de Toscane *(pars)*. Oligocène ?
***SERRAVALLIEN,** Pareto 1865, Bull. géol. France XXII, p. 232; de Serravalle (Apennin piémontais) = Miocène moyen du Piémont. Helvétien.*
SERVINO = Grès et Poudingue triasique inf. des Alp. italiennes. Werfénien littoral.
***SICILIEN**, Doderlein 1872, Not. s. Cart. géol. de Moden., p. 14; de Sicile = Brèche coquillière de Palerme. Plistocène ancien ; pour plusieurs Pliocène supér. (Voir p. 559*).
SIRONE (Poud. di) = Conglomérat à Rudistes de la Brianza (Lomb.) Turonien ?
SPILECCO (Calc. di Mte) = Calc. À *Num. bolcensis* du Vicentin. Suessonien pélagal.
STAMPI (Calc. degli) = Infralias à *Conchodon* du Lac de Côme. Hettangien.
***STAZZANIN**, Mayer-Eymar 1888, Tabl. Ter. sédim.; de Stazzano pr. Tortona = Marne à Pteurotoma. Tortonien supérieur.*
***SUBAPENNIN**, Orbigny 1852, Cours* élém*. Pal., p.800; des collines subapennines (Italie) = Pliocène (s. str.). Plaisancien + Astien.*
SUPERGA (Sabl. d. la) = Miocène arénacé serpentineux de Turin (Piémont). Helvétien littoral.
***TABIAN**, Doderlein 1870, Cart. géol. Modène = Marnes bleues subapennines. Plaisancien*
***TABIANO**, Coppi, 1880 (da Tabiano, villaggio nel parmigiano)*
TERRAIN CALCARÉO - TRAPPÉEN, Brongniart 1823 = Nummulitiq. du Vicentin. Eocène.
***TERRACIEN** ou **TERRAZZIANO**, Sacco F., 1886, Atti Acad. Torino XXIX, p.40 Graviers des Terrasses post-glaciaires di Piémont. Acheulien (1878).*
***TORTONIEN**, Mayer-Eymar 1857,Verh. Nat. Ges. Trogen (Tabl.); de Tortona (Italie) =* Étage *sup. du Miocène (s. str.).*
VARENNA (Marmo di) = Marbre noir triasique du Lac de Côme. Virglorien.
***VERRUCANO**, Savi; de M.te Verruca (Toscane) = Permien schistoarénacé, souvt poudinguiforme, de N Italie et des Alpes.*
VIGGIU (Calc. di) = Calc. gris de la Brianza (Pointe S du Tessin). Lias.
VIGILIO-OOLITH = Dogger inf. du Cap Sn Vigilio (Lac de Garda). Aalénien surtout.
***VILLAFRANCHIEN**, Pareto 1865, Bull. géol. Fr. XXII, p.262; de Villafranca (Piém.) = Pliocène sup. limnal. Sicilien.*
***ZANCLÉEN**, Seguenza 1868, Bull. géol. Fr. XXV, p. 465; de Zancla, Messine (Sicile) = Marnes blanches à Foraminifères, etc., de Sicile et Calabres. Plaisancien inf. ou Prépliocène pélagal.*
ZOVENCEDO (Lign. de) = Lignites à *Anthracotherium* du Vicentin

ULDERIGO BOTTI - BIOGRAPHICAL NOTE

Ulderigo Botti was born in Montelupo Fiorentino, near Florence on June 4, 1822. He graduated in law in Pisa, and became a magistrate in 1848; his choice of an administrative career, rather than judicial led him, in 1868, to Lecce, where he spent most of his life. His passion for geology and prehistoric archeology, cultivated from an early age, found a territory, the Salento, almost completely unexplored. His first essays, published in local magazines, aroused the interest of local cultural organizations, then very active. That interest, in particular by the provincial Archaeological Commission, took the form of assignements and financing. The discovery of some productive caves (especially the Devil's Cave, discovered along with Giovanni Capellini, rich in the Bronze Age artifacts, and Cardamone cave, rich in remains of Pleistocene vertebrates, visited and studied by distinguished scholars (such as C.F. Major, R. Vaufrey, G. De Lorenzo, G. D'Erasmo and G.A. Blanc), gave him a certain international repute, culminated in the participation in the II international Congress of prehistoric archeology and anthropology in Brussels (1872).

In the following years, Botti improved the knowledge of the geology of the Salento, contributing to the publication of the geological map of Otranto by Cosimo de Giorgi (1842-1922), in 1874, and, above all, created the Museum of Prehistory and Natural History, for his collections, but also for the materials due to the activity of the Archaeological Commission, led by a passionate amateur, duke Sigismondo Castromediano (1811-1895).

The creation of the museum was mainly due to "his industriousness, his generosity in spending to buy books and scientific material, his great love for science, his practical expertise in knowing how discern the useful and the good, acquired through his continuous field trips and frequent visits to Italian and foreign museums" (De Stefani, 1906).

The fate of the Museum was inextricably linked to Botti. In fact, after his move in 1880, first to Cagliari, then, finally, to Reggio Calabria, the Museum gradually "was left to itself without direction and without any surveillance, to the mercy of visitors, and many of them devastated it with that simple-minded and vulgar cynicism that characterizes our Athenians of Puglia, they christened it with the disparagingly nickname of Botti's ossuary" (De Giorgi, 1907). Fortunately, some of the most important collections, including the fauna of the cave Cardamone, were saved, transferring them in the Cabinet of Natural History at the Technical Institute O.G. Costa.

The last period of life of Ulderico Botti in Reggio Calabria is poorly known; he continued his museological activities, but also his research on the field. Of course, we put at this time the development of his "Manuale", the realization of which had to be accomplished with great difficulty, as evidenced by in his original letter sent to the French prehistorian Emile Cartailhac (1845-1921), reproduced in Figure A.

Ulderigo Botti took his life in Reggio Calabria, on June 25, 1906. De Stefani wrote (1906): "... his passing, as far as I foresaw as a fatal consequence, I would say, of his ethics, leaves a very painful and lasting impression."

In explaining the reason for his relatively poor scientific production, compared with his complete dedication to research, De Stefani (1906) gave us a significant portrait of his personality and his qualities. His scarce inclination to publish "happened for a kind of hesitation that he experienced always in his scientific opinions, together with a certain natural modesty which induced him to believe to be lesser than everyone. I would affirm that, in this sense, he was one of those men of the old school, which to a great value accompany a great modesty. Passionate to science, he never asked, in exchange for his long studies and great love, other reward than his moral satisfaction".

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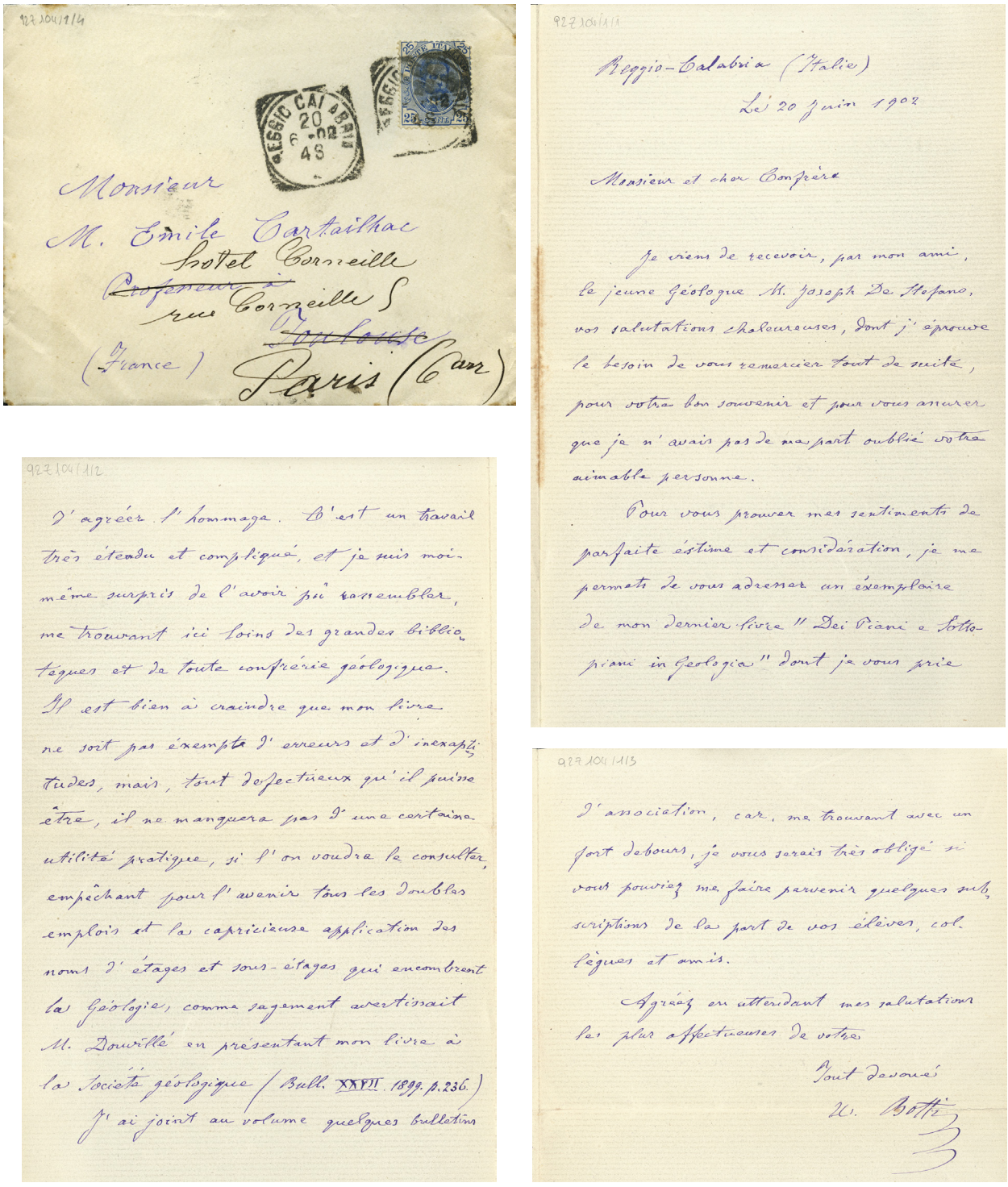

Fig. A - Botti's letter to the French prehistorian Emile Cartailhac, accompanied by a copy of his handbook in homage, and some "subscription bulletins" to be distributed to students, colleagues and friends "because I find myself with a strong anticipated expenditure". From: http://tolosana-univ-toulouse.fr/archives/92z-104-1