Graphic design and scientific research: the INGV experience

Daniela Riposati[1], Giuliana D'Addezio[2], Francesca Di Laura[1], Valeria Misiti[2], Patrizia Battelli[3]

[1] Istituto Nazionale di Geofisica e Vulcanologia, AC, Via di Vigna Murata 605, 00143 Rome, Italy

[2] Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Sismologia e Tettonofisica, Roma1, Via di Vigna Murata 605, 00143 Rome, Italy

[3] Istituto Nazionale di Geofisica e Vulcanologia, ONT, Via di Vigna Murata 605, 00143 Rome, Italy

Correspondence to: Giuliana D'Addezio (giuliana.daddezio@ingv.it), Via di Vigna Murata 605, 00143 Rome, Italy

1. Abstract

One of INGV's primary activities is the production of resources concerning educational and outreach projects in Geophysics and natural hazard topics. This activity is aimed at transferring periodically to the public the forefront results of ongoing research through an intense and comprehensive plan of scientific dissemination. Over the past 15 years, graphic and visual communication has become an essential tool for supporting institutional and research activities. In this paper we describe successful INGV's team experiences resulting from a close relationship and collaborative work between graphic designers and research scientists. The main goal of the projects devoted to the general public, such as the creation of a museum exhibition or the production of descriptive brochures, is to support scientist in getting their message through, making concepts fruitful and easier to understand, but also fully enjoyable, thanks to the emotional involvement that visual images may generate. Through a careful composition of signs and images, and through the use of different visual tools (colors, form, lettering) on different media (print, video, web), the graphics and editorial products together create a strong "INGV style" identity, making it easily recognizable in any educational and outreach project. A full project product package might include a logo or other artwork, organized text and pure design elements such as shapes and colors, which serve the purpose of unifying the whole set. Color is used not only to help the project logo to stand out from the international overview, but in our case also to generate a unifying return across all INGV sections. A recent and highly stimulating experience concerned the creation of edu-games, specifically designed for scientific dissemination, through a close collaboration between INGV graphic designers and their reference scientific community. The edu-games were designed as an effective combination of educational content and playful communicative aspects, leading the young players to learn while having fun.

2. Introduction

The Istituto Nazionale di Geofisica e Vulcanologia (INGV) is one of the largest research institutions worldwide for Geophysics, Geochemistry, Seismology and Volcanology. In addition to its scientific and technological activities, INGV pays special attention to projects focusing on education and outreach by promoting a number of initiatives, such as publications for school students and for the general public, scientific exhibitions and dedicated Internet pages.

The *Laboratorio Grafica e Immagini* (hereinafter *Laboratorio*) is INGV's reference structure for graphic and visual communication, supporting institutional and research activities. Since 2001 the *Laboratorio* has been playing a crucial role as a partner of INGV's scientific community, and is now a reference structure for the creation of any visual design institutional products. In this work we present some of the *Laboratorio*'s products, highlighting how this activity were leaded with a positive interaction between researchers and graphic designers. We start describing the managing of the institutional identity, the INGV style, starting from the new INGV logo. Then we present case histories related to the creation of corporate identity of research projects. In fact, in consideration of the ever increasing emphasis on the value of graphics in grant proposals (National Science foundation, 2004), the *Laboratorio* provides advanced graphics support for any materials required by the main European research projects infrastructures and partnerships involving INGV, such as SPACE EARTH, EMSO-ERIC, TSUMAPS-NEAM, IAPG, AGITHAR, FIERI, SaveMedCoast. The *Laboratorio*'s support for editorial productions is combined with the development of original web layouts dedicated to the representation of issues relating to Earth Sciences and to their dissemination. In this respect we will briefly discuss the ScienzaInsieme project.

As already mentioned, special attention was given to specifically designed layouts for education and outreach projects. In this contest we present our experiences in the production of edu-games as part of editorial products for scientific dissemination. Over the years the activities of the *Laboratorio Grafica e Immagini* have been restructured into a conceptualization, design and implementation phase of materials used for ordinary and institutional purposes, for exhibitions, for demonstrations and for special events, including science festivals (e.g. D'Addezio et al., 2014; D'Addezio et al., 2015; Rubbia et al. 2015). With respect to this latter category of events we present some excerpts from INGV's multi-annual participation in the Festival della Scienza di Genova, an unmissable appointment for all science enthusiasts, and from the New Space Economy European ExpoForum, held in Rome in December 2019

3. The partnership between graphic design and scientific research

The main task of *Laboratorio* is finding the correct relationship and cohesion between the interpretation of the scientists work and graphic design using the proper images and products. Our goal is to elaborate appropriate solutions to transfer purely scientific information, addressing the messages not only to the pertinent scientific community but also to the general public, looking for the right compromise in the graphic work between the scientist message and the visual design. But what do we mean by graphic design? What is graphic design, and why it is so important for graphic composition in scientific communication? Graphic design is the process of communicating visually and of solving communications issues- through the correct use of typography, space, images and colors. Graphics attracts viewers, and graphic designers use various methods to combine words, symbols, and images to create a visual representation of ideas and messages.

The importance of communicating complex ideas with clarity, precision and efficiency, avoiding ambiguities and confusion, was initially developed in the field of data visualization and information design (Tufte, 1983). In this field, graphical excellence is what gives the viewer the greatest number of ideas in the shortest time, with the least ink in the smallest space (Tufte, 1983). A graphic designer may use a combination of typography, visual arts and page layout techniques to produce the desired final result. Common uses of graphic design may include corporate identity, publications, posters, website graphics and elements, and product packaging. For example, a product package might include a logo or other artwork, organized text and pure design elements such as images, shapes and colors, all of which serve the scope of unifying the piece. Composition is one of the most important features of graphic design, especially when using pre-existing materials or various elements.

In visual scientific communication, common uses include the development of the institutional identity of research bodies and scientific projects, the preparation of publication layouts or posters for scientific meetings, web communication, and the design of the entire visual communication strategy of exhibitions aimed at the general public (from the logo, to the structure of the panels, all the way to gadgets and web promotion initiatives).

In any case, the opted of the graph is to operate a constant mediation between the scientific concept to be represented, and the visual form that can represent it more clearly.

4. The INGV style

The approach outlined above has already been used for many INGV productions, thus contributing to the creation of an INGV "identity" that is strongly characterized in terms of style, a sort of brand that is highly recognized by the scientific community. This identity has played an important role both in the creation of both products aimed to a specific target audience and more general purpose projects. The most important among the latter is certainly the restyling of the INGV logo.

4.1 The new INGV logo

In consideration of the almost thirty-years life of the INGV logo, in 2018 we proposed its restyling, to be accomplished by simply modernizing the previously adopted, well established image.

The INGV logo is formed by a graphic portion and by an accompanying text. For the lettering we adopted the modern and clean DIN Pro Bold Consented font in gray 90%, used in small/caps, which replaces the previous Arial bold black 100%. The graphic part represents schematically the Earth, a globe strongly characterized by lines representing the parallels and the meridians; the core element has therefore returned to a simpler sphericity, accentuated by the chromatic nuance. This new core image has already entered a number of new editorial projects and has been used on the occasion of several national and international events (see Figure 1). We will return to this later on.

4.2 The INGV anniversary

One of the most important events that involved the *Laboratorio* was the INGV twentieth anniversary in 2019.

We considered very carefully the structure of a logo for the event, starting from the analysis of its keywords: - twenty years, - geosciences - travel / future. An overview of the visual communication strategies used for publications dedicated to geosciences revealed that the most frequently used images concerned geologic stratigraphy (i.e. rock layers), and subordinately mountain ranges (i.e. www.usgs.gov; www.mdpi.com/journal/geosciences; www.agc.org.au). We hence decided to develop a graphic project starting from the INGV logo and adding a horizontal sign that is reminiscent of the stratigraphy and represents the separation between before and after, above and below: it also resembles an arrow indicating a movement towards the future, thus obtaining a strong, yet nondidactic "symbolic" element. The yellow color evokes the preciousness of gold on special occasions. We then developed the coordinated images, adapting them to the various materials provided for the event (internal signage, presentations, web promotion, gadgets). The logo turned out to be very versatile and easy to adapt to different types of reproduction and available spaces, while preserving its visual integrity (Figure 2).

5. Corporate identity of research projects: case histories

5.1 SPACE EARTH - www.spacearth.net

The *Laboratorio* constructed the entire branding for SPACE EARTH, an INGV spin-off company: a team of engineers, physicists and geologists with a long experience in research and business management. The company aimed to add value to the results of more than 60 years of experience on Space Earth designs; it develops applications, software and hardware products for the aerospace, maritime and environment industry, in cooperation with major European and Italian public and private organizations, universities and research centers.

The Space Earth Technology logo was conceived to graphically summarize the content of the message: "Space-Earth-Technology". To this end we adopted familiar forms such as two intersecting circles, representing the Earth and the space that surrounds it at first, later on moving to a more in-depth interpretation of the relationship between the Space Earth Technology project and INGV, the area that allowed the project to be born and developed.

Chromatically, we chose a single color, the "iconic blue of the sky", to state the mission of the company and add an emotional value to the pictogram.

Even the chosen lettering is simple, linear, sans serif, to recall once again the modern technological aspects of the company's mission and to endow the logo with further immediacy, making it easy to decipher and therefore to remember (Figure 3).

5.2 EMSO-ERIC - www.emso.eu

The European Multidisciplinary Seafloor and water column Observatory (EMSO) aims to explore the oceans, to gain a better understanding of phenomena occurring within and below them, and to explain the critical role that these phenomena play in the broader Earth systems. EMSO is a consortium of partners sharing scientific facilities (data, instruments, computing and storage capacity) in a common strategic framework. Formally it is a European Research Infrastructure Consortium (ERIC), a legal framework created for pan-European large-scale research infrastructures.

The main contribution of the *Laboratorio* on the construction of the brand of this very important infrastructure was a "textual" intervention: the acronym "ERIC" was introduced in an already existing logo. For this text we adopted the same color nuance used in the gestural element of the EMSO log. This solution allowed us to link the different parts with a simple but extremely effective interpolation: there existed a significant risk of "untying" among the various components, which would have certainly weakened the resulting artwork. A whole series of products have therefore been designed and manufactured under the new brand EMSO-ERIC (Figure 4; Dañobeitia, et al., 2019).

5.3 TSUMAPS-NEAM Project - www.tsumaps-neam.eu

Tsunami risk assessments and warning systems need Probabilistic Tsunami Hazard Assessment (PTHA) as input and reference. The TSUMAPS-NEAM project developed the first homogeneous long-term PTHA for earthquake-induced

tsunamis, that was unavailable for the coastlines of the NEAM region (NE Atlantic, the Mediterranean, and connected seas) until just a few years ago. TSUMAPS-NEAM is also promoting an informed process of outreach, guideline definition, and capacity-building through dedicated initiatives. The development of standardized PTHA products (hazard and probability curves, maps, documentation, web-tools for their analysis) is the first step to include also tsunamis in multi-hazard risk assessments.

In designing the logo of the project, we focused on a limited number of specific elements, deliberately moving away from the classic graphic representation of a tsunami: the wave. We believe that focusing on different elements allowed us to achieve a more original and therefore highly recognizable creation: the stylization of the "hands" to signify the help that the scientist may give to the investigation and forecast of tsunami serves this specific goal. The choice of colors was focused on how to separate anthropic from natural elements; therefore, a full orange was associated with human elements, while blue with was used for natural elements. The fusion of the two colors in the intertwining of the hands, which is meant to represent the scientific cooperation, gives life to a transparency that increases the desired effect (Figure 5).

5.4 International Association for Promoting Geoethics (IAPG) - www.geoethics.org

IAPG is a multidisciplinary scientific platform that was created to foster awareness and promote discussion about Geoethics issues, i.e. about questions of and ethics related to the Geosciences. IAPG promotes geoethics through international collaboration with several associations and institutions. All its activities have been supported by the *Laboratorio* for many years.

The inception of Geoethics indeed represented a breakthrough in the Geosciences. For this reason, its graphic identity had to be based on a strong, easily recognizable image: for this reason, we started our design work from the logo, which would then form the basis for all products of the "new brand". We focused on interaction between human activities and the Earth system: the use of circular elements and their concentricity gave us the possibility of creating a substantially spherical solution, with a core where patterns and textures were concentrated to represent social diversity, representing a stylized point of intersection between Sociology, Philosophy, Economy, and Geosciences.

Over time, the combination of these concepts have given rise to a number of different products (Figure 6).

5.5 Accelerating Global science In Tsunami HAzard and Risk analysis (AGITHAR) - www.agithar.uni-hamburg.de

AGITHAR is a network created to promote, improve and standardize tsunami research. We therefore concentrated on a graphical reinterpretation of a tsunami wave, combining colors, shades and textures with the goal of playing down the idea of danger, which is dealt with by introducing different colors both for the lettering and for other graphics. The proposal is easily expandable, given the size of the box that contains all graphic elements, and can therefore be used in standard web pages and in a wide range of applications, such as those foreseen in the coordinated image (Figure 7).

5.6 FIERI

FIERI (Forum for International cooperation among Environmental Research Infrastructures) is an international open platform for improving global, coordinated and long-term cooperation between Research Infrastructures and Networks in the environmental domain. In creating the logo, we planned to stress the "connection aspect", a sort of synapse that connects to the Earth, forming a sort of global network. As for the colors, we focused on a very green, modern and bright idea, which also guided the choice of the lettering (Figure 8).

5.7 SAVEMEDCOAST - www.savemedcoasts.eu

SAVEMEDCOASTS aims to respond to the need for reducing human and material losses potentially arising from natural disasters in the coastal zones of the Mediterranean Sea. This region is experiencing a fast rise of sea level as a result of climate changes, coastal land subsidence, tsunamis and storm surges impacts. The focus of the project are all coastal

zones that may suffer from sea level rise. Its main objective is to promote the awareness of different stakeholders concerning the potential effects of these phenomena.

Having in mind this background, in the designing the project logo we adopted a combination of wave icons and anthropic elements, which we strongly stylized and differentiated using color. For the lettering we used a rather squared *sans-serif* font, accompanying it in the leaflet with a more versatile font from another family.

The *Laboratorio* created many products for this project. In this respect, the diversification of the logo was fundamental: finding the most suitable solution easily allowed us to speed up the identification of the new "brand" by the reference scientific community (Figure 9).

6. WEB PRODUCTS: relating with the Earth Sciences and with their dissemination to the general public

6.1 SCIENZAINSIEME - www.scienzainsieme.it

The ScienzaInsieme project was meant to build a portal to be shared by a number of national research bodies and Universities, with the aim of creating a long-lasting tool for advertising scientific dissemination events. Therefore, we have chosen to adopt pictographs elements that are evocative of both *science* and *sharing*.

Infinity is a very ancient and very commonly used symbol, whose birth is explained in many different ways, all related to the ideas of quantity, time and space. The symbol of the inverted eight - associated with alchemy, Hermeticism and Gnosticism - as a variant of Ouroborus, the snake or dragon that eats its tail, represents the theory of eternal return, the cyclical nature of all things. It is attributable to all that can be represented through a cycle which, after reaching its end, starts again from the beginning, to infinity. It was first found in an ancient Egyptian funeral text, written in the Pharaoh Tutankhamun tomb.

Its origin in Roman times is attributable to the use of the CI letters, Roman numerals indicating "a large number".

As a mathematical symbol (∞ - lemniscata) it was first adopted in 1655 to identify a very large number, just because those two eyelets they can be endless paths.

Finally, it may be reminiscent of the *analemma*, a diagram used in astronomy to show the position of the sun as seen from the same location on Earth at different times of the year. It is a path that always begins and ends in the same point, thus representing "The eternal time, coming and going".

Starting from the study of this symbol in its perfect geometries, we chose to deform one of the two mirror parts to create two communicating sets, through which the contents mix to give shape to a new entity, in a virtuous and infinite circle of sharing and creation (Figure 10).

7. Editorial products: the interaction between graphic design and scientific production for science and scientific dissemination

7.1 The annual report of the High Pressures-High Temperature Laboratory for experimental geophysics and volcanology

In recent decades, the dizzying development of knowledge on material science has made it possible to build tools that are capable of reproducing the conditions that control the dynamics of chemical-physical processes inside the Earth's. Among these processes, those relating to seismicity and magmatism-volcanism are of particular economic and societal importance for the number of victims and the extent of losses they may cause. In this context, INGV developed the Laboratory for High Pressures-High Temperature Laboratory for Experimental Geophysics and Volcanology (HPHT Lab).

The *Laboratorio* created the editorial graphic project of the Annual Report of the HPHT Lab. The report is aimed essentially at an audience of professionals, and is considered an excellent combination of graphic design for disseminating geoscience research knowledge, including its forefront results (Figure 11).

7.2 School calendars

A significant part of the work of the *Laboratorio* is focused on the achievement of scientific dissemination through different projects and media. For example, we recently celebrated the tenth anniversary of a very successful initiative: the publication of a yearly calendar dedicated to the primary schools, that was designed to support and integrate the outreach activities conducted for over fifteen years in the school environment (D'Addezio, this volume). The graphic design was aimed at producing an "object" that would gather all 10 calendars under a common heading: The Planet Earth, 10 years with the Earth seen by the children. (Figure 12).

8. Edu-games

Over the past few years, much attention has been devoted also to the production of scientific games, or "edu-games": an efficient combination of educational contents and playful communicative aspects, designed with the aim to let children and youngsters learn while having fun.

Among these projects, Escape Volcano, Mareopoli, Catch the Plate and Geo-trivial stand out for the interest and success they generated. Following is a brief summary of these three edu-games.

8.1 Escape Volcano

The game was designed for transferring basic information on volcanoes, and their eruption styles and on the associated environmental and earthquake risks (Di Nezza et al., 2020; Misiti et al., 2019). The game is formed by a plastic 1.6 x 2.0 m billboard which represents a volcano with its magmatic chamber. Small chambers, ten in total, are located along the conduit up to crater. The goal of the game is to reach the crater before the volcano starts erupting, passing different tests. Four tokens, representing small volcanoes, are located in the magmatic chamber. The game requires a minimum of two and a maximum of four competing teams. To move from one chamber to the next one the players must roll a dice. The faces of the dice report the tests that players have to pass. The game has been designed and built with the cooperation of some high school students in the frame of the Italian Ministry of Education "Alternanza Scuola Lavoro" project.

The design and construction phase involved the analysis of the idea developed by the students, a study of the target audience, and the evaluation of problems possibly arising from the actual production of the game. We also considered the practicality of its use, striving to make it easy to handle, easily transportable and reproducible even with simple and economic means.

The centerpiece of the game is a large format billboard, designed to allow at least 20-25 players to participate simultaneously. As it is not a self-explanatory game, it is necessary to emphasize its visual aspects so as to enhance emotional impact on the participants. Therefore, we have chosen to stylize homogeneously the whole set, from the game board to its various components, including cards, the 3D pieces along with their assembly boards, the dice and the rules, using pastel colors and a playful graphics that suit the taste of the youth target audience.

The sinuous forms we used to represent the volcano refer directly to classical iconography, however deprived of the didactic aspect and of any scientific reference, but aimed to highlight the playful character of the instrument. We have chosen to characterize the various parts of the game through icons, deliberately winking at social ones, to seek a familiar connection in the visual baggage of today's kids, which would make the involvement in the activity even more fluid. Even the typographic choices have been oriented in this sense. The use of a calligraphic character (Princess Ivy) in the main titles of all game components strongly connotes the aspect of the game and is dictated by the need to create a dominant visual element conveying a sense of dynamism, freedom, but also lightness. The main trait of calligraphic characters is precisely to have the graces and to exhibit very elaborate and pronounced ascendants descendants, thus recalling handwriting and creating a more "artistic and emotional" perspective. This, however, is done at the expenses of readability, which we supported through explanatory texts written with a simpler font (Rotis serif). We assigned great importance also to the use of the black color, aiming to make the entire game appear more "for adults" before the eyes of pre-teens to avoid making them feel treated as young children: a very childish appearance could indeed have created a

preconception in adolescent participants, thus reducing the effectiveness of the message and they ability to appropriate the information (Figure 13).

Over the past few years the game was successfully presented in different Italian events:

1) L'Aquila (Abruzzi) in the frame of SHARPER 2019, a large science dissemination event for the European Research Night funded by the EU. Three laboratories have been conducted in three hours, totaling about 200 participants ranging in age between 6 and 18;
2) A special event for teachers organized in the frame of Visit Museum Grand Tour project held in Rome in 2018 (about 100 participants);
3) Open day 2019 at INGV with 7 laboratories and about 200 participants;
4) National Geographic Science Festival 2019 in Rome, with 63 laboratories in total (the duration of the event was of 7 days), and about 1600 participants;
5) Isola di Einstein 2019, held in the Umbria region, an international event involving researcher from all around the world, with about 150 participants.

In occasion of the Open day 2019 at INGV, we have collected 59 questionnaires compiled by participants ranging in age between 9 and 11. The questionnaire investigated the general activities impact, including the Escape Volcano game. The 93% of respondents found the game very interesting. The game was very easy to understand, very helpful and very well organized for the 63%, 74% and 71%, respectively. Only one participant found the experience difficult to understand.

8.2 Mareopoli

The game was inspired by the famous board game MONOPOLY. It was assembled in two formats: a bigger version to be used by groups in recreational-scientific laboratories, and a smaller version to be used as a gift for participants and as a take-home message (Locritani et al., 2018).

The game describes scientifically the phenomenon of tides, along with a summary of historical theories on their origin from the times of Ancient Greece to the end of the 18th century (Taramaschi, 2013). For centuries many scholars tried to understand and interpret this phenomenon. The game quotes Aristotle and Eratosthenes among the oldest who attempted to explain them, but also other eminent seventeenth century scientists, such as Galileo Galilei, up to the physicists who put forward modern theories, such as Newton and Laplace. Finally, the game provides scientific information on cross-cutting issues related to the tides, including their use as a source of renewable energy and the problem of protecting the ecosystems and their biodiversity.

Mareopoly is the result of a continuous interaction between researchers and graphic designers: working together made scientific concepts simpler to understand and allowed them to be translated into direct and captivating images. The most important historic and scientific topics have been simplified into the fundamental concepts underlying them while maintaining a common conceptual and stylistic approach. Most of the drawings are two-dimensional, although some shading is used to introduce a sense of background, perspective or motion. Nevertheless, we attempted to keep drawings as simple, plain and clear as possible, in order to convey definite ideas more effectively. All illustrations were made in the *Laboratorio* with painting techniques (Figure 14).

8.3 Acchiappa la Placca (Catch the Plate)

This game as simple as it is addicting. Children and adolescents in the age range 11 to 16 years will always be able to play smoothly under the guidance of an instructor.

First all participants divide themselves up into teams made up of a minimum of two players. The team with the youngest player will start, rolling the dice. Each roll determines which card or token must be drawn, and consequently the actions to be carried out:

1) *EARTHQUAKE CARD*
2) *VOLCANO CARD*
3) *TECTONIC PLATES CARD*

The objective of the game is to get the highest score by placing the largest number of tectonic plates, earthquakes and volcanoes. The game is thought to teach children and people how the earth moves, and what the Earth crust is made of.

EARTHQUAKE CARD

A card with an earthquake epicenter is drawn and delivered. The goal is to guess where the epicenter should be placed, based on questions shown on the card: placing it correctly yields 3 points, but if the team requires an extra clue to guess, it gets only 2 points (if the answer is correct). You can also give your turn to the competing team, which by answering correctly will get 1 point.

VOLCANO CARD

A volcano made of das (a synthetic modeling paste similar to clay) is delivered. The goal is to guess where to place the volcano based on the application shown on the card: placing it correctly yields 3 points, but if the team requires an extra clue to guess, it gets only 2 points (if the answer is correct). You can also give your turn to the competing team, which by answering correctly will get 1 point.

TECTONIC PLATES

Major tectonic plates are 15 in total. Players will have to draw a plate from a basket and place it correctly on the board. If the team misses the plate, it is put back into play. Guessing the plate immediately yields 3 points (Figure 15).

Acchiappa la Placca is a new game that has been tested less extensively than "Escape volcano", but that can be easily downloaded from the new Educational platform of the INGV website. Two versions can be currently downloaded: Italian and English. The game was tested during the "Isola di Einstein" event held in the Umbria region in September 2019, with an audience of about 30 people of different age.

8.4 Geo Trivial

The latest product created by the *Laboratorio* within the edu-games is the GEO-Trivial. We all know that games have the power to ignite imagination and place you in someone else's shoes or situation, often forcing you into making decisions from perspectives other than your own. This makes them potentially powerful tools for communicating, through their use in outreach, research dissemination, and education at all levels, but also as a method for training practitioners, decision makers and the general public into building environmental resilience.

In creating Geo Trivial we essentially revisited the classic Trivial, thus producing a real scientific game but also a tool to learn more about the amazing world of geosciences while having fun. This new game belongs to a INGV editorial project (Games in Geosciences) dedicated to education and outreach (see Figure 16: notice that this activity is still in progress).

The game was presented at the Virtual EGU congress and, because of the immediate interest by the researchers, we decided to load it on the new Educational platform of the INGV. Due to COVID19 we have not yet had the possibility to test the game in a school or during other events, but we are ready to do it as it will be possible to do it.

9. GRAPHIC DESIGN AND SCIENTIFIC RESEARCH

9.1 INTERACTIVE EXHIBITIONS

9.1.1 Il pianeta dei cambiamenti. La tettonica delle placche: una teoria rivoluzionaria (The planet of changes. Plate Tectonics: a revolutionary theory) - Festival della Scienza di Genova 2018

Celebrating the 50th anniversary of Plate Tectonics Theory, one of the most important scientific acquisitions of the twentieth century, this exhibition aimed to tell its fundamental steps, along with the discoveries and intuitions that built

its intellectual and disciplinary credibility. Its enunciation followed a golden age for the discoveries in the Earth Sciences, helped the scientific community to accept the basic ideas underlying the drift of the continents, and laid the foundations for a change in our perception of the dynamics of our planet. By bringing together results from various disciplines, the theory has unveiled many aspects of how the Earth works, transforming the Earth Sciences forever.

Based on this background, the study of the logo has focused on the Earth and its complexity: the geometric elements may remind you a puzzle, something that is continuously formed and destroyed just like the Earth, a planet that is always on the move.

The exhibition was set up at the prestigious premises of Palazzo Ducale in Genoa, which, precisely because of their uniqueness and beauty, allowed us to set up a venue of great impact (Figure 17). Over the 8 days of opening the exhibition welcomed the 2505 visitors with a composition of light and colors, the key elements of our interpretation, which accompanied the public throughout the journey. Indeed, the exhibition was remarkably successful as highlighted in the guestbook comments, some of which underline the excellence of the graphic design (D'Addezio, 2019).

The exhibition is having an editorial follow-up, in the form of an Exhibition Catalog; a real book that tells a story of changes, and that has recently been released. On the one hand, they are changes of our planet, a living and constantly evolving environment. On the other hand, they are changes in the way of considering, seeing and explaining our planet; changes that for over two thousand years of history have guided man in understanding the mechanisms that govern the evolution of the Earth. Figures 17 and 18 show the exhibition logo and some associated materials (panels, gadgets etc.), plus photos of the exhibition and a visual summary of the Catalog.

9.1.2 Terremoti: attenti agli elementi! Dettagli che salvano la vita (Earthquakes: beware of the elements! Details that save lives) - Festival della Scienza di Genova 2019

This exhibition was created by the *Laboratorio* on the occasion of the Festival della Scienza di Genova 2019 and in 10 days of opening welcomed 1066 visitors. The exhibition is now being brought throughout Italy with a very busy schedule (Grottaminarda, Varese, Milano, L'Aquila etc.). Its aim is to illustrate good practices to prepare for earthquakes and increase citizens' awareness on the continuous evolution of the Earth and of the environment.

In the frame of an interactive journey, visitors discover how the different elements that make up a building react to earthquake shocks, and what is the potential role of the ground on which our houses are built.

Our graphic project started from the choice of a sort of "vintage" style, that would result in a modern but not too minimalist appearance. Our goal was to create a communication style that is familiar and intimate, rather than cold, institutional and authoritarian, so that the message could be conveyed in an empathetic and welcoming fashion and that the main concepts could be perceived more willingly.

The dominant color is orange, that was chosen as a sort of "communicative compromise"; unlike red, which is generally evocative of an emergency, orange recalls cheerfulness, sociability, vitality and renewal. It therefore seemed perfect for this popular exhibition ,where dynamism is synonymous with awareness and action. The icon of the house is the dominant element, together with the crack in the ground and the oscillating chandelier, now part of the collective imagination related to earthquake risk. The ultimate objective of our visual project was to produce a playful visual communication that, together with the negative aspects of natural risk, recalled also the importance of being aware of the fragility of the structures around us and of the rules of behavior, which can save lives: in fact, these rules are the focus of the exhibition.

Figures 19 and 20 show the main products associated with this project, along with the exhibition booklet and some photos of the set-up.

9.1.3 New Space Economy Forum

INGV recently participated in the first NSE European Expoforum - Italian edition (Rome, December 2019), a point of reference for all companies that operate in the Space sector, but also and above all for all those companies that populate the New Space market: universities, research centers, SMEs, and innovative enterprises.

We have chosen to characterize our exhibition space by focusing strongly on a single visual element: an image of a volcanic eruption from space. This central element was then differentiated on the scientific products, flyers and gadgets created specifically for this event (Figures 21 and 22).

10. Discussion

Visual culture has become a prominent part of the cultural identity of the XXI century, and consequently, it has become also a fundamental tool for communicating science. Regrettably, so far visual material has generally been treated as an add-on, instead of being an integrated part of the whole, and little has been done in the way of identifying target audiences and refining specific visual elements for each of them (Rodríguez Estrada and Davis, 2014; Khoury et al., 2019).

Standing on the shoulders of INGV, one of the largest scientific institutions worldwide, we strived to overturn this course of things. This work represents for us a first synthesis that relate and describe the interaction and the synergy between graphic designers and researchers in a common research work. Our experience demonstrates that science communication becomes much more effective when it is supported by visual communication, i.e. when it incorporates elements of the theory and practice of the discipline of design. In this respect, the INGV experience that we presented in this paper highlights the enormous potential of a living interaction among scientists, graphic designers, and all the elements comprising visual communications. Over the years, our *Laboratorio* has developed into a fundamental component in the dissemination of scientific information, for the benefit of the general public and in any didactic context.

11. Author contribution

Daniela Riposati is the Coordinator of the *Laboratorio Grafica e Immagini* (Graphics and Images Laboratory) of INGV. She contributed to this work by doing research on the visual aspects of all activities presented and on their contents, with the aim of creating a homogeneous and usable product. She also did most of the writing.

Giuliana D'Addezio is the Coordinator of the *Laboratorio Attività con le Scuole* (Schools Activity Laboratory) of INGV. She cooperates closely with the *Laboratorio Grafica e Immagini* and contributed to this work by doing research on the interaction of graphic design in scientific dissemination and writing part of the text.

Francesca Di Laura is a fundamental component of the *Laboratorio*. She contributed to the general approach to the activities presented and to the writing.

Valeria Misiti is a volcanologist who provided scientific support for all the edu-games created by the *Laboratorio*.

Patrizia Battelli is a new entry of the *Laboratorio*. She contributed to the drafting the paper with her presence and her valuable advice, and helped in the general review.

12. Acknowledgements

The authors wish to thanks all colleagues who supported and sponsored their activities over the years. Their continuing support has made it possible to achieve the results shown here. We are especially indebted with Angela Chesi and Sabrina Palone, two colleagues who shared this trip with us for quite a few years. We also thanks Gianluca Valensise for the constructive revision which improved significantly the manuscript.

13. References

Dañobeitia, J.J., Bardaji, R., Basset, A., Beranzoli, L., Berry, A., Blandin, J., Cannat, M., Carval, T., Coppola, L., Del Rio Fernandez, J., Delory, E., Embriaco, D., Favali, P., Fredella, M.I., González Aranda, J.M., Gillooly, M., Giuntini, A., Gourcuff, C., Hartman, S. , Iudicone, D., Kutsch, W., Lanteri, N., Llínas, O., Magnifico, G., Marinaro, G., Materia, P., Miranda, M., Petihakis, G., Pfeil, B., Piera, J., Pouliquen, S., Radulescu, V., Rodero, I., Ruhl, H., and Sarradin,

P.M.: A European Marine Research Infrastructure Strategy for an Integrated and Sustainable Ocean Observation System. OCEANOBS' 19 Hawaii, 2019.

D'Addezio G., Rubbia G., and Marsili A.: The experience of ScienzAperta, a week of scientific information and dissemination. Eng. Geol. Soc. Terr., 7, 103-107, 2014.

D'Addezio, G., Giordani, A., Valle, V., and Riposati D.: 100 years after the Marsica earthquake: contribute of outreach activities. Geoph. Res. Abs. 17, EGU2015-13401-1,2015.

D'Addezio, G.: Il libro dei commenti di mostre scientifiche temporanee: analisi e prospettive, In: Studi empirici di educazione museale, edited by A. Poce, Edizioni Scientifiche Italiane, Napoli, ISBN 978-88-495-4063-5, 2019.

D'Addezio, G.: 10 years with planet Earth essence in the primary school children drawings. This volume.

Di Nezza, M., Misiti, V., and Di Laura, F.: Escape Volcano: un nuovo gioco geo-scientifico. Miscellanea in press, 2020.

Khoury, C.K., Kisel, Y., Kantar, M., Barber, E., Ricciardi, V., Klirs, C., Kucera, L., Mehrabi, Z., Jhonson, N., Kabin, S., Valiño, A., Nowakowski, K., Bartomeus, I., Ramankutty, N., Miller A., Schipanski, M., Gor,e A. M. and Novy, A.: Science–graphic art partnerships to increase research impact. Commun. Biol., 2, 295, 2019. https://doi.org/10.1038/s42003-019-0516-1

Locritani, M., Garvani S., Di Laura F., Merlino S. and Talamoni R. Giocando verso uno sviluppo sostenibile: il contributo della sede INGV di Porto Venere nella realizzazione di giochi didattico-scientifici. Miscellanea 39,2017.

Misiti V., Di Nezza M., Di Laura F., Cafarella L., and D'Addezio G. (2019). ESCAPE VOLCANO: a new game on volcanic hazards. Geoph. Res. Abs. 21, EGU General Assembly 2019.

National Science Foundation. A guide for proposal writing, https://www.nsf. gov/pubs/2004/nsf04016/start.htm, 2004.

Rodríguez, E., Fabiola, C., and Lloyd S. Davis: Improving Visual Communication of Science Through the Incorporation of Graphic Design Theories and Practices Into Science Communication. Sci. Comm., 37 2015 https://doi.org/10.1177/1075547014562914.

Rubbia, G., D'Addezio, G., Marsili, A., and Carosi, A.: Science and scientists from the children point of view, an overlook from drawings. Geol. Soc. London, Spec. Publ.419 (1), 161-170. http://dx.doi.org/10.1144/SP419.11, 2015.

Tufte, E.R.: The Visual Display of Quantitative Information. Graphics Press: Cheshire, CT, 1983; pp 1-197.

Figure 1. Above: the original INGV logo, dating back to 1986. Below: the logo revisitation of 2018. Copyright Laboratorio Grafica e Immagini INGV.

Figure 2. Products created for the 20th anniversary of INGV in 2019. Copyright Laboratorio Grafica e Immagini INGV.

Figure 3. The logo designed and created for the Space Earth spin-off and its modifications for the project brochure. Copyright Laboratorio Grafica e Immagini INGV.

Figure 4. The *EMSO-ERIC* logo and its modifications in some associated products (congress stands, totems, posters). Copyright Laboratorio Grafica e Immagini INGV.

Figure 5: The coordinated image of the *TSUMAPS-NEAM* project. Copyright Laboratorio Grafica e Immagini INGV.

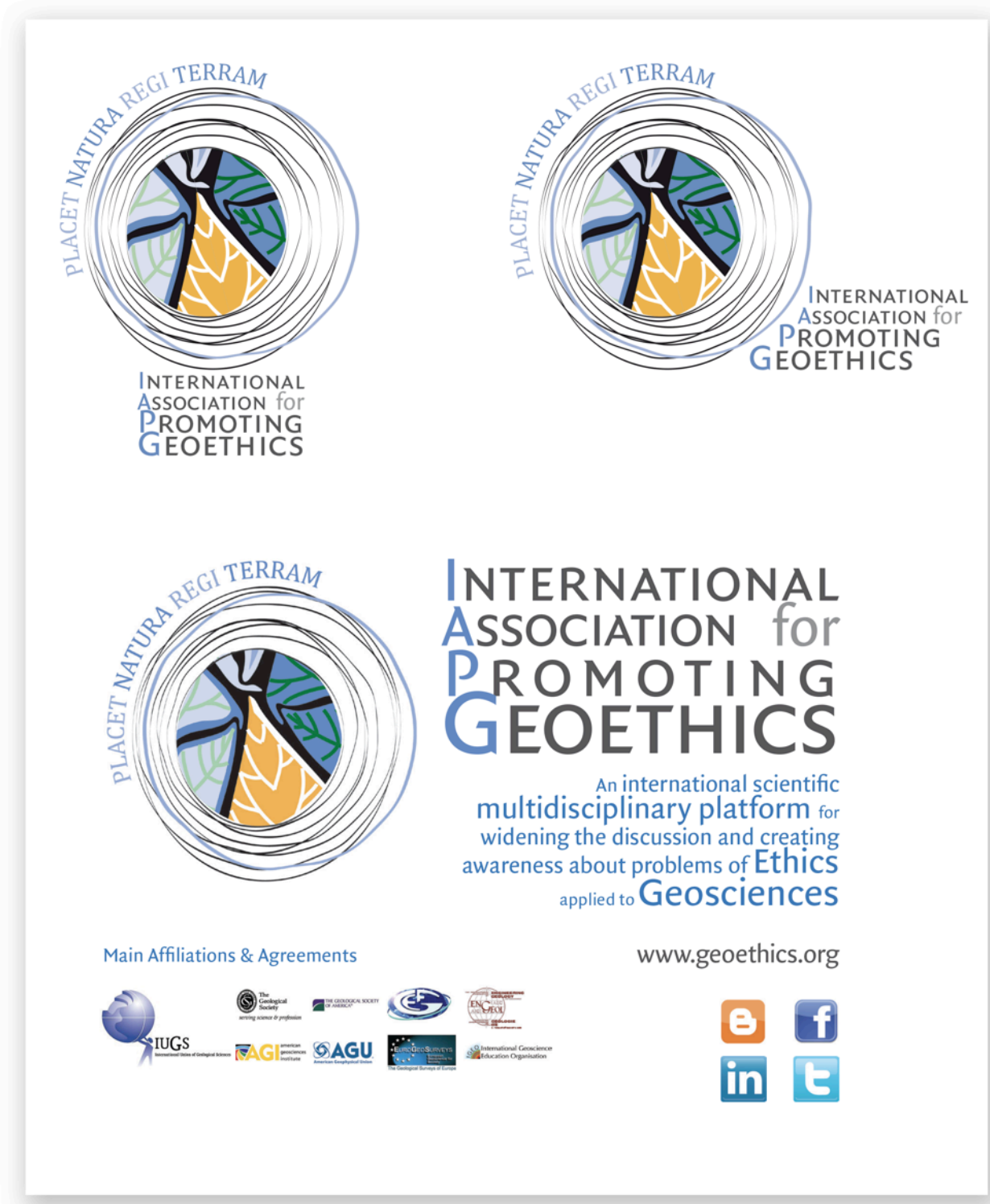


Figure 6. Some achievements for the *IAPG*. Copyright Laboratorio Grafica e Immagini INGV.

Figure 7. The solution chosen for the *AGITHAR* logo and for some associated gadgets. Copyright Laboratorio Grafica e Immagini INGV.

Figure 8. The solution chosen for the *FIERI* logo. Copyright Laboratorio Grafica e Immagini INGV.

Figure 9. Products created for the *SAVEMEDCOASTS* project. Copyright Laboratorio Grafica e Immagini INGV.

Figure 10. Products of the *ScienzaInsieme* project. Copyright Laboratorio Grafica e Immagini INGV.

Figure 11. The most recent issues of the Annual Report of INGV's HP-HT Laboratory. Copyright Laboratorio Grafica e Immagini INGV.

Figure 12. Covers and modifications of the 2016 calendar's monthly agenda. Copyright Laboratorio Grafica e Immagini INGV.

Figure 13. The billboard of the *Escape Volcano* game. Copyright Laboratorio Grafica e Immagini INGV.

Figure 14. The *Mareopoli* game: the game board, the playing cards, the dice and one of the illustrations created by the Laboratory. Copyright Laboratorio Grafica e Immagini INGV.

Figure 15. The billboard and the cards of *Catch the Plate* game. Copyright Laboratorio Grafica e Immagini INGV.

Figure 16. The *GEO Trivial* game. Copyright Laboratorio Grafica e Immagini INGV.

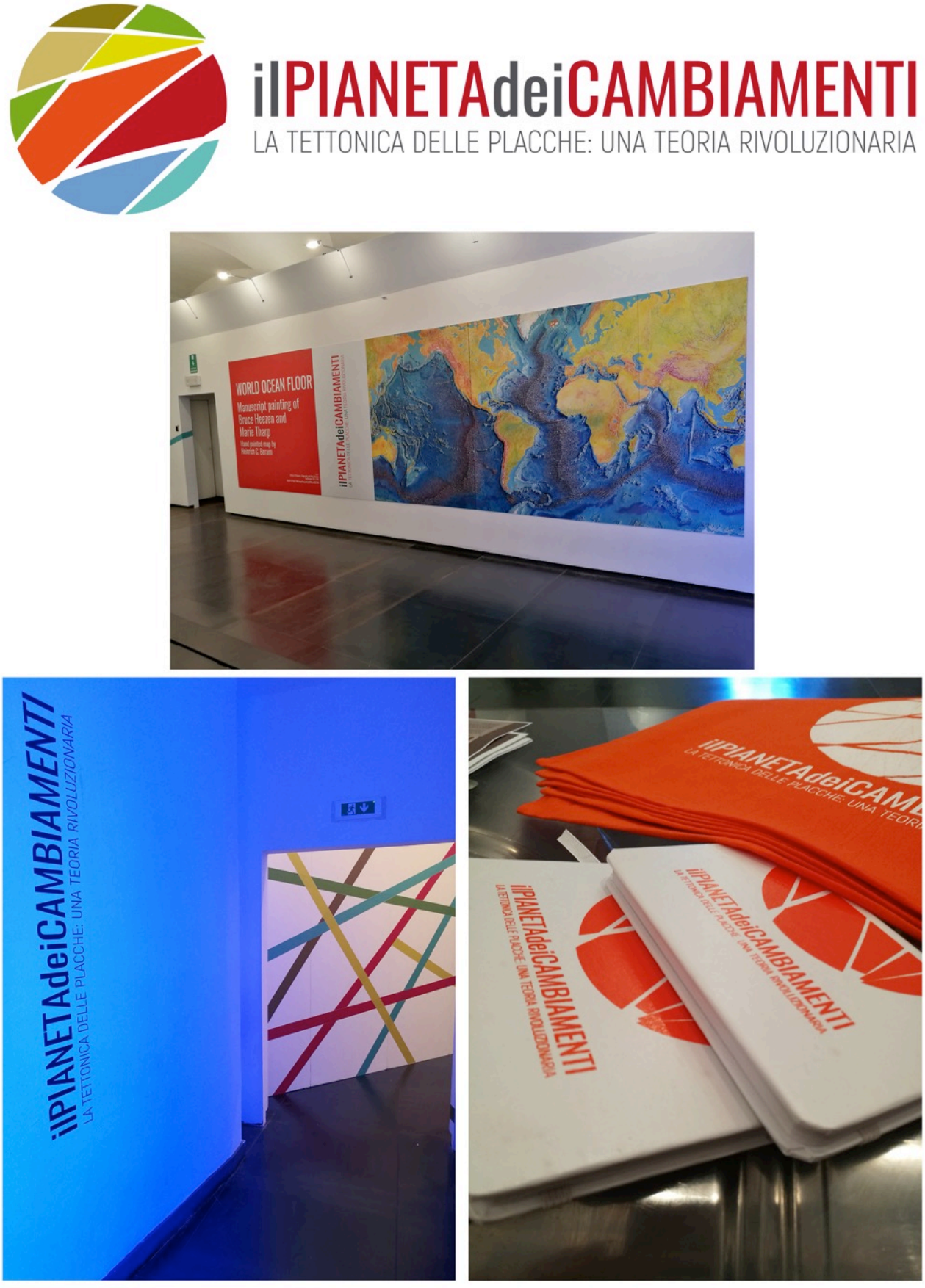
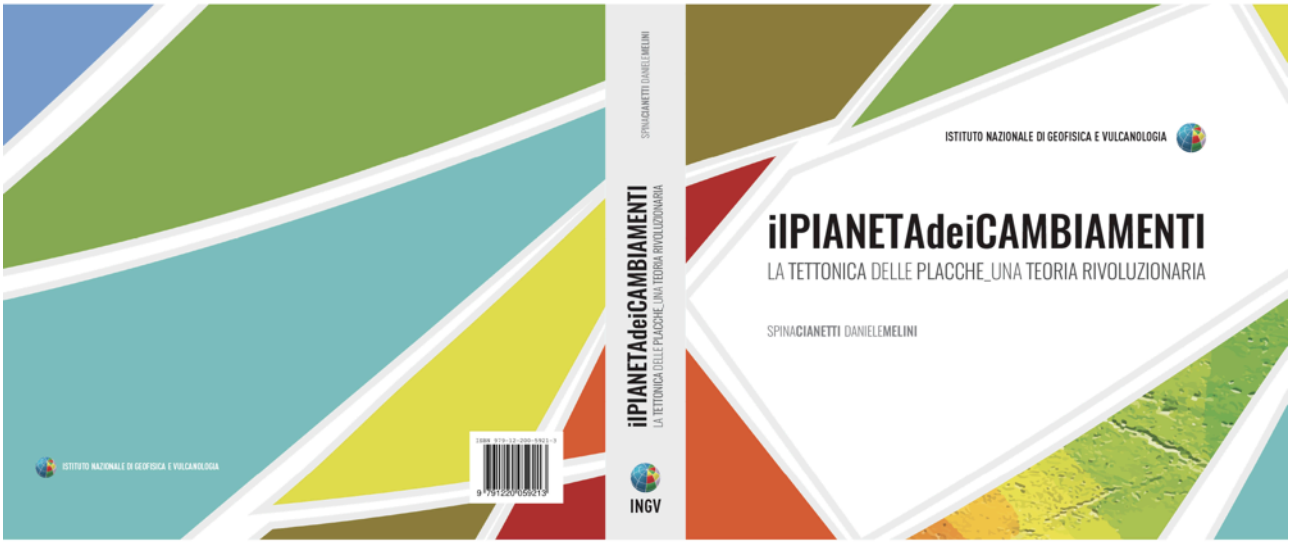
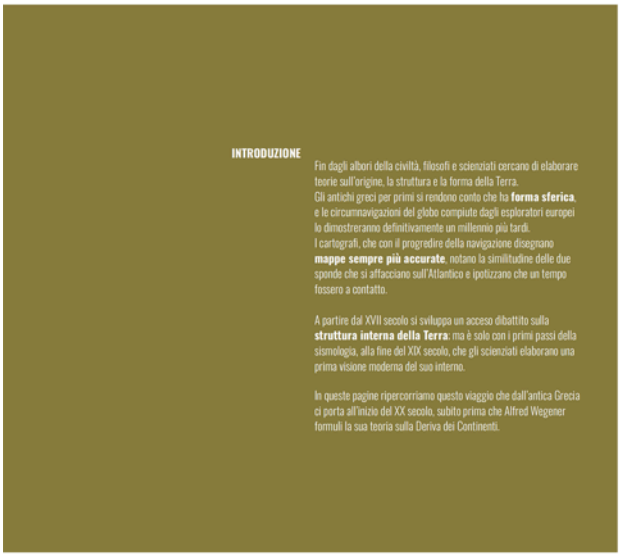


Figure 17. Details of the layout of the exhibition *Il pianeta dei cambiamenti. La tettonica delle placche: una teoria rivoluzionaria*, presented at the 2018 edition of the Genova Science Festival

in Palazzo Ducale (Genova, Italy). Copyright Laboratorio Grafica e Immagini INGV.





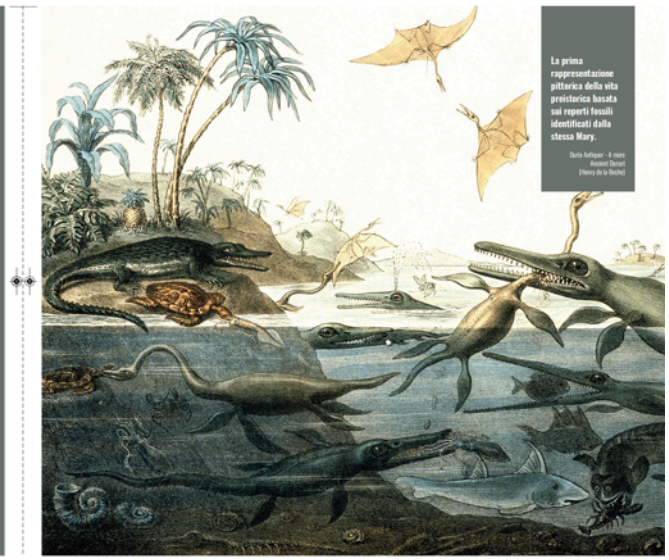


Figure 18. Selected pages of the Exhibition Catalog: *Il pianeta dei cambiamenti. La tettonica delle placche, una teoria rivoluzionaria*, presented at the 2018 edition of the Genova Science Festival. Copyright Laboratorio Grafica e Immagini INGV.

ATTENTI AGLI ELEMENTI TERREMOTI

DETTAGLI CHE SALVANO LA VITA

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Figure 19. Excerpts from the exhibition *Attenti agli elementi* , presenetd at the 2019 edition of the Genova Science Festival (Commenda da Prè, Genova, Italy). Copyright Laboratorio Grafica e Immagini INGV.

Figure 20. Booklet prepared for the exhibition *Attenti agli elementi*. Copyright Laboratorio Grafica e Immagini INGV.

Figura 21. The INGV participation at the *New Space Economy* Forum, December 2019, Rome, Italy. Copyright Laboratorio Grafica e Immagini INGV.

Figura 22. Materials created for the INGV participation in the *New Space Economy* Forum, December 2019, Rome, Italy. Copyright Laboratorio Grafica e Immagini INGV.