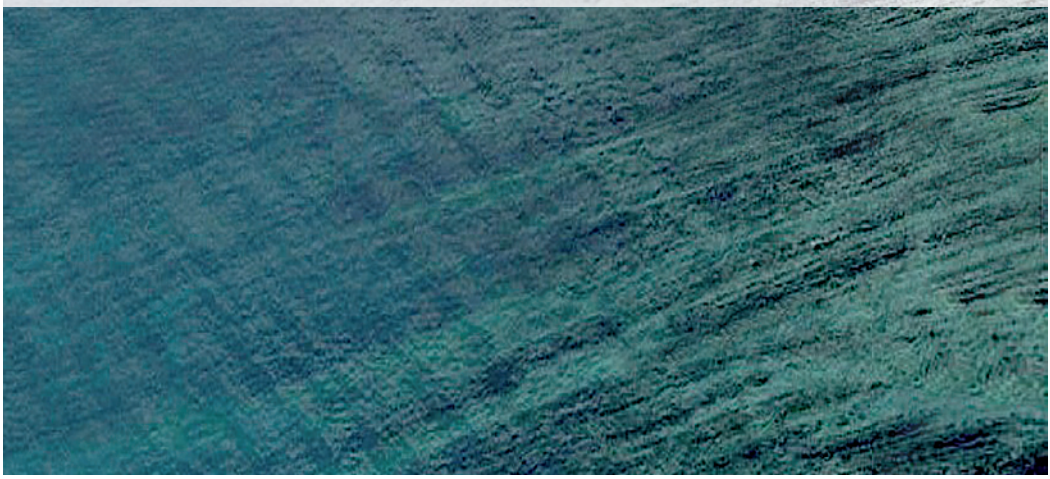
Research Networking Programme

Earthtime – The European Contribution (EARTHTIME-EU)

Standing Committee for Life, Earth and Environmental Sciences (LESC)



The EARTHTIME-EU Research Networking Programme (RNP) is part of a broader international initiative, 'EARTHTIME: a community-based scientific effort aimed at sequencing Earth history through an integrated geochronologic and stratigraphic approach'. The ambition is to broaden the EARTHTIME platform in Europe with this RNP which, combined with an ongoing FP7 Marie Curie Initial Training Network (GTSnext), will also serve as the basis for wider outreach towards the Earth Science community, and allow crucial construction of databases and teaching activities with a global dimension.

The Geological Time Scale (GTS) is the fundamental measurement yardstick and the key to reconstructing Earth history. We want to (1) develop a next generation fully integrated GTS for the last 100 million years, and (2) exploit the scientific predictions arising from this improvement. This time scale, with unprecedented accuracy, precision, resolution and stability, can be achieved by integrating independent dating techniques. The numerical calibration of the GTS is the main focus of GTSnext. With the RNP we specifically aim to link the much improved numerically calibrated time scale with other stratigraphic disciplines to arrive at a fully integrated GTS. Combining the RNP with GTSnext, the expected scientific contributions and breakthroughs are 1) new insights into key geological processes including climate change, catastrophic impacts and volcanic hazards; 2) a stable time scale that is beneficial for academia and industry; 3) full integration and intercalibration of different numerical dating and stratigraphic techniques, leading to 4) significant improvement in the consistency of these techniques; 5) progress towards a fully astronomically tuned and stratigraphically integrated GTS over the last 100 million years.

A fundamental comprehension of geological time and the time scales at which key processes occur is appropriate in view of the impact we have on System Earth.

The running period of the ESF EARTHTIME-EU Programme is for five years from June 2010 to May 2015.

Scientific Background

Research field

This ESF Research Networking Programme aims to bring together European and pan-European specialists to develop and improve the Geological Time Scale. Knowledge and understanding of detailed ages and durations of events, and, therefore, rates of processes, are the fundamental basis for Earth System Science in general. In addition, they are crucial for tackling current challenges such as driving forces and feedbacks at the global scale and understanding abrupt or extreme changes in the Earth System in particular.

Scientific context

The need for much improved knowledge of the durations and ages of climatic and geological events, such as the Palaeocene-Eocene Thermal Maximum (~55 million years ago), has become urgent within the Earth Science and climate modelling communities. The exact dating and timing of fluxes into and out of the marine carbon reservoir can differentiate between competing hypotheses of climatic change. Highly detailed reconstructions of Earth history allow us to assess whether past climatic change can be used as an analogue for the current and future change of ocean acidification and climate. The EARTHTIME project, together with this RNP, is an international effort with the goal to further this quest for a well calibrated and stable time scale that will allow more precise dating of rock layers and minerals (see Figure 1).

Radio isotopic dating methods have a small but significant error that hinders our ability to assess geologically short-lived climate events.

For instance, the most widely used method for the Cenozoic era is $^{40}Ar/^{39}Ar$, which has an (from Kuiper *et al*., 2008, *Science*) error of up to 2.5% and few tie points of known age (see Figure 2). Yet, over the last two decades much progress has been made in exploiting the imprint of Earth's orbital variations in palaeoclimatic records. This has dramatically increased the potential age resolution of approaches like cycle counting and pattern matching, to less than 40,000 years throughout much of

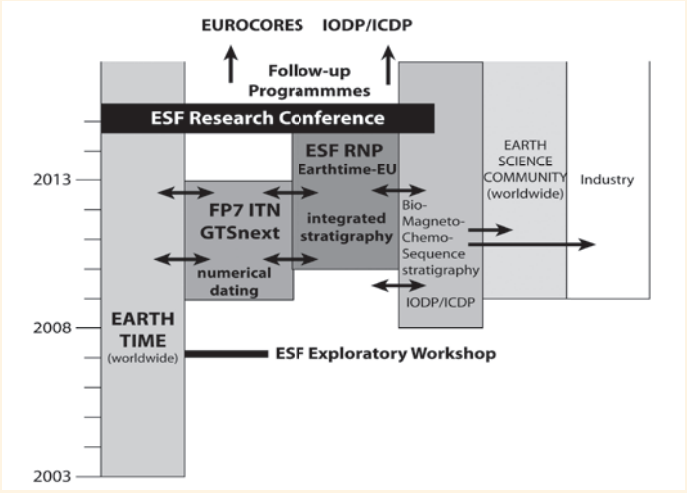


Figure 1. Relationship between the worldwide EARTHTIME initiative, the FP7 ITN GTSnext, this Research Networking Programme and external contributors and users.

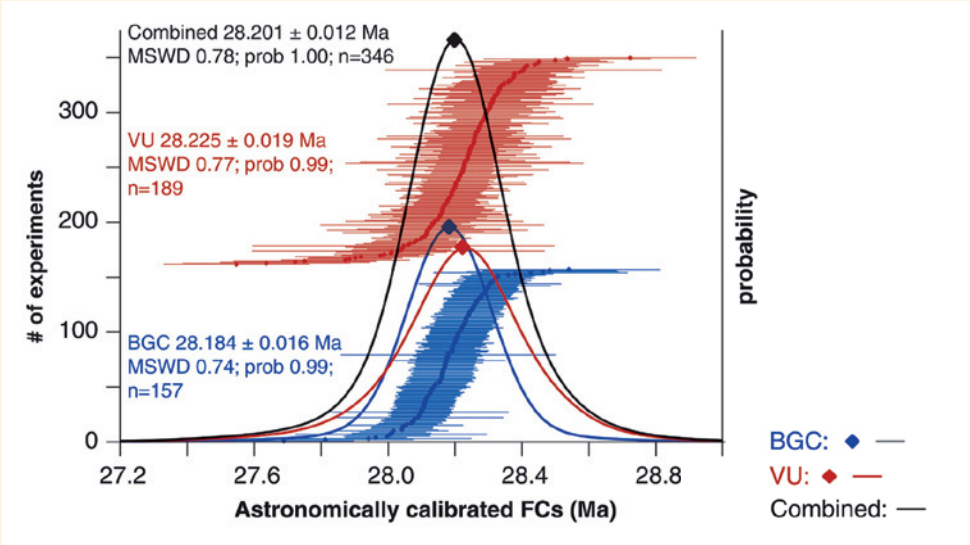


Figure 2. Astronomically calibrated Fish Canyon Tuff Standard Age. The $^{40}Ar/^{39}Ar$ ages of the ash layers are intercalibrated with astronomically dated sediments (from Kuiper *et al.*, 2008, *Science*).

Cenozoic time (the past ~66 million years, Pälike and Hilgen, 2008, see Figure 3).

Unfortunately, there have been a number of inconsistencies and discrepancies between ages and durations derived from radio isotopic and astronomical dating. What is now needed is a more systematic and coordinated approach to provide a detailed intercalibration of radio isotopic clocks (U-Pb, Ar-Ar methods), the rock standards that are used for these methods, and geological tie-points with astronomical ages. At the same time, Cenozoic palaeoclimatic compilations need to be improved by closing existing gaps, verifying data from single sites, and supplementing the database of magneto- and biostratigraphy in order to improve the accuracy of existing age calibrations.

For all Earth Science applications time is a fundamental parameter, essential for the integration of disparate datasets, for unravelling cause and effect relationships (not only in the climate context), and for the quantification of rates and durations of geological processes. Temporal relationships are often the key to causality arguments in Earth Sciences, for example between environmental and biological change during mass extinction events. The Geological Time Scale (GTS) is instrumental for the quantification of geological time. However, published time scales are commonly based upon a limited number of geochronological tie-points of variable quality, and derivative age models that are of different and widely disparate quality. The accuracy and resolution of such time scales are also variable, generally in the order of 1 to 0.5% at best. Large uncertainties, of the order of several millions of years, still exist in our estimates for the age and duration of key geological intervals. The integration of revised numerical ages with key stratigraphic information requires a concerted and coordinated approach at the European level to tackle these important research questions, and we thus seek a broad collaborative effort through workshops, outreach and scientific exchange activities.

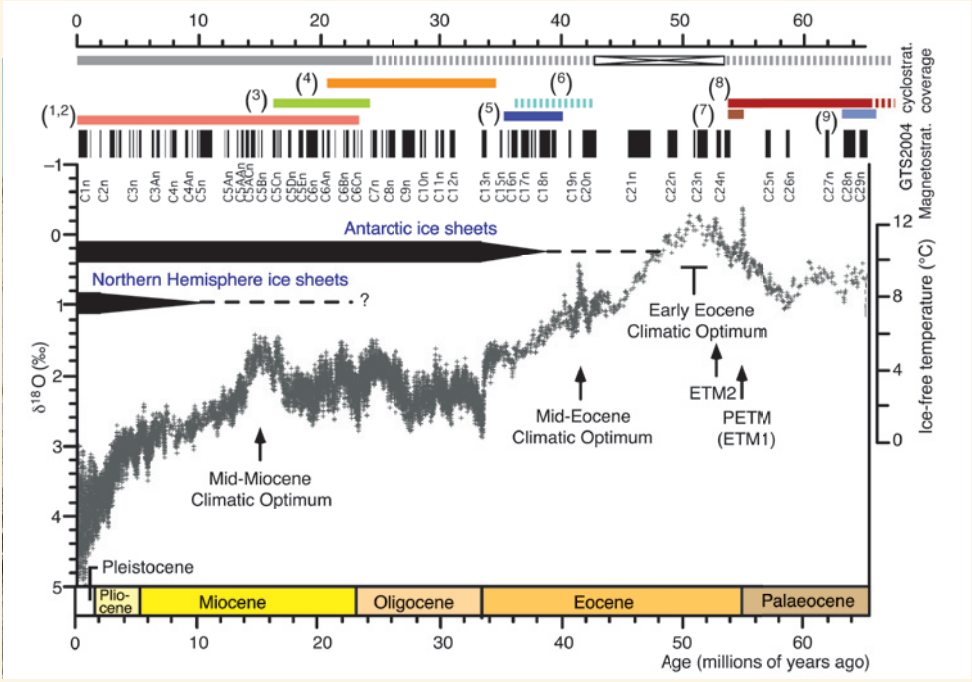
Objectives and Activities

Objectives and envisaged achievements

The principal scientific objective of the network is to link the much improved numerical calibration of the GTS that comes out of the numerical dating part of the programme to other stratigraphic disciplines (bio-, magneto-, chemo-, and cyclostratigraphy) in order to arrive at a fully integrated GTS for the last 100 million years (see Figure 4).

Such a time scale, with its stratigraphic underpinning, underlies all fields in the Earth Sciences. The broader stratigraphic community that will work on the integration can also directly start to apply the new time scale. Thus biostratigraphers can have a much more precise look at evolution and the influence of environmental changes, magnetostratigraphers are interested in reversal history and frequency, sequence stratigraphers in the potential link to eccentricity, cyclostratigraphers at the possible orbital control on sequence stratigraphy and long period hyperthermals and ocean anoxic events, astronomers are eager to find out about the expression of the chaotic behaviour of the Solar System. To achieve both objectives, EARTHTIME-EU will bring together acknowledged expertise in all subdisciplines of time scale calibration techniques found within the European Earth Science community, with a strong cross-disciplinary character including astronomers, the radio isotopic dating community, the wider stratigraphic community as well as climate scientists,

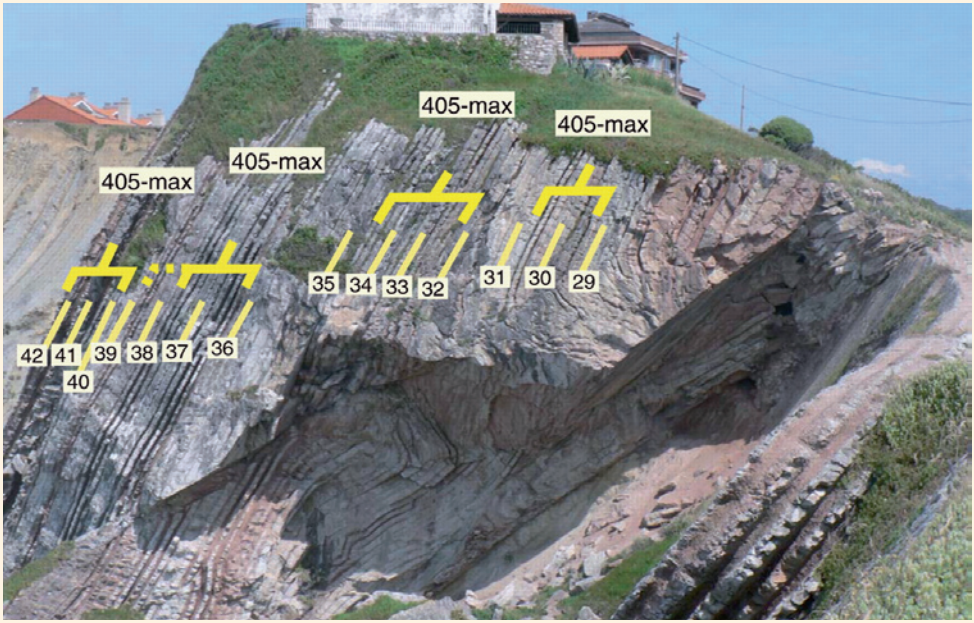
Figure 3. Existing gaps of Cenozoic age calibration, superimposed on a global record of a deep sea temperature and ice-volume proxy (from Pälike and Hilgen, 2008, *Nature Geoscience* 1).



industry and the Integrated Ocean Drilling Program (IODP) and similar initiatives. This European-centred effort (http://earthtime-eu.eu), which will be closely linked to a broader international initiative, EARTHTIME (www.earth-time.org), focuses on (1) the integration and intercalibration of these techniques in order to exploit both their strengths and to address their weaknesses and, specifically, (2) a major effort to intercalibrate different bio-, magneto- and cyclostratigraphic efforts under a strategic umbrella. Increased communication and cooperation between the different communities will result in a fundamental change in the approach Earth scientists take in quantifying geological time. The achievements are planned to be supported through several different strands:

- Training of a new generation of PhDs and postdocs is envisaged within the framework of a Marie Curie ITN (FP7-PEOPLE-2007-1-1-ITN, GTSnext)
- A networking component of stratigraphers is envisaged under this RNP, involving principal investigators, collaborators and the PhD and postdoc cohort, all from the wider science community. This will provide integration and synthesis of the results from (1), and result in applications such as better understanding of climatic changes for the past and future. This proposed effort will be made wholly in concert with the continuously ongoing work by the International Commission on Stratigraphy, within the International Union of Geological Sciences (IUGS/ICS) to improve the GTS.

Supported by these programmes, geochronologists will be capable of applying and evaluating the various state-of-the-art dating techniques for the first time.



Expected breakthroughs of EARTHTIME-EU

- Exchange of expertise, multidisciplinary training, and teaching for the next generation of young multidisciplinary geochronologists with established laboratories and key researchers in a pan-European context.
- Strengthening the ties between researchers across Europe (particularly new EU member countries) as stratigraphic data from Eastern European and circum-Mediterranean countries will be indispensable to reach the formulated targets.
- Development of extensive outreach activities encompassing the direct network-specific topics as well as highlighting the direct application of this science to societal challenges, including climatic change on different time scales. Outreach will be achieved through development of teaching materials ('e-learning'), workshops, summer schools, production of displays and exhibits, and through a dedicated website, hosted at http://earthtime-eu.eu.
- Development of an integrated stratigraphic database that incorporates and converts between different astronomically and radio isotopically derived ages and age models.
- An accurate and precise intercalibration of the improved numerical dating techniques in the context of stratigraphic data.
- Significant progress towards an integrated (astronomically-tuned and radio isotopically calibrated) Geological Time Scale (GTS) over the last 100 million years, in concert with GTSnext and EARTHTIME.
- A time scale which is robust and stable, and which will be employed by academia and industry because the proliferation of new time scales will essentially be avoided.
- Increased appreciation of the potential for highly resolved time scales in addressing outstanding issues in Earth System science.
- An improved understanding of Earth history through the application of this time scale by gaining new insights into key geological processes, including climate change, catastrophic impacts and volcanic hazards.

Figure 4. Outcrop expression of cyclical rock deposits, the timing of which is controlled by Earth's orbital variations around the Sun (from Kuiper *et al.*, *Science* 2008).

Several dedicated activities for the European EARTHTIME initiative are envisaged. All activities will follow an open call, either for participation of individual scientists or for proposing dedicated workshop themes, and will be operated through the EARTHTIME-EU Steering Committee. Industry involvement and input is sought where possible.

Steering Committee meetings

The EARTHTIME-EU Steering Committee will discuss overall strategy, organise open calls for workshops, meetings and outreach activities, and provide interaction between members on scientific grounds. The Steering Committee will assess crucial targets and milestones each year. The first kick-off meeting took place in Strasbourg on 1 June 2010.

Science workshops and summer schools

One of the main pillars of the Research Networking Programme will be a series of dedicated workshops and schools that bring together the EARTHTIME-EU science community, including researchers, students and postdocs.

The first EARTHTIME-EU scientific meeting is planned in Barcelona, Spain, in February 2011. In this meeting, scientists will map out new strategies and state-of-the art techniques in the fields of astrochronology, marine biostratigraphy, radio isotopic dating and regional correlation.

Later, several open-call workshops and one Summer School (15-20 participants each) during the first two years of the programme are envisaged. Two of the yearly workshops will be under a theme agreed by the Steering Committee, with an open call for participation. These themes will fall under the four main strands of GTSnext effort (confirming the Neogene; calibrating the Palaeogene; exploring the Cretaceous; and fundamental aspects of timescale calibration tools) and will be significantly broadened with expected participation from the cyclostratigraphy, radio isotopic dating and stratigraphic disciplines, closely aligned to the Marie Curie GTSnext initiative, but with wider and open participation of stratigraphers. The other two workshops will follow open calls for more specific aspects of the GTS and its application. Examples could include: integrated and revised chronologies for the Eocene/Oligocene greenhouse to ice-house transition; rates of change across the Palaeocene Eocene Thermal Maximum, etc. The Steering Committee will administer open calls for topical and cutting edge workshops that contribute to the EARTHTIME-EU initiative. Each year (for five years) there will be a call for a Summer School geared towards current PhD students, and taught by EARTHTIME-EU researchers, that focuses on a specific technique of time scale development. This activity will link with outreach activities (developing teaching material and providing e-learning web material such as recorded lecture webcasts).

ESF Research Conference

One of the key targets of the RNP for its final year will be the organisation of a larger (~120 participants over three days) ESF Research Conference, synthesising the scientific objectives, producing a contribution for the next update of *The Geological Time Scale* publication (together with the ICS), as well as formulating a strategy to continue the EARTHTIME-EU initiative through further initiatives, and/or participation in other funding mechanisms. This Conference will focus on the major achievements of the EARTHTIME-EU and GTSnext initiative.

Grants for short visits and exchange grants

A different pillar for the RNP will be provided by open calls for short visits (1-2 weeks) and exchange grants (2 weeks to 6 months) between European laboratories, ideally targeted at early career researchers and PhD students. These activities will provide crucial capacity building and knowledge exchange in the overall EARTHTIME-EU effort. Open calls will be formulated by the Steering Committee, and selected candidates of these travel grants will be expected to contribute to outreach and publication activities, as well as providing a report of scientific achievements (milestones).

Database development, maintenance and hosting

A major legacy of the network will be a web-enabled portal that integrates all new stratigraphic and radio isotopic ages and age models developed through the network, including facilities for easy access, conversion and integration with partner databases and their interfaces, for which joint standards have to be defined. Such a database will be a lasting tool for academia as well as industrial applications

in the Earth Science community. The development, set-up, maintenance, data-quality assurance and archiving of a portal, which will be linked to the EARTHTIME-EU and EARTHTIME dedicated websites are envisaged. Rather than duplicating efforts, this database will be a working document of the community and closely link with existing databases (such as the US CHRONOS initiative, the Integrated Ocean Drilling Program databases initiative SEDIS, PALEOSTRAT, WDC-MARE PANGAEA, as well as the ICS website that hosts the current GTS2004 ages).

Publicity, dedicated website and outreach

All of the above activities will be closely coupled with a strong outreach activity. A dedicated website (http://earthtime-eu.eu) will host the exchange of scientific achievements.

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For the latest information on this Research Networking Programme consult the EARTHTIME-EU websites:
http://earthtime-eu.eu
www.esf.org/earthtime-eu

Cover picture:
Monte Conero, south-east of Ancona, Italy. Cyclical succession of marine sedimentary rocks, deposited over several million years during the Miocene. Note the extension of bundled rock strata into the Mediterranean. Each rock layer encompasses about 20-100 thousand years. Successions such as this allow the intercalibration of stratigraphic and dating methods to improve the geological time scale.

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