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Our Magnetic Planet (Arthur Holmes Medal Lecture)

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It is a great honour to receive the Arthur Holmes Medal, certainly the highest scientific award of my life. My first thoughts and deep gratitude are with the people who have contributed to me being here today, from my PhD mentors, Pierre Berge and Pierre Pério, later Jacques Labeyrie, my colleagues and students and last, but not least, the members of the Committee on Education of EGU, with whom I have shared over 10 years of a wonderful educational activity.
In this presentation, among the various scientific arguments in which I have been involved, I will recall only those mentioned in my letter of nomination to the Holmes Medal, trying to replace them in what was known at the time.
After a PhD in Solid State Physics, working in a laboratory of the Commissariat à l'Énergie Atomique, I obtained a post doctoral research position for the the study of liquid binary critical fluids, and worked on this topics for 5 years.
I then joined the Centre des Faibles Radioactivités, a CNRS-CEA Institute dedicated to the study of geological-environmental phenomena. My first task there has been to develop a paleomagnetic laboratory, dedicated to the study of Earth Sciences, through the study of the magnetic properties of sediments and igneous rocks. From there on, my entire scientific activity has been devoted to the study of our "Magnetic Planet".
My first project in Geophysics dealt with the geodynamical evolution of the Aegean Arc. At the time, only a few paleomagnetic studies existed in the Mediterranean realm, and none in the Aegean region. Moreover all of them dealt with rather old geological formations, so that almost nothing was known about the recent post-cretaceous evolution. The originality of our study was to start from the most recent to the older formations, in order to precisely describe "retro-tectonically" the different phases of rotational deformation. This intensive study (over 700 sampling sites, over 10,000 samples spread over continental Greece, the Aegean and Turkey) allowed to show that the main post-cretaceous geodynamical evolution of the Aegean Realm is dominated since 30 My by two phases of rotational deformation in opposite sense around two poles: one just north of Albania for the western part, the second in the South Eastern Mediterranean for the eastern part.
During the sampling of Mio-Pliocene marls in Crete, using a LETI portable magnetometer to the development of which I have participated, we sampled a geomagnetic reversal registered over about 50 cm of sediments. Interestingly, some intermediate directions were clearly apparent. This gave me the idea that the dynamical directional behaviour of the reversing field could be studied. At the time, only a very few and very incomplete similar records existed. For me, this has been the beginning of an extraordinary adventure still going on today. From the accumulation of data, first from Crete, then from other worldwide spread sites, it became apparent, as illustrated in a cover of Nature, that sedimentary reversal transition paths had a tendency to coincide with the seismically cold deep regions, suggesting that a lower mantle control existed over the reversing geodynamo. This idea, sometimes greeted with scepticism, has stimulated joint efforts to test it both from different disciplines and different experimental and theoretical approaches. It is fair to say that 25 years after it was proposed, our idea is still "on the table" and discussed.
We then turned to the study of the changes of the geomagnetic field intensity, still inadequately described at the time. Because measurements of traditional small cubic samples was largely too time consuming to allow surveys of the amplitude we had in mind, I adapted the u-channel measurement techniques to small access pass-through cryogenic magnetometers, and suggested to W. Goree of 2G-Enterprises a modification of the standard pick-up coil geometry (called the Laj-system by the manufacturer) to allow high spatial resolution measurements. With this equipment we intensively worked on sedimentary sequences, focusing on those with high deposition rates. We successively constructed two paleointensity stacks, first NAPIS-75 (from cores in the North Atlantic), then a more global stack, GLOPIS-75. We could show that the main part of the fluctuations in 14C atmospheric concentration arises from changes in the geomagnetic dipole intensity modulating the flux of cosmic rays at the origin of the 14C production in the upper atmosphere.
Finally, the GLOPIS record, augmented with volcanic data, has allowed a reconstruction of the absolute geomagnetic field intensity for the last 75 kyr with a unique precision in both the intensity and the age model. This reconstruction shows that the Laschamp and the Mono Lake excursions are two distinct events separated by a

period of 7 kyr when the intensity recovered to almost non-transitional values. The present rate of decrease of the Earth dipole appears consistent with an impeding reversal or excursion, rather than with a simple fluctuation not related to a polarity change. Considered together with other results from different authors, this leads to the still unanswered question: are we witnessing the beginning of a polarity change of the geomagnetic field?