

Didier L. Bourlès (1955–2021), the 5 MV cosmogenic rock star

Regis Braucher, Pierre-henri Blard, Erik T Brown, Julien Carcaillet, Anne-Elisabeth Lebatard, Lionel Siame, Quentin Simon, Nicolas Thouveny, Georges Aumaître, Edouard Bard, et al.

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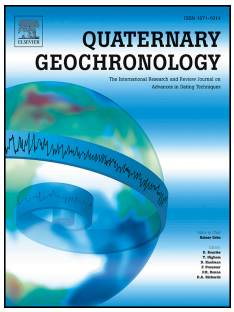
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Journal Pre-proof



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Journal Pre-proof

A brilliant scientist, a warm mentor and an incredible teacher

1st March 21, 1... 3… 21, on a date that sounds like the beginning of a sad song, terrible news darkened our day; Didier left us. His contagious laugh won't echo through the corridors of CEREGE anymore. It is a trying time for many of us. In addition to being an extraordinarily warm and accessible human being, a devoted husband and father, Didier was a scientific giant, a world-recognized leader in geochronology and an expert in the analyses and use of cosmogenic radionuclides. His research impacted scientific fields including, but not limited to, human evolution, paleoclimate, landscape processes, oceanography, and terrestrial magnetism. With exceptional teaching skills and a positive mindset, Didier was a great mentor and friend for many of us. He had a contagious enthusiasm, particularly in the classroom. Students who attended Didier's lectures remember his passion for sharing knowledge. When Didier was teaching, something unusual happened, and it could seem like time was suspended. Sometimes, the student audience literally applauded his lectures. Didier was passionate about science, but, beyond that, he was passionate about the people who do science. With his endearing personality, Didier was enthusiastic about meeting new people and developing human bonds. He treated everybody as his equal, reaching out to young students with kindness and respect. His former MSc student Guillaume LEDUC summarized this rare mix of personal warmth and scientific rigor: "*Travailler avec Didier c'était faire de la science dans un grand éclat de rire. – Working with Didier was doing science with a burst of laughter*."



Figure 1 - Didier BOURLÈS (April 26th, 1955 – March 1st, 2021)

A rich scientific carrier, from nuclear physics to the dating of Toumaï

Before becoming a geochronologist, Didier Bourlès studied physics, completing a doctorate in experimental physics (1981) at Université Paris XI, Faculté de Médecine des Saints-Pères. He was a pioneer in performing the first measurements of ^{10}Be using a low-energy (<3 MV) accelerator mass spectrometer, working with Grant Raisbeck and Françoise Yiou in the CSNSM group at the Tandetron in Gif-sur-Yvette (France). Didier measured ^{10}Be in all sorts of things, from sediments to ice cores, to corals, starfish and mussels. In 1982, he became a CNRS as a researcher at CSNSM. After completing his "Thèse d'Etat" (equivalent of the "Habilitation à Diriger des Recherches") in 1988, he spent two years as a postdoctoral fellow at the Massachusetts Institute of Technology, in John Edmond's Marine Geochemistry Lab. Collaborations initiated at MIT and at WHOI expanded his research horizons, using ^{10}Be as a tool to explore systems ranging from submarine hydrothermal vents to tropical rivers and landscapes.

Didier's pioneering contributions during the eighties ranged from discovery of increased ^{10}Be production during geomagnetic reversals and excursions (Raisbeck et al. 1985; 1987) to the development of sequential leaching experiments to extract the authigenic phase from marine sediments, which represents the ^{10}Be/^{9}Be ratio of soluble Be in the ocean at the time of deposition

(Bourles et al., 1989). Authigenic $^{10}Be/^{9}Be$ ratios remain an effective method for reconstructing paleo-denudation rates and variation in meteoric ^{10}Be production from sedimentary records. In that work Didier demonstrated the potential of $^{10}Be/^{9}Be$ for dating, but suggested that the accepted ^{10}Be half-life was likely about 7% too long, an assertion that was confirmed some 20 years later (Korschinek et al. 2010; Chmeleff et al. 2010).

In 1994, Didier received the prestigious CNRS Bronze Medal and in 1998 he moved to CEREGE with a professorship at Université Paul Cezanne, Aix-Marseille III (Aix-Marseille Université after 2012). Day after day, he developed the ASTER project at CEREGE, struggling with complex time-consuming French bureaucratic constraints, but ultimately establishing a research unit devoted to the measurement of cosmogenic radionuclides. In 2006, the National Cosmogenic Nuclide Laboratory (LN2C, composed of the ASTER AMS facility and the ASCHIM preparation laboratory) was launched, setting the state for innovative and fruitful collaborations worldwide. To increase accessibility to ASTER he worked to develop a French network of sample preparation laboratories. Didier never stopped improving analytical techniques and developing innovative applications of cosmogenic nuclides in geosciences; in 2018, to ensure that the ASTER AMS will remain a top-quality facility, he managed to convince the CNRS as well as local and regional institutions to fund a new magnet to improve ^{26}Al detection limits.

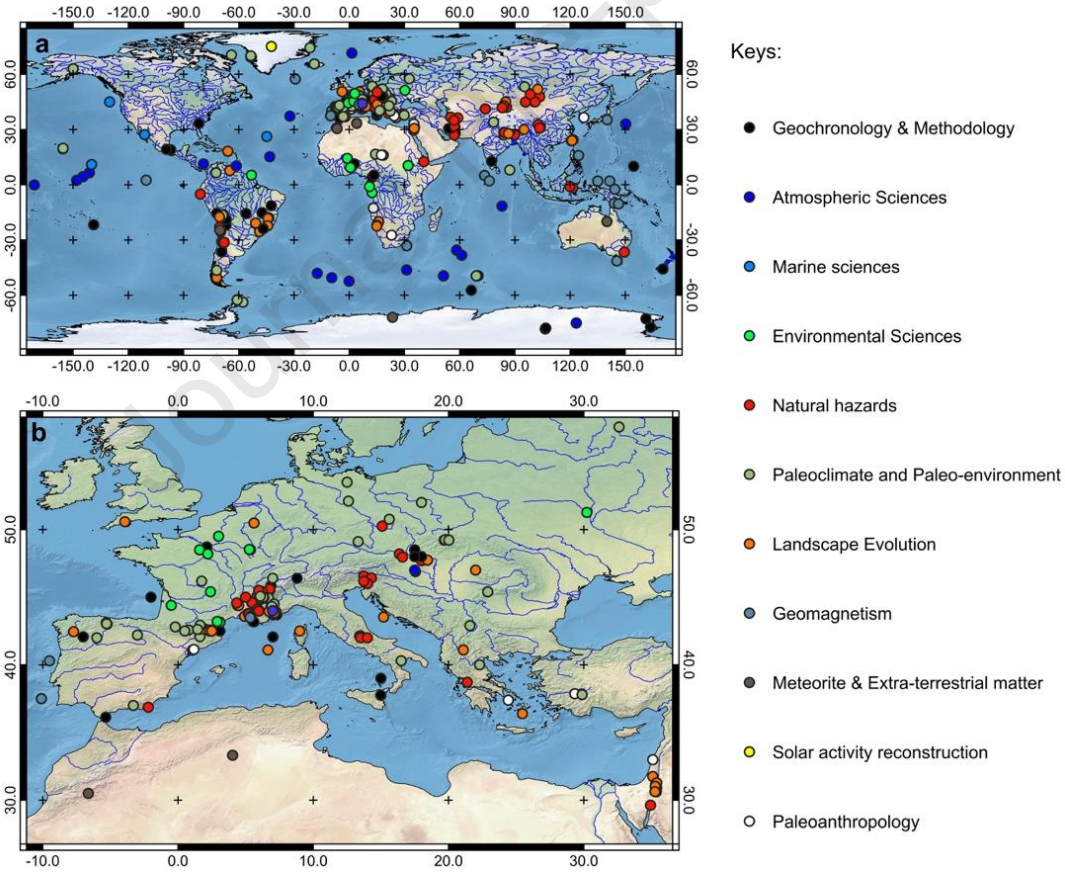


Figure 2 – a) World Map of locations of samples included in Didier Bourlès's publications. b) Map focusing on Western and Central Europe (accessible by train or car). Didier was author or co-author of 299 articles referenced in Scopus (https://orcid.org/0000-0001-5991-6126, Scopus Author Identifier: 7004693622). He worked with 920 co-authors to publish in 67 different scientific journals including: Earth and Planetary Science Letters (53 articles); Quaternary Science Reviews (36); Quaternary Geochronology (35); Nuclear Instruments and Methods in Physics Research Section B (30); Geomorphology (29); Geochimica et

Cosmochimica Acta (25); Journal of Geophysical Research (16); Geology (9); Tectonics (9); Geophysical Journal International (7); and Nature (7).

Didier trained a generation of students and scientists (~20 PhD) most of whom obtained long term or permanent positions and today belong to research networks dealing with tectonics, paleomagnetism, sedimentology, paleoclimatology, paleoceanography and paleoanthropology. Didier was a major scientific actor and a natural leader in the world of geochemistry and geosciences. He had a knack for selecting successful projects that led to scientific innovations and cutting-edge applications. This is manifested in 300 published articles, which have been cited some 9000 / 12 000 times (Scopus / Google scholar). He particularly enjoyed seeing his hard work on cosmogenic nuclides contribute to breakthroughs in paleoanthropology. This notably included using meteoric $^{10}Be/^{9}Be$ as a chronometer to improve the dating of the Toumaï fossil at ~7 Ma (Lebatard et al. 2008), or solving the controversies over the age of the Chauvet cave artwork, with ^{36}Cl exposure ages of >30 ka for the collapse that closed the cave entrance (Sadier et al. 2012).

His departure is a terrible loss to the geoscience community. However, Didier leaves a legacy in his family of students and colleagues, who now form the "Didier Bourlès Cosmo School" and carry the torch he has passed. Although greatly saddened, we will honor him by following the paths he showed us. "*Thank you so much Didier. Best wishes as you continue your cosmic journey."*

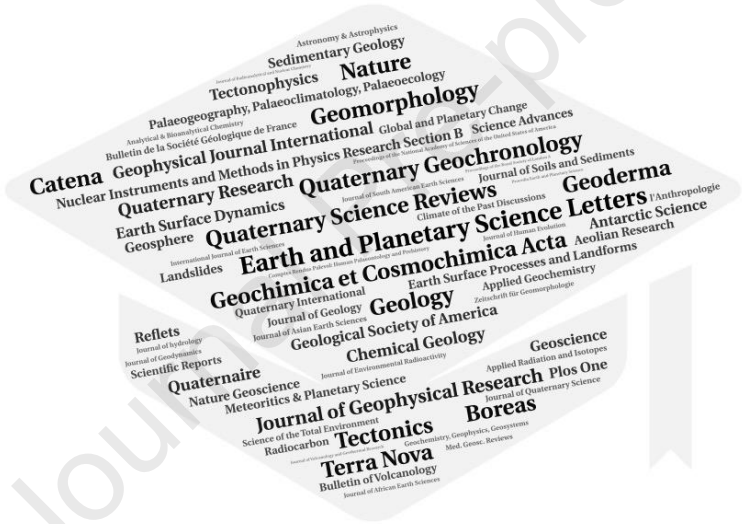


Figure 3 – Words clouds showing the main scientific journals in which Didier Bourlès published his 300 scientific articles

Memories of Didier from his friends and colleagues

Régis "Regino" BRAUCHER

November 1994, a group of "Master 2" students were waiting for their teacher at Campus Saint Jérôme (Aix Marseille 3). I was one of them when a man with long hair, earrings, cowboy boots and jeans arrived. My first thought was: "who is that cowboy?" It was the first day of my 25-years history with Didier. Coming from physical chemistry, I loved the first part of his course on cosmos and AMS, much less the second, on applications in geosciences. In June 1995, Professor Nahon gave me 20 hours to choose between 4 PhD subjects. After consultation, I chose the subject on ^{10}Be applied to laterites; "these red soils found in Africa", as defined by Didier. With Fabrice Colin and Didier, my scientific journey was launched! With these two characters, you can't get bored! I, thus, was officially Didier's first PhD student (quickly followed by Lionel).

Didier was interested in everything and with unfailing generosity. To me, the student from the South lost in the Paris region, he opened the doors of his family, Renaud, Cédric, Sabine (the "Boute", and

later "Bonemine", in reference to the chief's wife in the comics Asterix and Obélix). Since that time, we all together have traveled all around Europe at full speed (Didier barely respected speed limits) from the Vosges to Poland, via Germany, the Czech Republic, Slovenia, Belgium, Spain or Portugal, always by car because Didier was afraid of flying.
From the laboratory to everyday life, Didier always wanted the best and never cheated. In the laboratory, he was uncompromising on the quality of the data, at home he loved to share good food (homemade by him). He preferred the English Premier League to the boring French football Ligue 1. Almost every Monday morning he told me that he had seen, during the weekend, the most fantastic bird, the most fantastic painting or film, the most admirable place.
Didier was a lover of life, of human kind and one of the 3 most important men for me.

Lionel SIAME
I met Didier in 1995, at the beginning of my PhD thesis at University of Paris-Sud, in the Laboratory of Geodynamics headed by Jacques Louis Mercier. I still remember the day when Didier, with his kind of biker look (long hair and beard, rings and earrings....), came to present this still developing dating technique: "We use cosmogenic nuclides, they are produced by cosmic rays ..." At that time, there were very few published applications of these cosmogenic nuclides, but we could guess that this method had potential! I am proud of being part of these early years, when we still needed to convince (and it was sometimes harsh) that counting a few exotic nuclides with an Accelerator Mass Spectrometer could actually help to measure time, such an important parameter for active tectonic studies. So, I went out to the field, in some remote and desert location in Northwestern Argentina, and collected rocks on alluvial surfaces along the magnificent El Tigre Fault. Back in Orsay, Didier taught me how to bathe my samples in acids and to extract this extremely rare beryllium-10, ready to be accelerated at the TANDETRON in Gif-sur-Yvette. And here we go, 26 years and many papers later, we have the French accelerator mass spectrometer ASTER; 5 million volts dedicated to the measurement of cosmogenic nuclides for environmental sciences. It is rare in the world, unique in France, and it is in Aix-en-Provence thanks to Didier's will! I can't count all the good moments we spent together, often remaking the world, at home with his wife Sabine and friends, or in the field, as long as you could reach the place by land/sea routes! In 1996, we spent memorable days in the Irish Dingle Peninsula. To sample a profile, we needed a tall ladder. So, in the evening, we did a tour of the pubs in the village, looking for a fellow named John who supposedly had such a ladder. I can't remember how many pubs we had to visit (probably all of them). We couldn't find John, but we made many friends, and had many good pints of beer! The next morning, John's ladder awaited us leaning on the wall of the house. It is a small story, but it tells how Didier was, always friendly, always ready for an adventure. Didier's rigor ("accuracy is not precision"), his laughter and jokes, his lyrical outbursts against the system (never compromise yourself!), his relentless fight against administrative blockages and his ability to bypass them, I will miss all of this. Merci Didier, pour tout ce que tu nous as appris et pour tout ce que tu nous lègues !

Erik T. BROWN
Didier and I met in 1988 when he arrived at MIT as a postdoc with a striking personal style - long haired and bearded, with rings, bracelets, and earrings - and with a penchant for smoking Gauloises. I quickly came to appreciate his expertise in physics and in AMS analyses, and tried to reciprocate by sharing my third-year graduate student's perspectives on earth and ocean sciences. He posed probing and perceptive questions that sought to get to the bottom of things. Didier's curiosity and thirst for deep and rigorous understanding extended beyond the lab. He wanted not just to know about baseball rules, but to understand why having tickets to see a pitchers' duel between Nolan Ryan and Roger Clemens was a big deal. In parallel, he had a remarkable capacity for genuinely getting to know people, understanding who they were and valuing them as individuals. All of this was wrapped up in Didier's joyful enthusiasm and irrepressible humor.
Our paths merged again when I moved to Paris as a postdoc and ended up staying for five years at CSNSM and at the Tandetron - working with Didier to make "flufflee" beryllium oxide targets, to deal with grant management, and to write papers (speaking French while typing in English on a tobacco-stained AZERTY keyboard). Didier and his family opened doors to French life and culture. I

particularly remember epic dinners at “la Baraque” in Palaiseau centered around things like “les pommes de terre de Noirmoutier” and magnums of champagne.
Things change. Didier moved south. I moved west. We continued collaborating on projects, meeting when we could, and laughing about our crazy world. I have lost count of the number of visits I’ve made to Bouc-Bel-Air, many of them with my family. Barbara and I are fortunate to have known Didier and Sabine for so many years, to have seen their sons grow up, and to have had our kids meet Didier and appreciate his kind and enthusiastic spirit.
DDA, we hope you are looking back at all of us and saying “*Wow, what a ride*.”

Georges AUMAÎTRE
I met Didier in 2001 in Gif-sur-Yvette shortly after being hired at CNRS. Didier told me "come south--the weather’s nice and the sky's a different shade of blue." I decided to follow this anti-conformist guy in cowboy boots, earrings and rings on almost every finger. A decision I never regretted. I joined Didier’s lab in 2006. I discovered a great place to work, a group at the forefront of scientific researches based on simple, enjoyable and direct relationships. Didier created a team without barriers between researchers and engineers, where we fully invest ourselves to serve everyone in the lab, simply because we wanted to. Didier was more than a team leader, he was a friend, a confidant. He was a great admirer of what he called "ephemeral art" and he was not interested by proud persons.
Didier was invested at 200% in the life of the accelerator mass spectrometer facility he built, ASTER. He was present day and night, in the good and bad times, to run the machine at full capacity. I lost the counting of messages exchanged in the middle of the night between Didier, Karim and I to enquire about machine's alerts.
I remember our long conversations around coffee or at lunch, those little phrases he came up with: “*Action is born from reflection*” or “*Some people are doers and others are just talkers*” (Didier’s wordplay «*Certains ont le savoir-faire, d’autre ont uniquement le faire savoir* » is untranslatable).
Now that Didier transformed into a supernova, he is no longer with us, but his cosmic rays travel through our universe and through multiple parallel universes he envisioned. Didier remains present for those who know how to observe, those who have worked with him carry a large part of Didiergenic nuclides.

Karim “Karimou or Jean-Benoit” KEDDADOUCHE
In 2008, when I was looking to move back to my native Provence, ASTER Team was recruiting an Electronics Engineer. I was in charge of a classical mass spectrometry facility at the University of Orleans, but I was far from imagining the exceptional technical and, above all, human adventure that awaited me in Aix en Provence. So I turned up at CEREGE to meet, through a thick cloud of smoke from the cigarettes he was smoking in his office, a strangely dressed guy who was going to completely change my life, my way of working and make me take an extraordinary leap into the land of accelerator mass spectrometry. This guy was DIDIER Bourlès, a man capable of mobilizing you at 2000 per cent and making you addicted to your job in order to bring out the quintessence of yourself. To develop my comments on DIDIER's personality, I would say that when writing these few lines in the most sustained language, Didier would have said to me "there! you are doing your Jean Benoit", for a son of Algerian immigrants this meant that you didn't have to conform to ANY criteria to exist in his team but just give the best of yourself. Moreover, "From reflection comes action", it is with these words that Didier entrusted me in 2015 with the responsibility of ASTER following the retirement of Maurice Arnold, and then reminded me of them all these last years as a doctrine because he was attached to precise work, rigorously carried out in an optimized time. It was with this mixture of benevolence, kindness and rigor at work that DIDIER made you want to push back your limits by bringing all your energy for the benefit of the team of the National Laboratory of Cosmogenic Nuclides. Didier was my boss, my friend, and finally a big brother who will remain forever in my heart and I will do all necessary to perpetuate his work and try to transmit all that he generously offered us. Thank you again my Didier.

Bruno HAMELIN
Thank you Didier, thank you for everything. For taking the risk to leave the Tandetron and join us, with the faith that friendship and enthusiasm would move mountains. For the years of struggles to

convince our administration that the new French AMS had to land at Arbois, following the initial move of Daniel and CG13. For the years of building and growing your ASTER team, your cosmo-family. For the more recent adventure of EQUIPEX with the ASTER-CEREGE group. And then thank you for being an example, with your curious mind to explore the world with your cosmo-glasses, and your care of technical development and your conviction that the best data are those that have not been produced yet. Thank you for your communicative enthusiasm, and for your attention to young people. Thank you for your big laugh, thank you also for your anger and your revolts, privileges of the post-1968 bikers that we have always remained. Finally, thank you for your kindness: with science it is the basis of everything, and it is with them that you stay with us.

Nicolas THOUVENY

When I first met Didier in 1996, his connection to the brand new CEREGE dealt mostly with erosion, alteration and geodynamics events dating. Contacted by Edouard BARD, Bruno HAMELIN and Daniel NAHON in order to build a cosmogenic nuclide laboratory, he was a candidate for a Professorship position. We were both CNRS researchers and within two years we both became Professors at the Aix-Marseille Universities. Working with Ken CREER, Claude HILLAIRE-MARCEL and Yves LANCELOT on paleomagnetic field time series intensity recorded in Late Quaternary sediment sequences of Maar crater lakes and continental margin cores, I wanted to check the differences between excursions and full polarity reversals (studied on his side by my friend Jean Pierre VALET at Institut de Physique du Globe de Paris (IPGP). Since Didier had signed pioneer papers about cosmogenic ^{10}Be enhancements associated with reversals, I convinced him to develop cosmogenic Be studies coupled with high resolution paleomagnetism, although it was not his primary goal. We launched this cooperation with enthusiasm and got the adhesion of a young student, Julien CARCAILLET who just received our two respective teachings and was persuaded that mixing Geochemistry and Geophysics could be a funny adventure. The first beryllium extractions started at CEREGE, while ^{10}Be measurements were performed by AMS at the TANDETRON (CNRS-CEA, Gif-Sur-Yvette). The success of Julien's PhD (2003) and his following papers relied on the proof that cosmogenic ^{10}Be enhancements systematically accompanied the dipole field reductions that triggered excursions and reversals. In the following years, these studies were extended by Guillaume LEDUC, Guillaume JOUVE, and Lucie MENABREAZ (PhD 2012). Large data sets were obtained since 2013 by Quentin SIMON in the frame of the ANR MAGORB (CEREGE) and the EDIFICE European Research Council project (IPGP, Jean-Pierre VALET). After these 22 years of this cooperation Didier and I have produced with these young researchers numerous papers and congress communications. Meanwhile Didier contributed to Research and Teaching policies. He initiated the rehabilitation of a building dedicated to MASTER teachings and contributed to the CEREGE direction team from 2007 to 2017.

From instrumental, theoretical scientific points of views, the huge work capacity, the cleverness and the great human quality of Didier have brought an invaluable contribution to the CEREGE and the geoscience community.

Julien CARCAILLET

Neil Young said: "*As you go through life, you've got to see the valleys as well as the peaks."* Didier taught me how to quantify them. I met Didier when I was a Master's student at CEREGE (1998/99). With his flights of lyricism, his passion for teaching and his ~250 black and white plastic transparencies worn out by time, he opened the door to the "dark world" of cosmogenic nuclides. At his suggestion (as well as that of Nicolas Thouveny), I then started a PhD thesis on the geomagnetic modulation of cosmogenic nuclide production. Didier's first instruction was « *Vas-y mon Juju, monte-moi un labo de préparation d'échantillons* » (let's go my '"Juju", set me up a sample preparation lab). Recently arrived at CEREGE, I was his first student, he had just forgotten to tell me that there was no laboratory. So, I started my career in research as a lab manager... all experiences are good to take in, the future will confirm it...

At the time, the only AMS in France was in Gif-sur-Yvette (suburban Paris). Three or four times per year we would drive to Paris for a week's work at the lab. One of our pleasures was to eat on the road at a traditional restaurant in Beaujolais or Burgundy. Sharply in contrast with the traditional Sunday lunchtime clientele, our biker looks might have surprised the owners, so we always took care to take a

table in a quiet corner of the restaurant. That was generally the beginning of a banquet that only two epicureans can appreciate: "patés de tête", "andouillettes" and "tripoux"!, the whole accompanied by a bottle of "Morgon" or a "Condrieu" and a glass of still water (to rinse the fingers).
Didier was my shepherd in the research world, crazy dog that I was. He knew how to encourage me when I gave up and how to respond, sometimes with a little anger, when I let him down. He gave me the opportunity to grow up in my research and more generally in my life. Thanks to him, I have fulfilled the dream of a 15-year-old teenager who once read a popular press article on the landslide of the Clapière (France). Today, I study quantitative geomorphology and wear a figurative patch "Taught by Didier" on my chest, not far from the heart. Every time I hit a rock in the Alps, the Andes, the Himalayas or elsewhere, the vibrations I send into the ground will tell him "I'm here Didier. I'm what I wanted to be, thanks to you."

Pierre-Henri BLARD
Didier was my PhD advisor between 2002 and 2006. He was a fantastic mentor who taught me many important things, not only about science, but also about life. I will notably never forget three points Didier told me:
1) About science, he told me one day: "*Don't worry too much about the ideas that you put in the paper's discussion. Most of them will be blown away in 10 years, after new data will have been published. What matters in a paper is the quality of the data, this is the main important outcome from your work. So do your best to ensure they are obtained with the most accurate and precise methods and provide the information to prove this.*" I think he was totally right.
2) Although he was an anti-violent anarchist, he also found that mandatory military service had a positive impact on society, noting that this was one of the only times and places where people from all social classes mix together as equals to learn the basics of a common "savoir vivre" and profound respect. This is a lesson in tolerance that overcomes manicheism and prejudices. It is also a great metaphor of the complex and rich person Didier was. For him, humanity could make progress only by following along the narrow intersection of apparently opposite concepts.
3) He experienced a serious health problem in 2004. After this terrible near-death experience, he came back to us peacefully. One day, with his great smile, he told me about this experience: "*Dying is not frightening. I realized that this is a very easy thing to do, but I knew it was too early. I had to come back to life to take care of my dear family, friends and colleagues.*"
Thank you for having shown me all these traverse paths and treasures for thought. I will miss you Didier, I will never forget you. When I am working on data or papers, I often feel you're sitting next to me.

Anne-Elisabeth LEBATARD
I met Didier for the first time during a summer internship at CEREGE between my two years of master's degree in July 2002, when I shared my time between the preparation of cosmogenic samples and happy dinners at Sabine and Didier's Home. With his rings, earrings and long hairs, I was astonished and a little impressed at the beginning. Such welcome was amazing for me as a young shy student coming from Paris, and I felt rapidly at home. One year and half later, calling me by surprise, he offered me the great opportunity to start a PhD to answer this question: Is there any dating method that allows to date Toumaï (*Sahelanthropus tchadensis*) and the other Chadian fossils? After one year of trying with Fission Tracks, I tried the atmospheric ^{10}Be method under his supervision. At the end of my PhD, we proved that Didier's assumption to apply his method on continental environments was totally right. During these years and the years after at CEREGE, he was for me a mentor, my Father in Science. We explored together the fascinating (sometimes strange) world of paleoanthropology and archaeology, discovered new environments, hominin evolution pathways… During the scientific discussions we had and during field works, we combined his physic and his scientific experience with my geology to advance in the development of the use of the cosmogenic nuclides in archaeometry. We also shared the same love and curiosity for art, architecture, and crafts… Field expeditions and the congresses in Europe together were always a source of laughs, discoveries and, above all happiness, especially when Sabine was with us. When I would go to the field in Africa or Asia and bring him back souvenirs, Didier would listen and ask questions and it was like travelling with him back there

again! Not only was he for me an attentive and caring boss who knew how to push me to go further and further, he was also a dear friend. Didier, you will forever remain in my heart.

Quentin SIMON

I met Didier in 2013 as I started as a post-doc at CEREGE. He immediately became a mentor, an awesome cosmogenic-mentor, and a good friend. Didier was a passionate and curious man, an accurate, precise and rigorous scientist. He was a physicist in a world of geological hammers; he was Thor, from Britany, with his loud and communicative laugh. I've spent so many great working afternoons discussing the Earth's magnetic field and ^{10}Be production with him and Nicolas Thouveny. These meetings extended far into the afternoon, so long that Didier used to smoke at the open window (this is forbidden-don't tell anyone...), simultaneously coming up with brilliant insights and laughing at jokes, some goofy and silly, some absurdist and dark, and some slipping a little into off-color territory. Science is serious, but scientists shouldn't be. Didier had fun all his life doing innovative and brilliant research. I had hoped he'd be back in the saddle once again to continue discussing science and other unimportant banters, but not this time… Didier was supposed to start an emeritus career last September, escaping from administrative duties and teaching. I'm sure he would have developed dazzling new research avenues while hanging around at ASTER, drinking coffee with the guys. We'll never know what amazing scientific discoveries we've missed… but we know for sure Didier will be sorely missed. Geosciences (and beyond) lost a great professor loved by all his colleagues and students (the latter not only because of the extended cigarette breaks in class). He was able to make complex physics concepts look easy, even for sleepy students. In reality, in Didier's classes sleeping students were as difficult to find as dark matter in the Universe. Didier was a brilliant scientist, a gentleman pirate passionate about arts, motorcycles, birds, people, and any subjects his curious mind was drawn to. I smile imagining the atoms of Didier's spirit floating in the gas-filled magnet, colliding in a great burst of laughter with ions beams, to help increase the accuracy and precision of upcoming ASTER measurements. Thanks for everything Didier, love you!

Edouard BARD

Didier should be celebrated as a pioneer in geochemistry who measured and understood the fate of beryllium-10 in oceans and their sediments, including complex processes in hydrothermal systems. For me, Didier was also a long-time friend over more than thirty-five years. In the early days, we were both preparing our PhDs in the Chevreuse Valley (Orsay/Saclay/Gif-sur-Yvette) where we had to use the same Tandetron accelerator. Sharing the same AMS facility means a lot as we had plenty of time to discuss about science and life. Thereafter, we both went to the US for postdoctoral fellowships, Didier in Boston at MIT accompanied by his family and myself in New York at Lamont. As always, Didier was an enthusiast not only about his new lab and colleagues, but also on all other aspects of his new life (cowboy boots!). He even tried to lure me in his new passion for baseball, but was surely disappointed by my lack of fervor when we saw the Red Sox playing against the Orioles in Fenway Park! Back in France, we kept in touch discussing our science projects, but also realizing that France is a tiny, but large country with opportunities outside Paris and its immediate outskirt. I first headed south in 1991, but it took more time for Didier to make his mind as the Tandetron in Gif was still the only AMS facility in France able to perform his ^{10}Be measurements. With other CEREGE founders, Bruno Hamelin and Daniel Nahon, we managed to convince Didier to make the big jump to become a university professor in 1998 and help us building geochemistry laboratories from scratch in newly refurbished buildings located in the pine woods between Marseille and Aix-en-Provence. For all of us, this has been a difficult experience that inevitably slowed down our personal research, but proved to be useful since we had no real limitations except time. As a tremendous service to science and to the community, Didier took the lead to create the National Cosmogenic Nuclides Laboratory with its Accelerator for Earth Sciences, Environment and Risks (ASTERisques). As emphasized by many colleagues in this memorial paper, the ASTER facility has enabled a myriad of fruitful collaborations demonstrating the usefulness of cosmogenic isotopes in Earth and Space sciences. Thanks Didier for all of this and more, I will sorely miss our heated discussions on techniques and science enlightening our lives.

Irene SCHIMMELPFENNIG

I knew Didier since 2005 when I started my PhD project at CEREGE within the CRONUS-EU network, under his, Lucilla Benedetti's and Raphaël Pik's supervision. I was always impressed by Didier's prompt scientific support, personal kindness and the creativity he stimulated within the cosmo group. Didier was the pillar of our group and the whole French cosmonuclide community. Without his enthusiasm, communication skills, endurance and charism, we would never be where we are now. Thank you for all your hard work for the community!

Swann ZERATHE
Young geomorphologist, I will never forget the excitation I felt this day of 2010, during the beginning of my PhD, when I opened my first dataset from ASTER: I was on the point to discover the exposure age of a rockslide scarp, entering in the cosmogenic nuclide adventure. My meet with Didier and his Team will be changing definitely my life of young researcher and much more. They literally adopted me during my PhD, opening me their lab, facilities, and then always so kindly supported me and my research projects during my post-docs and so on until my recruitment. Didier was an extraordinary professor and personage. This professor who called me "mon swanou". To me Didier was also a real Gentleman of Science. Always writing with the good verb, having so much consideration for people around him, independently from their status. During my stays in CEREGE, I loved having breaks with them, around his dear AMS machine, a kind of microcosm where students, PhD, researchers, engineers simply could laugh together and discuss about everything. One last time: "*Cher Didier, merci infiniment et longue vie à la ASTER Team !! Je t'embrasse, amitiés, Swann*".

John GOSSE
He was a tremendous man from my perspective. A leader in our field, but also was devoted to the global environment, and was somehow able to maintain a fun life that extended way beyond science. A successful, impactful life.

Friedhelm VON BLANCKENBURG
Didier was a friend, a scientific giant, a mover of big developments, and a person of great kindness. Him not being not around anymore is a great loss for all of us.

Felix Martin HOFMANN
I first met Didier during my master thesis project at CEREGE and Lund University in 2017. I was impressed by his passion for science and his modesty. These two qualities at the same time are rare in the world of science. During the following years, he became one of my most important mentors. I would have liked to continue to work with Didier, but this will not be possible. The next time at CEREGE will be very different.

David FINK
I did not have the privilege nor the joy to work with Didier directly, but I am eternally thankful that I had the opportunity to have befriended this enigma of a scientist - the French, AMS ^{10}Be-cosmo bohemian who would stand out in any crowd. We first met in 1984 at the 3rd AMS conference in Zurich as young AMS PhD students. By the 5th AMS meeting in Paris in 1990 we had become good friends and a visit to Gif-sur-Yvette to watch him tinker with the erratic behavior of the 3MV Tandetron proved to me that this guy was a tad eccentric - but a genius with an affable personality. The many times we met up in CEREGE, or to enjoy dinners in Aix were a delight, and such great fun - and most of all Didier wanted to have fun doing science research. Whenever an idea came up in our many discussions and meetings he would say without a moment's hesitation and sparkle in his eye "yes, yes, we should try that, I think it will work." Didier had a booming personality that whenever he was in the vicinity you would either hear him, see him and then inevitably be drawn to him. He was always the optimist. Esteemed and respected as a devoted teacher and mentor to his students and colleagues, and with a knack to get around most bureaucratic impasses, his absence will be deeply felt by many. The ASTER AMS facility is part of his rich legacy to the next generation of young French AMS researchers in the earth sciences.

Robert FINKEL

What I will always remember about Didier is what a surprise of a man he was. Looking like he just walked off the set of Easy Rider, he was nevertheless both serious and rigorous in his science and also warm and welcoming as a colleague. I worked with Didier during the early days of ASTER. As with any endeavor as complicated as constructing an accelerator mass spectrometry laboratory, the beginning was not easy. Nearly endless problems had to be solved both in the chemistry labs and in the spectrometer hall. Didier was always present with his enigmatic smile and his cigarette. He was a master at keeping things on track in the labs and maintaining the morale of the ASTER family. ASTER and its multitude of research successes would not exist but for Didier. I will remember his unique spirit.

Mark D. KURZ
Didier was a true pioneer in the geochemical applications of cosmogenic nuclides. He loved all aspects of the field, from the innovative science to the methods to the people. He was a leader of a great team, and was particularly and justifiably proud of the AMS lab and "*L'équipe formidable*" that he helped to build at CEREGE. We will miss his enthusiasm and his generous spirit.

David PALACIOS
Unfortunately, my relationship with Didier is very limited in time. However, our scientific collaboration was long enough for me to discover in him two fundamental characteristics, on a level that impressed and admired me. Firstly, his capacity for work and his great scientific rigour. Secondly, his great generosity. These two characteristics allowed me and our scientific group at the Complutense University of Madrid to train in the field of glacial chronology and to improve, with his support, the advancement of knowledge of the glacial evolution of the Iberian Peninsula. People pass, science advances and with it, society progresses. For this reason, our Complutense group thanks you, Didier, for your work, your generosity and your push for the progress of society.

Vincent JOMELLI
I met "Monsieur" Didier in 2009 while I was working on tropical glaciers and started to use cosmogenic isotopes. Immediately I loved his look, nonconformist, combining a perfect verb, boots and rings to his fingers and obviously a brilliant scientist. As a professor at University this look was very infrequent. I was also fascinated and very impressed by his capacity to resist to the System while his grade, his responsibilities would force anyone to follow the line. Discussing in the morning at his office with colleagues in a smoky atmosphere was fun. As smoking is forbidden this was the place of rebellion. Recently transferred to CEREGE I would have liked to know him better. We have lost a very good man and it makes me sad.

Sophie CORNU
Void, vacuum, emptiness, this is what the departure of Didier leaves us after having brought so much enthusiasm and energy into scientific activities in different fields.
We had not finished our discussions on meteoric ^{10}Be in soils, despite 10 years of intense collaboration;
We had not finished submitting new projects despite your recent departure as emeritus;
We had not finished publishing our data...
May the olive tree under which you rest continue to spread your science and your ideas!
Until then, the memory and the void, vacuum, emptiness...

Chris GERMAN
I first met Didier when we shared an office together as a post-doc at MIT - it was a wild ride. To command each others' language better we had a pact that we should only discuss science together in the other's native tongue and that we could interrupt ONLY to correct our use of English/French. I got to witness, first-hand, as Didier developed his authigenic ^{10}Be/^{9}Be ideas and then had the opportunity to join in with spin-out hydrothermal collaborations. But the science was only half the fun - he and Sabine, together with their boys, did everything imaginable to help welcome me and my new family into life in the US. Then, when we had all moved back to Europe, it was Didier who

introduced me to his new colleagues at IFREMER sparking off a decade of further research. All the while, Didier and I continued to seize opportunities to work and visit together - not least on his 40th birthday, so that he could continue on to Stonehenge. He didn't make it onto the BBC news that night - so either he kept his clothes on or he was just too fast to be caught :) Somewhere in the Cosmos, I like to think that he is still running - and laughing :)

Chris MEASURES

I was a soft money researcher working in John Edmond's lab on ^{9}Be when Didier came to MIT. We of course struck up an immediate and fruitful collaboration along with Erik Brown and Chris German using the ^{10}Be/^{9}Be ratios to understand oceanographic processes. Didier was an individual who was very distinctive in many respects. He was an accomplished scientist, as many here have already underscored, but he was also a very enthusiastic human being with important opinions about many things beyond science. I remember a conversation with him about the National Service he had done in France. I had expected, given Didier's political views (which I broadly shared) that he would have had a lot of negative things to say about it, but he did not. In fact he said that he thought it was good that people like him served in the military because of the effect that people like him had on the military, preventing them becoming isolated from the people and their views of military activity. I had never thought of the issue from that point of view, but I realized he was right. Karen and I fondly remember in August 1993, when visiting Paris, Sabine and Didier invited us to their place where Didier had prepared the best Confit du Canard we have ever had, not to mention some very good whisky, I think, but that part is hazy as there was a lot of it! Didier, you have re-entered the grand biogeochemical cycle, to which we all will return, you have made great contributions to our understanding of these processes, which is the goal of all scientists. We will miss you, dear friend, but your legacy will live on in the literature and in our hearts.

Vincent REGARD

Personally, I feel like a scientific "nephew" of Didier. I did my PhD at the CEREGE under the supervision of O. Bellier, a friend of Didier. I learned about cosmos under Didier's direction with Julien, who was then doing his PhD, and then Régis, when he was appointed by the CNRS. All of them constitute a kind of family of which Didier was the mentor: intransigent on one side, always encouraging on the other. I remember how much he supported the development of the method for measuring the recession of coastal cliffs. Today my regret is to have never seen him give either a lecture or a presentation, because he was, it is claimed, excellent. Didier will be missing in my scientific life, a sign of the (great) place he had taken in it.

Silke MERCHEL

Besides it feels like carrying coals to Newcastle to praise Didier's scientific brilliance and his extraordinary soft skills, I will give it a try. I was hired as a Post-Doc within the CRONUS-EU project for three years in 2005 and shared the office with Régis BRAUCHER strategically well-placed directly opposite the chemistry lab on the ground floor. So, Dider very, very often stepped in the office for a short chat - of course mainly to see Régis, to find out what's going on in the Cosmo every-day life - but each time, Régis would be busy elsewhere, he would ask me in his typical sonar voice, nearly yelling "Wo ist der Braucher?" in the "hardest" German pronunciation you can imagine. So, this became somehow our inside joke between the three of us. And of course, Didier knew I needed a lot of jokes during my time in Aix to adapt more to the Southern French way of life. I drove everybody crazy with my German ambition for 110% - perfectionism and planning-ahead. Needless to say, thanks to Didier, I relaxed (a bit) and could be part of the wonderful Didier-working-family while my time at CEREGE and also afterwards being back at freezing-cold Germany.

I remember gorgeous times with Didier doing field-work. He was always carefully looking that I, the very slow chemist, did not get lost. I guess half of the breaks he suggested to have for a smoke were to give me some minutes to get breath again. How luxury and relaxing a field-trip can be: We hired a private boat to see where to take the best depth profile samples at the cliffs of the Calanques. I also learned from Didier how to "behave" in a French restaurant on numerous occasions and had the privilege to be invited to Sabine's and his cosy house at Bouc-Bel-Air. There were crazy times sharing

a single apartment - with one bathroom (!) - in Rome with four women and four men, but this way Didier saved some money and everybody who wanted could take-part in the trip.
And who of the world-wide cosmo and AMS family will forget the best-ever AMS conference in 2014? I still have tears in my eyes thinking of the outing to the Camargue where a few people got really scared by a life show of branding bulls and having most delicious beef at the banquet instantly thereafter. This is French humour at its best! Merci, Didier for making the world and the solar system a better place for me and many others!

Sébastien CARRETIER
I met Didier during my PhD thesis in the 90s, while he was developing in Orsay the dating of alluvial fans with my PhD supervisor Jeff Ritz (Montpellier) for applications in active tectonics. The first time I saw Didier, I thought to myself, wow, you can be a young researcher who is already well known and dress like a biker... Didier simply had the aura of a mentor. Not the kind that crushes you. The kind that accompanies you step by step, whether you are crushing samples with a hammer in a physics lab not designed for that or taking you on board in his anxious hunt against boron contamination by that time. Didier was present for important moments in my life or researcher, as participant to my PhD thesis and HDR committees in particular, but also to encourage me to pursue certain paths with cosmos. His death makes me very sad.

Vincent GODARD
I first met Didier at the end of my PhD, when I went to the Tandetron in Gif-surYvette to have my ^{10}Be samples measured (maybe one of the last runs here). What an exciting day! I remember a constant buzz of agitation around the accelerator and Didier laughing and joking in the middle of that. Our paths met again when I joined CEREGE as a young Assistant Professor. It was the early years of ASTER and already a tremendous achievement by Didier. So many things have already been said to recall the great scientific career of Didier, and I could not add much here that has not already been better explained by other colleagues. One of the things I like to remember about him is how he was always available to discuss and spend time with students, postdocs or young faculties and push them forward. For instance Didier was instrumental in a couple of key events in my early career and I will forever be grateful to him for that. As a scholar, Didier was also profoundly attached to academic values and liberties, and acutely aware of the crucial need to stand firmly for them. Over the years, I sat on various committees with Didier, at local or national levels, and I will always remember his passionate, no-nonsense and straightforward defense of these principles whenever he was feeling that the core missions of the University were at stake. This was also the "Bourlès touch", a part of Didier's heritage we should cherish.

References

Bourles, D., G.M. Raisbeck, and F. Yiou. 1989. "^{10}Be and ^{9}Be in Marine Sediments and Their Potential for Dating." *Geochimica et Cosmochimica Acta* 53 (2): 443–52. https://doi.org/10.1016/0016-7037(89)90395-5.

Chmeleff, Jérôme, Friedhelm von Blanckenburg, Karsten Kossert, and Dieter Jakob. 2010. "Determination of the ^{10}Be Half-Life by Multicollector ICP-MS and Liquid Scintillation Counting." *Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms* 268 (2): 192–99. https://doi.org/10.1016/j.nimb.2009.09.012.

Korschinek, G., A. Bergmaier, T. Faestermann, U.C. Gerstmann, K. Knie, G. Rugel, A. Wallner, et al. 2010. "A New Value for the Half-Life of 10Be by Heavy-Ion Elastic Recoil Detection and Liquid Scintillation Counting." *Nuclear Instruments and Methods in Physics Research Section*

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B: Beam Interactions with Materials and Atoms 268 (2): 187–91. https://doi.org/10.1016/j.nimb.2009.09.020.

Lebatard, A.-E., D. L. Bourles, P. Duringer, M. Jolivet, R. Braucher, J. Carcaillet, M. Schuster, et al. 2008. "Cosmogenic Nuclide Dating of Sahelanthropus Tchadensis and Australopithecus Bahrelghazali: Mio-Pliocene Hominids from Chad." *Proceedings of the National Academy of Sciences* 105 (9): 3226–31. https://doi.org/10.1073/pnas.0708015105.

Raisbeck, G. M., F. Yiou, D. Bourles, and D. V. Kent. 1985. "Evidence for an Increase in Cosmogenic ^{10}Be during a Geomagnetic Reversal." *Nature* 315 (6017): 315–17. https://doi.org/10.1038/315315a0.

Raisbeck, G.M., F. Yiou, D. Bourlès, J. Lestringuez, and D. Deboffle. 1987. "Measurements of 10Be and 26Al with a Tandetron AMS Facility." *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms* 29 (1–2): 22–26. https://doi.org/10.1016/0168-583X(87)90196-0.

Sadier, B., J.-J. Delannoy, L. Benedetti, D. L. Bourles, S. Jaillet, J.-M. Geneste, A.-E. Lebatard, and M. Arnold. 2012. "Further Constraints on the Chauvet Cave Artwork Elaboration." *Proceedings of the National Academy of Sciences* 109 (21): 8002–6. https://doi.org/10.1073/pnas.1118593109.

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Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

PH Blard, on behalf of all co-authors

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