Hugues Faure, 1928–2003 : The unique adventure of his life

1. Introduction

Hugues Faure was not only one of the greatest pioneers of the study of the Quaternary and a man of outstanding personality, with the highest integrity, an uncommon strength of character, with a lot of kindness and generosity, but also a man who made his dreams, conceived in the inhospitable solitudes of the Sahara, come true. He was very young when he chose his way: barely 10 years old and his passion for geology already filled his life. It was in Africa, a continent he discovered at his earliest years as a field-geologist, and deeply loved, that he nursed and matured many of his most stimulating ideas on Quaternary environmental change. It was in the desert that he built up his exceptional personality and found his truth, which finally allowed him to accomplish his destiny.

Hugues Faure was born in Paris, on the 11th March 1928, the son of a jeweller. The comfortable circumstances of the family were darkened by his father's death when Hugues was only 3 years old. As a consequence of this sad event, Hugues used to spend in England most of his school holidays far from his family. Then during World War 2, he lived the exodus on the roads of France, cycling under the bombs, with his dog in his basket. He was 12 years old, and it was the end of his youth. His passion for earth sciences had began before the age of ten, when he started collecting flint and fossils from the chalk of the Paris Basin, and decided to stop playing piano, so as to devote himself to Geology. Hugues graduated in Mathematics from Lycée Jacques-Decour in 1948, and in Sciences from the Faculté des Sciences de Paris Sorbonne in 1949. On the same year he enrolled as a geologist of the "France of Overseas", then as a hydrogeologist at the French Geological Survey (BRGM) (1949–1963), so as to work in Africa.

Fig. 1. Hugues Faure along the Red Sea coast, Ethiopia, in December 1974: "as the first man on the first day of creation, he was innocent, full of wonder and curiosity" (picture by Liliane Faure).

2. "From the field"… as a geologist in Ténéré Desert (Sahara of Niger), 1950–1963

At the age of 21 (in 1949), Hugues left Paris to work in Africa where he acquired a long and very determining field experience. After one year in Morocco, where he resolved the mystery of the intermittent springs in the Jurassic of the Beni Snassen Mountains (Faure, 1950), he defended his diploma as a "geological prospector", with Profs Cuvillier and Barrabe.

He was then sent to Eastern Niger where he spent 14 years of strenuous labour, in the Ténéré desert—between Aïr and Tibesti—staying in the field 8 months at a time, undergoing extreme conditions of climate and solitude, with the greatest difficulties to survive, whilst mapping one-half million square kilometres to fill in a large blank in the geological map of Western Africa. Mapping such an extensive and unknown region—this was in the early 1950s, with no aerial photographs, no topographic maps, no GPS!—offered a chance to the young geologist to show his true potential. Hugues' work on mapping and interpreting the *Post Paleozoic Formations in the Eastern Niger* led to one of the first geological maps of the southern Sahara, covering a surface of 500,000 km^2 (Faure and collaboration, 1960; Faure, 1963), and to an impressive number of important discoveries:

(1) the great extent of the widespread mid-Cretaceous marine deposits from the Ténéré to the north of the Sahara (Faure, 1959a).
(2) a Cretaceous tectonic rift more than 500 km long, extending from the Aïr massif to Lake Chad (rift Tefidet–Termit), (Faure, 1959b) which was confirmed later by petroleum drilling.
(3) deposits containing dinosaur fossils and extending over more than 140 km (Faure, 1962a), a discovery which later led to several works (including Ph. Taquet thesis).
(4) the migration of marine and continental facies throughout the course of time was taken as evidence for an epeirogenic undulation that was responsible for displacing the sedimentary basin from the northwest towards the southeast (Faure, 1959d, 1962b,c). Later he interpreted the speed of displacement of these late intra-cratonic basins (1.7 cm per year in the Cretaceous) as a measure of movement of the African plate above the mantle (Faure, 1971). Such a 'mobilist' vision was quite new in Africa at that time.

Hugues developed many new views on the geochemistry and palaeogeography of the sedimentary and residual formations of Cretaceous and Tertiary age, including a thick Eocene weathering mantle covered by deposits of ferruginous oolites to form an immense African province (Faure, 1962b,c).

But of utmost importance was the discovery of the Quaternary Holocene lakes (Faure, 1954, 1959c; Faure et al., 1963). Hugues initiated a new field of research, still very active, by looking carefully at the Quaternary deposits that covered the great plains of this region. This work led to the recognition of widespread diatomaceous lacustrine deposits, which were described, studied and dated. The first radiocarbon datings, from Hugues' samples, showed that the southern Sahara had been occupied by lakes between 9000 and 7000 years BP. Yet prior to this humid period, the Sahara dunes had progressed of more than 400 km toward the South. The rapidity of a great climatic change was thus evidenced and measured for the first time. This concept of a climate changing repeatedly between arid and humid at the scale of thousands of years was a new one to be applied to the tropics, and highlighted that there is no simple relationship between the Quaternary paleoclimatic evolutions of low latitudes and those of high latitudes. For the first time an attempt of global paleoclimatic interpretation on the Glacials/Interglacials in the tropics was made using the Milankovitch theory and the astronomical model proposed by Bernard (1962), linking the changes of the tropical climate to variations of the terrestrial orbit parameters. So the basis of modern tropical paleoclimatology was laid.

The idea of repeated and rapid climatic changes led Hugues to discover similar changes on the scale of centuries through a review of the evaporites of Niger which allowed him to explain deposits by referring to hydrogeology and Quaternary climatic variations (Faure, 1965).

We also owe Hugues Faure to have been the first to link the water resources of southern Sahara to the Quaternary climatic variations (Faure, 1967): the groundwater reservoirs which drain off today locally in some rare depressions were mostly supplied during the humid period of the Holocene. These results were confirmed by further studies based on isotopic methods.

We can imagine Hugues writing his notes in the serenity of evenings spent in the dunes or the regs of the Ténéré desert, next to the faint light of a campfire or a storm lantern, and conceiving the scientific strategy he would materialize later. Thus an impressive body of work, achieved during 15 years strenuously working "with an admirable physical effort" in the Sahara of Niger contributed to shape Hugues' destiny and to make him a rare human being: a man with an extraordinary need of human contacts, with an uncommon strength of character, a high ambition in the noblest sense joint to extreme modesty and detachment, with the strong conviction that his life could only be devoted to Geology. During his early years as a geologist, Hugues essentially single-handedly laid the groundwork for much of the modern Quaternary sciences.

Hugues Faure was awarded his Doctorat d'Etat degree at the Paris Sorbonne University in 1962, after defending his thesis on *the Post Paleozoic Sedimentary Formations in the Eastern Niger*, (Faure, 1962c) with well-known geologists Pierre Pruvost, Georges Millot and Raymond Furon, from which he had received much assistance and encouragement.

3. From 1963, as Professor at the University of Dakar: "Quaternary Geosciences in West Africa"

At the University of Dakar, Hugues Faure could develop strong links with some of well-known "African geologists", such as Jean Sougy and René Dars, with whom he will keep contact all along his life (Faure et al., 1956). He taught during 5 years and formed some of the best geologists of French-speaking Africa. While in Dakar, Hugues and some colleagues working on the Quaternary of West Africa founded in 1964 the ASEQUA (Senegalese Association for the Study of the African Quaternary) (Faure and Michel, 1965), which was very active, publishing a link Bulletin to favour the exchanges on African Quaternary and to assure strong connections with the research groups set up by D.A. Livingstone in East Africa and by E.M. Van Zinderen Bakker in South Africa. 70 numbers of the Bulletin appeared.

His research was focussing on the Quaternary of that part of West Africa (Senegal and Mauritania), specially the Holocene lakes, and the Quaternary variations in sea level. Moreover he began new research in the Afar in Ethiopia (East Africa).

Hugues initiated new research programs, which were very innovative at that time, because they took into consideration both the functioning of present lacustrine basins and their past modifications in response to climate changes.

The discovery of extended lake deposits in Sahara of Niger, led to further research by Hugues and his students (ORSTOM, CNRS, University). Several papers were issued as soon as 1966 (Faure, 1966) and a synthesis *Lacs Quaternaires du Sahara* was published for the first time in 1969 (Faure, 1969), providing the first graph of lake level compared with the variations of climate on high and mid latitudes.

Hugues was in charge of the new program he had launched in West Africa: he led an ORSTOM (now IRD: Institut de Recherche pour le Développement "French public research institute working for the development of southern countries") interdisciplinary team to the Chad Basin. The research program on the Chad Basin during the Upper Cenozoic, he had proposed to ORSTOM in 1965, was developed by M. Servant, the studies on diatoms of Quaternary lakes by S. Servant-Vildary, and geodynamic, hydrochemical, pedological studies by scientists including J. Maley, J.Y. Gac, G. Maglione among others (Faure and Servant, 1970; Faure et al. 1970).

Hugues began work on the Quaternary variations in sea level. With L. Hebrard and P. Elouard, he described the successions of sea-level deposits during the last 40,000 years in Senegal and Mauritania, which he could correlate to the variations of the global climate, and understand by referring to the geoidal changes and to the tectonic. His first paper issued in 1967 (Faure and Elouard, 1967), gave the first graph of sea-level variations for the Atlantic Ocean along the West African coasts.

4. From Senegal to the University of Paris in 1968: "Geodynamics and Neotectonics—from West to East Africa"

In 1968, Hugues moved from Dakar to the University Pierre and Marie Curie of Paris, where he taught during nine years at the Laboratory of Dynamic Geology, chaired by Louis Glangeaud, located first at La Sorbonne, then at Jussieu. His scientific contacts were very rich and fructuous.

Hugues was promoted, in 1969, to the leadership of the ORSTOM Committee on Geology, succeeding R. Furon and P. Routhier; and in 1970 of the CNRS-LGQ (Laboratory of Quaternary Geology), succeeding Henriette Alimen. Then he could train several generations of students to the Quaternary study.

Hugues' objective was clear: taking into account the whole subtropical northern Africa, from the Atlantic Ocean to the Red Sea, so as to reconstruct at the scale of the continent the climatic and environmental variations. Within a few years, all the teams were at work. In less than 10 years the climatic chronologies of Senegal, Mauritania, Chad, Djibouti, and northern Ethiopia were successfully set up by teams including for the first time a wide variety of specialists, such as field geologists, palynologists, diatomists, and geochemists, all of them stimulated by the infectious enthusiasm of the boss.

At that time Hugues led new research in East Africa, in the Afar (Ethiopia and Djibouti), with the team of Haroun Tazieff (CNRS) and Georgio Marinelli (University of Pisa). He took part in six CNRS international expeditions in Afar, during which the history of the Danakil rift and its Pleistocene marine invasions was established (Faure, in coll., 1972, Barberi et al. 1973).

His discovery of the Cretaceous rift valley of the Sahara led to an interest in other more recent rift valley processes. He worked on Cenozoic geodynamics in the Danakil depression of the Northern Afar rift. The studied region lies between the three blocks of the big Arabo–Nubian bulge: the Ethiopian high plateau, Arabia, and Somalia, at the connection of the three rift systems of the Red Sea, the Gulf of Aden and the Ethiopian Rift. One can observe there the effects of the mechanisms which generally play in the oceanic dorsal axis, at the first stages of rift opening. The study of Quaternary coasts (Fig. 1) (Faure, 1975b,c, 1976a,b) and the radiometric dating of coral reef formations (Lalou et al., 1969; Faure et al., 1973, 1980a,b) demonstrated the importance of the vertical component in the history of the Afar opening: during the late Pleistocene, the vertical movement of the Ethiopian plateau was proceeding at a rate of 0.5 to 1 mm per year, while the Rift was sinking in at the same rate. Moreover the sedimentary infilling of the continental and marine evaporites mirrored the one associated with the opening of the Atlantic Ocean during the Mesozoic (Faure, 1976c) The traces of great lakes which existed 9000 years ago, with important fluctuations of water level, like in the Sahel, were discovered. A geodynamic model Aden–Afar–Red Sea was proposed for the genesis and evolution of the rift system starting from a "hot spot" beneath the Afro-Arabian plate. It allowed to highlight the mechanisms involved during an ocean opening (Faure, 1972a,b, 1973a,b, 1975a,b).

Beside his own research in Afar, Hugues Faure was guiding the work of the CNRS-LGQ scientists, and supervising the thesis works of young researchers: F. Gasse on Quaternary diatoms in Afar; M. Taieb on Hadar deposits where new fossils of Plio-Pleistocene age (discovery of "Lucy") confirmed the great importance of the East African rift for the Quaternary studies. The study of sedimentation in the rifts was pursued (in collaboration with petroleum companies), with the thesis of J.J. Tiercelin (Tiercelin and Faure, 1978).

After 1968, Hugues was mostly working in East Africa, yet he went on animating a stream of research he had initiated in West Africa (including soil scientists, hydrologists, geochemists and biologists), so as to develop several aspects (geodynamic, hydrologic, pedologic, biologic, etc.) of the climatic variations of northern Africa. Research was successfully achieved in the Chad Basin with the thesis of M. Servant (1973), S. Servant-Vildary (1977), G. Maglione (1979), J.Y. Gac (1979), and J. Maley (1980), then extended to West Africa (Senegal, Mauritania), and East Africa (Ethiopia, Djibouti), with F. Gasse (1977).

5. From 1977, the LGQ at Luminy Campus: "Climatic and Environmental Changes—Global Change"

When the CNRS-LGQ, first located at Bellevue (south Paris), was moved to the campus of Luminy (south Marseille), Hugues went with it and held his chair as Professor at the University Aix-Marseille II until 1995. He was awarded the title of "Professeur de Classe Exceptionnelle" from 1986.

At Luminy, Hugues continued to develop the former themes of his research, and to value all the results obtained in a global approach. His work on aridification and climatic variation processes led to several synthesis. And as early as 1981, Hugues Faure was probably the first trying to predict the Sahelian drought end, in *Nature* (Faure and Gac, 1981), initiating the forecast efforts which were later developed (Faure, 1982, 1984a, 1987; Gac and Faure, 1987; Faure and Gac, 1989; Faure and Leroux, 1990). This paper placed the Saharan record of the monsoon system in a global context of glacials and interglacials, and considered the potential future climates of the monsoon belt.

After the first graph of the variations of the Atlantic sea level (Faure and Elouard, 1967), research was led on the coasts of West and East Africa, both for Holocene and Pleistocene (Faure, 1976b; Faure et al., 1981; Gac et al. 1983; Barusseau et al. 1988). Evidences of correlations between climatic variations and sea level contributed to the discovery of great accumulations of peats (Faure et al., 1984). In West Africa as well as in East Africa, quantitative values of vertical movements were determined with sea-level changes dated by isotopic chronology. The distribution of vertical movements in space in the course of time helped to understand the geodynamic evolution linking the crust movements to the rheological properties of the mantle, according to the proposed model published in *Science* (Faure et al., 1980a,b).

Other works led in the framework of thesis, developed on the coasts of Africa (Senegal, Ivory Coast), the Gulf of California (Mexico): Ortlieb (1986), Indonesia: Hantoro, (Hantoro et al., 1994, 1995), the Red Sea: El Moursi (El Moursi et al., 1994) allowed to validate this approach.

The records by the peats of Senegal and Mauritania over a period of 12,000 years were studied in the framework of the thesis of Lezine (Lezine et al., 1985).

5.1. As ORSTOM President of the Committee on Geology (1969–1982)

Hugues rapidly widened his view of the tropical world to South America and to the Pacific. He initiated new ORSTOM scientific interdisciplinary programs on Brazil shorelines, southern Bolivia tropical Andes and northwestern Mexico. For 13 years, he coordinated the work of more than 50 researchers in the tropical zones of Africa and South America, Brazil, Mexico, and later Peru. Studies have covered surface geochemistry, coastal geology, sea-level changes, neotectonics and geodynamics. Therefore French research on Quaternary could extend on both north and south tropics, east and west of the Atlantic. As soon as the early 1980s, most of our understanding of the climate variability in the tropics at the time scale of thousands years during the last 30,000 years was well established. At the same time, it becomes evident that the continental climate is highly variable, not only at the time scale of thousands years, but also at the century, ten-year and inter-annual scales. The extended drought of Sahel which began at the end of the sixties was a striking example. The tremendous warming of the eastern Pacific in 1982–1983, considered at that time as exceptional and accompanied by important climatic perturbations, was also a remarkable example of present climate variations. Hugues Faure immediately perceived its interest to better understand the past climate changes and he then initiated new research actions developed by ORSTOM on the Peru coasts.

5.2. At Luminy, as Director of the CNRS-LGQ (1970–1984)

The Luminy campus is situated in a stunning landscape, with its white cliffs plunging into the clear blue Mediterranean, also a place with facilities to accommodate visiting scientists, and graduate students from different countries, especially from Africa – West and East Africa (Yemane et al. 1985; El Moursi et al. 1994), and South America (Brazil, Bolivia). New and high performance techniques were introduced like the paleomagnetism for high resolution study of climatic variations recorded in lacustrine cores.

Hugues initiated with D.A. Livingstone the first international program of deep drilling in African lakes, a collaborative scientific program funded by NSF (which later on will be continued by IDEAL program, by K. Kelts). Scientists from ORSTOM (J. Maley, S. Servant-Vildary, L. Ortlieb), and from CNRS (F. Gasse, N. Thouveny) were involved in the project. Hugues proposal of a National Program for the study of lakes by Deep Drilling in African lakes was accepted (and funded) by the CNRS. It helped develop French research on lakes and environmental changes.

Close collaboration was maintained with the team of E.M. Van Zinderen Bakker in South Africa. Collaborative projects were developed with Russian teams of the Academy of Sciences of Moscow (Andrei Velichko, Olga Borisova, Kostia Kremenetski, Tatiana Morozova, Ella Zelikson, etc), as well as with English (Jonathan Adams) and Spanish (Cari Zazo) scientists (joint projects funded by INSU, CNRS, and CNES).

Long-time visiting scientists from all over the world came so as to work with Hugues, and have stimulating exchanges, specially members of the INQUA Commissions (such as Dan Livingstone, I.P. Gerasimov, Andrei Velichko, Douglas Grant, Niklas Morner, Cari Zazo, Jose Luis Goy, Claude Hillaire-Marcel, Serge Occhietti, etc.), members of the INQUA Executive (Vladimir Sibrava, Roland Paepe, Jane M. Soons, Bob Hageman, Liu Tungsheng, Sylvie Haldorsen, etc.) and IGCP (International Geological Correlation Program) Quaternary Projects funded jointly by IUGS and UNESCO (Arie Issar, Louis François, Jean-Luc Probst, Isabelle Niang, etc.), and many others (Martin Williams (Williams and Faure, 1980), Donald Johanson, Rhodes Fairbridge, Kerry Kelts, Jack McCauley, Carol Breed, Tony Berger, Dick Buffler, N. Yonekura, H. Kadomura, Jose Pereira de Queiroz Neto, Adolfo Melfi, Mario Sergio de Melo, Kenitiro Suguio, Ken Creer, Mamadou Fall, Mohamed Ould Sabar, the Russian team: A.A. Velichko, Olga Borisova, Kostia Kremenetski, Tatiana Morozova, Ella Zelikson, etc...

PhD students working hard (and late!), conferences being regularly organised with the contribution of the best world-wide Quaternarists "the lab was like a buzzing hive day and night". Thus the LGQ became a centre for Quaternary studies with a world-wide reputation.

6. "To the chair of President": President of INQUA (1982), of Global Change Committee (1987)

Hugues Faure was elected as President of INQUA Executive Committee (1982–1987) during the INQUA Congress held in Moscow in 1982 (Faure, 1984b). He served as Vice-President (VP) from 1977 and as Past President until 1995 (Fig. 2).

When elected President of INQUA Executive (in 1982), he devoted himself to the promotion of Quaternary studies in the world, then he initiated (in 1987) a "Global Change Committee" to promote the IGBP (International Geosphere–Biosphere Programme). When it was time for "retirement" (1995), he launched a new INQUA Commission on "Terrestrial Carbon Changes" (1995–2003), and a new IGCP Project on "Terrestrial Carbon in the past 125 Ka" (1996–2001).

6.1. Hugues and INQUA (1965) (1977–2003)

Hugues gave much of his time and energy to INQUA. He did so much during so many years (38 years!). Hugues found with INQUA a wide open forum where Quaternarists could meet and exchange, and develop all along strong links of friendship, sharing very special moments: the INQUA Commission meetings—and field meetings—were the opportunity to learn a lot and to contribute to the advancement of our understanding of the planet. In Hugues' opinion the spirit of INQUA has been up to 'his last years' of freedom and universal friendship for Science advancement, together with human and scientific excellence, the quest for truth (not for fame or personal interest!) and total devotion to Science with a strict code of ethics.

Since the Denver INQUA Congress held in 1965, Hugues had established strong links with the main leaders of international researches on Quaternary. From 1977, he was more and more involved in INQUA scientific activities:

(1) he was very active within several INQUA Commissions such as: *Stratigraphy*, sub-Commission on Africa (1965–1977), *Shorelines* (1977–1982), VP with D.R. Grant, Cari Zazo, Saskia Jelgersma, *Neotectonics* (1977–1982), VP with R.W. Fairbridge, N.A. Morner.
(2) he was e*lected President of the INQUA Executive Committee (1982–1987).*
(3) he initiated the *Committee on Global Change* (1987–1991) with a panel of INQUA scientists.
(4) he created and led the Commissions on Paleocarbon (1991–1995), then *on Terrestrial Carbon Changes* (1995–2003), with Andrei Velichko and Jonathan Adams.

6.2. Hugues held numerous international honorary positions within IGCP, IUGS, UNESCO, ICL, IUGG, UISPP, ICSU…

(1) project leader in successive IGCP Projects, among them: No 61 "Sea Level" (1974–1983) with P.A. Pirazzoli, No 404 "Carbon Cycle" (1996–2001) with A.A. Velichko, J.L. Probst.
(2) member then Vice-President of the IGCP Scientific Committee (IUGS-UNESCO) (1982–1988), he was in charge of working out a major sub-program "Quaternary Geology for Human Survival" (Faure et al., 1986a).
(3) Vice-Chairman of the Inter-Union Commission on the Lithosphere (IUGS/IUGG), Coordinating Committee no 3 "Earth Sciences in developing countries" (1981–1983/1983–1986).
(4) member of the Commission on Recent Crustal Movements (Africa), United Nations Economic Commission for Africa (UNECA) (1980–1988).

Fig. 2. INQUA Congress in Beijing, China, in August 1991. From left to right: A.A. Alekseev (VP), Edward Derbyshire, Andrei Velichko, Liliane Faure, Hugues Faure, INQUA President, Olivier Faure, Jim Bowler (VP), Liu Tungsheng (VP), a Chinese Officer.

(5) member of AGID Council (Association of Geoscientists for International Development) (1980–1988).
(6) member of the ICSU "Ad-Hoc Committee on the Geosphere–Biosphere Global Programme: a study of Global Change" (1983–1987).
(7) member of the ICSU "Climate Forum".

Beside an intense activity of international animation, attending many international meetings (INQUA, IGCP, ICL, IUGS, IUSS, IUGG ICSU, etc.), as well as scientific colloquia, congresses and workshops, Hugues greatly contributed within ICSU (International Council of Sciences) to the working out of the new global change program of IGBP "Global Change" (Faure et al., 1986a,b), and to its development, in France and the world (Faure, 1984c,d, Faure et al., 1991a).

Indeed, it is during his INQUA presidency (1982–1987) that this program was born (adopted in September 1986). The main reason was the increasing impact of man on the environment since one or two centuries, particularly the anthropogenic increase of greenhouse gases. The necessity to carefully study all the aspects of the Geosphere and Biosphere changes with a holistic approach, was imperative, particularly to attempt to solve the global problems. ICSU being composed of scientific expert groups, each separately working on great disciplines (mathematics, chemistry, biology, and physics) or on great domains (for earth sciences: oceans, continents, biosphere, and society), it was difficult to finalise a program on the integrated knowledge and on the global protection of the Earth for the future of humanity. It was in Ottawa in 1984 that the Global Change program was finalised. The necessary interdisciplinarity, closely associating the studies on all the Earth's spheres (lithosphere, hydrosphere, atmosphere and biosphere) traditionally separated, was taken into account, particularly through the impetus given by INQUA President. But the magic words so that Geosciences be accepted as a component of a future project were "modelling" and "global circulation models", while the real expertise of INQUA was the observation and the description of the past change records. For a long time, the discussion concerned a great program on the 200 last years. It was difficult to convince that the knowledge of 2000 years of evolution could be very useful and several years were necessary to include a component on past global changes (PAGLOCHA) which became the Core project "Past Global Changes" (PAGES).

6.3. INQUA "Committee on Global Change" (1987–1991)

After his time as President of INQUA, Hugues greatly contributed, within the INQUA Committee on "Global Change" he had initiated, to the launching and development of the IGBP Program in France and all over the world (Faure et al., 1991a).

He proposed to the ICSU-IGBP Scientific Committee two major programs recommended by his Committee:

(1) "Meridional Geotraverse Synthesis" (Geotraverses along the meridians from North Pole to South Pole): it led to PANASH project which will be followed by PEP (Pole–Equator–Pole) projects.
(2) "Continental Biogeoflux Changes" (estimate of continental carbon stocks and fluxes and setting up of paleomaps showing the spatial distribution of main ecosystems for different Quaternary times): it led to the INQUA "Commission on Carbon", (H. Faure, J.M. Adams, A.A. Velichko), and the IGCP Project 404 on "Terrestrial Carbon" (H. Faure, A.A. Velichko, J.L. Probst, L. François) which will be followed later by different projects on the Carbon Cycle.

During the period 1986–2002, Hugues organised nine international symposiums INQUA/IGBP with the main objective to value all the works realised and to make progress the Quaternary studies, at a time when it was so important to make the scientific community and the political world aware of the problems of the global environment.

(1) The first symposium and also the most memorable on "Global Change in Africa: Past, Present and Future", held in Dakar in 1986, (Faure, 1986b; Faure et al., 1986a,b) was organised by Hugues with Salif Diop and locally a team of young Senegalese scientists of the University of Dakar and IFAN. Nearly 250 experts from 40 countries, of which 20 African countries, and the officers of 15 INQUA Commissions experimented how their respective knowledge on different scientific fields could contribute to a better global understanding of the Earth system. It was the opportunity in particular to establish the indispensable links between the different scientific experts of almost all INQUA commissions and to stimulate their interest in the Global Change Program. Two field trips were organised (one towards the North and the desert, another towards the South and the more humid part of the country). It was a very successful meeting, both for science and for friendship.

It was followed by other "global" symposiums organised by Hugues

(2) Ottawa INQUA-1987 "Global Change" with Nat Rutter, (Rutter and Faure, 1989).
(3) Beijing INQUA-1991 "Quaternary Earth System changes" with Tungsheng Liu (Faure et al., 1993a,b).

One of the main concerns of Hugues was to favour exchanges and to coordinate the researches of all his colleagues at the earth scale. Not only did he pay a special attention to the organisation of many symposiums, but also (beside the ASEQUA Bulletin and NIVMER Newsletter) to the edition with his co-workers of Special Issues (nine special issues appeared).

Hugues was also the first to intervene as an expert in many national and international committees. Then, he became the spokes-person of this new program which he contributed to set up in France and in the world from the beginning of the eighties. He certainly helped to a better awareness of environmental problems at a global scale and to the necessary contribution of Quaternary studies.

6.4. From 1988, new research on "Terrestrial Carbon changes"

During the 1980s, inspired by early work on the CO_2 content of ice cores, and by the interpretations of the marine carbon isotope record, Hugues began to consider how the amount of carbon in the land–vegetation system might have changed between glacials and interglacials.

In 1988, for the first time (Faure et al., 1988; Faure, 1990; Adams et al., 1990 in *Nature*) the stocks of carbon were estimated for key periods of the recent evolution of the Earth: the Last Glacial Maximum (LGM) and the Holocene Climatic Optimum (HCO), by mapping ecosystems based on a range of sources of palaeoevidences,. Hugues calculations suggested that about 1000 billion tonnes of carbon were 'missing' from the land system during the LGM and were presumably held in the oceans. Several estimations and interpretations of the global biomass were made (Faure et al. 1992), for the last 18,000–20,000 years and for specific areas (Faure et al. 1989, 1991b, 1993a, 1996). Possible effects of Man on his environment and on the Carbon cycle were studied (Faure and Faure-Denard, 1990, Faure et al. 1990). After Hugues, other estimations using different methods were proposed, but it seems that values estimated by Hugues make today a consensus.

7. From 1995, Professor Emeritus of the University: "INQUA Carbon Commission" (1995–2003) and IGCP Project 404 "Terrestrial Carbon" (1996–2002)

The chair of President of the INQUA Executive, then of the Global Change Committee could have concluded the outstanding and creative career of Hugues Faure. But at an age when some people think of retirement, he was more active than ever. Hugues received the title of

Professor Emeritus of the University of the Mediterranean, Aix-Marseille II, (which he held from 1995 until 2003), and became again involved in a new research: the study of the terrestrial carbon changes.

In 1995 Hugues set up the Carbon Commission within INQUA (1995–2003), and the IGCP Project no 404, "Changes in terrestrial carbon storage over the last 125,000 years" (1996–2001) which through meetings and publications of work acted as a forum for many scientists working on the terrestrial carbon cycle (Faure et al. 1998d, 2001).

Hugues developed new collaborations (INTAS project funded by the European Commission) with Russia (Academy of Sciences of Moscow and Saint Petersburg), England and Spain. Close collaboration with Russian teams (Velichko et al. 1993, 1998) is to be emphasized. As well as strong contributions from J.L. Probst, L. François (Faure et al., 1998d; Probst et al., 1999; Francois et al., 2002), among many others. Possible effects of environmental changes on the carbon cycle during the Quaternary were investigated (Faure 1990; Faure et al. 1996; Faure and Faure-Denard, 1998; Faure et al. 1998a; 2002a,b). Hugues led new students working on carbon cycle (Adams et al., 1990, 1992; Branchu et al., 1993; Maslin et al., 1995; Adams and Faure, 1996, 1998; Lioubimsteva et al. 1998, 1996; Faure and Turcq, 2000).

Unfortunately at that time (1995), the LGQ had to move to new headquarters, and had to be "re-structured" and this led to various unexpected difficulties and obstacles. Nevertheless Hugues showed no signs of slowing down, either physically or mentally. Each day he cycled several miles to his small office based in the University campus of Luminy, and continued to write papers, organise symposiums and edit special volumes:

(1) Berlin INQUA-1995 "Quaternary Carbon Cycle Changes", (Faure, Faure-Denard, Adams, 1998b).
(2) Nouakchott IGCP349 and 404, Dec. 1996, "Desert margins Changes in Africa since 135,000 years: Implications for Water, Carbon and Man" with Ed Derbyshire, A. Singhvi, and from Nouakchott University M. Ould Sabar and Khalidou Lo (Faure et al., 1998b; Faure, Heine, Singhvi, 1998c).
(3) Strasbourg-EUG-1997, "Global Carbon Cycle" with J.L. Probst and J. Veizer (Probst et al., 1999).
(4) Durban INQUA-1999 "The global carbon cycle and its changes over glacial–interglacial cycles" with A. A. Velichko, J.M. Adams. (Francois et al., 2002).
(5) Rio IGC-2000, "The changing Carbon Cycle", with B. Turcq and L. Pessenda (Turcq et al., 2004).

His last paper published (Faure et al., 2002a,b), may well turn out to be one of his most influential: in which he held that groundwater springs would have ringed the emerged continental shelf during the lower sea levels of the last glacial. This would have proved an important, possibly the only, source of freshwater for prehistoric humans exposed to episodes of extreme aridity in tropical North Africa and migrating out of Africa, and a main biogeographical refuge.

From 1999, he contributed also to Arie Issar project (in the frame of the International Hydrological Program (IHP, UNESCO), "for utilization of fossil water found under the deserts" (Issar et al., 1999).

From the year 2000 he proved to be seminal in the shaping of the "CHANGES" initiative, its structure as a collaborative program between four IGCP Projects having an immediate appeal to his fervent belief in the importance of open scientific dialogue (Derbyshire et al., 2001).

8. Conclusion

Through his ecumenical approach to Science, Hugues acted as a catalyst for progress in many aspects of the Quaternary Sciences. Not only did Hugues lay down much of the groundwork for modern Quaternary sciences, but also did he extensively populate the professional ranks of the discipline with his students. Hugues acted as doctoral and postdoctoral supervisor to numerous graduate students whose work on lakes, soil formations, hydrology, fossils of the Sahara and eastern Africa further laid the foundations of our present understanding of the climate history of the northern monsoon belt, and environmental change around the world. Among many others: Michel Servant, Jean-Charles Fontes, Alayne F. Street-Perrott, Nicole Petit-Maire, Francoise Gasse, Simone Servant-Vildary, Lucien Montaggioni, Jean-Yves Gac, Jean-Pierre Tastet, Frédéric Baltzer, Jean Maley, Jean-Jacques Tiercelin, Annie Vincens, Kedamawit Yemane, Jean-Pierre Debenay, Joel Casanova, Jacques Monteillet, Mamadou Fall, Olivier Dutour, Luc Ortlieb, Anne-Marie Lezine, Babacar Dieng, Bassam Ghaleb, Momar N'Guer, David Williamson, El Moursi El Sherbini, Isabelle Niang, Soepri Wahyoe Hantoro, Brahim Damnati, Philippe Branchu, M.S. Ould Sabar, Jaime Argollo, Lysiane Raharisoa, Elena Lioubimsteva, and Jonathan M. Adams.

Whatever his exceptional international activities, his research and his teaching may be, he always showed a great availability and confidence toward his students and young researchers, as well as to any colleague or scientist on his way.

Hugues' career was always inspired by strong convictions he applied all along his life and succeeded to get through science.

The first one is "the Past is the key to the Future": the understanding of past changes at different Quaternary time scales must be linked to the thorough understanding of present systems and can lead to the assessment of future changes: One must proceed to permanent transfers between sciences of the present and those of the past, particularly to build models close to the reality. For these transfer functions, science and knowledge progressing every day, it is preferable that specialists of different scientific fields should be associated rather than to use fixed results of the past.

Working in pluridisciplinary teams, so as to solve the same problems and to answer the same questions using different approaches and techniques, was always essential for Hugues. He greatly contributed to it from the end of the sixties. The study of terrestrial environments needs a multiplicity of teams, because of their wide variety and complexity (geomorphological, geochemical, biological, and geographical), which constitutes an obstacle to the modelling of the environment at the Earth scale. Indeed, the functioning of the Earth system is closer to that of a living being than that of physical complex systems with many positive or negative feedback effects. Particularly different processes play an important role variable according to the time scale used. It is the reason why beside the modelling of these components, then the development of coupled models more and more sophisticated, another approach must be developed. This complementary approach is not empirical, it is based on the fine analysis of typical cases of which we could find the complete record in the past. The decoding of these "case studies" allow to build scenarios at the different time scales considered.

Among the principles Hugues much valued was the dialogue with the human sciences (anthropology, archaeology, etc.). It is important to integrate within the same teams specialists of human sciences together with specialists of paleoclimates. Evidences from paleontological data are important for the understanding of environmental and climatic changes. Hugues strongly supported archeological and anthropological studies, especially led on the Sahara south margin (Faure, Roubet, 1968, Faure, 1986a, Adams, Faure, 1997).

Close collaboration between researchers from different fields, different countries, with special emphasis on cooperation with developing countries, and of course the assertion of Science Universality were very important to Hugues.

For Hugues Faure, scientific research was above all "search for truth". All his life was devoted to Science and research. To him science was a mission that demanded complete devotion, and a strict code of ethics. His life was a remarkable one, not only for its achievements, but also beside its richness, for the choice of pioneer research topics in the field of the earth and environmental changes during the Quaternary. Thus in the course of the last 30 years Hugues Faure and his teams

established a new approach to the understanding of physical changes on the surface of our planet during the past thousands of years.

"Hugues had an infectious enthusiasm for science, a passion about scientists keeping in touch with 'the real world', a perennial concern for the future of research, and a visionary spirit allied to a remarkable instinct for synthesis as well as an exceptional capacity for work. Hugues Faure was a remarkable man and a distinguished Quaternary scholar". (Edward Derbyshire, INQUA Congress in Reno, 30 July 2003).

Discovering and understanding our planet, contributing to the advancement of our knowledge meant to him "to contribute to Evolution" and to assume a destiny. For all those who could meet him and work with him, he was a man with a rare nobility of soul and a great generosity, an exceptional man, shaped by the desert and used to an ascetic way of life. He chose to exist by and for the others. And nothing could turn him away from his principles.

In this unique adventure of his life, he closely associated his very own and his scientific "family", colleagues and friends all around the world, with whom he shared his enthusiasm for research, his passion for knowledge, his joy of living and his infinite and universal love for our planet Earth (for life and mankind on it).

Despite his ascetic, disciplined approach to the world, Hugues had a wonderfully irreverent sense of humour, including the impersonations of the famous. He was able to joke on serious subjects, refusing and denouncing dogmas and not taking himself seriously. "I do not think that in all the years I have known him, I ever heard him boast about anything. When pressed, he would reluctantly admit that he had achieved significant things, but only because he so loved the subject and worked very hard, and because he happened to be in the right place at the right time." (Jonathan M. Adams).

During his last months of life Hugues maintained his fortitude and his devotion to science, despite the everyday struggle against the illness. Only a few weeks before the end, he was so happy to be on the field ' climbing' on the flanks of the Teide Volcano (Fig. 3). Finally confined to a hospital bed, he was fighting so hard to survive. But he was still keeping smiling and never complaining, worrying only for others. To keep his mind clear and to 'write' his next paper, he endured and surpassed the physical suffering with a great courage. He remained faithful to himself until the end, illuminated by fondness and love (Faure-Denard, L., Faure, O., 2003).

Hugues was totally devoted to Science . "We are all serving the same "cause": the progress of Science, because Science that makes a man be more a man is the best proof of our evolution, and because further evolution and development will come from Science". (Faure, 1984b). He still had in him something of the desert. He left a lot of him (beside his 600 publications). Many are those who continue today in France, in Africa and the world to remember his message of Man and Scientist, to be inspired by his example, to respect his memory. Let his light shine on.

8.1. Academic career of Hugues Faure

(1) Maître de Conférences, then Professor at the University of Dakar (Senegal), from 1963 to 1968.

Fig. 3. Hugues in Tenerife Island (February 2003). "What really matters to me is my soul facing the eternity" (Communication, Hugues Faure). "He was a man who made his dream come true and his life become a destiny" (picture by Liliane Faure).

(2) Professor at the University Pierre and Marie Curie of Paris from 1968 to 1977.
(3) President of the ORSTOM Committee on Geology, from 1969 to 1982.
(4) Director of the CNRS Laboratory of Quaternary Geology (LGQ), from 1970 to 1984.
(5) Professor at the University of the Mediterranean (Aix-Marseille II), from 1978 until 1995 "Classe Exceptionnelle" from 1986.
(6) Professor Emeritus, from 1995 until the end in 2003.

8.2. Recognition of Hugues' talents led to numerous awards and promotions

(1) Chevalier dans l'Ordre des Palmes Académiques (Paris, 1965).
(2) Lauréat de l'Académie des Sciences, Paris, Prix de la Fondation Charles Jacob (Paris, 1971).
(3) Prix de Lamothe de la Société Géologique de France (Paris, 1976).
(4) Honorary Fellow of the Geological Society of Africa (Addis Abeba, 1982).
(5) Président d'Honneur de l'ASEQUA (Ass. Scientifique pour l'Etude du Quaternaire Africain), Dakar, 1986.
(6) He was member, or Vice-President of the French National Committees of: INQUA, IGCP, IGBP. Member of the Scientific Committee of Programmes DBT-INSU, CEPESBA-CNES, PIRAT, etc.

Acknowledgements

To all colleagues and friends who honoured Hugues' memory, especially those from Africa, from INQUA, IGCP, CNRS, IRD and Universities, those who paid tribute to Hugues Faure during the INQUA Congress in Reno, Nevada, USA, in late July 2003 (Nick Shackleton, Nicklas Morner, Cari Zazo, Ed Derbyshire, Jonathan Adams):

"The highlight of INQUA XVI was Sir Nick Shackleton's prefacing of his opening plenary address with a clarinet recital of Louis Cahuzac's "Pastorale Cévenole", in memory of recently deceased colleague, Hugues Faure, head of the Laboratoire de Geologie du Quaternaire at the University of Aix-Marseille, former INQUA President, and pioneering investigator of orbital scale controls on African monsoon circulation and on the glacial/ interglacial carbon cycle". (Quaternary Australasia 2003, 2, 21).

Special thanks are addressed to:

-Jonathan M. Adams, who had the difficult task to contribute several obituaries for his former supervisor. He was the last PhD Student of Hugues, and shared with him the "Carbon Cycle adventure" during the last 13 years of his life. "Among my many memories of Hugues, several aspects of his character stand out in my mind; his absolute integrity as a human being, his puckish sense of humour, and his devotion to the ideals of science". (Jonathan Adams, 9.05.2003)

-Jean-Philippe Brugal (ESEP, Aix) and the CNF-INQUA who organised, together with Luc Ortlieb (IRD, Bondy) and Jean-Luc Probst (IGCP 459) a Colloquium in homage to Hugues Faure, associated to the 20th Colloquium on African Geology, at BRGM Orléans, France, on June 3, 2004. (Vol. of Abstracts available on: www.cag20.brgm.fr)

-All the authors, colleagues and friends, who contributed to this Special Issue in homage to Hugues, and to all reviewers for valuable comments.

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List of Acronyms

CEPESBA: Centre Pilote d'Etudes Spatiales de la Biosphère Africaine,
CNES: Centre National d'Etudes Spatiales,
CNRS: Centre National de la Recherche Scientifique,
DBT: Dynamique et Bilan de la Terre,
INSU: Institut National des Sciences de l'Univers,
LGQ: Laboratoire de Géologie du Quaternaire,
ICL: Inter-Commission on the Lithosphere,
ICSU: Intern. Council of Sciences,
IDEAL: International Decade for the East African Lakes,
IFAN: Institut Fondamental d'Afrique Noire,
IGBP: Intern. Geosphere Biosphere Program,
IGCP: Intern. Geological Correlation Program,
INQUA: Intern. Union for Quaternary Research,
IUGG: Intern. Union of Geophysics and Geodesy,
IUGS: Intern. Union of Geological Sciences,
IUSS: Intern. Union of Soil Science,
UISPP: Union Intern. des Sciences Préhistoriques et Protohistoriques

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