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Preface

Recent developments on seafloor petrology and tectonics: A volume in honour of *Roger Hekinian* for his life-long contributions to marine petrology and tectonics reseach

Roger Hekinian was born at home in Marseilles, France on October 2, 1935, to *Anahid* and *Ohvannes Hekinian*. *Roger* grew up in the same home as his parents, his sister *Josette*, his grandparents and an Aunt and Uncle, so the family values of an Armenian home were quickly learned and assimilated. At age 13, his education in France ended because his family sent him to an Armenian parochial boarding school run by Mekhetarian priests in Venice, Italy. While at this school, he learned to read and write Armenian, as well as Italian. By the time he graduated from high school, *Hekinian* could already speak and read three languages. His initial university work took place in Padua, Italy, but he soon transferred to the University of Pisa to specialize in geology. He became extremely interested in the new frontier of oceanographic research, and in 1961 he decided to migrate to the USA where he entered a program at the Lamont–Doherty Geological Observatory (now Earth Observatory) of Columbia University in Palisades, New York. He worked in the core laboratory under the supervision of *Maurice Ewing* and *Charles Fray*. At first, the young immigrant was asked to do menial chores on board the Lamont–Doherty research vessels. *Hekinian's* first sea-going experience was to drop dynamite sticks off the end of the ship (to measure the ocean floor's seismicity) as well as to help with the dredging and coring operations. After 7 months at sea, his mastery of the English language had improved and Columbia accepted him in a full scholarship program to work on a Master's degree in petrology under the supervision of *Arie Poldervaart*, a South African specialist in the field. Unfortunately, *Dr. Poldervaart* died before *Hekinian* could finish the Master thesis, so he completed his work with the support of Poldervaart's assistant, *D. Vincent Manson*, in the summer of 1966. On the advice of *Paul Gast* and other professors at Columbia, *Hekinian* then went to a young school in Binghamton that was part of the SUNY (State University of New York) system, Harpur College. With *Thomas Donnelly* as his advisor, *Roger* rapidly completed the course of study and wrote and defended his PhD thesis (on spilitic formations from the Virgin Islands) in June 1969. This thesis was Harpur College's (now called SUNY Binghamton) first PhD thesis, a “dubious” distinction that helped young *Hekinian* obtain a job a month later.

Hekinian's first job was at the Smithsonian Institution (in the then called Sorting Center) in Washington, D.C., where he worked with *Dr. Tom Simkin*. The Sorting Center was a national repository for cores and dredge samples collected mainly from the South Pacific. This was an exciting time in the Earth Sciences during which the plate tectonics theory was gaining acceptance. Persuaded by his countryman *Xavier Le Pichon* and others, a year later *Roger* joined the team formed at the new oceanographic center being built near Brest, France, then called CNEXO, now known as IFREMER (Institut Français pour le Recherche et Exploitation de la Mer—French oceanographic research institution). He worked continually at IFREMER until his retirement in 2000 at age 65.

When he was a doctoral student at Binghamton, he met *Virginia (Ginny) Baker* and the two were married in August 1970. Thus, *Roger* returned to France nine years after immigrating to America with an American passport, a new wife, a Toyota automobile and 17 boxes of books. In January 1971, the couple set up housekeeping in Brittany, first by the sea in the village of Le Conquet, then inland in a stone house, in St Renan, where they have lived since 1975. Two sons were soon born into their family: *Aram* (1973) and *Diran* (1975). A daughter, *Anna*, was born in 1978. Since his retirement, *Roger* has been a patient gardener, a generous father and an enthusiastic grandfather to his three grandsons: *Sevan* and *Shahe Petit* and *Ara Hekinian*. He is frequently found on German ships on which, as an Alexandre von Humboldt Research Fellow, he continues his long-term Franco-German collaboration with Peter Stoffers and his research group at Kiel, collecting rocks at sea and writing papers and books back home on seafloor petrology and tectonics.

As the family was growing, *Roger* was also getting more involved in “state-of-the-art” oceanographic adventures. Over his seafloor research career, *Roger* has been on more than 60 missions at sea, mapping the seafloor and collecting rock samples from the Pacific, Atlantic and Indian oceans. These include a number of submersible diving expeditions, for which he has set the record for being one of the most experienced in the world in terms of total amount of time expended in deep ocean submersibles making *in situ* observations and sampling. He has worked with many oceanographic pioneers including *Xavier Le Pichon* (College de France), *Jean Francheteau* (Universite de Bretagne Occidentale) and *Bob Ballard* from Woods Hole Oceanographic Institution. *Roger* has

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published over 130 papers in scientific journals such as “Nature”, “Science”, “Geology”, “Earth and Planetary Science Letters”, “Journal of Geophysical Research”, “Tectonophysics”, “Marine Geology”, “Marine Geophysical Research”, “Journal of Volcanology and Geothermal Research”, “Contributions to Mineralogy and Petrology” etc., reporting new discoveries, and discussing inspiring ideas and new research frontiers. He has also published three books.

His book *Petrology of the Ocean Floor* (Elsevier, 1982) is the first comprehensive text of its kind, which, based mostly on his personal experience and knowledge, has inspired many. I myself am one of those inspired to choose the study of seafloor petrology and tectonics as a research career. His edited book (with P. Stoffers and J.-L. Cheminée) *Oceanic Hotspots* (Springer, 2004) summarized not only the state-of-the-art knowledge on magmatism of intraplate volcanic islands, but also offered new concepts on “plume–ridge” interactions and pointed to new research directions particularly important in the context of current “Great Mantle Plume Debate”. His (with N. Binard) *Le Feu des Abysses* (The fire of abysses) (Quae, 2008) is a valuable research document as well as an educational requisite for understanding the origin and evolution of ocean crust from ocean ridge magmatism to intraplate ocean island volcanism using photographs of seafloor structures and morphology taken during deep sea submersible operations.

It is a common knowledge today that most mid-ocean ridge basalts (MORB) are depleted in incompatible elements, called normal or N-type MORB, but some are incompatible element enriched E-type MORB, and still some are compositionally transitional to “plume-like” basalts, hence the acronyms of T-MORB and P-MORB. These distinctions, though somewhat arbitrary, are in fact documented through the famous collaborative project FAMOUS (Franco-American Mid-Ocean Undersea Study) in the early 1970s (1972, 1973, 1974) at the North Mid-Atlantic Ridge (MAR). *Roger* played a major role in this project supervising on-site (in submersible) operation in collaboration with his colleagues from IMFREMER and from Woods Hole Oceanographic Institution in the US. It is well-known that MORB from the MAR and EPR show some systematic differences, but *Roger* was among the first to recognize such differences. Hydrothermal venting and sulfide mineralization are now known to be widespread along the global ocean ridge system, but again *Roger* is among the first to identify and describe these systems. In 1978, *Roger* and his team discovered several hydrothermal vents at the East Pacific Rise (EPR), and in 1982, he discovered and described in great detail (submersible operation) hydrothermal chimneys and sulfide mineralization at 13°N on the EPR. To most of us, it seems quite natural to think of transforms as one type of plate boundaries, but the origin of transforms/fracture zones is rather poorly understood (or not understood at all). His discovery of intra-transform volcanism was a pleasant surprise for understanding mantle melting processes and for re-thinking the origin and tectonic evolution of transforms and fracture zones. His discoveries of mantle peridotites from transforms and tectonic deeps in the Pacific have led to the understanding that the extent of mantle melting beneath ocean ridges increases with increasing plate spreading rate. His new perspectives and ideas about the geology and volcanology of intraplate volcanic islands and island arcs are illuminating. It is fair to say that without *Roger* and his life-long contributions, our present-day knowledge of seafloor petrology and geology would not be the same because of all the above, and because over the past 40 years of his unselfish collaborations with others by offering advice, sharing experience, helping and encouraging younger scientists, and by providing precious samples for additional petrologic and geochemical studies towards an improved understanding of the chemical geodynamics.

This special Lithos volume is dedicated to *Roger Hekinian* for his lifetime contributions to marine petrology and tectonics research by his friends, colleagues, shipmates, students and those whose careers have benefited from his inspiration and encouragements. I first met *Roger* on board JOIDES RESOLUTION during ODP Leg 142 in early 1992 before I got my PhD in that year. I soon found this famous man was kind and resourceful and our 2-month drilling cruise marked the beginning of our friendship and pleasant collaboration (6 co-authored papers). I discovered later during my IFREMER visit in 1996 that this prolific scientist is also an admirable family man. How could one manage to do all these? He has a lovely and understanding wife and children! He worked triply hard at home to catch up with all that he had missed while at sea, from a few weeks to months each year—a long time for the family and for the growing children. His Armenian roots are well represented in the first names of his children and grandsons, his personal warmth is reflected in the many barbecues he has cooked and served to his friends and colleagues over the years, and he is modest almost to a fault since he would be the first to say “I haven't discovered anything” when asked about his accomplishments. He is not a publicity-seeker, and is certainly not a person to look for recognition (although he was honoured with a “Joubin-James Distinguished Lecturer” by the University of Toronto in 1989 and received the bronze “Hans Petterson Memorial Medal” from the Royal Swedish Academy of Sciences in 1999). His interest is entirely in science and the joy of discovery. He has set an example for many of us to follow. His achievements, his modesty and his spirit of unselfish collaboration are well recognized through this special volume—a long-lasting scientific legacy in the Earth Science.

The 10 articles in this special volume all take the “conventional approach” that *Roger* is familiar with, i.e., field observation and sampling, data collection and geologic interpretation with modeling. However, they have reached non-conventional, novel and provocative conclusions on important Earth problems. *Niu and O'Hara* demonstrate that primitive MORB melts have positive Eu and Sr anomalies, suggesting that the MORB mantle possess excess Eu and Sr. They further stress that MORB mantle hosts the missing Eu (Sr, Nb, Ta and Ti) in the continental crust and propose that ocean crust melting during continental collision (ocean basin closing) produces and preserves the juvenile crust, and hence maintains net continental crust growth. This new concept circumvents all the difficulties with the widely accepted ‘island arc magmatism’ model for continental growth. They also hypothesize that the seismic low velocity zone (LVZ) is compositionally stratified with small melt fractions concentrated towards the top to metasomatize the growing oceanic lithosphere before it reaches its full thickness after ~70 Myr. In contrast, deep portions of the LVZ, which are thus relatively depleted, become the primary source feeding MORB because of ridge suction. *Marques et al.* show that plagioclase phenocrysts in MORB melts in the vicinity of the Menez Gwen and Lucky Strike hydrothermal fields at North MAR have abundant melt inclusions with concentrated metallic precipitates ($Fe + Ni + Cu \pm Zn \pm S \pm Cl$) within the vapor bubbles. These observations lead them to propose that degassing and melt-rich fluid exsolution at magmatic conditions may be far more important than previously thought in direct metal contribution (vs. hydrothermal fluid leaching) to seafloor sulfide mineralization. *Peterson et al.* provide thus far the most comprehensive and clear documentation of hydrothermal activities and associated mineralization in “peridotite dominated host” at 14°45′N MAR. A detailed geochemical study of MORB and near-ridge seamounts at ~26°S MAR allows *Regelous et al.* to argue that the so-called Dupal Anomaly in the South Atlantic may be of shallow (vs. deep mantle plumes) origin with contributions from ancient lower continental crust, probably associated with the continental breakup and South Atlantic opening at ~134 Ma.

Natland and Dick interpret the two thin melt lenses detected geophysically beneath the fast spreading EPR to function differently in regulating the chemical and physical processes of magma differentiation. The deeper melt lens at the Moho depth represents a level of neutral buoyancy of primitive mantle melt laden with olivine crystals. The shallow melt lens at the base of the sheeted dikes represents a permeability barrier where much of the magma fractionation takes place, determining the compositions of erupted MORB melts. They base their interpretations on a composite lithostratigraphy observed in Hess Deep. *Castillo et al.* present geochemical data on basalts of old Pacific plate seafloor that is being subducted beneath the Tonga–Kermadec island arc system in the southwest Pacific. Despite lava compositional scatter, the first order along-latitude correspondence in Sr–Nd isotope ratios and ratios of incompatible elements between seafloor basalts and arc lavas is remarkable. It represents the first geochemical demonstration of the role of subducting ocean crust in arc magmatism. The new data will encourage us to think and re-think the petrogenesis of arc magmatism, and the geochemical consequences of subduction factory. *Bach and Klein* offer a thermodynamic reaction path model to explain the formation of rodingites at the interface between mafic and ultramafic contact zones in response to serpentinization, and conclude that rodingitization is most likely the result of diffusional metasomatism, controlled by a silica (vs. Ca) activity gradient in the fluid across the lithological boundary. The apparent Ca gain in the rodingite is a passive response to hydrous species diffusion.

Humphreys and Niu demonstrate that despite compositional variability of basalts from intraplate volcanic islands (i.e., OIB) between flows on single islands, between islands and between island groups, the lithosphere thickness at the time of volcanism exerts the first order control on OIB compositional systematics on a global scale. *Haase et al.* present geochemical data on new samples from seamounts in the vicinity of the Valu Fa Ridge in the southern Lau Basin, a backarc basin behind the Tonga island arc system in the southwest Pacific. The new data show that like seamounts near the EPR, the seamounts in back arc basins are also more primitive and compositionally more variable than the nearby ridge axis. This observation is thus of global significance. Furthermore, the data also show that both the slab component in the melt and melt production increase as the volcanoes approach the volcanic arcs. *Guilmette et al.* present data on old seafloor rocks exposed on land—the Tethyan ophiolite along the Yarlung Zanbo suture zone in southern Tibet as the result of India-Asia continental collision. They focus their study on strongly foliated amphibolite clasts in the ophiolitic mélange, and interpret the protoliths to be backup basin basalts metamorphosed in response to the inception of a new subduction zone as the older subduction ceased at ~130 Ma. These data contribute to the debate on the tectonic evolution of the Tethyan system and processes associated with the India-Asian collision and continued convergence.

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