

# Stony Brook's High-Pressure Laboratory Collaborations with French Scientists

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## Abstract

For more than a half century, my colleagues and I in the Stony Brook High Pressure Laboratory have profited from collaborations with French scientists in their laboratories in Orsay, Paris, Toulouse, Lille, Lyon, Strasbourg and Rennes. These interactions have included postdoctoral appointments of French colleagues in our laboratory as well as two année sabbatique by me; in 1983-84, in the Laboratoire de Géophysique et Géodynamique Interne at the Université Paris XI in Orsay and in 2020-2003 in the Laboratoire des Mécanismes et Transfert en Géologie at the Université Paul Sabatier in Toulouse. The objective of this report is to relate this history and to illustrate the scientific advances which resulted from these collaborations.

## Keywords

Mineral Physics, High Pressure, High Temperature, Multi-Anvil Apparatus, Atomic Diffusion, Mineral Deformation, U.S.-France Collaboration, Activation Volume for Creep, Ultrasonic Interferometry, Synchrotron X-Radiation

## 1. Introduction

The biennial Gordon Research conferences on Research at High Pressure often serve as a meeting place for scientists throughout the world to present talks on new scientific investigations; one of the fundamental rules of such GRCs is that no talk can be referenced in publication, which fosters an open exchange of ideas. My first GRC was in 1966 at the Kimball Union Academy in Meriden, New Hampshire; it was there that I met Boris Vodar and his colleague Christiane Lorier-Susse. I later visited their Laboratoire des Hautes Pressure in Meudon, France and had the opportunity to examine many different varieties of high-pressure apparatus.

In June 1976, I was Co-convenor of a Workshop on Anisotropy and Heterogeneity of the Lithosphere at the Castle of Liblice in Czechoslovakia. One of the attendees from France was Claude Froidevaux from the Université Paris XI, who was accompanied by his young protégé, Olivier Jaoul (**Figure 1(a)**).

## **2. Collaboration with Olivier Jaoul and Colleagues at Université Paris XI in Orsay**

When we met again at the IASEI in London, Ontario in 1981, Froidevaux asked if I would be interested in spending some time in France. In 1983, my election as chair of the Department of Earth and Space Sciences at Stony Brook was vetoed by my astronomy colleagues and I was thus free to take leave for une année sabbatique. When I contacted Froidevaux, he immediately invited me to spend a year as a visiting professor in his Laboratoire de Géophysique et Géodynamique Interne on the plateau de Moulon in Orsay. Froidevaux not only offered me his office in Bâtiment 510, but also a share of his salary while he was on leave. He recommended that I work with Jaoul and his colleagues on experimental studies of atomic diffusion in minerals at high temperature [1] [2]. During that period, I also had the opportunity to interact and learn from Froidevaux's young colleagues, including Luce Fleitout, Henri-Claude Nataf and Yanick Ricard, as well as visiting the labs of Yves Gueguen in Strasbourg and Adolphe Nicolas in Nantes.

I was accompanied by my wife Barbara and our three children; we rented the apartment of Jaoul in Palaiseau and our children attended French public schools [with home tutoring from Barbara, who is a prof de français]. I enjoyed being an experimentalist again and we collaborated with James Boland (from the University of Utrecht in The Netherlands), who suggested that our San Carlos olivine specimens had undergone surface destabilization and laboratory-induced non-stoichiometry during the diffusion experiments (**Figure 1(b)**) [1].

When we had installed our new 2000-ton Uniaxial Split-Sphere Apparatus [USSA-2000] in our high-pressure laboratory, Jaoul visited Stony Brook in 1987 to discuss the possibility of conducting atomic diffusion at high pressures and temperatures (**Figure 2**).

In subsequent years, several students of Jaoul spent time in our High-Pressure Laboratory at Stony Brook studying diffusion at high pressures in olivine (including Yves Bertran, Paul Raterron and Frédéric Béjina—see [3] [4] [5] [6] [7]).

## **3. History of Japan-U.S./High Pressure Mineral Physics Seminars: 1976 to 2012**

From 1976 to 1996, these seminars were held as bilateral meetings of Japanese and U.S. scientists. The transformation of the Japan-U.S. seminar series to a more international scope in 2002 was a consequence of the expansion of high-pressure laboratories throughout Europe. Subsequent seminars have been held at 5-year intervals on a rotating basis of Japan, U.S. and Europe. The most recent seminar was held in St. Malo, France and convened by Guillaume Fiquet and James Badro with Japanese and U. S. colleagues [8].



(a)



(b)

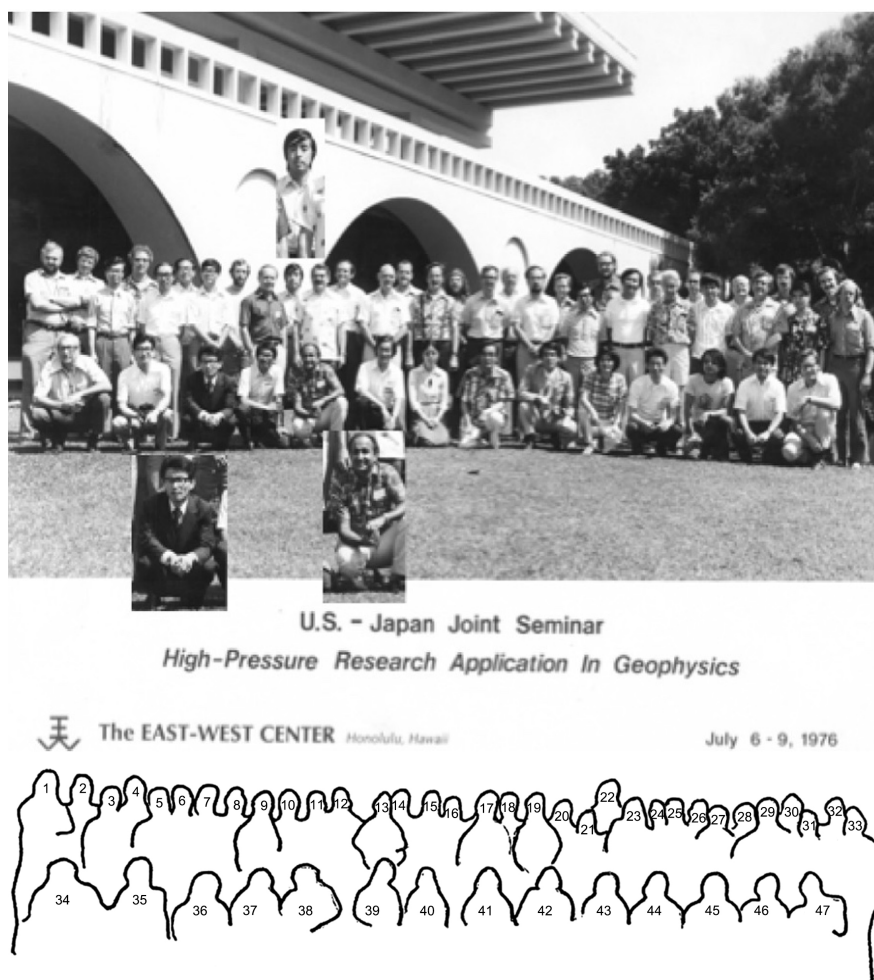
**Figure 1.** (a) Attendees at the Liblice workshop in 1976. See Claude Froidevaux at center in first row and Olivier Jaoul in second row behind Murli Manghnani. (b) Research group of Claude Froidevaux (standing right) at picnic in the Forêt de Rambouillet near Orsay. Also seen are Olivier Jaoul seated and facing and Luce Fleitout (standing and facing toward Jaoul).



**Figure 2.** Photo of graduate student Yanbin Wang (L) and Olivier Jaoul (R) planning how to study atomic diffusion at high pressures using the USSA-2000 apparatus.

1976: Many French scientists participated in the High-Pressure Mineral Physics Seminars from 1976 to 2017. Only Boris Vodar attended the first seminar in Honolulu in 1976, the only seminar I missed due to the birth of our son in Australia (**Figure 3**).

1981: The second Japan-U.S. seminar was held in Hakone, near Mt. Fujiyama in 1981. It was there that I first met Jean-Paul Poirier (**Figure 4**).



- |                  |                     |                 |
|------------------|---------------------|-----------------|
| 1. W.A.BASSETT   | 17. B.OLINGER       | 33. T.SHANKLAND |
| 2. A.L.BOETTCHER | 18. B.VODAR         | 34. R.MC QUEEN  |
| 3. Y.SYONO       | 19. M.ST.BUKOWINSKI | 35. K.SUITO     |
| 4. P.WYLLIE      | 20. G.GOETZE        | 36. E.ITO       |
| 5. I.KUSHIRO     | 21. K.ITO           | 37. H.MIZUTAMI  |
| 6. L.LIU         | 22. H.DEMAREST      | 38. M.MANGHNANI |
| 7. L.C.MING      | 23. D.CHUNG         | 39. S.AKIMOTO   |
| 8. G.DAVIES      | 24. L.MERRILL       | 40. Y.SATO      |
| 9. A.E.RINGWOOD  | 25. G.KENNEDY       | 41. N.KAWAI     |
| 10. T.YAGI       | 26. J.FRITZ         | 42. R.OTA       |
| 11. G.PIERMARINI | 27. H.MAO           | 43. Y.FUKAO     |
| 12. T.AHRENS     | 28. J.JAMIESON      | 44. M.KUMAZAWA  |
| 13. R.HANSON     | 29. O.ANDERSON      | 45. HISAO ITO   |
| 14. H.C.HEARD    | 30. D.GRANY         | 46. H.SAWAMOTO  |
| 15. H.SPETZLER   | 31. S.KUME          | 47. A.KUSUBOV   |
| 16. R.JEANLOZ    | 32. I.JACKSON       |                 |

**Figure 3.** Group photo from first U.S.-Japan Joint Seminar on High Pressure Research Application in Geophysics in Honolulu, Hawaii in 1976.





(a)



(b)

**Figure 4.** Photos from second Japan-U.S. high pressure seminar at Hakone, Japan in 1981. (a) Jean-Paul Poirier at earthquake response center of Tokyo in 1981; (b) Don Anderson, William Bassett, Jean-Paul Poirier and Mineo Kumazawa on “field trip” at Hakone in 1981.

2002: The sixth high-pressure mineral physics seminar was convened in Europe by David Rubie Takehiko Yagi and colleagues and held in Verbania, Italy in August 2002 (**Figure 5**).

2007: The seventh high-pressure, mineral physics seminar was convened in Japan by Eiji Ohtani and colleagues and held on Matsushima Island near Sendai (**Figure 6**).

2012: The eighth high-pressure, mineral physics seminar was convened by Yanbin Wang and colleagues and held at Granlibakken Lodge on the shores of Lake Tahoe in California (**Figure 7**).

2017: The ninth high-pressure, mineral physics seminar was convened by Guillaume Fiquet and James Badro and Japanese, Chinese and American colleagues and held in St. Malo, France (**Figure 8**).



**Figure 5.** Shun Karato explaining his poster to Hélène Couvy (L) and Patrick Cordier (R) at Sixth High Pressure Mineral Physics Seminar HPMP5-6 in Verbania, Italy in August 2002.



**Figure 6.** Social events and “field” trips at Seventh High Pressure Mineral Physics Seminar in Matsushima, Japan in 2007. Members of organizing committee “singing”? L. to R. Takehiko Yagi, Dave Rubie, James Badro and Murli Manghnani.



**Figure 7.** Frédéric Bějina, Misha Bystricky, Gabriel Gwanmesia and Tetsuo Irifune at breakfast with Barbara Liebermann at Eighth High Pressure Mineral Physics Seminar at Granlibakken, California in 2012.



**Figure 8.** Bob and Barbara Liebermann with French friends Paul Raterron, François Guyot and Frédéric Bějina and Chinese and Japanese colleagues at beachside restaurant in St. Malo, France.

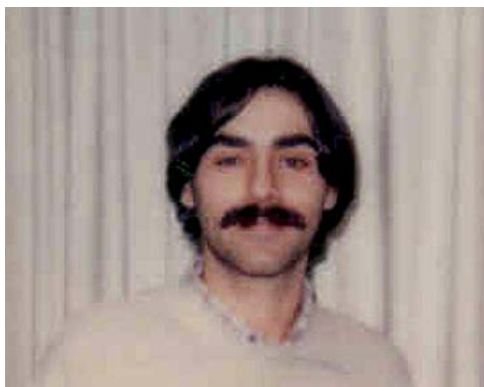
#### **4. Collaboration with Jean-Paul Poirier and Colleagues at Université Paris I in Jussieu**

While in France in 1983-84, I also worked with Jean-Paul Poirier at the Institut de Physique du Globe de Paris (IPGP) on investigations of the activation volume for creep and its variation with depth in the Earth's mantle [9]. When our sabbatical visit to Tokyo was delayed by 5 months, Poirier arranged for me to have a part-time position and salary at (IPGP). During this period, I spent each Tuesday at IPGP and had many discussions about elasticity with Poirier and his graduate students; one of these students, Jannick Ingrin, recalls these visits and their role in helping him complete his first paper on the preservation of coesite with Phillippe Gillet. On my return to Stony Brook, Poirier arranged for Ingrin to join our lab: Jannick was the first of many French postdocs who spent time in

the High-Pressure Laboratory. He used his knowledge of electron microscopy to measure the dislocation density of specimens recovered from high-pressure, high-temperature experiments in a girdle-anvil apparatus to determine the degree of deviatoric stress which the specimens had undergone [10]. This technique was later utilized in many deformation experiments in other multi-anvil apparatus (**Figure 9**, **Figure 10**).

International grants from the Centre National de Recherche Scientifique (CNRS) and the NSF, provided support for my students Anne Remsberg and Yanbin Wang, who worked with Poirier and Boland on the analysis of transmission electron images of their high-pressure samples; see [11] [12] [13].

Collaboration with the lab of Poirier continued for another 20 years via my students and French postdoctoral visitors [10] [14]-[19]. From 1985 to the present, we have also hosted visiting students from France on a “stage” from their home institutions (e.g., Delphine Cuny, Hélène Couvy, Pierre Emanuel Petit, Merlin Meheut, Chloé Michaut) (**Figures 11-15**).



**Figure 9.** Jannick Ingrin as postdoc at Stony Brook in 1985-86.



**Figure 10.** Installing girdle-anvil apparatus in 1977.





(a)



(b)

**Figure 11.** Visiting students Delphine Cuny (a) and H  l  ne Couvy (b).



**Figure 12.** CHiPR Summer Scholar Chlo   Michaut with Gabriel Gwanmesia and me in High Pressure Lab in 1991.



**Figure 13.** Yves Bertran-Alvarez in High Pressure Lab with Fran  ois Guyot watching. From 1987-1988, Yves was performing his mandatory military service in our lab; as France considered the United States as a higher status country, his salary needed to be paid from our research grants. This is the only time in my memory that France thought of the U.S. as a more advanced country.



François Guyot

Isabelle Martinez

**Figure 14.** François Guyot and Isabelle Martinez visiting me in Toulouse in 2003.



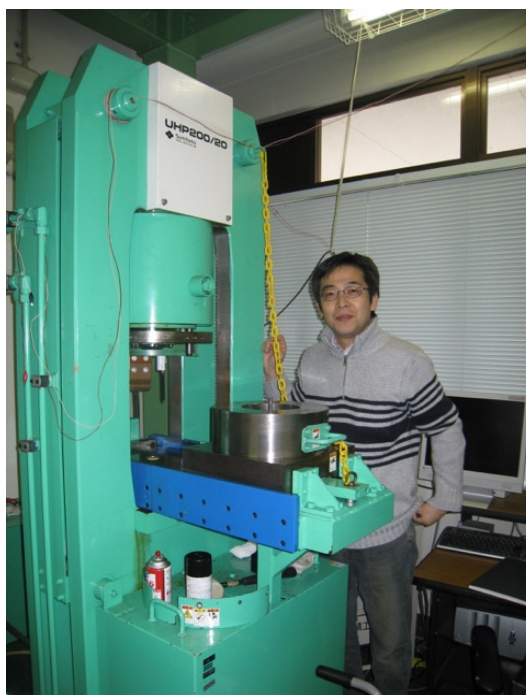
Paul Raterron and Bob (1993)

**Figure 15.** Visiting scientist Paul Raterron with me in ultrasonics laboratory in 1993.

During the stays of Paul Raterron as a visiting scientist at Stony Brook, we conducted investigations of deformation of silicate garnets in our multi-anvil apparatus in collaboration with Patrick Cordier from Université des Sciences et Technologies de Lille (see [20] [21]). Perhaps this should be described as an international collaboration of French, Chinese, Japanese and U.S. scientists (**Figure 16, Figure 17**).

In France, the doctoral candidate gives a short talk on their dissertation (with all faculty and students of the department present, as well as the parents and relatives of the candidate and even persons off the street). During this period, I also served as a member of the jury at the soutenance (thesis defense) for the doctoral theses of several French colleagues, including François Guyot, Jannick Ingrin, Paul Raterron and Frédéric Béjina and Agnès Dewaele. All of those scientists spent time in our laboratory at Stony Brook; after the soutenance of Dewaele in Lyon in 1999, she and a fellow student Chrystèle Sanloup took me on a field trip to the Roman ruins in Vienne, south of Lyon.

I also learned about several differences between soutenances in France and thesis defenses at Stony Brook. In our Department of Geosciences, the doctoral candidate gives a short talk on their dissertation, after which the general audience is invited to make comments or ask questions; then the examination committee retires to another room for a discussion with and questioning of the candidate. If the defense is successful, it is the custom for the thesis advisor to give a party, often at their home.



**Figure 16.** Jun-ichi Ando in his laboratory at Hiroshima University.



**Figure 17.** Yanbin Wang and wife Mei at High P Seminar at Granlibakken in 2012.

In France, the doctoral candidate gives a short talk on their dissertation [with all faculty and students of the department present, as well as the parents and relatives of the candidate and even persons off the street. After the talk, the jury is invited to make comments, but is not allowed to ask questions. After commenting: “Je voudrais faire mes compliments a M. Guyot pour a tres bonne these sous la direction of Jean-Paul Poirier.” I once made the mistake of asking questions in French, but was interrupted by Poirier who said loudly: “Bob, please speak English.” If the defense is successful, the candidate’s family is obligated to give a “pot” for all attendees (**Figure 18**).



**Figure 18.** Agnès Dewaele and Jean-Paul Poirier at pot following soutenance of Agnès in 1999.

At the GRC on High Pressure in 1986, I met Jean-Michel Besson of the Université Paris VI, who offered much valuable advice and guidance on the design and use of high-pressure apparatus and invited me to visit his lab in Paris (**Figure 19(a)**). That visit to Paris and a meeting in Kyoto at the 1997 AIRAPT meeting led to Frédéric Decremps coming to Stony Brook in the late 1990s and performed some pioneering research on simultaneous measurements of sound velocities, volume changes and structural transformations in ZnO [22] [23] [24].

After Georges Calas visited our lab in Stony Brook he invited me to give a series of lectures to the Institut de Minéralogie et de Physique des Milieux Condensés at Paris VI. Subsequently, his colleague Laurence Galois spent a year in my lab working on the high-pressure behavior of  $\text{Co}_2\text{SiO}_4$ . While in Paris, I also met Jean-Paul Itié who expressed an interest in the densified fused silica which my graduate students Gabriel Gwanmesia and Yanbin Wang had synthesized at 18 GPa in the USSA-2000 apparatus; they provided specimens to Itié who worked with his colleagues to conduct X-ray absorption measurements [25] (**Figure 19(b)**).

One of the main research programs in our high-pressure laboratory in the past three decades has been the development of techniques to measure the elasticity of Earth materials at high pressure and high temperature using ultrasonic interferometry in conjunction with synchrotron X-radiation (see summary in [26]). For these experiments, one of the essential ingredients is high-quality polycrystalline specimens which are homogeneous and free of cracks and pores, fine-grain size and have bulk densities within a few percent of the theoretical X-ray density. We have been fortunate in hot-pressing such specimens with the



collaboration of Daniel Neuville from Paris, who has provided us with starting materials of homogeneous glasses of the desired composition (see especially the study of  $\text{CaMgSi}_2\text{O}_6$ -diopside) [27]. Among the other materials studied with specimens produced with his glasses are  $\text{MgSiO}_3$ -perovskite [28],  $\text{MgSiO}_3$ -orthopyroxene [29],  $\text{MgSi}_3\text{O}_{12}$ -pyrope [30] and  $\text{KAlSi}_3\text{O}_8$ -hollandite/aka liebermannite [31]; the latter paper has a detailed description of the procedures used to produce these glasses in Neuville's laboratory by Charles Le Losq.



(a)



(b)

**Figure 19.** (a) Frédéric Decremps with his new toy; (b) Laurence Galois in our garden in Setauket with Jude and Crystal Gwanmesia, children of my colleague Gabriel Gwanmesia from Delaware State University.

## 5. Collaboration with Olivier Jaoul and Jannick Ingrin and Colleagues at the the Université Paul Sabatier in Toulouse

In 2002-2003, I enjoyed another année sabbatique in France hosted by Olivier Jaoul and Jannick Ingrin, who by now had moved their laboratory from Orsay to Toulouse in the south of France in the Laboratoire des Mécanismes et Transferts en Géologie at the Université Paul Sabatier. They generously offered me a “poste rouge” with a salary supplement and office space; and Ingrin located a house to rent in St. Orens de Gameville for Barbara and me. I met the new generation of students and postdocs, taught a seminar course in the DEA program and continued my work with Frédéric Bějina and Jaoul on diffusion [32] (**Figure 20**).

During that year, Jaoul and Ingrin conspired to nominate me for the degree Docteur Honoris Causa from the Université Paul Sabatier, which I received in Toulouse in April 2004 with an introduction by Olivier Jaoul (**Figure 21**).

In 2005, Olivier Jaoul died after a long illness. I attended the memorial service for him in Toulouse in 2006 and presented a talk on our scientific collaborations and personal friendship over a period of two decades (**Figure 22**, **Figure 23**).



**Figure 20.** Don Weidner and me with Frédéric Bějina and Olivier Jaoul in 2003 at a workshop in Fréjus, France co-sponsored by COMPRES.



**Figure 21.** Bob receiving degree of Docteur Honoris Causa from Olivier Jaoul at Université Paul Sabatier in Toulouse in 2004.



**Figure 22.** Jannick Ingrin and me in newly-dedicated Jaoul Experimental Laboratory at Université Paul Sabatier in Toulouse in 2006.



**Figure 23.** Paul Raterron and me with Nicolas and Delphine, children of Olivier and Martine Jaoul at the memorial service for Olivier in 2006.

## 6. Conclusion

This paper summarizes the collaborations of my High Pressure Laboratory at Stony Brook University over the past 50+ years with scientists in France. I have presented both the scientific achievements and the personal connections which resulted from these collaborations.

## Acknowledgements

I would like to dedicate this paper to Olivier Jaoul with whose laboratories in Orsay and Toulouse I have profited from connections over 30 years. My collaborations with French colleagues have been supported by research grants from



the NSF as well as international grants from the Centre National de Recherche Scientifique (CNRS) and NATO. This report was written with support from a research grant to Baosheng Li and myself from the National Science Foundation (EAR-1524078). One by product of our scientific collaborations was two marriages of French scientists to American women: Paul Raterron to Cynthia Long and Frédéric Béjina to Susan Vrona. I thank my many French colleagues for their friendship and contributions to our research programs at Stony Brook. I am especially grateful to Paul Raterron for his contribution of many photos which he presented in a paper on my French connections at the AGU in 2012 and to my other French colleagues for correcting my French language usage, as well as the two anonymous reviewers who offered constructive comments and suggestions.

### Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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