Jean Virieux – Curriculum Vitae

Born: September 5, 1954, Marseille (France); Citizenship: French
Present Position: Emeritus Professor, Institut des Sciences de la Terre at the Univ. Grenoble Alpes, France
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Education degree

Fellow of the Ecole Normale Supérieure (ULM) (Physics Sciences – 1974-1978)
Diploma University thesis at the University of Paris 6 on « Seismic rupture source modelling » under the direction of Pr. R. Madariaga, Paris, France, 1979.
State thesis (former PhD thesis) at the University of Paris 7 on « Earthquakes: rupture and waves » under the supervision of Pr. R. Madariaga, Paris, France, 1986.

Teaching and Research Activity

1978-1979: Post-doc position at Columbia University, New York, USA
1979-1980: French Military service in the French Navy
1980-1981: Lecturer Assistant at the Ecole Normale Supérieure
1981-1983: Teaching Assistant at the Univ. of Paris 6, France
1983-1990: Assistant professor at the Univ. of Paris 7, France.
1991- 2007: Full professor at the Univ. of Nice-Sophia Antipolis, Nice, France
1992-1997: Junior member of the Institut Universitaire de France
Since 2007: Full professor at the Univ. Joseph Fourier, Grenoble, France
2011-2015: Senior member of the Institut Universitaire de France
Since 2017: Emeritus professor at the Univ. Grenoble Alpes, Grenoble, France

Affiliations, Committees and Scientific Consulting and Evaluation

Member of American Geophysical Union (AGU) (since 1994)
Member of Seismological Society of America (SSA) (since 1994)
Member of Society of Exploration Geophysics (SEG) (since 1992)
Member of European Association of Geoscientists and Engineers (EAGE) (since 2003)
Member of various scientific committees (Institut INOGS at Trieste in Italy, of the society EAGE).
Member of the award committee of EAGE (2013-2014))
Recurrent expert for different national research funding (France, Norway, Germany, USA, Italy …)
Many former scientific management positions at national level (President of CNRS/PNRN, member of CNRS/CN sections 11 & 13, director of GEOAZUR laboratory (1993-2002) and of the agency CURARE (2004-2008), Vice-President of research CS6 evaluating committee (open junior and senior programs) (2005-2009) of the Agence Nationale de la Recherche (ANR), French representative for the ICG/NEAMTWS of IOC (UNESCO) for Tsunami Early warning (2005-2007), President of the Commission des Services Nationaux d'Observation en Terre Interne du CNRS/INSU (CSNO) (2007-2013)).
Associate editor of Geophys. J. Int. since January 2006. Reviewers in many international journals

Award (SEG and EAGE are the two main international societies for exploration geophysics)

Distinguished Lecturer 2015, Society of Exploration Geophysics (SEG),
Erasmus Award 2013, European Association of geoscientists and engineers (EAGE)
Barrabé Award 2012, Société Géologique de France
Adion Medal 2012, Observatoire de la Côte d'Azur
American Geophysical Union Fellow 2012

Jaffé Grand Award, Académie des Sciences, Institut de France, 2009
Bright Spots for « Seismic imaging of complex onshore structures by two-dimensional elastic frequency-domain full-waveform inversion » by R. Brossier, S. Operto and J. Virieux, Geophysics, 74(6), 2009
Best paper in 2008 for the journal Geophysics. « Velocity model building by 3D frequency-domain full-waveform inversion of wide-aperture seismic data » par H. Ben Hadj Ali, S. Operto and J. Virieux. Geophysics, 73(5), 2008.
Medal CAGNIARD of the EAGE with Stéphane Operto and Jean-Xavier Dessa in 2006.

Main Recent Research Project (only mentioned when I am involved as PI or co-PI)
2004-2008 Groupe d'intérêt Scientifique (GIS) **CURARE**, regional funding (3 000 000 €)
2005-2008 Quantitative Seismic Hazard Assessment (**QSHA**), French « Agence Nationale de la Recherche », funding (450 000 €)
2006-2011 **SEISCOPE**, an industrial consortium managed by CNRS and supported by BP, CGG, ENI, ExxonMobil, PETROBRAS, Shell, Statoil, Saudi Aramco, Total, funding (2 400 000 €).
2012-2014 Subduction: Standard and Slow Seismology (**S4**), French "Agence National de la Recherche", funding (380 000 €)
2013-2015 **SEISCOPE2**, an industrial consortium managed by University Joseph Fourier and supported by BP, CGG, Chevron, ExxonMobil, JGI, PETROBRAS, Saudi Aramco, Shell, Statoil, Sinopec, Schulmberger, Total, Woodside, funding (1 950 000 €)
2016-2018 **SEISCOPE2**, an industrial consortium managed by University Grenoble Alpes and supported by CGG, Chevron, ExxonMobil, JGI, Shell, Statoil, Sinopec, Total, Woodside, funding (1 350 000 €)

Complementary recent participation to different international and national projects: 3F-Corinth (2001-2003) (EU funding), HPPP/CO2 (2008-2011), CENTURISK (2009-2011) (ANR funding), SSSS (2012-2014) (ANR funding), HIWAI (2017-2022) (ANR funding).

Inspiration for younger researchers and engineers

I have supervised 32 PhD students with more than 50% implication and co-advised 3 PhD students with less than 50% implication (14 students in the last 10 years). I am currently involved in 3 PhD trainings with systematic supervision by junior researchers for promoting this supervision training.

Five PhDs are now assistant-professors in Universities around the world, eight have research positions at governmental structures (CNRS (France), IRSN (France), CEA (France), INGV (Italy)), eleven have research engineer positions at different enterprises (TOTAL, CGG, PGS, Saudi Aramco, Shell, Sinopec, SINTEF). Two are now involved in scientific administration (NSF, CSTBO). Finally, two have post-doc positions and one has moved to high school teaching. Some of them are now leading researchers in their own fields.

I have been interacting with 6 post-docs on different subjects from ray tracing to wave propagation problems for seismic tomography and seismic inversion. All of them have now active R&D or University positions.

Content and impact of major scientific contributions

- ✓ Pioneer contribution on the **dynamic rupture problem** for modelling earthquakes (early '80) where I have exhibited the intrinsic **numerical stiffness** when solving a Cauchy problem with mixed boundary conditions in collaboration with my supervisor R. Madariaga
- ✓ Pioneer contributions on **seismic wave propagation** in heterogeneous media by a finite difference method (early '80) (most cited articles) where I have shown that the staggered grid strategy preserves a discrete energy even when the shear wave speed is decreasing towards zero from elastic propagation to acoustic propagation. 90 % of industrial codes are based on such approach as mentioned during the ceremony of the Erasmus Award.
- ✓ Pioneer contributions on **full waveform inversion** of seismic acoustic data (early '80) as one of the earliest attempts of an inversion scheme on the first supercomputer (CRAY) available in France in collaboration with A. Tarantola and O. Gauthier.

- ✓ Pioneer contributions on the **dynamic rupture problem for complex geometries** (early ’00) with a mitigation of the numerical stiffness, thanks to ad-hoc discontinuous finite element approach with V. Cruz-Atienza and M. Ben Jemaa, enhanced by J. Tago.
- ✓ Pioneer contributions on **full waveform inversion on seismic elastic data** (early ’00) with S. Operto in the framework of the industrial consortium SEISCOPE (present highest rate of citations)

Selection of recent publications *(see websites https://jean-virieux.obs.ujf-grenoble.fr and https://scholar.google.fr for more extensive description)*

Virieux J., Asnaashari, A, Brossier, R., L. Métivier, A. Ribodetti, and W. Zhou. An introduction to Full Waveform Inversion, Encyclopedia of Exploration Geophysics, 2017.

Yang, P., R. Brossier, L. Métivier and **J. Virieux**. A review on the systematic formulation of 3D multiparameter full waveform inversion in viscoelastic medium, Geophysical Journal International, 207(1), 129-149, 2016.

Métivier, L., R. Brossier, Q. Mérigot, E. Oudet and **J. Virieux**. An optimal transport approach for seismic tomography: Application to 3D full waveform inversion. Inverse Problems, 32(11), 115008, 2016.

Virieux, J., R. Brossier, L. Métivier, S. Operto and A. Ribodetti. Direct and indirect inversions, Journal of Seismology, doi:10.1007/s10950-016-9587-3, 2016.

Dupuy, B., A. Asnaashari, R. Brossier, S. Garambois, L. Métivier, A. Ribodetti and **J. Virieux**, The Leading Edge, 35(2), 146-150, 2016.

Virieux, J. & G. Lambaré, Theory and observations - body waves: ray methods and finite frequency effects, Vol 1 Seismology and structure of the Earth, Editors B. Romanovitz and A. Diewonski in Treatise of Geophysics, Chief-Editor, Gerald Schubert, Elsevier Publ, second edition, 2015.

Zhou, W., R. Brossier, S. Operto, and **J. Virieux**: Full waveform inversion of diving & reflected waves for velocity model building with impedance inversion based on scale separation, Geophysical Journal International, 202 (3), 1535-1554, 2015.

Asnaashari, A., R. Brossier, S. Garambois, F. Audebert, P. Thore and **J. Virieux**, Time-lapse seismic imaging using regularized full-waveform inversion with a prior model: which strategy?, Geophysical Prospecting, 63(1), 78-98, 2015.

Métivier, L., R. Brossier, S. Labbé, S. Operto and **J. Virieux**, A robust absorbing layer method for anisotropic seismic wave modeling, Journal of Computational Physics, 279, 218-240, 2014.

Operto, Y. Gholami, V. Prieux, A. Ribodetti, R. Brossier, L. Métivier, and **J. Virieux**. A guided tour of multiparameter full-waveform inversion with multicomponent data : From theory to practice. The Leading Edge, 32(9), 2013.

Tago, J., V. M. Cruz-Atienza, **J. Virieux**, V. Etienne, and F. J. Sánchez-Sesma, A 3D hp-adaptive discontinuous Galerkin method for modeling earthquake dynamics, Journal of Geophysical Research, 117, B09312, doi:10.1029/2012JB009313.

Virieux, J. & S. Operto. An overview of full waveform inversion in exploration geophysics, Geophysics, 74(6), WCC127-WCC152, 2009.

Research monographs

1. Capuano P., Gasparini P., Zollo A., Virieux J., Casale R. and Yeroyanni M. (eds), The Internal Structure of Mt. Vesuvius through 3D High Resolution Seismic Tomography, Liguori ed. Napoli, pp.: 612, ISBN: 88-207-3503-2, 2003.
2. Participation for writing different chapters of the monograph “Geophysical Exploration of the Campi Flegrei Caldera’s Interiors: Data, Methods and Results”, Eds Zollo A., Capuano P., Corciulo M., Gruppo Nazionale Vulcanologia, Roma. ISBN 10: 88-89972-04-1; 13: 978-88-89972-04-5, 2005.
3. Larroque, C. and J. Virieux, Physique de la Terre Solide, observations et théories, Gordon & Breach, in French for undergraduate training (high rating for teacher competitions as “CAPES”), 2001.

Chapters in collective volumes (incomplete list)

1. *Virieux J., 1996 Seismic ray tracing, in Seismic Modelling of Earth Structure, eds Boschi, E., Ekström, G. & Morelli, A., Editrice Compositori, Bologna, Italy, pp223-304*
1. *Virieux, J., P.-Y. Bard and H. Modaressi, Quantitative seismic hazard Assessment, in Earthquake Early Warning Systems, eds Gasparini, P., Manfredi, G., J. Zchau, Springer, 2007.*
2. *Eight articles with co-authors on the book “I*n Conception, verification and application of innovative techniques to study active volcanoes, Eds Marzocchi W. and Zollo A, ISBN 978-88-89972-09-0, 2008.

3. Virieux J. & G. Lambaré, Theory and observations - body waves: ray methods and finite frequency effects, Vol 1 Seismology and structure of the Earth, Editors B. Romanovitz and A. Diewonski in Treatise of Geophysics, Chief-Editor, Gerald Schubert, Elsevier Publ, first edition (2007) and second edition (2015)

4.

International collaboration

I collaborate with research groups in France, Italy, Greece, Mexico and Canada**.**

- **Research field experiments**
- **TGRS** (1994-1997) – EU Interreg French-Italian project with a permanent seismic network (PIs C. Eva and J. Virieux)
- **DEVINE** (1998-2001) EU Interreg II French-Italian project with a permanent GPS network (PIs C. Eva and J. Virieux)
- **TomoVes** (1993-1997) – Active seismic imaging of Mt Vesuvius: Italian funding through National Civil Protection (PI A. Zollo) – French funding through CNRS/PNRN, IUF and IFREMER (PI J. Virieux)
- **3F-Corinth** (2001-2003) – Seismic tomography of the Western Corinth Gulf, EU (PI I. Moretti, IFP).
- ***SERAPIS*** (2001-2003) - SEismic Reflection/Refraction Acquisition Project for Imaging complex volcanic Structures: Italian funding through National Group of Volcanology and National Civil Protection (PI A. Zollo) – French funding through IFREMER (PI J. Virieux).
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International workshop organization

2006 Vienna EAGE workshop “What can E&P learn from Seismology and vice-versa?” with conveners Xander Campman, Jean Virieux, Kees Wapenaar and Helmut Jakubowicz with two special issues of Geophysical Prospecting (May 2008 and July 2008) because of the success of such workshop.

Outreach activities

European program SSA Na.R.As (Natural Risk Assessment) (PI. Pr. P. Gasparini, 2005-2007): workpackage for awareness of natural risks. Promotion of the now established structure ”Sismos à l’Ecole” integrated into the program « Sciences à l’Ecole » (http://www.edusismo.org).

French representative for the ICG/NEAMTWS of IOC (UNESCO) for Tsunami Early warning

Picq, T., J.-L. Bérenguer and J. Virieux, 2003, French Educational Seismological Network “sismo des écoles”, Seismological Research Letters, 74, 588-595.

J. Virieux and A. Zollo, Le puzzle des volcans napolitains, La Recherche, n°375, 2004