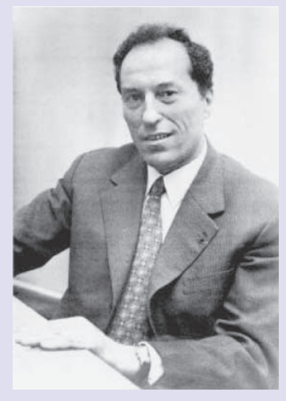
Raimond Castaing
1921-1998

Brief biography

Raimond Castaing was born on December 28, 1921 in Monaco. In 1940 he entered the Ecole Normale Superieure, (the highest academic institution for training in the physical sciences in Paris) and became the student of Frederic Joliot, at the College de France. He joined the French resistance during the war and graduated in 1946 with the highest grades for the teaching of physical sciences.



Castaing held the post of lecturer at the University of Toulouse from 1952 to 1956, then he became lecturer at the University of Paris from 1956 to 1959. He took part in the creation of the University of Paris, Orsay (with André Guinier), where he became a professor and Director of the Laboratory of Physics of Solids up to his retirement.

Electron probe microanalyzer (EMPA)

Castaing began his career as a research engineer at the Office National d'Etudes et de Recherches Aeronautiques (ONERA), where he did his thesis work under the direction of André Guinier. The work came from interest in aluminum-copper alloys, and the need to observe the zones of copper precipitation in the aluminum. The first EMPA was built by designing a new objective lens for the first French commercial TEM (made by CSF), which allowed x-rays to escape. It was fitted with a Johannson-crystal type of focusing wavelength-dispersive spectrometer, with a Geiger counter as the detector (Fig. 1). The first published report was in the proceedings of the 1949 Delft International EM meeting, then in the 1950 Paris International meeting, and finally in Castaing's 1951 thesis "Application des Sondes Electroniques a une Methode d'Analyse Ponctuelle Chimique et Crystallographique", for which he received his doctorate from the University of Paris. His thesis (Fig. 2) set out the principles for electron-probe microanalysis, which still apply today. Subsequently, he constructed a prototype EMPA, with magnetic lenses, at ONERA (Fig. 3), which, with minor modification, became the first commercial EMPA, the Cameca MS85 (1958).

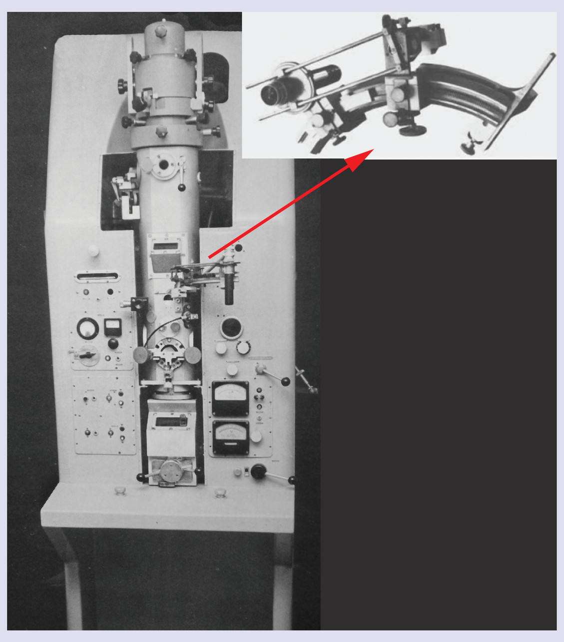
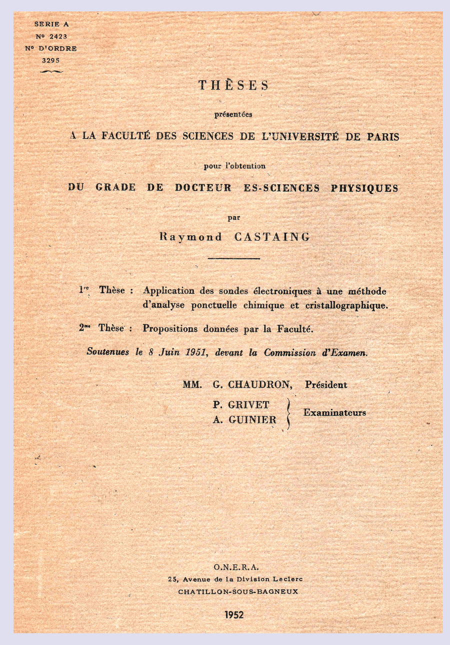


Fig. 1. The first electron microprobe, adapted from an CSF electrostatic TEM. Detail of the spectrometer is shown in the inset (image from Grivet, 1985).



THÈSES
présentées
A LA FACULTÉ DES SCIENCES DE L'UNIVERSITÉ DE PARIS
pour l'obtention
DU GRADE DE DOCTEUR ÈS-SCIENCES PHYSIQUES
par
Raymond CASTAING

Fig. 2. Cover of Castiang's 1951 PhD thesis (scan courtesy of Peter Duncumb).

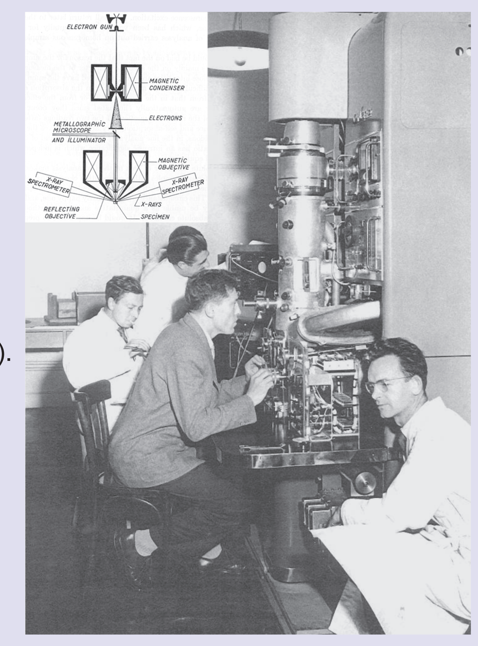
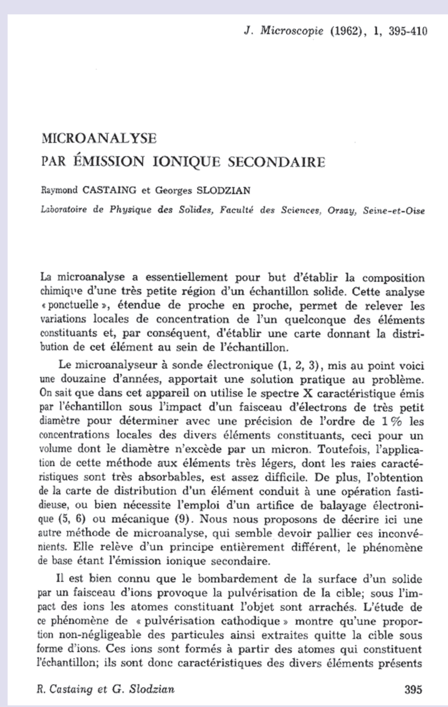


Fig. 3. Castiang operating his prototype ONERA EMPA (image from Castaing family; other individuals not identified).

Secondary ion microscopy and spectroscopy

Castaing was always interested in obtaining a compositional map of the specimen, although his original EMPA could only be used for point analysis. However he did not like the idea of scanning the specimen; he wanted direct images. The first realization of this was the secondary-ion microscope. This was initially developed as a student project under Castaing by Geroges Slodzian, who went on to pioneer SIMS (secondary-ion mass spectrometry). This was first reported in Castaing and Slodzian, 1962 (Fig. 4). A primary energetic ion beam sputters the sample surface. Secondary ions generated in this sputtering process are extracted from the sample and analysed by a mass spectrometer. The secondary-ion microscope required development of the first imaging mass spectrometer and a novel ion-to-electron converter in order to obtain adequate images (Fig. 5). The SIMS instrument (Castaing and Slodzian, 1981) provides: (1) Excellent depth resolution (a few nm), (2) High sensitivity (ppb), (3) Full periodic table coverage (including hydrogen), and (4) Rapid ion image acquisition capabilities. Slodzian's commercial realization was the Cameca SMI 300, and ultimately the Nanosims 50, which, in the interest of higher lateral resolution, was no longer a direct imaging device, but instead used a scanning ion probe (Hillion et al., 1993). It is interesting to note that the development work on the Nanosims project was done at ONERA, through the influence of Castaing.



J. Microscopie (1962), 1, 395-410

MICROANALYSE
PAR ÉMISSION IONIQUE SECONDAIRE

Raymond CASTAING et Georges SLODZIAN

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Fig. 4. First report of the development of secondary-ion microscopy.

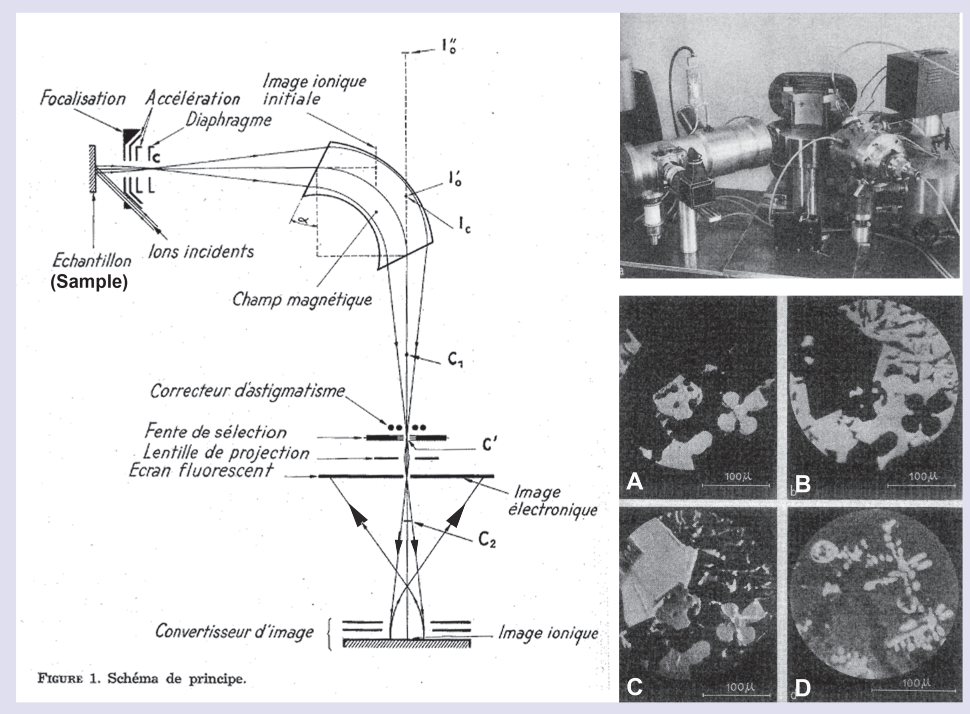
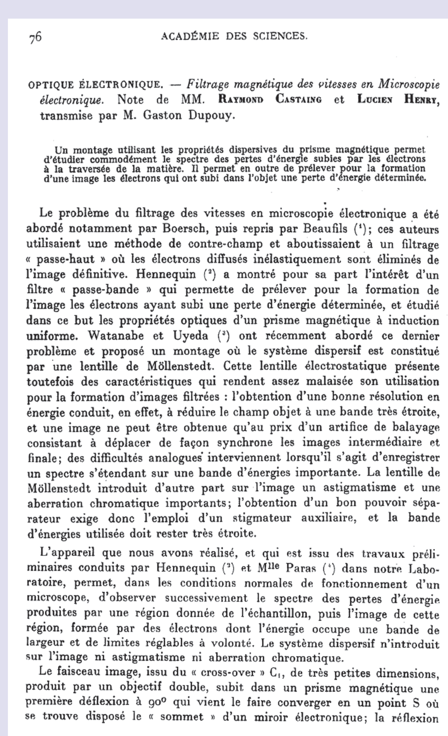


Fig. 5. Diagram and picture of the first secondary-ion microscope. Note that the ion-to-electron converter projects the image back to the fluorescent screen. Images:
(A) Mg^+ image of an Al-Mg-Si alloy,
(B) Al^+ image of the same specimen,
(C) Si^+ image of the same specimen,
(D) Cu^+ image of solid Cu with Cu_2O inclusions .
(from Castaing and Slodxian, 1962).

Electron energy-loss imaging and spectroscopy

Consistent with his desire to from direct (and quantitative) compositional images, and at about the same time as he was working on secondary ion microscopy with Georges Slodzian, Castaing set another student, Lucien Henry, to the task (as his thesis work) of designing an imaging electron energy filter for the TEM. The Castaing-Henry filter (Castaing and Henry, 1962; Castaing, 1975, Fig. 6) consisted of a triangular magnetic sector and an electrostatic mirror. This filter eventually appeared in a commercial TEM, the Zeiss EM902 (Fig. 7), and it encouraged development, by others, of other types of in-column energy filter, now used to great advantage in Zeiss and JEOL TEMs.



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OPTIQUE ÉLECTRONIQUE. — Filtrage magnétique des vitesses en Microscopie électronique. Note de MM. Raimond Castaing et Lucien Henry, transmise par M. Gaston Dupouy.

Fig. 6. First report of electron-energy-loss imaging.

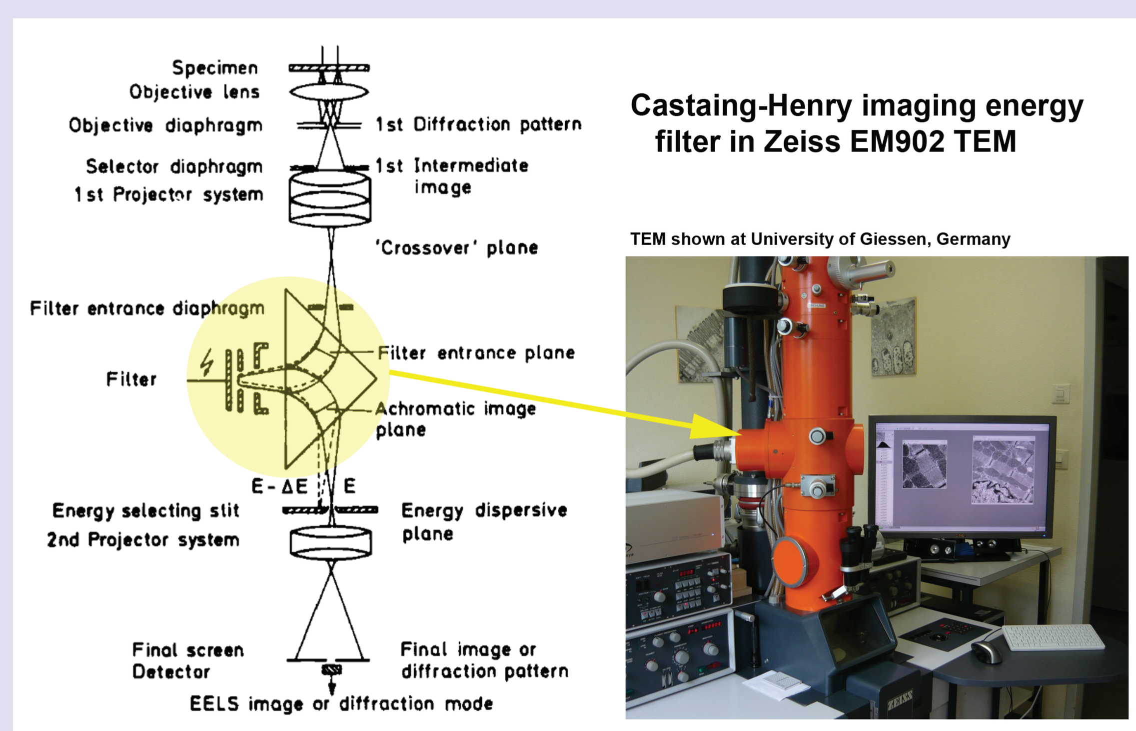

Fig. 7. Diagram of a Castaing-Henry electron imaging spectrometer on a Zeiss EM902 TEM (from Riemer, 1991), showing the location of the energy filter on the TEM.

Later responsibilities

Concurrently with being Director of the Laboratory of Physics of Solids of the University of Paris, Orsay, Castaing was scientific director and then General Director of ONERA from 1968 to 1973. He was elected to the Council of Nuclear Security in 1982 and was a member of the Atomic Energy Committee from 1982 to 1987. He was Administrator of the French civil research organization, CNRS, from 1983 to 1989, a member of the Administration Committee of Usinor (the French steel company) from 1984 to 1987, and in 1996 he became President of the Commission on the fast breeder reactor Superphenix.

Honors

Castaing was elected to the French Academy of Sciences in 1977, the same year he received the Roebling Medal of the Mineralogical Society of America. He was made an honorary member of MAS in 1974, the first year such titles were granted. In 1982 MAS established the Castaing Award for the outstanding student paper, with support (very appropriately) from Cameca. In 1993 he received the IMS Sorby award, that Society's highest. At M&M 1999 in Portland OR, MAS held a special symposium celebrating 50 years since Prof. Castaing reported his development of the electron microprobe (Fig. 8). At this time, MAS distributed copies of the Duwez and Wittry translation of Castaing's 1952 thesis.

MAS Celebrates

Fifty Years of Electron Probe Microanalysis

A Symposium Dedicated to Prof. Raimond Castaing

Keynote Address: *The Time of the Pioneers*	Jean Philibert
Microprobe Design in the 1950's - Some Examples in Europe	Peter Duncumb
The Golden Age of Microanalysis	Kurt Heinrich
Development of Electron Probe Instrumentation During those Early Days when Professor Castaing Visited Japan	Ryuichi Shimizu
Crystal Spectrometers and Monochromators in Microanalysis	David Wittry
Advances in WDS Crystal Performance	Charles Nielsen
EDS and WDS Automation: Past Development and Future Technology	Jon McCarthy
Today's and Tomorrow's Instruments	Claude Conty
Quantitative Electron Probe Microanlysis: Fifty Years of Developments in the Application of Castaing's "Z" and "A" Corrections	John Armstrong
Characterization and Continuum Fluorescence in Electron Beam X-ray Microanalysis	Clive Nockolds
Fundamental Constants for Quantitative X-ray Microanalysis	David Joy
Minimizing Errors in Electron Microprobe Analysis	Eric Lifshin
Selecting Standards to Optimize Electron Microprobe Analysis	Eric Essene
Application of the Electron Probe Microanalyzer to the Analysis of Planetary and Geological Materials: A Historical Perspective	Klaus Keil
A Few Examples of Electron Micronanalysis of Art Objects at the Boston Museum of Fine Arts	Robert Ogilvie
Minimally Invasive (Energy) Dispersive Analytical Spectroscopy (MIDAS). The Golden Touch for In-Situ X-ray Microanalysis of Bulk Bio-Organic Samples	Patrick Echlin
Castaing's Electron Microprobe and its Impact on Materials Science	Dale Newbury

Fig. 8. Program of the Castaing symposium organized by MAS at M&M 1999.

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Source material

Portions of the biography were taken from the obituary written by Ryna Marinenko in the Spring-Summer 1998 issue of the MSA newsletter, MicroNews.

Figure 3 was taken from John Fournelle's article in the Spring-Summer 2011 issue of the MSA newsletter, MicroNews.

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