cron-sized minerals in polished thin sections are possible. Although quantitative analysis with this technique is still difficult and many problems in its application have yet to be overcome, the potential of the instrument has already been demonstrated in a number of excellent recent studies in mineralogy and petrology. There is no doubt that in the next few years, this new tool will open new frontiers of research in mineralogy and petrology that heretofore have essentially been beyond experimental approach. I am thinking, for example, of the measurement of the distribution coefficients of trace elements in synthetic and natural systems. Undoubtedly, Castaing's work will once again have a profound impact on our science.

Raimond Castaing is a Professor in the "Laboratoire de Physique des Solides" at the University of Paris at Orsay, one of the most outstanding laboratories in the world in this field. I should also mention that he is an accomplished mountain climber and excellent rugby player. He has published over 100 papers and has lectured extensively not only in Europe, but also in the United States. In fact, Castaing's frequent visits since 1951 to the U.S.A., particularly in the early years of electron microprobe development, have much contributed to the considerable progress that was made in this country in this field. Professor Castaing has been honored over the years by many scientific institutions and organizations, both in Europe as well as in the United States. However, it is especially gratifying that recognition now comes from the mineralogical scientific community which has benefited more from his work than any other group of scientists.

Mr. President, it is a special honor for me to present the founding father of electron microprobe analysis, Professor Raimond Castaing, as the 1977 recipient of the Roebling Medal of the Mineralogical Society of America.
and the structure of the precipitating phases were
observations were made on well-defined binary or
dislocations along a polygonization boundary. Those
and their selective nucleation on the individual dis-
have been developed in the aluminum alloys,
heat treatments developed in the aluminum alloys,
platelets or needles, parallel to the cubic axes, that the
sor Guinier was carrying out on the same samples. It
was known from the X-ray diffraction studies that Profes-
was in the course of a discussion with him that I
realized how unprepared the metallurgists were at
this time for identifying: the various phases they ob-
served in the light microscope when looking at industrial
alloys, where the number of components and
impurity elements introduces a terrific amount of
possible combinations. X-ray diffraction, or indirect
methods based on the coloration by specific reagents,
were applicable to known phases only and no tech-
nique was available for analyzing an unknown in-
cclusion if its diameter was substantially less than one
tenth of a millimeter. Guinier suggested that I explore
the possibility of concentrating an electron beam
onto such tiny inclusions and identifying their con-
stituent elements from the emitted X-ray spectrum.
That was the beginning of two years of alternating
disappointment and excitement: disappointment
when I realized that, however small the diameter of
the electron probe, the spatial resolution would be
limited anyway to the micron level by the diffuse
penetration of the fast electrons in the specimen;
great excitement when I found that the comparison of
the same characteristic line, when emitted by the
sample or by a known standard under the same elec-
tron bombardment, made possible cancelling out all
instrumental parameters and getting the concentra-
tion of the emitting element in an absolute way. Fi-
nally, the experimental model of the microprobe that
I had built by converting an electron microscope
worked quite satisfactorily and a lot of workers came
to my laboratory to put their specimens through the
instrument. I still suspect that some of them tried to
lay a snare for me when it happened that none of the
elements they asked me to dose was present in their
sample!

Apart those applications to specific problems, I
shared my time between establishing the physical
foundations of microprobe analysis and building a
more sophisticated model of the microprobe itself,
including magnetic lenses, vacuum spectrometers and
an improved viewing system which used a reflecting
objective; that instrument was put on the market by
the CAMECA company and the first commercial unit
was sold in this country, twenty years ago, to Inter-
national Nickel. Meanwhile, a strong impulse had
been given to the technique when Cosslett and Dun-
cumb initiated the scanning mode of operation which
allowed an automatic visualization of the distribution
of the various component elements over an extended
area. As for me, I had been appointed lecturer at the
University of Toulouse; returning to my early loves, I
developed an ion thinning procedure for preparing
metallic samples thin enough for transmission elec-
tron microscopy. In the course of related experiments
that I carried out with my young student Slodzian, we
observed that the ion bombardment resulted in the
ejection of secondary ions from the target. This had
been reported by other workers several years before,
but I realized on that occasion that I could combine
both my fields of interest: microscopy and point anal-
ysis. I was not entirely satisfied with the scanning

I confess that, when Slodzian and I started the
development of secondary ion microanalysis, we were
attracted primarily by the nice exercise in particle
optics which consisted in producing high resolution
images with a mass spectrometer; I confess too that
we spent two uncomfortable years before being con-
vinced, by observing the first characteristic images on
a copper-beryllium sample, that the secondary ions
were produced at the sample surface—which was es-
ential for microanalysis—and not by charge ex-
change in vacuum between the primary ions and the
sputtered neutrals.

That procedure of producing sharp images through
the non-gaussian optics of a magnetic prism worked
surprisingly well and we spent exciting times in apply-
ing it with Hennequin and Henry to energy filtering
in electron microscopy. Isolating the images pro-
duced by the electrons which had undergone a char-
acteristic energy loss in the specimen provided the
equivalent of color microscopy, and we found there a
very convenient way for studying the so-called “co-
herency” of the various interaction processes between
the fast electrons and the sample lattice. It is clear
today that the development of field-emission electron
guns and high resolution scanning microscopy has
made this type of image filtering somewhat obsolete
in electron microscopy, but the situation is not the
same in secondary ion microscopy, due to the present
lack of ion guns delivering high intensities in micron-size probes. The work of Slodzian and his coworkers has brought secondary ion microscopy to the point where it becomes possible to get in a few seconds distribution images of any element or isotope with a spatial resolution much better than one micron. The instrument is especially convenient for the examination of minerals, where the ionic bonds enhance the emission of secondary ions very strongly. In the hands of mineralogists, it has made it possible to visualize exsolutions and zoned structures with component elements whose average concentration is less than 100 ppm, in images of a striking beauty. That is indeed another reason why I feel indebted to your fascinating science, much more than it is indebted to me.

Mr. President, I am much honored to have been adopted so kindly by the community of mineralogists, and I accept this Medal with deep thanks to the Mineralogical Society of America.

Mr. President, Members of the Society, and Guests:

It is an honor and a privilege for me to introduce the MSA Award Recipient for 1977, J. G. Liou, of Stanford University.

Louie entered UCLA as a beginning graduate student in 1965 and, after a brief period of adjustment, embarked on a remarkable course of geochemical studies and experimental research which set the pace in our laboratories for the next decade. The current crop of grad students surely has grown weary of my regaling them with how much Louie accomplished in just four years. Not only was he phenomenally adroit at p-chem and thermo, but he coaxed equilibrium phase assemblages from some of the most recalcitrant chemical systems known to man: P-T diagrams were cranked out for wairakite, laumontite, lawsonite + quartz, prehnite and analcime. Unlike some of my own work, his phase diagrams seem to have withstood the test of time. During 1970-72 at NASA-Houston, Louie focused his attention on such well-recognized extraterrestrial problems as the stability relations of epidote and of andradite + quartz, and he experimentally modeled the greenschist → epidote amphibolite facies P-T transition zone in a natural basaltic system. Louie evidently was too busy finding out about the Earth to look up. He has continued broadening his laboratory studies since joining the Stanford faculty in 1972, but at the same time has turned to the field + petrochemical investigation of the lower grades of metamorphism as developed in Vancouver Island, western California and the Coastal Range of Taiwan; in addition, Louie has undertaken a comprehensive and definitive petrochemical study of the East Taiwan ophiolite.

This latter work represents part of a U.S.-Republic of China project in which John Suppe of Princeton and I are coinvestigators. We have been continually astonished at the scientific drive, creativity and incredible productivity of Louie. John and I live in constant fear of receiving phone calls from him; these invariably begin with a modest recitation of his latest burst of data collection, followed by a communication that we are soon to be sent a first draft manuscript of eighty pages (single spaced), and conclude with an ever-so-mild reminder to please try to finish up our small parts. I now appreciate the meaning of being “killed with kindness.”

The MSA Award is meant to call attention to the significant accomplishments of a young mineralogically-oriented researcher, and to encourage his further activities. I am not sure whether the U.S.-Republic of China project—never mind the mineralogical world—is ready for increased productivity from Louie. Nevertheless, Mr. President, it is with the greatest pride and admiration that I give you our current MSA Award Recipient, J. G. Liou. Try not to encourage him too much!