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In memory of Giulio Cesare Borgia

Giulio Cesare Borgia: founder, promoter, and nurturer of the MRPM Conferences

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Giulio Cesare Borgia, usually going by his middle name "Cesare," was born in Bologna 7 July 1944 and was a physicist who spend much of his career at the University of Bologna teaching and doing research in geophysics, petroleum engineering and properties of reservoir rocks and other porous media. He will be greatly missed by the MRPM (Magnetic Resonance in Porous Media) community, as the founder of both the MR-Porous-Media laboratory at the University of Bologna, which has made important scientific contributions to NMR for fluids in porous media, and also the founder and steady promoter of our series of international meetings on MRPM, of which these proceedings are for MRPM6. Cesare died unexpectedly from a sudden illness 18 September 2002, only a few days after MRPM6, while attending a meeting in Southern Italy to organize the teaching of petroleum technology in an area with new deep petroleum reserves.

He received his doctorate in Physics at the University of Bologna in 1970, with a thesis on experimental work involving the nuclear reactor R-B2 of the then *Agip Nucleare,* at the Laboratory of Nuclear Engineering at Montecuccolino, near Bologna. He then did his required military service in the Air Corps Engineers, working in meteorology.

From 1971 until his death Cesare held various positions in the Engineering Faculty at the University of Bologna, gaining the rank of full professor in 2000. He taught courses in geophysics, petroleum reservoir engineering, fluid mechanics in porous media, formation evaluation, and other subjects. He took great interest in his students and in teaching, as I have learned when I have met his students and even their families. He has supervised many theses, including ones on porous media models, gas production in the Apennines of Emilia, gas storage in depleted formations, relative permeability studies, electrical prospecting, waterflooding and assisted recovery, petrophysics, magnetic resonance imaging studies of Basilicata reservoir rocks, subsidence in the Bologna area, and statistical modeling of petroleum reservoirs.

He pursued several lines of study recurrently over many years. One was fluid flow in reservoirs and reservoir rocks, with much effort to describe effects of reservoir heterogeneity, for instance, with permeability varying several orders of magnitude over short distances. The work included statistical treatments and also included applications such as the immiscible-fluid displacement of oil, including by waterflooding. He has always stressed the combined use of laboratory measurements ("core analysis") and field data to put reservoir management on a sound physical basis, with thirty publications in this area.

Another area of research was in the evaluation of marginal petroleum resources at times when this was motivated by the high price of oil. This included gas production in the Apennines of Emilia, for which Cesare attended meetings at Porretta in the Apennines only a few weeks before his death, and the gas-containing aquifers of the Po delta, with twenty publications on this subject.

Many papers, over a long period of time, are devoted to the effects of the production of water and oil on surface subsidence. This included early papers on Bologna's own leaning towers and later work on subsidence in the Po delta area. These works dealt with the wider problems of production, assisted recovery, pressure maintenance, and many factors in petroleum production in areas where subsidence could be a problem.

Cesare's wife, Paola Fantazzini, is also a physicist; they met in school and received their doctorates in Physics on the same day. In the mid-1980's she was doing work in the Physics Department on NMR relaxation in biological systems, and she and Cesare recognized that both petroleum reservoirs and biological materials can be classified as porous media and that their knowledge and skills could usefully be combined to study porous media in all contexts. With Paola's help Cesare added MR to the Porous Media research facilities in what was then the Mining Science Institute, which included petroleum technology, in the Engineering Faculty. The Bologna MRPM laboratories have

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Cesare and Bob (the author) after MRPM2 in Canterbury.

Cesare, Paola and Bob in the *tavernetta* of the Borgia home.

produced a steady stream of research results on NMR properties of fluids in porous media right up to the present time.

My first contact with Cesare and the University of Bologna was in the spring of 1988, when, as the leader of an NMR oilwell logging development in the 1950's, I was invited to the First International Meeting on Recent Advances in NMR Applications to Porous Media (MRPM1), which was held in Nov. 1990 but was originally planned for 1989, the year of the 900th anniversary celebrations at the University of Bologna. Since I had been recently retired but was still interested in research activity, I was very happy to connect with a group interested in both NMR and the oil industry, and I began a collaboration with Cesare, Paola, and all the Bologna group, which continues to this day. Cesare rescued me from retirement, to borrow a phrase.

I first met Cesare in person in May 1989, when I visited Bologna. I quickly came to appreciate his instinct and passion for finding useful patterns among data and his activity in organizing work and establishing connections with people worldwide. We also felt a bond through music, since we had both in the past had interest in the piano, and we made rusty attempts to resurrect pieces on his 2.5 meter grand piano of 1885 vintage.

Cesare and Paola have maintained a wide range of contacts with scientists worldwide, bringing visitors not only to their two departments in the University of Bologna but also to their home, where I have enjoyed being their frequent guest for well over a decade. Their's is the only home I have visited where in the kitchen there is a blackboard covered with equations and diagrams! Part of their unusual home is converted from a former warehouse by means of nearly-continuous remodeling over more than a decade, and it is tastefully appointed with antique furniture and works of art. There is of course also a library and work tables, with computers and piles of papers. Guests from numerous countries and several continents have stayed in their *tavernetta.* In the attached *cantina* is kept the delicious wine that Cesare and some of his friends bottled each year. I remember happily many discussions over glasses of this wine at dinner or afterwards over a few sips of *grappa,* with Cesare explaining Italian or Bolognese proverbs and sayings that illustrated the weighty matters at hand.

Cesare coordinated NMR work with colleagues at Bologna and at other institutions. He was able to accumulate a very substantial petrophysics database, with core samples from oil companies such as Agip and with measurements from various laboratories. The MRPM group at Bologna did sample preparation and several kinds of conventional core analysis in addition to NMR measurements. Numerous works documented correlations among parameters from NMR relaxation measurements and such oilfield parameters as porosity, permeability to fluid flow under pressure gradient *k,* irreducible water saturation S_{wi}, residual oil saturation S_{or}, and pore-system surface-to-volume ratio *S/V.* Since most sandstone rocks saturated with brine have NMR relaxation times distributed over several decades, it was not surprising to find that different forms of averages over relaxation times correlated best with different ones of the parameters mentioned above. Fast algorithms were developed to give these different averages without inversion of the relaxation data to get distributions of relaxation times. Cesare went to great lengths to find what correlations between porous- media physical parameters and NMR parameters were meaningful and useful.

Interest in valid interpretation of measurements led to extensive work also on the inversion of multiexponential relaxation data and the effects of inhomogeneous fields from susceptibility differences on distributions of relaxation times. He promoted extensive development of combined magnetic resonance imaging and relaxation measurements and of display methods for showing different important features. The porous media studied went far beyond oilfield rocks and included industrial porous materials, materials related to cultural heritage preservation, and even biological materials. Cesare is an author on over forty MRPM-related papers.

We shall all miss our friend and colleague, and the MRPM community has suffered an untimely loss. The unexpected shock is more than "untimely" to Paola and those closest to him, and I will deeply miss the warm friendship and enthusiasm of Giulio Cesare Borgia.