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differences of opinion that have surfaced during the planning phases of this program. Some of my administrative colleagues find it difficult to understand how science can accomplish its ends from a position of such disarray. It is very clear to me that the participation of science with other segments of our society in a search for the solution of some of these problems that face us will require much more than a demonstration or claim of relevance. The ability to address complex issues and decisions incisively will be essential. We live in a very pragmatic and empirical society. The managers and administrators of this society do not always place the same value on the heritage of open and free scholarship that we do. They place a high value on the ability to identify and solve problems. A major ingredient in these solutions consists of *decisions*. We may find ourselves in a position to affect these decisions by means of technical and expert advice. Only too often our advice is so transparently self-serving or contradictory that we forfeit our role in the decision-making. I can only hope that the upcoming generations of geochemists, geologists, and geophysicists have enough intellectual common ground to avoid the appearance of working at cross purposes. It is not hard to imagine that the success of future efforts in the geosciences may depend not only on the cooperation of different subdisciplines in this part of the intellectual arena, but on cooperation between such diverse disciplines as medicine and geoscience. Hopefully, the evolution of the scientific disciplines has not progressed to the point where fertile crossbreeding between diverse areas of science is no longer possible.

Clearly, I have no answers to the problems I have raised here. I can only suggest that less specialized education might be helpful. Otherwise, the best I can do this morning is to point to the problem. I hope that those in decision-making positions take note and that those who are deciding their own future will consider some career goals that have not been held in high esteem by most of their intellectual peers.

Introduction of Dimitri A. Papanastassiou for the F. W. Clarke Medal

G. J. Wasserburg*

There are, to me, three truly exciting personal experiences in science. The first of these is the experience of oneself, privately, observing and understanding something that is new and that is important. The second excitement is the act of precipitating understanding of some natural phenomenon in someone else. The third is to be honored to participate in the formal bestowal of professional recognition of a respected colleague, a student and a friend. I am greatly privileged to stand before two colleagues and friends of different scientific generations that are being recognized by this society today.

The early pioneer work on Rb–Sr dating which was to play a role in Dimitri's thesis was first carried out by Tom Aldrich at the Department of Terrestrial Magnetism under the stimulus of Louis Ahrens and later by G. W. Wetherill and G. R. Tilton of the Carnegie Institute of Washington.

When Dimitri Anastassios Papanastassiou (DAP) was entering Athens College in Greece, Paul W. Gast was measuring Sr isotopes. Paul was a rather bumptious

* Charles Arms Laboratory, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, U.S.A.

young man, who as a high school student would announce to his father and brother at the supper table that he, P. W. Gast, was personally going to go to the moon regardless of either technologic or theologic difficulties. Gast had just established that the change in $^{87}Sr/^{86}Sr$ over the history of geologic time was very small (1955). The work that Dimitri was to do some ten years later was a direct out-growth of this fact.

Dimitri was a student at Athens College, an American-sponsored high school for Greek boys. Through the enthusiasm and pedagogical skills of Andreas Remboulis, Dimitri became interested in science and as a result of his outstanding performance he was recommended to Cal Tech. In the forms sent out by Cal Tech, question three asks, "for what type of career is the applicant particularly suited?" Mr. Eliascos, the Assistant Principal of Athens College responded, "The type of career he wishes to follow." This information, in conjunction with his detailed academic record was transmitted to our admissions officer, who promptly put this data into a universal formula which has as much control over predicting the future of a student as a recently touted universal phase rule which purported to describe the interrelationship of all known geologic processes. After processing all of this information, the computer output showed that Dimitri would get a grade-point average of 1·96015 whereas the lowest passing grade-point average was 1·90000, so that this man's future was not essentially encouraging. However, with the perseverance of Mr. Peter Richardson, the student counselor at Athens College, Dimitri was admitted to Cal Tech. Well, the GPA formula was pretty good, at least it got the sign right, because Dimitri passed and did so with honors for four years, and graduated in physics in the top 10 per cent of his class with a GPA of 3·50037.

I tell this story because it is true and because I hate the incompetent, inhibiting, predictive testing of students.

In his undergradute years, Dimitri worked in the Kellogg Radiation Laboratory under Tommy Lauritsen, Tom Tombrello and Ward Whaling. He was then interested in low energy nuclear physics. This represented an exciting endeavor and one which kept him in touch with a variety of fields of modern physics and astrophysics. As a member of the Division of Geological Sciences and also a member of the Kellogg staff I had attempted since 1955 to attract bright young physicists to work jointly in problems of importance in earth and planetary sciences. The importance of continually interdigitating the concepts and developments of physics with our science seemed overwhelming to me, although some physicists considered it too 'classical' (that is, old fashioned) an area.

Since Dimitri was thinking of returning to Greece, this area of the physical sciences seemed of sufficient vigor and small enough in scale that it might reasonably be transported. In any event, he was considered an appropriate candidate and Tommy Lauritsen literally took Dimitri under his wing and guided him *halfway* from Kellogg to Arms. I think he mumbled something about DAP being a sacrificial lamb. In any event, DAP began to work with me when we had just started the design of a new generation of computer-interfaced isotope ratio mass-spectrometers with digital output, which I hoped would permit routine measurements at the level of a few parts in ten thousand. The spectrometer grew from conception through ion optical calculations to a hardware reality which in fact can produce data with a precision of five

parts in one hundred thousand. This permitted a look at minute isotopic differences which were previously invisible. Small or negligible effects became real and measurable quantities with deep petrogenetic and chronologic meaning. The change in $^{87}Sr/^{86}Sr$ in chondrites is about 0·01 per cent in 10 million years. With development of these techniques coupled with great attention to mineralogic properties, DAP showed that it was possible to date the basaltic achondrites and that there were resolvable variations in the initial strontium in meteorites which represented five million years in early solar system history. This has given us acronyms such as BABI and ADOR in the literature (1969, 1970). Since then he has spent his time establishing a lunar chronology using the ^{87}Rb–^{87}Sr decay scheme. (1971, 1972a, 1972b). It is this endeavor by a young man which is the subject of this award.

DAP is a true Athenian—he is a multilingual and versatile perfectionist who has made a temporary peace with the demigods who run the world imperfectly. He has learned to mispronounce Greek words and to scrawl Greek symbols in the vulgar fashion used by the large uneducated world. As a true Athenian he is a snob. During a late session when we were writing a paper, I referred to Alexander the Great as a Greek, to which Dimitri retorted, "Oh *that* Macedonian!" When, during a lecture on the cosmic time scale, he heard me recite part of the book of Genesis in Hebrew, he commented that it sounded peculiar since he was used to hearing it in the original Greek.

I don't know if DAP will fulfil his youthful hope of moving some of his science back to Greece. His infatuation with the United States is in great part due to a very intelligent and gracious young woman, his wife Teri. I expect he will stay and enrich our environment.

When Dimitri filled out his admission form twelve years ago he was obliged to write a short statement about his long term future. He wrote: "Indeed, what I think will play the decisive role in my choosing a career will be my love for science. Whether it is a place in industry or in the government, it will be the same to me as long as it won't be a routine work. . . . I guess all this sounds a little pompous. I remember [a] teacher telling me that, when you are young, you want to become a pioneer in science, and then, when you grow older, you find yourself engaged in an ordinary job, not caring any more for original research work. Still he [the teacher] loved to hear of boys having such hopes for the future."

Mr. President, may I present the Clarke Medalist, D. A. Papanastassiou, a young man who has been on the cutting edge of original research and will as *he* grows older undoubtedly stay there for a long time.

References

Gast P. W. (1955) Abundance of Sr^{87} during geologic time. *Bull. Geol. Soc. Amer.* **66,** 1449–1454.

Papanastassiou D. A. (1970) The determination of small time differences in the formation of planetary objects. Ph.D. Thesis, California Institute of Technology.

Papanastassiou D. A. and Wasserburg G. J. (1969) Initial strontium isotopic abundances and the resolution of small time differences in the formation of planetary objects. *Earth Planet. Sci. Lett.* **5,** 335.

Papanastassiou D. A. and Wasserburg G. J. (1971) Lunar chronology and evolution from Rb–Sr studies of Apollo 11 and 12 samples. *Earth Planet. Sci. Lett.* **11,** 37.

Papanastassiou D. A. and Wasserburg G. J. (1972) The Rb–Sr age of a crystalline rock from Apollo 16. *Earth Planet. Sci. Lett.* **16,** 289.

PAPANASTASSIOU D. A. and WASSERBURG G. J. (1972) Rb–Sr systematics of Luna 20 and Apollo 16 samples. *Earth Planet. Sci. Lett.* **17**, 52.

Acceptance Speech
F. W. Clarke Medal

D. A. PAPANASTASSIOU*

Not so long ago, Professor Wasserburg and I were involved in an erudite search for an eclectic name for our first six digit isotopic ratio. The final acronym for "basaltic achrondite best initial", BABI, has now become a recognizable entity found even in a subject index. It marks in a possibly more succinct manner than I may have appreciated originally the beginnings of a new chapter in what might be considered isotope archaeology for the sun, as opposed to the well-documented application of isotopes to the origins of Hellenic marbles.

A few years before that instant, several eager and egocentric Greeks, freshly out of high school, landed on a New York pier. We were very surprised at the absence of a red carpet which we expected for our arrival as new Fulbright scholars. As it turned out we were greeted instead by the insatiable open hand of a baggage handler. The obvious moral in this land of opportunity was that persistence beyond the norm must be commonplace. I received slightly more pertinent advice as a fledgling undergraduate from a physicist, close to four o'clock one morning. We were both waiting for some particularly slow ion counts to accumulate to a preset value, when he volunteered that physics is 95 per cent grind and 5 per cent fun. This has always seemed a fair proposition although it must be clear that occasions similar to the one this morning constitute a serious attempt to upset this delicate balance.

My first formal contact with science involved nuclear physics. I spent several summers as an undergraduate plotting cross-sections from a multichannel analyzer and Nilsson states from a computer output. While most probably still dizzy, I took Professor Lauritsen's advice to walk to the next building and talk to Wasserburg. He promptly concluded that my education would best be furthered by reading mass-spectrometer charts with a magnifying lens. That task was later changed to picking individual grains with a micro-manipulator under a microscope. At least chart reading must have been primarily a diversion, since he had already designed the next generation mass-spectrometer with automatic disgorging of digital data. The building of that machine proceeded while he toured Europe. It was possibly appropriate that the first preliminary statement of the capabilities of the new instrumentation was included in a review of the age of meteorites. This review was also notable for its emphasis on the strong similarities between the structure of a planet with a core and that of a hard-boiled egg.

I have of course been privileged to participate in the development of the new instrumentation. A slightly less appreciated but intimately connected advance has been the development of micro-techniques for handling very small samples. This approach may be described as the whole crystal method as opposed to whole rock analyses. The application of high precision mass-spectrometry and of clean micro-techniques for sample handling has been rather crucial for lunar samples. For

* Charles Arms Laboratory, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, U.S.A.