Commercial Geomechanics Development in Australia

John Jaeger Memorial Address – 1999

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Summary When the author commenced practice at the beginning of the 1950s, the business of consulting in geotechnical engineering did not yet exist, and the services available in its precursors, "soil mechanics and foundation engineering" and geology, were in their infancy. For larger projects limited services were available, mainly through Government Departments and the CSIRO. Smaller projects had to rely on the experience of "general practitioner" civil engineers and on crude subsurface information obtained through the services of untrained drilling contractors. Over the course of the author's subsequent experience the practice of geotechnical engineering consulting gradually developed and expanded until today there is a wide variety of specialist firms and specialist groups within larger generalist firms able to provide a well trained and multi-disciplinary group of geotechnical experts appropriate to projects of all types, sizes and degrees of complexity. This paper, the 1999 John Jaeger Memorial Address, discusses the development of the business of geotechnical consulting in Australia over the past 50 years.

1. INTRODUCTION

In this address I hope to be able to give a review of the development of geomechanics / geotechnics, soil mechanics and foundation engineering – call it what you will – in the Australian scene over the past nearly 50 years or so. My emphasis will be in the area that I know best, that is the commercial side as distinct from the technical, academic or research area. I will describe what it was like to practice in the area of geomechanics in the days of its infancy, some of the people who were great contributors, and some of the problems that beset the practitioner in those days. I hope also to describe how the trends have changed over the years, and where we seem to be headed in the future.

If in this discourse I have made some serious omissions or failure to recognise important sections or people then I apologise. The address is necessarily subjective and hence at the mercy of the foibles of human memory so I hope you will forgive me if I omit to touch on some areas that are obviously important.

2. MY EARLY DAYS IN SOIL MECHANICS

In order to establish my qualifications to discuss the early developmental phase it may be of help if I gave a potted version of my own early soil mechanics background.

In 1950/51 the Public Works Department in Sydney (PWD) were requested by the Snowy Mountains Authority (SMA) to undertake the investigation design and construction of what is now known as the Eucumbene Dam. In parallel to this the SMA also required the then Water Conservation and Irrigation Commission (WC&IC) to investigate design and construct Blowering Dam on the Tumut River. I was at that stage an employee of the PWD in Sydney working in the water supply branch on water treatment. The principal engineer, F. W. Potter, called me in one day and said that the materials engineer for the Eucumbene Dam project was departing and that the position was now available and posted me to it. Dismissing protestations that I knew nothing about materials, soils and such, he sent me down to the construction site in January 1952, whereupon I quickly bought 3 text books – Terzaghi's "Theoretical Soil Mechanics", Terzaghi and Peck and D. W. Taylor, "Fundamentals of Soil Mechanics" – and proceeded to devour these as rapidly as possible. On arrival at Cooma and Adaminaby I was introduced to the SMA Scientific Services Section which had established itself in Back Creek in Cooma. Prof. Tom Leach (ex NZ) was the head of the section and immediately offered in his generous way all assistance and cooperation. He was true to his word thereafter. The head of the materials section was Denison Campbell-Allen. Denison was sitting in for Aubrey Hosking who was at that time (early 1952) undertaking a diploma course in soil mechanics given by Skempton, Bishop and others at the Imperial College, London. Denison later joined Sydney University to ultimately become Professor of Civil Engineering and a world authority on all matters relating to concrete.

In early 1952 Dan Moye was establishing his credentials in the field of Applied Geology. He was later to become one of the founders of Engineering Geology as we now know it. He was a giant in his field and set the standards for those who followed him. Undoubtedly David Stapledon would testify to this. It was a great loss to the profession that he was killed in a car accident with others in his family in the Bermagui area some years ago. In recognition of his services a memorial plaque was installed in Tumut Ponds Dam in 1991 by his colleagues and admirers.

During these early years Ted Davis arrived from the UK as senior lecturer for the Soil Mechanics Department at Sydney University and he made some useful contribution to the investigation stage at Eucumbene Dam. He came down to visit several times, as did Gordon Aitchison, head of the CSIRO division of Soil Mechanics. I was privileged to have been influenced by these eminent people at that time.

But I digress. After more than four years working on Eucumbene Dam and seeing it rise to about 20 metres above river bed level I decided to gain experience in North America, having had little or no experience by then with structure foundations, soft soil, landslides, groundwater etc. In 1956 I went to Canada intending to join a consulting firm specialising in soils engineering. Before seeking a job with a soils consulting firm I joined the British Columbia Deptartment of Highways as Assistant Materials Engineer. I mention this because I had taken the place of C. O. Brawner, who had taken study leave to obtain his Masters degree in Nova Scotia under G. G. Meyerhof. In later years Chuck Brawner was to come to Australia as a consultant to the State Electricity Commission in Victoria working on pit slope stability on the brown coal open cuts at Yallourn. He was to make a significant contribution to the development of commercial geomechanics in this country. Later I joined R. C. Thurber and Associates (as an associate), working mainly on stabilising landslides that were occurring frequently on the PGE Railway extension from Squamish (near Vancouver) to Fort St.John in north central British Columbia. As in most countries in the early post-war period, development was at a frantic pace and any young engineer had responsibility thrust upon him. I was no exception. These two years gave me a broad background into the practice of soils engineering in British Columbia, which of course is totally geologically different to anywhere in Australia. The surface of BC was wiped clean by the Pleistocene ice sheets, the last of which occurred eight thousand years ago, resulting in soils above the bedrock being gravels of glacial origin or saturated normally loaded lacustrine clays or silts. Unsaturated over-consolidated soils were virtually unknown and consequently the experience I was gaining (although I did not recognise it then) was of little use in the Australian context.

At the end of 1958 my family and I departed Victoria, BC for Sydney and in early 1959 I announced my presence as a consultant in the field of soil mechanics and foundation engineering.

3. SOIL MECHANICS IN THE 50'S

If you had a problem in the geomechanics area in the 50s, how did you go about solving it? The setting was quite different to today's.

As a subject at engineering schools Soil Mechanics received very little attention although the subject was taught at Sydney University in 1936, even in the pre-Terzaghi days. It became established as a course in its own right in the early 50s with departments being founded by D.H. Trollope (Melbourne), E.H. Davis (Sydney) and Maurice Arnold (Adelaide), and students were receiving higher degrees majoring in the subject also at that time.

Private work of a large nature was generally undertaken by a consulting civil or structural engineer, who would investigate the site by means of the equipment available at the time. That is to say, a costean could be cut by a bulldozer or shovel, test pits were dug by hand and test bores could be drilled using the rigs of the day. Geophysics had not yet arrived on the scene, and you would probably look to the Department of Mines for geological help. For penetrating ground above bedrock, water boring rigs which were developed for obtaining artesian bore water from the late 1800s were used. These were known as percussion or churn or cable tool rigs and these could usually advance steel casing through practically all materials, cohesive or cohesionless. The driller would examine the cuttings returning in his bailer and write down his version of the log, hopefully getting the depths and materials right. The consultant engineer would then have to make what he could out of them, and decide on the type of foundation, usually leaning heavily on the results of other existing nearby investigations. He would use bearing capacities assigned from textbooks and building codes such as "soft shale – 4 tons per square foot". If in doubt he would use piles, much to the delight of the piling companies. He took pleasure in assessing bearing capacities by digging his heel into the ground.

The earliest use of a private soils consultant appears to be that of Dames and Moore, who were engaged for major projects in this country. One such project to my knowledge was the investigation in about 1956 of the site of the Caltex Oil Refinery at the Kurnell peninsula south of Sydney and constructed in a sand dune area. Dames and Moore used local cable tool drills, but in conjunction with their own sampling equipment and test gear, and of course supervising engineers or geologists.

Otherwise, for public work involving dam construction in NSW the WC&IC, and in Victoria the Melbourne Water Board and the State Rivers & Water Supply Commission, all were establishing soil testing laboratories. At least 7 or 8 major earth fill dams were under construction at that time. Practically all were rolled earth core with rock flanks. Rockfill dams with thin concrete upstream faces did not eventuate until later, these being pioneered by J. K. Wilkins in the Hydro-Electric Commission in Tasmania. The earlier testing laboratories were used principally for soil classification, strength testing and compaction control.

In 1950 skills in soils and materials engineering were so short that the bringing in of overseas consultants or advisers was deemed necessary. The SMA collaborated with the US Bureau of Reclamation (USBR) for general engineering consultative advice. The USBR had just completed the Tennessee Valley Scheme and were hence regarded as leaders in the field. On the soils side the USBR "Earth Manual" became the bible.

In the Commonwealth area the Experimental Building Research Station was established by David Isaacs, an eminent consultant at the time. They produced reports for all building construction, but specifically for recommended foundation design for structures, principally houses. These useful publications suggested building foundations for different areas of the country, e.g. arid, reactive, coastal and so on. These publications on soils and foundations were produced in the early 50s and were based on observational techniques rather than quantitative analyses. They were highly regarded.

Meanwhile at the CSIRO Gordon Aitchison as head of the Division of Soil Mechanics in Melbourne was working on the properties of unsaturated soils, and bringing to light such parameters as pore air pressure, negative pore pressure and the like. The effect of different clay mineralogy did not escape his attention. In 1954, as the result of a request from the Resident Engineer at Eucumbene Dam, the CSIRO Division of Physics in Sydney developed the nuclear gamma ray method of measuring density in place in soils. In addition methods for rapid measurement of soil moisture content were being explored. The Head of the Division of Physics (Alan Harper) and the Resident Engineer of Eucumbene Dam (Len Harper) were brothers, and consequently the development of these techniques received priority and were soon used on the construction of that dam.

There were very few people or organisations to turn to in those days for difficult or complex foundation work. For this reason CSIRO was used from time to time for projects like the investigation of the King Street bridge in Melbourne. Practically all road authorities in the various states had, at that time, their own soil and pavement testing laboratories. Pavement thicknesses were then determined by CBR or a synthetic production of the CBR. In NSW Department of Main Roads (DMR), for example, Sandy Britton developed his determination of T value from soil classification data and that technique, peculiar to NSW although adopted by other states, stood the test of time for 30 years or more.

Britton himself, after leaving the DMR, joined Bob McMillan to form the consulting firm of McMillan and Britton. Britton, who was very highly regarded, was one of the few consultants sought after in the 50s and 60s for his advice on foundation problems.

For an engineer recently graduated in the early 50s and wishing to pursue his or her chosen field of soils engineering, there were few opportunities in the private sector. Public government departments were developing their own laboratories, and some even had exploration tools including drilling rigs. In NSW for example there were the DMR, WC&IC, Railways, and some of the larger local government councils. Later in the 50s, the private sector started to become established. The UK moved along the path of deciding that soil mechanics work was more suited to being on a contract rather than on an advisory basis. Accordingly, a number of their large civil contractors set up their own soil mechanics divisions or sections. Notably there were Soil Mechanics Ltd. (Molems), Cementation Co., Foundation Engineering Ltd. (Costains) and Wimpeys. Of these Wimpeys set up in Sydney under Malcolm Wood and Foundation Engineering established in Melbourne under Dick Parry (the same Dick Parry who for many years has been the Secretary to the ISSMFE in Cambridge). Both companies established complete soils testing laboratories and also had drilling rigs, initially rotary and wash boring. Auger boring commenced with the advent in WA of the highly successful Gemco drills; and also blade auger truck-mounted drills (which were developed from post hole type augers) were used for soil exploration. Their main occupation was, however, drilling pier holes for pier and beam foundations, which became popular in the 50s. These drills became larger and larger with time and varied from blade (Pengo) to bucket (Calweld).

Diamond drilling was available as an exploration tool for many years, but using only a single tube core barrel. This may have been all right for minerals exploration in hard rock, but was practically useless for foundation testing because of the high core loss in soft, fractured or weathered rock. These deficiencies were overcome by the SMA who, with Triefus Ltd., developed the triple tube core barrel, capable of recovering in most cases 100% core. This was a most significant breakthrough in the field of exploration drilling.

4. EARLY PROBLEMS IN ESTABLISHING A SOIL MECHANICS PRACTICE

It seemed inevitable as early as the mid 50s that eventually there would be a demand for a consulting service specialising solely in soil mechanics and foundation engineering.

5. BUSINESS GROWTH

As the consulting business grew and rapidly expanded with the rest of the economy, the variety of work received required a multi-disciplinary approach. Although the need for this type of approach was not new, as it was recognised by the more advanced Government authorities (notably the SMA), it was new in the private field. For geological advice the NSW Department of Mines provided a free service from their geological survey section, as did the Commonwealth Bureau of Mineral Resources (BMR). The integration of applied geology with soil mechanics and foundation engineering was a reality following the work of Moye and Stapledon in the SMA. Hydrogeology quickly followed suit. For geophysics, again there was the BMR, but some excellent private sources were available, such as Wimpeys in the UK. As a matter of interest, the use of geophysics had a chequered career caused mainly by the over optimism of the early geophysicists in interpreting data from refractive seismic surveys. Errors from these works resulted in costly redesigns of foundations, but importantly caused hesitancy by the civil engineering profession to use the technique. These early errors probably set back the use of geophysics 10 to 20 years as an effective exploration tool.

By the 80s most of the larger private practices had become multi-disciplined. Whilst the geo sciences were well represented and founded, on the business side management skills leaned more and more heavily on the accountant. No longer was it satisfactory to have the financial affairs executed piecemeal by unqualified bookkeepers, external accountants etc. The financial section had to be coordinated by an accountant who was as skilful in his field as the chief geologist or engineer was required to be in theirs. Around the chief accountant or financial controller was built a system of accounts preparation showing accurate profit and loss statements and capital flow on a regular basis, at least monthly. The introduction of a highly competent financial section had indirect benefits in that the whole team could take pride in the efficiency and effectiveness of their operations.

6. THE FINANCIAL SIDE

It is axiomatic that a commercial company has to be profitable and it is the duty of management to make the profit as high as possible. In this respect a geomechanics company is no different to any other. If profits are high, capital can be spent on new equipment, research and development, office infrastructure, vehicles etc. Morale becomes higher and there is a general feeling of comfort. To achieve this, fees and schedule rates had to be calculated as high as possible but limited by the knowledge that if they were too high work would flow to competitors and valued clients could become disenchanted. So there was a fine balance in fee structuring and it was up to management to recognise this.

Fees for services by members of the ACEA had traditionally been calculated on a percentage basis, that is, a percentage of the total cost of the works designed. This system worked well for the civil, structural, mechanical and electrical engineers but was not satisfactory for the new breed of geotechnical engineers. For them, systems generated in North America were adopted. The fees were calculated on a time basis, usually hourly and assessed by taking the annual salary of an employee divided by the number of pay hours he could reasonably be expected to work – around 1600 – and then multiplied by a factor to account for overheads and profit. This factor was normally about 2.1. Based on these calculations hourly or daily rates were set for the average employee classification such as junior geologist, senior technician, senior engineer etc. Fees for partners or directors were based on the individual's background experience but were more likely governed by external fees charged by comparable professionals. Nevertheless we have always lagged behind the medical, legal and financial people and probably always will.

Laboratory tests were charged as a schedule of rates based on the average time to do a test, but in some cases modified by the capital cost of the equipment involved.

Clients would generally want to know the estimated costs of a geotechnical assignment and therefore such had to be given. As often as not this was taken as an upper limit and so the consultant may have been restricted by this budgetary process. Thus there were many factors influencing total charges and negotiations for these charges were quite delicate to say the least. Rarely would the consultant be out of pocket because of an underbid job. If that happened the consultant would not stay afloat for long, as happened on a number of occasions.

7. RISK MANAGEMENT

High risk usually goes hand in glove with geomechanics endeavours because of the nature of the beast, but even though there is high risk, negligence does not have to be involved in the event of a failure. In the 60s the professional indemnity (PI) insurance premiums were not costly. Also litigation was not so rampant then. In fact, I did not carry PI at all for many years. With the errors that were made these would be admitted to, compensation given, and no real damage done except for embarrassment. Unlike contracting, the site investigation industry in those days was relatively free of claims.

However, with the growth of business came a dark side – lines of communication became thin and

In most cases, the advice given or offered by the public agencies at this time was essentially free, or nearly so. Consequently services that carried a fee were placed in a difficult position except perhaps on the basis of quality of service and expediency.

In Australia in 1959/60 the concept of providing a private consulting service in soil mechanics was new and was not readily accepted. For too long had the evaluation of foundation, soil and rock conditions been the domain of the general practitioner. He saw the practice as being ancillary to the field exploration contractor – mainly contract drillers. The need for a report on the driller's logs was the first step but this was highly risky, as it was impossible to accept the driller's logs as being accurate. They were also usually accompanied by a miscellany of samples in various containers left on the doorstep. So the first requirement was to educate the client into allowing full time supervision of the field exploration. This was undertaken by a trained technician and although engineers or geologists were desirable, that came later. Costs of the supervision were absorbed initially by the marking up of drillers' prices but this was soon separated to an hourly rate.

Convincing the client that soil mechanics consulting was a separate and bona fide pursuit proved to be very difficult. It was made even harder by the introduction of contract packaged services which were offered by the UK companies who had arrived on the scene. These and others encouraged foundation investigation work to be set out on a tender basis either at a schedule of rates or a lump sum. Almost invariably the analysis and the results of the report were required to be a lump sum. This led to unbalanced bidding in which the professional service costs could be depressed against the drilling or laboratory testing costs. These procedures were very difficult to compete against because the method was relatively easy to sell to the client, being seen as an extension to subsurface exploration contracts.

Eventually client education began to bear fruit when they were influenced by the new breed of engineers who were receiving in-depth training from their engineering schools. In addition, the example of soil mechanics consulting practices being frequently used in North America was becoming increasingly obvious, particularly in overseas work.

During this time the Association of Consulting Engineers in Australia (ACEA) had been formed, and it dealt with regulatory matters, including fees. In my case a breakthrough of recognition by our engineering peers came at an ACEA conference in Brisbane in about 1968. Dennis Hodgson from Dames and Moore and myself pleaded our case at this conference for the creation of a separate and discrete engineering group in the ACEA – that of the consulting geotechnical engineer. This was accepted by the conference, and so the first major hurdle had been overcome. It has to be said here that Dames and Moore were very strong on their belief about this, Bill Moore himself becoming president of the American Association of Consulting Engineers. Later in the 60s and early 70s other soil consulting groups established in various States. Chuck Brawner came in from Vancouver to found Golders here, bringing with him Brickell Moss from NZ. Don Douglas started Groundtest as Frankipile's soil engineering arm, and so on. So at that time there came to be developed two different soil engineering groups – those who offered their services as contractors, and those who offered their services as consultants.

Laboratory testing of soils and materials was one area which was accepted by the profession in the 60s. Although bidding for jobs on a tender basis was strenuously lobbied against, it could not be ignored in these early days as it was the major source of the larger jobs available. The establishment of laboratory testing facilities was therefore necessary. Standards adopted were initially British or more commonly ASTM. Both were replaced by Australian standards as these became available. The early laboratory facilities were in many cases quite crude and the registration of testing procedures with the National Association of Testing Authorities (NATA) was sought after quite eagerly. The commercial reality was that accreditation of laboratories was quickly incorporated into the tender documents as a requirement. This registration process with NATA lifted the quality of testing work very considerably. NATA itself was established in 1949 as an initiative of the Chifley Government and its first registrar was Frank Monaghan. The organisation has grown through skilful management in recent years under John Gillmour to an enterprise of very large proportions and its influence on the provision of high quality physical testing work in commercial engineering laboratories cannot be overstated.

Income from laboratory testing was relatively high in those days, compared to the total practice income, and from the capital generated quite sophisticated equipment could be acquired. For field testing, drilling contractors were encouraged to provide their own sampling and SPT gear but it became the norm for the consultant to provide the specialised field exploration equipment.

There was a temptation then to extend the laboratory tests to include concrete and bitumen or asphaltic concrete testing and mix design. Although the market was there, the profit margins were too low, it being intensely competitive work. In any case it did not marry well with the other geotechnical operations, and was hence discontinued in most laboratories.

putting out fires resulting from mistakes more difficult. Involvement in errors made by third parties was an unfair but not uncommon situation. Large jobs – each involving perhaps 10 or more field personnel – were becoming more frequent in remote areas in and out of Australia. It was vital that a major effort be made to keep standards up and errors down. This was achieved by "standardising" technical approaches between offices, developing manuals, logging methods and the like. These were the early days of quality control in a geographically fragmented organisation. In the past decade quality assurance techniques have emerged, generally involving certification to the relevant ISO standards. This, together with NATA registration, should result in a product of high quality. The effort to carry out these procedures is great and costly but worth while in the long run. In any case they are probably unavoidable, as certification to the quality assurance standards has become a requirement by a great many clients.

But despite all this, errors persist. Since risk management is a very private affair, I do not know what techniques other people have adopted. I can only describe my own techniques on how to cope with this based on experience. I should say that in recent years I have been an arbitrator, referee, expert witness and spent six years as a member of the Administrative Appeals Tribunal so have some knowledge of dispute resolution. However, I have never been in a court or hearing as a litigant as a result of faulty workmanship on my or my team's part. Not that we did not make errors – we did, and probably too many. So if trouble appeared and if negligence had occurred pride was put to one side, and the matter settled as rapidly as possible. Court or arbitration hearings where only the lawyers win would be avoided at all costs. In recent years I have formed the opinion that mediation is the only procedure in dispute resolution which has merit because it is fast, final and of low cost.

8. FUTURE DEVELOPMENTS

Practicing in a mature market has seen many changes, and possibly the most satisfying is the complete acceptance of the geotechnical profession by our peers and the public at large.

Inwardly looking, however, despite the enormous technical changes that have occurred in geomechanics over the past 40 years, certain fundamentals remain the same. These are the moral issues. Integrity, ethics, honesty are all essences of the business, for if any of these becomes tarnished, then the business and its personnel will suffer badly.

On the business or management side, the requirement to maintain a healthy profit is still the same – the stakeholders have to be satisfied with their dividend, capital will be needed, staff have to be paid a decent wage and so on. Management skills have to change to utilise new technologies.

Looking ahead, in this country geotechnical firms have grown over the years following both expanding markets and expanding technology. Because of the current trend for governments to privatise as much as possible, expansion should continue. In some cases civil consultants have become so large with local and overseas work that they have generated enough geotechnical work to establish their own in-house geotechnical divisions. This is true, for example GHD, Maunsells, Ove Arup and others. None the less, there is plenty of room for the independent geotechnical consultant to prosper because of the broader horizons encompassed by the discipline. In recent years we have seen new markets in the areas of environmental sciences, contaminated landfill and the remediation thereof, geotextiles and membranes, trenchless technology, etc., and there is every reason to believe that further markets will develop.

My view is one of optimism, but we seem to be losing sight of the fact that we are after all providing a public service. As an example, in the early 60's the then geotechnical industry assisted the agricultural industry by studying the cause of failure of an alarming number of farm dams. From those studies – particularly the CSIRO – came the understanding of the relationship between ion exchange, pedological soil types and soil dispersivity, and so helpful advice was able to be given to the farmer.

These days other problems exist, some unique to Australia. Soil salinity is one example that has an immense effect on the country and its GDP. The AGS membership has been strangely quiet on this issue. Surely some of the large expenditure said to be made available to the Murray Darling Basin could find its way to suitable members of the AGS as a research grant. Salinity issues are 90% within the domain of geomechanics.

We should be thinking bigger and providing a balance to the propaganda that the environmentalists and greens have so effectively developed. By advertising our achievements and lobbying with the IEAust and the AusIMM we can promote the geotechnical awareness necessary to solve the issues that the environmentalists raise.

9. ACKNOWLEDGEMENTS

It would be remiss of me not to thank the Australian Geomechanics Society for offering me the Jaeger Award and how honoured I feel to receive it. I did not have the pleasure of personally knowing Professor Jaeger but of course I knew of him and his pioneering work on rock mechanics at the Australian National University in Canberra. He was, I understand, a mathematician by background, but

specialising in geophysics, using that term in its broadest sense. He was engaged as a consultant in the Snowy Scheme. There he studied temperature change with depth in rock mass as it affected underground power stations and also the influence of reservoir masses on the stability of surrounding country rock. He was keen to explore the mathematical analysis of elasticity and plasticity, a subject taken up with enthusiasm by Ted Davis. Some of his post graduate students have contributed greatly to the development of geomechanics – notably Kevin Rosengren who is a highly sought consultant these days in the field of rock mechanics in mining projects. The previous recipients of this award I knew, and most of them very well indeed. Suffice it to say that it is extremely gratifying that the Society recognises not only the contribution to the overall field of geomechanics by the development of theories and the practical application of these theories and research but also the need for a soundly based infrastructure that is necessary in a business sense to support and complement the practice. The business side is a necessary part of the whole scene. If I have contributed to this side of the industry then so be it; but nothing would have developed had it not been for the support and friendship of a whole host of people, not the least of whom are the previous recipients of this award.