

Integration

– the Foundation for the Asset Team

For many years, Dr. Alain Gringarten considered that "Integration of geological and engineering disciplines is the key to successful exploration and production." Now Professor of Petroleum Engineering at Imperial College, he is putting this into practice.

Alain Gringarten is Professor of Petroleum Engineering and Director of the Centre for Petroleum Studies at Imperial College, co-ordinating all research and postgraduate teaching and activities in petroleum related studies at the College.

Walking through the imposing entrance to the Royal School of Mines at Imperial College in Kensington in London, one is aware of a great sense of history and scientific advancement. The many years of innovative and groundbreaking science and research, which has been conducted in this famous institution, seem almost palpable. It is gratifying to realise that this pioneering approach to the teaching of earth sciences is still cherished and practiced.

Educating future geoscientists

Dr. Alain Gringarten, Professor of Petroleum Engineering at Imperial College, believes that "Integration of geological and engineering disciplines is the key to the optimisation of the exploration and production of hydrocarbons." Oil companies agree with this and have eliminated their separate departments for geology, geophysics, drilling, geochemistry and various other subdivisions, consolidating their experts into multi-disciplinary teams.

When he became Director of the Centre for Petroleum Studies in Imperial College in 1997, Prof. Gringarten rapidly reorganised the MSc. courses in the department to reflect these ideas. Students are educated



The Reservoir Management Process.

to understand the workflow concepts prevalent in the modern oil industry. As Prof. Gringarten says, they become "petroleum professionals who are specialists in their own fields but trained to work efficiently in multi-disciplinary teams." The MSc. course in Petroleum Engineering enables students to understand the fundamental concepts of field management, reservoir characterisation, modelling and simulation as well as the processes of integrating available data. On completing the course, students are well equipped to step into an oil company's multi-disciplinary "asset" team, immediately able to make a useful contribution.

The key to this new approach is understanding and using the reservoir management process. Prof. Gringarten defines reservoir management as "the application of available technology and knowledge to a reservoir system in order to maximise the economic value of the reservoir and make the best possible decisions." There are 3 main phases to this approach: reservoir characterisation and modelling, followed by well and reservoir performance and finally field development.

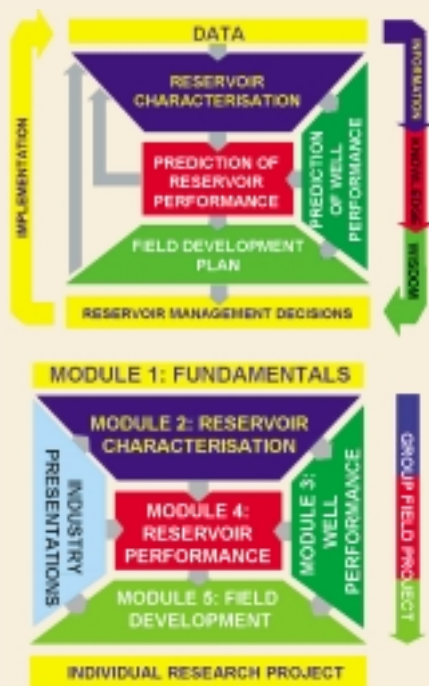
Reservoir characterisation and performance

The importance of the integrated approach becomes apparent in the **first stage** of this process, reservoir characterisation. To fully understand a reservoir, data from many disciplines is needed, including geology, geophysics, petrophysics, geome-

chanics, flowmetrics, well testing and tracing. Each discipline creates its own model, but the next step is to amalgamate these into a single, integrated, consistent reservoir model, which can be verified and matched against real data.

All MSc. students of petroleum studies at Imperial College are taught fundamental courses together, to enhance their full understanding of every aspect of petroleum geoscience. The petroleum geoscience student will spend some time studying well testing, although not to the level of the petroleum engineer, who will in turn have had a number of hours tuition in geological and geophysical modelling. This enables students to understand both the power and the shortcomings of the various techniques involved in building the full reservoir model. Well test data, for example, can elucidate faults and compartmentalisation, which may not fully accord with the seismic interpretation, allowing the geophysicist to refine the interpretation.

To teach the technical and interpersonal skills required to create a reservoir model in an oil company environment, students form multidisciplinary 'asset teams'. They are presented with real oil company data and expected to come up with a working reservoir model. This project is introduced 2 months after the start of the course and is a very important aspect of both the engineering and geoscience courses, each team being made up of both geoscientists and petroleum engineers. At the end of the 15-day project they present their results,



complete with STOIP, a 3D reservoir model and preliminary reserve estimates. They are guided by staff and external industry consultants, but are expected to act as a team and to resolve any technical differences. They are marked as this team rather than individually.

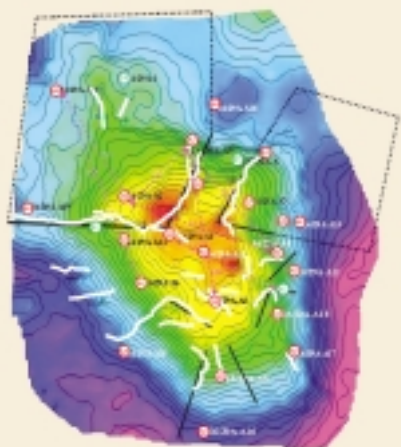
Once a consistent reservoir model has been obtained through this project, Petroleum Engineering students move on to consider the behaviour of the reservoir through a range of development scenarios. In the **second stage** the *production behaviour* of the reservoir is viewed with well test data, in order to come up with a calibrated simulation model, an optimised well placement plan and a prediction of reservoir performance. For this phase the team does not include geoscientists, so students must work in new teams. With only six days allowed for the project, they are also under time pressure.

The **third stage** of the Petroleum Engineering course covers *field development*, including process engineering, pipelines, surface facilities, field life, HSE and petroleum economics. By this stage students are fully aware that to predict the final behaviour of a field, it is necessary to have an understanding of the total system, from reservoir characterisation, through well performance to surface facilities. As with stages 1 and 2, a group project is the final

product of this phase, the ultimate deliverable being a development plan for the Maureen Field.

Using external expertise

The two best Group Projects, incorporating all the work from Phases 1, 2 and 3, are presented to an industry audience at the end of the third phase of the project work. The winning project performance, as judged by the audience, is awarded the Colin Wall prize, an award that is much sought after, more for the accolade and recognition from peers than the value of the actual



Example from Maureen Group Field project: Top Structure Map With Boundaries from Well Tests (seismic faults in white; well test faults in black).

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World renowned expert

Professor Alain Gringarten came to the post of Director of the Centre for Petroleum Studies in 1997, after 25 years in the oil industry, having begun his post-doctorate career in the Bureau de Recherches Geologiques et Minieres in France.

He moved from there to Schlumberger, where amongst other things he was responsible for the development and worldwide implementation of well test interpretation services, working in both France and Houston. From 1983 to 1997 he worked for Scientific Software-Intercomp in senior technical, marketing and managerial roles. He is a world-renowned expert in well test analysis and has taught many industry and academic courses on the subject throughout the world.

On joining Imperial College in 1997 he was determined to revolutionise the teaching of geoscience courses in order to make them more useful to the industry. He reorganised the MSc. Petroleum Engineering course onto reservoir management lines, initiating the concept in June 1997 and welcoming the first new students in October the same year. To achieve the integrated approach to educating petroleum professionals he says: "It was important that the faculties worked together to formulate the new courses, with no contradiction and no repetition. Each step of the course has to build on the previous steps and prepare for the next ones." He knew that students needed to use real data and he also involved speakers from all aspects of the oil business. After his many years in the industry, his numerous contacts and friends in oil producing, service and consultancy companies were happy to support him with data and specialist lecturers.

Prof. Gringarten speaks with great enthusiasm about both the course and his students and he is justifiably proud of both. As he summarises "a student can start this course knowing nothing, and can leave one year later as a bone fide petroleum engineer. It works!"

A long-term investment

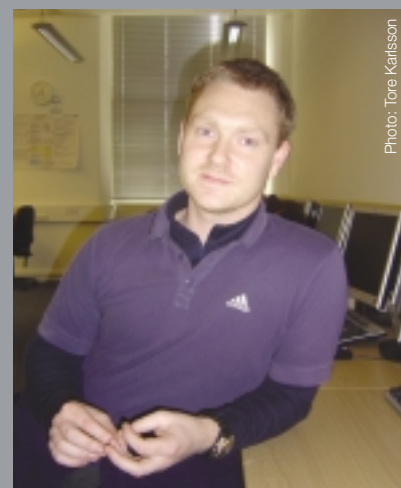


Photo: Tore Karlsson

Ian Morgan, a graduate of Exploration Geophysics from University College, London, worked as a geophysicist with PGS before deciding to take the Imperial College MSc. in Petroleum Engineering. "I enjoy working offshore and want to stay in the technical rather than administrative fields, but I felt I could progress further and keep interested by moving into well operations and production. I looked at a number of options and this course appeared to offer the most powerful combination of teaching, expertise and hands-on experience." He is funding the course himself, but considers it is a good long-term investment.

He finds the course intense but fascinating, although he admits that returning to studying was quite difficult. With his background in geophysics, he considered the integrated project in Phase 1 very interesting, and he now feels that he has a much greater awareness of the many facets of reservoir management. "The team-work aspect of the projects was a good, although challenging experience. It is very important to realise what the other team members contribute and to understand the strengths and weaknesses of their disciplines. Using raw industry data for this is important."

Ian is looking forward to returning to the oil industry after he graduates in September, hoping for a position as an offshore drilling engineer. He feels happy that this course will help towards his eventual ambition to be an exploration manager in a major oil company.

prize - £300 in pound coins!

Following exams and a two week field trip, the students spend several months on individual dissertations, building on their integrated knowledge of all aspects of Petroleum Engineering and where possible using industry data to build realistic models and scenarios.

An important feature of the Imperial College Petroleum Engineering MSc. is the use of external industry experts in a variety of roles. Some guest speakers represent software vendors in the industry, who are happy to train the petroleum engineers of the future in their products. For example, students know how to use Interpret, PIE and Saphir for well testing or Eclipse for reservoir simulations. Computing facilities include top of the range PCs, a server and fibre optic network and a fully immersive 3-D visualisation system.

Lecturers also come from oil companies,

such as Dr Satinder Purewal from BG, who helps students with practical aspects of petroleum engineering and feels that he is able to offer them a worldwide professional perspective. This year, reserves assessment is being taught by Shell – Prof Gringarten feels that they are well-suited to explain the potential rewards and pitfalls in this area!

Oil companies are very happy to lend their staff and expertise in this way and they feel it is an important contribution to the future of the industry. Additional presentations by industry experts are provided every Friday afternoon and industry specialists act as mentors to the students, offering valuable advice and guidance.

Multi-disciplinary specialists

Dr. Matthew Jackson, lecturer in Petroleum Engineering at Imperial College, points out: "This course is very hard work. It is intense, with students working long hours and there is no chance to slack or relax. But it works! Every year I see a group of unsure and confused students arrive in September, and just a few months later when they make their Phase 2 presentations, they are already professional petroleum engineers."

Feedback from past graduates of the integrated Petroleum Engineering MSc. in Imperial College suggests that the diversity of experience and quality of teaching on this course has been a major asset to them

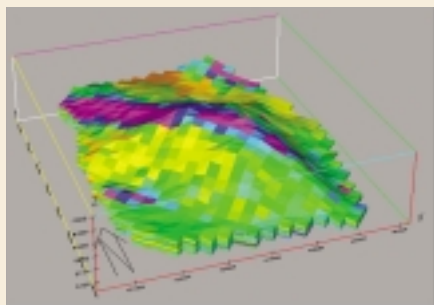
Teamwork

Nolwenn Perzo comes from Brittany and is taking a degree in Fluid Mechanics in Toulouse. She is spending the final year of her graduate studies on the Petroleum Engineering MSc. in Imperial College and will therefore graduate in September with both the MSc. and her B.Eng. She came to Imperial College with no knowledge of geology or the oil industry, but thought "It sounded interesting – and I would be able to improve my English!" Nolwenn was sponsored by Wintershall for the MSc. course, and will do her individual project with Total in Paris.

She likes the Reservoir Engineering course and the way it is constructed. She particularly likes the integrated approach and teamwork on the Maureen Field projects. "I learnt a lot from the other team members and relied on them for their experience of working in the industry." She found that the teams worked well together, with the different backgrounds and skills enhancing and supporting each other – for example, she was able to contribute her strong mathematical and engineering knowledge despite of her lack of industry experience.

Nolwenn is keen to continue in the oil industry, which she finds challenging and exciting. She thinks there will be interesting job opportunities for reservoir engineers as they meet the challenge of optimising production from the world's declining resources.

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Example from Maureen Group Field project: 3D reservoir model.

Positive students

MSc. Petroleum Engineering students at Imperial College come from a very wide range of background and experience, their only common feature being that they are all of a very high calibre. Only graduates with First Class Honours degrees are accepted on the course, although this can be waived if a candidate has relevant industry experience. On average, of the 40 students who graduate from this course each year, about 40% will have up to 5 years previous industry experience. Some 60% of the students come from overseas, and this year 15 different nationalities are represented, with the largest foreign contingent coming from Nigeria. A third of students are women and for many students English is not their first language, all of which makes for an eclectic and dynamic mix.

The students interviewed for this article had only positive comment and praise for the course and the way in which it is structured and taught. The teaching of subjects in blocks is very effective, as they logically follow one another according to the reservoir management process, rather than being taught concurrently to suit timetabling issues.

Students build up knowledge in a coherent fashion, finding they have the information they need and the means to apply it at the appropriate time. They found the use of projects with genuine data very helpful, and particularly relished the teamwork element, when people with diverse backgrounds and skills had to work effectively and efficiently together, as will be required in a working situation. They even thought that the considerable pressure of the course was a positive feature – having prepared a reservoir characterisation model with a team of novices in only 15 days, anything an oil company could throw at them in the future would be easy!

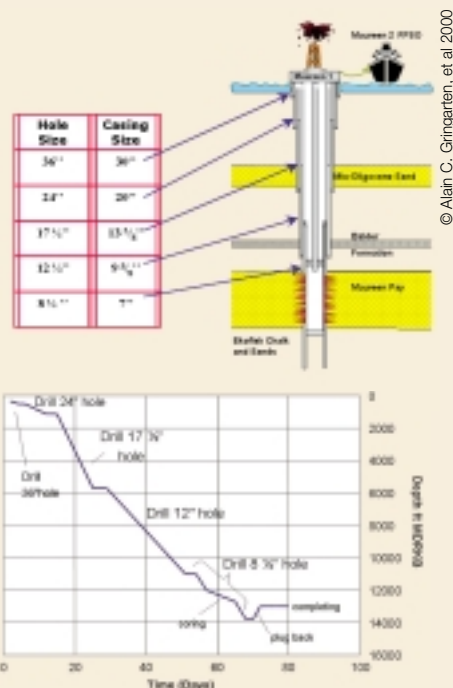


Photo: Tore Karlsson

in their professional life. All graduates wishing to find employment in the hydrocarbon industry have done so and most consider that the course has substantially improved their job prospects and accelerated their career progression. A major endorsement is found in Thabo Kgogo, a student from South Africa who is on the course this year. He was sent to Imperial College by his employers, PetroSA, on the recommendation of his manager, who himself took this course four years ago.

Now well established, it would appear that this programme, with its integrated subject approach, block teaching by objective and use of industry specialist lecturers, is a great success. By teaching students to follow the reservoir management process and to work with real data, Imperial College are producing specialists with in-depth knowledge of their chosen field. They understand all facets of reservoir management and are trained to work in multi-disciplinary teams.

Professor Gringarten and his colleagues are to be congratulated for their success in formulating this innovative and effective approach to the teaching of petroleum geoscience and Petroleum Engineering.



Example from Maureen Group Field project: Casing design and Drilling Program.

250 million barrels left out

It is considered crucial for the success of the course that students use actual oil company data to build up their reservoir model. The course uses data from the Maureen Field in the North Sea made available to the College by the operator, Philips Petroleum, and their partners. Data includes seismic traces, geological maps, core photographs, routine and special core analysis reports, PVT analysis, RFT, DST and production information.

The data has now been reanalysed by more than 40 teams of students over 7 years, and Prof. Gringarten finds it is interesting to see the progress that has been made. While all groups come up with essentially the same results, he feels that the standard of students has improved over the years and that they are now capable of reaching deeper into the data to refine their conclusions. He also considers that history matching has produced some interesting results: "for example, the Maureen Field was abandoned after the production of 250 million barrels of oil, but recent analysis by the students suggests that it may have contained as much as 500 million barrels of oil recoverable"

However, the Maureen Field data set is aging, and the 2005 intake of students will be presented with new data from the BP Wytch Farm Field.

Using real data for the project work gives students an experience close to the true working environment. Carmen Morataya, one of the industry external lecturers on the course, says: "It is important that students learn where to find the information they require and how the different data types interact. They learn that there are no perfect datasets, and it is necessary to get the best out of the existing data. This is a 'real world situation' and I think it is a very important lesson."

Through using authentic data the students also learn about risk management, becoming fully aware of the importance of risk assessment in the hydrocarbon exploration and production process.

Best available anywhere



Carmen Morataya has been a consultant lecturer for the Petroleum Engineering MSc. for 2 years. She comes from Venezuela, gained a Masters degree from London University and has over 25 years experience in managing facilities projects all over the world. She tutors the students in surface facilities and economics in the third phase of the course and advises on these aspects of the field development project.

"The use of industry lecturers in this course is crucial to its success," she says. "They can offer students invaluable advice on how to look for and at data and how to extract the best from data sets which are not perfect. We give the course worldwide expertise." She considers the external lecturer should be interactive with the students, more mentor and guide than teacher, particularly during the team project phases. "Our main aim is to expose them to practical ideas and stimulate their thought processes."

Carmen considers that the course offered in Imperial College is the best available anywhere in the world. She has reviewed a number of similar courses and feels that none of them offer the same breadth of teaching combined with experience and practical skills.