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Mozambique Creates a Star of Africa – A World Class Petroleum Engineering Program at the University of Eduardo Mondlane (UEM)

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Abstract

This work documents the creation of a post-graduate (Master’s) degree program in Petroleum Engineering (MSPE) at the University of Eduardo Mondlane (UEM) in Maputo, Mozambique. The genesis of this program was a request from the government of Mozambique to a corporate entity to provide assistance with the development of a domestic talent pool in petroleum engineering (in this case, the entity is Anadarko Mozambique Area 1 [AMA1], a subsidiary of Anadarko Petroleum Corporation [APC]).

This program is unique in that it is a working partnership amongst the sponsor (AMA1), the education entity (UEM), and a team of renowned U.S.-based faculty.

Historically, multinational companies would simply make philanthropic contributions to a local institution and then turn their focus on their core business. Today, all parties expect more from each other; host governments and their industry partners want equal input on where and how social responsibility projects are directed, including which projects should be undertaken. Likewise, the beneficiaries of these contributions are requesting increased levels of involvement and assistance to deliver maximum benefits for their constituents. This is the situation in Mozambique; all of the parties—-the government, the University of Eduardo Mondlane (UEM), and Anadarko Mozambique Area 1 (AMA1)—have agreed to and fully support this collaborative development model.

The goal of this project is to provide an approach which fully meets the academic standards and rigor of a world-class post-graduate degree program in Petroleum Engineering while providing sustainable capability development in terms of the students and the faculty. This model relies on the commitment of all parties to achieve “steady-state” in as short a time as possible; in this case, the planned time-scale from inception to independence is on the order of four years. At present, the project is on schedule with two cohorts of students and seven UEM faculty progressing.

Introduction

As historical reference, in 2010 Anadarko Mozambique Area 1 (AMA1), a subsidiary of Anadarko Petroleum Corp. (APC), discovered gas resources in northern Mozambique which are currently estimated
to be between 45 to 70 trillion cubic feet (tcf). AMA1 is in the process of constructing a LNG complex which is expected to be operational in 2018.

Given the success of the AMA1 exploration program, Mozambican government leaders and Anadarko corporate leadership discussed ways in which Anadarko could provide a social responsibility contribution that would have a significant impact on the people of Mozambique in terms of technical skills and capabilities, which would (in turn) stimulate the Mozambican economy. AMA1 specifically sought a program that would reflect its core values while supporting its commitment to partner responsibly with the Government of Mozambique to safely and efficiently develop its natural gas resources.

Recommendations were proposed in the areas of health, the environment, and education. The proposal that the Mozambican government and Anadarko corporate leadership converged upon was the development and implementation of a Master’s of Science in Petroleum Engineering (MSPE) at the University of Eduardo Mondlane (UEM) in Maputo. In setting the vision for the MSPE program, both parties agreed to the following objectives:

- To develop sustainable improvements for UEM in science and technology;
- To promote the development and retention of top technical talent in Mozambique; and
- To provide for ongoing benefits to the oil and gas industry in technology research and development.

With these objectives in mind, the Mozambican government approved the recommendation to assess the current capability/capacity for a post-graduate program in Petroleum Engineering program at UEM.

**Initial Assessment**

In March 2012, the project manager from Anadarko invited and accompanied two experienced Petroleum Engineering professors (one from Texas A&M University and the other from the University of Oklahoma) in an onsite assessment of the facilities and capacities of the Department of Engineering at the University of Eduardo Mondlane (UEM). In this assessment, the curriculum, staff, students, supporting infrastructure, and existing/planned degree programs were reviewed in the context of the possibility of creating a post-graduate degree program in Petroleum Engineering.

The U.S.-based professors benchmarked other Petroleum Engineering education initiatives around the world and compared the initiatives to the data gathered from the UEM onsite assessment. In doing so, the team proposed several education models that could accomplish the vision of a robust and sustainable post-graduate degree program in Petroleum Engineering as envisioned by the Mozambican government and Anadarko corporate leadership. These models were proposed in consideration of the existing and evolving needs and capabilities of UEM. For example, the team took into account the need to create a faculty of petroleum engineering from the existing senior faculty at UEM, the need to provide a teaching facility that could support remote teaching (as well as provide access to global electronic resource databases), and the need to create the Petroleum Engineering program in a sustainable fashion.

After careful consideration of the proposed models, the Mozambican government, Anadarko corporate leadership, and the UEM leadership agreed to implement the model of a two-year Master’s of Science in Petroleum Engineering (MSPE) program. The proposed MSPE program would closely resemble that of an MS degree from top U.S. schools, with additional components such as technical and research seminars to add a “non-classroom” perspective, as well as having a focus on safety, ethics, and the environment. There was universal consensus that the two-year MSPE program should be preceded by a one-year Core program in foundational geoscience and engineering concepts, both of which would be delivered in English at the UEM Faculty of Engineering campus in Maputo, Mozambique.

In addition to recommendations for the structure of MSPE program, the U.S.-based faculty evaluators also provided guidance for further strengthening of the curriculum, faculty, students, and infrastructure at UEM to reinforce the sustainability of the program. Specifically, the faculty evaluators recommended that
the Petroleum Engineering program be delivered in a “partnership” fashion with UEM faculty managing the classroom activities and U.S.-based teaching faculty providing the initial curriculum development and instruction, working together to transition “ownership” of the program over a three-year cycle.

Elements for Program Sustainability

In order to attain sustainability for the UEM MSPE program, a number of specific elements were included in the program design. These elements are: (see Fig. 1 for a diagram of the elements for this program)

- Committed UEM leadership and private industry support;
- Dedicated, experienced U.S. and UEM faculty;
- A “fit for purpose” curriculum;
- Capable and motivated students;
- A virtual delivery approach; and
- Metrics-driven project management.

Committed UEM Leadership and Private Industry Support

In May 2013, UEM and AMA1 jointly signed a Memorandum of Understanding (MoU) which outlined the purpose, objectives, and scope of the program and the responsibilities of each party, including overall governance of the MSPE program at UEM. For reference, this initial MoU is valid until the end of 2015.

UEM and AMA1 appointed leadership representatives responsible for adherence to the terms and conditions of the MoU, providing overall program guidance and communicating progress to the Mozambican government and AMA1. As of March 2014, the MSPE Steering Committee members included: Prof. Orlando Quilambo, Rector (UEM); Prof. Ana Mondjana, Vice-Rector for Academic Affairs (UEM); Prof. Alberto Tsamba, Dean of the Faculty of Engineering (UEM); John Peffer, President (AMA1); Antonio Sevilla, Director of Human Resources and Administration (AMA1); and Alcido Mausse, Director of Government and Social Affairs (AMA1). This group meets on a quarterly basis. In addition to the joint commitment of UEM and AMA1 to the MSPE program at UEM, other government entities and private industry partners have been actively engaged—including the Swedish International Development Cooperation Agency (SIDA), GE Oil and Gas, Halliburton, and Schlumberger.

Dedicated, Experienced UEM and U.S. Faculty

A critical requirement of any quality education program is its teaching staff. The leadership at UEM assigned seven ranking professors to the MSPE program—all of whom are staff members and department leads from within the Faculty of Engineering and the Faculty of Natural Sciences (Geology). It is important to note that this assignment represents additional responsibilities to the UEM professors’ current teaching loads.

The professors selected for the MSPE program are leaders in their respective programs; however, the curriculum for the MSPE program consists of entirely new content. As such, the development and initial delivery of the MSPE curriculum requires the immersion of the UEM faculty into the Petroleum Engineering discipline. A “teaching partner” approach was developed to ensure development of Petroleum Engineering skills and familiarity with the practice of Petroleum Engineering.
Nine external Petroleum Engineering professors with outstanding academic and industry credentials were recruited from internationally renowned universities: Colorado School of Mines, Pennsylvania State University, Texas A&M University, Texas Tech University, the University of Houston, and the University of Tulsa. As noted, the external (U.S.-based) Petroleum Engineering faculty members were teamed with seven UEM professors for three years to co-develop and co-instruct the MSPE program, with the intent of systematically shifting more and more teaching and research responsibility each year from the U.S professor to the UEM professor.

In addition to creating a one-on-one partnership model between the U.S.-based Petroleum Engineering faculty and the UEM professors, the joint UEM-AMA1 MSPE program Sponsorship Committee created an Academic Advisory Council (AAC) to ensure engagement and cross-collaboration amongst the UEM and U.S. professors. The AAC was also tasked with the MSPE program curriculum design and sharing of academic and practical experiences in the field of Petroleum Engineering.

The AAC conducted its first meeting in Houston, Texas, U.S.A. in September 2012. The group outlined the MSPE program framework and curriculum, constructed the curriculum development approach and timelines, and provided opportunities for relationship building amongst the UEM professors and their U.S.-based faculty counterparts. Subsequent AAC meetings have been held every 6-12 months, with a continued focus on curriculum and academic development. Additionally, UEM faculty development has been enhanced by attendance at SPE technical conferences and onsite visits to U.S. universities.

“Fit for Purpose” Curriculum
The initial class of applicants had yet to be identified, but it was agreed by the joint UEM-AMA1 Steering Committee that all students entering the MSPE program would first complete a one-year introductory “Core program” that would provide foundational skills in Petroleum Engineering in order to level the students’ knowledge base prior to the start of the more rigorous MSPE program. The Core program consists of the following topical subjects:

- Geoscience for Petroleum Engineers;
- Drilling and Completions Engineering;
- Reservoir Engineering and Petrophysics; and
- Production Operations and Facilities Engineering.

In addition to the Core program, an intensive English program was offered to any student wishing to participate in the opportunity. The English program was designed to enhance English proficiency and introduce and familiarize the students with terminology specific to the oil and gas industry. While obvious to most practitioners in the oil and gas industry that the vast majority of the literature, standards, practices, and vocabulary are in the English language and thus the need for a petroleum engineer to function in English is a critical for success, this is a relatively new concept in Mozambique.

Upon successful completion of the Core Program, students matriculate to the two-year MSPE program. The MSPE is comprised of eight distinct courses, a research dissertation project, and research and technical seminars. The dissertation consists of original research on a topic chosen by the student and the student’s UEM and U.S.-based co-professors. Topics are focused on the importance of and value to Mozambique in terms of exploration, drilling, production, facilities, and oil and gas industry infrastructure. It should (again) be noted that the MSPE program is very rigorous, and although the Core program might be considered a “soft start,” the MSPE program is executed with the expectation of foundational skills and the ability to handle a very heavy technical course load. (see Fig. 2 for a diagram of the “Fit for Purpose Curriculum”)

With the guidance of an instructional designer, the UEM and U.S.-based professors and the designated Anadarko subject matter experts co-developed detailed subject course outlines and instructional approaches for the Core and Masters courses.
For each course, the development teams created detailed materials, activities, quizzes, and exams. Each party in the course development team had distinct responsibilities. The U.S.-based professor recommended texts, provided content expertise, and ensured content accuracy. The Anadarko expert provided industry practical applications to theoretical models and concepts. The UEM professor reviewed the materials to ensure clarity and “fit for purpose” for Mozambique and within the university environment. The instructional designers had dual roles: (1) they structured the objectives and reviewed the content for clarity, and (2) they helped ensure consistency and ease of use for the UEM professor and for the students. Furthermore, the instructional designers facilitated the work effort and communications amongst the UEM and U.S.-based course development team and ensured that the course development progress stayed on track while providing for other resources, as required.

**Capable and Motivated Students**

With the success of the Mozambique Rovuma Basin exploration programs in 2010 still on the minds of many in Mozambique, interest in the new MSPE program was extremely high during the call for the first student cadre in 2012. Over 120 applications were vetted (even more received), ensuring that all 25 seats in the initial Core program would be filled with qualified candidates. It is important to note that the entire first student cohort was made up of professionals in fields completely unrelated to petroleum engineering, as well as a selection of UEM instructional (teaching) faculty members. The subsequent student cadre, selected in late 2013, was augmented with recent university graduates. All individuals had undergraduate degrees in Engineering or Natural Sciences and presented varying degrees of English-language proficiency during the interview process.

As one might expect, some of the working professional students in the first cadre struggled as they adjusted to the addition of academic requirements to their full-time work and family responsibilities. Interesting, in the first cadre, those students with the most demanding work-life (managers, in particular) performed very well in the Core program—some were at the top of the class. For the next cadre, about half of the students are recent university graduates, and many are experiencing challenges in adjusting to
the intensity of a post-graduate program—primarily, “work-life balance” issues. As recent B.S. graduates, it is believed that even the Core program may present unique issues because of the intensity of the program and the “self-study” aspects of post-graduate studies. It must also be noted that essentially all of the students (both cadres) have faced significant challenges in paying for program tuition and administrative fees (undergraduate programs in Mozambique do not charge fees, but post-graduate programs do).

Based upon an evaluation and assessment of the various challenges faced by the students, a graduate advisory program was developed to support student academics, student management, and student retention. Through a combination of planning and progress reports, students have taken accountability for their own success, actively seeking guidance from program advisors. Retention has remained high with 22 of the original 25 students successfully completing the Core program and advancing to their first year of the MSPE program. In the second student cadre, a similar situation has resulted; two students who were admitted did not enroll in the program, and one student elected to withdraw from the program shortly after the semester commenced because of work demands. A total enrollment of almost 50 students currently exists (combined enrollment of the Core and MSPE programs).

In support of student learning experiences and to provide exposure to industry professionals, a recommendation was made to establish a student chapter of the Society for Petroleum Engineers (SPE). Collaboration with Anadarko, Schlumberger, and other Mozambique petroleum industry professionals has resulted in the formation of a SPE Maputo Section, as well as the formation of a UEM SPE student chapter.

Virtual Delivery Approach
With the MSPE curriculum in development and the initial group of students selected, the joint UEM-AMA1 Steering Committee recognized an important issue—specifically, how can UEM commit to consistent delivery of a top-tier MSPE program year-over-year, especially with the U.S.-based professors physically located 7 to 9 time zones away? The joint UEM-AMA1 Steering Committee made the bold decision to retrofit the existing classrooms in the UEM post-graduate facility to accommodate virtual delivery capabilities.

The virtual delivery model consists of a fully networked environment (current bandwidth is on the order of 10 Mb/s — sufficient for voice/video collaborations), back-up power for the classrooms, state-of-the-art laptop computers, Microsoft SharePoint for virtual file storage and access, and use of the Microsoft Lync application, an onsite LCD projector and screen, and web camera for providing a real-time, virtual face-to-face connection between the U.S.-based professor and the onsite UEM professor and MSPE program students.

The initial cadre in the Core program officially launched on April 29, 2013, and the MSPE program commenced in February 2014. The virtual delivery capabilities have been the key enabler for the UEM-U.S. faculty teaching approach. Along with co-instruction of the course materials, the UEM professor manages the physical linkage between onsite and remote delivery. The UEM professor also manages the classroom administration (with staff support provided by UEM). The primary responsibility of U.S.-based faculty is to focus on course delivery, and the primary focus of UEM faculty is on co-instruction. For the initial delivery of each subject, an instructional designer is engaged, providing technology and general classroom support. In addition, the instructional designer revises materials as appropriate and records the classroom instruction via Microsoft Lync. The classroom instruction transcript, along with an audio recording, are made available within 2 hours after each class ends to reinforce concept understanding. The video recording of the class is available within 48 hours after each session to allow UEM faculty and students to review the classroom experience in its entirety.

Metric-Driven Project Management
This has been an incredibly ambitious project, to proceed from a cold start to an expected graduating class in approximately 3 years is almost unrealistic, but the program is on track to deliver just such results. To
ensure delivery of this project in such a short period of time, to reinforce collaboration amongst all parties, and to transition content knowledge between the U.S. and UEM professors, a third-party consulting firm with project management expertise was engaged to assist with development and delivery of the program. The project management experts provided the day-to-day operational guidance on behalf of the UEM-AMA1 Steering Committee for the duration of the MoU.

A number of metrics have been used since the onset of the project to ensure a successful launch as well as ongoing sustainability of the MSPE program. For example, the development of each course has been planned, monitored, and transitioned. A student management program, which monitors attendance and grades, provides interventions to those students who may be in jeopardy. Routine metric-based status reports are developed and reviewed weekly by the MSPE project team to make adjustments to project schedules and development and delivery methods. The project management team then provides summary versions of the metrics report to the Sponsorship Committee and other relevant stakeholders on a monthly and quarterly basis.

Challenges and Opportunities

With strong teamwork, planning, and execution, the project team has successfully met every major milestone to-date (April 2014). The first cohort of students completed the Core Program in December 2013 and began the MSPE program in February 2014; this cohort will begin their dissertations in February 2015. The second class of students commenced the Core program in February 2014 and will begin MSPE coursework in February 2015.

There are still future challenges (known and unknown) that must be addressed. A selection of “known” challenges that the team has identified and is currently addressing include the following:

- **Ensuring the sustainability of the MSPE**: In January 2014, the UEM leadership appointed Prof. Rui Sitoe as the lead administrator of the MSPE program. The MSPE Project team is working with Dr. Sitoe to develop a transition plan which outlines the gradual shift of U.S.-based professor and third-party project management responsibilities to the UEM professors and to UEM administration.

- **Ensuring the MSPE program remains relevant**: Given the curricula and the teaching/research partnerships, we believe that the MSPE program will, in the short-term, deliver well-qualified and high-quality graduates. The long-term relevance of the UEM MSPE program will require a continued commitment and communication amongst UEM, the Mozambican government, and private industry.

- **Ensuring the right students are selected for and mentored within the MSPE program in future years**: As the oil and gas industry evolves in Mozambique, other fields such as gas processing, environmental engineering, and petroleum geology will also evolve and compete with petroleum engineering for a somewhat limited talent intake pool. In this scenario, private industry must continue to guide the Mozambican government and UEM administration regarding the skills required by industry for new graduates, as well as emphasize the need for a sufficient quantity of petroleum engineers that will be required to serve in the Mozambican oil and gas industry.

Summary

The MSPE degree program delivered at the University of Eduardo Mondlane (UEM) is a unique model of a tripartite partnership amongst government, industry, and academia stakeholders. Each stakeholder is responsible for elements of the program; but more importantly, each stakeholder recognizes the mission of sustainable development:

- Specialized faculty of Petroleum Engineering at UEM;
- Attraction, retention, and matriculation of best-in-class students; and
• Binding partnerships with U.S.-based faculty who possess extensive portfolios in teaching and research.

Although the first student cohort is only mid-way through the Petroleum Engineering education experience, the influence and impact of the MSPE degree program at UEM is being felt. Both the Geology and Chemical Engineering departments are contemplating similar engagements with industry partners, and the UEM administration is considering the development of a “post-graduate” school which would house all of the post-graduate degree programs within the Faculty of Engineering.

It is important to note that stakeholder expectations have been realistic since the inception of the MSPE program. In many ways the model selected has charted new territory. For example, the one-on-one partnering with renowned and highly experienced U.S.-based faculty is a new prototype, as is also the assignment of a project management team to oversee the execution of the program. However, these elements were carefully selected to maximize impact and provide optimal efficiency of resources. The goal of the MSPE program is to provide “ready-to-contribute” talent to the industry and to build the educational capabilities of the Faculty of Engineering at UEM—not only for Petroleum Engineering, but also for other engineering and science disciplines which support the energy resource development in Mozambique.

The motto of the UEM MSPE program is “building capabilities and changing lives,” and the team is committed to this end. The goal has not changed from the beginning—to create a world-class Petroleum Engineering program at the University of Eduardo Mondlane (UEM). While this initiative is part of the social responsibility goals set forth by Anadarko Petroleum Corp. and its partners, it satisfies the requirements of UEM and the Mozambique government by improving UEM’s capabilities and increasing the country’s technical talent pool. What matters most is the engagement and education of the first generation of Mozambican petroleum engineers.

As a closing statement, this program is among the most intensive educational programs in Petroleum Engineering. It is simultaneously delivering a world-class education for Mozambique while providing a rapid evolution of the School of Petroleum Engineering at the University of Eduardo Mondlane.

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Prof. Ana Mondjana, Vice-Rector for Academic Affairs (UEM)
Dr. Carlos Lucas, Director of Cooperation Office (UEM)
Mr. John Peffer, President (AMA)
Mr. Bob Daniels, Executive Vice President, International and Deepwater Exploration (Anadarko Petroleum Corp.)
Mr. James Kleckner, Executive Vice President, International & Deepwater Operations (Anadarko Petroleum Corp.)
Mr. Don MacLiver, Vice President, International Operations (Anadarko Petroleum Corp.)
Mr. Frank Patterson, Senior Vice President, International Operations (Anadarko Petroleum Corp.)
Mr. Don Vardeman, Vice President, Worldwide Project Management (Anadarko Petroleum Corp.)

References
## Appendix—UEM Project Team as of April 2014

### Petroleum Engineering Program Leadership

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<tr>
<th>Role</th>
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<tr>
<td>AMA1 Program Lead</td>
<td>Antonio Sevilla</td>
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<td>U.S. Faculty Lead</td>
<td>Prof. Tom Blasingame</td>
<td>Texas A&amp;M</td>
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<td>Prof. Alberto Tsamba</td>
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<td>UEM Faculty of Engineering</td>
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<td>UEM Graduate Program Advisor</td>
<td>Prof. Luis Lucas</td>
<td>UEM Faculty of Engineering</td>
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<tr>
<td>Project Management Lead</td>
<td>Claire Markwardt</td>
<td>Markwardt Performance Consulting</td>
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<tr>
<td>Lead Instructional Designers</td>
<td>Lisa Rankin</td>
<td>Markwardt Performance Consulting</td>
</tr>
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<td>Susanne Rothschild</td>
<td>Markwardt Performance Consulting</td>
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<tr>
<td>Instructional Designers</td>
<td>Vicki Johnson</td>
<td>Markwardt Performance Consulting</td>
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<td>Erin O’Toole Murphy</td>
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<td>Delivery Lead</td>
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<td>Dominique Rothschild</td>
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### Core Petroleum Engineering Program (Faculty and Subject Matter Experts)

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<tr>
<td>Geoscience for Petroleum Engineers</td>
<td>Prof. Walt Ayers (Texas A&amp;M)</td>
<td>Prof. Mussa Achimo</td>
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<td>Production Operations/Facilities</td>
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<td>Drilling and Completion Systems</td>
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<td>Reservoir Engineering/Petrophysics</td>
<td>Prof. Erdal Ozkan (Colorado/Mines)</td>
<td>Prof. Luis Cristoua</td>
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### Master’s Petroleum Engineering Program (Faculty and Subject Matter Experts)

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<td>Applied Math/Flow in Porous Media</td>
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<td>Phase Behavior</td>
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<td>Doug Jordan, PK Pande</td>
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<td>Steve Randolph, Richard Sullivan</td>
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<td>Prof. Daud Jamal</td>
<td>Roger Reagan, Thuy Rocque</td>
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<td>Reservoir Modeling</td>
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<td>Prof. Antonio Cumbane</td>
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