Introduction

FracRisk aims in understanding, preventing and mitigating the potential environmental impacts and risks of shale gas exploration and exploitation. It starts with the collection and collation of important baseline data, including the generic characterization of the reservoir source in situ. The project progresses through understanding important processes operating in the reservoir and overlying strata, developing the forward modeling of the flow and transport of a multiphase fluid, and finally inputs into an assessment of the respective risks using dynamic monitoring tools on six key scenarios exemplifying key risks identified within the project. This information is captured in terms of the development of a knowledge base, the provision of scientific recommendations and an overview, with recommendations, of current EU legislation related to shale gas development.
Directing our approach to address these areas is a hydro-geo-chemical-mechanical facies concept whereby we consider the subsurface to be comprised of a number of facies subdivided according to their mechanical and hydrogeological properties and not necessarily their geology. This approach has been adopted by a few authors recently [1, 2] and is being increasingly recognized as a useful holistic approach to investigating, characterizing, understanding and providing the basis for forward modeling subsurface geo-engineering problems. Additionally the function of the facies is taken into account during the engineering operation, whilst still addressing holistically the issues of the environmental foot print of shale gas extraction. It also provides a framework for the evaluation of the effectiveness of the regulatory and legislative authority operative in that area and a rational for suggested refinement to come out of this project. Importantly these areas will also be the focus of FracRisk's legislative review and subsequent suggested refinements based on the scientific outcomes.

FracRisk's objectives

The objectives of FracRisk are to develop a knowledge base for understanding, preventing and mitigating the potential impact of the exploration and exploitation through hydraulic fracturing (fracking) of significant shale gas reserves found throughout Europe, and to develop a decision support tool for risk quantification of the environmental impacts of the technology. In order to achieve our main objectives, we have developed a research program focused around the following activities:

- Assessment of the environmental impact (footprint) expressed in seismic activities and released substances in the environment involved in the exploration and production of shale gas resources. This is mainly based on the understanding of the geophysical, subsurface flow and transport processes involved, available geological, hydrogeological and geophysical data and appropriate source term and boundary conditions;
- Forward modelling with mathematical models to predict the effect of migration of chemicals and gases, and the mechanical effects (seismics), together with risk and uncertainty assessment based on six focused exemplary scenarios (before, during and after fracking operations) to direct cost effective data gathering;
- Develop and test a framework for risk assessment to be used both by regulators and contractors, based on the well-known ASTM RBCA (Risk Based Corrective Action) paradigm;
- Development of criteria for appropriate monitoring strategies to measure baseline conditions, as a pre-warning system and to validate mathematical models and concepts;
- Provision of scientific recommendations and a knowledge base for best practices for shale gas development and with direct application and relevance to the provision of consistent regulation.

Methods in the FracRisk's research

FracRisk coordinates its main research activity in seven working packages (WP), hereafter described:

WP 1: *Management*
Carry out administrative management. Coordinate the scientific management of the project. Manage the collaboration and interaction with international partners and advisors, scientific industrial regulatory advisory board (SIRAB). Coordinate the dissemination plan.

WP 2: *Data Collection and Analysis*
Identify and collect key baseline data for a number of sites in the EU and USA. Includes baseline carbon isotope data, stress field data, fluid composition data, seismic data, dynamic fracking data, water production data and experimental data. Provide hydro-geo-chemo-mechanical facies analysis of different sites, provide common data storage and access.

WP 3: *Features, Events and Processes*
Characterize main geological features, define key events and level of understanding of main processes occurring during the exploration and exploitation of shale gas, produce a Features Events Processes (FEP) risk register. Use a source-pathway-target conceptual approach. Identify high uncertainty risks and carry out fundamental research in these areas to improve understanding and reduce uncertainty.

WP 4: *Environmental Impact and Risk Assessment*
Identify key events, develop multi-level environmental impact and risk assessment site screening tool. Rank key risk FEPs associated with lack of understanding or uncertainty identified in the FEP risk register.

WP 5: *Model Development and Modeling*
Review standard industry modeling capabilities, develop scenario specific model capabilities, model scenarios including key processes and key events, validate with real data, identify optimal data density for cost effective uncertainty quantification and reduction. Develop new model concepts and codes for improved understanding of the thermo-hydro-mechanical- and chemical processes involved in hydraulic fracturing.

WP 6: *Monitoring and Mitigation of Key Events*
Provide optimal monitoring and mitigation strategies associated with key events (FEP's) that can potentially arise from shale gas production and waste-water injection. Investigate the monitoring and mitigation possibilities and develops new concepts to increase the certainty around the FEP's and reduce the impact of events. Providing technological enhancements for monitoring. Testing mitigation strategies based on the sealing potential of slurries. Formulating specific monitoring and mitigation strategies, using the focused scenarios.

WP 7: *Dissemination*
Provide scientific recommendations for best practices, knowledge base and legislative review. Maintain and develop a knowledge data base to augment the EU member states regulatory practice, undertake a review of EU legislation and member states regulatory practices. Best practice guide. Disseminate data and scientific recommendations for wide range of stake holders. Undertake a dissemination program to promote the project so that its findings reach a broad audience.

Figure 1 shows the summary of concepts and approach used within FracRisk.

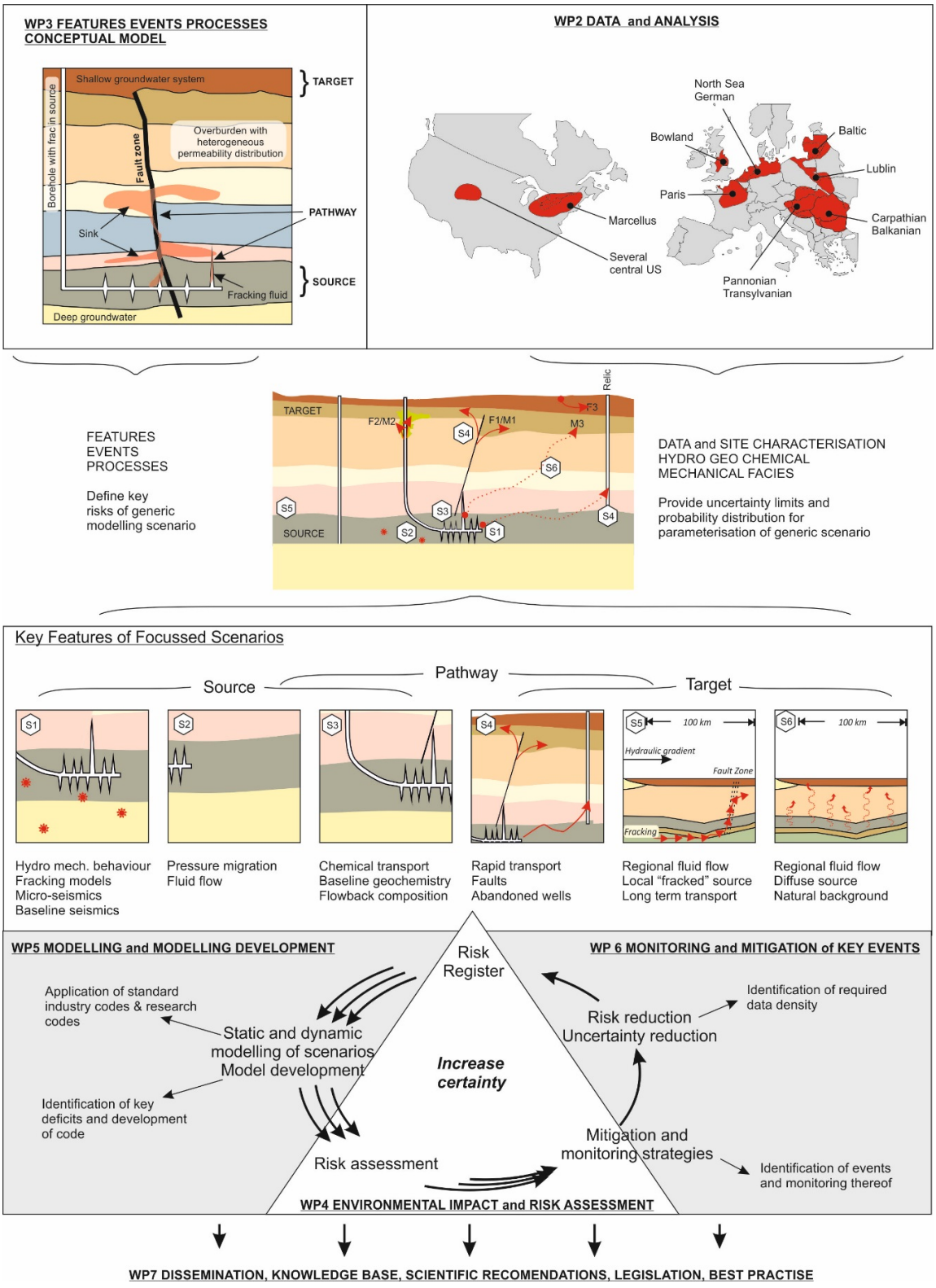

Figure 1 *Summary of concepts and approaches of FracRisk*

Expected results

FracRisk will develop a knowledge base for understanding, preventing and mitigating the impact of the exploration and exploitation of shale gas reserves found throughout Europe. The knowledge base will include international experience, state of the art process understanding, state of the art modeling techniques and fully accepted risk assessment tools for site selection and management. Key scientific recommendations will be formulated and overarching EU legislative refinement suggested. Public concerns about the management of risk related to fracking operations will be addressed, a firm scientific basis and demonstrable data to validate recommendations will be provided. The technological readiness level from a number of multidisciplinary approaches and applications will be noticeably improved. There will be provision for a much more focused, coherent and scientifically founded approach to member states enabling the regulation of the shale gas industry.
Specifically the expected impacts include:

1. Reducing the uncertainty of the evaluation of the environmental impacts of shale gas exploration and exploitation
2. Providing an understandable, ready to use, platform for risk analysis, based on a widely applied paradigm (the SG-RBCA), relying on extensive data collection and a judicious use of quantitative models
3. Contributing to the formulation of regulations for environmentally safe shale gas exploration in Europe
4. Preparation of a document summarizing a set of best practices recommendations for both exploration and production
5. Enabling a more rational approach to site certification, capable of gaining public acceptance

Conclusion

The project FracRisk financed by the European Union (programme Horizon2020) aims in the development of a knowledge base for understanding, preventing and mitigating the potential impact of the exploration and exploitation through hydraulic fracturing (fracking). Significant shale gas reserves have been identified throughout Europe, and one of the FracRisk's target is to develop a decision support tool for risk quantification of the environmental impacts of the technology. The research activity is conducted and coordinated by seven working packages. Expected results include reducing the uncertainty in the environmental impact and contributing in the formulation of regulation for environmentally safe shale gas exploitation in Europe.

Acknowledgements

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References

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