Ongoing cooperative EGS activities within the IEA GIA framework

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Vice Chairman, IEA GIA Executive Committee

- The IEA GIA framework
- Ongoing activities related to **EGS**
- Results obtained so far
- Outlook

ENGINE Final Conference, Vilnius/LT, 12-15 February 2008

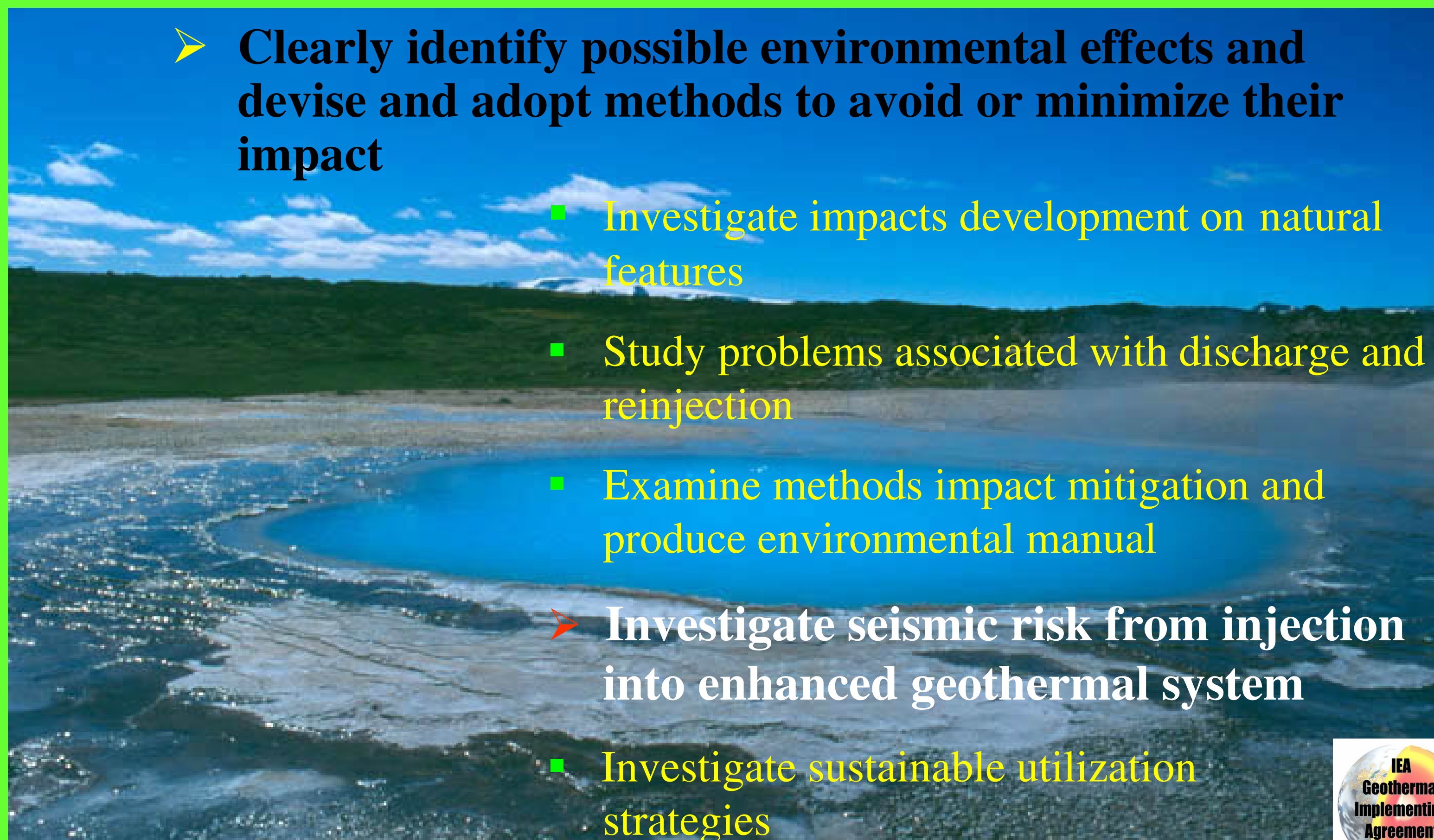
IEA Geothermal Implementing Agreement (GIA)

- Established in March 1997
- Provides flexible framework for international cooperation among national geothermal programmes for
  - Exploration
  - Development
  - Utilization
- Members currently include:
  - 11 Countries: Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Republic of Korea, Switzerland and the United States
  - The EC
  - 3 Industry Members: Geodynamics, Green Rock Energy and ORMAT Technologies
- Started 3rd 5-year Term of operation in April 2007

Current GIA Research

Studies now being conducted in four research areas, specified in four Annexes

Annex I: Environmental Impacts of Geothermal Energy Development



- **Clearly identify possible environmental effects and devise and adopt methods to avoid or minimize their impact**
  - Investigate impacts development on natural features
  - Study problems associated with discharge and reinjection
  - Examine methods impact mitigation and produce environmental manual
- **Investigate seismic risk from injection into enhanced geothermal system**
  - Investigate sustainable utilization strategies

IEA Geothermal Implementing Agreement

Current GIA Research

Annex III: Enhanced Geothermal Systems (EGS)

- **Investigate new and improved technologies to stimulate geothermal resources to allow commercial heat extraction**

- Modify use of conventional and develop new geothermal technology to EGS
- Collect information needed for decision making, design and realization of commercial EGS plant
- Field studies of EGS reservoir performance

IEA Geothermal Implementing Agreement

EGS in IEA GIA Annexes and Tasks

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With respect to EGS there are specific R&D activities, termed in the Annexes as Tasks:

Annex I - Environmental Impacts of Geothermal Energy Development – Annex Leader: C. Bromley

Task D: Seismic Risk of Fluid Injection into EGS (Task Leaders: R. Baria and D. Wyborn)

Annex III - Enhanced Geothermal Systems (EGS) – Annex Leader: R. Baria

Task A: Economic modelling (completed in 2001)

Task B: Application of Conventional Geothermal Technology to EGS (Task Leader: J. Renner)

Task C: Data Acquisition and Processing (Task Leader: T. Mégel)

Task D: Reservoir Evaluation (Task Leader: D. Wyborn)

Task E: Field Studies of EGS Reservoir Performance (Task Leaders: P. Rose, A. Genter)

Activities relevant for EGS and ENGINE are also conducted in Annex VII: Advanced Geothermal Drilling.

IEA GIA results

- In general, results and products of IEA GIA are accessible through its website www.iea-gia.org - in particular under www.iea-gia.org/activities.asp/
- Collaborative EGS R&D activities undertaken by the IEA GIA address the issue of induced seismicity, particularly in relation to engineered or artificially fractured geothermal reservoirs.
- The focus for EGS is currently on the flourishing scene in Australia, where 6 companies are listed in the Australian Stock Exchange (ASX), 25 companies hold exploration rights over 170 licences, ranging in size from 120 to 12’000 km^2.

Particular EGS results of IEA GIA (1)

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EGS economic modelling (completed)

An economic model that allows the user to define the engineering and financial characteristics and the available geothermal resources of a proposed enhanced geothermal system project to determine the resulting economics and to optimize the plant configuration was completed in 2001 and is available for download on-line. Usefulness of the model has been demonstrated through extensive applications at Fenton Hill (USA), Soultz-sous-Forêts (France), and a site at Hunter Valley (Australia). The model operates on a PC in the Windows environment and is available at: http://web.mit.edu/hjherzog/www/ ; there go to go ONLINE DOCUMENTATION

Particular EGS results of IEA GIA (2)

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Further, recent EGS results can be found on

http://www.iea-gia.org/publications.asp

EGS induced seismicity

The activities so far culminated in three international workshops, a "White paper" (IEA-GIA 2006), and a suggested Protocol (IEA-GIA, 2007).

A website was established to record detailed results of the research (http://esd.lbl.gov/EGS/).

EGS induced seismicity - downloads

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"White paper": Induced Seismicity Associated with Enhanced Geothermal Systems
(Produced in association with Annex I research)
To access, click: Induced Seismicity and EGS (doc, 1.2 MB)

Draft - "Protocol for Induced Seismicity Associated with Enhanced Geothermal Systems"
(Produced as part of the Annex I activities)
To access, click: Draft Protocol (doc, 53 kB)

Draft Report - Cooper Basin HDR Hazard Evaluation: Predictive Modelling of Local Stress Changes due to HFR Geothermal Energy Operations in South Australia
To access, click: Draft Report- Cooper Basin Hazard Evaluation (pdf, 3.65 MB)

„White paper“

Induced Seismicity Associated with Enhanced Geothermal Systems

E. Majer, R. Baria, M. Stark, B. Smith, S. Oates, J. Bommer, and H. Asanuma

I. Introduction

Purpose and Objective

As the global demand for energy increases, it is evident that geothermal energy cannot play a significant part in meeting this demand unless the commercial resource base can be expanded by an order of magnitude or more. The geothermal resource is extremely large, and eventually this potentially-economic resource must be accessed. The United States Geological Survey (USGS) estimates that in the 48 contiguous states alone, there are 300,000 quads of energy in the 200˚C heat sources down to 6 km. Obviously, because the U.S. uses only 100 quads per year, the potential of geothermal energy is enormous. To access this energy, both sufficient fluid and permeability must be present in the heated rock. Each may exist together, or separately, or not at all. Thus, the need exists to enhance permeability and/or fluid content, to enhance geothermal systems. As with any development of new technology, some aspects of the new technology have been accepted by the general public, but some have not yet been accepted and await further clarification before such acceptance is possible. One of the issues associated with Enhanced Geothermal Systems (EGS) is the role of microseismicity during the creation of the underground reservoir and the subsequent extraction of the geothermal energy.

„Traffic light“ system

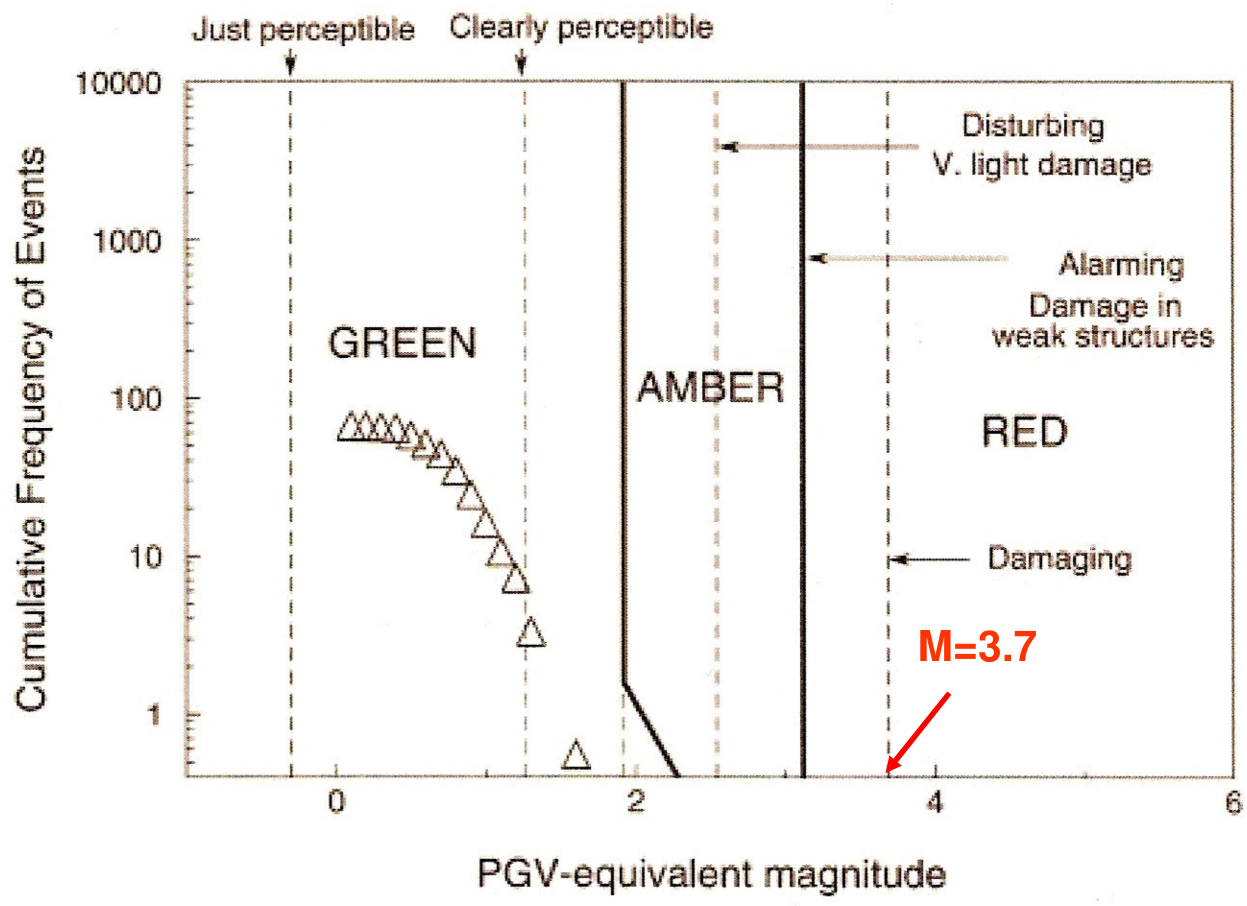

Figure 8.“Traffic light” boundaries superimposed on recurrence defined in terms of magnitudes adjusted to produce the same epicentral PGV if their focal depth were exactly 2 km. The triangles represent the cumulative recurrence data from the three episodes of pumping (totalling 54 days of pumping) normalized to a period of 30 days, from Bommer et al. 2006.

„Protocol“

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(DRAFT FOR DISCUSSION)

PROTOCOL FOR INDUCED SEISMICITY ASSOCIATED WITH ENHANCED GEOTHERMAL SYSTEMS

INTRODUCTION

As the global demand for energy increases, the contribution from geothermal energy can be extremely large if resources developed with Enhanced Geothermal Systems (EGS) technology are incorporated in the total energy picture. The geothermal resource is extremely large, and eventually this potentially-economic resource must be accessed. The United States Geological Survey (USGS) estimates that in the 48 contiguous states alone, there are 300,000 quads of energy in the 200˚C heat sources down to 6 km. Obviously, because the U.S. uses only 100 quads per year, the potential of geothermal energy is enormous. Because implementation of EGS affects subsurface conditions, especially fractures, there may exist the potential to cause induced seismicity. Induced seismicity has occurred in the development and production of oil and gas resources, large water impoundments, and mining applications. In each of these instances, properly monitored and analyzed induced seismicity has provided valuable information in developing the particular resource, but has not prevented the technology from proceeding. To help gain acceptance from the general public for geothermal generally and EGS specifically, it would be beneficial to clarify the role of microseismicity (MEQ, "micro-earthquakes," etc.) during the development stages of the underground reservoir and the subsequent extraction of the geothermal energy.

„Protocol“

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cause extensive damage. For example, experience and scientific data indicate that the vibration at depth due to fluid injection is unlikely to cause any damage to most modern buildings. On the other hand, the sound emitted can be a nuisance, particularly at night or on a very calm day, when the ambient cultural noise is very low. On some occasions, observers have reported that the effect from a microseismic event sounds like a small explosion, a truck going by, or a thud from a small object hitting a hard floor.

POSSIBLE STEPS IN ADDRESSING EGS INDUCED SESIMICITY ISSUES

Induced seismicity is one of a number of issues that the developer needs to address in order to proceed with project development. This document outlines the suggested steps that a developer could follow in extending their education and outreach campaign and cooperating with regulatory authorities and local groups. The following steps (not necessarily in the order given) are proposed for handling of the induced seismicity issue as it relates to the whole project.

Step One: Review Laws and Regulations

The developer should conduct a thorough study and evaluation of applicable laws and governing regulations that may affect the project. These legal stipulations may apply at national, state/provincial, county/town, or local levels of government. Any legal precedents that include induced seismicity (or related activity, such as noise) should be identified and assessed relative to the proposed project. The developer should formulate a plan for meeting any legal requirements.

Cooper Basin/Australia - EGS Seismic Risk Study

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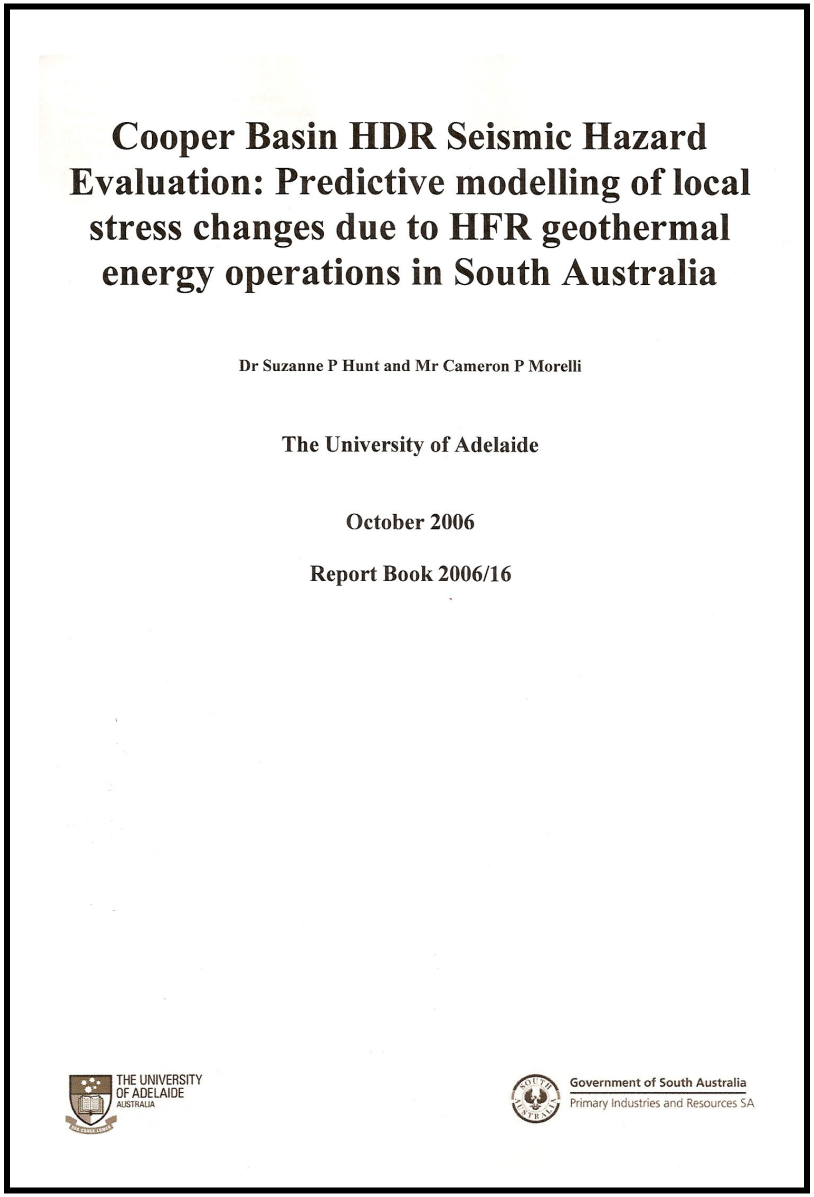

Cooper Basin HDR Seismic Hazard Evaluation: Predictive modelling of local stress changes due to HFR geothermal energy operations in South Australia

Dr Suzanne P Hunt and Mr Cameron P Morelli

The University of Adelaide

October 2006

Report Book 2006/16

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Government of South Australia
Primary Industries and Resources SA

Cooper Basin Seismic Risk Study on www.iea-gia.org

Methodology of seismic risk analysis

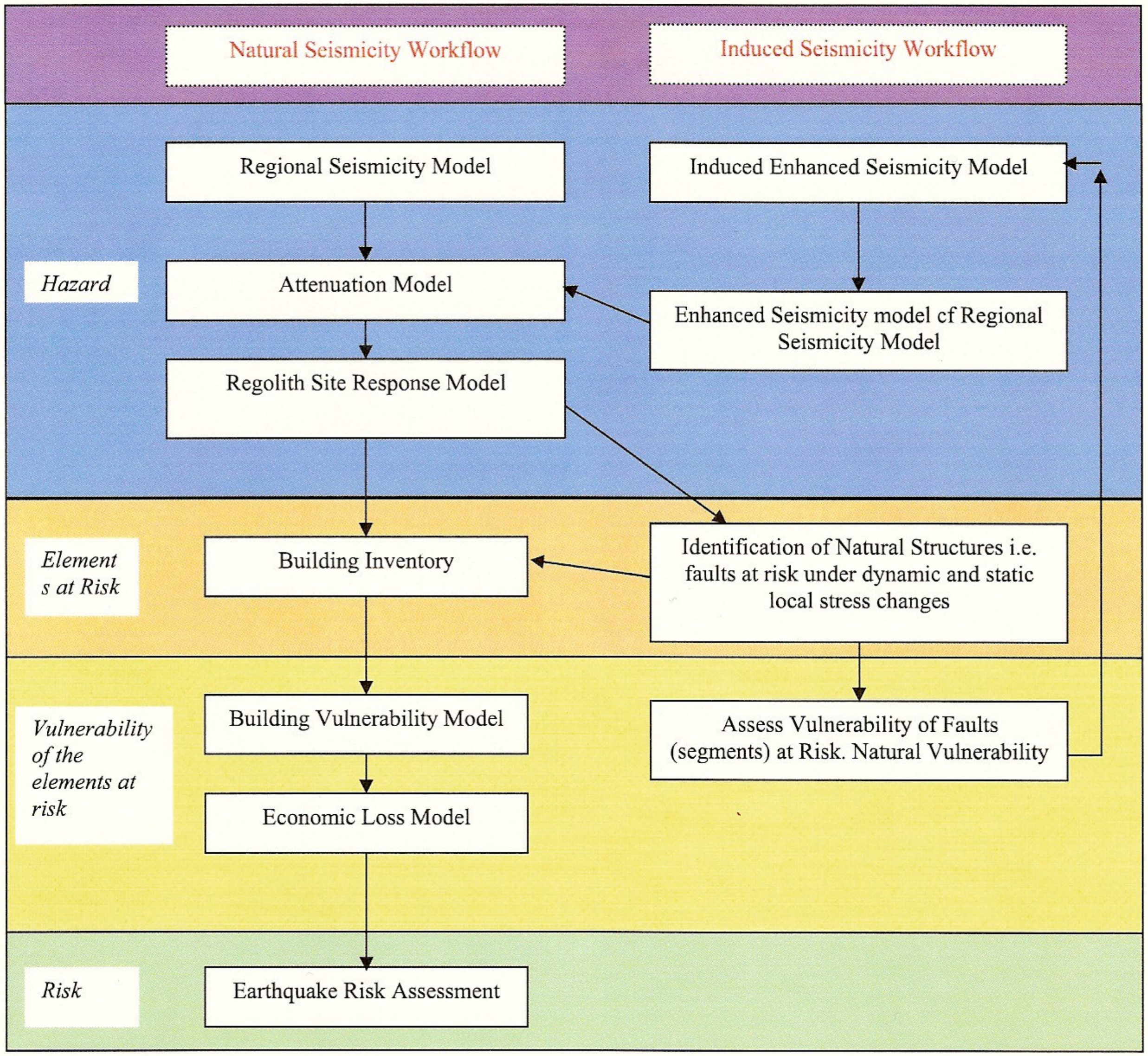

Figure 1: Flowchart describing earthquake risk assessment process usual for natural seismicity and that proposed for induced seismicity (after Sinadinovski et al., 2000).

Table of EGS-related events

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DATE	TIME (UTC)	LAT	LON	DEPTH	MAG	COMMENTS
19611228	73435.6	-28.12	141.57	10	4.7	SW Queensland
19630330	124027	-27.2	140.9	10	3.8	No comments for this record
19630331	2545	-27.2	140.9	10	4	No comments for this record
19790610	3323.9	-28.027	140.336	15	2.9	No comments for this record
19850130	204129.6	-26.58	140.94	0	3.1	No comments for this record
19880622	63133	-26.706	140.28	7	3.5	BIRDSVILLE
19890808	65423.4	-27.63	141.52	10	3.3	No comments for this record
19970205	1514.6	-28.803	139.117	0	4.3	Mid North SA
19990306	235440.9	-28.506	139.072	5	4.1	Near Mungeranie SA Homestead
19990603	155343	-27.128	140.8	0	2.6	Near Haddon Corner SA
20010227	10206.4	-28.67	142.082	0	3.3	Grey Mare Range near Cameron Corner, QLD
20010309	161001.7	-28.604	141.995	8	3.2	Cameron Corner Qld area
20011212	4325.97	-28.63	139.121	10	3.1	Etadunna Area SA
20021011	70933.13	-28.007	140.698	9.9	2.8	Innamincka SA.
20031113	140327.7	-27.884	140.744	0	3	Innamincka SA.
20031202	140024.2	-27.846	140.711	1	3.3	Innamincka SA. Felt.
20031204	15545.32	-27.858	140.65	0	3.6	Innamincka SA.
20031205	174538	-27.776	140.632	6.7	3.7	Innamincka SA. Felt.
20031207	12142.14	-27.73	140.523	5	3.3	Innamincka SA.
20031207	80303.06	-27.741	140.548	10	2.7	Innamincka SA.

Identified fault segments, ready to shear

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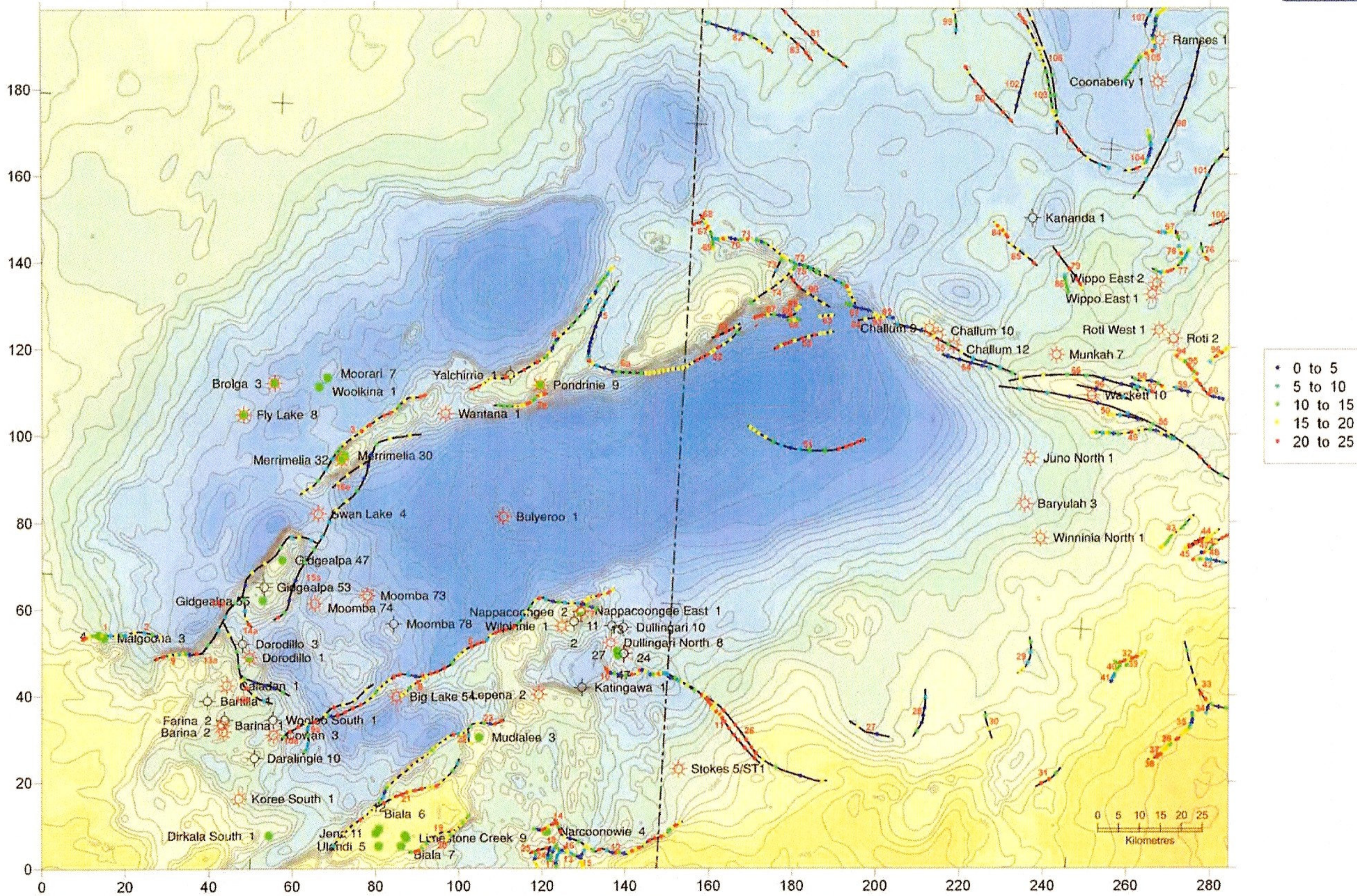

Figure 13 Slip tendency values for faults in the Cooper–Eromanga Basin basement faults. Stress regime expected strike-slip; Case 1.

Seismic risk distribution around well Habanero-1

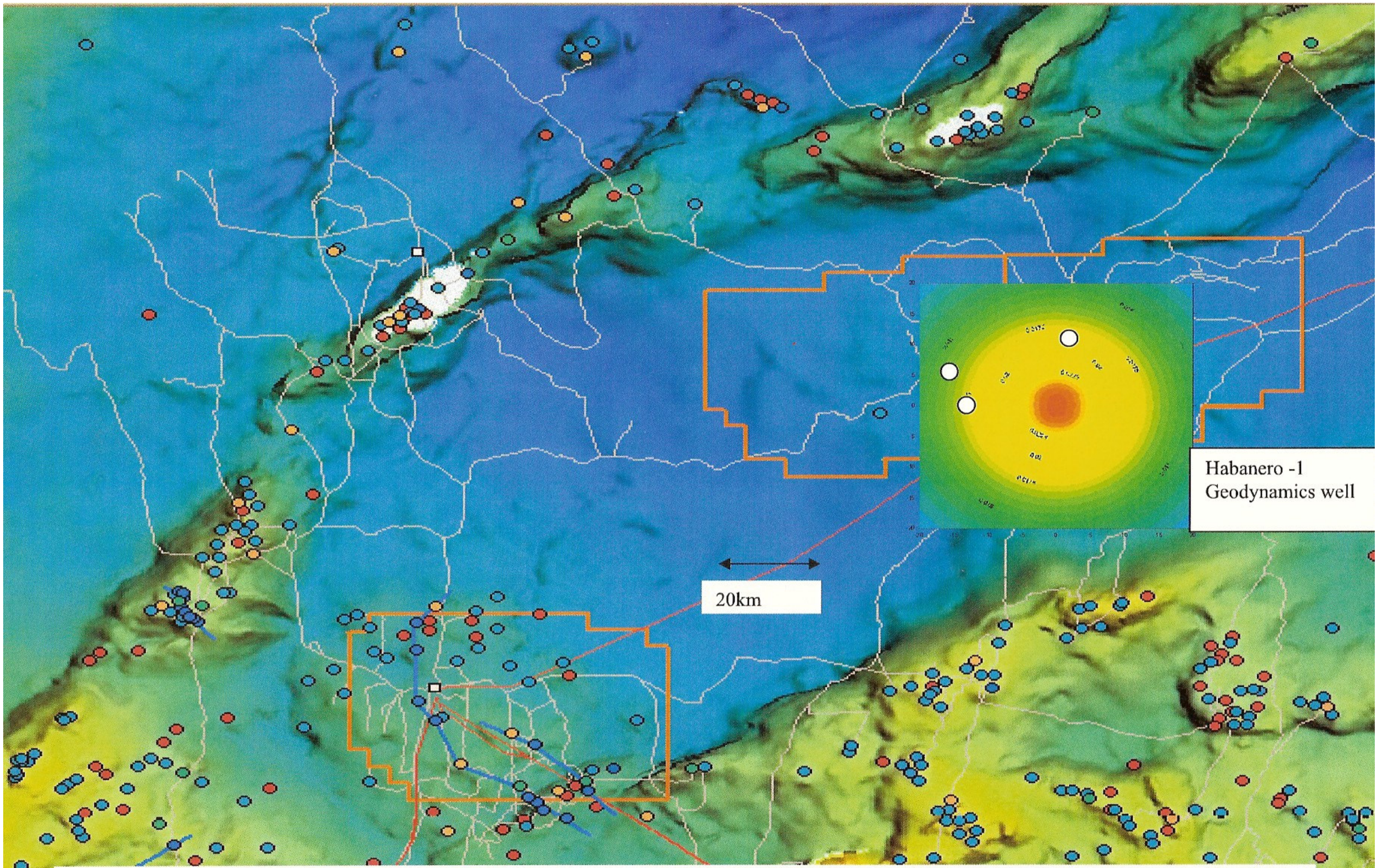

Figure 9 Map of basement in the Cooper Eromanga basin showing well locations. The inset bullet figure shows the attenuation radiation distance from Habanero 1 at the centre of the Geodynamics site.

The EGS P M D A - a Geowatt AG product

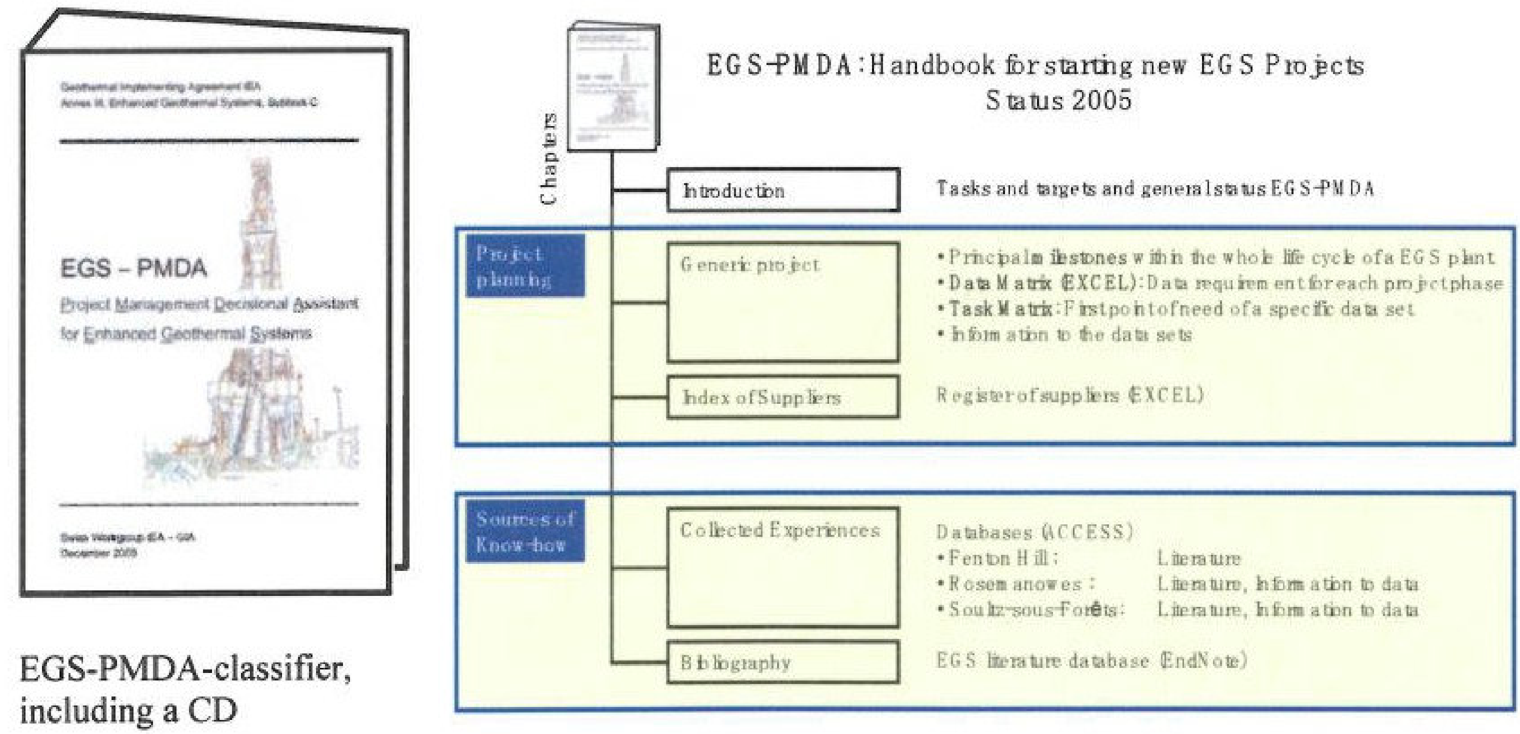

Figure 3.5. The EGS Project Management Decision Assistant (PMDA) handbook.

OUTLOOK

EGS R & D work will continue in the various Annexes and Tasks of IEA GIA;

Hopefully the impressive EGS activities in Australia will trigger similar activities elsewhere;

International cooperation in EGS is already significant and should be even more intensified.

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