The 7-day training course in seismology and tsunami warnings was held in the Department of Mineral Resources, Bangkok from the 15th-22nd May 2006. The course was designed to improve the understanding of the science of earthquake seismology and tsunami warning system operations to National Disaster Warning Center (NDWC) and Meteorological Department staff employed in the day-to-day running of the Thai tsunami warning system and earthquake data processing. The course was also attended by a number of geologists from the Department of Mineral Resources, engineers from the Generating Authority of Thailand and academic Earth Scientists from the local universities. A list of participants is provided in Appendix 1. The training course was sponsored by US Agency for International Development, the NDWC, the UNESCO Intergovernmental Oceanographic Commission, and the US Geological Survey.

The training was directly relevant to the daily duties for the majority of the participants. The level of previous knowledge of earthquake seismology and tsunami warning was very varied, with experience ranging from less than one year employment at the NDWC following a degree not in Earth Science, to an Assistant Professor of Geophysics. The range in experience among the participants, combined with a variation in English language skills, presented a considerable challenge to presenting the course at an appropriate level. However, a balance was largely achieved as indicated by the participants who provided feedback at the end of the course (16 responses), all except one said they gained knowledge on the course, 80% said the course fulfilled their expectations and 73% said that the starting level of the lectures was appropriate. The expertise present in the audience was also used to augment the training course, with several of the academics asked to give short presentations on their areas of research. Although these presentations did not constitute a formal part of the training course, they were popular with the other
participants as they were given in Thai, provided a break from the structured lecture course, and introduced some of the research being conducted in Thailand.

The course was designed to cover theoretical seismology and the interpretation of seismic data relevant to tsunami warning systems in the first two days. On the morning of the third day the students participated in the Pacific-wide tsunami exercise. The afternoon and all of the fourth day covered more general earthquake seismology, such as forecasting, instrumentation and arrays. Learning was directed through lectures complemented with nearly 4 hours of computer-based practical sessions.

The seismology training was followed by two days of training in tsunami warnings and warning center operations. Learning was directed entirely through lectures given by experts with considerable experience in operations at the Japan Meteorological Agency and the Pacific Tsunami Warning Center. The topics included: tsunami science; tsunami warning systems (history and organizational structure); data processing, warning dissemination and emergency response following a warning; warning center staffing and training; the TsunamiTeacher resource; and tsunami hazard mitigation. This completed the formal training portion of the course. On day seven a roundtable meeting was held which discussed the current warning system in Thailand and formulated a plan for development of the system.

The training course agenda is given in Appendix 2. The lecture and practical material was supported by a course handout which contained information on the training course (such as sponsoring organizations and timetabling) and additional information on the topics covered in the training course. In addition, at the end of the course the participants were all provided with a copy of the lecture PowerPoint slides and the computer codes used in the practical sessions.

Photos: a) Dr Kelly helping participants with a practical; b) Dr Mereu showing information on a seismogram; c) Some of the participants from the NDWC; d) Dr Yamamoto lecturing on tsunami warning systems; e) Participants analyzing seismic data during a practical session; f) Burin Wechbunthung lecturing on the seismicity and earthquake location procedures in Thailand.
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<tr>
<th>(No.)</th>
<th>(Agency)</th>
<th>(Name)</th>
<th>(Position)</th>
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<tbody>
<tr>
<td>1</td>
<td>Meteorological Department Of Thailand</td>
<td>Mr. Puwiang Prachammin</td>
<td>Senior Meteorologist</td>
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<td></td>
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<td>Mr. Burin Wechungthung</td>
<td>Senior Meteorologist</td>
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<td>Mr. Aothai Panya</td>
<td>Meteorologist</td>
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<td>Mrs. Kamonrat Saringkanpasit</td>
<td>Meteorologist</td>
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<td>Mr. Adisorn Fungkajorn</td>
<td>Meteorologist</td>
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<td>2</td>
<td>Department of Mineral Resources</td>
<td>Mr. Wisut Chotikasathien</td>
<td>Geologist</td>
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<td>Mr. Weerachat Wiwegwin</td>
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<td>Mr. Sakda Thammavitwas</td>
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<td>Mr. Wallop Wisedsind</td>
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<td>Mr. Wachirachai Sakapa</td>
<td>Geologist</td>
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<td>3</td>
<td>Prince of Songkla University</td>
<td>Dr. Tripob Bhongsuwan</td>
<td>Assistant Professor of Geophysics</td>
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<td>4</td>
<td>Chulalongkorn University</td>
<td>Dr. Anat Ruanggrassamee</td>
<td>Lecturer</td>
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<td>6</td>
<td>Mahidol University</td>
<td>Dr. Prinya Putthapiba</td>
<td>Instructor</td>
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<td>7</td>
<td>Electricity Generating Authority of Thailand</td>
<td>Mr. Somboon Gesrarut</td>
<td>Engineer 8</td>
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<td>Mr. Anucha Intawichan</td>
<td>Engineer 7</td>
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<td>8</td>
<td>National Disaster Warning Center (NDWC)</td>
<td>Mr. Sanchai Sujaritwongsan</td>
<td>Expert in GIS</td>
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<td>Mr. Tawan Sukkho</td>
<td>Senior Geologist</td>
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<td>Mr. Suwit Khosuwan</td>
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<td>Mr. Passkorn Kanthasap</td>
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<td>Ms. Tamonwun Wunpun</td>
<td>Scientist</td>
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<td>Mr. Pisnupong Anuratpanich</td>
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<td>Mr. Tinnakorn Tatong</td>
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<td>Mr. Supamit Jantakham</td>
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<td>Ms. Tipsakorn Aiadmusk</td>
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<td>Ms. Jumleang Chutab</td>
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<td>Ms. Apinya Chaila</td>
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<td>Ms. Chantana Da-te</td>
<td>Geologist</td>
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**Lecturers**

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<tr>
<th>Name</th>
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<tr>
<td>Dr. George Choy</td>
<td>US Geological Survey</td>
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<td>Dr. Annabel Kelly</td>
<td>US Geological Survey</td>
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<tr>
<td>Dr. Laura Kong</td>
<td>International Tsunami Information Center</td>
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<tr>
<td>Dr. Charles McCreery</td>
<td>Pacific Tsunami Warning Center, Hawaii</td>
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<tr>
<td>Dr. Robert Mereu</td>
<td>University of Western Ontario, Canada</td>
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<td>Dr. Walter Mooney</td>
<td>US Geological Survey</td>
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<td>Dr. Koichiro Nagasaka</td>
<td>Japan Meteorological Agency</td>
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<tr>
<td>Yuji Nishimae</td>
<td>Japan Meteorological Agency</td>
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<tr>
<td>Dr. Masahiro Yamamoto</td>
<td>UNESCO IOC</td>
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Appendix 2 – Agenda

Day 1 – SEISMOLOGY: Introduction and the Tectonic Situation of Thailand, Introduction to Earthquakes

9am- Session I.1: Introductions
  Welcome by Thailand
  Welcome by IOC and USGS: Walter Mooney (also on behalf of IOC)
  Welcome by US Embassy and USAID: Timothy Beans, Mission Director, USAID
  Regional Development Mission for Asia
  Welcome on behalf of US IOTWS Program: Orestes Anastasia, USAID
  Outline of Training Course: Annabel Kelly
  Logistical Information (maps, rooms, meals, etc): Cherdsak Virapat

10:15am- Session I.2
  Topic: Introduction to Earthquake Science: A Historical Perspective
  Lecturer: Bob Mereu

11:15am- Coffee Break

11:30am- Session I.3
  Topic: The Earth’s Structure and Seismicity
  Lecturer: Walter Mooney

12:30pm- Lunch Break

1:45pm- Session I.4
  Topic: Practical Session
  Lecturer: Bob Mereu

2:45pm- Coffee Break

3pm- Session I.5
  Topic: Theoretical Seismology 1: Sources
  Lecturer: George Choy

4:15pm- Discussions

5pm- TV Documentary: Nature Tech Earthquakes

Day 2 – SEISMOLOGY: Seismic Theory & Applications

9am- Session II.1
  Topic: Theoretical Seismology 2: Wave Propagation
  Lecturer: George Choy

10am- Session II.2
  Topic: Structure & Interpretation of Seismograms 1: Waveforms and Hypocentral Locations
  Lecturer: Walter Mooney

11:00am- Coffee Break

11:15am- Session II.3
  Topic: Structure & Interpretation of Seismograms 2: Magnitude and Source Mechanisms
  Lecturer: Walter Mooney

12:15pm- Lunch Break

1:30pm- Session II.4
  Topic: Practical Session
  Lecturer: Bob Mereu

4pm- Coffee Break

4:15pm- Session II.5
  Topic: Damaging Effects of Earthquakes
Lecturer: Annabel Kelly

5pm- TV Documentary: Nature Tech Tsunamis

**Day 3 – SEISMOLOGY: Pacific Tsunami Early Warning Center Exercise, Global and Local Seismic Networks, Instrumentation & Seismic Data Analysis**

8am- *Special Session: Exercise Pacific Wave 06*  
_Location: National Disaster Warning Center*

12:30pm- Lunch Break  
*Training resumes at Department of Mineral Resources at 3 pm*

3pm - Session III.1  
*Topic: Global & Local Arrays*  
*Lecturer: Bob Mereu*

4pm – Session III.2  
*Topic: Instrumentation, Recording systems, Data Transmission & Archiving*  
*Lecturer: Bob Mereu*

5pm- Discussions

6pm- Dinner

**Day 4 - Earthquake Hazard Assessment & Tsunami Science**

9am- Session IV.1  
*Topic: Earthquake Forecasting*  
*Lecturer: George Choy*

10am- Session IV.2  
*Topic: Challenges in Observational Seismology in the Indian Ocean with special reference to the 2004 Sumatra-Andaman earthquake*  
*Lecturer: Annabel Kelly*

11am- Coffee Break  

11:15am- Session IV.3  
*Topic: Web Resources for Earthquake Information (Hands-On Computer Lab Exercise)*  
*Lecturer: Annabel Kelly*

12:15pm- Lunch Break

1:45pm- Session IV.4  
*Topic: Practical Session*  
*Lecturer: Bob Mereu*

3:15pm- Coffee Break

3:30pm- Session IV.4  
*Topic: Practical Session*  
*Lecturer: Bob Mereu*

4:30pm- Session IV.5  
*Topic: Summary of seismology component of training course*  
*Lecturer: Annabel Kelly*

5pm- Discussions

6pm- Dinner

**Day 5 - Tsunami Warnings and Tsunami Warning Center Operations**

9am- Session V.1
**Day 6 - Tsunami Warnings and Tsunami Warning Center Operations**
9:00am - Session VI.1
Topic: Tsunami Warning Center Data Processing (national / local systems) - JMA
Seismic Analysis
a. TWC data processing history & background
b. Signal acquisition and transmission format
c. Disk writing format
d. Earthquake locations and associations
e. Magnitudes and mechanisms
f. Alarm types and notifications

Tsunami / Sea Level Analysis
a. Geographical Information system
b. Tsunami travel-times
c. Tsunami modeling and wave forecasting

Lecturer: JMA

10:45am - Coffee Break

11am - Session VI.2
Topic: Component: Warning Guidance - Tsunami Emergency Response after
Tsunami Warnings Issued (included: hazards, shelters, etc)

a. Objectives and Activities involved in Emergency Response - IOC
b. Guidance on developing tsunami response - IOC
c. Thailand Tsunami Emergency Response – Present and Future - NDWC

Lecturer: L. Kong, Thailand NDWC

12pm - Lunch Break

1:30pm - Session VI.3
Topic: Component: Tsunami Hazard Risk Assessment and Preparedness
a. Hazard and Risk Identification of Vulnerable Communities
b. Tsunami numerical modeling
c. Inundation and Evacuation Maps

Lecturer: IOC or PTWC

2:30pm - Coffee Break

2:45pm - Session VI.4
Topic: Component: Tsunami Hazard Mitigation - Preparedness, Education, and Outreach
(Earthquake Hazard Mitigation building codes and design guidance here)

a. Preparedness - risk assessment, exercises and drills, structural mitigation
b. Education and Outreach - reasons for, examples, and how carried out
c. IOC TsunamiTeacher Resource Toolkit
d. Thailand Preparedness Program and other initiatives – NDWC or other Agency

Lecturer: L. Kong, Thailand NDWC or appropriate Agency

4:15pm - Session VI.5
Topic: Discussion, Conclusions, and Recommendations
Lecturer: IOC (Kong, Yamamoto), PTWC, JMA

5:15pm - Closing

Day 7 - Roundtable Discussion – Tsunami Warnings for Thailand

Participants:
Thailand Government Representatives and other invited responsible organizations
Pacific Tsunami Warning Center (Dr. Charles McCreery, Director)
Japan Meteorological Agency (Koichi Nagasaka, Former Director-General; Yuji Nishimae, Senior Scientific Officer)
IOC (International Tsunami Information Centre, Dr. Laura Kong, Director)
Training Participants

9am
Opening
Welcome by Thailand
Welcome by IOC

9:15am
JMA’s Tsunami Warning and Earthquake Information Service
Koichi Nagasaka, Former Director-General, JMA

10:15am
Coffee Break
The Morning Session will cover how the PTWC and JMA respond to earthquake and tsunami alarms, and include timelines for alarms, data receipt and evaluation, decision making for determining message content, and alert dissemination. Each Presentation is followed by 10-min Question-and-Answer and Discussion.

10:30am
Tsunami Warning Center Operations - Scenarios
Procedures of the Northwest Pacific Tsunami Advisory Center for the South China Sea Region – JMA
Case Study: Exercise Pacific Wave 06 source – JMA
Case Study: Other sources of concern – PTWC

11:45am
Tsunami Warning Center Operations - Scenarios
Procedures of the IOTWS Interim System – PTWC
Case Study: Northern and Southern Sumatra source – PTWC
Case Study: Andaman-Nicobar Islands sources - JMA

12:30pm
Lunch Break

2pm
Recent developments and future plans of Thailand organizations – Thailand Agencies

3pm
Coffee Break

3:15pm
Panel Discussion – Opportunities and Challenges for Thailand
IOC (L. Kong), PTWC (C. McCreery), JMA (K. Nagasaka, Y. Nishimae)
PDC (S. Goosby), Thailand (NDWC, TMD, others)
5 min statements, followed by moderated discussion

4:45pm
Recommendations and Conclusions

5pm
Closing

5:30 – 8 pm
Farewell Dinner