NORSAR

Årsmelding
Annual Report
2006

THE NORSAR FOUNDATION

NORSAR is an independent foundation established with the following objectives:

- To conduct research and development in the areas of geophysics and geophysical software.
- To promote the application of research results for the benefit of the Norwegian society and Norwegian industry.
- To establish and further develop the professional competence of its staff within its areas of activity,
- To act as a Norwegian national resource center for verifying compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

NORSAR's research activities are focused on three main areas:

1. Development of methods and processing systems for seismic monitoring and verification of compliance with the Comprehensive Nuclear-Test-Ban Treaty.
2. Basic seismological research associated with the recording of small and large earthquakes as well as assessing earthquake hazard.
3. Developing methods and software for seismic modelling of geological structures.

■ NORSAR is an internationally recognized research institution in seismology, and provides advanced, innovative products and services to its customers both in the public and private sectors.

■ Seismic modelling methods developed by NORSAR provide value-added services to oil companies, seismic contractors and consultant companies.

■ "Seismology for society" is an appropriate designation of NORSAR's activities in seismological R&D, which are supported through national as well as international organizations, and which focus on global, regional and local safety and security issues.

■ The Annual Report of the NORSAR Foundation gives an overview of activities that have generated interest among our customers, cooperative partners and governmental agencies. Besides containing basic information about NORSAR, it also highlights some selected research activities in 2006. The Annual Report describes the organization of NORSAR, presents the report from the Board of Directors for 2006 and also includes a report on the financial status of the foundation. Furthermore, a list is provided of scientific publications as well as professional presentations in 2006 by the NORSAR staff.

STIFTELSEN NORSAR

Stiftelsen NORSAR har som formål, på idéelt og samfunnsnyttig grunnlag å:

- Utføre forskning og utvikling innen geofysiske og datatekniske fagområder.
- Arbeide for anvendelse av denne forskningens resultater i praksis til fremme av norsk nærings- og samfunnsliv.
- Bidra til opparbeidelse og utvikling av kompetanse og utdanning av fagpersonell innen stiftelsens fagområder.
- Fungere som nasjonalt kompetanse- og driftssenter knyttet til avtalen om forbud mot kjernefysiske prøvesprengninger.

Forskningen ved NORSAR konsentreres i tre hovedområder:

1. Utvikling av metoder og systemer for seismisk overvåkning og verifikasjon av etterlevelse av prøvestansavtalen, Comprehensive Nuclear-Test- Ban Treaty (CTBT).
2. Grunnleggende seismologisk forskning knyttet til registrering av små og store jordskjelv og risiko ved jordskjelv.
3. Utvikling av metoder og software for seismisk modellering av geologiske strukturer.

■ NORSAR er en internasjonalt ledende aktør innen forskning og utvikling av innovative, seismiske løsninger for kunder både i offentlig og privat sektor.
■ NORSARs metoder for seismisk modellering bidrar i verdiskapningen hos oljeselskap, seismiske kontraktører og konsulentselskap.
■ "Seismologi for samfunnet" er betegnende for virksomheten i NORSARs seismologiske FoU, som støttes av både nasjonale og internasjonale offentlige organer med fokus på global, regional og lokal samfunnssikkerhet.
■ Årsmeldingen for Stiftelsen NORSAR gir en oversikt over forhold som ofte blir etterspurt av oppdragsgivere, samarbeidspartnere og offentlige institusjoner. Den inneholder en del sentrale opplysninger fra virksomheten samt noen utvalgte eksempler fra NORSARs forskning og faglige aktiviteter i 2006. Årsmeldingen beskriver også organiseringen, den viser årsberetningen og det økonomiske resultatet for 2006, og den lister opp årets publikasjoner, foredrag og posters der forskere fra NORSAR har gitt sine bidrag.

Activities in 2006

An important event in 2006 was the underground nuclear explosion conducted by North Korea on 9 October. With this explosion, an additional country demonstrated a nuclear weapons capability, at a time when the international community is carrying out extensive technical work towards establishing a verification system for the CTBT. NORSAR is contributing to this technical work, which is progressing well even though entry into force of the treaty is being delayed by political factors. NORSAR's primary seismic stations showed excellent recordings of the North Korean explosion, thereby demonstrating their high capabilities for detecting explosions in Eurasia, even at large distances (in this case more than 6000 km).

The catastrophic Sumatra earthquake and the resulting tsunami on 26 December 2004, together with the large earthquake in Pakistan in the fall of 2005 led to increased international interest in the seismological expertise at NORSAR. During 2006, NORSAR expended considerable effort in establishing cooperative projects related to seismic hazard in India, Pakistan and Central America.

The number of users and areas of application of NORSAR's seismic modelling software for the petroleum industry is increasing. In recent years, NORSAR has increasingly focused on developing new methods and software for seismic reservoir modelling, and we believe that this will lead to an even broader application of our software products.

NORSAR Innovation AS, a fully owned, commercial subsidiary of the NORSAR Foundation, had its first full year of operation in 2006. The subsidiary has two full time employees, and had a total turnover of about 13 million NOK in 2006. A large part of this amount is directed towards buying research and development efforts from its parent company.

Virksomhet i 2006

■ Den nord-koreanske, underjordiske, kjernefysiske prøvesprengningen 9. oktober 2006 var en viktig hendelse. Med denne sprengningen ble nok en atommakt realisert i en tid hvor det arbeides konstruktivt på teknisk side, også ved NORSAR, med å forberede iverksettelse av prøvestansavtalen, men hvor den internasjonale politiske situasjonen hindrer utviklingen fram mot en slik viktig milepæl. Alle NORSARs feltanlegg registrerte hendelsen og demonstrerte sin spesielle evne til å registrere underjordiske kjernefysiske sprengninger på det Eurasiske kontinentet selv på store avstander (mer en 6000 km).

■ Sumatrajordskjelvet og tsunamien som ble generert av dette jordskjelvet 2. juledag 2004, samt det store jordskjelvet i Pakistan høsten 2005, medførte en økende interesse for NORSARs kompetanse. I løpet av 2006 ble det lagt ned et stort arbeid i etablering av nye samarbeidsprosjekter knyttet til jordskjelvrisiko i India, Sentral-Amerika og Pakistan.

■ NORSAR Seismisk Modellering får stadig flere brukere og anvendelsesområder i petroleumsindustrien. I de senere år har det vært satset mye på utvikling av nye metoder og software for seismisk reservoarmodellering, og NORSAR tror dette vil lede til en enda bredere anvendelse av seismisk modellering i den seismiske verdikjeden.

■ NORSAR Innovation AS, det heleide, kommersielle datterselskapet av Stiftelsen NORSAR, hadde sitt første hele driftsår i 2006. Selskapet har to heltidsansatte og omsatte for ca 13 mill kroner. En betydelig del av selskapets omsetning rettes inn mot kjøp av forskningsoppdrag i morselskapet.

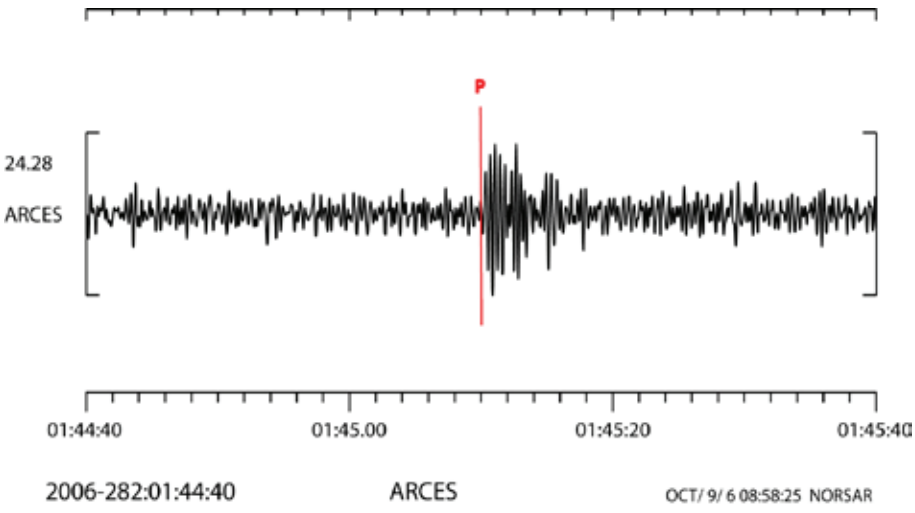
North Korea's nuclear explosion on 9 October 2006

■ The Comprehensive Nuclear-Test-Ban Treaty (CTBT) bans all nuclear explosions, whether made for military or civilian purposes. It was opened for signature in 1996, but has yet to enter into force as it has not been ratified by a sufficient number of key countries. Among the non-signatories are India, Pakistan and North Korea, all of which have later conducted nuclear tests - India and Pakistan in May 1998, and, most recently, North Korea on 9 October 2006.

■ The North Korean nuclear test was the first (and until now the only) nuclear explosion that has taken place after the CTBT organization in Vienna, Austria began (in February 2000), regular processing of signals from a global monitoring network. This network, which is now nearing completion, uses seismic, radionuclide, infrasound and hydroacoustic technologies, and will, when completed, comprise more than 300 monitoring stations. Six of these stations, among them some of the largest and most advance ones, are situated on Norwegian territory.

■ The North Korean nuclear explosion was detected and located immediately after it took place, and the monitoring system thus passed this unforeseen test. From radionuclide measurements, it became clear that the explosion was nuclear (and not chemical). The size of the explosion was relatively moderate, with a Richter magnitude of 4.2. This corresponds to approximately one kiloton of TNT if the explosion is fully coupled and carried out in hard rock.

■ The pictures below show the location of the explosion together with recordings from one of NORSAR's seismic monitoring stations (the ARCES array). ARCES is located at a distance of 6260 km from the explosion site, and the seismic pressure waves were recorded at this station 9 minutes and 43 seconds after the explosion took place.



Figuren viser registrering av eksplosjonen ved NORSARs seismiske målestasjon ARCES i Karasjok. Førsteankomst av den seismiske trykk-bølgen er markert som P (rødt). Tiden er angitt i Greenwich Mean Time (GMT).

The figure shows the recording of the explosion by the ARCES seismic array in Karasjok, northern Norway. The onset of the seismic pressure wave is marked in red. The time corresponds to Greenwich Mean Time (GMT).

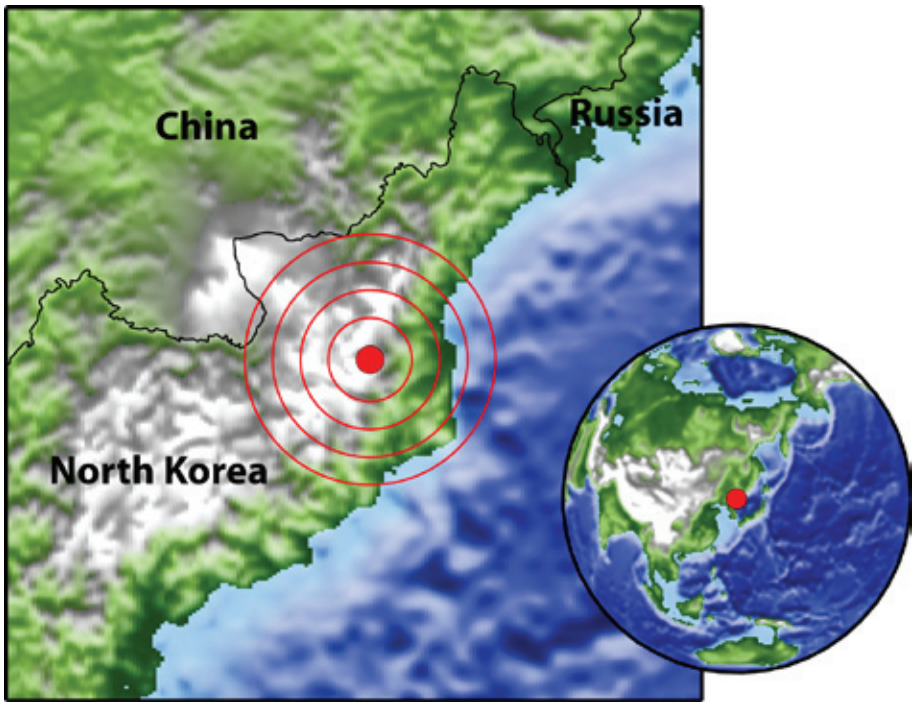
Nord-Koreas atomprøve den 9. oktober 2006

■ Den kjernefysiske prøvestansavtalen, som forbyr alle atomsprengninger, enten de er for militære eller sivile formål, ble vedtatt av FN i september 1996. Avtalen er imidlertid ennå ikke trådt i kraft ettersom den ikke er ratifisert av et tilstrekkelig antall nøkkelstater. Blant annet har India, Pakistan og Nord-Korea ikke undertegnet avtalen, og alle disse har siden gjennomført kjernefysiske prøver - India og Pakistan i mai 1998 og senest Nord-Korea den 9. oktober 2006.

■ Nord-Koreas atomprøve var den første (og hittil eneste) som har funnet sted etter at prøvestansorganisasjonen i Wien i februar 2000 begynte regulær prosessering av data fra et verdensomspennende overvåkingssystem, som nå nærmer seg fullførelse. Dette overvåkingssystemet vil bestå av mer enn 300 målestasjoner, innenfor seismologi, infralyd, hydroakustikk og radioaktivitetsmålinger. Norge har 6 av disse målestasjonene, deriblant noen av de største og mest avanserte.

■ Den nordkoreanske atomeksplosjonen ble detektert og lokalisert umiddelbart etter at den fant sted, og overvåkingssystemet besto dermed denne uforutsette prøven. Ved bruk av radioaktivitetsmålinger ble det videre klart at det dreide seg om en kjernefysisk (og ikke kjemisk) eksplosjon. Styrken var relativt lav, med et Richter-tall på 4.2, noe som svarer til omtrent 1 kilotonn TNT dersom eksplosjonen settes av i fast fjell.

■ Bildene nedenfor viser lokasjonen av eksplosjonen, samt registreringene foretatt av en av NORSARs seismiske målestasjoner (ARCES-stasjonen ved Karasjok). Stasjonen ligger 6260 km fra eksplosjonsstedet, og de seismiske trykkbølgene ble registrert ved denne målestasjonen 9 minutter og 43 sekunder etter at eksplosjonen fant sted.



Lokasjon av Nord-Koreas kjernefysiske eksplosjon den 9. oktober 2006

Location of the North Korean nuclear explosion on 9 October 2006

Increased international engagement in earthquake hazard studies

■ Over the past 35 years, NORSAR has systematically developed the organization's competence within seismic hazard studies. Initially, this was done through work related to nuclear power plants and offshore oil and gas installations on the Norwegian continental shelf, and later through projects for hydroelectric power plants in regions with significant earthquake activity. During the past 10-15 years, we have also been contributing to competence building in countries with high earthquake risk. As part of these activities, the NORSAR staff have visited some of the most significant deformation zones on the Earth, such as the Himalayas, Kashmir, the Indonesian subduction zone which was the source area for the earthquake generating the great tsunami in 2004, as well as Central America where the cities are extremely vulnerable to earthquakes.

■ The competence built and applied at NORSAR will be extended in the near future through cooperation with institutions in Central America (especially Guatemala, Nicaragua and El Salvador) as well as research institutions and universities in Pakistan and India.

■ An important factor in this development is NORSAR's partnership in the International Centre for Geohazards (ICG). Through this partnership and in cooperation with other partners, NORSAR has developed the SELENA software package, which can be used for analyzing disaster scenarios, including estimating the financial costs that earthquakes can cause for a city or a region. This software has been made freely available on the Internet through http://www.norsar.no/seismology/selena.html.

■ The cooperative projects in Central America and India established in 2006 are expected to contribute further to building competence and developing software for the purpose of mitigating the damage from future large earthquakes. In addition, NORSAR now employs a scientist specializing in evaluating the ability of buildings to withstand shaking from earthquakes. This will enable us to better meet the challenges in earthquake risk mitigation in the future.

Kashmir-jordskjelvet 8. oktober 2005 førte til at terrenget i bakgrunnen på bildet løftet seg 4 meter.

The Kashmir earthquake on 8 October 2005 caused the terrain in the background of the picture to be elevated by 4 meters.

Økende internasjonal virksomhet innen jordskjelvrisiko

■ NORSAR har over de siste 35 år systematisk bygget opp en kompetanse innen jordskjelvrisiko. Først gjennom arbeid rettet mot kjernekraft og oljeinstallasjoner på norsk sokkel og senere gjennom oppdrag for vannkraftindustrien i jordskjelvutsatte områder i verden. I de seneste 15-20 år har virksomheten også omfattet kompetanseoverføring til land med høy jordkjelvrisiko. Dette har bragt våre fagfolk til jordens store deformasjonssoner: Himalaya og Kashmir, Indonesias subduksjons-sone som var kilden til den store tsunamien i 2004, og Mellom-Amerikas vulkanrekke der byene er ekstremt utsatt for jordskjelv.

■ Den kompetanse som NORSAR har bygget opp anvender vil bli utvidet i de nærmeste årene gjennom samarbeid med tilsvarende fagorganisasjoner i Mellom Amerika (spesielt Guatemala, Nicaragua og El Salvador) samt med universiteter og forskningsinstitutter i Pakistan og India.

■ Kompetanseutvidelsen skjer bl. a. ved at NORSAR gjennom partnerskapet i senteret for fremragende forskning ICG (International Centre of Geohazards) har utviklet SELENA-programvaren som kan brukes for katastrofescenarier og analyse av de økonomiske kostnader jordskjelv kan påføre en by eller et område. Denne programvaren er gjort fritt tilgjengelig under http://www.norsar.no/seismology/selena.html.

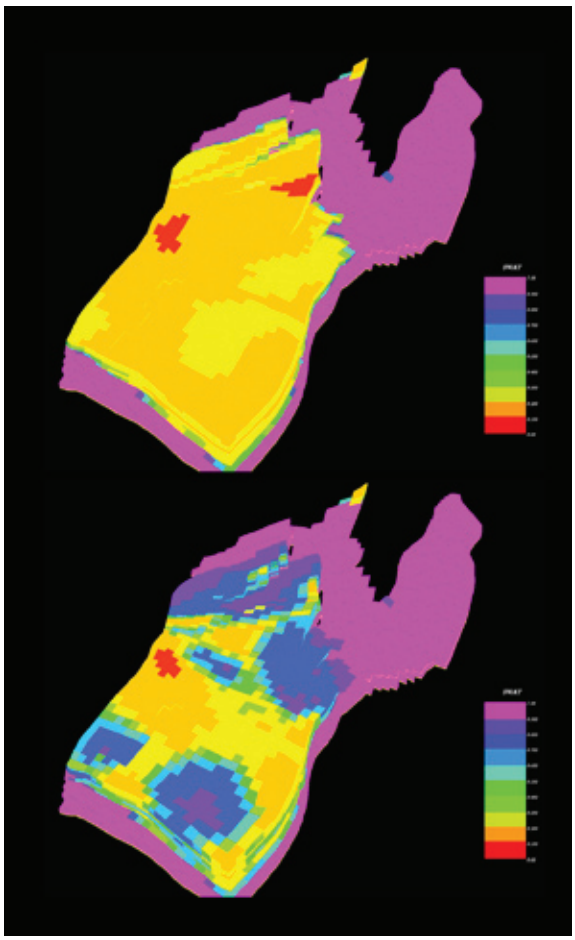
■ Samarbeidsprosjektene i Mellom-Amerika og India, som ble etablert i 2006, ventes å bidra til en videreutvikling av kompetanse og programvare, samtidig som den kan anvendes på en måte som kan redusere skadene fra fremtidige store jordskjelv. I tillegg har NORSAR utvidet sin stab med en forsker med spesialerfaring på evaluering av bygningers evne til å motstå jordskjelvrystelser. Dette gjør oss bedre i stand til å møte nye utfordringer innen reduksjon av jordskjelvrisiko i årene som kommer.

Gruppen som samarbeider i India omfatter institusjonene NORSAR, NGI og Indian Institute of Technology i Roorkee.

The cooperation in India includes the institutions NORSAR, Norwegian Geotechnical Institute (NGI) and the Indian Institute of Technology in Roorkee.

SeisRoX: A new system for quantitative model-assisted seismic interpretation

Today's seismic interpretation and attribute analysis are performed at many levels in the E&P cycle – from structural horizon picking in early exploration, to advanced 4D reservoir studies during petroleum production. In many cases the interpretation process is simply a systematic collection of seismic attributes without any direct relation to a particular *model* behind. In more advanced interpretation, it can be very fruitful to relate the interpretation to a well-defined *geo-model* representation. NORSAR has developed a new software tool called *SeisRoX*, which is based on the idea that such *a geo-model should always exist*. In this context, the geo-model is defined as a spatial representation of geophysical and geological properties in a certain volume of the subsurface, containing sufficient information to allow a *simulation of the seismic response* of that model. In SeisRoX, the seismic response is a simulated *migrated seismic cube ('3D seismic image')*, or seismic attributes deduced from such a cube as this is the usual working domain for most interpreters.

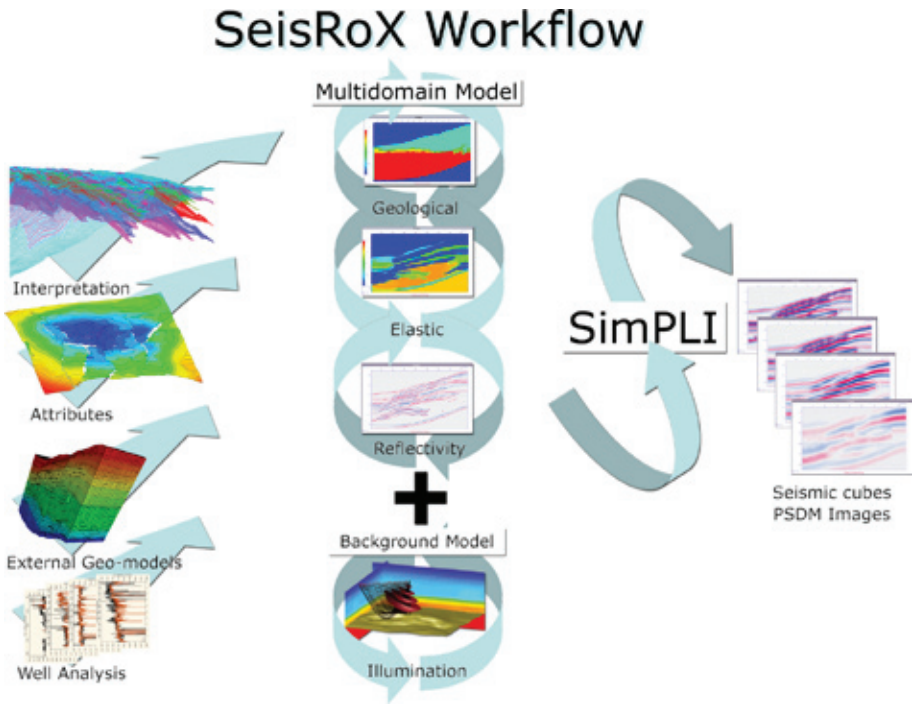


Vannmetning for to tidspunkter plottet på en SeisRoX modell-flate.

The water saturation from two time steps plotted on the SeisRoX model horizons.

SeisRoX: Et nytt system for kvantitativ, modelldrevet seismisk tolkning

Tolkning og analyse av seismiske parametere blir gjort på mange nivåer i lete og utvinningsfasen - fra kartlegging av strukturelle horisonter i den tidlige letefasen til avanserte 4D reservoarstudier under produksjon. Enkel tolkning kan ofte bare dreie seg om systematisk innsamling av seismiske parametere uten noen direkte modellkobling, men i mer avansert tolkning kan det være fruktbart å relatere den til en veldefinert geo-modell. NORSAR har utviklet SeisRoX, en software som forutsetter en slik geo-modell, definert ved en romlig representasjon av geofysiske og geologiske egenskaper i et volum av undergrunnen, og tilstrekkelig beskrevet for simulering av seismisk respons i modellen. SeisRoX beregner denne responsen i form av et tredimensjonalt seismisk bilde eller en tredimensjonal framstilling av seismiske parametere, siden slike romlige framstillinger er arbeidsområdet for de fleste tolkere.

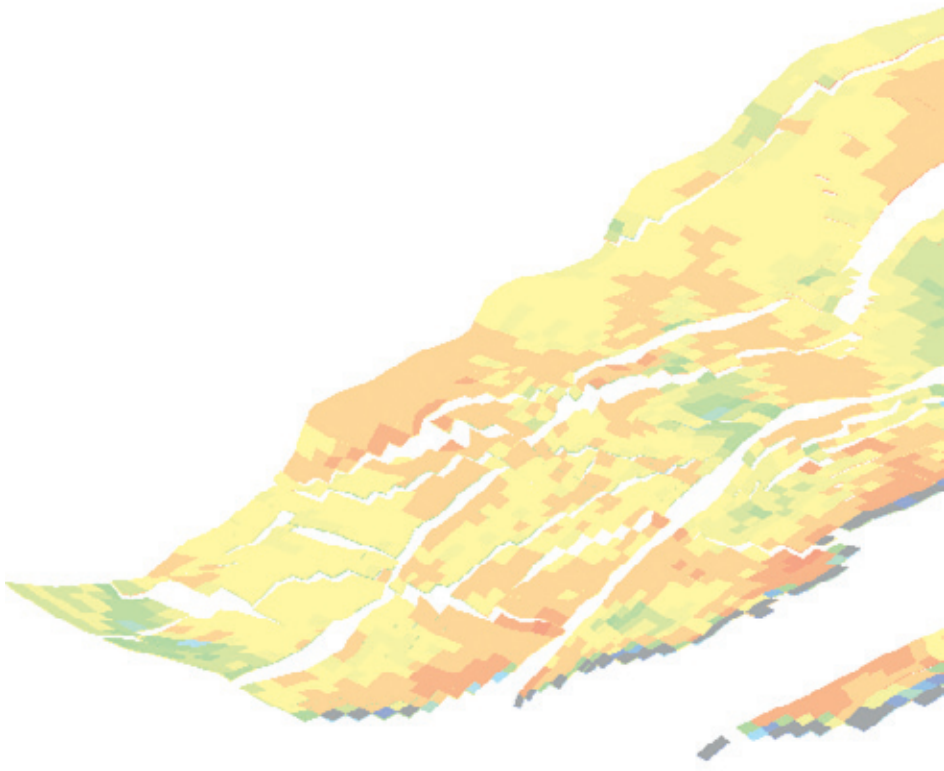


Arbeidsflyten i SeisRoX. Kjernen er multi-domene modellen, som omfatter geologiske-, elasiske (seismiske)- og reflektivitets-domener. Bakgrunnsmodell og survey-geomtri bestemmer belys-ningen av den geologiske strukturen. SimPLI kombinerer belysningen og reflektivitetsmodellen til et seismisk bilde. Muligheten til å variere multi-domene modellene på mange nivåer i arbeidsflyten gjør SeisRoX til et høyst anvendelig redskap.

The SeisRoX workflow. The core is the SeisRoX multi-domain model, including the geological domain, the elastic domain and the reflectivity domain. The background model and survey geometry determine the illumination of the geological structure. SimPLI combines the illumination and the reflectivity into a seismic image. Input from numerous sources into any stage of the workflow results in a highly versatile tool.

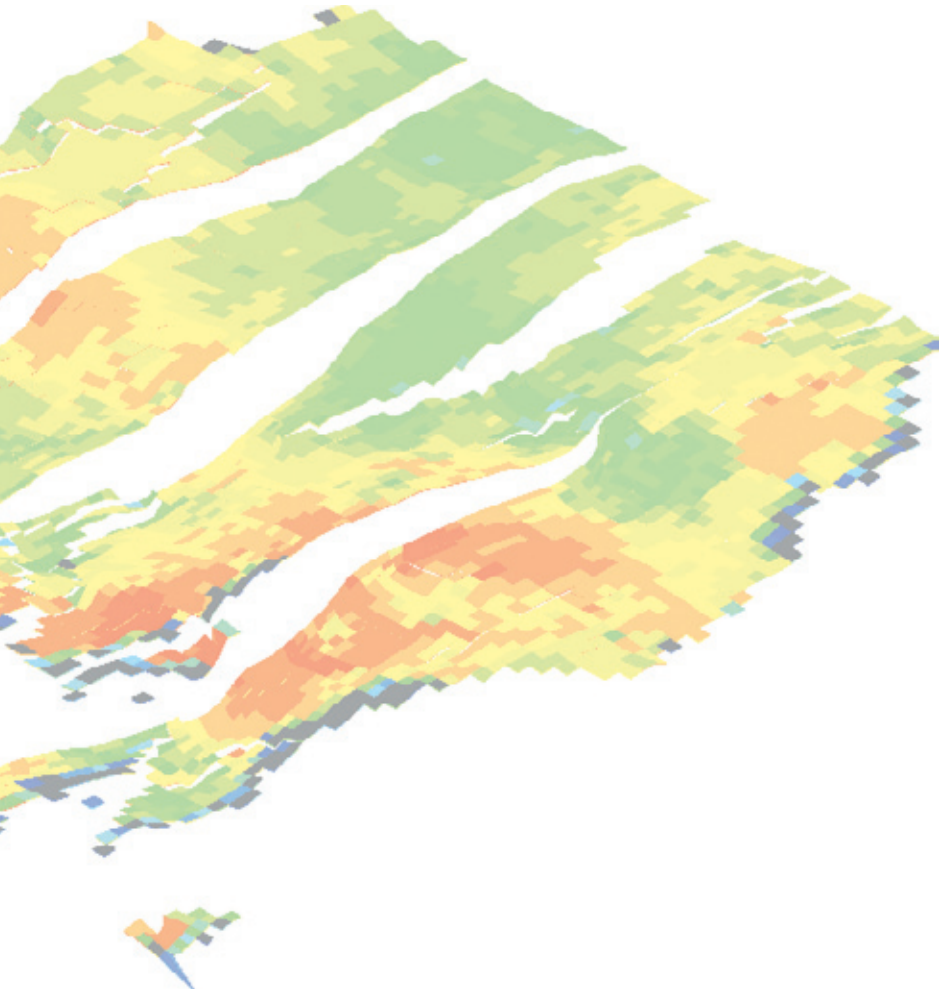
Using the SeisRoX tool, the interpreter/analyst is offered the possibility to perform the interpretation in the context of a geo-model containing *physical properties* rather than just *observational attributes* which have been extracted directly from the seismic image. The type of physical properties needed by the interpreter varies from case to case. For example, a structural interpretation will typically be related to seismic velocities, whereas a 4D interpreter will focus on variations in reservoir properties such as rock porosity and fluid content. The concept behind the model-based analysis described here, is that as soon as a physical geo-model has been established, any model parameter can be interactively perturbed and the effect on the seismic response can be seen by the interpreter immediately. This environment makes the understanding of parameter uncertainties and their effects a real possibility as it enables the interpreter to perform sensitivity analyses and to efficiently check the seismic consequence of different model hypotheses. The core technology within the SeisRoX model based interpretation is a very fast and robust procedure for simulating local seismic images, the NORSAR patented *SimPLI* method.

A principal goal of NORSAR seismic modelling is to incorporate more quantitative interpretation into the E&P cycle. This is not an easy route to take but with the introduction of the SeisRoX multi-domain model concept, integrating rock physics with innovative seismic modelling technology we have moved some way to achieving this. The value of this step change in technology is the introduction to the interpreter's desktop, of a viable software solution that provides a direct means of visualising the relationship between the rock properties and the seismic image and understanding the effects that the inherent uncertainties in these properties have on that image. By doing so, the interpreter can have a higher degree of confidence in the quality of their decisions resulting in an over all reduction of risk in the E&P cycle.



Ved å benytte SeisRoX har tolkeren/analytikeren mulighet til å utføre tolkingen i en geo-modell beskrevet med fysiske parametere og ikke bare ved hjelp av observasjoner trukket direkte ut av det seismiske bildet. De fysiske egenskapene tolkeren velger å benytte kan variere fra prospekt til prospekt. Eksempelvis vil en strukturell tolking typisk tilordnes seismiske hastigheter, mens en 4D tolkning vil fokusere på reservoaregenskaper som porøsitet og væskeinnhold i bergarten. Konseptet for den modellbaserte analysen er at så snart geo-modellen er etablert, kan enhver modellparameter varieres (interaktivt), og virkningen av denne variasjonen på det seismiske bildet kan ses umiddelbart. Analysesystemet tilbyr en reell mulighet for å forstå effekten av usikkerhet i parametere, utføre følsomhetsanalyser og effektivt beregne seismisk respons (bilde) for forskjellige modell-hypoteser. Kjerneteknologien i SeisRoX er en rask og robust metode for beregning av "lokalt seismisk bilde", patentert av NORSAR under navnet SimPLI.

Et hovedmål for NORSARs seismiske modellering er å øke innslaget av kvantitativ tolking i den seismiske verdikjeden ved å introdusere SeisRoX i et multi-domene konsept som integrerer bergartsfysikk med innovativ seismisk modellering i en skrivebordsløsning for tolkere. SeisRoX representerer et teknologisteg som synliggjør sammenhenger mellom bergartsegenskaper og seismisk bilde, og de virkninger usikkerheter i bergartsegenskapene har på det seismiske bilde. Tolkerens og endelig oljeselskapenes utbytte ved å benytte SeisRoX er større trygghet og kvalitet i beslutninger og redusert risiko ved leting og produksjon.



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Organization

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Earthquakes and the Environment

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Seismic Modelling Research

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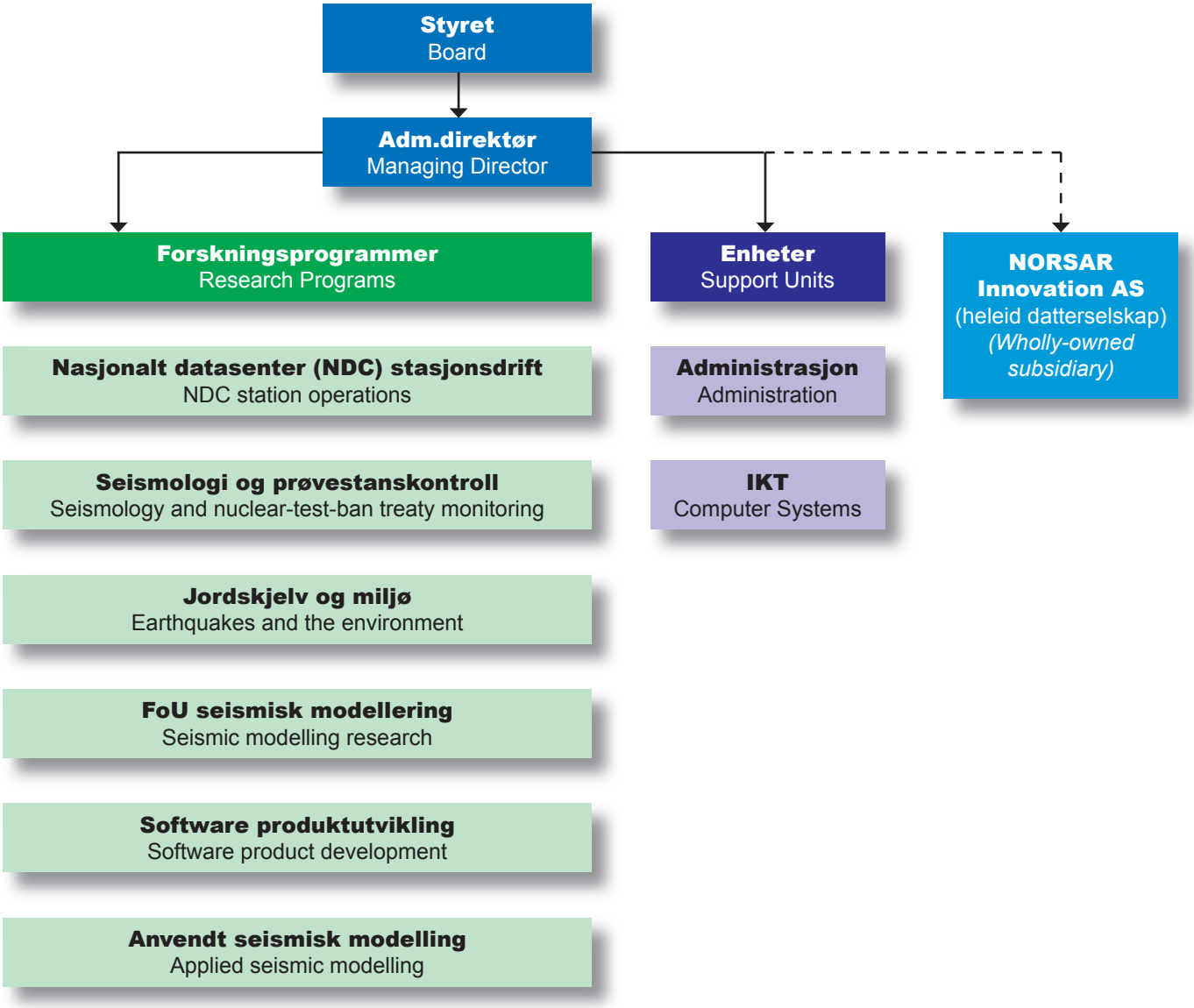
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Enheter
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NDC station operations
Administrasjon
Administration
Seismologi og prøvestanskontroll
Seismology and nuclear-test-ban treaty monitoring
IKT
Computer Systems
Jordskjelv og miljø
Earthquakes and the environment
FoU seismisk modellering
Seismic modelling research
Software produktutvikling
Software product development
Anvendt seismisk modelling
Applied seismic modelling

Annual Report 2006

■ NORSAR is an independent foundation established for the purpose of conducting research and development in the areas of geophysics and geophysical software, and to act as a national resource center for verifying compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT).

■ NORSAR is one of the group of 14 technical-industrial research institutions which receive governmental support through the Research Council of Norway.

■ NORSAR's activities are organized within six research programs, together with an administrative section and an IT-department. NORSAR Innovation AS, a fully owned subsidiary of the NORSAR Foundation, has been established to carry out the commercial activities in connection with marketing and sales of NORSAR software and services.

■ NORSAR has its headquarters at Kjeller, while a branch office for seismic modelling is located in Bergen. NORSAR's field installations are situated in Hedmark (southern Norway), Finnmark (northern Norway) and on the islands of Spitsbergen and Jan Mayen. A field maintenance section is located at Hamar.

Economy

■ NORSAR's gross revenue during 2006 was 48.4 MNOK (49.2 MNOK in 2005). The operating profit was 0.7 MNOK (2.2 in 2005). Financial transactions provided a profit of 0.1 MNOK (0.5 in 2005). The overall profit in 2006 was 0.9 MNOK, (2.7 in 2005).

■ NORSAR's operating profit corresponds to 1.5% of the total revenues for 2006 (4.5% in 2005). By the end of 2005, NORSAR's capital assets comprised 62.7% of total assets (62.2% in 2004).

■ For comparison, the Norwegian Ministry of Trade and Industry has established target guidelines for the research institutions corresponding to an operating profit of 3% of total revenues and capital assets of 30% of total assets.

■ The Board considers the annual report to present an accurate view of the NORSAR Foundation's assets and obligations, financial situation and operating profit.

Årsberetning 2006

■ Stiftelsen NORSARs formål er å drive forskning og utvikling innen geofysiske og datatekniske fagområder, samt å fungere som nasjonalt kompetanse- og driftssenter knyttet til avtalen om forbud mot kjernefysiske prøvesprengninger.

■ NORSAR er ett av til sammen 14 teknisk-industrielle forskningsinstitutter som mottar statlig støtte til sin forskning gjennom Norges forskningsråd.

■ Virksomheten er organisert i seks forskningsprogrammer, en enhet for administrasjon og en enhet for IKT. Kommersiell virksomhet med utspring i NORSARs forskning og utvikling ivaretas av det heleide datterselskapet NORSAR Innovation AS.

■ NORSARs hovedkontor er lokalisert i Instituttveien 25, 2007 Kjeller, Skedsmo kommune. Et av forskningsprogrammene er lokalisert i Thormøhlensgate 55, Bergen. Feltanleggene ligger i Hedmark, i Finnmark, på Svalbard og Jan Mayen. Et vedlikeholdssenter for feltanleggene er lokalisert i Ajerhagan 98, Hamar.

Økonomi

■ Driftsinntektene beløp seg i 2006 til 48.4 mill kroner (49.2 mill kroner i 2005). Driftsresultatet ble 0.7 mill kroner (2.2). Finanspostene summerer seg til 0.1 mill kroner (0.5). Totalresultatet ble dermed 0.9 mill kroner (2.7).

■ Driftsresultatet tilsvarer en resultatgrad på 1.5 % (4.5) av driftsinntektene, og egenkapitalen beløp seg til 62.7 % (62.2) av totalkapitalen. Nærings- og handelsdepartementets målsetting for instituttsektoren er til sammenligning hhv 3% for resultatgraden og 30% for egenkapitalandelen.

■ Styret anser årsregnskapet å gi et rettvisende bilde av Stiftelsen NORSARs eiendeler og gjeld, finansielle stilling og resultat.

Perspectives

The Research Council of Norway is currently working on establishing a new funding system for the research institutions. The plan is to provide a base funding which is dependent upon the institution's performance in five different categories: scientific publications, cooperation with universities and other institutes for higher education, total project income, amount of funding by the Research Council and level of international activity. NORSAR is positive to these developments, but nevertheless considers that the national research allocations need to be considerably increased in order to enable the new system to provide a much needed increase in the base funding of the research institutions.

The funding by the Norwegian Ministry of Foreign Affairs with regard to NORSAR's CTBT-related activities continued to be a central theme in 2006. NORSAR has now been given the opportunity to apply for supplementary funding through participation in relevant projects financed by the Ministry, in addition to the basic financing already provided.

In recent years, the amount of funding in the United States for research projects relevant to nuclear test ban monitoring has been declining. If this trend continues, it will become difficult for NORSAR to maintain its traditional participation in such projects.

Following the earthquake-related disasters in the Indian Ocean and Pakistan during the past two years, there has been a marked increase in the interest for earthquake-related risk analysis. NORSAR's engagement in this field has been increasing during 2006. The International Centre for Geohazards (ICG), where NORSAR is a partner, received a positive evaluation in 2006, and will continue its activities for another five years, with financing from the Research Council of Norway.

The cooperation with NORSAR Innovation AS has contributed to an increase in NORSAR's petroleum related research activities, and the plan is to further enhance this cooperation. High priority is given to a project to develop a new software product within geological and seismic modelling of oil and gas reservoirs. A successful launching of this product will be important for generating future research projects for NORSAR, both in the short and long term.

To maintain a degree of continuity in the project portfolio within seismic modelling is one of the prerequisites for NORSAR to meet its financial goals, as well as to maintain the necessary contact with and feedback from its customers. The availability of such projects is, however, highly variable, and this represents a significant challenge for the future.

During 2006, NORSAR established new framework agreements with the universities in Oslo and Bergen. These agreements are expected to become increasingly important in view of the envisaged future new funding system for the research institutions.

The Board considers the future prospects of NORSAR to be promising, and notes that the foundation is in a good financial position. In accordance with requirements in the Norwegian accounting legislation, the Board confirms that the annual accounts have properly taken into consideration the continued operation of the foundation.

Framtidsutsikter

Norges forskningsråd arbeider nå med et nytt finansieringssystem for instituttsektoren. Det legges opp til at grunnbevilgningen blir resultatbasert med utgangspunkt i hvordan instituttene skårer på fem utvalgte indikatorer; vitenskapelig publisering, samarbeid med universiteter og høyskoler, totale oppdragsinntekter, inntekter fra Forskningsrådet, og internasjonale oppdrag. NORSAR ser med forventning fram til praktiseringen av det nye systemet, men innser samtidig at forskningsbudsjettene må tilføres betydelige midler for at innføringen av det nye systemet kan gi en vesentlig og nødvendig økning i grunn-bevilgningen.

Finansiering av NORSARs rolle i tilknytning til den internasjonale prøvestansavtalen var et sentralt tema for NORSAR også i 2006. NORSAR søker å forbedre denne finansieringen ved å søke på og eventuelt oppnå UD-finansiering av relevante prosjekter i tillegg til det faste oppdraget innen prøvestans-kontroll.

Nasjonale prioriteringer i USA har de seneste par år medført sterk reduksjon i midler til amerikanske forskningsprogrammer innen verifikasjonsseismologi. Dersom denne utviklingen fortsetter, vil det bli svært utfordrende for NORSAR å opprettholde sin historiske prosjektportefølje fra disse programmene.

I etterkant av de seneste årenes store, jordskjelvrelaterte katastrofer i Det Indiske hav og i Pakistan, har interessen for risikoanalyser knyttet til jordskjelv blitt større. NORSARs internasjonale prosjektvirksomhet viser en fin økning innen dette feltet. Senteret for fremragende forskning, International Centre of Geohazards (ICG), der NORSAR er partner, fikk i 2006 en positiv, midtveis evaluering og vil fortsette i fem nye år med finansiering fra Norges forskningsråd.

Samarbeidet med NORSAR Innovation AS har gitt NORSARs petroleumsrelaterte forskning et bredere oppdragstilfang, og det er lagt opp til en økning i oppdragsmengden fra datterselskapet i årene som kommer. Et prioritert oppdrag er utviklingen av et nytt softwareprodukt innen bergartsfysisk- og seismisk modellering for petroleums-reservoarer. En god lansering av dette produktet i markedet vil få betydning for den framtidige oppdragssituasjonen for stiftelsen både på kort og lang sikt.

Kontinuitet i oppdragene innen anvendt seismisk modellering er en forutsetning for at NORSAR skal nå sine økonomiske mål og oppnå den nødvendige kontakt med og tilbakemelding fra kundene. Tilgangen på slike oppdrag er imidlertid svært variabel og representerer en stor, driftsmessig utfordring.

NORSAR etablerte nye rammeavtaler for samarbeid med Universitetene i Oslo og Bergen i løpet av 2006. I lys av det nye finansieringssystemet for instituttsektoren vil disse avtalene få økende relevans framover.

Styret vurderer samlet sett framtidsutsiktene som tilfredsstillende, og stiftelsen er i en god økonomisk stilling. Forutsetningen om fortsatt drift er lagt til grunn ved avleggelsen av årsregnskapet.

Personnel and working environment

By the end of 2006, NORSAR had 47 employees, two of which were working at the field maintenance center at Hamar and five at the branch office in Bergen. A total of 43.8 man-years of work was conducted during 2006.

NORSAR is an equal opportunity employer. The foundation has established working conditions that provides equal opportunities for male and female employees with regard to recruiting, conditions of employment, and possibilities for professional development and advancement.

Total sick leave at NORSAR was 2.5% during 2005. Including sick leave due to children's sickness, the percentage was 2.9. No accidents or injuries have been recorded in connection with NORSAR's activities during the year.

The working environment at NORSAR is considered satisfactory. NORSAR encourages the improvement of this environment through an active dialog between employees and management, and through emphasis on HSE-work and quality assurance. NORSAR's activities do not contribute to environmental pollution.

NORSAR's future prospects depend on the efforts of each individual employee and their working together as a team. The Board of Directors thanks each individual for their contributions during the past year.

Personal og arbeidsmiljø

■ Pr 31.12.2006 var det 47 ansatte ved NORSAR, hvorav 2 hadde arbeidsplass ved feltavdelingen på Hamar og 5 ved kontoret i Bergen. Det ble utført 43.8 årsverk ved bedriften i 2006.

■ NORSAR har tilrettelagt arbeidsforholdene ved bedriften for arbeidstakere av begge kjønn og praktiserer kjønnsmessig likebehandling i saker som handler om rekruttering, ansettelsesbetingelser og utviklings- og avansementsmuligheter.

■ Fravær ved ansattes egen sykdom var på 2.5 %, og fravær inkludert barns sykdom på 2.9 %. Det har ikke forekommet eller blitt rapportert arbeidsuhell eller ulykker knyttet til NORSARs virksomhet.

■ Arbeidsmiljøet anses som godt, men søkes kontrollert og opprettholdt gjennom aktiv dialog mellom ledelse og personale, internt HMS arbeid, og et system for kvalitetssikring. NORSARs virksomhet forurenser ikke det ytre miljø.

■ Verdiskapningen i kunnskapsorganisasjoner som NORSAR avhenger av faglig gode bidrag fra hver medarbeider i et konstruktivt samspill med kolleger og organisasjon for øvrig. Styret takker hver enkelt for innsatsen i 2006.

Kjeller, 12. april 2007

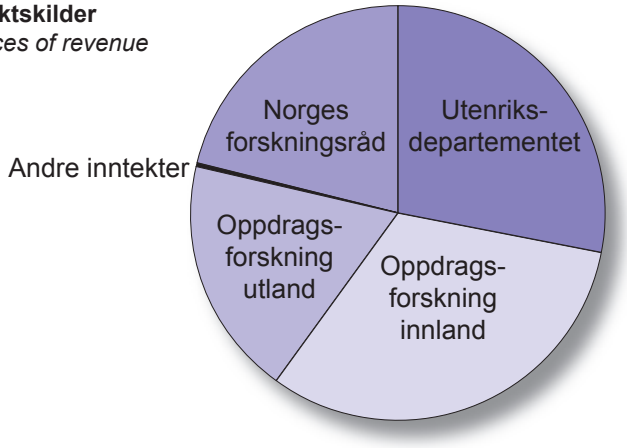
Hege M. Nordgård Bolås Styreleder	Bjørn Grandal Styremedlem	Annik M. Myhre Styremedlem
Tore Olsen Pran Styremedlem	Ketil Åstebøl Styremedlem	Anders Dahle Adm. direktør

Økonomi
Economy

Resultatregnskap 2006 / ***Profit and Loss 2006***

	2006	2005
Midler fra NFR *Grants from the Research Council of Norway*	12 394 498	9 920 343
Prosjektmidler fra UD *Funding by the Ministry of Foreign Affairs*	13 670 000	13 388 130
Andre salgs- og oppdragsinntekter *Other sales and project income*	22 320 400	25 928 446
Sum driftsinntekter *Total operating revenues*	48 384 898	49 236 919
Lønn og sosiale kostnader *Payroll and social costs*	31 763 466	30 738 439
Avskrivninger / *Depreciation*	1 578 441	1 408 294
Prosjektrelaterte kostnader *Project expenses*	8 317 533	9 192 558
Administrative kostnader *Administrative expenses*	6 003 713	5 664 754
Sum driftskostnader *Total operating expenses*	47 680 122	47 004 045
Driftsresultat / *Operating result*	721 745	2 232 874
Netto finansposter *Net financial transactions*	138 565	464 619
Resultat / *Result*	860 310	2 697 493
Ekstraordinær inntekt *Extraordinary income*		-
Årsresultat / *Annual net result*	860 310	2 697 493

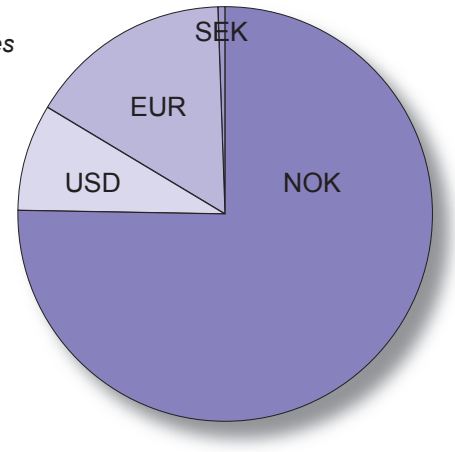
Inntektskilder
Sources of revenue
2006



Balanse 2006 / *Balance 2006*

	2006	2005
Eiendeler / *Assets*		
Anleggsmidler / *Fixed assets*	24 956 722	24 551 430
Oppdrag i arbeid / *Work in progress*	1 174 223	1 571 513
Debitorer / *Debitors*	15 017 510	8 564 598
Andre kortsiktige fordringer *Other short-term receivables*	463 845	346 652
Kasse, bank / *Cash, bank*	9 032 486	14 612 337
Sum eiendeler / Total assets	50 644 786	49 696 530
Egenkapital / *Equity*		
Grunnkapital / *Basic capital*	200 000	200 000
Overkursfond / *Share premium reserve*	843 000	843 000
Annen egenkapital / *Other equity*	29 211 835	28 351 525
Avsetning vedr. feltanlegg *Allocation field installations*	1 500 358	1 500 358
Sum egenkapital / Total equity	31 755 193	30 894 883
Gjeld / *Liabilities*		
Langsiktig gjeld / *Long-term debt*	1 150 491	1 592 173
Leverandørgjeld / *Suppliers*	2 044 251	3 951 185
Skyldige avgifter og skattetrekk *Tax withholding reserves*	3 615 041	2 084 497
Skyldig lønn og feriepenger *Payable salary and holiday pay*	3 717 730	3 638 152
Annen kortsiktig gjeld *Other short-term liabilities*	8 362 080	7 535 640
Sum gjeld / *Total liabilities*	17 739 102	18 801 647
Sum egenkapital og gjeld *Total equity and liabilities*	50 644 786	49 696 530

Inntekter – Valuta
Revenue – Currencies
2006



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Foredrag *Lectures*

■ Bungum, H. (2006): Regional seismicity and future earthquake scenarios affecting Thailand. CCOP-DMR-NGI International Dissemenation Seminar “Tsunami Risk Reduction Measures with Focus on Landuse and Rehabilitation”, Bangkok, Thailand, 9 March

■ Bungum, H. (2006): Jordskjelv i Norge - Hva vet vi og hva gjør vi? Norges Tekniske Vitenskapsakademi, Oslo, 15 March

■ Bungum, H. (2006): Development of strong ground motion attenuation relationships for the Himalaya region. Workshop on Seismic Hazard and Risk Assessment, Indo-Norwegian Programme of Institutional Cooperation, New Delhi, India, 18-19 March

■ Bungum, H. (2006): New strong ground-motion spectral acceleration relations for the Himalayan region. 1st European Conference on Earthquake Engineering and Seismology (1ECEES), Geneva, Switzerland, 3-8 September

■ Bungum, H. (2006): Tsunami hazard and risk assessment along the western coast of Thailand. 1st European Conference on Earthquake Engineering and Seismology (1ECEES), Geneva, Switzerland, 3-8 September

■ Bungum, H. (2006): Modelling earthquake activities on faults. Key Note Lecture, 13th Symposium on Earthquake Engineering, Indian Institute of Technology, Roorkee, 18-20 December

■ Bungum, H. (2006): Tsunami hazard and risk along the western coast of Thailand. 13th Symposium on Earthquake Engineering, Indian Institute of Technology, Roorkee, 18-20 December

■ Bungum, H., T. Kvaerna, S. Mykkeltveit, N. Maercklin, M. Roth, K. Åstebøl, D. Harris and S. Larsen (2006): Energy partitioning for seismic events in Fenniscandia and NW Russia. 28th Seismic Research Review, Orlando, Florida., 19-21 September (poster)

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■ Gibbons, S.J., T. Kværna, and F. Ringdal (2006): Consideration in event detection and location using small-aperture seismic arrays. 37th Nordic Seminar, Nesjavellir, Iceland, 22 August

■ Harbitz, C.B., F. Løvholt, H. Bungum, S. Glimsdal, C. Lindholm, and F. Nadim (2006): Tsunami Hazard Assessment along the Western Coast of Thailand.

EGU General Assembly, Vienna, Austria, 2-7 April

- Iversen, E., and I. Psencik (2006): Ray tracing in continuously rotated coordinates belonging to a specified anisotropy. Seismic Waves in Complex 3-D Structures, Presented at the annual meeting of the SW3D consortium, Prague, 19-20 June

- Iversen, E. (2006): Toward a unified theory for propagation of composite wavefields along common trajectories. International Symposium in Appiled Geophysics, honoring the 60th birthday of Prof. Martin Tygel, IMEC/UNICAMP, Campinas, Brasil, 9-10 November

- Iversen, E., T. Kaschwich, I. Lecomte, J. Mispel, and H. Gjøystdal (2006): Ray tracing tailored to seismic imaging and parameter estimation in the presence of generally oriented anisotropic structures. Workshop 4 - Seismic Anisotropy - State of the Art in Parameter Estimation and Imaging, EAGE 68th Annual Meeting, 12-15 June

- Kaschwich, T., E. Iversen, I. Lecomte, J. Mispel, and H. Gjøystdal (2006): Aspects of imaging tilted anisotropic media: Model representation, model parameter specification, and selection of wave types. 12th International Workshop on Seismic Anisotropy, Beijing, 22-27 October

- Krüger, K. and J. Schweitzer (2006): Crust and upper mantle structure of northernmost Fennoscandia. 1st European Conference on Earthquake Engineering and Seismology (1ECEES), Geneva, 3-8 September (poster)

- Kühn, D., J. Schweitzer, T. Dahm, and F. Krüger (2006): Momententensorinversion regionaler Ereignisse in Fennoskandien und benachbarten Gebieten. 66. Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bremen, 6–9 March

- Kværna, T., J. Schweitzer, F. Ringdal, and S.J. Gibbons (2006): Data processing and analysis of infrasound signals in Fennoscandia and NW Russia. 37th Nordic Seminar on Detection Seismology, Nesjavellir, Iceland, August

- Kværna, T., S.J. Gibbons, F. Ringdal and D.B. Harris (2006): Integrated Seismic Event Detection and Location by Advanced Array Processing. 28th Seismic Research Review, Orlando, Florida, 19-21 September

- Lecomte, I. (2006): ICG Theme 1: Geophysics for Geohazards in 2006, ICG Annual Workshop, Oslo, December

- Lecomte, I. (2006): Illumination and resolution in seismic imaging for all acquisition geometries, in passive or active mode: a general approach, “What Can EP Learn from Seismology and Vice-Versa” workshop, 68th EAGE Conference & Exhibition, Vienna, 12-15 June (poster)

- Lindholm, C.D., S. Molina , H. Bungum and V. Oye (2006): Near Real-Time Damage Estimation, 13th Symposium on Earthquake Engineering. Indian Institute of Technology, Roorkee, 18-20 December

- Lindholm C. (2006): Seismic hazard and risk; The bridge between Seismology and Engineering, National Institute of Research and Development for Earth Physics, Bucharest, Romania.

- Lindholm C. (2006): Earthquake Science and its Contribution to Society; A report for the OECD-Global Science Forum, Helsinki, 11 July

- Molina S. and C. Lindholm (2006): The Confidence of Earthquake Damage Scenarios; Examples from the Capacity Spectrum Method. 1st European Conference on Earthquake Engineering and Seismology (1ECEES), Geneva, Switzerland, 3-8 September

- Molina S. and C. Lindholm (2006): A Capacity Spectrum Method based Tool developed to properly include the uncertainties in the seismic risk assessment, under a logic tree scheme. ECI meeting, Lillehammer, Norway, 19-21 June

- Molina S. and C. Lindholm (2006): A Capacity Spectrum Method based Tool developed to properly include the uncertainties in the seismic risk assessment, under a logic tree scheme. 37th Nordic Seminar on Detection Seismology, Nesjavellir, Iceland, August

- Oye, V. (2006): Real-time Monitoring and Analysis of SAFOD Microearthquakes. Seismology Working Group Meeting, Haidhof, Germany, 4-6 October

- Oye, V., M. Roth, and C. Lindholm (2006): Monitoring of induced microearthquakes for improved seismic risk estimates. 1st European Conference on Earthquake Engineering

and Seismology, Geneva, Switzerland, 3-8 September (poster)

- Oye, V. (2006): Real-time Monitoring of SAFOD Microearthquakes. 66th meeting of the German Geophysical Society, Bremen, Germany, 6-9 March

- Prasad J.S.R., Y. Singh, A. M. Kaynia and C. Lindholm (2006): Socio-Economic Clustering in Seismic Risk Estimation of Dehradun City. 13th Symposium on Earthquake Engineering. Indian Institute of Technology, Roorkee, 18-20 December

- Pzybilla, J., M. Korn, J. Schweitzer, U. Wegler: Acoustic and elastic radiative transfer theory with nonisotropic scattering: applications to a local event in South Norway.
EGU, General Assembly, Vienna 2006

- Ringdal, F., T. Kværna, S. Mykkeltveit, S.J. Gibbons, and J. Schweitzer (2006): Basic *research on seismic and infrasonic monitoring of the European Arctic.* 28th Seismic Research Review,. Orlando, Florida, 19-21 September (poster)

- Ringdal, F., S.J. Gibbons, and D.B. Harris (2006): Adaptive Waveform Correlation Detectors for Arrays: Algorithms for Autonomous Calibration, In: Proceedings of the 28th Seismic Research Review: Ground-based Nuclear explosion Monitoring Technologies, Orlando, Florida, 19-21 September (poster)

- Roth, M., and L.H. Blikra (2006): Installation of a permanent microseismic monitoring system at the unstable rock slope at Åknes, Norway. Annual Meeting of the German Geophysical Society, Bremen, Germany, 6-9 March

- Roth, M., M. Dietrich, L.H. Blikra, and I. Lecomte (2006): Seismic Monitoring of the Unstable Rock Slope at Åknes, Norway, 19th annual Symposium on the Application of Geophysics to Engineering and Environmental Problems, Seattle, USA

- Roth, M., and L.H. Blikra (2006): Microseismic Monitoring at the Unstable Rock Slope Site at Åknes, Norway, Nordic Seminar on Detection Seismology, Nesjavellir, Iceland, August

- Schweitzer, J. (2006): Array Seismologie. NIEP, Bucharest, 16 October (invited lecture)

- Schweitzer, J., and T. Kværna (2006): Infrasound observations of two meteor impacts with arrays and single stations. AG Seismologie, Haidhof, October

- Schweitzer, J., A. Levshin, Ch. Weidle, N. Maercklin, N. Shapiro, and M. Ritzwoller (2006): Surface wave tomography of the European Artic. 66. Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bremen, 6–9 March (poster)

- Schweitzer, J., A. Levshin, Ch. Weidle, N. Maercklin, N. Shapiro, M. Ritzwoller (2006): Surface wave tomography of the European Artic. 1st European Conference on Earthquake Engineering and Seismology, Geneva, 3-8 September (poster)

- Schweitzer, J. and F. Ringdal (2006): Infrasound observations in Northern Fennoscandia
66. Jahrestagung der Deutschen Geophysikalischen Gesellschaft, Bremen, 6–9 March

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- Weidle, Ch., A. Levshin, J. Schweitzer, N. Maercklin, N. Shapiro, and M. Ritzwoller (2006): Surface wave tomography of the European Artic. EGU, General Assembly, Vienna (poster)

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Diverse
Miscellaneous

- Lecomte, I.: Seismic imaging for non-geophysicists, SVALEX 2006 field course, August, Svalbard Archipelago.

- ICG Theme 1 activities: http://www.geohazards.no/projects/geophys.htm

Deltagelse i internasjonale prosjekter og vitenskapelige konferanser bringer NORSARs medarbeidere til en rekke interessante steder. I 2006 til blant annet Nord Sverige, Island, Svalbard, USA og Sentral Amerika.
Participation in international projects and scientific conferences takes NORSAR employees to a number of interesting places; in 2006 to Northern Sweden, Iceland, Svalbard, USA and Central America, among others.

Aitik open pit copper mine, Sweden

Foto: Michael Roth, NORSAR

The mine

Tormod Kværna and Svein Mykkeltveit, NORSAR

37th Nordic Seminar on Detection Seismology, Iceland

Foto: Michael Roth, NORSAR

Allthing at Thingvellir, Iceland

Geysir, Iceland

Symposium on the Application of Geophysics to Engineering and Environmental Problems, USA

Foto: Michael Roth, NORSAR

Mount St. Helens, Washington, USA

Debris deposit as a result of the St. Helens eruption in 1980.

Central America

Foto: Dominik Lang, NORSAR

Lago Atitlán with volcanos Tolimán and Atitlán in Guatemala.

The crater of the active volcano Masaya in Nicaragua.

SVALEX - Multi-discipinary course organized by all Norwegian Universities, Svalbard – sponsored by Statoil

Foto: Isabelle Lecomte, NORSAR

Polar bear.

Students and teachers walking toward the Storvola site.

Fieldwork at Aknes, Møre og Romsdal, Norway

Foto: Michael Roth, NORSAR

Parking the helicopter.

Walking in the scarp.

Forsidebilde: Den ca 1600 m høye vulkanen Concepcion ligger på øya Ometepe i innsjøen Lago Nicaragua. Vulkanen har hatt minst 24 utbrudd siden 1883. Concepcion inngår i en kjede av vulkaner i Sentral Amerika, et område som ikke bare hjemsøkes av vulkanutbrudd, men også av ødeleggende jordskjelv og skred. Foto: A. Dahle, NORSAR

The figure on the cover shows the volcano Conception, which has a height of 1600 meters and is located on the island Ometepe in the lake Lago Nicaragua. The volcano has had at least 24 eruptions since 1883. Conception is part of a chain of volcanoes in Central America, a region which is exposed not only to volcano eruptions, but also to destructive earthquakes and landslides.

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