

Final project report

<i>Project ID</i>	2006/3.01
<i>Title</i>	<i>Integrated analysis of geophysical data to characterize slopes with gas hydrate offshore South Shetland Margin (IGEOS)</i>
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<i>Duration</i>	3 years
<i>Assigned funding</i>	80,000 Euro

Activities and results

IGEOS project aimed at applying integrated methodologies, such as in situ measurements (multibeam, seismic and CHIRP data), laboratory measurements (static and dynamic geotechnical tests) and theoretical models (Biot theory) to obtain a geophysical model of the superficial sedimentary cover that characterizes the South Shetland margin, where an important gas hydrate system is present. The final model can be considered a solid result thanks to the support given by the correlation of the data available. The principal reached objectives of the project can be summarized in the following points:

- 1) Analysis of all geophysical data available, acquired in the South Shetland Margin. We re-processed the available seismic data to obtain an adequate seismic imaging in time and depth domain to allow petrophysical analysis of the data.
- 2) Background velocity of the area, i.e., seismic velocity in absence of hydrate and free gas in the pore space.
- 2) Characteristics and spatial variability of hydrate in the margin. By using inversion method of seismic reflected events and theoretical models, we estimated the gas hydrate and free gas concentrations in the pore space and the thickness of the hydrate and free gas zone. This step was obtained by using the software ISTRICI and DRAGO produced in the frame of IGEOS project.
- 3) 3D models. Interpolating the 2D seismic velocity and 2D gas-phase sections, we obtained a 3D model of the hydrate system. Considering an area of 410 km², the gas volume trapped in the sediments was estimated about 16 10⁹ m³. Supposing that 1 m³ of gas in situ produces 140 m³ gas in standard condition, the studied hydrate system contains 2.3 10¹² m³ of gas in standard condition.
- 4) Slope stability studies. The elastic models obtained by seismic analysis were used to study the slope stability versus climate change. The simulations suggested that the free gas thickness strongly influences the slope stability of the margin.
- 5) Simulation of the effects of the variation of the sea level. We reconstructed several elastic models supposing 100 m sea level change and a sea bottom temperature change of 1 °C, in agreement with the literature. The results indicated that the slope stability is mainly influenced at the beginning of the global warming. In addition, a rapid drop of the sea level change can significantly influence the stability of the margin.
- 6) Integration of results by using GIS. All the results and products obtained in IGEOS were included in a GIS project. Integrating results and data, we recognized several features related to gas hydrate presence, such as mud volcanoes, fluid expulsions. Moreover, we observed that the highest hydrate concentration has been found in proximity of the major faults.

The results of the IGEOS project have been published in several international journals and in a special issue dedicated to gas hydrate in continental margin, organized by the leader of the IGEOS project.

It is important to mention that the project reinforced the collaboration with the Korean Polar Research Institute (KOPRI), formalised by the Memorandum of Understanding between OGS and KOPRI. Moreover, the leader of IGEOS participated to the Korean Antarctic leg in the South Shetland margin in order to

Products

A – papers in scientific magazines

- U. Tinivella, F. Accaino and B. Della Vedova (2007). New geophysical data to map the active fluid outflow in gas hydrate reservoir offshore Antarctic Peninsula. *GeoMarine Letters*, DOI 10.1007/s00367-007-0093-z
- U. Tinivella, M.F. Loreto, and F. Accaino (2009). Regional versus detailed velocity analysis to quantify hydrate and free gas in marine sediments: the South Shetland Margin case study. From: LONG, D., LOVELL, M. A., REES, J. G. & ROCHELLE, C. A. (eds) *Sediment-Hosted Gas Hydrates: New Insights on Natural and Synthetic Systems*. The Geological Society, London, Special Publications, 319, 103–119
- M. Giustiniani, D. Accettella, M. F. Loreto, U. Tinivella and F. Accaino (2009). Geographic information system: an application to manage geophysical data. *EAGE*
- U. Tinivella (2009), Gas idrati: risorsa energetica per il futuro? *Le Scienze Web News*, http://www.lswn.it/chimica/articoli/gas_idrati_risorsa_energetica_per_il_futuro
- U. Tinivella, M. Giustiniani, and D. Accettella, BSR versus climate change: example of preantarctic regions. *Journal of Geological Research*, Article ID 390547, doi:10.1155/2011/390547
- U. Tinivella and M. Giustiniani. Overpressure condition versus BSR. *EAGE/SEG Summer Research Workshop*.
- M.F. Loreto, U. Tinivella, F. Accaino, and M. Giustiniani. Gas Hydrate Reservoir Characterization by Geophysical Data Analysis (Offshore Antarctic Peninsula). *Energies*, 4(1), 39-56; doi:10.3390/en4010039
- U. Tinivella and M. Giustiniani. GAS HYDRATE, FREE GAS AND OVERPRESSURE. *ICGH*, paper 62.00.
- U. Tinivella and M. Giustiniani, Numerical simulation of coupled waves in borehole drilling BSR. *Geophysical Journal International*, submitted
- M.F. Loreto and U. Tinivella. Gas hydrate versus geological features: the South Shetland case study. *Marine and Petroleum Geology*. Submitted.
- U. Tinivella and M. Giustiniani. Gas hydrate stability versus pore pressure. *Global and Planetary Change*, submitted

B – book chapters

- Energia immensa e sfida ambientale. Gli idrati del metano. C. Giavarini (with the collaboration of U. Tinivella), ed. *Universita' la Sapienza* (2007), 192 p.
- Trieste e la moderna ricerca polare. E. Mazzolini. With the contribution of U. Tinivella, charter: *I vulcani di fango*

C - proceedings of international conferences

- U. Tinivella, Accaino F., and Loreto M.F. (2007). Gas hydrate and free gas concentration from seismic data analysis. *Second International Symposium on Continental Margin Tectonics and Georesources*, Qingdao, China, p. 5
- F. Accaino, Tinivella U., and Loreto M.F. (2007). Seismic velocity field to quantify hydrate and free gas: the South Shetland Margin case history. *Second International Symposium on Continental Margin Tectonics and Georesources*, Qingdao, China, p. 6
- Loreto M.F., Tinivella U., Accaino F. (2007). Gas hydrate and free gas occurrence vs climate changes from seismic data analysis and modelling. *ECEM 2007*, Trieste November 27-30
- U. Tinivella, F. Accaino, M. Giustiniani, and M.F. Loreto (2009). Gas hydrate and seismic data analysis by using theoretical approaches. *EGU General Assembly*, Vienna
- U. Tinivella, F. Accaino, M. Giustiniani, M. F. Loreto (2009). CIG analysis to obtain gas hydrate reservoir information

Programma Nazionale di Ricerche in Antartide (PNRA)

International Lithosphere Program Meeting, Clermond-Ferrand

- D. Accettella, M. Giustiniani, Umberta Tinivella, and Valentina Volpi (2009). The gas hydrate: potential future energy for Italy? OWEMES, Brindisi. Terzo premio come migliore poster.
- U. Tinivella, M.F. Loreto, F. Accaino, M. Giustiniani (2009). Geophysical Data Analyses and GIS to Characterise the Gas Hydrate Reservoir AOGS, Singapore. Invited.
- M. Giustiniani, U. Tinivella, M.F. Loreto and F. Accaino. Geophysical methods to characterize gas hydrate reservoir. Annual International Symposium of Unconventional Oil & Gas, China.
- U. Tinivella and M. Giustiniani. Gas hydrate, free gas and overpressure. IGCH, UK.
- D. Accettella, G. Böhm, M. Busetti, B. Della Vedova, M. Rebesco, U. Tinivella, N. Zitellini. Seafloor bathymetry in polar areas from Italian Research Programs (2004-2006). Arctic-Antarctic Seafloor Mapping Meeting. Stockholm.
- Accettella, D., Accaino, F., Della Vedova, B., Giustiniani, M., Loreto M.F., Rebesco, M. And Tinivella, U. Integration and analysis of multibeam bathymetry west of Antarctic Peninsula: inventory of new colcanoes, seamounts and mus-volcanoes. SCAR conference
- U. Tinivella, F. Accaino, M. Giustiniani, and M.F. Loreto. An approach to characterise the gas hydrate reservoir by geophysical analysis. Brazilian Symposium on Non-Conventional Energy Generation from Coal and Gas Hydrates and Workshop on Production of Clean Fuels from Coal in Rio Grande do Sul, Brasile.
- U. Tinivella, F. Accaino, M. Giustiniani and M.F. Loreto. Geophysical data and GIS: an approach to characterise the gas hydrate reservoir (South Shetland Margin). International Workshop on Methane Hydrate Research & Development, NZ

D – proceedings of national meetings and conferences

- Loreto M.F., Tinivella U., Accaino F., 2007. GeoItalia 2007. Analysis of gas hydrate reservoir by integrated geophysical data processing, South to elephant island. Rimini 12-14 settembre.
- Accaino F., Tinivella U., Loreto M.F., 2007. A method to estimate gas hydrate from seismic data. GeoItalia 2007, Rimini 12-14 settembre.
- Tinivella U., Accaino F., Della Vedova B., Loreto M. F., 2007. Active mud volcanism associated to gas hydrate from multibeam and core analysis (Antarctic Peninsula). GNGTS 2007, Roma 13-15 novembre.
- M.F. Loreto, U. Tinivella, F. Accaino, M. Giustiniani, 2009. Geophysical characterization of a gas hydrate reservoir present offshore Antarctic Peninsula. 28° GNGTS
- M. Giustiniani, D. Accettella, U. Tinivella, MF Loreto and F Accaino. Geographical information system applied to geophysical data to study gas hydrate. VII forum Italiano, Geoitalia 2009, Rimini
- Loreto M.F., Tinivella U., Accaino F., Giustiniani M., Analysis of a geophysical dataset to estimate the gas hydrate reservoir present South Elephant Island. VII forum Italiano, Geoitalia 2009, Rimini.
- V. Volpi, D. Accettella, M. Giustiniani & U. Tinivella: Seismic amplitude anomalies related to fluid migration in the Ionian Sea. VII forum Italiano, Geoitalia 2009, Rimini.
- N. Zanette, U. Tinivella & E. Gordini: Gas hydrate and slope stability offshore the South Shetland margin. VII forum Italiano, Geoitalia 2009, Rimini.
- Loreto M.F., Tinivella U., Accaino F., Giustiniani M., 2008. Analysis of Geophysical Data to Characterize the Gas Hydrate Reservoir Present along the Continental Margin of the Antarctic Peninsula, 27° Convegno GNGTS
- Giustiniani M., Accettella D., Loreto M.F., Tinivella U. and Accaino F., 2008. Seismic data and Geographic Information System: an Application to Gas Hydrate Reservoir. 27° Convegno GNGTS
- U. Tinivella, F. Accaino, M. Giustiniani and M.F. Loreto, 2009. Gas hydrate and mud volcanoes offshore Antarctic Peninsula: a geophysical study. 19th Annual V.M. Goldschmidt Conference
- U. Tinivella, M. Giustiniani, and D. Accettella. BSR versus climate change: example of periantarctic regions. Geoitalia

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F – patents, prototypes and data bases

In the frame of the IGEOS project, five structures have been identified offshore the South Shetland Margin. So, the 7th december 2007 we named three mud volcanoes (Flop, Sernio and Vualt) and a structural high named Cjavalz. The 15th may 2008, the mud volcano Grauzaria was certified.

IGEOS project implemented a GIS project in which all the results have been included.

Two softwares have been created: ISTRICI and DRAGO. The first one is used to determine the velocity by Common Image Gather analysis and the second one is dedicated to estimate the gas hydrate, the free gas and the pore pressure by seismic velocity by using theoretical approach.



G – exhibits, organization of conferences, editing and similar

GEOITALIA 2007 – section T02: Gas hydrate: from impact to environment to possible energy resource. Organized by Tinivella and Fontana

GEOITALIA 2009 – section D1: Gas hydrate: from impact to environment to possible energy resource. Organized by Tinivella and Fontana

Workshop Italy- Korea 2008. Organized by Tinivella in order to promote collaboration between italian scientific community and the KOPRI (Korea). In this context, a Memorandum of Understanding between OGS and KOPRI was signed.

OMC 2009 - Workshop "Energy from methane hydrates - Resource potential and technology challenges". Organized by Tinivella and Ruben

Workshop 2009 – Workshop organized in the frame of the IGEOS project, in order to planify collaboration with Korean colleagues.

EGU 2010 – section ERE1.4: "Gas-hydrates, petroleum and coal - Resources and hazards". Organized by V. Kutcherov, A. Shapiro, U. Tinivella, K. Sain, and U. Meyer

Fiery Ice Workshop 2010 – Tinivella was member of Scientific Commity and organised in collaboration with R. Coffin the section: Polar gas hydrate.

2011 – Lead Guest Editor of the Special Issue "Gas Hydrate on Continental Margins (JGR)". Guest editor: M. Giustiniani, X. Liu e I. Pecher (<http://www.hindawi.com/journals/jgr/si/ghcm.html>).

H - formation (PhD thesis, research fellowships, etc.)

2009 – PhD in Science of marine and coastal environment (University of Trieste). The target area is the Antarctic Peninsula and Southern Chilean Margin.

2009 – Installation and training at the NGRI (India) of the software ISTRICI produced and used in the frame of the IGEOS project.

2010 – Invited lesson at "Symposium on Non-Conventional Energy Generation from Coal and Gas Hydrates", Porto Alegre (Brasil), titled: "An approach to characterise the gas hydrate reservoir by geophysical analysis"

I – Reports

Tinivella. Italy-Korea workshop to promote bilateral cooperations. Report OGS 2009/34 GDL 12 REDAS

Tinivella. 9th Offshore Mediterranean Conference: energy from methane hydrates - resource potential and technology

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challenges. Report OGS 2009 /57 GDL 26 REDAS

Loreto, Tinivella. Modello preliminare di velocità 3D di un reservoir di gas idrato ottenuto dall'interpolazione di modelli 2D.
Report OGS 2009/78 GDL 36 REDAS

Giustiniani, Accettella. Sistemi informativi territoriali (GIS): applicazione allo studio dei gas idrati - Risultati preliminari.
Report OGS 2008/96-GDL 25REDAS

Loreto, Tinivella, Accaino. Migrazione Post-Stack in profondità di dati sismici acquisiti al largo della Penisola Antartica in
prossimità di un reservoir di idrato. Report OGS 2008/104 GDL 31 REDAS

Loreto, Tinivella, Accaino. Inversione di Velocità e Migrazione Pre-Stack in Profondità dall'analisi dei CIGs. Report OGS
2008/89 GDL 24 REDAS

Loreto, Della Vedova, Accaino, Tinivella, Accettella. Passive subduction of the Phoenix plate remnant by seismic and
morpho-bathymetry data analysis, Antarctic Peninsula. Report OGS 2008/70 GDL 18 REDAS

Gordini, Tinivella et al.. Prove Geotecniche di Laboratorio – Progetto IGEOS. Report OGS 2008/22 RIMA 2 GEA

Loreto., Hong, Tinivella. 2007 Antarctic Marine Geological Survey. Report OGS 2008/18 GDL 4

Tinivella. Modelli teorici a confronto: un esempio. Report OGS 2008/8 GDL 2

Tinivella. Campagna Antartica a Bordo della rompighiaccio Coreana Araon. Report OGS 2011/29 GDL 9 REDAS

Accettella, Tinivella, Accaino, Della Vedova, Rebesco, Giustiniani. Penisola Antartica: batimetria, strutture e mud volcanos
riconducibili a seepages e/o presenza di gas idrati. Report OGS 2010/109 RIMA 21 ADEST

Accettella, Tinivella, Giustiniani. South Shetland: integrazione di dati batimetrici provenienti da diverse fonti per lo studio
dei gas idrati. Report OGS 2010/108 RIMA 20 ADEST

Tinivella. Software per stimare gas idrato, Gas libero, pressione dei pOri – DRAGO. Report OGS 2010/51 GDL 20 REDAS

Research units

RU-1 – Seismic data processing and analysis. Theoretical and elastic 2D and 3D models. Climate change simulations.

Umberta Tinivella (PI)

Flavio Accaino

Daniela Accettella

Michela Giustiniani

Claudio Zanolla

RU-2 – GIS. Integration of available data. Interpolation of data.

PI: Michela Giustiniani (PI)

Daniela Accettella

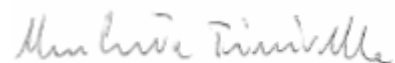
Umberta Tinivella

RU-3 - Laboratory geotechnical tests. Finite elements analysis of the slopes stability.

Emiliano Gordini (PI)

Nelly Zanette

Date: 31/01/2012



Notes