**Linda Soma (XXVII)**

**ITitolo Tesi:** ***nterplay between opposite vergence thrusts along the Southern Alps margin in Canton Ticino (Switzerland): geometry, kinematics and geochemistry in support of the characterization of geothermal potential.***

**Tutore: Prof. Silvio Seno, Co-tutori: Dott. Christian Ambrosi, Dott. Sebastian Pera**

**SSD GEO 03**

Lo scopo della tesi di dottorato è valutare le potenzialità geotermiche nell'area di Stabio attraverso un approccio integrato che vede l'interpretazione geologico strutturale in connessione con l'analisi geochimica proveniente dalle acque. L'attività svolta durante l'ultimo anno è stata necessaria per acquisire le informazioni mancanti per concludere la ricerca. Nello specifico le fasi svolte sono state le seguenti: i) creazione del modello geologico 3D attraverso l'interpolazione delle principali superfici geologiche; ii) acquiszione dei dati di conducibilità termica su campioni rocciosi prelevati nell'area di studio ii) campionamento delle acque nell'area del mendrisiotto (7 siti di prelievo); iv) applicazione dei geotermometri per la stima delle temperature. Tali dati sono stati integrati nel modello geologico e sono serviti per chiarire il contesto geochimico e per stimare il range di temperatura presente nel contesto studiato.

Dalle attività effettuate si possono trarre le seguenti principali conclusioni: i) dai dati geologici di superficie e dall'interpretazione dell linea sismica S7 viene confermata la presenta di una struttura EW (faglia di Stabio); ii) tale struttura è connessa al back-thust della Gonfolite; iii) le acque di Stabio si sono infiltrate in un range di quota fra 515 e 991 m, compatibile con l'area del M. S. Giorgio; iv) la presenza di fluoro viene connessa ai depositi minerali ($CaF_2$) associati alle dolomie Anisiche note in superficie (M. Grumello, Besano and M. Casolo); vi) i dati di radiocarbonio indicano un'elevata età delle acque, vii) i geotermometri applicati, confrontati con la stima delle temperature ottenute con il metodo di Bullard suggerisce di escludere elevate temperature (> 100°) a profondità interessanti dal punto di vista dello sfruttamento geotermico, finalizzato alla produzione di energia elettrica; al contrario potrebbe essere interessante per lo sfruttamento dal punto di vista termico (es. teleriscaldamento).

**Attività didattica**

Supporto al corso di Geologia generale (primo anno Ingegneria Civile, SUPSI)

*Uscita didattica (Parco delle Gole della Breggia, CH)*

**Corsi, Seminari, Convegni**

*15 Dicembre 2011* - Conferenza interna organizzata dall'Università di Pavia

*09 Febbraio 2012* – Corso di formazione continua: Sistemi di monitoraggio automatico (IST-SUPSI)

*17 Febbraio 2012* – Conferenza: Integrated application of geochemical and geophysical methods for hydrogeological impact assessment for tunneling in fractured rock, R. Marzocchi, Université de Lausanne

*07 Marzo 2012* - Conferenza interna organizzata dall'Università di Pavia

*20 Marzo 2012* – Seminario organizzato dall'Università di Pavia

*30 Marzo 2012* – Corso per l'utilizzo e l'applicazione della sismica passiva attraverso l'analisi spettrale delle onde di superficie (HVSR). Relatori esterni: Dal Moro, Pirchio (IST-SUPSI)

*Aprile-Maggio* - Corso di Idrogeologia - Prof. Pilla (Università degli Studi di Pavia)

*12 Aprile 2012* - Conferenza interna organizzata dall'Università di Pavia

*18 Aprile 2012* – Corso: Atelier GeoNE-1Méthodes d'échantillonnage et mesures physico-chimiques des fluides géothermiques (Lavey Les Bains, Université de Neuchâtel)

*10 Maggio 2012* - Conferenza interna organizzata dall'Università di Pavia

*15 Maggio 2012* - Seminario organizzato dall'Università di Pavia

*Dal 15 al 18 Agosto 2012* – Microtectonics Course - Prof. Dr. Cees W. Passchier (Johannes Gutenberg Universität Mainz, Germany )

*5 Settembre 2012* – Corso per l'utilizzo di Tool Map, software libero per la digitalizzazione in ambiente GIS degli elementi geologici per la cartografia ufficiale svizzera (Universität Bern)

*Dal 14 al 16 Settembre 2012* – Deuxième rencontre des Jeunes Géomorphologues Suisses - Région du projet de Parc National de l'Adula, Tessin/Grisons.

*Dal 25 settembre al 1 Ottobre 2012* - 39th Course of the International School of Geophysics - Understanding Geological Systems for Geothermal Energy (EMFCSC, Erice, Sicily)

*23 Novenbre 2012* - Le vulcaniti Permiane dei F° CGI Varese e 1353 Lugano (Atlante geologico della Svizzera): petrografia e stratigrafia, Pr.ssa Laura Gaggero (Genova)

*23 Novenbre 2012* - Nouvelles découvertes stratigraphiques autour de la klippe de Sambuco, Henri Masson (Lausanne)

*23 Novenbre 2012* - Cartographie des formes périglaciaires dans le contexte tessinois, Cristian Scapozza (SUPSI-Lugano)
*2-5 Aprile 2013* - Structural geology course: Corso pratico di rilevamento strutturale nell'area di Domodossola. Docente: Prof. N. Mancktelow (ETH, Zürich)
*10-11 Giugno 2013* – Project Management sulla ricerca. Imparare a progettare in Europa (6 ore). Università degli Studi di Pavia
*24-27 Giugno 2013* - Attività Interdisciplinare di Terreno (9CFU): La Geologia delle Dolomiti. Docenti: A. Di Giulio, M. Cobianchi, A. Ronchi
*8-11 Ottobre 2013* - Third Geothermal Training Course, Pisa , Italy (GEOELEC)
Conferenze interne e seminari organizzati dall'Università di Pavia.
*Settembre 2014*– Scuola SCS - Scienza, Comunicazione, Società. Il ricercatore visibile -Strumenti per comunicare la scienza. Agorà Scienza – Centro Interuniversitario.

**Pubblicazioni**

Soma L., Ambrosi C., Bernoulli D., Bonini L., Pera S. & Seno S. (2013) Geochemical and structural data for the evaluation of the geothermal potential. Swiss Geosciences Meeting, Lausanne (abstract). Poster

Soma L., Bonini L., Ambrosi C., Bernoulli D. & Seno S. (2013) Geological surface data improve understanding of deep structures in Southern Alps, Rendiconti on-line della Società Geologica Italiana (short notes). Poster

Soma L., Bonini L., Ambrosi C., Bernoulli D. & Seno S., 2013. *Geological surface data improve understanding of deep structures in Southern Alps*. Rendiconti on-line della Società Geologica Italiana, vol. 29. pp. 165-168. ISSN 2035-8008 (short notes e poster).

## Federico Filipponi (XXVII ciclo)

## Titolo Tesi: *Investigating suspended sediment dispersal patterns in a shallow marine depositional environment using Remote Sensing*

## Tutore: Prof. Francesco Zucca, Co-tutore: Prof. Andrea Taramelli

## Settore Scientifico Disciplinare di riferimento

## SSD GEO 04

**Breve descrizione del lavoro svolto**

Research study is focused on the investigation of suspended sediment dispersal patterns using Remote Sensing.
Objective of the research study is to develop a quantitative methodology to estimate sediment fluxes in a shallow marine depositional environment.
The study aim to identify, in a considered time range: i) the sedimentary process dominating a selected shallow marine depositional environment; ii) the deposit areas of new sediment supply, potentially accumulated in the seabed active layer and available for later sediment resuspension; iii) to which extent the seabed active layer influenced by coastal hydrodynamic processes.
To address these issues, estimates of suspended sediment spatial patterns from Remote Sensing data are related to in-situ measured physical forcings in order to describe and quantify the extent, strength and variability of sediment dispersal patterns and explain its behavior in relation to the main hydro-climatic forcings. Special attention is given to the analysis of events of extreme hydro-climatic conditions, located at the far end of their distribution tail, triggering changes that perturb sediment steady state.
Study area is located in northern part of the Adriatic Sea, a shallow semi-enclosed shelf sea located between western and eastern parts of the Mediterranean Sea, it is about 800 Km long and 150 Km wide. Northern Adriatic Sea occupy the northern and shallower area of the Adriatic Sea (depth < 100 m) and has a gentle slope (about 0.02°).
Total Suspended Matter (TSM) geophysical product is composed of fine grained inorganic particles and material of organic origin that is suspended in the water column and has been identified as proxy for the qualitative and quantitative estimation of suspended sediment dispersal patterns from Remote Sensing. TSM has been estimated from MEdium Resolution Imaging Spectrometer (MERIS) sensor for the period 2002-2012.
Despite online services provide several Ocean Color datasets for the exploitation of Remote Sensing applied to marine and coastal areas, full resolution gridded datasets at regional scale are not available. In order to provide a higher resolution datasets better suitable for coastal sediment transport analysis, an efficient processing chain was developed to generate full resolution Ocean Color (OC) gridded geophysical products from MEdium Resolution Imaging Spectrometer (MERIS) L1b data, using open source tools and software and parallel processing (Filipponi et al., 2014). It makes use of standard MEGS® (MERIS Ground Segment development platform) processor for geophysical parameters estimation from MERIS full resolution data (300 m spatial resolution) with improvements on cloud pixel identification, where the geophysical parameters estimation is uncertain due to cloud effects.
In northern Adriatic Sea mechanisms associated with river-derived sediments and wave resuspended sediments under strong winds, produces depositional patterns similar to the observed late Holocene deposits, suggesting that event scale models can provide insight about sedimentation on geologic timescales (Lee et al., 2005). This consideration is in

agreement with depositional patterns modeled by Harris et al. (2008) for time scales of months to few years, that have been seen to be similar to observed patterns that have developed over longer timescale. Therefore, the considered time scale of ten-years may result enough representative for the description of sedimentation processes. It has long been recognized that the fine sediments such as fine sand, silt and clay are mainly supplied from the northern Adriatic Sea rivers, and transported southward by the Western Adriatic Coastal Current (WACC). Po river is the main source of freshwater and nutrients in northern Adriatic Sea, with an annual average discharge rate of 1500 $m^3s^{-1}$, carrying 47 $Km^3yr^{-1}$ of water and $6*10^6$ t $yr^{-1}$ of solid transport. Minor rivers located in the study area are Adige, Brenta, Tagliamento, Piave, Livenza, Isonzo. Freshwater discharge rate has been collected for each of the rivers, in order to related discharge rate to suspended sediment concentration. Two distinct wind regimes, Bora and Sirocco, dominate conditions in NAS and influence basin-wide circulation. Statistical analysis using using a two-sample Kolmogorov-Smirnov test was done in order to evaluate the representativeness of the EO dataset with respect to the to the temporal coverage and the occurrence principal hydro-climatic forcing events. Wind indices were calculated from wind speed and direction collected in-situ (following Bever et al. 2009) to identify events of intense Bora and Sirocco winds, the main wind regimes in the basin, in order to characterize the climatic conditions contributing to sediment resuspension from seafloor and significantly influencing sediment transport. Signal decomposition analysis was applied to in situ collected temporal series of river discharge, wind and waves, to identify seasonal and trend signals in temporal series.
Spatial distributed wind fields, estimated from Synthetic Aperture Radar (SAR) Remote Sensing data, were collected from Soprano archive for the years 2011-2012 to analyze distribution patterns of main winds and were used for data assimilation in numerical models. Wave downscaling was done for northern Adriatic Sea using Simulating WAves Nearshore (SWAN) physically based numerical model and Radial Basis Function interpolation (Gutierrez et al., 2015). Simulated wave fields were used to calculate the seaward limit of the littoral zone (Depth of Closure) using the method proposed by Hallermier (1981). A total of 59 transects were used to plot the profiles of estimated TSM concentration for each of the 700 MERIS observations available in the study area for the period 2002-2012. Transect has been provided with additional information about seabed depth and seabed sediment grainsize (Brambati et al., 1986), in order to support the interpretation of the variability in space dimension, and provided with dominant condition (either wave dominated or river dominated) in order to support the interpretation of the profiles variability in time dimension. TSM time series were analyzed for intra- and inter- annual variability, in addition Empirical Orthogonal Function analysis (EOF; Björnsson and Venegas, 1997) and Empirical Orthogonal Teleconnections (EOT; Van den Dool et al., 2000) analysis were done to better describe the sediment dispersal pattern variability in both time and space dimensions. The occurrence of flood events has been determined for each single river by identifying the satellite observation cases resulting in the class of flood river runoff condition. Four statistics (average, $90^{th}$ percentile, sum and standard deviation) have been calculated from the corresponding flood events identified for each river. As result, northern Adriatic Sea basin results to be dominated by wave processes in the ten-years period considered in this research study. Riverine runoff influences almost exclusively the alongshore area, confining the supplied sediment load to a narrow coastal strip. Intense hydro-climatic pulses responsible for abrupt changes that perturb sediment steady state in the northern Adriatic Sea basin are represented by few single events of significant sediment supply during river flood condition or strong sediment resuspension from seafloor during intense wind stress. The observation of EO products corresponding to periods of intense wind stress allowed the investigation of three important sedimentation processes: resuspension, transport and deposition. During intense bora wind forcing sediments are resuspended from seabed at lower depths generating an alongshore band, increased circulation velocity have the ability of transport and distribute sediments all over the basin, included the offshore area before being slowly settled on the seabed when fluid turbulence is not enough to keep the sediment moving. Seaward limit of the littoral zone can be find in correspondence of the limit of the high turbid alongshore band that is generated by sediment resuspension, which is wide 3 km on average and corresponds to -10 m depth. Appropriate spatial representation has been computed averaging the concentrations estimated from satellite observation acquired in correspondence of the most intense wind stress conditions. From a qualitatively comparison with the Depth of Closure estimated using the method based on wave forcing using the modeled wave fields, higher TSM average concentrations form a wider alongshore band which suggest that sediment resuspension may occur at deeper location. From a qualitatively comparison with the Depth of Closure estimated using the method based on wave forcing, higher TSM average concentrations form a wider alongshore band which suggest that sediment resuspension may occur at deeper locations. Deposition areas of new sediment supply, accumulated in the seabed active layer from river runoff, has to be found in the proximity of the main river mouths. The decreasing gradient in TSM concentration indicates an effective particulate settling process that promote the removal of coarser suspended sediments and maintain a buoyant plume of muddy flocculating sediments. As conclusion, sediment dispersal patters can be advantageously investigated integrating Remote Sensing techniques and in-situ data. This study shows how superficial processes in sedimentary depositional marine environment can benefits from analysis of Earth Observation products, which offer a sight of spatial and temporal patterns of sediment dynamics at unprecedented spatial detail.

**Attività didattica**

*Marzo – Aprile 2012* – "Analisi Geo-Spaziale" (6 CFU) (*Corso*, Dott. G. Ciotoli, Dipartimento di Scienze Geologiche, Roma)

*Marzo – Aprile 2013* – Corso "Applied Numerical Modeling in Earth Sciences (6CFU)" (*Corso*, Prof. Maurizio Battaglia, Università La Sapienza, Roma)
*Giugno 2013* – Corso "Attività Interdisciplinare di Terreno (9CFU): La Geologia delle Dolomiti" (*Corso*, Prof. A. Di Giulio, Prof. M. Cobianchi)
*Settembre 2013* – Corso "3rd Advanced Training on Ocean Remote Sensing" (*Corso*, Dr. Carsten Broackmann, Dr. Val Byfield, Dr. Paolo Cipollini, Dr. Fabrice Collard, Prof. Johnny Johannessen, Prof. Christopher Merchant, Dr. Francoise Mertz, Prof. Trevor Platt, Dr. Nicolas Reul, Dr. Shubha Sathyendranath, National Maritime College of Ireland, Cork, Ireland)
*Settembre 2014* - Summer school "EROSIONE: scale spazio-temporali" (*Summer school*, 8-12 settembre 2014, Prof. Francesco Zucca)

**Corsi, Seminari, Convegni**

***Anno Accademico 2011-2012***

*Dicembre 2011* – "Le risorse forestali nazionali e i servizi ecosistemici. Il ruolo delle istituzioni" (*Convegno*, ISPRA, Roma)
*Febbraio 2012* – "2nd TERRABITES Symposium, Modelling the terrestrial biosphere: From Ecological Processes to Remote Sensing Observations" (*Convegno*, ESA, Frascati)
*Aprile 2012* – "Sentinel-2 Preparatory Symposium" (*Convegno*, ESA, Frascati)
Maggio 2012 – "I modelli per l'analisi del ciclo di vita (LCA-LCC-LCM) come strumenti per predire o stimare la sostenibilità, ambientale, economica e sociale di un materiale, di un processo o di un prodotto finite" (*Conferenza*, Dipartimento di Scienze della Terra e dell'Ambiente, Pavia)
*Giugno 2012* – "2012 IEEE GOLD Remote Sensing Conference" (*Conferenza*, CNR, Roma)
*Giugno 2012* – "ENVI User Group 2012 Italia" (*Convegno*, Exelis, Roma)
*Giugno 2012* – "SEASAR 2012 - Advances in SAR Oceanography" (*Convegno*, ESA, Tromso, Norvegia)

***Anno Accademico 2012-2013***

*Ottobre 2012* – Convegno "Sentinel-3 OLCI/SLSTR and MERIS/(A)ATSR Workshop" (ESA ESRIN, Frascati)
*Ottobre 2012* – Convegno "Meeting marino" (ISPRA e Università Roma Tre, Roma)
*Dicembre 2012* – Conferenza "Sismicità, azione sismica e aspetti geotecnici del terremoto emiliano del 20 maggio 2012" (Dott. Carlo Giovanni Lai, Università di Pavia)
*Gennaio – Febbraio 2013* – Convegno "POLinSAR 2013" (ESA ESRIN, Frascati)
*Febbraio 2013* – Convegno "SMOS Land Application Workshop" (ESA ESRIN, Frascati)
*Marzo – Aprile 2013* – Corso "Applied Numerical Modeling in Earth Sciences (6CFU)" (Prof. Maurizio Battaglia, Università La Sapienza, Roma)
*Giugno 2013* – Convegno "Big Data from Space" (ESA ESRIN, Frascati)

***Anno Accademico 2013-2014***

*Marzo 2014* – Examples and applications of Network Common Data Form (Seminario interno Università degli Studi di Pavia)
*Maggio 2014* – Convegno "Sentinel-2 for Science workshop" (ESA-ESRIN, Frascati)
*Giugno 2014* – Convegno "IEEE GOLD Remote Sensing conference 2014" (IEEE, Berlino)

***Anno Accademico 2014-2015***

*Ottobre 2014* – Convegno "ESA-SOLAS-EGU 2014 Earth Observation for Ocean-Atmosphere Interactions Science" (ESA ESRIN, Frascati)
*Giugno 2015* – Convegno "Sentinel-3 for Science Workshop" (Palazzo del Casinò, Lido di Venezia)
*Settembre 2015* – Convegno "ECSA 55 Unbounded boundaries and shifting baselines: Estuaries and coastal seas in a rapidly changing world" (London International Convention Centre at ExCeL, Londra)
*Settembre 2015* – Convegno "SedNet conference" (Faculty of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology, Cracovia)

**Stages e/o soggiorni in Italia**

17 Giugno 2013 – 30 settembre 2015 - ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale), gruppo "Validazione dei processi di acquisizione dati da remoto con studio di processi sedimentari, morfologici ed ambientali in fascia costiera (DIP II CRA15 – Prevenzione e mitigazione degli impatti)" sotto la supervisione del Prof. Taramelli Andrea

**Stages e/o soggiorni all'estero**

2 Marzo 2015 – 18 Marzo 2015 - Visiting student presso "DELTARES" (Delft, Paesi Bassi) sotto la supervisione della Dott.ssa Ghada El Serafy. Durante il periodo di scambio sono state effettuate analisi di dati telerilevati con tecniche di Empirical Orthogonal Function analysis (EOF; Björnsson and Venegas, 1997) e ricostruzione di serie temporali con tecnica DINEOF.

**Pubblicazioni**

Filipponi F., Taramelli A., Zucca F., Valentini E., El Serafy G.Y., (in press). *Ten years sediment dynamics in northern Adriatic Sea investigated through optical Remote Sensing observations*. Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS) 2015, Milan (Italy).

Filipponi F., Zucca F., Taramelli A., Valentini E., (in press). *Total Suspended Matter (TSM) and maximum signal depth (Z90_max) for monitoring the evolution of sediment resuspension processes in shallow coastal environments*. Proceedings of "Sentinel-3 for Science Workshop", Venice (Italy) 2-5 June 2015, ESA SP-734 (CD-ROM).
Filipponi F., Bassani C., Taramelli A., (in press). *Comparison of Sentinel-3 OLCI simulated data with MERIS for Ocean Color parameter estimation*. Proceedings of "Sentinel-3 for Science Workshop", Venice (Italy) 2-5 June 2015, ESA SP-734 (CD-ROM).
Gutiérrez O.Q., Filipponi F., Taramelli A., Valentini E., Camus P., Méndez F.J., 2015. *On the feasibility of the use of wind SAR to downscale waves on shallow water*. Ocean Science Discussion, 12, pp. 1567-1593, doi:10.5194/osd-12-1567-2015.
Zanuttigh B., Angelelli E., Bellotti G., Romano A., Krontira Y., Troianos D., Suffredini R., Franceschi G., Cantù M., Airoldi L., Zagonari F., Taramelli A., Filipponi F., Jimenez C., Evriviadou M., Broszeit S., 2015. Boosting Blue Growth in a Mild Sea: *Analysis of the Synergies Produced by a Multi-Purpose Offshore Installation in the Northern Adriatic, Italy*. Sustainability, 7(6), 6804-6853, doi:10.3390/su7066804.
Manzo C., Valentini E., Taramelli A., Filipponi F., Disperati L., 2015. *Spectral characterization of coastal sediments using Field Spectral Libraries, Airborne Hyperspectral Images and Topographic LiDAR Data (FHyL)*. International Journal of Applied Earth Observation and Geoinformation 36: 54-68, DOI: 10.1016/j.jag.2014.11.003.
Filipponi F., Valentini E., Liberti L., Zucca F., Taramelli A., 2014. *Generation of gridded Ocean Color products from MERIS: an efficient processing chain*. IEEE GOLD Remote Sensing conference 2014, Berlin 5-6 Giugno, Proceedings.
Valentini E., Taramelli A., Filipponi F., Giulio S., 2014. *An effective procedure for EUNIS and Natura 2000 habitat type mapping in estuarine ecosystems integrating ecological knowledge and remote sensing analysis*. Ocean & Coastal Management, Elsevier, doi:10.1016/j.ocecoaman.2014.07.015.
Innocenti C., Filipponi, F., Valentini E., Taramelli A., 2013. *Multisensory data fusion methods for the estimation of beach sediment features: mineralogical, grain size and moisture*. Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS) 2013, Melbourne (Australia), pp. 3064-3067, ISBN: 978-1-4799-1114-1/13/$31.00, IEEE.
Filipponi F., Taramelli A., Zucca F., 2012. Seafloor Topography modeling in northern Adriatic Sea using Sysnthetic Aperture Radar. Proceedings of 4th SAR oceanography workshop "Advances in SAR Oceanography" (SeaSAR 2012), Tromsø (Norway) 18-22 Giugno 2012, ESA SP 709, pp. 273-275, ISBN: 9789292212735.