**Programma Nazionale di Ricerche in Antartide (PNRA)**

# Final project report

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| *Project ID* | 2004/4.01 |
| *Title* | *Cenozoic Magmatism in Victoria Land: a tracer of geodynamic processes and of global evolution of climate.* |
| *Principal investigator* | Prof. Pietro Armienti |
| *Institution* | Università di Pisa – Dipartimento di scienze della Terra |
| *Email* | *armienti*@dst.unipi.it |
| *Duration* | 3 years |
| *Assigned funding* | 240.000,00 Euro |

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## Activities and results

In the project worked six groups and the results indicate:
1- Petrography and $^{40}Ar$-$^{39}Ar$ dating of pseudotachylytes from the southern termination of the Priestley Fault and other areas (e.g. Prior Island and Maswon Glacier) indicate an age of 34.11±0.96 Ma, that overlaps with the emplacement age of syn-tectonic dykes from nearby areas and date a single episode of coseismic faulting. Regionally, the age of the pseudotachylytes represents the first direct onshore evidence of Cenozoic right-lateral strike-slip fault system activity in NVL.

2- The Ar-Ar ages combined with O and H isotope data of altered granitoids along the Ross Sea coastline, suggest that glacial events occurred after the Paleocene-Eocene Thermal Maximum, well before the Eocene-Oligocene icehouse transition. The estimated surface temperatures (T) at the time of hydrothermal circulation varied between -1 to -10°C, similar to the modern T range measured along the Ross Sea.

3-The small-scale analogue modeling used to investigate the process of Cretaceous orthogonal extension in the WARS, supports the hypotheses about the strong control exerted by lateral variations in lithospheric structures (East Antarctic Craton vs. Ross Sea weak lithosphere) on the extension process. Strain was mostly accommodated at the boundary between the two types of lithosphere, with a relative uplift of the undeformed cratonic block and a wide rifting on the weaker lithosphere. According to the natural prototype, this tectonic scenario led to a long-lasting extension without continental break-up without relevant surface magmatism.

4- Metasomatism induced in NVL lithospheric mantle was investigated experimentally studying the effects of nephelinite/lherzolite (1.5-2.0 GPa, T=975-1300°C) and nephelinite/wehrlite (1.0 GPa, T=1050-1250°C) interactions. Compositional variations affected particularly clinopyroxenes (Cpx) which enriched in Mg, Cr and Na in lherzolite, and in Ti, Al, Fe and Na in wehrlite. Experiments with wehrlite produce intergranular glasses due to Cpx dissolution coupled Ol+Cpx recrystallization, which compositions approach that of melt patches associated to both amphibole-free and amphibole-bearing natural samples.

5- Two textural types of amphibole (amph) were found into Mt. Melbourne and Mt. Overlord mantle xenoliths: pargasite-amph disseminated grown around Cpx and spinel, associated with high-$TiO_2$ silicate glass; kaersutite-amph into glass-rich veins. Cpx has a wide compositional range from primary unmetasomatized diopside to high-MgO salite, with REE patterns varying from flat to slightly LREE enriched. The metasomatizing agent was likely a Na-alkaline silicate melt. Estimates of melt infiltration timing indicate that both amph types formed within a similar time span due to different magma/wall rock ratios which control the mode of melt migration, porous flow vs. cracking.

6- Magma-water interactions were investigated in late Miocene volcanoes cropping out along NVL coastline, at the Ross Sea margin of the East Antarctic Ice Sheet. The glaciovolcanic sequences comprise multiple

mafic aa lava-fed deltas, mafic glaciovolcanic sheet-like sequences with minor felsic and pyroclastic volcanics, and ice-marginal lacustrine deposits. Interpretation of these sequences point out for the presence of a late Miocene ice dome or regional ice sheet situated in NVL when eruptions occur, and that the basal glacial thermal regime varied from wet-based to cold-based, presumably between 9.7 and 7.5 Ma ago.

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## Products

**A – papers in scientific magazines**


1. Armadillo, E., Ferraccioli, F., Zunino, A., Bozzo, E., Rocchi, S., and Armienti, P., 2007, Aeromagnetic search for Cenozoic magmatism over the Admiralty Mountains Block (East Antarctica): USGS OF-2007-1047, Short research Paper 075, p. 1-4.
2. Armienti P. Perinelli C. (2010) Cenozoic thermal evolution of lithospheric mantle in northern Victoria Land (Antarctica): evidences from mantle xenoliths. Tectonophysics, doi:10.1016/j.tecto.2010.02.006.
3. Bonini M., G. Corti, C. Del Ventisette, P. Manetti, G. Mulugeta, D. Sokoutis, (2007) Modelling the lithospheric rheology control on the Cretaceous rifting in West Antartica. Terra Nova, 19, 360-366; doi:10.1111/j.1365-3121.2007.00760.x
4. Coltorti M., Beccaluva L., Bonadiman C., Faccini B., Ntaflos T., Siena F. 2004. Amphibole genesis via metasomatic reaction with clinopyroxene in mantle xenoliths from Victoria Land, Antartica. Lithos Sp.Vol. Goldschmidt Conf, 75/1-2 pp 115-139.
5. Corti G., (2005) Dynamics of periodic instabilities during stretching of the continental lithosphere: View from centrifuge models and comparison with natural examples. Tectonics, 24, TC2008, doi:10.1029/2004TC001739.
6. Di Vincenzo G., Rocchi S., Rossetti F., Storti F. (2006) Dating brittle faulting: exploiting the complementarity of the step-heating and in situ 40Ar–39Ar laser techniques to solve the complexity of Cenozoic pseudotachylytes from the West Antarctic System. Terra Antartica Reports, 12, 49–56.
7. Di Vincenzo, G., Rocchi, S., Rossetti, F., and Storti, F., 2004, 40Ar–39Ar dating of pseudotachylytes: the effect of clast-hosted extraneous argon in Cenozoic fault-generated friction melts from the West Antarctic Rift System: Earth and Planetary Science Letters, v. 223, p. 349-364.
8. Ferraccioli, F., Armadillo, E., Zunino, A., Bozzo, E., Rocchi, S., and Armienti, P., 2009, Magmatic and tectonic patterns over the Northern Victoria Land sector of the Transantarctic Mountains from new aeromagnetic imaging: Tectonophysics, v. 478, p. 43-61.
9. Johnson, J. S., Hillebrand, C.-D., Smellie, J. L., and Rocchi, S., 2008, The last deglaciation of Cape Adare, northern Victoria Land, Antarctica: Antarctic Science, v. 20, p. 581-587.
10. LeMasurier, W., and Rocchi, S., 2005, Terrestrial record of post-Eocene climate history In Marie Byrd Land, West Antarctica: Geografiska Annaler, v. 87A, p. 1-16.
11. Nardini, I., Armienti, P., Rocchi, S., Dallai, L., Harrison, D., (2009) Sr-Nd-Pb-He-O isotope and geochemical constraints to the genesis of Cenozoic magmas from the West Antarctic rift. Journal of Petrology, 50, 1359-1375; doi:10.1093/petrology/egn082.
12. Perinelli C., Armienti P. & Dallai L. (2006): Geochemical and O-isotope constraints on the evolution of lithospheric mantle in the Ross Sea rift area (Antarctica). Contributions to Mineralogy and Petrology,151, pp. 245-266
13. Rocchi S., Armienti P., Di Vincenzo G., Nardini I., Rossetti F., Storti F. (2006) Tight link between Cenozoic magmatism and local-regional fault activity in the West Antarctic System. Terra Antartica Reports, 12, 73–80.
14. Rocchi, S., LeMasurier, W. E., and Di Vincenzo, G., 2006b, Oligocene to Holocene erosion and glacial history in Marie Byrd Land, West Antarctica, inferred from exhumation of the Dorrel Rock intrusive complex and from volcano morphologies: Geological Society of America Bulletin, v. 118, p. 991-1005, doi: 10.1130/B25675.1.
15. Rossetti F., Storti F., Busetti M., Lisker F., Di Vincenzo G., Läufer A., Rocchi S., Salvini F. (2006) Eocene initiation of Ross Sea dextral faulting and implications for East Antarctic neotectonics. Journal of the Geological Society, 163, 119–126.
16. Smellie J.L., Rocchi S., Armienti P. (2007) Joint Italian-British petrological-palaeoenvironmental investigations of Neogene volcanic sequences in northern Victoria Land. Terra Antartica Reports, vol. 13,pp 103-111.
17. Smellie J.L., Rocchi S., Armienti P. (2010) Late Miocene volcanic sequences in northern Victoria Land, Antarctica: 1 products of glaciovolcanic eruptions under different thermal regimes. Submitted to Bull. Vocanol.


**B – book chapters**


1. Coltorti M., Bonadiman C., Faccini B., Grégoire M., O'Reilly S.Y, Powell W. (2007) Amphibole from suprasubduction and intraplate litospheric mantle. Lithos SpIs Piccardo G.B, Muntener O. (eds) "Melt-rock reaction processes in the mantle and their bearing on mantle petrology, chemistry and rheology" Lithos 99, 68-84.
2. Perinelli C., Orlando A., Conte A. M., Armienti P., Borrini D., Faccini B. & Misiti V. (2008) - Metasomatism induced by alkaline magma on upper mantle of the Northern Victoria Land (Antarctica): an experimental approach. In

"Mantle metasomatism in intra-plate and suprasubduction settings", Coltorti, M. & Grégoire, M. (eds) Geological Society, London, Special Publications, 293, 197–221.DOI: 10.1144/SP293.10.

**C - proceedings of international conferences**

1. Armienti P. & Perinelli C. Local heating of lithosphere: a common source for Cenozoic magmatism and Transantartic Mountains uplift. Petrological evidence from north Victoria Land mantle peridotites. 7° Forum Italiano di Scienze della Terra; Rimini (Italia); 8-11 Settembre 2009.
2. Armienti P. & Perinelli C. - Cumulus processes in the upper mantle of northern Victoria Land (Antarctica): implications for the thermal evolution of sub-continental lithosphere. 33rd International Geological Congress 2008 ; Oslo (Norvegia), 6-14 Agosto 2008.
3. Bonini M., G. Corti, C. Del Ventisette, P. Manetti, 2007. Modelling the lithospheric rheology control on the Cretaceous rifting in West Antarctica. EGU General Assembly 2007, Vienna, Austria, 15-20 April 2007, Geophysical Research Abstracts, Vol. 9, 02890.
4. Coltorti M., Arai S., Bonadiman C., Faccini B., Ishimaru S. 2007. Nature of metasomatizing agents in suprasubduction and intraplate settings as deduced by glass and amphibole geochemistry. 17° Goldschmidt Conf, 19-24 August 2007, Koln, Germany.
5. Coltorti, M., Bonadiman, C., Faccini, B. 2007. Geochemical features of minerals and glasses in intraplate and suprasubduction lithospheric mantle. EGU 2007, Vienna 10-15 Aprile 2007.
6. Coltorti M., Bonadiman C., Faccini B., Melchiorre M., Ntaflos T., Siena F. 2006. Mantle Xenoliths from Northern Victoria Land, Antarctica: evidence for heterogeneous different lithospheric metasomatism. 16° Goldschmidt Conf, 27 August-1 September 2006, Melbourne, Australia.
7. Coltorti M., Bonadiman C. (invited) 2006. Metasomatism in intraplate and suprasubduction lithospheric mantle. 16° Goldschmidt Conf, 27 August-1 September 2006, Melbourne, Australia.
8. Coltorti M., Bonadiman C., Faccini B., Gregoire M., O'Reilly S. 2004. Amphiboles in mantle xenoliths from anorogenic and orogenic settings. Evidence bearings on different style of metasomatism and implication for Nb and Ti anomalies in calk-alkaline magmas. IGC2004, 20-28 Agosto 2004, Firenze.
9. Corti G., 2004. Centrifuge modelling of periodic instabilities during continental extension. GeoMod 2004 International Conference, Emetten - Lake Lucerne, Switzerland, 9-11 June 2004. Bollettino di Geofisica Teorica ed Applicata/, 45 (N. 1 supplement), 202-205.
10. Gemelli M., S. Rocchi, G. Di Vincenzo, J.L. Smellie. Mineralogical-geochemical-isotopic tools for the reconstruction of subglacial vs. marine eruptive paleoenvironment in Antarctica." IAVCEI 2008 General Assembly: Understanding Volcanoes Reykjavik, Islanda (17-22 Agosto, 2008
11. LeMasurier, W., and Rocchi, S., , The Case for a Late Oligocene-Early Miocene Ice Sheet in Marie Byrd Land, in AGU Meeting, San Francisco. 2004
12. Perinelli C., Armienti P. - Local heating of lithosphere in northern Victoria Land (Antarctica): a common source for Cenozoic magmatism and Transantartic Mountains uplift. Petrological evidence from mantle peridotites in AGU Meeting, San Francisco. 2009
13. Perinelli C., Andreozzi G.B., Armienti P., Conte A.M., Giuli G., Eeckhout S.G. - Continental spinel-peridotites from northern Victoria Land (Antarctica): relationships between oxidation state of upper mantle and metasomatism. 33rd International Geological Congress 2008 ; Oslo (Norvegia), 6-14 Agosto 2008.
14. Perinelli C., Orlando A., Conte A. M., Armienti P., Borrini D., Faccini B., Misiti V. - Experimental investigation on peridotite/alkaline-melt reactions: implications for metasomatism of northern Victoria Land (Antarctica) upper mantle . EMAW 2007 - European Mantle Workshop. Petrological evolution of the European Lithospheric mantle:from Archean to present day; Ferrara (Italia), 29-31 Agosto 2007.
15. Perinelli C., Orlando A., Conte A. M., Armienti P. & Borrini D. - Metasomatism induced by alkaline magma on upper mantle of the Northern Victoria Land (Antarctica): an experimental approach. EGU-European Geosciences Union- Congress; Vienna (Austria), 2-7 Aprile 2006.
16. Perinelli C. & Armienti P. - Pyroxenites and megacrysts in alkaline basaltic magmas from northern Victoria Land (Antarctica): constraint on the thermal evolution of sub-continental lithosphere. Peridotite Workshop 2005; Lanzo (Torino), 27-30 September 2005.
17. Perinelli C. & Armienti P. - Mantle xenoliths from northern Victoria Land (Antarctica): geochemical composition and implication for the evolution of the subcontinental lithosphere. 32nd International Geological Congress, Firenze (Italia), 20-28 Agosto 2004.
18. J. Smellie, S. Rocchi, M. Gemelli, G. Di Vincenzo, P. Armienti; "Late Miocene terrestrial record of East Antarctic Ice Sheet configuration and dynamics recorded by volcanic lithofacies and sequence characteristics in northern Victoria Land, Antarctica"; EGU, 02 – 07 Maggio 2010

**D – proceedings of national meetings and conferences**

1. Coltorti M. 2008. (invited). Metasomatism in mantle xenoliths from intraplate and suprasubduction settings. SIMP2008, Sestri Levante, September 8-12, 2008.
2. Coltorti M., Bonadiman C., Faccini B., Siena F. 2007. Metasomatism in intraplate and suprasubduction settings: a geochemical approach. FIST Geoitalia2007, Rimini, 13-15 Settembre 2007.

3. Coltorti M., Bonadiman C., Faccini B., Melchiorre M., Ntaflos T., Siena F. 2007. Different lithospheric domains in the Antarctic Lithospheric Mantle of Northern Victoria Land. FIST Geoitalia2007, Rimini, 13-15 Settembre 2007.
4. Coltorti M., Bonadiman C., Faccini B., Siena F. 2005. Minerals and glasses as indicators of metasomatic processes in the lithospheric mantle. FIST, Geoitalia2005, Spoleto 20-22 Settembre 2005.
5. Corti G., 2004. Centrifuge modelling of periodic instabilities during continental extension. GeoMod 2004 International Conference, Emetten - Lake Lucerne, Switzerland, 9-11 June 2004. Bollettino di Geofisica Teorica ed Applicata/, 45 (N. 1 supplement), 202-205.
6. Faccini B., Mantle xenoliths from Northern Victoria Land, Antarctica: evidence for heterogeneous Lithospheric metasomatism. Workshop PNRA-BAS "Geological and geophysical investigations from the Transtantarctic Mountains to Dome C", Genova, September 26, 2008.
7. Faccini B., Bonadiman C., Coltorti M., Melchiorre M., Ntaflos T., Siena F. 2006. Eterogeneità degli agenti metasomatici e delle condizioni termobarometriche nel mantello superiore della Terra Vittoria settentrionale. Workshop "Interazione evoluzione tettonica e magmatismo nella Terra Vittoria: contributi alla ricerca italiana nella NVL prospettive e ricerche future", Certosa di Pontignano, 13-14 Ottobre 2006.
8. Faccini B., Beccaluva L., Bonadiman C., Coltorti M., Ntaflos T., Siena F. 2005. Within-plate and suprasuduction metasomatisms in mantle amphiboles from Antarctica and Austria. A comparison with the case of Tallante. Progetto PRIN 2002, Evoluzione petrologica del sistema litosfera-astenosfera nell'area circum-tirrenica, Napoli 22 Aprile 2005.
9. Perinelli C., Orlando A., Conte A. M., Armienti P. & Borrini D. - Metasomatism induced by alkaline magma on upper mantle of the Northern Victoria Land (Antartica): an experimental approach. Convegno Geoitalia 2005, 5° Forum Italiano di Scienze della Terra; Spoleto (Perugia - Italia); 21-23 Settembre 2005.

**E – thematic maps**

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**F – patents, prototypes and data bases**

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**G – exhibits, organization of conferences, editing and similar**

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

1. Maurizio Gemelli - "Mineralogical, geochemical, and isotopic tools for the reconstruction of subglacial and marine eruptive paleoenvironments in Antarctica." Tesi di Dottorato, 2009
2. N°1 Assegno di ricerca U.O. 5 titolo "I processi metasomatici nella litosfera Antartica della Terra Vittoria"
3. N°1 Borsa di studio U.O. 6 titolo "Studio dei processi metasomatici nel mantello superiore nella Terra Vittoria settentrionale secondo l'approccio della petrologia sperimentale"
4. N°1 Assegno di ricerca U.O. 6 titolo "Studio sperimentale per la caratterizzazione della sorgente dei magmi primitivi cenozoici della Terra Vittoria settentrionale: implicazioni sull'evoluzione mineralogica e chimica del mantello superiore in relazione ad eventi metasomatici e di fusione parziale.

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**Date:** Pisa, 9 April 2010

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## *Notes*

Despite the very strong delays and the incomplete disbursement of funds (it was awarded the annual PEA2006 and therefore I require the expenses anticipated as reported in the attached statement of accounts), the program of ARMIEN7 project has been developed and have been adequately achieved excellent results both on the geology of Victoria Land, and on relation to general topics, advanced topics and original basic research, that can be extend to the study of other volcanic regions.

*Principal investigator*

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