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1D Numerical modelling of crustal heat transfer in the Antarctic glaciers of Northern Victoria Land

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The Antarctic glacial system is both highly sensitive to, and driver of global climate changes being as well sensitive to other external events, such as endogenous factors, that may affect glaciers energy balance. In this framework, thermal regime and heat flow evolution within the continental crust below the ice sheet must be considered. The present work focused on preliminary result of 1D numerical modelling of pure conductive heat transfer model pointing out the role of several factor in crustal heat transfer and its effects of thermal regime of east Antarctic glacial system. Here we present a case study on northern Victoria Land (Antarctica) glacial system ,a key site for investigating the amplitude of past ice volume variations in the East Antarctic Ice Sheet (EIAS, Baroni et al.[1]), comprising a relevant sector of the Transantarctic Mountains and the Mt. Melbourne Volcanic Province (MVP). With the support of thermo-barometric data obtained by the study of spinel-peridotites xenoliths, Armienti and Perinelli [2] inferred a change of mantle's geothermal gradients from 0.5 °C/km to 3 °C/km, as response to lithospheric thinning caused by Ross Sea Rifting. On the basis of such petrologic and geo-thermometric data, combined, in a first analysis, with bibliographic thermal properties of rock materials, a simulation of the heat flow propagation from the upper mantle across the continental crust has been performed. These data provided the input for a multi-parametric analysis that has assumed a stationary and conductive heat flow and was performed through a sensitivity approach by varying thermal parameters and stratigraphic profiles, i.e. considering different thickness for the different proportions of the continental crust. A local heat source in the upper crust has been also considered and no surficial thermal perturbation due to volcanic systems were modelled. The numerical model so defined, took into account a crustal heat flux of 120 mW/m^2 (Della Vedova et al. [3]), typical value of Victoria Land Basin, and temperature values at Moho ranging between 750 and 1450 °C. In addition we considered a sensitivity analysis to the ice thickness of the glacial system up to 800 m, according to Pleistocene EAIS variations and ice fluctuations amplitudes reconstructed in NVL (Strasky et al.[4]). At lateral boundary of 1D model a thermal isolation has been also assumed. The 1D thermal model, has been validated matching experimental data obtained from a nearby deep borehole (Morin et al. [5]), assumed as reference point, representative of the geodynamic and volcanic conditions of the study area, in which a

temperature of about 75 °C at depth of 1000 m b.s.l. has been reached. The modelling provides encouraging results, highlighting a main contribution of regional heat source and ice sheet thickness on the thermal regime of the upper crust respect to geometrical and thermal parameters. Our results lead to a deep origin in thermal perturbations of glacial system, which seems to be less sensitive to thermal anomalies in the upper crust. Notably, the high pressure accumulation (i.e. upper mantle/lover crust) of hot parental magmas in the Ross Island and MVP, that has been proposed on experimental (Iacovino et al. [6]) and cumulate rocks (Perinelli and Gaeta [7]) studies, proves the regional, deep thermal perturbations beneath the studied area. The 1D thermal model represent the basis for further analysis focused on the evaluation of thermo-mechanical interactions between bedrock and ice masses with particular interest on stress-strain effects on the kinematic of the glaciers.

References:

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