Ice dynamics inferred from the detection of icequake seismicity near the Princess Elisabeth base, eastern Dronning Maud Land, East-Antarctica

*Denis Lombardi, Guilhem Barruol[1], Lionel Benoit[2], Thierry Camelbeeck[3], Irina Gorodetskaya[4], Olivier Martin[5], Christophe Meynard[5], Christian Thom[5]

1. Institut de Physique du Globe, Paris, France, 2. Université de Lausanne, Lausanne, Switzerland, 3. Royal Observatory of Belgium, Brussels, Belgium, 4. Centre for Environmental and Marine Studies,University of Aveiro, Portugal, 5. Institut National de l’ Information Géographique et Forestière, St-Mandé, France

In a world threatened by a “climate crisis”, the polar regions have now become the center of attention of everyone, and in particular of the science community which developed new tools to investigate the cryosphere evolution. Here, we use “cryoseismology” to investigate the dynamics of the East Antarctic ice sheet near the Belgian Princess Elisabeth base (PEA) in the eastern Dronning Maud Land. Filling a ca. 1000 km wide gap between Novo and Syowa and located 200 km from the coast, PEA provides an incredibly balanced situation to study both the inland plateau and the coastal margin of the continent. In this study, we present the results of three passive seismic experiments conducted over the past 10 years inland and at the coast, in the vicinity of PEA.

Inland, the permanent seismic station allows the detection of thousands of surface waves dominated icequakes. Their occurrence is anti-correlated with surface temperatures which are modulated by diurnal solar radiation variations in summer and by episodes of cold katabatic regimes in winter. The locations of these icequakes point towards nearby blue ice areas suggesting these events are related to thermal contraction of the blue ice areas, creating thin surface crevasses. These thermally induced icequakes can be regarded as a proxy for monitoring the thermal state of ablation surface. To study the ice-related seismicity on a wider region, five additional temporary broadband seismic stations separated by 25-30 km were deployed for a 3 month duration allowing for the detection of nearly one thousand seismic events, one third being reliably located. Most of these events occur in areas where the ice sheet meets the mountains outcrops at the edge of the polar plateau, at the initiation of narrow and thin outlet glaciers and characterized by intense ice deformation. Only one event cluster departs from this observation and hypothetical sliding of thick ice layer may be evoked.

At the coast, the dynamics of ice shelves is dominated by its shear margin and its interactions with the ocean. To monitor this sensitive zone, two temporary experiments were conducted with light weight seismic and GPS devices for about 1 month each. Our study indicated that this zone experiences periodic seismic activity resulting from surface crevassing during oceanic tide-induced flexure of the ice shelf. Furthermore, apparent fortnightly tide-modulated low-frequency, long-duration seismic events are originating near the ice shelf rifting characterizing the seaward front of an ice rise promontory. A basal origin for these events may be postulated explained by ocean water surge at each new spring tide triggering basal crevassing. In addition, other low-frequency seismic events are also found upstream of the grounding line and their clustered location and occurrence at low tide may suggest the presence of a subglacial topography such as an esker, a glacial deposit feature, as it has been suggested by a previous ground penetrating radar study. We acknowledge detection and monitoring of such seismicity may help identifying the characteristics of ice shelves sensitive to external forcing.

Keywords: cryoseismology, icequake, ice sheet, antarctica, ice shelf