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(Examples)

Is submarine groundwater discharge a control on Arctic permafrost-associated gas hydrate formation on the Beaufort Shelf?

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Methane hydrate is an ice-like solid that can sequester large quantities of methane gas in marine sediments along most continental margins where thermodynamic conditions permit its formation. Along the circum-Arctic shelf, relict permafrost-associated methane hydrate deposits formed when non-glaciated portions of the shelf experienced sub-aerial exposure during ocean transgressions. Gas hydrate stability and the permeability of circum-Arctic shelf sediments to gas migration is closely linked with relict submarine permafrost. Heat flow observations on the Alaskan North Slope and Canadian Beaufort Shelf suggest the movement of groundwater offshore, but direct observations of groundwater flow do not exist. Submarine groundwater discharge, an offshore flow of fresh terrestrial water, can affect the temperature and salinity field in shelf sediments, and may be an important factor in submarine permafrost and gas hydrate evolution on the Arctic continental shelf. Submarine groundwater discharge may also enhance the transport of organic matter for methanogenesis within marine sediments. Because it is buoyancy-driven, the velocity field contains regions with a vertical (upward) component as groundwater flows offshore. This combination of factors makes submarine groundwater discharge a potential mechanism controlling permafrost-associated gas hydrate evolution on the Arctic continental shelf.

In this study, we quantitatively investigate the feasibility of submarine groundwater discharge as a control on permafrost-associated gas hydrate formation on the Arctic continental shelf, using the Canadian Beaufort Shelf as an example. We have developed a shelf-scale, two-dimensional numerical model based on the finite volume method for two-phase flow of pore fluid and methane gas within Arctic shelf sediments. The model tracks the evolution of the pressure, temperature, salinity, methane gas, methane hydrate, and permafrost fields given imposed boundary conditions, with latent heat of water ice and hydrate formation included. The permeability structure of the sediments is coupled to changes in the permafrost and gas hydrate deposits, and the model can be run over several glacial cycles. Model development and preliminary results will be presented.

The North Greenland dyke swarm within the Greenland-Svalbard convergenze zone

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Late Cretaceous isotopic ages, mainly in the 81 to 69 Ma range, have been obtained for the North Greenland Dyke Swarm which coincide with the Greenland-Svalbard convergence. Isotope, REE and trace element data support derivation of the dyke parent magmas from MORB to OIB sources which were subject to some limited lower crustal contamination. Ar/Ar isotopic ages obtained from the mylonites in the Eurekan fold belt of North Greenland suggest that the main thrust emplacement ended in Palaeocene time, prior to the onset of sea floor spreading in the Eurasian Basin. Aeromagnetic data show that the onshore North Greenland Dyke Swarm is continuous with N-S and NW-SE trending linear anomalies which extend, unbroken, 150 km across the Lincoln Sea indicating that there has been no significant strike-slip displacement between Ellesmere Island and North Greenland. The dyke and the offshore magnetic anomalies distribution appears to have been controlled by the boundary conditions as they are continuously orthogonal to the North Greenland margin. The intrusion of these dykes appears to have been guided by tension gash like fractures generated by the 200 km Greenland-Svalbard convergence produced by the anticlockwise rotation of the Greenland craton following the opening of the Labrador Sea-Baffin Bay basins. The further northward opening of these basins was prevented by the presence of the strong northern border of the thinned continental lithosphere of the Lincoln Sea and the oceanic lithosphere of the Alpha Ridge-Makarov Basin. As a consequence sea floor spreading jumped to the North Atlantic- Eurasian Basin. The continued northward motion of Greenland during this time coincided with a switch from orthogonal to oblique convergence to across the Greenland Svalbard Margin.

Early Carboniferous (?) volcanic complex of the Wrangel Island

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Structure of Wrangel Island belong to Wrangel–Herald Arch which is a linear rise the Eastern Arctic shelf sedimentary cover’s basement. It composed of Neoproterozoic metamorphic basement (Berri Formation, Wrangel Complex) and carbonate and clastic Upper Silurian–Triassic sediments (Til'man et al. 1964; Kos'ko et al. 2003) which are complexly folded with north vergency. During 2006 an International expedition organized by Geological Institute RAS, carried out comprehensive studies that led to several important conclusions.

1. U-Pb SHRIMP zircon dating for conformable bodies of gneissosed and foliated granitoides been confirmed metamorphic rocks of Neoproterozoic age: 702.3 Ma (N=19), 701.7 Ma (N=3), 707.4 Ma (N=25). Furthermore, some zircons contain inherited cores: (1.1-2.6 Ga). These data suggest presence of ancient (Neoproterozoic-Mesoproterozoic) rocks in the basement of Wrangel Island (Luchitskaya et al. 2014).

2. Fundamentally new results of the mesostructural studies (Verzhbitskii et. al. 2014) were establishment of different structural styles in the Carboniferous–Triassic (sublatitudinally striking compression structures) and the Silurian–Lower Devonian complexes (with submeridional strike). This fact, as well as the presence of conglomerates in the Upper Devonian–Lower Carboniferous (Til'man et al. 1964; Kos'ko et al. 2003) implies the presence of a structural unconformity between these complexes. Thus, this is the first evidence of the Ellesmerian orogeny in Wrangel Island. It is important to examine the geodynamic position of Early Carboniferous (?) magmatism which may be associated with the Post-Ellesmerian event.

The volcanic rock exposed in the central part of the island along Neizvestnaya River banks, were collected. It overlain by Lower-Middle Carboniferous limestones. A discontinuous exposure of basal conglomerate separates the carbonate and volcanic rocks. Basal conglomerates contain fragments of metamorphic rocks and underlying volcanites. Both the volcanic rocks and carbonate are in fault contact with Devonian slate. There are different points of views on the age: (1) Proterozoic (Kameneva, 1975) and Lower Cambrian; (2) Early Carboniferous (Ageev 1979, Cecil, kosko). The apparent thicknesses of volcanic rocks are about 150-200 m.

Six basalt samples were analyzed. The volcanic rocks are basaltic in composition and metamorphosed in greenschist facies. Geocemical composition (high LILE, HFSE, TiO_2, REE concentrations and they соотношения) suggest basalts were formed from enriched melt. On TiO_2/Yb vs Nb/Yb diagram (Pearce 2008) samples fall in OIB field, reflecting melt origin below continental lithosphere during early stage of its destruction. Strong negative Nb-Ta and Zr anomalies (Nb/Nb*=0.26-0.60; Ta/Ta*=0.34-0.63) indicate most likely the interaction between melt and continental crust during its ascent to the surface.

Conclusions: Early Carboniferous (?) volcanic rocks reflect rifting event, and may be associated with Post-Ellesmerian tectonic reorganization.

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