Widespread deposition of a seismically distinctive unit across Canada Basin and southern Alpha Ridge during the initial period of basin subsidence

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Summary

The harsh environment of the Arctic Ocean hinders geophysical investigation of underlying Canada Basin and southern Alpha Ridge. Shielded by thick perennial sea ice, fundamental questions remain about the geology and tectonic evolution of this basin and its surrounding margins. In 2006, seismic reflection data coverage totalled less than about 3000 km and was mainly concentrated outside regions of multiyear ice. A modern system for seismic acquisition using a single icebreaker was designed and tested, resulting in successful collection of basin-scale transects in 2007 under heavy ice conditions. Then, in 2008 and 2009, surveying continued with two icebreakers operating jointly under a program between Canada and the United States. Altogether, 9866 km of good quality 16-channel, vertical incidence seismic reflection data have been acquired. Coincident data include 82 records of wide-angle reflection and refraction data recorded using expendable sonobuoys, single- and multibeam bathymetric soundings, and gravimetric profiles. A coordinated effort is underway with these datasets to determine the crustal types, rifting processes, subsidence history, and sedimentary sequences of this poorly known region.

The seismic reflection data reveal over a dozen seismostratigraphic units that have been mapped across Canada Basin and onto the southern flank of Alpha Ridge. In some regions the entire sedimentary sequence exceeds 4.5 s in two-way travel time, or about 6.5 km in thickness. Units generally thin northward, toward Alpha Ridge, and onlap the oldest regionally mappable unit which is informally named “bisque”. Characterized by high amplitude, continuous, parallel and subparallel internal reflections, the bisque unit averages about 0.3 s, or about 600 m, in thickness, although there are significant local variations. Along southern Alpha Ridge, the base of the bisque unit is marked by a prominent angular unconformity which can be traced into Canada Basin, but which is eventually obscured by thick overlying units. Though affected by faulting and compaction drape, the bisque unit appears to be concordant with the underlying topography of the acoustic basement. It is also spatially and temporally associated with large structures that are interpreted to be volcanic edifices.

Across the entire survey area, 62 of the 82 sonobuoy records clearly exhibit seismic phases with anomalously low apparent velocities. These are interpreted as phases that underwent P- to S-wave conversion, and also S- to P-wave conversion, at discrete unit boundaries. Forward modelling of the ray-paths demonstrates that the mode-conversion is associated with the top and base of the bisque unit, and possibly also from strong reflectors within the bisque unit. Interval velocities within the bisque unit range from 2.1 km/s, in shallowly buried regions of southern Alpha Ridge, to 4.2 km/s in more deeply buried regions of Canada Basin.

The bisque unit is interpreted to consist of layered biogenic and volcanogenic sediments associated with widespread volcanism along Alpha Ridge and the Canadian Arctic margin. The volcanogenic facies may correlate with mid to upper Cretaceous tuffs of the Christopher and Kanguk formations on Banks and Prince Patrick islands. Though the bisque unit is not yet sampled, it is clearly an important tectonostratigraphic marker deposited during the initial period of subsidence across Canada Basin.