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Ice Observations

I. Introduction

Throughout cruise NBP07-09 a team of 9 volunteers made 192 observations of local sea ice conditions over a period of 63 days broken up into two voyages. The protocol used was devised by the ASPeCt (Antarctic Sea Ice Processes and Climate) working group of the Scientific Committee of Antarctic Research (SCAR). This data set was supplemented by estimates of the number of icebergs. The data were recorded manually and transcribed into electronic format for inclusion in the cruise data set. The observations are necessarily subjective and reflections of each person's individual biases are inevitable, but when taken as a whole, the data set reveals some statistically valid trends.

II. Methods

Four groups of 2-3 began conducting the ice observations. This process entailed making qualitative observations every hour (GMT) of sea ice conditions, weather, and iceberg conditions from the bridge of the RVIB Nathanial B. Palmer and recording them onto the ASPeCt standard log sheets. The observations included recording the latitude, longitude, overall sea ice concentration, and conditions for the primary, secondary, and tertiary ice types (if any) observed. The ice type descriptions incorporated the concentration of each ice type with regards to the overall concentration, ice type, ice thickness, floe size, topography, snow cover, and snow depth. The air/water temperature, wind speed, and direction were recorded from the vessel's underway data acquisition system (DAS). NOAA's meteorological observation weather codes were used to identify the weather conditions for precipitation and visibility. Observations incorporated ice conditions within 1km from the ship per the ASPeCt protocol, and used radar images to estimate approximate icebergs within 6 nautical miles. During stops for CTD casts, XBT launches, and ice coring no ice observations were made as was noted in the comments section of the ASPeCt spreadsheet.

One informal training session was held for the collective group on the SIMBA cruise that didn't specifically cover all the information in the ASPeCt tutorial; however, most observers had prior training on past cruises. Therefore, individual training was conducted via the ASPeCt tutorial made available on the ship's network. Experienced observers were distributed on each shift accordingly in order to help limit potential errors from biased classification observation. In order to help determine the scale of ice thickness, an inflatable ball 0.5 meters in diameter was installed on the starboard side of the ship to gauge ice thickness more accurately as it was being overturned by the ship. Additionally, two time lapse cameras were installed with a 5 second shutter speed to help capture the ice conditions from the starboard side and the ice tower. An analysis of the captured video will help compare subjective ice observations on the ASPeCt log sheet with real time ice conditions to determine any errors that may be inherent

with ASPeCt standards.

Approximate iceberg observations were determined from a repeater display running from the bridge navigation radar and visual bias. Estimates could only be made because any accurate iceberg counts would depend on visibility conditions, and since the radar iceberg counts were taken simultaneously with the ship's movement, successive observations would incorporate the same icebergs. In addition, the radar could not distinguish between large or small bergs, so a general range was determined for the counts.

The observation log sheets were transcribed into the ASPeCt database provided in the training tutorial. This format allowed for checks when inputting the observation data to correct any mismatched codes that may have been recorded when describing ice conditions. Due to the nature of the area studied, some of the standardized codes in the ASPeCt database needed to be overwritten. This was recommended in order to clearly capture ice conditions in this area that may appear inconsistent with past observations in other areas of Antarctica.

III. Limitations

Some problems should be acknowledged regarding ice observations including the subjective nature of deciding on ice classifications, having a mixture of experienced and inexperienced observers, little prior knowledge of ice conditions for the Bellingshausen Sea areas, and limitations in visibility. Some inconsistencies in ice observations found on this trip were that every observer had their own individual perception of how to categorize the ice conditions during each observation. Four groups of three were initially required to maintain shifts for 6 hours each, but after observations made at Palmer Station, that proved to be excessive, and the observations were narrowed down to 1-2 persons per 6 hour shift. This helped minimize any potential errors; since experienced observers may disagree on certain sea ice classifications, it became difficult to agree on conditions with too many other inexperienced observers. Fortunately, the mounted cameras will help to alleviate these problems.

The ice type, concentration, and ridging varied slightly during the observation periods which caused some delays in the time of ice observation. These delays led to additional problems since there was a constant fluctuation of ice types being observed. These changes were noted in the comments section of the ASPeCt spreadsheet. The visibility was fair overall throughout the cruise except at night when there was a large amount of precipitation or fog. Ultimately night observations were made by the light emitted from the ship at a range of a few tens of meters.

The majority of incidences where the ASPeCt software internal checks had to be overwritten were with regards to the thickness of what was being considered pancake ice and multiyear ice. The set parameters did not always coincide with what was observed in both areas. Although pancakes were observed with the ice around Palmer Station and Ice Station Belgica, the thickness of what we observed correlated with young grey ice or first year ice. Therefore, the software would consider that our observations were

overestimated. A similar problem was found with multiyear ice. The ASPeCt software overestimated what we considered multiyear ice that fell into the first year ice >1.2m category. Although the first year ice states anything >1.2m, it doesn't specify the optimal range, and therefore, causes some ambiguity with that category. Although what was recorded as multiyear ice was thinner than the ~200m minimum required for the ASPeCt software, the corrections were noted in the comment section of the ice observations. In addition, the option for describing the topography for brash, frazil, and grease wasn't listed; they therefore were recorded as 0.

IV. Results
The first set of ice observations were conducted during September 6 – September 9 while entering and departing Palmer Station, Antarctica in the Bellingshausen Sea beginning at 3:00 GMT. According to ASPeCt statistics the overall concentration of this area were as follows:

Total ice concentration (%):	67.73
Open water within pack (%):	32.27
Av level ice thickness (total area) cm:	18.70
Av level ice thickness (ice area) cm:	27.61
Fraction of surface area ridged (%):	0.03
Av ridged ice thickness (total area) cm:	23.41
Av ridged ice thickness (ice area) cm:	34.57
Av snow thickness (total area) cm:	3.93
Av snow thickness (ice area) cm:	5.80
Av snow thickness (snow covered area) cm:	8.72
Snow covered ice within pack (total area):	45.00
Snow free ice within pack (total area):	22.73
Percent ice with snow cover:	66.44
Percent ice with no snow:	33.56

Our manual observation shows that upon entering the ice edge a 90 to 100% overall concentration of pancake ice was observed with some small secondary concentrations of nilas and frazil. The pancake ice was recorded as approximately 15 – 50 cm, with the thickness increasing further into the ice edge, while the snow depth remained constant at approximately 10 cm (Figure 1).
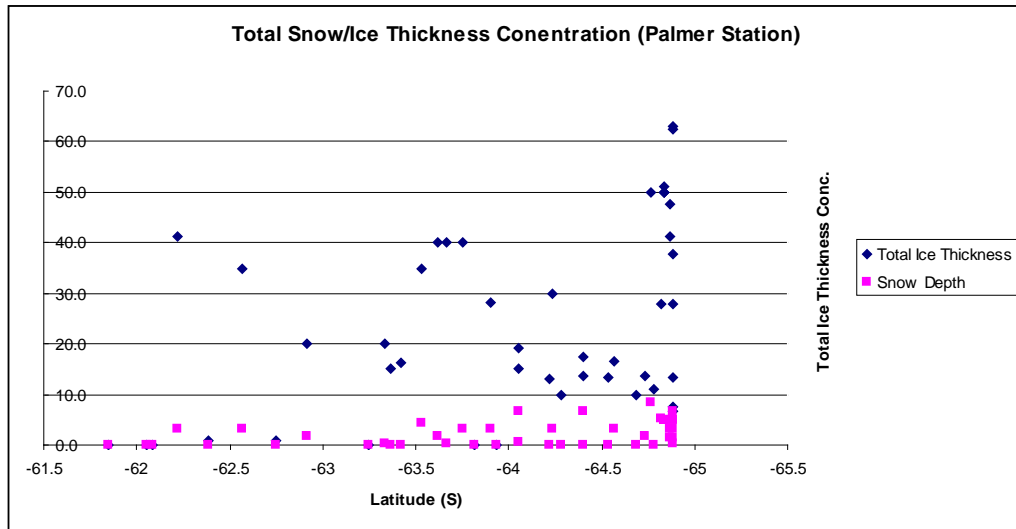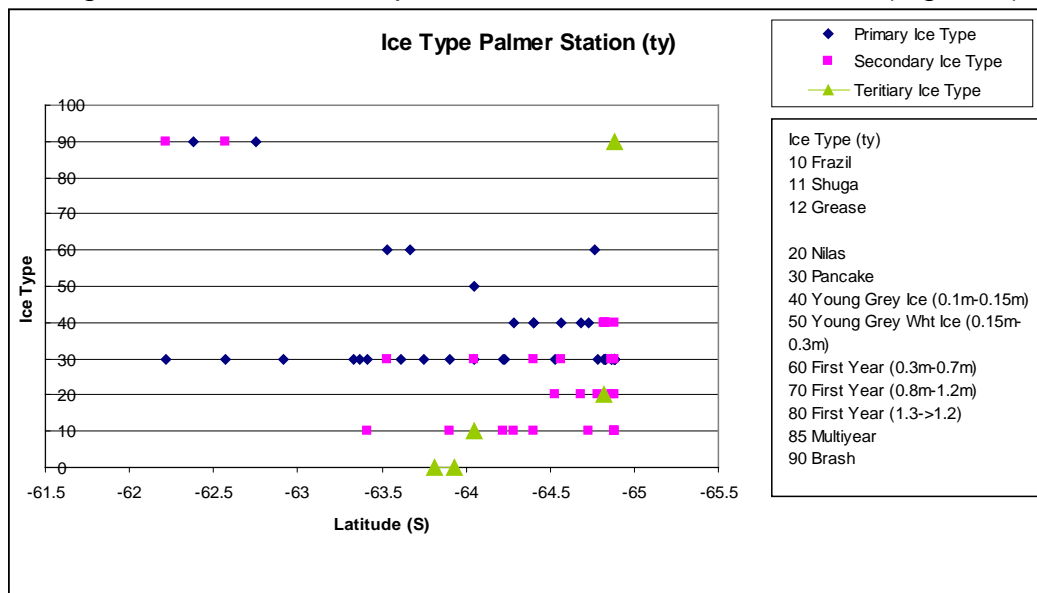

Figure 1. Ice thickness and snow depth trends incoming and outgoing from Palmer Station, Antarctica September 6- September 9, 2007.

Also, with increased latitude into the ice edge, a higher concentration of nilas is observed at almost 50% on average. Both of these ice types show a floe type average of 100 and 400 for pancakes, and 0 and 200 for nilas (Figure 2).
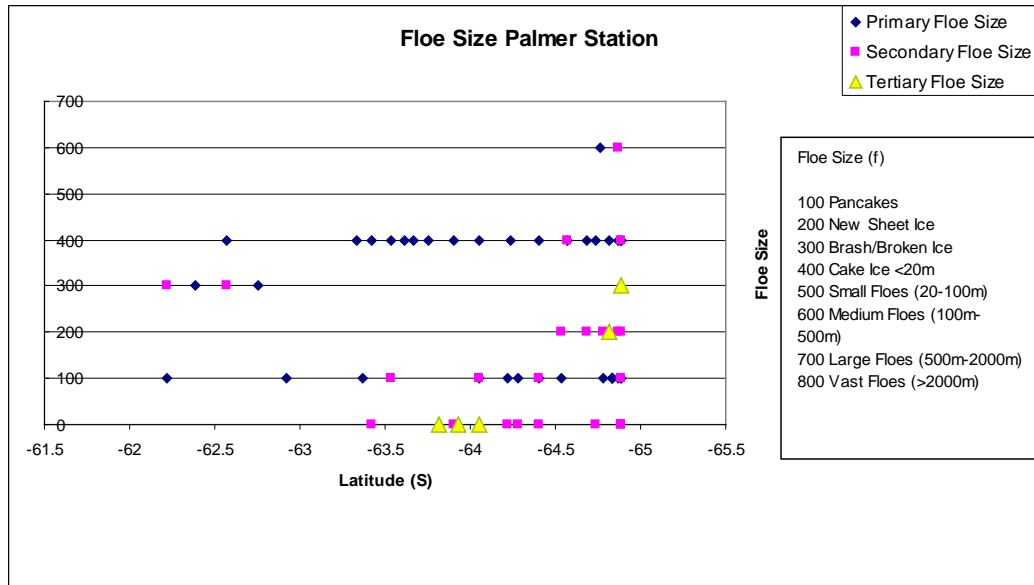
Figure 2. Ice type and floe size for each primary, secondary, and tertiary ice types at Palmer Station September 6 – September 9, 2007.

Icebergs were not notated during this time due to the lack of radar resources at the time. In addition, the NOAA visibility codes were unavailable at this time but it was noted that visibility was very good with an average of 6/8 to 8/8 cloud cover. SSMI, Quickscat, and Amsr-e data showed a steady increase of thickening ice conditions closer toward the continent which is what these trends show for the ASPeCt observations.

The second set of ice observations was conducted from September 25 – 27, 2007 upon entering into the ice edge in the Bellingshausen Sea at 17:00 GMT and upon our departure on October 24 – 27, 2007 at 11:30 GMT. We first encountered small concentrations of frazil and brash on the outer ice edge and then it abruptly changed into (60) first year ice at -69°13 latitude and -89°55 longitude during our incoming route. According to ASPeCt statistics the overall concentration of this area were as follows:

Total ice concentration:	89.64
Open water within pack:	10.36
Av level ice thickness (total area) cm:	80.80
Av level ice thickness (ice area) cm:	90.14
Fraction of surface area ridged:	0.10
Av ridged ice thickness (total area) cm:	111.39
Av ridged ice thickness (ice area) cm:	124.26

Av snow thickness (total area) cm:	28.48
Av snow thickness (ice area) cm:	31.77
Av snow thickness (snow covered area) cm:	34.41
Snow covered ice within pack (total area):	82.77
Snow free ice within pack (total area):	7.05
Percent ice with snow cover:	92.15
Percent ice with no snow:	7.85

Our manual observations showed that the average total ice thickness primarily ranged from 70-200 cm with the majority lying in the 50-200 cm range. Then snow depth became increasingly thicker with lower latitude and higher ice thickness (Figure 3).
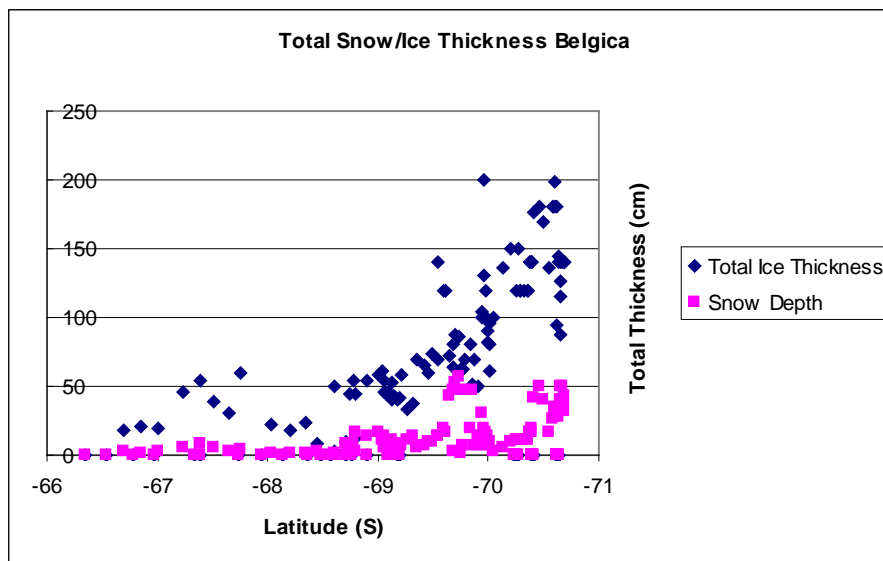

Figure 3. Ice thickness and snow depth trends incoming and outgoing from Ice Station Belgica, September 24 - October 27, 2007.

The ice types shown in Figure 4 indicate that the primary ice type between -69° and -70° at Belgica are first year and multiyear ice. These floes began from Belgica as large or vast floes, eventually becoming smaller and thinner as pancake ice when the floes neared the ice edge, and became broken up by swells or compacted with wind drift. Some leads were stable around Belgica but constantly shifted with the floes. Secondary pancake ice was observed on the outer edge, and was followed by a thickening of first year ice closer to Belgica. The tertiary ice type was predominantly brash or frazil, which formed in between the smaller flows and leads toward the edge. The middle point in the ice edge

began to see nilas forming but either turned into brash toward the multiyear or frazil as it went toward the edge. Some combinations of the multiyear and first year ice types also showed some flooding that was noted in the comments section as we were departing Belgica.
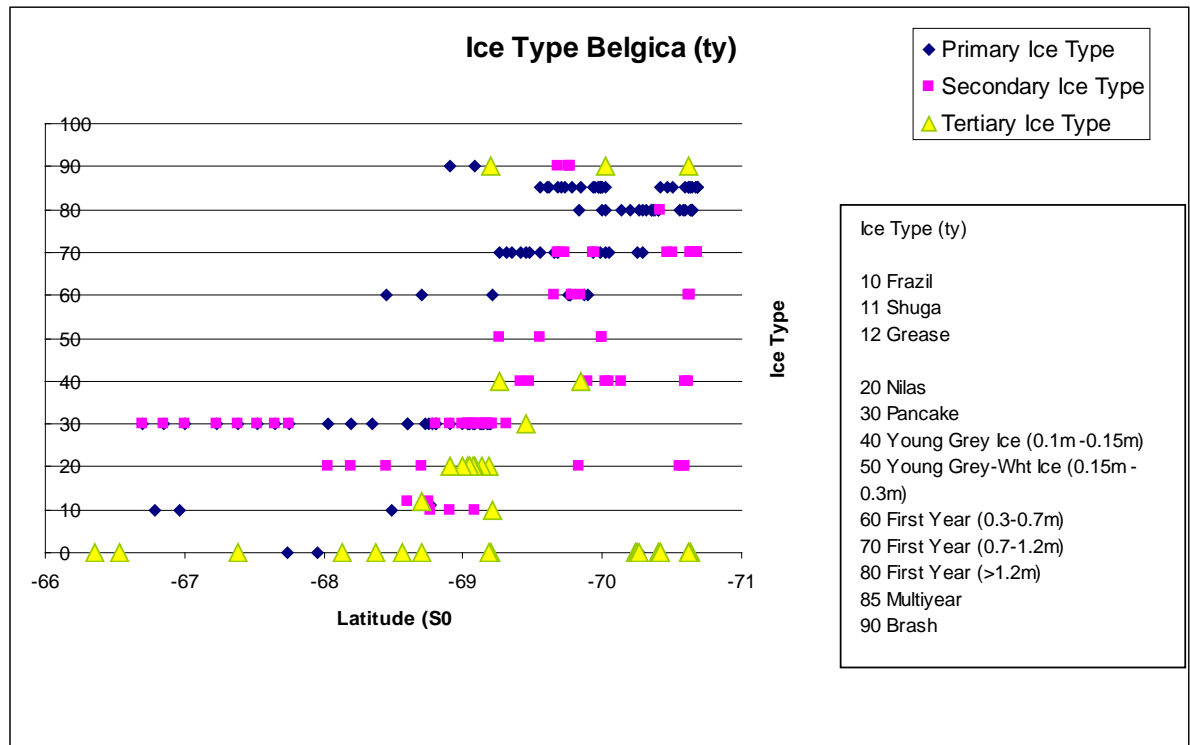

Figure 4. Ice types for Belgica for primary, secondary, and tertiary ice types.

As we left the ice edge on October 27th, 2007, a similar abrupt change from 90% ice concentration of 25cm pancake ice to 100% open water was recorded similar to our data upon entering the ice edge. As we approached Peter I island, the first year ice ended and pancake ice became more prevalent. Some remote sensing data show similar trends shown in the next section. Geophysical analysis of this area at 3 sites (Fabra, Brussels, and Patria) additionally supports these assessments per the ASPeCt data.

V. Remote Sensing
          Remote sensing imagery was received from three different sources. The R/V Palmer's Terrascan station was used throughout the cruise for receiving SSMI and was quite reliable. Other imagery used was split between those received from the Naval Ice Center (NIC) and those obtained from Polar View via Burcu Cicek (UTSA). These images consisted of AMSR-E (12km), ENVISAT (1km), ASAR, and Quickscat (12km). Quickscat, AMSR, and Envisat imagery were utilized as the Palmer made its second transit to the edge on 18 Sep. Other imagery from as far back as 30 Aug was received, but not until the ships email system came on line the third week of September.
    13 RADARSAT (100m) images have been ordered via the NIC. 10 images were ordered for our operating area and 3 in the East Antarctic for the Aurora

Australis. The first radarsat image was received 12 Oct and the others will follow into Nov. To date 4 have been received for the Palmer and 2 for the Australis. Once received radarsat images were overlaid with coordinates, and the ships position when applicable using GIS software.

Beginning 27 Sep MODIS imagery from the NIC was also received when the skies were clear enough to make it useful. This imagery was particularly helpful in delineating floe boundaries. Figure 5 shows some of the better examples of the ice conditions transmitted through Radarsat.
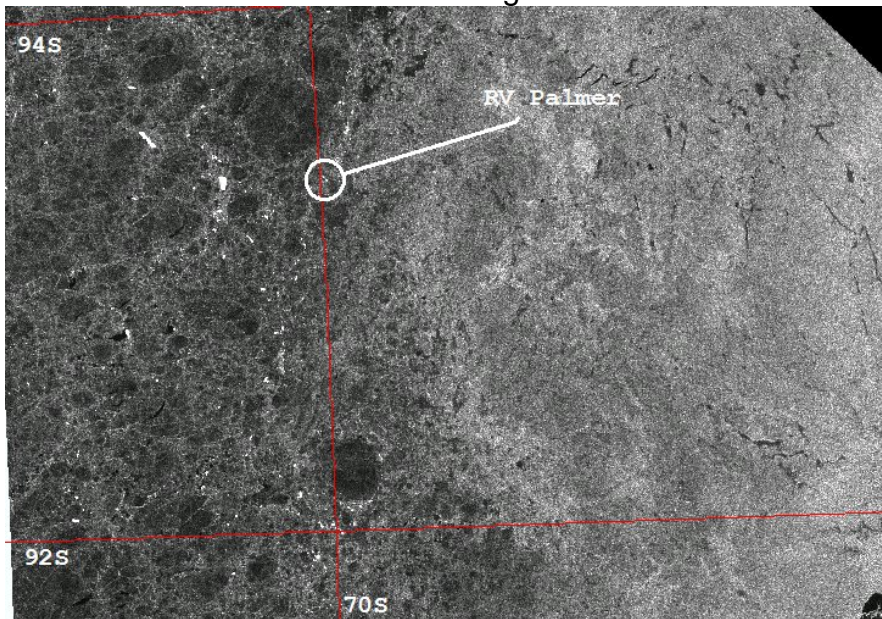

Figure 5. Placement of RVIB Nathanial B. Palmer at Belgica

Many of the images received as jpeg files were georeferenced using GIS software and processed further by overlaying coordinate information. Some images were also received as raw geotiff files with embedded data. The geotiff images provide the added utility of being able to manipulate and further exploit the data. Many of the geotiff files were too large to be received through the ships email system so they were compressed using Mr Sid software. After compression these files took on the .sid extension, but are still essentially geotiff files. All of these images were posted to the R/V Palmer LAN for easy access to those interested. In addition to remote sensing imagery there was also access to IR and visible imagery from NOAA and DMSP via Terrascan. With resolutions of NOAA (2km) and DMSP (500m) this imagery was also useful for observing ice features when sky conditions allowed. Selected images were annotated and archived to the ships LAN.

In addition some images were made into a project for use in the PolarTREC educational outreach program. The objective of the project is to teach students about different types of satellite imagery, its uses on the SIMBA project, and various types of sensors used on satellite spacecraft.

VI. Conclusions

The sea ice observations conducted on the SIMBA cruise have helped to capture undefined conditions in the Bellingshausen Sea during the winter months with support of simultaneous time lapse pictures and geophysical data. Constant fluctuation of thinner ice types was frequent for conditions in the Bellingshausen Sea, whereas the thick pack-ice was consistent until we began to get closer to the ice edge where the floes were susceptible to swell and drift displacement. Many small icebergs were prevalent until we passed Peter I island where the ice became a mixture of pancake and frazil. Besides a small polyna that was observed on our departure from Belgica at Peter I island, the snow concentration remained constant. Towards the end of the cruise as the spring season was approaching, the ice edge seemed to retreat per images transmitted from radar images such as Radarsat and Envisat. With these resources, and the ASPeCt observations, we can determine preliminary ice conditions for this region to set a precedent for future studies.

Notes

The ice observations recorded during the SIMBA cruise and transcribed into electronic format will be submitted to the ASPeCt data office at the Antarctic Cooperative Research Centre, University of Tasmania. For further information on the observation on the observation program please contact:

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