TITLE: Laboratory Studies of Baroclinic Instability at Small Richardson Number

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SIGNIFICANT ACCOMPLISHMENTS IN FY-84:

As part of the scientific support studies program for the AGCE, laboratory studies of baroclinic and other convective instabilities have been performed for a thin layer of fluid between thermally conducting horizontal discs. A horizontal gradient is equally imposed upon the two (sapphire) discs, while a vertical temperature difference is also imposed. The apparatus is rotated with constant angular velocity. The Richardson number (Ri) is thereby controlled and can be made on the average arbitrarily small or large (although there can be a large spatial variation within the fluid volume).

There have been three types of modes identified. The first has a "spiral-arm" appearance, and exists for large enough horizontal thermal forcing, weak enough static stability, and large enough rotation. The source of this wave has been shown to be the Eady mode of instability by performing comparative experiments with the more traditional side-heated apparatus.

The second mode is due to convective instability in the thermal boundary layers which exist due to the thermally conducting horizontal boundaries. Without rotation, this appears as small-scale radially oriented rolls. For slow rotation, the rolls are skewed into a spiral. If the static stability is not large (and especially for negative static stability), these spirals persist for large enough rotation that the rolls appear to extend through the interior of the fluid. The appearance is almost symmetric for these higher rotation rates. Because this phenomenon does not occur for moderate-to-large horizontal heating, we do not believe this to be the symmetric (or almost symmetric) baroclinic instability (Solberg mode).

Finally, for strong enough negative static stability, thermal convection of the Benard type, but under the influence of rotation and horizontal heating, appears. We have not pursued a study of these modes in much detail.

Probably the most significant result of our research is that the symmetric (Solberg) mode was <u>not</u> found, even though it would be expected under certain experimental conditions according to infinite-plane theory.

PLANS FOR FY-85:

Laboratory studies will be coordinated with theoretical studies in an attempt to explain the lack of appearance thus far of the symmetric modes. (See the report by Miller, herein.) Some minor modifications to the apparatus may be necessary to allow the simultaneous imposition of small Ri, large thermal Rossby number, and small Ekman number.

We shall begin studies with an apparatus with differentially rotating top and bottom boundaries. Continuous stratification will be provided by heating and cooling the top and bottom surfaces, respectively, analogous to the two-layer experiments of Hart.

RECOMMENDATIONS FOR FURTHER RESEARCH:

Detailed study of the second and third modes above would also have great relevance to GFFC. It would be advisable to perform such studies as scientific back-up for GFFC.

The Eady modes seen in this study have striking visual similarities to cold fronts in the troposphere. More detailed studies, mapping temperature and velocity fields, may prove to be very valuable aids to developing and testing theories of frontogenesis. Such studies are recommended.

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T. L. Miller and W. W. Fowlis, "Baroclinic Instability at Small Richardson Number," Bull. APS, 28(9), 1369 (1983) (36th Meeting of the Division of Fluid Dynamics of the American Physical Society, Houston, Texas, November, 1983).