Int. J. Heat Mass Transfer. Vol. 22, pp. 1687–1693.
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0017-9310/79/1201-1687 $02.00/0

A NOTE ON THE FORMATION OF "SALT-FINGER" AND "DIFFUSIVE" INTERFACES IN THREE-COMPONENT SYSTEMS

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(*Received* 15 *November* 1978)

Abstract – Thin density interfaces determine the fluxes of heat or solute through doubly-diffusive convection. Vertical transports are achieved by either "salt finger" convection or molecular diffusion. The influence of a third diffusing property upon the type of interface formed at an initial density discontinuity is explored here. There may be a strong dependence upon molecular diffusivities, and some interfaces are observed to have a complicated structure.

NOMENCLATURE

C_i,	concentration of the ith component [kg m^{-3}];
ΔC_i,	concentration difference between lower and upper layers [kg m^{-3}];
g,	acceleration due to gravity [ms^{-2}];
h,	a vertical length scale;
R_i,	Rayleigh number for the ith component;
R_1,	Rayleigh number for the fastest-diffusing component;
R_ρ,	ratio of stabilizing to destabilizing contributions to the density step;
R'_ρ,	$= R_\rho^{-1}$;
t, z,	time and vertical space coordinates;
Greek symbols	
$\alpha\Delta T$,	dimensionless density step due to temperature;
$\beta\Delta S$,	dimensionless density step due to salt;
β_i,	expansion coefficients [m^3 Kg^{-1}];
κ_T, κ_S,	molecular diffusion coefficients for heat and salt [m^2 s^{-1}];
κ_i,	diffusivity of the ith component [m^2 s^{-1}];
κ_1,	the greatest diffusivity [m^2 s^{-1}];
ν,	kinematic viscosity of fluid [m^2 s^{-1}];
ρ, ρ_m,	density and mean density of fluid [kg m^{-3}];
τ_i	$= \kappa_i/\kappa_1$, ratio of diffusivities.

1. INTRODUCTION

DOUBLE-DIFFUSIVE convection is characterized by well-mixed convecting layers which are separated by relatively sharp density steps. These steps may be of the "salt finger" or "diffusive" kind [1] and both types of interface must enable a net release of potential energy by preferentially transporting the "destabilizing" property, where a "destabilizing" concentration gradient refers to one which tends to cause the fluid density to increase with height. "Salt finger" interfaces contain up- and down-going columns of fluid which most rapidly transport the property with the smaller molecular diffusivity. "Diffusive" interfaces occur when the faster-diffusing component is destabilizing and (apart from some mechanical mixing) transport is simply by molecular diffusion.

A series of convecting layers and thin density interfaces can form from an instability of smooth density gradients [2, 3]. However, the laboratory interfaces are more easily produced by pouring a homogeneous layer of fluid onto a heavier layer such that there are opposing concentration steps of two properties. In this case the subsequent development of double-diffusive convection is considered to be relevant to the situation in the ocean when sharp concentration gradients are produced by mechanical stirring or horizontal advection. For two components, Huppert and Manins [4] have shown that salt fingers will form and grow to large amplitude at such a density discontinuity when the condition

$$1 < \left|\frac{\alpha\Delta T}{\beta\Delta S}\right| < \left(\frac{\kappa_S}{\kappa_T}\right)^{-3/2} \tag{1.1}$$

is satisfied. The ratio of diffusivities is $\kappa_S/\kappa_T < 1$, and $\alpha\Delta T$ and $\beta\Delta S$ are the individual component contributions to the density step. The two layers will overturn if $|\alpha\Delta T| < |\beta\Delta S|$ (S is destabilizing) while no convection occurs if the upper limit is not satisfied. When $\kappa_S \ll \kappa_T$, very small values of ΔS may cause fingers to form.

When a third property with a different diffusivity is added to the fluid, interesting questions arise about the nature of the interface. For example, the addition of a more slowly diffusing property to the bottom layer of a system that would otherwise have produced a finger interface could cause a "diffusive" interface to form. Similarly, addition of the same property to the top layer of another system may change the resulting interface from a "diffusive" to a "salt finger" kind. A knowledge of the type of convection is the first step toward determining the individual fluxes of several components through a density interface (see [5]).

The onset of convection in smooth concentration gradients of three components has already been investigated [6]. The relevant results are outlined in Section 2 and used in Section 3 to determine criteria for the formation of "salt finger" and "diffusive" interfaces from initially sharp steps. The approach is similar to that of Huppert and Manins [4]. Predicted boundaries are then compared to those conditions at which fingers are seen in a laboratory tank, and the subsequent evolution of the interfaces is observed.

2. STABILITY OF SUPERPOSED CONCENTRATION GRADIENTS

For a layer of fluid with depth h, linear vertical gradients of three components and "free-free" boundary conditions, the condition for instability to direct modes becomes

$$\sum_i R_i \tau_i^{-1} > \frac{27\pi^4}{4}, \tag{2.1}$$

where $R_i = gh^4\beta_i(\partial C_i/\partial z)/\kappa_1 \nu$ is a Rayleigh number for the ith component and $\tau_i = \kappa_i/\kappa_1$. When the gradient of the ith component is destabilizing, $R_i > 0$. The diffusivities are such that $\kappa_1 > \kappa_2 > \kappa_3$ and the fluid density is given by

$$\rho = \rho_m\left(1 + \sum_i \beta_i C_i\right), \tag{2.2}$$

where ρ_m is a mean density, C_i are the individual concentrations and β_i are local constants.

If (2.1) is satisfied but the fluid is stably stratified ($\mathrm{d}\rho/\mathrm{d}z < 0$), then salt finger modes are unstable. Some oscillatory modes are also unstable when (2.1) is satisfied and the fastest and slowest diffusing components have the same sign. However, the fastest growing mode will be realized at large amplitude, and this will be a direct mode under all conditions excepting those which are only marginally unstable to monotonic convection, so that (2.1) still predicts the appearance of salt fingers to a good approximation. When (2.1) is not satisfied and $\mathrm{d}\rho/\mathrm{d}z < 0$, it is sufficient to say that the system is stable to monotonic convection.

3. LIMITING CONDITIONS FOR SALT FINGERS AT AN INTERFACE

The formation of a "salt finger" interface requires firstly, that the diffusion profile at the original concentration step be unstable to monotonically growing perturbations and secondly, that large amplitude fingers are possible. For initial discontinuities at $z = 0$ separating two semi-infinite layers of uniform density, diffusion produces concentration gradients

$$\frac{\partial C_i}{\partial z} = (\pi t)^{-1/2}\, \Delta C_i \kappa_i^{-1/2} \exp\left(\frac{-z^2}{4\kappa_i t}\right). \tag{3.1}$$

The difference in layer properties is $\Delta C_i = C_{iu} - C_{il}$, where the subscripts u and l refer to upper and lower layers respectively. Thus a destabilizing distribution of the ith component has $\Delta C_i > 0$.

The gradients (3.1) and the necessary condition (2.1) for instability to direct modes give the criterion for the centre of the interface ($z = 0$) to be unstable to salt fingers. It may be written as

$$\sum_{i=1}^{3} \beta_i \Delta C_i \kappa_i^{-3/2} > \frac{27\pi^4}{4}\,\frac{\nu(\pi t)^{1/2}}{g h_1^4}, \tag{3.2}$$

where h is the length scale appropriate to the Rayleigh number R_1. With $t \sim h^2/4\kappa_1$ and the properties of aqueous solutions given by $g \sim 10$, $\nu \sim 10^{-6}$, $\kappa_1 \sim 10^{-9}$, and $h \geq 2 \times 10^{-3}$ in MKS units, the RHS may be equated to zero whenever $\beta_i \Delta C_i \gg 10^{-2}\,\mathrm{kg\ m^{-3}}$. When temperature is involved, $\kappa_1 \sim 10^{-7}\,\mathrm{m^2\ s^{-1}}$ while h increases as $\kappa_1^{1/2}$ so that this assumption remains good. Thus, the criterion

$$\sum_i \beta_i \Delta C_i \kappa_i^{-3/2} > 0 \tag{3.2}$$

becomes the generalization of the upper limit in (1.1). Huppert and Manins have also shown that (1.1) is the necessary and sufficient criterion for large amplitude salt finger convection to persist at a two-component interface. Their analysis based on the vertical momentum equation may be readily extended to include a third component in the manner of (2.2). An instability will grow to large amplitude when the condition

$$\sum_i \beta_i (\mathrm{d}\bar{C}_i/\mathrm{d}z)\kappa_i^{-1} > 0$$

is satisfied, where the concentration $\bar{C}_i$ is a horizontal average through the fingers, and use of (3.1) reduces this inequality to (3.2).

The behaviour contained in (3.2) is best illustrated by dividing three-component systems into three classes. A total density anomaly ratio R_ρ may be defined for each class. When the two faster-diffusing components are stabilizing ($\Delta C_{1,2} < 0$) and the component with smallest molecular diffusivity is destabilizing ($\Delta C_3 > 0$), the ratio of stabilizing to destabilizing density steps is $R_\rho = |\beta_1 \Delta C_1 + \beta_2 \Delta C_2|/|\beta_3 \Delta C_3|$. For this system, inequality (3.2) is shown as the hatched area of Fig. 1(a), where $\tau_* = \kappa_3/\kappa_2 = \tau_3/\tau_2$. Figure 1 has vertical axes at $R_\rho = 1$ and a logarithmic vertical scale so that $\beta_2 \Delta C_2/\beta_1 \Delta C_1 = 1$ at the horizontal axis. Note that the limiting condition for salt fingers asymptotically approaches the appropriate two-component criteria, $R_\rho < (\kappa_i/\kappa_j)^{-3/2}$, at $\pm\infty$ on the vertical axis. No convection is possible when (3.2) is not satisfied and $R_\rho > 1$. When $R_\rho < 1$ the system must be inverted to keep the top layer less dense than the bottom layer. However, the criterion for salt fingers at $z = 0$ cannot then be satisfied since the two faster-diffusing components are in the top layer. A "diffusive" interface, confined by convection above and below, develops instead.

A second class of interface has the two slower-diffusing components in the same layer. Then $R_\rho = |\beta_1 \Delta C_1|/|\beta_2 \Delta C_2 + \beta_3 \Delta C_3|$. Conditions given by (3.2) are shown in the hatched area of Fig. 1(b). When $\Delta C_1 < 0$ and $\Delta C_{2,3} > 0$, gravitational stability requires $R_\rho > 1$ and fingers are possible. The inverted system at $R_\rho < 1$ again cannot produce fingers and a "diffusive" interface forms.

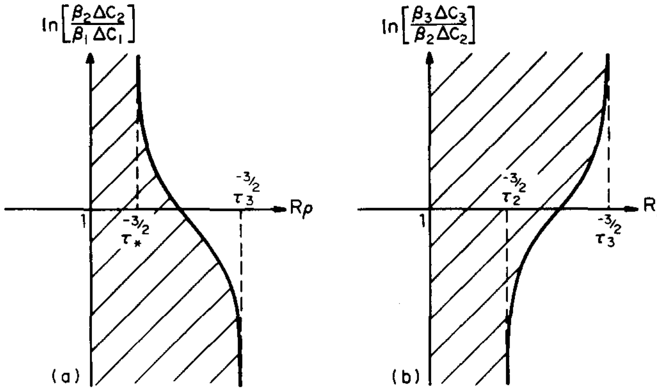

FIG. 1. Schematic diagrams showing the conditions (hatched) for the appearance of salt fingers at the centre of an interface. (a) $\Delta C_{1,2} < 0$ and $\Delta C_3 > 0$; (b) $\Delta C_1 < 0$, and $\Delta C_{2,3} > 0$. R_ρ is the ratio of stabilizing to destabilizing density contributions. Axes are $\beta_i \Delta C_i / \beta_j \Delta C_j = 1$ and $R_\rho = 1$. Values of R_ρ at asymptotes are marked.

A third class of interface is that in which the fastest- and slowest-diffusing components have gradients of the same sign. Both salt finger convection in a statically stable density gradient at $z = 0$ and overstable or monotonic convection* at $z \neq 0$ are now possible. Defining $R_\rho = |\beta_2 \Delta C_2| / |\beta_1 \Delta C_1 + \beta_3 \Delta C_3|$ and $R'_\rho = R_\rho^{-1}$, (3.2) implies that fingers will form in the hatched areas of Fig. 2. Salt fingers may this time occur in the inverted system ($R'_\rho > 1$) and conditions satisfying (3.2) are bounded by conditions which produce "diffusive" interfaces and layered convection. It is this third class of system, in which two types of instability "complete", that is most interesting. In particular, it may be seen from Fig. 2 that a relatively small concentration of component 1 or 3 could determine the nature of a density interface.

Formation of fingers at the centre of an interface has been considered; however, the diffusion profiles (3.1) may become unstable at some $z \neq 0$ while gradients at $z = 0$ remain stable. Alternatively, salt fingers predicted by (3.2) might not form due to the modification of gradients at the interface centre by the earlier occurrence of either overstable or direct motions at $z \neq 0$. The latter possibility has a time and space dependence so that the general case will not be investigated. To consider the occurrence of a salt finger instability away from the interface centre, (3.2) is extended to arbitrary z. Then instability requires $S > 0$, where

$$S \equiv (\pi t)^{-1/2} \sum_i \beta_i \Delta C_i \kappa_i^{-3/2} \exp(-z^2/4\kappa_i t).$$

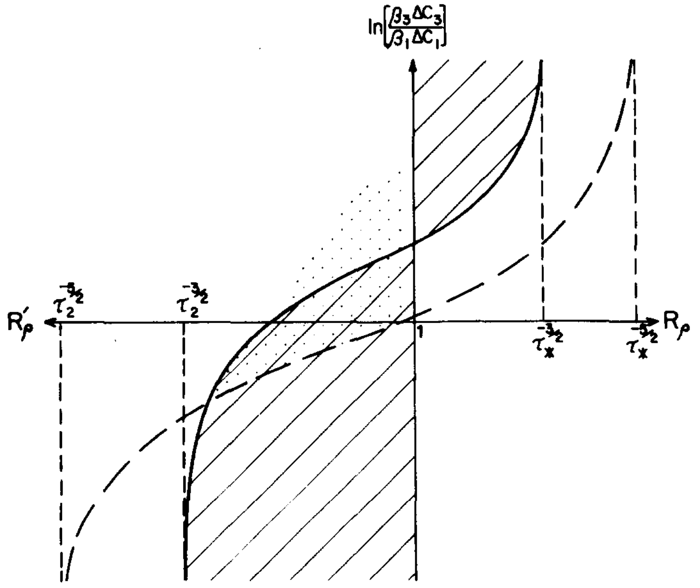

FIG. 2. Conditions (hatched) for formation of fingers when ΔC_1 and ΔC_3 are of the same sign. The ratio $R_\rho \geq 1$ and $\Delta C_2 > 0$ to the right of the axis, while $R'_\rho = R_\rho^{-1} \geq 1$ and $\Delta C_2 > 0$ to the left. Inequality (3.3) is satisfied below the broken line for $R_\rho > 1$ and above it for $R'_\rho > 1$; the dotted area suggests the type of conditions which allow salt fingers to occur at $z \neq 0$.

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* Instability at the edge of a "diffusive" interface need not be oscillatory. The density gradient may become positive and allow monotonic motions.

Fingers will first occur at a position given by the maximum in $S(z)|_t$ and such a maximum will occur at $z = 0$ whenever the inequality

$$\sum_{i=1}^{3} \beta_i \Delta C_i \kappa_i^{-5/2} > 0 \tag{3.3}$$

is satisfied. There is a minimum of S at $z = 0$ when (3.3) is not satisfied so that salt fingers will form at some $z \neq 0$ first, if they form at all. Assuming that (3.3) gives a global maximum in S at $z = 0$, we may conclude that no fingers are possible if (3.3), but not (3.2), is satisfied. If neither is satisfied, then we do not know whether fingers may form at $z \neq 0$.

Both inequalities (3.2) and (3.3) hold in the shaded areas of Fig. 1, and there is no disturbance to these systems by other instabilities. Such is not the case when the fastest- and slowest-diffusing components contribute density gradients of the same sign (Fig. 2). Then the criterion (3.2) is satisfied in the hatched areas while (3.3) is satisfied above the broken curve for $R_\rho > 1$ ($\Delta C_{1,3} > 0$) and below it for $R'_\rho > 1$($\Delta C_{1,3} < 0$). When $R_\rho > 1$ the limiting conditions for salt fingers at the interface centre are bounded by a wide region (below 3.2 but above 3.3) in which no salt fingers can occur. Instead, a "diffusive" interface develops. There may also be a complication if (3.2) is satisfied: salt fingers which are predicted to form at $z = 0$ may be prevented from doing so by a double-diffusive instability between components '1' and '2' at $z \neq 0$, since these components are able to diffuse more rapidly, leaving the component '3' gradient behind. Such processes are likely to be most important when $\kappa_1, \kappa_2 \gg \kappa_3$ and when $R_\rho \gtrsim 1$.

The opposite effect may occur in the inverted system ($R'_\rho > 1$) where layer conditions producing "salt finger" interfaces may be extended by a tendency for the two faster-diffusing components to form fingers at $z \neq 0$. This possibility too is most important for $\kappa_1, \kappa_2 \gg \kappa_3$. The dotted area of Fig. 2 shows the conditions for which fingers form first at $z \neq 0$ if they occur at all. We know that they do form when (3.2) is satisfied, but the limit to such conditions when (3.2) is not satisfied cannot be found for the general case. This limit will occur when $\Delta C_3/\Delta C_1$ is sufficiently large that component '2' causes a local density inversion and subsequent convection before salt fingers are able to form in the gradients of components '1' and '2'.

4. EXPERIMENTAL OBSERVATIONS OF THREE-COMPONENT INTERFACES

Laboratory observations of the third class of interface using aqueous solutions of three solutes (KCl, NaCl and sucrose) are compared with the criterion (3.2) in Fig. 3(a) for $R_\rho > 1$ and in Fig. 3(b) for the inverted system $R'_\rho > 1$. All experiments were conducted with solutions at a temperature of 20.0 ± 0.5°C for at least the first 30 min after forming the interface. In all but two experiments the layers were of equal depth in a tank with cross-section 5 × 15 cm. A layer depth, D, of 12 cm ensured that $D \gg (4\kappa t)^{1/2}$ for a diffusion coefficient, κ, of 10^{-5} cm^2 s^{-1} and a time, t, of 60 min. Timing started from the moment at which pouring of the top layer onto a permeable float began. Solutions were prepared beforehand to the required concentrations, always 0.5–1.5 M for NaCl and in the ranges [1.0 M KCl + 10^{-3} M sucrose] to [0.02 M KCl + 0.2 M sucrose]. A density bottle was used to determine the density of each solution.

The remaining two experiments used a tank of cross-section 5 × 40 cm in which a stably stratified, 40 cm deep layer of one solution was established by filling the tank using the two-bucket method [2]. Into this gradient an intrusion of the second solution at its equilibrium depth was produced from a line source so that the upper and lower interfaces (see [7]) could be observed. Density anomaly ratios of R_ρ, $R'_\rho \lesssim 1.005$ were obtained and the four results are shown as triangles in Fig. 3.

Each experiment was classified according to whether salt-fingers or sharp density gradients appeared on a shadowgraph. Near marginal conditions some interfaces were not distinctly of one type or the other (crossed points) and salt fingers were visible over only a small fraction of the tank width. Although the recorded character of the interface was that determined near $t = 60$ min, many were observed for a much longer time and their character did not alter significantly. The approximation of the RHS of (3.2) to zero was valid for the interfaces observed.

All available data for the diffusion coefficients [8–14] were used to find values at 20°C and at concentrations equal to the mean concentrations of the relevant component across an interface. Due to the concentration ranges involved, the theoretical curves shown in Fig. 3 were calculated from (3.2) in two sections meeting each other at $\beta_3 \Delta C_3/\beta_1 \Delta C_1 \sim 1$. The values used for the diffusivities are those in Table 1.

The observations recorded in Fig. 3 appear to be well described by (3.2), as might be expected for diffusivities of the same order of magnitude. There are small discrepancies only for $R_\rho \sim 1$, where an extension of salt-fingering activity in one system (Fig. 3b) and a roughly similar decrease in the inverted system (Fig. 3a) probably indicates interaction of the two fastest diffusing components at $z \neq 0$ after leaving the stabilizing sucrose gradient closer to $z = 0$. However, the concentration ratio $\beta_3 \Delta C_3/\beta_1 \Delta C_1 \sim 10^{-1}$ is still sufficient to alter the nature of the interface formed near $R_\rho = 1$.

Some interfaces through which properties appeared to be transported by both salt fingers and direct molecular diffusion were observed in the experiments. When a solution of KCl and sucrose was placed above a NaCl solution such that $R_\rho \gtrsim 4.5$ and $\beta_3 \Delta C_3/\beta_1 \Delta C_1 \sim 10$, interfaces which appeared to be of the "diffusive" type formed but 30 min later exhibited a thin layer of salt fingers near their centre. That is, a 1–2 cm layer, predominantly with a smooth density gradient and no convection, separated two deep convecting layers while a thin layer (0.2 cm) of faint vertical striations

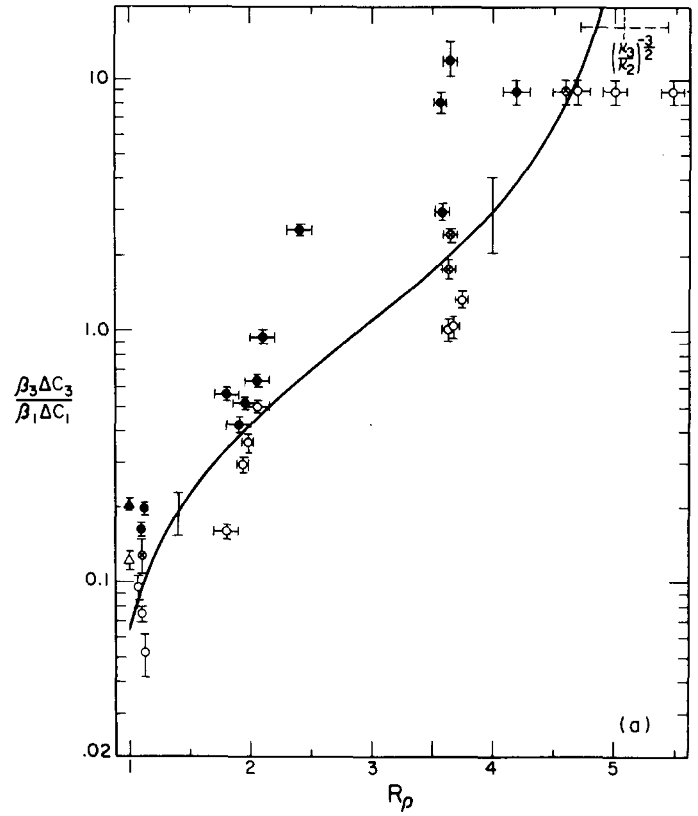

Fig. 3. Experimental observations on the configuration of Fig. 2 using components 1 : KCl; 2 : NaCl and 3 : sucrose. (a) NaCl above sucrose and KCl; (b) KCl and sucrose above NaCl. Error bars shown for the solid curve (3.2) and its asymptotes result from uncertainties shown in Table 1. The broken curve is given by (3.3). ●, salt fingers visible all along interface; ◐, two layers of salt fingers; ⊗, fingers seen but not all along interface; ○, convection but no fingers visible; ▲, △, intrusion experiments.

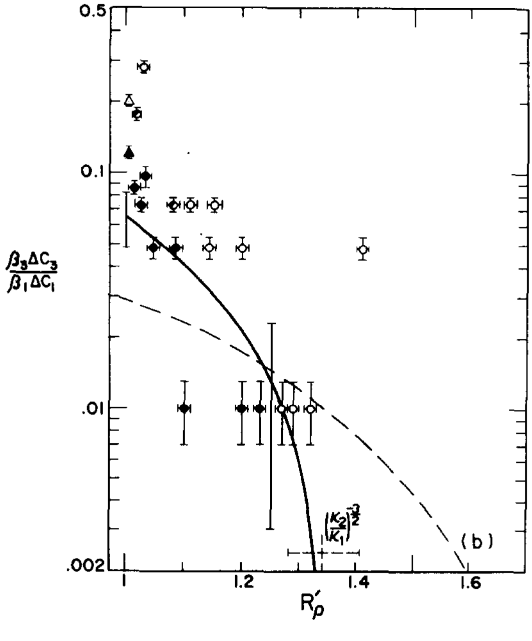

Table 1. Values of diffusion coefficients for the aqueous experimental system. Component 1 : KCl; component 2 : NaCl; component 3 : sucrose

	Component	Mean concentration (M/l)	Diffusivity ($10^{-9}\,m^2\,s^{-1}$)
$\frac{\Delta C_3}{\Delta C_1} > 1$	1	0	1.67 ± 0.02
	2	0.5	1.30 ± 0.05
	3	0.1	0.44 ± 0.02
$\frac{\Delta C_3}{\Delta C_1} < 1$	1	0.5	1.58 ± 0.02
	2	0.5	1.30 ± 0.05
	3	0	0.45 ± 0.02

appeared near $z = 0$. Although fingers were visible along no more than 50% of the interface, the diffusive core, once established, is concluded to have become unstable. The small density variations within the fingers and resulting low contrast on the shadowgraph screen prohibited close study of the time dependence involved but suggest that, at least in these experiments, such salt fingers do not make an important contribution to the fluxes. Interfaces consisting of two layers of salt-fingers were also observed. The two layers of vertical striations were separated from a non-convecting core by sharp density gradients and bounded on the outside by the upper and lower convecting layers. Such interfaces occurred at $R'_\rho \sim 1$ and $\beta_3\Delta C_3/\beta_1\Delta C_1 \sim 0.1$ when the NaCl solution was placed above the solution of KCl and sucrose, and are those observations identified by half-filled circles on Fig. 3b. The behaviour was due to the formation of fingers at $z \neq 0$ and to the existence of a large sucrose gradient, which the fingers could not pass, near $z = 0$. Both the diffusive core and the fingers grew in thickness as the layer properties ran down.

Some experiments using heat, sucrose and suspended bentonite illustrate the importance, to systems in which $\kappa_1 \gg \kappa_2 \gg \kappa_3$, of the prevention of salt fingers by the "diffusive" instability. Here, $\tau_2 \sim 10^{-2}$ and $\tau_3 \ll 10^{-2}$. When, for example, a layer of bentonite suspension was placed over a hot sucrose solution such that $R_\rho \sim 6$ and $\beta_3\Delta C_3/\beta_1\Delta C_1 \sim 0.6$, a vigorous "diffusive" interface developed. Although these conditions satisfy (3.2) fingers at $z = 0$ were too slow to form before the concentration profiles were altered by thermal convection. However, they did appear in the diffusive core after allowing the layer properties to run down for many hours. Conversely, when a layer of hot sucrose was placed over a (dilute) bentonite suspension such that $R'_\rho \sim 2$ and $\beta_3\Delta C_3/\beta_1\Delta C_1 \sim 0.15$, 'sugar-fingers' were vigorous but (3.2) was not satisfied. Fingers formed first at $z \neq 0$ but the clay did not prevent their formation at the centre of the interface.

5. CONCLUSIONS

The limiting condition for the formation of salt fingers at an initially sharp density step in a three component system implies that relatively small concentrations of properties with very small molecular diffusion coefficients can have an important influence in determining whether a "salt finger" or a "diffusive" interface develops. Such considerations are relevant to the bottom boundary layer of the ocean and to tidal and estuarine areas where there are often measured gradients of temperature, salinity and suspended particulate matter. The use of dyes in laboratory experiments on double-diffusive convection can also be examined.

An interesting case is that in which two of the properties tend to produce salt fingers while two of the components tend to produce a "diffusive" interface. Experiments show that the predicted limiting condition for salt fingers does not hold in this case if $\kappa_1, \kappa_2 \gg \kappa_3$. Indeed, even comparable concentrations of a property with very low diffusivity may have no influence at all upon the final nature of the interface. On the other hand, interesting combinations of salt fingers and direct molecular diffusion in the vertical have been observed within some interfaces.

Finally, many "salt finger" interfaces cannot be steady. Fingers may only exist in linear gradients of two properties when the ratio of gradients satisfies $T_z/S_z < (\kappa_S/\kappa_T)^{-1}$. Extending this to three components implies that a finger interface between mixed layers can only be steady when

$$\sum_i \beta_i \Delta C_i \kappa_i^{-1} < 0,$$

a more restrictive criterion than that allowing the appearance of salt fingers. At the remaining conditions only intermittent growth and sweeping away of fingers is possible.

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NOTE SUR LA FORMATION D'INTERFACES EN "DOIGT DE SEL" ET "DIFFUSIFS" DANS DES SYSTEMES A TROIS COMPOSANTES

Résumé—Les interfaces minces de densité déterminent les flux de chaleur ou de soluté par convection doublement diffusive. Les transports sont menés soit par la convection en "doigt de sel", soir par la diffusion moléculaire. On étudie ici l'influence d'une troisième propriété diffusante sur le type d'interface formé à une discontinuité initiale de densité. Il peut y avoir une forte dépendance vis-à-vis des diffusivités moléculaires et on observe que quelques interfaces ont une structure compliquée.

ÜBER DIE BILDUNG VON "SALZFINGERN"-UND DIFFUSIONS-GRENZFLÄCHEN IN DREI-KOMPONENTEN-SYSTEMEN

Zusammenfassung—Dünne Dichte-Grenzschichten bestimmen den Wärme- oder Stoffstrom infolge Konvektion, die durch zweifache Diffusion bedingt ist. Der Transport wird entweder durch 'Salzfinger'-Konvektion oder durch molekulare Diffusion bewirkt. Hier wird der Einfluß einer dritten diffundierenden Größe auf den Grenzflächentyp untersucht, der sich bei einer Anfangsdiskontinuität der Dichte ausbildet. Es besteht eine starke Abhängigkeit von der molekularen Diffusion, bei einigen Grenzschichten wurden komplizierte Strukturen beobachtet.

ОТНОСИТЕЛЬНО ОБРАЗОВАНИЯ «СОЛЕВОГО ПАЛЬЦА» И «ДИФФУЗИОННЫХ» ПОВЕРХНОСТЕЙ РАЗДЕЛА В ТРЁХКОМПОНЕНТНЫХ СИСТЕМАХ

Аннотация — Тонкие поверхности раздела плотности определяют потоки тепла и растворённого вещества посредством двойной диффузионной конвекции. Перенос при этом происходит или за счёт конвекции типа «солевого пальца», либо посредством молекулярной диффузии. В работе исследуется влияние третьего диффузионного свойства на тип поверхности раздела, образующейся в месте первоначального разрыва плотности. Отмечается сильное влияние молекулярных коэффициентов диффузии и сложность структуры образующихся поверхностей раздела.